15:49:37 OCA PAD AMENDMENT - PROJECT HEADER INFORMATION 12/12/96

Active

Project #: E-20-M09 Cost share #: Rev #: 1
Center # : 10/24-6-R8803-0A0 Center shr #: OCA file #:
Work type : RES
Contract#: RR336-372/2437514 Mod #: 1 Document : SUBCONT
Prime #: 751-490109 Contract entity: GTRC

Subprojects ? : N CFDA: NA
Main project #: PE #: NA

Project unit: CIVIL ENGR Unit code: 02.010.116
Project director(s):
AMIRTHARAJAH A CIVIL ENGR (404)894-2265

Sponsor/division names: UNIVERSITY OF GEORGIA / ATHENS, GA
Sponsor/division codes: 400 / 009

Award period: 950501 to 961231 (performance) 961231 (reports)

Sponsor amount	New this change	Total to date
Contract value	0.00	41,000.00
Funded	0.00	41,000.00
Cost sharing amount		0.00

Does subcontracting plan apply ?: N

Title: LAKE LANIER - CLEAN LAKES PROJECT: DISCRETE POLLUTANT SOURCES

PROJECT ADMINISTRATION DATA

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ATHENS, GA 30602-7411

Security class (U,C,S,TS) : U ONR resident rep. is ACO (Y/N): N
Defense priority rating : NA NA supplemental sheet
Equipment title vests with: Sponsor X GIT
NONE PROPOSED.
Administrative comments -
MOD 1 AUTHORIZES A NO-COST EXTENSION THRU 12/31/96, AS REQUESTED.

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

NOTICE OF PROJECT CLOSEOUT

Closeout Notice Date 01/24/97

Project No. E-20-M09____________ Center No. 10/24-6-R8803-0A0_

Project Director AMIRTHARAJAH A___________ School/Lab CIVIL ENGR_____

Sponsor UNIVERSITY OF GEORGIA/ATHENS, GA_____________________________

Contract/Grant No. RR336-372/2437514_____________ Contract Entity GTRC

Prime Contract No. 751-490109____________________

Title LAKE LANIER - CLEAN LAKES PROJECT: DISCRETE POLLUTANT SOURCES____________

Effective Completion Date 961231 (Performance) 961231 (Reports)

Closeout Actions Required:	Y/N	Date Submitted
Final Invoice or Copy of Final Invoice	Y	______
Final Report of Inventions and/or Subcontracts	N	______
Government Property Inventory & Related Certificate	N	______
Classified Material Certificate	N	______
Release and Assignment	N	______
Other ________________________________	N	______

Comments____
____

Subproject Under Main Project No. __________________

Continues Project No. __________________

Distribution Required:

Project Director	Y
Administrative Network Representative	Y
GTRI Accounting/Grants and Contracts	Y
Procurement/Supply Services	Y
Research Property Managment	Y
Research Security Services	N
Reports Coordinator (OCA)	Y
GTRC	Y
Project File	Y
Other ________________________________	N
________________________________	N

E-20-M09

Georgia Institute of Technology
Environmental Engineering
School of Civil and Environmental Engineering

January 21, 1997

TO: The OCA Reports Coordinator
Office of Contracts Administration
CRB Room 117A, Campus

FROM: A. Amirtharajah

RE: Draft Final Report for Project E-20-M09 titled
"Lake Lanier: Discrete Pollutant Sources"
funded by University of Georgia

The draft final report on this project was sent to Dr. Kathy Hatcher on December 20, 1996.

Two copies of the draft final report are herewith enclosed for your files. Please remove the listing of this project under overdue deliverables since the draft final report has been sent to the sponsor by the due date of December 31, 1996.

Thanks.

Enclosure

/hb

cc: Aris Georgakakos, Associate Chair for Research
Ina Lashley, OCA/PAD

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Atlanta, Georgia 30332-0512 U.S.A.
PHONE 404•894•2265 FAX 404•894•8266

DRAFT

(Do not quote or copy)

CHAPTER 5. IMPACT OF DISCRETE POLLUTANT SOURCES INTO LAKE LANIER

M. Timmerly York, Barbara Brouckaert, A. Amirtharajah

Revised: 12/19/96

School of Civil and Environmental Engineering

Georgia Institute of Technology, Atlanta, GA 30332

Final Report Submitted to the University of Georgia, Athens, GA

December 1996

CHAPTER 5. IMPACT OF DISCRETE POLLUTANT SOURCES INTO LAKE LANIER

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CHAPTER 5. IMPACT OF DISCRETE POLLUTANT SOURCES INTO LAKE LANIER

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Outline of Chapter 5:

5.1 INTRODUCTION

Because of the importance of Lake Lanier to the surrounding ecosystem, to the population of North Georgia, and to the inhabitants downstream of the dam, it is imperative that the lake's watershed be managed to ensure that the lake is healthy and viable. In order to properly manage a watershed it is neccessary to identify the potential pollutant sources in the watershed and to determine the extent of pollution from these sources. A previous Lake Lanier Clean Lakes Study (Hatcher et al., 1994) assessed the current water quality of the lake and investigated nonpoint source pollutant loadings into the lake. The purposes of the research presented here are to identify and investigate the discrete pollutant sources in the watershed and to calculate pollutant loadings from some of these sources and from urban stormwater runoff. There is currently no up-to-date information on these pollutant sources and loadings into Lake Lanier.

In this report, the potential discrete pollutant sources in the Lake Sidney Lanier watershed are identified and investigated. The results of a sampling program, conducted to determine typical concentrations of pollutants from ten wastewater treatment facilities and for urban stormwater runoff into three streams, are presented. Average yearly pollutant loadings into the lake calculated on the basis of the results from the sampling program and the facilities' discharge monitoring data are also presented. The report concludes with alternatives analysis and recommendations for decreasing the contribution of pollutants from these sources.

5.2 POLLUTANT SOURCES AND CONTAMINANTS FROM THESE SOURCES

Lake Lanier's watershed consists of a large part of Forsyth, Habersham, Hall, Lumpkin and White counties and small sections of Dawson, Union and Gwinnett counties. There are many different potential sources of pollution in the watershed. The sources investigated as a part of this project are: municipal wastewater treatment plants, industrial wastewater treatment plants, marinas, landfills, septic tanks, hazardous waste sites, underground storage tanks, cemeteries, and urban areas.

Municipal Wastewater Treatment Plants

Wastewater treatment facilities are the most common point sources of pollution into lakes. Most treatment facilities discharge treated effluent into streams or larger bodies of water. This discharge is regulated under the National Pollutant Discharge Elimination System (NPDES) which is enforced through the Georgia Environmental Protection Division (EPD). NPDES files were reviewed at the EPD's Water Protection (municipal wastewater) Office. The file review resulted in identification of municipal wastewater treatment facilities and private industrial developments (PIDs) in the Lake Lanier watershed. Because of their low flow, PIDs are considered to have a lesser environmental impact than wastewater treatment facilities. There are thirteen municipal facilities and thirty-three PIDs in the watershed. Tables 5-1 and 5-2 provide a brief description of these facilities and show the body of water into which the effluent flows. The locations of the thirteen wastewater treatment facilities in the watershed are shown in Figure 5-1. As can be seen from the tables, the PIDs may not cause significant contributions of pollutants because of their low flows. Most of the flows are one-tenth to one-hundreth times smaller than the flows from the municipal wastewater treatment facilities.

Table 5-1. Municipal Wastewater Treatment Facilities

Facility Name	NPDES Permit #	Type of Operation	Permitted Flow (MGD)	Receiving Water
Baldwin WPCP	GA0033243	activated sludge	0.3	Little Mud Creek
Clarkesville WPCP	GA0032514	trickling filter	0.75	Soque River
Cleveland	GA0036820	aqua culture / UV disinf.	0.75	Tesnatee Creek
Cornelia WPCP	GA0021504	trickling filter	3	S. Fork Little Mud
Dahlonega	GA0026077	activated sludge	0.72	Yahoola Creek
Demorest WPCP	GA0032506	activated sludge	0.4	Hazel Creek
Flowery Branch WPCP	GA0031933	activated sludge	0.2	Lake Lanier
Gainesville #1 Flat Creek	GA0021156	activated sludge	7	S. Flat Creek
Gainesville #2 Linwood	GA0020168	trickling filter	3	Lake Lanier
Gainesville #3 White Sulphur	GA0030716	activated sludge	0.1	Chattahoochee R.
Helen	GA003259	aerated lagoon, land appl.	0.5	Chattahoochee R.
Lake Lanier Islands	GA0049115	oxidation pond	0.35	Lake Lanier
Lula WPCP	GA0024767	oxidation pond	0.03	Lula Creek

Wastewater treatment plants are often the most significant form of point source pollution into lakes. As a part of the NPDES, these facilities are required to monitor certain parameters and report the results to the EPD in discharge monitoring reports (DMRs). Available DMRs from 1991 to 1996 were obtained from the EPD. This information was collated into a database and analyzed (York, 1997). Tables 5-16 to 5-19 include data collected from the DMRs and the sampling data collected in this study and are presented under the Results section of the report. However, to cross reference the information presented in these tables they are also discussed in this section. This information is summarized in Table 5-16 which compares the permitted concentration to the flow-weighted averages of the DMR concentration and the results obtained by sampling during this study (the details of sampling are explainted later in this report). The Helen wastewaster facility is not included in the calculations in the remainder of the report becasue it is a land application facilitiy, and, thus, does not directly discharge into a stream. The shaded numbers in Table 5-16 indicate that the permitted concentration has been exceeded. The most common water quality parameters to assess pollution from municipal wastewater treatment facilities are biochemical oxygen demand (BOD), fecal coliform, ammonia, phosphorus and suspended solids. As can be seen in Table 5-16, according to the available data, most of the facilities are meeting the permit requirements.

Table 5-2. List of Private Industrial Developments (PIDs)

Site Name	NPDES Permit #	Type of Operation	Permitted Flow (MGD)	Receiving Water
Camp Barney Medintz	GA0034983	act. sludge/polish pond	0.04	Jenny Creek
Camp Coleman	GA0035467	STSF	0.02	Trib to Town Creek
Camp Glisson	GA0033979	STSF	0.0005	Cane Creek
Chattahoochee Bay	GA0024189	STSF	0.0004	Lake Lanier
Chattahoochee Country Club WPCP	GA0022471	STSF	0.01	Lake Lanier
Cinnamon Cove Condos WPCP	GA0049051	activated sludge/filter	0.07	Lake Lanier
Dixie MHP	GA0023043	oxidation pond	0.0053	Trib to Flat Creek
Flowery Branch Elementary	GA0027090	STSF/Cl	0.012	Mud Creek South
Friendship Health Care Center	GA0026379	oxid. pond/sand filter	0.02	Stephens Creek
Glover & Baker MHP #1,#2	GA0027049	oxidation ponds	0.0195	Trib to Little River
Gainesville - Chatt.	GA0034916	STSF	0.004	Lake Lanier
Habersham Center H.S.	GA0033952	activated sludge	0.02	Licklog Creek
Habersham-On-Lanier	GA0030261	activated sludge	0.11	Lake Lanier
Holiday on Lake Lanier	GA0022080	STSF	0.01	Lake Lanier
Lakeshore Campsites - Flowery Bch	GA0024198	STSF	0.005	Lake Lanier
Lakeside MH Community	GA0049891	oxidation pond	0.0028	Wahoo Creek
Lanier Beach South WWTP	GA0031674	activated sludge	0.038	Lake Lanier
Lanier Elementary School	GA0034843	STSF/Cl	0.00605	Wahoo Creek
Mountain Lake Resort	GA0046400	STSF	0.009	Lake Qualatchee-Cathy Crk
North Hall HS	GA0034886	activated sludge	0.03	Trib to Wahoo
Oakgrove Elementary				
Oak Grove MHP	GA0034207	oxidation pond	0.00235	Trib to Cane Creek
Oakwood Elementary	GA0048089	STSF/Cl	0.012	Trib to Balus Creek
R Ranch in the Mountains	GA03-972	act. sludge/land appl.	0.1	Jarrard Creek
Sardis Elementary	GA0034860	STSF	0.01	Trib to Lake Lanier
Shady Grove MHP	GA0023469	oxidation pond	0.02	Trib to Balus Creek
South Hall Industrial Park	GA0034924	activated sludge	0.01	Balus Creek
Unicoi State Park	GA02-066	aeration pond/land appl.	0.075	Smith Creek
Wauka Mountain Elementary	GA0032697		0.0136	East Fork Little River
Wauka Mountain Nursing Home	GA0034568	activated sludge	0.01	Little River
West Hall High School	GA03-615	oxidation ponds	0.03	

Note: STSF - Septic tank sand filter Cl - chlorination

In an effort to compare the effluent concentrations of these pollutants to in-stream water quality standards, dilution factors were used as per the Rules and Regulations for Water Quality Control (GA DNR EPD, 1995). The dilution factor is the sum of the 7Q10 flow for the stream into

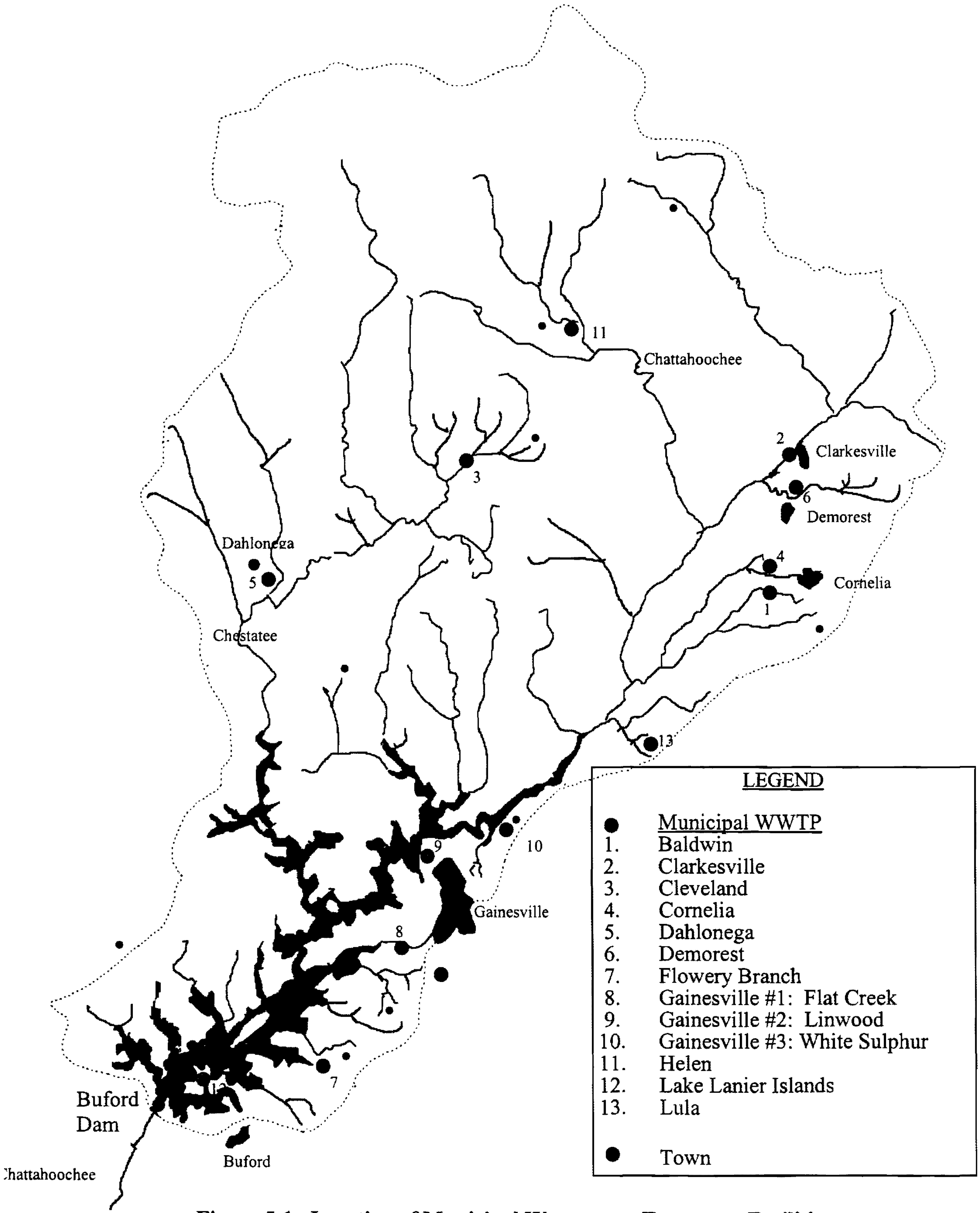


Figure 5-1. Location of Municipal Wastewater Treatment Facilities

which the effulent is discharged and the effluent flow from the facility, divided by the effluent flow from the facility. The 7Q10 flow values indicate low flow conditions in a stream (7-day, 10-year minimum stream flow). Thus, using the 7Q10 value is a conservative measure to indicate what a probable concentration of a pollutant would be when the stream quality is more sensitive due to low flows. Using the 7Q10 flow gives an indication of acute concentrations rather than chronic effects. When the facility's effluent concentration is divided by the dilution factor it can be compared to in-stream water quality standards. Because stream flow data is not available for each stream, the closest known flow downstream of the treatment plant outfall was used for analysis. For three facilities, Clarkesville, Cleveland, and Dahlonega, the flow data for the approximate stream location of the outfall was available and was used. For four others, Baldwin, Cornelia, Demorest, and Lula, stations closest to the treatment plant sites were used. An interpolation method based on drainage areas was used to approximate the 7Q10 values for the streams near these sites. The interpolation method is as follows:

$$\text{Estimated } 7Q10_F = \frac{D.A._F}{D.A._G} \times 7Q10_G$$

where D.A. = drainage area; F = facility; G = nearest gaging station.

For Gainesville-Flat Creek, where no USGS flow data was available, the average flow for South Flat Creek in 1991 as reported in the Diagnostic/Feasibility Study of Lake Lanier was used (Hatcher et al., 1994). Because a low-flow value was not used it is incorrect to compare the Gainesville-Flat Creek values to in-stream standards, but they do give an indication as to what might be the probable concentration. Flowery Branch, Gainesville-Linwood and Lake Lanier Islands discharge directly into the lake. Thus, it is unknown what the dilution and mixing effects are at their points of discharge. However, it is assumed that a large amount of dilution would occur, thus a factor of 30 was used. This number is reasonable based on the equation for calculating dilution factors into stratified lakes:

$$D.F. = 0.28 * X / D$$

where X = distance of mixing and D = diameter of pipe. The use of a dilution factor assumes steady-state complete mixing due to discharge-induced mixing and ambient-induced mixing. This analysis of dilution also does not account for a background concentration of pollutants in the stream. Thus, the diluted concentrations in the table represent only the contribution from the discharges. This is not an exact method for quantifying the concentration of pollutants in the stream, but it does provide values for order of magnitude comparison purposes. Table 5-17 shows the diluted concentrations for each facility and Table 5-3 shows typical concentration ranges for these pollutants. The headwaters to Buford Dam are classified as recreational by the Georgia Department Natural Resources (DNR).

Table 5-3. Diluted Concentration Ranges for Municipal Wastewater Treatment Plants

Pollutant	Units	Concentration Range	Average	GA DNR	Drinking
BOD5	mg/L	0.04 - 25	3.8		
Fecal Coliform[3]	# / 100mL	0 - 167	25	200	0[1]
Ammonia	mg N/ L	0.02 - 20	2.3		0.5[2]
Phosphorus	mg P/L	0.01 - 2	0.4		5[2]
Suspended Solids	mg/L	0.05 - 30	6		

Notes:
[1] EPA drinking water maximum contaminant level goal
[2] World Health Organization Standard
[3] Not diluted; actual effluent concentration

Industrial Wastewater Dischargers

The NPDES files were reviewed at the EPD's industrial wastewater office to determine which facilities are in the Lake Lanier watershed. There are eight facilities that fit this description (listed in Table 5-4). Figure 5-2 is a map showing the location of these facilities.

Table 5-4. List of Industrial NPDES Facilities

Facility Name	NPDES Permit #	Type of Discharge	Permitted Flow (MGD)	Receiving Water
Buckhorn Minerals	GA0037290	quarry runoff	0.65	Six Mile Creek
Davidson Mineral Prop. - Habersham	GA0046086	sed pond	2.59	Hazel Creek
Dutch Quality House	GA0037044	non contact cooling H2O	0.01	Balus Creek
Habersham Mills Inc.	GA0001694	filter backwash	0.009	Soquee River
High Point Minerals, Inc.-Turkey Knob	GA0037281	stormwater runoff	0.002	Cavenders Creek
JA Hudson Construction Co	GA0046311	quarry; sed basin		Trib to Gold Branch
Scovill Inc.	GA0001112	process water	0.144	Soque River
SKF Bearing Industries	GA0037265	non contact cooling H2O	0.02	Trib to Mud Creek South

The industries in the watershed were identified from the Georgia Manufacturers Directory (Harris InfoSource International, 1996). A summary of the industries present in the Lake Lanier watershed is shown in Table 5-5. Questionairres were sent to these facilities to ascertain additional information. However, there was a poor response to the survey. It is assumed that the wastes from these facilities are disposed of in an appropriate manner (such as being sent to a municipal wastewater treatment facility).

Table 5-5. Summary of Industries in the Counties Surrounding Lake Lanier

SIC Code	Type of Industry	Number in Counties Surrounding Lake Lanier
2000	Food (14 Poultry facilities)	40
2200	Textile Mill Products	12
2300	Apparel & Other Finished Products Made from Fabrics & Similar Mat.	28
2400	Lumber & Wood Products, Except Furniture	39
2500	Furniture & Fixtures	13
2600	Paper & Allied Products	4
2700	Printing, Publishing & Allied Industries	35
2800	Chemical & Allied Products	15
2900	Petroleum Refining & Related Industries	3
3000	Rubber & Miscellaneous Plastic Products	10
3100	Leather & Leather Products	1
3200	Stone, Clay, Glass & Concrete Products	19
3300	Primary Metal Industries	4
3400	Fabricated Metal Products, Except Machinery & Tansportation Eqmt	23
3500	Industrial & Commerical machinery & Computer Equipment	58
3600	Electronic & Other Electrical Equipment & Components	4
3700	Transportation Equipment	9
3800	Measuring, Analyzing & Controlling Instruments	1
3900	Misc. Mfg. Industries	24

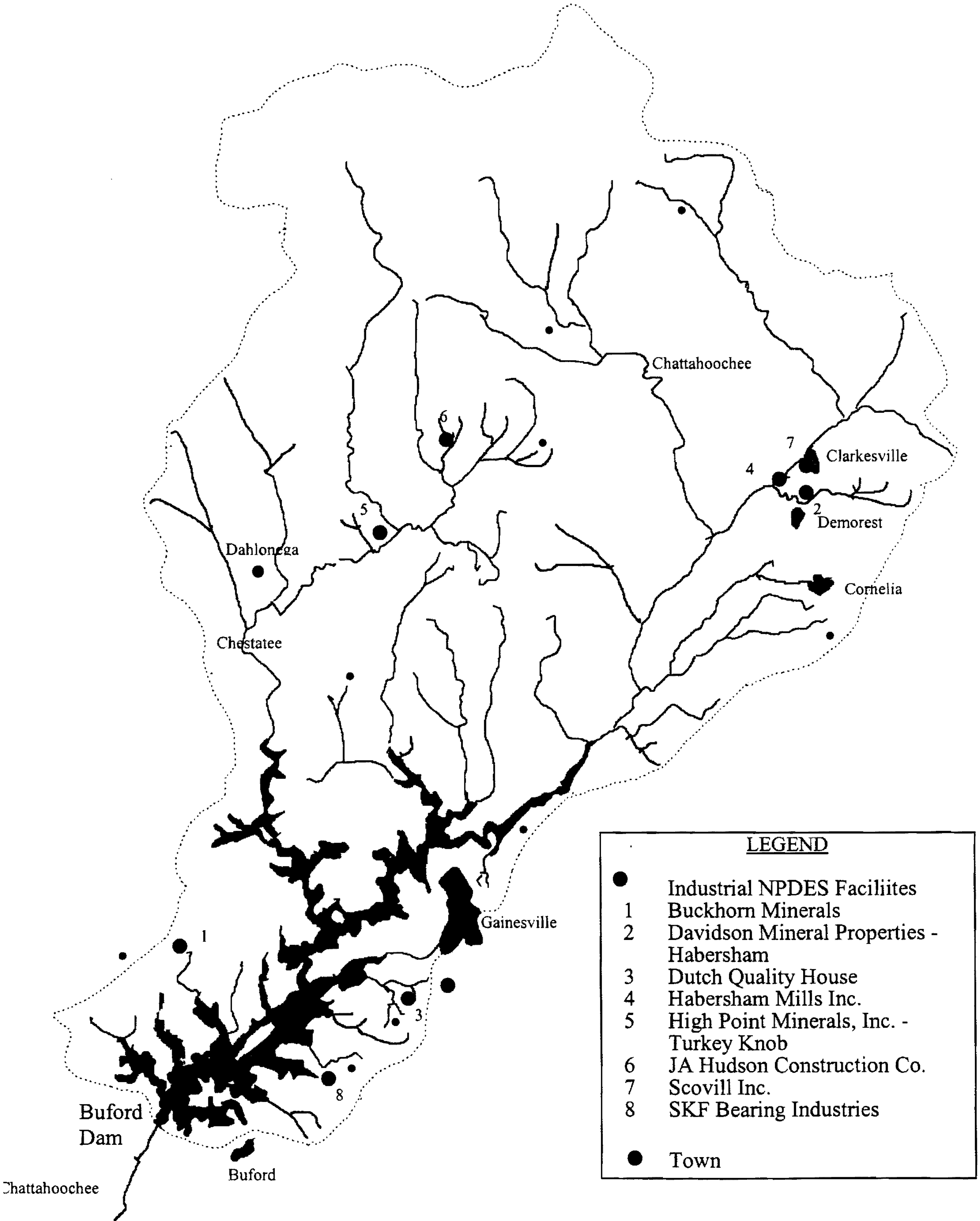


Figure 5-2. Location of Industrial Dischargers

The effluent from industrial facilities can vary greatly in quality depending on the type of industry. The available NPDES DMR information was obtained from the EPD and analyzed (presented in York, 1997). A summary of the types of pollutants and their concentrations from these facilities is shown in Table 5-18. Based on the limited data available, it appears that these sites are meeting their permit requirements. The use of dilution factors was employed as in the municipal facility analysis and the results are displayed in Table 5-19. For most facilities, Davidson Mineral Properties, Habersham Mills, High Point Minerals, JA Hudson Construction Company, and Scovill, the 7Q10 flow values were interpolated downstream from USGS monitoring stations. For Buckhorn Minerals and SKF Bearing, there was no USGS data available. The minimum flow for these streams from the tributary sampling analysis from the Diagnostic/Feasibility Study of Lake Lanier(1994) was used. This does not provide the 7Q10 dilution values, but it does give an estimate of the concentration that might be encountered because of these facilities. Table 5-6 displays a summary of this information as compared to water quality standards.

Table 5-6. Typical Concentration Ranges for Industrial Dischargers

Pollutant	Units	Concentration Range Adjusted for Dilution Effects	Average Concentration	GA DNR Water Quality Standards	EPA Drinking Water MCL
BOD5	mg/L	0.001 - 0.08	0.04		
COD	mg/L	0.004 - 0.09	0.06		
Fecal Coliform	# /100 mL	10 - 41		200	0 *
Iron	mg/L	0.00004 - 0.001	0.0005		0.2 **
Mercury	mg/L	< 0.00002		0.000012	0.002
Total Nitrogen	mg/L	0.0003 - 0.005	0.003		10
Ammonia	mg/L	0.0003 - 0.04	0.01		
Oil & Grease	mg/L	0.0002 - 1.2	0.3		
pH	mg/L	6 - 9		6 - 8.5	
Phosphorus	mg/L	.00009 - .02	0.008		
Sulfate	mg/L	0.005 - 3.157	1.58		500
Suspended Solids	mg/L	0.001 - 18	0.8		
TOC	mg/L	0.0008 - 0.5	0.16		
Zinc	mg/L	< 0.01	0.0004	0.06	

Note *: Maximum contaminant level goal **: WHO guideline or ECC max

Marinas

Marinas are a potential source of contamination because of the requirements and activities associated with boating such as gas, oil and paint spills. A map from the Corps of Engineers Lake Lanier Resource Manager's Office was obtained that shows the locations of marinas and other recreational facilities on the lake. There are ten marinas on the lake. Table 5-7 lists the marinas and Figure 5-3 shows their location.

Information about the effects of marinas on lake water quality is very sparse. The impact that a marina will have is dependent largely upon the actions of individuals and is, thus, difficult to quantify. Marinas can impact a body of water by increasing the toxicity, increasing pollutant concentrations in aquatic organisms and sediment, causing eutrophication and creating high levels of pathogens (US EPA "Managing Nonpoint Sources...from Boating and Marinas"). Some potential pollutants that can result from boating activities are antifouling paints, gasoline, oil, and fecal coliforms due to improper disposal of human waste from boats. Sewage discharge can result in human health problems, destroying shellfish and creating a low dissolved oxygen content in the

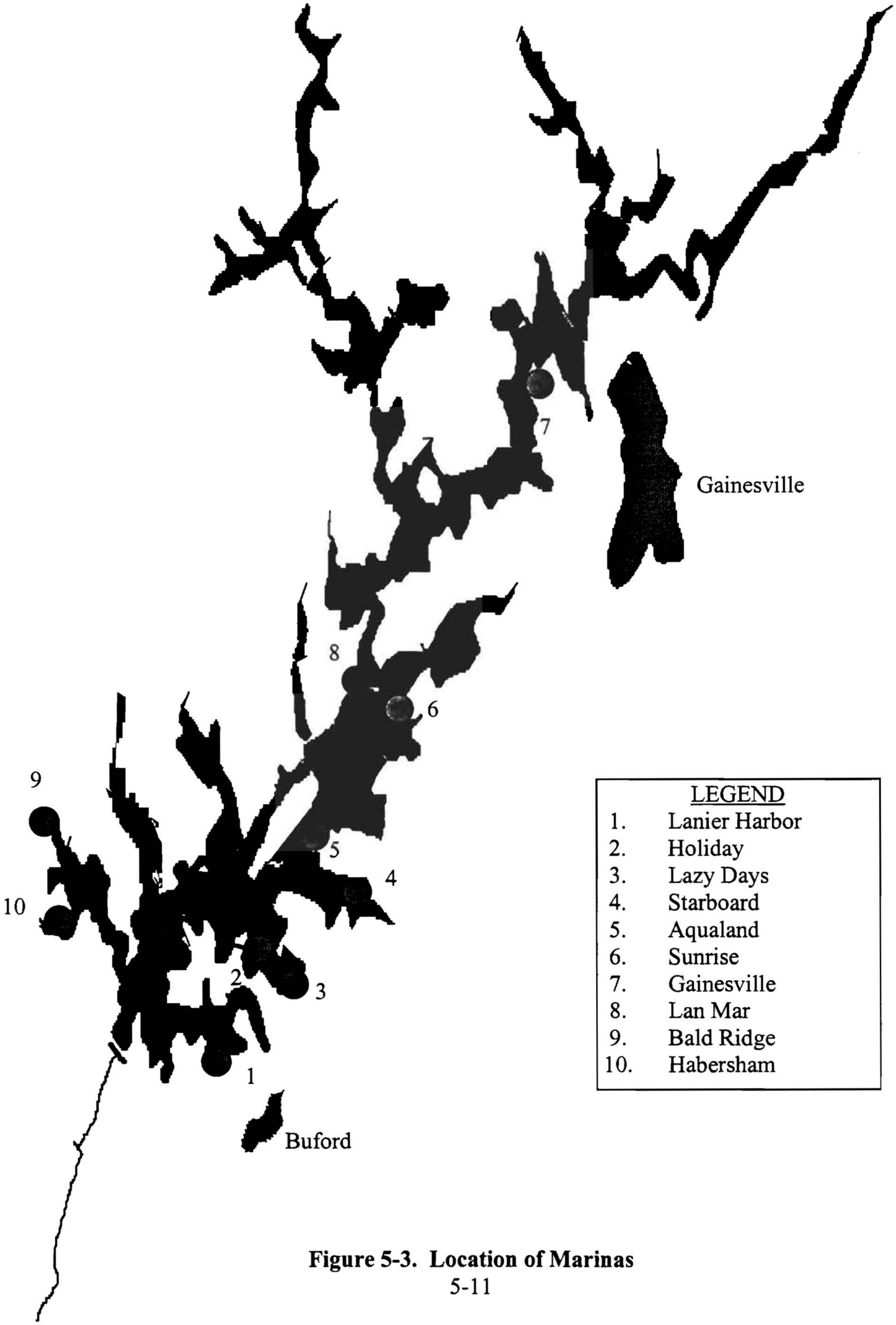


Figure 5-3. Location of Marinas

water. Amendments to the Georgia Water Quality Control Act require that toilets or other disposal units on boats have securely affixed suitable treatment devices. An approved treatment device provides maceration, chlorination and detention prior to discharge. In 1969 it was reported that 70% of marine toilets at Lake Lanier had appropriate treatment devices (GWQCB, 1969). A Georgia Water Quality Control Board study (1969) in 1968-1969 of marinas at Lake Lanier showed results of fecal contamination with a geometric mean of 230 MPN/100 mL of total coliforms and 30 MPN/100 mL of fecal coliforms at one marina. Comparison of results from control stations showed that the concentration of coliforms was higher at the marinas than in areas away from the immediate influence of the pleasure crafts. The study showed that fecal coliform water quality standards were met in more than 90 percent of all samples collected (GWQCB, 1969). There is also concern that the marinas may contaminate the lake with elevated levels of metal concentrations. The EPA (USEPA "Management Measures...Boating") reports that typical metals that may pollute water surrounding boating activities are as follows:

Lead: used as fuel additive and ballast - released through incomplete fuel combustion and boat bilge discharges
Arsenic: used in paint pigments, pesticides and wood preservatives
Zinc anodes: used to deter corrosion of metal hulls and engine parts
Copper and Tin: biocides in antifoulant paints
Others (Iron, Chrome): used in construction of marinas and boats

The most common metal at toxic concentrations is copper. Tin in the form of bytyltin, which is now illegal for use, has been found in toxic levels at marinas nationwide (USEPA "Management Measures ... Boating"). Refueling activities and fuel discharges cause the release of petroleum hydrocarbons which are also harmful to aquatic life. Fish tissue analysis conducted under the diagnostic/feasibility study of Lake Lanier (1994) demonstrated that there were detectable levels of arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc and DDE in the fish tissue from fish caught at two marinas at Lake Lanier. However, these concentrations were not significantly different from the concentrations found in other parts of the lake. It is uncertain whether these metals are originating from activities associated with boating, but it is quite possible that marinas are the source of these metals.

Table 5-7. List of Marinas

Marina	County
Aqualand Marina	Hall
Bald Ridge Marina	Forsyth
Gainesville Marina	Hall
Habersham Marina	Forsyth
Holiday Marina	Hall
Lanier Harbor	Hall/Gwinnett
Lan Mar Marina	Forsyth
Lazy Days Marina	Hall
Starboard Marina	Hall
Sunrise Marina	Hall

Landfills

Landfills have been used for centuries as a way for society to dispose of solid waste. However, the materials in the landfill can leach into the groundwater below the landfill causing the ground water to become contaminated. Solid waste is regulated under the Hazardous and Solid Waste Amendments of 1984 (RCRA Subtitle D). This amendment to the Resource Conservation and Recovery Act requires minimum technology requirements for new land disposal facilities including mandates for soil liners, leachate collection systems and final covers. Some operating criteria are daily covering of refuse, restrictions on placement of liquids, programs for management of codisposal of hazardous waste, postclosure care for at least thirty years, groundwater monitoring and location restrictions. However, in 1988 the EPA found that only 1% of landfills were using flexible membrane liners and 15-27% used soil or clay liners (Adriano, 1994). However, if leachate does reach the groundwater, the contaminant concentration can be reduced in the groundwater due to dispersion, dilution and chemical and biological reactions. Some organics will be reduced by volatilization, biodegradation, and hydrolysis or oxidation reactions. Despite nature's remediation ability, if the contaminants are in a large enough volume, or are extremely toxic or resistant to remediation, they will contaminate the groundwater. This leads to a potential contamination of drinking water sources and surface water.

The Georgia Environmental Protection Division's land protection branch has files only on solid waste facilities that are currently in operation and some closed landfills. This office does, however, have a notebook containing county maps with the locations of some closed solid waste facilities. Thus, no information other than location was found for most closed facilities. Based on this information collection, there are eight municipal landfills in the Lake Lanier watershed. These landfills are listed in Table 5-8 and their locations are shown in Figure 5-4.

Table 5-8. Landfills

Site Name	Permit Number	Closing Date	Nearest Stream
Camp Merril	093-0040 (SL)		Trib to Cane Creek
Clarkesville		Closed 6/82	Soquee River
Cornelia		Closed 11/73	South Fork Mud Creek
Cumming		Closed 10/75	Trib to Lake Lanier
Habersham Co.- Pea Ridge	068-0160 (SL)	Closed 12/95	Little Mud Creek
Lumpkin Co.	093-003D(SL)	Closing 96	Cane Creek
Union Co.-Haralson Mem. Drive	144-0010(SL)	Closed 4/96	Soque River
White Co.-Dukes Cr.	154-0030 (SL)		Ash Creek

New solid waste disposal facilities and facilities requesting closure are required to monitor the surfacewater and groundwater surrounding the site. This monitoring data for 1996 from Union Co., Habersham Co., and Lumpkin Co. was obtained from files at the EPD's Land Protection Branch Solid Waste Management office (this material is presented in York, 1997). Groundwater sampling is accomplished by testing the groundwater from monitoring wells (often denoted GWx-#) surrounding the site. Surfacewater sampling occurs at streams near the site (often denoted SWx-#). The sampling locations marked with A (e.g. GWA-1 or SWA-2) are often background sampling locations. The contamination from these background locations should not contain contamination from the site. The contamination found in the surfacewater is of primary concern for this project, because the contamination will flow into Lake Lanier. The contamination in the groundwater will also eventually flow into Lake Lanier, but only after percolating through the soil. This slow process will most likely cause a change in the composition and toxicity of the contamination. In many cases, the contaminant will be transformed or removed. However, it is possible that some parameters will change form becoming more toxic and more mobile. This process takes a very long time and is

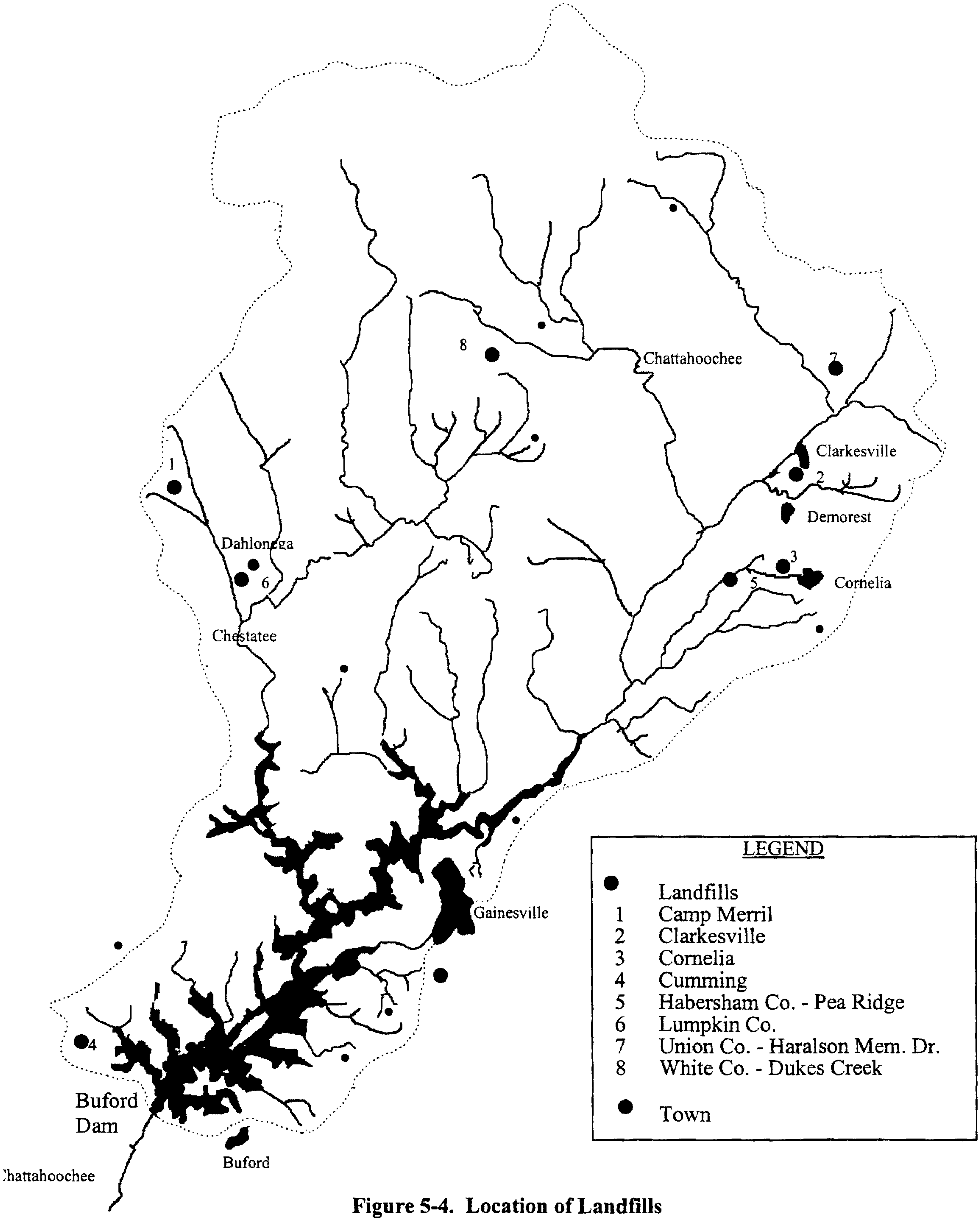


Figure 5-4. Location of Landfills

difficult to quantify. A landfill would only likely be a threat to the water quality of the lake if it were in close proximity to the lake or if it had a significant toxic leak. There are no known landfills in close proximity to the lake. Tables 5-9 and 5-10 show the range of pollutants found in the surfacewater and groundwater near these landfills. Paramaters that exceed the MCLs or 7Q10 limits are shaded. Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) are included in the tables as are in-stream 7Q10 limits. An analysis of this data indicates that possible pollutants of concern are chromium, lead, zinc, benzene, tetrachloroethene, toluene, and trichloroethene.

Table 5-9. Surfacewater Pollutant Ranges Near Landfills

Parameter	Units	Concentration Range	Average Concentration of Measurements over Detection Limit	SDWA MCLs '94	7Q10 Limits
Chloride	mg/L	1.4 - 19	7	250	
TOC	mg/L	2 - 440	49		
COD	mg/L	5 - 1200	186		
Ba	mg/L	0.01 - 0.24	0.04	2	
Cr	mg/L	< 0.01 - 0.87	0.45	0.1	0.011
Pb	mg/L	< 0.025 - 0.16		0.05	0.0013
Hg	mg/L	< 0.0005 - 0.001		0.002	0.000012
Ni	mg/L	< 0.02 - 0.11		0.1	0.088
Zn	mg/L	< 0.02 - 0.52	0.136	2	0.06

Table 5-10. Groundwater Concentration Ranges Near Landfills

Parameter	Units	Concentration Range	Avg. Concentration of Measurements over Detection Limit	SDWA MCLs '94	7Q10 Limits
Ba	mg/L	< 0.02 - 2.7	0.18	2	
Be	mg/L	< 0.003 - 0.003	0.003	0.001	
Cr	mg/L	< 0.01 - 0.05	0.03	0.1	0.011
Co	mg/L	< 0.04 - 0.2	0.13		
Ni	mg/L	< 0.02 - 0.04	0.03	0.1	0.088
V	mg/L	< 0.02 - 0.03	0.03		
Zn	mg/L	< 0.02 - 0.14	0.05	2	0.06
Benzene	ug/L	< 2 - 16	7.7	5	
Chloroethane	ug/L	< 2 - 33	16		
1,1-Dichloroethane	ug/L	< 2 - 34	18		
1,2-Dichloroethane	ug/L	< 2 - 12		5	
cis-1,2-Dichloroethene	ug/L	< 2 - 240	50	70	
1,2-Dichloropropane	ug/L	< 2 - 8	4	5	
Ethylbenzene	ug/L	< 2 - 21	8	700	
Methylene chloride	ug/L	< 5 - 210	56	5	
Tetrachloroethene	ug/L	< 2 -49	10	5	
Toluene	ug/L	< 2 - 49	18	1	
1,1,1-Trichloroethane	ug/L	< 2 - 7		200	
1,1,2-Trichloroethane	ug/L	< 2 - 12	5	5	
Trichloroethene	ug/L	< 2 - 39	12	5	
Vinyl chloride	ug/L	< 2 - 74	20	2	
Xylenes	ug/L	< 5 - 65	25	10000	
Dichlorodifluorometha n	ug/L	< 10 - 130	55		

Septic Tanks

Septic tanks operate by removing solids by settling and/or liquifaction by biological processes. The anaerobic tank provides conditions for anaerobic digestion to reduce organic concentrations. The sludge in the bottom of the tank is periodically pumped out by a licensed septic tank plumber. The clarified liquid at the top of the tank is displaced into the soil as new septage enters the tank. The clarified effluent from septic tanks can potentially degrade groundwater with chloride, nitrate, phosphate salts, oil fractions, fuel oil, TCE, gasoline, turpentine, and pathogens.

The most significant problem associated with septic tank pollution is the contamination of water supplies. When well water is contaminated with fecal coliform bacteria, septic tanks are the prime suspect as the source of contamination. The primary concerns with drinking water contaminated by septic tanks are pathogens and nitrate which can cause death in infants by the disease methemoglobinemia. However, if the septic tank is sufficiently above the groundwater table (two to four feet is often sufficient), the soil can prevent contamination of the water. The depth above groundwater needed depends on the properties of the soil. The soil matrix acts as a sieve for parasites greater than 3 um. Thus, microbes can only travel a few feet in unsaturated soil. Many organisms will die in the soil due to poor conditions for survival or predation. Fine textured soil (such as Georgia clay) increases the adsorption of microorganisms. Average water quality conditions five feet below septic tanks are BOD5 concentrations < 2 mg/L and suspended solids < 1 mg/L (USEPA, 1984). Phosphate anions are precipitated by cations that are abundant in the soil. Phosphorus can also be removed by sorption, plant uptake and bio-immobilization (Reckhow and Simpson, 1980). Generally, phosphorus is not a problem in groundwater unless the soil is coarse or is near a body of water (Kaplan, 1991). The nitrogen content from the septic tank effluent is comprised mainly of ammonia (Kaplan, 1991). In the aerobic, unsaturated percolation field surrounding the septic tank, the ammonia will nitrify into nitrate. Provided there is enough substrate, the nitrate will denitrify to nitrogen gas in the anaerobic soil beyond the aerobic soil region. However, it is difficult to determine the rate by which nitrogen compounds will be nitrified and denitrified without conducting tests. Nitrate is very soluble and can stay in solution in the groundwater. If the septic tanks are in close proximity to the lake, it is possible that some of the contaminants will reach the lake before they can be "treated" by the soil and microbes. If the plume of septic leachate reaches a body of water it can stimulate plant growth and cause eutrophication. However, wave action in lakes can control this growth in large bodies of water.

In the 1950s the U.S. Public Health Service compiled standard design requirements for septic tanks in response to frequent septic tank failures. In the 1960s and 1970s state and local governments began requiring preconstruction approval for installing septic tanks. However, if these facilities become overloaded or are not well maintained they will still fail. It is commonly assumed that from one third to one half of existing septic tanks are operating improperly (Adriano, 1994). There are three main types of failure: surface malfunctions of soil absorption systems due to inadequate hydraulic capacity, backup into household plumbing, and contamination of groundwater.

It is assumed that most homes and businesses in the Lake Lanier watershed (with the exception of those in the larger towns with wastewater treatment facilities) use septic tanks to treat and dispose of waste. It is not within the scope of this project to determine the exact number of septic tanks in the watershed. For the purposes of calculating loadings into Lake Lanier, United States Geological Survey 7.5 minute quadrangle maps were used to count the number of structures within 300 feet of the lake shore. Three hundred feet was used because in the 1975 Eutrophication Study, the EPA considered this to be the distance from the shoreline that would impact a lake. This count of structures that were not in towns with wastewater treatment facilities, resulted in enumeration of nearly 5,200 structures within 300 feet of the lake. It is assumed that each of these structures has a septic tank. Most of the maps used were revised in 1985. Thus, the count is not exact, but in lieu of more precise methods, this estimate will suffice for loading calculations.

Hazardous Waste Sites

RCRA: The Resource Conservation and Recovery Act (RCRA) of 1976 provided for a cradle-to-grave method to maintain control over hazardous waste production, use, transportation and disposal. It is inevitable that spills of toxic substances will occur. Facilities that manufacture, treat, transport, recycle and dispose of hazardous materials are required to notify the EPA and EPD of their activities. The Georgia EPD Hazardous Waste Management Office has a listing of all facilities that have notified the EPD of their activities (a copy of this list is in York, 1997). This list of RCRA notifiers in the counties surrounding Lake Lanier is summarized in Table 5-11. It should be noted that all of these facilities are not necessarily in the Lake Lanier watershed.

Table 5-11. Summary of RCRA Notifiers in Counties Surrounding Lake Lanier

Type of Operation	Number
Land Disposal TSD	2
Store/Treat TSD	0
Combustion (Incin. and BIFs)	0
Large Quantity Generator (> 1000 kg/mo)	12
Small Quantity Generator (100-1000 kg/mo)	85
Conditionally Exempt Generator	90
Transporter	5
Burner/Blender	4
Recycler	0

The EPD also has a list of the facilities for which they have files. According to the EPD's 1993 Hazardous Waste Report, Habersham county is the ninth largest hazardous waste generating county in the state with a yearly production of 144,527 tons. A listing of select large quantity hazardous waste generators in the counties surrounding Lake Lanier follows in Table 5-12. The Hazardous Waste Management Act amended in 1990 requires that large quantity generators develop and submit hazardous waste reduction plans biennially. Thus, theoretically these facilities will be producing less hazardous waste in the future.

CERCLA: RCRA covers spills from newly generated hazardous wastes. Thus, to cleanup contamination from past episodes, Congress passed the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) in 1980. This act, amended in 1986 by the Superfund Amendments and Reauthorization Act (SARA), provides for identification and cleanup of old hazardous waste sites. The CERCLA Information Service (CERCLIS) provides a listing of these hazardous waste sites. The facilities from this list that are in the Lake Lanier watershed are presented in Table 5-13 and some are shown in Figure 5-5. The locations of SCM and Yearwood were not available. The Environmental Protection Agency (EPA) uses a method called the Hazard Ranking System (HRS) to determine the degree of risk a site poses to humans and the environment. If the HRS score is above a threshold level, the site is placed on the National Priorities List (NPL). These NPL sites (called Superfund sites) are considered the most hazardous sites in the country. There are no national NPL sites in the Lake Lanier watershed.

Table 5-12. Select Hazardous Waste Generators in Counties Surrounding Lake Lanier

County	Facility	ID #	Tons Generated
Habersham	Ethicon Inc.	GAD000614347	127.92
	Scovill Mfg. Inc.	GAD003480530	144,399.28
Hall	Cottrell Inc.	GAD066477142	37.287
	Cummins Engine	GAD980602999	13,688.784
	Dittler Brothers-Oakwood	GAD980709604	113.68
	Dittler Brothers Prod. Color Inc.	GAD981026388	38.677
	Elan Pharm. Research	GAD981216609	17.084
	Harris Calorific	GAD115319204	23.824
	Indalex	GAD981238199	617.203
	J & J Advanced Material	GAD114452113	3.455
	Packaging Specialist of GA Inc.	GAD980804207	4.685
	Piedmont Labs	GAD131327546	224.519
	SKF Bearing	GAD075870873	20.862
White	Freudenberg-NOK	GAD981267735	9.970
	Talon Inc.	GAD981474299	18.246

Table 5-13. CERCLIS Facilities in the Lake Lanier Watershed

Facility	County	EPA ID #	Event Type	Event Lead	Finish Date	Status
Ethicon Inc.	Habersham	GAD000614347	DS	EPA (Fund)	8/1/80	
			PA	State (Fund)	8/1/84	Lower Prior.
			SI	EPA (Fund)	12/1/89	NFRAP
Abrams Big Star Properties Dump Site	Hall	GAD984278150	RV	EPA (Fund)	6/9/89	Clean-up
			DS	"	4/28/92	
			PA	"	7/5/90	
Cummins Engine Co.	Hall	GAD980602999	DS	EPA In-House	11/30/94	
			PA	State (Fund)	5/25/95	Lower Prior. Delisted
SCM Corp Glidden Coatings & Resins Div.	Hall	GAD000622985	DS	EPA (Fund)	8/1/80	
			PA	State (Fund)	9/1/84	Lower Prior.
			SI	EPA (Fund)	8/19/84	
Wrigley Jr Wm Co	Hall	GAD056206717	DS	EPA (Fund)	8/1/80	
			PA	State (Fund)	7/23/85	NFRAP
Yearwood Drums	Hall	GAD984316497	RV	EPA (Fund)	12/10/92	Clean-up
			DS	"	9/14/92	
			PA	"	5/5/94	Higher Prior.
			AR	"	6/11/93	Admin Rec Comp/Rmvl Event

Note: NFRAP - No Further Remedial Action Planned
DS- discovery; PA: preliminary assessment; SI: site investigation; RV: removal; AR: administrative record

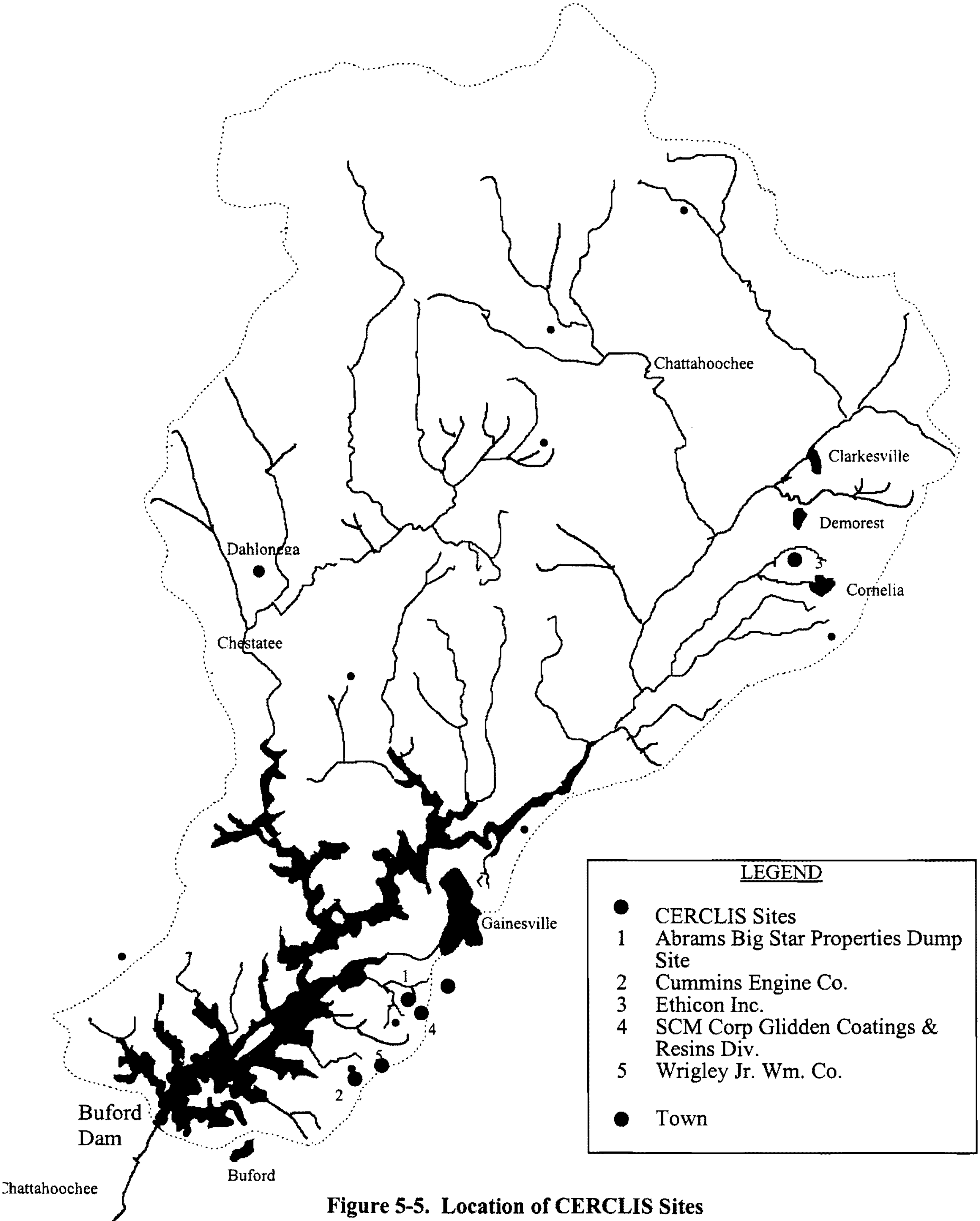


Figure 5-5. Location of CERCLIS Sites

HSI: The Hazardous Site Index (HSI) is Georgia's local version of the NPL. Many sites on CERCLIS do not make the NPL and are, thus, not applicable for federal superfund funding for cleanup unless they pose an imminent danger to human health and the environment. These sites that are not remediated by the USEPA are placed on Georgia's Hazardous Site Inventory (HSI). Other sites that are on the HSI include RCRA facilities and landfills that meet certain criteria. When a site has a release of a regulated substance they must notify the EPD about the release. Using the Reportable Quantities Screening Method (RQSM), the EPD determines a score for the facility. This is similar to the EPA's Hazard Ranking System. If the site's score is higher than a threshold level it is placed on the HSI. Regulated solid waste landfills that have significant releases to groundwater are also placed on the HSI. There is only one site in the watershed that was on the HSI in the last year. Cummins Engine Company was designated Class II meaning that further evaluation of the site was warranted to determine what if any corrective action was needed. Further investigation resulted in the facility being delisted from the HSI. As of July, 1996 there are no facilities in the Lake Lanier watershed that are on the HSI.

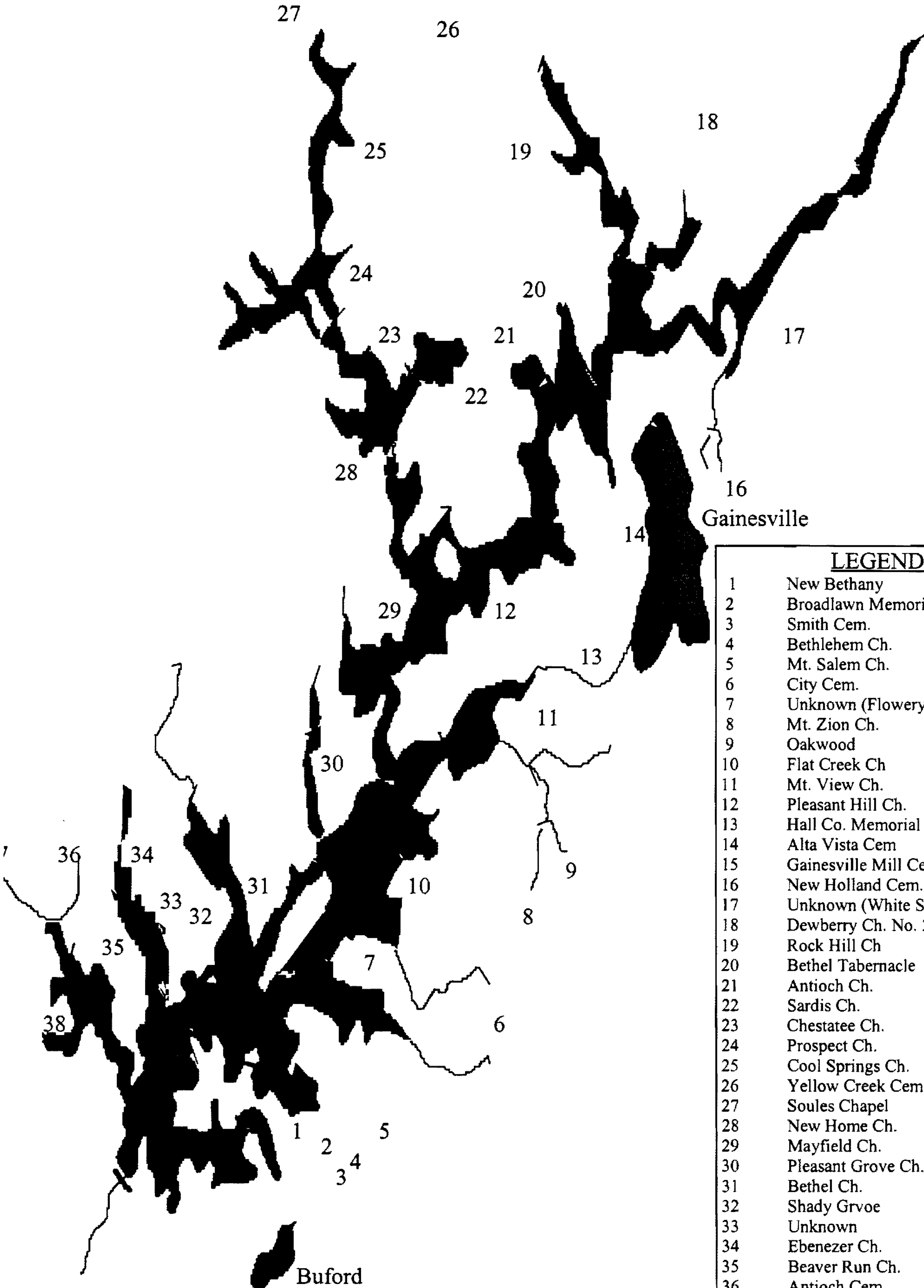
Underground Storage Tanks

Underground Storage Tanks (USTs) have the potential to contaminate the soil and groundwater when its contents are leaked. Most USTs contain fuel and are located at gasoline stations. Petroleum products from USTs are regulated under RCRA Subtitle I. The Hazardous and Solid Waste Amendments (HSWA) require that the owner of a UST provide either a leak detection system or an inventory control with regular testing of tanks. Owners are required to maintain detailed records of monitoring and tank testing, report releases, and take appropriate corrective actions when leaks do occur. The tanks are also required to be structurally sound, e.g. corrosion resistant. USTs are also regulated under the Clean Water Act and Occupational Safety and Health Act. A list of USTs in the counties surround Lake Lanier that have confirmed or suspected releases was obtained from the EPD's UST department (and is presented in York, 1997). It is not included in this report since USTs are not considered a significant source of pollution in Lake Lanier.

Underground storage tanks have the potential to contaminate the groundwater with fuel compounds. It is estimated that approximately twenty-five percent of USTs are currently leaking (Cheremisinoff, 1992). Common gasoline is a mixture of around two hundred different hydrocarbons and additives. Some of the most common are benzene, toluene, xylenes and additives such as ethylene dibromide. Some of these compounds will biodegrade due to naturally occurring microbes in the soil. Because it is unknown whether there are any spills in close proximity to the lake, it is inappropriate to estimate concentrations of potential pollutants. However, it is unlikely that UST spills will cause a significant contamination problem for the lake if the UST owners follow the EPA regulations.

Cemeteries

Cemeteries were located from United States Geological Survey 7.5 minute quadrangle maps that were revised in 1985. They are presented in Figure 5-6. There is little information in the literature concerning the potential for cemeteries to contaminate the ground water. It is possible that the microbes from the decomposition of bodies and compounds used to preserve bodies (such as arsenic) can reach the groundwater. There is no pollution data available on any cemeteries in this watershed.



LEGEND

1	New Bethany
2	Broadlawn Memorial Gardens
3	Smith Cem.
4	Bethlehem Ch.
5	Mt. Salem Ch.
6	City Cem.
7	Unknown (Flowery Branch)
8	Mt. Zion Ch.
9	Oakwood
10	Flat Creek Ch
11	Mt. View Ch.
12	Pleasant Hill Ch.
13	Hall Co. Memorial Pk
14	Alta Vista Cem
15	Gainesville Mill Cem.
16	New Holland Cem.
17	Unknown (White Sulfur)
18	Dewberry Ch. No. 2
19	Rock Hill Ch
20	Bethel Tabernacle
21	Antioch Ch.
22	Sardis Ch.
23	Chestatee Ch.
24	Prospect Ch.
25	Cool Springs Ch.
26	Yellow Creek Cem.
27	Soules Chapel
28	New Home Ch.
29	Mayfield Ch.
30	Pleasant Grove Ch.
31	Bethel Ch.
32	Shady Grvoe
33	Unknown
34	Ebenezer Ch.
35	Beaver Run Ch.
36	Antioch Cem.
37	Sawnee View Gardens
38	Corinth Ch.

Figure 5-6. Location of Cemeteries

Urban Areas

Urban areas were identified by land use maps for each county. These maps were obtained from the Georgia Mountains Regional Development Center and show existing and future land use patterns for the counties. Runoff from urban areas can transport many different contaminants from the land into bodies of water. A recent National Water Quality Inventory reports that urban runoff is the third largest source of water quality impairments to lakes (USEPA, "Managing Urban Runoff"). Urban areas affect runoff by increasing the runoff and pollutant loads. The increase in runoff is due to the large sections of nonporous areas (e.g. pavement) common in urban areas. Storm sewers also increase the runoff by quickly channeling the runoff. Urbanization also causes an increase in the variety and amounts of pollutants. Development and construction provide the largest volume of pollution in the form of sediment. Other potential pollutants from surface runoff include oil, grease and toxic chemicals from automobiles; nutrients and pesticides from gardening and landscaping; viruses and bacteria from failing septic systems; road salts from winter conditions; and heavy metals from various industrial activity. Common trace elements from automobile traffic and industrial activity are: lead, zinc, cadmium, mercury, copper, arsenic, chromium, iron, nickel, antimony and manganese. The most common heavy metals in urban runoff are copper, lead, zinc and cadmium (Woodward-Clyde Consultants 1990).

Summary of Pollutant Sources

The following Table 5-14 provides a summary of the pollutants that could be found at the different source categories previously mentioned.

Table 5-14. Summary of Potential Pollutants and Source Categories

Municipal WWTP	Industrial WWTP	Marinas	Landfills	Septic Tanks	USTs	Cemeteries	Urban Runoff
Ammonia	Ammonia	F. Coliform	Ammonia	BOD	Benzene	Arsenic	Arsenic
BOD	Arsenic	Gasoline	Antimony	F. Coliform	Toluene	Microbes	Cadmium
DO	BOD5	Oil	Arsenic	Nitrogen	Xylenes		Chromium
Fecal Coliform	Total Chromium	Lead	Barium	Oil & Grease	Additives		Copper
Phosphorus	COD	Arsenic	Beryllium	Phosphorus	Oil		Iron
TSS	Copper	Zinc	BOD				Lead
	Fecal Coliform	Copper	Cadmium				Mercury
	Iron	Tin	TOC				Nickel
	Mercury	Iron	Chromium				Nitrogen
	Total Nitrogen	Chromium	COD				Oil & Grease
	Oil & Grease		Lead				Organics
	pH		Mercury				Pathogens
	Phosphorus		Oil & Grease				Pesticides
	Suspended Solids		Various Organics				Phosphorus
	TOC		Phosphorus				Trace Elements
	Zinc		TSS				TSS
			Zinc				Zinc

5.3. SAMPLING PROGRAM

In an effort to obtain more accurate information about the contribution of point source pollution and urban runoff into the lake, a sampling and analysis program was employed during a nine month period in 1995-1996. The information gathered and described previously about facilities in the watershed and interactions with EPD and EPA specialists led to a ranked list of facilities at which sampling and analysis should occur. (More detailed information about this process is outlined in York, 1997) Two types of sampling occurred: wastewater treatment effluents and urban stormwater runoff. All samples were grab samples. The locations of the sampling sites are shown in Figure 5-7.

Wastewater Sampling

The effluent of municipal and industrial wastewater treatment plants was collected and analyzed over a period of nine months in 1995 and 1996. The effluent sampling was planned at sites categorized in two tiers. Tier one facilities were considered to have the greatest impact on the lake and were sampled twelve to fourteen times. The tier two facilities, considered to have a lesser impact, were sampled three times each. The impact on the lake was based on total mass loadings into the lake, which was a product of flow times concentration [Q x C]. Table 5-15, below, is the list of facilities sampled.

Table 5-15. Effluent Sampling Sites

	Facility	Type of Facility	Permitted Flow (MGD)	No. of Sampling Events
TIER ONE				
	Clarkesville	Municipal ww-trickling filter	0.75	13
	Cornelia	Municipal ww-trickling filter	3.0	14
	Gainesville - Flat Creek	Municipal ww - activated sludge	7.0	14
	Gainesville - Linwood	Municipal ww-trickling filter	3.0	14
	Scovill	Industrial ww - Mfg. fasteners	0.14	12
TIER TWO				
	Baldwin	Municipal ww - Activated sludge	0.30	3
	Cleveland	Municipal ww - Aquaculture	0.75	3
	Dahlonega	Municipal ww - Activated sludge	0.72	3
	Demorest	Municipal ww - Activated sludge	0.40	3
	Flowery Branch	Municipal ww - Activated sludge	0.20	3

The effluent samples were analyzed for the following: CBOD5 (carbonaceous 5-day BOD), total and fecal coliforms, conductivity, mercury, ammonia, nitrite, nitrate, total phosphorus, total organic carbon, total suspended solids, turbidity, and a scan of trace metals including arsenic and selenium. Details about the sampling and analysis is presented in York, 1997. The results from the sampling and analysis are contained in Appendix A.

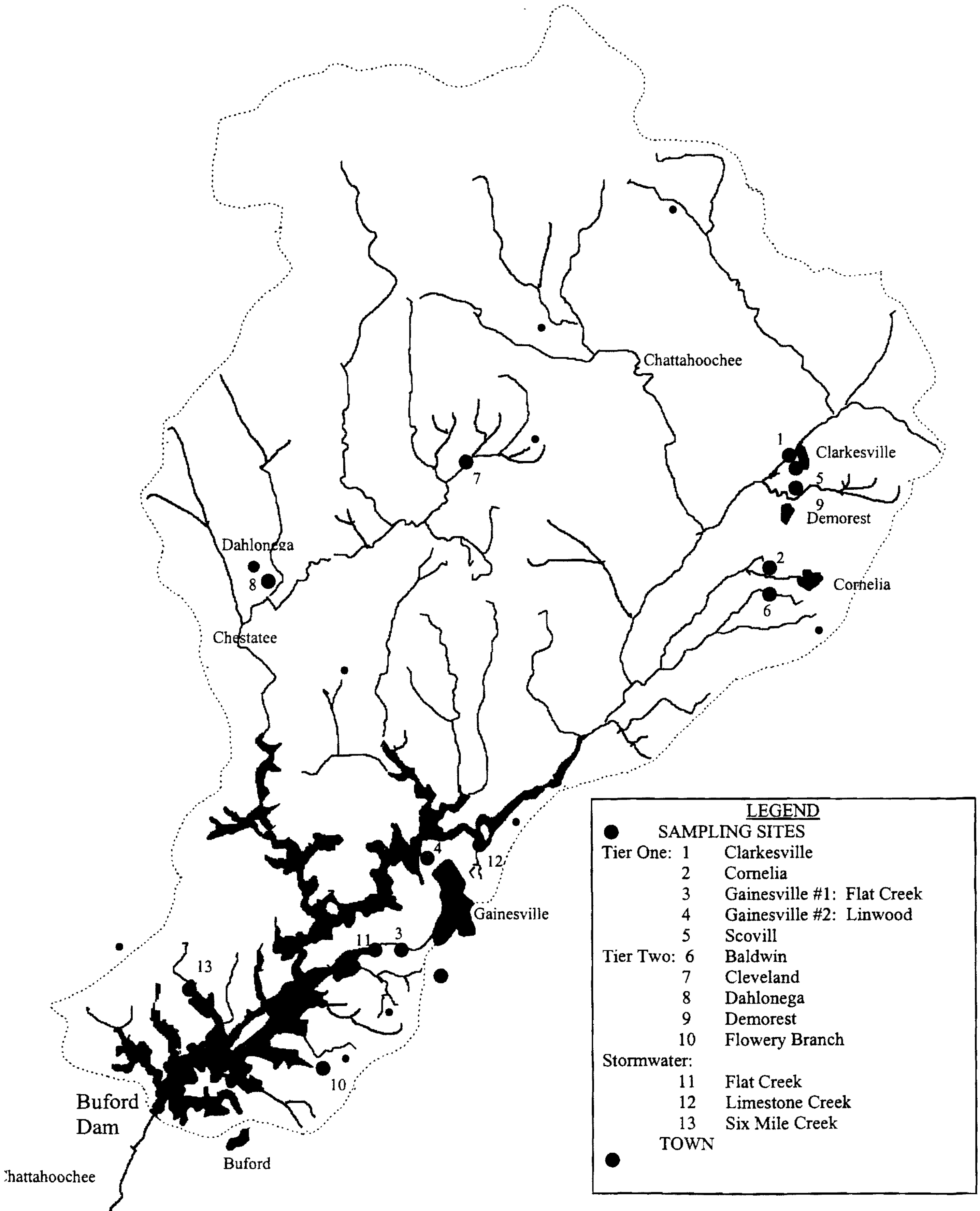


Figure 5-7. Location of Sampling Sites

Urban Runoff Sampling

Urban stormwater runoff is the primary discrete non-point source of concern. Gainesville is the only city of significant size in the watershed. Because it is alongside the lake, there are unlimited areas for stormwater runnoff. There are two streams that collect runoff from urbanized areas of Gainesville, South Flat Creek and Limestone Creek. These creeks and Six Mile Creek, which has a history of problems, were chosen to be sampled for stormwater runoff. They were sampled three to four times. The analyses included: conductivity, mercury, ammonia, nitrite, nitrate, total phosphorus, total suspended solids, turbidity, a scan of trace metals, and insectices. The results from this sampling is also presented in Appendix A.

5.3. RESULTS

Wastewater File Review and Sampling Results

The results from the file review (the discharge monitoring reports) and the sampling program are summarized in Tables 5.16 through 5.19. Tables 5.16 and 5.18 present the permit and average effluent concentrations for each municipal and industrial facility. The shaded numbers indicate that the permitted concentrations have been exceeded. Tables 5.17 and 5.19 compare water quality standards to the theoretical stream concentration due to the dilution of the facility effluent in the stream. See Section 5.2 Municipal Wastewater Treatment Plants for more discussion on the dilution values. Mercury was measured using a Perkin-Elmer Mercury analyzer. All of the samples were below the detection limit of 0.2 ug/L.

A few comments about the sampling results from each facility follows.

Baldwin's wastewater treatment facility consists of aeration, clarification, chlorination and detention in a large polishing pond. Because of the simplicity of the operation, there is no operator per say for the facility. The monitoring for this site is conducted by a nearby facility on a contract basis. According to the limited sampling, the facility is not meeting the BOD and suspended solids requirements. The average CBOD5 concentration measured is twice the permit requirement as is the suspended solids concentration. The DMR data for this facility available in files at EPD, did not show concentrations of BOD and suspended solids greater than the permit limits. However, this data was available only through 1993. It is possible that the water quality has degraded significantly since that time. Yet even in the DMR data from 1991-1993, the BOD requirement was exceeded twice and the suspended solids level ten times (with a maximum of 72). Due to the odorous nature of the facility, it appears that the facility is not operating under optimum conditions. While this facility may have worked well for many years, it is advisable that the city consider renovations or an alternate means of disposing of its waste.

The trickling filters at the Clarkesville facility seem to be operating adequately. On average, the facility met all permit requirements except for suspended solids. However, the BOD5 permit limit was exceeded on four dates, with a high value of 42 mg/L (12 mg/L over the limit). The suspended solids permit value was exceeded on nine sampling dates with a maximum value of 86 mg/L.

The Cleveland facility uses an innovative treatment train consisting of a two-stage aquaculture (LEMNA system), UV disinfection and cascade reaeration. The plant seems to be operating quite well, but they do have problems on occasion due to the seasonal changes in treatment quality due to the duckweed. All the permit requirements were met on the days sampling was conducted.

Table 5-16. Municipal Wastewater Treatment Facilities
Typical Pollutants and Concentrations

	Facility	Flow MGD	BOD5 (CBOD5)* mg/L	DO mg/L	Fecal Coliform #/100mL (Geo. Mean)	NH3-N mg/L	P mg/L	SS mg/L
Baldwin	Permit Conc	0.30	30		200			30
n=36 ('91-'93)	DMR Avg	0.23	19	7.3	120			30
n=3 ('96)	Sampling Avg	0.22	**63**		**223**	12.1	6.5	**69**
Clarkesville	Permit Conc	0.75	30		200	17.4		30
n=12 ('92)	DMR Avg	0.28	20	6.7	37	22.6		17
n=13 ('95-'96)	Sampling Avg		**30**		**575**	7.5	2.4	**40**
Cleveland	Permit Conc	0.75	20	2.0	200	10.0		30
n=24 ('94-'95)	DMR Avg	0.34	13	8.2	21	9.6		7
n=3 ('96)	Sampling Avg	0.45	13		15	2.6	2.2	17
Cornelia	Permit Conc	3.00	30	6.0	200	1.5		30
n=60 ('91-'95)	DMR Avg	1.92	19	6.3	119	**26.7**	2.2	16
n=14 ('95-'96)	Sampling Avg	2.51	6		5	**20.8**	1.2	22
Dahlonega	Permit Conc	0.72	30	2.0	200	17.4		30
n=48 ('92-'95)	DMR Avg	0.56	6	4.2	9	0.6		5
n=3 ('96)	Sampling Avg	0.55	5		**312**	0.6	2.3	5
Demorest	Permit Conc	0.40	30	5.0	200			30
n=36 ('91-'93)	DMR Avg	0.07	9	6.6	14			7
n=3 ('96)	Sampling Avg		4		**2037**	3.7	0.8	4
Flowery Branch	Permit Conc	0.20	10	6.0	200	2.0	1.0	30
n=60 ('91-'95)	DMR Avg	0.13	5	6.7	44	0.6	0.6	7
n=3 ('96)	Sampling Avg	0.17	**11**		6	**5.2**	1.7	21
G - Flat Creek	Permit Conc	7.00	20	5.0	200		1.0	30
n=60 ('91-'95)	DMR Avg	5.12	6	6.8	5	0.3	0.6	13
n=14 ('95-'96)	Sampling Avg	5.87	3		<1	0.6	0.2	3
G- Linwood	Permit Conc	3.00	30	2.0	200	17.4		30
n=60 ('91-'95)	DMR Avg	1.54	17	4.8	2	10.9	4.0	13
n=14 ('95-'96)	Sampling Avg	1.96	17		<1	7.7	3.7	20
G - White Sulphur	Permit Conc	0.10						
Lake Lanier Islands	Permit Conc	0.35	30		200			30
n=24 ('91-'92)	DMR Avg	0.10	6		46			8
Lula	Permit Conc	0.03	30		200			90
n=30 ('91-'93)	DMR Avg	0.03	22					47

Notes:

n: number of data points; The numbers in parentheses are the years the data was accumulated.

DMR: Discharge Monitoring Report

*: CBOD5 for Sampling Avg

The shaded numbers indicate that the permitted concentrations have been exceed.

Table 5-17. Municipal Wastewater Treatment Facilities Diluted Concentrations

Facility		Dilution Factor	BOD5 mg/L	Fecal Coli. #/100mL (Geo. Mean)	NH3-N mg/L	P mg/L	SS mg/L
Water Quality Standards (EPD 1995)				200			
Drinking Water Standards (Pontius 1996)				0*	0.5****	5****	
Baldwin	Diluted Permit	2.5	11.9	80			12
(Interp)	Diluted DMR	3.0	6.3	40			10
	Dilute Sampling	3.1	20.7	73	4.0	2.1	23
Clarkesville	Diluted Permit	40	0.8	5	0.4		1
	Diluted DMR	103	0.2	0.4	0.2		0.2
	Dilute Sampling	105	0.3	5	0.1	0.02	0.4
Cleveland	Diluted Permit	6	3.4	34	1.7		5
	Diluted DMR	12	1.1	2	0.8		1
	Dilute Sampling	9	1.4	2	0.3	0.2	2
Cornelia	Diluted Permit	1.2	25.0	167	1.3		25
(Interp)	Diluted DMR	1.3	14.8	90	20.4	1.7	12
	Dilute Sampling	1.2	4.8	4	16.8	1.0	18
Dahlonega	Diluted Permit	19	1.6	11	0.9		2
	Diluted DMR	24	0.2	0.4	0.03		0.2
	Dilute Sampling	24	0.2	13	0.03	0.1	0.2
Demorest	Diluted Permit	15	2.0	14			
(Interp)	Diluted DMR	80	0.1	0.2			0.1
	Dilute Sampling	92	0.04	22		0.01	30
Flowery Branch***	Diluted Permit	30	0.3	7	0.1	0.03	1
	Diluted DMR	30	0.2	1	0.02	0.02	0.2
	Dilute Sampling	30	0.4	0.2	0.2	0.1	1
Gainesville **	Diluted Permit	2	10.1	101		0.5	15
Flat Creek	Diluted DMR	2	2.4	2	0.1	0.2	6
	Dilute Sampling	2	1.4		0.3	0.1	1
Gainesville***	Diluted Permit	30	1.0	7	0.6		1
Linwood	Diluted DMR	30	0.6	0.1	0.4	0.1	0.4
	Dilute Sampling	30	0.6		0.3	0.1	1
Lake Lanier Islands	Diluted Permit	30	1.0	7			1
***	Diluted DMR	30	0.2	2			0.3
Lula	Diluted Permit	10	3.0	20			9
(Interp)	Diluted DMR	9	2.5				5

Notes:

Dilution Factor = (Q7 + Qe) / Qe; where Q7 = 7Q10 flow and Qe = effluent flow
Q7 = 7Q10 flow
Qe (permit) = permitted effluent flow; Qe (DMR) = average DMR flow;
Qe(sampling) = average sampling flow

Interp: 7Q10 value from interpolation based on drainage areas

*: Maximum Contaminant Level Goal in drinking water standards

**: stream flow data based on average of flow values found in 1991 (Hatcher et al., 1994)

***: discharges into lake, assume 30 fold dilution. Dillution factor into stratified lakes should be
DF = 0.28 * X / D; where x = distance of mixing and D = diameter of pipe

****: European Economic Comunity (EEC) Std and/or
World Health Organization (WHO) Standard (AWWA 1990)

Typical Pollutants and Concentrations

Facility		Flow MGD	Al mg/L	Sb mg/L	As mg/L	Be mg/L	BOD5 mg/L	Bromide mg/L	Cd mg/L	Cl mg/L	Cr,Tot mg/L	COD mg/L	Cu mg/L	Cyanide mg/L	F. Coli #/100mL	Flouride mg/L	Fe mg/L	Pb mg/L
Buckhorn Minerals	Permit Conc	0.65																
	DMR Avg	0.02					5	1		1.3		5			41	0.3		
Davidson Minerals	Permit Conc	2.59																
n = 1 ('95)	DMR Avg	1					BDL					BDL						
Habersham Mills	Permit Conc	0.009													200			
n=2	DMR Avg	0.003	14				13			0.5		46			10		0.51	
High Point Minerals	Permit Conc	0.002																
	DMR Avg																	
JA Hudson Const.	Permit Conc																	
	DMR Avg																	
Scovill Inc.	Permit Conc	0.27		2.13					0.26		1.71		2.07	0.65				0.43
n = 5	DMR Avg	0.12		1.538					<0.01	0.04	0.17		0.8	<0.01			0.31	<0.01
	Sampling Avg				0.003	0	41		<0.001		0.014		0.19		<1			0
SKF Bearing	Permit Conc	0.02																
n = 1 ('93)	DMR Avg	0.018					11					28						

Facility		Hg mg/L	Ni mg/L	N, Tot mg/L	NH3-N mg/L	O&G mg/L	pH Min	pH Max	Phenol mg/L	P, T mg/L	SS mg/L	Se mg/L	Ag mg/L	Sulfate mg/L	Sulfide mg/L	Tl mg/L	TOC mg/L	Zn mg/L
Buckhorn Minerals	Permit Conc						6.0	9.0			55							
	DMR Avg			0.3	0.2	5	6			0.1	15							
Davidson Minerals	Permit Conc						6.0	8.5			55							
n = 1 ('95)	DMR Avg				0.2	8		8.4			21						3	
Habersham Mills	Permit Conc						6.0	9.0			30							
n=2	DMR Avg			3	5.1 / 0.5	1.8	7	6.6		1.1	9			60.3			10	0.11
High Point Minerals	Permit Conc																	
	DMR Avg																	
JA Hudson Const.	Permit Conc																	
	DMR Avg																	
Scovill Inc.	Permit Conc		2.38			26					31		0.24					1.48
n = 5	DMR Avg		1.17		0.09	16.7				6.57	5		<0.03	947		<0.02		0.22
	Sampling Avg	< 0.000	0.38		0.79					3.38	3	<0.00	<0.0001				26	0.15
SKF Bearing	Permit Conc																	
n = 1 ('93)	DMR Avg				0.7	6.0		7.0									6.5	

Notes:

BDL: Below Detection Limit

DMR: Discharge Monitoring Reports

O & G: Oil and Grease

Table [illegible]: Industrial Dischargers

Diluted Concentrations

Facility		Dilution Factor	Al mg/L	Sb mg/L	As mg/L	Be mg/L	BOD5 mg/L	Bromide mg/L	Cd mg/L	Cl mg/L	Cr,Tot mg/L	COD mg/L	Cu mg/L	Cyanide mg/L	F. Coli #/100ml	Flouride mg/L	Fe mg/L
Water Quality Standards (EPD, 1995)				4.308	0.0001				0.0007		0.011		0.12	0.0065	200		
Drinking Water Standards (Pontius, 1996)			0.2***	0.006	0.05	0.004			0.005	4.0	0.1		1.3*	0.2	0*	4	0.2 ****
Buckhorn Minerals **	Diluted Permit	3															
	Diluted DMR	66					0.08	0.02		0.02		0.08			0.62	0.005	
Davidson Mineral	Diluted Permit	3															
(Interp)	Diluted DMR	6															
Habersham Mills	Diluted Permit	3990													0.05		
	Diluted DMR	11960	0.001				0.001			4E-05		0.004			0.001		4.3E-05
High Point Minerals	Diluted Permit	710															
	Diluted DMR																
JA Hudson Const.	Diluted Permit																
(Interp)	Diluted DMR																
Scovill Inc.	Diluted Permit	130		0.016					0.002		0.013		0.015923	0.005			
n = 5	Diluted DMR	300		0.005					3E-05	0.0001	0.0006		0.002658	3E-05			0.00103
	Diluted Sampling	300			1E-05	4E-07	0.1367				5E-05		0.000645				
SKF Bearing **	Diluted Permit	270															
	Diluted DMR	300					0.04					0.09					

Facility		Pb mg/L	Hg mg/L	Ni mg/L	N, Tot mg/L	NH3-N mg/L	O&G mg/L	Phenols mg/L	P, Tot mg/L	SS mg/L	Se mg/L	Ag mg/L	Sulfate mg/L SO4	Sulfide mg/L	Tl mg/L	TOC mg/L	Zn mg/L
Water Quality Standard		0.0013	1E-05	0.088				0.3			0.005				0.048		0.06
Drinking Water Standard		0*	0.002	0.1	10	0.5 ****		.0005***	5 ****		0.050	.01 ***	500	.05 ***	0.002		5 ***
Buckhorn Minerals **	Diluted Permit									18							
	Diluted DMR				0.005	0.003	0.0762		0.002	0.2							
Davidson Mineral	Diluted Permit									18							
(Interp)	Diluted DMR					0.0308	1.2			3						0.4623	
Habersham Mills	Diluted Permit									0.008							
	Diluted DMR				0.0003		0.0002		9E-05	0.001			0.005042			0.0008	9.2E-06
High Point Minerals	Diluted Permit																
	Diluted DMR																
JA Hudson Const.	Diluted Permit																
(Interp)	Diluted DMR																
Scovill Inc.	Diluted Permit	0.003		0.0183		0	0.2			0.2385		0.002					0.01138
	Diluted DMR	3E-05		0.0039		0.0003	0.0557		0.0219	0.0169		1E-04	3.157492		7E-05		0.00072
	Diluted Sampling	5E-06		0.0013	0	0.0026			0.0113	0.01						0.0867	0.0005
SKF Bearing **	Diluted Permit																
	Diluted DMR					0.0022	0.02									0.0217	

Notes:
DMR: Discharge Monitoring Report
O&G: Oil and Grease
n: number of data points; The numbers in parenthesis are the years the data was accumulated.
Interp: interpolated values based on drainage areas
*: Maximum Contaminant Level Goal in drinking water standards
**: stream flow data based on minimum flow encountered in 1991 sampling (Hatcher et al., 1994)
*** World Health Organization guideline **** European Economic Community max (AWWA, 1990)

The influent to Cornelia's trickling filter plant consists of approximates 60% poultry waste and 40% domestic waste. The ammonia permit level was exceeded significantly on every sampling day (12 days). The average concentration from sampling (21 mg/L) is consistent with the DMR report average (26.7 mg/L). This facility has had chronic ammonia toxicity problems. Otherwise, the facility seems to be meeting all its requirements.

Dahlonega operates an activated sludge oxidation ditch facility. The permit requirements of pollutants analyzed were not exceeded on the days of sampling. They are currently building an extention of the plant to upgrade it to a larger flow.

Activated sludge and polishing ponds are used at the Demorest plant. This facility also does not have a full time operator. The duties of overseeing and monitoring the site has been contracted out to a neighboring town. The permit requirements were not surpassed during the days of sampling.

Flowery Branch utilizes the activated sludge process. During the period of sampling (3 days), the ammonia permit requirement was not met. On one date the BOD5, ammonia, phosphorus and suspended solids permit limits were not met. These values are in contrast to the average concentrations from the DMR data. However, the plant was experiencing difficulty during this time (especially on the first sampling date) due to belated sludge removal. This problem was resolved after the period of sampling occurred. On an inspection during a visit to the facility on a later date, the effluent water quality visually appeared to be better. However, there could be a problem with the ammonia concentrations from this plant.

Gainesville's Flat Creek facility is the largest wastewater treatment facility in the watershed. It is permitted for 7 MGD, and is, thus, the target of many investigations into water quality. Because of its location, 70% of its influent is from industrial sources. The results from the sampling show that this facility is meeting its permit requirements exceptionally well. In fact, they are already meeting their stringent future permit requirements.

The Linwood plant in Gainesville uses trickling filters. This facility appears to be operating well. The BOD5 and suspended solids permit limits were exceeded only once during the long sampling period.

Scovill Inc. is a manufacturer of zippers, buttons, and snap fasteners. The wastewater is generated from plating, parts cleaning and copper-blackening activities. Treatment consists of pH adjustment, chlorination, chromate reduction, clarification, neutralization and filtration. During the period of sampling, the facility appears to have had difficulty meeting the phosphorus requirements on six dates. On one occasion the suspended solids limit was exceeded. The nitrate concentrations appear to be very large. It is possible that the composition of the waste (as indicated by the high conductivity readings) is such that it causes interferences with the electrode probe used to measure nitrate. Because of these concerns, the nitrate data is not included here but is available in Appendix 5-A. If nitrate reduction at this plant is considered a major objective of future treatment, then additional research to pinpoint the errors due to interference from high conductivity need to be studied.

Urban Runoff Results

A summary of the results obtained from the urban stormwater runoff sampling is shown in Table 5-20. The values seem to be typically of urban runoff. The pesticides analyzed (carbaryl, diazinon, dursban, and malathion) were not detected in the samples. Mercury was measured using a Perkin-Elmer Mercury analyzer. All of the samples were below the detection limit of 0.2 ug/L. As expected, the urban runoff is contributing significant amounts of particulate matter (as represented by Total Suspended Solids, TSS). This is important because siltation is often one of greatest threats to a lake's health.

Trace Metals Analysis Results

Inductively coupled plasma mass spectrometry allows the simultaneous determination of trace metals at the parts per billion level. In this project, samples of wastewater treatment effluent and stream water were analyzed for total recoverable arsenic (As), selenium (Se), chromium (Cr), nickel (Ni), copper (Cu), zinc (Zn), cadmium (Cd), barium (Ba) and lead (Pb). The reported detection limits (RDLs) and method detection limits (MDLs) are shown in Table 5-21. Detection limits for ICP-MS were generally at least an order of magnitude smaller than the detection limits reported in the EPD files allowing the maximum contaminant loading of low concentration elements to be more accurately estimated.

Table 5-20. Urban Runoff Summary

Parameter	Units	Minimum	Maximum	Average
NH3	mg N/L	0.37	3.55	1
NO3-	mg N/L	0.19	8.24	3.8
NO2-	mg N/L	< 0.01	0.19	0.03
P	mg P/L	0.04	1.15	0.45
TSS	mg/L	8	444	96
Conductivity	umohs/cm	82	311	168
Mercury	ug/L		< 0.2	< 0.2
Turbidity	NTU	33	198	79
Carbaryl	ug/L		< 1	< 1
Diazinon	ug/L		< 0.5	< 0.5
Dursban	ug/L		< 0.5	< 0.5
Malathion	ug/L		< 1.4	< 1.4
Barium	ug/L	20	158	55
Zinc	ug/L	33	97	63

Table 5-21 ICP-MS Detection Limits:
Reported and Method Detection Limits (RDLs and MDLs) for EPA Method 200.8

Element	Reported detection limit		EPA 200.8 estimated detection limit	
	Dilution	RDL (ug/L)	Dilution factor	MDL (ug/L)
As	1	1.4	1.25	1.4
Se	1	1.4	1.25	7.9
Cr	5	2.4	1.25	0.4
Ni	5	2.5	1.25	0.5
Cu	5	2.2	1.25	0.5
Zn	5	22.7	1.25	1.8
Cd	5	1.0	1.25	0.5
Ba	5	1.0	1.25	0.8
Pb	5	1.5	1.25	0.3

Two types of analyses were carried out: semi-quantitative and quantitative. The Elan 5000 TotalQuant II option was used to scan selected samples over wide mass ranges to determine which metals were present in significant concentrations and to identify potential interferences. In this analytical mode, the instrument is calibrated using a blank, a single multielement standard containing only a few of the elements analyzed for and a preprogrammed table of instrument response ratios for the entire mass spectrum.

Quantitative analysis requires the instrument to be directly calibrated for each analyte measured. A blank and two non-zero standards within the linear response range for the instrument were used to calibrate each element.

The analyses were conducted in three groups: arsenic and selenium analysis, semiquantitative scans, and quantitative scans. The results are presented in Appendix 5-A. A sampling of the results are presented in the ensuing discussion.

Arsenic and Selenium Results

First, all the effluent samples were analyzed for arsenic and selenium. Table 5-22 shows the tier one facility results from the arsenic and selenium analyses respectively. No As and Se were detected in any of the WWTP effluents except for As at Scovill. Samples from Scovill were reanalyzed to confirm the presence of As and the data was reproducible and is shown in Table 5-22.

Table 5-22 Arsenic in Tier One Facilities' Effluent (ug/L)

Facility	Clarkesville	Cornelia	Flat Creek	Linwood	Scovill
11/16/95					4.7
12/11/95			< 1.4		4.2
12/18/95	< 1.4	< 1.4	< 1.4	< 1.4	1.9
1/2/96	< 1.4	< 1.4	< 1.4	< 1.4	1.5
1/19/96	< 1.4	< 1.4		< 1.4	2.4
2/9/96	< 1.4	< 1.4	< 1.4	< 1.4	2.1
3/15/96	< 1.4	< 1.4	< 1.4	< 1.4	2.9
3/28/96	< 1.4	< 1.4	< 1.4	< 1.4	4.1

Semiquantitative Scans

Table 5-23 shows results of the semiquantitative scans conducted for the tier one facilities. Semiquantitative scans of the WWTP effluents indicated that trace metal concentrations were low (generally < 20 ppb) with the exception of Mn and Zn in most of the samples and Cu, Ni and Zn in samples taken at Scovill. Ba concentrations of up to 30 ppb were measured in some samples. The samples from each stream in the study were scanned (see Appendix 5-B) and based on the results it was decided to analyze the stream samples for the same nine elements as the effluent samples.

Table 5-23 Semiquantitative Scan Results for Tier One Facilities (ug/L)

Facility	Clarkesville		Cornelia		Flat Creek		Linwood	Scovill
Date	12/11/95	1/19/96	1/2/96	3/15/96	2/9/96	3/28/96	1/2/96	12/11/95
Sb	< 0.01	<0.01	< 0.01	<0.01	<0.01	< 0.01	<0.01	0.14
Ba	20.26	28.25	5.61	9.11	4.56	8.17	26.89	1.34
Be	0.02	0.02	0.02	0	0	0	<0.01	0.11
Cd	0.36	0.3	0.03	0.16	0.06	0.06	0.13	0.05
Cr	0.86	1.96	0.89	0.48	0.51	0.81	1.34	1.59
Co	0.3	0.47	1.56	1.76	0.71	0.87	0.5	0.23
Cu	21.19	23.59	3.3	3.09	3.43	5.26	20.88	219.7
Pb	3.5	5.35	0.57	1.31	1.23	1.99	8.87	1.44
Mn	24.86	39.11	137.8	162.3	73.4	137.5	60.9	1.89
Mo	3.96	1.61	2.29	1.14	13.19	24.82	0.9	41.94
Ni	2.31	2.54	8	4.06	8.93	6.06	2.49	441.2
Ag	0.05	0.01	< 0.01	<0.01	<0.01	< 0.01	0.04	<0.01
V	18.93	3.28	14.77	0.55	3.27	17.98	0.59	10.81
Zn	223.1	73.92	50.46	48.51	73.38	68.45	71.33	213

Quantitative Scans

It was finally decided to measure Cr, Ni, Cu, Zn, Cd, Ba and Pb quantitatively. Cr was included in the analysis since the Scovill effluent includes wastewater from chromating. Cd and Pb were included because the state instream 7Q10 regulatory limits are very low (0.7 and 1.3 ppb respectively). Since metals concentrations in the municipal WWTP effluents were generally low,only two samples - representing average and worst case conditions based on other parameters measured - were analyzed. The results from the tier one facilities and the urban runoff are shown in Tables 5-24 and 5-25 respectively. Metal levels in samples taken on different days from the same facility or stream were generally fairly close. Zinc showed the greatest fluctuation in samples between days.

Table 5-24 a) Quantitative Scans of Effluents from Tier One Facilities (ug/L)

Facilitv	Clarkesville		Cornelia		Flat Creek		Linwood	
Date	1/2/96	2/9/96	2/9/96	3/15/96	2/9/96	3/15/96	1/19/96	3/15/96
Cr	2.9	< 2.4	< 2.4	< 2.4.	< 2.4.	< 2.4.	3.9	< 2.4.
Ni	2.9	6.6	7.1	4.7	9.7	6.2	3.6	4.1
Cu	40	39	7.5	5.7	5.1	11	25	33
Zn	124	312	69	67	112	110	86	118
Cd	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ba	23	25	5.6	9.2	9	8.3	41	46
Pb	4.4	6.2	< 1.0.	1.5	2.2	2.4	13	14

Table 5-24 b) Quantitative Scans of Effluent from Scovill (ug/L)

Date	12/18/95	1/2/96	1/19/96	2/9/96	3/15/96	3/28/96
Cr	86	3.7	6	3.1	2.9	5.1
Ni	199	154	638	483	171	561
Cu	93	166	320	221	108	218
Zn	438	69	135	163	75	105
Cd	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ba	5.1	5.6	2.6	1.9	1.5	1.3
Pb	< 1.5	< 1.5	2.5	1.6	< 1.5	< 1.5

Table 5-25 Quantitative Scan Results for Urban Runoff (ug/L)

Stream	South Flat Creek			Limestone Creek		Six Mile Creek	
Date	4/30/96	5/28/96	6/12/96	5/28/96	6/12/96	5/28/96	6/12/96
As	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	1.5	< 1.4
Se	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4
Cr	< 2.4	< 2.4	3.5	< 2.4	< 2.4	< 2.4	12
Ni	3.8	3.6	4.8	< 2.5	< 2.5	< 2.5	5.8
Cu	8.9	9.7	5.7	8.3	6.1	10	12
Zn	65	97	50	58	33	85	73
Cd	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ba	21	20	34	22	27	100	158
Pb	9.1	4.6	5.7	1.8	9.0	2.8	10

Split Samples

Due to non-availability of the instrument, it was not possible to complete all the analyses at Georgia Tech. Therefore, the stream samples and selected effluent samples were prepared for analysis at Georgia Tech and then sent to the Department of Crop and Soil Sciences at the University of Georgia for analysis. In order to assess reproductibility and quality assurance in the analyses, four split samples were analyzed at the two laboratories for several metals. Results for the split samples from Georgia Tech and the University of Georgia (shown in Table 5-26) agreed very well except for Cu and Zn which were different by up to 25 ug/L. This may have been due to contamination or interference problems. However, the uncertainty in these data is probably not significant compared to other factors in the loading calculations.

Table 5-26 Georgia Tech and UGA Results for Split Samples (ug/L)

Facility	Baldwin		Dahlonega		Linwood		Scovill	
Date	4/11/96		4/11/96		3/15/96		1/2/96	
Laboratory	Georgia Tech	UGA	Georgia Tech	UGA	Georgia Tech	UGA	Georgia Tech	UGA
As	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	1.5	1.8
Se	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	1.6	< 1.4	< 1.4
Cr	2.7	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	3.7	2.9
Ni	8.1	7.8	< 2.5	3.2	4.1	3.9	154	151
Cu	22	14	12	6.4	33	25	166	142
Zn	83	62	66	41	118	114	69	53
Cd	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ba	24	23	6.5	5.9	46	42	5.6	5.1
Pb	2.7	2.3	< 1.5	< 1.5	14	13	< 1.5	< 1.5

Summary of Trace Metals Analysis

Mercury, cadmium (RDL = 0.5 ug/L) and selenium (RDL = 1.4 ug/L) concentrations were below the detection limit in all samples. Arsenic was detected in effluent from Scovill only and concentrations were very low (<5 ug/L). A summary of the remaining metals concentrations from all the facilities is presented in Table 5-27. Since metal concentrations are often related to stream flows, hence the average metal concentrations in Table 5-27 are flow weighted averages.

Table 5-27 Summary of Average Metals Concentrations (ug/L)

	Cr	Ni	Cu	Zn	Ba	Pb
Tier One WWTPs						
Baldwin	3.0	8.0	21.7	127.5	40.1	3.6
Clarkesville	2.3	5.1	39.6	236.7	24.1	5.5
Cleveland	1.0	3.6	14.4	42.1	8.1	1.3
Cornelia	1.5	5.9	6.6	67.6	7.4	1.4
Dahlonega	1.5	2.6	15.0	70.8	12.4	1.1
Demorest	1.6	1.4	12.2	79.9	25.6	1.5
Flat Creek WWTP	1.6	8.1	7.6	110.9	8.7	2.3
Flowery Branch	8.2	3.4	26.3	52.6	18.7	2.4
Linwood	3.0	3.8	28.8	100.5	43.2	13.9
Scovill	13.8	381.0	193.3	149.3	2.8	1.5
Stormwater Runoff						
S. Flat Creek	2.2	4.2	7.6	67.9	27.1	6.0
Limestone Creek	1.7	1.6	6.9	42.1	25.0	6.2
Six Mile Creek	7.9	4.6	11.0	77.0	137.9	7.6

Measurements of chromium were all below 10 ug/L except in one sample taken at Scovill on 18 December 1995 in which 86 mg/L was measured. The Scovill effluent is expected to contain chromium since it includes wastewater from chromating. However, it appears that chromium removal is usually very efficient. Overall the chromium load from Scovill was small compared to those from the three largest municipal facilities, Flat Creek, Linwood and Cornelia which in turn were small compared to the load due to stormwater runoff from the creeks.

Nickel and copper concentrations were less than 10 and 50 ug/L respectively except at Scovill. The largest nickel loads came from Scovill, Flat Creek WWTP, South Flat Creek and Six Mile Creek. The largest copper loads were from Flat Creek WWTPand the three creeks. Lead concentrations were less than 10 ug/L except at Linwood where up to 14 mg/L was measured. Linwood and Flat Creek WWTP accounted for almost all the lead from the facilities but their contribution was small compared to the stormwater runoff.

Barium and zinc loads were an order of magnitude greater than those of the other metals. Zinc was the most abundant metal and showed the most variation in samples taken from the same source. The three largest treatment plants and the stormwater runoff accounted for almost all the zinc load. Barium concentrations ranged between 5 and 55 ug/L for the municipal WWTP's and two urban runoff streams but were less than 5 ug/L in Scovill. Up to 158 ug/L barium was measured in Six Mile Creek. The contribution of effluent discharges to the barium load was small compared to the stormwater runoff.

Maximum Diluted Concentrations

Maximum diluted concentrations in Table 5-28 were estimated based on the maxiumum concentration measured at a given facility and the minimum dilution permit. The dilution permit was calculated as the sum of the permit discharge rate for the plant and 7Q10 flow for the receiving stream (or average flow if low flow data was not available) divided by the permit discharge flow. A dilution factor of 30 was assumed for the two facilities, Linwood and Flowery Branch, discharging directly into the lake. If all measured concentrations were below the detection limit, the detection limit concentration was used. Results were compared with state instream 7Q10 water quality standards. Note that these calculations do not take into account the background concentrations of metals in the streams and consequently, only represent the contribution of the facilities to the total downstream concentration. Based on the available information, it appears that all the facilities except Baldwin are meeting discharge standards. Flat Creek might have problems with copper, zinc and lead since these elements are ubiquitous and its permit dilution factor is only 2.

Table 5-28 Diluted Metals Concentrations for Municipal WWTPs (ug/L)

Tier One Facilities

Facility	Clarkesville	Cornelia	Flat Creek	Linwood	Scovill	State 7Q10
Dil. permit	40	6	2	30	134	
Cr	0.1	0.4	1.2	0.1	0.6	120.0
Ni	0.2	1.2	4.9	0.1	5.0	88.0
Cu	1.0	1.3	5.5	1.1	2.4	6.5
Zn	7.8	11.5	56.0	3.9	3.3	60.0
Cd	0.0	0.2	0.5	0.0	0.0	0.7
Pb	0.2	0.3	1.2	0.5	0.0	1.3

Tier Two Facilities

Facility	Baldwin	Cleveland	Dahlonega	Demorest	Flowery Branch	State 7Q10
Dil. permit	2.51	6	19	11	30	
Cr	1.3	0.4	0.1	0.2	0.3	120.0
Ni	3.2	0.6	0.2	0.2	0.1	88.0
Cu	8.8	2.5	0.9	1.2	0.9	6.5
Zn	66.1	8.8	3.9	9.5	1.8	60.0
Cd	0.4	0.2	0.1	0.1	0.0	0.7
Pb	1.8	0.3	0.1	0.2	0.1	1.3

5.5. LOADING CALCULATIONS

General Methodology

Several different analyses were conducted to determine the loading of various pollutants into Lake Lanier. Individual pollutant measurements are best analyzed using log-normal techniques. However, it has been found that the averages of those individual measurements can be modeled by the normal distribution (USEPA, 1991). According to the Central Limit Theory the data set needs to be larger than ten to assume that this average is approximately normally distributed. Thus, all of the loading calculations for this study assume normal distribution. This assumption seems to be accurate for the data sets used in these analyses. Different loading values were calculated based on permit, discharge monitoring reports (DMRs) and sampling data. An explanation of the computations is explained below.

Permit/Max Values: For facilities and pollutants where permitted concentrations were given, a loading was calculated based on the permitted concentration and flow. This represents a maximum allowable loading from a source. When a permitted value was not given, an estimated maximum concentration (based on permit values for other facilities) was used for the purposes of calculating a loading from all facilities.

Monitoring/Average Values: For the facilities and parameters that DMR data was available in files at EPD, the weighted average of concentration and flow were used to calculate an average loading for the site. Flow-weighted averages of the pollutant concentrations were used because varying flow conditions can significantly affect the calculations of the average concentrations. Where DMR data was not availabe, average concentrations (based on a flow-weighted average of concentrations from other facilities) were used to compute loadings from the rest of the facilities.

Sampling Values: Because the DMR data is not complete, not always up-to-date, and subject to analysis bias of the facilities, loadings were also calculated from the sampling data. Again, flow-weighted averages of the parameter concentration and flows were used to calculate the loading. For the facilities that were not sampled, the values used for the loadings were based on DMR data. The calculations of total loadings into Lake Lanier by various pollutants are presented in Appendix B.

Stormwater Values: The loadings for urban runoff were computed using the flow-weighted average concentrations, precipitation information and land use information. The runoff volume was computed using the Soil Conservation Service (SCS) Method for Abstractions. Note that the all the loadings calculated under the title "urban runoff" only represent the contribution from the three streams that were sampled as a part of this project. The actual loadings from all urban runoff in the watershed would be higher.

For the trace metal loadings, all measured concentrations were included in the calculation of the flow weighted averages and annual loadings, including those concentrations below the detection limit. The rationale behind this was that excluding such values or replacing them with the detection limit would inflate the calculated average while setting them equal to zero would result in an under estimate. It was assumed that the instrument response was the best available estimate of the true value.

Results of Loading Calculations

A summary of the loading calculations is presented in this section. For more specific information see Appendix 5-C. The average annual loadings are based upon the results from the sampling data. The range of pollutant loadings are based upon the average annual loadings plus and minus the standard deviation.

Biochemical Oxygen Demand

As can be seen from the summary of BOD loadings in Table 5-29, the largest portion of BOD comes from the urban runoff and municipal wastewater treatment facilities. The concentration of BOD from urban runoff used was based off of a typical value (12 mg/L) from the literature (Woodward-Clyde, 1990). Based on this information, a reasonable range for BOD loading into the lake would be 670,000 to 772,000 kg/yr. The maximum allowable loading would be around 1,500,000 kg/yr according to permits. The most probable loading is 726,000 kg/yr. Figure 5-8 shows the relative contribution of BOD from the point sources.

Table 5-29. BOD Loading Summary

Source	Max/Permit Loading (kg/yr)	Monitoring Data Loading (kg/yr)	Std. Deviation (kg/yr)	Sampling Data Loading (kg/yr)	Std. Deviation (kg/yr)	% of Total from Sampling Loading Data
Municipal WWTP	600,000	160,000	68,000	143,000	53,000	19
PIDs	31,000	3,000	2,000	(3,000)		0.5
Industrial WWTP	40,000	14,000	4,000	8,000	3,000	1
Urban Runoff*	860,000	570,000		(570,000)		79
Septic Tanks	3,000	2,000		(2,000)		0.5
TOTAL	1,534,000	749,000	74,000	726,000	56,000	

Note: Figures in parenthesis indicate the the number was take from a different column because data was not available for that calculation. For example, PIDs were not sampled so the average loading from the DMR data (3,000) was transferred to the sampling data column so that total loadings could be calculated.

*: Urban runoff only for three streams.

Total Organic Carbon

The only total organic carbon (TOC) data that was available was from the sampling conducted. However, "maximum" and "average" values were determined using a factor based on the BOD5 from permit values and DMR data respectively. Table 5-30 shows that the largest contribution is from the municipal facilities. Thus, a reasonable range of TOC loading is 79,000 to 149,000 kg/yr. The most likely loading is 114,000 kg/yr.

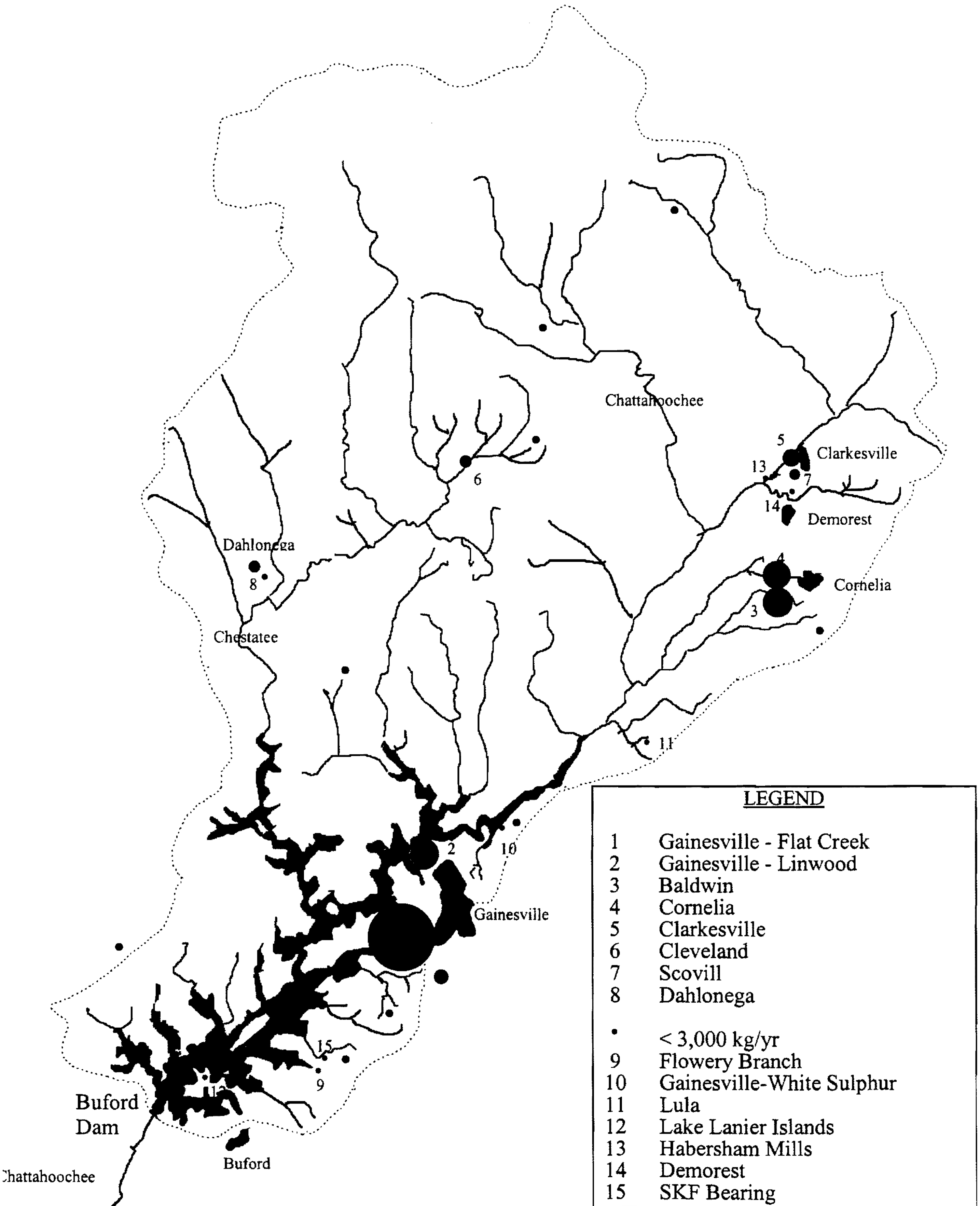


Figure 5-8. BOD Loading

Table 5-30. Total Organic Carbon Loading Summary

Source	Maximum Loading (kg/yr)	Average Loading (kg/yr)	Sampling Data Loading (kg/yr)	Std. Deviation (kg/yr)	% of Total from Sampling Loading Data
Municipal WWTP	400,000	112,000	100,000	33,000	88
PIDs	23,000	5,000	(5,000)		4
Industrial WWTP	25,000	9,000	9,000	2,000	8
TOTAL	448,000	126,000	114,000	35,000	

Fecal Coliforms

Data was available for fecal coliform concentrations in the effluent of the various facilities. However, an accurate loading cannot be calculated based on the concentration and flow because the coliforms will die-off with time and environmental conditions. A typical equation for bacterial die-off is rate of die-off, $r_B = -K_B * C_B$, where K_B = first order rate constant and C_B is the concentration of the bacteria. According to Metcalf and Eddy (1991), typical values of K_B range from 0.12 to 26 d^{-1} with a median of 1 d^{-1}. If a value of 1 d^{-1} is used, one can see that the result is an output of zero coliforms. This makes sense, because eventually all the coliforms will die. The time required for 90% bacterial death is generally accepted to be 2.3 d. It is possible to estimate how long it takes for the coliforms to reach the lake and thus estimate the loading into the lake. However, without the dimensions and flows of all the streams, it is not appropriate to make these calculations. A much more intensive sampling and analysis of rate of die-off are necessary for making these calculations. Because most facilities are meeting their regulatory requirements, it is assumed that the contribution of fecal coliforms into the lake is managable.

Nitrogen

Nitrogen loading is of concern to the lake because excess nitrogen can cause eutrophication. Nitrogen occurs in the forms of organic nitrogen, ammonia, nitrate and nitrite. For wastewater treatment facilities, the parameter of concern is ammonia. It is assumed that organic nitrogen is negligible because it is converted to ammonia during the treatment processes. Thus, the permit and DMR data has information only on the ammonia form. In the sampling program ammonia, nitrate and nitrite were measured. Loadings have been calculated for ammonia and total nitrogen. For the ammonia calculations, the amount contributed due to septic tanks is unknown because the methods of determination are based on total nitrogen. If one assumes that the percentage of the septic tanks to the total for total nitrogen and ammonia is the same, then estimates of the ammonia contribution can also be determined. Table 5-31 A schematic figure showing the mass loadings of ammonia from the major sources is shown in Figure 5-9.

Table 5-31. Ammonia Loading Summary

Source	Max/Permit Loading (kg/yr)	Monitoring Data Loading (kg/yr)	Sampling Data Loading (kg/yr)	Std. Deviation (kg/yr)	% of Total from Sampling Loading Data
Municipal WWTP	390,000	112,000	110,000	60,000	64
PIDs	20,000	5,000	(5,000)		3
Industrial WWTP	1,000	700	800	100	< 1
Urban Runoff *	67,000	(45,000)	45,000		26
Septic Tanks**			*11,000*		6
TOTAL	469,000	163,000	172,000	60,000	

*: Urban runoff only for three streams.

** Estimated based on 6% of total.

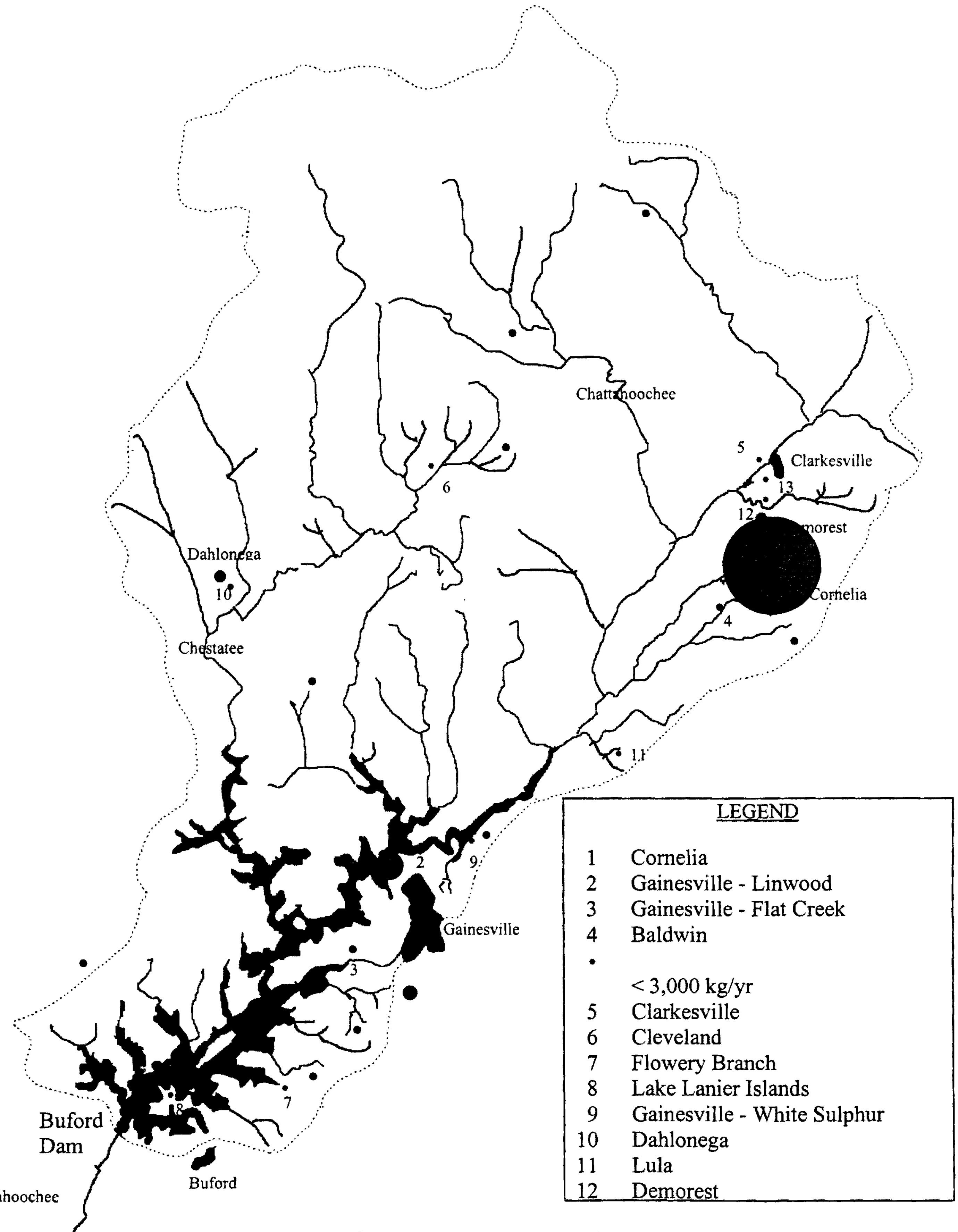


Figure 5-9. Ammonia Loading

A reasonable range of loadings of total nitrogen is 462,000 to 990,000 kg/yr based on Table 5-32. The loading that is most likely is 726,000 kg/yr. The nitrogen is composed of approximately 24% ammonia. The nitrogen loading from septic tanks can comprise a significant part of the total mass load to the lake (9%) based on the assumptions made in the analysis and described previously. Figure 5-10 shows the nitrogen mass loadings into the lake.

In 1973, the EPA conducted a eutrophication study that included an approximation of nitrogen and phosphorus loadings. In 1991, the Clean Lakes Project also estimated nitrogen and phosphorus loadings. A comparison of the nitrogen loadings from these two studies and the current study is shown in Table 5-33. The increase in nitrogen from 1973 to 1991 noted by the 1991 Clean Lakes study is confirmed by the 1996 Clean Lakes study. This increase is likely due to the increase in population in this region, resulting in construction of more wastewater treatment plants and higher permitted flows from existing plants. The increase from 1991 to 1996 is primarily due to more accurate estimates of concentrations from the wastewater plants and the industrial sources. The

Table 5-32. Nitrogen Loading Summary

Source	Max/Permit Loading (kg/yr)	Monitoring Data Loading (kg/yr)	Sampling Data Loading (kg/yr)	Std. Deviation (kg/yr)	% of Total from Sampling Loading Data
Municipal WWTP			450,000	250,000	62
PIDs	22,000	9,000	(9,000)		1
Industrial WWTP	5,000	3,000	(3,000)	14,000	< 1
Urban Runoff*	335,000	(220,000)	220,000		30
Septic Tanks	60,000	44,000	(44,000)		6
TOTAL			726,000	264,000	

*: Urban runoff only for three streams.

difference between septic tank loadings from 1991 to 1996 is because the 1991 value was a result of using a multiplying factor of 3 to the 1973 data. The 1996 value is based on counting structures within 300 feet of the lake as shown on 1985 USGS quadrangle maps. Of interest is the difference in tributary loadings. The loadings in 1973 and 1991 were based on average flows for the streams and average nitrogen concentrations. Thus, it is not specific to stormwater runoff. The concentrations and loadings for the stormwater runoff are higher as would be expected because additional pollutants are being added to the streams from the land. The ratios of nitrogen concentration between the streams seems to remain constant from 1991 to 1996. This is because the average flow conditions represent a diluting of the urban runoff over time.

<u>Phosphorus</u>

Like nitrogen, phosphorus can cause eutrophication of a body of water. Based on Table 5-34, the estimated loading range of phosphorus is from 42,000 to 62,000 kg/yr with a probable loading of 52,000 kg/yr. It is common for septic tanks along the shoreline to contribute less than 10% of the total phosphorus load (USEPA, 1983). This holds true for Lake Lanier based on these loading calculations, where the contribution from septic tanks is estimated to be 2%. Figure 5-11 shows the relative contribution of phosphorus from the point-sources. As with the nitrogen loadings, a comparison of phosphorus loadings based on data obtained in 1973 and 1991 is presented in Table 5-35. The difference between 1991 and 1996 loadings is because the 1991 phosphorus concentrations were based on assumptions of phosphorus concentrations. The large decrease in phosphorus loading from 1973 to 1996 is likely due to the ban on phosphorus detergents instituted in

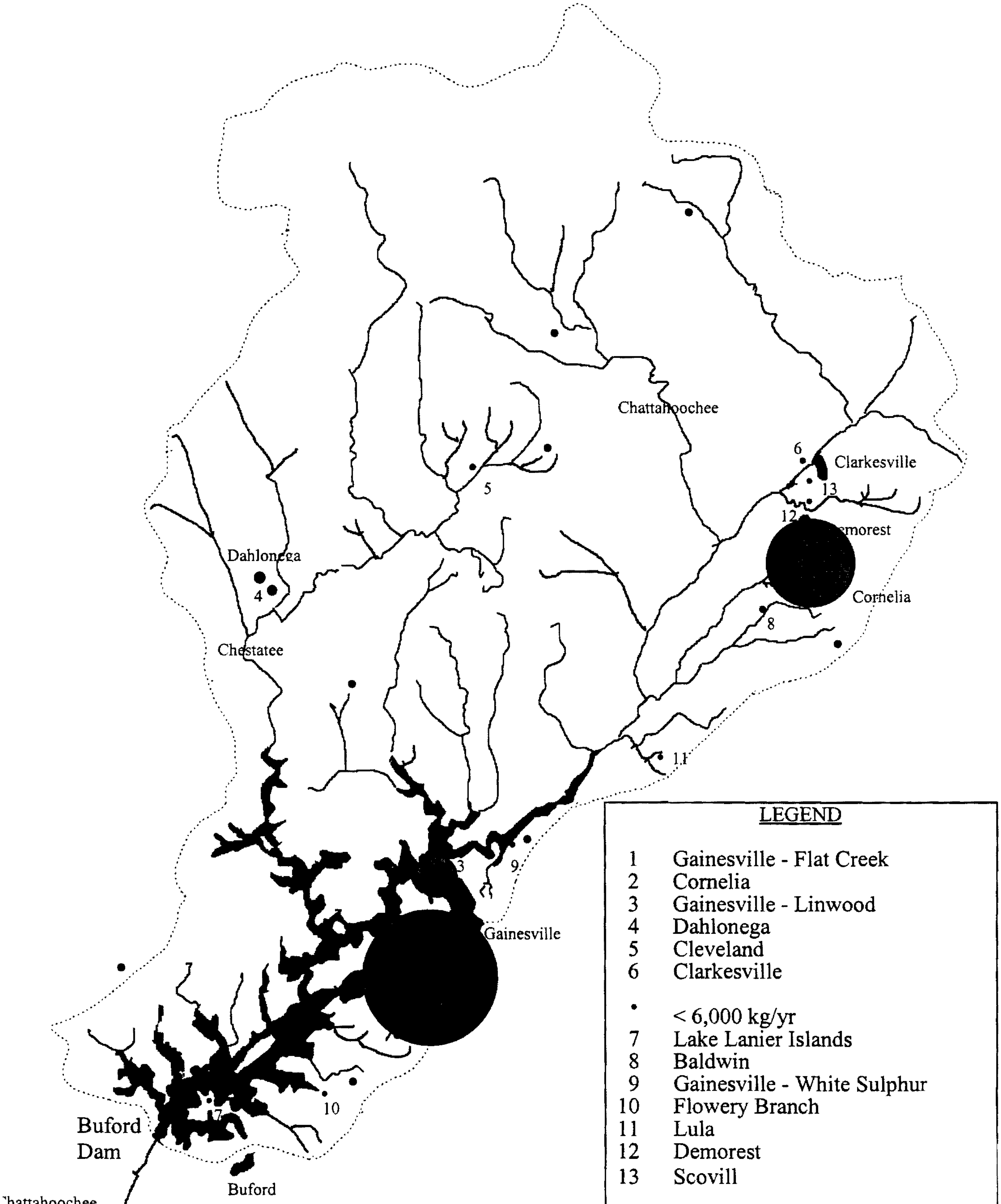


Figure 5-10. Nitrogen Loading

Table 5-33. Comparison of Nitrogen Loadings for 1973, 1991 and 1996

	EPA 1973		Clean Lakes 1991		Clean Lakes 1996		
	mg/L	kg/yr	mg/L	kg/yr	mg/L	kg/yr	
LARGE TRIBUTARIES							
Total from tributaries		(15,900)		(42,305)		(208,991)	
S. Flat Creek	1	9,515	0.78	7,382	4.24	91,841	
Limestone Creek	1.01	6,385	0.58	3,112	1.08	12,376	
Six Mile Creek			6.25	31,811	9.15	104,773	
MUNICIPAL WWTP							
Total from municipal WWTP		(229,325)		(432,409)		(454,419)	
Gain-Flat Creek	20.7	101,985	40	265,757	28	208,753	
Gain - Linwood	18.23	43,080	20	39,587	22.62	60,585	
Gain - White Sulphur			20	2,768	30	4,145	a
Lake Lanier Islands			20	2,768	30	14,508	a
Flowery Branch			10	1,661	5.98	1,470	
Baldwin	11.5	1,225	20	8,582	14.00	3,417	
Cornelia	16.22	56,015	30	66,439	38.58	130,405	
Clarksville	24.62	4,400	20	6,921	21.14	6,967	
Cleveland	24.62	4,600	20	9,689	12.94	7,423	
Dahlonega	24.62	9,040	20	11,627	16.14	12,893	
Demorest	24.62	3,640	20	11,073	5.89	453	
Lula					30	3,399	a
New Holland	24.62	5,340					
Misc.			20	5,537			
INDUSTRIAL DISCHARGERS							
Total from Industrial Dischargers						(2,848)	
Buckhorn					0.30	1	b
Davidson Minerals					1.00	1,340	a
Deering-Milliken							
Fieldale (Marell) Poultry (Land App)							
Habersham Mills					0	0	b
High Point Minerals					1.00	3	a
JA Hudson					1.00	1,195	a
Queen City Foods							
N. GA Rendering (Land App)							
William Wrigley (to WWTP)							
Gold Kist Feedmill							
Scovill Fasteners					1.97	294	
SKF Bearing					0.65	16	a
SEPTIC TANKS		15,275		46,000		44,199	
NET ANNUAL LOADING		**260,500**		**520,714**		**710,456**	

Notes:

a) Based on assumed values

b) Based on Discharge Monitoring Reports

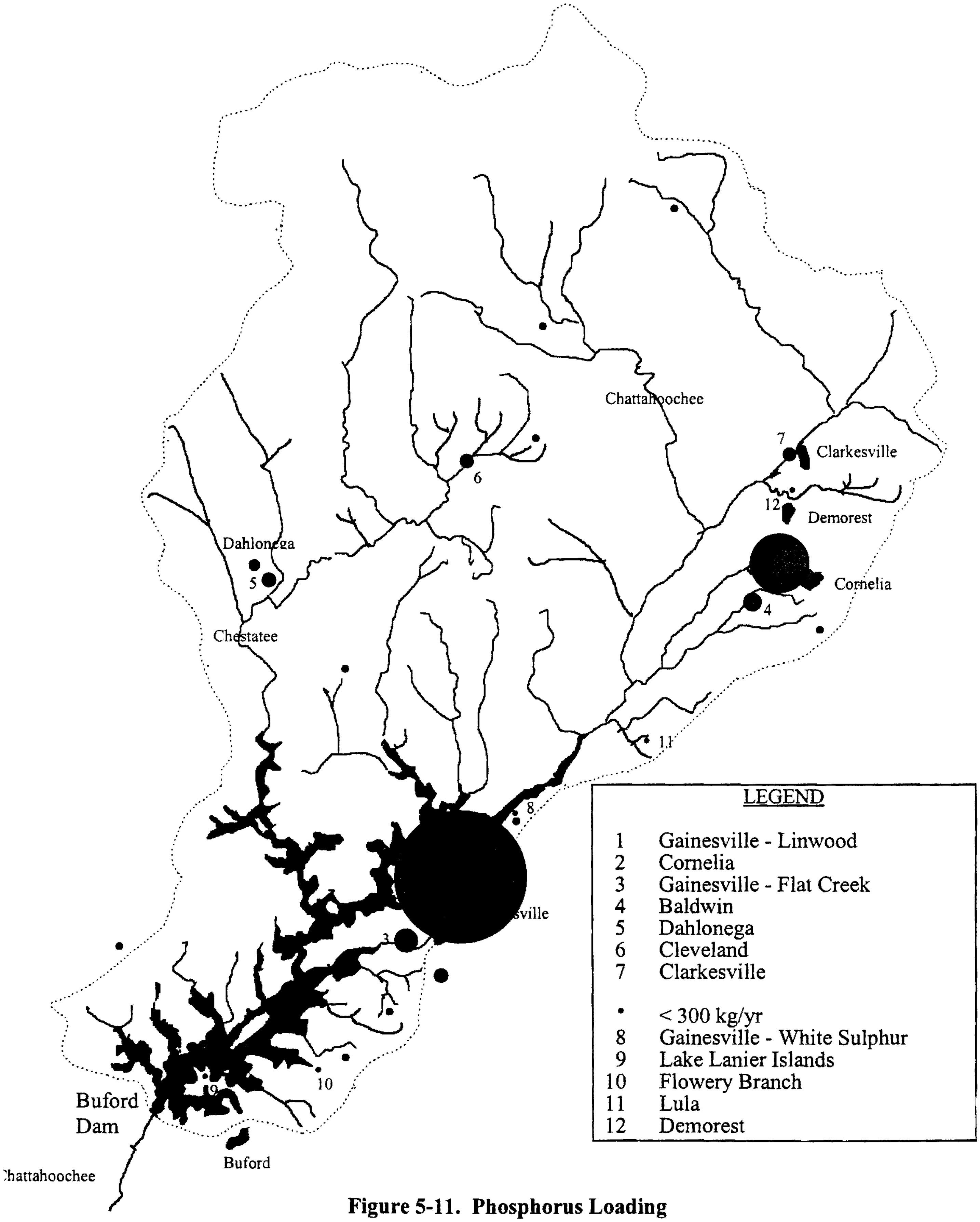


Figure 5-11. Phosphorus Loading

Table 5-34. Phosphorus Loading Summary

Source	Max/Permit Loading (kg/yr)	Monitoring Data Loading (kg/yr)	Std. Deviation (kg/yr)	Sampling Data Loading (kg/yr)	Std. Deviation (kg/yr)	% of Total from Sampling Loading Data
Municipal WWTP	47,000	32,000	9,000	24,000	10,000	46
PIDs	2,000	1,000	30	(1,000)		2
Industrial WWTP	1,000	1,000		1,000	5	2
Urban Runoff*	38,000	(25,000)		25,000		48
Septic Tanks	6,000	2,000		(1,000)		2
TOTAL	94,000	61,000	9,000	52,000	10,000	

*: Urban runoff only for three streams.

Georgia. An alternate analysis was performed to see what the attainable loadings would be if the permit for all the point-source facilities was changed to 1 mg/L. The result is as follows: maximum: 29,000 kg/yr (as compared to 50,000) and average: 12,000 kg/yr (as compared to 25,000). However, it should be noted that obtaining phosphorus removal to this level in the effluents would be very difficult for some wasteater treatment facilities to accomplish.

Summary of BOD5, Nitrogen, and Phosphorus Loadings

Figure 5-12 compares the concentration of BOD5, nitrogen and phosphorus to the annual loading of these pollutants from each sampling site. Note that the three sites at the far right of each figure are from stormwater runoff, whereas the other data is from wastewater treatment facilities. The stream data is for only three streams. It does not represent the total loading from all urban runoff in the watershed. However, it is apparant that stormwater runoff contributes significant amounts of BOD5, nitrogen, and phosphorus. This figure also shows that the flows from the wastewater treatment facilities play a significant role in the loadings. For example, the concentration of phosphorus from Linwood and Scovill is nearly identical, yet the loading from Linwood (permitted 3 MGD) is nearly 1,500 times larger than from Scovill (permitted 0.14 MGD).

Trace Metals

Table 5-36 shows a summary of the annual loading of Cr, Ni, Cu, Zn, Ba, and Pb into the lake from the sources sampled (more detailed information is in Appendix 5-C). Maximum loads from each of the thirteen sources were calculated based on the detection limits which were 1.0, 0.2, 1.4 and 1.4 ug/L respectively for cadmium, mercury, arsenic and selenium. The corresponding loads were 62, 12, 87 and 87 kg/y respectively. Basing stream loadings on the stormwater concentrations probably results in overestimates.Trace metals tend to be strongly associated with particulate matter. During high flow conditions, fine solids remain in suspension resulting in high total metal measurements. However, particulate phases have a longer average residence time in the stream than the aqueous phase; that is, the metals measured in stormwater samples are not necessarily representative of what, on average, reaches the lake. Leigh (1996) estimated toxic metal loads in the lake tributaries based on average flow conditions. Estimates obtained in this way were an order of magnitude lower than those based on storm water flow. However, loads based on average conditions are likely to be underestimates since high flow conditions correspond to high concentrations. Consequently, the true loading values probably lie between the two types of estimates.

Figure 5-13 shows a comparison of the pollutant concentrations and annual loading values for zinc, barium, and lead. The results indicate that the relative importance of various pollutant sources with respect to the total pollutant load is primarily determined by the volume of flow.

Table 5-35. Comparison of Phosphorus Loadings for 1973, 1991, and 1996

	EPA 1973		Clean Lakes 1991		Clean Lakes 1996		
	mg/L	kg/yr	mg/L	kg/yr	mg/L	kg/yr	
LARGE TRIBUTARIES							
Total from tributaries		(820)		(825)		(23,826)	
S. Flat Creek	0.052	490	0.035	333	0.41	8,912	
Limestone Creek	0.052	330	0.027	146	0.23	2,639	
Six Mile Creek			0.068	346	1.07	12,274	
MUNICIPAL WWTP							
Total from municipal WWTPs		(78,100)		(53,652)		(23,731)	
Gain-Flat Creek	6.25	30,775	0.54	3,588	0.21	1,720	
Gain - Linwood	8.91	21,055	7	13,855	3.71	10,404	
Gain - White Sulphur			7	969	2	276	a
Lake Lanier Islands			7	969	2	271	a
Flowery Branch			0.42	70	1.70	418	
Baldwin	8.2	875	7	3,003	6.46	1,999	
Cornelia	4.74	16,385	7	15,502	1.20	4,417	
Clarksville	8.2	1,465	7	2,422	2.40	929	
Cleveland	8.2	1,535	7	3,391	2.18	1,443	
Dahlonega	8.2	3,015	7	4,070	2.25	1,693	
Demorest	8.2	1,215	7	3,875	0.84	68	
Lula					2	94	a
New Holland	8.2	1,780					
Misc.			7	1,938			
INDUSTRIAL DISCHARGERS							
Total from Industrial Dischargers						(831)	
Buckhorn					0.10	0	b
Davidson Minerals					0.10	138	a
Deering-Milliken							
Fieldale (Marell) Poultry (Land App)							
Habersham Mills					1.13	12	b
High Point Minerals					0.10	0	a
JA Hudson					0.10	119	a
Queen City Foods							
N. GA Rendering (Land App)							
William Wrigley (to WWTP)							
Gold Kist Feedmill							
Scovill Fasteners					3.38	560	
SKF Bearing					?		
SEPTIC TANKS		16,880		1,200		0	
NET ANNUAL LOADING		**95,800**		**55,677**		**48,388**	

Notes:

a) Based on assumed values

b) Based on Discharge Monitoring Reports

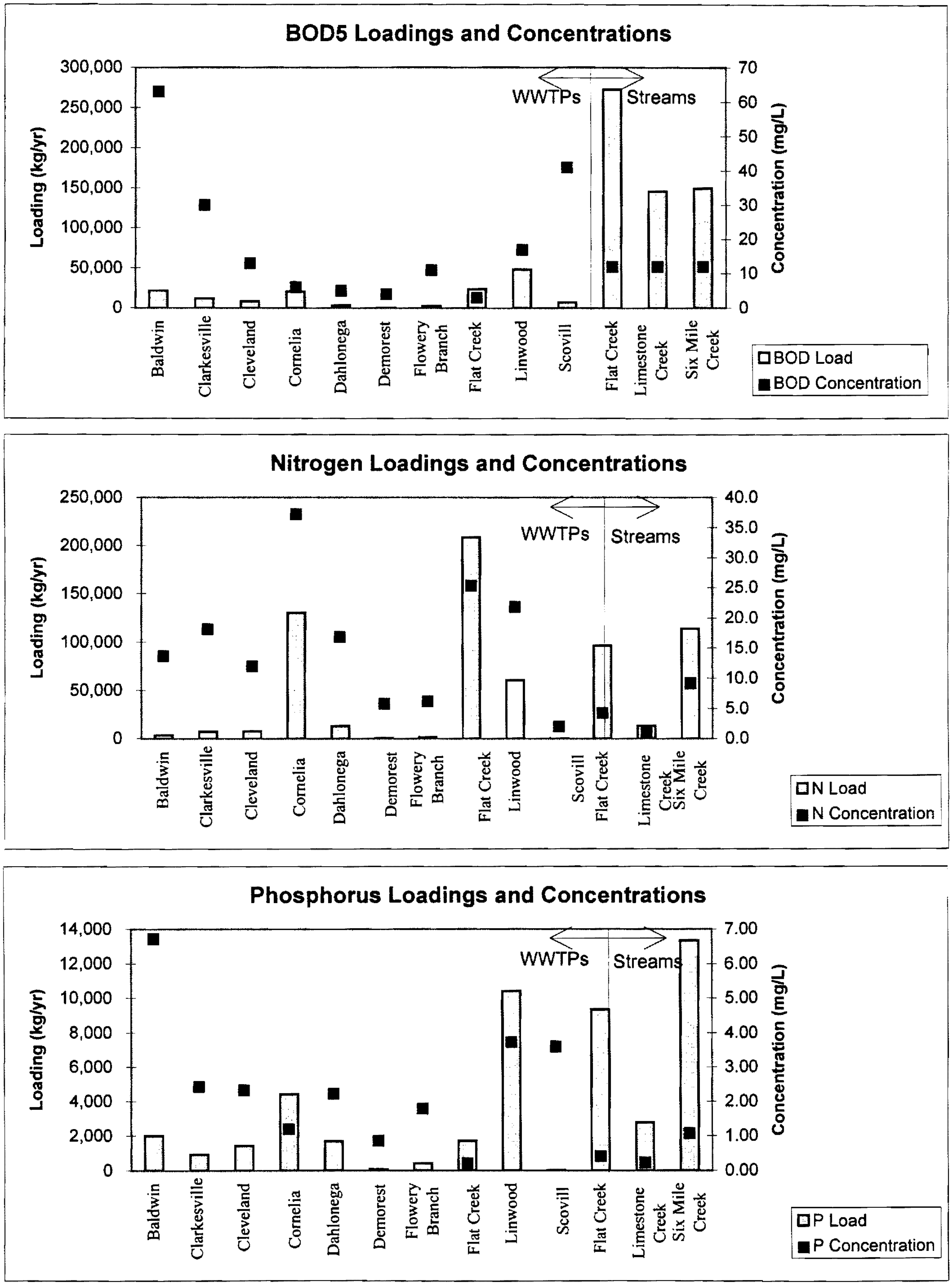


Figure 5-12. Comparison of Loadings and Average Concentrations

Consequently, the Flat Creek plant contributes more to the total metal load and is more likely to have difficulties meeting instream water quality standards than Scovill, which has much higher pollutant concentrations.

Similarly, pollutant loads due to stormwater runoff are likely to be at least an order of magnitude greater than loads due to effluent discharges. Furthermore, the combined drainage areas of the three creeks sampled constitute less than 0.2% of the total drainage area of the lake above the Buford Dam. Consequently, while yields of trace metals per unit drainage area are expected to be relatively high in the creeks sampled because they drain urban areas, they may not have a very large impact on the overall pollutant load. However, the point and non-point sources investigated may well cause localized water quality problems.

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Table 5-36. Annual Metal Loading Summary (kg/y)

		Cr	Ni	Cu	Zn	Ba	Pb
Municipal WWTPs	Baldwin	0.9	2.4	6.5	37.9	11.9	1.1
	Clarkesville	1.0	2.1	16.4	98.1	10.0	2.3
	Cleveland	0.5	1.7	6.9	20.1	3.9	0.6
	Cornelia	5.9	22.9	25.8	262.9	28.6	5.4
	Dahlonega	1.0	1.7	9.7	46.0	8.1	0.7
	Demorest	0.1	0.1	1.0	6.6	2.1	0.1
	Flat Creek WWTP	13.5	70.0	65.8	958.1	74.9	19.9
	Flowery Branch	0.8	0.3	2.5	5.1	1.8	0.2
	Linwood	8.8	11.0	83.1	290.0	124.6	40.0
Industrial WWTP	Scovill	2.6	72.0	36.5	28.2	0.5	0.3
Stormwater Locations	S. Flat Creek	47.6	91.2	164.7	1469.3	587.0	129.6
	Limestone Creek	19.6	18.1	79.4	483.1	286.5	71.7
	Six Mile Creek	90.4	52.5	126.3	881.8	1577.7	87.5

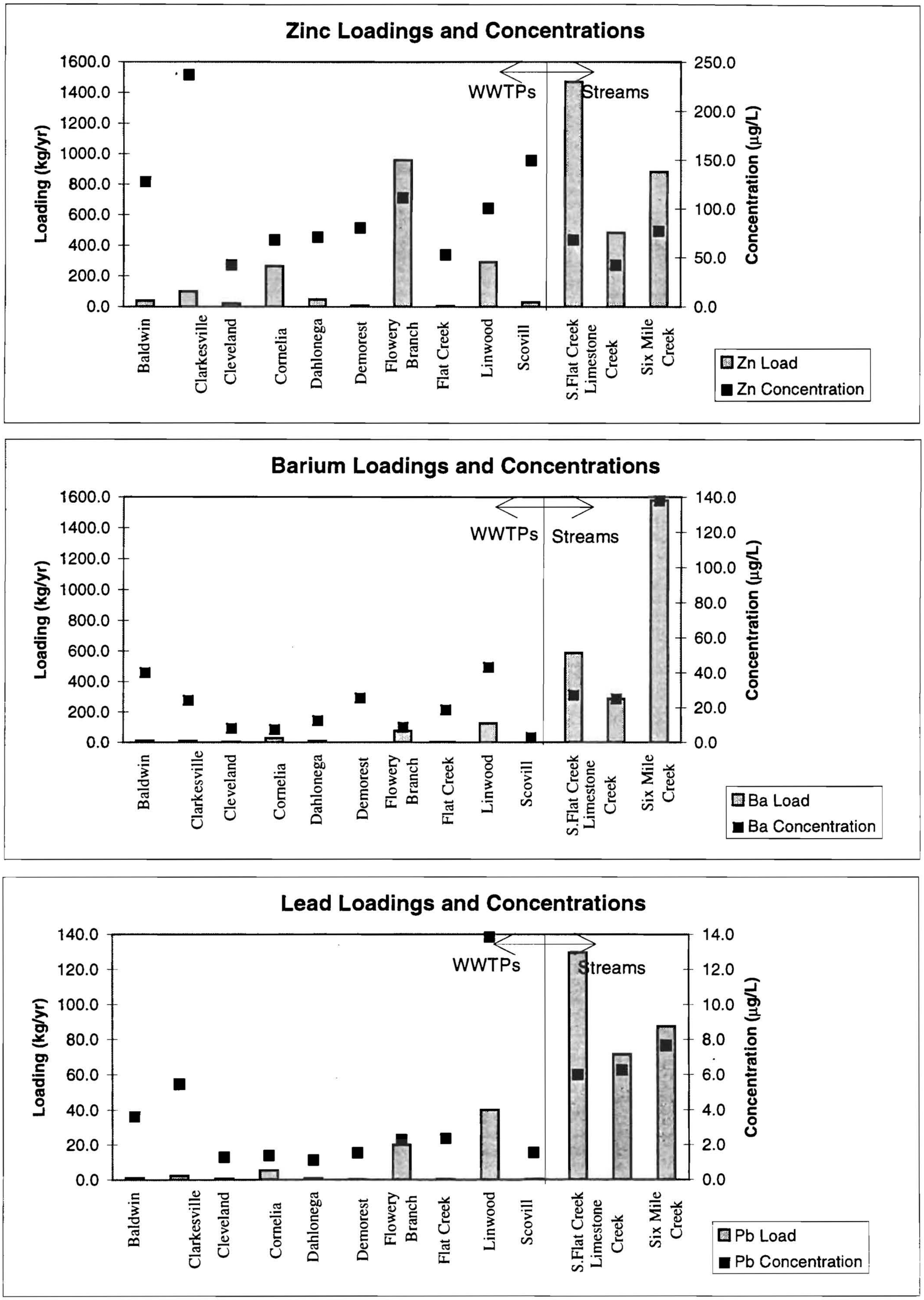

Figure 5-13. Comparison of Loadings and Average Concentrations for Zinc, Barium, and Lead

5.6. ALTERNATIVES ANALYSIS

Municipal WWTP / Industrial Dischargers

Most of the dischargers in the watershed are meeting their permit requirements. However, if better water quality is desired for the lake some thought needs to be given to reducing the amounts of pollutants contributed by wastewater treatment facilities. As was shown by the loadings analyses, wastewater treatment facilities contribute the largest portion of TOC, nitrogen and phosphorus from point-sources and discrete non-point sources. Nutrients (nitrogen, phosphorus) are of particular concern to lake systems because of the threat of eutrophication. Nitrogen and phosphorus permit limits could be lowered, thus requiring the facilities to improve their effluent water quality. This can be very expensive and nearly impossible for some systems to accomplish using the current facilities. However, some facilities can improve their effluent water quality by optimizing their current treatment system. Further education of operators and the support of the municipalities would be necessary. It was demonstrated that by lowering the phosphorus limit for all facilities to 1 mg/L that the loadings from point-sources could be cut in half. The two faciliites that currently have a permitted phosphorus limit of 1 mg/L (Gainesville Flat Creek and Flowery Branch) have typical effluent concentrations of 0.6 mg/L.

Marinas

Some of the main problems associated with marinas are sewage releases from boats; use of cleaners containing chlorine, ammonia and phosphate that can harm plankton and fish; and oil spills that can attach to sediments causing harm to bottom-dwelling organisms. Public education of the owners of marinas and boat users may be the best method to combat pollution from this source. This is because most pollution associated with boating is done by individuals who probably do not know the consequences of their actions. Some solutions recommended by the EPA ("Management Measures...Boating") for boat owners and users are as follows: 1) Select nontoxic cleaning products; 2) Use drop cloths; 3) Clean & maintain boats out of the water; 4) Vacuum loose paint chips and paint dust; 5) Fuel the boats carefully; 6) Recycle used oil; 7) Discard worn motor parts in proper receptacles; 8) Drain water out of waterlines and tanks during winter freezes; 9) Keep boat motors well-tuned to prevent fuel & lubricant leaks and to improve fuel efficiency.

Landfills / Hazardous Waste Sites / Underground Storage Tanks

Local and regional groups who have an interest in Lake Lanier should encourage owners of these facilities to comply with the national and state regulations. If the facilities are not meeting the regulations they should alert the appropriate authorities. Local governments should also be supportive of improving the requirements and being conscientious about remediation.

Septic Tanks

Septic tank failure can cause contamination of drinking water supplies and contribute to the eutrophication of lakes. It is uncertain to what extent septic tanks are failing in the Lake Lanier watershed. Currently septic tanks are being used primarily by the more rural areas of the watershed. The alternative to septic systems would be the creation of wastewater treatment facilities and sewer systems to convey the waste to the treatment plant. However, in rural areas 80% of the capital costs for creating a wastewater treatment system are for the sewer network (USEPA, 1983). Constructing the sewer networks can also cause environmental problems such as erosion and destruction of wildlife. According to the EPA's Seven Rural Lake EIS, "abandoning septic tank/soil absorption systems along the shorelines will seldom result in significant change in lake trophic status" (EPA, 1983). This does not imply that septic tanks do not contribute to lake pollution. To minimize the impact of septic tanks on the lake it is necessary to ensure that they are being used properly. The first step is to determine the extent of the problem.

The EPA presents several ways in which information can be gained to determine the performance of septic tanks in the watershed (USEPA, 1983). Aerial photography at the scale of 1:8000 (1in=1667ft) provides information about surface failures of septic tanks. Septic leachate detection devices can locate groundwater inflow that conveys the wastewater. Questionnaires sent to homeowners could provide information about the occurrence of failures (such as plumbing backup) and provide for community education and involvement. Investigations along the lakeshore for growth of attached and floating plants may indicate septic problems. The use of the septic leachate detectors can confirm the presence of septage.

After determining the extent of septic tank failure, the problems should be investigated to determine solutions. There are several models available for varying levels of private and community involvement that can help with these problems. The main problems with inappropriate use of septic tanks are using them beyond their life expectancy (50 years for concrete/fiberglass/plastic, 10 years for metal) and the tanks not being pumped and emptied frequently enough. This can be combated by

Table 5-37. Means to Control Septic Tank Failure

Cause of Failure	Ways to Control Future Failures
System Usage	Water meters
	Flow reduction devices
	Limit number of persons per septic tank
	Limit garbage disposals
Maintenance Problem	Renewable permit contingent upon proof of periodic inspection & maintenance
	Public maintenance services
	Required maintenance contracts
	Public education
Surface Failure &	Upgrade facilities that aren't adequate
Plumbing Backup	Change design of facility
	Off-site treatment when septic tanks aren't appropriate for site characteristics (soil groundwater hydrology)

having the tanks inspected at least every two years and having them pumped once every three to five years. Another problem lies with the cumulative effect of having too many septic tanks in the same area. There should be fewer than five per hectare (Adriano, 1994). The EPA provides some of the modes of failure and ways to control that are presented in Table 5-37 (USEPA, 1983).

Cemeteries

The limited analysis completed in this study suggests that cemeteries do not pose a significant threat to Lake Lanier. Further investigation including sampling and analysis would be needed to determine if they are a problem.

Urban Runoff

The loadings analyses conducted in this study show the large impact that stormwater runoff has on the quality of the lake. "Experience in the seven rural lake EIS's suggests ... that reduction of non-point source pollution may produce a much greater water quality improvement at a lower cost [than sewering rural areas] (USEPA, 1983)." There are two main types of activities which can be implemented to improve stormwater quality: 1) community planning and 2) better management practices (BMPs). The main community plans which should be considered are presented by the EPA (USEPA, "Managing Urban Runoff"):

* plans for new development - structural controls and pollution prevention
* plans for existing development - expensive
* plans for onsite disposal
* public education

These types of plans could be incorporated in municipal or regional planning strategies. Some of the BMPs that will improve stormwater quality as explained by Woodward-Clyde Consultants (1990) are shown in Table 5-38.

Table 5-38. Better Management Practices for Urban Runoff Control

BMP	How it Works
Detention Basin	Stores runoff temporarily providing reduction in pollutants due to settling.
Retention Devices	Permanently captures runoff - generally employs infiltration.
Vegetative Control	Pollutants can be removed by filtration, sedimentation or biological uptake.
Source Control	Reduce amounts of accumulated pollutants on land surface Regulate the amount of impervious area Exclude inappropriate discharges to storm drains

The best type of control will be determined based on site specific conditions such as drainage area, soil characteristics, acceptability and other factors.

5.7 SUMMARY AND FURTHER STUDY

Potential discrete sources of pollution in the Lake Lanier watershed (municipal wastewater treatment facilities, industrial dischargers, marinas, landfills, septic tanks, hazardous waste sites, underground storage tanks, cemeteries, and urban areas) were identified and investigated. Based on this examination, a sampling program was conducted to better characterize the effluent from ten wastewater treatment facilities and urban runoff into three streams. In general, the wastewater treatment facilities seem to be meeting their permit requirements and the sampling results are in agreement with the discharge monitoring reports (DMRs). A few facilities are in need of upgrading. See pages 5-25 and 5-30 for more information for each facility. Mercury, selenium, and cadmium were below the detection limits in all of the samples collected during the sampling program. Arsenic was only detected from one facility, Scovill, yet the concentration was very low (< 5 ug/L).

Pollutant loadings of BOD, TOC, nitrogen, and phosphorus were calculated from the municipal wastewater facilities, PIDs, industrial dischargers, septic tanks, and urban runoff based on the sampling results, DMRs and typical values from the literature. From the limited sampling it appears that the largest contribution of BOD comes from urban runoff. Municipal wastewater treatment facilities contribute large amounts of nitrogen. Urban runoff and municipal facilities contribute large portions of the phosphorus load. The loading of phosphorus has decreased significantly since 1973. However, the application of a phosphorus permit limit for some of the larger facilities which do not currently have a phosphorus limit (Linwood and Cornelia), would cause a significant decrease in the phosphorus loading. Loadings of Cr, Ni, Cu, Zn, Ba, and Pb were calculated from the results of the wastewater and urban runoff sampling programs. It appears that urban runoff contributes large loadings of these metals to the lake.

The research presented in this report provides valuable information on some potential pollutant sources in the Lake Lanier watershed. However, there is room for further study. The pollutant loadings calculated from septic tanks did not appear to contribute significantly as compared to the other sources investigated (0.5% for BOD, 6% for N, 2% for P). However, the septic tank calculations were based on an estimated number of septic tanks and estimated pollutant contributions. It is recommended that a study be conducted to determine the extent of septic tank failures near the lake. Suggestions are present in Section 5.6.

The contribution of pollutants from marinas on the lake is also uncharacterized. A study of the water quality surrounding the marinas would be worthwhile.

The results presented here for urban stormwater runoff were based on a very limited sampling program. The purpose was to determine if urban stormwater runoff is a significant threat to the health of the lake. It has been determined that urban stormwater runoff does contribute significant loadings of pollutants (nitrogen, phosphorus, BOD5, TSS and trace metals) into the lake. Further study of the contribution from all types of stormwater runoff (urban, agricultural, residential, forested) and ambient stream conditions would provide better insight into which types of stormwater runoff are more threatening to the lake and more accurate calculations of pollutant loadings from all types of runoff. This is especially true for metals analysis because of the relationship between the metals and particulate matter.

5.8 REFERENCES

Adriano, Domy C., Alex K. Iskandar, and Ishwar P. Murarka. 1994. *Contamination of Groundwaters.* Northwood: Science Reviews.

Alley, William M. 1976. *A Conference Report for Guide for Collection, Analysis, and Use of Urban Stormwater Data.* New York: American Society of Civil Engineers.

American Public Health Association, AWWA, WEF. 1992. *Standard Methods for the Examination of Water and Wastewater.* 18th ed. Washington D.C.

American Water Works Association. 1990. *Water Quality and Treatment: A Handbook of Community Water Supplies.* 4th ed. Ed. Fredrick Pontius. New York: Mc-Graw Hill.

Harris InfoSource International. 1996. *1997 Harris Georgia Manufacturers Directory.* Ed. Frances L. Carlsen. Twinsburg, Ohio.

Carter, R.F., E.H. Hopkins, and H.A. Pearlman. 1989. *Low-flow Profiles of the Upper Chattahoochee River and Tributaries in Georgia..* Georgia: U.S. Geological Survey Water-Resources Investigations Report 89-4056.

Carter, R.F., and S.A. Putnum. 1978. *Low-Flow Frequency of Georgia Streams.* Georgia: U.S. Geological Survey Water-Resources Investigations Open-File Report 77-127.

Cheremisinoff, Paul N. 1992. *A Guide to Underground Storage Tanks: Evaluation, Site Assessment, and Remediation.* New Jersey: Prentice Hall.

Chow, Ven Te, David R. Maidment, and Larry W. Mays. 1988. *Applied Hydrology.* New York: McGraw-Hill.

Cowie, G. M. and J. L. Cooley. 1989. *Guidelines for Development of Watershed Protection Programs in Georgia.* Georgia: University of Georgia.

Dudley, John G. and David A. Stephenson. 1973. *Nutrient Enrichment of Groundwater from Septic Tank Disposal Systems.*

Fisher, J.S., R.R. Perdue, M.F. Overton, M.D. Sobsey, and B.L. Sill. 1987. *Comparison of Water Quality at Two Recreational Marinas During a Peak-use Period.* North Carolina State at Raleigh. Sea Grant College Program

General Accounting Office. 1986. "Nation's Water: Key Unanswered Questions About the Quality of Rivers and Streams." Washington D.C.: General Accounting Office.

Georgia Department of Natural Resources Environmental Protection Division. 1995. "Rules and Regulations for Water Quality Control." Georgia: Chapter 391-3-6 Water Quality Control.

________. 1996. *1993 Hazardous Waste Report.* Georgia.

Georgia Water Quality Control Board. 1971. *Gainesville Area Water Quality Study.* Georgia.

________. 1969. *Water Quality Investigation at Two Marinas on Lake Lanier.* Georgia.

Hagedorn, C., E.L. McCoy, and T.M. Rahe. 1981. The Potential for Ground Water Contamination from Septic Effluents. *Journal of Environmental Quality.* Vol. 10, no.1.

Hatcher, Kathryn et al. 1994. "Diagnostic/Feasibility Study of Lake Sidney Lanier, Georgia." Project Completion Report prepared for Georgia Environmental Protection Division.

James, William. 1993. *New Techniques for Modeling the Management of Stormwater Quality Impacts.* Florida: Lewis Publishers.

Kaplan, O. Benjamin. 1991. *Septic Systems Handbook.* 2nd ed. Michigan: Lewis Publishers.

LaGrega, Michael D. , Phillip L. Buckingham, and Jeffrey C. Evans. 1994. *Hazardous Waste Management.* New York: McGraw-Hill.

Linsley, Ray K., Joseph B. Franzini, David L. Freyberg, and George Tchobanoglous. 1992. *Water-Resources Engineering.* 4th ed. New York: McGraw-Hill.

Metcalf & Eddy, Inc. 1991. *Wastewater Engineering: Treatment, Disposal & Reuse.* 3rd ed. Revised by George Tchobanoglous, Franklin L. Burton. New York: McGraw-Hill New York.

National Climatic Center of NOAA. 1991. Climatological Data Annual Summary - Georgia. Ashville, NC. 95:13.

Pacheco, A., J.M.B. Mendes, T. Martins, S. Hassuda, and A.A. Kimmelmann. 1991. Cemeteries - A Potential Risk to Groundwater. *Water Science Technology.* Vol 24, No 11 pp97-104.

Pontius, Frederick W. 1996. An Update of the Federal Regs. *Journal of the American Water Works Association.* 88:3:36.

Puckett, Larry J. 1994. *Nonpoint and Point Sources of Nitrogen in Major Watersheds of the United States.* U.S. Geological Survey.

Reckhow, K.H. and J.T. Simpson. 1980. A Procedure Using Modeling and Error Analysis for the Prediction of Lake Phosphorus Concentration from Land Use Information. *Canadian Journal of Fishing and Aquatic Sciences.* 37:1439-1448.

Senft, W.H., and K.E. Roberts. 1983. *Diagnostic Feasibility Study of Lake of the Woods, Marshall Co., Indiana.* Indiana: Indiana State Department of Natural Resources.

U.S. Environmental Protection Agency. 1993. *Commitment to Watershed Protection: A Review of the Clean Lakes Program.* Washington D.C.: Office of Wetlands, Oceans and Watersheds.

________. 1980. *Design Manual: Onsite Wastewater Treatment and Disposal Systems*. Ohio: Office of Research and Development.

________. 1983. *Final-Generic Environmental Impact Statement for Wastewater Management in Rural Lake Areas*. Illinois.

________. 1994. *Guide to Septage Treatment and Disposal*. Cincinnati. Ohio.

________. "Management Measures...Boating". Internet Address for Access to Information: www.epa.gov/OWOW/M...ter5/ch5- 1.html#Pollutant

________. "Managing Nonpoint Sources...from Boating and Marinas." Internet Address for Access to Information: www.epa.gov/OWOW/NPS/Facts/point9.htm.

________. "Managing Urban Runoff." Internet Address for Access to Information: www.epa.gov/OWOW/NPS/Facts/point7.htm

________. *National Eutrophication Survey: Working Paper Series*. Pacific Northwest Environmental Research Laboratory. PB 248/886.

________. 1984. *Process Design Manual for Land Treatment of Municipal Wastewater: Supplement on Rapid Infiltration and Overland Flow*. Ohio: USEPA Center for Environmental Research Information.

________. 1991. *Technical Support Document for Water Quality-based Toxics Control*. Washington D.C.: Office of Water.

________. 1993. *UST Program Facts: Preventing Leaks: Technical Regulations*. Washington D.C.

Woodward-Clyde Consultants. 1990. *Urban Targeting and BMP Selection: An Information and Guidance Manual for State Nonpoint Source Program Staff Engineers and Managers*. Washington D.C.: Terrene Institute.

York, M. Timmerly. 1997. Special Topics Paper. Georgia Institute of Technology.

Young, David R., Theadore C. Heesen, Deirdre J. McDermott, and Paul E. Smokler. 1974. *Marine Inputs of Polychlorinated Biphenyls and Copper From Vessel Antifouling Paints*. California: Southern California Coastal Water Research Project.

APPENDICES

APPENDIX 5-A

SUMMARY OF SAMPLING RESULTS

APPENDIX 5-A. SUMMARY OF SAMPLING RESULTS

CBOD5
(mg/L)

TIER ONE FACILITIES

		8/16	8/30	9/13	9/25	10/6	10/27	11/16	12/11	12/18	1/2	1/19	2/9	3/15	3/28	Max	Min	Avg
Clarkesville							30	17	18	42	38		40	31	28	42	17	30
Scovill									47	29	25		37	42	62	62	25	41
Cornelia								8	6	3	6		5	7	5	8	3	6
Linwood	Tech						9	15	20	11	34		16	18	18	34	9	18
	Gainesville		16	16	20	12	9	9	22	9		10	18	11	10	22	9	14
Flat Creek	Tech						5		2	2	2		3	4	3	5	2	3
	Gainesville		<2	<2	<2	<2	3	<2	<2	<2	<2	3	3	<2	<2	3	3	3

TIER TWO FACILITIES

	2/9	3/15	3/28	4/11	4/30	Max	Min	Avg
Baldwin	37	> 90		85	49	85	37	57
Demorest		X		<4	<4	0	0	
Flowery Branch		18		6	8	18	6	11
Cleveland			17	12	7	17	7	12
Dahlonega			8	4	<3	8	4	6

APPENDIX 5-A. SUMMARY OF SAMPLING RESULTS

CONDUCTIVITY
(umohs/cm)

TIER ONE FACILITIES

		8/16	8/30	9/13	9/25	10/6	10/27	11/16	12/11	12/18	1/2	1/19	2/9	3/15	3/28	Max	Min	Avg
Clarkesville		267	289	298		171	338	254	232	307	271	139	225	202	142	338	139	241
Scovill		2260	2720	2110		2200		3110	2850	3150	2170	2250	2240	2990	2790	3150	2110	2570
Cornelia		877	870	823	468	618	750	764	531	625	683	633	844	771	719	877	468	713
Linwood	Tech	381	398	344	339	306	365	463	351	404	411	245	494	437	316	494	245	375
	Gainesville	380	380		330	280	380	430	330	390	370	220	550	440	330	550	220	370
Flat Creek	Tech	875	808	704	206	636	746	857	878		952	807	808	862	786	952	206	763
	Gainesville	910	800		870	600	800	800	770	880	860	820	910	870	870	910	600	828

TIER TWO FACILITIES

	2/9	3/15	3/28	4/11	4/30	Max	Min	Avg
Baldwin		383		329	291	383	291	334
Demorest		492		253	184	492	184	310
Flowery Branch		869		761	1,271	1271	761	967
Cleveland			369	332	330	369	330	344
Dahlonega			382	328	274	382	274	328

STORMWATER RUNOFF

	4/30	5/28	8/12	Max	Min	Avg
Flat Creek	233	239	311	311	233	261
Limestone Creek	89	83	82	89	82	85
SixMile Creek		191	113	191	113	152

APPENDIX 5-A. SUMMARY OF SAMPLING RESULTS

TOTAL COLIFORM
(# Colonies/100 mL)

FECAL COLIFORM
(# Colonies/100 mL)

TIER ONE FACILITIES

Total Coliform:

		12/18	1/2	2/9	3/15	3/28	Max	Min	Avg
Clarkesville		>800000	40,000	>80000	TNTC	######	######	40,000	######
Scovill		>800	70	>800	87	500	500	70	219
Cornelia		2,300	80	29,000	>800	7,000	29,000	80	9,595
Linwood	Tech	60	12	3	4	4	60	3	17
	Gainesville	190	145	1,118	354	500	1,118	145	461
Flat Creek	Tech	50	120	100	>80	>80	120	50	90
	Gainesville	80	136	991	691	164	991	80	412

Fecal Coliform:

12/18	1/2	2/9	3/15	3/28	Max	Min	Avg
>8000	850	0	450	1,000	1,000	0	575
TNTC	0	0	0	0	0	0	0
7	8	10	0	0	10	0	5
0	0	0	0	0	0	0	0
1	<1	24	6	10	24	1	10
0	0	1	0	0	1	0	0
1	<1	30	7	1	30	1	10

TIER TWO FACILITIES

Total Coliform:

	2/9	3/15	3/28	4/11	4/30	Max	Min	Avg
Baldwin	TNTC	00,000		8,000	54,250	54,250	8,000	31,125
Demorest		21,000		######	40,000	######	21,000	97,000
Flowery Branch		1,600		373	200	1,600	200	724
Cleveland			> 800	4,500	49,740	49,740	4,500	27,120
Dahlonega			> 80,000	10,000	NA	10,000	10,000	10,000

Fecal Coliform:

2/9	3/15	3/28	4/11	4/30	Max	Min	Avg
44	10		> 800	615	> 800	10	223
	510		500	5,100	5100	500	2037
	18		0	1	18	0	6
		14	6	25	25	6	15
		620	4	NA	620	4	312

APPENDIX 5-A. SUMMARY OF SAMPLING RESULTS

MERCURY
(ug/L)

TIER ONE FACILITIES

		8/16	9/13	9/25	10/6	10/27	11/16	12/11	12/18	1/2	1/19	2/9	3/15	3/28
Clarkesville					< 0.2		< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Scovill					< 0.2		< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Cornelia				< 0.2	< 0.2		< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Linwood	Tech			< 0.2	< 0.2		< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
	Gainesville			<0.5		<0.5	<0.5							
Flat Creek	Tech			< 0.2	< 0.2		< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
	Gainesville			<0.5		<0.5	<0.5							

TIER TWO FACILITIES

	2/9	3/15	3/28	4/11	4/30
Baldwin		< 0.2		< 0.2	< 0.2
Demorest		< 0.2		< 0.2	< 0.2
Flowery Branch		< 0.2		< 0.2	< 0.2
Cleveland			< 0.2	< 0.2	< 0.2
Dahlonega			< 0.2	< 0.2	< 0.2

URBAN RUNOFF

	4/30	5/28	8/12
Flat Creek	<0.2	< 0.2	< 0.2
Limestone Creek	<0.2	< 0.2	< 0.2
SixMile Creek		< 0.2	< 0.2

APPENDIX 5-A. SUMMARY OF SAMPLING RESULTS

TOTAL ORGANIC CARBON
(mg/L)

TIER ONE FACILITIES

		8/16	9/13	9/25	10/6	10/27	11/16	12/11	12/18	1/2	1/19	2/9	3/15	3/28	Max	Min	Avg
Clarkesville		14	13		6	14	10	8	11	8	7	11	9	6	14	6	10
Scovill		43	26		26		43	27	23	14	25	23	19	20	43	14	26
Cornelia		10	7	6	6	6	8	4	4	3	5	4	3	4	10	3	5
Linwood	Tech	19	13	10	9	11	12	9	7	9	13	10	10	8	19	7	11
	Gainesville		17	13		17	19	20	15	32	16	24	27	21	32	13	20
Flat Creek	Tech	8	5	6	4	6	5	5	3	3	6	4	4	4	8	3	5
	Gainesville		5	4		7	7	6	5	6	9	7	7	7	9	4	6

TIER TWO FACILITIES

	2/9	3/15	3/28	4/11	4/30	Max	Min	Avg
Baldwin	12	18		13	11	18	11	14
Demorest		8		4	3	8	3	5
Flowery Branch		6		5	6	6	5	6
Cleveland			7	7	6	7	6	7
Dahlonega			4	3	3	4	3	3

APPENDIX 5-A. SUMMARY OF SAMPLING RESULTS

AMMONIA
(mg NH3-N /L)

TIER ONE FACILITIES

		8/16	8/30	9/13	9/25	10/6	10/27	11/16	12/11	12/18	1/2	1/19	2/9	3/15	3/28	Max	Min	Avg
Clarkesville				13.90		3.08	11.46	8.39	6.44	8.52	10.20	4.17	6.83	7.46	2.05	13.90	2.05	7.50
Scovill				1.76		1.10		0.68	0.27	0.92	1.66	0.91	0.25	0.26	0.05	1.76	0.05	0.79
Cornelia				47.40	6.14	16.40	22.00	20.83	4.66	10.40	27.10	25.07	31.58	27.30	10.50	47.40	4.66	20.78
Linwood	Tech			15.30	5.30	4.88	4.00	8.97	9.10	9.77	12.30	2.11	9.48	8.93	2.33	15.30	2.11	7.71
	Gainesville				5.59	4.56	3.47	8.96	9.25	10.20	16.20	2.00	9.00	10.30	6.00	16.20	2.00	7.78
Flat Creek	Tech			1.08	0.11	0.12	1.40	0.10	1.07	1.18	0.92	0.68	0.32	0.20	0.06	1.40	0.06	0.60
	Gainesville				0.62	<0.1	1.00	<0.1	<0.1	<0.1	<0.1	0.28	0.12	0.14	<0.1	1.00	0.12	0.43

TIER TWO FACILITIES

	3/15	3/28	4/11	4/30	Max	Min	Avg
Baldwin	12.17		12.37	11.9	12.37	11.90	12.15
Demorest	9.97		0.73	0.4	9.97	0.40	3.70
Flowery Branch	4.8		3.93	6.98	6.98	3.93	5.24
Cleveland		1.28	2.59	3.77	3.77	1.28	2.55
Dahlonega		0.54	0.44	0.75	0.75	0.44	0.58

URBAN RUNOFF

	4/30	5/28	8/12	Max	Min	Avg
Flat Creek	0.61	0.37	0.83	0.83	0.37	0.60
Limestone Creek	0.62	0.41	0.76	0.76	0.41	0.60
SixMile Creek		3.55	0.94	3.55	0.94	2.25

APPENDIX 5-A. SUMMARY OF SAMPLING RESULTS

NITRATE
(mg NO3--N/L)

TIER ONE FACILITIES

		8/16	8/30	9/13	9/25	10/6	10/27	11/16	12/11	12/18	1/2	1/19	2/9	3/15	3/28	Max	Min	Avg
Clarkesville						1.4	5.1	4.0	18.0	66.3	10.5	14.0	3.6	0.5	7.7	66.3	0.5	13.1
Scovill						29.2		138.5	67.0	301.2	187.7	132.5	22.8	32.4	101.7	301.2	22.8	112.6
Cornelia						0.7	4.2	15.1	46.4	59.2	31.7	4.2	1.3	1.1	1.2	59.2	0.7	16.5
Linwood	Tech					7.6	10.9	6.2	25.4	27.5	19.5	17.4	11.0	11.7	9.5	27.5	6.2	14.7
	Gainesville						6.9	2.6								6.9	2.6	4.8
Flat Creek	Tech					6.5	8.3	18.2	41.1	89.1	18.1	30.2	23.0	23.9	15.7	89.1	6.5	27.4
	Gainesville				21.0		7.7	21.0								21.0	7.7	16.6

TIER TWO FACILITIES

	2/9	3/15	3/28	4/11	4/30	Max	Min	Avg
Baldwin	2.7	0.7		2.2	1.8	2.7	0.7	1.8
Demorest		0.7		2.0	3.8	3.8	0.7	2.2
Flowery Branch		0.5		0.7	1.0	1.0	0.5	0.7
Cleveland			3.4	6.6	20.9	20.9	3.4	10.3
Dahlonega			7.5	16.5	21.1	21.1	7.5	15.0

URBAN RUNOFF

	5/28	8/12		Max	Min	Avg
Flat Creek	3.35	3.75		3.75	3.35	3.55
Limestone Creek	0.19	0.61		0.61	0.19	0.40
SixMile Creek	8.24	6.76		8.24	6.76	7.50

APPENDIX 5-A. SUMMARY OF SAMPLING RESULTS

NITRITE
(mg NO2--N/L)

TIER ONE FACILITIES

		8/16	8/30	9/13	9/25	10/6	10/27	11/16	12/11	12/18	1/2	1/19	2/9	3/15	3/28	Max	Min	Avg
Clarkesville				2.21		2.74	0.17	0.22	0.25	0.04	0.07	0.06	0.03	0.03	0.04	2.74	0.03	0.53
Scovill				2.14		0.17		0.42	0.79	0.66	0.90	0.22	0.26	0.74	0.60	2.14	0.17	0.69
Cornelia				3.86	2.22	2.09	0.50	2.50	1.76	1.51	0.32	0.12	0.06	0.03	0.42	3.86	0.03	1.28
Linwood	Tech			0.92	0.32	0.15	0.27	0.16	0.13	0.10	0.14	0.13	0.24	0.30	0.20	0.92	0.10	0.26
	Gainesville							0.60								0.60	0.60	0.60
Flat Creek	Tech			0.17	0.01	0.03	0.08	0.02	0.02	0.02	0.02	0.03	0.03	0.05	0.02	0.17	0.01	0.04
	Gainesville				<0.05													

TIER TWO FACILITIES

	2/9	3/15	3/28	4/11	4/30	Max	Min	Avg
Baldwin	0.02	0.03		0.003	0.01	0.03	0.00	0.02
Demorest		0.06		0.01	0.02	0.06	0.01	0.03
Flowery Branch		0.01		0.02	0.01	0.02	0.01	0.01
Cleveland			0.12	0.10	0.09	0.12	0.09	0.10
Dahlonega			1.00	0.14	0.51	1.00	0.14	0.55

URBAN RUNOFF

	4/30	5/28	8/12	Max	Min	Average
Flat Creek	0.008	0.016	0.010	0.016	0.008	0.011
Limestone Creek	0.005	0.008	0.007	0.008	0.005	0.007
SixMile Creek		0.189	0.017	0.189	0.017	0.103

APPENDIX 5-A. SUMMARY OF SAMPLING RESULTS

TOTAL PHOSOPHORUS
(mg P /L)

TIER ONE FACILITIES

		9/25	10/6	10/27	11/16	12/11	12/18	1/2	1/19	2/9	3/15	3/28	Max	Min	Avg
Clarkesville				3.60	2.75	2.96	2.30	1.42	1.06	2.35	2.78	2.40	3.60	1.06	2.40
Scovill					3.13	2.01	1.23	0.92	3.09	3.45	4.31	8.90	8.90	0.92	3.38
Cornelia				1.45	0.67	2.57	1.51	0.58	1.37	1.98	0.04	0.65	2.57	0.04	1.20
Linwood	Tech			3.67	3.33	3.61	2.74	2.32	3.88	3.98	5.82	4.04	5.82	2.32	3.71
	Gainesville	4.52	3.38	3.89		3.52	3.83	4.69	2.20	3.88	5.90	4.01	5.90	2.20	3.98
Flat Creek	Tech			0.22	0.10	0.55	0.01	0.10	0.16	0.29	0.19	0.27	0.55	0.01	0.21
	Gainesville	0.65	0.76	0.34		0.47	0.25	0.19	0.24	0.28	1.05	0.28	1.05	0.19	0.45

TIER TWO FACILITIES

	2/9	3/15	3/28	4/11	4/30	Max	Min	Avg
Baldwin	3.92	8.53		6.87	6.51	8.53	3.92	6.46
Demorest		0.05		1.58	0.88	1.58	0.05	0.84
Flowery Branch		2.84		0.29	1.97	2.84	0.29	1.70
Cleveland			2.62	1.54	2.37	2.62	1.54	2.18
Dahlonega			2.14	2.50	2.10	2.50	2.10	2.25

URBAN RUNOFF

	4/30	5/28	8/12	Max	Min	Avg
Flat Creek	0.06	0.31	0.62	0.62	0.06	0.33
Limestone Creek	0.06	0.04	0.41	0.41	0.04	0.17
SixMile Creek		0.92	1.15	1.15	0.92	1.04

APPENDIX 5-A. SUMMARY OF SAMPLING RESULTS

TOTAL SUSPENDED SOLIDS
(mg/L)

TIER ONE FACILITIES

		9/13	9/25	10/6	10/27	11/16	12/11	12/18	1/2	1/19	2/9	3/15	3/28	Max	Min	Avg
Clarkesville		34		19	67	50	35	86	34	40	28	31	36	86	19	40
Scovill		1		1		2	9	1	1	2	3	1	6	9	1	3
Cornelia		6	12	185	4	9	12	11	13	8	8	7	5	185	4	22
Linwood	Tech	25	21	26	7	9	18	12	19	39	27	22	30	39	7	20
	Gainesville	26	23	36	15	14	23	11	42	45	22	29	53	53	11	28
Flat Creek	Tech	1	1	8	2	3	2	2	3	5	4	5	5	8	1	3
	Gainesville	3	1	3	8	4	3	2	3	6	5	6	4	8	1	4

TIER TWO FACILITIES

	2/9	3/15	3/28	4/11	4/30	Max	Min	Avg
Baldwin	22	107		68	80	107	22	69
Demorest		4		5	4	5	4	4
Flowery Branch		33		17	12	33	12	21
Cleveland			30	18	5	30	5	17
Dahlonega			7	4	4	7	4	5

URBAN RUNOFF

	4/30	5/28	8/12	Max	Min	Avg
Flat Creek	19	19	137	137	19	58
Limestone Creek	19	8	101	101	8	43
SixMile Creek		24	444	444	24	234

APPENDIX 5-A. SUMMARY OF SAMPLING RESULTS

TURBIDITY
(NTU)

TIER ONE FACILITIES

		9/13	9/25	10/6	10/27	11/16	12/11	12/18	1/2	1/19	2/9	3/15	3/28	Max	Min	Avg
Clarkesville	xxx	35		30	45	35	35	65	35	75	40	25	50	75	20	40
Scovill		2.2		6.5		15	19	10	6.0	6.5	13	7.0	13	19	2	9
Cornelia		3.8	6.5	3.5	4.8	10	6.4	4.5	5.5	7.7	4.2	4.5	3.7	12	4	6
Linwood	Tech	21	21	34	8.5	16	13	9.0	15	52	31	26	31	52	9	23
	Gainesville	17.5	15.8	26.4	5.48	12.7	14.0	6.81	27.2	42.2	8.2	26.7	38	42	5	21
Flat Creek	Tech	1.4	0.8	2.0	3.8	6.0	2.3	2.0	1.8	7.0	2.4	5.7	3.3	7	1	3
Gainesville	Gainesville	0.81	0.50	1.58	2.20	2.88	1.10	1.06	1.48	1.55	2.66	3.97	2.4	4	1	2

TIER ONE FACILITIES

	2/9	3/15	3/28	4/11	4/30	Max	Min	Avg
Baldwin	23	100		120	75	120	23	80
Demorest		4.5		5.5	5	5.5	4.5	5.0
Flowery Branch		33		12	11	33	11	19
Cleveland			18	18	18	18	18	18
Dahlonega			9.0	6.0	3	9.0	2.9	6.0

URBAN RUNOFF

	4/30	5/28	8/12	Max	Min	Avg
Flat Creek	58	60	> 200	60	58	59
Limestone Creek	57	33	198	198	33	96
SixMile Creek		69	> 200	69	69	69

APPENDIX 5-B

DETERMINATION OF TRACE METALS IN WASTEWATER BY ICP-MS

APPENDIX 5-B

Determination of Trace Metals in Wastewater by ICP-MS

ICP-MS Principles of operation

An aqueous sample is pneumatically nebulized and introduced into a high purity argon radio frequency inductively coupled plasma at 10,000 °C and atmospheric pressure. In the plasma, energy transfer processes result in the desolvation, atomisation and ionization of a large fraction of the constituent elements. Most of the ions formed are monocharged. A fraction of the ions are extracted from the plasma to the mass spectrometer (ambient temperature and ~3.4x10-2 Pa absolute) via a differentially pumped vacuum interface consisting of a sampling and a skimmer cone. The sampling cone extracts ions from the hottest part of the plasma where the greatest degree of ionisation occurs. The skimmer cone further reduces the number of ions going to the spectrometer.

The stream of ions from the skimmer cone is focused by a series of four ion lenses and then passes into the quadrupole mass spectrometer which selects the ions which will reach the detector, a channel electron multiplier (CEM) on the basis of charge-to-mass ratio.The spectrum of mass-to-charge ratios is achieved by linearly varying the RF and DC voltage amplitudes on the quadrupole rods. The mass of the ions which reach the detector is a linear function of the applied voltage.

The intensity of the ion current reaching the detector at a given charge to mass ratio is processed by a data handling system which also controls the sampling time, resolution and mass-to-charge ratios for data acquisition (Perkin-Elmer, 1995),(Long et al., 1990)

Interferences

Isobaric Interferences

Isobaric interferences result from the formation of atomic or molecular ions of other elements at the same nominal mass to charge ratio as the analyte of interest. Element corrections may be used to correct for these interferences. This involves measuring the intensity of the interfering species at other mass to charge ratios (resulting from different isotopes) and using relative isotope abundances to determine the contribution of the interference to the analyte signal (Long et al, 1990).

For example, the interference of the $^{40}Ar^{35}Cl^{+}$ molecule ion on ^{75}As has been well documented. In order to calculate the contribution of $^{40}Ar^{35}Cl^{+}$ to the signal at mass 75, the signal for $^{40}Ar^{37}Cl^{+}$ at mass 77 is measured. The ratio of the relative abundances of the isotopes ^{35}Cl and ^{37}Cl is 3.12. Therefore, the contribution of $^{40}Ar^{35}Cl^{+}$ to the counts at mass 75 should be 3.12 the contribution of $^{40}Ar^{37}Cl^{+}$ to the counts at mass 77 assuming the same degree of molecule-ion formation for both isotopes. However, ^{77}Se may also contribute the counts at mass 77. The contribution of Se to the counts at 77 may be determined from the counts for ^{82}Se and the ratio of relative abundances of ^{77}Se to ^{82}Se (0.825). The overall element equation for As is therefore:

$$\mathbf{^{75}As = {}^{75}Counts - 3.12 \times {}^{77}Counts + 2.57 \times {}^{82}Se}$$

(course notes: Perkin-Elmer customer training, October 1995)

Less common but more difficult to deal with than isobaric interferences is interferences due to high ion currents at adjacent masses to the mass of interest. The spectrometer provides a nominal resolution of 10 % of the peak height

Physical interferences

Changes in surface tension or viscosity may affect nebulization and aerosol transport. Solids deposition on the nebulizer tip and sampling cones will reduce instrument performance and response. The presence of high concentrations of readily ionizable atoms in the sample matrix may also affect the ionisation efficiency of the analyte of interest. Internal standardization compensates for sampling interferences. The use of an appropriate internal standard also helps compensate for matrix effects on ionisation efficiency in the plasma. Sample dilution also generally reduces interferences due to matrix effects.

Memory effects

Memory interferences may occur when there are large concentration differences between samples or standards which are analyzed sequentially. This can be avoided by using a sufficiently long rinse time between samples.

Chemicals and equipment

1,000 ppm standard solutions were purchased from Perkin-Elmer. 10 ppm multielement standard solutions were prepared in 1 % nitric acid and stored in teflon bottles. Calibration standards were prepared daily by diluting the multielement stocks in 1 % nitric acid.

Standards, samples and the rinse blank were prepared using DI or E-pure water and trace metal grade acid.

Glassware used in the digestion was soaked overnight in a soap bath and then for 4 hours in a 1:2:9 HNO_3:HCl:H_2O bath and thoroughly rinsed with DI water. Glassware used for the preparation of the final batch of samples were cleaned further by heating on a hot plate with a mixture of 1:1:5 HNO_3:HCl:H_2O to extract residual metals from previous digestions.

Samples and standards were prepared and analyzed in disposable centrifuge tubes.

The calibrations of all pipettors used were regularly checked.

Analyses were carried out using a Perkin-Elmer Sciex Elan 5000 Inductively Coupled Plasma - Mass Spectrometer and Perkin-Elmer AS 90 Autosampler connected by a peristaltic pump. Data acquisition and processing was controlled by a 386 PC using the Xenix System V based Perkin-Elmer Sciex Elan 5000 ICP-Mass Spectrometer Version 2.2 software (1992)

Sample collection and storage:

Samples were collected in acid-washed bottles, acidified to pH < 2 and stored at 4 °C.

Sample preparation

The digestion method used was based on EPA Method 200.8 version 4.3 (Long et al, 1990). This method uses both nitric and hydrochloric acid in the digestion for total recoverable metals. The author notes, however, that chloride interferes were several elements, especially arsenic and should be eliminated where possible. Chloride is specifically required to stabilize silver and antimony, however, neither of these elements were included in the analysis. Hydrochloric acid was used for the preparation of samples for semiquantitative scans and for the seven element analysis of the effluent samples. However, it was replaced by additional nitric acid in the arsenic and selenium analysis and in the samples sent to the University of Georgia laboratory.

Digestion method:

1. 50 mL of well mixed sample was transferred to a 150 mL Griffin beaker.
2. 0,5 mL concentrated HNO_3 and 0,25 mL concentrated HCl were added to the sample. (0.75 mL HNO_3)

3. The beaker was covered with a ribbed watch glass.

4. The beaker was heated on a hot plate in a metal free fume hood and the liquid evaporated to a low volume (> 10 mL) without boiling or allowing the temperature to exceed 85 °C and without allowing any part of the bottom of the beaker to go dry.

5. The digestate was quantitatively transferred to a 50 mL centrifuge tube and diluted to volume with DI or E-pure water.

6. The sample was allowed to stand overnight or centrifuged to settle out solids.

7. For the determination of As and Se 10 mL of supernatant was pipetted into a second centrifuge tube For the determination of the other six metals, 2 mL of supernatant was diluted to 10 mL with 1 % nitric acid. Samples were spiked with 100 ppb internal standard prior to analysis.

Analysis

The instrument was initially tuned to optimize the response in each method. A warm-up period of at least 30 minutes after ignition of the plasma was allowed before commencing with the analysis.

The parameter sets for each analysis are summarized in Tables 1 (a) - (c). The instrument was rinsed with 2 % nitric acid solution in between each sample.

Bismuth (^{209}Bi) was used as the internal standard for lead while all other metals were calibrated using Yttrium. (^{89}Y)

The measured analyte concentrations in each sample were required to be less than the highest calibration standard (50 ppb for As and Se and 500 ppb for the other metals), or else the sample was diluted and reanalyzed. Blank subtraction was used in the analysis for Cr etc., but not for As and Se. All calibration curves were calculated by linear regression through zero.

Table 1 (a): Parameter Set for Determination of Arsenic and Selenium

Sweeps / reading		1		
Readings / replicate		1		
Number of replicates		10		
Points across peak		3		
Resolution		normal		
Scanning mode		peak hop		
Baseline time (ms)		0		
Transfer frequency		measurement		
Polarity		+		
Element	**Mass**	**Internal Standard**	**Replicate time (ms)**	**Dwell time (ms)**
As	75	Y	300	300
Se	82	Y	1500	1500
	77	Y	300	300
Y	89		300	300
Element equations:				
As	75 = As 75 - 3.13 x mass 77 + 2.53 x mass 82			
Manual settings				
Plasma gas flow	15 L/min	RF Power	1000 Watts	
Nebulizer gas flow	0.93 L/min	CEM Voltage	3.35 kV	
Auxiliary gas flow	0.85 L/min	Sample uptake	0.9 mL/min	

Table 1 (b): Parameter Set for Determination of Chromium, Nickel, Copper, Zinc, Cadmium, Barium and Lead

Sweeps / reading		10		
Readings / replicate		1		
Number of replicates		5		
Points across peak		3		
Resolution		normal		
Scanning mode		peak hop		
Baseline time (ms)		0		
Transfer frequency		replicate		
Polarity		+		
Element	**Mass**	**Internal Standard**	**Replicate time (ms)**	**Dwell time (ms)**
Cr	52	Y		
Ni	60	Y		
Cu	63	Y		
Zn	66	Y		
Y	89			
	106	Y		
	108	Y		
Cd	111	Y		
Ba	138	Y		
	206	Bi		
	207	Bi		
Pb	208	Bi		
Bi	209			

Table 1(b) cont.

Element equations:				
Cd	111 = Cd 111 - 1.073 x mass 108 - 0.712 x mass 106			
Pb	208 = Pb 208 + mass 206 + mass 207			
Manual settings				
Plasma gas flow	15 L/min		RF Power	1000 Watts
Nebulizer gas flow	0.921 L/min		CEM Voltage	3.35 kV
Auxiliary gas flow	0.87 L/min		Sample uptake	1 mL/min

Table 3(c): Parameter Set for Crop and Soil Sciences Laboratory

QA/QC

1 Method detection limit (MDL) and reported detection limits (RDL)

The MDL's were established by taking 9 replicate aliquots of DI or water fortified at a concentration of 10 ppb for As, 20 ppb for Se and 10 aliquots of E-pure water fortified at 2 ppb for the other metals through the entire analytical method including digestion but excluding 5 fold dilution for the second group of metals. The MDL for each analyte was then calculated as the standard deviation of the measurements of the replicates multiplied by the one sided t statistic for a 99 % confidence interval:

MDL = (t)x(S)

where t= 2.9 and 2.82 for 9 and 10 samples respectively and S = standard deviation of the replicate analyses.

Since the RDL's established at Georgia Tech were fairly conservative and reflected the difficulties encountered with contamination in the digestion step, they have also been used in the reporting of the storm water samples.

2. Assessing Laboratory Performance

Each batch of samples digested included a reagent blank, a fortified reagent blank, matrix spikes and matrix duplicates or matrix spike duplicates. In the determination of As and Se, one matrix spike and one duplicate or spike duplicate was analyzed for each facility analyzed. For the second group spikes and duplicates were analyzed at a frequency of greater than 5 % of the samples.

Fortified reagent blanks and matrix spikes were spiked with 20 ppb in the determination of As and Se and 100 ppb in the determination of the other metals.

Analyte concentrations in the reagent blank were required to be less than the MDL's. Recoveries of 90 to 110 % and 80 to 120 % were required for the fortified reagent blanks and matrix spikes respectively.

3. Interference Checks

The following measures were adopted from SW-846 Method 6020 to check for interferences:

a) Interference check standard

A set of interference check standards were purchased from Perkin-Elmer. The ICS-AB solution was diluted 10 times and analyzed to assess the potential error due to interfering ions, especially Cl, on As and Se, and the effectiveness of element correction equation. 10X dilution yielded final concentrations of 10 ppb for As and Se and 360 ppm Cl. Recoveries of As and Se were within 10 % of these values.

b) Post digestion spike

Selected samples were spiked with 50 ppb of As and Se or 100 ppb of the other metals just prior to analysis. 90 to 110 % recovery of the post digestion spike was required.

4. Calibration checks

The calibration was checked by running the calibration blank and one calibration standard as samples immediately after the initial calibration was established, and once every 10 samples thereafter. If the calibration check was not within 10 % of the initial value, it was reanalyzed and if it was again outside the limits, the instrument was recalibrated and the previous 10 samples reanalyzed.

The internal standard response was required to be within 60 to 125 % of the original response in the calibration blank.

5. Split Samples

Four effluent samples were sent to the University of Georgia laboratory for digestion and analysis in order to compare results from the two laboratories. Samples were prepared by microwave digestion using nitric and hydrofluoric acid followed by filtration to remove solids. They were then analyzed for all eight metals simultaneously using an Elan 6000 ICP-MS.

Contamination problems

The multielement analysis of the WWTP effluent was plagued by zinc contamiantion as evidenced concentrations of up to 6 mg/L background zinc measured in blanks. This led to a high calculated detection limit for zinc. Prior to the stormwater analysis, additional problems were noted with copper, chromium and lead. Multiple measurements of the same sample confirmed that this was due to contamination of the digestate rather than an unstable analyte signal. It is suspected that the contamination came from the beakers used in the digestion since no contamination in the DI water was observed. Various attempts were made to eliminate this problem including soaking beakers twice in successivly cleaner acid baths and heating them on the hot plate with a strong acid mixture to leach out contaminants. Unfortunately the quality control samples sent to the UGA laboratory indicated that there was still a problem with zinc contamination.

This background contamination results in a high degree of uncertainty in low measurements of Zn in the samples. However, since recoveries of Zn in the laboratory controls, matrix spikes and post digestion spikes were within the acceptable limits, it appears that high Zn measurements may be trusted. Since Zn is a common element which was present at relatively high concentrations in most of the samples analyzed, it is felt that this contamination problem does not have serious impact on the quality of the data for the purposes of this project.

Flow weighted averages and loading calculations

All measured concentrations were included in the calculation of the flow weighted averages and annual loadings, including those concentrations below the detecton limit. The rationale behind this was that excluding such values or replacing them with the detection limit would inflate the calculated average whilesetting them equal to zero would result in an under estimate. It was assumed that the instrument response was the best available estimate of the true value.

Results

All results are in µg/L

1. Detection limits

Table 2: Reported detection limits and estimated MDL's for EPA 200.8

Element	Reported detection limit		EPA 200.8 estimated detection limit	
	Dilution factor	RDL (µg/L)	Dilution factor	MDL (µg/L)
As	1	1.4	1.25	1.4
Se	1	1.4	1.25	7.9
Cr	5	2.4	1.25	0.4
Ni	5	2.5	1.25	0.5
Cu	5	2.2	1.25	0.5
Zn	5	22.7	1.25	1.8
Cd	5	1.0	1.25	0.5
Ba	5	1.0	1.25	0.8
Pb	5	1.5	1.25	0.3

Detection limits for ICP-MS were generally at least an order of magnitude smaller than the detection limits reported in the EPD files allowing the maximum contaminant loading of low concentration elements to be more accurately estimated.

2. Semiquantitative Results

Table 3 (a): Semiquantitative Scan Results for Tier One Facilities(µg/L).

Facility	Clarkesville		Cornelia		Flat Creek		Linwood	Scovill
Date	11-Dec	19-Jan	2-Jan	15-Mar	9-Feb	28-Mar	2-Jan	11-Dec
Sb	< 0.01	<0.01	< 0.01	<0.01	<0.01	< 0.01	<0.01	0.14
Ba	20.26	28.25	5.61	9.11	4.56	8.17	26.89	1.34
Be	0.02	0.02	0.02	0	0	0	<0.01	0.11
Cd	0.36	0.3	0.03	0.16	0.06	0.06	0.13	0.05
Cr	0.86	1.96	0.89	0.48	0.51	0.81	1.34	1.59
Co	0.3	0.47	1.56	1.76	0.71	0.87	0.5	0.23
Cu	21.19	23.59	3.3	3.09	3.43	5.26	20.88	219.7
Pb	3.5	5.35	0.57	1.31	1.23	1.99	8.87	1.44
Mn	24.86	39.11	137.8	162.3	73.4	137.5	60.9	1.89
Mo	3.96	1.61	2.29	1.14	13.19	24.82	0.9	41.94
Ni	2.31	2.54	8	4.06	8.93	6.06	2.49	441.2
Ag	0.05	0.01	< 0.01	<0.01	<0.01	< 0.01	0.04	<0.01
V	18.93	3.28	14.77	0.55	3.27	17.98	0.59	10.81
Zn	223.1	73.92	50.46	48.51	73.38	68.45	71.33	213

Table 3 (b): Semiquantitative Scan Results for Tier Two Facilities (μg/L).

Facility	Baldwin	Cleveland	Dahlonega	Demorest	Flowery Branch
Date	11-Apr	25-Apr	11-Apr	19-Jan	15-Mar
Sb	<0.01	<0.01	< 0.01	<0.01	<0.01
Ba	32.86	9.09	6.02	25.32	32.64
Be	0	0	0	0.02	0.03
Cd	0.11	0.14	0.19	0.39	0.23
Cr	2.21	1.25	0.85	2.18	24.31
Co	1.2	0.42	0.79	0.47	3.4
Cu	3.3	12.22	10.83	19.15	28.09
Pb	1.56	1.96	1.14	2.62	2.25
Mn	15.78	62.96	61.86	51.63	113.4
Mo	0.44	35	11.28	19.11	33.04
Ni	3.42	3.56	1.55	7.16	10.76
Ag	<0.01	<0.01	< 0.01	<0.01	<0.01
V	20	18.14	14.4	21.32	19.57
Zn	128.2	46.24	52.24	75.64	119.8

Table 3(c): Semiquantitative Scan Data for Stream Samples (μg/L).

Stream	Flat Creek	Limestone Creek	Six Mile Creek
Date	6-Jun	6-Jun	11-Apr
Sb	0	0	0
Ba	67.46	36.51	266.7
Be	0	0	0
Cd	2.36	1.93	0.77
Cr	21.94	23.11	26.53
Co	4.96	1.76	11.53
Cu	8.51	8.85	19.43
Pb	17.03	12.46	15.78
Mn	0.86	0.64	5.13
Mo	9.28	15.09	0
Ni	0.06	0.32	0.2
Ag	0	0	0
V	21.22	15.21	45.26
Zn	60.26	49.21	91.19

3. Quantitative Results

Table 4 (a): As in Tier One Facilities Effluent (μg/L).

Facility	Clarkesville	Cornelia	Flat Creek	Linwood	Scovill
16-Nov					4.7
11-Dec			< 1.4		4.2
18-Dec	< 1.4	< 1.4	< 1.4	< 1.4	1.9
2-Jan	< 1.4	< 1.4	< 1.4	< 1.4	1.5
19-Jan	< 1.4	< 1.4		< 1.4	2.4
9-Feb	< 1.4	< 1.4	< 1.4	< 1.4	2.1
15-Mar	< 1.4	< 1.4	< 1.4	< 1.4	2.9
28-Mar	< 1.4	< 1.4	< 1.4	< 1.4	4.1

Table 4 (b): As in Tier Two Facilities Effluent (μg/L).

Facility	Baldwin	Cleveland	Dahlonega	Demorest	Flowery Branch
19-Jan				< 1.4	
9-Feb	< 1.4	< 1.4			
15-Mar	< 1.4				< 1.4
28-Mar		< 1.4	< 1.4		
11-Apr	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4
25-Apr	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4

Table 5 (a): Se in Tier One Facilities Effluent (μg/L).

Facility	Clarkesville	Cornelia	Flat Creek	Linwood	Scovill
16-Nov					< 1.4
11-Dec			< 1.4		< 1.4
18-Dec	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4
2-Jan	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4
19-Jan	< 1.4	< 1.4		< 1.4	< 1.4
9-Feb	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4
15-Mar	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4
28-Mar	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4

Table 5(b): Se in Tier Two Facilities Effluent (μg/L).

Facility	Baldwin	Cleveland	Dahlonega	Demorest	Flowery Branch
19-Jan				< 1.4	
9-Feb	< 1.4	< 1.4			
15-Mar	< 1.4				< 1.4
28-Mar		< 1.4	< 1.4		
11-Apr	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4
25-Apr	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4

No As and Se was detected in any of the WWTP effluents except for As at Scovill. Samples from Scovill were reanalyzed to confirm the presence of As.

Table 6 (a): Cr, Ni, Cu, Zn, Cd, Ba and Pb in Tier One Municipal WWTP Effluent (μg/L).

Facility	Clarkesville		Cornelia		Flat Creek		Linwood	
Date	2-Jan	9-Feb	9-Feb	15-Mar	9-Feb	15-Mar	19-Jan	15-Mar
Cr	2.9	< 2.4	< 2.4	< 2.4.	< 2.4.	< 2.4.	3.9	< 2.4.
Ni	2.9	6.6	7.1	4.7	9.7	6.2	3.6	4.1
Cu	40	39	7.5	5.7	5.1	11	25	33
Zn	124	312	69	67	112	110	86	118
Cd	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ba	23	25	5.6	9.2	9	8.3	41	46
Pb	4.4	6.2	< 1.0.	1.5	2.2	2.4	13	14

Table 6 (b): Cr, Ni, Cu, Zn, Cd, Ba and Pb in Tier Two Municipal WWTP Effluent (μg/L).

Facility	Baldwin		Cleveland		Dahlonega		Demorest		Flowery Branch
Date	15-Mar	11-Apr	11-Apr	30-Apr	28-Mar	11-Apr	11-Apr	30-Apr	11-Apr
Cr	3.2	2.7	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	8.2
Ni	7.9	8.1	3.6	3.7	2.9	< 2.5	< 2.5	< 2.5	3.4
Cu	22	22	14	15	18	12	13	12	26
Zn	166	83	53	35	75	66	104	56	53
Cd	< 1.0	< 1.0	< 1.0	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ba	54	24	9	7.7	17	6.5	22	29	19
Pb	4.4	2.7	< 1.5	< 1.5	< 1.5	< 1.5	1.8	< 1.5	2.4

Table 6 (c): Cr, Ni, Cu, Zn, Cd, Ba and Pb in Scovill Industrial WWTP Effluent (µg/L).

Date	18-Dec	2-Jan	19-Jan	9-Feb	15-Mar	28-Mar
Cr	86	3.7	6	3.1	2.9	5.1
Ni	199	154	638	483	171	561
Cu	93	166	320	221	108	218
Zn	438	69	135	163	75	105
Cd	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ba	5.1	5.6	2.6	1.9	1.5	1.3
Pb	< 1.5	< 1.5	2.5	1.6	< 1.5	< 1.5

4. Stormwater results

Table 7: Stormwater results (µg/L).

Stream	South Flat Creek			Limestone Creek		Six Mile Creek	
Date	30-April	28-May	12-Jun	28-May	12-Jun	28-May	12-Jun
As	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	1.5	< 1.4
Se	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4
Cr	< 2.4	< 2.4	3.5	< 2.4	< 2.4	< 2.4	12
Ni	3.8	3.6	4.8	< 2.5	< 2.5	< 2.5	5.8
Cu	8.9	9.7	5.7	8.3	6.1	10	12
Zn	65	97	50	58	33	85	73
Cd	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ba	21	20	34	22	27	100	158
Pb	9.1	4.6	5.7	1.8	9.0	2.8	10

Metal levels in samples taken on different days from the same facility or stream were generally fairly close. Zinc showed the greatest fluctuation between days.

5. Split Sample Data

Table 8: Georgia Tech and UGA Results for Split Samples (µg/L).

Facility	Baldwin		Dahlonega		Linwood		Scovill	
Date	11-Apr		11-Apr		15-Mar		2-Jan	
Laboratory	Georgia Tech	UGA	Georgia Tech	UGA	Georgia Tech	UGA	Georgia Tech	UGA
As	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	1.5	1.8
Se	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	1.6	< 1.4	< 1.4
Cr	2.7	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	3.7	2.9
Ni	8.1	7.8	< 2.5	3.2	4.1	3.9	154	151
Cu	22	14	12	6.4	33	25	166	142
Zn	83	62	66	41	118	114	69	53
Cd	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ba	24	23	6.5	5.9	46	42	5.6	5.1
Pb	2.7	2.3	< 1.5	< 1.5	14	13	< 1.5	< 1.5

Results from Georgia Tech and the University of Georgia agreed very well except for Cu and Zn which were different by up to 25 µg/L. This may have been due to contamination or interference problems. However, the uncertainty in these data is probably not significant compared to other factors in the loading calculations.

APPENDIX 5-C

LOADING CALCULATIONS

BOD5
Ammonia
Nitrogen
Phosphorus
Total Organic Carbon

Appendix 5-C
BOD5 Loading Calculations

MUNICIPAL WWTP

	PERMIT			DMR AVERAGE					SAMPLING			
	Flow	Avg Monthly	Load	n	Data Set	Wgt. Avg.	Load	Std. Dev.	n	Wgt. Avg.	Load	Std. Dev.
	(MGD)	(mg/L)	(kg/yr)			(mg/L)	(kg/yr)	(kg/yr)		(mg/L)	(kg/yr)	(kg/yr)
Baldwin	0.30	30	12,435	35	91-93	19	5,913	3,113	3	63	21,566	2,892
Clarkesville	0.75	30	31,088	11	92	20	7,883	1,790	8	30	11,782	4,348
Cleveland	0.75	20	20,725	24	95,94	13	6,116	2,488	3	13	8,039	6,405
Cornelia	3.00	30	124,351	60	91-95	19	51,343	23,248	7	6	20,234	4,996
Dahlonega	0.72	30	29,844	48	92-95	6	4,516	2,525	3	5	3,511	1,593
Demorest	0.40	30	16,580	33	91-93	9	871	1,659	2	4	324	0
Flowery Branch	0.20	10	2,763	60	91-95	5	804	517	3	11	2,485	1,374
Gain-Flat Creek	7.00	20	193,434	60	91-95	6	40,163	22,659	7	3	23,513	10,412
Gain-Linwood	3.10	30	128,496	60	91-95	17	36,143	7,893	8	17	47,957	19,715
Gain-White Sulphur	0.1	*30 **	*4,145*			*11*	*1,520*				*(1,520)*	
Lake Lanier Islands	0.35	30	14,508	22	91-92	6	893	772			*(893)*	*(772)*
Lula	0.08	30	3,399	30	91-93	22	1,235	888			*(1,235)*	*(888)*
TOTAL:			581,768				157,400	67,553			143,059	53,396

Notes:
*: not a permit value, used to estimate a maximum loading
n: number of data points
Wgt. Avg.: weighted average (weighted according to flow)
Italicized numbers are assumed values

INDUSTRIAL WWTP

	PERMIT			DMR AVERAGE					SAMPLING			
	Flow	Avg Monthly	Load	n	Data Set	Wgt. Avg.	Load	Std. Dev.	n	Wgt. Avg.	Load	Std. Dev.
	(MGD)	(mg/L)	(kg/yr)			(mg/L)	(kg/yr)	(kg/yr)		(mg/L)	(kg/yr)	(kg/yr)
Buckhorn	*0.0017*	*5*	12	1	94	5	12				(12)	
Davidson Minerals	2.59	*5*	17,893	1		BDL						
Habersham Mills Inc	0.009	30	373	24	91-92	16	369	737			(369)	
High Point Minerals*	0.002	*5*	14				(14)				(14)	
JA Hudson Const*	*0.86*	*5*	5,973				*(5,973)*				(5,973)	
Scovill	*0.27*	*41*	15,296				(7,046)	(3,129)	6	41	7,046	3,129
SKF Bearing	0.02	*11*	*304*	1	1	11	274				(274)	
SUB-TOTAL			39,865				13,687	3,866			7,700	#REF!

Note:
* No information available. Because this site is a quarry, the assumptions are based on information from the other quarrys.

SEPTIC TANKS

Assuming:	Max.		Avg.		
BOD Concentration	2		2	mg/L	(Kaplan, 142)
Average flow from septic tanks:	64	(Kaplan)	55	gal/d/cap	(EPA value, from Kaplan)
No. structures w/in 300' of lake	5184		5184	structure	(USGS quad maps; w/in 300' o
No. persons per structure	3.5	(Reckhow :	2.5	cap/structure	(EPA Eutrophication Study)
BOD:	3,209		1,970	kg/yr	

Appendix 5-C
BOD5 Loading Calculations

PID

	PERMIT			DMR AVERAGE				
	Flow (MGD)	Conc. (mg/L)	Load (kg/yr)	n	Data Set	Wgt. Avg (mg/L)	Load (kg/yr)	Std. Dev. (kg/yr)
Camp Barney Medintz	0.040	30	1,658	8	91-'92	14	61	128
Camp Coleman	0.002	30	83	6	91-'92	37	17	37
Camp Coleman	0.002	30	83	6	91-'92	78	224	0
Camp Glisson	0.005	30	207	2	91-'92	20	8	26
Chattahoochee Bay	0.0004	*30*	*17*			*15*	*4*	
Chattahoochee Country	0.010	30	415	24	91-'92	13	21	32
Cinnamon Cove Condos	0.070	30	2,902	24	91-'92	3	120	95
Dixie MHP	0.005	30	220	8	91-'92	26	57	47
Flow Br. Elem	0.012	30	497	28	91-93	6	19	29
Forsyth School	0.039	30	1,596	30	91-94	8	25	32
Friendship Health Care	0.020	*30*	*829*	12	92	8	25	22
Gainesville-Chatt.	0.004	*30*	*166*			*15*	*41*	
Glover & Baker MHP	0.020	*30*	*808*			*15*	*200*	
Habersham HS	0.020	30	829	24	91-92	8	25	32
Habersham on Lanier	0.110	30	4,560	48	91-94	3	270	269
Holiday on LL	0.010	30	415	8	91-92	14	70	20
Lakeshore Campsites	0.005	30	207	8	91-92	3	5	9
Lakeside MH	0.003	30	116	7	91-92	16	65	72
LL Beach South	0.038	10	525	48	91-94	3	54	72
LL Elem	0.006	30	249	12	91-93	13	91	95
Mountain Lake Resort	0.009	*30*	*373*			*15*	*93*	
N. Hall HS	0.030	30	1,244	35	91-93	19	295	268
Oakgrove Elem	0.005	30	207	12	91-93	28	107	77
Oakgrove MHP	0.005	30	207	8	91-92	28	107	77
Oakwood Elem	0.013	30	518	12	91-93	12	54	35
R Ranch in the Mnts	0.100	*30*	*4,145*	12	91	4	*293*	
Sardis Elem	0.009	30	381	12	93	3	19	15
Shady Grove MHP	0.020	30	829	22	91-92	23	80	56
South Hall Indust. Pk	0.010	30	415	12	91-92	15	40	54
Unicoi State Pk	0.075	*30*	*3,109*			*15*	*771*	
Wauka Mtn Elem	0.014	30	564	36	91-93	6	47	66
Wauka Mnt Nursing	0.010	30	415	12	92	10	105	131
West Hall HS	0.030	50	2,073	36	91-93	10	*0*	
TOTAL PID			30,858				3,412	1,796

Note: Italicized numbers are assumptions, not actual permit or monitoring data.

URBAN RUNOFF

Creek	Area (hectare)	Assumec (mg/L)	Avg. Rainfall (in)	Avg. Loading (kg/yr)	Min. Rainfall (in)	Min. Loading (kg/yr)	Max Rainfall (in)	Max Loading (kg/yr)
Flat Creek	1626	12	55	272583	36.29	179,855	83	410,956
Limestone Creek	869	12	55	145679	36.29	96,122	83	219,631
Six Mile Creek	891	12	55	149367	36.29	98,555	83	225,191
TOTAL				567629		374,532		855,778

Appendix 5-C
Ammonia Loading Calculations

Municipal WWTP

	PERMIT			DMR AVERAGE					SAMPLING			
	Flow MGD	NH3 mg N/L	Load kg/yr	n	Data Set	NH3 mg N/l	Load kg/yr	Std. Dev. kg/yr	n	NH3 mg N/L	Load kg/yr	Std. Dev. k/yr
Baldwin	0.3	*17.4* *	*7,212*		91-93	*8.0*	*2,557*		3	12.12	4,035	671
Clarkesville	0.75	17.4	18,031	2	92	22.6	9,513	1,553	11	7.50	2,892	1,507
Cleveland	0.75	10.0	10,363	24	95,94	9.6	4,566	1,468	3	2.33	1,438	696
Cornelia	3	17.4	72,123	54	91-95	26.7	64,834	33,001	12	20.90	72,370	44,567
Dahlonega	0.72	17.4	17,310	31	92-95	0.6	334	677	3	0.61	462	252
Demorest	0.4	*17.4* *	*9,616*		91-93	*8.0*	*774*		3	3.52	277	401
Flowery Branch	0.2	2.0	553	59	91-95	0.6	102	96	3	5.48	1,289	693
Gain-Flat Creek **	7	*17.4* *	*168,288*	9	95	0.3	2,077	2,063	12	0.57	4,650	3,868
Gain-Linwood	3.1	17.4	74,528	26	91-95	10.9	24,659	10,563	12	7.41	20,104	9,705
Gain-White Sulphur	0.1	*17.4* *	*2,404*			*8.0*	*757*				(757)	
Lake Lanier Islands	0.35	*17.4* *	*8,414*		91-92	*8.0*	*1,088*				(1,088)	
Lula	0.082	*17.4* *	*1,971*		91-93	*8.0*	*379*				(379)	
TOTAL:			390,813				111,640	49,420			109,743	62,359

* No permit requirements found. For purposes of calculations, 17.4 mg/L was assumed.
**Flat Creek based on values from April to December 1995. The average loading for the data from 1991-1995 is 156,283 kg/y
Italicized values are assumed values based on the weighted averages of the known concentrations.

INDUSTRIAL WWTP

	MAX			DMR AVERAGE					SAMPLING			
	Flow (MGD)	Conc. (mg/L)	Load (kg/yr)		Data Set	Conc. (mg/L)	Load (kg/yr)	Std. Dev. (kg/yr)		Conc. (mg/L)	Load (kg/yr)	Std. Dev. (mg/L)
Buckhorn	*0*	*0.2*	*0*	1		0.2	0.5				(0)	
Davidson Mineral Prop	2.59	*0.2*	*716*	1		0.2	415				(415)	
Habersham Mills Inc	0.009	*5.1*	*63*	1		5.1	28				(28)	
High Point Minerals	0.002	*0.2* *	*1*				(1)				(1)	
JA Hudson Construction	*0.86*	*0.2* *	*239*				(239)				(239)	
Scovill	*0.27*	*0.1*	*34*	1		0.1	13		12	0.76	132	101
SKF Bearing	0.02	*0.7*	*18*	1	93	0.7	16				(16)	
TOTAL			1,071				712				831	101

* No NH3 information available for these facilities. Assumptions based on values for other quarrys.

Appendix 5-C
Ammonia Loading Calculations

PID

	PERMIT			AVERAGE				
	Flow MGD	NH3 mg N/L	Loading kg/yr	n	Data Set	Nh3 mg N/L	Loading kg/yr	St. Dev. kg/yr
Camp Barney Medintz	0.040	*17.4*	*962*			*8.0*	*219*	
Camp Coleman	0.020	*17.4*	*481*			*8.0*	*110*	
Camp Glisson	0.001	*17.4*	*12*			*8.0*	*3*	
Chattahoochee Bay	#####	*17.4*	*10*			*8.0*	*2*	
Chattahoochee Country	0.010	*17.4*	*240*			*8.0*	*55*	
Cinnamon Cove Condos	0.070	*17.4*	*1,683*			*8.0*	*384*	
Dixie MHP	0.005	*17.4*	*127*			*8.0*	*29*	
Flow Br. Elem	0.012	*17.4*	*288*			*8.0*	*66*	
Forsyth School	0.039	*17.4*	*926*			*8.0*	*211*	
Friendship Health Care	0.020	*17.4*	*481*			*8.0*	*110*	
Gainesville-Chatt.	0.004	*17.4*	*96*			*8.0*	*22*	
Glover & Baker MHP	0.020	*17.4*	*469*			*8.0*	*107*	
Habersham HS	0.020	*17.4*	*481*			*8.0*	*110*	
Habersham on Lanier	0.110	*17.4*	*2,645*			*8.0*	*603*	
Holiday on LL	0.010	*17.4*	*240*			*8.0*	*55*	
Lakeshore Campsites	0.005	*17.4*	*120*			*8.0*	*27*	
Lakeside MH	0.003	*17.4*	*67*			*8.0*	*15*	
LL Beach South	0.038	2.0	105	48	91-94	0.8	14	34
LL Elem	0.006	*17.4*	*144*			*8.0*	*33*	
Mountain Lake Resort	0.009	*17.4*	*216*			*8.0*	*49*	
N. Hall HS	0.030	*17.4*	*721*			*8.0*	*164*	
Oakgrove	*0.025*	*17.4*	*601*			*8.0*	*137*	
Oakgrove MHP	0.025	*17.4*	*601*			*8.0*	*133*	
Oakwood Elem	0.013	*17.4*	*301*			*8.0*	*69*	
R Ranch in the Mnts	0.100	*17.4*	*2,404*			*8.0*	*548*	
Sardis Elem	0.009	*17.4*	*221*			*8.0*	*50*	
Shady Grove MHP	0.020	*17.4*	*481*			*8.0*	*110*	
South Hall Indust. Pk	0.010	*17.4*	*240*			*8.0*	*55*	
Unicoi State Pk	0.075	*17.4*	*1,803*			*8.0*	*411*	
Waoka Mtn Elem	0.014	*17.4*	*327*			*8.0*	*75*	
Wauka Mnt Nursing	0.010	*17.4*	*240*			*8.0*	*55*	
West Hall HS	0.030	*17.4*	*721*			*8.0*	*164*	
TOTAL			18,456				4,194	34

Italicized values are assumptions

URBAN RUNOFF

Creek	Area (hectar	Flow Wgt Avg. (mg/L)	Avg. Rainfall (in)	Avg. Loading (kg/yr)	Min. Rainfa (in)	Min. Loading (kg/yr)	Max Rainfall (in)	Max Loading (kg/yr)
Flat Creek	1626	0.64	55	14,536	36.3	9,591	82.92	21,916
Limestone Creek	869	0.624	55	7,576	36.3	4,999	82.92	11,423
Six Mile Creek	891	1.82	55	22,656	36.3	14,949	82.92	34,157
TOTAL				44,769		29,539		67,495

Appendix 5-C
Total Nitrogen Loading

	SAMPLING				
	Flow		N*	Loading	St. Dev.
	MGD	n	mg/L	kg/yr	kg/yr
Baldwin	0.3	3	13.7	3,417	2,374
Clarkesville	0.75	10	18.2	6,967	5,386
Cleveland	0.75	3	12.0	7,423	6,251
Cornelia	3	10	37.2	130,405	71,108
Dahlonega	0.72	3	16.9	12,893	8,286
Demorest	0.4	3	5.8	453	304
Flowery Branch	0.2	3	6.2	1,470	784
Gain-Flat Creek	7	10	25.3	208,753	130,807
Gain-Linwood	3.1	10	21.8	60,585	25,762
Gain-White Sulphur	0.1		*30.0*	*4,145*	
Lake Lanier Islands	0.35		*30.0*	*14,508*	
Lula	0.082		*30.0*	*3,399*	
TOTAL				410,316	251,061

* N = ammonia, nitrate and nitrite

INDUSTRIAL WWTP

	MAX			AVERAGE				
	Flow	N	Loading		Data	N	Loading	St. Dev.
	MGD	mg/L	kg/yr	n	Set	mg/L	kg/yr	kg/yr
Buckhorn	*0.002*	*0.30*	*1*	1		0.30	1	
Davidson Minerals*	2.59	*1.00*	*3,579*			*1.00*	1,340	
Habersham Mills	0.009	*0.00*	*0*	1		0.00	0	
High Pt Min.*	0.002	*1.00*	*3*				(3)	
JA Hudson Const*	*0.86*	*1.00*	*1,195*				(1,195)	
Scovill	*0.27*	*1.97*	*735*	1		1.97	294	
SKF Bearing **	0.02	*0.65*	*18*			*0.65*	16	
TOTAL			5,529				2,848	

* Nitrogen information not available for these facilities. Assumptions based off of data from other quarrys.

** Total nitrogen data not available, used ammonia value

Appendix 5-C
Total Nitrogen Loading

PID

	MAX *							
	Flow	NH3	Loading		Data	Nh3	Loading	St. Dev.
	MGD	mg N/L	kg/yr	n	Set	mg N/L	kg/yr	kg/yr
Camp Barney Medintz	0.040	20	*1,105*			17	*466*	
Camp Coleman	0.020	20	*553*			17	*233*	
Camp Glisson	0.001	20	*14*			17	*6*	
Chattahoochee Bay	0.0004	20	*11*			17	*5*	
Chattahoochee Country	0.010	20	*276*			17	*117*	
Cinnamon Cove Condo:	0.070	20	*1,934*			17	*816*	
Dixie MHP	0.005	20	*146*			17	*62*	
Flow Br. Elem	0.012	20	*332*			17	*140*	
Forsyth School	0.039	20	*1,064*			17	*449*	
Friendship Health Care	0.020	20	*553*			17	*233*	
Gainesville-Chatt.	0.004	20	*111*			17	*47*	
Glover & Baker MHP	0.020	20	*539*			17	*227*	
Habersham HS	0.020	20	*553*			17	*233*	
Habersham on Lanier	0.110	20	*3,040*			17	*1,282*	
Holiday on LL	0.010	20	*276*			17	*117*	
Lakeshore Campsites	0.005	20	*138*			17	*58*	
Lakeside MH	0.003	20	*77*			17	*33*	
LL Beach South	0.038	20	1,050			17	*179*	
LL Elem	0.006	20	*166*			17	*70*	
Mountain Lake Resort	0.009	20	*249*			17	*105*	
N. Hall HS	0.030	20	*829*			17	*350*	
Oakgrove	*0.025*	20	*691*			17	*291*	
Oakgrove MHP	0.025	20	*691*			17	*0*	
Oakwood Elem	0.013	20	*345*			17	*146*	
R Ranch in the Mnts	0.100	20	*2,763*			17	*1,165*	
Sardis Elem	0.009	20	*254*			17	*107*	
Shady Grove MHP	0.020	20	*553*			17	*233*	
South Hall Indust. Pk	0.010	20	*276*			17	*117*	
Unicoi State Pk	0.075	20	*2,073*			17	*874*	
Waoka Mtn Elem	0.014	20	*376*			17	*158*	
Wauka Mnt Nursing	0.010	20	*276*			17	*117*	
West Hall HS	0.030	20	*829*			17	*350*	
TOTAL			22,143				8,780	

Max and Avg concentrations based on reasonable values for total nitrogen.

Appendix 5-C
Total Nitrogen Loading

SEPTIC TANKS

# Structures within 300' of Lake Lanier	5184	(USGS quad maps, w/in 300' of lake)
Assumed persons per structure	2.5	(EPA Eutroph. Study)

Reckhow & Simpson

	Max	Min	Avg	
Denitrification (SR- soil retention)	0%	40%	20%	
En: N export coeff.	2.2	2.2	2.2	(used by Hook fo
Ct: Capita	12960	12960	12960	
N = En * Ct * (1-SR)	28,512	17,107	22810	

Kaplan

Cn: Concentration of N	62 mg N/L/cap			(Ranges 48-96; 62 from Bauman)
Q: Discharge from tank	55 gal/d			(EPA value, from Kaplan)
				(Ingham found 64 gal/d)
Denitrification	0%	40%	20%	(fine texture - 20-40% N
Ct: Capita	12960	12960	12960	
N = Ct * Cn * Q * (1- Denitrif)	61,055	36,633	48844	

EPA - Eutrophication Study

Denitrification	0%	40%	20%	(EPA assumes 0%
Capita	12,960	12,960	12960	
Cn; N that reaches lake	4.263 kgN/cap/yr	4.263	4.263	(EPA assumption)
N = Ct * Cn * (1-Den)	55,248	33149	44199	

Min:	33,149
Max:	61,055
Probable:	44,199

URBAN RUNOFF

Creek	Area (hectare)	Wgt. Avg. (mg/L)	Avg. Rainfall (in)	Avg. Loading (kg/yr)	Min. Rainfall (in)	Min. Loading (kg/yr)	Max Rainfall (in)	Max Loading (kg/yr)
Flat Creek	1626	4.243	55	96,370	36.29	63,586	82.92	145,290
Limestone Creek	869	1.079	55	13,099	36.29	8,643	82.92	19,749
Six Mile Creek	891	9.154	55	113,945	36.29	75,183	82.92	171,788
TOTAL				223,414		147,413		336,827

Appendix 5-C
Phosphorus Loadings

MUNICIPAL

	MAX/PERMIT			DMR AVERAGE						SAMPLING			
	Flow	P	Load		Data	Flow	P	Load	St. Dev.		P	Load	St. Dev.
	MGD	mg/L	kg/yr	n	Set	MGD	mg/L	kg/yr	kg/yr	n	mg/L	kg/yr	kg/yr
Baldwin	0.3	*6.72*	*2,786*			0.23	*6.72*	*2,136*		4	6.72	1,999	907
Clarkesville	0.75	*2.44*	*2,527*			0.28	*2.44*	*956*		9	2.44	929	369
Cleveland	0.75	*2.33*	*2,417*			0.34	*2.33*	*1,108*		3	2.33	1,443	915
Cornelia	3	*2.18*	*9,029*	32	91-95	1.92	2.18	10,832	6,231	9	1.20	4,417	2,897
Dahlonega	0.72	2.22	*2,204*			0.56	*2.22*	*1,699*		3	2.22	1,693	341
Demorest	0.4	*0.86*	*476*			0.07	*0.86*	*83*		3	0.86	68	62
Flowery Branch	0.2	1	276	60	91-95	0.13	0.58	101	58	3	1.78	418	314
Gain-Flat Creek	7	1	9,672	59	91-95	5.12	0.58	4,096	1,182	9	0.21	1,720	1,052
Gain-Linwood	3.1	*3.72*	*15,930*	22	91-95	1.54	4.00	10,123	1,671	9	3.72	10,404	3,131
Gain-White Sulphur	0.1	*2*	*276*			*0.1*	*2*	*276*				*(276)*	
Lake Lanier Islands	0.35	*2*	*967*			0.10	*2*	*271*				*(271)*	
Lula	0.08	*2*	*227*			0.03	*2*	*94*				*(94)*	
TOTAL:			46,787					31,775	9,142			23,731	9,987

Italicized values are assumptions

INDUSTRIAL WWTP

	MAX			DMR AVERAGE						SAMPLING			
	Flow	P	Load		Data	Flow	P	Load	St. Dev.		P	Load	St. Dev.
	MGD	mg/L	kg/yr	n	Set	MGD	mg/L	kg/yr	kg/yr	n	mg/L	kg/yr	kg/yr
Buckhorn	*0.002*	*0.10*	0	1		0.00	0.10	0.23				(0)	
Davidson Mineral Prop	2.59	*0.1*	358			1	*0.10*	138				(138)	
Habersham Mills Inc	0.01	*1.13*	14	1		0.01	1.13	12				(12)	
High Pt. Minerals	0	*0.1*	0.28					(0)				(0)	
JA Hudson Constructic	0.86	*0.1*	119					(119)				(119)	
Scovill	*0.27*	1.702	635	5		0.12	6.57	1,089			3.38	560	5
SKF Bearing	0.02	?				0.02	?						
TOTAL			1,127					1,360				831	5

Appendix 5-C
Phosphorus Loadings

PID

	MAX/PERMIT			AVERAGE					
	Flow	P	Loading		Data	Flow	P	Loading	St. Dev.
	MGD	mg/L	kg/yr	n	Set	MGD	mg/L	kg/yr	kg/yr
Camp Barney Medintz	0.040	2	111			0.020	2	55	
Camp Coleman	0.020	2	55			0.010	2	27	
Camp Glisson	0.001	2	1			0.000	2	1	
Chattahoochee Bay	####	2	1			0.000	2	1	
Chattahoochee Countr	0.010	2	28			0.005	2	14	
Cinnamon Cove Condo	0.070	2	193			0.035	2	96	
Dixie MHP	0.005	2	15			0.003	2	7	
Flow Br. Elem	0.012	2	33			0.006	2	16	
Forsyth School	0.039	2	106			0.019	2	53	
Friendship Health Care	0.020	2	55			0.010	2	27	
Gainesville-Chatt.	0.004	2	11			0.002	2	5	
Glover & Baker MHP	0.020	2	54			0.010	2	27	
Habersham HS	0.020	2	55			0.010	2	27	
Habersham on Lanier	0.110	2	304			0.055	2	151	
Holiday on LL	0.010	2	28			0.005	2	14	
Lakeshore Campsites	0.005	2	14			0.002	2	7	
Lakeside MH	0.003	2	8			0.001	2	4	
LL Beach South	0.04	1	53	48	91-94	0.01	0.88	15	27
LL Elem	0.006	2	17			0.003	2	8	
Mountain Lake Resort	0.009	2	25			0.004	2	12	
N. Hall HS	0.030	2	83			0.015	2	41	
Oakgrove	0.025	2	69			0.012	2	34	
Oakgrove MHP	0.025	2	69			0.012	2	33	
Oakwood Elem	0.013	2	35			0.006	2	17	
R Ranch in the Mnts	0.100	2	276			0.050	2	137	
Sardis Elem	0.009	2	25			0.005	2	13	
Shady Grove MHP	0.020	2	55			0.010	2	27	
South Hall Indust. Pk	0.010	2	28			0.005	2	14	
Unicoi State Pk	0.075	2	207			0.037	2	103	
Waoka Mtn Elem	0.014	2	38			0.007	2	19	
Wauka Mnt Nursing	0.010	2	28			0.005	2	14	
West Hall HS	0.030	2	83			0.015	2	41	
TOTAL			2,162					1,061	27

Appendix 5-C
Phosphorus Loadings

SEPTIC TANKS

# Structures within 300' of Lake Lanier	5184	(USGS quad maps)
# Persons per structure	2.5	(EPA Eutroph. Study)
Ct:	12960	

Kaplan (not his exact method)

Cp (mg/L)	10	12	14	(sewage effluent, 10-14 mg
Q (gal/d)	55	55	64	(EPA value, from Kaplan)
				(Ingham found 64 gal/d)
P: Tanks*Cp*Q	3,939	4,727	6,418	kg/yr

Reckhow & Simpson

P = Es * Ct * (1-SR)	Low	Avg.	High	
Es = export coefficient, kg/cap/yr	0.3	0.6	1	(ranges up to 1.8)
SR = soil retention coeff	0.95	0.75	0.5	
P:	194	1944	6,480	kg/yr

EPA Eutrophication Study

Cp	0.1134	kg/cap/yr	(amount that reaches lake from w/in 300')
P: Cp * Ct	1,470	kg/yr	

Summary:

Min	194
Max	#####
Avera;	#####
Probat	#####

URBAN RUNOFF

Creek	Area (hectai	Flow V Avg. (mg/L)	Avg. Rainfall (in)	Avg. Load (kg/yr)	Min. Rainfal (in)	Min. Load (kg/yr)	Max Rainfall (in)	Max Load (kg/yr)
Flat Creek	1626	0.412	55	9352	36.29	6171	82.92	14099
Limestone Creek	869	0.23	55	2793	36.29	1843	82.92	4212
Six Mile Creek	891	1.072	55	13349	36.29	8808	82.92	20125
TOTAL				25494		16822		38436

Appendix 5-C
TOC Loading

	MAX *			AVERAGE *					SAMPLING			
	Flow MGD	TOC mg/L	Load kg/yr	n	Data Set	TOC mg/L	Load kg/yr	Std. Dev. kg/yr	n	TOC mg/L	Load kg/yr	Std. Dev. kg/yr
Baldwin	0.3	21	8,882			13	4,232		4	14	4,082	1,482
Clarkesville	0.75	21	22,205			14	5,631		12	10	3,777	1,377
Cleveland	0.75	14	14,804			9	4,369		3	7	4,209	2,117
Cornelia	3	21	88,822			14	36,674		12	5	15,600	6,621
Dahlonega	0.72	21	21,317			4	3,226		3	3	2,516	456
Demorest	0.4	21	11,843			7	638		3	5	393	157
Flowery Branch	0.2	7	1,974			3	574		3	6	1,316	421
Gain-Flat Creek	7	14	138,167			4	28,688		13	5	37,859	14,659
Gain-Linwood	3.1	21	91,782			12	25,816		13	10	26,701	5,887
Gain-White Sulphur	0.1	21	2,902			8	1,086				(1,086)	
Lake Lanier Islands	0.35	21	10,363			4	585				(585)	
Lula	0.082	21	2,428			16	735				(735)	
TOTAL			415,488				112,252				98,860	33,179

* "Average" and "Max" values based on a ratio of BOD5/TOC of 1.4, where the BOD5 values are from the permit an

INDUSTRIAL WWTP

	MAX			DMR AVERAGE					SAMPLING			
	FLOW (MGD)	TOC (mg/L)	Load (kg/yr)	n	Data Set	TOC (mg/L)	Load (kg/yr)	Std. Dev. (kg/yr)	n	TOC mg/L	Load (kg/yr)	Std. Dev. (mg/L)
Buckhorn	0	5	12	1		5	12				(12)	
Davidson Mineral Prop	2.59	3	10,736	1		3	5				(5)	
Habersham Mills Inc	0.01	10	124	1		10	0				0	
High Pt. Minerals	0	4	11				(11)				(11)	
JA Hudson Construction	0.86	4	4,778				(4,778)				(4,778)	
Scovill	0.27	25	9,150			25	3,660		12	25	4,279	1,667
SKF Bearing	0.02	7	180	1		7	162				(162)	
TOTAL			24,991				8,627				9,246	1,667

Appendix 5-C
TOC Loading

PID

	MAX *			AVERAGE *				
	FLOW (MGD)	CONC. (mg/L)	Load (kg/yr)	n	Data Set	Wgt. Avg (mg/L)	Load (kg/yr)	Std. Dev. (kg/yr)
Camp Barney Medintz	0.040	*21*	*1,184*	8	91-'92	*10*	*277*	
Camp Coleman	0.020	*21*	*592*	6	91-'92	*26*	*363*	
Camp Glisson	0.001	*21*	*15*	2	91-'92	*56*	*19*	
Chattahoochee Bay	#####	*21*	*12*			*14*	*4*	
Chattahoochee Country	0.010	*21*	*296*	24	91-'92	*11*	*73*	
Cinnamon Cove Condos	0.070	*21*	*2,073*	24	91-'92	*9*	*436*	
Dixie MHP	0.005	*21*	*157*	8	91-'92	*2*	*7*	
Flow Br. Elem	0.012	*21*	*355*	28	91-93	*19*	*52*	
Forsyth School	0.039	*21*	*1,140*	30	91-94	*4*	*56*	
Friendship Health Care	0.020	*21*	*592*	12	92	*6*	*83*	
Gainesville-Chatt.	0.004	*21*	*118*			*6*	*16*	
Glover & Baker MHP	0.020	*21*	*577*			*11*	*143*	
Habersham HS	0.020	*21*	*592*	24	91-92	*11*	*147*	
Habersham on Lanier	0.110	*21*	*3,257*	48	91-94	*6*	*624*	
Holiday on LL	0.010	*21*	*296*	8	91-92	*2*	*15*	
Lakeshore Campsites	0.005	*21*	*148*	8	91-92	*10*	*34*	
Lakeside MH	0.003	*21*	*83*	7	91-92	*2*	*4*	
LL Beach South	0.038	*21*	*1,125*	48	91-94	*12*	*122*	
LL Elem	0.006	*7*	*59*	12	91-93	*2*	*15*	
Mountain Lake Resort	0.009	*21*	*266*			*9*	*57*	
N. Hall HS	0.030	*21*	*888*	35	91-93	*11*	*118*	
Oakgrove	*0.025*	*21*	*740*	12	91-93	*14*	*29*	
Oakgrove MHP	0.005	*21*	*148*	8	91-92	*20*	*48*	
Oakwood Elem	0.013	*21*	*370*	12	91-93	*20*	*92*	
R Ranch in the Mnts	0.100	*21*	*2,961*	12	91	*20*	*1,371*	
Sardis Elem	0.009	*21*	*272*	12	93	*8*	*0*	
Shady Grove MHP	0.020	*21*	*592*	22	91-92	*3*	*42*	
South Hall Indust. Pk	0.010	*21*	*296*	12	91-92	*2*	*14*	
Unicoi State Pk	0.075	*21*	*2,221*			*16*	*839*	
Waoka Mtn Elem	0.014	*21*	*403*	36	91-93	*11*	*86*	
Wauka Mnt Nursing	0.010	*21*	*296*	12	92	*11*	*73*	
West Hall HS	0.030	*21*	*888*	36	91-93	*4*	*86*	
TOTAL PID			23,014				5,347	

* "Average" and "Max" values based on a ratio of BOD5/TOC of 1.4, where the BOD5 values are from the permit an

APPENDIX 5-D

QUALITY ASSURANCE / QUALITY CONTROL

APPENDIX 5-D. QUALITY ASSURANCE / QUALITY CONTROL

TABLE OF CONTENTS

PROJECT DESCRIPTION

The purpose of the overall project is to determine the loadings of certain pollutants to Lake Lanier. In order to better assess the contribution of wastewater treatment facilities a sampling program was determined to sample and analyze the effluent from certain wastewater treatment facilities in the watershed. The monitoring data that is submitted by the facilities to the EPD only consists of parameters for which there are permit requirements (e.g. BOD5, NH3, TSS). This project is interested in other parameters that are not required by permit to be tested (e.g. P, metals). Thus, in order to obtain a reasonable estimate of these parameters is necessary to test the effluent from selected facilities. The parameters that are routinely tested by the facilities are also tested as a part of this project. This is to determine the current status of the plant's effluent since historical and current data is not available for every facility. The parameters of interest are: BOD5, conductivity, coliforms, mercury, total organic carbon, nitrogen, phosphorus, TSS, turbidity, arsenic, selenium and other metals. The purpose of this sampling and analysis is to determine a reasonable range of loading concentrations of various pollutants from each facility. The intent is neither to determine if a facility is meeting its regulatory requirements nor to act as an agent of the EPD to checkup on a facility. Because the ultimate loading result is of order of magnitude certainty, it is not deemed necessary to conduct a comprehensive sampling plan that would run through all seasons, different days of the week and different times of day.

The purpose of the urban runoff sampling and analysis is to determine a general idea of the types of pollutants and their loadings into the lake from urban sources. Fewer sampling events and analyses will be conducted for this part of the project. The parameters of interest are: nitrogen, mercury, conductivity, phosphorus, TSS, turbidity and certain pesticides (carbaryl, chlorpyrifos, diazinon, and malathion). The pesticides are measured by Dr. Parshal Bush's lab from the University of Georgia's Agricultural Services Laboratory.

STAFF ORGANIZATION & RESPONSIBILITIES

Barbara Brouckaert, Adam Dowd, and Timmerly York are Georgia Tech students working on this project. Ms. York and Ms. Brouckaert are responsible for collecting, preserving and delivering the samples. The analyzes are performed by the following people:

Table 1. Staff Responsibilities

Analyst	Analysis	Date of Analysis (1)
Barbara Brouckaert	$CBOD_5$	Day 1
	Total Phosphorus	Day 1-2
	Total Inorganic Phosphorus	Day 1-2
	Metal Analysis - ICPMS	
Adam Dowd	Fecal Coliform	Day 1-2
	Total Coliform	Day 1-2
Timmerly York	Total Suspended Solids	Day 1
	NO_2^-	Day 1
	NO_3^-	Day 1
	Turbidity	Day 1
	Conductivity	Day 1
	Total Organic Carbon	By Day 7
	NH_3	By Day 7
	Mercury	

Note: (1) Days counted from the sampling day, where Day 1 is the day of sampling, Day 2 the day after sampling etc...

Ms. Brouckaert, Mr. Dowd and Ms. York are responsible for cleaning all glassware and appliances. All analyzes except pesticides are conducted in Daniel Laboratory at the Georgia Institute of Technology.

SAMPLE CONTROL & DOCUMENTATION PROCEDURES

Ms. Brouckaert and Ms. York travel to each facility to collect samples. After checking in with the supervisor, they proceed to collect the samples. The fecal and total coliform samples are collected first at the post-chlorination effluent sampling area. The other samples are obtained at a pre-chlorination sampling port. The bottles are first rinsed with the sample. The grab samples are then collected by submersing the bottles in the flow until the bottles are full. Ms. Brouckaert and Ms. York collect the samples and preserve them. Each sample bottle has a label stating the facility name, sample ID, date of sampling and preservative used. A bottle blank is also used for each sampling event. It is filled with distilled water while in the field. The samples are kept in coolers filled with ice until receipt at the laboratory. Once back at the lab, the samples are kept at 4°C in a temperature controlled room until time for analysis. The following table shows the containers and preservatives used for each sample:

Table 2. Sample Bottles

Sample ID	Type of Container	Preservative	Constituents to be Analyzed	Sample Location
A	1 L Glass	None	$CBOD_5$	Pre-chlorination Effluent
B	1 L Glass	None	Turbidity NO_2^- NO_3^- TSS Conductivity	Pre-chlorination Effluent
C	500 mL Glass	HNO_3 to pH<2	Hg	Pre-chlorination Effluent
D	250 mL Glass	None	Total Phosphorus Total Org. P	Pre-chlorination Effluent
E	125 mL Glass	HCl to pH<2	TOC	Pre-chlorination Effluent
F	125 mL Glass	H_2SO_4 to 1.5<pH<2	NH_3	Pre-chlorination Effluent
G	500 mL Glass	HNO_3 to pH<2	ICPMS	Pre-chlorination Effluent
Baggies	100 mL Bags (3 bags per site)	Chlorine Inhibitor Tablets	Fecal Coliform Total Coliform	Post-chlorination Effluent

All bottles are acid washed in a 10% nitric acid bath and rinsed repeatedly with tap and dionized water. The glass bottles are also baked at 300°C. The containers for the coliforms are sterilized in an autoclave. New bottles were used each time for the metals analysis to avoid possible contamination from the laboratory environment.

STANDARD OPERATING PROCEDURE FOR EACH METHOD

Table 3. Procedures

Parameter	Method #	Method Title	Detection Limit
CBOD5	SM 5210B	5-Day BOD Test	2 mg/L
Total Coliform	Hach 8074	Total Coliform Procedure	
Fecal Coliform	Hach 8074	Fecal Coliform Procedure	
Conductivity	EPA 120.1	Conductance	
Mercury	PE 245.1A	Determination of mercury in drinkingwater and wastewater by flow injection atomic absorption spectrometry	0.2 ug/L
Ammonia	Hach Model 50250	Direct Calibration Method	0.01 mg N/L
Nitrate	Hach Model 44430	Nitrate-Nitrogen in Water and Wastewater	0.1 mg N/L
Nitrite	SM 4500-NO2-B	Colorimetric Method	10 ug N/L
Pesticide: Carbaryl	EPA 507		2 ug/L
Other Pesticides	EPA 507	Organophosph. Scan	Chlor. 0.8 ug/L Diaz. 1.0 ug/L Malath. 1.4 ug/L
Total Phosphorus	SM 4500P E	Ascorbic Acid Method	10 ug/L
Total Inorg. P	SM 4500P E	Ascorbic Acid Method	10 ug/L
Total Organic Carbon	SM 5310 C	Persulfate-Ultraviolate Oxidation Method	0.05 mg/L
Total Suspended Solids	SM 2450 D	Total Suspended Solids Dried at 103-105 C	
Turbidity	SM 2130 B	Nephelometric Method	

Coliforms: The Hach method follows Standard Methods 9222B and 9222D for total and fecal coliforms. The broths used are Hach's m-Endo broth and m-FC Broth with Rosalic acid for total and fecal coliforms respectively. Sterilization prior to starting the analysis is by autoclaving. Sterilization during the analysis is conducted by igniting alcohol on the apparatus.

Conductivity: Conductivity was measured using a YSI Model 32 Conductance Meter and probe. A conductivity calibration standard was used to calibrate the meter.

Mercury: The Perkin Elmer method is an EPA approved version of the EPA method 245.1. The Perkin Elmer Mercury Analyzer is used for this analysis. A mercury standard was used and trace-metal grade reagents were used when available.

Ammonia: The Hach method using the model 50250 combination ammonia electrode and an Accumet pH/mV/Ion meter follows the Standard Method 4500-NH3F (ammonia-selective electrode method). The main differences are that the Hach method calls for 25 mL samples and use of ionic strength adjuster pillows. Hach ammonia standards are used for calibration.

Nitrate: This Hach method is equivalent to Standard Method 4500-NO3-D (Nitrate Electrode Method) except 25 mL of sample and liquid ionic strength adjuster are used. A Hach combination nitrate electrode model 44430 and Accumet pH/mV/Ion meter are used. Hach nitrate standards are used for calibration.

Nitrite: The Standard Method 4500-NO2-B is followed using a Hewlett Packard 8452A Diode Array Spectrophotometer. For samples with significant turbidity, the samples are first filtered through glass-fiber filters before being filtered through the membrane filters.

Total Phosphorus: Standard Method 4500-P B Persulfate Digestion Method is used to prepare the samples. Digestion occurs in an autoclave. A Hewlett Packard 8452A Diode Array Spectrophotometer is used.

Inorganic Phosphorus: Standard Method 4500-P B Preliminary Acid Hydrolysis is used to prepare samples and digest in an autoclave. The Hewlett Packard 8452A Diode Array Spectrophotometer is used.

Total Organic Carbon: A Dohrman DC-180 Carbon Analyzer with an automatic sampler is used, so sample injection is not required. The equipment does a one-point calibration.

Total Suspended Solids: The Standard Method is followed.

Turbidity: A Hach Ratio Turbidimer turbidimer is used.

INTERNAL QUALITY CONTROL

To ensure quality control in analysis, several checks are performed for most analyses. The quality control measures used for each procedure are as follows:

Table 4. Quality Control Measures By Procedure

Test	# Calib. Stds	Calib. Verification	Reagent Blank	Field Bottle Blank	Facility Duplicate	MS	MSD	LCS	LCSD	Equip. Dup
CBOD5	1		X	X	X					
Conductivity	1	X			X					X
T. Coliform			X		X					
F. Coliform			X		X					
Mercury	6	X	X	X	X	X	X	X	X	X
Metals		X	X	X	X	X	X	X	X	X
N: Ammonia	3	X			X	X	X			X
N: Nitrate	3	X			X	X	X			X
N: Nitrite	6	X	X		X	X	X	X	X	X
T Phosphorus	5	X	X	X	X	X		X		X
I. Phosphorus	5	X	X	X	X	X		X		X
TOC	1	X	X	X	X	X		X		X
TSS			X		X					
Turbidity	3	X			X					X

Calibration
Calibration of standards will be performed when appropriate. The standards will be dilutions from a stock standard. Calibration will be performed prior to each analysis. After calibration, a mid-point standard will be run to verify the calibration.

Blanks
Next a reagent blank and field bottle blank are analyzed. The reagent blank is the water used for the analysis (D.I., distilled etc..) carried through the procedure as if it were a sample. The field bottle blank is a sample from a bottle that was filled with water at one of the facilities.

Facility Samples
The samples from the facilities are then analyzed. For one facility, two samples are prepared and analyzed. This duplicate serves as a confirmation of the results.

Spikes
For one facility, a known addition is made. This is the sample plus a known amount of standard (MS). The amount of standard added will be about five times the expected concentration. A duplicate of the spike is also performed (MSD). A spike of the dilution water is also made in duplicate (LCS and LCSD) with the same amount of standard added as in the MS and MSD.

Equipment Duplicate
Where applicable, an equipment duplicate will be made. This means that the same sample will be analyzed twice to see if the same reading is obtained from the equipment.

Notes About Each Procedure

CBOD5: The "calibration" is actually the glucose-glutamic acid check.

Ammonia & Nitrate: Triplicates are made for each sample. After the initial reading, a spike is added.

Georgia Institute of Technology
Environmental Engineering
School of Civil and Environmental Engineering

August 29, 1997

Dr. Kathryn Hatcher
Institute of Ecology
Ecology Building, Room 135
The University of Georgia
Athens, Georgia 30602-2202

Final Report - Lake Lanier Clean Lakes Project
Project No. E-20-M09

Dear Kathy:

Please find enclosed our chapter of the Lake Lanier project's final report. Due to further review of our draft report and your e-mail dated June 13, several changes have been made since the draft report. An overview of the main changes are presented by task number:

1.1 (b) Tables have been reorganized by county.
1.1 (c) This information is in Appendix 5-A.
1.2 (a) This information is presented in text throughout section 5.2 of this report.
1.2 (b) Concentration ranges have been added to Table 5-14.
1.3 (a) Latitude and longitudes have been added.
1.3 (b) The insecticide data is presented in text and in Table 5-20.
1.3 (c) Computer disk with monitoring data is enclosed with this report.
1.3 (d) After further evaluation of the method used to compute the loadings from the stormwater runoff, a slightly different (and more accurate) method was used. The method is now explained

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in further detail in text (section 5.5). This report reflects the changes in the urban runoff loadings. These values are reasonable and show good correspondence to previous calculations from 1991.

1.4 With the time and resources that were available, this task (section 5.6 in the report) has been expanded to better address your concerns. In addition, rough estimates have been made for obtaining better removals of nitrogen and phosphorus at the wastewater facilities.

It has been a pleasure working with you on this project.

Sincerely,

A. Amirtharajah
Professor

Enclosures

cc: Reports Coordinator

CHAPTER 5. IMPACT OF DISCRETE POLLUTANT SOURCES INTO LAKE LANIER

M. Timmerly Richman, Barbara Brouckaert, Appiah Amirtharajah

School of Civil and Environmental Engineering
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Final Report Submitted to the University of Georgia, Athens, GA

August 1997

CHAPTER 5. IMPACT OF DISCRETE POLLUTANT SOURCES INTO LAKE LANIER

List of Figures

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CHAPTER 5. IMPACT OF DISCRETE POLLUTANT SOURCES INTO LAKE LANIER

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School of Civil and Environmental Engineering
Georgia Institute of Technology, Atlanta, GA 30332

Outline of Chapter 5:

5.1 INTRODUCTION

Because of the importance of Lake Lanier to the surrounding ecosystem, to the population of North Georgia, and to the inhabitants downstream of the dam, it is imperative that the lake's watershed be managed to ensure that the lake is healthy and viable. In order to properly manage a watershed it is necessary to identify the potential pollutant sources in the watershed and to determine the extent of pollution from these sources. A previous Lake Lanier Clean Lakes Study (Hatcher et al., 1994) assessed the current water quality of the lake and investigated nonpoint source pollutant loadings into the lake. The purposes of the research presented here are to identify and investigate the discrete pollutant sources in the watershed and to calculate pollutant loadings from some of these sources and from urban stormwater runoff. There is currently no up-to-date information on these pollutant sources and loadings into Lake Lanier.

In this report, the potential discrete pollutant sources in the Lake Sidney Lanier watershed are identified and investigated. The results of a sampling program, conducted to determine typical concentrations of pollutants from ten wastewater treatment facilities and for urban stormwater runoff into three streams, are presented. Average yearly pollutant loadings into the lake calculated on the basis of the results from the sampling program and the facilities' discharge monitoring data are also presented. The report concludes with analyses of alternatives and recommendations for decreasing the contribution of pollutants from these sources.

5.2 POLLUTANT SOURCES AND CONTAMINANTS FROM THESE SOURCES

Lake Lanier's watershed consists of a large part of Forsyth, Habersham, Hall, Lumpkin and White counties and small sections of Dawson, Union and Gwinnett counties. There are many different potential sources of pollution in the watershed. The sources investigated as a part of this project are: municipal wastewater treatment plants, industrial wastewater treatment plants, marinas, landfills, septic tanks, hazardous waste sites, underground storage tanks, cemeteries, and urban areas.

Municipal Wastewater Treatment Plants

Wastewater treatment facilities are the most common point sources of pollution into lakes. Most treatment facilities discharge treated effluent into streams or larger bodies of water. This discharge is regulated under the National Pollutant Discharge Elimination System (NPDES) which is enforced through the Georgia Environmental Protection Division (EPD). NPDES files were reviewed at the EPD's Water Protection (municipal wastewater) Office. The file review resulted in identification of municipal wastewater treatment facilities and private industrial developments (PIDs) in the Lake Lanier watershed. Because of their low flow, PIDs are considered to have a lesser environmental impact than wastewater treatment facilities. There are thirteen municipal facilities and thirty-three PIDs in the watershed. Tables 5-1 and 5-2 provide a brief description of these facilities and show the body of water into which the effluent flows. More information about these facilities can be found in Appendix 5-A. The locations of the thirteen wastewater treatment facilities in the watershed are shown in Figure 5-1. As can be seen from the tables, the PIDs may not cause significant contributions of pollutants because of their low flows. Most of the flows are one-tenth to one-hundredth times smaller than the flows from the municipal wastewater treatment facilities.

Table 5-1. Municipal Wastewater Treatment Facilities

Facility Name	NPDES Permit #	Type of Operation	Permitted Flow (MGD)	Receiving Water
HABERSHAM COUNTY				
Baldwin WPCP	GA0033243	activated sludge	0.3	Little Mud Creek
Clarkesville WPCP	GA0032514	trickling filter	0.75	Soque River
Cornelia WPCP	GA0021504	trickling filter	3	S. Fork Little Mud
Demorest WPCP	GA0032506	activated sludge	0.4	Hazel Creek
HALL COUNTY				
Flowery Branch WPCP	GA0031933	activated sludge	0.2	Lake Lanier
Gainesville #1 Flat Creek	GA0021156	activated sludge	7	S. Flat Creek
Gainesville #2 Linwood	GA0020168	trickling filter	3	Lake Lanier
Gainesville #3 White Sulphur	GA0030716	activated sludge	0.1	Chattahoochee R.
Lake Lanier Islands	GA0049115	oxidation pond	0.35	Lake Lanier
Lula WPCP	GA0024767	oxidation pond	0.03	Lula Creek
WHITE COUNTY				
Cleveland	GA0036820	aqua culture / UV disinf.	0.75	Tesnatee Creek
Helen	GA003259	aerated lagoon, land appl.	0.5	Chattahoochee R.
LUMPKIN COUNTY				
Dahlonega	GA0026077	activated sludge	0.72	Yahoola Creek

Table 5-2. List of Private Industrial Developments (PIDs)

Site Name	NPDES Permit #	Type of Operation	Permitted Flow (MGD)	Receiving Water
FORSYTH COUNTY				
Habersham-On-Lanier	GA0030261	activated sludge	0.11	Lake Lanier
Lanier Beach South WWTP	GA0031674	activated sludge	0.038	Lake Lanier
HABERSHAM COUNTY				
Habersham Center H.S.	GA0033952	activated sludge	0.02	Licklog Creek
HALL COUNTY				
Chattahoochee Bay	GA0024189	STSF	0.0004	Lake Lanier
Chattahoochee Country Club WPCP	GA0022471	STSF	0.01	Lake Lanier
Cinnamon Cove Condos WPCP	GA0049051	activated sludge/filter	0.07	Lake Lanier
Dixie MHP	GA0023043	oxidation pond	0.0053	Trib to Flat Creek
Flowery Branch Elementary	GA0027090	STSF/Cl	0.012	Mud Creek South
Gainesville - Chatt.	GA0034916	STSF	0.004	Lake Lanier
Glover & Baker MHP #1,#2	GA0027049	oxidation ponds	0.0195	Trib to Little River
Holiday on Lake Lanier	GA0022080	STSF	0.01	Lake Lanier
Lakeshore Campsites - Flowery Bch	GA0024198	STSF	0.005	Lake Lanier
Lakeside MH Community	GA0049891	oxidation pond	0.0028	Wahoo Creek
Lanier Elementary School	GA0034843	STSF/Cl	0.00605	Wahoo Creek
North Hall HS	GA0034886	activated sludge	0.03	Trib to Wahoo
Oakwood Elementary	GA0048089	STSF/Cl	0.012	Trib to Balus Creek
Sardis Elementary	GA0034860	STSF	0.01	Trib to Lake Lanier
Shady Grove MHP	GA0023469	oxidation pond	0.02	Trib to Balus Creek
South Hall Industrial Park	GA0034924	activated sludge	0.01	Balus Creek
Wauka Mountain Elementary	GA0032697		0.0136	East Fork Little River
Wauka Mountain Nursing Home	GA0034568	activated sludge	0.01	Little River
West Hall High School	GA03-615	oxidation ponds	0.03	
LUMPKIN COUNTY				
Camp Glisson	GA0033979	STSF	0.0005	Cane Creek
Oak Grove MHP	GA0034207	oxidation pond	0.00235	Trib to Cane Creek
R Ranch in the Mountains	GA03-972	act. sludge/land appl.	0.1	Jarrard Creek
WHITE COUNTY				
Camp Barney Medintz	GA0034983	act. sludge/polish pond	0.04	Jenny Creek
Camp Coleman	GA0035467	STSF	0.02	Trib to Town Creek
Friendship Health Care Center	GA0026379	oxid. pond/sand filter	0.02	Stephens Creek
Mountain Lake Resort	GA0046400	STSF	0.009	Lake Qualatchee-Cathy Crk
Unicoi State Park	GA02-066	aeration pond/land appl.	0.075	Smith Creek

Note: STSF - Septic tank sand filter Cl - chlorination

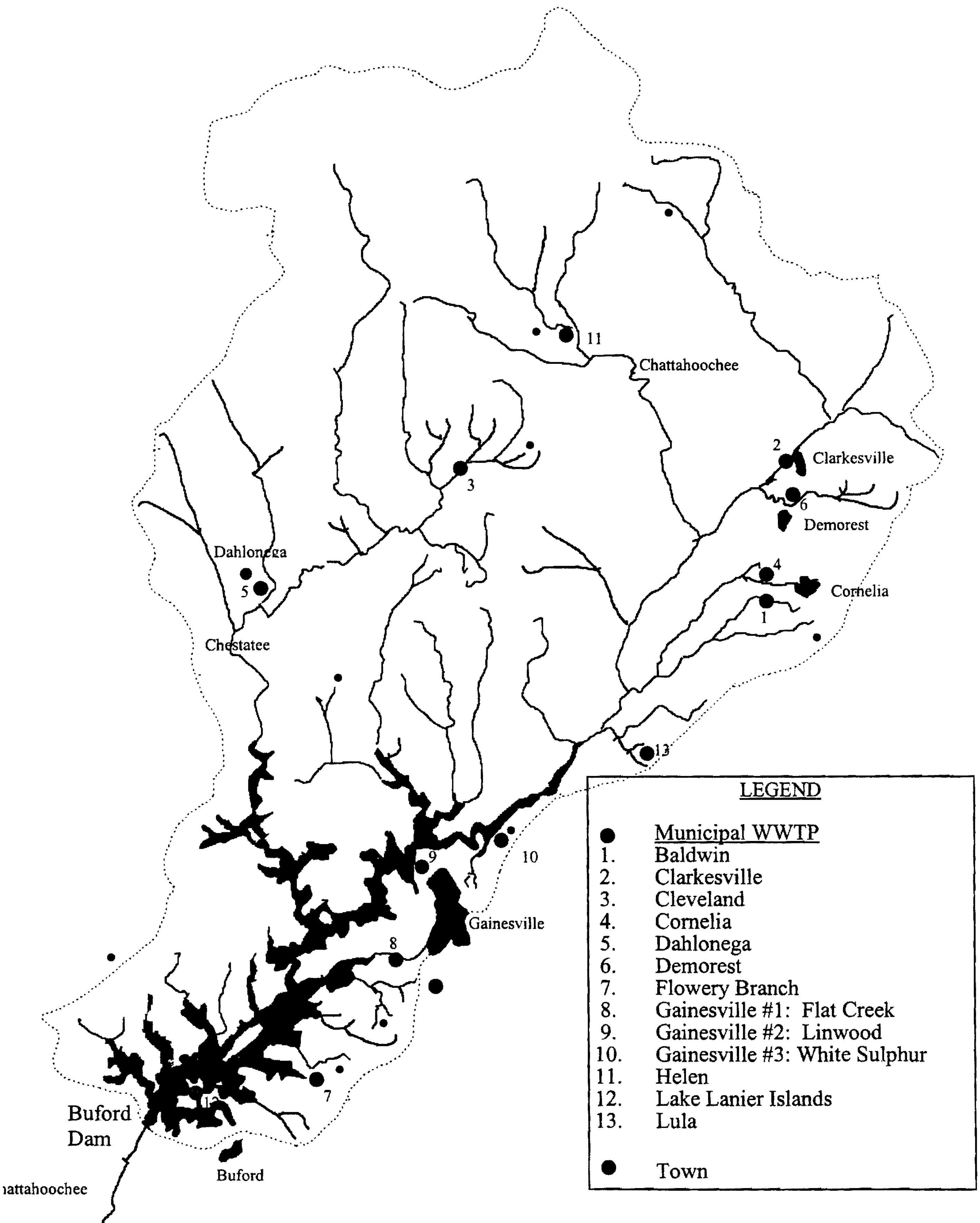

Figure 5-1. Location of Municipal Wastewater Treatment Facilities

Wastewater treatment plants are often the most significant form of point source pollution into lakes. As a part of the NPDES, these facilities are required to monitor certain parameters and report the results to the EPD in discharge monitoring reports (DMRs). Available DMRs from 1991 to 1996 were obtained from the EPD. This information was collated into a database and analyzed (Richman, 1997). Tables 5-16 to 5-17 include data collected from the DMRs and results from the sampling program. They are presented under the Results section of this report. However, to cross reference the information presented in these tables they are also discussed in this section. Table 5-16 compares the permitted concentration to the flow-weighted average of the DMR concentration and the result obtained by sampling during this study (the details of sampling are explained later in this report). The Helen wastewater facility is not included in the calculations in the remainder of the report because it is a land application facility, and, thus, does not directly discharge into a stream. The shaded numbers in Table 5-16 indicate that the permitted concentration has been exceeded. The most common water quality parameters to assess pollution from municipal wastewater treatment facilities are biochemical oxygen demand (BOD), fecal coliform, ammonia, phosphorus and suspended solids. As can be seen in Table 5-16, according to the available data, most of the facilities are meeting the permit requirements.

In an effort to compare the effluent from the facilities to in-stream water quality standards, dilution factors were used as per the Rules and Regulations for Water Quality Control (GA DNR EPD, 1995). The dilution factor is the sum of the 7Q10 flow for the stream into which the effluent is discharged and the effluent flow from the facility, divided by the effluent flow from the facility. The 7Q10 flow value indicates a low flow condition in a stream (7-day, 10-year minimum stream flow). Thus, using the 7Q10 value is a conservative measure to indicate what a probable concentration of a pollutant would be when the stream quality is more sensitive due to low flows. Using the 7Q10 flow gives an indication of acute concentrations rather than chronic effects.

When the facility's effluent concentration is divided by the dilution factor it can be compared to in-stream water quality standards. Because stream flow data is not available for each stream, the closest known flow downstream of the treatment plant outfall was used for analysis. For three facilities, Clarkesville, Cleveland, and Dahlonega, the flow data for the approximate stream location of the outfall was available and was used. For four others, Baldwin, Cornelia, Demorest, and Lula, stations closest to the treatment plant sites were used. An interpolation method based on drainage areas was used to approximate the 7Q10 values for the streams near these sites. The interpolation method is as follows:

$$\text{Estimated } 7Q10_F = \frac{D.A._F}{D.A._G} \times 7Q10_G$$

where D.A. = drainage area; F = facility; G = nearest gaging station.

For Gainesville-Flat Creek, where no USGS flow data was available, the average flow for South Flat Creek in 1991 as reported in the Diagnostic/Feasibility Study of Lake Lanier was used (Hatcher et al., 1994). Because a low-flow value was not used it is incorrect to compare the Gainesville-Flat Creek values to in-stream standards, but they do give an indication as to what might be the probable concentration. Flowery Branch, Gainesville-Linwood and Lake Lanier Islands discharge directly into the lake. Thus, it is unknown what the dilution and mixing effects are at their points of discharge. However, it is assumed that a large amount of dilution would occur, thus a factor of 30 was used. This number is reasonable based on the equation for calculating dilution factors into stratified lakes:

$$D.F. = 0.28 * X \; / \; D$$

where X = distance of mixing and D = diameter of pipe. The use of a dilution factor assumes steady-state complete mixing due to discharge-induced mixing and ambient-induced mixing. This analysis of dilution also does not account for a background concentration of pollutants in the stream. Thus, the diluted concentrations in the table represent only the contribution from the discharges. This is not an exact method for quantifying the concentration of pollutants in the stream, but it does provide values for order of magnitude comparison purposes. Table 5-17 shows the diluted concentrations for each facility and Table 5-3 shows typical concentration ranges for these pollutants. The headwaters to Buford Dam are classified as "recreational" by the Georgia Department Natural Resources (DNR).

Table 5-3. Diluted Concentration Ranges for Municipal Wastewater Treatment Plants

Pollutant	Units	Concentration Range	Average	GA DNR	Drinking
BOD5	mg/L	0.04 - 25	3.8		
Fecal Coliform[3]	# / 100mL	0 - 167	25	200	0 [1]
Ammonia	mg N/ L	0.02 - 20	2.3		0.5 [2]
Phosphorus	mg P/L	0.01 - 2	0.4		5 [2]
Suspended Solids	mg/L	0.05 - 30	6		

Notes:
[1] EPA drinking water maximum contaminant level goal
[2] World Health Organization Standard [3] Not diluted; actual effluent concentration

Industrial Wastewater Dischargers

The NPDES files were reviewed at the EPD's industrial wastewater office to determine which facilities are in the Lake Lanier watershed. There are eight facilities that fit this description (listed in Table 5-4). More information about these facilities can be found in Appendix 5-A. Figure 5-2 is a map showing the location of these facilities.

Table 5-4. List of Industrial NPDES Facilities

Facility Name	NPDES Permit #	Type of Discharge	Permitted Flow (MGD)	Receiving Water
FORSYTH COUNTY				
Buckhorn Minerals	GA0037290	quarry runoff	0.65	Six Mile Creek
HABERSHAM COUNTY				
Davidson Mineral Prop. - Habersham	GA0046086	sed pond	2.59	Hazel Creek
Habersham Mills Inc.	GA0001694	filter backwash	0.009	Soquee River
Scovill Inc.	GA0001112	process water	0.144	Soque River
HALL COUNTY				
Dutch Quality House	GA0037044	non contact cooling H2O	0.01	Balus Creek
SKF Bearing Industries	GA0037265	non contact cooling H2O	0.02	Trib to Mud Creek South
LUMPKIN COUNTY				
High Point Minerals, Inc.-Turkey Knob	GA0037281	stormwater runoff	0.002	Cavenders Creek
WHITE COUNTY				
JA Hudson Construction Co	GA0046311	quarry; sed basin		Trib to Gold Branch

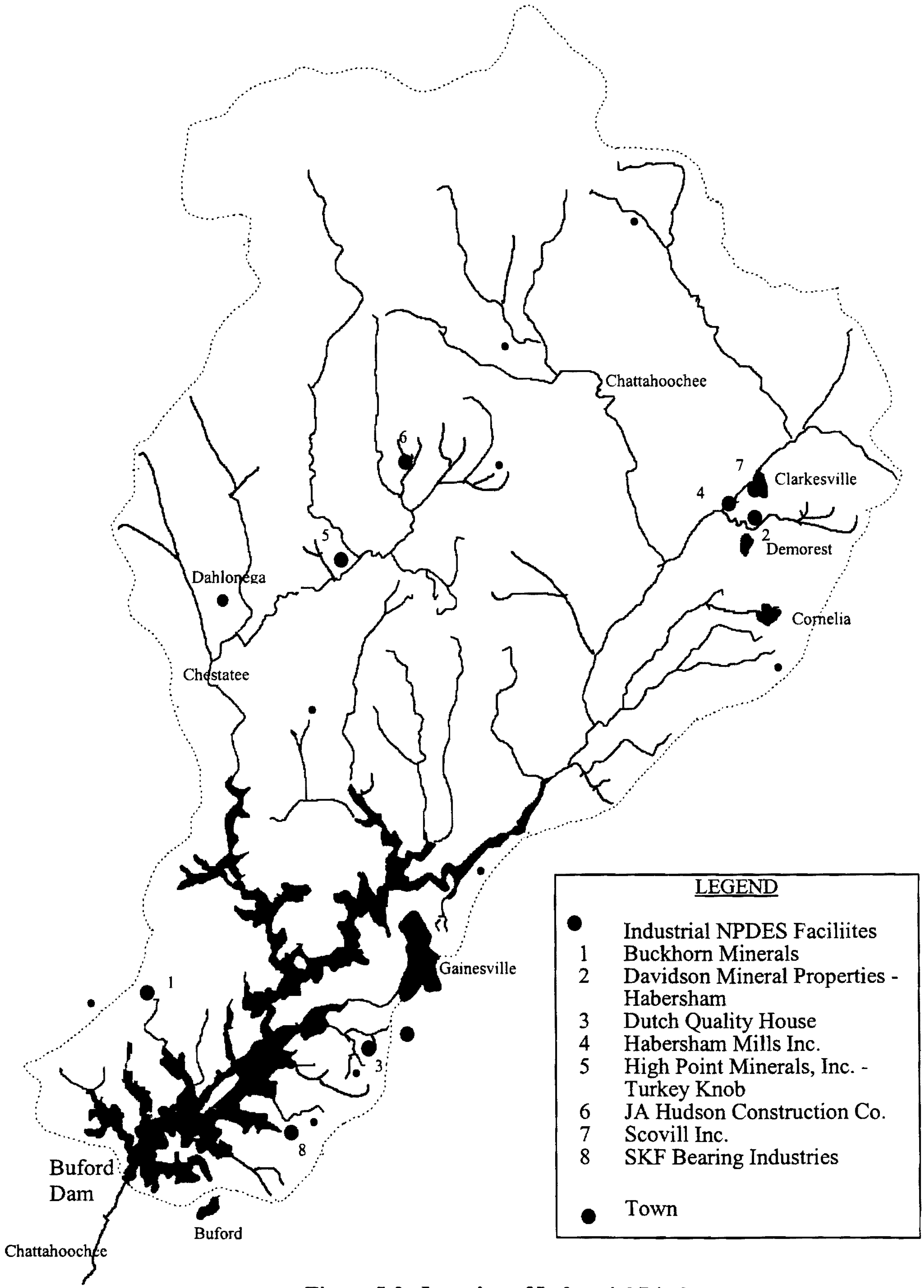

Figure 5-2. Location of Industrial Dischargers

The industries in the watershed were identified from the Georgia Manufacturers Directory (Harris InfoSource International, 1996). A summary of the industries present in the Lake Lanier watershed is shown in Table 5-5. Questionnaires were sent to these facilities to ascertain additional information. However, there was a poor response to the survey. It is assumed that the wastes from these facilities are disposed of in an appropriate manner (such as being sent to a municipal wastewater treatment facility).

Table 5-5. Summary of Industries in the Counties Surrounding Lake Lanier

SIC Code	Type of Industry	Number in Counties Surrounding Lake Lanier
2000	Food (14 Poultry facilities)	40
2200	Textile Mill Products	12
2300	Apparel & Other Finished Products Made from Fabrics & Similar Mat.	28
2400	Lumber & Wood Products, Except Furniture	39
2500	Furniture & Fixtures	13
2600	Paper & Allied Products	4
2700	Printing, Publishing & Allied Industries	35
2800	Chemical & Allied Products	15
2900	Petroleum Refining & Related Industries	3
3000	Rubber & Miscellaneous Plastic Products	10
3100	Leather & Leather Products	1
3200	Stone, Clay, Glass & Concrete Products	19
3300	Primary Metal Industries	4
3400	Fabricated Metal Products, Except Machinery & Transportation Eqmt	23
3500	Industrial & Commercial machinery & Computer Equipment	58
3600	Electronic & Other Electrical Equipment & Components	4
3700	Transportation Equipment	9
3800	Measuring, Analyzing & Controlling Instruments	1
3900	Misc. Mfg. Industries	24

The effluent from industrial facilities can vary greatly in quality depending on the type of industry. The available NPDES DMR information was obtained from the EPD and analyzed (presented in Richman, 1997). A summary of the types of pollutants and their concentrations from these facilities is shown in Table 5-18. Based on the limited data available, it appears that these sites are meeting their permit requirements. The use of dilution factors was employed as in the municipal facility analysis and the results are displayed in Table 5-19. For most facilities, Davidson Mineral Properties, Habersham Mills, High Point Minerals, JA Hudson Construction Company, and Scovill, the 7Q10 flow values were interpolated downstream from USGS monitoring stations. For Buckhorn Minerals and SKF Bearing, there was no USGS data available. The minimum flow for these streams from the tributary sampling analysis from the Diagnostic/Feasibility Study of Lake Lanier(1994) was used. This does not provide the 7Q10 dilution values, but it does give an estimate of the concentration that might be encountered because of these facilities. Table 5-6 displays a summary of this information as compared to water quality standards.

Table 5-6. Typical Concentration Ranges for Industrial Dischargers

Pollutant	Units	Concentration Range Adjusted for Dilution Effects	Average Concentration	GA DNR Water Quality Standards	EPA Drinking Water MCL
BOD5	mg/L	0.001 - 0.08	0.04		
COD	mg/L	0.004 - 0.09	0.06		
Fecal Coliform	# /100 mL	10 - 41		200	0 *
Iron	mg/L	0.00004 - 0.001	0.0005		0.2 **
Mercury	mg/L	< 0.00002		0.000012	0.002
Total Nitrogen	mg/L	0.0003 - 0.005	0.003		10
Ammonia	mg/L	0.0003 - 0.04	0.01		
Oil & Grease	mg/L	0.0002 - 1.2	0.3		
pH	mg/L	6 - 9		6 - 8.5	
Phosphorus	mg/L	.00009 - .02	0.008		
Sulfate	mg/L	0.005 - 3.157	1.58		500
Suspended Solids	mg/L	0.001 - 18	0.8		
TOC	mg/L	0.0008 - 0.5	0.16		
Zinc	mg/L	< 0.01	0.0004	0.06	

Note *: Maximum contaminant level goal **: WHO guideline or ECC max

Marinas

Marinas are a potential source of contamination because of the requirements and activities associated with boating such as gas, oil and paint spills. A map from the Corps of Engineers Lake Lanier Resource Manager's Office was obtained that shows the locations of marinas and other recreational facilities on the lake. There are ten marinas on the lake. Table 5-7 lists the marinas and Figure 5-3 shows their location.

Table 5-7. List of Marinas

County	Marina
Forsyth	
	Bald Ridge Marina
	Habersham Marina
	Lan Mar Marina
Hall / Gwinnett	
	Lanier Harbor
Hall	
	Aqualand Marina
	Gainesville Marina
	Holiday Marina
	Lazy Days Marina
	Starboard Marina
	Sunrise Marina

Information about the effects of marinas on lake water quality is very sparse. The impact that a marina will have is dependent largely upon the actions of individuals and is, thus, difficult to quantify. Marinas can impact a body of water by increasing the toxicity, increasing pollutant concentrations in aquatic organisms and sediment, causing eutrophication and creating high levels of pathogens (US EPA "Managing Nonpoint Sources...from Boating and Marinas"). Some potential pollutants that can result from boating activities are antifouling paints, gasoline, oil, and fecal

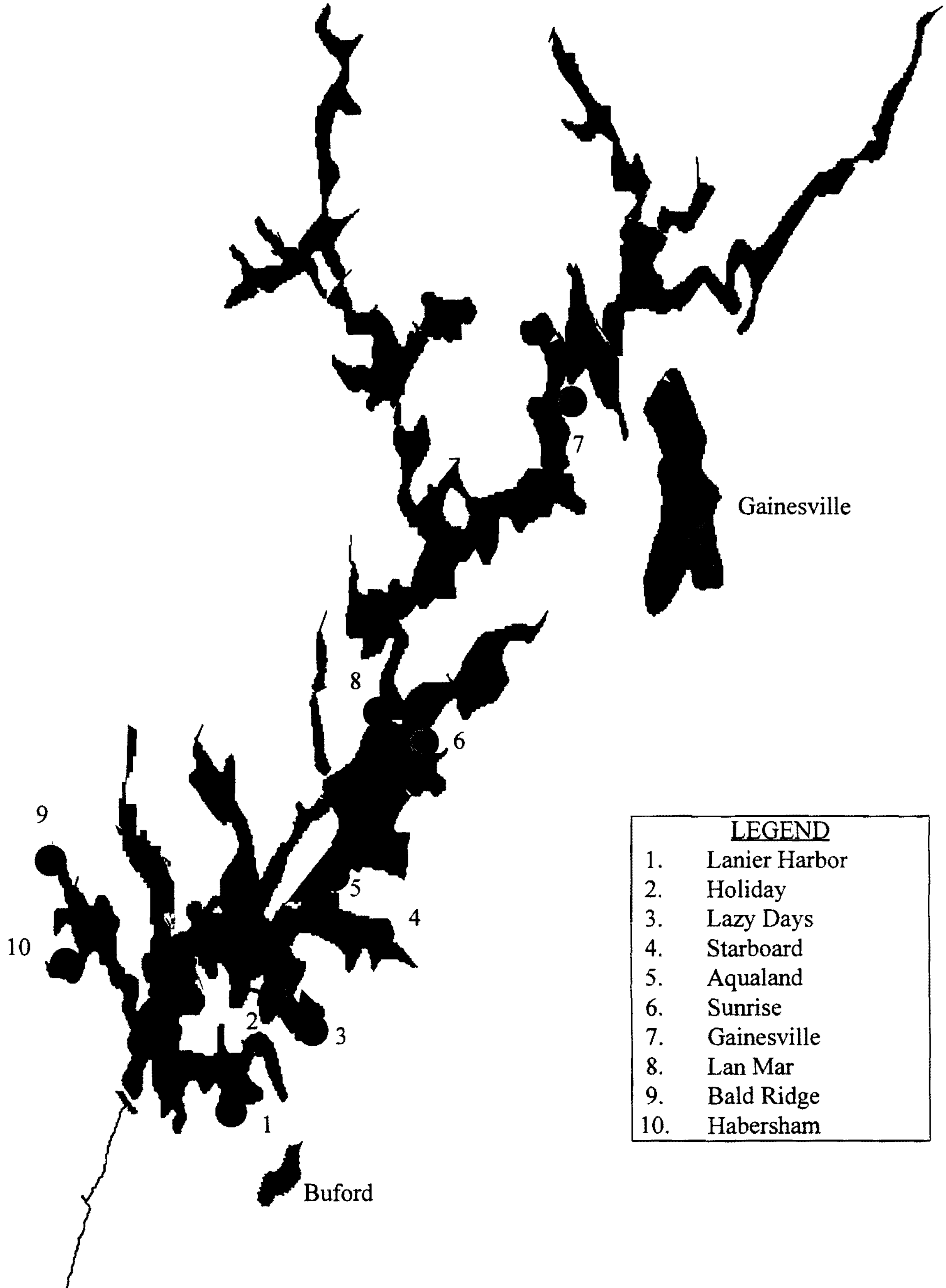

Figure 5-3. Location of Marinas

coliforms due to improper disposal of human waste from boats. Sewage discharge can result in human health problems, destroying shellfish and creating a low dissolved oxygen content in the water. Amendments to the Georgia Water Quality Control Act require that toilets or other disposal units on boats have securely affixed suitable treatment devices. An approved treatment device provides maceration, chlorination and detention prior to discharge. In 1969 it was reported that 70% of marine toilets at Lake Lanier had appropriate treatment devices (GWQCB, 1969). A Georgia Water Quality Control Board study (1969) in 1968-1969 of marinas at Lake Lanier showed results of fecal contamination with a geometric mean of 230 MPN/100 mL of total coliforms and 30 MPN/100 mL of fecal coliforms at one marina. Comparison of results from control stations showed that the concentration of coliforms was higher at the marinas than in areas away from the immediate influence of the pleasure crafts. The study showed that fecal coliform water quality standards were met in more than 90 percent of all samples collected (GWQCB, 1969). There is also concern that the marinas may contaminate the lake with elevated levels of metal concentrations. The EPA (USEPA "Management Measures...Boating") reports that typical metals that may pollute water surrounding boating activities are as follows:

Lead: used as fuel additive and ballast - released through incomplete fuel combustion and boat bilge discharges
Arsenic: used in paint pigments, pesticides and wood preservatives
Zinc anodes: used to deter corrosion of metal hulls and engine parts
Copper and Tin: biocides in antifoulant paints
Others (Iron, Chrome): used in construction of marinas and boats

The most common metal at toxic concentrations is copper. Tin in the form of bytyltin, which is now illegal for use, has been found in toxic levels at marinas nationwide (USEPA "Management Measures ... Boating"). Refueling activities and fuel discharges cause the release of petroleum hydrocarbons which are also harmful to aquatic life. Fish tissue analysis conducted under the diagnostic/feasibility study of Lake Lanier (1994) demonstrated that there were detectable levels of arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc and DDE in the fish tissue from fish caught at two marinas at Lake Lanier. However, these concentrations were not significantly different from the concentrations found in other parts of the lake. It is uncertain whether these metals are originating from activities associated with boating, but it is quite possible that marinas are the source of these metals.

Landfills

Landfills have been used for centuries as a way for society to dispose of solid waste. However, the materials in the landfill can leach into the groundwater below the landfill causing the ground water to become contaminated. Solid waste is regulated under the Hazardous and Solid Waste Amendments of 1984 (RCRA Subtitle D). This amendment to the Resource Conservation and Recovery Act requires minimum technology requirements for new land disposal facilities including mandates for soil liners, leachate collection systems and final covers. Some operating criteria are daily covering of refuse, restrictions on placement of liquids, programs for management of codisposal of hazardous waste, postclosure care for at least thirty years, groundwater monitoring and location restrictions. However, in 1988 the EPA found that only 1% of landfills were using flexible membrane liners and 15-27% used soil or clay liners (Adriano, 1994). However, if leachate does reach the groundwater, the contaminant concentration can be reduced in the groundwater due to dispersion, dilution and chemical and biological reactions. Some organics will be reduced by volatilization, biodegradation, and hydrolysis or oxidation reactions. Despite nature's remediation ability, if the contaminants are in a large enough volume, or are extremely toxic or resistant to remediation, they will contaminate the groundwater. This leads to a potential contamination of drinking water sources and surface water.

The Georgia Environmental Protection Division's land protection branch has files only on solid waste facilities that are currently in operation and some closed landfills. This office does, however, have a notebook containing county maps with the locations of some closed solid waste facilities. Thus, no information other than location was found for most closed facilities. Based on this information collection, there are eight municipal landfills in the Lake Lanier watershed. These landfills are listed in Table 5-8 and their locations are shown in Figure 5-4. More information about these facilities can be found in Appendix 5-A.

Table 5-8. Landfills

County	Site Name	Permit Number	Closing Date	Nearest Stream
Forsyth				
	Cumming		Closed 10/75	Trib to Lake Lanier
Habersham				
	Clarkesville		Closed 6/82	Soquee River
	Cornelia		Closed 11/73	South Fork Mud Creek
	Habersham Co.- Pea Ridge	068-0160 (SL)	Closed 12/95	Little Mud Creek
Lumpkin				
	Camp Merril	093-0040 (SL)		Trib to Cane Creek
	Lumpkin Co.	093-003D(SL)	Closing 1996	Cane Creek
White				
	White Co.-Dukes Cr.	154-0030 (SL)		Ash Creek
Union				
	Union Co.-Haralson Mem. Drive	144-0010(SL)	Closed 4/96	Soque River

New solid waste disposal facilities and facilities requesting closure are required to monitor the surfacewater and groundwater surrounding the site. This monitoring data for 1996 from Union Co., Habersham Co., and Lumpkin Co. was obtained from files at the EPD's Land Protection Branch Solid Waste Management office (this material is presented in Richman, 1997). Groundwater sampling is accomplished by testing the groundwater from monitoring wells (often denoted GWx-#) surrounding the site. Surfacewater sampling occurs at streams near the site (often denoted SWx-#). The sampling locations marked with A (e.g. GWA-1 or SWA-2) are often background sampling locations. The contamination from these background locations should not contain contamination from the site. The contamination found in the surfacewater is of primary concern for this project, because the contamination will flow into Lake Lanier. The contamination in the groundwater will also eventually flow into Lake Lanier, but only after percolating through the soil. This slow process will most likely cause a change in the composition and toxicity of the contamination. In many cases, the contaminant will be transformed or removed. However, it is possible that some parameters will change form becoming more toxic and more mobile. This process takes a very long time and is

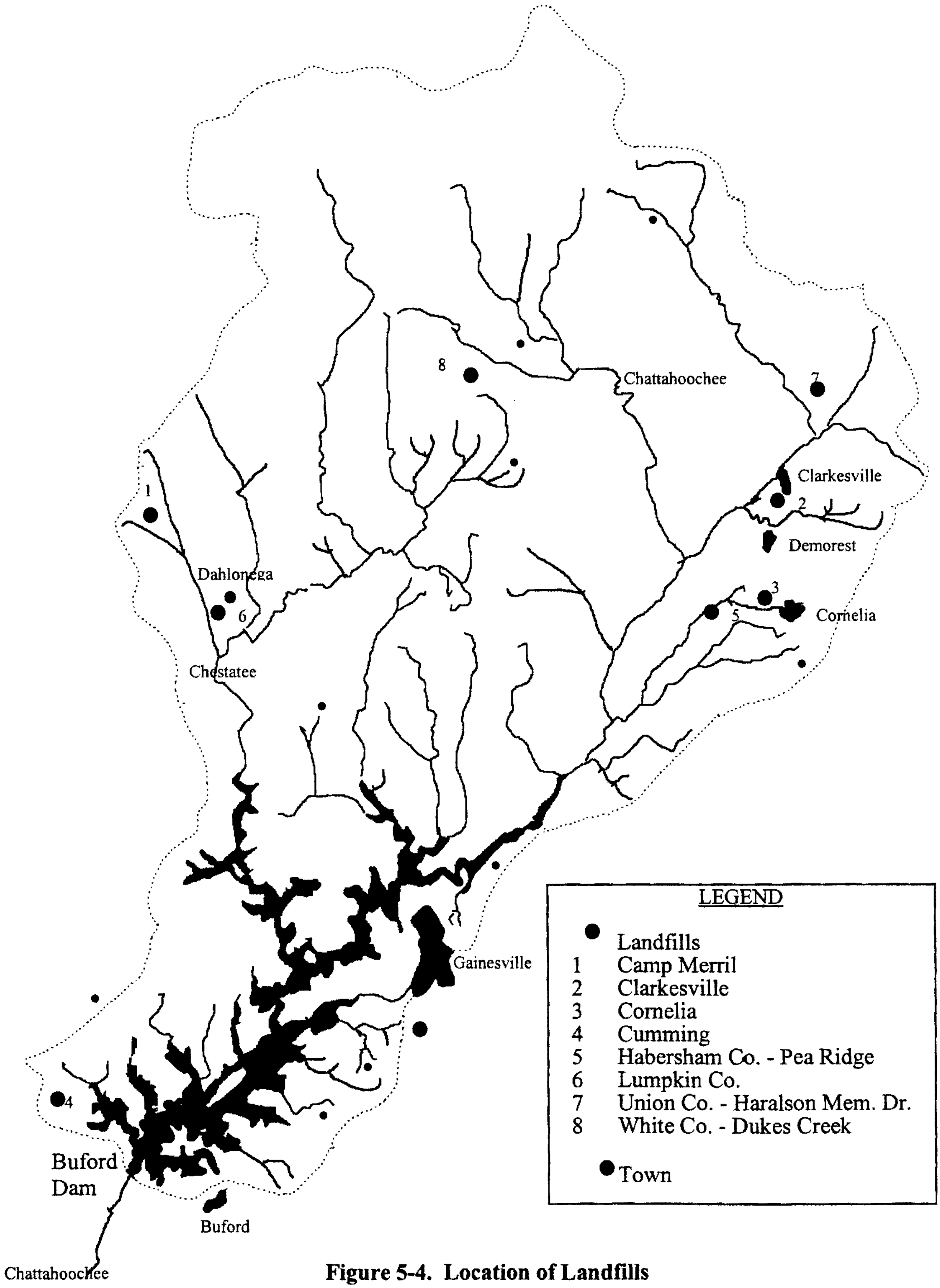

Figure 5-4. Location of Landfills

difficult to quantify. A landfill would only likely be a threat to the water quality of the lake if it were in close proximity to the lake or if it had a significant toxic leak. There are no known landfills in close proximity to the lake. Tables 5-9 and 5-10 show the range of pollutants found in the surfacewater and groundwater near these landfills. Parameters that exceed the MCLs or 7Q10 limits are shaded. Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) are included in the tables as are in-stream 7Q10 limits. An analysis of this data indicates that possible pollutants of concern are chromium, lead, zinc, benzene, tetrachloroethene, toluene, and trichloroethene.

Table 5-9. Surfacewater Pollutant Ranges Near Landfills

Parameter	Units	Concentration Range	Average Concentration of Measurements over Detection Limit	SDWA MCLs '94	7Q10 Limits
Chloride	mg/L	1.4 - 19	7	250	
TOC	mg/L	2 - 440	49		
COD	mg/L	5 - 1200	186		
Ba	mg/L	0.01 - 0.24	0.04	2	
Cr	mg/L	< 0.01 - 0.87	0.45	0.1	0.011
Pb	mg/L	< 0.025 - 0.16		0.05	0.0013
Hg	mg/L	< 0.0005 - 0.001		0.002	0.000012
Ni	mg/L	< 0.02 - 0.11		0.1	0.088
Zn	mg/L	< 0.02 - 0.52	0.136	2	0.06

Table 5-10. Groundwater Concentration Ranges Near Landfills

Parameter	Units	Concentration Range	Avg. Concentration of Measurements over Detection Limit	SDWA MCLs '94	7Q10 Limits
Ba	mg/L	< 0.02 - 2.7	0.18	2	
Be	mg/L	< 0.003 - 0.003	0.003	0.001	
Cr	mg/L	< 0.01 - 0.05	0.03	0.1	0.011
Co	mg/L	< 0.04 - 0.2	0.13		
Ni	mg/L	< 0.02 - 0.04	0.03	0.1	0.088
V	mg/L	< 0.02 - 0.03	0.03		
Zn	mg/L	< 0.02 - 0.14	0.05	2	0.06
Benzene	ug/L	< 2 - 16	7.7	5	
Chloroethane	ug/L	< 2 - 33	16		
1,1-Dichloroethane	ug/L	< 2 - 34	18		
1,2-Dichloroethane	ug/L	< 2 - 12		5	
cis-1,2-Dichloroethene	ug/L	< 2 - 240	50	70	
1,2-Dichloropropane	ug/L	< 2 - 8	4	5	
Ethylbenzene	ug/L	< 2 - 21	8	700	
Methylene chloride	ug/L	< 5 - 210	56	5	
Tetrachloroethene	ug/L	< 2 -49	10	5	
Toluene	ug/L	< 2 - 49	18	1	
1,1,1-Trichloroethane	ug/L	< 2 - 7		200	
1,1,2-Trichloroethane	ug/L	< 2 - 12	5	5	
Trichloroethene	ug/L	< 2 - 39	12	5	
Vinyl chloride	ug/L	< 2 - 74	20	2	
Xylenes	ug/L	< 5 - 65	25	10000	
Dichlorodifluoromethan	ug/L	< 10 - 130	55		

Septic Tanks

Septic tanks operate by removing solids by settling and/or liquefaction by biological processes. The anaerobic tank provides conditions for anaerobic digestion to reduce organic concentrations. The sludge in the bottom of the tank is periodically pumped out by a licensed septic tank plumber. The clarified liquid at the top of the tank is displaced into the soil as new septage enters the tank. The clarified effluent from septic tanks can potentially degrade groundwater with chloride, nitrate, phosphate salts, oil fractions, fuel oil, TCE, gasoline, turpentine, and pathogens.

The most significant problem associated with septic tank pollution is the contamination of water supplies. When well water is contaminated with fecal coliform bacteria, septic tanks are the prime suspect as the source of contamination. The primary concerns with drinking water contaminated by septic tanks are pathogens and nitrate which can cause death in infants by the disease methemoglobinemia. However, if the septic tank is sufficiently above the groundwater table (two to four feet is often sufficient), the soil can prevent contamination of the water. The depth above groundwater needed depends on the properties of the soil. The soil matrix acts as a sieve for parasites greater than 3 um. Thus, microbes can only travel a few feet in unsaturated soil. Many organisms will die in the soil due to poor conditions for survival or predation. Fine textured soil (such as Georgia clay) increases the adsorption of microorganisms. Average water quality conditions five feet below septic tanks are BOD5 concentrations < 2 mg/L and suspended solids < 1 mg/L (USEPA, 1984). Phosphate anions are precipitated by cations that are abundant in the soil. Phosphorus can also be removed by sorption, plant uptake and bio-immobilization (Reckhow and Simpson, 1980). Generally, phosphorus is not a problem in groundwater unless the soil is coarse or is near a body of water (Kaplan, 1991). The nitrogen content from the septic tank effluent is comprised mainly of ammonia (Kaplan, 1991). In the aerobic, unsaturated percolation field surrounding the septic tank, the ammonia will nitrify into nitrate. Provided there is enough substrate, the nitrate will denitrify to nitrogen gas in the anaerobic soil beyond the aerobic soil region. However, it is difficult to determine the rate by which nitrogen compounds will be nitrified and denitrified without conducting tests. Nitrate is very soluble and can stay in solution in the groundwater. If the septic tanks are in close proximity to the lake, it is possible that some of the contaminants will reach the lake before they can be "treated" by the soil and microbes. If the plume of septic leachate reaches a body of water it can stimulate plant growth and cause eutrophication. However, wave action in lakes can control this growth in large bodies of water.

In the 1950s the U.S. Public Health Service compiled standard design requirements for septic tanks in response to frequent septic tank failures. In the 1960s and 1970s state and local governments began requiring preconstruction approval for installing septic tanks. However, if these facilities become overloaded or are not well maintained they will still fail. It is commonly assumed that from one third to one half of existing septic tanks are operating improperly (Adriano, 1994). There are three main types of failure: surface malfunctions of soil absorption systems due to inadequate hydraulic capacity, backup into household plumbing, and contamination of groundwater.

It is assumed that most homes and businesses in the Lake Lanier watershed (with the exception of those in the larger towns with wastewater treatment facilities) use septic tanks to treat and dispose of waste. It is not within the scope of this project to determine the exact number of septic tanks in the watershed. For the purposes of calculating loadings into Lake Lanier, United States Geological Survey 7.5 minute quadrangle maps were used to count the number of structures within 300 feet of the lake shore. Three hundred feet was used because in the 1975 Eutrophication Study, the EPA considered this to be the distance from the shoreline that would impact a lake. This count of structures that were not in towns with wastewater treatment facilities, resulted in enumeration of nearly 5,200 structures within 300 feet of the lake. It is assumed that each of these structures has a septic tank. Most of the maps used were revised in 1985. Thus, the count is not exact, but in lieu of more precise methods, this estimate will suffice for loading calculations.

Hazardous Waste Sites

RCRA: The Resource Conservation and Recovery Act (RCRA) of 1976 provided for a cradle-to-grave method to maintain control over hazardous waste production, use, transportation and disposal. It is inevitable that spills of toxic substances will occur. Facilities that manufacture, treat, transport, recycle and dispose of hazardous materials are required to notify the EPA and EPD of their activities. The Georgia EPD Hazardous Waste Management Office has a listing of all facilities that have notified the EPD of their activities (a copy of this list is in Richman, 1997). This list of RCRA notifiers in the counties surrounding Lake Lanier is summarized in Table 5-11. It should be noted that all of these facilities are not necessarily in the Lake Lanier watershed.

Table 5-11. Summary of RCRA Notifiers in Counties Surrounding Lake Lanier

Type of Operation	Number
Land Disposal TSD	2
Store/Treat TSD	0
Combustion (Incin. and BIFs)	0
Large Quantity Generator (> 1000 kg/mo)	12
Small Quantity Generator (100-1000 kg/mo)	85
Conditionally Exempt Generator	90
Transporter	5
Burner/Blender	4
Recycler	0

The EPD also has a list of the facilities for which they have files. According to the EPD's 1993 Hazardous Waste Report, Habersham county is the ninth largest hazardous waste generating county in the state with a yearly production of 144,527 tons. A listing of select large quantity hazardous waste generators in the counties surrounding Lake Lanier follows in Table 5-12. The Hazardous Waste Management Act amended in 1990 requires that large quantity generators develop and submit hazardous waste reduction plans biennially. Thus, theoretically these facilities will be producing less hazardous waste in the future.

Table 5-12. Select Hazardous Waste Generators in Counties Surrounding Lake Lanier

County	Facility	ID #	Tons Generated
Habersham	Ethicon Inc.	GAD000614347	127.92
	Scovill Mfg. Inc.	GAD003480530	144,399.28
Hall	Cottrell Inc.	GAD066477142	37.287
	Cummins Engine	GAD980602999	13,688.784
	Dittler Brothers-Oakwood	GAD980709604	113.68
	Dittler Brothers Prod. Color Inc.	GAD981026388	38.677
	Elan Pharm. Research	GAD981216609	17.084
	Harris Calorific	GAD115319204	23.824
	Indalex	GAD981238199	617.203
	J & J Advanced Material	GAD114452113	3.455
	Packaging Specialist of GA Inc.	GAD980804207	4.685
	Piedmont Labs	GAD131327546	224.519
	SKF Bearing	GAD075870873	20.862
White	Freudenberg-NOK	GAD981267735	9.970
	Talon Inc.	GAD981474299	18.246

CERCLA: RCRA covers spills from newly generated hazardous wastes. Thus, to cleanup contamination from past episodes, Congress passed the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) in 1980. This act, amended in 1986 by the Superfund Amendments and Reauthorization Act (SARA), provides for identification and cleanup of old hazardous waste sites. The CERCLA Information Service (CERCLIS) provides a listing of these hazardous waste sites. The facilities from this list that are in the Lake Lanier watershed are presented in Table 5-13 and some are shown in Figure 5-5. More information about these facilities can be found in Appendix 5-A. The locations of SCM and Yearwood were not available. The Environmental Protection Agency (EPA) uses a method called the Hazard Ranking System (HRS) to determine the degree of risk a site poses to humans and the environment. If the HRS score is above a threshold level, the site is placed on the National Priorities List (NPL). These NPL sites (called Superfund sites) are considered the most hazardous sites in the country. There are no national NPL sites in the Lake Lanier watershed.

HSI: The Hazardous Site Index (HSI) is Georgia's version of the NPL. Many sites on CERCLIS do not make the NPL and are, thus, not applicable for federal superfund funding for cleanup unless they pose an imminent danger to human health and the environment. These sites that are not remediated by the USEPA are placed on Georgia's Hazardous Site Inventory (HSI). Other sites that are on the HSI include RCRA facilities and landfills that meet certain criteria. When a site has a release of a regulated substance they must notify the EPD about the release. Using the Reportable Quantities Screening Method (RQSM), the EPD determines a score for the facility. This is similar to the EPA's Hazard Ranking System. If the site's score is higher than a threshold level it is placed on the HSI. Regulated solid waste landfills that have significant releases to groundwater are also placed on the HSI. There is only one site in the watershed that was on the HSI in the last year. Cummins Engine Company was designated Class II meaning that further evaluation of the site was warranted to determine what if any corrective action was needed. Further investigation resulted in the facility being delisted from the HSI. As of July, 1996 there are no facilities in the Lake Lanier watershed that are on the HSI.

Table 5-13. CERCLIS Facilities in the Lake Lanier Watershed

County	Facility	EPA ID #	Event Type	Event Lead	Finish Date	Status
Habersham						
	Ethicon Inc.	GAD000614347	DS	EPA (Fund)	8/1/80	
			PA	State (Fund)	8/1/84	Lower Prior.
			SI	EPA (Fund)	12/1/89	NFRAP
Hall						
	Abrams Big Star Properties Dump Site	GAD984278150	RV	EPA (Fund)	6/9/89	Clean-up
			DS	"	4/28/92	
			PA	"	7/5/90	
	Cummins Engine Co.	GAD980602999	DS	EPA In-House	11/30/94	
			PA	State (Fund)	5/25/95	Lower Prior. Delisted
	SCM Corp Glidden Coatings & Resins Div.	GAD000622985	DS	EPA (Fund)	8/1/80	
			PA	State (Fund)	9/1/84	Lower Prior.
			SI	EPA (Fund)	8/19/84	
	Wrigley Jr Wm Co	GAD056206717	DS	EPA (Fund)	8/1/80	
			PA	State (Fund)	7/23/85	NFRAP
	Yearwood Drums	GAD984316497	RV	EPA (Fund)	12/10/92	Clean-up
			DS	"	9/14/92	
			PA	"	5/5/94	Higher Prior.
			AR	"	6/11/93	Admin Rec Comp/Rmvl Event

Note: NFRAP - No Further Remedial Action Planned
DS- discovery; PA: preliminary assessment; SI: site investigation; RV: removal; AR: administrative record

Underground Storage Tanks

Underground Storage Tanks (USTs) have the potential to contaminate the soil and groundwater when its contents are leaked. Most USTs contain fuel and are located at gasoline stations. Petroleum products from USTs are regulated under RCRA Subtitle I. The Hazardous and Solid Waste Amendments (HSWA) require that the owner of a UST provide either a leak detection system or an inventory control with regular testing of tanks. Owners are required to maintain detailed records of monitoring and tank testing, report releases, and take appropriate corrective actions when leaks do occur. The tanks are also required to be structurally sound, e.g. corrosion resistant. USTs are also regulated under the Clean Water Act and Occupational Safety and Health Act. A list of USTs in the counties surround Lake Lanier that have confirmed or suspected releases was obtained from the EPD's UST department (and is presented in Richman, 1997). It is not included in this report since USTs are not considered a significant source of pollution in Lake Lanier.

Underground storage tanks have the potential to contaminate the groundwater with fuel compounds. It is estimated that approximately twenty-five percent of USTs are currently leaking (Cheremisinoff, 1992). Common gasoline is a mixture of around two hundred different hydrocarbons and additives. Some of the most common are benzene, toluene, xylenes and additives such as ethylene dibromide. Some of these compounds will biodegrade due to naturally occurring microbes in the soil. Because it is unknown whether there are any spills in close proximity to the lake, it is inappropriate to estimate concentrations of potential pollutants. However, it is unlikely that UST spills will cause a significant contamination problem for the lake if the UST owners follow the EPA regulations.

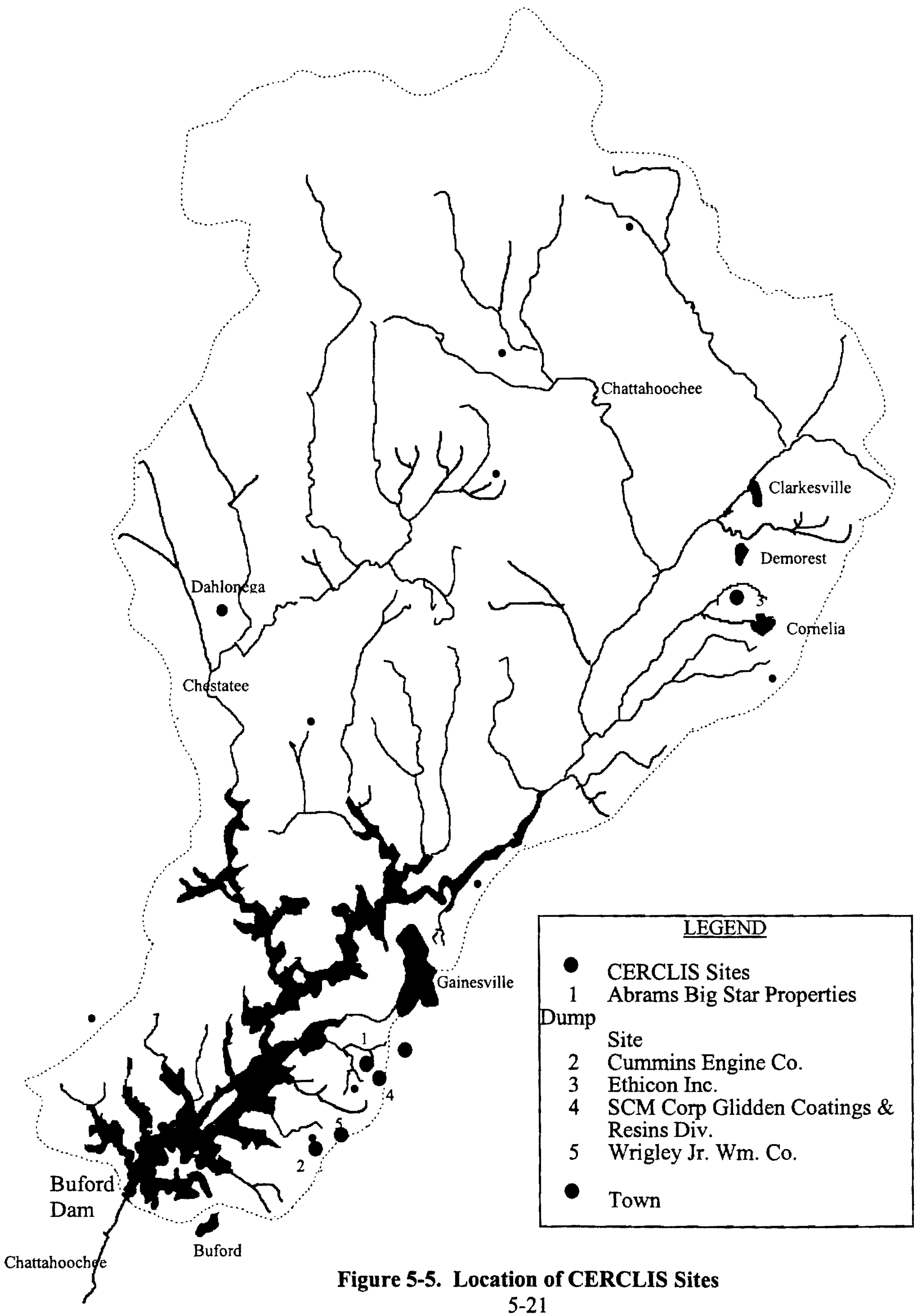

Figure 5-5. Location of CERCLIS Sites

Cemeteries

Cemeteries were located from United States Geological Survey 7.5 minute quadrangle maps that were revised in 1985. They are presented in Figure 5-6. There is little information in the literature concerning the potential for cemeteries to contaminate the ground water. It is possible that the microbes from the decomposition of bodies and compounds used to preserve bodies (such as arsenic) can reach the groundwater. There is no pollution data available on any cemeteries in this watershed.

Urban Areas

Urban areas were identified by land use maps for each county. These maps were obtained from the Georgia Mountains Regional Development Center and show existing and future land use patterns for the counties. Runoff from urban areas can transport many different contaminants from the land into bodies of water. A recent National Water Quality Inventory reports that urban runoff is the third largest source of water quality impairments to lakes (USEPA, "Managing Urban Runoff"). Urban areas affect runoff by increasing the runoff and pollutant loads. The increase in runoff is due to the large sections of nonporous areas (e.g. pavement) common in urban areas. Storm sewers also increase the runoff by quickly channeling the runoff. Urbanization also causes an increase in the variety and amounts of pollutants. Development and construction provide the largest volume of pollution in the form of sediment. Other potential pollutants from surface runoff include oil, grease and toxic chemicals from automobiles; nutrients and pesticides from gardening and landscaping; viruses and bacteria from failing septic systems; road salts from winter conditions; and heavy metals from various industrial activity. Common trace elements from automobile traffic and industrial activity are: lead, zinc, cadmium, mercury, copper, arsenic, chromium, iron, nickel, antimony and manganese. The most common heavy metals in urban runoff are copper, lead, zinc and cadmium (Woodward-Clyde Consultants 1990).

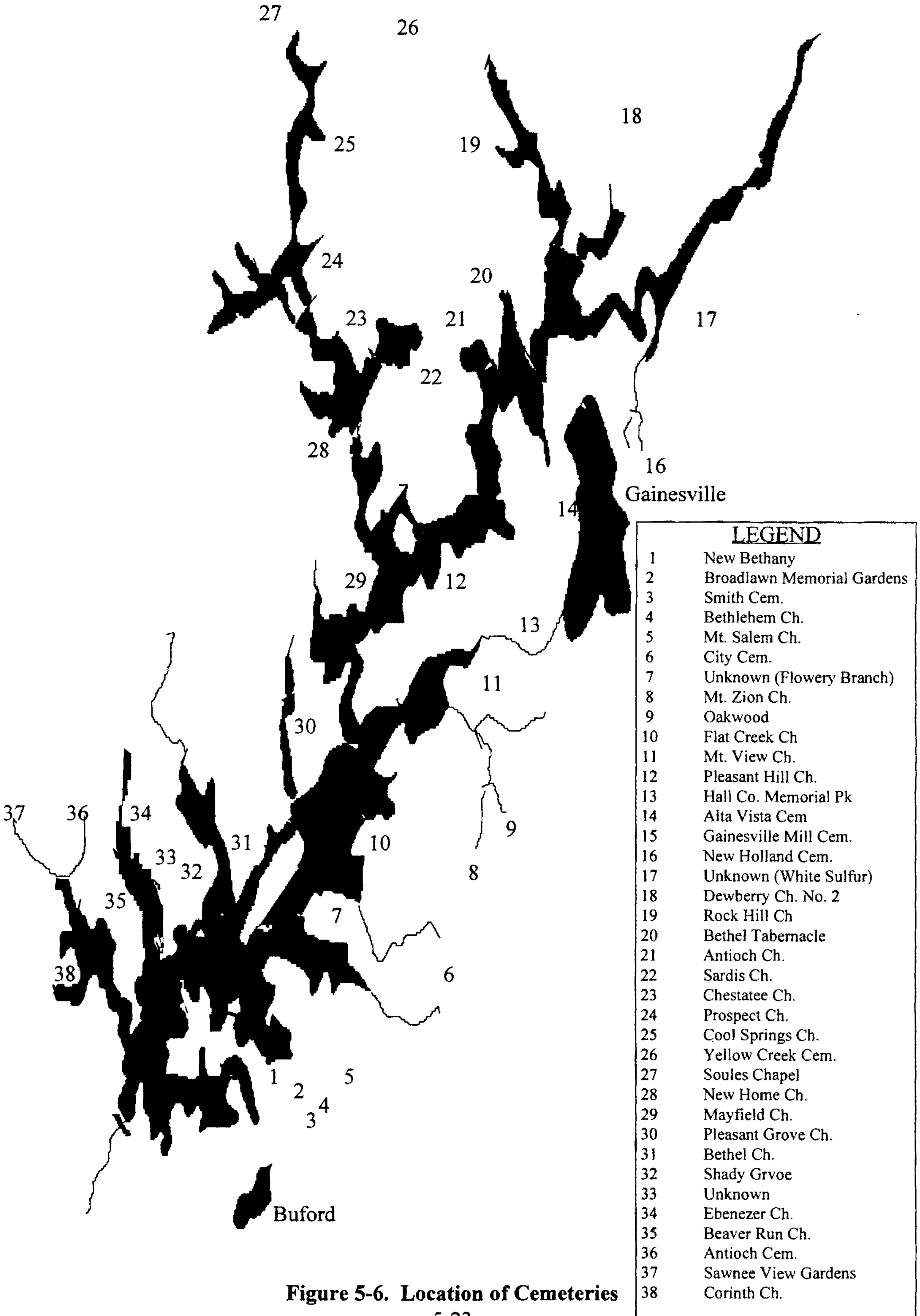

Figure 5-6. Location of Cemeteries

Summary of Pollutant Sources

The following Table 5-14 provides a summary of the pollutants that could be found at the different source categories previously mentioned. Where available, pollutant concentration ranges are presented.

Table 5-14. Summary of Potential Pollutants and Source Categories

	Municipal WWTP[1]	Industrial WWTP[1]	Marinas	Landfills[2]	Septic Tanks	USTs	Cemeteries	Urban Runoff[3]
Ammonia (mgN/L)	0.02 - 20	0.003 - 0.04		√				
Arsenic		√	√	√			√	√
Antiomony				√				
Barium				0.01 - 0.24				
Benzene						√		
Beryllium				√				
BOD5 (mg/L)	0.04 - 25	0.001-0.08		√	2			6.5 - 20
Cadmium				√				√
Carbon, (mg/L) Organic		0.0008 - 0.5		2 - 440				√
COD		0.004-0.09		5 - 1200				40 - 175
Chromium		√	√	< 0.01 - 0.87				√
Copper		√	√					15 - 120
Fecal Coliform (#/100mL)	0-167	10-41	√		√			
Gasoline			√					
Iron (ug/L)		0.04 - 1	√					√
Lead			√	< 0.025 - 0.16				60 - 465
Mercury (ug/L)		<0.02		< 0.5 - 1				√
Microbes							√	√
Nickel (mg/L)				< 0.02 - 0.11				√
Nitrogen (mg/L)		0.0003 - 0.005			√			0.95 - 4.45
Oil & Grease (mg/L)		0.0002 - 1.2	√	√	√	√		√
Pesticides								√
Phosphorus (mg P/L)	0.01 - 2	0.00009 - 0.02		√	√			0.18 - 0.93
Suspended Solids (mg/L)	0.05 - 30	0.001 - 18		√				35 - 390
Tin			√					
Toluene						√		
Xylenes						√		
Zinc (mg/L)		<0.01	√	< 0.02 - 0.52				80 - 540

Notes:

1) Concentration ranges based on discharge monitoring reports from facilities in the watershed.
2) Based on surfacewater concentrations near landfills in the watershed.
3) From Woodward-Clyde (1990).
√ Indicates that this pollutant is common for this source, but typical concentrations are unknown.

5.3. SAMPLING PROGRAM

In an effort to obtain more accurate information about the contribution of point source pollution and urban runoff into the lake, a sampling and analysis program was employed during a nine month period in 1995-1996. The information gathered and described previously about facilities in the watershed and interactions with EPD and EPA specialists led to a ranked list of facilities at which sampling and analysis should occur. (More detailed information about this process is outlined in Richman, 1997.) Two types of sampling occurred: wastewater treatment effluents and urban stormwater runoff. All samples were grab samples. The locations of the sampling sites are shown in Figure 5-7.

Wastewater Sampling

The effluent of municipal and industrial wastewater treatment plants was collected and analyzed over a period of nine months in 1995 and 1996. The effluent sampling was planned at sites categorized in two tiers. Tier one facilities were considered to have the greatest impact on the lake and were sampled twelve to fourteen times. The tier two facilities, considered to have a lesser impact, were sampled three times each. The impact on the lake was determined based on total mass loadings into the lake, which was a product of flow times concentration [Q x C]. Table 5-15, below, is the list of facilities sampled.

Table 5-15. Effluent Sampling Sites

Facility	Type of Facility	Permitted Flow (MGD)	No. of Sampling Events	Latitude & Longitude
TIER ONE				
Clarkesville	Municipal ww-trickling filter	0.75	13	34°36'43"; 83°32'04"
Cornelia	Municipal ww-trickling filter	3.0	14	34°31'35"; 83°33'35"
Gainesville - Flat Creek	Municipal ww - activated sludge	7.0	14	34°15'59.6"; 83°52'0.2"
Gainesville - Linwood	Municipal ww-trickling filter	3.0	14	34°19'30"; 83°51'30"
Scovill	Industrial ww - Mfg. fasteners	0.14	12	34°36'25"; 83°32'15"
TIER TWO				
Baldwin	Municipal ww - Activated	0.30	3	34°30; 83°32'07"
Cleveland	Municipal ww - Aquaculture	0.75	3	34°36'17"; 83°47'55"
Dahlonega	Municipal ww - Activated	0.72	3	34°31'06"; 83°58'21"
Demorest	Municipal ww - Activated	0.40	3	34°34'36"; 83°32'48"
Flowery Branch	Municipal ww - Activated	0.20	3	34°11'10"; 83°55'50"

The effluent samples were analyzed for the following: CBOD5 (carbonaceous 5-day BOD), total and fecal coliforms, conductivity, mercury, ammonia, nitrite, nitrate, total phosphorus, total organic carbon, total suspended solids, turbidity, and a scan of trace metals including arsenic and selenium. See Appendix 5-E for more information about sampling and analysis. The results from the sampling and analysis are contained in Appendix 5-B.

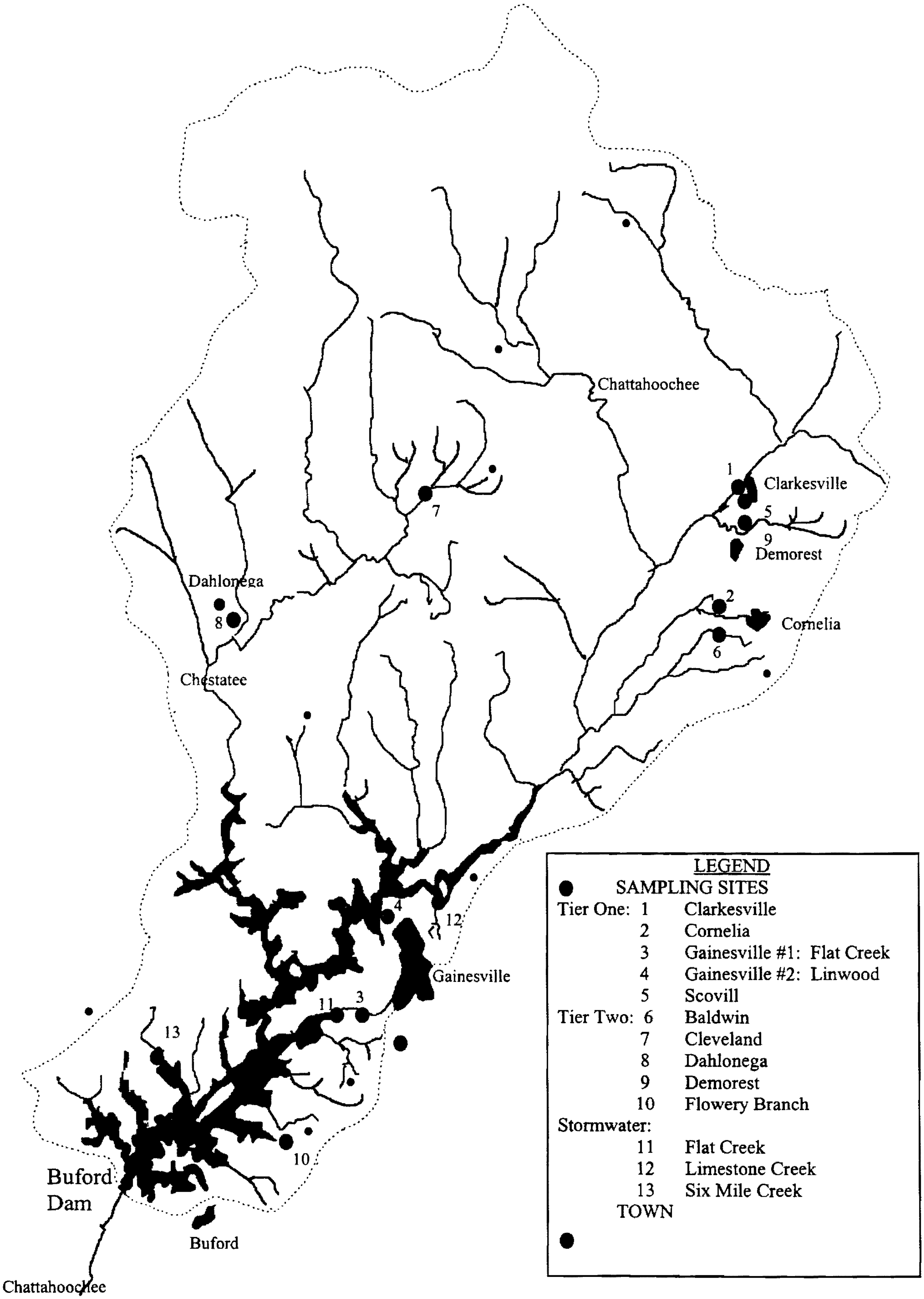

Figure 5-7. Location of Sampling Sites

Urban Runoff Sampling

Urban stormwater runoff is the primary discrete non-point source of concern. Gainesville is the only city of significant size in the watershed. Because it is alongside the lake, there are unlimited areas for stormwater runnoff. However, there are two streams that collect runoff from urbanized areas of Gainesville, South Flat Creek and Limestone Creek. These creeks and Six Mile Creek, which has a history of problems, were chosen to be sampled for stormwater runoff. They were sampled three to four times. The analyses included: conductivity, mercury, ammonia, nitrite, nitrate, total phosphorus, total suspended solids, turbidity, a scan of trace metals, and insecticides. The results from this sampling is also presented in Appendix 5-B.

5.3. RESULTS

Facility File Review and Sampling Results

The results from the file review (the discharge monitoring reports) and the sampling program are summarized in Tables 5-16 through 5-19. Tables 5-16 and 5-18 present the permit and average effluent concentrations for each municipal and industrial facility. The shaded numbers indicate that the permitted concentrations have been exceeded. Tables 5-17 and 5-19 compare water quality standards to the theoretical stream concentration due to the dilution of the facility effluent in the stream. See Section 5.2 Municipal Wastewater Treatment Plants for more discussion on the dilution values.

Mercury was measured using a Perkin-Elmer Mercury analyzer. All of the samples were below the detection limit of 0.2 ug/L.

A few comments about the sampling results from each facility follows.

Baldwin's wastewater treatment facility consists of aeration, clarification, chlorination and detention in a large polishing pond. Because of the simplicity of the operation, there is no operator per se for the facility. The monitoring for this site is conducted by a nearby facility on a contract basis. According to the limited sampling, the facility is not meeting the BOD and suspended solids requirements. The average CBOD5 concentration measured is twice the permit requirement as is the suspended solids concentration. The DMR data for this facility available in files at EPD, did not show concentrations of BOD and suspended solids greater than the permit limits. However, this data was available only through 1993. It is possible that the water quality has degraded significantly since that time. Yet even in the DMR data from 1991-1993, the BOD requirement was exceeded twice and the suspended solids level ten times (with a maximum of 72). Due to the odorous nature of the facility, it appears that the facility is not operating under optimum conditions. While this facility may have worked well for many years, it is advisable that the city consider renovations or an alternate means of disposing of its waste.

The trickling filters at the **Clarkesville** facility seem to be operating adequately. On average, the facility met all permit requirements except for suspended solids. However, the BOD5 permit limit was exceeded on four dates, with a high value of 42 mg/L (12 mg/L over the limit). The suspended solids permit value was exceeded on nine sampling dates with a maximum value of 86 mg/L.

The **Cleveland** facility uses an innovative treatment train consisting of a two-stage aquaculture (LEMNA system), UV disinfection and cascade reaeration. The plant seems to be operating quite well, but they do have problems on occasion due to the seasonal changes in treatment

Table 5-16. Municipal Wastewater Treatment Facilities
Typical Pollutants and Concentrations

Facility		Flow MGD	BOD5 (CBOD5)* mg/L	DO mg/L	Fecal Coliform #/100mL (Geo. Mean)	NH3-N mg/L	P mg/L	SS mg/L
Baldwin	Permit Conc	0.30	30		200			30
n=36 ('91-'93)	DMR Avg	0.23	19	7.3	120			30
n=3 ('96)	Sampling Avg	0.22	**63**		**223**	12.1	6.5	**69**
Clarkesville	Permit Conc	0.75	30		200	17.4		30
n=12 ('92)	DMR Avg	0.28	20	6.7	37	22.6		17
n=13 ('95-'96)	Sampling Avg		**30**		**575**	7.5	2.4	**40**
Cleveland	Permit Conc	0.75	20	2.0	200	10.0		30
n=24 ('94-'95)	DMR Avg	0.34	13	8.2	21	9.6		7
n=3 ('96)	Sampling Avg	0.45	13		15	2.6	2.2	17
Cornelia	Permit Conc	3.00	30	6.0	200	1.5		30
n=60 ('91-'95)	DMR Avg	1.92	19	6.3	119	**26.7**	2.2	16
n=14 ('95-'96)	Sampling Avg	2.51	6		5	**20.8**	1.2	22
Dahlonega	Permit Conc	0.72	30	2.0	200	17.4		30
n=48 ('92-'95)	DMR Avg	0.56	6	4.2	9	0.6		5
n=3 ('96)	Sampling Avg	0.55	5		**312**	0.6	2.3	5
Demorest	Permit Conc	0.40	30	5.0	200			30
n=36 ('91-'93)	DMR Avg	0.07	9	6.6	14			7
n=3 ('96)	Sampling Avg		4		**2037**	3.7	0.8	4
Flowery Branch	Permit Conc	0.20	10	6.0	200	2.0	1.0	30
n=60 ('91-'95)	DMR Avg	0.13	5	6.7	44	0.6	0.6	7
n=3 ('96)	Sampling Avg	0.17	**11**		6	**5.2**	1.7	21
G - Flat Creek	Permit Conc	7.00	20	5.0	200		1.0	30
n=60 ('91-'95)	DMR Avg	5.12	6	6.8	5	0.3	0.6	13
n=14 ('95-'96)	Sampling Avg	5.87	3		<1	0.6	0.2	3
G- Linwood	Permit Conc	3.00	30	2.0	200	17.4		30
n=60 ('91-'95)	DMR Avg	1.54	17	4.8	2	10.9	4.0	13
n=14 ('95-'96)	Sampling Avg	1.96	17		<1	7.7	3.7	20
G - White Sulphur	Permit Conc	0.10						
Lake Lanier Islands	Permit Conc	0.35	30		200			30
n=24 ('91-'92)	DMR Avg	0.10	6		46			8
Lula	Permit Conc	0.03	30		200			90
n=30 ('91-'93)	DMR Avg	0.03	22					47

Notes:

n: number of data points; The numbers in parentheses are the years the data was accumulated.

DMR: Discharge Monitoring Report

*: CBOD5 for Sampling Avg

The shaded numbers indicate that the permitted concentrations have been exceed.

Table 5-17. Municipal Wastewater Treatment Facilities
Diluted Concentrations

Facility		Dilution Factor	BOD5 mg/L	Fecal Coli. #/100mL (Geo. Mean)	NH3-N mg/L	P mg/L	SS mg/L
Water Quality Standards (EPD 1995)				200			
Drinking Water Standards (Pontius 1996)				0*	0.5****	5****	
Baldwin	Diluted Permit	2.5	11.9	80			12
(Interp)	Diluted DMR	3.0	6.3	40			10
	Dilute Sampling	3.1	20.7	73	4.0	2.1	23
Clarkesville	Diluted Permit	40	0.8	5	0.4		1
	Diluted DMR	103	0.2	0.4	0.2		0.2
	Dilute Sampling	105	0.3	5	0.1	0.02	0.4
Cleveland	Diluted Permit	6	3.4	34	1.7		5
	Diluted DMR	12	1.1	2	0.8		1
	Dilute Sampling	9	1.4	2	0.3	0.2	2
Cornelia	Diluted Permit	1.2	25.0	167	1.3		25
(Interp)	Diluted DMR	1.3	14.8	90	20.4	1.7	12
	Dilute Sampling	1.2	4.8	4	16.8	1.0	18
Dahlonega	Diluted Permit	19	1.6	11	0.9		2
	Diluted DMR	24	0.2	0.4	0.03		0.2
	Dilute Sampling	24	0.2	13	0.03	0.1	0.2
Demorest	Diluted Permit	15	2.0	14			
(Interp)	Diluted DMR	80	0.1	0.2			0.1
	Dilute Sampling	92	0.04	22		0.01	30
Flowery Branch***	Diluted Permit	30	0.3	7	0.1	0.03	1
	Diluted DMR	30	0.2	1	0.02	0.02	0.2
	Dilute Sampling	30	0.4	0.2	0.2	0.1	1
Gainesville **	Diluted Permit	2	10.1	101		0.5	15
Flat Creek	Diluted DMR	2	2.4	2	0.1	0.2	6
	Dilute Sampling	2	1.4		0.3	0.1	1
Gainesville***	Diluted Permit	30	1.0	7	0.6		1
Linwood	Diluted DMR	30	0.6	0.1	0.4	0.1	0.4
	Dilute Sampling	30	0.6		0.3	0.1	1
Lake Lanier Islands	Diluted Permit	30	1.0	7			1
***	Diluted DMR	30	0.2	2			0.3
Lula	Diluted Permit	10	3.0	20			9
(Interp)	Diluted DMR	9	2.5				5

Notes:

Dilution Factor = (Q7 + Qe) / Qe; where Q7 = 7Q10 flow and Qe = effluent flow
Q7 = 7Q10 flow
Qe (permit) = permitted effluent flow; Qe (DMR) = average DMR flow;
Qe(sampling) = average sampling flow

Interp: 7Q10 value from interpolation based on drainage areas

*: Maximum Contaminant Level Goal in drinking water standards

**: stream flow data based on average of flow values found in 1991 (Hatcher et al., 1994)

***: discharges into lake, assume 30 fold dilution. Dilution factor into stratified lakes should be
DF = 0.28 * X / D; where x = distance of mixing and D = diameter of pipe

****: European Economic Comunity (EEC) Std and/or
World Health Organization (WHO) Standard (AWWA 1990)

Typical Pollutants and Concentrations

Facility		Flow MGD	Al mg/L	Sb mg/L	As mg/L	Be mg/L	BOD5 mg/L	Bromide mg/L	Cd mg/L	Cl mg/L	Cr,Tot mg/L	COD mg/L	Cu mg/L	Cyanide mg/L	F. Coli #/100mL	Flouride mg/L	Fe mg/L	Pb mg/L
Buckhorn Minerals	Permit Conc	0.65																
	DMR Avg	0.02					5	1		1.3		5			41	0.3		
Davidson Minerals	Permit Conc	2.59																
n = 1 ('95)	DMR Avg	1					BDL					BDL						
Habersham Mills	Permit Conc	0.009													200			
n=2	DMR Avg	0.003	14				13			0.5		46			10		0.51	
High Point Minerals	Permit Conc	0.002																
	DMR Avg																	
JA Hudson Const.	Permit Conc																	
	DMR Avg																	
Scovill Inc.	Permit Conc	0.27		2.13					0.26		1.71		2.07	0.65				0.43
n = 5	DMR Avg	0.12		1.538					<0.01	0.04	0.17		0.8	<0.01			0.31	<0.01
	Sampling Avg				0.003	0	41		<0.001		0.014		0.19		<1			0
SKF Bearing	Permit Conc	0.02																
n = 1 ('93)	DMR Avg	0.018					11					28						

Facility		Hg mg/L	Ni mg/L	N, Tot mg/L	NH3-N mg/L	O&G mg/L	pH Min	pH Max	Phenol mg/L	P, T mg/L	SS mg/L	Se mg/L	Ag mg/L	Sulfate mg/L	Sulfide mg/L	Tl mg/L	TOC mg/L	Zn mg/L
Buckhorn Minerals	Permit Conc						6.0	9.0			55							
	DMR Avg			0.3	0.2	5	6			0.1	15							
Davidson Minerals	Permit Conc						6.0	8.5			55							
n = 1 ('95)	DMR Avg				0.2	8		8.4			21						3	
Habersham Mills	Permit Conc						6.0	9.0			30							
n=2	DMR Avg			3	5.1 / 0.5	1.8	7	6.6		1.1	9			60.3			10	0.11
High Point Minerals	Permit Conc																	
	DMR Avg																	
JA Hudson Const.	Permit Conc																	
	DMR Avg																	
Scovill Inc.	Permit Conc		2.38			26					31		0.24					1.48
n = 5	DMR Avg		1.17		0.09	16.7				6.57	5		<0.03	947		<0.02		0.22
	Sampling Avg	< 0.000	0.38		0.79					3.38	3	<0.00	<0.0001				26	0.15
SKF Bearing	Permit Conc																	
n = 1 ('93)	DMR Avg				0.7	6.0		7.0									6.5	

Notes:

BDL: Below Detection Limit

DMR: Discharge Monitoring Reports

O & G: Oil and Grease

Diluted Concentrations

Facility		Dilution Factor	Al mg/L	Sb mg/L	As mg/L	Be mg/L	BOD5 mg/L	Bromide mg/L	Cd mg/L	Cl mg/L	Cr,Tot mg/L	COD mg/L	Cu mg/L	Cyanide mg/L	F. Coli #/100ml	Flouride mg/L	Fe mg/L
Water Quality Standards (EPD, 1995)				4.308	0.0001				0.0007		0.011		0.12	0.0065	200		
Drinking Water Standards (Pontius, 1996)			0.2***	0.006	0.05	0.004			0.005	4.0	0.1		1.3*	0.2	0*	4	0.2 ****
Buckhorn Minerals **	Diluted Permit	3															
	Diluted DMR	66					0.08	0.02		0.02		0.08			0.62	0.005	
Davidson Mineral	Diluted Permit	3															
(Interp)	Diluted DMR	6															
Habersham Mills	Diluted Permit	3990													0.05		
	Diluted DMR	11960	0.001				0.001			4E-05		0.004			0.001		4.3E-05
High Point Minerals	Diluted Permit	710															
	Diluted DMR																
JA Hudson Const.	Diluted Permit																
(Interp)	Diluted DMR																
Scovill Inc.	Diluted Permit	130		0.016					0.002		0.013		0.015923	0.005			
n = 5	Diluted DMR	300		0.005					3E-05	0.0001	0.0006		0.002658	3E-05			0.00103
	Diluted Sampling	300			1E-05	4E-07	0.1367				5E-05		0.000645				
SKF Bearing **	Diluted Permit	270															
	Diluted DMR	300					0.04					0.09					

Facility		Pb mg/L	Hg mg/L	Ni mg/L	N, Tot mg/L	NH3-N mg/L	O&G mg/L	Phenols mg/L	P, Tot mg/L	SS mg/L	Se mg/L	Ag mg/L	Sulfate mg/L SO4	Sulfide mg/L	Tl mg/L	TOC mg/L	Zn mg/L
Water Quality Standard		0.0013	1E-05	0.088				0.3			0.005				0.048		0.06
Drinking Water Standard		0*	0.002	0.1	10	0.5 ****		.0005***	5 ****		0.050	0.01 ***	500	.05 ***	0.002		5 ***
Buckhorn Minerals **	Diluted Permit									18							
	Diluted DMR				0.005	0.003	0.0762		0.002	0.2							
Davidson Mineral	Diluted Permit									18							
(Interp)	Diluted DMR					0.0308	1.2			3						0.4623	
Habersham Mills	Diluted Permit									0.008							
	Diluted DMR				0.0003		0.0002		9E-05	0.001			0.005042			0.0008	9.2E-06
High Point Minerals	Diluted Permit																
	Diluted DMR																
JA Hudson Const.	Diluted Permit																
(Interp)	Diluted DMR																
Scovill Inc.	Diluted Permit	0.003		0.0183		0	0.2			0.2385		0.002					0.01138
	Diluted DMR	3E-05		0.0039		0.0003	0.0557		0.0219	0.0169		1E-04	3.157492		7E-05		0.00072
	Diluted Sampling	5E-06		0.0013	0	0.0026			0.0113	0.01						0.0867	0.0005
SKF Bearing **	Diluted Permit																
	Diluted DMR					0.0022	0.02									0.0217	

Notes:
DMR: Discharge Monitoring Report
O&G: Oil and Grease
n: number of data points; The numbers in parenthesis are the years the data was accumulated.
Interp: interpolated values based on drainage areas
*: Maximum Contaminant Level Goal in drinking water standards
**: stream flow data based on minimum flow encountered in 1991 sampling (Hatcher et al., 1994)
*** World Health Organization guideline **** European Economic Community max (AWWA, 1990)

quality due to the duckweed. All the permit requirements were met on the days sampling was conducted.

The influent to **Cornelia**'s trickling filter plant consists of approximates 60% poultry waste and 40% domestic waste. The ammonia permit level was exceeded significantly on every sampling day (12 days). The average concentration from sampling (21 mg/L) is consistent with the DMR report average (26.7 mg/L). This facility has had chronic ammonia toxicity problems. Otherwise, the facility seems to be meeting all its requirements.

Dahlonega operates an activated sludge oxidation ditch facility. The permit requirements of pollutants analyzed were not exceeded on the days of sampling. They are currently building an extension of the plant to upgrade it to a larger flow.

Activated sludge and polishing ponds are used at the **Demorest** plant. This facility also does not have a full time operator. The duties of overseeing and monitoring the site has been contracted out to a neighboring town. The permit requirements were not surpassed during the days of sampling.

Flowery Branch utilizes the activated sludge process. During the period of sampling (3 days), the ammonia permit requirement was not met. On one date the BOD5, ammonia, phosphorus and suspended solids permit limits were not met. These values are in contrast to the average concentrations from the DMR data. However, the plant was experiencing difficulty during this time (especially on the first sampling date) due to belated sludge removal. This problem was resolved after the period of sampling occurred. On an inspection during a visit to the facility on a later date, the effluent water quality visually appeared to be better. However, there could be a problem with the ammonia concentrations from this plant.

Gainesville's **Flat Creek** facility is the largest wastewater treatment facility in the watershed. It is permitted for 7 MGD, and is, thus, the target of many investigations into water quality. Because of its location, 70% of its influent is from industrial sources. The results from the sampling show that this facility is meeting its permit requirements exceptionally well. In fact, they are already meeting their stringent future permit requirements.

The **Linwood** plant in Gainesville uses trickling filters. This facility appears to be operating well. The BOD5 and suspended solids permit limits were exceeded only once during the long sampling period.

Scovill Inc. is a manufacturer of zippers, buttons, and snap fasteners. The wastewater is generated from plating, parts cleaning and copper-blackening activities. Treatment consists of pH adjustment, chlorination, chromate reduction, clarification, neutralization and filtration. During the period of sampling, the facility appears to have had difficulty meeting the phosphorus requirements on six dates. On one occasion the suspended solids limit was exceeded. The nitrate concentrations appear to be very large. It is possible that the composition of the waste (as indicated by the high conductivity readings) is such that it causes interferences with the electrode probe used to measure nitrate. Because of these concerns, the nitrate data is not included here but is available in Appendix 5-B. If nitrate reduction at this plant is considered a major objective of future treatment, then additional research to pinpoint the errors due to interference from high conductivity need to be studied.

Urban Runoff Results

A summary of the results obtained from the urban stormwater runoff sampling is shown in Table 5-20. The values seem to be typically of urban runoff. The pesticides (carbaryl, diazinon, dursban, and malathion) concentrations were below the detection limit in all samples analyzed. Mercury was measured using a Perkin-Elmer Mercury analyzer. All of the samples were below the detection limit of 0.2 ug/L. As expected, the urban runoff is contributing significant amounts of particulate matter (as represented by Total Suspended Solids, TSS). This is important because siltation is often one of greatest threats to a lake's health.

Table 5-20. Urban Runoff Summary

Parameter	Units	Minimum	Maximum	Average
NH3	mg N/L	0.37	3.55	1
NO3-	mg N/L	0.19	8.24	3.8
NO2-	mg N/L	< 0.01	0.19	0.03
P	mg P/L	0.04	1.15	0.45
TSS	mg/L	8	444	96
Conductivity	umohs/cm	82	311	168
Mercury	ug/L		< 0.2	< 0.2
Turbidity	NTU	33	198	79
Carbaryl	ug/L		< 1	< 1
Diazinon	ug/L		< 0.5	< 0.5
Dursban	ug/L		< 0.5	< 0.5
Malathion	ug/L		< 1.4	< 1.4
Barium	ug/L	20	158	55
Zinc	ug/L	33	97	63

Trace Metals Analysis Results

Inductively coupled plasma mass spectrometry allows the simultaneous determination of trace metals at the parts per billion level. In this project, samples of wastewater treatment effluent and stream water were analyzed for total recoverable arsenic (As), selenium (Se), chromium (Cr), nickel (Ni), copper (Cu), zinc (Zn), cadmium (Cd), barium (Ba) and lead (Pb). Mercury was not analyzed via ICP-MS. Mercury was measured using a Perkin-Elmer mercury analyzer. The results are presented in the previous section (all samples were less than the detection limit of 0.2 ug/L). The reported detection limits (RDLs) and method detection limits (MDLs) are shown in Table 5-21. Detection limits for ICP-MS were generally at least an order of magnitude smaller than the detection limits reported in the EPD files allowing the maximum contaminant loading of low concentration elements to be more accurately estimated.

Table 5-21 ICP-MS Detection Limits:
Reported and Method Detection Limits (RDLs and MDLs) for EPA Method 200.8

Element	Reported detection limit		EPA 200.8 estimated detection limit	
	Dilution	RDL (μg/L)	Dilution factor	MDL (μg/L)
As	1	1.4	1.25	1.4
Se	1	1.4	1.25	7.9
Cr	5	2.4	1.25	0.4
Ni	5	2.5	1.25	0.5
Cu	5	2.2	1.25	0.5
Zn	5	22.7	1.25	1.8
Cd	5	1.0	1.25	0.5
Ba	5	1.0	1.25	0.8
Pb	5	1.5	1.25	0.3

Two types of analyses were carried out: semi-quantitative and quantitative. The Elan 5000 TotalQuant II option was used to scan selected samples over wide mass ranges to determine which metals were present in significant concentrations and to identify potential interferences. In this analytical mode, the instrument is calibrated using a blank, a single multielement standard containing only a few of the elements analyzed for and a preprogrammed table of instrument response ratios for the entire mass spectrum.

Quantitative analysis requires the instrument to be directly calibrated for each analyte measured. A blank and two non-zero standards within the linear response range for the instrument were used to calibrate each element.

The analyses were conducted in three groups: arsenic and selenium analysis, semiquantitative scans, and quantitative scans. The results are presented in Appendix 5-B. A sampling of the results are presented in the ensuing discussion.

Arsenic and Selenium Results

First, all the effluent samples were analyzed for arsenic and selenium. Table 5-22 shows the tier one facility results from the arsenic and selenium analyses respectively. No As and Se were detected in any of the WWTP effluents except for As at Scovill. Samples from Scovill were reanalyzed to confirm the presence of As and the data was reproducible and is shown in Table 5-22.

Table 5-22 Arsenic in Tier One Facilities' Effluent (μg/L)

Facility	Clarkesville	Cornelia	Flat Creek	Linwood	Scovill
11/16/95					4.7
12/11/95			< 1.4		4.2
12/18/95	< 1.4	< 1.4	< 1.4	< 1.4	1.9
1/2/96	< 1.4	< 1.4	< 1.4	< 1.4	1.5
1/19/96	< 1.4	< 1.4		< 1.4	2.4
2/9/96	< 1.4	< 1.4	< 1.4	< 1.4	2.1
3/15/96	< 1.4	< 1.4	< 1.4	< 1.4	2.9
3/28/96	< 1.4	< 1.4	< 1.4	< 1.4	4.1

Semiquantitative Scans

Table 5-23 shows results of the semiquantitative scans conducted for the tier one facilities. Semiquantitative scans of the WWTP effluents indicated that trace metal concentrations were low (generally < 20 ppb) with the exception of Mn and Zn in most of the samples and Cu, Ni and Zn in samples taken at Scovill. Ba concentrations of up to 30 ppb were measured in some samples. The samples from each stream in the study were scanned (see Appendix 5-C) and based on the results it was decided to analyze the stream samples for the same nine elements as the effluent samples.

Table 5-23 Semiquantitative Scan Results for Tier One Facilities (μg/L)

Facility	Clarkesville		Cornelia		Flat Creek		Linwood	Scovill
Date	12/11/95	1/19/96	1/2/96	3/15/96	2/9/96	3/28/96	1/2/96	12/11/95
Sb	< 0.01	<0.01	< 0.01	<0.01	<0.01	< 0.01	<0.01	0.14
Ba	20.26	28.25	5.61	9.11	4.56	8.17	26.89	1.34
Be	0.02	0.02	0.02	0	0	0	<0.01	0.11
Cd	0.36	0.3	0.03	0.16	0.06	0.06	0.13	0.05
Cr	0.86	1.96	0.89	0.48	0.51	0.81	1.34	1.59
Co	0.3	0.47	1.56	1.76	0.71	0.87	0.5	0.23
Cu	21.19	23.59	3.3	3.09	3.43	5.26	20.88	219.7
Pb	3.5	5.35	0.57	1.31	1.23	1.99	8.87	1.44
Mn	24.86	39.11	137.8	162.3	73.4	137.5	60.9	1.89
Mo	3.96	1.61	2.29	1.14	13.19	24.82	0.9	41.94
Ni	2.31	2.54	8	4.06	8.93	6.06	2.49	441.2
Ag	0.05	0.01	< 0.01	<0.01	<0.01	< 0.01	0.04	<0.01
V	18.93	3.28	14.77	0.55	3.27	17.98	0.59	10.81
Zn	223.1	73.92	50.46	48.51	73.38	68.45	71.33	213

Quantitative Analyses

It was finally decided to measure Cr, Ni, Cu, Zn, Cd, Ba and Pb quantitatively. Cr was included in the analysis since the Scovill effluent includes wastewater from chromating. Cd and Pb were included because the state instream 7Q10 regulatory limits are very low (0.7 and 1.3 ppb respectively). Since metals concentrations in the municipal WWTP effluents were generally low, only two samples - representing average and worst case conditions based on other parameters measured - were analyzed. The results from the tier one facilities and the urban runoff are shown in Tables 5-24 and 5-25 respectively. Metal levels in samples taken on different days from the same facility or stream were generally fairly close. Zinc showed the greatest fluctuation in samples between days.

Table 5-24 a) Quantitative Analysis of Effluents from Tier One Facilities (μg/L)

Facility	Clarkesville		Cornelia		Flat Creek		Linwood	
Date	1/2/96	2/9/96	2/9/96	3/15/96	2/9/96	3/15/96	1/19/96	3/15/96
Cr	2.9	< 2.4	< 2.4	< 2.4.	< 2.4.	< 2.4.	3.9	< 2.4.
Ni	2.9	6.6	7.1	4.7	9.7	6.2	3.6	4.1
Cu	40	39	7.5	5.7	5.1	11	25	33
Zn	124	312	69	67	112	110	86	118
Cd	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ba	23	25	5.6	9.2	9	8.3	41	46
Pb	4.4	6.2	< 1.5	1.5	2.2	2.4	13	14

Table 5-24 b) Quantitative Analysis of Effluent from Scovill (μg/L)

Date	12/18/95	1/2/96	1/19/96	2/9/96	3/15/96	3/28/96
Cr	86	3.7	6	3.1	2.9	5.1
Ni	199	154	638	483	171	561
Cu	93	166	320	221	108	218
Zn	438	69	135	163	75	105
Cd	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ba	5.1	5.6	2.6	1.9	1.5	1.3
Pb	< 1.5	< 1.5	2.5	1.6	< 1.5	< 1.5

Table 5-25 Quantitative Analysis of Urban Runoff (μg/L)

Stream	South Flat Creek			Limestone Creek		Six Mile Creek	
Date	4/30/96	5/28/96	6/12/96	5/28/96	6/12/96	5/28/96	6/12/96
As	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	1.5	< 1.4
Se	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4
Cr	< 2.4	< 2.4	3.5	< 2.4	< 2.4	< 2.4	12
Ni	3.8	3.6	4.8	< 2.5	< 2.5	< 2.5	5.8
Cu	8.9	9.7	5.7	8.3	6.1	10	12
Zn	65	97	50	58	33	85	73
Cd	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ba	21	20	34	22	27	100	158
Pb	9.1	4.6	5.7	1.8	9.0	2.8	10

Split Samples

Due to non-availability of the instrument, it was not possible to complete all the analyses at Georgia Tech. Therefore, the stream samples and selected effluent samples were prepared for analysis at Georgia Tech and then sent to the Department of Crop and Soil Sciences at the University of Georgia for analysis. In order to assess reproducibility and quality assurance in the analyses, four split samples were analyzed at the two laboratories for several metals. Results for the split samples from Georgia Tech and the University of Georgia (shown in Table 5-26) agreed very well except for Cu and Zn which were different by up to 25 ug/L. This may have been due to contamination or interference problems. However, the uncertainty in these data is probably not significant compared to other factors in the loading calculations.

Table 5-26 Georgia Tech and UGA Results for Split Samples (μg/L)

Facility	Baldwin		Dahlonega		Linwood		Scovill	
Date	4/11/96		4/11/96		3/15/96		1/2/96	
Laboratory	Georgia Tech	UGA	Georgia Tech	UGA	Georgia Tech	UGA	Georgia Tech	UGA
As	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	1.5	1.8
Se	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	1.6	< 1.4	< 1.4
Cr	2.7	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	3.7	2.9
Ni	8.1	7.8	< 2.5	3.2	4.1	3.9	154	151
Cu	22	14	12	6.4	33	25	166	142
Zn	83	62	66	41	118	114	69	53
Cd	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ba	24	23	6.5	5.9	46	42	5.6	5.1
Pb	2.7	2.3	< 1.5	< 1.5	14	13	< 1.5	< 1.5

Summary of Trace Metals Analysis

Mercury, cadmium (RDL = 0.5 ug/L) and selenium (RDL = 1.4 ug/L) concentrations were below the detection limit in all samples. Arsenic was detected in effluent from Scovill only and concentrations were very low (<5 ug/L). A summary of the remaining metals concentrations from all the facilities is presented in Table 5-27. Since metal concentrations are often related to stream flows, hence the average metal concentrations in Table 5-27 are flow weighted averages.

Table 5-27 Summary of Average Metals Concentrations (μg/L)

	Cr	Ni	Cu	Zn	Ba	Pb
WWTPs						
Baldwin	3.0	8.0	21.7	127.5	40.1	3.6
Clarkesville	<2.4	5.1	39.6	236.7	24.1	5.5
Cleveland	<2.4	3.6	14.4	42.1	8.1	<1.5
Cornelia	<2.4	5.9	6.6	67.6	7.4	<1.5
Dahlonega	<2.4	2.6	15.0	70.8	12.4	<1.5
Demorest	<2.4	<2.5	12.2	79.9	25.6	1.5
Flat Creek WWTP	<2.4	8.1	7.6	110.9	8.7	2.3
Flowery Branch	8.2	3.4	26.3	52.6	18.7	2.4
Linwood	3.0	3.8	28.8	100.5	43.2	13.9
Scovill	13.8	381.0	193.3	149.3	2.8	1.5
Stormwater Runoff						
S. Flat Creek	<2.4	4.2	7.6	67.9	27.1	6.0
Limestone Creek	<2.4	<2.5	6.9	42.1	25.0	6.2
Six Mile Creek	7.9	4.6	11.0	77.0	137.9	7.6

Measurements of chromium were all below 10 µg/L except in one sample taken at Scovill on 18 December 1995 in which 86 µg/L was measured. The Scovill effluent is expected to contain chromium since it includes wastewater from chromating. However, it appears that chromium removal is usually very efficient. Overall the chromium load from Scovill was small compared to those from the three largest municipal facilities, Flat Creek, Linwood and Cornelia which in turn were small compared to the load due to stormwater runoff from the creeks.

Nickel and copper concentrations were less than 10 and 50 µg/L respectively except at Scovill. The largest nickel loads came from Scovill, Flat Creek WWTP, South Flat Creek and Six Mile Creek. The largest copper loads were from Flat Creek WWTP and the three creeks. Lead concentrations were less than 10 µg/L except at Linwood where up to 14 µg/L was measured. Linwood and Flat Creek WWTP accounted for almost all the lead from the facilities but their contribution was small compared to the stormwater runoff.

Barium and zinc loads were an order of magnitude greater than those of the other metals. Zinc was the most abundant metal and showed the most variation in samples taken from the same source. The three largest treatment plants and the stormwater runoff accounted for almost all the zinc load. Barium concentrations ranged between 5 and 55 µg/L for the municipal WWTP's and two urban runoff streams but were less than 5 µg/L in Scovill. Up to 158 µg/L barium was measured in Six Mile Creek. The contribution of effluent discharges to the barium load was small compared to the stormwater runoff.

Maximum Diluted Concentrations

Maximum diluted concentrations in Table 5-28 were estimated based on the maximum concentration measured at a given facility and the minimum dilution permit. The dilution permit was calculated as the sum of the permit discharge rate for the plant and 7Q10 flow for the receiving stream (or average flow if low flow data was not available) divided by the permit discharge flow. A dilution factor of 30 was assumed for the two facilities, Linwood and Flowery Branch, discharging directly into the lake. If all measured concentrations were below the detection limit, the detection limit concentration was used. Results were compared with state instream 7Q10 water quality standards. Note that these calculations do not take into account the background concentrations of metals in the streams and consequently, only represent the contribution of the facilities to the total downstream concentration. Based on the available information, it appears that all the facilities except Baldwin are meeting discharge standards. Flat Creek might have problems with copper, zinc and lead since these elements are ubiquitous and its permit dilution factor is only 2.

Table 5-28 Diluted Metals Concentrations for Municipal WWTPs (µg/L)

Tier One Facilities

Facility	Clarkesville	Cornelia	Flat Creek	Linwood	Scovill	State 7Q10
Dil. permit	40	6	2	30	134	
Cr	0.1	0.4	1.2	0.1	0.6	120.0
Ni	0.2	1.2	4.9	0.1	5.0	88.0
Cu	1.0	1.3	5.5	1.1	2.4	6.5
Zn	7.8	11.5	56.0	3.9	3.3	60.0
Cd	0.0	0.2	0.5	0.0	0.0	0.7
Pb	0.2	0.3	1.2	0.5	0.0	1.3

Table 5-28 Diluted Metals Concentrations for Municipal WWTPs (μg/L) cont.

Tier Two Facilities

Facility	Baldwin	Cleveland	Dahlonega	Demorest	Flowery Branch	State 7Q10
Dil. permit	2.51	6	19	11	30	
Cr	1.3	0.4	0.1	0.2	0.3	120.0
Ni	3.2	0.6	0.2	0.2	0.1	88.0
Cu	8.8	2.5	0.9	1.2	0.9	6.5
Zn	66.1	8.8	3.9	9.5	1.8	60.0
Cd	0.4	0.2	0.1	0.1	0.0	0.7
Pb	1.8	0.3	0.1	0.2	0.1	1.3

5.5. LOADING CALCULATIONS

General Methodology

Several different analyses were conducted to determine the loading of various pollutants into Lake Lanier. Individual pollutant measurements are best analyzed using log-normal techniques. However, it has been found that the averages of those individual measurements can be modeled by the normal distribution (USEPA, 1991). According to the Central Limit Theory the data set needs to be larger than ten to assume that this average is approximately normally distributed. Thus, all of the loading calculations for this study assume normal distribution. This assumption seems to be accurate for the data sets used in these analyses. Different loading values were calculated based on permit, discharge monitoring reports (DMRs) and sampling data. An explanation of the computations is explained below.

Permit/Max Values: For facilities and pollutants where permitted concentrations were given, a loading was calculated based on the permitted concentration and flow. This represents a maximum allowable loading from a source. When a permitted value was not given, an estimated maximum concentration (based on permit values for other facilities) was used for the purposes of calculating a loading from all facilities.

Monitoring/Average Values: For the facilities and parameters that DMR data was available in files at EPD, the weighted average of concentration and flow were used to calculate an average loading for the site. Flow-weighted averages of the pollutant concentrations were used because varying flow conditions can significantly affect the calculations of the average concentrations. Where DMR data was not available, average concentrations (based on a flow-weighted average of concentrations from other facilities) were used to compute loadings from the rest of the facilities.

Sampling Values: Because the DMR data is not complete, not always up-to-date, and subject to analysis bias of the facilities, loadings were also calculated from the sampling data from this report. Again, flow-weighted averages of the parameter concentration and flows were used to calculate the loading. For the facilities that were not sampled, the values used for the loadings were based on DMR data. The calculations of total loadings into Lake Lanier by various pollutants are presented in Appendix 5-D.

Stormwater Values: The loading of each pollutant was determined based upon the concentration of pollutants and typical rainfall data for a year. The pollutant concentration used was the average concentration from the stormwater sampling program, weighted according to rainfall. The loading of the pollutant was calculated for each day during a typical year, based upon rainfall data for a typical year. These loadings were then summed to determine the total pollutant loading during a year. The loadings were computed using the following equation:

$$L = A * Pe * C * 0.262$$

where L represents the loading of the pollutant in kg. The area of the watershed feeding the stream (A, hectares) was determined from the previous Diagnostic/Feasibility Study of Lake Lanier (Hatcher, 1994). The concentration of the pollutant is represented by the variable C (mg/L). The factor 0.262 is a unit conversion factor. The direct runoff, Pe (inches), was calculated using the SCS method for abstractions (Chow, 1988). The method determines Pe using the following equation:

$$Pe = \frac{(P - 0.2 * S)^2}{P + 0.8 * S}$$

Depth of precipitation data, P (inches), were obtained from the Southeast Regional Climate Center for the Gainesville, GA station. The potential maximum retention, S, was calculated from the following equation:

$$S = \frac{1000}{CN} - 1$$

where CN is the curve number for the watershed. The curve number is a dimensionless number between zero and one hundred (impervious surface). Curve numbers are tabulated by the Soil Conservation Service based upon the soil type and land use. The percent land use (forest, pasture, residential, urban) for each watershed was obtained from the Diagnostic/Feasibility Study of Lake Lanier (Hatcher, 1994). Using the percent land use values and associated curve numbers (from Chow, 1988), a weighted average curve number was calculated for each watershed. Hydrologic soil group values for "C" (clay loams, shallow sandy loam, soils low in organic content, and soils usually high in clay) were assumed.

Note that all the loadings calculated under the title "urban runoff" only represent the contribution from the three streams that were sampled as a part of this project. The actual loadings from all urban runoff in the watershed would be higher.

For the trace metal loadings, all measured concentrations were included in the calculation of the flow weighted averages and annual loadings, including those concentrations below the detection limit. The rationale behind this was that excluding such values or replacing them with the detection limit would inflate the calculated average while setting them equal to zero would result in an under estimate. It was assumed that the instrument response was the best available estimate of the true value.

Results of Loading Calculations

A summary of the loading calculations is presented in this section. For more specific information see Appendix 5-D. The average annual loadings are based upon the results from the sampling data. The range of pollutant loadings are based upon the average annual loadings plus and minus the standard deviation.

Biochemical Oxygen Demand

As can be seen from the summary of CBOD5 loadings in Table 5-29, the largest portion of CBOD5 comes from the urban runoff and municipal wastewater treatment facilities. The concentration of CBOD5 from urban runoff was based on a typical value (12 mg/L) from the literature (Woodward-Clyde, 1990). Based on this information, a reasonable range for CBOD5 loading into the lake would be 250,000 to 360,000 kg/yr. The maximum allowable loading would be around 924,000 kg/yr according to permits. The most probable loading is 306,000 kg/yr. Figure 5-8 shows the relative contribution of CBOD5 from the point sources.

Table 5-29. CBOD5 Loading Summary

Source	Max/Permit Loading (kg/yr)	Monitoring Data Loading (kg/yr)	Std. Deviation (kg/yr)	Sampling Data Loading (kg/yr)	Std. Deviation (kg/yr)	% of Total from Sampling Loading Data
Municipal WWTP	600,000	160,000	68,000	143,000	53,000	47
PIDs	31,000	3,000	2,000	(3,000)		1
Industrial WWTP	40,000	14,000	4,000	8,000	3,000	2.5
Urban Runoff*	250,000	150,000		(150,000)		49
Septic Tanks	3,000	2,000		(2,000)		0.5
TOTAL	924,000	329,000	74,000	306,000	56,000	

Note: Figures in parenthesis indicate that the number was taken from a different column because data were not available for that calculation. For example, PIDs were not sampled so the average loading from the DMR data (3,000) was transferred to the sampling data column so that total loadings could be calculated.

*: Urban runoff only for three streams.

Total Organic Carbon

The only total organic carbon (TOC) data that was available was from the sampling conducted. However, "maximum" and "average" values were determined using a factor based on the CBOD5 from permit values and DMR data respectively. Table 5-30 shows that the largest contribution is from the municipal facilities. Thus, a reasonable range of TOC loading is 79,000 to 149,000 kg/yr. The most likely loading is 114,000 kg/yr.

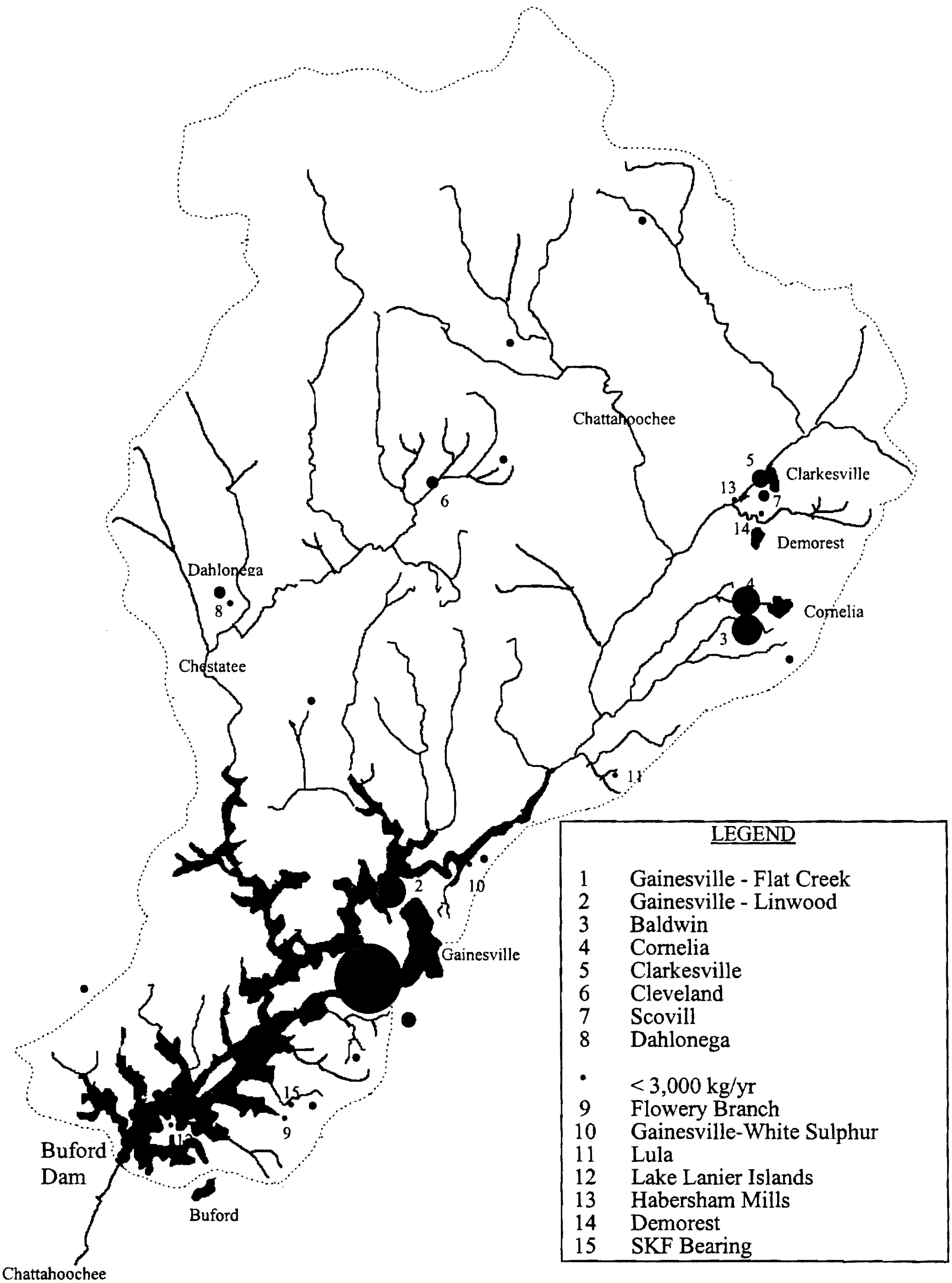

Figure 5-8. CBOD5 Loading

Table 5-30. Total Organic Carbon Loading Summary

Source	Maximum Loading (kg/yr)	Average Loading (kg/yr)	Sampling Data Loading (kg/yr)	Std. Deviation (kg/yr)	% of Total from Sampling Loading Data
Municipal WWTP	400,000	112,000	100,000	33,000	88
PIDs	23,000	5,000	(5,000)		4
Industrial WWTP	25,000	9,000	9,000	2,000	8
TOTAL	448,000	126,000	114,000	35,000	

Fecal Coliforms

Data were available for fecal coliform concentrations in the effluent of the various facilities. However, an accurate loading cannot be calculated based on the concentration and flow because the coliforms will die-off with time and environmental conditions. A typical equation for bacterial die-off is rate of die-off, $r_B = -K_B * C_B$, where K_B = first order rate constant and C_B is the concentration of the bacteria. According to Metcalf and Eddy (1991), typical values of K_B range from 0.12 to 26 d^{-1} with a median of 1 d^{-1}. If a value of 1 d^{-1} is used, one can see that the result is an output of zero coliforms. This makes sense, because eventually all the coliforms will die. The time required for 90% bacterial death is generally accepted to be 2.3 d. It is possible to estimate how long it takes for the coliforms to reach the lake and thus estimate the loading into the lake. However, without the dimensions and flows of all the streams, it is not appropriate to make these calculations. A much more intensive sampling and analysis of rate of die-off are necessary for making these calculations. Because most facilities are meeting their regulatory requirements, it is assumed that the contribution of fecal coliforms into the lake is manageable.

Nitrogen

Nitrogen loading is of concern to the lake because excess nitrogen can cause eutrophication. Nitrogen occurs in the forms of organic nitrogen, ammonia, nitrate and nitrite. For wastewater treatment facilities, the parameter of concern is ammonia. It is assumed that organic nitrogen is negligible because it is converted to ammonia during the treatment processes. Thus, the permit and DMR data have information only on the ammonia form. In the sampling program ammonia, nitrate and nitrite were measured. Loadings have been calculated for ammonia and total nitrogen. For the ammonia calculations, the amount contributed due to septic tanks is unknown because the methods of determination are based on total nitrogen. If one assumes that the percentage of the septic tanks to the total for total nitrogen and ammonia is the same, then estimates of the ammonia contribution can also be determined. Table 5-31 displays a summary of the ammonia loadings. A schematic figure showing the mass loadings of ammonia from the major sources is shown in Figure 5-9.

Table 5-31. Ammonia Loading Summary

Source	Max/Permit Loading (kg/yr)	Monitoring Data Loading (kg/yr)	Sampling Data Loading (kg/yr)	Std. Deviation (kg/yr)	% of Total from Sampling Loading Data
Municipal WWTP	390,000	112,000	110,000	60,000	80
PIDs	20,000	5,000	(5,000)		4
Industrial WWTP	1,000	700	800	100	0.5
Urban Runoff *	(12,000)	(12,000)	12,000		8.5
Septic Tanks**			*9,600*		7
TOTAL	423,000	130,000	137,400	60,000	

*: Urban runoff only for three streams.
** Estimated on the basis of 7% of total.

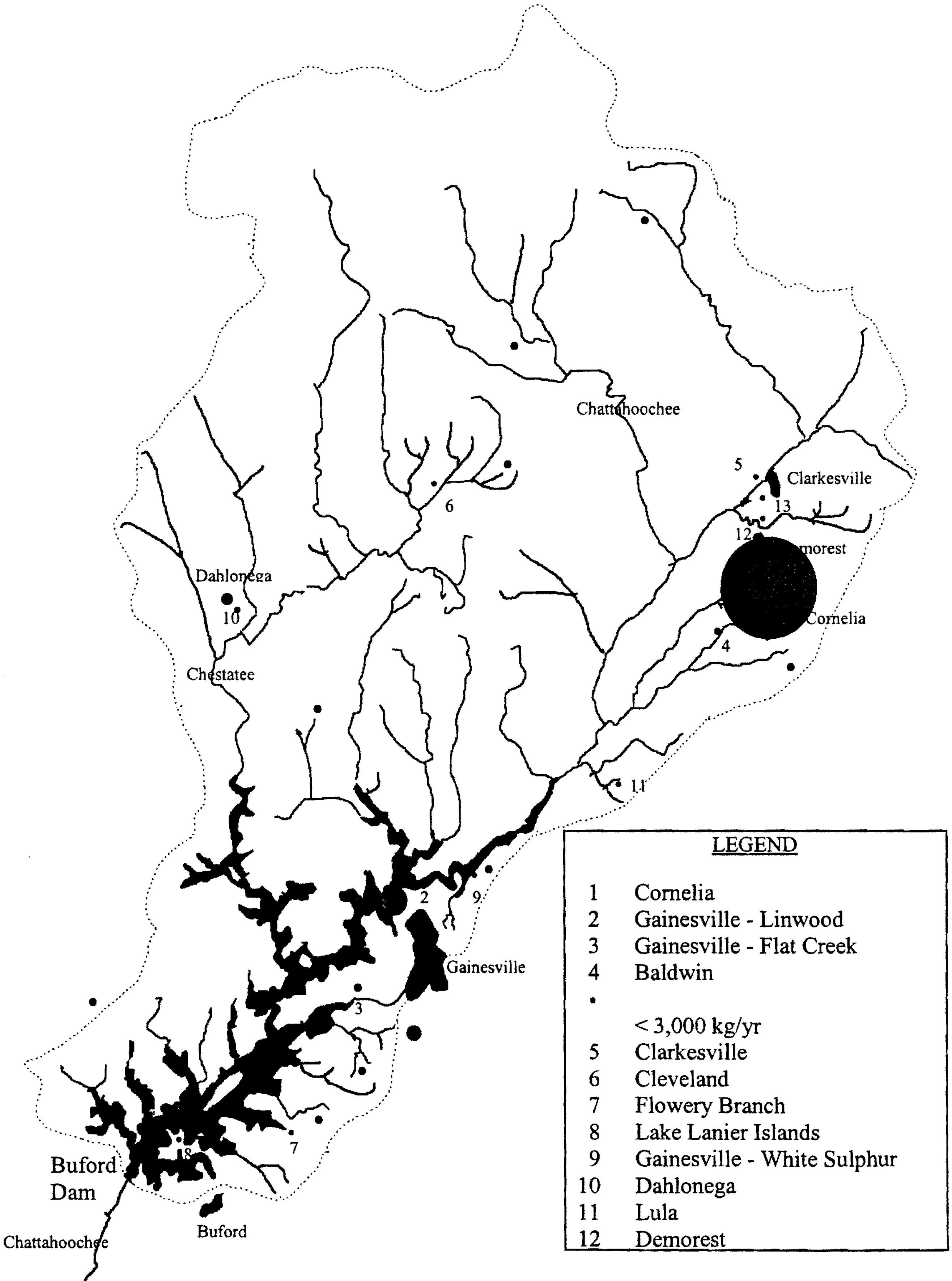

Figure 5-9. Ammonia Loading

A reasonable range of loadings of total nitrogen is 300,000 to 830,000 kg/yr based on Table 5-32. The loading that is most likely is 566,000 kg/yr. The nitrogen is composed of approximately 24% ammonia. The nitrogen loading from septic tanks can comprise a significant part of the total mass load to the lake (7%) based on the assumptions made in the analysis and described previously. Figure 5-10 shows the nitrogen mass loadings into the lake.

Table 5-32. Nitrogen Loading Summary

Source	Max/Permit Loading (kg/yr)	Monitoring Data Loading (kg/yr)	Sampling Data Loading (kg/yr)	Std. Deviation (kg/yr)	% of Total from Sampling Loading Data
Municipal WWTP			450,000	250,000	80
PIDs	22,000	9,000	(9,000)		1.5
Industrial WWTP	5,000	3,000	(3,000)	14,000	0.5
Urban Runoff*	100,000	(60,000)	60,000		11
Septic Tanks	60,000	44,000	(44,000)		7
TOTAL			566,000	264,000	

*: Urban runoff only for three streams.

In 1973, the EPA conducted a eutrophication study that included an approximation of nitrogen and phosphorus loadings. In 1991, the Clean Lakes Project also estimated nitrogen and phosphorus loadings. A comparison of the nitrogen loadings from these two studies and the current study is shown in Table 5-33. The increase in nitrogen from 1973 to 1991 noted by the 1991 Clean Lakes study is confirmed by the 1996 Clean Lakes study. This increase is likely due to the increase in population in this region, resulting in construction of more wastewater treatment plants and higher permitted flows from existing plants. The increase from 1991 to 1996 is primarily due to more accurate estimates of concentrations from the wastewater plants and the industrial sources. The difference between septic tank loadings from 1991 to 1996 is because the 1991 value was a result of using a multiplying factor of 3 to the 1973 data. The 1996 value is based on counting structures within 300 feet of the lake as shown on 1985 USGS quadrangle maps. Of interest is the difference in tributary loadings. The loadings in 1973 and 1991 were based on average flows for the streams and average nitrogen concentrations. Thus, it is not specific to stormwater runoff. The concentrations and loadings for the stormwater runoff are higher as would be expected because additional pollutants are being added to the streams from the land runoff.

Phosphorus

Like nitrogen, phosphorus can cause eutrophication of a body of water. Based on Table 5-34, the estimated loading range of phosphorus is from 24,000 to 44,000 kg/yr with a probable loading of 34,000 kg/yr. It is common for septic tanks along the shoreline to contribute less than 10% of the total phosphorus load (USEPA, 1983). This holds true for Lake Lanier based on these loading calculations, where the contribution from septic tanks is estimated to be 3%. Figure 5-11 shows the relative contribution of phosphorus from the point-sources. As with the nitrogen loadings, a comparison of phosphorus loadings based on data obtained in 1973 and 1991 is presented in Table 5-35. The difference between 1991 and 1996 loadings is because the 1991 phosphorus concentrations were based on assumptions of phosphorus concentrations. The large decrease in phosphorus loading

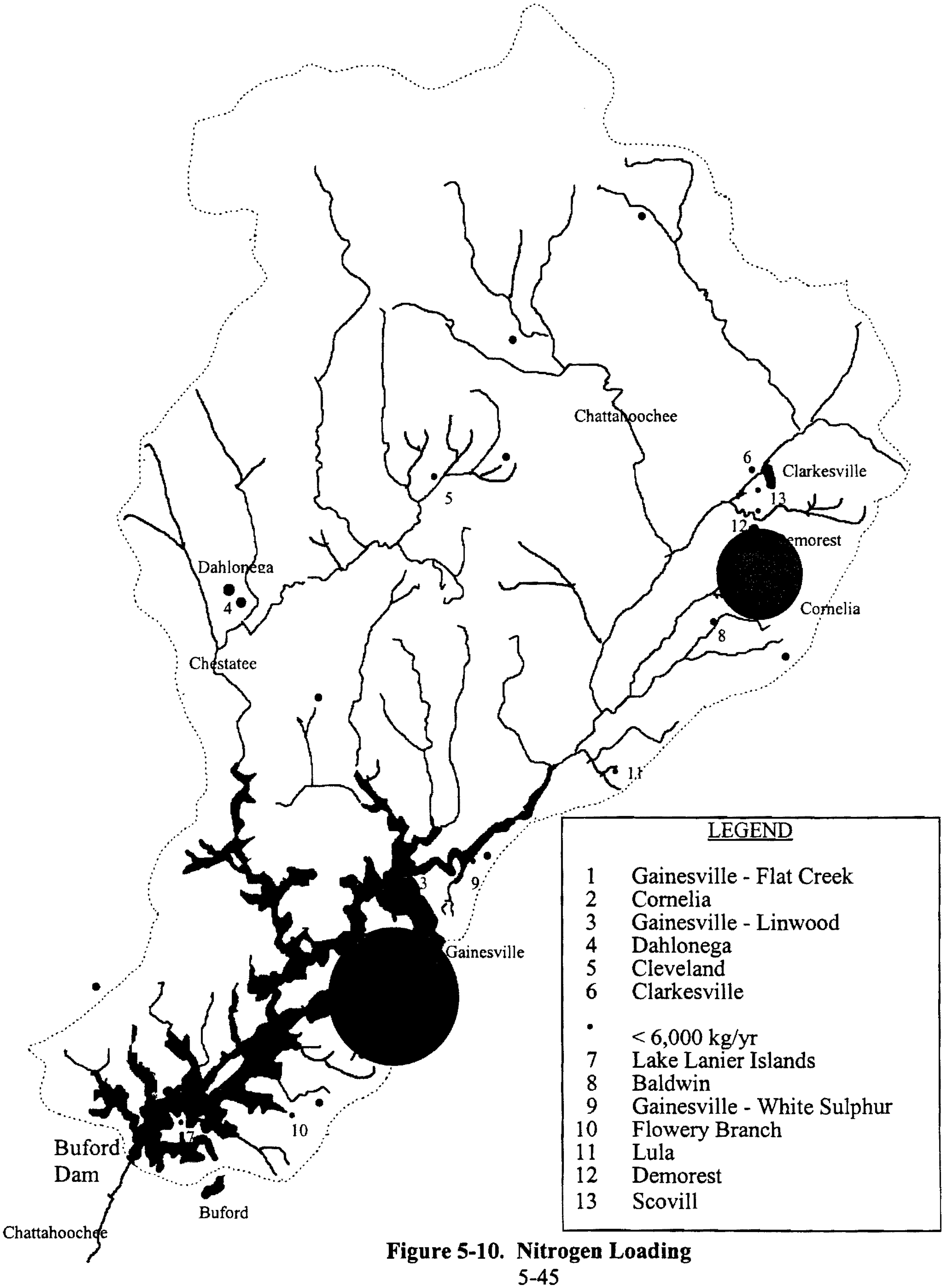

Figure 5-10. Nitrogen Loading

Table 5-33. Comparison of Nitrogen Loadings for 1973, 1991 and 1996

	EPA 1973		Clean Lakes 1991		Clean Lakes 1996		
	mg/L	kg/yr	mg/L	kg/yr	mg/L	kg/yr	
LARGE TRIBUTARIES							
Total from tributaries		(15,900)		(42,305)		(60,931)	
S. Flat Creek	1	9,515	0.78	7,382	4.24	23,567	
Limestone Creek	1.01	6,385	0.58	3,112	1.08	3,222	
Six Mile Creek			6.25	31,811	9.15	34,142	
MUNICIPAL WWTP							
Total from municipal WWTP		(229,325)		(432,409)		(454,419)	
Gain-Flat Creek	20.7	101,985	40	265,757	28	208,753	
Gain - Linwood	18.23	43,080	20	39,587	22.62	60,585	
Gain - White Sulphur			20	2,768	30	4,145	a
Lake Lanier Islands			20	2,768	30	14,508	a
Flowery Branch			10	1,661	5.98	1,470	
Baldwin	11.5	1,225	20	8,582	14.00	3,417	
Cornelia	16.22	56,015	30	66,439	38.58	130,405	
Clarksville	24.62	4,400	20	6,921	21.14	6,967	
Cleveland	24.62	4,600	20	9,689	12.94	7,423	
Dahlonega	24.62	9,040	20	11,627	16.14	12,893	
Demorest	24.62	3,640	20	11,073	5.89	453	
Lula					30	3,399	a
New Holland	24.62	5,340					
Misc.			20	5,537			
INDUSTRIAL DISCHARGERS							
Total from Industrial Dischargers						(2,848)	
Buckhorn					0.30	1	b
Davidson Minerals					1.00	1,340	a
Deering-Milliken							
Fieldale (Marell) Poultry (Land App)							
Habersham Mills							
High Point Minerals					1.00	3	a
JA Hudson					1.00	1,195	a
Queen City Foods							
N. GA Rendering (Land App)							
William Wrigley (to WWTP)							
Gold Kist Feedmill							
Scovill Fasteners					1.97	294	
SKF Bearing					0.65	16	a
SEPTIC TANKS		15,275		46,000		44,199	
NET ANNUAL LOADING		**260,500**		**520,714**		**562,396**	

Notes:

a) Based on assumed values

b) Based on Discharge Monitoring Reports

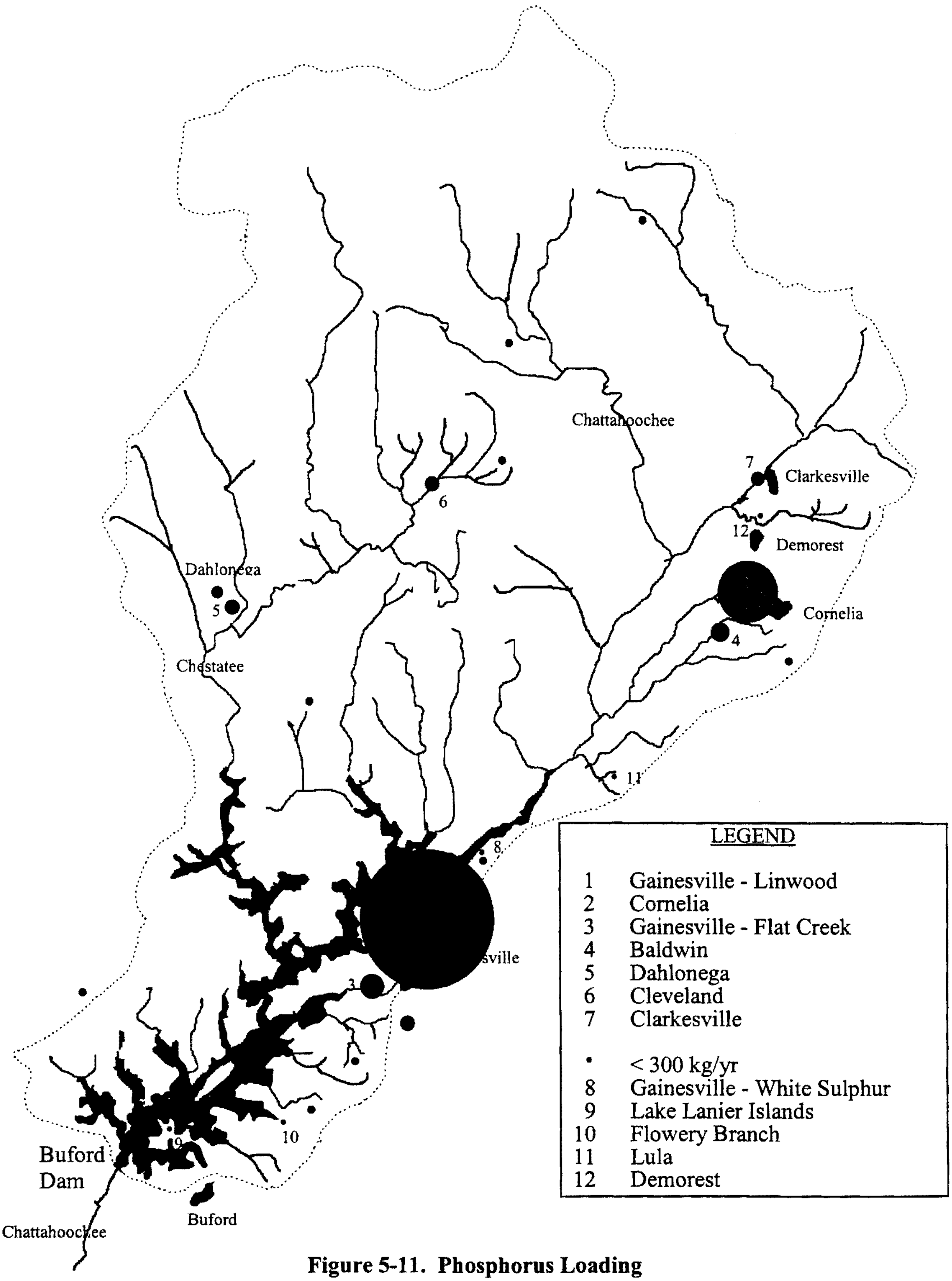

Figure 5-11. Phosphorus Loading

Table 5-35. Comparison of Phosphorus Loadings for 1973, 1991, and 1996

	EPA 1973		Clean Lakes 1991		Clean Lakes 1996		
	mg/L	kg/yr	mg/L	kg/yr	mg/L	kg/yr	
LARGE TRIBUTARIES							
Total from tributaries		(820)		(825)		(6,973)	
S. Flat Creek	0.052	490	0.035	333	0.41	2,287	
Limestone Creek	0.052	330	0.027	146	0.23	687	
Six Mile Creek			0.068	346	1.07	3,999	
MUNICIPAL WWTP							
Total from municipal WWTPs		(78,100)		(53,652)		(23,731)	
Gain-Flat Creek	6.25	30,775	0.54	3,588	0.21	1,720	
Gain - Linwood	8.91	21,055	7	13,855	3.71	10,404	
Gain - White Sulphur			7	969	2	276	a
Lake Lanier Islands			7	969	2	271	a
Flowery Branch			0.42	70	1.70	418	
Baldwin	8.2	875	7	3,003	6.46	1,999	
Cornelia	4.74	16,385	7	15,502	1.20	4,417	
Clarksville	8.2	1,465	7	2,422	2.40	929	
Cleveland	8.2	1,535	7	3,391	2.18	1,443	
Dahlonega	8.2	3,015	7	4,070	2.25	1,693	
Demorest	8.2	1,215	7	3,875	0.84	68	
Lula					2	94	a
New Holland	8.2	1,780					
Misc.			7	1,938			
INDUSTRIAL DISCHARGERS							
Total from Industrial Dischargers						(831)	
Buckhorn					0.10	0	b
Davidson Minerals					0.10	138	a
Deering-Milliken							
Fieldale (Marell) Poultry (Land App)							
Habersham Mills					1.13	12	b
High Point Minerals					0.10	0	a
JA Hudson					0.10	119	a
Queen City Foods							
N. GA Rendering (Land App)							
William Wrigley (to WWTP)							
Gold Kist Feedmill							
Scovill Fasteners					3.38	560	
SKF Bearing							
SEPTIC TANKS		16,880		1,200		0	
NET ANNUAL LOADING		**95,800**		**55,677**		**31,535**	

Notes:
a) Based on assumed values
b) Based on Discharge Monitoring Reports

Table 5-34. Phosphorus Loading Summary

Source	Max/Permit Loading (kg/yr)	Monitoring Data Loading (kg/yr)	Std. Deviation (kg/yr)	Sampling Data Loading (kg/yr)	Std. Deviation (kg/yr)	% of Total from Sampling Loading Data
Municipal WWTP	47,000	32,000	9,000	24,000	10,000	70
PIDs	2,000	1,000	30	(1,000)		3
Industrial WWTP	1,000	1,000		1,000	5	3
Urban Runoff*	12,000	(7,000)		7,000		21
Septic Tanks	6,000	2,000		(1,000)		3
TOTAL	68,000	43,000	9,000	34,000	10,000	

*: Urban runoff only for three streams.

from 1973 to 1996 is likely due to the ban on phosphorus detergents instituted in Georgia. An alternate analysis was performed to see what the attainable loadings would be if the permit for all the point-source facilities was changed to 1 mg/L. The result is as follows: maximum: 29,000 kg/yr (as compared to 47,000) and average: 12,000 kg/yr (as compared to 24,000). However, it should be noted that obtaining phosphorus removal to this level in the effluents would be very difficult for some wastewater treatment facilities to accomplish.

Summary of CBOD5, Nitrogen, and Phosphorus Loadings

Figure 5-12 compares the concentration of CBOD5, nitrogen and phosphorus to the annual loading of these pollutants from each sampling site. Note that the three sites at the far right of each figure are from stormwater runoff, whereas the other data are from wastewater treatment facilities. The stream data are for only three streams. It does not represent the total loading from all urban runoff in the watershed. However, it is apparent that stormwater runoff contributes significant amounts of CBOD5, nitrogen, and phosphorus. This figure also shows that the flows from the wastewater treatment facilities play a significant role in the loadings. For example, the concentration of phosphorus from Linwood and Scovill is nearly identical, yet the loading from Linwood (permitted 3 MGD) is nearly 1,500 times larger than from Scovill (permitted 0.14 MGD).

Trace Metals

Table 5-36 shows a summary of the annual loading of chromium (Cr), nickel (Ni), copper (Cu), zinc (Zn), barium (Ba), and lead (Pb) into the lake from the sources sampled. Maximum loads from each of the thirteen sources were calculated based on the detection limits which were 1.0, 0.2, 1.4 and 1.4 μg/L respectively for cadmium (Cd), mercury (Hg), arsenic (As), and selenium (Se). The corresponding loads were 29, 6, 41 and 41 kg/y respectively. Basing stream loadings on the stormwater concentrations may result in overestimates of trace metals. Trace metals tend to be strongly associated with particulate matter. During high flow conditions, fine solids remain in suspension resulting in high total metal measurements. However, particulate phases have a longer average residence time in the stream than the aqueous phase; that is, the metals measured in stormwater samples are not necessarily representative of what, on average, reaches the lake.

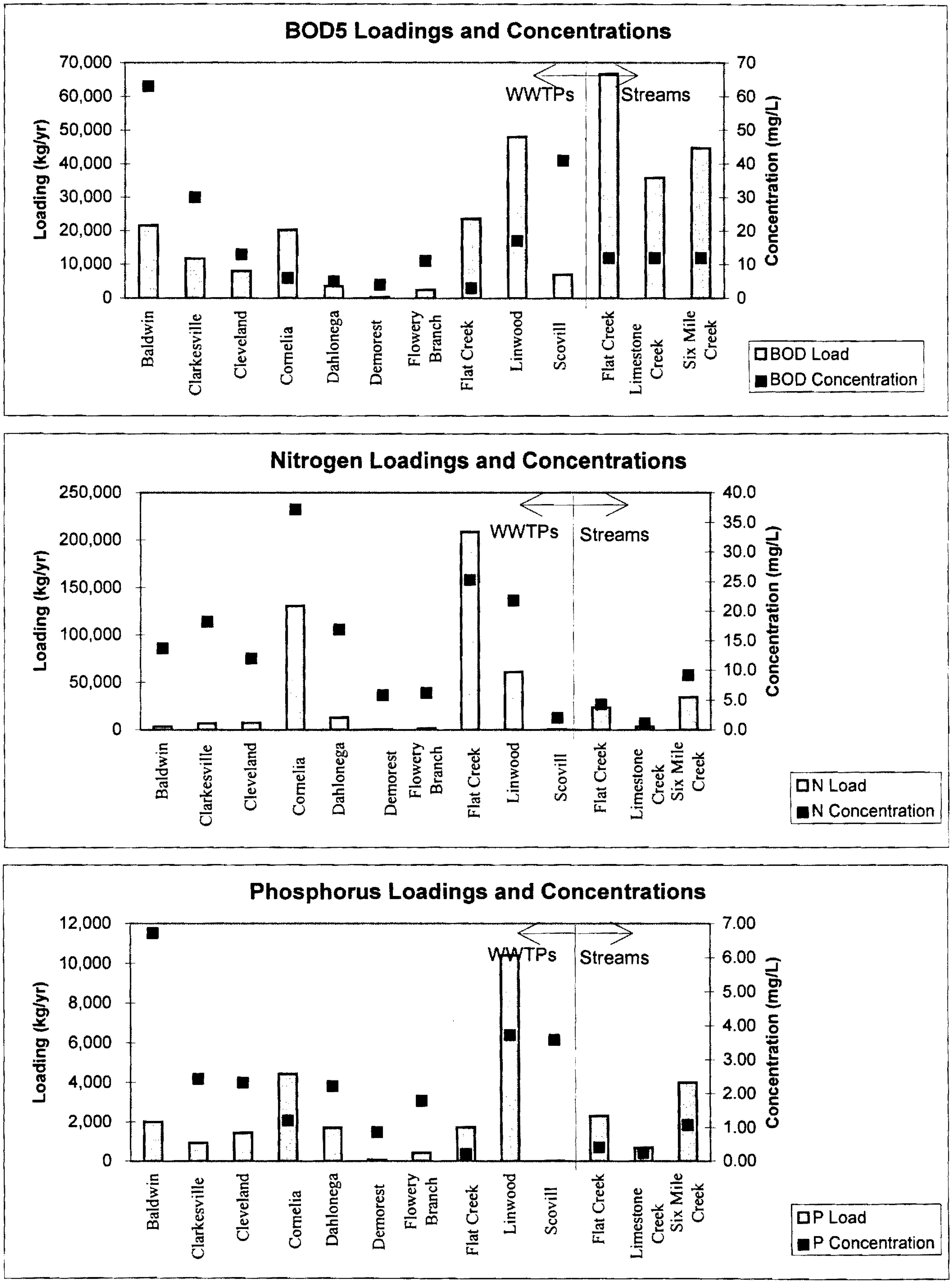

Figure 5-12. Comparison of Loadings and Average Concentrations

Table 5-36. Annual Metal Loading Summary (kg/y)

		Cr	Ni	Cu	Zn	Ba	Pb
Municipal WWTPs	Baldwin	0.9	2.4	6.5	37.9	11.9	1.1
	Clarkesville	1.0	2.1	16.4	98.1	10.0	2.3
	Cleveland	0.5	1.7	6.9	20.1	3.9	0.6
	Cornelia	5.9	22.9	25.8	262.9	28.6	5.4
	Dahlonega	1.0	1.7	9.7	46.0	8.1	0.7
	Demorest	0.1	0.1	1.0	6.6	2.1	0.1
	Flat Creek WWTP	13.5	70.0	65.8	958.1	74.9	19.9
	Flowery Branch	0.8	0.3	2.5	5.1	1.8	0.2
	Linwood	8.8	11.0	83.1	290.0	124.6	40.0
Industrial WWTP	Scovill	2.6	72.0	36.5	28.2	0.5	0.3
Stormwater Locations	S. Flat Creek	12.2	23.4	42.3	377	150.6	33.3
	Limestone Creek	5.1	4.7	20.7	125.8	74.6	18.7
	Six Mile Creek	29.4	17.1	41.1	287.4	514.2	28.5

Figure 5-13 shows a comparison of the pollutant concentrations and annual loading values for zinc, barium, and lead. The variation in the concentration of a given metal between sampling sites was always within an order of magnitude whereas the flow from the various sources ranged over two orders of magnitude. Therefore flow was often the major factor determining the relative contribution of the various sources to the overall load. Consequently, the Flat Creek plant contributes more to the total metal load and is more likely to have difficulties meeting instream water quality standards than Scovill, which has much higher pollutant concentrations.

Overall, the combined loads from all the facilities sampled were greater than those for the streams sampled for copper, nickel and zinc whereas the opposite was true for chromium, barium and lead. However, the differences between the combined loads for the point and non-point sources sampled were less than a factor of six. Since the facilities sampled represent more than 80 % of the effluent discharged into the watershed, whereas the streams sampled represented less than 0.2 % of the drainage area of the lake, it is likely that the overall contribution of non-point sources is significantly greater than point sources.

5.6. ALTERNATIVES ANALYSIS

Municipal WWTP / Industrial Dischargers

Most of the dischargers in the watershed are meeting their permit requirements. However, if better water quality is desired for the lake some thought needs to be given to reducing the amounts of pollutants contributed by wastewater treatment facilities. As was shown by the loadings analyses, wastewater treatment facilities contribute the largest portion of TOC, nitrogen and phosphorus from the sources investigated. Nutrients (nitrogen, phosphorus) are of particular concern to lake systems because of the threat of eutrophication. Nitrogen and phosphorus permit limits could be lowered, thus requiring the facilities to improve their effluent water quality. This can be very expensive and nearly impossible for some systems to accomplish using the current facilities. However, some facilities can improve their effluent water quality by optimizing their current treatment system.

Approximately 10 percent of phosphorus is removed due to primary settling at wastewater treatment facilities (Metcalf & Eddy, 1991). Several methods are available to effectively remove phosphorus from wastewater (see Table 5-37). The most popular methods are chemical precipitation and tertiary biological treatment. Chemicals (such as ferric chloride, alum, and lime) can be added

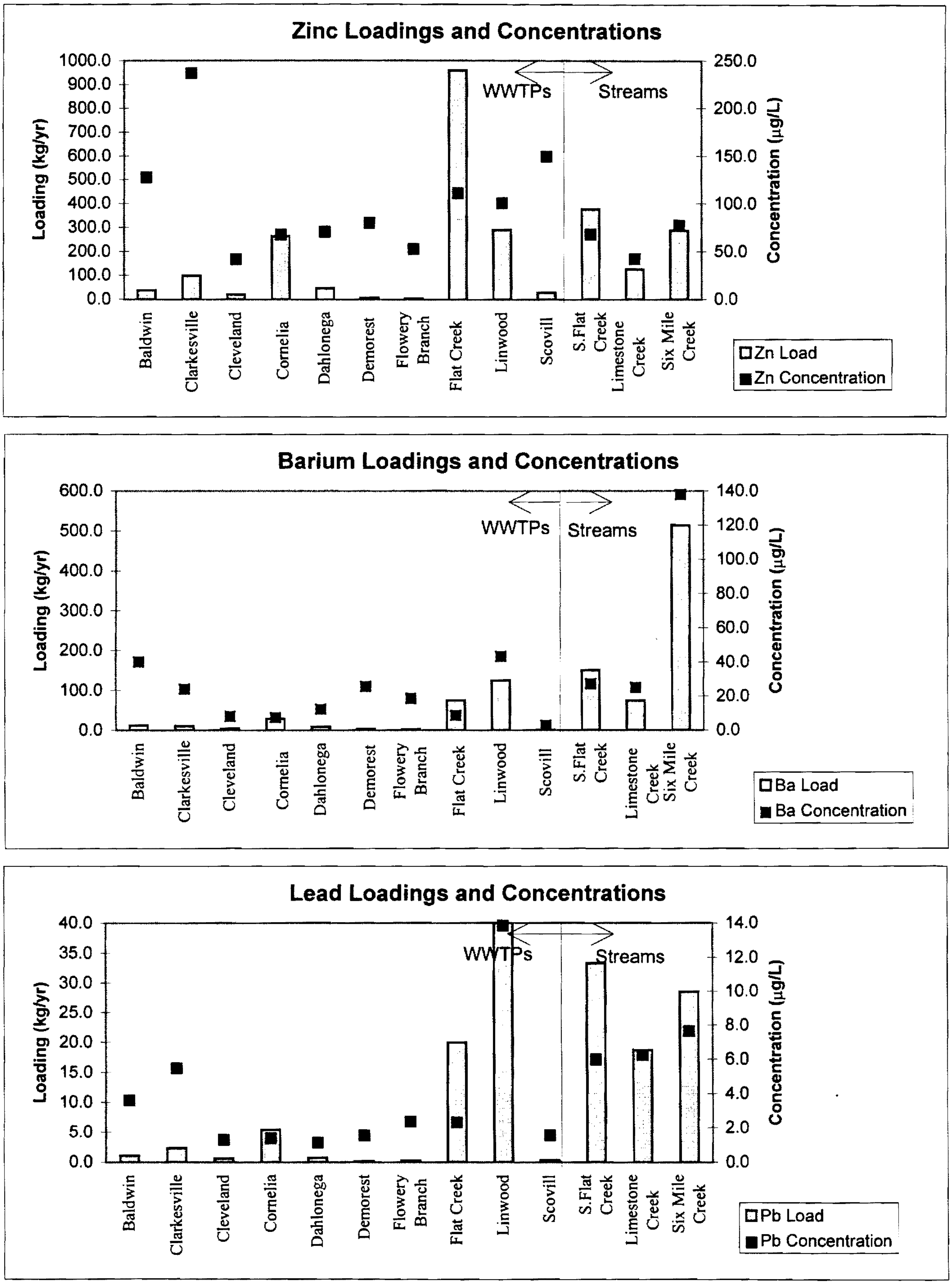

Figure 5-13. Comparison of Loadings and Average Concentrations for Zinc, Barium, and Lead

during the treatment train. The chemicals combine with phosphorus to form a precipitate that settles out in a clarifier. Phosphorus removal by biological means would require additional (tertiary) biological treatment from conventional secondary treatment facilities. Biological removal of phosphorus requires that the microorganisms be exposed to alternating anaerobic and aerobic conditions. Additional reactors would likely be required at most facilities to encourage the growth of the necessary microorganisms to enhance phosphorus uptake. This process requires more operator expertise than conventional wastewater treatment processes. The advantage of chemical precipitation is the relative ease of operation. The advantage of biological removal is lowered annual costs, because there would be no chemical costs. It was demonstrated that by lowering the phosphorus limit for all facilities to 1 mg/L that the loadings from point-sources could be cut in half. The two facilities that currently have a permitted phosphorus limit of 1 mg/L (Gainesville Flat Creek and Flowery Branch) have typical effluent concentrations of 0.6 mg/L. To obtain this goal, further education of operators and the support of the municipalities would be necessary.

Table 5-37. Removal Efficiencies and Estimated Costs for Phosphorus Removal (from Laws, 1993)

Technique	% Removal Efficiency	Estimated 1989 Cost[1] ($ / million L)
Tertiary biological treatment	70-90	
Chemical precipitation	88-95	9-65
Sorption	90-98	37-65
Chemical precipitation with filtration	95-98	65-83
Ion exchange	86-98	157-277
Reverse osmosis	65-95	231-370
Distillation	90-98	370-925

[1] Eliassen and Tchobanoglous (1969). Costs were multiplied by a factor of 3.5 to correct for inflation (Anonymous, 1989).

Less than 30 percent of nitrogen is removed by conventional secondary treatment (Metcalf & Eddy, 1991). If this is true of the facilities in the Lake Lanier watershed, then, by increasing the removal to 90% would result in a 30% decrease in nitrogen loading into the lake from the wastewater treatment facilities. Techniques that can be used to remove nitrogen are presented in Table 5-38. Ammonia stripping and biological removal are the common and economical methods used to remove nitrogen. There are many different options to removing nitrogen biologically including nitrification and/or denitrification. Many of the nitrogen removal techniques can be adjusted to also remove phosphorus. See *Wastewater Engineering: Treatment, Disposal, Reuse* (Metcalf & Eddy, 1991)for detailed information about these processes. However, most facilities are meeting their ammonia permit requirements and it is estimated that the in-stream standards for ammonia at these facilities are less than drinking water standards (see Table 5-17).

Table 5-38. Removal Efficiencies and Estimated Costs for Nitrogen Removal (from Laws, 1993)

Technique	% Nitrogen Removal	Estimated 1989 Cost [1] ($ / million liters)
Ammonia stripping	80-98	8-23
Anaerobic denitrification	60-95	23-28
Ion exchange	80-92	157-277
Reverse osmosis	65-95	231-370
Distillation	90-98	370-925
Breakpoint chlorination	95-99	714-1615

[1] Eliassen and Tchobanoglous (1969). Costs were multiplied by a factor of 3.5 to correct for inflation (Anonymous, 1989).

The annual costs for increased nitrogen and phosphorus removal for the wastewater treatment facilities in the Lake Lanier watershed were estimated (see Table 5-39). The costs were based upon median costs shown in Tables 5-37 and 5-38 for chemical precipitation of phosphorus and biological nitrogen removal. A facility is listed for nitrogen removal in Table 5-39 if it has had a history (see Table 5-16) of non-compliance for ammonia or an ammonia concentration greater than 10 mg/L. Facilities are listed for phosphorus removal if they have a history (see Table 5-16) of phosphorus concentrations greater than 1 mg/L. These costs are rough estimates. Engineering surveys would need to be conducted at each facility to determine better cost estimates.

Table 5-39. Estimated Costs for Nitrogen and Phosphorus Removal

Facility	Permitted Flow (MGD)	For Removal of	Unit Cost ($/MG)	Total Annual Cost
Baldwin	0.3	N	97	$11,000
		P	140	$15,000
Clarkesville	0.75	N	97	$26,000
		P	140	$38,000
Cleveland	0.75	P	140	$38,000
Cornelia	3	N	97	$106,000
		P	140	$153,000
Dahlonega	0.72	P	140	$37,000
Flowery Branch	0.2	N	97	$7,000
		P	140	$10,000
Gainesville #2 Linwood	3	P	140	$153,000
Gainesville #3 White Sulphur	0.1	N	97	$4,000
		P	140	$5,000
Lake Lanier Islands	0.35	N	97	$12,000
		P	140	$18,000
Lula	0.03	N	97	$1,000
		P	140	$2,000
Total Nitrogen				$167,000
Total Phosphorus				$470,000
TOTAL				**$637,000**

Marinas

Some of the main problems associated with marinas are sewage releases from boats; use of cleaners containing chlorine, ammonia and phosphate that can harm plankton and fish; and oil spills that can attach to sediments causing harm to bottom-dwelling organisms. For a reduction in pollution from marinas, two options should be considered: requiring action on the part of the marinas and public education. Requiring the marinas and service yards to minimize waste generation and to capture and dispose of waste would help to minimize the impact of the marinas on the lake. One of the first steps that needs to be taken is an assessment of the wastes being generated by the marinas. A routine sampling program of the runoff from the marinas and of the water surrounding the marinas would be necessary. After prioritizing the potential hazards, options can be reviewed to determine the best means to minimize the impact of the marinas. *Guides to Pollution Prevention: The Marine Maintenance and Repair Industry* (USEPA, 1991) provides a description of waste minimization options for marine maintenance and repair yards. The options include waste segregation, use of less toxic materials, reuse of materials, recycling of materials, use of alternate techniques, good housekeeping, spill control measures, and inventory control. Suggested management measures are presented in detail in *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Water* (USEPA, 1993b). The costs of such measures are discussed in *Economic Impacts of EPA Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters* (USEPA).

Public education of the owners of marinas and boat users may be the best method to combat pollution from this source. This is because most pollution associated with boating is done by individuals who probably do not know the consequences of their actions. Some solutions recommended by the EPA ("Management Measures...Boating") for boat owners and users are as follows: 1) Select nontoxic cleaning products; 2) Use drop cloths; 3) Clean and maintain boats out of the water; 4) Vacuum loose paint chips and paint dust; 5) Fuel the boats carefully; 6) Recycle used oil; 7) Discard worn motor parts in proper receptacles; 8) Drain water out of waterlines and tanks during winter freezes; 9) Keep boat motors well-tuned to prevent fuel and lubricant leaks and to improve fuel efficiency.

Landfills / Hazardous Waste Sites / Underground Storage Tanks

Local and regional groups who have an interest in Lake Lanier should encourage owners of these facilities to comply with the national and state regulations. If the facilities are not meeting the regulations they should alert the appropriate authorities. Local governments should also be supportive of improving the requirements and being conscientious about remediation.

Cemeteries

The limited analysis completed in this study suggests that cemeteries do not pose a significant threat to Lake Lanier. Further investigation including sampling and analysis would be needed to determine if they are a problem.

Septic Tanks

Septic tank failure can cause contamination of drinking water supplies and contribute to the eutrophication of lakes. It is uncertain to what extent septic tanks are failing in the Lake Lanier watershed. Currently septic tanks are being used primarily by the more rural areas of the watershed.

The alternative to septic systems would be the creation of wastewater treatment facilities and sewer systems to convey the waste to the treatment plant. However, in rural areas 80% of the capital costs for creating a wastewater treatment system are for the sewer network (USEPA, 1983). Constructing the sewer networks can also cause environmental problems such as erosion and destruction of wildlife. According to the EPA's Seven Rural Lake EIS, "abandoning septic tank/soil absorption systems along the shorelines will seldom result in significant change in lake trophic status" (EPA, 1983). This does not imply that septic tanks do not contribute to lake pollution. To minimize the impact of septic tanks on the lake it is necessary to ensure that they are being used properly. The first step is to determine the extent of the problem.

The EPA presents several ways in which information can be gained to determine the performance of septic tanks in the watershed (USEPA, 1983). Aerial photography at the scale of 1:8000 (1in=1667ft) provides information about surface failures of septic tanks. Septic leachate detection devices can locate groundwater inflow that conveys the wastewater. Questionnaires sent to homeowners could provide information about the occurrence of failures (such as plumbing backup) and provide for community education and involvement. Investigations along the lakeshore for growth of attached and floating plants may indicate septic problems. The use of the septic leachate detectors can confirm the presence of septage.

After determining the extent of septic tank failure, the problems should be investigated to determine solutions. There are several models available for varying levels of private and community involvement that can help with these problems. The main problems with inappropriate use of septic tanks are using them beyond their life expectancy (50 years for concrete/fiberglass/plastic, 10 years for metal) and the tanks not being pumped and emptied frequently enough. This can be combated by having the tanks inspected at least every two years and having them pumped once every three to five years. Another problem lies with the cumulative effect of having too many septic tanks in the same area. There should be fewer than five per hectare (Adriano, 1994). Local zoning requirements may need to be developed to control the concentration of septic tanks in certain areas. The EPA provides some of the modes of failure and ways to control that are presented in Table 5-40 (USEPA, 1983).

Table 5-40. Means to Control Septic Tank Failure

Cause of Failure	Ways to Control Future Failures
System Usage	Water meters
	Flow reduction devices
	Limit number of persons per septic tank
	Limit garbage disposals
Maintenance Problem	Renewable permit contingent upon proof of periodic inspection and maintenance
	Public maintenance services
	Required maintenance contracts
	Public education
Surface Failure and Plumbing Backup	Upgrade facilities that aren't adequate
	Change design of facility
	Off-site treatment when septic tanks aren't appropriate for site characteristics (soil groundwater hydrology)

Urban Runoff

The loadings analyses conducted in this study show the large impact that stormwater runoff has on the quality of the lake. "Experience in the seven rural lake EIS's suggests ... that reduction of non-point source pollution may produce a much greater water quality improvement at a lower cost [than sewering rural areas] (USEPA, 1983)." There are two main types of activities which can be implemented to improve stormwater quality: 1) community planning and 2) better management practices (BMPs). The main community plans which should be considered are presented by the EPA (USEPA, "Managing Urban Runoff"):

* plans for new development - structural controls and pollution prevention
* plans for existing development - expensive
* plans for onsite disposal
* public education

These types of plans could be incorporated in municipal or regional planning strategies. Schueler *et al.* (1992), USEPA (1993b), and Woodward-Clyde Consultants (1990) provide comparative assessments of the effectiveness and relative costs of BMPs (see Table 5-41).

Table 5-41. Better Management Practices for Urban Runoff Control

BMP	How it Works
Detention Basin/Trench	Stores runoff temporarily providing reduction in pollutants due to settling.
Retention Devices	Permanently captures runoff - generally employs infiltration.
Pavement Control	Allows infiltration through the pavement
Constructed wetlands	Stores and "treats" runoff
Vegetative Control	Pollutants can be removed by filtration, sedimentation or biological uptake.
Source Control	Reduce amounts of accumulated pollutants on land surface Regulate the amount of impervious area Exclude inappropriate discharges to storm drains

The best type of control will be determined based on site specific conditions such as drainage area, soil characteristics, acceptability and other factors. More information on urban runoff management can be found in these sources:

GADNR. 1990. *We All Live Downstream.* Georgia Department of Natural Resources, Environmental Protection Division, Atlanta, GA.

James, William. 1993. *New Techniques for Modeling the Management of Stormwater Quality Impacts.* Florida: Lewis Publishers.

Livingston, E.H. and E. McCarron. 1992. *Stormwater Management: A Guide for Floridians.* Florida Department of Environmental Regulation, Tallahassee.

Mikalsen, T. 1993. "Managing the Quality of Urban Streams in Georgia." *Proceedings of the 1993 Georgia Water Resources Conference.* Institute of Natural Resources, The University of Georgia, Athens, GA.

Schueler, T.R., P.A. Kumble, and M.A. Heraty. 1992. *A Current Assessment of Urban Best Management Practices: Techniques for Reducing Non-Point Source Pollution in the Coastal Zone.* Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, D.C..

USEPA. 1993. *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Water.* 840-B-92-002, Washington D.C.

USEPA. "Managing Urban Runoff." Internet Address for Access to Information: www.epa.gov/OWOW/NPS/Facts/point7.htm

Woodward-Clyde Consultants. 1990. *Urban Targeting and BMP Selection: An Information and Guidance Manual for State Nonpoint Source Program Staff Engineers and Managers*. Washington D.C.: Terrene Institute.

5.7 SUMMARY AND FURTHER STUDY

Potential discrete sources of pollution in the Lake Lanier watershed (municipal wastewater treatment facilities, industrial dischargers, marinas, landfills, septic tanks, hazardous waste sites, underground storage tanks, cemeteries, and urban areas) were identified and investigated. Based on this examination, a sampling program was conducted to better characterize the effluent from ten wastewater treatment facilities and urban runoff into three streams. In general, the wastewater treatment facilities seem to be meeting their permit requirements and the sampling results are in agreement with the discharge monitoring reports (DMRs). A few facilities are in need of upgrading. See pages 5-27 and 5-32 for more information for each facility. Mercury, selenium, and cadmium were below the detection limits in all of the samples collected during the sampling program. Arsenic was only detected from one facility, Scovill, yet the concentration was very low (< 5 ug/l).

Pollutant loadings of CBOD5, TOC, nitrogen and phosphorus were calculated from the municipal wastewater facilities, PIDs, industrial dischargers, septic tanks, and urban runoff based on the sampling results, DMRs and typical values from the literature. From the limited sampling it appears that the largest contribution of BOD comes from urban runoff and municipal wastewater treatment facilities. Municipal wastewater treatment facilities contribute large amounts of the nutrients nitrogen and phosphorus. The loading of phosphorus has decreased significantly since 1973. However, the application of a phosphorus permit limit for some of the larger facilities which do not currently have a phosphorus limit (Linwood and Cornelia), would cause a significant decrease in the phosphorus loading. Loadings of Cr, Ni, Cu, Zn, Ba, and Pb were calculated from the results of the wastewater and urban runoff sampling programs. It appears that urban runoff contributes significant loadings of these metals into the lake.

The research presented in this report provides valuable information on some potential pollutant sources in the Lake Lanier watershed. However, there is room for further study. The pollutant loadings calculated from septic tanks did not appear to contribute significantly as compared to the other sources investigated (0.5% for CBOD5, 7% for N, 3% for P). However, the septic tank calculations were based on an estimated number of septic tanks and estimated pollutant contributions. It is recommended that a study be conducted to determine the extent of septic tank failures near the lake. Suggestions are presented in Section 5.6.

The contributions of pollutants from marinas on the lake have not been characterized. A study of the water quality surrounding the marinas would be worthwhile.

The results presented here for urban stormwater runoff were based on a very limited sampling program. The purpose was to determine if urban stormwater runoff is a significant threat to the health of the lake. It has been determined that urban stormwater runoff does contribute significant loadings of pollutants (nitrogen, phosphorus, CBOD5, TSS, and trace metals) into the lake. Further study of the contribution from all types of stormwater runoff (urban, agricultural, residential, forested) and ambient stream conditions would provide better insight into which types of stormwater runoff are more threatening to the lake and more accurate calculations of pollutant loadings from all types of runoff. This is especially true for metals analysis because of the relationship between the metals and particulate matter.

5.8 REFERENCES

Adriano, Domy C., Alex K. Iskandar, and Ishwar P. Murarka. 1994. *Contamination of Groundwaters.* Northwood: Science Reviews.

Alley, William M. 1976. *A Conference Report for Guide for Collection, Analysis, and Use of Urban Stormwater Data*. New York: American Society of Civil Engineers.

American Public Health Association, AWWA, WEF. 1992. *Standard Methods for the Examination of Water and Wastewater.* 18th ed. Washington D.C.

American Water Works Association. 1990. *Water Quality and Treatment: A Handbook of Community Water Supplies*. 4th ed. Ed. Fredrick Pontius. New York: Mc-Graw Hill.

Anonymous. 1989. "Treatment Plants: Cost Hikes Back on Track." *Engineering News Record.* 223 (24), 81.

Harris InfoSource International. 1996. *1997 Harris Georgia Manufacturers Directory*. Ed. Frances L. Carlsen. Twinsburg, Ohio.

Carter, R.F., E.H. Hopkins, and H.A. Pearlman. 1989. *Low-flow Profiles of the Upper Chattahoochee River and Tributaries in Georgia..* Georgia: U.S. Geological Survey Water-Resources Investigations Report 89-4056.

Carter, R.F., and S.A. Putnum. 1978. *Low-Flow Frequency of Georgia Streams*. Georgia: U.S. Geological Survey Water-Resources Investigations Open-File Report 77-127.

Cheremisinoff, Paul N. 1992. *A Guide to Underground Storage Tanks: Evaluation, Site Assessment, and Remediation.* New Jersey: Prentice Hall.

Chow, Ven Te, David R. Maidment, and Larry W. Mays. 1988. *Applied Hydrology*. New York: McGraw-Hill.

Cowie, G. M. and J. L. Cooley. 1989. *Guidelines for Development of Watershed Protection Programs in Georgia.* Georgia: University of Georgia.

Dudley, John G. and David A. Stephenson. 1973. *Nutrient Enrichment of Groundwater from Septic Tank Disposal Systems.*

Eliassen, R., and G. Tchobanoglous. 1969. "Removal of Nitrogen and Phosphorus from Wastewater." *Environmental Science and Technology*., 3, 536-541.

Fisher, J.S., R.R. Perdue, M.F. Overton, M.D. Sobsey, and B.L. Sill. 1987. *Comparison of Water Quality at Two Recreational Marinas During a Peak-use Period.* North Carolina State at Raleigh. Sea Grant College Program

General Accounting Office. 1986. "Nation's Water: Key Unanswered Questions About the Quality of Rivers and Streams." Washington D.C.: General Accounting Office.

Georgia Department of Natural Resources Environmental Protection Division. 1995. "Rules and Regulations for Water Quality Control." Georgia: Chapter 391-3-6 Water Quality Control.

________. 1996. *1993 Hazardous Waste Report.* Georgia.

Georgia Water Quality Control Board. 1971. *Gainesville Area Water Quality Study.* Georgia.

________. 1969. *Water Quality Investigation at Two Marinas on Lake Lanier.* Georgia.

Hagedorn, C., E.L. McCoy, and T.M. Rahe. 1981. The Potential for Ground Water Contamination from Septic Effluents. *Journal of Environmental Quality.* Vol. 10, no.1.

Hatcher, Kathryn et al. 1994. "Diagnostic/Feasibility Study of Lake Sidney Lanier, Georgia." Project Completion Report prepared for Georgia Environmental Protection Division.

James, William. 1993. *New Techniques for Modeling the Management of Stormwater Quality Impacts.* Florida: Lewis Publishers.

Kaplan, O. Benjamin. 1991. *Septic Systems Handbook.* 2nd ed. Michigan: Lewis Publishers.

LaGrega, Michael D. , Phillip L. Buckingham, and Jeffrey C. Evans. 1994. *Hazardous Waste Management.* New York: McGraw-Hill.

Laws, Edward A. 1993. *Aquatic Pollution: An Introductory Text.* New York: John Wiley & Sons, Inc.

Linsley, Ray K., Joseph B. Franzini, David L. Freyberg, and George Tchobanoglous. 1992. *Water-Resources Engineering.* 4th ed. New York: McGraw-Hill.

Metcalf & Eddy, Inc. 1991. *Wastewater Engineering: Treatment, Disposal & Reuse.* 3rd ed. Revised by George Tchobanoglous, Franklin L. Burton. New York: McGraw-Hill New York.

National Climatic Center of NOAA. 1991. Climatological Data Annual Summary - Georgia. Ashville, NC. 95:13.

Pacheco, A., J.M.B. Mendes, T. Martins, S. Hassuda, and A.A. Kimmelmann. 1991. Cemeteries - A Potential Risk to Groundwater. *Water Science Technology.* Vol 24, No 11 pp97-104.

Pontius, Frederick W. 1996. An Update of the Federal Regs. *Journal of the American Water Works Association.* 88:3:36.

Puckett, Larry J. 1994. *Nonpoint and Point Sources of Nitrogen in Major Watersheds of the United States*. U.S. Geological Survey.

Reckhow, K.H. and J.T. Simpson. 1980. A Procedure Using Modeling and Error Analysis for the Prediction of Lake Phosphorus Concentration from Land Use Information. *Canadian Journal of Fishing and Aquatic Sciences*. 37:1439-1448.

Richman, M. Timmerly York. 1997. Special Topics Paper. Georgia Institute of Technology.

Schueler, T.R., P.A. Kumble, and M.A. Heraty. 1992. *A Current Assessment of Urban Best Management Practices: Techniques for Reducing Non-Point Source Pollution in the Coastal Zone*. Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, D.C..

Senft, W.H., and K.E. Roberts. 1983. *Diagnostic Feasibility Study of Lake of the Woods, Marshall Co., Indiana.* Indiana: Indiana State Department of Natural Resources.

U.S. Environmental Protection Agency. 1980. *Design Manual: Onsite Wastewater Treatment and Disposal Systems*. Ohio: Office of Research and Development.

________. 1983. *Final-Generic Environmental Impact Statement for Wastewater Management in Rural Lake Areas*. Illinois.

________. 1984. *Process Design Manual for Land Treatment of Municipal Wastewater: Supplement on Rapid Infiltration and Overland Flow.* Ohio: USEPA Center for Environmental Research Information.

________. 1991a. *Guides to Pollution Prevention: The Marine Maintenance and Repair Industry*. Cincinnati, OH: Office of Research and Development. EPA/625/7-91/015.

________. 1991b. *Technical Support Document for Water Quality-based Toxics Control.* Washington D.C.: Office of Water.

________. 1993a. *Commitment to Watershed Protection: A Review of the Clean Lakes Program*. Washington D.C.: Office of Wetlands, Oceans and Watersheds.

________. 1993b. *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters*. Washington, D.C.: Office of Water. 840-B-92-002.

________. 1993c. *UST Program Facts: Preventing Leaks: Technical Regulations.* Washington D.C.

________. 1994. *Guide to Septage Treatment and Disposal.* Cincinnati. Ohio.

________. "Management Measures...Boating". Internet Address for Access to Information: www.epa.gov/OWOW/M...ter5/ch5- 1.html#Pollutant

________. "Managing Nonpoint Sources...from Boating and Marinas." Internet Address for Access to Information: www.epa.gov/OWOW/NPS/Facts/point9.htm.

________. "Managing Urban Runoff." Internet Address for Access to Information: www.epa.gov/OWOW/NPS/Facts/point7.htm

________. *National Eutrophication Survey: Working Paper Series*. Pacific Northwest Environmental Research Laboratory. PB 248/886.

Woodward-Clyde Consultants. 1990. *Urban Targeting and BMP Selection: An Information and Guidance Manual for State Nonpoint Source Program Staff Engineers and Managers*. Washington D.C.: Terrene Institute.

Young, David R., Theadore C. Heesen, Deirdre J. McDermott, and Paul E. Smokler. 1974. *Marine Inputs of Polychlorinated Biphenyls and Copper From Vessel Antifouling Paints.* California: Southern California Coastal Water Research Project.

Appendix 5-A.
Description of Sites

Municipal Wastewater Treatment Facilities

Baldwin WPCP Habersham County NPDES #: GA0033243
≈ 34° 30' 83°32'07" Hwy 365, Baldwin
PO Box 247, Baldwin GA 30511 (Hon. Wayne Kelsey, mayor)
Monitored Parameters: flow, BOD, SS, Fecal coliform, pH, DO
Physical Description: aeration basin, clarifier, chlorination, polish pond
Receiving Stream: Little Mud Creek

Clarkesville WPCP Habersham County NPDES #: GA0032514
≈ 34° 36'43" 83°32'04" Cleveland Hwy, Clarkesville
Box 21 Water St., Clarkesville GA 30523 (Charles McGugan ?)
Monitored Parameters: flow, ammonia, DO, BOD, TSS, fecal coliform, pH, TRC
Physical Description: trickling filter, 4 industrial influents in 1992
Receiving Stream: Soque River

Cleveland WPCP White County NPDES#: GA0036820
34° 36'17" 83°47'55" Claud Simms Rd., Cleveland
85 S. Main St., Cleveland, GA 30528 (Danny Ingram)
Monitored Parameters: flow, BOD, ammonia, DO, TSS, pH, fecal coliform, pH
Date of Construction: 1992
Physical Description: macerators, aeration 2-stage LEMNA system using duckweed, UV disinfection, cascade reaeration
7 industrial influents in 1991
Past Problems: had problems meeting ammonia limits, but now has been corrected
has problems meeting BOD limits in the winter when the duckweed becomes dormant
Receiving Stream: Tesnatee Creek
Comments: replaced an activated sludge facility (GA 0023345)

Cornelia WPCP Habersham County NPDES #: GA 0021504
34° 31'35" 83°33'35" off Old Cleveland Rd., Cornelia
PO Box 217, Cornelia, GA 30531 (Jerris Gilkey)
Monitored Parameters: flow, BOD, TSS, fecal coliform, pH, DO ammonia, TRC, P, Zn
Date of Construction: 1963
Expansions or Upgrades: 1980
Physical Description: trickling filter
in 1992: 60% Poultry 40% Domestic influent
Industrial: Fieldale Farms, Ethicon
Past Problems: chronic ammonia toxicity
Receiving Stream: South Fork of Mud Creek

Dahlonega WPCP Lumpkin County NPDES #: GA0026077
≈ 34° 31'06" 83°58'21" Mechanicsville Rd.
PO Box 2073, Dahlonega, GA (Wayne Barrett)
Monitored Parameters: flow, BOD, TSS, fecal coliform, pH, DO, ammonia, TRC
Date of Construction: 1976
Expansions or Upgrades: in process of expanding plant
Physical Description: activated sludge, clarifier, chlorinator, aerobic digestion (aerated lagoon)
Past Problems: not enough space for solids
Receiving Stream: Yahoola Creek

Demorest WPCP Habersham County NPDES #: GA0032506
≈ 34° 34'36" 83°32'48" Ivy Street
Box 128, Demorest, GA 30535 (mayor)
Monitored Parameters: flow, BOD, SS, Fecal coliform, pH, DO, TRC
Physical Description: activiated sludge, chlorination, holding pond (no industrial influent)
Receiving Stream: Hazel Creek

Flowery Branch WPCP Hall County NPDES #: GA0031933
34° 11'10" 83°55'50" 5572 Atlanta Hwy S
PO Box 757, Flowery Branch, GA (Charles Weaver)
Monitored Parameters: flow, BOD, TSS, fecal coliform, pH, DO, NH3, P
Date of Construction: 1977
Expansions or Upgrades: new facility to be constructed beginning June 1996
Physical Description: activated sludge aeration basins, clarification, chlorination
80-85% municipal; 15% industrial
Past Problems: poor sludge disposal; poor aerating ability
Receiving Stream: Lake Lanier

Gainesville #1: Flat Creek Hall County NPDES #: GA0021156
34° 15'59.6" 83°52'0.2" 2640 Old Flowery Branch Rd
PO Box 2496, Gainesville, GA 30503 (Eddie Smallwood)
Monitored Parameters: flow, BOD, TSS, fecal coliform, pH, DO, ammonia, P, TRC, Zn
Date of Construction: 1960
Expansions or Upgrades: 1965,1969,1978,1983,1995,2000
Physical Description: extended aeration, clarification, chlorination/dechlorination, reaeration
70% industrial; 30% commercial/residential
Past Problems: TRC, ammonia
Receiving Stream: S. Flat Creek

Gainesville #2: Linwood Hall County NPDES #: GA0020168
34° 19'30" 83°51'30" Linwood Dr.
PO Box 2496, Gainesville, GA 30503 (Eddie Smallwood)
Monitored Parameters: flow, BOD, TSS, fecal coliform, pH, DO, ammonia, P, TRC
Date of Construction: 1956
Expansions or Upgrades: 1972
Physical Description: trickling filter
Past Problems: TRC
Receiving Stream: Lake Lanier

Gainesville #3: White Sulphur Hall County NPDES #: GA0030716
≈ 34° 22'51" 83°48'32" Lake Rd.
PO Box 2496, Gainesville, GA 30503 (Eddie Smallwood)
Monitored Parameters:
Physical Description: activated sludge
Receiving Stream: Chattahoochee River

Helen LAS White County LAS Permit #: GA02-157
≈ 34° 41'46" 83°42'27"
PO Box 280, Helen, GA 30545 (Kim Cox)
Monitored Parameters: depth to GW, nitrate, pH, fecal coliform
Physical Description: aerated lagoons, land application
Comment: used to discharge into Chattahoochee River under NPDES # GA0032590

Lake Lanier Islands Authority Hall County NPDES #: GA0049115
≈ 34° 11'07" 83°02'10" 6950 Holiday Rd.
PO Box 605, Buford, GA 30518 (Ralph Revis)
Monitored Parameters: flow, BOD, TSS, fecal coliform, pH
Physical Description: 2 oxidation ditches, clarifier, chlorination
Receiving Stream: Lake Lanier

Lula WPCP Hall County NPDES #: GA0024767

≈ 34° 23'29" 83°40'11"

PO Box 99, 6055 Main St., Lula, GA 30554 (Frank McKinney, Tim Allen)

Monitored Parameters: flow, BOD, TSS, fecal coliform, pH

Physical Description: waste stabilizatin pond:

Receiving Stream: Lula Creek

Industrial NPDES Factilities

Buckhorn Minerals (Martin Marietta Agg.) Forsyth County NPDES #: GA0037290

34° 16'20" 83°03'00" Rendering Plant Rd.

PO Box 83005, Cumming, GA 31030

246 Stoneridge Dr., Suite 102, Columbia, SC 29210 (Richard Broughton)

Monitored Parameters: flow, BOD, TSS, fecal coliform, pH

Plant Operation: crushed stone quarry and sand

Waste: stormwater runoff/overflow

Impact Avoidance/Pollution Prevention: air quality and surface mining permits

Receiving Stream: Six Mile Creek

Davidson Mineral Properties - Habersham Habersham County NPDES #: GA0046086

34° 35'30" 83°33'00" Hwy 105, Demorest

PO Box 130, Clarkesville, GA 30523 (Pete Bradbury)

Davidson Mineral Properties 100 Crescent Center Pky #1240, Tucker, GA 30084

Owner: Habersham Quarry, DMP Inc.

Monitored Parameters: flow, BOD, TSS, fecal coliform, pH

Date of Construction: 1964

Plant Operation: granite quarry

Waste: runoff into sedimentation ponds, overflow discharged to stream

Receiving Stream: Hazel Creek

Habersham Mills Inc. Habersham County NPDES #: GA0001694

34° 35'31" 83°33'07"

PO Box 385, Habersham, GA 30544 (Reeves Hill)

Russell Corp Lee St, Alexander City, AL 35011

Monitored Parameters: flow, BOD, TSS, fecal coliform, pH, DO, TRC

Date of Construction: 1906

Plant Operation: manufactures cotton & synthetic yarns

Waste: two releases 1) sanitary waste, air wash, sludge disposal; 2) filter backwash, sedimentation basin washdown

Receiving Stream: Soquee River

High Point Minerals-Turkey Knob Mine Lumpkin County NPDES #: GA0037281

34° 32'35" 83°55'36" Rocktree Rd.

227 W. Moreno St., Buford, GA 30518

Date of Construction: 1993

Plant Operation: quarry

Waste: stormwater runoff runs into settling basin with overflow going into stream

Receiving Stream: Tributary to Cavenders Creek

JA Hudson Construction Co. White County NPDES #: GA0046311

34° 37'17" 83°49'47" Adair Mill Rd.

Rt. 3, Box 3182, Cleveland, GA 30528

Plant Operation: granite quarry

Waste: runoff: plant dust water, sed. basin storm water, quarry sump storm water, storm water , mine seepage

Receiving Stream: Tributary to Gold Branch

Scovill Inc. Mfg. Co. Habersham County NPDES #: GA0001112
34° 36'25" 83°32'15" Hwy 385 S. / 441 Business
PO Box 44, Clarksville, GA 30523 (Dave Barrett)
Alper Holding 767 3rd Ave., New York, NY 10017
Monitored Parameters: flow, total heavy metals, chromium (hexavalent), cyanide, cadmium, iron, phosphorus, TSS, chromium, copper, nickel, zinc
Date of Construction: 1957
Plant Operation: manufactures zippers, plastic buttons and apparel fasteners
Waste: cyanide plating rinses, chromating (after zinc), plating acid-alkaline rinses, laundry & incline rinses, rolling barrel rinses, non contact cooling water, water wash spray booth
Waste Treatment: pH adjustment fo rmetalhydroxide ppt, chlorination for cyanices, chromate reduction, dewatering of sludges, clarification, neutralization, filtration
Past Problems: '89: possible Cu, Ni; 5/95: P and cyanide violations
an aquatic toxicity evaluation was conducted in 12/95 that exhibited acute and chronic toxicity to C. dubia
Impact Avoidance/Pollution Prevention: emergency plan, evacuation plan, hazardous waste facility permit (#HW-090(D)), stormwater permit
Receiving Stream: Soque River

SKF Bearing Industries HallCounty NPDES #: GA0037265
34° 11'15" 83°56'00" McEver Rd & Radford Rd
PO Box 545, Flowery Branch, GA 30542 (Steve Stuart)
SKF USA Inc 1100 1st Ave, King of Prussia, PA 19406
Date of Construction: 1976
Plant Operation: manufactures ball and roller bearings
Waste: non contact cooling water
Past Problems: petroleum release in 1993
Receiving Stream: Tributary of Mud Creek

CERCLA Facilities

Abrams Big Star Property Dump Hall County EPA ID#: GAD984278150
Map Coords Mundy Mill Rd. behind Merchants Crossing Shopping Center
5775A Glenridge Dr., Suite 203, Atlanta, GA 30328
History: In January of 1989, eight drums were discovered on the site. The site was invetigated and the drums were removed. The drums were to undergo a full scale priority pollutant analysis to identify the contents. There was no evidence of any leakage from the abandoned drums.
Nearest Stream: Tributary to Balus Creek

Cummins Engine Co. Hall County EPA ID#: GAD980602999
34° 11'28" 83°54'20" 4515 Cantrell Rd, Flowery Branch, GA 30542
PO Box 3005-Mail Code 60024, Columbus, IN 47202 (Richard Breese)
History: This site is classified as a RCRA large quantity generator of hazardous waste. This site has a known release of arsenic in soil at levels exceeding the reportable quantity. The director of the GA EPD Hazardous Site Inventory has designated this site as Class II> Corrective action is pending as of July 1, 1994. It is classified as a very low priority because the site has low level contamination and is 1.9 miles from perennial water.

Ethicon Inc. Habersham County EPA ID#: GAD000614347
34° 31'05" 84°32' 70 Clarksville Hwy (Hwy 441)
PO Box 70, Cornelia, GA 30531
History: This facility has manufacture medical devices since 1980. It previously had a wastewater treatment facility (NPDES # GA0001783) that was taken out of operation ten years ago. Their wastewater now goes to Cornelia's municipal wastewater treatment facility. It is classified as being a RCRA large quantity generator of hazardous substances. There was a concern about spent solvents used in degreasing of dye stuffs from dying medical sutures and for sodium dichromate. The lagoon that was used for storage of residual solvents, good grade dyes and biodegradable detergents (that is out of service) has been tested for contamination. The depth to water table is 35' and the distance to static water is 1500'. It was designated No Further Remedial Action Planned in 1989.

SCM Corp Glidden Coatings & Resins Div. Hall County EPA ID#: 000622985

33° 12'40" 83°53'46"

Route 2, Box 300, Oakwood, GA 30566

SCM Corp. 299 Park Ave., New York, NY 10017

History: This site began operations in 1982. Its wastewaters are from latex paint manufacturing, with sludges dewartered and sent to landfill. The site is currently No Further Remedial Action Planned.

Wrigley Jr. Wm Co Hall County EPA ID#: EPA056206717

33° 11'45.5" 83°54'5" Rt 13 & 365, Flowery Branch

410 N. Michigan Ave., Chicago, IL 60611

History: This chewing gum manufacturer began operation in 1971 with a non-hazardous wastewater lagoon. It is clasified as a RCRA small quantity generator of hazardous substances. Apparently during the EPD investigation no contamination was found so the site was designated No Further Remedial Action Planned.

Landfills

Camp Merrill Lumpkin County Permit #: 093-0040 (SL)

Camp Wahsega Rd.

5th Ranger Training Bridge, Dahlonega, GA 30533-9499 (Michael Nuckols)

This site is classified as a RCRA small quantity generator, a transporter, and a burner/blender of hazardous substances. Its EPA identification number is GAR000001511.

Cumming Forsyth County Permit #

Facility reportedly opened in 1973 was abandoned in September 1975 and closed in October of 1975.

Habersham Co.-Pea Ridge HabershamCounty Permit #: 068-0160 (SL)

Facility stopped receiving waste on 10/8/93 and was supposedly closed 30 days after Dec. 11, 1995. In 1995 it was reported that the groundwater may be contaminated due to landfill gas condensate.

Lumpkin Co.-Barlow Homes Rd. Lumpkin County Permit #: 093-003D(SL)

280 Courthouse Hill, Dahlonega, GA 30523 (J.B. Jones)

Union Co.-Haralson mem. Drive County Permit #: 144-0010(SL)

114 Courthouse St., Box 1, Blairsville, GA 30512 (Hon. Glen Gooch)

Facility stopped receiving waste on 4/8/94 and was supposed closed 30 days after April 2, 1996. Residents nearby have complained of chromium and lead in the groundwater. This has not been substantiated according to information in the file.

White Co.-Dukes Cr. White County Permit #: 154-0030(SL)

1650 S. Main St., Suite A, Cleveland, GA 30528

APPENDIX 5-B. SUMMARY OF SAMPLING RESULTS

CBOD5
(mg/L)

TIER ONE FACILITIES

		8/16	8/30	9/13	9/25	10/6	10/27	11/16	12/11	12/18	1/2	1/19	2/9	3/15	3/28	Max	Min	Avg
Clarkesville							30	17	18	42	38		40	31	28	42	17	30
Scovill									47	29	25		37	42	62	62	25	41
Cornelia								8	6	3	6		5	7	5	8	3	6
Linwood	Tech						9	15	20	11	34		16	18	18	34	9	18
	Gainesville		16	16	20	12	9	9	22	9		10	18	11	10	22	9	14
Flat Creek	Tech						5		2	2	2		3	4	3	5	2	3
	Gainesville		<2	<2	<2	<2	3	<2	<2	<2	<2	3	3	<2	<2	3	3	3

TIER TWO FACILITIES

	2/9	3/15	3/28	4/11	4/30	Max	Min	Avg
Baldwin	37	> 90		85	49	85	37	57
Demorest		X		<4	<4	0	0	
Flowery Branch		18		6	8	18	6	11
Cleveland			17	12	7	17	7	12
Dahlonega			8	4	<3	8	4	6

APPENDIX 5-B. SUMMARY OF SAMPLING RESULTS

CONDUCTIVITY
(umohs/cm)

TIER ONE FACILITIES

		8/16	8/30	9/13	9/25	10/6	10/27	11/16	12/11	12/18	1/2	1/19	2/9	3/15	3/28	Max	Min	Avg
Clarkesville		267	289	298		171	338	254	232	307	271	139	225	202	142	338	139	241
Scovill		2260	2720	2110		2200		3110	2850	3150	2170	2250	2240	2990	2790	3150	2110	2570
Cornelia		877	870	823	468	618	750	764	531	625	683	633	844	771	719	877	468	713
Linwood	Tech	381	398	344	339	306	365	463	351	404	411	245	494	437	316	494	245	375
	Gainesville	380	380		330	280	380	430	330	390	370	220	550	440	330	550	220	370
Flat Creek	Tech	875	808	704	206	636	746	857	878		952	807	808	862	786	952	206	763
	Gainesville	910	800		870	600	800	800	770	880	860	820	910	870	870	910	600	828

TIER TWO FACILITIES

	2/9	3/15	3/28	4/11	4/30	Max	Min	Avg
Baldwin		383		329	291	383	291	334
Demorest		492		253	184	492	184	310
Flowery Branch		869		761	1,271	1271	761	967
Cleveland			369	332	330	369	330	344
Dahlonega			382	328	274	382	274	328

STORMWATER RUNOFF

	4/30	5/28	8/12	Max	Min	Avg
Flat Creek	233	239	311	311	233	261
Limestone Creek	89	83	82	89	82	85
SixMile Creek		191	113	191	113	152

APPENDIX 5-B. SUMMARY OF SAMPLING RESULTS

TIER ONE FACILITIES

TOTAL COLIFORM (# Colonies/100 mL)

		12/18	1/2	2/9	3/15	3/28	Max	Min	Avg
Clarkesville		>800000	40,000	>80000	TNTC	360,000	360,000	40,000	200,000
Scovill		>800	70	>800	87	500	500	70	219
Cornelia		2,300	80	29,000	>800	7,000	29,000	80	9,595
Linwood	Tech	60	12	3	4	4	60	3	17
	Gainesville	190	145	1,118	354	500	1,118	145	461
Flat Creek	Tech	50	120	100	>80	>80	120	50	90
	Gainesville	80	136	991	691	164	991	80	412

FECAL COLIFORM (# Colonies/100 mL)

		12/18	1/2	2/9	3/15	3/28	Max	Min	Avg
Clarkesville		>8000	850	0	450	1,000	1,000	0	575
Scovill		TNTC	0	0	0	0	0	0	0
Cornelia		7	8	10	0	0	10	0	5
Linwood	Tech	0	0	0	0	0	0	0	0
	Gainesville	1	<1	24	6	10	24	1	10
Flat Creek	Tech	0	0	1	0	0	1	0	0
	Gainesville	1	<1	30	7	1	30	1	10

TIER TWO FACILITIES

TOTAL COLIFORM (# Colonies/100 mL)

	2/9	3/15	3/28	4/11	4/30	Max	Min	Avg
Baldwin	TNTC	00,000		8,000	54,250	54,250	8,000	31,125
Demorest		21,000		230,000	40,000	230,000	21,000	97,000
Flowery Branch		1,600		373	200	1,600	200	724
Cleveland			> 800	4,500	49,740	49,740	4,500	27,120
Dahlonega			> 80,000	10,000	NA	10,000	10,000	10,000

FECAL COLIFORM (# Colonies/100 mL)

	2/9	3/15	3/28	4/11	4/30	Max	Min	Avg
Baldwin	44	10		> 800	615	> 800	10	223
Demorest		510		500	5,100	5100	500	2037
Flowery Branch		18		0	1	18	0	6
Cleveland			14	6	25	25	6	15
Dahlonega			620	4	NA	620	4	312

APPENDIX 5-B. SUMMARY OF SAMPLING RESULTS

MERCURY
(ug/L)

TIER ONE FACILITIES

		8/16	9/13	9/25	10/6	10/27	11/16	12/11	12/18	1/2	1/19	2/9	3/15	3/28
Clarkesville					< 0.2		< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Scovill					< 0.2		< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Cornelia				< 0.2	< 0.2		< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Linwood	Tech			< 0.2	< 0.2		< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
	Gainesville			<0.5		<0.5	<0.5							
Flat Creek	Tech			< 0.2	< 0.2		< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
	Gainesville			<0.5		<0.5	<0.5							

TIER TWO FACILITIES

	2/9	3/15	3/28	4/11	4/30
Baldwin		< 0.2		< 0.2	< 0.2
Demorest		< 0.2		< 0.2	< 0.2
Flowery Branch		< 0.2		< 0.2	< 0.2
Cleveland			< 0.2	< 0.2	< 0.2
Dahlonega			< 0.2	< 0.2	< 0.2

URBAN RUNOFF

	4/30	5/28	8/12
Flat Creek	<0.2	< 0.2	< 0.2
Limestone Creek	<0.2	< 0.2	< 0.2
SixMile Creek		< 0.2	< 0.2

APPENDIX 5-B. SUMMARY OF SAMPLING RESULTS

TOTAL ORGANIC CARBON
(mg/L)

TIER ONE FACILITIES

		8/16	9/13	9/25	10/6	10/27	11/16	12/11	12/18	1/2	1/19	2/9	3/15	3/28	Max	Min	Avg
Clarkesville		14	13		6	14	10	8	11	8	7	11	9	6	14	6	10
Scovill		43	26		26		43	27	23	14	25	23	19	20	43	14	26
Cornelia		10	7	6	6	6	8	4	4	3	5	4	3	4	10	3	5
Linwood	Tech	19	13	10	9	11	12	9	7	9	13	10	10	8	19	7	11
	Gainesville		17	13		17	19	20	15	32	16	24	27	21	32	13	20
Flat Creek	Tech	8	5	6	4	6	5	5	3	3	6	4	4	4	8	3	5
	Gainesville		5	4		7	7	6	5	6	9	7	7	7	9	4	6

TIER TWO FACILITIES

	2/9	3/15	3/28	4/11	4/30	Max	Min	Avg
Baldwin	12	18		13	11	18	11	14
Demorest		8		4	3	8	3	5
Flowery Branch		6		5	6	6	5	6
Cleveland			7	7	6	7	6	7
Dahlonega			4	3	3	4	3	3

APPENDIX 5-B. SUMMARY OF SAMPLING RESULTS

AMMONIA
(mg NH3-N /L)

TIER ONE FACILITIES

		8/16	8/30	9/13	9/25	10/6	10/27	11/16	12/11	12/18	1/2	1/19	2/9	3/15	3/28	Max	Min	Avg
Clarkesville				13.90		3.08	11.46	8.39	6.44	8.52	10.20	4.17	6.83	7.46	2.05	13.90	2.05	7.50
Scovill				1.76		1.10		0.68	0.27	0.92	1.66	0.91	0.25	0.26	0.05	1.76	0.05	0.79
Cornelia				47.40	6.14	16.40	22.00	20.83	4.66	10.40	27.10	25.07	31.58	27.30	10.50	47.40	4.66	20.78
Linwood	Tech			15.30	5.30	4.88	4.00	8.97	9.10	9.77	12.30	2.11	9.48	8.93	2.33	15.30	2.11	7.71
	Gainesville				5.59	4.56	3.47	8.96	9.25	10.20	16.20	2.00	9.00	10.30	6.00	16.20	2.00	7.78
Flat Creek	Tech			1.08	0.11	0.12	1.40	0.10	1.07	1.18	0.92	0.68	0.32	0.20	0.06	1.40	0.06	0.60
	Gainesville				0.62	<0.1	1.00	<0.1	<0.1	<0.1	<0.1	0.28	0.12	0.14	<0.1	1.00	0.12	0.43

TIER TWO FACILITIES

	3/15	3/28	4/11	4/30	Max	Min	Avg
Baldwin	12.17		12.37	11.9	12.37	11.90	12.15
Demorest	9.97		0.73	0.4	9.97	0.40	3.70
Flowery Branch	4.8		3.93	6.98	6.98	3.93	5.24
Cleveland		1.28	2.59	3.77	3.77	1.28	2.55
Dahlonega		0.54	0.44	0.75	0.75	0.44	0.58

URBAN RUNOFF

	4/30	5/28	8/12	Max	Min	Avg
Flat Creek	0.61	0.37	0.83	0.83	0.37	0.60
Limestone Creek	0.62	0.41	0.76	0.76	0.41	0.60
SixMile Creek		3.55	0.94	3.55	0.94	2.25

APPENDIX 5-B. SUMMARY OF SAMPLING RESULTS

NITRATE
(mg NO3--N/L)

TIER ONE FACILITIES

		8/16	8/30	9/13	9/25	10/6	10/27	11/16	12/11	12/18	1/2	1/19	2/9	3/15	3/28	Max	Min	Avg
Clarkesville						1.4	5.1	4.0	18.0	66.3	10.5	14.0	3.6	0.5	7.7	66.3	0.5	13.1
Scovill						29.2		138.5	67.0	301.2	187.7	132.5	22.8	32.4	101.7	301.2	22.8	112.6
Cornelia						0.7	4.2	15.1	46.4	59.2	31.7	4.2	1.3	1.1	1.2	59.2	0.7	16.5
Linwood	Tech					7.6	10.9	6.2	25.4	27.5	19.5	17.4	11.0	11.7	9.5	27.5	6.2	14.7
	Gainesville						6.9	2.6								6.9	2.6	4.8
Flat Creek	Tech					6.5	8.3	18.2	41.1	89.1	18.1	30.2	23.0	23.9	15.7	89.1	6.5	27.4
	Gainesville				21.0		7.7	21.0								21.0	7.7	16.6

TIER TWO FACILITIES

	2/9	3/15	3/28	4/11	4/30	Max	Min	Avg
Baldwin	2.7	0.7		2.2	1.8	2.7	0.7	1.8
Demorest		0.7		2.0	3.8	3.8	0.7	2.2
Flowery Branch		0.5		0.7	1.0	1.0	0.5	0.7
Cleveland			3.4	6.6	20.9	20.9	3.4	10.3
Dahlonega			7.5	16.5	21.1	21.1	7.5	15.0

URBAN RUNOFF

	5/28	8/12		Max	Min	Avg
Flat Creek	3.35	3.75		3.75	3.35	3.55
Limestone Creek	0.19	0.61		0.61	0.19	0.40
SixMile Creek	8.24	6.76		8.24	6.76	7.50

APPENDIX 5-B. SUMMARY OF SAMPLING RESULTS

NITRITE
(mg NO2--N/L)

TIER ONE FACILITIES

		8/16	8/30	9/13	9/25	10/6	10/27	11/16	12/11	12/18	1/2	1/19	2/9	3/15	3/28	Max	Min	Avg
Clarkesville				2.21		2.74	0.17	0.22	0.25	0.04	0.07	0.06	0.03	0.03	0.04	2.74	0.03	0.53
Scovill				2.14		0.17		0.42	0.79	0.66	0.90	0.22	0.26	0.74	0.60	2.14	0.17	0.69
Cornelia				3.86	2.22	2.09	0.50	2.50	1.76	1.51	0.32	0.12	0.06	0.03	0.42	3.86	0.03	1.28
Linwood	Tech			0.92	0.32	0.15	0.27	0.16	0.13	0.10	0.14	0.13	0.24	0.30	0.20	0.92	0.10	0.26
	Gainesville							0.60								0.60	0.60	0.60
Flat Creek	Tech			0.17	0.01	0.03	0.08	0.02	0.02	0.02	0.02	0.03	0.03	0.05	0.02	0.17	0.01	0.04
	Gainesville				<0.05													

TIER TWO FACILITIES

	2/9	3/15	3/28	4/11	4/30	Max	Min	Avg
Baldwin	0.02	0.03		0.003	0.01	0.03	0.00	0.02
Demorest		0.06		0.01	0.02	0.06	0.01	0.03
Flowery Branch		0.01		0.02	0.01	0.02	0.01	0.01
Cleveland			0.12	0.10	0.09	0.12	0.09	0.10
Dahlonega			1.00	0.14	0.51	1.00	0.14	0.55

URBAN RUNOFF

	4/30	5/28	8/12	Max	Min	Average
Flat Creek	0.008	0.016	0.010	0.016	0.008	0.011
Limestone Creek	0.005	0.008	0.007	0.008	0.005	0.007
SixMile Creek		0.189	0.017	0.189	0.017	0.103

APPENDIX 5-B. SUMMARY OF SAMPLING RESULTS

TOTAL PHOSOPHORUS
(mg P /L)

TIER ONE FACILITIES

		9/25	10/6	10/27	11/16	12/11	12/18	1/2	1/19	2/9	3/15	3/28	Max	Min	Avg
Clarkesville				3.60	2.75	2.96	2.30	1.42	1.06	2.35	2.78	2.40	3.60	1.06	2.40
Scovill					3.13	2.01	1.23	0.92	3.09	3.45	4.31	8.90	8.90	0.92	3.38
Cornelia				1.45	0.67	2.57	1.51	0.58	1.37	1.98	0.04	0.65	2.57	0.04	1.20
Linwood	Tech			3.67	3.33	3.61	2.74	2.32	3.88	3.98	5.82	4.04	5.82	2.32	3.71
	Gainesville	4.52	3.38	3.89		3.52	3.83	4.69	2.20	3.88	5.90	4.01	5.90	2.20	3.98
Flat Creek	Tech			0.22	0.10	0.55	0.01	0.10	0.16	0.29	0.19	0.27	0.55	0.01	0.21
	Gainesville	0.65	0.76	0.34		0.47	0.25	0.19	0.24	0.28	1.05	0.28	1.05	0.19	0.45

TIER TWO FACILITIES

	2/9	3/15	3/28	4/11	4/30	Max	Min	Avg
Baldwin	3.92	8.53		6.87	6.51	8.53	3.92	6.46
Demorest		0.05		1.58	0.88	1.58	0.05	0.84
Flowery Branch		2.84		0.29	1.97	2.84	0.29	1.70
Cleveland			2.62	1.54	2.37	2.62	1.54	2.18
Dahlonega			2.14	2.50	2.10	2.50	2.10	2.25

URBAN RUNOFF

	4/30	5/28	8/12	Max	Min	Avg
Flat Creek	0.06	0.31	0.62	0.62	0.06	0.33
Limestone Creek	0.06	0.04	0.41	0.41	0.04	0.17
SixMile Creek		0.92	1.15	1.15	0.92	1.04

APPENDIX 5-B. SUMMARY OF SAMPLING RESULTS

TOTAL SUSPENDED SOLIDS
(mg/L)

TIER ONE FACILITIES

		9/13	9/25	10/6	10/27	11/16	12/11	12/18	1/2	1/19	2/9	3/15	3/28	Max	Min	Avg
Clarkesville		34		19	67	50	35	86	34	40	28	31	36	86	19	40
Scovill		1		1		2	9	1	1	2	3	1	6	9	1	3
Cornelia		6	12	185	4	9	12	11	13	8	8	7	5	185	4	22
Linwood	Tech	25	21	26	7	9	18	12	19	39	27	22	30	39	7	20
	Gainesville	26	23	36	15	14	23	11	42	45	22	29	53	53	11	28
Flat Creek	Tech	1	1	8	2	3	2	2	3	5	4	5	5	8	1	3
	Gainesville	3	1	3	8	4	3	2	3	6	5	6	4	8	1	4

TIER TWO FACILITIES

	2/9	3/15	3/28	4/11	4/30	Max	Min	Avg
Baldwin	22	107		68	80	107	22	69
Demorest		4		5	4	5	4	4
Flowery Branch		33		17	12	33	12	21
Cleveland			30	18	5	30	5	17
Dahlonega			7	4	4	7	4	5

URBAN RUNOFF

	4/30	5/28	8/12	Max	Min	Avg
Flat Creek	19	19	137	137	19	58
Limestone Creek	19	8	101	101	8	43
SixMile Creek		24	444	444	24	234

APPENDIX 5-B. SUMMARY OF SAMPLING RESULTS

TURBIDITY
(NTU)

TIER ONE FACILITIES

		9/13	9/25	10/6	10/27	11/16	12/11	12/18	1/2	1/19	2/9	3/15	3/28	Max	Min	Avg
Clarkesville		35		30	45	35	35	65	35	75	40	25	50	75	20	40
Scovill		2.2		6.5		15	19	10	6.0	6.5	13	7.0	13	19	2	9
Cornelia		3.8	6.5	3.5	4.8	10	6.4	4.5	5.5	7.7	4.2	4.5	3.7	12	4	6
Linwood	Tech	21	21	34	8.5	16	13	9.0	15	52	31	26	31	52	9	23
	Gainesville	17.5	15.8	26.4	5.48	12.7	14.0	6.81	27.2	42.2	8.2	26.7	38	42	5	21
Flat Creek	Tech	1.4	0.8	2.0	3.8	6.0	2.3	2.0	1.8	7.0	2.4	5.7	3.3	7	1	3
	Gainesville	0.81	0.50	1.58	2.20	2.88	1.10	1.06	1.48	1.55	2.66	3.97	2.4	4	1	2

TIER ONE FACILITIES

	2/9	3/15	3/28	4/11	4/30	Max	Min	Avg
Baldwin	23	100		120	75	120	23	80
Demorest		4.5		5.5	5	5.5	4.5	5.0
Flowery Branch		33		12	11	33	11	19
Cleveland			18	18	18	18	18	18
Dahlonega			9.0	6.0	3	9.0	2.9	6.0

URBAN RUNOFF

	4/30	5/28	8/12	Max	Min	Avg
Flat Creek	58	60	> 200	60	58	59
Limestone Creek	57	33	198	198	33	96
SixMile Creek		69	> 200	69	69	69

APPENDIX 5-C

Determination of Trace Metals in Wastewater by ICP-MS

ICP-MS Principles of operation

An aqueous sample is pneumatically nebulized and introduced into a high purity argon radio frequency inductively coupled plasma at 10,000 °C and atmospheric pressure. In the plasma, energy transfer processes result in the desolvation, atomisation and ionization of a large fraction of the constituent elements. Most of the ions formed are monocharged. A fraction of the ions are extracted from the plasma to the mass spectrometer (ambient temperature and ~3.4x10-2 Pa absolute) via a differentially pumped vacuum interface consisting of a sampling and a skimmer cone. The sampling cone extracts ions from the hottest part of the plasma where the greatest degree of ionisation occurs. The skimmer cone further reduces the number of ions going to the spectrometer.

The stream of ions from the skimmer cone is focused by a series of four ion lenses and then passes into the quadrupole mass spectrometer which selects the ions which will reach the detector, a channel electron multiplier (CEM) on the basis of charge-to-mass ratio.The spectrum of mass-to-charge ratios is achieved by linearly varying the RF and DC voltage amplitudes on the quadrupole rods. The mass of the ions which reach the detector is a linear function of the applied voltage.

The intensity of the ion current reaching the detector at a given charge to mass ratio is processed by a data handling system which also controls the sampling time, resolution and mass-to-charge ratios for data acquisition (Perkin-Elmer, 1995),(Long et al., 1990)

Interferences

Isobaric Interferences

Isobaric interferences result from the formation of atomic or molecular ions of other elements at the same nominal mass to charge ratio as the analyte of interest. Element corrections may be used to correct for these interferences. This involves measuring the intensity of the interfering species at other mass to charge ratios (resulting from different isotopes) and using relative isotope abundances to determine the contribution of the interference to the analyte signal (Long et al, 1990).

For example, the interference of the $^{40}Ar^{35}Cl^+$ molecule ion on ^{75}As has been well documented. In order to calculate the contribution of $^{40}Ar^{35}Cl^+$ to the signal at mass 75, the signal for $^{40}Ar^{37}Cl^+$ at mass 77 is measured. The ratio of the relative abundances of the isotopes ^{35}Cl and ^{37}Cl is 3.12. Therefore, the contribution of $^{40}Ar^{35}Cl^+$ to the counts at mass 75 should be 3.12 the contribution of $^{40}Ar^{37}Cl^+$ to the counts at mass 77 assuming the same degree of molecule-ion formation for both isotopes. However, ^{77}Se may also contribute the counts at mass 77. The contribution of Se to the counts at 77 may be determined from the counts for ^{82}Se and the ratio of relative abundances of ^{77}Se to ^{82}Se (0.825). The overall element equation for As is therefore:

$$^{75}\mathbf{As} = {}^{75}\mathbf{Counts} - 3.12 \times {}^{77}\mathbf{Counts} + 2.57 \times {}^{82}\mathbf{Se}$$

(course notes: Perkin-Elmer customer training, October 1995)

Less common but more difficult to deal with than isobaric interferences is interferences due to high ion currents at adjacent masses to the mass of interest. The spectrometer provides a nominal resolution of 10 % of the peak height

Physical interferences

Changes in surface tension or viscosity may affect nebulization and aerosol transport. Solids deposition on the nebulizer tip and sampling cones will reduce instrument performance and response. The presence of high concentrations of readily ionizable atoms in the sample matrix may also affect the ionisation efficiency of the analyte of interest. Internal standardization compensates for sampling interferences. The use of an appropriate internal standard also helps compensate for matrix effects on ionisation efficiency in the plasma. Sample dilution also generally reduces interferences due to matrix effects.

Memory effects

Memory interferences may occur when there are large concentration differences between samples or standards which are analyzed sequentially. This can be avoided by using a sufficiently long rinse time between samples.

Chemicals and equipment

1,000 ppm standard solutions were purchased from Perkin-Elmer. 10 ppm multielement standard solutions were prepared in 1 % nitric acid and stored in teflon bottles. Calibration standards were prepared daily by diluting the multielement stocks in 1 % nitric acid.

Standards, samples and the rinse blank were prepared using DI or E-pure water and trace metal grade acid.

Glassware used in the digestion was soaked overnight in a soap bath and then for 4 hours in a 1:2:9 HNO_3:HCl:H_2O bath and thoroughly rinsed with DI water. Glassware used for the preparation of the final batch of samples were cleaned further by heating on a hot plate with a mixture of 1:1:5 HNO_3:HCl:H_2O to extract residual metals from previous digestions.

Samples and standards were prepared and analyzed in disposable centrifuge tubes.

The calibrations of all pipettors used were regularly checked.

Analyses were carried out using a Perkin-Elmer Sciex Elan 5000 Inductively Coupled Plasma - Mass Spectrometer and Perkin-Elmer AS 90 Autosampler connected by a peristaltic pump. Data acquisition and processing was controlled by a 386 PC using the Xenix System V based Perkin-Elmer Sciex Elan 5000 ICP-Mass Spectrometer Version 2.2 software (1992)

Sample collection and storage:

Samples were collected in acid-washed bottles, acidified to pH < 2 and stored at 4 ^{o}C.

Sample preparation

The digestion method used was based on EPA Method 200.8 version 4.3 (Long et al, 1990). This method uses both nitric and hydrochloric acid in the digestion for total recoverable metals. The author notes, however, that chloride interferes were several elements, especially arsenic and should be eliminated where possible. Chloride is specifically required to stabilize silver and antimony, however, neither of these elements were included in the analysis. Hydrochloric acid was used for the preparation of samples for semiquantitative scans and for the seven element analysis of the effluent samples. However, it was replaced by additional nitric acid in the arsenic and selenium analysis and in the samples sent to the University of Georgia laboratory.

Digestion method:

1. 50 mL of well mixed sample was transferred to a 150 mL Griffin beaker.

2. 0,5 mL concentrated HNO_3 and 0,25 mL concentrated HCl were added to the sample. (0.75 mL HNO_3)

3. The beaker was covered with a ribbed watch glass.

4. The beaker was heated on a hot plate in a metal free fume hood and the liquid evaporated to a low volume (> 10 mL) without boiling or allowing the temperature to exceed 85 ^{o}C and without allowing any part of the bottom of the beaker to go dry.

5. The digestate was quantitatively transferred to a 50 mL centrifuge tube and diluted to volume with DI or E-pure water.

6. The sample was allowed to stand overnight or centrifuged to settle out solids.

7. For the determination of As and Se 10 mL of supernatant was pipetted into a second centrifuge tube For the determination of the other six metals, 2 mL of supernatant was diluted to 10 mL with 1 % nitric acid. Samples were spiked with 100 ppb internal standard prior to analysis.

Analysis

The instrument was initially tuned to optimize the response in each method. A warm-up period of at least 30 minutes after ignition of the plasma was allowed before commencing with the analysis.

The parameter sets for each analysis are summarized in Tables 1 (a) - (c). The instrument was rinsed with 2 % nitric acid solution in between each sample.

Bismuth (^{209}Bi) was used as the internal standard for lead while all other metals were calibrated using Yttrium. (^{89}Y)

The measured analyte concentrations in each sample were required to be less than the highest calibration standard (50 ppb for As and Se and 500 ppb for the other metals), or else the sample was diluted and reanalyzed. Blank subtraction was used in the analysis for Cr etc., but not for As and Se. All calibration curves were calculated by linear regression through zero.

Table 1 (a): Parameter Set for Determination of Arsenic and Selenium

Sweeps / reading		1		
Readings / replicate		1		
Number of replicates		10		
Points across peak		3		
Resolution		normal		
Scanning mode		peak hop		
Baseline time (ms)		0		
Transfer frequency		measurement		
Polarity		+		
Element	**Mass**	**Internal Standard**	**Replicate time (ms)**	**Dwell time (ms)**
As	75	Y	300	300
Se	82	Y	1500	1500
	77	Y	300	300
Y	89		300	300
Element equations:				
As	75 = As 75 - 3.13 x mass 77 + 2.53 x mass 82			
Manual settings				
Plasma gas flow	15 L/min	RF Power	1000 Watts	
Nebulizer gas flow	0.93 L/min	CEM Voltage	3.35 kV	
Auxiliary gas flow	0.85 L/min	Sample uptake	0.9 mL/min	

Table 1 (b): Parameter Set for Determination of Chromium, Nickel, Copper, Zinc, Cadmium, Barium and Lead

Sweeps / reading		10		
Readings / replicate		1		
Number of replicates		5		
Points across peak		3		
Resolution		normal		
Scanning mode		peak hop		
Baseline time (ms)		0		
Transfer frequency		replicate		
Polarity		+		
Element	**Mass**	**Internal Standard**	**Replicate time (ms)**	**Dwell time (ms)**
Cr	52	Y		
Ni	60	Y		
Cu	63	Y		
Zn	66	Y		
Y	89			
	106	Y		
	108	Y		
Cd	111	Y		
Ba	138	Y		
	206	Bi		
	207	Bi		
Pb	208	Bi		
Bi	209			

Table 1(b) cont.

Element equations:			
Cd	111 = Cd 111 - 1.073 x mass 108 - 0.712 x mass 106		
Pb	208 = Pb 208 + mass 206 + mass 207		
Manual settings			
Plasma gas flow	15 L/min	RF Power	1000 Watts
Nebulizer gas flow	0.921 L/min	CEM Voltage	3.35 kV
Auxiliary gas flow	0.87 L/min	Sample uptake	1 mL/min

Table 3(c): Parameter Set for Crop and Soil Sciences Laboratory

QA/QC

1 Method detection limit (MDL) and reported detection limits (RDL)

The MDL's were established by taking 9 replicate aliquots of DI or water fortified at a concentration of 10 ppb for As, 20 ppb for Se and 10 aliquots of E-pure water fortified at 2 ppb for the other metals through the entire analytical method including digestion but excluding 5 fold dilution for the second group of metals. The MDL for each analyte was then calculated as the standard deviation of the measurements of the replicates multiplied by the one sided t statistic for a 99 % confidence interval:

MDL = (t)x(S)

where t= 2.9 and 2.82 for 9 and 10 samples respectively and S = standard deviation of the replicate analyses.

Since the RDL's established at Georgia Tech were fairly conservative and reflected the difficulties encountered with contamination in the digestion step, they have also been used in the reporting of the storm water samples.

2. Assessing Laboratory Performance

Each batch of samples digested included a reagent blank, a fortified reagent blank, matrix spikes and matrix duplicates or matrix spike duplicates. In the determination of As and Se, one matrix spike and one duplicate or spike duplicate was analyzed for each facility analyzed. For the second group spikes and duplicates were analyzed at a frequency of greater than 5 % of the samples.

Fortified reagent blanks and matrix spikes were spiked with 20 ppb in the determination of As and Se and 100 ppb in the determination of the other metals.

Analyte concentrations in the reagent blank were required to be less than the MDL's. Recoveries of 90 to 110 % and 80 to 120 % were required for the fortified reagent blanks and matrix spikes respectively.

3. Interference Checks

The following measures were adopted from SW-846 Method 6020 to check for interferences:

a) Interference check standard

A set of interference check standards were purchased from Perkin-Elmer. The ICS-AB solution was diluted 10 times and analyzed to assess the potential error due to interfering ions, especially Cl, on As and Se, and the effectiveness of element correction equation. 10X dilution yielded final concentrations of 10 ppb for As and Se and 360 ppm Cl. Recoveries of As and Se were within 10 % of these values.

b) Post digestion spike

Selected samples were spiked with 50 ppb of As and Se or 100 ppb of the other metals just prior to analysis. 90 to 110 % recovery of the post digestion spike was required.

4. Calibration checks

The calibration was checked by running the calibration blank and one calibration standard as samples immediately after the initial calibration was established, and once every 10 samples thereafter. If the calibration check was not within 10 % of the initial value, it was reanalyzed and if it was again outside the limits, the instrument was recalibrated and the previous 10 samples reanalyzed.

The internal standard response was required to be within 60 to 125 % of the original response in the calibration blank.

5. Split Samples

Four effluent samples were sent to the University of Georgia laboratory for digestion and analysis in order to compare results from the two laboratories. Samples were prepared by microwave digestion using nitric and hydrofluoric acid followed by filtration to remove solids. They were then analyzed for all eight metals simultaneously using an Elan 6000 ICP-MS.

Contamination problems

The multielement analysis of the WWTP effluent was plagued by zinc contamiantion as evidenced concentrations of up to 6 mg/L background zinc measured in blanks. This led to a high calculated detection limit for zinc. Prior to the stormwater analysis, additional problems were noted with copper, chromium and lead. Multiple measurements of the same sample confirmed that this was due to contamination of the digestate rather than an unstable analyte signal. It is suspected that the contamination came from the beakers used in the digestion since no contamination in the DI water was observed. Various attempts were made to eliminate this problem including soaking beakers twice in successivly cleaner acid baths and heating them on the hot plate with a strong acid mixture to leach out contaminants. Unfortunately the quality control samples sent to the UGA laboratory indicated that there was still a problem with zinc contamination.

This background contamination results in a high degree of uncertainty in low measurements of Zn in the samples. However, since recoveries of Zn in the laboratory controls, matrix spikes and post digestion spikes were within the acceptable limits, it appears that high Zn measurements may be trusted. Since Zn is a common element which was present at relatively high concentrations in most of the samples analyzed, it is felt that this contamination problem does not have serious impact on the quality of the data for the purposes of this project.

Flow weighted averages and loading calculations

All measured concentrations were included in the calculation of the flow weighted averages and annual loadings, including those concentrations below the detecton limit. The rationale behind this was that excluding such values or replacing them with the detection limit would inflate the calculated average whilesetting them equal to zero would result in an under estimate. It was assumed that the instrument response was the best available estimate of the true value.

Results

All results are in μg/L

1. Detection limits

Table 2: Reported detection limits and estimated MDL's for EPA 200.8

Element	Reported detection limit		EPA 200.8 estimated detection limit	
	Dilution factor	RDL (μg/L)	Dilution factor	MDL (μg/L)
As	1	1.4	1.25	1.4
Se	1	1.4	1.25	7.9
Cr	5	2.4	1.25	0.4
Ni	5	2.5	1.25	0.5
Cu	5	2.2	1.25	0.5
Zn	5	22.7	1.25	1.8
Cd	5	1.0	1.25	0.5
Ba	5	1.0	1.25	0.8
Pb	5	1.5	1.25	0.3

Detection limits for ICP-MS were generally at least an order of magnitude smaller than the detection limits reported in the EPD files allowing the maximum contaminant loading of low concentration elements to be more accurately estimated.

2. Semiquantitative Results

Table 3 (a): Semiquantitative Scan Results for First Tier Facilities(μg/L).

Facility	Clarkesville		Cornelia		Flat Creek		Linwoo d	Scovill
Date	11-Dec	19-Jan	2-Jan	15-Mar	9-Feb	28-Mar	2-Jan	11-Dec
Sb	< 0.01	<0.01	< 0.01	<0.01	<0.01	< 0.01	<0.01	0.14
Ba	20.26	28.25	5.61	9.11	4.56	8.17	26.89	1.34
Be	0.02	0.02	0.02	0	0	0	<0.01	0.11
Cd	0.36	0.3	0.03	0.16	0.06	0.06	0.13	0.05
Cr	0.86	1.96	0.89	0.48	0.51	0.81	1.34	1.59
Co	0.3	0.47	1.56	1.76	0.71	0.87	0.5	0.23
Cu	21.19	23.59	3.3	3.09	3.43	5.26	20.88	219.7
Pb	3.5	5.35	0.57	1.31	1.23	1.99	8.87	1.44
Mn	24.86	39.11	137.8	162.3	73.4	137.5	60.9	1.89
Mo	3.96	1.61	2.29	1.14	13.19	24.82	0.9	41.94
Ni	2.31	2.54	8	4.06	8.93	6.06	2.49	441.2
Ag	0.05	0.01	< 0.01	<0.01	<0.01	< 0.01	0.04	<0.01
V	18.93	3.28	14.77	0.55	3.27	17.98	0.59	10.81
Zn	223.1	73.92	50.46	48.51	73.38	68.45	71.33	213

Table 3 (b): Semiquantitative Scan Results for Second Tier Facilities (μg/L).

Facility	Baldwin	Cleveland	Dahlonega	Demorest	Flowery Branch
Date	11-Apr	25-Apr	11-Apr	19-Jan	15-Mar
Sb	<0.01	<0.01	< 0.01	<0.01	<0.01
Ba	32.86	9.09	6.02	25.32	32.64
Be	0	0	0	0.02	0.03
Cd	0.11	0.14	0.19	0.39	0.23
Cr	2.21	1.25	0.85	2.18	24.31
Co	1.2	0.42	0.79	0.47	3.4
Cu	3.3	12.22	10.83	19.15	28.09
Pb	1.56	1.96	1.14	2.62	2.25
Mn	15.78	62.96	61.86	51.63	113.4
Mo	0.44	35	11.28	19.11	33.04
Ni	3.42	3.56	1.55	7.16	10.76
Ag	<0.01	<0.01	< 0.01	<0.01	<0.01
V	20	18.14	14.4	21.32	19.57
Zn	128.2	46.24	52.24	75.64	119.8

Table 3(c): Semiquantitative Scan Data for Stream Samples (μg/L).

Stream	Flat Creek	Limestone Creek	Six Mile Creek
Date	6-Jun	6-Jun	11-Apr
Sb	0	0	0
Ba	67.46	36.51	266.7
Be	0	0	0
Cd	2.36	1.93	0.77
Cr	21.94	23.11	26.53
Co	4.96	1.76	11.53
Cu	8.51	8.85	19.43
Pb	17.03	12.46	15.78
Mn	0.86	0.64	5.13
Mo	9.28	15.09	0
Ni	0.06	0.32	0.2
Ag	0	0	0
V	21.22	15.21	45.26
Zn	60.26	49.21	91.19

3. Quantitative Results

Table 4 (a): As in First Tier Facilities Effluent (μg/L).

Facility	Clarkesville	Cornelia	Flat Creek	Linwood	Scovill
16-Nov					4.7
11-Dec			< 1.4		4.2
18-Dec	< 1.4	< 1.4	< 1.4	< 1.4	1.9
2-Jan	< 1.4	< 1.4	< 1.4	< 1.4	1.5
19-Jan	< 1.4	< 1.4		< 1.4	2.4
9-Feb	< 1.4	< 1.4	< 1.4	< 1.4	2.1
15-Mar	< 1.4	< 1.4	< 1.4	< 1.4	2.9
28-Mar	< 1.4	< 1.4	< 1.4	< 1.4	4.1

Table 4 (b): As in Second Tier Facilities Effluent (µg/L).

Facility	Baldwin	Cleveland	Dahlonega	Demorest	Flowery Branch
19-Jan				< 1.4	
9-Feb	< 1.4	< 1.4			
15-Mar	< 1.4				< 1.4
28-Mar		< 1.4	< 1.4		
11-Apr	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4
25-Apr	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4

Table 5 (a): Se in First Tier Facilities Effluent (µg/L).

Facility	Clarkesville	Cornelia	Flat Creek	Linwood	Scovill
16-Nov					< 1.4
11-Dec			< 1.4		< 1.4
18-Dec	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4
2-Jan	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4
19-Jan	< 1.4	< 1.4		< 1.4	< 1.4
9-Feb	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4
15-Mar	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4
28-Mar	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4

Table 5(b): Se in Second Tier Facilities Effluent (µg/L).

Facility	Baldwin	Cleveland	Dahlonega	Demorest	Flowery Branch
19-Jan				< 1.4	
9-Feb	< 1.4	< 1.4			
15-Mar	< 1.4				< 1.4
28-Mar		< 1.4	< 1.4		
11-Apr	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4
25-Apr	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4

No As and Se was detected in any of the WWTP effluents except for As at Scovill. Samples from Scovill were reanalyzed to confirm the presence of As.

Table 6 (a): Cr, Ni, Cu, Zn, Cd, Ba and Pb in First Tier Municipal WWTP Effluent (μg/L).

Facility	Clarkesville		Cornelia		Flat Creek		Linwood	
Date	2-Jan	9-Feb	9-Feb	15-Mar	9-Feb	15-Mar	19-Jan	15-Mar
Cr	2.9	< 2.4	< 2.4	< 2.4.	< 2.4.	< 2.4.	3.9	< 2.4.
Ni	2.9	6.6	7.1	4.7	9.7	6.2	3.6	4.1
Cu	40	39	7.5	5.7	5.1	11	25	33
Zn	124	312	69	67	112	110	86	118
Cd	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ba	23	25	5.6	9.2	9	8.3	41	46
Pb	4.4	6.2	< 1.0.	1.5	2.2	2.4	13	14

Table 6 (b): Cr, Ni, Cu, Zn, Cd, Ba and Pb in Second Tier Municipal WWTP Effluent (μg/L).

Facility	Baldwin		Cleveland		Dahlonega		Demorest		Flowery Branch
Date	15-Mar	11-Apr	11-Apr	30-Apr	28-Mar	11-Apr	11-Apr	30-Apr	11-Apr
Cr	3.2	2.7	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	8.2
Ni	7.9	8.1	3.6	3.7	2.9	< 2.5	< 2.5	< 2.5	3.4
Cu	22	22	14	15	18	12	13	12	26
Zn	166	83	53	35	75	66	104	56	53
Cd	< 1.0	< 1.0	< 1.0	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ba	54	24	9	7.7	17	6.5	22	29	19
Pb	4.4	2.7	< 1.5	< 1.5	< 1.5	< 1.5	1.8	< 1.5	2.4

Table 6 (c): Cr, Ni, Cu, Zn, Cd, Ba and Pb in Scovill Industrial WWTP Effluent (µg/L).

Date	18-Dec	2-Jan	19-Jan	9-Feb	15-Mar	28-Mar
Cr	86	3.7	6	3.1	2.9	5.1
Ni	199	154	638	483	171	561
Cu	93	166	320	221	108	218
Zn	438	69	135	163	75	105
Cd	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ba	5.1	5.6	2.6	1.9	1.5	1.3
Pb	< 1.5	< 1.5	2.5	1.6	< 1.5	< 1.5

4. Stormwater results

Table 7: Stormwater results (µg/L).

Stream	South Flat Creek			Limestone Creek		Six Mile Creek	
Date	30-April	28-May	12-Jun	28-May	12-Jun	28-May	12-Jun
As	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	1.5	< 1.4
Se	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4
Cr	< 2.4	< 2.4	3.5	< 2.4	< 2.4	< 2.4	12
Ni	3.8	3.6	4.8	< 2.5	< 2.5	< 2.5	5.8
Cu	8.9	9.7	5.7	8.3	6.1	10	12
Zn	65	97	50	58	33	85	73
Cd	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ba	21	20	34	22	27	100	158
Pb	9.1	4.6	5.7	1.8	9.0	2.8	10

Metal levels in samples taken on different days from the same facility or stream were generally fairly close. Zinc showed the greatest fluctuation between days.

5. Split Sample Data

Table 8: Georgia Tech and UGA Results for Split Samples (μg/L).

Facility	Baldwin		Dahlonega		Linwood		Scovill	
Date	11-Apr		11-Apr		15-Mar		2-Jan	
Laboratory	Georgia Tech	UGA	Georgia Tech	UGA	Georgia Tech	UGA	Georgia Tech	UGA
As	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	1.5	1.8
Se	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	1.6	< 1.4	< 1.4
Cr	2.7	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	3.7	2.9
Ni	8.1	7.8	< 2.5	3.2	4.1	3.9	154	151
Cu	22	14	12	6.4	33	25	166	142
Zn	83	62	66	41	118	114	69	53
Cd	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ba	24	23	6.5	5.9	46	42	5.6	5.1
Pb	2.7	2.3	< 1.5	< 1.5	14	13	< 1.5	< 1.5

Results from Georgia Tech and the University of Georgia agreed very well except for Cu and Zn which were different by up to 25 μg/L. This may have been due to contamination or interference problems. However, the uncertainty in these data is probably not significant compared to other factors in the loading calculations.

Appendix 5-D
BOD5 Loading Calculations

MUNICIPAL WWTP

	PERMIT			DMR AVERAGE					SAMPLING			
	Flow (MGD)	Avg Monthly (mg/L)	Load (kg/yr)	n	Data Set	Wgt. Avg. (mg/L)	Load (kg/yr)	Std. Dev. (kg/yr)	n	Wgt. Avg. (mg/L)	Load (kg/yr)	Std. Dev. (kg/yr)
Baldwin	0.30	30	12,435	35	91-93	19	5,913	3,113	3	63	21,566	2,892
Clarkesville	0.75	30	31,088	11	92	20	7,883	1,790	8	30	11,782	4,348
Cleveland	0.75	20	20,725	24	95,94	13	6,116	2,488	3	13	8,039	6,405
Cornelia	3.00	30	124,351	60	91-95	19	51,343	23,248	7	6	20,234	4,996
Dahlonega	0.72	30	29,844	48	92-95	6	4,516	2,525	3	5	3,511	1,593
Demorest	0.40	30	16,580	33	91-93	9	871	1,659	2	4	324	0
Flowery Branch	0.20	10	2,763	60	91-95	5	804	517	3	11	2,485	1,374
Gain-Flat Creek	7.00	20	193,434	60	91-95	6	40,163	22,659	7	3	23,513	10,412
Gain-Linwood	3.10	30	128,496	60	91-95	17	36,143	7,893	8	17	47,957	19,715
Gain-White Sulphur	0.1	*30 **	*4,145*			*11*	*1,520*				*(1,520)*	
Lake Lanier Islands	0.35	30	14,508	22	91-92	6	893	772			*(893)*	*(772)*
Lula	0.08	30	3,399	30	91-93	22	1,235	888			*(1,235)*	*(888)*
TOTAL:			581,768				157,400	67,553			143,059	53,396

Notes:
*: not a permit value, used to estimate a maximum loading
n: number of data points
Wgt. Avg.: weighted average (weighted according to flow)
Italicized numbers are assumed values

INDUSTRIAL WWTP

	PERMIT			DMR AVERAGE					SAMPLING			
	Flow (MGD)	Avg Monthly (mg/L)	Load (kg/yr)	n	Data Set	Wgt. Avg. (mg/L)	Load (kg/yr)	Std. Dev. (kg/yr)	n	Wgt. Avg. (mg/L)	Load (kg/yr)	Std. Dev. (kg/yr)
Buckhorn	*0.0017*	*5*	12	1	94	5	12				(12)	
Davidson Minerals	2.59	*5*	17,893	1		BDL						
Habersham Mills Inc	0.009	30	373	24	91-92	16	369	737			(369)	
High Point Minerals*	0.002	*5*	14				(14)				(14)	
JA Hudson Const*	*0.86*	*5*	5,973				*(5,973)*				(5,973)	
Scovill	*0.27*	*41*	15,296				(7,046)	(3,129)	6	41	7,046	3,129
SKF Bearing	0.02	*11*	*304*	1	1	11	274				(274)	
SUB-TOTAL			39,865				13,687	3,866			7,700	3,129

Note:
* No information available. Because this site is a quarry, the assumptions are based on information from the other quarrys.

SEPTIC TANKS

Assuming:	Max.		Avg.		
BOD Concentration	2		2	mg/L	(Kaplan, 142)
Average flow from septic tanks:	64	(Kaplan)	55	gal/d/cap	(EPA value, from Kaplan)
No. structures w/in 300' of lake	5184		5184	structure	(USGS quad maps; w/in 300' of lal
No. persons per structure	3.5	(Reckhow)	2.5	cap/structure	(EPA Eutrophication Study)
BOD:	3,209		1,970	kg/yr	

Appendix 5-D
BOD5 Loading Calculations

PID

	PERMIT			DMR AVERAGE				
	Flow (MGD)	Conc. (mg/L)	Load (kg/yr)	n	Data Set	Wgt Avg (mg/L)	Load (kg/yr)	Std. Dev. (kg/yr)
Camp Barney Medintz	0.040	30	1,658	8	91-'92	14	61	128
Camp Coleman	0.002	30	83	6	91-'92	37	17	37
Camp Coleman	0.002	30	83	6	91-'92	78	224	0
Camp Glisson	0.005	30	207	2	91-'92	20	8	26
Chattahoochee Bay	0.0004	*30*	*17*			*15*	*4*	
Chattahoochee Country	0.010	30	415	24	91-'92	13	21	32
Cinnamon Cove Condos	0.070	30	2,902	24	91-'92	3	120	95
Dixie MHP	0.005	30	220	8	91-'92	26	57	47
Flow Br. Elem	0.012	30	497	28	91-93	6	19	29
Forsyth School	0.039	30	1,596	30	91-94	8	25	32
Friendship Health Care	0.020	*30*	*829*	12	92	8	25	22
Gainesville-Chatt.	0.004	*30*	*166*			*15*	*41*	
Glover & Baker MHP	0.020	*30*	*808*			*15*	*200*	
Habersham HS	0.020	30	829	24	91-92	8	25	32
Habersham on Lanier	0.110	30	4,560	48	91-94	3	270	269
Holiday on LL	0.010	30	415	8	91-92	14	70	20
Lakeshore Campsites	0.005	30	207	8	91-92	3	5	9
Lakeside MH	0.003	30	116	7	91-92	16	65	72
LL Beach South	0.038	10	525	48	91-94	3	54	72
LL Elem	0.006	30	249	12	91-93	13	91	95
Mountain Lake Resort	0.009	*30*	*373*			*15*	*93*	
N. Hall HS	0.030	30	1,244	35	91-93	19	295	268
Oakgrove Elem	0.005	30	207	12	91-93	28	107	77
Oakgrove MHP	0.005	30	207	8	91-92	28	107	77
Oakwood Elem	0.013	30	518	12	91-93	12	54	35
R Ranch in the Mnts	0.100	*30*	*4,145*	12	91	4	*293*	
Sardis Elem	0.009	30	381	12	93	3	19	15
Shady Grove MHP	0.020	30	829	22	91-92	23	80	56
South Hall Indust. Pk	0.010	30	415	12	91-92	15	40	54
Unicoi State Pk	0.075	*30*	*3,109*			*15*	*771*	
Wauka Mtn Elem	0.014	30	564	36	91-93	6	47	66
Wauka Mnt Nursing	0.010	30	415	12	92	10	105	131
West Hall HS	0.030	50	2,073	36	91-93	10	*0*	
TOTAL PID			30,858				3,412	1,796

Note: Italicized numbers are assumptions, not actual permit or monitoring data.

URBAN RUNOFF

Creek	Area (hectare)	Assumed Conc. (mg/L)	Avg. Rainfall (in)	Avg. Runoff (in)	Avg. Loading (kg/yr)
Flat Creek	1626	12	55	13.45	66,659
Limestone Creek	869	12	55	13.53	35,837
Six Mile Creek	891	12	55	16.48	44,756
TOTAL					147,252

Appendix 5-D
Ammonia Loading Calculations

Municipal WWTP

	PERMIT			DMR AVERAGE					SAMPLING			
	Flow MGD	NH3 mg N/L	Load kg/yr	n	Data Set	NH3 mg N/l	Load kg/yr	Std. Dev. kg/yr	n	NH3 mg N/L	Load kg/yr	Std. Dev. k/yr
Baldwin	0.3	_17.4_ *	_7,212_		91-93	_8.0_	_2,557_		3	12.12	4,035	671
Clarkesville	0.75	17.4	18,031	2	92	22.6	9,513	1,553	11	7.50	2,892	1,507
Cleveland	0.75	10.0	10,363	24	95,94	9.6	4,566	1,468	3	2.33	1,438	696
Cornelia	3	17.4	72,123	54	91-95	26.7	64,834	33,001	12	20.90	72,370	44,567
Dahlonega	0.72	17.4	17,310	31	92-95	0.6	334	677	3	0.61	462	252
Demorest	0.4	_17.4_ *	_9,616_		91-93	_8.0_	_774_		3	3.52	277	401
Flowery Branch	0.2	2.0	553	59	91-95	0.6	102	96	3	5.48	1,289	693
Gain-Flat Creek **	7	_17.4_ *	_168,288_	9	95	0.3	2,077	2,063	12	0.57	4,650	3,868
Gain-Linwood	3.1	17.4	74,528	26	91-95	10.9	24,659	10,563	12	7.41	20,104	9,705
Gain-White Sulphur	0.1	_17.4_ *	_2,404_			_8.0_	_757_				(757)	
Lake Lanier Islands	0.35	_17.4_ *	_8,414_		91-92	_8.0_	_1,088_				(1,088)	
Lula	0.082	_17.4_ *	_1,971_		91-93	_8.0_	_379_				(379)	
TOTAL:			390,813				111,640	49,420			109,743	62,359

* No permit requirements found. For purposes of calculations, 17.4 mg/L was assumed.

**Flat Creek based on values from April to December 1995. The average loading for the data from 1991-1995 is 156,283 kg/y

Italicized values are assumed values based on the weighted averages of the known concentrations.

INDUSTRIAL WWTP

	MAX			DMR AVERAGE					SAMPLING			
	Flow (MGD)	Conc. (mg/L)	Load (kg/yr)		Data Set	Conc. (mg/L)	Load (kg/yr)	Std. Dev. (kg/yr)		Conc. (mg/L)	Load (kg/yr)	Std. Dev. (mg/L)
Buckhorn	_0_	_0.2_	_0_	1		0.2	0.5				(0)	
Davidson Mineral Prop	2.59	_0.2_	_716_	1		0.2	415				(415)	
Habersham Mills Inc	0.009	_5.1_	_63_	1		5.1	28				(28)	
High Point Minerals	0.002	_0.2_ *	_1_				(1)				(1)	
JA Hudson Construction	_0.86_	_0.2_ *	_239_				(239)				(239)	
Scovill	_0.27_	_0.1_	_34_	1		0.1	13		12	0.76	132	101
SKF Bearing	0.02	_0.7_	_18_	1	93	0.7	16				(16)	
TOTAL			1,071				712				831	101

* No NH3 information available for these facilities. Assumptions based on values for other quarrys.

Appendix 5-D
Ammonia Loading Calculations

PID

	PERMIT			AVERAGE				
	Flow MGD	NH3 mg N/L	Loading kg/yr	n	Data Set	Nh3 mg N/l	Loading kg/yr	St. Dev. kg/yr
Camp Barney Medintz	0.040	17.4	962			8.0	219	
Camp Coleman	0.020	17.4	481			8.0	110	
Camp Glisson	0.001	17.4	12			8.0	3	
Chattahoochee Bay	#####	17.4	10			8.0	2	
Chattahoochee Country	0.010	17.4	240			8.0	55	
Cinnamon Cove Condos	0.070	17.4	1,683			8.0	384	
Dixie MHP	0.005	17.4	127			8.0	29	
Flow Br. Elem	0.012	17.4	288			8.0	66	
Forsyth School	0.039	17.4	926			8.0	211	
Friendship Health Care	0.020	17.4	481			8.0	110	
Gainesville-Chatt.	0.004	17.4	96			8.0	22	
Glover & Baker MHP	0.020	17.4	469			8.0	107	
Habersham HS	0.020	17.4	481			8.0	110	
Habersham on Lanier	0.110	17.4	2,645			8.0	603	
Holiday on LL	0.010	17.4	240			8.0	55	
Lakeshore Campsites	0.005	17.4	120			8.0	27	
Lakeside MH	0.003	17.4	67			8.0	15	
LL Beach South	0.038	2.0	105	48	91-94	0.8	14	34
LL Elem	0.006	17.4	144			8.0	33	
Mountain Lake Resort	0.009	17.4	216			8.0	49	
N. Hall HS	0.030	17.4	721			8.0	164	
Oakgrove	0.025	17.4	601			8.0	137	
Oakgrove MHP	0.025	17.4	601			8.0	133	
Oakwood Elem	0.013	17.4	301			8.0	69	
R Ranch in the Mnts	0.100	17.4	2,404			8.0	548	
Sardis Elem	0.009	17.4	221			8.0	50	
Shady Grove MHP	0.020	17.4	481			8.0	110	
South Hall Indust. Pk	0.010	17.4	240			8.0	55	
Unicoi State Pk	0.075	17.4	1,803			8.0	411	
Waoka Mtn Elem	0.014	17.4	327			8.0	75	
Wauka Mnt Nursing	0.010	17.4	240			8.0	55	
West Hall HS	0.030	17.4	721			8.0	164	
TOTAL			18,456				4,194	34

Italicized values are assumptions

URBAN RUNOFF

Creek	Area (hectare	'low Wgt Avg. (mg/L)	Avg. Rainfall (in)	Avg. Runoff (in)	Avg. Loading (kg/yr)
Flat Creek	1626	0.64	55	13.45	3,555
Limestone Creek	869	0.624	55	13.53	1,864
Six Mile Creek	891	1.82	55	16.48	6,788
TOTAL					12,207

Appendix 5-D
Total Nitrogen Loading

			SAMPLING		
	Flow		N*	Loading	St. Dev.
	MGD	n	mg/L	kg/yr	kg/yr
Baldwin	0.3	3	13.7	3,417	2,374
Clarkesville	0.75	10	18.2	6,967	5,386
Cleveland	0.75	3	12.0	7,423	6,251
Cornelia	3	10	37.2	130,405	71,108
Dahlonega	0.72	3	16.9	12,893	8,286
Demorest	0.4	3	5.8	453	304
Flowery Branch	0.2	3	6.2	1,470	784
Gain-Flat Creek	7	10	25.3	208,753	130,807
Gain-Linwood	3.1	10	21.8	60,585	25,762
Gain-White Sulphur	0.1		*30.0*	*4,145*	
Lake Lanier Islands	0.35		*30.0*	*14,508*	
Lula	0.082		*30.0*	*3,399*	
TOTAL				410,316	251,061

* N = ammonia, nitrate and nitrite

INDUSTRIAL WWTP

		MAX			AVERAGE			
	Flow	N	Loading		Data	N	Loading	St. Dev.
	MGD	mg/L	kg/yr	n	Set	mg/L	kg/yr	kg/yr
Buckhorn	*0.002*	*0.30*	*1*	1		0.30	1	
Davidson Minerals*	2.59	*1.00*	*3,579*			*1.00*	1,340	
Habersham Mills	0.009	*0.00*	*0*	1		0.00	0	
High Pt Min.*	0.002	*1.00*	*3*				(3)	
JA Hudson Const*	*0.86*	*1.00*	*1,195*				(1,195)	
Scovill	*0.27*	*1.97*	*735*	1		1.97	294	
SKF Bearing **	0.02	*0.65*	*18*			*0.65*	16	
TOTAL			5,529				2,848	

* Nitrogen information not available for these facilities. Assumptions based off of data from other quarrys.

** Total nitrogen data not available, used ammonia value

Appendix 5-D
Total Nitrogen Loading

PID

	Flow	MAX * NH3	Loading	n	Data Set	Nh3	Loading	St. Dev.
	MGD	mg N/L	kg/yr			mg N/L	kg/yr	kg/yr
Camp Barney Medintz	0.040	20	*1,105*			17	*466*	
Camp Coleman	0.020	20	*553*			17	*233*	
Camp Glisson	0.001	20	*14*			17	*6*	
Chattahoochee Bay	0.0004	20	*11*			17	*5*	
Chattahoochee Country	0.010	20	*276*			17	*117*	
Cinnamon Cove Condos	0.070	20	*1,934*			17	*816*	
Dixie MHP	0.005	20	*146*			17	*62*	
Flow Br. Elem	0.012	20	*332*			17	*140*	
Forsyth School	0.039	20	*1,064*			17	*449*	
Friendship Health Care	0.020	20	*553*			17	*233*	
Gainesville-Chatt.	0.004	20	*111*			17	*47*	
Glover & Baker MHP	0.020	20	*539*			17	*227*	
Habersham HS	0.020	20	*553*			17	*233*	
Habersham on Lanier	0.110	20	*3,040*			17	*1,282*	
Holiday on LL	0.010	20	*276*			17	*117*	
Lakeshore Campsites	0.005	20	*138*			17	*58*	
Lakeside MH	0.003	20	*77*			17	*33*	
LL Beach South	0.038	20	1,050			17	*179*	
LL Elem	0.006	20	*166*			17	*70*	
Mountain Lake Resort	0.009	20	*249*			17	*105*	
N. Hall HS	0.030	20	*829*			17	*350*	
Oakgrove	*0.025*	20	*691*			17	*291*	
Oakgrove MHP	0.025	20	*691*			17	*0*	
Oakwood Elem	0.013	20	*345*			17	*146*	
R Ranch in the Mnts	0.100	20	*2,763*			17	*1,165*	
Sardis Elem	0.009	20	*254*			17	*107*	
Shady Grove MHP	0.020	20	*553*			17	*233*	
South Hall Indust. Pk	0.010	20	*276*			17	*117*	
Unicoi State Pk	0.075	20	*2,073*			17	*874*	
Waoka Mtn Elem	0.014	20	*376*			17	*158*	
Wauka Mnt Nursing	0.010	20	*276*			17	*117*	
West Hall HS	0.030	20	*829*			17	*350*	
TOTAL			22,143				8,780	

Max and Avg concentrations based on reasonable values for total nitrogen.

Appendix 5-D
Total Nitrogen Loading

SEPTIC TANKS

# Structures within 300' of Lake Lanier		5184		(USGS quad maps, w/in 300' of lake)
Assumed persons per structure		2.5		(EPA Eutroph. Study)

Reckhow & Simpson

	Max	Min	Avg	
Denitrification (SR- soil retention)	0%	40%	20%	
En: N export coeff.	2.2	2.2	2.2	(used by Hook for a stu
Ct: Capita	12,960	12,960	12,960	
N = En * Ct * (1-SR)	28,512	17,107	22,810	

Kaplan

Cn: Concentration of N	62 mg N/L/cap		(Ranges 48-96; 62 from Bauman)	
Q: Discharge from tank	55 gal/d		(EPA value, from Kaplan)	
			(Ingham found 64 gal/d)	
Denitrification	0%	40%	20%	(fine texture - 20-40% N
Ct: Capita	12,960	12,960	12,960	
N = Ct * Cn * Q * (1- Denitrif)	61,055	36,633	48,844	

EPA - Eutrophication Study

Denitrification	0%	40%	20%	(EPA assumes 0%
Capita	12,960	12,960	12,960	
Cn; N that reaches lake	4.263 kgN/cap/yr	4.263	4.263	(EPA assumption)
N = Ct * Cn * (1-Den)	55,248	33,149	44,199	

Min:	33,149
Max:	61,055
Probable:	44,199

URBAN RUNOFF

Creek	Area (hectare)	Wgt. Avg. (mg/L)	Avg. Rainfall (in)	Avg. Runoff (in)	Avg. Loading (kg/yr)
Flat Creek	1626	4.243	55	13.45	23,567
Limestone Creek	869	1.079	55	13.53	3,222
Six Mile Creek	891	9.154	55	16.48	34,142
TOTAL					60,931

Appendix 5-D
Phosphorus Loadings

MUNICIPAL

	MAX/PERMIT			DMR AVERAGE						SAMPLING			
	Flow MGD	P mg/L	Load kg/yr	n	Data Set	Flow MGD	P mg/L	Load kg/yr	St. Dev. kg/yr	n	P mg/L	Load kg/yr	St. Dev. kg/yr
Baldwin	0.3	*6.72*	*2,786*			0.23	*6.72*	*2,136*		4	6.72	1,999	907
Clarkesville	0.75	*2.44*	*2,527*			0.28	*2.44*	*956*		9	2.44	929	369
Cleveland	0.75	*2.33*	*2,417*			0.34	*2.33*	*1,108*		3	2.33	1,443	915
Cornelia	3	*2.18*	*9,029*	32	91-95	1.92	2.18	10,832	6,231	9	1.20	4,417	2,897
Dahlonega	0.72	*2.22*	*2,204*			0.56	*2.22*	*1,699*		3	2.22	1,693	341
Demorest	0.4	*0.86*	*476*			0.07	*0.86*	*83*		3	0.86	68	62
Flowery Branch	0.2	1	276	60	91-95	0.13	0.58	101	58	3	1.78	418	314
Gain-Flat Creek	7	1	9,672	59	91-95	5.12	0.58	4,096	1,182	9	0.21	1,720	1,052
Gain-Linwood	3.1	*3.72*	*15,930*	22	91-95	1.54	4.00	10,123	1,671	9	3.72	10,404	3,131
Gain-White Sulphur	0.1	*2*	*276*			*0.1*	*2*	*276*				*(276)*	
Lake Lanier Islands	0.35	*2*	*967*			0.10	*2*	*271*				*(271)*	
Lula	0.08	*2*	*227*			0.03	*2*	*94*				*(94)*	
TOTAL:			46,787					31,775	9,142			23,731	9,987

Italicized values are assumptions

INDUSTRIAL WWTP

	MAX			DMR AVERAGE						SAMPLING			
	Flow MGD	P mg/L	Load kg/yr	n	Data Set	Flow MGD	P mg/L	Load kg/yr	St. Dev. kg/yr	n	P mg/L	Load kg/yr	St. Dev. kg/yr
Buckhorn	*0.002*	*0.10*	0	1		0.00	0.10	0.23				(0)	
Davidson Mineral Prop	2.59	*0.1*	358			1	*0.10*	138				(138)	
Habersham Mills Inc	0.01	*1.13*	14	1		0.01	1.13	12				(12)	
High Pt. Minerals	0	*0.1*	0.28					(0)				(0)	
JA Hudson Constructio	0.86	*0.1*	119					(119)				(119)	
Scovill	*0.27*	1.702	635	5		0.12	6.57	1,089			3.38	560	5
SKF Bearing	0.02	?				0.02	?						
TOTAL			1,127					1,360				831	5

Appendix 5-D
Phosphorus Loadings

PID

	MAX/PERMIT			AVERAGE					
	Flow	P	Loading		Data	Flow	P	Loading	St. Dev.
	MGD	mg/L	kg/yr	n	Set	MGD	mg/L	kg/yr	kg/yr
Camp Barney Medintz	0.040	*2*	*111*			*0.020*	*2*	*55*	
Camp Coleman	0.020	*2*	*55*			*0.010*	*2*	*27*	
Camp Glisson	0.001	*2*	*1*			*0.000*	*2*	*1*	
Chattahoochee Bay	####	*2*	*1*			*0.000*	*2*	*1*	
Chattahoochee Countr)	0.010	*2*	*28*			*0.005*	*2*	*14*	
Cinnamon Cove Condc	0.070	*2*	*193*			*0.035*	*2*	*96*	
Dixie MHP	0.005	*2*	*15*			*0.003*	*2*	*7*	
Flow Br. Elem	0.012	*2*	*33*			*0.006*	*2*	*16*	
Forsyth School	0.039	*2*	*106*			*0.019*	*2*	*53*	
Friendship Health Care	0.020	*2*	*55*			*0.010*	*2*	*27*	
Gainesville-Chatt.	0.004	*2*	*11*			*0.002*	*2*	*5*	
Glover & Baker MHP	0.020	*2*	*54*			*0.010*	*2*	*27*	
Habersham HS	0.020	*2*	*55*			*0.010*	*2*	*27*	
Habersham on Lanier	0.110	*2*	*304*			*0.055*	*2*	*151*	
Holiday on LL	0.010	*2*	*28*			*0.005*	*2*	*14*	
Lakeshore Campsites	0.005	*2*	*14*			*0.002*	*2*	*7*	
Lakeside MH	0.003	*2*	*8*			*0.001*	*2*	*4*	
LL Beach South	0.04	1	53	48	91-94	0.01	0.88	15	27
LL Elem	0.006	*2*	*17*			*0.003*	*2*	*8*	
Mountain Lake Resort	0.009	*2*	*25*			*0.004*	*2*	*12*	
N. Hall HS	0.030	*2*	*83*			*0.015*	*2*	*41*	
Oakgrove	*0.025*	*2*	*69*			*0.012*	*2*	*34*	
Oakgrove MHP	0.025	*2*	*69*			*0.012*	*2*	*33*	
Oakwood Elem	0.013	*2*	*35*			*0.006*	*2*	*17*	
R Ranch in the Mnts	0.100	*2*	*276*			*0.050*	*2*	*137*	
Sardis Elem	0.009	*2*	*25*			*0.005*	*2*	*13*	
Shady Grove MHP	0.020	*2*	*55*			*0.010*	*2*	*27*	
South Hall Indust. Pk	0.010	*2*	*28*			*0.005*	*2*	*14*	
Unicoi State Pk	0.075	*2*	*207*			*0.037*	*2*	*103*	
Waoka Mtn Elem	0.014	*2*	*38*			*0.007*	*2*	*19*	
Wauka Mnt Nursing	0.010	*2*	*28*			*0.005*	*2*	*14*	
West Hall HS	0.030	*2*	*83*			*0.015*	*2*	*41*	
TOTAL			2,162					1,061	27

Appendix 5-D
Phosphorus Loadings

SEPTIC TANKS

# Structures within 300' of Lake Lanier		5184	(USGS quad maps)
# Persons per structure		2.5	(EPA Eutroph. Study)
Ct:		12960	

Kaplan	(not his exact method)				
	Cp (mg/L)	10	12	14	(sewage effluent, 10-14 mg
	Q (gal/d)	55	55	64	(EPA value, from Kaplan)
					(Ingham found 64 gal/d)
	P: Tanks*Cp*Q	3,939	4,727	6,418	kg/yr

Reckhow & Simpson					
	P = Es * Ct * (1-SR)	Low	Avg.	High	
	Es = export coefficient, kg/cap/yr	0.3	0.6	1	(ranges up to 1.8)
	SR = soil retention coeff	0.95	0.75	0.5	
	P:	194	1944	6,480	kg/yr

EPA Eutrophication Study				
	Cp	0.1134	kg/cap/yr	(amount that reaches lake from w/in 300')
	P: Cp * Ct	1,470	kg/yr	

Summary:	Min	194
	Max	6480
	Average	2522
	Probable	1470

URBAN RUNOFF

Creek	Area (hectare	low W_f Avg. (mg/L)	Avg. Rainfall (in)	Avg. Runoff (in)	Avg. Load (kg/yr)
Flat Creek	1626	0.412	55	13.45	2287
Limestone Creek	869	0.23	55	13.53	687
Six Mile Creek	891	1.072	55	16.48	3999
TOTAL					6973

Appendix 5-D
TOC Loading

	MAX *			AVERAGE *					SAMPLING			
	Flow	TOC	Load		Data	TOC	Load	Std. Dev.		TOC	Load	Std. Dev.
	MGD	mg/L	kg/yr	n	Set	mg/L	kg/yr	kg/yr	n	mg/L	kg/yr	kg/yr
Baldwin	0.3	21	8,882			13	4,232		4	14	4,082	1,482
Clarkesville	0.75	21	22,205			14	5,631		12	10	3,777	1,377
Cleveland	0.75	14	14,804			9	4,369		3	7	4,209	2,117
Cornelia	3	21	88,822			14	36,674		12	5	15,600	6,621
Dahlonega	0.72	21	21,317			4	3,226		3	3	2,516	456
Demorest	0.4	21	11,843			7	638		3	5	393	157
Flowery Branch	0.2	7	1,974			3	574		3	6	1,316	421
Gain-Flat Creek	7	14	138,167			4	28,688		13	5	37,859	14,659
Gain-Linwood	3.1	21	91,782			12	25,816		13	10	26,701	5,887
Gain-White Sulphur	0.1	21	2,902			8	1,086				(1,086)	
Lake Lanier Islands	0.35	21	10,363			4	585				(585)	
Lula	0.082	21	2,428			16	735				(735)	
TOTAL			415,488				112,252				98,860	33,179

* "Average" and "Max" values based on a ratio of BOD5/TOC of 1.4, where the BOD5 values are from the permit and monitoring

INDUSTRIAL WWTP

	MAX			DMR AVERAGE					SAMPLING			
	FLOW	TOC	Load		Data	TOC	Load	Std. Dev.		TOC	Load	Std. Dev.
	(MGD)	(mg/L)	(kg/yr)	n	Set	(mg/L)	(kg/yr)	(kg/yr)	n	mg/L	(kg/yr)	(mg/L)
Buckhorn	0	5	12	1		5	12				(12)	
Davidson Mineral Prop	2.59	3	10,736	1		3	5				(5)	
Habersham Mills Inc	0.01	10	124	1		10	0				0	
High Pt. Minerals	0	4	11				(11)				(11)	
JA Hudson Construction	0.86	4	4,778				(4,778)				(4,778)	
Scovill	0.27	25	9,150			25	3,660		12	25	4,279	1,667
SKF Bearing	0.02	7	180	1		7	162				(162)	
TOTAL			24,991				8,627				9,246	1,667

Appendix 5-D
TOC Loading

PID

	MAX *			AVERAGE *				
	FLOW (MGD)	CONC. (mg/L)	Load (kg/yr)	n	Data Set	Wgt. Avg (mg/L)	Load (kg/yr)	Std. Dev. (kg/yr)
Camp Barney Medintz	0.040	21	1,184	8	91-'92	10	277	
Camp Coleman	0.020	21	592	6	91-'92	26	363	
Camp Glisson	0.001	21	15	2	91-'92	56	19	
Chattahoochee Bay	#####	21	12			14	4	
Chattahoochee Country	0.010	21	296	24	91-'92	11	73	
Cinnamon Cove Condos	0.070	21	2,073	24	91-'92	9	436	
Dixie MHP	0.005	21	157	8	91-'92	2	7	
Flow Br. Elem	0.012	21	355	28	91-93	19	52	
Forsyth School	0.039	21	1,140	30	91-94	4	56	
Friendship Health Care	0.020	21	592	12	92	6	83	
Gainesville-Chatt.	0.004	21	118			6	16	
Glover & Baker MHP	0.020	21	577			11	143	
Habersham HS	0.020	21	592	24	91-92	11	147	
Habersham on Lanier	0.110	21	3,257	48	91-94	6	624	
Holiday on LL	0.010	21	296	8	91-92	2	15	
Lakeshore Campsites	0.005	21	148	8	91-92	10	34	
Lakeside MH	0.003	21	83	7	91-92	2	4	
LL Beach South	0.038	21	1,125	48	91-94	12	122	
LL Elem	0.006	7	59	12	91-93	2	15	
Mountain Lake Resort	0.009	21	266			9	57	
N. Hall HS	0.030	21	888	35	91-93	11	118	
Oakgrove	0.025	21	740	12	91-93	14	29	
Oakgrove MHP	0.005	21	148	8	91-92	20	48	
Oakwood Elem	0.013	21	370	12	91-93	20	92	
R Ranch in the Mnts	0.100	21	2,961	12	91	20	1,371	
Sardis Elem	0.009	21	272	12	93	8	0	
Shady Grove MHP	0.020	21	592	22	91-92	3	42	
South Hall Indust. Pk	0.010	21	296	12	91-92	2	14	
Unicoi State Pk	0.075	21	2,221			16	839	
Waoka Mtn Elem	0.014	21	403	36	91-93	11	86	
Wauka Mnt Nursing	0.010	21	296	12	92	11	73	
West Hall HS	0.030	21	888	36	91-93	4	86	
TOTAL PID			23,014				5,347	

* "Average" and "Max" values based on a ratio of BOD5/TOC of 1.4, where the BOD5 values are from the permit an

APPENDIX 5-E.
QUALITY ASSURANCE / QUALITY CONTROL

PROJECT DESCRIPTION

The purpose of the overall project is to determine the loadings of certain pollutants to Lake Lanier. In order to better assess the contribution of wastewater treatment facilities a sampling program was determined to sample and analyze the effluent from certain wastewater treatment facilities in the watershed. The monitoring data that is submitted by the facilities to the EPD only consists of parameters for which there are permit requirements (e.g. BOD5, NH3, TSS). This project is interested in other parameters that are not required by permit to be tested (e.g. P, metals). Thus, in order to obtain a reasonable estimate of these parameters is necessary to test the effluent from selected facilities. The parameters that are routinely tested by the facilities are also tested as a part of this project. This is to determine the current status of the plant's effluent since historical and current data is not available for every facility. The parameters of interest are: BOD5, conductivity, coliforms, mercury, total organic carbon, nitrogen, phosphorus, TSS, turbidity, arsenic, selenium and other metals. The purpose of this sampling and analysis is to determine a reasonable range of loading concentrations of various pollutants from each facility. The intent is neither to determine if a facility is meeting its regulatory requirements nor to act as an agent of the EPD to checkup on a facility. Because the ultimate loading result is of order of magnitude certainty, it is not deemed necessary to conduct a comprehensive sampling plan that would run through all seasons, different days of the week and different times of day.

The purpose of the urban runoff sampling and analysis is to determine a general idea of the types of pollutants and their loadings into the lake from urban sources. Fewer sampling events and analyses will be conducted for this part of the project. The parameters of interest are: nitrogen, mercury, conductivity, phosphorus, TSS, turbidity and certain pesticides (carbaryl, chlorpyrifos, diazinon, and malathion). The pesticides are measured by Dr. Parshal Bush's lab from the University of Georgia's Agricultural Services Laboratory.

SAMPLE CONTROL & DOCUMENTATION PROCEDURES

The Georgia Tech students travel to each facility to collect samples. After checking in with the supervisor, they proceed to collect the samples. The fecal and total coliform samples are collected first at the post-chlorination effluent sampling area. The other samples are obtained at a pre-chlorination sampling port. The bottles are first rinsed with the sample. The grab samples are then collected by submersing the bottles in the flow until the bottles are full. Each sample bottle has a label stating the facility name, sample ID, date of sampling and preservative used. A bottle blank is also used for each sampling event. It is filled with distilled water while in the field. The samples are kept in coolers filled with ice until receipt at the laboratory. Once back at the lab, the samples are kept at 4°C in a temperature controlled room until time for analysis. The following table shows the containers and preservatives used for each sample:

Table 1. Sample Bottles

Sample ID	Type of Container	Preservative	Constituents to be Analyzed	Sample Location
A	1 L Glass	None	$CBOD_5$	Pre-chlorination Effluent
B	1 L Glass	None	Turbidity NO_2^- NO_3^- TSS Conductivity	Pre-chlorination Effluent
C	500 mL Glass	HNO_3 to $pH<2$	Hg	Pre-chlorination Effluent
D	250 mL Glass	None	Total Phosphorus Total Org. P	Pre-chlorination Effluent
E	125 mL Glass	HCl to $pH<2$	TOC	Pre-chlorination Effluent
F	125 mL Glass	H_2SO_4 to $1.5<pH<2$	NH_3	Pre-chlorination Effluent
G	500 mL Glass	HNO_3 to $pH<2$	ICPMS	Pre-chlorination Effluent
Baggies	100 mL Bags (3 bags per site)	Chlorine Inhibitor Tablets	Fecal Coliform Total Coliform	Post-chlorination Effluent

All bottles are acid washed in a 10% nitric acid bath and rinsed repeatedly with tap and dionized water. The glass bottles are also baked at 300°C. The containers for the coliforms are sterilized in an autoclave. New bottles were used each time for the metals analysis to avoid possible contamination from the laboratory environment.

STANDARD OPERATING PROCEDURE FOR EACH METHOD

Table 2. Procedures

Parameter	Method #	Method Title	Detection Limit
CBOD5	SM 5210B	5-Day BOD Test	2 mg/L
Total Coliform	Hach 8074	Total Coliform Procedure	
Fecal Coliform	Hach 8074	Fecal Coliform Procedure	
Conductivity	EPA 120.1	Conductance	
Mercury	PE 245.1A	Determination of mercury in drinkingwater and wastewater by flow injection atomic absorption spectrometry	0.2 ug/L
Ammonia	Hach Model 50250	Direct Calibration Method	0.01 mg N/L
Nitrate	Hach Model 44430	Nitrate-Nitrogen in Water and Wastewater	0.1 mg N/L
Nitrite	SM 4500-NO2-B	Colorimetric Method	10 ug N/L
Pesticide: Carbaryl	EPA 507		2 ug/L
Other Pesticides	EPA 507	Organophosph. Scan	Chlor. 0.8 ug/L Diaz. 1.0 ug/L Malath. 1.4 ug/L
Total Phosphorus	SM 4500P E	Ascorbic Acid Method	10 ug/L
Total Inorg. P	SM 4500P E	Ascorbic Acid Method	10 ug/L
Total Organic Carbon	SM 5310 C	Persulfate-Ultraviolate Oxidation Method	0.05 mg/L
Total Suspended Solids	SM 2450 D	Total Suspended Solids Dried at 103-105 C	
Turbidity	SM 2130 B	Nephelometric Method	

Coliforms: The Hach method follows Standard Methods 9222B and 9222D for total and fecal coliforms. The broths used are Hach's m-Endo broth and m-FC Broth with Rosalic acid for total and fecal coliforms respectively. Sterilization prior to starting the analysis is by autoclaving. Sterilization during the analysis is conducted by igniting alcohol on the apparatus.

Conductivity: Conductivity was measured using a YSI Model 32 Conductance Meter and probe. A conductivity calibration standard was used to calibrate the meter.

Mercury: The Perkin Elmer method is an EPA approved version of the EPA method 245.1. The Perkin Elmer Mercury Analyzer is used for this analysis. A mercury standard was used and trace-metal grade reagents were used when available.

Ammonia: The Hach method using the model 50250 combination ammonia electrode and an Accumet pH/mV/Ion meter follows the Standard Method 4500-NH3F (ammonia-selective electrode method). The main differences are that the Hach method calls for 25 mL samples and use of ionic strength adjuster pillows. Hach ammonia standards are used for calibration.

Nitrate: This Hach method is equivalent to Standard Method 4500-NO3-D (Nitrate Electrode Method) except 25 mL of sample and liquid ionic strength adjuster are used. A Hach combination nitrate electrode model 44430 and Accumet pH/mV/Ion meter are used. Hach nitrate standards are used for calibration.

Nitrite: The Standard Method 4500-NO2-B is followed using a Hewlett Packard 8452A Diode Array Spectrophotometer. For samples with significant turbidity, the samples are first filtered through glass-fiber filters before being filtered through the membrane filters.

Total Phosphorus: Standard Method 4500-P B Persulfate Digestion Method is used to prepare the samples. Digestion occurs in an autoclave. A Hewlett Packard 8452A Diode Array Spectrophotometer is used.

Inorganic Phosphorus: Standard Method 4500-P B Preliminary Acid Hydrolysis is used to prepare samples and digest in an autoclave. The Hewlett Packard 8452A Diode Array Spectrophotometer is used.

Total Organic Carbon: A Dohrman DC-180 Carbon Analyzer with an automatic sampler is used, so sample injection is not required. The equipment does a one-point calibration.

Total Suspended Solids: The Standard Method is followed.

Turbidity: A Hach Ratio Turbidimer turbidimer is used.

INTERNAL QUALITY CONTROL

To ensure quality control in analysis, several checks are performed for most analyses. The quality control measures used for each procedure are as follows:

Table 3. Quality Control Measures By Procedure

Test	# Calib. Stds	Calib. Verification	Reagent Blank	Field Bottle Blank	Facility Duplicate	MS	MSD	LCS	LCSD	Equip. Dup
CBOD5	1		X	X	X					
Conductivity	1	X			X					X
T. Coliform			X		X					
F. Coliform			X		X					
Mercury	6	X	X	X	X	X	X	X	X	X
Metals		X	X	X	X	X	X	X	X	X
N: Ammonia	3	X			X	X	X			X
N: Nitrate	3	X			X	X	X			X
N: Nitrite	6	X	X		X	X	X	X	X	X
T Phosphorus	5	X	X	X	X	X		X		X
I. Phosphorus	5	X	X	X	X	X		X		X
TOC	1	X	X	X	X	X		X		X
TSS			X		X					
Turbidity	3	X			X					X

<u>Calibration</u>

Calibration of standards will be performed when appropriate. The standards will be dilutions from a stock standard. Calibration will be performed prior to each analysis. After calibration, a mid-point standard will be run to verify the calibration.

<u>Blanks</u>

Next a reagent blank and field bottle blank are analyzed. The reagent blank is the water used for the analysis (D.I., distilled etc..) carried through the procedure as if it were a sample. The field bottle blank is a sample from a bottle that was filled with water at one of the facilities.

<u>Facility Samples</u>

The samples from the facilities are then analyzed. For one facility, two samples are prepared and analyzed. This duplicate serves as a confirmation of the results.

<u>Spikes</u>

For one facility, a known addition is made. This is the sample plus a known amount of standard (MS). The amount of standard added will be about five times the expected concentration. A duplicate of the spike is also performed (MSD). A spike of the dilution water is also made in duplicate (LCS and LCSD) with the same amount of standard added as in the MS and MSD.

<u>Equipment Duplicate</u>

Where applicable, an equipment duplicate will be made. This means that the same sample will be analyzed twice to see if the same reading is obtained from the equipment.

Notes About Certain Procedures

CBOD5: The “calibration” is actually the glucose-glutamic acid check.

Ammonia & Nitrate: Triplicates are made for each sample. After the initial reading, a spike is added.