Water quality sampling in Lullwater

Background

The quality of aquatic ecosystems is a good indicator of the effects of human impact on those systems and surrounding terrestrial ecosystems. The intent of this study is to establish initial data for a long-term data set on the quality of aquatic ecosystems within Lullwater. The data that we will collect is a follow-up of a more extensive study of the ecology of Emory's campus carried out in 1970 (see Appendix). By comparing our data to those of the previous study, we can draw some tentative conclusions on how stream quality has change over the last three decades. In addition, by establishing a long-term data set we will be able to monitor how current uses of Lullwater and areas surrounding Lullwater affect the quality of ecosystems there. Ultimately, these data could be used to make suggestions about the management of Lullwater.

Methods

Sample sites. – We will sample water quality of four stream, Candler Lake, and the research pond (Figure 1). The streams include the two streams that flow into the research pond (titled Lullwater streams in the 1970 Environmental Report), the stream that flows through the grassy area and enters the western end of Candler Lake, and South Fork of Peachtree Creek that feeds Candler Lake. For each stream, we will sample two locations along the length of the stream. For Peachtree Creek, the sampling sites will be on either side of the dam that creates Candler Lake. We will take samples from both sides of the research pond and from five locations spaced approximately equidistant around Candler Lake.

Qualitative sampling. – Following the 1970 Environmental Report, we will use both qualitative and quantitative estimates of ecosystem health. At each site, we will record (1) evidence of human impacts (e.g., trash, debris, etc.), (2) relative flow rate, (3) description of stream bottom, (4) water color, (5) obvious odor, and (6) number and type of organisms within a 10m segment of stream from the sampling site.

Quantitative sampling. – At each site, we will record (1) water depth, (2) water temperature, (3) pH, (4) conductivity, and (5) dissolved oxygen content (in mg/L). We will also take water samples to determine (1) phosphate levels, (2) nitrate levels, (3) fecal coliform counts, (4) total coliform counts, (5) total bacteria counts, and (6) gross and net primary productivity.

Nutrient levels. – We will determine nutrient levels using Chemtrics test kits.

Coliform and total bacteria counts. – To determine fecal coliform, total coliform, and total bacteria counts, we will use the Coliscan Easygel and Total Count Easygel systems from Micrology Laboratories. Below are the steps for determining coliform and total counts.

Coliform

1. Use a sterile dropper pipet to sample 3.0 mL of water from the source.
2. Add water to Coliscan medium and swirl gently.
3. Label sample and put on ice.
4. Once we return to the lab, pour medium into a labeled plate and swirl to cover entire dish.
5. Leave the dishes right-side-up. The medium will solidify in 45 minutes.
6. We will incubate the plates at 35C overnight.
7. Count the purple colonies and report in terms of MPN/100 mL by multiplying colonies/mL by 100 (MPN = most probable number). These represent *E. coli* or fecal coliform.

8. Count all red, pink, and purple colonies and report in terms of MPN/100 mL. These represent all forms of coliform bacteria.

Total count

The procedure is identical to that for coliform bacteria, except use only 0.5 mL of water (5 drops). When counting the plates count all of the colonies on the plates.

Primary Production. – We can determine gross and net primary production by determining change in oxygen concentration over a short period of time. At each site, fill both a light and a dark bottle with water to overflowing and then replace stopper. At the lab, we will determine the initial oxygen concentration in the bottles using a BOD (biological oxygen demand) probe. The next day we will again measure the oxygen concentration. In the dark bottles, there is no production because of the absence of light. As a result, change in oxygen concentration in the dark bottles is a measure of respiration. In contrast, in light bottles, both photosynthesis and respiration are occurring. Thus, change in oxygen concentration in light bottles is a measure of net primary production. Gross primary production can be estimated as the sum of net primary production and respiration.

respiration = change in oxygen concentration of dark bottle
net primary production = change in oxygen concentration of light bottle
gross primary production = net primary production + respiration

Appendix

Orser, PN and G Kritsas. 1970. Water quality. Pages 69 - 79 *In* Platt, RB et al. The quality of Emory's natural environment. http://www.environment.emory.edu/ecology/1970.shtml.

Introduction

This study of the water quality of the Emory University campus was planned and undertaken for two primary reasons. The first of these was to determine the present status of the aquatic communities found on the central as well as on the peripheral areas of the Emory University property. Secondly, in light of the findings of this primary analysis, certain recommendations may be made with respect to the clarification and establishment of water quality standards for the campus.

A total of six streams, shown on the attached map, were surveyed in an attempt to determine the present quality of the water on the Emory University campus proper and the areas closely associated with and/or owned by the University. Three of these, designated the Woodruff-Cox Hall Stream, the Hospital-Library Stream, and the Physical Plant Stream, are located on heavily used parts of the campus. Two others, Lullwater Stream I and Lullwater Stream II, are situated on the periphery with minimum human use, while the sixth, Peavine Creek, is one of the two major creeks passing by the campus. These six streams were chosen for study with the hope of obtaining a relatively accurate measure of water quality through an examination of a variety of stream types. In every case, the tests for water quality were performed at stations of approximately uniform depth and stream flow rate.

Two primary methods were employed for the appraisal of water quality. The first of these is a qualitative estimate measurement. In this instance, records were made according to the following criteria: (1) evidence of urbanization in the form of discarded trash and debris, (2) stream flow rate, (3) stream bottom description, (4) water color, (5) obvious odor, (6) water temperature, and (7) the existence and diversity of life revealed by turning over rocks and with the aid of forceps and a hand lens. It is contended that each of these criteria, when analyzed in conjunction with other suitable criteria, aid in the development of an approximation of the water quality of a stream.

The second method was a quantitative measure of a number of parameters having a direct bearing upon water quality. First, a measure of the dissolved oxygen content was taken with a Precision Galvanic Cell Oxygen Analyzer. Secondly, the pH was measured with an Analytical Measurements pH meter. In order to assay the ion content of the water, the presence of certain ions was tested for at the Georgia Water Quality Control Board as per Standard Methods for the Examination of Water and Wastewater, twelfth edition, 1965. The ions tested include total phosphate, nitrate, ammonia, and chromate. In addition, total coliform and fecal coliform bacterial counts were obtained by the GWQCB.

While the justification for qualitative measures in this study are quite apparent, the reasons for the specific quantitative determinations are less obvious. The measurement of alkalinity reflects the bicarbonate, and hence the buffer capacity, of the water reported as mg/l CaCO3. Since all values for the streams are within the ranges encountered in Piedmont, Georgia, alkalinity may be of "...no great significance to water quality within the spectrum of this study." (Otis Woods, chemist at GWQCB). It must be noted that most of the streams in the Piedmont exhibit some sort of pollution. Therefore, when certain results are designated as "not significant", this is with reference to other similarly polluted urban streams of Piedmont Georgia.

Specific conductance, on the other hand, is a rapid, relatively inexpensive method of assaying the amount of ionic substances in the water which are capable of conducting electricity. This measurement is important as it reveals the relative presence of other ions for which no tests were performed.

Phosphates, reported as total phosphate, may be attributed to the presence of detergents or horticultural fertilizers. Nitrate, while it may reflect the presence of fertilizers, may be present as an oxidation product of ammonia from sewage. It is felt that due to the relatively low concentrations reported, neither the test for nitrate nor the test for ammonia are important in any further discussion of water quality in this report.

Total coliform counts as well as total fecal coliform counts are usually performed when water quality is being determined. A total coliform count represents the presence of coliform bacteria including the fecal coliforms, i.e., the source may be soil bacteria as well as animal coliform bacteria. Fecal coliforms, on the other hand, are traceable to homeothermic animals. Edward Hall states that the importance of these two counts is evident when both counts for a given sample are identical. Such an instance usually indicates the presence of raw sewage in the stream.

Results

The following discussion of the results of this study will be presented in a station-by-station manner in which the pertinent qualitative as well as quantitative data will be summarized. It is necessary to rely heavily upon the quantitative evidence as the streams investigated were, for all practical purposes, devoid of macroinvertebrate life forms. In addition, there were certain factors which limited the scope of both the qualitative as well as the quantitative studies. These factors will be presented in a subsequent portion of the report.

Data were collected from the Woodruff-Cox Hall Stream on May 7, and May 13, at a single station indicated on the Map. With respect to the qualitative estimate of water quality in this stream, the total absence of any macroinvertebrate life forms was noted. Also the water exhibited a yellow coloration as well as a distinct "chemical" odor. Concerning the water, it was noted as being slightly warm to the touch, giving a temperature reading of 23.2° C with an air temperature reading of 20.5°C. Oxygen analysis gave a reading of 7.5 mg/l. Sampling was done at a station where the rate of flow of water was designated as moderate. The depth of the water in this station was approximately 4 cm. The bottom composition consisted of sand deposition with variously sized rocks and debris interspersed. Specifically, this debris included portions of discarded mortar, concrete, metal cans, and glass bottles.

Quantitative analyses of water samples submitted to the GWQCB on the previously cited dates yielded three highly significant adverse values with respect to total phosphate, specific conductance, and total chromium content. These and other measurements alluded to in this section are summarized in Table I.

Data were collected at two stations along the Hospital-Library Stream. While qualitative measurements were taken at both sites on May 7 and May 13, quantitative analyses were run only at station B-2A as indicated on the Map. Qualitative examination of station B-2A revealed the presence of only one larval insect type, possible midge larvae. The rate of water flow at this station was designated as moderate with a water depth of 4 cm. The stream bottom was composed of sand and small rocks. The water temperature was recorded as 20.0°C with an air temperature reading of

22.5°C. The dissolved oxygen content was recorded as 7.37 mg/l. The one quantitative measurement which appears to be significant is the specific conductance reading of 220 mho/cm @ 25°C.

Qualitative examination of station B-2B on the Hospital-Library Stream showed an absence of macroinvertebrate life forms. The water flow rate was moderate with a water depth of 3 to 4 cm. The bottom of the stream at this station consisted of small rocks and gravel. Temperature readings were 17°C for the water temperature and 23°C for the air temperature. The dissolved oxygen content was 8.55 mg/l.

A total of three stations were investigated along the length of Peavine Creek as it flows along the western border of the Emory University property. The first of these stations, P-A, is located on Peavine Creek as it passes under a small bridge on North Decatur Road. This station was surveyed for qualitative data on May 13, and May 16. With the exception of four insect larvae which appeared on the under surface of rocks, this station showed no evidence of macroinvertebrate life forms. The water was flowing at a rate designated as fast, while the water depth was between five and six cm. The bottom was described as containing numerous rocks of varying sizes which appeared to be covered with a detrital deposition. The water appeared clear in color and no particular odor was evident. The dissolved oxygen content was. 12.67 mg/l. The water temperature reading was 19°C whereas the air temperature reading was 26°C. A single water sample was taken at station P-A on May 13, for partial chemical analysis. No extraordinary results were reported with respect-to this analysis; however, the findings of this analysis are summarized in Table I.

The second station along Peavine Creek is located immediately below the effluent source of the Physical Plant Stream and the Emory dump. While the Physical Plant Stream was not chemically analyzed due to financial reasons, it was found to be devoid of macroinvertebrate forms. In addition, large amounts of debris were found lining its banks and stream bed. A qualitative investigation of station P-B on May 13, and May 16, revealed the total absence of macroinvertebrate life forms. The water, at a depth of five to six cm, flowed at a fast rate over a bottom of rocks at various sizes which were covered with a detritus-like film. The dissolved oxygen content was 10.48 mg/l. The water temperature was 18.5°C while the air temperature was 26°C. A particularly foul odor was noted on both occasions. With respect to the sample taken on May 13, for chemical analysis, the one pertinent factor which deserves closer analysis is the identical values received for total coliform bacteria and fecal coliform bacteria, 15,000 MPN/100 mL.

The third station, P-C, is located approximately 100 yards north of station P-B before the entrance of Peavine Creek into the South Fork of Peachtree Creek. The water, described as having a fast flow rate, had a depth of five to six cm with a dissolved oxygen content of 9.31 mg/l. In addition, the water appeared clear at this station while it had a bluish-green cast in adjacent areas where the flow rate was less. The bottom was composed of large rocks which appeared to be covered with a detrital slime A persistent, foul odor was also noted at this station on both May 13 and May 16. No life forms were noted at station P-C. Furthermore, no highly significant results were reported by the GWQCB in the analysis of the water sample submitted to them on May 13.

Two stations on each of two streams were surveyed on the Candler Estate. These streams, which empty into the Biological Research Pond, were designated as L-1 and L-2. Exact station sites are indicated on the Map. Qualitative investigations of both streams were undertaken on May 6, and May 13. Fecal coliform determinations were made from samples submitted on May 6, while chemical analyses were run on samples submitted on May 13. It is to be noted that all quantitative results were derived from single samples taken from the B-sites on each stream.

An examination of station Ll-A showed the water to be clear, of moderate rate of flow, and having a depth of approximately five cm. The bottom was described as coarsely granular, having rocks 10 to 20 cm in length interspersed on the bottom and along the stream bank. The water temperature was 14.8°C with an air temperature of 19°C. The dissolved oxygen content was recorded as 8.9-2 mg/l. With respect to life forms present at this station, isopods, water spiders, and small insects were the only macroinvertebrates found. The chemical assay of this water resulted in no significant findings.

Qualitative investigations of station Ll-B showed water to be clear, flowing at a moderate rate, and having a depth of four to five cm. As in the case of station Ll-A, the bottom was composed of coarse, granular rock and sand with small rocks along the stream bottom and bank. The dissolved oxygen content was 9.84 mg/l. Water temperature was recorded as 14.7°C while the air temperature was 20.5°C. The macroinvertebrate fauna present at this station included Tipula, an herbivorous insect larva, a beetle larva, and one crayfish. Again, no strikingly significant results were reported by GWQCB's assay of this water.

Station L2-A was described as having a slow to moderate rate of flow with a depth of three to four cm. The dissolved oxygen content [...illegible...] .59 mg/l.. The sandy bottom appeared to be covered with a light slime, perhaps due to bacterial growth (this was not verified in the laboratory). A reading of 15°C was taken for the water temperature whereas the air temperature was 21°C. There were no macroinvertebrate representatives found at this station.

The water of station of L2-B flowed at a moderate rate over a coarse, sandy bottom. The water was clear and odorless with a depth of approximately 5 cm. A dissolved oxygen content of 9.40 mg/l was recorded. The temperature of the water was 14.9°C, and that of the air was 20°C. The macroinvertebrates found at this station were isopods, Tipula, water spiders, and crayfish. Neither station L2-A nor L2-B revealed questionable or suspicious data with respect to chemical analysis of the water.

Limitations

In this attempt to appraise the water quality of the Emory University property, certain weaknesses were encountered; however, these by no means invalidate the importance of this study nor its consequent ans invalidate recommendations.

The limit of one academic quarter imposed a major limitation on sampling. Samples could not be taken over continuous time periods nor they occur in a spatially continuous manner along each stream.

Due to certain equipment and facility shortages, water analyses were performed by the Georgia Water Quality Control Board at its financial expense. Because samples had to be analyzed at specific and due to the expense of such analyses, the total number of samples was diminished. This decreased number of samples in turn reduced the total number of sample stations. Related to the above factors, it was necessary to limit each station size to approximately five feet in length.

With the aforementioned problems presented, it is worthy to note that the conditions reported in this study reflect certain events, catastrophic in many cases, which occurred prior to sampling or were actually occurring during sampling. Combining both qualitative and quantitative approaches in this study has, in part, obviated reports entirely static nature. Although the present study is of a preliminary nature, it is a point of departure from which further, more detailed studies may and should ensue.

Discussion and Conclusions

Woodruff-Cox Hall Stream: The source of this stream is an underground spring located approximately 50 yards west of the Woodruff Building. The only exposed portion lies between the small cooling tower in front of Cox Hall and the stream's entrance into an underground culvert directly behind the Geology Building.

The Woodruff-cox Hall Stream is completely devoid of all macroinvertebrate life forms. This is without question a direct result of the use of biocides .These biocides are employed specifically as algicides, fungicides, and bacteriocides in the treatment and protective maintenance of the above mentioned cooling tower. This treatment, containing 70 ppm of sodium bisulfate, 100 ppm of sodium dichromate, and 30 ppm of sodium salt of orthobenzyl-parachlorophenol, is applied three times per week during the seasonal use of the cooling tower. These chemical agents are flushed directly into the Woodruff-Cox Hall Stream after application to the tower. (Communication from Mr. R. K. Conaway, Plant Engineer, Physical Plant Department.)

Chromium, even in trace amounts, is known to be a highly toxic substance to aquatic macroinvertebrates as well as vertebrate organisms. Concentrations of 11 and 12 mg/l, as found in the Woodruff-Cox Hall Stream, are regarded as lethal to most life forms.

Ortho-benzyl-parachlorophenol is a chlorinated hydrocarbon whose effects as an insecticide quite possibly parallel those of other commercially prepared chlorinated hydrocarbons such as DDT.

An unusually high phosphate concentration was found in the Woodruff-Cox Hall Stream. The two factors which may be contributing to this high concentration are the discharge of detergents and the leaching of phosphates from fertilizers into the stream. With regard to the former, an investigation should be made to determine the exact source and nature of these detergents.. Furthermore, the continuation of any such effluent should be curtailed immediately for reasons discussed later.

The specific conductance reading of 205 mho/cm @ 25°C indicates the presence of other unknown ions. One source of these ions is most probably the biocides used in the cooling tower and consists mostly of sodium ions.

In all streams but the Woodruff-Cox Hall Stream the water temperature was found to be lower than the air temperature at the time tested. This increase in the water temperature is perhaps due to the operation of the cooling tower and is not likely to increase the possibility of life in the stream.

The serious condition of the Woodruff-Cox Hall Stream merits immediate attention. Action should be taken to determine the sources of phosphates as well as ions which would produce a high specific conductance reading. If it is necessary to maintain treatments using lethal substances including chromium, it is highly recommended that steps be taken to direct these agents into sanitary sewers rather than into a potentially productive and more esthetically pleasing stream. This was the only study made of effluents from cooling towers and other air conditioning apparatus on the campus. The study should be extended to include all such units.

Hospital-Library Stream: This stream has its origin in a small spring situated near the Uppergate House. While all physical parameters investigated indicated that a wide diversity of life forms should exist in this stream, only one macroinvertebrate form was discovered. While it is common for this stream to be a chalk white color, especially in the early morning as it flows near Woodruff Memorial Library, it was not possible to obtain a chemical analysis of water of this condition during the time of this study, nor was the Physical Plant Department able to provide an account of the kinds of effluents discharged into the stream. Apparently it is not customary for construction companies and engineers to keep records of this kind.

In this light, it is necessary to rely heavily upon the quantitative chemical data received from the analysis of the water in this stream. Taking these data into consideration, only the specific conductance measurement of 220 mho/cm @ 25°C is of significance in assaying the water quality, i.e., all other measurements are well within the expected range of values obtained from other urban streams. This specific conductance value leads one to believe that unknown effluents of reasonably high ionic content are entering this stream at periodic or intermittent times from one or more sources. While it is not possible to enumerate these compounds within the scope of this investigation, complete chemical analyses of this water at frequent intervals, in addition to a study designed to trace specific effluent sources, would allow one to define better the limiting factors affecting the water quality of this stream. It is, therefore, urgently requested that such a course of action be taken by the proper University officials.

Peavine Creek: Peavine Creek flows along the western border of the Emory University campus and enters the South Fork of the Peachtree Creek at the northwest corner of the Emory-owned property. It is that portion of Peavine Creek along Emory's perimeter for which the University is responsible. The Physical Plant Stream, which passes through the Physical Plant-Crematory Complex, has been found to be in a gross state of pollution as can be readily seen from pictures taken along this stream. The stream enters Peavine Creek immediately below the Emory University dump and usually maintains an opaque, whitish-green coloration.

The banks of Peavine Creek are laden with trash and remains of various rusting appliances and machinery including washing machines, dryers, fencing, and radiators. Severe soil erosion is in progress due to the inability of the soil to withhold water and support vegetation. As a direct result, silt and sand are being deposited into the creek bed, which possibly contributed to the absence of life forms in the creek. The bacterial growth enhanced by metal oxidation may also contribute to this lack of macroinvertebrate fauna.

Once again it is necessary to rely greatly upon the quantitative analyses of the Georgia Water Quality Control Board. While nothing irregular with respect to chemical analyses was found at either station P-A or P-C, at station P-B, below the dump, the total coliform and fecal coliform counts were found to be identical at 15,000 MPN/100 mL. Edward Hall, biologist at GWQCB, stated that when such a similarity in both bacterial counts occurs, a leakage or breakage in a sanitary sewer may be suspected. Although these values are neither extreme nor critical, they suggest the urgency of a more detailed study of this portion of Peavine Creek.

Lullwater Streams I and II; These arise from springs within or adjacent to the Biology Research area. Stream I arises from the large spring from which the initial water supply for the Candler Estate was obtained. In all of the physical as well as chemical parameters studied at the two streams within the Lullwater Biology Research Area, data reflect the relatively undisturbed nature of these streams. Specifically, this is evident as one notes an ecologically balanced and highly diverse number of macroinvertebrate organisms and of the salamanders which are the predators upon these forms. Ecologically, these two streams reflect stable, self-sustaining aquatic ecosystems.

None of the studies revealed any significant urban intrusion in the form of chemical additives. This is undoubtedly due to the relative isolation of these streams.

Lullwater Lake: Lullwater Lake, or as it is often called, Candler Lake, is located on the Candler Estate of Emory University. Historically, the present lake bed was constructed in 1952, by diverting the South Fork of the Peachtree Creek into its present path and by dredging the formerly existing stream basin.

There are five inlets into Lullwater Lake. Two of these are persistent, spring-fed streams, two are intermittent inlets which drain the surrounding forest, and one is a small waterfall which acts as a spillway for the Biological Research Pond.

As a direct result of construction work and poor surface soil and road management within its watershed, severe soil erosion has occurred and is occurring at both the western and eastern portions of the lake. This erosion is particularly evident by the resultant extensive deltas which have formed over a period of years, the persistent turbidity of the water, and the sedimentation on the lake bottom. Furthermore, periodic overflowing of the South Fork of the Peachtree Creek deposits considerable amounts of sand and eroded soil into the lake basin. Prior studies by the Biology Department have shown varying degrees of pollution and eutrophication.

These adverse conditions can be controlled, and the lake put in a good quality condition by good management practice. These would include: (1) curtailment of sheet erosion from the surrounding areas, as discussed in the section on Soils, (2) adequate surface water management of the adjacent dirt roads, (3) positive insistence that erosion sediments from adjacent private property be stopped, as for example from the University Apartments, (4) extension of these controls to the upper watershed around the Graduate Residence Hall, (5) prevention of the periodic overflow into the lake of Peachtree Creek during floods by removal of the dam on Peachtree Creek near the lower end of the lake, (6) possible limitation of ducks and geese because of the effects of their waste on eutrophication or over-enrichment of the water, and (7) positive steps to prevent intermittent pollution from chemical wastes which are introduced into the watersheds and streams from both University-owned and adjacent property, as from the University Apartments and from the Graduate and Professional Dormitory and Egleston Hospital areas.

Effects of Urbanization

One can make certain predictions on the overall quality of the water on the Emory University campus by comparing a given factor (for each stream) with respect to increasing distance from the Woodruff-Cox Hall complex. Regardless of the relative importance of the individual substances tested for, one overriding principle seems evident: the water quality increases as one proceeds away from the central campus. This is as one might expect since the degree of urbanization decreases as one proceeds from these central locations. The following graphs demonstrate this generality. The values plotted represent an average of all values obtained for each stream.

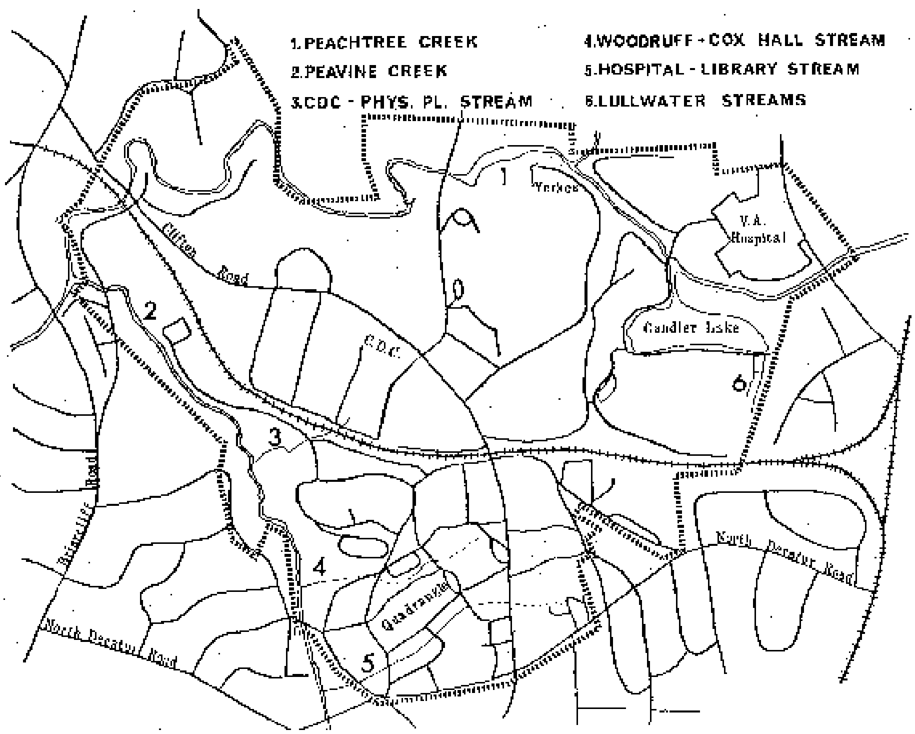
1.PEACHTREE CREEK
2.PEAVINE CREEK
3.CDC - PHYS. PL. STREAM
4.WOODRUFF - COX HALL STREAM
5.HOSPITAL - LIBRARY STREAM
6.LULLWATER STREAMS
Yerkes
V.A. Hospital
Clifton Road
C.D.C.
Candler Lake
Briarcliff Road
North Decatur Road
Quadrangle
North Decatur Road

TABLE I

	Biology	Library	P-A	P-B	P-C	L-1	L-2
pH	6.5	7.0	6.8	6.6	6.7	6.4	6.9
Alk. (P) mg/l as $CaCo_3$	35	53	41	42	42	18	28
Specific Conductance mho/cm 25°	205	220	137	142	141	78	104
Phosphate (total) mg/l	2.6	0.74	0.55	0.43	0.38	0.10	0.20
Nitrate mg/l	1.56	1.10	1.04	1.06	1.08	0.56	1.14
Ammonia mg/l	-	0.1	0.1	0.1	0.1	0.1	0.1
Chromium mg/l	12, 11	-	-	-	-	-	-
Coliform MPN/ 100 ml	230,000	6,400	93,000	15,000	15,000	43,000 (A) 4,300 (B)	4,300 (A) 1,500 (B)
Fecal Coliform MPN/100 ml	4,300	3,900	23,000	15,000	3,900	2,300 (A) 930 (B)	930 (A) 230 (B)