BIOLOGICAL AND CHEMICAL MONITORING OF THREE STREAMS
IN THE AREA OF BLACKSBURG, VIRGINIA

by

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INTRODUCTION

For several years investigators have sought the most sensitive, efficient, and economical method for assessing water quality changes. Historically, the majority of people concerned with water quality changes were engineers, chemists, and public health officials, and consequently chemical parameters and microbial methods were used more frequently than any other methods of water quality assessment. Chemical data were relatively easy to collect and process and, thus were the most frequently used quantitative index to measure changes in bodies of water. Recently, however, an increasing amount of study has centered around biological measurements. Patrick (1949) stated that although chemical data produced useful information on stream conditions it should be used only as supportive evidence for biological data. Cairns and Dickson (1971) reported that it is well known that pollution destroys aquatic organisms and further, that the type of organisms destroyed and the extent of destruction reflect the nature and quantity of waste entering the aquatic system. However, they maintained that biological and chemical data are supplemental but not mutually exclusive. With the increase in interest in the use of biological parameters for water quality analysis, increased attention has been directed toward developing techniques making the collection and analysis of biological data more feasible for industrial pollution control groups.

Aquatic organisms provide "summary" information on water quality in that they spend their life, or a great part of it, in water, and any detrimental changes in water quality that occur at any point in their life cycle have an effect on community numbers and diversity of the resident biota. Chemical analyses have the disadvantage of measuring chemical quality only at a particular location at a specific point in time. A combination of chemical and biological measurements provides information yielding a more complete and integrated understanding of the aquatic systems under investigation.

This study was undertaken to collect both chemical and biological data for the purposes of (1) comparing the sensitivity of the two approaches (biological and chemical) in evaluating stream conditions, (2) examining several techniques of analyzing biological data, and (3) attempting to assess water quality in the three streams investigated.

REVIEW OF THE LITERATURE

The word pollution is derived from the Latin pollutionem meaning defilement. Historically, the word pollution has held meanings ranging from spiritual to physical defilement of man or his environment. However, since the eighteenth century, pollution has been used more in the context of degradation of man's environment (Warren 1971).

In this work the concern will be confined to consideration of water pollution, but even in this restricted area there are still many definitions of pollution. Water pollution has been defined in terms of changing the water quality from its "natural" condition (Reid 1961), having adverse effects on aquatic organisms (Patrick 1953 and Ide 1954 as cited by Warren 1971), and as any man-caused detrimental change in water quality resulting in the loss of value for some user (McKee 1952, President's Science Advisory Committee 1965, National Research Council Committee on Pollution 1966, all as cited by Warren 1971; Warren 1971; Stroud 1967; Dean 1968; and Wisdom 1956 as cited by Hynes 1960).

Aquatic organisms have been used in a variety of ways as pollution indices. Kolkwitz and Marsson (1908 and 1909 as cited by Warren 1971) listed species of aquatic organisms associated with zones of water quality below sewage outfalls. However, the use of particular species as indicator organisms must be approached with certain restrictions. In speaking of macroinvertebrates Warren (1971) states that in order for the concept of indicator organisms to be useful, the organism must have a rather narrow range of tolerance to particular environmental conditions that are of interest to man. Richardson (1928), Gaufin and Tarzwell (1952), and Warren (1971) state that species which meet these criteria seldom occur in sufficient numbers to give reliable results. Gaufin and Tarzwell (1952) add that many organisms found in polluted water in large numbers are also found in clean water in small numbers. These investigators emphasize that ecological factors other than pollution frequently limit the distribution of particular species. These factors include erosion, floods, size of the stream, and type of substrate. They report that the association of organisms is important and that all organisms and their relative abundance should be considered. Mackenthum (1966 and 1969), Cairns and Dickson (1971), and Mason, Anderson, Kreis, and Johnson (1970) divide aquatic macroinvertebrates into categories in relation to their tolerance of pollution: (1) sensitive (intolerant) - Plecoptera, Tricoptera, Ephemeroptera, Elmidae, and Megaloptera; (2) facultative (tolerant) - several kinds of snails, Isopods, Amphipods, Simulidae, Tipulidae, Odonata, and several kinds of midges; and (3) pollution tolerant - sludgeworms, midges with ventral bloodgills, certain leeches, and some snails.

Cairns and Dickson (1971) state that macroinvertebrates are suitable for study of pollution effects because: (1) they are important in the food chain; (2) many species are sensitive to pollution and show quick response to it; (3) macroinvertebrates usually have complex life cycles; and (4) they are somewhat restricted to a specific area therefore making them natural monitors.

Wilhm and Dorris state that since effluents introduce changes in the structure of the biotic community, another method of monitoring these changes would be to measure diversity and changes in diversity of the biotic community. Wilhm and Dorris (1968) state that a diversity index to be useful must be dimensionless, independent of sample size, and express the relative importance of particular species. In 1956, Margalef (as cited by Wilhm and Dorris 1968) proposed that methods derived from information theory be used to analyze mixed-species populations. The information theory formulae proposed by Brillouin (1960 as cited by Wilhm *et al.* 1968) met the requirements of a sensitive diversity index given above. Wilhm and Dorris (1968) cite an example where subjective valuation of species lists indicated that a pollutant was not detrimental to the aquatic community, but a re-evaluation of the same data, using the information diversity index, showed a decrease in the diversity of the biota below the source of contamination. Warren (1971) maintains that valuable information can be gleaned from an analysis of community composition, even though such analyses are subjective. He further states that the use of tabular analyses and good diversity indices are both necessary, adding that diversity indices are only manifestations of phenomena and that the explanation for these phenomena requires other knowledge. However, Warren adds that if data reduction is "necessary or desirable", diversity indices based on information theory "are far more efficient than other procedures".

Cairns, Albaugh, Busey, and Chanay (1968), using a modification of the sign test and theory of runs as described by Dixon and Massey (1951 as cited by Cairns et al. 1968) developed a simpler diversity index that can be used by a non-professional to evaluate, in numerical form, the biological consequences of pollution. In a refinement, Cairns and Dickson (1971) incorporated the number of taxa into the index (Sequential Comparison Index, DI_T). This refinement, although not recommended by the authors to place more accurate techniques, has many advantages; it does not require personnel skilled in taxonomy, produces numerical data which can be analyzed statistically, and quickly produces mathematically expressed results.

One method of collecting aquatic organisms utilizes artificial substrates which are structures placed in the water for a specified period of time for aquatic organisms to colonize. After colonization has occurred, the substrate is collected and the organisms removed. Mackenthun (1969) states that the type of artificial substrate is not extremely important as long as the same type is used at all sampling sites for a particular study. If this criterion is met, data collected at the stations should be comparable. He adds that any type of artificial substrate is somewhat selective as to the organisms that will colonize it and that there is a tendency for artificial substrates to collect drifting organisms. Mason et al. cites the following advantages of artificial substrate: (1) the availability to the organisms of a fairly uniform surface area and (2) the advantage of placing a substrate at a specific depth and for a specific period of time. Cairns and Dickson (1971) add that the use of artificial substrates require less time and, to a certain extent, standardizes sampling procedures if ecologically similar habitats are sampled. Hynes (1970) maintained, on the other hand, that artificial substrates were unlikely to yield [sic] any measure of the macroinvertebrate population although in certain instances the use of artificial substrates may be the only way to collect large numbers of organisms.

Various types of artificial substrate used for the collection of macrobenthic organisms have been proposed and used. Among some of the structures used Simmons and Winfield (1971) list: Noon (1940) used wire trays covered with sand and vegetative material from the native habitat; Hester and Dendy (1962) and Arthur and Horning (1969) constructed an artificial sampler of multiple plates of masonite; Wene and Wickliff (1940) constructed samplers of rubble contained in wire baskets; and Mason, Anderson, and Morrison (1967) used "Bar-B-Q" baskets filled with limestone rocks. Simmons and Winfield (1971) compared the species obtained using artificial substrate of interwoven plastic material, Conservation Webbing, with those obtained by sampling with a dip net. They concluded that Conservation Webbing would be suited for a life history study of certain macroinvertebrate species but that it collected only 63% of the number of species collected with the dip net.

Artificial substrates have been used to collect aquatic organisms other than macroinvertebrates, e.g. Patrick (1966) used glass slides to collect diatoms and Cairns et al. (1968) used sponges to collect protozoa. Patrick and Reimer (1966) concluded that a Catherwood diatometer using glass slides was an acceptable means of collecting diatoms and that the glass slide method of diatom sampling could be used to compare sections of a body of water or separate bodies of water. In their investigation the slides were exposed for two weeks; Hohn (1959) also found that exposure of glass slides for two weeks gave a sample adequate for statistical analysis.

Chemical water quality measurements are a necessary part of pollution assessment. Chemical information often can be used to assist in the interpretation of biological information. If concentrations of substances such as phosphate, nitrate, and toxic materials are found above expected concentration in water samples hypotheses can be formulated regarding type and source of pollution. For example, a high concentration of chloride or of phosphate might indicate sewage pollution (Venkateswarlee 1969, Mackenthun 1969). The presence of chlorine might indicate effluent from a sewage treatment plant (Hynes 1960) and an abnormal increase in suspended solids could indicate poor farming practices (Weidner et al. 1969).

STUDY AREA

Three streams in the area of Blacksburg, Virginia, were monitored chemically and biologically for a period of one year. Stroubles Creek, a New River tributary, heads in the downtown area of Blacksburg, and passes through the VPISU campus. The stream receives urban runoff which may include contaminants such as oil and gasoline from gas stations, litter, and storm sewage overflow. The stream also drains a eutrophic pond on the campus, receives runoff from a livestock feedlot, and effluent from a sewage treatment plant. The headwaters of Cedar Run are on the edge of Blacksburg, and the stream receives effluent from a sewage treatment plant and, possibly, drainage from septic tanks, Federal Mogal Inc., and a limestone quarry before flowing into the North Fork of the Roanoke River. Toms Creek is a clear, cold, mountain stream that is categorized as trout water by the Virginia State Water Control Board and flows into the New River. The possible sources of contaminants include a recently abandoned municipal landfill, septic tank leakage from residences, and agricultural runoff. Toms Creek meanders through land recently annexed by the town of Blacksburg and is slated for residential development.

Figure 1 shows a map of the study area and the locations of the stations on the three streams. Table 1 gives a description of each station.

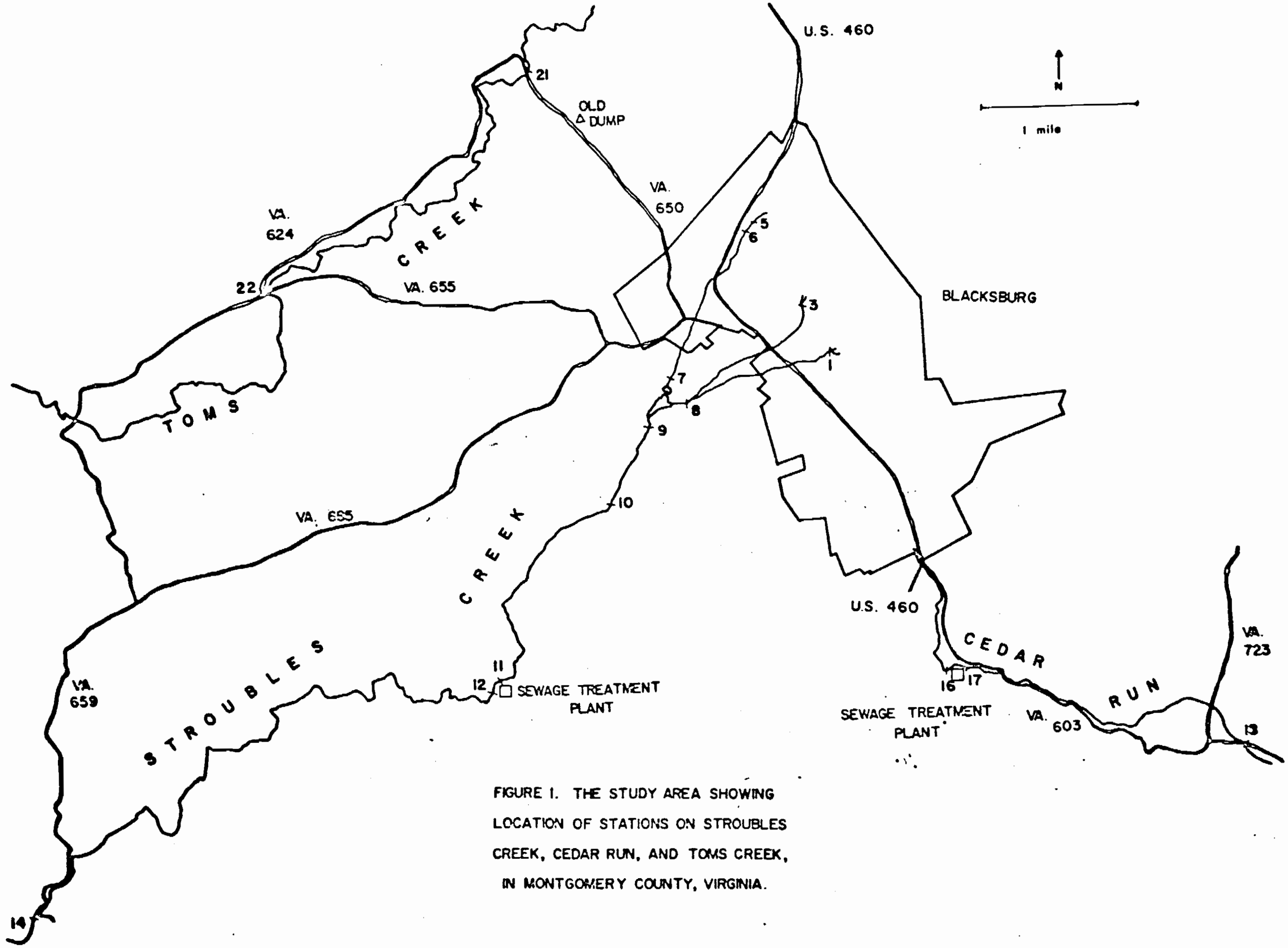

FIGURE 1. THE STUDY AREA SHOWING LOCATION OF STATIONS ON STROUBLES CREEK, CEDAR RUN, AND TOMS CREEK, IN MONTGOMERY COUNTY, VIRGINIA.

Table 1. Location and Description of Stream Stations in the Vicinity of Blacksburg, Virginia, that were studied from August 1971 through August 1972.

Station Number	Stream	Location	Description
1	Stroubles	Clay Street, 175' N. of corner of Clay and Wharton, Blacksburg	riffle, gravel and mud substrate, vegetated banks, water cress, 4' wide, .25-3.0" deep
3	Stroubles	behind Georgetown Apts. on Owen St., Blacksburg	riffle, mud and small rock substrate, vegetated banks, 5' wide, 1.25-5.0" deep
5	Stroubles	behind Atlantic Concrete, Inc., on 460 W. of Blacksburg	riffle, sand, rock and fine silt substrate, vegetated banks, 6' wide, 1.25-4.0" deep
6	Stroubles	behind Ray's Hamburger on 460 W. in Blacksburg	riffle, small rock and mud substrate, vegetated banks, 6' wide, 1.25-4.0" deep
7	Stroubles	stream underground .25 mi before this station, corner of Greenhouse Rd. and South Gate Dr. on campus of VPISU, Blacksburg	riffle, small rock substrate, vegetated banks, 7' wide, 4-5" deep
8	Stroubles	underground for .75 mi before this station, where bridge on Greenhouse Rd. crosses Stroubles Creek at end of Drill Field, campus VPISU, Blacksburg	riffle, rock and sand substrate, vegetated banks, 8' wide, 2-7" deep

Table 1. (continued)

Station Number	Stream	Location	Description
9	Stroubles	beside Archery Range on Smithfield Plantation Rd., campus VPISU, Blacksburg	riffle, small rock substrate, vegetated banks, overhanging trees, 12' wide, 2-6" deep
10	Stroubles	on farm road to Swine Center, before double culvert going under U.S. 460 bypass, campus VPISU	riffle, small rock substrate, vegetated banks, 12' wide, 3.75-7.0" deep
11	Stroubles	115' upstream of 1st effluent outlet from Blacksburg-VPI Sanitation Authority Sewage Treatment plant located on Rt. 657, 2 mi from jct. of Rt. 685 and 657	riffle, small rock and sand substrate, vegetated banks, 11.5' wide, 2-11" deep
12	Stroubles	105' downstream of 2nd effluent pipe of Blacksburg-VPI Sanitation Authority Sewage Treatment Plant, on Rt. 657, 2 mi from jct. of Rt. 685 and 657	riffle, small rock and clay substrate, vegetated banks, 12' wide, 11-22" deep
14	Stroubles	on Rt. 659, 2.3 mi from jct. of Rt. 659, 652 & 685 - 4.4 mi downstream of Sewage Treatment Plant	riffle, small rock substrate, some vegetation on banks, overhanging trees, 20' wide, 3-10" deep

Table 1. (continued)

Station Number	Stream	Location	Description
16	Cedar Run	150' above sewage lagoon at Blacksburg VPISU Sanitation Authority Sewage Treatment Plant on Rt. 603, .7 mi from jct. of Rt. 603 & 460, Blacksburg	riffle, small rock and mud substrate, vegetated banks with overhanging grass, 3.5' wide, 2-8" deep
17	Cedar Run	18' below effluent pipe of Treatment Plant and effluent pipe of Federal Mogul, located on Rt. 603, .7 mi from jct. of Rt. 603 & 460, Blacksburg	riffle, small and medium size rock substrate, vegetated banks with overhanging grass, 6' wide, 4.5-5.0" deep
18	Cedar Run	on Rt. 603, .2 mi from jct. of Rt. to3 & 732, 2.75 mi downstream of Treatment Plant	riffle, small and medium size rock substrate, vegetated bank with overhanging grass, shaded by trees, 12' wide, 3-12" deep
21	Toms Creek	on Rt. 650, 1 mi from jct. of 650 & 460 bypass around Blacksburg	riffle, small rock and sand substrate, vegetated banks, overhanging grass and shrubs, 9.5' wide, 5-10" deep
22	Toms Creek	on Rt. 655 at jct. of Rt. 655 & 650	riffle, medium size rock substrate, vegetated banks, overhanging trees, 13' wide, 2.25-7.0" deep

TECHNIQUES AND PROCEDURES

Sixteen stations were selected on the three streams: eleven on Stroubles Creek, three on Cedar Run, and two on Toms Creek. Measurements were taken at the sixteen stations from August 1971 through August 1972.

Chemical analyses were conducted weekly on samples collected at six selected stations on the three streams. The parameters studied weekly were chemical oxygen demand (COD), biochemical oxygen demand (BOD), total organic carbon (TOC), pH, dissolved oxygen (DO), chlorine, and temperature. At 21-day intervals, water samples were collected at all of the sixteen stations and analyzed for: COD, BOD, TOC, pH, DO, chlorine, temperature, solids (total, suspended, and dissolved), alkalinity, phosphate (total and ortho), nitrate, total Kjeldahl nitrogen (TKN), and chloride.

The diversity of two elements of the biota (diatoms and macro-invertebrates) was studied. All aquatic organisms were collected using artificial substrates and were analyzed by either the Sequential Comparison Index (Cairns et al. 1968) or Community Diversity Index, $\bar{d}$, (Wilhm and Dorris 1966). In some instances the analysis included both methods.

Biological Techniques

Diatoms:

Equipment and Collection Methods: Diatoms were collected with diatometers constructed from two 3 1/2-inch pieces of slotted angle iron, joined in the center with a slide fitted into each end of the angle iron (Figure 2). Two diatometers were used at each sampling site: one in swift water and one in quieter, somewhat deeper, water. The slides were removed after 14 days and placed in jars containing 4% formalin solution.

Treatment in Laboratory: The diatoms were scraped from the slides into 4% formalin and cleaned either with concentrated sulfuric acid modified after Patrick and Reimer (1966) or with hydrogen peroxide and an ultra-violet lamp (Swift 1967).

Sulfuric Acid Method

1. Diatom-formalin solution was placed in 100 ml beaker. Approximately 15 mls of concentrated sulfuric acid was added and the solution boiled for one hour. One teaspoon of potassium dichromate was added to the solution and the mixture boiled for an additional one-half hour. After cooling, tap water was added and the solution centrifuged and rinsed three times in tap water followed by a rinse with 70% ethanol.
2. Several drops of the diatom-alcohol mixture were placed on a clean coverslip and either air dried or dried on a hot plate. Several drops of mounting medium (Hyrax

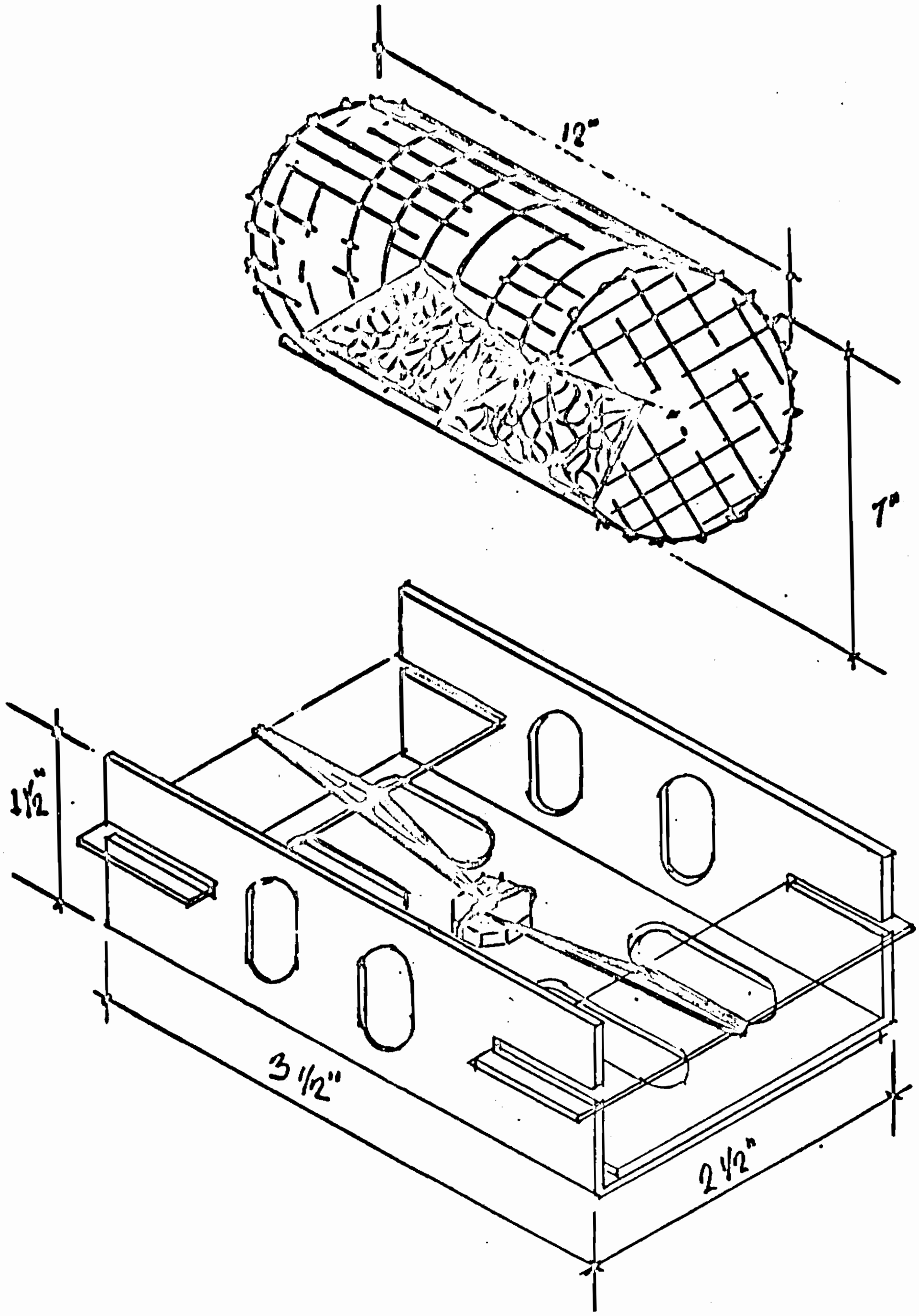

Figure 2. Artificial Substrate Samplers Used in the Study--Upper right, the macroinvertebrate sampler; lower center, the diatometer.

or Basalm) were placed on a clean slide and the coverslip inverted and mounted on the slide.

Hydrogen-peroxide Method

1. 30-40 ml of tap water was added to the diatom-formalin solution. The mixture was centrifuged and rinsed twice in tap water. Ten ml of the diatom-water sludge was placed in a watch glass, 5-10 ml of 30% hydrogen-peroxide was added to the solution, and the mixture was placed under an ultraviolet lamp for 1 1/2 hours.

2. Mounting procedure is the same as used in step 2 of the Sulfuric Acid Method.

Data Analysis: The Sequential Comparison Index (Cairns *et al.* 1968) was used as a measure of the diversity of the diatom community. A random point was selected as the starting point on the slide, and a strip was scanned across the slide. The width of the strip was measured as the width of the Whipple disk in the eyepiece. A second starting point was randomly selected and a second strip scanned. The first 200 individuals encountered were used as the sample for the Sequential Comparison Index (SCI) analysis. The diversity index (DI) as calculated from this method is as follows:

$$DI = \frac{\text{number or runs}}{\text{number of individuals}}$$

A final SCI value was determined, according to the method outlined by Cairns and Dickson (1971), by multiplying the DI value by the total number of taxa encountered in the sample:

$$DI_T = DI \times \text{number of taxa}$$

Macroinvertebrates:

Equipment and Collection Methods: The collection device (Figure 2) used for macroinvertebrates was a cylindrical basket constructed from chicken wire, containing three 5" x 5" strips of #200 Conservation Webbing (3M Company, St. Paul, Minnesota). The baskets, three at each station, were held in place by a 4' iron reinforcing rod driven into the streambed. All macroinvertebrates collected were preserved in 4% formalin solution.

Treatment in Laboratory: Macroinvertebrates (organisms retained in a U.S. Standard #40 Sieve) were removed from the Conservation Webbing and preserved in 70% ethanol.

Data Analysis: A macroinvertebrate community structure diversity index was calculated using the DI_T (Cairns-Dickson 1971) and the community diversity index ($\bar{d}$) of Wilhm and Dorris (1966).

Chemical Techniques

Equipment and Collection Methods: All water samples were collected in clean glass containers rinsed with distilled water and with no preservatives added. Dissolved oxygen (azide modification of the Winkler Method), temperature (Celsius thermometer), pH, and chlorine (Hach Water Chemistry Kit, Hach Chemical Co., Ames, Iowa) measurements were made in the field.

Treatment in Laboratory: The water samples were analyzed in the Sanitary Engineering Laboratory of the Civil Engineering Department, College of Engineering at Virginia Polytechnic Institute and State University (VPISU), Blacksburg, Virginia using the 13th edition of Standard Methods for the Examination of Water and Wastewater.

Data Analysis: All raw data collected during the study are shown in Appendix B Tables 1 - 17. For the purpose of discussion in this study the data are reported using the annual mean and range for individual chemical parameters. Correlation among chemical parameters and among chemical and biological parameters also was tested.

RESULTS AND DISCUSSION

Biological Parameters

Diatoms:

Table 2 presents a summary of bimonthly diatom community diversity indices (DI_T) obtained through a one year period for the three streams. An examination of this table shows the data to lack a consistent pattern with regard to station-to-station comparisons or month-to-month comparisons. For example, DI_T's at Station 1 are neither consistently higher or lower than Station 3 over a year's time, nor does the month of October consistently show higher or lower DI_T values than December.

A mean, annual, diversity index was calculated for each station by pooling the six DI_T measurements (Figure 3). The large coefficient of variation (20-105% of the mean) at each station suggests that this mean annual value is not a reliable estimate of the difference between stations. On a station-to-station basis, the greatest number of high DI_T values was found for the month of December, and the greatest number of low DI_T's was found for the months of June and August.

A bimonthly mean DI_T was calculated for each month by pooling and averaging information from all stations for that month (Table 2). These mean DI_T's were compared on a month-to-month basis, and it was found that the highest DI_T value was for the month of December, and the lowest DI_T value was for the month of June. However, when coefficients of variation and standard deviations were calculated

Table 2. Bimonthly DI_T for Diatoms from October 1971 through August 1972.

Station Number	October	December	DI_T February	April	June	August
			Stroubles Creek			
1	0.83	-**	5.18	6.50	3.08	3.78
3	5.12*	8.70	5.99	6.00	2.46	-
5	10.14	8.58	7.21	5.54	6.55	12.03
6	7.70	4.06	5.48	6.70	3.54	9.36
7	-	8.25	5.54	7.32	3.88	12.24
8	6.00	7.15	7.05	-	-	-
9	5.43*	5.10	3.84	2.30	3.90	9.20
10	4.95	10.27	6.70	5.99	-	8.75
11	6.66	10.01	5.84	6.27	7.70	7.32
12	-	7.85	8.14*	4.35	6.85	9.38
14	-	4.27	8.76	8.70	6.75	1.26
			Cedar Run			
16	6.05	6.90	6.40	5.84*	2.08	1.80
17	-	4.60	6.60	7.27*	7.30	4.73
18	-	3.60	9.12	5.70*	2.94	1.44
			Toms Creek			
21	-	7.98	-	7.75	0.54	0.14
22	7.15	9.48	4.91	-	6.93	0.78
			Mean Bimonthly Diversity			
$\bar{x}$	6.00	7.12	6.45	6.15	4.60	5.87

* less than 200 diatoms in sample
** substrate not recovered from stream

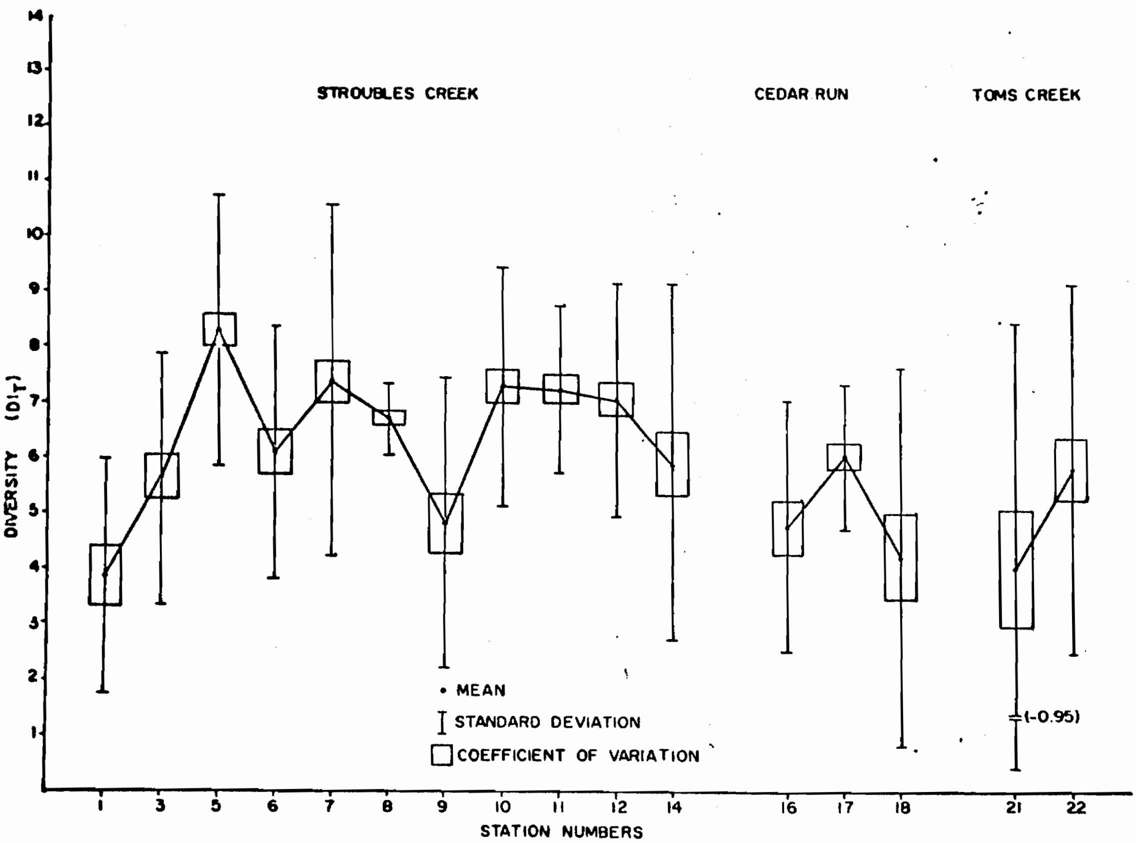

Figure 3. Mean Annual Diversity (DI_T) of Diatom Communities in Stroubles Creek, Cedar Run, and Toms Creek from October 1971 through August 1972.

for each mean it was found that the values were too large (coefficient of variation = 23-74% of the mean) to permit the mean DI_T values to reliably estimate differences between months (Figure 4).

To test the repeatability of individual DI_T values (Table 2) a series of four readings was made from one slide (refer to Techniques and Procedures). The basic information derived from each reading was used in a computer simulation which produced four cumulative frequency distributions of DI_T values, each distribution based on 1000 simulated DI_T's. The Kolmogorov-Smirnov goodness of fit test (Schmidt and Taylor 1970) was applied to measure overlay of the four distributions. In this test the greatest difference between any distribution must not exceed the critical rejection point of 0.061 to show that the distributions are similar at the 95% confidence level. When this test was applied to the study data, the greatest difference was 0.653 thereby greatly exceeding the critical rejection point. This shows at the 95% confidence level that replicate analyses of a single diatom sample would not necessarily produce similar DI_T values. Although the difference among these replicates is statistically significant, it should be noted that it cannot be determined whether this difference is actually biologically significant or if it is simply due to operator error, to the unsuitability of the DI_T as a measure of diversity in diatoms, or to all of these.

Cairns and Dickson (1971) while working with bottom fauna found the following: healthy streams with high diversity and balanced

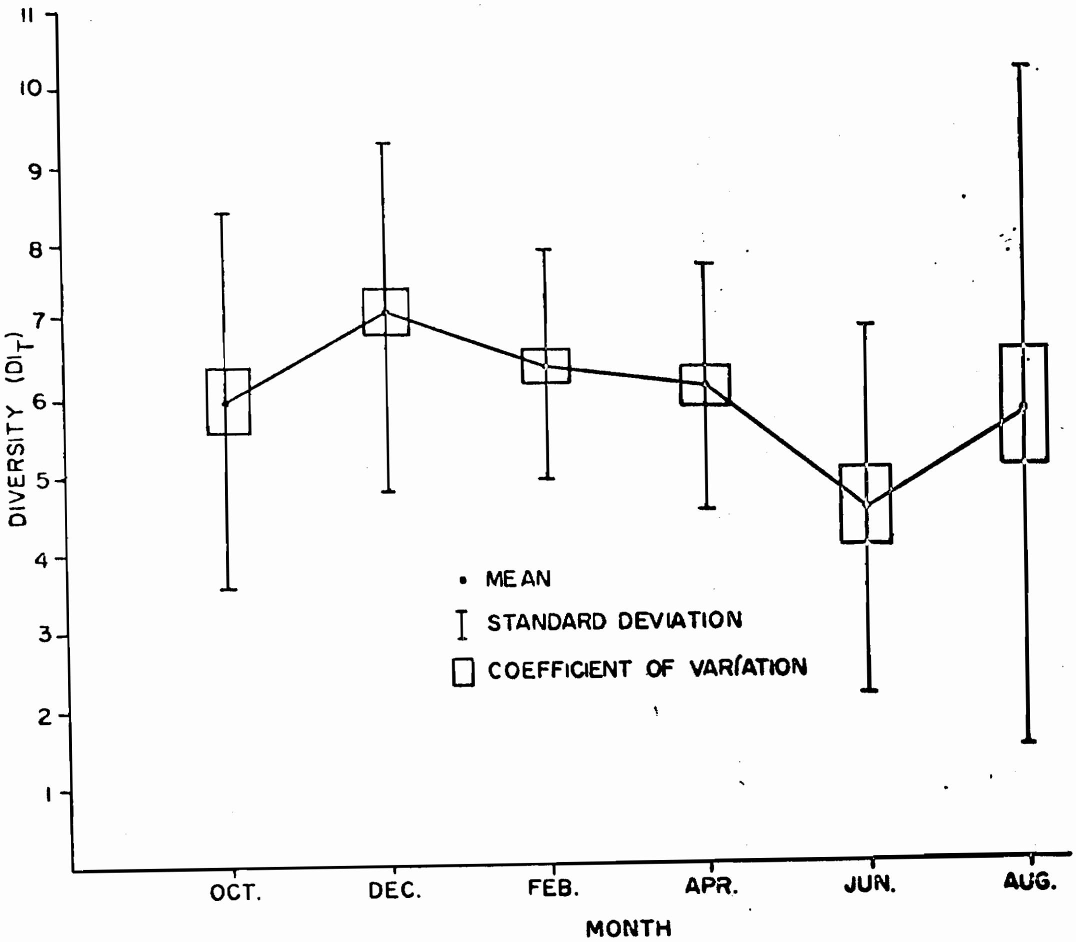

Figure 4. Mean Bimonthly Diversity (DI_T) of Diatom Communities in Stroubles Creek, Cedar Run, and Toms Creek from October 1971 through August 1972.

density had DI_T values greater than twelve; polluted communities with skewed population structures had values of eight or less; and semipolluted waters had DI_T values between eight and twelve. If these data (Table 2) were applied to the Cairns-Dickson scale Stroubles Creek, Cedar Run, and Toms Creek would be regarded as badly polluted throughout most of the year.

An examination of the information in Table 3 shows that the greatest number of diatom taxa collected at any one station does not exceed 16.

In Patrick's et al. (1966) Peruvian-Amazon Expedition, six rivers were studied in the headwater region of the Amazon. These rivers included a variety of water quality and watershed characteristics, including hard and soft water; high and low degree of turbidity; forested watershed; and mining, lumbering, and sewage drainage. Even with this variety of factors affecting diversity of the diatom flora, no less than 38 species were found at any sampling location. Patrick et al. (1967) in an investigation of the Savannah River, which receives municipal and industrial effluents, found no less than 54 species of diatoms any any sampling location at any period of the year. Cairns et al. (1972) while investigating the South River near Waynesboro, Virginia found that even below a municipal-industrial outfall of organic material, 17 species of diatoms occurred. This low number of species was said to denote "...severe stress." From a consideration of these studies it seems reasonable to state that the diatom flora in Stroubles Creek, Cedar Run, and Toms Creek

Table 3. Number of Diatom Taxa Collected at Each Station in Stroubles Creek, Cedar Run, and Toms Creek from October 1971 through August 1972.

Month	Stroubles Creek Stations										
	1	3	5	6	7	8	9	10	11	12	14
October	5	8	13	10	-*	10	6	7	10	-	-
December	-	12	15	7	11	11	10	13	13	10	9
February	9	9	11	8	9	10	6	10	8	11	12
April	10	10	9	10	11	-	10	11	11	10	12
June	8	6	11	7	8	-	6	-	11	10	10
August	7	-	15	12	16	-	12	11	12	14	7
Mean	8	9	12	9	11	10	8	10	11	11	10

	Cedar Run Stations			Toms Creek Stations	
	16	17	18	21	22
October	10	-	-	-	12
December	10	8	8	11	12
February	10	11	12	-	9
April	8	8	9	10	-
June	5	9	6	9	9
August	9	11	9	4	6
Mean	9	9	9	9	10

* substrate not recovered from stream

represent stressed communities.

The technique used to determine diversity index values for the diatom community, DI_T, poses special problems in correctly estimating diversity. Proper use of the Sequential Comparison Technique requires (1) samples obtained from ecologically similar habitats, (2) equal sampling effort at each collection site, (3) sufficient numbers of organisms, (4) random distribution of the organisms when the test is performed, (5) the investigator to be able to recognize differences between organisms, and (6) the organisms to be arranged so that the investigator can examine them sequentially (Cairns et al. 1968).

In this study the first three conditions were met without difficulty, i.e., similar habitats sampled, standard sampling procedure used, and a sufficient number of organisms collected. However, the effort to ensure random distribution in the diatom aliquot tested was not entirely successful. Diatoms tended to clump in certain areas of the slide despite efforts to prevent it. Organisms should be compared sequentially for the DI_T, but this was difficult to do when a clump of diatoms was encountered and individuals overlapped each other obscuring body shape and sequential order.

The investigator in this study was not familiar with diatom taxonomy and, therefore, was not able to adequately differentiate between many diatoms. Also, the angle from which the diatoms were viewed changed the appearance of some of the diatoms, perhaps causing more taxa to be reported than were actually present.

The clumping effect also caused difficulties in comparing diatoms sequentially when several fields were examined before another diatom was encountered. This taxed the memory of the investigator in comparing differences between diatoms and resulted in inaccurate reports of the number of taxa and the size of the run.

Cairns et al. (1968) found that applying the Sequential Comparison Index, DI_T, to diatoms was feasible and that diatom community diversity changes did delineate the source of pollution. While I agree that studying diatom communities might be a valid approach for measuring changes in water quality, I have reservations about using community diversity indices rather than identification of species and associations as suggested by Patrick (1949). This reservation especially is apparent if the ability of untrained personnel to provide adequate information on diversity is in question.

Although reservations are held for each type of analysis used in discussing diatom data each method of examination indicates that the stream systems are stressed, uniformly depressed, and do not appear to recover at any season of the year.

Macroinvertebrates:

Table 4 presents a summary of DI_T values for Stroubles Creek, Cedar Run, and Toms Creek during the year of study. A mean annual diversity index was calculated for each station by pooling the values throughout the year for that station. Figure 5 summarizes these data and, in addition, shows that the coefficient of variation is

Table 4. Monthly DI_T for Macroinvertebrates for October 1971 through August 1972.

Station Number	October	December	DI_T February	April	June	August
			Stroubles Creek			
1	10.72	1.99	8.72	5.04	2.17	2.84
3	3.99	1.50	3.38	4.37	6.36	-
5	6.97	0.42	4.18	1.87	0.92	1.82
6	3.19	2.40	2.67	2.90	-	3.08
7	1.25	4.00*	1.00*	2.62	1.20	3.33
8	2.44	2.40	3.00*	-	-	-
9	2.30	1.05	5.25	3.13	3.09	5.13
10	15.15	1.64	0.00**	8.98	3.74	2.76
11	6.99	3.91	8.85	10.58	4.24	3.58
12	9.55	0.04	0.00**	4.07	1.71	1.83
14	9.22	2.42	7.11	7.77	4.51	4.88
			Cedar Run			
16	15.73	8.81	9.97	4.53	8.14	4.27
17	1.00*	3.69	7.16	4.48	1.49	5.44
18	2.82	1.45	6.29	5.93	0.11	4.43
			Toms Creek			
21	7.99	9.33	3.46	6.75	7.77	2.20
22	1.33	3.91	2.24	5.19	4.05	3.63
			Mean Bimonthly Diversity			
$\bar{x}$	6.29	3.06	4.58	5.21	3.54	3.52

* 5 or less macroinvertebrates in sample
** no macroinvertebrates in sample
\- substrate not recovered from stream

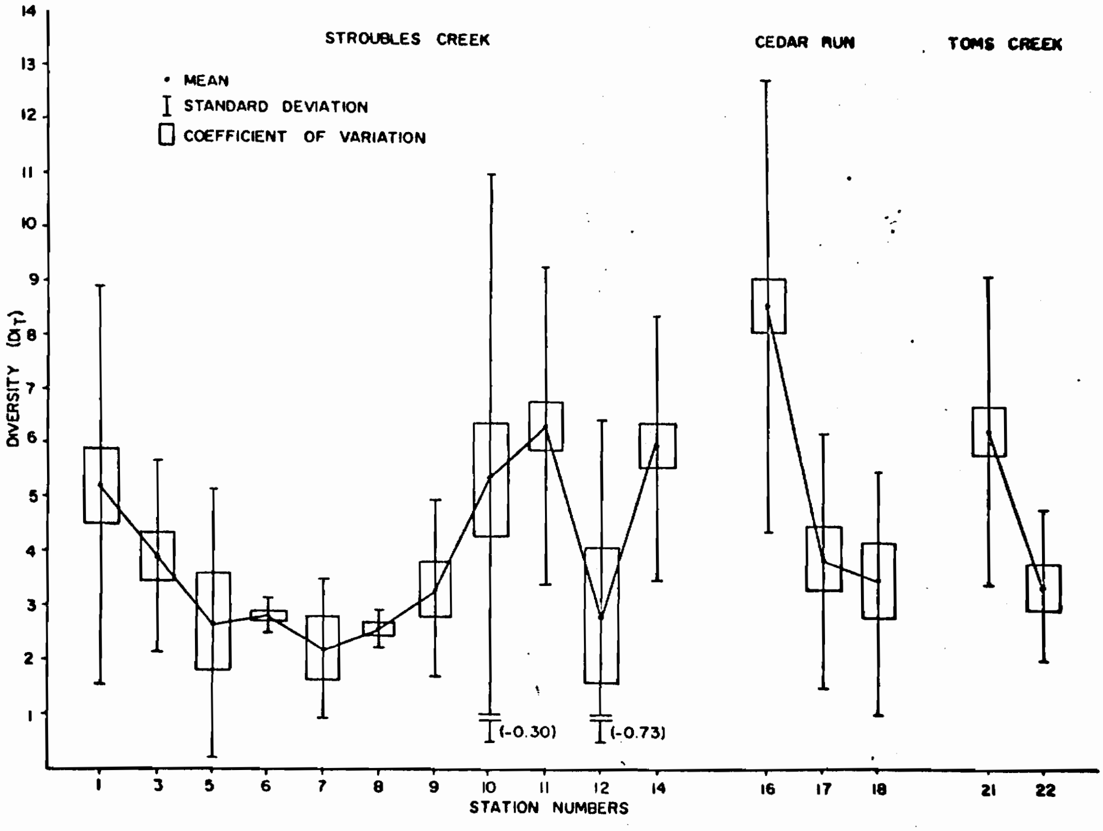

Figure 5. Mean Annual Diversity ($\dot{D}I_T$) of Macroinvertebrate Communities in Stroubles Creek, Cedar Run, and Toms Creek from October 1971 through August 1972.

too large (11-125% of the mean) to allow the mean annual diversity index to be considered a reliable method of measuring station-to-station differences. This variation is probably due, in large part, to the normal, annual fluctuations of the macroinvertebrate community resulting from the life cycles of the organisms. For example, many kinds of macroinvertebrate leave the water to become adults during the spring and summer, decreasing the diversity of the stream community. Also, in the fall the eggs that were laid during the summer hatch, and the diversity of the stream community rises.

On a station-to-station basis, the greatest number of high DI_T's was found in December. After pooling information from all stations sampled for a particular month, a mean DI_T was calculated for that month. Figure 6 presents these data and shows that the mean bimonthly DI_T is highest in October and lowest in December. However, it must be noted that the coefficient of variation for each mean is too large (34-86% of the mean) to permit the mean bimonthly DI_T values to reliably estimate the differences between months.

To test the repeatability of individual DI_T's, a given sample was re-randomized and a DI_T determined three separate times. This basic information was used in a computer simulation which produced three cumulative frequency distributions of DI_T numbers, each distribution based on 1000 simulations. To test the overlay of these distributions, the Kolmogorov-Smirnov goodness of fit test

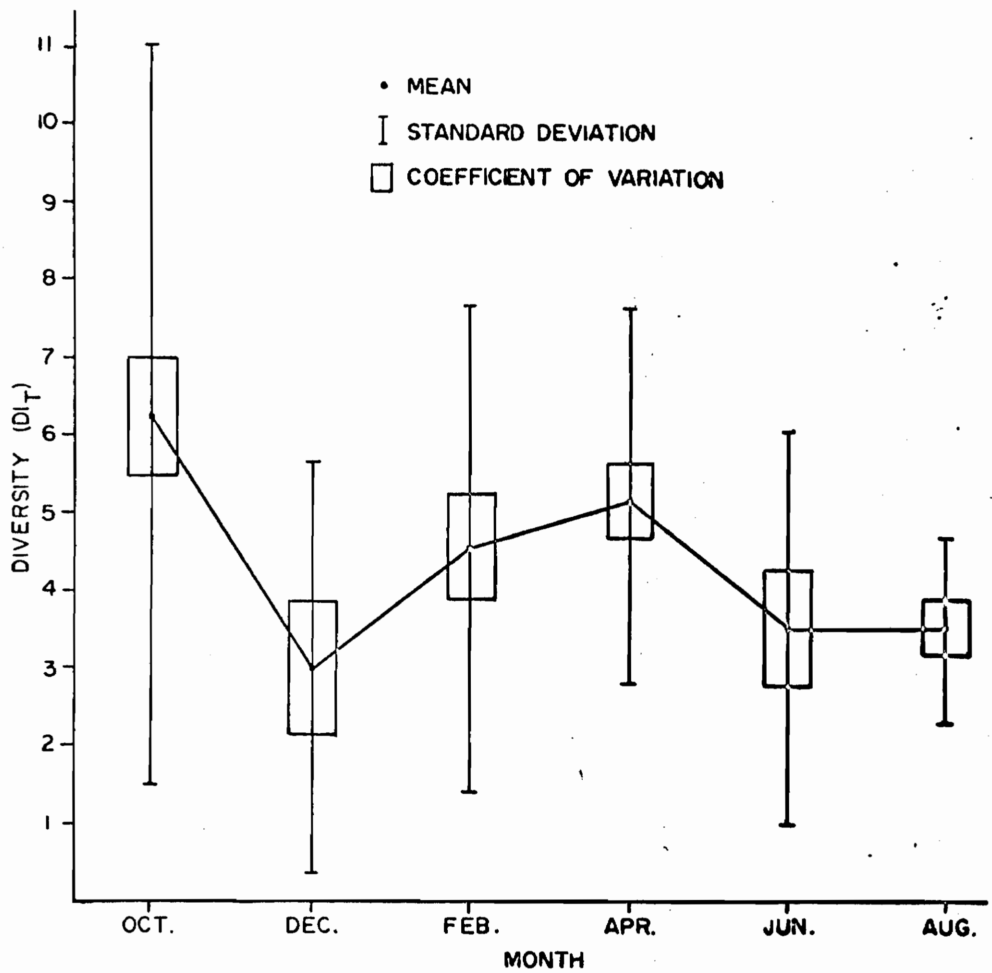

Figure 6. Mean Bimonthly Diversity (DI_T) of Macroinvertebrate Communities in Stroubles Creek, Cedar Run, and Toms Creek from October 1971 through August 1972.

was used. In this test, the greatest difference between any two distributions must not exceed the critical rejection point, 0.061 in this case, to show that the distributions are similar at the 95% level of confidence. When these criteria were applied to the macroinvertebrate data, it was found that the greatest difference was 0.058 thereby showing that DI_T values for a particular station are reliably repeatable.

According to the Cairns-Dickson DI_T classification system, Stroubles Creek and Toms Creek would be considered as badly polluted throughout the year. The station (16) on Cedar Run above the sewage treatment plant, would be classified semipolluted although the stations below the plant (17 and 18) would definitely be classified as badly polluted.

In addition to the DI_T diversity index, the Wilhm and Dorris $\bar{d}$ diversity measure was applied to studying the three streams. Table 5 presents a summary of the $\bar{d}$ values as calculated for Stroubles Creek, Cedar Run, and Toms Creek. Figure 7 presents the mean annual $\bar{d}$ values for each station, and Figure 8 shows the mean bimonthly $\bar{d}$ measurements calculated in the same manner as the DI_T means above. The shape of the $\bar{d}$ curves closely approximate the curves for the same type of information reported for DI_T. The same reservations concerning the use of means in comparing data points apply to the $\bar{d}$ information. The DI_T and $\bar{d}$, as applied to macroinvertebrates were found to have a positive correlation with each other at the 95% level of confidence. (The test of hypothesis used was to

Table 5. Monthly $\bar{d}$ for Macroinvertebrates for October 1971 through August 1972.

Station Number	October	December	$\bar{d}$ February	April	June	August
			Stroubles Creek			
1	2.60	1.25	2.41	2.07	1.64	1.83
3	2.56	1.00	1.24	1.96	1.59	-
5	1.78	0.25	1.90	1.01	0.88	1.19
6	1.57	1.52	1.85	1.44	-	1.71
7	1.62	1.37*	0.00*	1.34	0.99	1.92
8	0.70	1.33	0.92*	-	-	-
9	0.99	0.66	1.86	1.31	0.26	1.74
10	2.61	0.93	0.00**	2.14	1.55	1.07
11	1.48	1.32	2.39	2.57	1.89	1.55
12	2.60	0.05	0.00**	0.90	1.09	0.56
14	2.50	1.47	1.99	1.48	2.04	2.04
			Cedar Run			
16	3.41	2.95	3.05	2.37	2.85	1.89
17	0.00*	0.73	2.71	0.98	0.54	1.88
18	1.48	1.35	1.82	1.38	0.18	2.60
			Toms Creek			
21	-	2.68	1.59	2.57	1.65	1.78
22	2.73	0.50	1.16	2.32	1.66	1.87
			Mean Bimonthly Diversity			
$\bar{x}$	1.91	1.21	1.56	1.72	1.34	1.69

* 5 or less macroinvertebrates in sample

** no macroinvertebrates in sample

\- substrate not recovered from stream

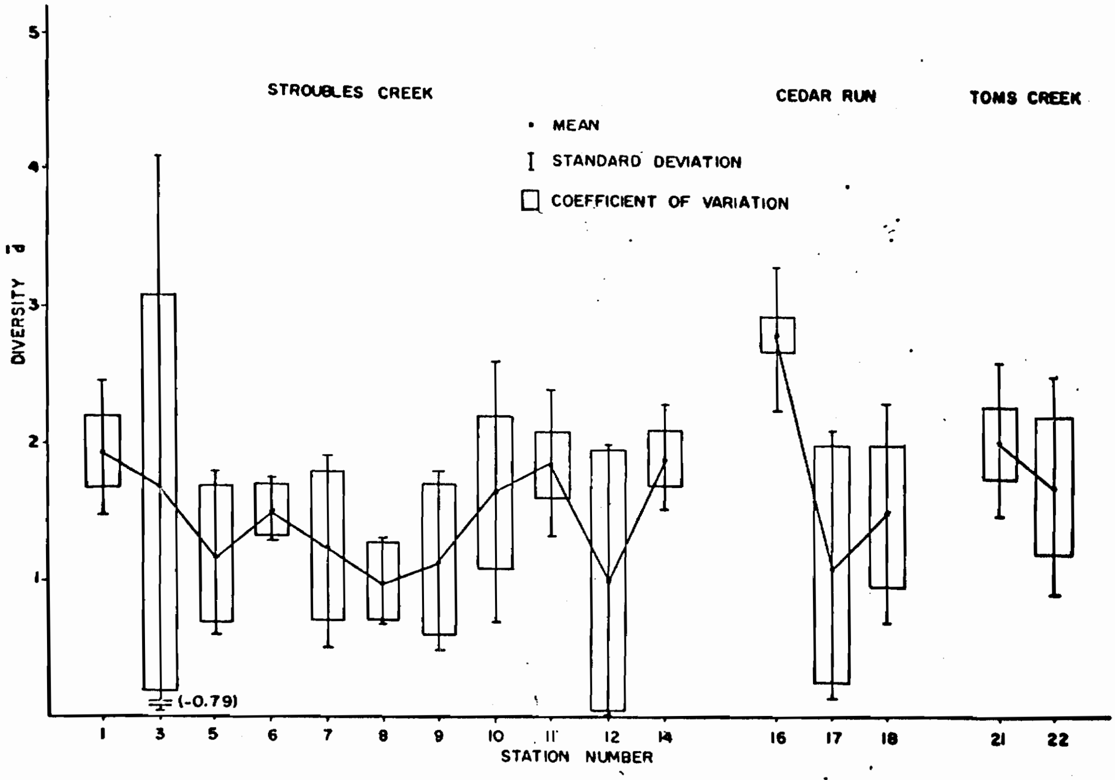

Figure 7. Mean Annual Diversity ($\bar{d}$) of Macroinvertebrate Communities in Stroubles Creek, Cedar Run, and Toms Creek from October 1971 through August 1972.

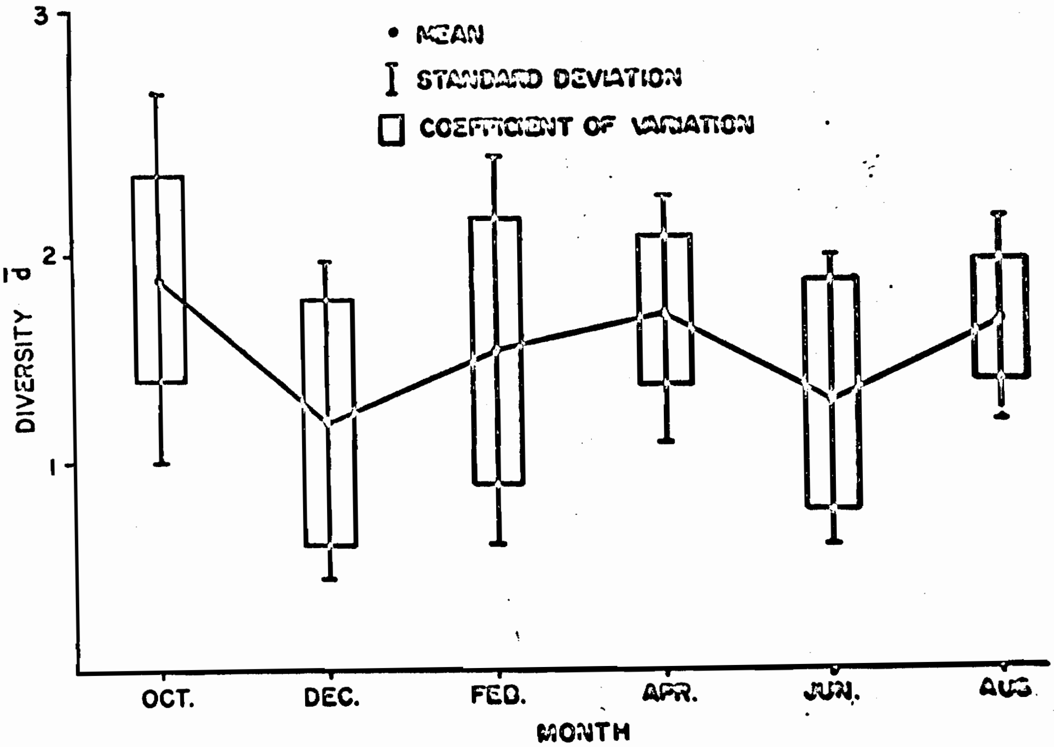

Figure 8. Mean Bimonthly Diversity ($\bar{d}$) of Macroinvertebrate Communities in Stroubles Creek, Cedar Run, and Toms Creek from October 1971 through August 1972.

test the null hypothesis of rho equal zero against the alternate hypothesis of rho not equal to zero at the 95% level of confidence. The correlation coefficient used was by the Spearman Rho technique.) Due to the nature of the $\bar{d}$ measure, individual $\bar{d}$ values would be repeatable every time with replicates of a given sample yielding the same value.

Wilhm and Dorris (1968) state that a $\bar{d}$ value of less than one indicates heavy pollution; one to three shows moderate pollution; and greater than three indicates clean water. Using this scheme Stroubles Creek and Toms Creek would be considered moderately polluted throughout the year. However, some stations on Stroubles Creek (5,7,8,9,10) show readings indicating heavy pollution on several occassions, and Station 12, immediately below the sewage treatment plant, would be classified as heavily polluted the majority of the time (Table 5). On Cedar Run the stream at Station 16 above the treatment plant would be classified as clean water or moderately polluted. However, Station 17, immediately below the sewage plant, would be considered to be heavily polluted frequently although at Station 18 further downstream, there is evidence of recovery to the level of moderate pollution.

Figure 9 presents information concerning the number of kinds of organisms (usually at the generic level, although some organisms could not be identified beyond the familiar or ordinal level) at each station, summarizing data for the study period. Stations 1, 3 and 5 are located at springs on Stroubles Creek and the numbers

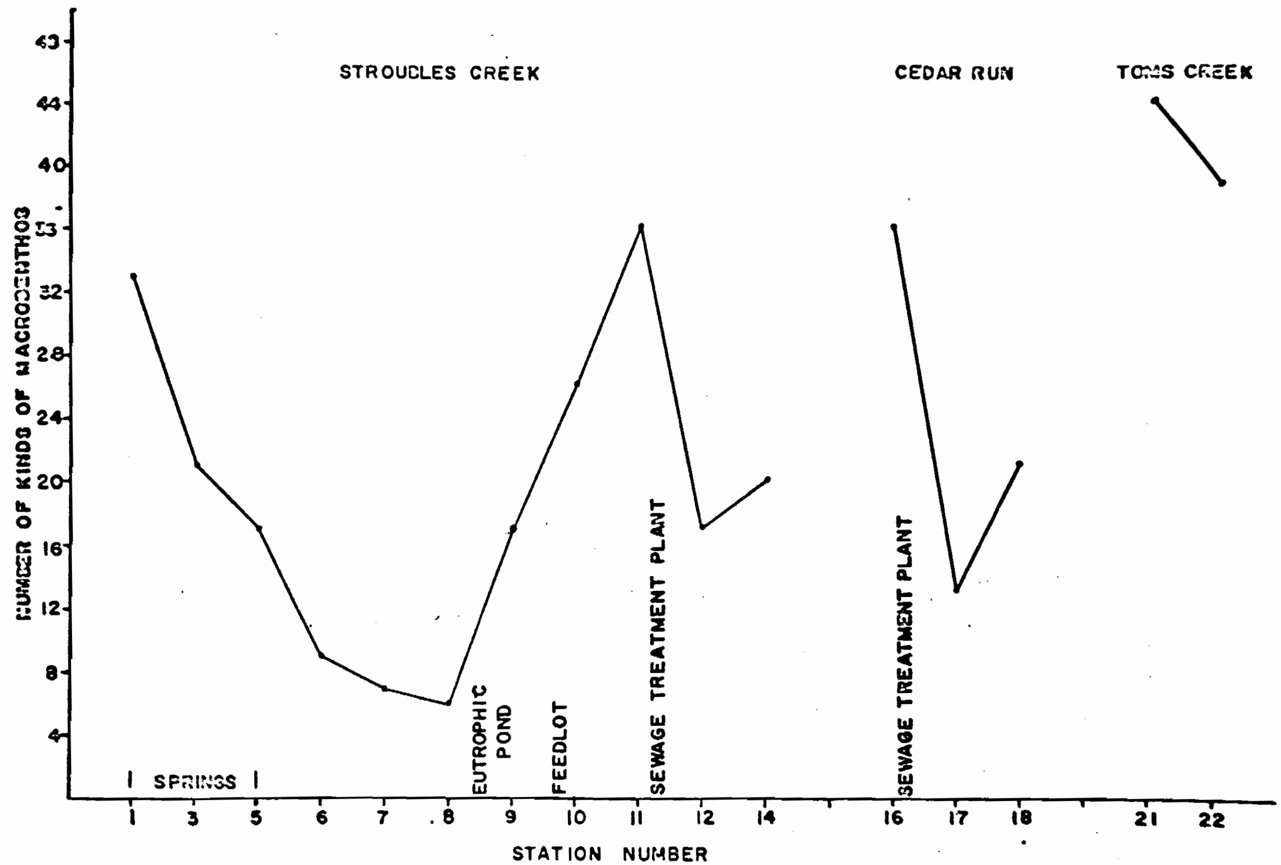

Figure 9. Number of Taxa of Macroinvertebrates at each Station in Stroubles Creek, Cedar Run, and Toms Creek from October 1971 through August 1972.

of genera found at these stations vary considerably. However, downstream from Station 5, the west branch of Stroubles, the diversity decreased at Station 6 and is lower still at Station 7 after the stream has drained residential and business areas, received effluent from the VPISU power plant, and passed underground for several hundred yards. Station 8 represents the combined flow of the two arms of Stroubles Creek which joined and coursed underground for approximately 0.5 miles. The number of genera found at Station 8 is lower than at any other point in the entire stream. The two branches of Stroubles Creek flow into a eutrophic pond and the number of genera rises fairly quickly at Station 9 on the single creek draining the pond. The diversity continues to increase as the stream drains a feedlot (Station 10) and continues on through agricultural land to Station 11. The number of macroinvertebrate genera is greater at Station 11 than at any other section of the stream but the influence of the sewage effluent greatly reduces these numbers (Station 12). The number of genera increase somewhat from Station 12 to Station 14.

Cedar Run shows high diversity at Station 16, but the number of taxa is greatly reduced at Station 17 below the sewage treatment plant. Toms Creek shows the greatest diversity of macroinvertebrates at Station 21, and, even though this diversity is reduced at Station 22, it remains greater at Station 22 than on the other two streams.

When the information in Table 6 is compared with the information

Table 6. Percent Composition by Taxa of the Macroinvertebrate Community at Each Station on Stroubles Creek, Cedar Run, and Toms Creek for the period October 1971 through August 1972.

	Station Number															
	Stroubles Creek											Cedar Run			Toms Creek	
Taxa	1	3	5	6	7	8	9	10	11	12	14	16	17	18	21	22
Ephemeroptera	3	<1	<1	0	1	<1	<1	<1	1	0	0	15	1	<1	3	4 *
Odonata	<1	0	0	<1	0	0	0	2	2	<1	<1	2	<1	0	<1	1
Plecoptera	0	0	0	0	0	0	0	0	1	0	<1	1	0	0	10	5
Megaloptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0
Coleoptera	<1	1	0	<1	0	0	0	<1	1	<1	<1	1	0	3	1	1
Tricoptera	<1	<1	<1	2	0	0	18	8	35	4	2	4	2	2	13	20
Diptera	31	61	9	33	43	15	80	63	48	66	70	34	92	71	71	63
Non-insects	67	37	91	63	56	84	1	27	12	29	27	43	4	24	2	6

* all numbers in percent

in Figure 9, it is evident that the diversity of the macroinvertebrates is due largely to the presence of non-insect Arthropods at Station 1, 3, 5 (Amphipods and Isopods), 6, 7 and 8 (Oligochaetes and Decapods). For the remainder of Stroubles Creek the composition of the macroinvertebrates is predominantly true flies (Diptera), although the number of orders represented in the community increases below the eutrophic pond.

On Cedar Run, above the treatment plant (Station 16) the number of orders represented is high although the community is dominated by Isopods, Oligochaetes, and true flies. Immediately below the Cedar Run plant (Station 17) and at Station 18 further downstream, the macroinvertebrate community is predominately true flies. True flies dominate in Toms Creek but the communities are represented by more insect orders than in either Stroubles Creek or Cedar Run.

Appendix A, Table 1 summarizes bimonthly information concerning the number of macroinvertebrate taxa per number of specimens at each station and Appendix A, Tables 2 and 3 present information regarding the presence or absence of macroinvertebrate taxa at each station during the year of study.

As mentioned in the case of diatoms, certain criteria must be met in using the Sequential Comparison Index, DI_T. All of these requirements were met with ease in applying the DI_T to macroinvertebrates with the possible exception of having a sufficient number of organisms in a collection. While Cairns and Dickson (1971) recommend that only the first 250 organisms in a bottom fauna collection need be examined they do not specifically state a minimum number of organisms that must be examined. Unfortunately, in the present study, there were frequently less than 250 organisms in a sample and at some stations, frequently fewer than 25 (Appendix A, Table 1).

It is possible that the DI_T and $\bar{d}$ values were based on too few organisms (less than 25); however, these values were consistently low in relation to stations with both greater numbers of individuals and greater numbers of genera, so the relative differences between stations were maintained. It is also important to note that at particular stations (6,7,8 for example) consistently low numbers of individuals and of genera indicated a stressed community at those locations.

Since equal sampling effort was applied at every station and stations with high diversity maintained that condition while other stations consistently showed low diversity, I feel that station-to-station differences in diversity measurements, using DI_T adequately reflected prevailing conditions at those stations.

Both diversity indices indicated that the three streams represent stressed aquatic systems. The DI_T classification showed that all the streams are badly polluted and the $\bar{d}$ values would permit classification of Stroubles Creek and Toms Creek as moderately polluted with the station above the treatment plant on Cedar Run registering as moderately polluted, the station directly below the plant as heavily polluted, and the station downstream as moderately polluted.

That the systems are stressed also is indicated by information (Figure 9, Table 6) concerning the low number of genera and the high percent composition of non-insects (predominantly Oligochaetes and Decapods below the springs) and true flies (after the creek receives organic enrichment from the eutrophic pond and agricultural runoff).

Although identical, artificial substrate was used at each station the natural stream substrate would play an important part in determining the type of macroinvertebrates that would occur there. The majority of stations on all three streams were located in riffle areas, but the streams were small and the riffles were not as "fast" as those in a river system. Also, the natural substrate was composed of sand or silt, small rocks, and gravel at most stations--a substrate that in itself would limit the number of kinds of organisms found there. It is possible that the dominance of true flies and non-insects at the stations is more a reflection of the characteristics of the natural streambed than of the effects of pollutants. However, even after taking into consideration the major role that natural substrate may assume as a limiting factor, it should be noted that this study found definite station-to-station changes in diversity - the eastern most spring on Stroubles Creek (Station 1) had a higher diversity than either of the other two springs, the stations above the treatment plants had greater diversity than the stations immediately below the plants, and diversity was greater on Toms Creek than on either Stroubles Creek or Cedar Run.

Chemical Parameters

Appendix B, Tables 1 - 17 summarize all chemical information derived from the three streams during the year of study. Table 7 shows the correlation among chemical parameters and among chemical and biological parameters. Selected parameters at particular stations were investigated also for correlation among chemical, and among chemical and biological parameters. In correlation analysis the null hypothesis that two variables are mutually independent is tested (at the appropriate confidence level - 90% or greater in this case), versus the hypothesis that the two variables are not mutually independent, i.e., the two variables are correlated. If the null hypothesis is rejected it shows statistically that either the two variables have a positive correlation - there is a tendency for the values to parallel each other, or the two variables have a negative correlation - there is a tendency for the values to diverge. In applying this test to the data, all data were pooled from the three streams over the study period for each variable; therefore, correlations could be noted only among variables and not among stations. The test for correlation was performed among DI_T diatoms, DI_T macroinvertebrates, $\overline{d}$ macroinvertebrates, COD, BOD, total solids, phosphate, nitrate, and chloride although only those parameters correlated at the 90% confidence level (or higher) were reported in Table 7.

Diatom community diversity appeared to have a significant positive correlation with chloride; however, the diatom data were

Table 7. Correlation Among Chemical Parameters and Among Biological and Chemical Parameters.

Correlations Significant at the 95% Level of Confidence		Correlations Significant at the 90% Level of Confidence	
Parameters Correlated	Corr.	Parameters Correlated	Corr.
Total Solids & COD	+*	DI_T Macro & Total Solids	-
Total Solids & Nitrate	+		
Total Solids & Chloride	-	$\bar{d}$ Macro & Total Solids	-
		$\bar{d}$ Macro & BOD	-
COD & BOD	+		
COD & Phosphate	+	DI_T Diatoms & Chloride	+
COD & Nitrate	-		
COD & Chloride	+		
BOD & Phosphate	+		
BOD & Nitrate	-		
BOD & Chloride	+		
Phosphate & Nitrate	+		
Phosphate & Chloride	+		
DI_T Macro & COD	-		
$\bar{d}$ Macro & COD	-		
$\bar{d}$ Macro & Chloride	-		

* + positive correlation
  - negative correlation

shown to be statistically unreliable, so this apparent relationship may be an artifact. Both types of diversity indices for macroinvertebrates were negatively correlated (significant at the 95% confidence level) with COD and total solids and $\bar{d}$ macroinvertebrate diversity showed negative correlation with BOD (significant at the 90% confidence level). The correlations were probably due to the fact that an increase in total soilds resulted in an increase in COD and BOD and possibly in greater turbidity, silt accumulation on the artificial substrates, interference with the organisms' feeding habits, and a decrease in the oxygen content of the water. This combination of factors tends to limit the types of organisms that could inhabit the area in question.

In Table 8 a comparison of the range and means of selected chemical measurements at selected stations are shown. Of particular interest is the generally similar characteristics of Station 1 on Stroubles Creek, the spring on the eastern branch with the highest diversity of macroinvertebrates, and the two stations on Toms Creek (Station 21 and 22). In comparing effects of the sewage treatment plant on Stroubles Creek (Stations 11, 12, 14) and on Cedar Run (Stations 16, 17, 18) it was found that concentrations of COD, BOD, chloride, phosphate, nitrate, chlorine, TOC, and TKN increased directly downstream from the plant and then decreased further downstream to levels more nearly that of the streams above the treatment plants. In both streams, total solids remained nearly the same above and below the treatment plants and were lower in concentration several miles downstream from the plant than they were

Table 8. The range and means of selected chemical parameters at selected stations on Stroubles Creek, Cedar Run, and Toms Creek for the period of August 1971 through August 1972.

Station number	Percent DO saturation range	Percent DO saturation mean	Chlorine range	Chlorine mean	pH range	pH mean	COD range	COD mean	BOD range	BOD mean
1	82-112	88	0	0	7.0-7.5	7.3	1.7-11.9	5.2	0.05-2.9	1.2
21	82-103	96	0	0	7.5-8.0	7.9	1.8-15.3	8.7	0.5-15.0	2.8
22	84-104	96	0	0	7.5-8.0	7.9	0.0-22.6	8.5	0.5- 3.6	1.4
11	61-149	101	0	0	7.0-8.5	7.9	3.2-69.2	14.5	1.0-18.0	3.1
12	62-125	87	0.0-3.0	1.03	6.5-8.0	7.4	7.8-149.0	57.1	0.5-23.0	11.3
14	70-142	94	0.0-0.6	0.13	0.3-8.0	7.7	3.0-130.0	22.3	2.7-17.4	7.9
16	33-122	92	0	0	6.0-8.0	7.9	0.0-101.0	12.8	0.1-17.0	2.9
17	50-124	93	0.0-2.0	0.8	6.0-8.0	7.6	1.4-62.0	22.1	0.0-10.0	4.3
18	70-132	97	0.0-0.4	0.1	7.5-8.0	7.9	0.0- 2.0	14.4	0.3-12.0	2.9

Table 8. (continued)

Station	TOC		Alkalinity		TKN		Chloride		Nitrate	
number	range	mean	range	mean	range	mean	range	mean	range	mean
1	0.5-13.0	5.8	180-340	225	0.0-2.0	0.0	8.0-23.0	13.0	0.8-3.1	2.1
21	3.0- 7.0	5.2	58-155	96	0.0-1.0	0.0	5.0-57.6	13.0	0.1-0.6	0.4
22	0.5-11.0	5.7	86-204	137	0.0-0.5	0.0	4.0-16.5	15.0	0.1-0.70	0.45
11	2.0-28.1	8.2	161-226	201	0.0-26.0	2.0	12.6-50.1	25.0	0.3-2.4	1.2
12	4.0->50.0	17.2	130-212	187	3.0-31.0	16.0	16.9-55.2	32.0	0.3-3.0	1.4
14	4.0-14.0	8.3	117-188	152	0.0-6.0	3.0	13.4-31.5	24.0	1.2-3.4	1.9
16	1.8-39.0	8.5	152-264	212	0.6-1.5	0.0	12.0-59.6	22.0	0.8-3.60	1.4
17	4.0-24.0	10.2	112-185	156	0.5-16.0	6.0	12.0-52.8	25.0	1.10-5.80	2.32
18	1.9-18.0	7.5	109-224	192	0.0-15.0	1.0	9.0-32.4	17.0	1.1-3.2	1.9

Table 8. (continued)

Station number	Phosphate range	Phosphate mean	Total Solids range	Total Solids mean
1	.02 - .84	0.19	198-380	275
21	<.02 - .90	0.24	80-305	200
22	0.06 - 9.14	0.21	136-327	223
11	0.04 - 0.80	0.26	268-564	398
12	1.4 -53.0	16.10	262-685	390
14	1.50 -13.3	7.20	234-545	350
16	<0.04 - 1.60	0.29	218-573	378
17	0.86 -70.3	11.40	200-569	349
18	0.4 -27.0	5.30	235-510	351

above the plant. The percent saturation of dissolved oxygen decreased below the Stroubles Creek plant, probably because of increased COD and BOD. However, dissolved oxygen did not decrease below 62% saturation at any time during the year of study. The percent saturation of DO on Cedar Run remained nearly constant below the plant.

Alkalinity decreased below the treatment plant on both creeks, possibly because the water processed in the treatment plant was from the New River which generally has alkalinity below 60 ppm (Water Chemistry Laboratory, Biology Department, VPISU). The pH also decreased below the treatment plant due to the fact that the treatment plant effluent averages between 7.2 and 7.6 (Blacksburg - VPI Sanitation Authority).

The occurrence of flyash and chromium at Station 7 on Stroubles Creek was observed several times during the course of the study. These observations were made infrequently and do not represent a close monitoring of the creek for these two parameters. These parameters were quantified on seven occasions and the results of the observations and measurements are summarized in Table 9. The main effect of flyash on a water system is an increase in turbidity, therefore, the flyash concentration was measured in Jackson Turbidity Units. The chromium concentration was measured by means of a Hach kit direct reading colorimeter and reported in parts per million. Diversity of macroinvertebrates at Station 6 (above the contamination) and Station 7 were quite low and it was not possible to quantify the

Table 9. Occurrence of Flyash (Jackson Turbidity Units) and Chromium (ppm) at Station 7 on Stroubles Creek.

Date	Flyash
1/18/72	--*
1/25/72	-
2/1/72	-
2/15/72	-
3/7/72	90
3/20/72	400
3/27/72	-
4/3/72	325
4/10/72	225**
10/27/72	-
10/30/72	-

Date	Chromium
11/23/71	12.2
12/14/71	16.5
6/14/72	3.2

* No concentration recorded
** Creek above the flyash = 50 JTU for this date

effects of the flyash or chromium on the biota of the stream. In addition, a fuel oil spill, reported to be 600 gallons, occurred immediately above station 7 on November 17, 1971.

The Report of the Committee on Water Quality Criteria (1968) suggested guidelines for the concentrations or levels of pH, DO, total phosphorus, and nitrogen-phosphorus ratio for natural fresh water. The Committee reported that the pH range of 6.5-8.5 was the most productive for freshwaters - a criterion met by all three streams in this study. It was suggested that DO should be above 5 ppm for the maintenance of aquatic life, although if other stream conditions were favorable, the DO concentration might remain between 4 and 5 ppm for short periods of time. The DO concentrations at the two stations on Toms Creek never fell below 5 ppm. However, Station 8 on Stroubles Creek showed a DO concentration of 4 ppm on one occasion in August 1971, Cedar Run (Station 16) showed a DO concentration of 3 ppm in August 1971, and Station 17 measured 4 ppm during the same month. Although these concentrations may have represented the actual conditions at these three stations, these values may be in error because the analyst was using a YSI DO meter with which she was unfamiliar. After November 1971 DO measurements were made using the Winkler method, and for August 1972 the DO concentrations never fell below 6.8 ppm at any station.

The Committee recommended that the concentration of total phosphorus should not exceed 0.1 ppm in flowing streams. All three streams in this study had total phosphate concentrations exceeding this limit at some time during the year. The Committee offered the nitrogen-phosphorus ratio of 10:1 as a guide to the relative concentrations of these chemicals in a "normal" stream. This ratio is infrequently attained in Stroubles Creek, Cedar Run, or Toms Creek due to the comparatively low nitrogen levels.

The value of the water chemistry data lies in the fact that they establish baseline data for these streams. Since it is exceedingly difficult to describe the criteria that all streams should meet in regard to chemical parameters, it is frequently more meaningful to compare the characteristics of a stream with itself through time to ascertain "normality" for that particular water system or changes in the system through time.

In carrying out this investigation several areas for further study became apparent. These areas include: (1) periodic measurement of biological and chemical parameters of Stroubles Creek, Cedar Run, and Toms Creek for comparison with present baseline data presented in the thesis, (2) chlorine toxicity studies for diatom and macroinvertebrate communities in Stroubles Creek and Cedar Run, (3) research on chemical components of urban runoff and their effects on the biota of Stroubles Creek, and (4) research concerning the effects of flyash and chromium on the biota of Stroubles Creek.

CONCLUSIONS

This investigation has shown that the Sequential Comparison Index (DI_T) for diatoms does not give reliable results and that measuring associations of diatom species might give more valuable information for streams where the number of taxa is low, as was the case in these streams. The chemical data did give good baseline information about some chemical characteristics of the water in the three streams but since these chemical parameters were not shown to correlate with biological parameters, perhaps many of them could be excluded in further studies. Analyses run for heavy metals, pesticides, or silicon, for instance, perhaps would have been more useful for relating water chemistry to the biological community.

Although I approached studies of the diatom and macroinvertebrate communities with an almost equal lack of training I found that the DI_T was much easier to apply to macroinvertebrates and gave more reliable results than when applied to diatoms. In my opinion if a single parameter must be selected and measured in a stream to indicate its water quality, the diversity of macroinvertebrate species and the association of macroinvertebrate species would be the easiest, least time consuming, and most informative of the three methods I investigated.

I conclude that Toms Creek has the best water quality of the three streams studies based on the facts that the macroinvertebrate communities of this creek had the highest diversity of the three creeks. The stream had representatives of the six insect orders and also supported a relatively wide variety of non-insects. These measures indicated a reasonably stable macroinvertebrate community which would generally be considered as characteristic of a healthy stream. This creek also has swifter water and larger gravel for substrate which increases the number and variety of habitats. These conditions undoubtedly contributed to the increased diversity in the macroinvertebrate community in Toms Creek.

SUMMARY

1. Three streams in the area of Blacksburg, Virginia were monitored biologically and chemically for a period of one year.
2. The Cairns-Dickson diversity index, DI_T, was applied to both diatom and macroinvertebrate communities in the streams and the Wilhm-Dorris diversity index, $\bar{d}$, was applied to macroinvertebrate communities.
3. Chemical parameters measured included: pH, dissolved oxygen, chlorine, temperature, chemical oxygen demand, biochemical oxygen demand, total Kjeldahl nitrogen, chloride, alkalinity, nitrate, total and ortho-phosphate, and total, suspended, and dissolved solids.
4. The DI_T applied to diatoms did not give reliable results.
5. The DI_T and $\bar{d}$ as applied to macroinvertebrates gave reliable results.
6. The two diversity indices for macroinvertebrates, DI_T and $\bar{d}$, were postively correlated at the 95% confidence level. This meant that a high diversity value for DI_T was associated with a high diversity value for $\bar{d}$.
7. The diversity indices for diatoms and macroinvertebrates indicated that all three streams were stressed aquatic systems.
8. The natural substrate of these three streams, silt and gravel, might be an important limiting factor in the diversity of the three streams.

9. Water chemistry characteristics of a spring on Stroubles Creek appeared similar to the chemical characteristics of Toms Creek, while the stations on Stroubles Creek downstream of the springs were similar to the stations on Cedar Run.
10. Phosphate, nitrate, chloride, chlorine, total organic nitrogen, COD, and BOD increase in concentration after the sewage treatment plants on both Stroubles Creek and Cedar Run.
11. The presence of flyash, chromium, and fuel oil are reported at Station 7 on Stroubles Creek. However, it was not possible to measure the effects of these contaminants on stream biota due to the low diversity of macroinvertebrates both above and below the source of contamination.

LITERATURE CITED

Arthur, J. W., and W. B. Horning II. 1969. Am. Midl. Nat. 82:83.

Brillouin, L. 1960. Science and Information Theory. 2nd ed. Academic Press, Inc., New York.

Cairns, J. Jr., D. W. Albaugh, F. Busey, and M. D. Chanay. 1968. The sequential comparison index - a simplified method for non-biologists to estimate relative differences in biological diversity in stream pollution studies. Jour. Wat. Pol. Contr. Fed. 40(9): 1607-1613.

Cairns, J. Jr., and K. L. Dickson. 1971. A simple method for the biological assessment of the effects of waste discharges on aquatic bottom dwelling organisms. Jour. Wat. Pol. Contr. Fed. 43(5):755-772.

Cairns, J. Jr., and K. L. Dickson. 1972. An ecosystematic study of the South River, Virginia. Bull. V.P.I.&S.U. Wat. Res. Rer. Cent. No. 54.

Dean, R. B. 1968. Ultimate disposal of waste water concentrates to the environment. Environ. Sci. Techn. 2(12):1079-1085.

Dixon, W. J., and F. J. Massey, Jr. 1951. Introduction to statistical analysis. McGraw-Hill, New York.

Gaufin, A. R., and C. M. Tarzwell. 1952. Aquatic invertebrates as indicators of stream pollution. Pub. Health Repts. 67(1):57-64.

Hester, F. E., and J. S. Dendy. 1962. Trans. Am. Fish. Soc. 91:420.

Hohn, M. H. 1959. The use of diatom populations as a measure of water quality in selected areas of Galveston and Chocolate Bay, Texas. Publ. Inst. Mar. Sci. 6:206-212.

Hynes, H. B. N. 1960. The biology of polluted waters. Liverpool University Press, Liverpool. 202 pp.

Hynes, H. B. N. 1970. The ecology of running waters. University of Toronto Press, Toronto. 555 pp.

Ide, F. P. 1954. Pollution in relation to stream life. Pages 86-108. In First Ontario Industrial Waste Conference. Pollution Control Board of Ontario, Toronto. 121 pp.

Kolkwitz, R., and M. Marsson. 1908. Translated 1967. Ecology of plant saprobria. Pages 47-52. In L. E. Keup, W. M. Ingram, and K. M. Mackenthun (Editors), Biology of Water Pollution. Federal Water Pollution Control Administration, U.S. Department of the Interior. 290 pp.

Kolkwitz, R., and M. Marsson. 1909. Translated 1967. Ecology of animal saprobria. Pages 85-95. In L. E. Keup, W. M. Ingram, and K. M. Mackenthun (Editors). Biology of Water Pollution. Federal Water Pollution Control Administration, U.S. Department of the Interior. 290 pp.

Mackenthun, K. M. 1966. Biological evaluation of polluted streams. Jour. Wat. Pol. Contr. Fed. 38:241-247.

Mackenthun, K. M. 1969. The practice of water pollution biology. U.S. Department of the Interior, Federal Water Pollution Control Administration, Division of Technical Support. 281 pp.

McKee, J. E. (Editor) 1952. Water Quality Criteria. California State Water Pollution Control Board Publication 3. 512 pp.

Margalef, R. 1956. Informacion y diversidad espicfica en las cominudades de organismos. Invest. Pesquera. 3:99-106.

Mason, W. T., Jr., J. B. Anderson, and G. E. Morrison. 1967. Prog. Fish. Cult. 29:74.

Mason, W. T., Jr., J. B. Anderson, R. D. Kreis, and W. C. Johnson. 1970. Artificial substrate sampling, macroinvertebrates in a polluted reach of the Klamath River, Oregon. Jour. Wat. Pol. Contr. Fed. 42:R315-328.

Moon, H. P. 1940. Jour. Anim. Ecol. 9:76.

National Research Council Committee on Pollution. 1966. Waste management and control. Nat. Acad. Sci., Washington, D.C. 257 pp. (NAS Pub. 1400).

Patrick, Ruth. 1949. A proposed biological measure of stream conditions, based on a survey of the Conestoga Basin, Lancaster County, Pennsylvania. Proc. Acad. Nat. Sci. 101:277-295.

Patrick, Ruth. 1953. Biological phases of stream pollution. Proc. of Penn. Acad. Sci. 27:33-36.

Patrick, Ruth, and C. W. Reimer. 1966. The Diatoms of the United States. Mon. Acad. Nat. Sci. Phil. Number 13. May 10, 1966. 688 pp.

Patrick, Ruth and collaborators: F. A. Aldrich, J. Cairns, Jr., F. Drouet, M. H. Hohn, S. S. Roback, H. Skeija, P. J. Spangler, Y. H. Swabey, and L. A. Whitford. 1966. The Catherwood Foundation Peruvian-Amazon expedition: limnilogical and systematic studies. Monogr. Acad. Nat. Sci. Phil. Number 14. Philadelphia. 495 pp.

Patrick, Ruth, J. Cairns, Jr., and S. S. Roback. 1967. An ecosystematic study of the fauna and flora of the Savannah River. Proc. Acad. Nat. Sci. Phil. 118(5):109-407.

President's Science Advisory Committee. 1965. Restoring the Quality of Our Environment. Environmental Pollution Panel Report. U.S. Government Printing Office. 317 pp.

Reid, G. K. 1961. Ecology of inland waters and estuaries. Van Nostrand Reinhold Company, New York. 373 pp.

Report of the Committee on Water Quality Criteria. 1968. Federal Water Pollution Control Administration, U.S. Department of the Interior, Washington. 234 pp.

Richardson, R. E. 1928. The bottom fauna of the Middle Illinois River, 1913-1925. Ill. Nat. Hist. Sur. Bull. 17:387-475.

Schmidt, J. W., and R. E. Taylor. 1970. Simulation and analysis of industrial systems. Richard D. Erwin Inc., Homewood, Illinois. 644 pp.

Simmons, G. M., Jr., and A. Winfield. 1971. A feasibility study of using conservation webbing as an artificial substrate in macrobenthic studies. Virginia Jour. Sci. 22(2):52-59.

Standard Methods for the Examination of Water and Wastewater. 1971. American Public Health Association, American Water Works Association, and Water Pollution Control Federation, 13th ed. Am. Pub. Health Assoc., New York. 874 pp.

Stroud, P. H. 1967. Water quality criteria to protect aquatic life: a summary. in A symposium on water quality criteria to protect aquatic life. Am. Fish. Soc. Special Publication Number 4.

Swift, E. 1967. Cleaning diatom frustules with ultraviolet radiation and peroxide. Phycologia. 6(2/3):161-162.

Venkateswarlu, V. 1969. An ecological study of the algae of the Moosi, Hyderabad (India) with special reference to water pollution. Hydrobiologia. 33(1):117-143.

Warren, C. E. 1971. Biology and water pollution control. W. B. Saunders Company, Philadelphia. 434 pp.

Weider, R. B., A. G. Christianson, S. R. Weibel, and G. G. Robeck. 1969. Rural runoff as a factor in stream pollution. Jour. Wat. Pol. Contr. Fed. 4(1/4):377-384.

Wene, G., and E. L. Wickliff. 1940. Can. Ent. 72:131.

Wilhm, J. L., and T. C. Dorris. 1966. Species diversity of benthic macroinvertebrates in a stream receiving domestic and oil refinery effluents. Am. Midl. Nat. 76:427-449.

Wilhm, J. L., and T. C. Dorris. 1968. Biological parameters for water quality criteria. Bioscience. 18(6):477-481.

Wisdom, A. S. 1956. The law on the pollution of waters. London.

APPENDIX A

Table 1. Number of Macroinvertebrate Taxa Per Number of Specimens for Each Station During the Study Period October 1971 through August 1972.

Station Number	October	December	February	April	June	August
1	15/561	3/6	11/447	14/437	10/141	8/69
3	11/37	2/4	9/196	9/101	7/38	--*
5	7/791	8/2017	9/139	10/1030	4/190	5/171
6	6/32	3/5	4/10	5/61	--	4/15
7	4/26	3/5	1/1	4/30	3/20	4/6
8	5/100	3/12	2/3	--	--	--
9	8/671	5/93	7/24	9/141	5/2111	7/155
10	17/867	8/240	0/0	11/123	5/125	13/262
11	20/237	11/195	17/294	20/246	7/114	13/162
12	15/186	2/229	0/0	7/430	4/14	6/384
14	12/650	4/281	9/654	10/1410	9/235	8/64
16	26/167	16/188	16/77	16/173	9/21	9/68
17	1/1	4/40	8/18	4/57	2/40	6/18

* substrate not recovered from stream

Table 1. (continued)

Station Number	October	December	February	April	June	August
18	7/71	4/23	12/417	7/48	2/36	11/42
21	--*	14/140	16/429	14/453	14/269	25/1337
22	19/205	8/498	8/54	18/558	13/451	16/357

* substrate not recovered from stream

Table 2. Taxa of Macroinvertebrates by Station on Stroubles Creek for the sampling period October 1971 through August 1972.

Organisms	Station Number 1	3	5	6	7	8	9	10	11	12	14
EPHEMEROPTERA											
Leptophlebiidae											
Paraleptophlebia Lestage	-	-	-	-	-	-	-	-	+	-	-*
Siphlonuridae											
Ameletus Eaton	-	+	-	-	-	+	-	+	+	-	-
Ephemerellidae											
Ephemerella Walsh	+	-	-	-	-	-	-	-	+	-	-
Baetidae											
Baetis Leach	+	-	-	-	-	-	-	+	+	-	-
Centroptilum Eaton	-	+	-	-	-	-	-	+	+	-	-
ODONATA											
Agrionidae											
Agrion Latreille	-	-	-	-	-	-	-	+	-	+	+
Coenagrionidae											
Argia Rambur	-	-	-	-	-	-	-	+	+	+	-
Amphiagrion Selys	+	-	-	-	-	-	+	-	-	-	-
Enallagma Charpentier	-	-	-	+	-	-	-	-	-	-	-
Ischnura Charpentier	-	-	-	-	-	-	+	+	+	+	-
Aeshnidae											
Boyeria MacLachlan	-	-	-	-	-	-	+	-	-	-	-
PLECOPTERA											
Nemouridae											
Nemoura Pictet	-	-	-	-	-	-	-	-	+	-	+
Brachyptera Newport	-	-	-	-	-	-	-	-	+	-	-
Isogenus Newman	-	-	-	-	-	-	-	-	+	-	-
COLEOPTERA											
Dytiscidae											
Copelatus Erichson	+	-	-	-	-	-	-	-	-	-	-
Oreodytes Seidlitz	-	+	-	-	-	-	-	-	-	-	-
Hydrophilidae											
Berosus Leach	+	+	-	-	-	-	-	-	-	-	-
Trophisternus Solier	+	-	-	-	-	-	-	-	-	-	-
Psephenidae											
Ectoparia LeConte	-	-	-	-	-	-	-	-	-	-	+
Elmidae											
Dubiraphia Sanderson	-	-	-	-	-	-	-	+	+	+	-
Optioseruus Sanderson	-	-	-	-	-	-	-	-	+	-	-

* + taxa present
  - taxa absent

Table 2. (continued)

Organisms	Station Number 1	3	5	6	7	8	9	10	11	12	14
Promoresia Sanderson	-	-	-	-	-	-	-	-	-	-	+*
Stenelmis Dufour	-	-	-	+	-	-	-	+	+	-	-
TRICOPTERA											
Hydropsychidae											
Cheumatopsyche Wallengren	-	+	-	+	-	-	+	+	+	+	+
Hydropsyche Pictet	-	-	-	-	-	-	-	-	-	-	+
Psychomyiidae											
Neureclipsis McLachlan	-	-	-	-	-	-	-	-	+	-	-
Limnephilidae											
Hesperophylax Banks	+	-	+	-	-	-	-	-	+	-	-
Pycnopsyche Banks	-	-	-	-	-	-	-	-	-	-	+
DIPTERA											
Tipulidae											
Pedicia Latreille	-	-	+	-	-	-	-	-	-	-	-
Limnophila Macquart	-	+	-	-	-	-	-	-	-	-	-
Pilaris Sintenis	+	+	-	-	-	-	-	-	-	-	-
Limonia Meigen	+	-	-	-	-	-	-	-	-	-	-
Tipula Linnaeus	+	+	+	-	+	+	-	+	+	+	+
Psychodidae											
Pericoma Walker	-	-	-	-	-	+	-	-	-	+	-
Psychoda Latreille	+	-	-	-	-	-	-	-	-	+	+
Tendipedidae	+	+	+	+	+	+	+	+	+	+	+
Simulidae											
Simulium Latreille	+	+	+	-	+	-	+	+	+	+	+
Liriopeidae											
Liriope Meigen	-	-	+	-	-	-	-	-	-	-	-
Dixidae											
Dixa Meigen	+	-	-	-	-	-	-	-	-	-	-
Stratiomyidae											
Euparyphus Gerstaecker	+	-	-	-	-	-	-	-	-	-	-
Hermione Meigen	+	-	-	-	-	-	-	-	-	-	-
Stratiomys Geoffroy	-	+	-	-	-	-	-	-	-	-	-
Empididae											
Hemerodromia Meigen	-	+	-	-	-	-	+	+	+	-	+
Syrphidae											
Tubifefa Meigen	-	-	-	-	-	-	-	-	-	+	-

* + taxa present
 - taxa absent

Table 2. (continued)

Organisms	Station Number 1	3	5	6	7	8	9	10	11	12	14
Ephydridae											
Paralimna Loew	+	-	-	-	-	-	-	-	-	-	-*
Muscidae											
Limnophora Robineau-Desvoidy	+	-	-	-	-	-	-	-	-	-	-
ANNELIDA											
Oligochaeta	+	+	+	+	+	+	+	+	+	+	+
Hirudinea											
A	-	-	-	-	-	-	+	+	+	-	-
B	-	-	-	-	-	-	+	+	+	-	+
AMPHIPODA											
Gammaridae											
Gammarus minus Say	+	+	+	-	-	-	-	-	-	-	-
CHORDATA											
Urodela											
Desmognathus fuscus fuscus Rafinesque	+	+	+	+	-	-	-	-	+	-	-
DECAPODA											
Cambaridae	+	+	+	+	+	+	+	+	+	-	+
ISOPODA											
Asellidae											
Asellus racovitzai Williams	+	+	-	-	-	-	-	+	+	+	+
MOLLUSCA											
Planorbidae											
Helisoma Swainson	-	-	-	-	-	-	+	+	-	-	-
Hydrobiidae (=Amnicolidae)											
Hydrobia Hartmann	+	-	-	-	-	-	-	-	-	-	-
Lymnaeidae											
Lymnaea Lamarck	+	-	-	-	-	-	-	-	-	-	-
Physidae											
Physa Draparnaud	+	+	+	+	-	-	+	+	+	+	+

* + taxa present
- taxa absent

Table 2. (continued)

Organisms	Station Number 1	3	5	6	7	8	9	10	11	12	14
Pleuroceridae											
Goniobasis Lea	+	-	-	-	-	-	-	+	+	+	-*
Sphaeriidae											
Sphaerium Scopoli	+	-	+	-	-	-	-	+	-	-	-
PLATYHELMENTHES											
Planariidae											
Dugesia Girard	+	-	+	-	-	-	+	-	+	-	+

* + taxa present
  - taxa absent

Table 3. Taxa of Macroinvertebrates by station on Cedar Run, and Toms Creek for the sampling period October 1971 through August 1972.

Organisms	Cedar Run 16	Cedar Run 17	Cedar Run 18	Toms Creek 21	Toms Creek 22
EPHEMEROPTERA					
Leptophlebiidae	+	-	-	-	+*
Paraleptophlebia Lestage					
Siphlonuridae					
Ameletus Eaton	-	-	-	+	-
Isonychia Eaton	-	-	-	-	+
Ephemerellidae					
Ephemerella Walsh	+	-	-	+	+
Heptageniidae					
Stenonema Traver	+	+	-	+	+
Caenidae					
Caenis Stephens	+	-	-	-	-
Baetidae					
Baetis Leach	+	+	+	+	+
Pseudocloeon Klapalek	-	-	-	+	-
Centroptilum Eaton	-	-	-	+	-
ODONATA					
Agrionidae					
Agrion Latreille	+	-	-	+	+
Hetaerina Hagen	-	-	-	+	+
Coenagrionidae					
Enallagma Charpentier	-	+	-	-	-
Aeshnidae					
Boyeria MacLachlan	+	-	-	+	+
PLECOPTERA					
Nemouridae					
Allocapnia Claassen	-	-	-	+	+
Isoperla Banks	-	-	-	+	+
Nemoura Pictet	+	-	-	+	+
Brachyptera Newport	-	-	-	+	+
Taeniopteryx Pictet	-	-	-	+	+
Perlidae					
Acroneuria Pictet	-	-	-	+	+

* + taxa present
  - taxa absent

Table 3. (continued).

Organisms	Cedar Run 16	17	18	Toms Creek 21	22
Perlodidae					
Isogenus Newman	+	-	-	-	-*
MEGALOPTERA					
Corydalidae					
Nigronia Banks	-	-	-	+	-
COLEOPTERA					
Gyrinidae					
Dineutus MacLeay	-	-	-	+	-
Dryopidae					
Helichus Erichson	-	-	-	+	+
Chrysomelidae					
Galerucella Crotch	-	-	+	-	-
Psephenidae					
Ectoparia LeConte	+	-	+	+	-
Psephenus Haldeman	-	-	-	-	+
Elmidae					
Dubiraphia Sanderson	-	-	-	+	+
Promoresia Sanderson	+	-	+	+	-
Stenelmis Dufour	+	-	+	+	+
TRICOPTERA					
Hydropsychidae					
Cheumatopsyche Wallengren	+	+	+	+	+
Hydropsyche Pictet	+	+	+	+	+
Philopotamidae					
Chimarra Stephens	-	-	-	+	+
Psychomiidae					
Neureclipsis McLachlan	+	-	-	+	-
Polycentropus Curtis	+	-	-	+	-
Phryganeidae					
Ptilostomis Kolenati	-	-	-	+	-
Odontoceridae					
Psilotreta Banks	-	-	-	-	+
DIPTERA					
Tipulidae					

* + taxa present
  \- taxa absent

Table 3. (continued).

Organisms	Cedar Run 16	Cedar Run 17	Cedar Run 18	Toms Creek 21	Toms Creek 22
Antocha Osten Sacken	-	-	-	+	+*
Pilaria Sintenis	+	-	-	-	-
Limonia Meigen	-	-	+	-	-
Hexatoma Latreille	-	-	+	-	-
Tipula Linnaeus	+	+	-	+	+
Tabanidae					
Chrysops Meigen	-	-	-	+	-
Psychodidae					
Pericoma Walker	-	-	+	-	-
Psychoda Latreille	+	+	+	-	+
Tendipedidae	+	+	+	+	+
Simulidae					
Simulium Latreille	+	+	+	+	+
Dolichopodidae	+	-	-	-	+
Empididae					
Hemerodromia Meigen	-	-	-	+	-
Rhagionidae	-	-	-	-	+
ANNELIDA					
Oligochaeta	+	+	+	+	+
AMPHIPODA					
Gammaridae					
Gammarus minus Say	+	-	-	-	-
CHORDATA					
Urodela					
Desmognathus fuscus fuscus Rafinesque	+	-	+	-	-
DECAPODA					
Cambaridae	+	-	+	+	+
ISOPODA					
Asellidae					
Asellus racovitzai Williams	+	+	-	-	-

* + taxa present
  - taxa absent

Table 3. (continued).

Organisms	Station Number				
	Cedar Run			Toms Creek	
	16	17	18	21	22
MOLLUSCA					
Planorbidae					
Helisoma Swainson	-	-	+	+	+*
Physidae					
Physa Draparnaud	+	+	+	-	+
Pleuroceridae					
Goniabasis Lea	-	-	-	+	+
Sphaeriidae					
Sphaerium Scopoli	+	-	-	-	-
PLATYHELMENTHES					
Planariidae					
Dugesia Girard	+	-	+	+	+

* + taxa present
 - taxa absent

APPENDIX B

Table 1. Weekly measurement of pH for Stroubles Creek, Cedar Run and Toms Creek from August 1971 through August 1972.

Station number	1971												
	Aug.				Sept.				Oct.				
	2	10	17	25	31	7	17	21	28	5	12	19	26
1	*	-	-	7.5	-	-	7.5	-	-	7.5	-	-	7.0
3	-	-	-	8.0	-	-	8.0	-	-	8.0	-	-	7.0
5	-	-	-	7.5	-	-	7.5	-	-	7.5	-	-	7.5
6	-	-	-	8.0	-	-	7.8	-	-	8.0	-	-	7.5
7	7.8	8.0	7.8	8.0	6.8	8.0	7.5	7.0	7.5	6.0	7.5	8.0	7.5
8	8.0	7.8	8.0	8.0	8.0	8.0	8.0	7.0	9.3	7.5	8.0	8.0	6.8
9	-	-	-	8.0	-	-	7.5	-	-	7.8	-	-	7.5
10	7.8	8.0	8.0	8.0	7.5	8.0	7.5	7.5	6.5	7.5	6.5	8.0	7.5
11	8.5	8.0	7.8	8.0	7.5	8.0	8.0	7.5	8.0	8.0	7.5	8.0	7.5
12	7.5	7.3	7.5	7.5	7.5	7.0	7.5	7.0	6.5	7.0	7.5	7.5	7.5
14	8.0	-	-	-	-	-	8.0	-	-	7.5	-	-	8.0
16	8.0	8.0	6.0	8.0	8.0	7.8	7.5	7.8	8.0	7.8	8.0	8.0	7.5
17	7.5	7.8	8.0	7.5	7.5	7.5	7.5	7.5	6.0	7.0	7.5	7.5	7.5
18	-	-	-	8.0	-	-	8.0	-	-	8.0	-	-	8.0
21	-	-	-	-	-	-	-	-	-	-	-	-	7.8
22	-	-	-	8.0	-	-	8.0	-	-	8.0	-	-	7.5

* no data collected

Table 1. (continued)

Station number	1971						1972			
	Nov.					Dec.	Jan.			
	2	9	16	23	30	7	4	11	18	25
1	—*	-	7.5	-	-	7.5	7.5	-	-	7.5
3	-	-	8.0	-	-	8.0	7.5	-	-	8.0
5	7.5	7.5	8.0	7.5	-	7.5	7.5	-	-	8.0
6	7.5	-	8.0	-	-	8.0	7.5	-	-	8.0
7	-	-	8.0	7.5	8.0	7.8	7.5	7.7	-	8.0
8	-	-	8.0	-	-	7.5	8.0	-	-	8.0
9	-	-	7.5	8.0	-	7.8	8.0	-	-	8.0
10	-	-	8.0	8.0	-	8.0	7.5	-	-	8.0
11	8.0	8.0	8.0	8.0	7.5	8.0	8.0	8.0	8.0	8.0
12	7.5	7.5	7.5	7.5	7.5	7.3	7.3	7.3	7.5	7.5
14	8.0	7.5	8.0	-	7.3	8.0	7.3	8.0	8.0	8.0
16	8.0	8.0	8.0	8.0	8.0	8.0	7.5	8.0	8.0	8.0
17	7.5	7.8	7.5	7.5	7.5	7.0	7.0	7.5	8.0	7.5
18	-	8.0	8.0	-	8.0	8.0	8.0	8.0	8.0	8.0
21	-	-	-	-	-	7.5	7.5	-	-	8.0
22	-	-	-	-	-	8.0	7.8	-	-	8.0

* no data collected

Table 1. (continued)

Station number	1972 Feb. 1	15	22	29	Mar. 7	13	20	27	Apr. 3	10	17	24
1	—*	7.0	–	–	7.0	–	–	7.5	–	–	7.3	–
3	–	8.0	–	–	8.0	–	–	8.0	–	–	7.5	–
5	–	8.0	–	–	7.5	–	–	7.8	–	–	7.8	–
6	–	8.0	–	–	6.8	–	–	8.0	–	–	8.0	–
7	–	8.0	–	–	8.0	–	–	8.0	–	–	8.0	–
8	–	8.0	–	–	7.8	–	–	8.0	–	–	–	–
9	–	8.0	–	–	8.0	–	–	8.0	–	–	8.0	–
10	–	8.0	–	–	8.0	–	–	8.0	–	–	8.0	–
11	8.0	8.0	8.0	8.0	8.0	8.0	7.8	8.0	8.0	8.0	8.0	8.0
12	7.5	7.5	7.5	8.0	7.5	7.5	7.8	7.5	7.5	7.5	7.5	7.5
14	8.0	7.8	8.0	7.8	8.0	7.8	8.0	8.0	8.0	8.0	8.0	7.5
16	8.0	8.0	8.0	8.0	8.0	8.0	7.8	8.0	8.0	8.0	8.0	8.0
17	7.5	8.0	8.0	8.0	8.0	7.5	7.8	7.8	7.5	7.8	8.0	7.3
18	8.0	8.0	8.0	8.0	8.0	8.0	7.8	8.0	8.0	7.8	8.0	8.0
21	–	8.0	–	–	7.5	–	–	8.0	–	–	7.5	–
22	–	7.5	–	–	8.0	–	–	7.8	–	–	8.0	–

* no data collected

Table 1. (continued)

Station number	1972											
			May				Jun.				Jul.	
	1	8	15	22	29	7	14	30	6	14	20	28
1	7.0	__*	-	7.5	-	-	7.3	-	7.0	-	-	7.3
3	8.0	-	-	8.0	-	-	8.0	-	7.8	-	-	8.0
5	7.5	-	-	7.3	-	-	7.8	-	7.5	-	-	7.5
6	7.8	-	-	8.0	-	-	7.5	-	8.0	-	-	8.0
7	7.8	-	-	8.0	-	-	8.0	-	8.0	-	-	8.0
8	-	-	-	-	-	-	-	-	8.0	-	-	7.8
9	8.0	-	-	8.0	-	-	9.5	-	7.5	-	-	7.5
10	8.0	-	-	7.8	-	-	8.0	-	8.0	-	-	8.0
11	8.0	8.0	7.0	8.0	7.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0
12	7.0	7.5	7.0	7.5	7.3	7.0	7.5	7.5	7.5	7.8	7.3	8.0
14	8.0	8.0	7.8	7.8	8.0	7.0	8.0	8.0	8.0	8.0	8.0	8.0
16	7.8	8.0	8.0	8.0	7.5	8.0	7.8	8.0	8.0	8.0	8.0	7.5
17	7.5	7.5	7.5	7.8	7.3	8.0	8.0	8.0	8.0	8.0	8.0	8.0
18	8.0	8.0	8.0	7.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
21	8.0	-	-	8.0	-	-	8.0	-	7.8	-	-	8.0
22	7.8	-	-	8.0	-	-	8.0	-	8.0	-	-	8.0

* no data collected

Table 1. (continued)

	1972			
	Aug.			
Station number	4	11	18	25
1	–*	–	7.0	–
3	–	–	8.0	–
5	–	–	7.5	–
6	–	–	8.0	–
7	–	–	8.0	–
8	–	–	8.0	–
9	–	–	7.5	–
10	–	–	7.0	–
11	8.0	8.0	8.0	8.0
12	7.5	7.5	7.3	7.5
14	8.0	8.0	8.0	8.0
16	8.0	8.0	8.0	8.0
17	8.0	7.5	8.0	8.0
18	8.0	8.0	8.0	7.5
21	–	–	8.0	–
22	–	–	8.0	–

* no data collected

Table 2. Weekly measurements of dissolved oxygen (ppm) for Stroubles Creek, Cedar Run and Toms Creek from August 1971 through August 1972.

Station number	1971												
			Aug.					Sept.				Oct.	
	2	10	17	25	31	7	17	21	28	5	12	19	26
1	—*	-	-	9.0	-	-	8.0	-	-	8.0	-	-	8.0
3	-	-	-	9.0	-	-	8.5	-	-	9.0	-	-	8.0
5	-	-	-	7.0	-	-	8.0	-	-	7.5	-	-	8.0
6	-	-	-	5.0	-	-	8.0	-	-	8.0	-	-	8.5
7	5.0	5.0	8.3	8.0	8.5	7.5	8.0	8.0	7.5	7.5	8.5	9.0	8.5
8	5.0	4.0	8.1	7.5	8.5	7.3	11.0	8.5	7.5	7.0	8.5	8.0	8.5
9	-	-	-	7.5	-	-	7.0	-	-	8.5	-	-	9.0
10	5.0	5.0	8.5	10.5	8.5	8.5	7.3	7.0	9.3	7.5	9.8	9.5	8.0
11	9.0	5.0	8.3	8.3	-	9.0	7.5	7.5	8.5	8.0	9.0	8.5	8.0
12	8.0	5.0	7.0	7.0	-	6.3	5.5	5.5	5.4	5.0	7.3	7.5	6.3
14	-	-	-	-	-	-	6.5	-	-	6.0	-	-	13.0
16	5.0	5.0	8.5	3.0	9.0	7.5	7.5	8.0	7.0	7.5	8.3	8.5	8.5
17	4.0	5.0	8.0	5.0	8.5	8.3	7.5	7.5	7.5	7.5	8.5	9.0	8.0
18	-	-	-	6.0	-	-	8.5	-	-	12.0	-	-	8.5
21	-	-	-	-	-	-	-	-	-	-	-	-	7.5
22	-	-	-	7.0	-	-	7.3	-	-	7.5	-	-	8.5

* no data collected

Table 2. (continued)

Station number	1971						1972						
	Nov.					Dec.	Jan.				Feb.		
	2	9	16	23	30	7	4	11	18	25	1	15	22
1	*	-	8.5	-	-	10.8	9.2	-	-	8.8	-	8.4	-
3	-	-	9.0	-	-	-	11.6	-	-	10.6	-	10.8	-
5	-	9.0	7.5	10.5	-	6.8	8.4	-	-	9.6	-	9.0	-
6	-	-	9.5	-	-	11.2	10.0	-	-	10.2	-	10.4	-
7	7.0	-	8.5	10.5	10.0	8.8	9.2	10.4	-	9.4	-	9.8	-
8	8.0	-	8.5	-	-	6.4	9.2	-	-	6.8	-	9.8	-
9	-	-	8.3	10.5	-	9.6	10.8	-	-	9.4	-	10.8	-
10	-	-	9.5	14.0	-	10.4	9.8	-	-	11.8	-	12.8	-
11	9.0	14.0	13.5	12.0	11.0	11.2	11.0	12.5	14.8	11.8	12.8	-	12.4
12	6.0	10.5	8.5	7.8	9.0	7.2	8.0	8.2	8.0	8.6	7.6	8.8	8.8
14	6.5	9.0	7.5	-	11.0	8.8	8.8	9.8	12.2	10.0	11.4	10.6	11.0
16	8.5	10.5	9.0	11.5	11.0	10.8	10.8	10.6	12.0	10.4	4.0	10.2	10.8
17	7.5	10.5	8.5	11.0	11.0	7.6	10.6	9.9	10.8	9.8	10.2	9.8	10.8
18	-	9.0	8.0	-	12.0	10.0	9.8	10.4	12.4	10.4	10.4	10.2	10.4
21	-	-	-	-	-	10.8	11.6	-	-	10.0	-	11.8	-
22	-	-	-	-	-	10.6	10.2	-	-	11.0	-	12.8	-

* no data collected

Table 2. (continued)

Station number	1972											
	Mar.				Apr.			May				
	7	13	20	27	3	10	17	1	8	15	22	29
1	8.4	*	-	9.2	-	-	8.4	9.2	-	-	8.6	-
3	9.6	-	-	12.0	-	-	9.2	10.4	-	-	8.4	-
5	10.0	-	-	13.2	-	-	10.0	9.4	-	-	9.2	-
6	10.6	-	-	10.6	-	-	9.2	10.4	-	-	9.0	-
7	9.8	-	-	8.8	-	-	9.6	9.2	-	-	8.2	-
8	9.2	-	-	9.6	-	-	-	-	-	-	-	-
9	12.2	-	-	13.0	-	-	9.2	9.6	-	-	8.2	-
10	15.2	-	-	14.2	-	-	11.2	12.6	-	-	8.4	-
11	13.0	14.2	14.0	13.2	15.2	11.4	10.0	9.4	9.6	8.0	9.2	10.8
12	9.4	9.8	11.0	10.0	12.4	8.0	8.0	7.0	8.4	7.6	7.8	8.6
14	11.6	10.0	12.0	10.8	11.2	10.6	8.4	10.4	9.6	8.4	8.6	7.6
16	11.0	10.2	12.0	11.2	11.6	10.2	9.6	9.0	9.6	9.0	8.8	9.4
17	10.0	9.0	9.4	10.0	10.0	10.0	9.2	11.2	8.8	8.4	8.4	8.6
18	11.0	10.6	11.8	8.6	12.0	10.2	9.6	-	10.0	9.4	9.2	8.8
21	12.0	-	-	11.8	-	-	9.2	9.8	-	-	9.2	-
22	12.0	-	-	11.6	-	-	10.4	10.2	-	-	9.0	-

* no data collected

Table 2. (continued)

Station number	1972 Jun. 7	Jun. 14	Jun. 30	Jul. 6	Jul. 14	Jul. 20	Jul. 28	Aug. 4	Aug. 11	Aug. 18	Aug. 25
1	*	8.4	-	8.0	-	-	8.0	-	-	8.4	-
3	-	9.2	-	8.8	-	-	9.0	-	-	8.4	-
5	-	8.6	-	9.8	-	-	8.2	-	-	8.4	-
6	-	8.2	-	6.8	-	-	8.2	-	-	8.0	-
7	-	7.6	-	8.0	-	-	8.0	-	-	7.8	-
8	-	-	-	7.8	-	-	8.4	-	-	8.0	-
9	-	6.4	-	7.4	-	-	6.2	-	-	6.8	-
10	-	10.0	-	8.0	-	-	8.2	-	-	7.2	-
11	8.8	8.4	9.6	9.0	7.6	9.0	7.6	8.0	9.6	8.4	10.2
12	7.8	8.0	8.0	8.0	-	8.2	6.6	7.0	9.0	8.0	8.8
14	7.8	8.6	8.2	9.4	9.2	8.0	7.6	8.4	9.0	8.2	8.2
16	8.6	8.2	8.8	9.4	8.0	8.8	7.6	8.6	9.6	9.0	7.8
17	7.2	7.6	8.4	8.8	6.8	8.0	7.2	7.2	8.2	8.0	7.4
18	8.6	8.0	8.4	9.6	8.0	8.6	7.0	8.4	9.0	8.2	7.8
21	-	8.6	-	9.6	-	-	8.0	-	-	8.6	-
22	-	8.6	-	9.6	-	-	7.6	-	-	8.6	-

* no data collected

Table 3. Weekly measurements of dissolved oxygen (percent saturation) for Stroubles Creek, Cedar Run and Toms Creek from August 1971 through August 1972.

Station number	1971												
	Aug.				Sept.				Oct.				
	2	10	17	25	31	7	17	21	28	5	12	19	26
1	—*	-	-	91	-	-	87	-	-	81	-	-	81
3	-	-	-	99	-	-	99	-	-	102	-	-	84
5	-	-	-	74	-	-	84	-	-	79	-	-	83
6	-	-	-	54	-	-	87	-	-	88	-	-	96
7	61	63	97	96	99	88	93	91	93	92	94	98	93
8	58	45	94	85	99	85	128	96	87	84	93	87	90
9	-	-	-	95	-	-	82	-	-	102	-	-	98
10	63	67	104	145	99	105	85	82	119	90	107	103	88
11	105	61	96	111	-	105	95	85	99	96	91	85	88
12	101	62	86	92	-	77	71	67	71	64	83	83	73
14	-	-	-	-	-	-	80	-	-	70	-	-	142
16	60	57	96	33	95	85	85	88	81	87	90	88	88
17	50	58	93	62	104	109	96	92	95	92	99	104	87
18	-	-	-	70	-	-	99	-	-	132	-	-	90
21	-	-	-	-	-	-	-	-	-	-	-	-	82
22	-	-	-	84	-	-	87	-	-	88	-	-	90

* no data collected

Table 3. (continued)

Station number	1971						1972									
	Nov.					Dec.	Jan.			Feb.			Mar.			
	2	9	16	23	30	7	4	11	25	1	15	22	7	13	20	27
1	*	-	86	-	-	112	87	-	84	-	82	-	85	-	-	92
3	-	-	95	-	-	-	99	-	91	-	98	-	98	-	-	112
5	-	90	77	100	-	70	78	-	89	-	86	-	101	-	-	126
6	-	-	98	-	-	116	86	-	90	-	97	-	107	-	-	101
7	-	-	93	106	93	91	89	-	90	-	93	-	99	-	-	89
8	-	-	90	-	-	65	95	-	62	-	93	-	89	-	-	91
9	-	-	86	86	-	89	86	-	85	-	91	-	110	-	-	132
10	-	-	100	118	-	99	87	-	104	-	110	-	150	-	-	128
11	99	127	149	98	93	107	99	119	109	119	-	104	120	141	130	117
12	70	108	99	78	77	74	78	85	82	72	84	80	91	100	112	95
14	72	77	79	-	95	84	80	93	86	96	94	95	99	90	114	95
16	96	98	91	104	97	103	93	99	94	35	92	95	99	105	122	101
17	88	105	93	105	97	74	91	96	91	92	87	95	90	93	96	97
18	-	81	81	-	109	95	87	99	92	92	95	92	95	110	115	80
21	-	-	-	-	-	100	99	-	86	-	96	-	103	-	-	99
22	-	-	-	-	-	99	88	-	95	-	102	-	103	-	-	98

* no data collected

Table 3. (continued)

Station number	1972														
	Apr.			May					Jun.			Jul.			
	3	10	17	1	8	15	22	29	7	14	30	6	14	20	28
1	*	–	85	93	–	–	91	–	–	89	–	88	–	–	83
3	–	–	93	107	–	–	97	–	–	107	–	93	–	–	104
5	–	–	102	97	–	–	102	–	–	95	–	103	–	–	87
6	–	–	95	107	–	–	99	–	–	91	–	74	–	–	89
7	–	–	96	102	–	–	91	–	–	91	–	91	–	–	96
8	–	–	–	–	–	–	–	–	–	–	–	85	–	–	95
9	–	–	95	109	–	–	96	–	–	79	–	84	–	–	76
10	–	–	118	146	–	–	98	–	–	132	–	93	–	–	100
11	148	111	120	102	101	84	102	119	100	104	106	99	89	114	91
12	128	81	93	77	93	84	88	100	88	98	91	91	–	104	82
14	104	96	93	113	101	89	95	84	85	100	91	94	107	99	91
16	110	97	101	95	99	93	93	102	100	100	93	99	93	103	91
17	100	100	100	124	97	89	95	94	88	97	97	102	84	101	89
18	114	97	99	118	103	97	97	91	100	99	92	101	93	100	84
21	–	–	92	100	–	–	97	–	–	–	–	99	–	–	93
22	–	–	101	104	–	–	95	–	–	–	–	101	–	–	91

* no data collected

Table 3. (continued)

Station number	1972 Aug. 4	11	18	25
1	—*	–	87	–
3	–	–	108	–
5	–	–	98	–
6	–	–	93	–
7	–	–	97	–
8	–	–	93	–
9	–	–	87	–
10	–	–	95	–
11	98	109	103	122
12	87	104	99	108
14	103	102	98	96
16	100	106	104	93
17	91	98	99	94
18	103	102	98	96
21	–	–	103	–
22	–	–	103	–

* no data collected

Table 4. Weekly measurements of chlorine (ppm) for Stroubles Creek, Cedar Run and Toms Creek from August 1971 through August 1972.

Station number	1971														
	Aug.					Sept.				Oct.				Nov.	
	2	10	17	25	31	7	17	21	28	5	12	19	26	2	9
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	1.0	0.9	1.0	1.0+	0.9	1.0	0.4	0.8	0.0	0.0	0.3	0.8	0.4	0.1	0.3
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-*	-	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.3	0.3	0.2	0.2	0.0	0.1	0.2	0.2	0.4	0.7	0.3	0.2	0.2	0.4	0.8
18	-	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	0.0

Station number	1971				1972										
	Nov.			Dec.	Jan.				Feb.				Mar.		
	16	23	30	7	4	11	18	25	1	15	22	29	7	13	20
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.8	1.0	1.0	1.0	1.0	1.5	1.3	1.0	1.2	1.0	0.4	1.3	1.3	1.8	0.4
14	P+	-	0.0	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.4
16	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.9	1.0+	1.0	1.0+	0.1	1.8	0.9	1.2	1.0	0.6	0.9	0.8	1.2	1.3	1.4
18	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

* no data collected
+ present in minute quantity

Table 4. (continued)

Station number	1972 Mar. 27	3	Apr. 10	17	24	May 1	8	15	22	29	Jun. 7	14	30	Jul. 6	14
11	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	1.8	1.5	1.5	1.4	1.5	1.3	1.7	1.7	2.4	2.7	3.0	2.4	2.0	2.6	0.4
14	0.3	0.5	0.3	0.4	0.4	0.5	0.3	0.0	0.3	0.5	0.4	0.4	0.0	0.3	0.5
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.3	1.4	1.0	0.8	1.0	0.8	2.0	1.8	0.7	1.7	0.3	0.3	1.3	1.3	0.6
18	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.3	0.3	0.4	0.3	0.4	0.3

Station number	1972 Jul. 20	28	Aug. 4	11	18	25
11	0.0	0.0	0.0	0.0	0.0	0.0
12	2.4	0.3	0.0	2.6	2.3	2.8
14	0.0	P+	0.0	0.4	0.3	0.6
16	0.0	0.0	0.0	0.0	0.0	0.0
17	1.1	0.3	P	1.0	1.1	0.6
18	0.3	0.3	0.4	0.2	0.3	0.3

+ present in minute quantity

Table 5. Weekly measurements of temperature (C°) for Stroubles Creek, Cedar Run and Toms Creek from August 1971 through August 1972.

Station number	1971 Aug. 2	10	17	25	31	Sept. 7	17	21	28	Oct. 5	12	19	26
1	*	–	–	13	–	–	16	–	–	13	–	–	13
3	–	–	–	17	–	–	19	–	–	18	–	–	15
5	–	–	–	15	–	–	15	–	–	15	–	–	14
6	–	–	–	16	–	–	16	–	–	17	–	–	18
7	22	24	20	21	20	20	20	18	23	22	17	16	16
8	19	18	19	18	19	19	19	18	19	21	16	16	15
9	–	–	–	24	–	–	20	–	–	21	–	–	16
10	24	27	22	29	20	23	19	20	25	21	16	16	17
11	20	22	19	27	21	20	24	18	19	21	13	12	17
12	24	23	22	26	23	22	25	22	26	25	18	17	19
14	–	–	–	–	–	–	22	–	–	20	–	–	16
16	21	18	18	17	15	18	18	17	19	17	16	14	14
17	23	19	20	22	22	26	25	22	24	22	20	19	16
18	–	–	–	19	–	–	20	–	–	17	–	–	15
21	–	–	–	–	–	–	–	–	–	–	–	–	16
22	–	–	–	21	–	–	21	–	–	20	–	–	15

Station number	1972 Nov. 2	9	16	23	30	Dec. 7	4	11	Jan. 18	25	1	Feb. 15	22
1	–	–	13	–	–	14	10	–	–	10	–	11	–
3	–	–	15	–	–	13	6	–	–	6	–	8	–
5	15	12	14	10	–	14	9	–	–	9	–	10	–
6	16	–	14	–	–	14	6	–	–	7	–	9	–
7	–	–	16	13	9	14	11	13	–	10	–	10	–
8	–	–	15	–	–	13	–	–	–	8	–	10	–
9	–	–	14	4	–	9	7	–	–	8	–	5	–
10	–	–	15	5	–	10	7	–	–	7	–	6	–
11	17	8	17	4	5	10	8	10	–	9	6	7	5
12	20	14	20	12	6	14	11	14	–	10	10	10	8
14	17	6	15	–	6	10	8	10	–	6	5	7	6
16	18	9	13	8	7	10	6	9	–	8	7	8	7
17	20	12	16	10	7	11	6	11	–	9	8	8	7
18	–	8	13	–	8	10	7	10	–	7	7	9	7
21	–	–	–	–	–	9	6	–	–	6	–	4	–
22	–	–	–	–	–	9	6	–	–	6	–	3	–

* no data collected

Table 5. (continued)

Station number	1972 Feb. 29	Mar. 7	13	20	27	Apr. 3	10	17	24	May 1	8	15	22
1	*	13	–	–	12	–	–	13	–	13	–	–	15
3	–	13	–	–	9	–	–	15	–	14	–	–	19
5	–	13	–	–	10	–	–	13	–	14	–	–	17
6	–	13	–	–	10	–	–	14	–	14	–	–	17
7	–	13	–	–	13	–	–	12	–	17	–	–	17
8	–	11	–	–	10	–	–	–	–	–	–	–	–
9	–	8	–	–	13	–	–	14	–	18	–	–	20
10	–	11	–	–	8	–	–	15	–	19	–	–	20
11	17	9	12	9	7	11	11	21	14	16	15	15	17
12	17	11	13	10	10	14	13	20	16	17	17	17	18
14	15	6	10	8	7	9	8	17	12	16	15	15	17
16	15	8	14	13	8	10	10	15	13	15	14	14	15
17	16	8	14	13	11	12	12	16	14	17	17	15	18
18	15	6	14	11	9	10	10	14	12	15	14	14	15
21	–	6	–	–	5	–	–	12	–	13	–	–	15
22	–	6	–	–	5	–	–	11	–	13	–	–	15

Station number	1972 May 29	Jun. 7	14	30	Jul. 6	14	20	28	Aug. 4	11	18	25
1	–	–	15	–	17	–	–	14	–	–	14	–
3	–	–	19	–	15	–	–	19	–	–	25	–
5	–	–	17	–	15	–	–	15	–	–	20	–
6	–	–	17	–	16	–	–	16	–	–	20	–
7	–	–	21	–	18	–	–	21	–	–	23	–
8	–	–	–	–	16	–	–	18	–	–	19	–
9	–	–	23	–	18	–	–	22	–	–	25	–
10	–	–	26	–	20	–	–	22	–	–	26	–
11	17	18	23	17	17	20	24	21	22	18	22	21
12	19	18	22	18	18	21	24	23	23	19	23	22
14	17	16	20	17	12	20	23	21	22	18	21	20
16	16	19	22	15	15	19	20	21	20	17	19	21
17	16	22	25	19	19	23	24	23	24	21	23	24
18	14	19	23	16	15	20	20	21	22	18	21	22
21	–	–	21	–	14	–	–	20	–	–	21	–
22	–	–	20	–	15	–	–	21	–	–	21	–

* no data collected

Table 6. Weekly measurements of chemical oxygen demand (ppm) for Stroubles Creek, Cedar Run and Toms Creek from August 1971 through August 1972.

Station	1971												
			Aug.					Sept.			Oct.		
number	2	10	17	25	31	7	17	21	28	5	12	19	26
1	*		-	4.0	-	-	3.8	-	-	8.9	-	-	6.9
3	-	-	-	14.0	-	-	7.6	-	-	22.6	-	-	20.9
5	-	-	-	0.0	-	-	3.8	-	-	14.1	-	-	3.5
6	-	-	-	0.0	-	-	7.6	-	-	5.7	-	-	8.7
7	12.7	3.9	9.9	4.0	11.0	38.7	15.1	17.6	4.2	72.0	9.5	3.1	10.4
8	38.1	19.5	13.8	16.0	9.0	16.1	15.1	41.2	18.2	42.4	6.3	23.1	5.2
9	-	-	-	8.0	-	-	30.2	-	-	16.9	-	-	7.0
10	25.4	15.6	13.8	1.0	18.0	19.4	22.6	14.7	12.6	16.9	12.7	10.8	7.0
11	25.4	15.6	3.9	16.0	14.0	9.7	15.1	22.1	15.4	16.9	11.1	7.7	10.4
12	84.6	35.2	7.8	11.6	66.0	106.4	60.4	61.8	121.7	93.3	99.6	72.4	60.8
14	-	-	-	-	38.0	-	22.6	-	-	33.9	-	-	17.4
16	33.8	7.8	23.7	0.0	32.0	12.9	15.1	20.6	26.9	8.5	7.9	3.1	3.5
17	42.3	27.3	35.5	16.0	45.0	25.8	22.6	14.7	1.4	31.1	23.7	20.0	24.3
18	-	-	-	0.0	-	-	22.6	-	-	14.1	-	-	10.4
21	-	-	-	-	-	-	-	-	-	-	-	-	10.7
22	-	-	-	0.0	-	-	22.6	-	-	14.1	-	-	8.7

* no data collected

Table 6. (continued)

Station number	1971						1972			
	Nov. 2	9	16	23	30	Dec. 7	Jan. 4	11	18	25
1	*	-	1.7	-	-	11.9	7.8	-	-	3.8
3	-	-	1.7	-	-	13.6	17.5	-	-	7.6
5	23.9	8.6	6.9	11.8	-	15.3	13.6	-	-	5.6
6	20.5	-	6.9	-	-	13.6	21.4	-	-	11.3
7	-	-	6.9	8.4	11.8	32.2	21.4	3.8	-	22.6
8	-	-	17.2	-	-	16.9	5.8	-	-	37.7
9	-	-	6.9	21.9	-	25.4	17.5	-	-	16.9
10	-	-	6.9	21.9	-	25.4	17.5	-	-	11.3
11	13.7	3.5	12.1	33.8	69.2	23.7	11.7	7.6	9.0	7.6
12	56.7	86.4	87.9	82.7	11.8	59.3	60.2	67.0	77.8	56.6
14	22.2	29.4	10.3	-	15.2	35.6	33.0	38.2	14.5	22.6
16	8.6	3.5	3.5	11.8	11.8	25.4	21.4	7.7	1.8	7.6
17	13.4	24.2	20.7	32.1	18.6	42.4	25.2	42.1	30.8	11.3
18	-	10.4	6.9	-	15.2	22.0	33.0	15.3	1.8	11.3
21	-	-	-	-	-	15.3	9.7	-	-	15.1
22	-	-	-	-	-	17.0	9.7	-	-	3.8

* no data collected

Table 6. (continued)

Station number	1972 Feb. 1	15	22	29	Mar. 7	13	20	27	Apr. 3	10	17	24
1	—*	3.8	-	-	9.8	-	-	3.7	-	-	2.0	-
3	-	11.3	-	-	15.7	-	-	3.7	-	-	3.9	-
5	-	3.8	-	-	7.8	-	-	3.7	-	-	3.9	-
6	-	3.8	-	-	7.8	-	-	3.7	-	-	3.9	-
7	-	9.4	-	-	7.8	-	-	3.7	-	-	2.0	-
8	-	7.6	-	-	31.4	-	-	47.7	-	-	-	-
9	-	3.8	-	-	43.1	-	-	7.3	-	-	3.9	-
10	-	7.6	-	-	11.8	-	-	7.3	-	-	15.5	-
11	3.8	11.3	16.0	54.0	3.9	38.2	7.5	7.3	14.7	8.0	3.9	7.9
12	60.1	64.2	28.0	149.0	47.1	99.4	22.4	36.7	36.7	36.0	85.4	43.4
14	15.0	11.3	24.0	113.0	18.6	76.5	14.9	18.3	14.7	12.0	11.7	5.9
16	11.3	3.8	16.0	101.0	11.8	49.7	7.5	3.7	3.7	4.0	7.7	5.9
17	18.8	18.9	28.0	62.0	11.8	53.5	22.4	16.5	18.4	20.0	3.9	29.6
18	7.5	5.7	16.0	86.0	11.8	72.6	14.9	3.7	3.7	12.0	11.7	39.4
21	-	3.8	-	-	11.8	-	-	1.8	-	-	3.9	-
22	-	7.6	-	-	7.8	-	-	7.3	-	-	3.9	-

* no data collected

Table 6. (continued)

Station number	1972										
	May					Jun.			Jul.		
	1	8	15	22	29	14	30	6	14	20	28
1	5.8	—*	-	5.6	-	-	-	3.7	-	-	2.8
3	5.8	-	-	5.6	-	-	-	3.7	-	-	4.0
5	1.9	-	-	5.6	-	-	-	5.5	-	-	3.7
6	1.9	-	-	3.7	-	-	-	7.3	-	-	3.0
7	3.8	-	-	5.6	-	76.3	-	7.3	-	-	5.2
8	-	-	-	-	-	-	-	14.7	-	-	24.0
9	9.6	-	-	12.9	-	-	-	29.6	-	-	21.0
10	5.8	-	-	9.3	-	-	-	11.0	-	-	18.3
11	5.8	3.7	24.5	9.3	5.4	25.4	11.3	18.3	5.5	22.0	15.0
12	32.7	29.7	47.2	29.6	47.1	76.3	24.4	47.7	32.7	43.0	76.5
14	13.5	11.1	39.6	16.9	12.7	12.7	18.8	11.0	20.0	3.0	12.0
16	3.8	3.7	-	7.3	5.4	12.7	11.3	11.0	7.3	10.0	9.2
17	11.5	11.1	-	18.5	38.0	-	16.9	11.0	29.1	10.0	10.5
18	9.6	1.8	-	5.6	5.4	12.7	1.9	5.5	14.5	10.0	7.4
21	9.6	-	-	14.8	-	-	-	7.3	-	-	5.7
22	11.5	-	-	5.6	-	-	-	7.3	-	-	5.7

* no data collected

Table 6. (continued)

Station number	1972 Aug. 4	11	18	25
1	__*	-	2.0	-
3	-	-	5.3	-
5	-	-	4.0	-
6	-	-	3.5	-
7	-	-	4.5	-
8	-	-	21.0	-
9	-	-	5.8	-
10	-	-	4.0	-
11	8.0	10.0	4.0	3.2
12	32.0	41.0	51.5	8.0
14	11.7	15.0	22.0	4.5
16	11.5	8.7	3.0	2.5
17	8.0	10.0	5.0	2.5
18	7.0	10.0	7.2	2.0
21	-	-	4.0	-
22	-	-	3.0	-

* no data collected

Table 7. Weekly measurements of biochemical oxygen demand (ppm) for Stroubles Creek, Cedar Run and Toms Creek from August 1971 through August 1972.

Station number	1971 Aug. 2	Aug. 10	Aug. 17	Aug. 25	Aug. 31	Sept. 7	Sept. 17	Sept. 21	Sept. 28	Oct. 5	Oct. 12	Oct. 19	Oct. 26
1	—*	-	-	0.6	-	-	2.9	-	-	2.3	-	-	1.8
3	-	-	-	1.4	-	-	1.6	-	-	0.8	-	-	2.2
5	-	-	-	1.9	-	-	1.8	-	-	0.0	-	-	2.0
6	-	-	-	1.7	-	-	1.4	-	-	0.5	-	-	1.9
7	3.0	2.9	3.4	2.9	4.7	5.8	4.6	6.6	1.4	5.9	0.5	1.6	2.0
8	18.5	15.7	6.2	7.4	1.6	4.6	1.6	17.0	14.8	9.3	2.9	3.8	1.8
9	-	-	-	3.8	-	-	2.8	-	-	4.3	-	-	2.2
10	3.8	5.3	4.8	4.1	5.6	4.2	2.7	7.0	4.7	10.9	2.5	2.3	2.5
11	3.6	6.1	4.0	5.5	12.8	3.8	4.6	8.5	4.6	3.3	1.0	2.0	2.4
12	6.7	0.5	5.5	2.8	5.7	6.9	19.7	9.3	20.2	16.0	18.3	7.1	4.5
14	-	-	-	-	-	-	11.7	-	-	12.7	-	-	2.7
16	2.2	6.8	3.5	1.5	5.6	4.2	2.2	4.9	1.0	3.2	1.5	1.3	2.3
17	2.8	6.7	7.0	4.8	8.0	8.3	7.0	11.9	4.3	4.0	2.6	2.6	2.4
18	-	-	-	0.7	-	-	1.9	-	-	1.9	-	-	2.5
21	-	-	-	-	-	-	-	-	-	15.0	-	-	2.5
22	-	-	-	1.2	-	-	0.7	-	-	0.5	-	-	2.2

* no data collected

Table 7. (continued)

Station number	1971						1972			
			Nov.			Dec.		Jan.		
	2	9	16	23	30	7	4	11	18	25
1	—*	-	0.5	-	-	0.5	0.6	-	-	0.6
3	-	-	0.5	-	-	0.5	2.7	-	-	1.0
5	0.9	1.0	0.4	0.5	-	1.8	1.2	-	-	1.4
6	3.4	-	0.7	-	-	1.5	3.1	-	-	1.6
7	-	-	2.0	0.4	0.5	2.8	6.8	1.2	-	2.2
8	-	-	6.6	-	-	7.2	2.9	-	-	19.2
9	-	-	2.6	3.5	-	3.5	3.1	-	-	2.6
10	-	-	2.3	3.0	-	4.0	4.2	-	-	2.3
11	1.7	1.5	2.5	5.2	7.1	4.6	2.0	1.6	3.0	1.1
12	15.0	18.0	16.0	15.8	0.6	18.0	10.0	16.6	18.0	11.9
14	7.9	10.1	8.5	-	6.3	8.2	6.8	10.3	7.6	9.7
16	1.5	1.5	2.0	1.0	0.4	2.2	2.5	0.1	2.2	0.6
17	1.5	1.0	1.6	0.4	0.0	7.0	1.5	2.2	2.9	2.7
18	-	1.6	1.2	-	0.3	1.9	6.2	2.4	1.0	2.1
21	-	-	-	-	-	2.2	1.8	-	-	-
22	-	-	-	-	-	1.6	1.0	-	-	-

* no data collected

Table 7. (continued)

Station number	1972											
	Feb.				Mar.				Apr.			
	1	15	22	29	7	13	20	27	3	10	17	24
1	—*	0.8	-	-	0.8	-	-	1.5	-	-	0.5	-
3	-	0.9	-	-	1.0	-	-	2.5	-	-	0.5	-
5	-	1.1	-	-	1.3	-	-	2.9	-	-	0.3	-
6	-	0.9	-	-	1.3	-	-	1.4	-	-	0.5	-
7	-	1.5	-	-	1.5	-	-	3.5	-	-	0.6	-
8	-	3.4	-	-	8.4	-	-	8.0	-	-	-	-
9	-	2.5	-	-	1.4	-	-	2.8	-	-	1.6	-
10	-	2.3	-	-	1.6	-	-	3.4	-	-	1.4	-
11	1.2	1.8	1.5	3.8	3.2	18.0	2.0	4.9	1.3	2.4	1.7	1.0
12	15.1	18.3	17.4	15.0	16.0	23.0	16.3	13.3	6.9	11.3	14.3	10.4
14	7.3	11.2	12.3	14.1	7.2	12.0	10.2	17.4	14.0	8.9	4.5	6.8
16	4.3	1.3	1.3	1.4	1.1	17.0	1.5	3.0	1.0	1.1	0.4	0.6
17	1.0	3.2	3.0	3.0	4.5	12.0	3.3	8.4	5.7	7.8	1.3	3.8
18	4.1	2.7	2.5	1.8	2.4	12.0	2.7	6.0	1.7	2.9	0.9	0.9
21	-	1.7	-	-	0.9	-	-	2.3	-	-	0.5	-
22	-	1.3	-	-	1.1	-	-	2.0	-	-	0.9	-

* no data collected

Table 7. (continued)

Station number	1972 May 1	8	15	22	29	Jun. 14	30	6	Jul. 14	20	28
1	0.7	—*	–	0.8	–	–	–	2.4	–	–	1.8
3	1.3	–	–	1.5	–	–	–	3.1	–	–	1.2
5	0.5	–	–	0.9	–	–	–	1.7	–	–	2.1
6	1.2	–	–	0.7	–	–	–	2.2	–	–	1.8
7	2.0	–	–	1.5	–	12.6	–	4.0	–	–	1.5
8	–	–	–	–	–	–	–	7.2	–	–	9.3
9	1.8	–	–	1.4	–	–	–	7.2	–	–	6.9
10	2.4	–	–	2.5	–	–	–	5.6	–	–	2.7
11	3.2	3.3	3.6	2.1	2.5	6.0	7.2	5.0	1.8	3.0	2.1
12	10.7	6.4	7.2	8.6	7.2	10.2	6.0	11.7	4.5	2.4	12.6
14	6.5	3.6	5.6	5.3	10.1	3.6	8.4	8.2	3.6	8.1	4.8
16	1.1	3.1	1.8	2.8	2.2	3.6	4.2	3.9	1.8	2.7	3.6
17	3.5	0.2	5.2	1.7	6.5	–	7.2	6.7	3.3	3.9	6.0
18	1.6	1.0	1.9	1.5	3.0	4.8	5.4	4.1	2.4	3.9	6.6
21	1.3	–	–	1.8	–	–	–	2.6	–	–	2.4
22	–	–	–	1.0	–	–	–	1.9	–	–	3.6

* no data collected

Table 7. (continued)

Station number	1972 Aug. 4	11	18	25
1	—*	-	1.2	-
3	-	-	9.3	-
5	-	-	1.2	-
6	-	-	1.8	-
7	-	-	1.2	-
8	-	-	5.1	-
9	-	-	4.2	-
10	-	-	3.6	-
11	3.3	2.7	2.1	3.0
12	11.1	13.0	10.2	0.6
14	5.0	3.0	3.0	3.9
16	4.8	4.8	1.2	13.5
17	4.2	6.0	1.2	6.3
18	3.0	3.0	1.8	3.3
21	-	-	1.2	-
22	-	-	0.9	-

* no data collected

Table 8. Weekly measurements of total organic carbon (ppm) for Stroubles Creek, Cedar Run and Toms Creek from August 1971 through August 1972.

Station number	1971												
	Aug.				Sept.				Oct.				
	2	10	17	25	31	7	17	21	28	5	12	19	26
1	—*	-	-	4.0	-	-	5.0	-	-	7.0	-	-	8.0
3	-	-	-	4.0	-	-	6.0	-	-	9.0	-	-	8.0
5	-	-	-	6.0	-	-	5.0	-	-	7.0	-	-	4.0
6	-	-	-	5.0	-	-	3.0	-	-	6.0	-	-	2.0
7	16.0	29.0	9.0	6.5	6.0	5.0	6.0	10.0	7.0	16.0	7.0	4.0	11.0
8	35.0	46.0	15.0	24.0	5.0	4.0	6.0	15.0	10.0	20.0	4.0	5.0	6.0
9	-	-	-	9.0	-	-	7.0	-	-	8.0	-	-	4.0
10	11.0	33.5	4.0	26.0	9.0	5.0	8.0	8.0	7.0	12.0	5.0	7.0	3.0
11	24.0	28.1	5.0	5.5	12.0	5.0	6.0	9.0	10.0	14.0	4.0	5.0	4.0
12	28.0	28.5	12.0	20.0	14.0	16.0	16.0	13.0	25.0	28.0	18.0	25.5	9.0
14	-	-	-	-	-	-	10.0	-	-	14.0	-	-	5.0
16	31.0	21.5	8.0	3.5	7.0	6.0	8.0	4.9	16.0	9.0	3.0	8.0	3.0
17	30.0	24.0	16.0	9.0	10.0	11.0	9.0	11.9	11.0	13.0	7.0	13.0	4.0
18	-	-	-	5.0	-	-	7.0	-	-	18.0	-	-	3.0
21	-	-	-	-	-	-	-	-	-	-	-	-	5.0
22	-	-	-	5.0	-	-	5.0	-	-	10.0	-	-	3.0

* no data collected

Table 8. (continued)

Station number	1971							1972		
	2	9	Nov. 16	23	30	Dec. 7	4	11	Jan. 18	25
1	—*	-	3.5	-	-	4.0	7.0	-	-	0.5
3	-	-	3.0	-	-	3.0	7.0	-	-	2.0
5	5.0	4.0	2.0	5.0	-	5.0	9.0	-	-	3.0
6	4.0	-	4.0	-	-	7.0	12.0	-	-	3.5
7	-	-	4.5	4.0	7.0	7.0	6.0	3.0	-	7.5
8	-	-	5.0	-	-	5.0	8.0	-	-	6.0
9	-	-	4.0	4.0	-	5.0	7.0	-	-	2.5
10	-	-	7.0	5.0	-	6.0	7.0	-	-	4.0
11	7.0	5.0	11.0	7.0	20.0	6.0	13.0	2.0	4.0	4.0
12	15.0	10.0	23.0	30.0	5.5	11.0	23.0	7.0	28.0	13.0
14	6.5	6.0	8.0	4.0	7.0	6.0	10.0	8.0	9.0	5.5
16	4.0	4.0	4.5	7.5	5.0	39.0	8.0	2.0	7.0	3.0
17	5.5	4.0	10.0	-	6.0	9.0	10.0	4.0	12.0	5.5
18	-	3.0	4.0	-	8.0	8.0	16.0	3.0	8.0	10.0
21	-	-	-	-	-	6.0	7.0	-	-	3.0
22	-	-	-	-	-	5.0	11.0	-	-	2.5

* no data collected

Table 8. (continued)

Station number	1972										
	Feb.				Mar.			Apr.			
	1	15	22	29	7	20	27	3	10	17	24
1	_*	13.0	-	-	4.5	-	8.0	-	-	6.5	-
3	-	12.0	-	-	6.0	-	9.0	-	-	3.9	-
5	-	16.0	-	-	4.5	-	12.0	-	-	6.0	-
6	-	13.0	-	-	4.0	-	13.0	-	-	1.5	-
7	-	13.0	-	-	7.0	-	7.0	-	-	5.0	-
8	-	12.0	-	-	5.0	-	28.0	-	-	-	-
9	-	10.0	-	-	4.0	-	10.0	-	-	5.5	-
10	-	11.0	-	-	4.5	-	9.0	-	-	5.0	-
11	7.0	9.0	3.0	12.0	4.3	4.0	13.0	9.0	15.0	5.0	5.0
12	14.0	22.0	4.0	27.0	10.0	11.5	15.0	12.5	16.0	16.0	7.0
14	5.0	8.0	10.0	10.0	8.5	8.0	12.0	12.0	10.0	4.0	9.0
16	4.0	13.0	2.0	15.0	5.0	5.5	15.0	10.0	16.0	3.0	4.0
17	7.0	11.0	7.5	10.0	8.0	7.3	12.0	8.0	13.0	5.0	13.0
18	8.0	12.0	5.0	9.0	5.0	2.5	15.0	7.0	9.0	3.5	5.0
21	-	4.0	-	-	4.8	-	6.0	-	-	3.0	-
22	-	4.0	-	-	7.0	-	8.0	-	-	4.5	-

* no data collected

Table 8. (continued)

Station number	1972 May 8	15	22	29
1	—*	–	4.0	–
3	–	–	7.0	–
5	–	–	2.0	–
6	–	–	2.0	–
7	–	–	2.0	–
8	–	–	–	–
9	–	–	3.0	–
10	–	–	4.0	–
11	4.0	3.6	3.0	5.0
12	15.0	7.2	8.0	>50.0
14	9.0	5.6	6.0	7.0
16	3.0	1.8	3.0	8.0
17	4.0	5.2	5.0	7.0
18	3.0	1.9	7.0	8.0
21	–	–	3.0	–
22	–	–	3.0	–

June-August 1972, no data.
* no data collected

Table 9. Triweekly measurements of alkalinity (ppm) for Stroubles Creek, Cedar Run and Toms Creek from August 1971 through August 1972.

Station number	1971 Aug. 25	1971 Oct. 26	1971 Nov. 16	1971 Dec. 7	1972 Jan. 4	1972 Jan. 25	1972 Feb. 15	1972 Mar. 7	1972 Mar. 27
1	220	207	340	202	208	240	250	220	210
3	252	132	328	208	198	252	206	244	245
5	256	215	288	230	202	266	228	246	245
6	252	223	268	214	134	256	198	232	235
7	142	175	244	180	136	220	158	214	195
8	236	200	272	208	198	246	232	240	225
9	194	131	248	188	142	200	208	236	220
10	192	138	240	186	162	208	202	222	215
11	206	162	212	180	162	208	182	224	220
12	170	166	200	180	130	190	194	212	190
14	-*	117	188	136	132	136	162	168	145
16	240	195	264	152	132	238	188	236	235
17	124	149	164	112	114	152	164	182	160
18	224	103	224	170	154	202	202	224	175
21	-	94	-	90	102	60	130	76	70
22	204	115	-	130	144	110	192	102	95

Station number	1972 Apr. 17	1972 May 1	1972 May 22	1972 Jul. 6
1	216	210	180	222
3	230	242	230	192
5	244	260	220	256
6	230	224	200	240
7	228	218	215	250
8	-	-	-	238
9	210	222	195	166
10	206	220	185	182
11	198	226	215	214
12	202	198	205	188
14	140	160	175	160
16	216	208	220	230
17	182	170	185	170
18	218	218	160	224
21	58	85	155	140
22	86	128	170	162

* no data collected

Table 10. Triweekly measurements of total Kjeldahl nitrogen (ppm) for Stroubles Creek, Cedar Run and Toms Creek from August 1971 through August 1972.

Station number	1971 Oct. 5	Oct. 26	Nov. 16	Dec. 7	1972 Jan. 4	Jan. 25	Feb. 15	Mar. 7	Mar. 27	Apr. 17	May 1	May 22
1	0.5	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0
3	0.5	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.5
5	0.5	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0
6	0.5	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0
7	2.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.5
8	2.5	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	-*
9	2.5	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.5	0.0	0.0	1.0
10	2.5	0.0	0.5	0.0	0.0	0.0	1.5	0.0	0.0	0.5	0.0	1.0
11	2.5	0.5	0.0	0.5	0.0	0.5	1.8	0.0	26.0	0.3	0.0	1.0
12	31.0	8.0	17.0	16.0	15.0	17.0	14.0	10.0	3.0	14.0	14.0	25.0
14	6.0	3.0	2.0	3.0	4.0	4.0	3.0	2.0	0.0	0.0	0.5	0.8
16	1.5	0.5	0.0	0.5	0.0	0.5	2.0	0.0	0.0	2.0	0.5	0.8
17	3.0	0.5	3.0	3.5	5.0	3.0	3.0	2.5	4.0	16.0	8.0	10.0
18	1.0	0.0	0.5	1.5	3.0	0.5	2.5	0.0	0.0	15.0	0.3	0.5
21	0.5	0.0	-	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
22	0.5	0.0	-	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0

* no data collected

Table 10. (continued)

Station number	1972 Jun. 14	Jul. 6	Jul. 28	Aug. 18
1	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0
6	0.0	0.5	0.0	0.0
7	0.0	0.5	0.5	0.5
8	*	1.5	0.5	0.3
9	0.0	1.0	1.0	0.5
10	0.5	1.5	0.5	1.5
11	0.6	2.0	0.5	1.5
12	28.0	18.0	14.0	22.0
14	3.0	4.0	1.0	2.3
16	1.0	0.5	0.0	0.0
17	14.0	3.0	6.0	12.0
18	0.5	0.0	0.0	0.5
21	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.5

* no data collected

Table 11. Triweekly measurements of chloride (ppm) for Stroubles Creek, Cedar Run and Toms Creek from August 1971 through August 1972.

Station number	1971 Aug. 25	Oct. 5	Oct. 26	Nov. 16	Dec. 7	1972 Jan. 4	Jan. 25	Feb. 15	Mar. 7	Mar. 27	Apr. 17	May 1	May 22
1	12.6	11.0	11.4	9.2	17.0	17.0	13.1	12.1	9.6	9.6	9.1	23.0	14.0
3	19.7	18.0	11.4	15.4	19.4	19.3	14.0	24.6	41.2	16.4	10.3	21.0	12.0
5	17.7	15.0	18.1	13.5	26.6	29.0	15.9	18.4	16.9	19.3	10.5	9.0	9.0
6	15.1	13.0	18.1	13.0	30.0	20.7	16.4	21.3	16.0	17.0	12.0	6.0	15.0
7	12.6	11.0	20.0	15.4	36.8	25.0	19.8	23.7	21.3	21.8	26.2	21.0	25.0
8	16.7	6.0	20.0	14.5	37.3	18.8	20.8	26.6	20.6	20.3	-*	-	-
9	31.3	15.0	27.6	43.0	57.8	30.0	43.5	38.2	28.5	47.0	32.0	30.0	20.0
10	29.8	15.0	27.1	37.2	77.0	26.5	30.0	34.4	19.3	46.5	36.0	32.0	41.0
11	21.7	13.0	19.0	22.7	50.1	25.6	24.6	22.7	24.0	34.0	26.8	34.0	39.0
12	30.8	30.0	25.2	30.5	55.2	36.2	29.0	31.4	16.9	32.0	30.6	34.0	32.0
14	-	24.0	13.4	21.3	31.5	25.1	15.9	16.0	19.3	25.6	29.4	28.0	19.0
16	17.7	16.0	19.0	16.4	59.6	23.2	20.8	29.0	24.6	19.4	28.6	16.0	21.0
17	26.3	26.0	21.5	28.0	52.8	20.3	26.6	30.5	24.2	28.5	28.0	12.0	20.0
18	15.1	13.0	14.3	14.5	32.4	20.7	17.9	18.4	15.0	14.5	16.3	25.0	22.0
21	-	-	12.4	-	57.6	21.7	9.6	10.6	8.4	8.3	8.3	6.0	9.0
22	13.6	12.0	12.7	-	16.5	10.6	9.6	9.2	8.4	8.3	8.4	9.0	10.0

* no data collected

Table 11. (continued)

Station number	1972 Jun. 14	Jul. 6	Jul. 28	Aug. 18
1	16.0	8.0	12.0	9.0
3	12.0	7.0	13.0	10.0
5	25.0	9.0	20.0	12.0
6	20.0	8.0	16.0	12.5
7	10.0	12.0	14.0	15.0
8	-*	6.0	11.0	16.0
9	18.0	17.0	15.0	28.0
10	17.0	17.0	14.0	34.0
11	19.0	13.0	12.0	16.0
12	35.0	32.0	35.0	25.0
14	26.0	21.0	20.0	20.0
16	12.0	20.0	16.0	18.0
17	15.0	23.0	26.0	24.0
18	22.0	9.0	11.0	16.0
21	5.0	5.0	7.0	9.0
22	5.0	4.0	8.0	9.1

* no data collected

Table 12. Triweekly measurements of nitrate (ppm) for Stroubles Creek, Cedar Run and Toms Creek from August 1971 through August 1972.

Station number	1971						1972					
	Aug.		Oct.		Nov.	Dec.	Jan.		Feb.	Mar.		Apr.
	18	25	5	26	16	7	4	25	15	7	27	17
1	1.40	2.50	1.70	3.10	1.60	2.50	2.45	2.40	2.78	3.00	1.60	1.55
3	1.80	1.60	1.10	1.40	2.25	2.05	1.85	2.10	2.20	2.25	1.80	1.65
5	1.60	2.10	1.80	2.80	2.50	1.95	1.85	1.85	3.20	2.40	2.30	2.10
6	2.10	1.60	1.20	2.40	3.05	1.45	1.15	1.30	2.55	2.35	2.10	2.65
7	2.00	0.05	0.50	2.00	1.80	1.40	1.00	1.70	2.25	2.30	1.90	1.95
8	1.90	1.70	0.70	2.30	2.50	1.65	1.65	1.65	2.60	2.50	2.40	-*
9	2.00	0.60	0.30	1.10	1.75	1.25	0.75	1.50	1.90	2.20	1.80	1.75
10	1.70	0.50	0.50	1.40	1.50	0.90	0.65	1.25	2.35	2.50	1.60	1.75
11	0.90	0.60	0.70	1.40	0.70	1.40	0.95	0.80	2.00	2.40	0.40	1.85
12	1.20	3.00	0.30	1.30	1.50	1.20	1.15	1.30	0.80	1.65	1.30	1.35
14	2.20	-	1.80	1.40	2.50	1.20	2.00	1.75	1.95	1.45	2.10	2.30
16	2.10	0.90	0.70	1.60	1.40	0.70	0.65	1.25	1.55	1.70	1.20	2.10
17	3.30	5.80	2.00	1.70	3.30	2.35	1.70	2.25	1.45	1.35	3.20	3.48
18	3.00	1.50	1.70	1.60	3.00	1.80	1.90	1.65	2.00	1.90	2.60	3.20
21	0.45	-	-	0.10	-	0.30	0.45	0.55	0.35	0.55	0.45	0.45
22	0.45	0.30	0.60	0.10	-	0.60	0.60	0.65	0.55	0.70	0.45	0.45

* no data collected

Table 12. (continued)

Station number	1972 May 1	1972 May 22	1972 Jun. 14	1972 Jul. 6	1972 Jul. 28
1	2.80	3.00	0.80	0.80	1.20
3	2.01	2.05	1.30	0.80	1.30
5	2.00	2.00	1.35	0.90	1.10
6	2.10	2.35	1.30	1.20	0.80
7	1.80	1.75	1.80	0.80	1.20
8	-*	-	-	0.90	0.50
9	1.85	1.95	1.60	1.20	0.40
10	1.90	1.80	1.75	1.20	0.60
11	1.90	1.90	1.70	1.00	0.30
12	1.90	2.50	2.00	0.60	0.30
14	2.35	3.40	1.30	0.75	1.20
16	3.60	1.25	1.25	0.80	1.10
17	1.35	1.30	2.05	1.10	1.80
18	1.10	1.45	1.20	1.20	1.50
21	0.35	0.40	0.40	0.30	0.30
22	0.35	0.40	0.45	0.30	0.30

* no data collected

Table 13. Triweekly measurements of total phosphate (ppm) for Stroubles Creek, Cedar Run and Toms Creek from August 1971 through August 1972.

Station number	1971 Oct. 5	1971 Oct. 26	1971 Nov. 16	1971 Dec. 7	1972 Jan. 4	1972 Jan. 25	1972 Feb. 15	1972 Mar. 7	1972 Mar. 27	1972 Apr. 17	1972 May 1	1972 May 22
1	0.84	0.16	0.07	0.17	0.09	0.07	0.34	0.38	0.08	0.50	<0.04	0.20
3	0.79	0.20	0.07	0.14	0.09	0.08	0.30	0.12	1.80	0.50	<0.04	0.85
5	0.23	0.11	0.08	0.16	0.12	0.09	0.30	0.20	0.28	0.72	<0.04	0.34
6	0.27	0.14	0.05	0.12	0.10	0.15	0.36	0.10	0.88	0.58	<0.04	0.38
7	0.34	0.22	0.25	0.15	0.14	0.34	2.14	1.20	1.60	0.50	<0.04	0.30
8	0.93	0.35	0.24	0.60	0.27	0.31	0.74	0.68	1.04	-*	-	-
9	0.17	0.18	0.10	0.16	0.20	0.15	0.42	0.22	0.54	0.72	<0.04	3.00
10	21.40	2.70	0.20	1.40	0.30	0.00	2.00	2.00	0.40	1.70	<0.04	0.88
11	0.20	0.19	0.16	0.25	0.16	0.12	0.50	0.22	0.18	0.56	<0.04	0.42
12	53.00	19.30	2.07	2.40	10.50	1.40	20.50	17.50	>22.50	20.00	3.00	14.60
14	-	2.70	7.30	5.00	3.60	4.70	4.40	7.00	6.50	6.50	1.50	11.10
16	0.19	0.19	0.13	0.18	1.60	0.16	0.34	0.18	0.12	0.50	<0.04	0.46
17	-	3.80	12.80	12.50	5.80	4.70	70.30	6.10	5.50	4.33	0.80	8.10
18	27.00	1.55	3.30	3.30	4.20	1.90	3.20	2.90	0.55	3.00	0.40	4.70
21	-	0.14	-	0.15	0.08	0.12	0.90	0.20	<0.02	0.52	0.35	0.08
22	0.28	0.15	-	0.14	0.10	0.08	0.38	0.24	0.06	0.46	0.35	0.28

* no data collected

Table 13. (continued)

Station number	1972 Jun. 14	Jul. 6	28	Aug. 18
1	0.03	0.02	0.10	0.02
3	0.04	0.17	0.10	0.03
5	0.04	0.05	0.90	0.04
6	0.29	1.75	0.50	0.03
7	0.43	0.50	2.50	0.45
8	-*	0.63	2.75	0.50
9	0.23	0.87	0.15	0.30
10	0.13	0.90	0.03	0.15
11	0.21	0.80	0.05	0.20
12	18.50	18.60	15.83	17.65
14	13.30	10.10	11.35	13.30
16	0.11	0.17	0.30	0.10
17	10.10	5.80	9.55	11.00
18	5.80	12.00	4.65	6.00
21	0.22	0.09	0.30	0.20
22	0.14	0.21	0.30	0.10

* no data collected

Table 14. Triweekly measurements of ortho phosphate (ppm) for Stroubles Creek, Cedar Run and Toms Creek from August 1971 through August 1972.

Station number	1971				1972					
	Oct. 5	Oct. 26	Nov. 16	Dec. 7	Jan. 4	Jan. 25	Feb. 15	Mar. 7	Mar. 27	Apr. 17
1	0.01	0.02	0.03	0.02	0.09	0.02	<0.03	0.01	<0.01	0.00
3	0.10	0.20	0.04	0.03	0.03	0.04	<0.03	0.04	<0.01	<0.03
5	0.01	0.05	0.04	0.06	0.06	0.05	<0.03	0.01	0.03	<0.03
6	0.02	0.06	0.03	0.04	0.05	0.05	0.11	0.01	<0.01	<0.03
7	0.10	0.21	0.11	0.14	0.08	0.20	0.13	0.09	0.17	0.06
8	0.37	0.22	0.06	0.28	0.21	0.26	0.18	0.07	0.08	-*
9	0.04	0.18	0.04	0.15	0.13	0.13	0.71	0.04	<0.02	0.16
10	0.28	0.70	0.10	0.50	0.30	0.00	1.10	0.00	<0.01	<0.03
11	0.11	0.23	0.08	0.23	0.10	0.09	0.23	0.01	<0.01	<0.03
12	18.00	12.00	5.30	10.60	2.50	11.90	12.45	7.80	10.70	13.50
14	21.00	2.70	1.70	4.10	2.00	4.50	3.65	3.00	4.70	1.80
16	0.41	0.12	0.05	0.15	0.30	0.10	<0.20	0.01	<0.02	<0.03
17	16.80	3.50	2.70	11.40	3.20	4.00	3.80	3.60	4.15	1.30
18	0.26	1.55	1.30	2.60	3.20	1.80	2.00	1.30	1.16	0.80
21	0.19	0.05	-	0.09	0.03	0.08	0.12	0.48	0.00	0.00
22	0.24	0.10	-	0.11	0.04	0.08	0.13	0.12	0.00	<0.03

* no data collected

Table 14. (continued)

Station number	1972 May 1	1972 May 22	1972 Jun. 14	1972 Jul. 6	1972 Jul. 28	1972 Aug. 18
1	0.00	0.00	0.00	0.00	0.30	0.00
3	<0.01	0.02	0.00	0.00	0.30	0.00
5	0.00	0.01	0.00	0.00	0.40	0.00
6	0.00	0.00	0.16	0.10	0.50	0.10
7	<0.01	0.14	0.51	0.10	0.55	0.10
8	-*	-	-	0.15	0.40	-
9	<0.01	0.02	0.07	0.17	0.33	0.20
10	<0.01	0.02	0.06	0.14	0.35	0.15
11	<0.01	0.10	0.02	0.10	0.30	0.10
12	2.25	9.40	13.50	7.50	12.75	9.50
14	1.10	6.00	8.30	3.30	9.00	6.00
16	0.00	0.02	0.00	0.00	0.65	0.00
17	0.60	5.70	6.40	3.00	7.20	6.00
18	<0.10	14.80	2.70	1.00	3.40	14.80
21	0.00	0.00	0.00	0.00	0.30	0.00
22	0.00	0.00	0.00	0.00	0.30	0.00

* no data collected

Table 15. Triweekly measurements of total solids (ppm) for Stroubles Creek, Cedar Run and Toms Creek from August 1971 through August 1972.

	1971						1972					
Station number	Aug. 25	Sept. 17	Oct. 5	Oct. 26	Nov. 16	Dec. 7	Jan. 4	Jan. 25	Feb. 15	Mar. 7	Mar. 27	Apr. 17
1	285	325	234	332	273	318	380	315	376	318	352	310
3	365	349	245	487	350	385	467	392	488	814	374	374
5	471	365	315	380	403	481	487	410	600	366	452	456
6	345	332	290	400	332	431	618	422	416	340	348	414
7	331	352	1611	468	341	442	367	495	536	376	366	312
8	386	288	596	406	317	377	353	349	420	372	402	-*
9	374	327	275	391	372	536	391	430	410	352	386	534
10	442	380	749	470	392	529	380	416	440	370	436	460
11	457	385	313	385	301	518	412	375	452	372	366	564
12	685	338	295	392	310	495	398	374	490	344	378	436
14	-	315	286	262	300	535	529	276	276	284	318	312
16	376	356	330	401	310	445	354	379	280	372	398	412
17	301	270	200	343	286	423	407	313	362	324	328	302
18	367	372	272	388	324	466	467	328	362	332	356	344
21	-	-	-	260	-	252	220	147	102	122	136	196
22	323	321	289	265	-	297	294	170	136	190	160	144

* no data collected

Table 15. (continued)

Station number	1972 May 1	May 22	Jun. 14	Jul. 6	Jul. 28	Aug. 18
1	198	297	299	295	76	277
3	274	437	346	323	50	496
5	288	366	362	363	127	378
6	264	317	1601	356	205	350
7	270	315	377	336	195	331
8	-*	-	-	372	367	307
9	290	342	293	390	391	348
10	308	380	404	454	454	361
11	268	393	429	360	422	388
12	262	346	375	391	410	296
14	234	283	327	545	545	318
16	218	357	307	573	573	354
17	250	316	271	493	531	567
18	236	323	298	510	510	336
21	80	143	268	308	308	260
22	108	172	257	327	327	305

* no data collected

Table 16. Triweekly measurements of suspended solids (ppm) for Stroubles Creek, Cedar Run and Toms Creek from August 1971 through August 1972.

Station	1971						1972		
	Aug.	Sept.	Oct.		Nov.	Dec.	Jan.		Feb.
number	25	17	5	26	16	7	4	25	15
1	8	1	18	13	11	3	29	10	21
3	2	36	26	265	14	12	132	36	47
5	72	11	49	33	56	53	88	67	78
6	2	8	50	20	2	24	375	166	41
7	4	6	1378	53	34	36	63	175	125
8	290	2	448	24	12	5	15	17	15
9	0	45	20	70	18	40	96	80	15
10	892	54	850	69	20	35	85	42	18
11	46	38	39	59	22	60	67	35	12
12	28	26	82	55	40	76	84	61	26
14	-*	5	17	27	12	122	225	28	27
16	2	17	10	22	12	57	107	33	24
17	0	13	22	27	14	35	170	25	15
18	0	27	10	32	10	81	175	24	25
21	-	-	-	10	-	7	14	28	9
22	12	9	18	15	-	39	50	32	19

	1972								
	Mar.		Apr.	May		Jun.	Jul.		Aug.
	7	27	17	1	22	14	6	28	18
1	20	20	48	12	10	2	2	30	25
3	516	0	40	12	172	13	8	12	47
5	26	14	36	8	261	20	36	25	34
6	30	8	134	6	16	1477	33	49	248
7	82	140	32	6	43	85	20	30	15
8	16	4	-	-	-	-	39	8	11
9	20	6	244	2	17	23	16	56	30
10	34	4	104	10	74	7	8	47	48
11	24	4	220	8	27	90	3	176	44
12	32	4	76	28	48	53	4	118	50
14	56	10	92	6	19	9	9	266	15
16	20	20	44	20	33	20	10	460	35
17	62	4	86	2	15	9	19	236	12
18	46	8	22	6	12	9	6	180	19
21	8	0	94	4	5	3	4	12	13
22	54	4	38	12	19	19	2	33	68

* no data collected

Table 17. Triweekly measurements of dissolved solids (ppm) for Stroubles Creek, Cedar Run and Toms Creek from August 1971 through August 1972.

Station number	1971 Aug. 24	Sept. 17	Oct. 5	Oct. 26	Nov. 16	Dec. 7	1972 Jan. 4	Jan. 25	Feb. 15
1	112	184	216	319	262	315	351	305	355
3	253	188	219	222	336	373	335	356	441
5	246	224	276	347	347	428	399	343	522
6	203	205	240	380	330	407	243	144	375
7	228	228	233	415	307	406	304	320	411
8	-*	175	148	382	305	372	338	332	405
9	239	327	255	321	354	496	295	350	395
10	-	186	-	401	372	494	295	374	422
11	213	162	274	326	279	458	345	340	440
12	528	187	213	337	270	419	314	313	464
14	-	-	269	235	288	413	304	248	249
16	231	187	320	379	288	388	247	346	256
17	150	148	178	316	272	368	237	288	347
18	202	182	262	356	314	385	292	304	337
21	-	-	-	250	-	245	206	119	93
22	174	166	271	250	-	258	244	138	117

Station number	1972 Mar. 7	Mar. 27	Apr. 17	May 1	May 22	Jun. 14	Jul. 6	Jul. 28	Aug. 18
1	298	332	262	186	287	297	293	46	252
3	298	374	334	262	265	333	315	38	449
5	340	438	420	280	105	342	327	102	344
6	310	340	280	258	301	124	323	156	102
7	294	226	280	264	272	292	116	165	316
8	356	398	-	-	-	-	333	359	296
9	332	380	290	288	325	270	374	335	318
10	336	432	356	298	306	397	446	407	313
11	348	362	344	260	366	339	357	246	344
12	312	374	360	234	298	322	387	292	246
14	248	308	220	228	264	318	536	279	303
16	352	378	368	198	324	287	563	113	319
17	262	324	216	248	301	262	474	295	555
18	286	348	322	230	311	289	504	330	317
21	114	136	102	76	138	265	304	296	247
22	136	156	106	96	153	238	325	294	237

* no data collected

VITA

Virginia Anderson Mosby was born in Lynchburg, Virginia, in September 1948. She subsequently resided with her parents, Dr. and Mrs. Henry S. Mosby, in Blacksburg, Virginia, where she was graduated from Blacksburg High School in 1966. In the fall of 1966, she enrolled at Mary Baldwin College, Staunton, Virginia, from which she graduated with a B.A. in Biology in June 1970. She entered graduate school in January 1971, at Virginia Polytechnic Institute and State University, Blacksburg, Virginia to begin work on a master of science degree in Biology. In March 1973 she received her M.S.

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In December 1972, she married George Carlton Hayles, originally from Water Valley, Mississippi.

Virginia Mosby Hayles

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BIOLOGICAL AND CHEMICAL MONITORING OF THREE STREAMS
IN THE AREA OF BLACKSBURG, VIRGINIA

by

Virginia Mosby Hayles

(ABSTRACT)

This study compares the sensitivity of biological and chemical parameters for monitoring water quality, examines several methods of analyzing diversity of the aquatic organisms and attempts to assess water quality in the three streams investigated.

The Cairns-Dickson DI_T diversity index was applied to two trophic levels of aquatic organisms and the results were compared to ascertain whether this diversity index is applicable to all levels of the trophic structure or of greater use for a particular level. Two diversity indices, Cairns-Dickson DI_T and Wilhm-Dorris $\overline{d}$, were used to analyze the same component of the biological community and the results of these two indices were compared.

A correlation test was performed among chemical and biological data and among chemical parameters.