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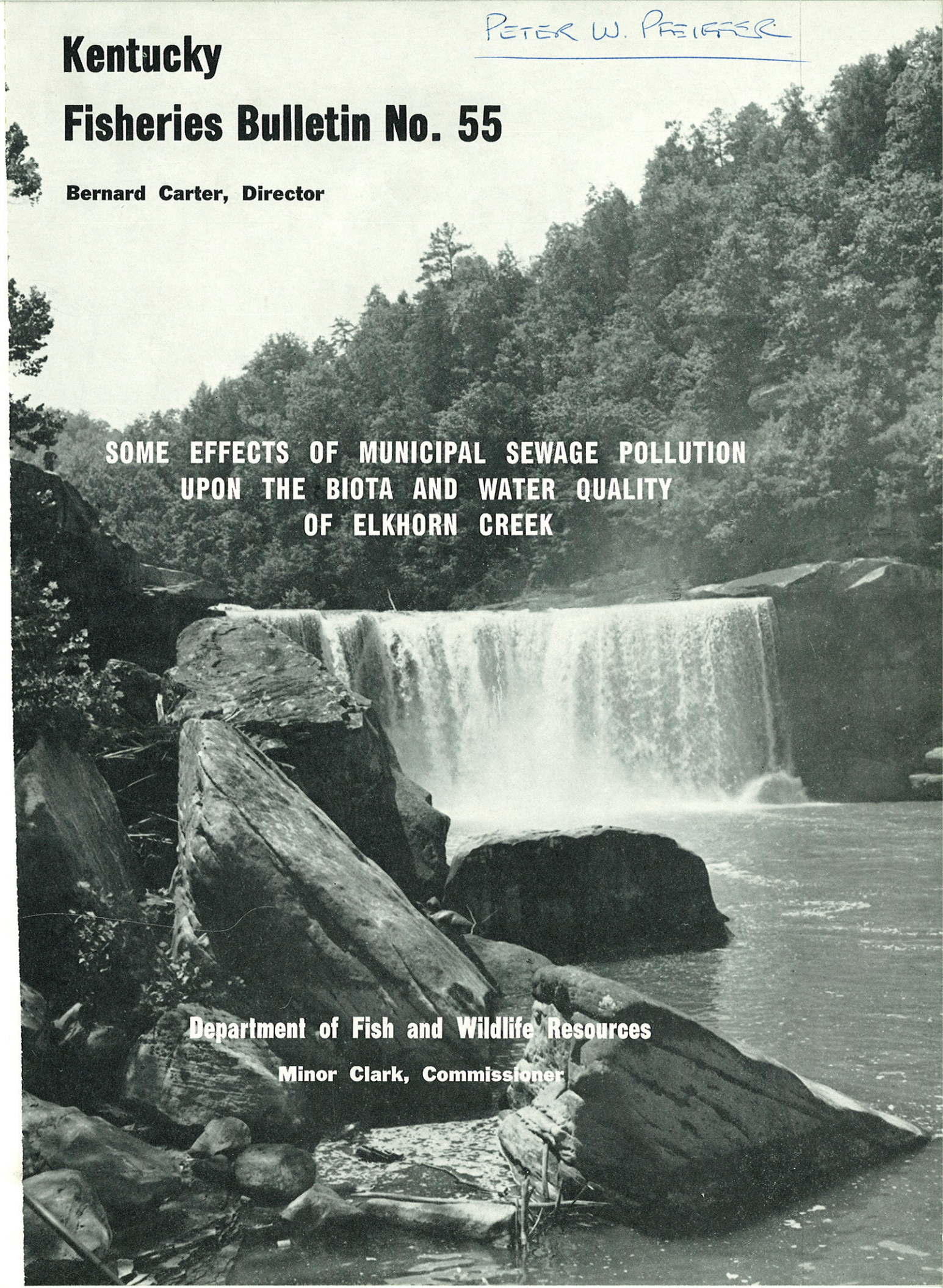

SOME EFFECTS OF MUNICIPAL SEWAGE POLLUTION UPON THE BIOTA AND WATER QUALITY OF ELKHORN CREEK

Department of Fish and Wildlife Resources

Minor Clark, Commissioner

SOME EFFECTS OF MUNICIPAL SEWAGE POLLUTION UPON THE BIOTA AND WATER QUALITY OF ELKHORN CREEK

by

Bonny Dale Laflin

Senior Fishery Biologist

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ABSTRACT

The North and South Forks of Elkhorn Creek are geologically comparable streams but biologically they differ substantially. The South Fork, unlike the North Fork, receives a large amount of treated sewage effluent from the city of Lexington, Kentucky, which drastically alters its environment. Although there are other sources of pollution on the South Fork, North Fork and Main Creek, the effluents released from Lexington have the greatest effect on the creek. The average daily release from the sewage treatment plant into Town Branch, a tributary of the South Fork, is from 16,000,000 to 16,500,000 gallons per day or approximately 24.8 to 25.5 cubic feet of treated sewage per second.

Investigations were conducted on the Elkhorn Creek to document the present effect that the city of Lexington's sewage effluents are having on the water quality, bottom fauna and fish populations of the South Fork and to a lesser degree the Main Elkhorn Creek.

Water quality studies revealed a dissolved oxygen concentration below Town Branch, the source of pollution on the South Fork, of less than 2.6 ppm from June through November with a low of 0.4 ppm occurring in November. The mean Biochemical Oxygen Demand (BOD) at this station was 12.8 ppm with a monthly high of 30.0 ppm. Free carbon dioxide was also higher at this station than any other location with a mean of 7.5 ppm. In contrast the dissolved oxygen on the North Fork remained above 5.0 ppm, except for one month when it decreased to 4.6 ppm, and the mean BOD was only 3.7 ppm.

The type and quantity of the bottom fauna in the South Fork reflects the degree of pollution. Below the mouth of Town Branch, the bottom fauna is composed almost entirely of sewage worms. There was an average of 643 of these organisms per sample in the polluted area.

The fish population of the polluted area of the South Fork is approximately one tenth that of the North Fork and was composed of only 84 fish (4.7 pounds) per acre. The Main Creek contained 164 fish (91 pounds) but the North Fork contained the largest population with 792 fish per acre which weighed 78 pounds. Smallmouth bass and largemouth bass were common in the Main Creek and the North Fork but they were all but absent in the South Fork.

INTRODUCTION

Before the nineteen fifties Elkhorn Creek was known as an excellent smallmouth bass fishing stream. Now the stream has been degraded by sewage pollution to such an extent on the South Fork that very few if any smallmouth remain.

Although there are several sources of pollution on the South Fork, e.g. Midway, Kentucky sewage treatment plant and local residents, the main source and the one that has had the most drastic effect on the stream is Lexington, Kentucky's sewage treatment effluents. Lexington releases 16,000,000 gallons per day into a small tributary of the South Fork, Town Branch. The Main Creek is being affected by the waters of the South Fork but it still produces good fishing. The North Fork is sometimes polluted by industries in Fayette County and by the municipal sewage treatment plant of Georgetown, Kentucky but this segment of Elkhorn Creek is not affected by the pollutant as is the Main Creek and South Fork.

This project was initiated in 1968 to document the water quality conditions and fish populations in the three stream segments and to describe the bottom fauna of the North and South Forks.

LOCATION AND DESCRIPTION

Elkhorn Creek is composed of three main streams, the North Fork, the South Fork, and the Main Creek (Figure 1). The North and South Forks are considered geologically comparable streams and at one time they were probably very similar in composition of both aquatic life and water quality. Both streams flow through the Inner Bluegrass Physiographic Region in a northwesterly direction until they join to form the Main Elkhorn Creek.

The headwaters of both the North and South Forks are located in Fayette County near Lexington, Kentucky. The North Fork originates on the eastern

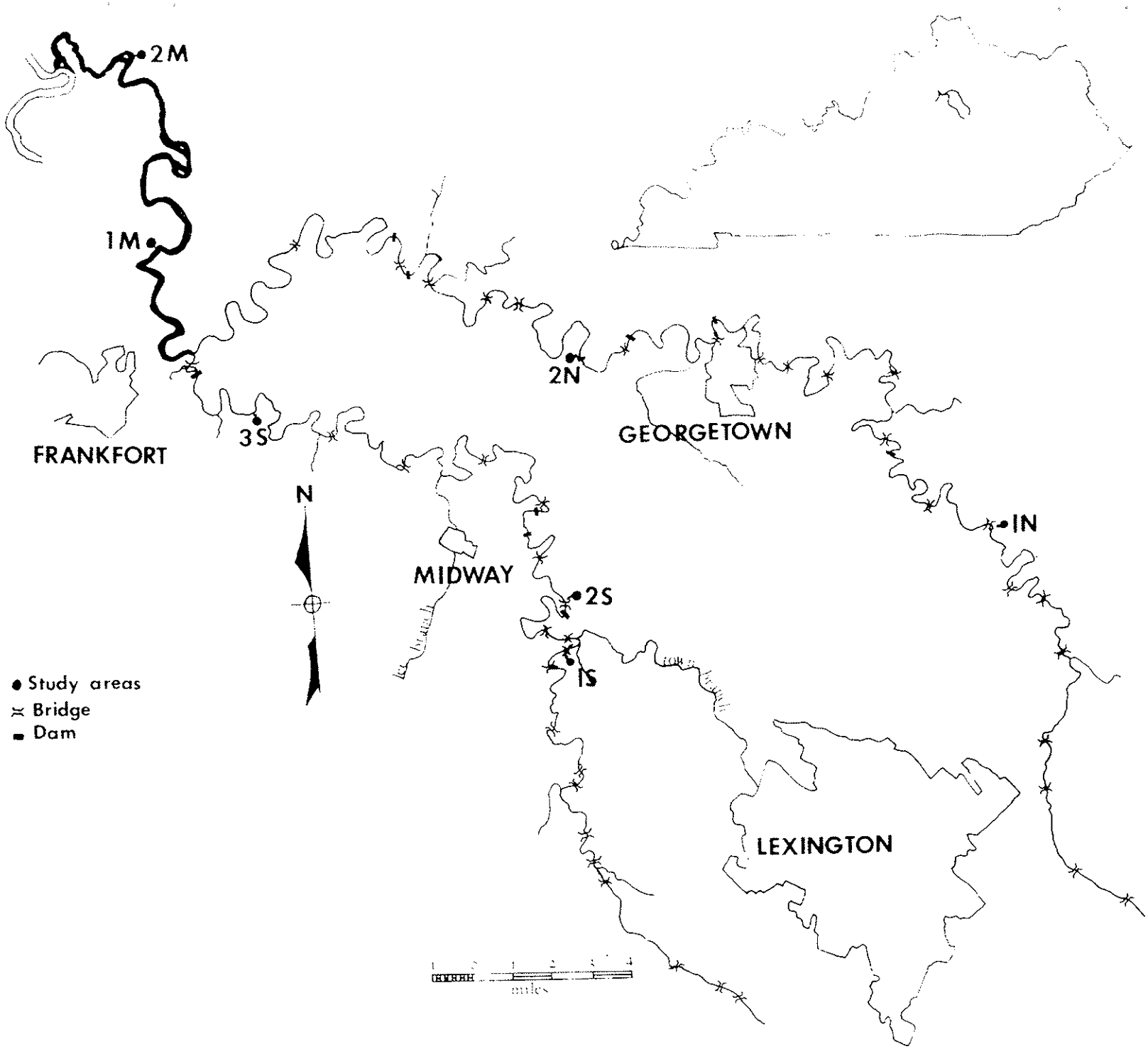

Figure 1. Map of Elkhorn Creek showing sampling stations and location in Kentucky.

side of Lexington, flows north to Georgetown and then westwardly toward Frankfort. The total distance transversed by the North Fork is approximately 55 stream miles. The South Fork originates south of Lexington and flows northwesterly for approximately 35 stream miles toward Frankfort. The Main Creek formed by the junction of the two forks two miles east of Frankfort then flows northwesterly approximately 16 stream miles to the Kentucky River.

METHODS

Water Quality

Water samples were collected twice a month at each of three sampling stations on the South Fork, and the two stations on the North Fork in 1968, and at each of the same stations plus two stations on the Main Stream in 1969. Sampling was conducted on approximately the first and fifteenth of each month.

Dissolved oxygen was determined by the azide modification of the Winkler method. Total alkalinity was determined by titration with 0.02N sulfuric acid using brom cresol green - methyl red as an indicator. Free carbon dioxide was measured by titration with N-44 sodium hydroxide with phenolphthalein as the indicator. The pH was measured with a portable pH meter and nitrates were measured with a Bausch and Lomb Spectronic 20 with Nessler's Reagent as the indicator. Stream temperatures were recorded with a mercury and alcohol stream thermometer. BOD (Biochemical Oxygen Demand) was determined with a Hach BOD Manometric Apparatus.

Bottom Fauna

Three square foot samples were collected each month during 1968 at each of the five sampling areas on the North and South Forks whenever the stream flow would permit. The samples were collected in a Surber square-foot sampler

mounted in a plywood box 1' x 1' x 2'. This box allowed the sampler to collect samples at times when high water would have prevented any sampling.

Each sample was washed through a 1/4 inch mesh screen onto a 1/40 inch mesh screen. The larger gravel and stones not washed through the larger mesh screen were examined closely for clinging organisms and discarded. The remaining sample was washed and placed in pint jars, preserved in 10% formalin and returned to the laboratory where all organisms were removed and identified.

Numbers and weights, expressed in milligrams, were recorded per square foot. Wet weights were determined by blotting the organisms on paper towels for at least 20 seconds and weighing on a Fisher Torsion balance, 0.2 milligrams accuracy. The larger Pelecypods, however, were weighed on a Central Scientific Trip balance, 0.1 gram accuracy.

Fish Population Studies

Two fish population studies were conducted on the North Fork, and three studies were made on the South Fork in 1968. In 1969, the same number of studies were made on the Forks and two studies were made on the Main Stream. The fish samples were collected with an electro-seine. A Homelite three phase 230 volt AC - 110 volt DC generator mounted in an aluminum boat was the power source. A 65-foot cable from which electrodes were suspended was operated from bank to bank by two men while three to five men waded behind the seine and collected the stunned fish. The fish were held in portable live nets until they could be identified, counted, measured, weighed and returned to the stream.

WATER QUALITY

Water quality data are presented in Tables 1 through 7.

During 1968, all sampling was conducted below an eight foot dam at sampling station 2 South, the first station below the source of pollution, but

in 1969 samples were collected above the dam. The 1968 data, therefore, reflect the influence of the action of the falling water, whereas the 1969 data are more indicative of the main portion of the South Fork where there are no falls.

The dissolved oxygen content is one of the main obvious limiting factors of the fish population in the polluted area of the South Fork. The lowest value recorded above the pollution was below 5.0 ppm* (4.6 ppm) only one month during the two year period; however, below Town Branch (station 2 South) the oxygen content above the dam in 1969 remained below 5.0 ppm from May through November. In fact, the oxygen concentration was below 2.6 ppm from June through November with a low oxygen content of 0.8 ppm in October and 0.4 ppm in November. Further downstream the oxygen concentration increased at the lowest station on the South Fork (3 South) but it still was below 5.0 ppm both years, 3.6 ppm (1968) and 2.4 ppm (1969). In contrast, the monthly oxygen content of the North Fork remained approximately 5.0 ppm or above while the Main Creek remained above 6.0 ppm.

The Biochemical Oxygen Demand (BOD) was highest at the station immediately below Town Branch where the mean BOD values exceeded the amount of oxygen available for oxidation. The mean BOD for 2 South was 12.8 ppm with a range of from 4.0 ppm to 30.0 ppm while the mean dissolved oxygen content above the dam in 1969 was only 4.0 ppm. Above Town Branch the BOD ranged from a trace to 19.0 ppm with a mean of 4.8 ppm. The mean of station 3 South was 4.7 ppm. In contrast to the South Fork, the North Fork remained more stable with a BOD range of from a trace to 9.5 ppm and a mean of 3.7 ppm. The Main Creek varied from the first station to the second station from a mean of 5.4 ppm to a mean of 3.4 ppm. The BOD of the Main Creek varied more than it did in the North Fork but less than it did in the South Fork.

* The accepted minimal dissolved oxygen concentration for a warmwater fish habitat is 5.0 ppm Doudoroff & Shumway (1967) and Tarzwell (1957).

Ammonium nitrates in the South Fork usually remained below 1.00 ppm except for the area below Town Branch, the source of pollution, on the South Fork. Below Town Branch the ammonium nitrates increased to a high of 5.82 ppm. The North Fork and the Main Creek remained below 1.00 ppm throughout the study period.

Free carbon dioxide also indicated areas of pollution. Although it is normally a function of pH and alkalinity in moving waters, the concentration was substantially higher than normally expected below the source of pollution on the South Fork and even down through the first station on the Main Creek. The highest monthly concentration was recorded at 2 South in October of 1968 with a reading of 17.5 ppm.

Total alkalinity and pH seemed to remain fairly constant throughout the stream during this study. The alkalinity varied from 83 ppm to 237 ppm and the pH remained between 7.0 and 8.6 at all stations.

Stream temperatures varied according to the season of the year and the distance transversed by the stream except that the area immediately below the source of pollution on the South Fork remained from 1 to 4 degrees warmer than either of the other two stations on the South Fork during the warmer months.

BOTTOM FAUNA

South Fork Elkhorn Creek

The composition of the bottom fauna of the South Fork is presented in Tables 8 - 13.

The type and quantity of the bottom fauna of the South Fork reflects the degree of pollution and the distance of the sampling station from the source of pollution. As with most pollution, there is a zone of pollution and a zone of recovery for each biologically degradable pollutant. Sampling

station 1 South is above the main source of pollution, station 2 South is the first station below where the pollution enters the South Fork and station 3 South is 27 miles downstream from where the pollution enters the South Fork in the zone of recovery for the bottom fauna. The station above the major source of pollution (1 South) contained an average of 163 organisms per square foot which weighed 7,274 milligrams whereas the station immediately below the source of pollution (2 South) contained an average of 666 organisms which weighed only 2,224 milligrams. The furthest station below the pollution (3 South) contained an average of 364 organisms or 8,641 milligrams. By the time the pollution had reached 3 South the stream had begun to recover from the major effects of the pollution which were present at 2 South.

Graphic representation of Trichoptera, Ephemeroptera, Coleoptera, Isopoda, Diptera and Annelida collected on the South Fork is presented in Tables 18 - 23 and illustrates the monthly changes in the three stations as well as the difference between stations. Ephemeroptera, Coleoptera, Trichoptera and Isopoda are organisms which survive better in unpolluted water and Diptera is a representative of an organism which survives well in a partially polluted environment. Annelida is the main representative of the pollution indicators and they are usually abundant in areas of domestically polluted waters.

Ephemeroptera and Coleoptera were more abundant in the unpolluted station 1 South than at either of the other two stations although they were present in substantial numbers at 3 South. Trichoptera and Isopoda were more abundant in the recovery station of 3 South than they were in relatively unpolluted station 1 South. Diptera were also more abundant in the recovery station 3 South than in 1 South. All five types of organisms were almost absent from the heavily polluted station 2 South. The bottom fauna of station 2 South was predominantly Annelida, primarily sewage worms *Tubifex*, which comprised

over 97% of all organisms collected. Almost no Annelida were collected above the main source of pollution (1 South) and relatively few of these organisms were collected in the recovery area (3 South).

Both Coleoptera and Trichoptera accounted for 22% of the organisms in the unpolluted station, 1 South. Diptera accounted for 17% of the organisms, Gastropoda 16% and Ephemeroptera 14%. Although Decapoda comprised only 1% of the organisms, they comprised 49% of the weight and Gastropoda accounted for an additional 42%.

Annelida accounted for 97% of the organisms at station 2 South and 67% of the weight. *Tubifex* comprised an average of 643 organisms per sample or approximately 52% of the total weight. Amphipoda was present only during January, February and March after which they were not collected again. No leeches were collected during these months, however, leeches appeared in May and were collected through November.

At station 3 South, the stream had begun to recover somewhat from the effects of the pollution present at station 2 South. Diptera were present in large numbers early in the year with a monthly high occurring in May of 690 organisms per square foot. They accounted for 30% of the total organisms. Trichoptera averaged 83 organisms per sample or 23% of the organisms while Isopoda accounted for an additional 12% and Gastropoda 10%. A total of 47% of the weight was composed of Gastropoda, 26% was Decapoda and 10% was Pelecypoda.

North Fork Elkhorn Creek

The composition of the bottom fauna of the North Fork is presented in Tables 14 - 17.

The North Fork is relatively free of pollution and therefore the bottom fauna remained fairly constant. The yearly average between the two stations

was approximately equal in the total number of organisms, 215 at 1 North and 193 at 2 North. The average weight however, reflects the larger Pelecypoda collected at 2 North. The average weight at 1 North was 4,280 milligrams per square foot while the average weight at 2 North was 16,255 milligrams.

Graphic representation of Trichoptera, Ephemeroptera, Coleoptera, Isopoda, Diptera and Annelida is presented in Tables 24 - 29. Although there is little difference between the two stations, the graphs may be compared to the South Fork for the same organisms.

Gastropoda comprised 53% of the weight at 1 North while 55% of the weight at 2 North was composed of Pelecypoda. Trichoptera accounted for 25% of the bottom fauna at 1 North, Coleoptera 20%, Diptera 18%, Ephemeroptera 15% and Gastropoda 10%. At 2 North, 34% of the bottom fauna was Gastropoda, 15% Coleoptera, 14% Pelecypoda, 13% Diptera, 12% Trichiptera and 9% Ephemeroptera.

FISH POPULATION STUDIES

South Elkhorn Creek

Three stations totaling 6.69 surface acres were sampled in 1968 and 1969 on the South Fork. A total of 28 species were collected during the study period (Table 30). Sampling station 1 South is above the main source of pollution, Town Branch, however it still receives some pollution as evidenced by the low production and composition of the fish population present at this station. The standing crop of 1 South consisted of 426 fish per surface acre which weighed only 17 pounds. Only one largemouth bass, *Micropterus salmoides* (Lacepede), was collected during both years. Rock bass, *Ambloplites rupestris* (Rafinesque) represented less than 1/2 of 1% of the fish population and bluegill sunfish, *Lepomis macrochirus* Rafinesque, represented only 4%. White suckers, *Catostomus commersoni* (Lacepede), comprised 4% of the fish but they accounted for 42% of the weight. A total of 80% of the population was comprised of cyprinids.

Sampling station 2 South which is below the source of pollution was located below an 8 foot dam. Above the dam where the water samples were collected in 1969, four mosquitofish, *Gambusia affinis* (Baird and Girard), and one two-inch bluegill sunfish were observed in June of 1969 at the water's surface. These fish were in distress at that time apparently from the lack of oxygen. Below the dam where the dissolved oxygen concentration is higher, the standing crop of fish consisted of only 62 fish per acre which weighed 4 pounds. Panfish were represented by 17 fish per acre. White suckers comprised 27% of the fish (17 fish) or 69% of the weight. Commercial fish including white suckers accounted for 72% of the total weight. Forage fish comprised the remaining 44% of the population. There were no game fishes.

Sampling station 3 South, the station in the area of recovery for the bottom fauna, was not in the recovery area for the fish population as it contained only 100 fish per acre which weighed only 5 pounds. The fish population at this station had not improved much from 2 South even though both largemouth bass and smallmouth bass, *Micropterus dolomieui* (Lacepede), were collected at this station. Black basses represented only 1% of the total population. Panfish comprised over 24% of the population and 44% of the weight while commercial fish represented only 8% of the population and 28% of the weight. The remaining 67% of the standing crop was forage fish.

The average standing crop of fishes for the South Fork was 120 fish per acre or 6.0 pounds, Table 31. The average standing crop for the portion of the South Fork below the mouth of Town Branch, the source of pollution, however, was composed of only 84 fish per acre of 4.7 pounds, Table 32.

Main Elkhorn Creek

Two sampling stations totaling 6.25 surface acres were sampled on the Main Creek in 1969. A total of 26 species were collected, Table 30. The

average standing crop was 164 fish per acre or 91 pounds, Table 33. Game fishes, which included largemouth bass and smallmouth bass, comprised 12% of the total population. Of the 20 basses collected, 6 were over 10 inches or legal size fish. Panfishes comprised only 7% of the population of which only 4 fish were harvestable, six inches or greater. Commercial fishes comprised 42% of the population and 77% of the weight. Forage fishes comprised the remaining 39% of the population.

The large representation of commercial fishes was due to the large population of these fish collected at station 1 Main, 109 fish per acre of 124 pounds. The primary commercial species collected at 1 Main was golden redhorse, *Moxostoma erythrurum* (Rafinesque).

North Fork Elkhorn Creek

Two sampling stations on the North Fork were sampled both in 1968 and 1969 during which 35 species were collected, Table 30. The average fish population consisted of 792 fish per acre which weighed 78 pounds, Table 34. A little over 3% of the population was composed of game fish which included not only largemouth bass and smallmouth bass but both black crappie, *Pomoxis annularis* Rafinesque, and white crappie, *Pomoxis nigromaculatus* (LeSueur). Similar to the Main Creek, the North Fork contained a substantial population of harvestable black basses per surface acre. Panfishes were well represented in the North Fork too, representing 19% of the population. Harvestable rock bass, six inches or greater, accounted for 28 fish per acre or 8.5 pounds. Commercial fishes comprised 11% of the population and forage fishes accounted for the remaining 67%.

Rainbow trout, *Salmo gairdneri* Richardson, were stocked at station 1 North in 1969 which caused an increase in the fishing pressure at that location. This increased fishing pressure resulted in a reduction of harvestable

sized rock bass and smallmouth bass at this station. It is probable that a larger population of these fish would have been collected at this station had it not been chosen for a stocking site for trout.

Discussion of Population Studies

The North and South Forks are geologically identical streams. If it was not for the complete disregard for the South Fork by just about everyone who lives along the stream and the discharge of municipal sewage effluents into the stream, the two forks should contain approximately the same fish population. However, the South Fork is grossly polluted, and the effect of this pollution is reflected by its fish population.

The North Fork contains an average of 792 fish per acre but the South Fork supports only an average of 120 fish. The weight per acre decreases from 78 pounds to 6 pounds, respectively. Excluding station 1 South because it is above the main source of pollution from the fish population estimates, the standing crop of the polluted area of the South Fork below Town Branch averages only about 84 fish per acre (4.7 pounds) or about 0.1 of that found in the North Fork.

Goldfish, *Carassius auratus* (Linnaeus), carp, *Cyprinus carpio* Linnaeus, blacknose dace, *Rhinichthys atrathus* (Hermann), brown bullhead, *Ictalurus nebulosus* (LeSueur) and mosquitofish were collected only in the South Fork. The North Fork in contrast contained 18 species not collected in the South Fork and the Main Creek contained six species not found in either the North or South Forks.

SUMMARY

The North and South Forks of Elkhorn Creek are comparable streams geologically, however, because of the pollution of the South Fork, the streams no longer support the same biological environments. The South Fork was at one

time an excellent smallmouth bass fishing stream but the city of Lexington located their sewage treatment plant on one of its tributaries and thus began the degradation of the entire South Fork. Although there are other sources of pollution on this stream, Lexington remains the main source of pollution as they discharge their effluents into Town Branch, a tributary of the South Fork. Even above Town Branch there is a general disregard for the South Fork as it receives all types of pollution along its entire length.

Although the North Fork does not receive as much pollution as the South Fork, it does receive some pollution from Georgetown and other smaller towns along its banks. The Main Creek receives the pollution of the South Fork but its effects are ameliorated somewhat by the recovery of the South Fork and the diluting effects of the North Fork.

The water quality studies on the creek define the areas of heavy pollution and indicate at least in part the reason for the lack of a fisheries in the polluted areas. The dissolved oxygen below Town Branch decreased to a low of 0.4 ppm which is lethal to most fish life. The dissolved oxygen in the unpolluted portions of Elkhorn rarely decreased below 5.0 ppm and it never decreased below 4.5 ppm. The BOD in the polluted area of the South Fork had a mean value of 12.8 ppm with a monthly high of 30.0 ppm. In contrast, the mean BOD for the North Fork was 3.7 ppm. Ammonium nitrates averaged about 0.12 to 0.21 ppm in the North Fork however, in the polluted area of the South Fork the ammonium nitrates averaged 0.56 ppm with a high of 5.82 ppm. Free carbon dioxide differed from a mean of 4.6 ppm in the North Fork to a mean of 7.5 ppm in the polluted area of the South Fork. The highest monthly value recorded in the polluted area of the South Fork was 17.5 ppm.

The bottom fauna of the South Fork was drastically altered by the effects of the pollution. The bottom fauna of the station immediately below the pollution was composed almost entirely of *Tubifex* worms indicating the large

amount of sewage. The stream at 3 South, the station furthest from the pollution on the South Fork, had begun to recover from the effects of the pollution although some effects remained. Stations 1 and 3 South, above and downstream from the pollution, contained a variety of organisms unlike 2 South which contained almost only one type of organism, sewage worms.

The fish population of the polluted area of the South Fork is approximately one tenth of that of the North Fork. The fish population of the polluted area of the South Fork was composed of only 84 fish per acre (4.7 pounds), but the North Fork in contrast contained 792 fish per acre which weighed 78 pounds. The Main Creek contained an average of 164 fish per acre (91 pounds). Smallmouth bass and largemouth bass were common in the Main creek and the North Fork but they were all but absent in the South Fork. Harvestable game fish accounted for six fish per acre in the Main Creek and five fish in the North Fork. Five species of fish were collected only in the South Fork but 12 species were collected only in the North Fork. The Main Creek contained 26 species, six of which were not collected in either the North Fork or the South Fork.

Because of the large amount of discharge of effluent released from Lexington through their sewage treatment facilities and the relatively small size of the South Fork, it seems apparent that the South Fork cannot assimilate such large amounts of sewage effluents from a secondary treatment facility. The discharge from Lexington exceeds the normal stream flow throughout the summer months when the effects of this type of pollution have their greatest effects. Until Lexington returns their effluents back into the Kentucky River where they get their water supply and where the effluents may be assimilated to a greater degree, the South Fork and Main Elkhorn Creek will not contain the fishable fishery that the stream is capable of supporting.

ACKNOWLEDGEMENTS

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A P P E N D I X

Table 1. Monthly physico-chemical analysis expressed in parts per million and degrees Fahrenheit for station 1 South (the unpolluted area) in 1968 and 1969.

Month	Oxygen		BOD		pH		Temp.		NH_3		Alkalinity		CO_2	
	1968	1969	1968	1969	1968	1969	1968	1969	1968	1969	1968	1969	1968	1969
Jan.	13.2	11.1	4.0	16.0	8.9	7.8	39	34	0.13	0.12	110	170	5.5	2.0
Feb.	11.1	11.2	5.0	19.9	7.3	7.9	44	41	0.05	0.15	89	145	3.5	4.0
March	12.1	10.9	5.5	1.0	8.0	7.6	41	42	0.37	0.06	100	156	2.5	4.0
April	10.1	9.3	0.5	7.5	8.6	7.6	54	52	0.02	0.14	90	156	4.0	3.5
May	8.2	9.5	3.0	11.0	7.4	7.5	60	53	0.01	0.20	100	147	3.5	3.0
June	6.9	5.2	0.5	7.0	7.5	7.3	64	66	0.01	0.22	106	169	5.0	3.0
July	5.9	4.6	3.0	5.5	7.2	7.3	71	73	0.01	0.38	118	162	8.5	7.0
Aug.	7.8	6.3	tr.	3.5	7.8	7.5	70	67	0.14	0.22	150	184	1.5	3.5
Sept.	6.4	5.9	2.5	5.0	8.2	7.4	68	68	0.16	0.08	180	197	6.0	3.0
Oct.	5.4	5.8	tr.	1.0	8.0	7.3	56	64	0.29	0.10	202	224	2.0	3.5
Nov.	7.5	8.7	6.0	1.5	7.6	7.2	49	44	0.24	0.10	205	202	4.5	5.0
Dec.	11.7	12.4	4.0	2.0	7.4	7.5	42	36	0.16	0.11	116	186	6.5	6.0
MEAN	8.9	8.4	2.8	6.7	7.8	7.5	55	53	0.13	0.16	136	175	4.4	4.0

Table 2. Monthly physico-chemical analysis expressed in parts per million and degrees Fahrenheit in the polluted area station 2 South in 1968 and 1969.

Month	Oxygen		BOD		pH		Temp.		NH_3		Alkalinity		CO_2	
	1968	1969	1968	1969	1968	1969	1968	1969	1968	1969	1968	1969	1968	1969
Jan.	9.9	10.2	5.0	20.5	7.8	7.5	40	34	0.16	0.49	118	200	8.5	3.2
Feb.	9.4	8.6	11.0	26.0	7.5	7.6	48	42	0.06	0.40	99	158	4.8	6.5
March	10.6	6.7	10.0	5.0	8.0	7.4	42	46	0.37	0.48	96	174	5.0	6.5
April	9.3	5.8	7.0	4.0	8.4	7.4	54	52	0.01	0.71	98	156	4.0	6.0
May	8.3	4.0	25.5	5.0	7.2	7.4	63	56	0.04	0.07	114	167	5.5	6.0
June	7.0	1.5	20.0	4.0	7.3	7.4	65	70	0.19	0.44	123	191	9.0	9.0
July	7.2	1.0	8.5	7.0	7.0	7.2	73	77	0.94	1.68	120	152	8.5	10.0
Aug.	8.0	1.6	8.0	4.5	7.7	7.2	73	72	1.31	0.30	156	188	6.0	6.5
Sept.	7.1	2.5	30.0	16.5	8.0	7.3	70	72	2.77	2.80	200	219	17.5	12.0
Oct.	6.9	0.8	4.5	12.5	7.8	7.4	62	65	0.56	0.14	210	237	4.5	8.0
Nov.	7.5	0.4	12.5	23.5	7.4	7.1	57	50	0.33	0.11	216	141	14.0	6.5
Dec.	9.9	5.4	17.5	18.0	7.2	7.4	42	41	0.74	0.12	184	190	4.5	7.0
MEAN	8.4	4.0	13.3	12.2	7.6	7.4	57	56	0.62	0.65	144	181	7.7	7.3

Table 3. Monthly physico-chemical analysis expressed in parts per million and degrees Fahrenheit downstream from the source of pollution at station 3 South in 1968 and 1969.

Month	Oxygen		BOD		pH		Temp.		NH_3		Alkalinity		CO_2	
	1968	1969	1968	1969	1968	1969	1968	1969	1968	1969	1968	1969	1968	1969
Jan.	12.0	12.5	2.0	10.0	7.8	7.4	38	34	0.28	0.15	114	190	6.5	6.0
Feb.	10.1	10.5	7.0	21.0	7.9	7.7	47	42	0.10	0.31	104	158	4.2	2.5
March	12.1	9.5	7.5	3.0	8.0	7.7	41	42	0.41	0.02	92	162	4.0	3.0
April	9.4	6.8	2.5	2.5	8.3	7.8	54	52	0.01	0.15	83	152	3.0	6.5
May	8.5	7.7	4.0	5.0	7.4	7.4	62	54	0.01	0.06	104	144	4.5	4.0
June	7.1	4.6	0.5	2.0	7.3	7.4	66	67	tr.	0.14	108	156	4.5	5.0
July	5.5	4.2	7.5	4.0	7.0	7.4	72	74	0.03	1.42	128	163	9.0	5.5
Aug.	6.9	5.4	2.0	5.5	8.2	7.2	71	67	0.16	0.21	135	174	2.5	5.0
Sept.	7.4	4.7	4.0	3.0	8.2	7.3	70	69	0.10	0.10	152	162	11.0	7.0
Oct.	5.6	2.4	1.0	1.0	7.8	7.3	56	63	0.75	0.88	166	184	4.5	9.0
Nov.	3.6	5.1	7.5	1.5	7.5	7.2	50	44	5.82	0.10	173	190	11.5	10.5
Dec.	10.0	8.0	7.0	1.0	7.3	7.3	40	36	0.15	0.12	166	180	5.5	6.0
MEAN	8.2	6.8	4.4	5.0	7.7	7.4	56	54	0.65	0.31	127	168	5.9	5.8

Table 4. Monthly physico-chemical analysis expressed in parts per million and degrees Fahrenheit for station 1 North in 1968 and 1969.

Month	Oxygen		BOD		pH		Temp.		NH_3		Alkalinity		CO_2	
	1968	1969	1968	1969*	1968	1969	1968	1969	1968	1969	1968	1969	1968	1969
Jan.	12.4	13.0	5.0	-	7.3	7.8	38	35	0.12	0.11	108	185	6.0	2.5
Feb.	11.1	12.3	5.5	-	6.9	7.8	42	42	0.17	0.18	100	155	3.5	5.0
March	12.4	12.7	7.0	-	8.0	7.6	40	43	0.38	0.05	90	161	2.0	3.5
April	10.1	9.2	2.5	-	8.4	7.5	53	52	0.01	0.19	92	154	4.5	3.5
May	8.0	7.5	4.0	-	7.4	7.3	61	55	0.01	0.04	98	142	2.0	5.5
June	6.4	5.4	0.5	-	7.8	7.6	65	66	0.01	0.24	116	178	4.0	4.5
July	7.6	4.8	3.5	-	7.2	7.4	68	73	0.06	0.11	146	180	8.5	3.5
Aug.	6.9	6.2	1.5	-	7.8	7.6	72	68	0.14	0.18	147	185	1.5	5.5
Sept.	6.7	6.2	4.0	-	8.6	7.6	66	68	0.04	0.06	197	194	8.0	5.5
Oct.	5.7	4.6	tr.	-	8.0	7.6	55	66	0.28	0.11	194	232	2.5	3.0
Nov.	5.7	9.3	9.5	-	8.0	7.0	55	46	0.28	0.10	194	220	2.5	6.5
Dec.	11.9	12.0	1.5	-	7.4	7.4	38	38	0.20	0.12	183	174	4.5	4.0
MEAN	8.7	8.6	3.7	-	7.7	7.5	54	54	0.13	0.12	139	182	4.1	4.4

* Not taken in 1969 because of low readings in 1968.

Table 5. Monthly physico-chemical analysis expressed in parts per million and degrees Fahrenheit for station 2 North in 1968 and 1969.

Month	Oxygen		BOD		pH		Temp.		NH_3		Alkalinity		CO_2	
	1968	1969	1968	1969*	1968	1969	1968	1969	1968	1969	1968	1969	1968	1969
Jan.	13.3	13.1	5.0	-	7.8	7.4	34	33	0.10	0.10	114	170	3.0	3.5
Feb.	11.5	11.7	1.5	-	7.7	7.6	44	41	0.06	0.18	100	156	5.0	3.5
March	12.2	11.4	8.5	-	7.8	7.7	40	42	0.38	0.06	90	166	13.2	2.5
April	9.6	10.0	1.0	-	8.5	7.6	54	51	0.01	0.11	88	172	5.0	6.0
May	8.8	9.1	3.5	-	7.6	7.4	62	54	0.01	0.10	108	148	2.5	6.5
June	7.2	8.2	2.5	-	7.9	7.6	67	71	tr.	0.24	116	170	4.5	3.0
July	7.3	5.4	5.5	-	7.9	7.4	72	78	0.15	0.48	131	138	8.5	7.5
Aug.	7.4	7.0	2.5	-	7.6	7.6	74	76	0.10	0.22	142	147	2.0	3.0
Sept.	7.0	7.1	4.5	-	8.4	7.6	66	72	0.14	0.03	199	166	8.5	3.5
Oct.	7.5	7.0	tr.	-	8.5	7.2	58	66	0.96	0.10	176	178	2.5	3.5
Nov.	8.2	11.1	5.5	-	7.7	7.2	50	47	0.26	0.09	192	186	8.5	3.5
Dec.	11.5	12.2	4.0	-	7.5	7.5	39	36	0.32	0.12	169	164	4.5	3.0
MEAN	9.3	9.4	3.7	-	7.9	7.5	55	56	0.21	0.15	135	158	5.6	4.1

* Not taken in 1969 because of low readings in 1968.

Table 6. Monthly physico-chemical analysis expressed in parts per million and degrees Fahrenheit at station 1 Main in 1969.

Month	Oxygen	BOD	pH	Temp.	NH_3	Alk.	CO_2
Jan.	14.0	7.0	7.5	33	0.23	184	4.0
Feb.	9.9	16.5	7.8	42	0.29	160	3.0
March	12.4	1.5	7.8	44	0.11	162	1.5
April	10.0	1.5	7.6	54	0.37	156	3.0
May	11.3	1.5	7.6	56	0.16	150	6.5
June	9.8	3.0	7.8	72	0.24	148	1.0
July	7.8	3.0	7.9	78	0.16	159	1.0
Aug.	7.2	tr.	7.6	74	0.26	148	3.0
Sept.	7.6	6.0	7.7	72	0.14	157	7.0
Oct.	7.0	1.5	7.2	68	0.50	148	7.5
Nov.	9.6	11.0	7.2	46	0.27	164	10.5
Dec.	13.9	12.0	7.6	38	0.20	168	3.0
MEAN	10.0	5.4	7.6	56	0.24	159	4.3

Table 7. Monthly physico-chemical analysis expressed in parts per million and degrees Fahrenheit at station 2 Main in 1969.

Month	Oxygen	BOD	pH	Temp.	NH_3	Alk.	CO_2
Jan.	14.6	6.0	7.4	33	0.12	183	5.0
Feb.	13.5	20.0	7.8	42	0.26	169	4.5
March	11.7	1.0	7.6	43	0.20	166	0.0
April	9.6	2.0	7.6	54	0.29	176	3.5
May	10.0	0.5	7.6	57	0.04	153	3.5
June	7.1	3.0	8.0	71	0.18	158	1.0
July	6.1	1.5	7.7	79	0.22	164	0.0
Aug.	7.0	0.5	7.6	74	0.26	160	3.0
Sept.	7.3	3.5	8.0	70	0.06	167	1.0
Oct.	7.5	1.0	7.2	67	0.44	166	5.5
Nov.	10.8	1.5	7.2	46	0.20	158	7.0
Dec.	14.1	tr.	7.8	37	0.12	204	3.0
MEAN	9.9	3.4	7.6	56	0.20	169	3.1

Table 8. Average numbers and weights in milligrams (italicized) per square foot of each type of organisms, excluding Decapoda (crayfish), Gastropoda (snails) and Pelecypoda (mussels) collected at station 1 South Fork of Elkhorn Creek in 1968.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Mean
	36	77	38	7	6	35	60	49	49	31	4	36
Trichoptera	*229*	*693*	*323*	*40*	*36*	*98*	*242*	*121*	*83*	*88*	*62*	*183*
	5	2	2	1	4	17						4
Plecoptera	*10*	*6*	*3*	*2*	*24*	*16*						*5*
	20	82	67	81	29	13	8	6	3	3	1	28
Diptera	*33*	*132*	*86*	*102*	*37*	*19*	*13*	*9*	*3*	*3*	*1*	*40*
	26	18	15	15	5	12	34	57	28	20	24	23
Ephemeroptera	*53*	*82*	*96*	*64*	*27*	*19*	*63*	*76*	*20*	*26*	*66*	*54*
			5					tr.	tr.		1	1
Odonata			*230*					*2*	*4*		*6*	*22*
	tr.	2	1	1		1	1	tr.	tr.	2	tr.	1
Megaloptera	*10*	*129*	*31*	*34*		*152*	*1*	*58*	*5*	*183*	*41*	*59*
	25	9		1	5	1	3				1	4
Annelida	*42*	*18*		*1*	*135*	*6*	*70*				*6*	*26*
	35	45	23	17	9	44	65	46	30	28	38	35
Coleoptera	*104*	*316*	*172*	*130*	*43*	*203*	*270*	*170*	*201*	*161*	*107*	*171*
	tr.	tr.			1				tr.	tr.	2	tr.
Amphipoda	*tr.*	*tr.*			*3*				*tr.*	*tr.*	*8*	*1*
	tr.				3		2	tr.	1		tr.	1
Isopoda	*4*				*25*		*3*	*1*	*4*		*tr.*	*3*
	147	235	161	123	62	123	173	158	111	84	71	132
TOTAL	*485*	*1,376*	*941*	*373*	*331*	*513*	*686*	*437*	*320*	*461*	*297*	*564*

Table 9. Average numbers and weights in milligrams (italicized) per square foot of Decapoda (crayfish), Gastropoda (snails) and Pelecypoda (mussels) at station 1 South Fork of Elkhorn Creek in 1968.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Mean
Decapoda	1 *5,967*	tr. *2,458*		tr. *7,433*	1 *10,125*	tr. *1,052*	1 *3,973*	1 *2,958*	1 *1,543*			1 *3,551*
Gastropoda	31 *4,158*	26 *3,116*	25 *3,834*	30 *3,968*	16 *2,660*	19 *2,624*	37 *2,817*	52 *5,367*	16 *1,573*	19 *1,807*	16 *1,828*	26 *3,068*
Pelecypoda	7 *384*	7 *83*	2 *82*	1 *17*	7 *319*	1 *2*	7 *88*	3 *7*	3 *6*	1 *4*		3 *91*
TOTAL	39 *10,509*	33 *5,667*	27 *3,916*	31 *11,418*	24 *13,104*	20 *3,678*	45 *6,878*	56 *8,332*	20 *3,126*	20 *1,811*	16 *1,828*	30 *6,710*

Table 10. Average numbers and weights in milligrams (italicized) per square foot of each type of organisms, excluding Decapoda (crayfish) and Gastropoda (snails), collected at station 2 South Fork of Elkhorn Creek in 1968.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Mean
	1					8	1	tr.	tr.			1
Trichoptera	*9*					*9*	*1*	*9*	*1*			*3*
	1	1	1		9	11	5	tr.	3	1	2	3
Diptera	*4*	*5*	*2*		*20*	*16*	*18*	*tr.*	*5*	*1*	*4*	*7*
						2		tr.	tr.		1	tr.
Ephemeroptera						*6*		*4*	*2*		*4*	*2*
						tr.						tr.
Odonata						*tr.*						*tr.*
					tr.	3	2	7	3	1	1	2
Annelida					*161*	*141*	*397*	*1,604*	*446*	*209*	*235*	*319*
	766	552	302		342	3,230	694	112	289	70	67	643
Tubifex	*1,579*	*2,260*	*999*		*1,071*	*3,295*	*1,241*	*198*	*450*	*218*	*276*	*1,159*
	tr.		1		tr.	1	1	tr.	tr.			tr.
Coleoptera	*1*		*2*		*tr.*	*1*	*1*	*3*	*1*			*1*
	2	29	48									8
Amphipoda	*48*	*409*	*943*									*140*
	tr.	2	1			6	6	8	1	7	9	4
Isopoda	*3*	*25*	*44*			*72*	*29*	*68*	*6*	*61*	*155*	*46*
	770	584	353		351	3,261	709	127	296	79	80	661
TOTAL	*1,644*	*2,699*	*1,990*		*1,252*	*3,540*	*1,687*	*1,886*	*910*	*489*	*674*	*1,677*

Table 11. Average numbers and weights in milligrams (italicized) per square foot of Decapoda (crayfish) and Gastropoda (snails) collected at station 2 South Fork of Elkhorn Creek in 1968.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Mean
Decapoda			tr. *973*					tr. *825*			tr. *3.207*	tr. *501*
Gastropoda						35 *163*	18 *151*	2 *144*		1 *2*		6 *46*
TOTAL			tr. *973*			35 *163*	18 *151*	2 *969*		1 *2*	tr. *3,207*	6 *547*

Table 12. Average numbers and weights in milligrams (italicized) per square foot of each type of organisms, excluding Decapoda (crayfish), Gastropods (snails) and Pelecypoda (mussels), collected at station 3 South Fork of Elkhorn Creek in 1968.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Mean
	127	58		3	13	77	123	201	79	35	114	83
Trichoptera	*1,308*	*918*		*38*	*130*	*371*	*515*	*697*	*203*	*124*	*558*	*486*
					5	3		1				1
Plecoptera					*39*	*6*		*1*				*5*
	206	138		5	690	13	5	5	3	9	12	109
Diptera	*488*	*508*		*3*	*1,686*	*20*	*7*	*9*	*3*	*8*	*15*	*275*
	6	3		1	4	16	4	62	50	43	32	22
Ephemeroptera	*5*	*3*		*1*	*39*	*40*	*67*	*107*	*82*	*81*	*78*	*50*
										tr.		tr.
Odonata										*3*		*tr.*
		tr.							tr.			tr.
Megaloptera		*4*							*4*			*1*
	4	7		7	10	12	7	8	8	5	14	8
Annelida	*40*	*772*		*108*	*861*	*814*	*56*	*69*	*129*	*35*	*220*	*310*
	11	9			43	6	9	6	12	4	11	11
Coleoptera	*25*	*24*			*140*	*17*	*15*	*15*	*24*	*4*	*22*	*29*
											1	tr.
Hemiptera											*3*	*tr.*
	6	6		4		123	3	52	40	14	48	30
Amphipoda	*141*	*146*		*147*		*96*	*4*	*35*	*27*	*18*	*76*	*69*
	28	17		10	9	92	70	40	58	21	73	42
Isopoda	*594*	*509*		*188*	*42*	*257*	*125*	*110*	*137*	*66*	*248*	*228*
	388	240		30	774	342	221	373	250	131	305	306
TOTAL	*2,561*	*2,384*		*485*	*2,937*	*1,621*	*789*	*1,043*	*609*	*339*	*1,220*	*1,453*

Table 13. Average numbers and weights in milligrams (italicized) per square foot of Decapoda (crayfish), Gastropoda (snails) and Pelecypoda (mussels) collected at station 3 South Fork of Elkhorn Creek in 1968.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Mean
Decapoda	1 *9,000*	tr. *464*		1 *1,029*	1 *5,518*	2 *3,498*	1 *150*	tr. *79*	1 *413*	tr. *1,851*	tr. *529*	1 *2,253*
Gastropoda	22 *909*	8 *1,398*		21 *3,540*	17 *1,373*	63 *6,165*	59 *4,982*	44 *4,201*	25 *2,458*	47 *5,268*	74 *10,207*	38 *4,050*
Pelecypoda	46 *1,062*	44 *1,018*		1 *24*	9 *224*	8 *458*	6 *271*	7 *502*	13 *440*	7 *708*	51 *4,146*	19 *885*
TOTAL	69 *10,971*	52 *2,880*		23 *4,593*	27 *7,115*	73 *10,121*	66 *5,403*	51 *4,782*	39 *3,311*	54 *7,827*	125 *14,882*	58 *7,188*

Table 14. Average numbers and weights in milligrams (italicized) per square foot of each type of organisms, excluding Decapoda (crayfish), Gastropoda (snails) and Pelecypoda (mussels), collected at station 1 North Fork of Elkhorn Creek.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Mean
	10	33	138		49	23	51	71	21	69	65	53
Trichoptera	*77*	*204*	*860*		*365*	*90*	*126*	*195*	*56*	*200*	*393*	*257*
	21	11	21		7	1	1			1		6
Plecoptera	*48*	*16*	*75*		*40*	*2*	*tr.*			*1*		*18*
	17	80	223		15	3	21	3	3	13	3	38
Diptera	*31*	*91*	*280*		*96*	*8*	*12*	*4*	*3*	*16*	*6*	*55*
	3	34	18		20	15	100	35	65	27	12	33
Ephemeroptera	*23*	*160*	*108*		*78*	*31*	*72*	*73*	*37*	*35*	*51*	*67*
		tr.			1				tr.	1	1	tr.
Odonata		*6*			*11*				*4*	*7*	*2*	*3*
	tr.	9	11		1	1	1	4	2	1		3
Annelida	*5*	*187*	*217*		*22*	*2*	*2*	*32*	*65*	*1*		*53*
								tr.		tr.		tr.
Lepidoptera								*tr.*		*2*		*tr.*
	13	87	75		23	33	39	58	37	46	31	44
Coleoptera	*44*	*138*	*330*		*137*	*198*	*96*	*144*	*144*	*134*	*88*	*145*
						tr.			1		tr.	tr.
Hemiptera						*tr.*			*3*		*1*	*tr.*
		tr.							1			tr.
Amphipoda		*1*							*1*			*tr.*
		2			3	1	2	1	tr.		1	1
Isopoda		*12*			*6*	*3*	*1*	*3*	*tr.*		*8*	*3*
			3					2		3	2	1
Planaria			*18*					*4*		*6*	*14*	*4*
	64	254	489		119	77	214	174	129	160	115	179
TOTAL	*228*	*810*	*1,988*		*753*	*334*	*309*	*455*	*310*	*399*	*657*	*605*

Table 15. Average numbers and weights in milligrams (italicized) per square foot of Decapoda (crayfish), Gastropoda (snails) and Pelecypoda (mussels) at station 1 North Fork of Elkhorn Creek in 1968.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Mean
Decapoda	1 *1,452*	1 *3,583*	2 *1,399*			1 *115*	tr. *33*	1 *128*		1 *829*		1 *755*
Gastropoda	18 *676*	13 *1,205*	6 *823*		11 *1,316*	28 *2,944*	35 *4,049*	34 *3,404*	46 *6,046*	12 *1,420*	5 *676*	21 *2,256*
Pelecypoda	7 *60*	25 *1,015*	50 *1,455*		5 *223*	8 *557*	14 *741*	13 *279*	16 *1,986*	3 *289*	2 *38*	14 *664*
TOTAL	26 *2,188*	39 *5,803*	58 *3,677*		16 *1,539*	37 *3,616*	49 *4,823*	48 *3,811*	62 *8,032*	16 *2,538*	7 *714*	36 *3,675*

Table 16. Average numbers and weights in milligrams (italicized) per square foot of each type of organisms, excluding Decapoda (crayfish), Gastropoda (snails) and Pelecypoda (mussels), collected at station 2 North Fork of Elkhorn Creek in 1968.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Mean
	24	11				30	34	39	8	18	41	23
Trichoptera	*285*	*120*				*104*	*116*	*163*	*32*	*116*	*326*	*140*
		tr.			2	3	tr.			2		1
Plecoptera		*tr.*			*10*	*4*	*3*			*1*		*2*
	73	126				5	2	9	3	3	6	25
Diptera	*150*	*145*				*7*	*1*	*9*	*3*	*4*	*8*	*47*
	tr.				1	4	31	29	21	38	31	17
Ephemeroptera	*1*				*7*	*28*	*72*	*52*	*26*	*62*	*48*	*33*
	10	23			1	3	tr.	1		tr.		4
Annelida	*23*	*20*			*3*	*9*	*tr.*	*5*		*tr.*		*7*
										tr.		tr.
Lepidoptera										*1*		*tr.*
	49	50			1	23	29	29	16	25	32	28
Coleoptera	*88*	*101*			*1*	*50*	*125*	*47*	*52*	*52*	*49*	*63*
								1				tr.
Hemiptera								*4*				*2*
	2						tr.	tr.		1		tr.
Amphipoda	*8*						*tr.*	*tr.*		*1*		*1*
	3	1			1	3	4	2	3	1	1	2
Isopoda	*74*	*16*			*3*	*13*	*8*	*5*	*6*	*3*	*4*	*15*
	161	211			6	71	100	110	51	85	111	100
TOTAL	*619*	*502*			*24*	*214*	*325*	*285*	*119*	*277*	*435*	*310*

Table 17. Average numbers and weights in milligrams (italicized) per square foot of Decapoda (crayfish), Gastropoda (snails) and Pelecypoda (mussels) collected at station 2 North Fork of Elkhorn Creek in 1968.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Mean
Decapoda		tr. *852*			1 *834*	1 *69*	1 *4,621*	2 *8,104*	1 *478*	tr. *428*	1 *698*	1 *1,787*
Gastropoda	48 *2,384*	9 *3,717*			4 *491*	21 *1,918*	114 *8,342*	54 *3,771*	127 *8,706*	162 *11,823*	45 *5,631*	65 *5,198*
Pelecypoda	71 *4,566*	39 *4,221*			7 *29,613*	5 *22,775*	2 *2,122*	21 *2,135*	30 *4,796*	51 *8,370*	20 *2,042*	27 *8,960*
TOTAL	119 *6,950*	48 *8,790*			12 *30,938*	27 *24,762*	117 *15,085*	77 *14,010*	158 *13,980*	213 *20,621*	66 *8,371*	93 *15,945*

Table 18. Comparison of the monthly sampling of Trichoptera collected per square foot at 1 South (unpolluted), 2 South (immediately below the pollution) and 3 South (downstream from the pollution).

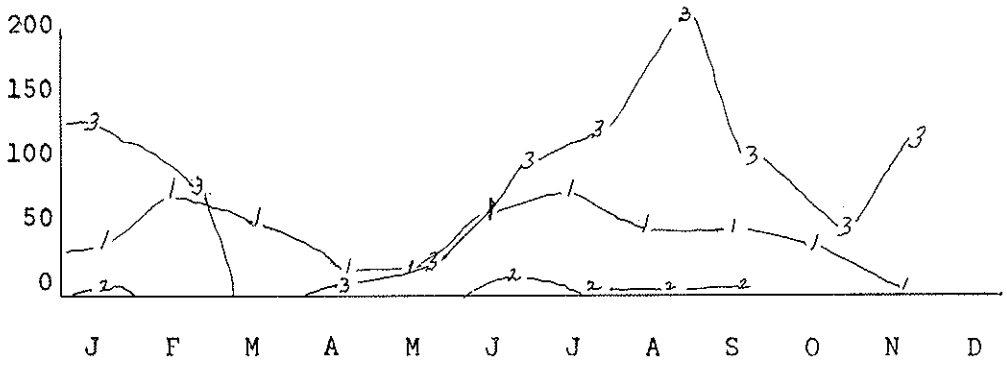

Table 19. Comparison of the monthly sampling of Ephemeroptera collected per square foot at 1 South (unpolluted), 2 South (immediately below the pollution) and 3 South (downstream from the pollution).

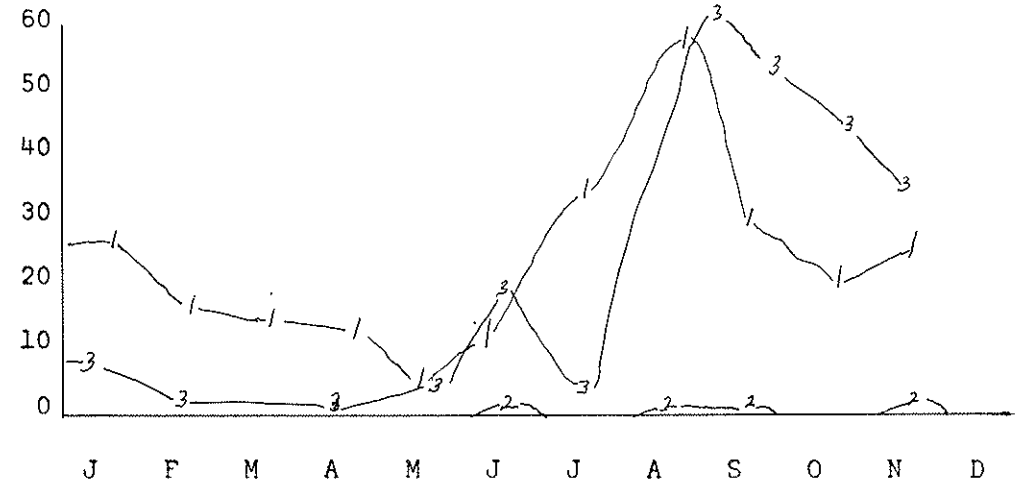

Table 20. Comparison of the monthly sampling of Annelida collected per square foot at 1 South (unpolluted), 2 South (immediately below the pollution) and 3 South (downstream from the pollution).

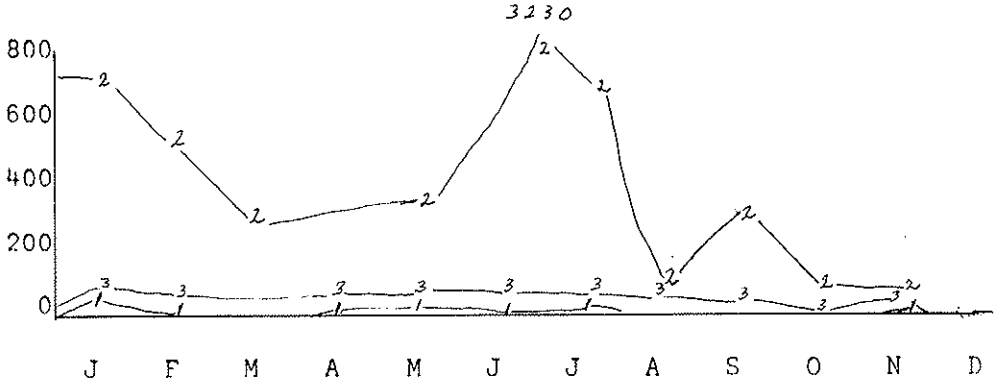

Table 21. Comparison of the monthly sampling of Coleoptera collected per square foot at 1 South (unpolluted), 2 South (immediately below the pollution) and 3 South (downstream from the pollution).

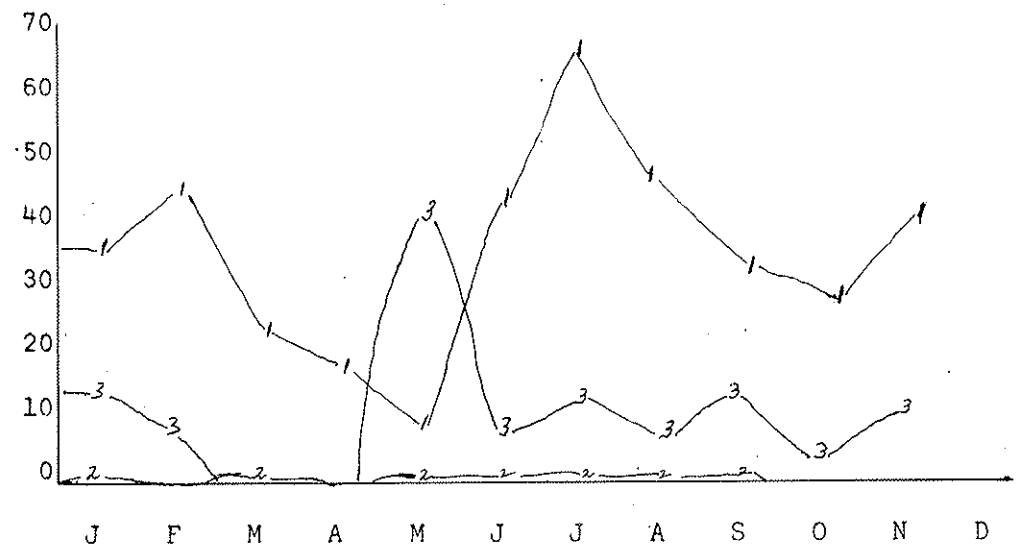

Table 22. Comparison of the monthly sampling of Isopoda collected per square foot at 1 South (unpolluted), 2 South (immediately below the pollution) and 3 South (downstream from the pollution).

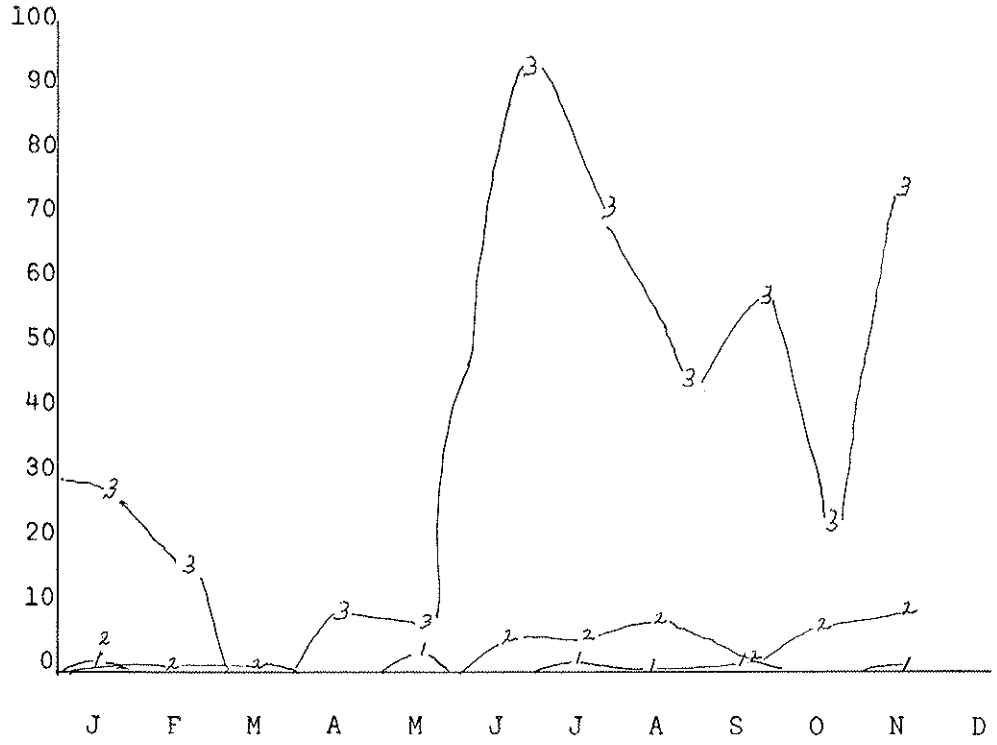

Table 23. Comparison of the monthly sampling of Diptera collected per square foot at 1 South (unpolluted), 2 South (immediately below the pollution) and 3 South (downstream from the pollution).

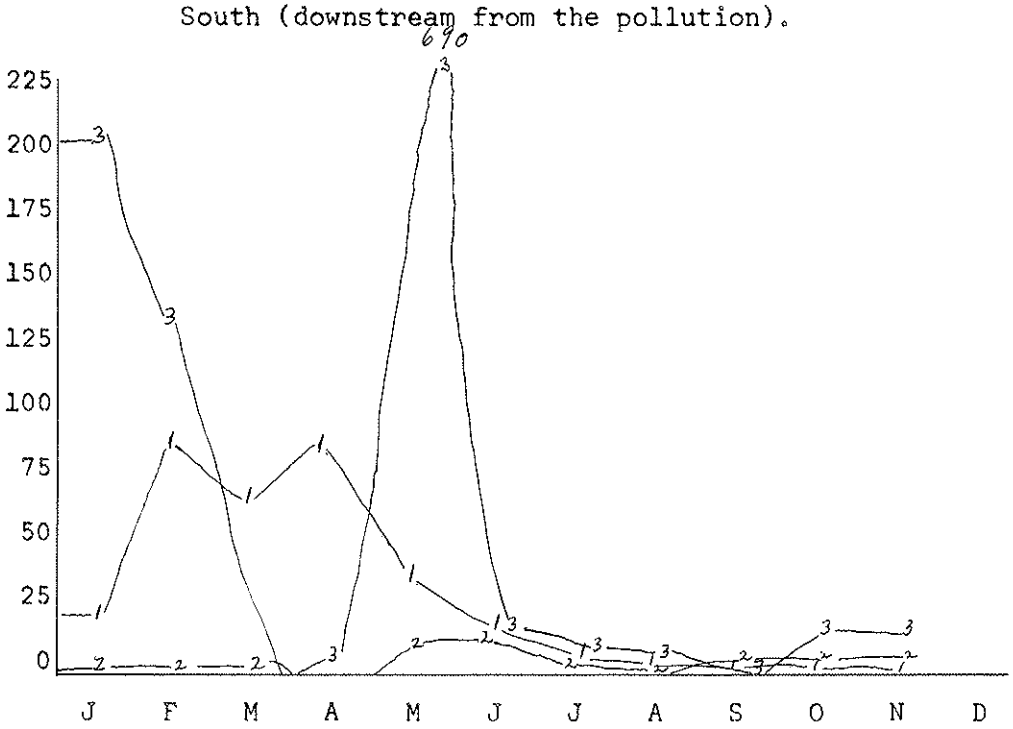

Table 24. Comparison of monthly sampling of Trichoptera collected per square foot at 1 and 2 North in 1968.

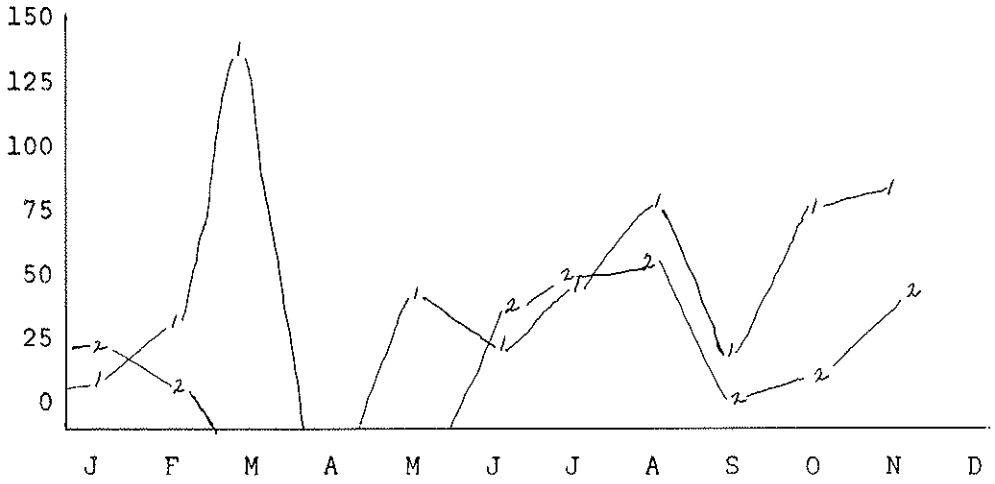

Table 25. Comparison of monthly sampling of Ephemeroptera collected per square foot at 1 and 2 North in 1968.

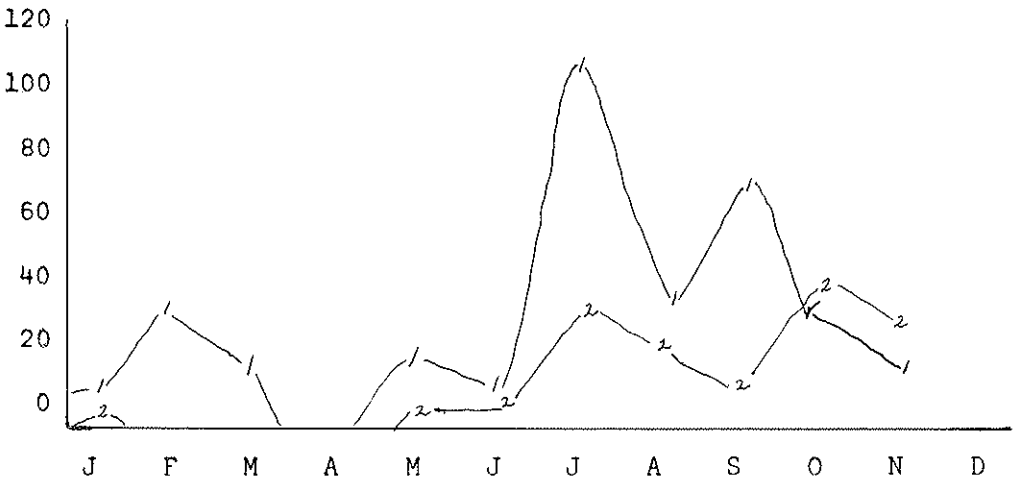

Table 26. Comparison of monthly sampling of Annelida collected per square foot at 1 and 2 North in 1968.

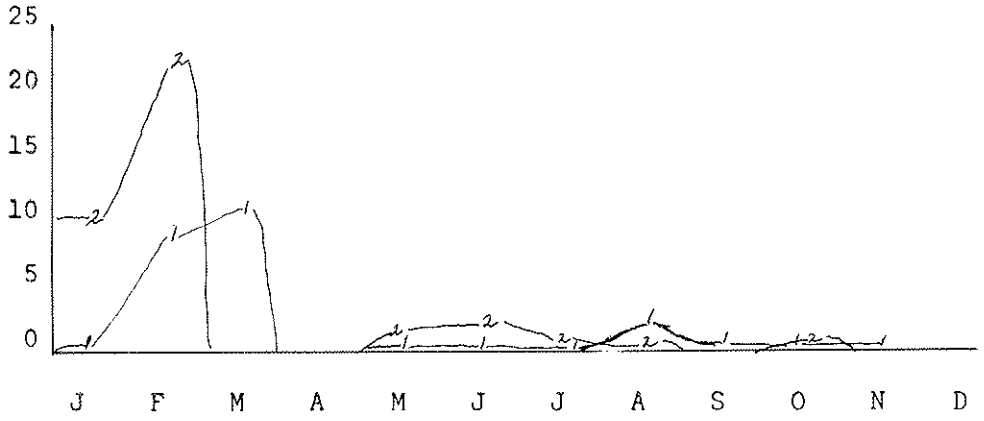

Table 27. Comparison of monthly sampling of Coleoptera collected per square foot at 1 and 2 North in 1968.

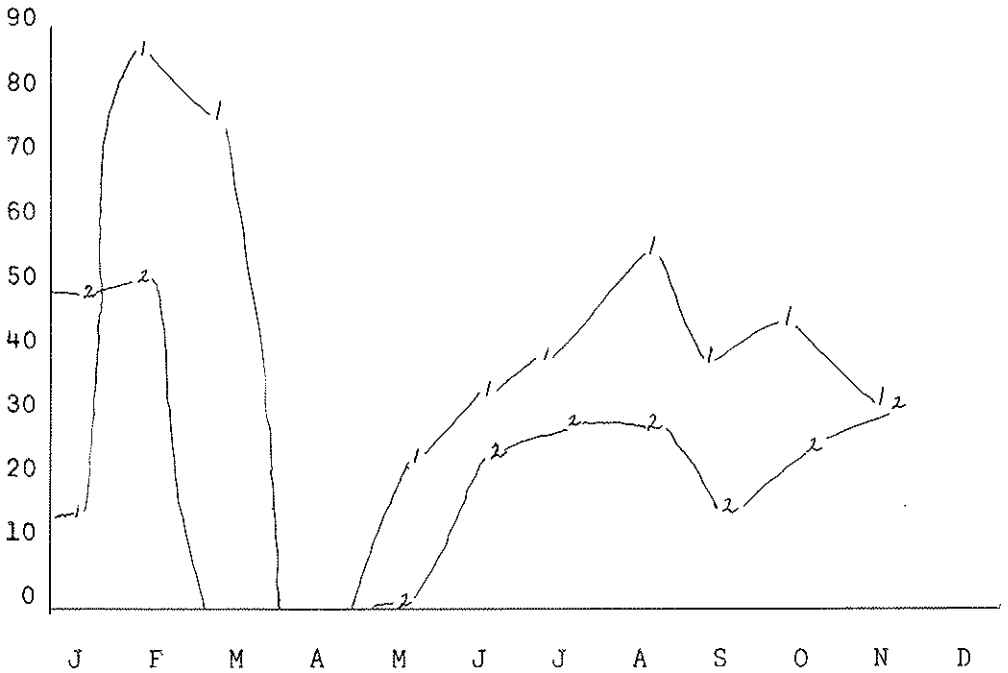

Table 28. Comparison of monthly sampling of Isopoda collected per square foot at 1 and 2 North in 1968.

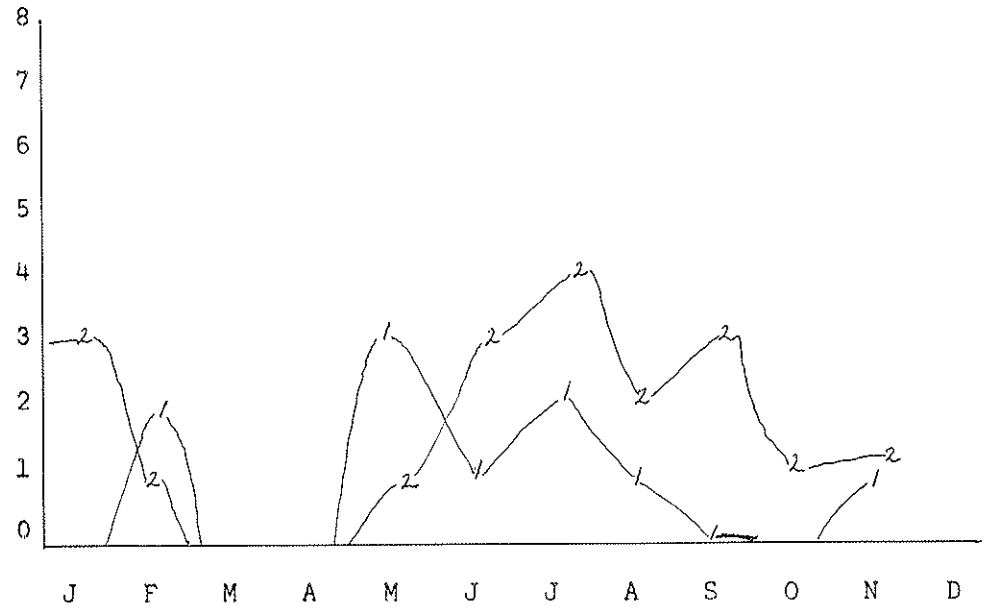

Table 29. Comparison of monthly sampling of Diptera collected per square foot at 1 and 2 North in 1968.

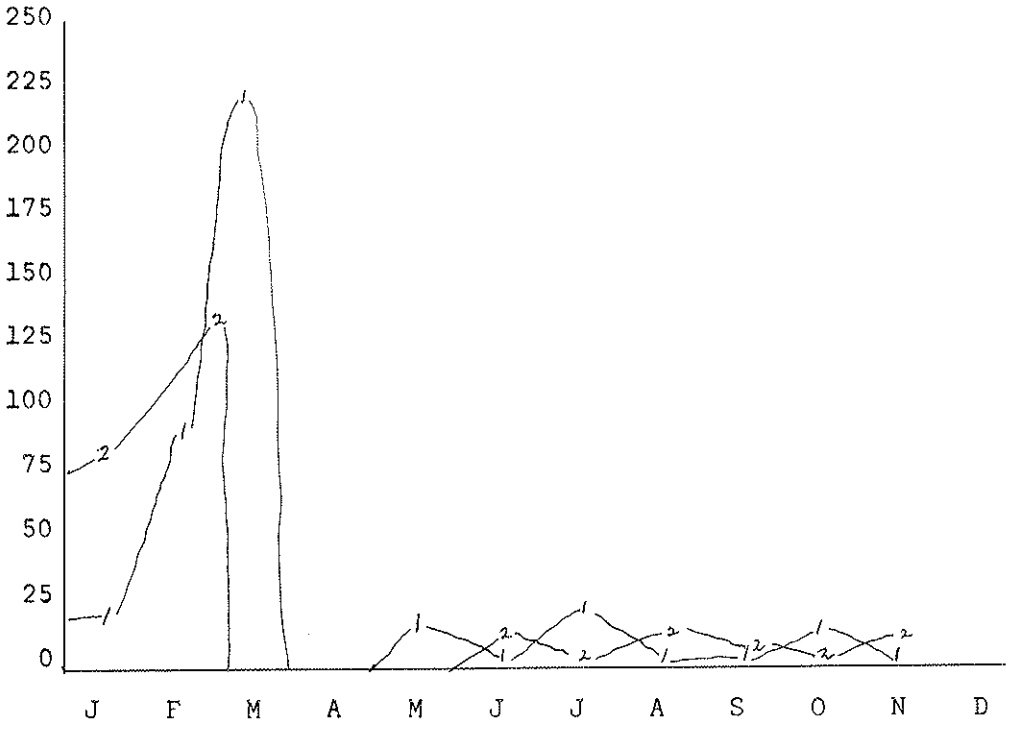

Table 30. Species collected in the South Fork (S), North Fork (N) and Main Creek (M) during 1968 and 1969 population studies.

			LEPISOSTEIDAE	
		M	*Lepisosteus osseus* (Linnaeus)	Longnose gar
			CLUPEIDAE	
		M	*Dorosoma cepedianum* (LeSueur)	Gizzard shad
			HIODONTIDAE	
		M	*Hiodon tergisus* LeSueur	Mooneye
			CYPRINIDAE	
S	N	M	*Campostoma anomalum* (Rafinesque)	Stoneroller
S			*Carassius auratus* (Linnaeus)	Goldfish
S			*Cyprinus carpio* Linnaeus	Carp
	N		*Hybopsis amblops* (Rafinesque)	Bigeye chub
S	N		*Hybopsis biguttata* (Kirtland)	Hornyhead chub
S		M	*Hybopsis micropogon* (Cope)	River chub
	N		*Notemigonus crysoleucas* (Mitchill)	Golden shiner
S	N	M	*Notropis ardens* (Cope)	Rosefin shiner
	N	M	*Notropis atherinoides* Rafinesque	Emerald shiner
S	N	M	*Notropis cornutus* (Mitchill)	Common shiner
	N	M	*Notropis photogenis* (Cope)	Silver shiner
	N		*Notropis volucellus* (Cope)	Mimic shiner
	N	M	*Notropis whipplei* (Girard)	Steelcolor shiner
S	N	M	*Pimephales notatus* (Rafinesque)	Bluntnose minnow
S			*Rhinichthys atratulus* (Hermann)	Blacknose dace
S	N		*Semotilus atromaculatus* (Mitchill)	Creek chub
			CATOSTOMIDAE	
		M	*Carpiodes carpio* (Rafinesque)	River carpsucker
S	N		*Catostomus commersoni* (Lacepede)	White sucker
S	N	M	*Hypentelium nigricans* (LeSueur)	Northern hog sucker
	N		*Moxostoma carinatum* (Cope)	River redhorse
S	N	M	*Moxostoma erythrurum* (Rafinesque)	Golden redhorse
			ICTALURIDAE	
	N		*Ictalurus melas* (Rafinesque)	Black bullhead
	N		*Ictalurus natalis* (LeSueur)	Yellow bullhead
S			*Ictalurus nebulosus* (LeSueur)	Brown bullhead
		M	*Ictalurus punctatus* (Rafinesque)	Channel catfish
			POECILIIDAE	
S			*Gambusia affinis* (Baird and Girard)	Mosquitofish
			CENTRARCHIDAE	
S	N	M	*Ambloplites rupestris* (Rafinesque)	Rock bass
	N		*Chaenobryttus gulosus* (Cuvier)	Warmouth
S	N		*Lepomis cyanellus* Rafinesque	Green sunfish
S	N	M	*Lepomis macrochirus* Rafinesque	Bluegill
S	N	M	*Lepomis megalotis* (Rafinesque)	Longear sunfish

Table 30. (continued)

			CENTRARCHIDAE (continued)	
S	N	M	*Micropterus dolomieui* Lacepede	Smallmouth bass
S	N	M	*Micropterus salmoides* (Lacepede)	Largemouth bass
	N		*Pomoxis annularis* Rafinesque	White crappie
	N		*Pomoxis nigromaculatus* (LeSueur)	Black crappie
		M	*Lepomis microlophus* (Gunther)	Redear sunfish
S	N	M	*Lepomis* sp. x sp.	Hybrid sunfish
			PERCIDAE	
	N	M	*Etheostoma blennioides* Rafinesque	Greenside darter
S	N	M	*Etheostoma flabellare* Rafinesque	Fantail darter
	N		*Etheostoma nigrum* Rafinesque	Johnny darter
	N	M	*Percina caprodes* (Rafinesque)	Logperch
	N		*Percina maculata* (Girard)	Blackside darter
			SCIAENIDAE	
		M	*Aplodinotus grunniens* Rafinesque	Freshwater drum
			COTTIDAE	
S	N		*Cottus carolinae* (Gill)	Banded sculpin
			ATHERINIDAE	
	N		*Labidesthes sicculus* (Cope)	Brook silverside

Table 31. The fish population composition of the South Fork of Elkhorn Creek in 1968 and 1969.

SPECIES	FINGERLING SIZE Range inches	Number per acre	Pounds per acre	INTERMEDIATE SIZE Range inches	Number per acre	Pounds per acre	HARVESTABLE SIZE Minimum length inches	Number per acre	Pounds per acre
GAME FISHES									
Largemouth bass	0-4	0.1	tr.	5-9	0.3	0.03	10	-	-
Smallmouth bass	0-4	-	-	5-9	0.1	0.02	10	0.1	0.03
TOTAL		0.1	tr.		0.4	0.05		0.1	0.03
PANFISHES									
Rock bass	0-2	0.1	tr.	3-5	0.2	0.01	6	0.7	0.28
Bluegill	0-2	1.2	0.01	3-5	9.0	0.45	6	2.8	0.51
Green sunfish	0-2	0.1	tr.	3-5	2.0	0.11	6	0.1	0.03
Longear sunfish	0-2	0.4	0.01	3-5	6.8	0.38	6	0.5	0.09
Hybrid sunfish	0-2	1.0	0.02	3-5	0.6	0.03	6	0.1	0.02
TOTAL		2.8	0.04		18.6	0.97		4.3	0.92
COMMERCIAL FISHES									
Hogsucker	0-4	-	-	5-11	0.1	0.06	12	-	-
White sucker	0-4	2.2	0.04	5-11	9.0	1.70	12	0.7	0.71
Carp	0-4	-	-	5-11	0.1	0.01	12	0.1	0.03
Bullheads	0-4	-	-	5-8	0.1	0.01	9	0.1	0.04
TOTAL		2.2	0.04		9.3	1.78		0.8	0.78
							ABOVE FORAGE SIZE		
FORAGE FISHES									
Misc. cyprinids	0-3	62.0	0.61	4-7	17.9	0.73	8	0.1	0.02
Darters	0-3	0.1	tr.	4-7	-	-	8	-	-
Sculpins	0-3	0.9	0.01	4-7	-	-	8	-	-
TOTAL		62.9	0.63		17.9	0.74		0.1	0.02
GRAND TOTAL		68.0	0.71		46.2	3.53		5.3	1.75

Standing crop: 119.5 fish per acre; 5.99 pounds per acre.

276 acres.

Table 32. The fish population compositiom of the polluted area of the South Fork of Elkhorn Creek below Town Branch in 1968 and 1969.

SPECIES	FINGERLING SIZE Range inches	Number per acre	Pounds per acre	INTERMEDIATE SIZE Range inches	Number per acre	Pounds per acre	HARVESTABLE SIZE Minimum length inches	Number per acre	Pounds per acre
GAME FISHES									
Largemouth bass	0-4	-	-	5-9	0.3	0.03	10	-	-
Smallmouth bass	0-4	-	-	5-9	0.2	0.02	10	0.1	0.04
TOTAL		-	-		0.5	0.06		0.1	0.04
PANFISHES									
Rock bass	0-2	0.1	tr.	3-5	0.2	0.01	6	0.6	0.22
Bluegill	0-2	0.9	0.01	3-5	8.3	0.42	6	3.1	0.55
Green sunfish	0-2	-	-	3-5	1.5	0.07	6	0.2	0.03
Longear sunfish	0-2	0.2	tr.	3-5	4.2	0.26	6	0.4	0.07
Redear sunfish	0-2	0.8	0.02	3-5	0.4	0.03	6	0.1	0.02
TOTAL		2.1	0.03		14.7	0.79		4.3	0.89
COMMERCIAL FISHES									
Hogsucker	0-4	-	-	5-11	0.1	0.06	12	-	-
White sucker	0-4	2.0	0.04	5-11	9.1	1.57	12	0.3	0.29
Carp	0-4	-	-	5-11	0.1	0.02	12	0.1	0.03
Bullheads	0-4	-	-	5-8	0.1	0.01	9	0.1	0.05
TOTAL		2.0	0.04		9.3	1.66		0.5	0.37
FORAGE FISHES							ABOVE FORAGE SIZE		
Misc. cyprinids	0-3	44.7	0.53	4-7	4.8	0.26	8	0.1	0.02
Darters	0-3	0.1	tr.	4-7	-	-	8	-	-
Sculpins	0-3	1.0	0.01	4-7	-	-	8	-	-
TOTAL		45.8	0.54		4.8	0.26		0.1	0.02
GRAND TOTAL		49.9	0.61		29.4	2.77		5.0	1.31

Standing crop: 84.3 fish per acre; 4.70 pounds per acre.

TOTAL Value of fishes in 2.3 mile polluted section being polluted → $3858.60

Table 33. The fish population composition of the Main Elkhorn Creek in 1969.

SPECIES	FINGERLING SIZE			INTERMEDIATE SIZE			HARVESTABLE SIZE		
	Range	Number per acre	Pounds per acre	Range	Number per acre	Pounds per acre	Minimum length inches	Number per acre	Pounds per acre
GAME FISHES									
Largemouth bass	0-4	0.2	tr.	5-9	0.6	0.12	10	0.2	0.32
Smallmouth bass	0-4	5.6	0.37	5-9	7.7	1.66	10	5.9	4.71
TOTAL		5.8	0.37		8.3	1.78		6.1	5.03
FOOD FISHES									
Channel catfish	0-4	-	-	5-9	-	-	10	0.2	0.53
TOTAL		-	-		-	-		0.2	0.53
PREDATORY FISHES									
Mooneye	0-4	-	-	5-9	0.2	0.04	10	0.8	0.47
Longnose gar	0-4	-	-	5-23	-	-	24	0.2	0.27
TOTAL		-	-		0.2	0.04		1.0	0.74
PANFISHES									
Rock bass	0-2	0.5	tr.	3-5	0.6	0.05	6	1.6	0.46
Bluegill	0-2	0.2	tr.	3-5	1.0	0.07	6	1.8	0.26
Longear sunfish	0-2	0.8	0.02	3-5	3.0	0.28	6	0.2	0.02
Redear sunfish	0-2	-	-	3-5	0.5	0.04	6	0.5	0.31
TOTAL		1.4	0.02		5.1	0.44		4.0	1.06
COMMERCIAL FISHES									
Carpsuckers	0-4	-	-	5-11	0.8	0.55	12	0.8	1.00
Hogsucker	0-4	-	-	5-11	6.6	3.31	12	2.4	2.25
Redhorses	0-4	2.4	0.05	5-11	1.4	0.76	12	53.4	61.89
Drum	0-4	-	-	5-9	0.2	0.06	10	0.2	0.40
TOTAL		2.4	0.05		7.0	4.67		56.8	65.52

Table 33. (continued)

SPECIES	FINGERLING SIZE			INTERMEDIATE SIZE			ABOVE FORAGE SIZE		
	Range inches	Number per acre	Pounds per acre	Range inches	Number per acre	Pounds per acre	Minimum length inches	Number per acre	Pounds per acre
FORAGE FISHES									
Gizzard shad	0-3	-	-	4-7	2.4	0.42	8	20.8	9.92
Misc. cyprinids	0-3	16.0	0.11	4-7	21.6	0.27	8	-	-
Darters	0-3	1.4	0.02	4-7	1.3	0.04	8	-	-
TOTAL		17.4	0.14		25.3	0.73		20.8	9.92
GRAND TOTAL		27.0	0.59		47.8	7.66		88.8	82.90

Standing crop: 163.7 fish per acre; 91.05 pounds per acre.

Table 34. The fish population composition of the North Fork of Elkhorn Creek in 1968 and 1969.

SPECIES	FINGERLING SIZE Range inches	Number per acre	Pounds per acre	INTERMEDIATE SIZE Range inches	Number per acre	Pounds per acre	HARVESTABLE SIZE Minimum length inches	Number per acre	Pounds per acre
GAME FISHES									
Largemouth bass	0-4	0.6	0.01	5-9	2.2	0.68	10	2.8	3.52
Smallmouth bass	0-4	4.7	0.13	5-9	12.5	4.16	10	1.9	1.10
Crappie	0-4	-	-	5-7	0.9	0.10	8	0.4	0.14
TOTAL		5.2	0.14		15.6	4.95		5.2	4.80
PANFISHES									
Rock bass	0-2	1.1	0.01	3-5	15.5	1.28	6	28.5	8.52
Bluegill	0-2	0.9	0.01	3-5	7.3	0.61	6	1.9	0.22
Green sunfish	0-2	1.1	0.01	3-5	1.7	0.12	6	2.2	0.43
Longear sunfish	0-2	4.3	0.05	3-5	80.8	5.12	6	2.4	0.44
Hybrid sunfish	0-2	-	-	3-5	1.5	0.08	6	-	-
Warmouth	0-2	0.2	tr.	3-5	0.2	0.01	6	2.0	0.58
TOTAL		7.6	0.08		105.2	7.22		37.1	10.30
COMMERCIAL FISHES									
Hogsucker	0-4	1.3	0.01	5-11	34.8	9.61	12	1.3	1.03
Redhorses	0-4	0.2	tr.	5-11	17.3	8.25	12	30.4	22.30
White sucker	0-4	-	-	5-11	1.3	0.36	12	-	-
Bullheads	0-4	-	-	5-8	0.2	0.02	9	0.4	0.13
TOTAL		1.5	0.02		53.6	18.25		32.0	23.45
FORAGE FISHES							ABOVE FORAGE SIZE		
Misc. cyprinids	0-3	376.3	2.52	4-7	139.5	6.15	8	0.7	0.15
Darters	0-3	9.5	0.05	4-7	2.4	0.13	8	-	-
Brook silversides	0-3	0.6	0.01	4-7	-	-	8	-	-
Sculpins	0-3	0.4	tr.	4-7	-	-	8	-	-
TOTAL		386.7	2.58		141.9	6.28		0.7	0.15
GRAND TOTAL		401.1	2.81		316.4	36.70		75.0	38.70

Standing crop: 792.5 fish per acre; 78.22 pounds per acre.