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Studies of Pollution
of the
Tennessee River System

TVA, 1945

① Types
② Sources

Major Tributaries

TENNESSEE VALLEY AUTHORITY

HEALTH AND SAFETY DEPARTMENT

STUDIES OF THE POLLUTION OF THE TENNESSEE RIVER SYSTEM

II. Detailed Discussion of Types and Sources of Pollution and Their Effects on the River System with Results of Studies of the Major Tributaries 1937-1939

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KNOXVILLE, TENNESSEE

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CONTENTS

	Page
Acknowledgment	xiii
Summary	1
Population	1
Water Supplies	2
Sewerage Systems	5
Industrial Plants	8
Extent of Pollution	9
Pollution in 1943	10
Effects of Pollution	11
Introduction	17
Sampling Procedures	19
Analytical Procedure	20
Presentation of Analytical Results	20
Discussion of Results	21
Additional Sources of Information	23
Geology	23
Precipitation	23
Stream Flows	24
Population Estimates	24
Analytical Data	24
Section I. Holston River	25
General	25
Geology	25
Precipitation	27
Stream Flows	27
Water Supplies	27
Sources of Pollution	30
Population Estimates	30
Sewerage Systems	30
Industrial Plants	31
Extent of Pollution	33
Sampling and Sampling Stations	34
Sampling	34
Sampling Stations	34
Discussion of Results	35
Stream Flows	35
Observed Conditions	36
Classification Based on Conditions of Normal Stream Flows	40
Effects of Pollution	42

CONTENTS
(Continued)

	Page
Section II. French Broad River	71
General	71
Geology	71
Precipitation	72
Stream Flows	72
Water Supplies	74
Sources of Pollution	76
Population Estimates	76
Sewerage Systems	76
Industrial Plants	76
Extent of Pollution	80
Sampling and Sampling Stations	81
Sampling	81
Sampling Stations	81
Discussion of Results	82
Stream Flows	82
Observed Conditions	83
Classification Based on Conditions of Normal Stream Flows	88
Effects of Pollution	90
Section III. Little Tennessee River	115
General	115
Geology	115
Precipitation	116
Stream Flows	116
Water Supplies	117
Sources of Pollution	118
Population Estimates	118
Sewerage Systems	118
Industrial Plants	119
Extent of Pollution	121
Sampling and Sampling Stations	122
Sampling	122
Sampling Stations	122
Discussion of Results	123
Stream Flows	123
Observed Conditions	123
Section IV. Clinch River	129
General	129
Geology	129
Precipitation	130
Stream Flows	130
Water Supplies	132
Sources of Pollution	134
Population Estimates	134
Sewerage Systems	134

CONTENTS
(Continued)

	Page
Industrial Plants	134
Extent of Pollution	137
Sampling and Sampling Stations	139
Sampling	139
Sampling Stations	139
Discussion of Results	139
Section V. Hiwassee River	155
General	155
Geology	155
Precipitation	155
Stream Flows	156
Water Supplies	157
Sources of Pollution	158
Population Estimates	158
Sewerage Systems	158
Industrial Plants	159
Extent of Pollution	161
Sampling and Sampling Stations	162
Sampling	162
Sampling Stations	162
Discussion of Results	163
Effects of Pollution	165
Section VI. Elk River	169
General	169
Geology	169
Precipitation	171
Stream Flows	171
Water Supplies	171
Sources of Pollution	173
Population Estimates	173
Sewerage Systems	173
Industrial Plants	174
Extent of Pollution	176
Sampling and Sampling Stations	177
Sampling	177
Sampling Stations	177
Discussion of Results	177
Observed Conditions	177
Effects of Sewage from Camp Forrest	179
Section VII. Duck River	201
General	201
Geology	201
Precipitation	202
Stream Flows	202
Water Supplies	204

CONTENTS
(Continued)

	Page
Sources of Pollution	205
Population Estimates	205
Sewerage Systems	205
Industrial Plants	205
Extent of Pollution	207
Sampling and Sampling Stations	208
Sampling	208
Sampling Stations	208
Discussion of Results	209
Effects of Pollution	211
Section VIII. Tennessee River	237
General	237
Geology	237
Precipitation	239
Stream Flows	239
Water Supplies	240
Sources of Pollution	240
Population Estimates	244
Sewerage Systems	244
Industrial Plants	250
Extent of Pollution	254
Sampling and Sampling Stations	259
Reservoir Conditions	259
Fort Loudoun Reservoir	259
Watts Bar Reservoir	260
Chickamauga Reservoir	261
Hales Bar Reservoir	261
Guntersville Reservoir	262
Wheeler Reservoir	262
Wilson Reservoir	263
Pickwick Reservoir	263
Kentucky Reservoir	264
Area Below Kentucky Dam	264
Appendix I. Qualities of Water Used in the Description of Streams in the Tennessee Valley	265

TABLES

Number		Page
1.	Population in the Tennessee Valley Based on U.S. Census of 1940 in Main Tributaries and above Designated Points on the Tennessee River	3
2.	Water Supplies, Tennessee River Valley, 1937-1940	5
3.	Sewered Population, Tennessee River Valley, 1937-1940	7
4.	Industrial Pollution, Tennessee River Valley, 1937-1940	8
5.	Estimated Population Equivalent of Pollution Reaching Tennessee River System, 1937-1940	9
6.	Mean Monthly Discharges in Cubic Feet per Second at Designated Points on Elk River	28
7.	Water Supplies, Holston River Basin, 1937-1940	29
8.	Sewerage Systems, Holston River Basin, 1937-1940	30
9.	Industrial Pollution, Holston River Basin, 1937-1940	32
10.	Estimated Population Equivalent of Pollution Reaching Holston River System, 1937-1940	33
11.	Holston River, Mineral Analyses	43-50
12.	Holston River, Solids	51-55
13.	Holston River, Nitrogens	56-58
14.	Holston River, Dissolved Oxygen and Biochemical Oxygen Demand	59-63
15.	Holston River, Bacteria	64-69
16.	Mean Monthly Discharges in Cubic Feet per Second at Designated Points on the French Broad River System	73
17.	Water Supplies, French Broad River Basin, 1937-1940	74-75
18.	Sewerage Systems, French Broad River Basin, 1937-1940	78
19.	Industrial Pollution, French Broad River Basin, 1937-1940	79
20.	Estimated Population Equivalent of Pollution Reaching French Broad River System, 1937-1940	80

TABLES
(Continued)

Number		Page
21.	French Broad River, Mineral Analyses	91-95
22.	French Broad River, Solids	96-99
23.	French Broad River, Nitrogens	100-101
24.	French Broad River, Dissolved Oxygen and Biochemical Oxygen Demand	102-107
25.	French Broad River, Bacteria	108-113
26.	Mean Monthly Discharges in Cubic Feet per Second at Designated Points on Little Tennessee River	116
27.	Water Supplies, Little Tennessee River Basin, 1937-1940	117
28.	Sewerage Systems, Little Tennessee River Basin, 1937-1940	118
29.	Industrial Pollution, Little Tennessee River Basin, 1937-1940	120
30.	Estimated Population Equivalent of Pollution Reaching Little Tennessee River System, 1937-1940	121
31.	Little Tennessee River, Mineral Analyses and Solids	126
32.	Little Tennessee River, Dissolved Oxygen, Biochemical Oxygen Demand, and Bacteria	127
33.	Mean Monthly Discharges in Cubic Feet per Second at Designated Points on Clinch River	131
34.	Water Supplies, Clinch River Basin, 1937-1940	132-133
35.	Sewerage Systems, Clinch River Basin, 1937-1940	135
36.	Industrial Pollution, Clinch River Basin, 1937-1940	136
37.	Estimated Population Equivalent of Pollution Reaching Clinch River System, 1937-1940	138
38.	Clinch River, Mineral Analyses	142-144
39.	Clinch River, Solids	145-147
40.	Clinch River, Nitrogens	148

TABLES
(Continued)

Number		Page
41.	Clinch River, Dissolved Oxygen and Biochemical Oxygen Demand	149-151
42.	Clinch River, Bacteria	152-154
43.	Mean Monthly Discharges in Cubic Feet per Second at Designated Points on Hiwassee River	156
44.	Water Supplies, Hiwassee River Basin, 1937-1940	157
45.	Sewerage Systems, Hiwassee River Basin, 1937-1940	158
46.	Industrial Pollution, Hiwassee River Basin, 1937-1940	160
47.	Estimated Population Equivalent of Pollution Reaching Hiwassee River System, 1937-1940	161
48.	Hiwassee River, Mineral Analyses and Solids	166
49.	Hiwassee River, Dissolved Oxygen, Biochemical Oxygen Demand, and Bacteria	167
50.	Hiwassee River, Bacteria	168
51.	Mean Monthly Discharges in Cubic Feet per Second at Designated Points on Elk River	172
52.	Water Supplies, Elk River Basin, 1937-1940	173
53.	Sewerage Systems, Elk River Basin, 1937-1940	174
54.	Industrial Pollution, Elk River Basin, 1937-1940	175
55.	Estimated Population Equivalent of Pollution Reaching Elk River System, 1937-1940	176
56.	Elk River, Mineral Analyses	180-181
57.	Elk River, Turbidity and Solids	182
58.	Elk River, Nitrogens	183-188
59.	Elk River, Dissolved Oxygen and Biochemical Oxygen Demand	189-194
60.	Elk River, Bacteria	195-200

TABLES
(Continued)

Number		Page
61.	Mean Monthly Discharges in Cubic Feet per Second at Designated Points on the Duck, Piney, and Buffalo Rivers	203
62.	Water Supplies, Duck River Basin, 1937-1940	204
63.	Sewerage Systems, Duck River Basin, 1937-1940	205
64.	Industrial Pollution, Duck River Basin, 1937-1940	206
65.	Estimated Population Equivalent of Pollution Reaching Duck River System, 1937-1940	207
66.	Duck River, Mineral Analyses	212-214
67.	Duck River, Solids	215
68.	Duck River, Nitrogens	216-220
69.	Duck River, Dissolved Oxygen and Biochemical Oxygen Demand	221-228
70.	Duck River, Bacteria	229-236
71.	Drainage Areas, Tennessee River	238
72.	Expected Flows in Cubic Feet per Second at Designated Points on Tennessee River for the Period May through September	239
73.	Water Supplies, Tennessee River, 1937-1940	241-243
74.	Population, Tennessee Valley	244
75.	Sewerage Systems, Tennessee Valley, 1937-1940	245-249
76.	Industrial Pollution, Tennessee River, 1937-1940	251-253
77.	Estimated Population Equivalent of Pollution Reaching Tennessee River, 1937-1940	256-258
78.	Minimum Acceptable Qualities of Water for Various Uses Proposed for Surface Waters in the Tennessee Valley	271

FIGURES

Number		Following Page
1.	Extent of Pollution in Subdivisions of the Tennessee Valley	10
2.	Holston River Drainage Basin	24
3.	Holston River Sources of Pollution and Sampling Stations	32
4.	Holston River Stream Conditions	40
5.	French Broad River Drainage Basin	70
6.	French Broad River Sources of Pollution and Sampling Stations	80
7.	French Broad River Stream Conditions	82
8.	Little Tennessee River Drainage Basin	114
9.	Little Tennessee River Sources of Pollution and Sampling Stations	120
10.	Clinch River Drainage Basin	128
11.	Clinch River Sources of Pollution and Sampling Stations	138
12.	Hiwassee River Drainage Basin	154
13.	Hiwassee River Sources of Pollution and Sampling Stations	162
14.	Elk River Drainage Basin	168
15.	Elk River Sources of Pollution and Sampling Stations	176

FIGURES
(Continued)

Number		Following Page
16.	Elk River Stream Conditions	178
17.	Duck River Drainage Basin	200
18.	Duck River Sources of Pollution and Sampling Stations	208
19.	Duck River Stream Conditions	210
20.	Tennessee River Drainage Basin	236
21.	Tennessee River Sources of Pollution	254
22.	Relationship Between Monthly Average Density of Coliform Group and Monthly Average 5-Day B.O.D.	272
23.	Relationship Between Monthly Average Density of Coliform Group and Monthly Average Dissolved Oxygen . .	272
24.	Relationship Between Monthly Average and Maximum Observed 5-Day B.O.D.	272
25.	Relationship Between Monthly Average and Observed Minimum Daily Dissolved Oxygen	272

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As the collection of some of the information was undertaken in collaboration with the U.S. Public Health Service in connection with the Ohio River Pollution Survey, the Public Health Service assigned some of its personnel to work with the Authority in the Tennessee Valley. Mr. Richard F. Poston, associate public health engineer, was assigned to this work in 1939 and collected most of the information on industries. Mr. Ralph Porges, assistant sanitary engineer(R), and Mr. Arvo A. Solander, assistant public health engineer, obtained the information on the water supplies and sewerage systems in the Valley. Mr. Solander was located in Nashville, Tenn., but Mr. Poston and Mr. Porges were stationed in the Authority's offices. All three of these men assisted when needed in the special studies of industrial wastes.

The major portion of the population equivalents of industrial wastes which are used in this report were estimated by the Public Health Service, and the remainder were determined from the results obtained by special studies of the individual wastes.

In the study of the French Broad River in North Carolina, the samples were collected by Mr. E. W. Kearney, sanitary engineer with the State Board of Health, and a portion of the analytical work was done by the state laboratory. Mr. Kearney and Mr. W. S. McKimmon, district sanitary engineer, also assisted in some of the studies of wastes from industries located in North Carolina.

Mr. F. W. Kittrell, at that time a chief sanitary engineer of the Tennessee Department of Public Health, collected all of the samples from the Duck River and made sanitary chemical determinations on the samples and sent the samples for mineral analyses and bacteriological examinations to the TVA laboratory at Norris. Later, as a member of the Public

Health Engineering Staff of the Health and Safety Department of the Authority, he reviewed this report.

Mr. G. R. Frith, assistant engineer, Division of Sanitary Engineering, and Mr. N. M. DeJarnette, chemist, Public Health Engineering Division of the State Department of Public Health, assisted in the surveys which were carried out on wastes from industries in Georgia.

In the Authority, the Hydraulic Data Division cooperated in the field and laboratory work until the laboratory was transferred to the Health and Safety Department in 1938. This division also measured the volumes of industrial wastes when necessary and installed special stream gaging stations where they were needed in the studies. All discharges shown in the tabulations presenting the results of the examinations were provided by this division.

In the Health and Safety Department, many of the resident sanitary engineers were called upon from time to time to collect routine samples and to assist in special studies. The laboratory personnel, while not mentioned individually, deserve a lot of credit for their interest and enthusiasm and for being careful and painstaking in carrying out the large amount of analytical work.

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In preparing this in retrospect, it appears to the writers that they have served as a reporting agency through which the data collected by this group of excellent men are being made available for use by those interested in the preservation of the streams in the Tennessee Valley.

SUMMARY

Studies to determine the amounts, sources, and kinds of pollution and their effects on the Tennessee River system in its natural condition and also as impoundage develops were started in 1936 at the request of the state health departments of the seven Valley states. This work was undertaken in cooperation with the Valley states, the United States Public Health Service, and the United States Geological Survey.

One report has been prepared:

STUDIES OF THE POLLUTION OF THE TENNESSEE RIVER SYSTEM
I. A General Description of the Valley with Results of Studies on the Knoxville, Chattanooga, Decatur, and Tri-Cities Sections of the Tennessee River 1936-1937

This report presented the results obtained during the studies of the four sections of the Tennessee River in 1936 and 1937.

The present report, number II, presents the conditions which have been observed in the tributary streams and discusses changes in the Tennessee River brought about by increased impoundage. It also presents detailed information on the sources and kinds of pollution as of 1940 and correlates this information with the results of field and laboratory observations. A method has been developed for the description of the conditions observed in the streams of the river system. This method of description correlates the minimum acceptable qualities of water for various uses with chemical and bacteriological measurements of pollution.

Population

A summary of the population in the Valley was given in the first report, which was based upon the 1930 U.S. Census. In order to present the same information under conditions existing in 1940, table 1 has been prepared.

In 1930 the estimated population in the Valley was 2,207,280. In 1940 the table shows 2,519,408, or an increase of 14.1 percent during

the decade. This increase is almost two times the increase of 7.3 percent which was experienced in continental United States. This increase in the Valley has not been accomplished in the cities at the expense of rural areas. The increase in urban population is 17.7 percent while the increase in rural population is 12.9 percent. During the same period the increase in urban population in the states was 7.9 percent and in rural population 6.4 percent. In the Valley the increase in urban population was 1.37 times the increase in rural population, whereas in the United States it was 1.23. More interesting comparisons might be made of the population growth in the Valley and of population shifts within the Valley itself. The above information is intended only to show that while the population in the Valley has grown more rapidly than in the United States as a whole, the growth is well distributed between urban and rural areas. The increase in population since 1940, however, has resulted in a marked increase in urban population, as indicated by the congested conditions in urban communities, particularly those adjacent to defense activities.

Water Supplies

Table 2 gives the number of water supplies in the Valley and their sources and methods of treatment by subdivisions and drainage areas. The 262 supplies furnish water for approximately 850,000 people. Approximately one-third of the supplies are drawn either in whole or in part from surface sources and most of them receive treatment in filter plants. While only one-third of the supplies are drawn from surface streams, these supplies furnish water for 69 percent of the 850,000 people served.

It is this population obtaining water supplies from surface streams which is affected by pollution. The pollution in some of these supplies now causes serious problems of treatment; and if pollution is allowed to increase as the Valley develops, many more supplies will be endangered. Many of the other supplies from springs and wells are being taxed to their capacity, and as the municipalities continue to grow, new sources will be required. In some cases the only undeveloped supplies are surface streams which may be grossly polluted.

POPULATION IN THE TENNESSEE

IN MAIN TRIBUTARIES AND ABOVE D

Watershed	Rural Population				
	Unsewered	Sewered	Having Sewage Treatment	Total	Unse
Holston River	242,097	3,960	580	246,057	22
French Broad River	264,388	35,360	3,870	299,748	2
Above Knoxville	506,485	39,320	4,450	545,805	25
Fort Loudoun Reservoir	57,625	1,740	0	59,365	20
Above Ft. Loudoun Dam	564,110	41,060	4,450	605,170	45
Little Tennessee River	75,174	8,180	2,700	83,354	
Clinch River	237,013	14,140	4,560	251,153	10
Watts Bar Reservoir	28,207	290	290	28,497	5
Above Watts Bar Dam	904,504	63,670	12,000	968,174	62
Hiwassee River	99,439	8,350	920	107,789	6
Chickamauga Reservoir	37,673	1,370	1,370	39,043	
Above Chickamauga Dam	1,041,616	73,390	14,290	1,115,006	68
Hales Bar Reservoir	65,925	2,160	2,040	68,085	30
Above Hales Bar Dam	1,107,541	75,550	16,330	1,183,091	98
Sequatchie River	17,328	0	0	17,328	
Guntersville Reservoir	85,554	2,960	950	88,514	3
Above Guntersville Dam	1,210,423	78,510	17,280	1,288,933	102
Elk River	82,355	2,090	2,090	84,445	5
Wheeler Reservoir	135,449	6,090	40	141,539	
Above Wheeler Dam	1,428,227	86,690	19,410	1,514,917	108
Wilson Reservoir	54,664	1,070	1,070	55,734	
Above Wilson Dam	1,482,891	87,760	20,480	1,570,651	108
Pickwick Reservoir	63,592	1,050	0	64,642	11
Above Pickwick Dam	1,546,483	88,810	20,480	1,635,293	120
Kentucky Reservoir Above Duck River	55,130	1,230	530	56,360	
Above Duck River	1,601,613	90,040	21,010	1,691,653	120
Duck River	102,570	2,060	540	104,630	11
Kentucky Reservoir Below Duck River	48,148	1,200	700	49,348	
Above Kentucky Dam	1,752,331	93,300	22,250	1,845,631	133
Kentucky Dam to Mouth	28,353	2,240	1,910	30,593	
Total Tennessee Valley	1,780,684	95,540	24,160	1,876,224	133

TABLE 1

VALLEY BASED ON U.S. CENSUS OF 1940

ESIGNATED POINTS ON THE TENNESSEE RIVER

Urban Population				Total Population				
wered	Sewered	Having Sewage Treatment	Total	Unsewered	Sewered	Having Sewage Treatment	Total	Population Per Square Mile
,995	79,670	12,100	102,665	265,092	83,630	12,680	348,722	92.4
,488	86,270	6,400	88,758	266,876	121,630	10,270	388,506	75.8
,483	165,940	18,500	191,423	531,968	205,260	22,950	737,228	82.8
,290	95,500	10,420	115,790	77,915	97,240	10,420	175,155	269.5
,773	261,440	28,920	307,213	609,883	302,500	33,370	912,383	95.5
0	0	0	0	75,174	8,180	2,700	83,354	31.7
,638	16,100	0	26,738	247,651	30,240	4,560	277,891	63.0
,884	8,080	5,780	13,964	34,091	8,370	6,070	42,461	59.0
,295	285,620	34,700	347,915	966,799	349,290	46,700	1,316,089	76.0
,343	15,300	9,600	21,643	105,782	23,650	10,520	129,432	47.9
0	0	0	0	37,673	1,370	1,370	39,043	50.1
,638	300,920	44,300	369,558	1,110,254	374,310	58,590	1,484,564	71.4
,110	104,530	12,000	134,640	96,035	106,690	14,040	202,725	202.7
,748	405,450	56,300	504,198	1,206,289	481,000	72,630	1,687,289	77.4
0	0	0	0	17,328	0	0	17,328	29.5
,643	7,240	4,240	10,883	89,197	10,200	5,190	99,397	47.9
,391	412,690	60,540	515,081	1,612,814	491,200	77,820	1,804,014	73.8
,517	11,790	7,940	17,307	87,872	13,880	10,030	101,752	45.2
530	36,050	5,500	36,580	135,979	42,140	5,540	178,119	61.6
,438	460,530	73,980	568,968	1,536,665	547,220	93,390	2,083,885	70.4
207	3,600	3,600	3,807	54,871	4,670	4,670	59,541	51.3
,645	464,130	77,580	572,775	1,591,536	551,890	98,060	2,143,426	69.7
,381	20,620	6,100	32,001	74,973	21,670	6,100	96,643	46.7
,026	484,750	83,680	604,776	1,666,509	573,560	104,160	2,240,069	68.3
886	1,640	0	2,526	56,016	2,870	530	58,886	28.2
,912	486,390	83,680	607,302	1,722,525	576,430	104,690	2,298,955	65.9
,434	14,280	3,600	25,714	114,004	16,340	4,140	130,344	37.2
835	5,560	5,560	6,395	48,983	6,760	6,260	55,743	31.1
,181	506,230	92,840	639,411	1,885,512	599,530	115,090	2,485,042	61.8
373	3,400	3,400	3,773	28,726	5,640	5,310	34,366	48.4
,554	509,630	96,240	643,184	1,914,238	605,170	120,400	2,519,408	61.6

TABLE 2

WATER SUPPLIES

TENNESSEE RIVER VALLEY, 1937-1940

Basin	Number of Systems	Source			Treatment		
		Wells	Springs	Streams	None	Disinfection	Purification Plant
Holston River	33	3	27	8	10	16	9
French Broad River	38	8	12	24	11	20	8
Fort Loudoun Reservoir	8	4	3	2	3	4	2
Little Tennessee River	16	4	3	9	4	9	3
Clinch River	59	25	26	15	22	24	15
Watts Bar Reservoir	6	0	4	3	0	4	2
Hiwassee River	20	6	11	6	7	10	5
Chickamauga Reservoir	1	0	1	1	0	0	1
Hales Bar Reservoir	6	1	2	3	1	1	4
Guntersville Reservoir	15	5	11	4	6	6	4
Elk River	10	5	6	1	1	6	3
Wheeler Reservoir	9	3	5	2	1	7	2
Wilson Reservoir	5	3	2	0	0	3	2
Pickwick Reservoir	7	2	1	4	0	2	5
Duck River	14	2	9	4	1	9	4
Kentucky Reservoir	9	9	0	0	2	5	2
Below Kentucky Dam	5	4	0	1	1	1	3
Total Tennessee River	261	84	123	87	70	127	74

Sewerage Systems

Table 3 gives a summary of the data relative to the amount of domestic sewage discharged into the Tennessee River system.

In the earlier report it was estimated that 514,357 people were connected to sewer systems in 1935, and that the sewage from 79,163 received some form of treatment. The present estimate that 605,700 are connected to sewers and that the sewage from 120,400 receives some form of treatment in 1940 indicates an improvement during the five-year interim. It is difficult to say whether this difference represents actual progress or is the result of more adequate information. The increase in sewered population is 17.7 percent of the 1935 estimate, and the increase in the amount of sewage treated is 52 percent.

The table indicates that there are 186 sewer systems serving 605,700 people. Approximately 24 percent of the Valley population is

connected to sewers. In 1938 it was estimated[1] that 56 percent of the total population in the United States was sewered. This would indicate that the Tennessee Valley is either behind in its sewerage program or that a smaller percentage of its population is urban. In the continental United States the 1940 U.S. Census classed 56.5 percent of the total population as urban. In the Tennessee Valley the urban population is 25.5 percent of the total, or less than one-half of the proportion existing in the entire United States. If it is assumed that the relationship of the percentage of sewered population in the Valley to the percentage of urban population is the same as is indicated by the data for the United States, approximately 25.3 percent of the Valley population should be sewered. This agrees quite closely with the 24 percent which is indicated by the collected data. The sewerage program in the Valley then appears to be as well advanced as the average in the United States.

The same report of the National Resources Committee estimates that 54 percent of the sewage from the sewered population in the United States received some form of treatment. In the Tennessee Valley the results indicate that the sewage from only 19.8 percent of the connected population receives treatment. While the data indicate that about one-third of the systems have some form of treatment, all plants are small and many do not provide more than primary sedimentation in septic tanks. It is estimated that the over-all reduction in pollution due to domestic sewage by these sewage-treatment plants is only 7.8 percent. On the same basis of efficiency of the different types of plants, it is estimated that in the United States the reduction in pollution accomplished in the treatment plants is approximately 30 percent of the total domestic sewage load.

In conclusion, it appears that while the sewerage program is as well advanced in the Valley as in the country as a whole, the treatment of the sewage has not kept pace with the progress elsewhere. Progress in sewage treatment has not advanced as rapidly as in the sewerage program, and as a result the amount of pollution due to domestic sewage increased at a much higher rate than would be expected if the two programs had developed at the same rate.

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1. Water Pollution in the United States, Third Report of the Special Advisory Committee on Water Pollution, National Resources Committee, 1939, pp. 5-7.

TABLE 3

SEWERED POPULATION

TENNESSEE RIVER VALLEY, 1937-1940

Basin	Number of Sewer Systems	Population Connected to System	Systems Having Sewage Treatment Plants	Population Connected to Sewage Treatment Plant	Population Equivalent of Discharged Sewage
Holston River	20	83,600	6	12,700	79,300
French Broad River	27	122,000	8	10,300	114,000
Fort Loudoun Reservoir	4	97,200	2	10,400	91,500
Little Tennessee River	13	8,200	5	2,700	7,200
Clinch River	44	30,200	7	4,600	27,900
Watts Bar Reservoir	6	8,400	5	6,100	6,800
Hiwassee River	15	23,600	6	10,500	16,900
Chickamauga Reservoir	2	1,400	2	1,400	900
Hales Bar Reservoir	8	107,000	7	14,000	104,000
Guntersville Reservoir	6	10,200	4	5,200	8,500
Elk River	8	13,900	7	10,000	11,800
Wheeler Reservoir	5	42,100	3	5,500	40,700
Wilson Reservoir	4	4,700	4	4,700	3,100
Pickwick Reservoir	7	21,700	4	6,100	19,800
Duck River	7	16,300	3	4,100	14,100
Kentucky Reservoir	7	9,600	4	6,800	8,100
Below Kentucky Dam	3	5,600	3	5,300	4,000
Total Tennessee River	186	605,700	80	120,400	558,600

Industrial Plants

A list of the industries and the amount of pollution originating from each type of industry is shown in table 4. The table also summarizes the manner in which the wastes are disposed. In 47 plants corrective measures are taken to reduce the pollutional material in the wastes before they are discharged.

From the table, it will be seen that the pulp and paper, cellulose, and textile industries in the order named are the sources of the greater portion of the industrial pollution. The pulp and paper industry accounts for 44.5 percent, cellulose industry 26.8 percent, and the textile industry 11 percent; and the three are responsible for 82.3 percent of the total industrial pollution.

TABLE 4

INDUSTRIAL POLLUTION

TENNESSEE RIVER VALLEY, 1937-1940

Types of Industry	Number of Plants	Methods of Disposal			Estimated Population Equivalent
		Municipal Sewers	Stream	Some Correction	
Canning	27	8	19	8	41,800
Cellulose	5	0	5	1	352,000
Chemical	26	2	24	10	26,900
Meat	19	11	8	1	40,200
Milk	34	24	10	14	14,200
Mining	10	0	10	6	-
Pulp and Paper	9	2	7	0	584,000
Tanning	9	2	7	2	79,900
Textiles	85	40	45	5	144,000
Miscellaneous	25	5	20	1	29,200
Total	249	94	155	48	1,312,200

Extent of Pollution

Table 5 summarizes the pollution found in the Valley. Approximately 30 percent of the total pollution is due to domestic sewage and 70 percent to industrial wastes. The table also shows that about two-thirds of the total pollution originates in the French Broad River basin, Hales Bar Reservoir area, and the Holston River basin. About 29.8 percent originates in the French Broad River basin, 20 percent in the Hales Bar area, mostly around Chattanooga, and 17.6 percent in the Holston River basin, with a total of 67.4 percent in the three areas.

This information is shown graphically in figure 1.

TABLE 5

ESTIMATED POPULATION EQUIVALENT OF POLLUTION

REACHING TENNESSEE RIVER SYSTEM, 1937-1940

Basin	Estimated Population Equivalent		
	Domestic Sewage	Industrial Waste	Total
Holston River	79,300	247,000	326,300
French Broad River	114,000	440,000	554,000
Fort Loudoun Reservoir	91,500	81,100	172,600
Little Tennessee River	7,200	100,000	107,200
Clinch River	27,900	85,100	113,000
Watts Bar Reservoir	6,800	20,600	27,400
Hiwassee River	16,900	9,200	26,100
Chickamauga Reservoir	900	1,200	2,100
Hales Bar Reservoir	104,000	270,000	374,000
Guntersville Reservoir	8,500	300	8,800
Elk River	11,800	7,600	19,400
Wheeler Reservoir	40,700	5,200	45,900
Wilson Reservoir	3,100	900	4,000
Pickwick Reservoir	19,800	3,700	23,500
Duck River	14,100	29,400	43,500
Kentucky Reservoir	8,100	100	8,200
Below Kentucky Dam	4,000	300	4,300
Total Tennessee Valley	558,600	1,301,700	1,860,300

Pollution in 1943

The extent of pollution which has been discussed above represents the conditions which existed at about 1940. Since that time new war activities have located in the Valley and many of the original industries have increased their production and hence the amount of waste.

Early in 1943 a questionnaire was sent to eleven of the larger original industries in the Valley requesting information on their production at that time. Replies were received from ten. Additional studies were also made of one industry in 1942 and of another in 1943. The total earlier estimate of the population equivalent of the ten industries and the two industries on which studies were made is 866,000, or about 66 percent of the estimated industrial pollution from all plants as given in table 4.

The 1943 population equivalent of these twelve industries calculated from the results of studies for two and estimated on the basis of increased production for ten is 1,512,000, or 175 percent of the earlier estimate. If it can be assumed that the remaining original industries have increased in the same proportion, the 1943 population equivalent of the wastes from the original industries in the Valley is approximately 2,300,000.

In addition to this increase in activity on the part of the original industries, a number of new war industries have located in the Valley. Of these, five are now in operation and, while no detailed studies have been made of the wastes, they are known to contain high concentrations of pollutional material. Another large activity is under construction in the Clinch River basin about which no information concerning the amount and characteristics of wastes is available. With the added load of these industries and the pollution from smaller industries which have been started, it is quite possible that the present population equivalent of the industrial wastes now reaching the Tennessee River system may approximate 3,000,000.

Coincident with the increase in industrial activity has been an increase in the urban population and hence an increase in the amount of domestic sewage from the municipalities. There have been no studies to

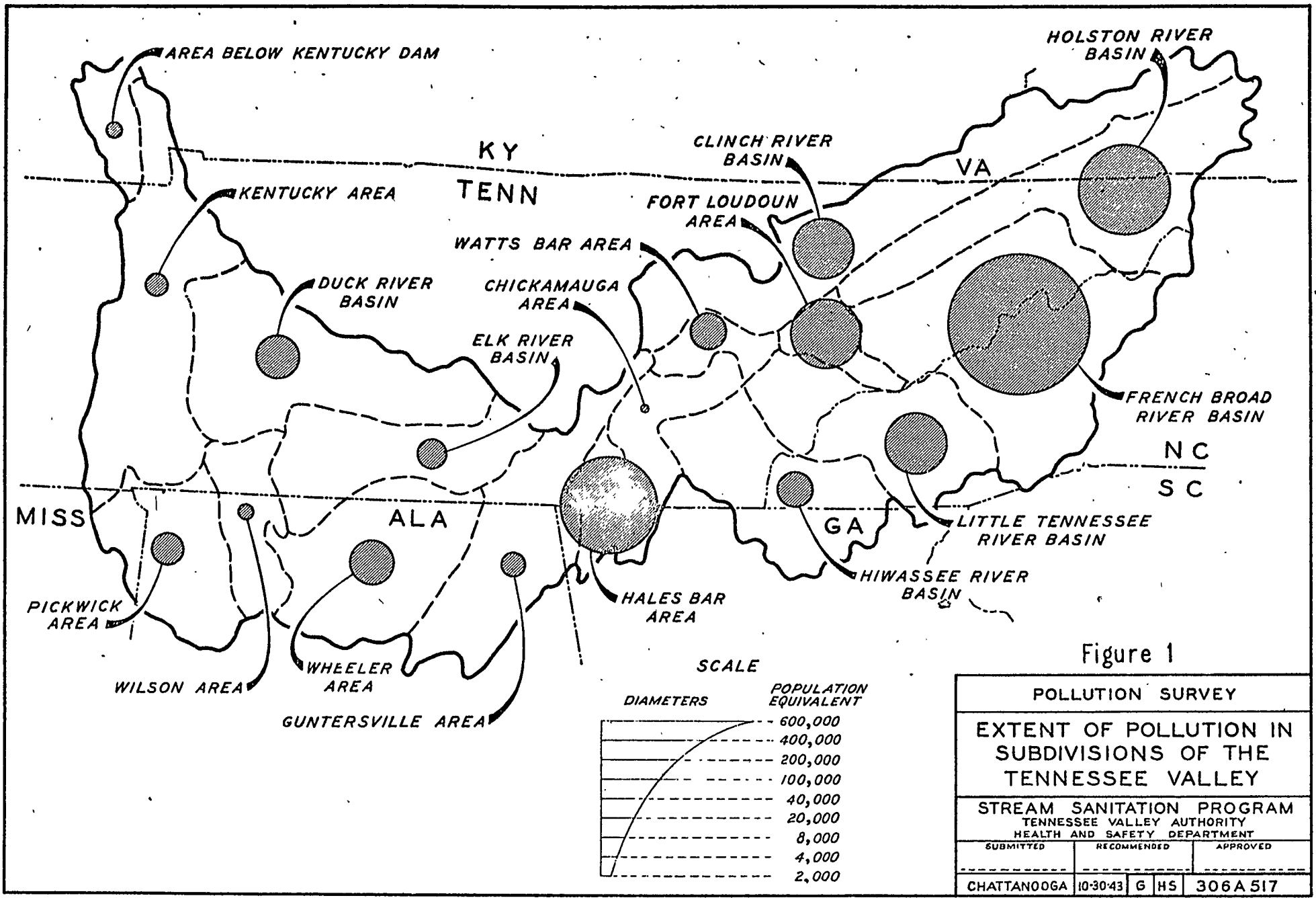

Figure 1

POLLUTION SURVEY

EXTENT OF POLLUTION IN SUBDIVISIONS OF THE TENNESSEE VALLEY

STREAM SANITATION PROGRAM
TENNESSEE VALLEY AUTHORITY
HEALTH AND SAFETY DEPARTMENT

SUBMITTED	RECOMMENDED	APPROVED

CHATTANOOGA	10-30-43	G	HS	306A 517

determine the extent of this increase, but it is known to be a significant amount, as seriously congested conditions exist in all centers of population near the larger defense activities.

In addition to this increase in urban population is the increase in personnel stationed at Ft. Oglethorpe near Chattanooga and the establishment of a large training center in the Elk River Valley and two centers in Wheeler Reservoir area.

The effects of these activities which contribute additional amounts of domestic sewage and industrial wastes impose more severe burdens on the streams of the Valley than were observed during the periods of study. An attempt has been made to point out these effects in the detailed reports.

While it was earlier assumed that most of the war industries would be dismantled after the war, some are now known to be permanent, and others may be converted to peace-time activities. Also, while some of the original plants may revert to their prewar size and activities, all of them will attempt to utilize their recently extended capacities and facilities to the fullest extent. It is also expected that numerous plants making finished products for peacetime consumption from the basic materials now being processed in the Valley and from raw materials will locate here and further increase the amount of pollution to be carried by the river. It would seem logical to assume, therefore, that any appreciable reduction in pollution due to reduced activity in the Valley can not be expected and that an increase will result with the unfolding of anticipated expansion.

Effects of Pollution

The Special Advisory Committee on Water Pollution, National Resources Committee, summarizes the effects of pollution as follows:

> "Water pollution affects man in a variety of ways, some direct and others indirect, and none in a degree which can be expressed satisfactorily in monetary terms. Human health may be impaired and life may be lost; the supply of aquatic life may be reduced, the suitability of water for domestic and industrial use may be impaired; the life of bridges and other structures may be shortened; and recreational use of water bodies and adjacent lands may be hampered or prevented. These effects may result from

deposits of foreign substances of four major types: (1) Chemically inactive substances, (2) active putrescible substances, (3) bacteria, and (4) chemically active nonputrescible substances."[1]

This brief summary of the effects of pollution on the Tennessee River system is intended to point out only those sections of the system which are grossly polluted and to give a general statement of the effects of pollution on municipal water supplies, recreational use of the reservoirs, aquatic life, and submerged structures. More detailed discussions of the conditions are given in the body of the report.

As shown in figure 1, the greatest amount of pollution originates in the French Broad River basin, the Holston River basin, and in the Hales Bar area around Chattanooga. In general the streams in these areas are the most seriously affected by the pollution.

Gross conditions of pollution are found in the Holston River system in Beaver Creek from Bristol to its mouth and in the South Holston from this point to its confluence with the North Holston. Even with the dilution afforded by the cleaner water from the North Fork, serious conditions exist in the Holston River to the upper end of Cherokee Reservoir.

The French Broad River from Brevard, N.C., to the upper end of Douglas Reservoir is highly colored and frothy from industrial wastes. The Pigeon River from Canton, N.C., to its mouth at the upper end of Douglas Reservoir is the most seriously polluted long stretch in the Valley. Studies have not been completed to determine the effect of these wastes on the reservoir; but water drawn from the bottom of the lake when not diluted with aerated water from the spillway is devoid of oxygen and may be toxic to fish, and it does not recover by the time it joins the Holston River at Knoxville.

Fort Loudoun Reservoir was filled in August and September 1943. Preliminary studies, yet incomplete, indicate very low dissolved oxygen concentrations in the upper end of the reservoir, caused in part perhaps

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1. Water Pollution in the United States, Third Report of the Special Advisory Committee on Water Pollution, National Resources Committee, 1939, p. 31.

by low concentrations in the French Broad River and in part by the decomposition of organic matter received at Knoxville.

While not apparent from figure 1, the Tuckasegee River of the Little Tennessee River system is in a serious condition from the mouth of Scott Creek near Sylva, N.C., to its mouth. The color effect of the pollution carried by this stream is apparent at the mouth of the Little Tennessee River.

The Emory arm of Watts Bar Reservoir is grossly polluted by industrial wastes originating at Harriman, Tenn. These wastes cause almost total depletion of oxygen in this arm of the lake and impart an intense black color to the water, which is apparent in the main Tennessee section of the reservoir below the mouth of the Clinch River.

The Ocoee River below Copperhill, Tenn., carries a large amount of silt from the eroded area and high concentrations of minerals and acids discharged by the industries in that region.

Hales Bar Reservoir receives a large amount of domestic sewage and industrial wastes from Chattanooga, which imposes a severe burden upon the reservoir. Undesirable conditions exist throughout the reservoir and the influence of this pollution extends through the upper twenty miles of Guntersville Reservoir.

There are a number of small streams serving as sewers to carry sewage and industrial wastes from municipalities or industries to larger streams. Among those known to be seriously polluted are Brush Creek below Johnson City, Tenn.; Davidson River below Pisgah Forest, N.C.; Hominy Creek below Enka, N.C.; Scott Creek below Sylva, N.C.; South Mouse Creek below Cleveland, Tenn.; Chattanooga Creek in Chattanooga, Tenn.; Huntsville Spring Branch and the lower section of Indian Creek below Huntsville, Ala.; and Big Bigby Creek below the phosphate mining operations in the Duck River basin.

Cities which have already experienced difficulties directly attributable to pollution in the treatment of their water supplies are Bristol, Knoxville, and Harriman, Tenn. Kingsport, Tenn., may be faced with treatment problems in the near future, and if the pollution is permitted to increase unduly immediately above the Chattanooga, Tenn.. water-supply intake, troubles may be expected in that supply.

Because of the broad range of water characteristics suitable for the various forms of recreation, it is rather difficult in a brief statement to outline the effects of the pollution on such uses of the reservoirs. If the aesthetic requirements can be overlooked, boating might be enjoyed in all reservoirs. The requirements of water quality for swimming, however, are more restricted and this activity should not be considered except in the cleaner sections. The areas in which this form of recreation might be developed are given in the body of the report. Since swimming is desirable at boat harbors and is indulged in without approval at most docks, a considerable amount of thought should be given to the selection of sites for such developments.

Consideration should be given to the establishment of adequate facilities for recreation on the reservoirs and streams of the Tennessee River system as this activity is an important source of income to the area. It is reported that the United States Travel Bureau[1] estimates that in 1938 "North Carolina received $100,000,000 and Tennessee $81,000,000 from recreation travelers." These figures, of course, apply to the entire area of each state, but a considerable portion of these amounts resulted from the activities within the Tennessee Valley. No figures were given in the report for the remaining states in the Valley. The Tennessee Department of Conservation[2] estimates that the income from out-of-state tourists in 1941 amounted to $104,000,000.

Where the pollution is present in sufficient amounts to reduce the dissolved oxygen below an average of 5.5 ppm, desirable fish fauna cannot develop. Such conditions of pollution exist in the sections which have already been listed in this summary. In portions of most of these heavily polluted sections the dissolved oxygen has been entirely depleted, and in some, toxic materials are present, both of which prevent the development of any form of fish life. In the unpolluted sections of the streams and in the greater part of the reservoirs, conditions are favorable for the development of a wide variety of desirable species of fish.

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1. Recreation Development of the Tennessee River System, House of Representatives, Document No. 565, 1940, p. 90.
2. The Tourist Industry in Tennessee, issued by the Department of Conservation, Paul S. Mathes, Commissioner.

In only one stream in the Valley are conditions such as to damage submerged structures. The high acid concentration perhaps along with the silt carried by the Ocoee River appears to be responsible for abnormal deterioration of the runners of the hydroelectric plants on that stream. Additional studies will be necessary before the separate effects of erosion, corrosion, and cavitation can be determined.

INTRODUCTION

In the introduction to the preceding report,[1] published in 1941, it was stated that detailed studies of the individual tributaries and of the major industries in the Valley were being carried out and that a report would be prepared when the work was completed. This report, number II, presents the results of these studies on the seven major tributaries (Holston River, French Broad River, Little Tennessee River, Clinch River, Hiwassee River, Elk River, and Duck River), most of which were made during 1937 and 1938, and summarizes the results of surveys extending through 1940 of industrial pollution in the Tennessee Valley.

As in the case of the earlier work, with the exception of the studies on Duck River, the upper French Broad River, and the Elk River, the routine collection of samples from the tributaries and the analytical work were done by the Hydraulic Data Division under the technical supervision of the Health and Safety Department. Personnel of the Tennessee Department of Public Health collected the samples and made most of the laboratory determinations for the Duck River, although certain laboratory studies were made by the Water Analysis Laboratory of the Hydraulic Data Division on samples shipped to its laboratory at Norris, Tenn. Similarly, the collection of samples and some of the determinations required for the studies on the upper French Broad River were made by the North Carolina State Board of Health with samples for certain determinations sent to the Norris laboratory. In the Elk River studies, the samples were collected by personnel of the Health and Safety Department and most of the laboratory determinations were made at its laboratory at Wilson Dam, Ala., with the remainder made at the Norris laboratory.

In the summer of 1938 after the completion of the routine river studies and at the beginning of the studies of industrial wastes, the Water Analysis Laboratory was transferred to the Health and Safety Department, and in November 1939 the laboratory was moved to Wilson Dam.

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1. Studies of the Pollution of the Tennessee River System, A General Description of the Valley with Results of Studies on the Knoxville, Chattanooga, Decatur, and Tri-Cities Sections of the Tennessee River 1936-1937, Tennessee Valley Authority, Health and Safety Department, 1941.

At the beginning of the Ohio River Pollution Survey by the Army Engineer Corps and the U.S. Public Health Service in 1939, a sanitary engineer of the U.S.P.H.S. was assigned to work with the Authority in completing the survey of industrial wastes. Later, in 1940, another engineer was assigned to assist in the surveys of the municipal water supplies and sewerage systems. Additional assistance was also furnished by the U.S.P.H.S. and by the interested state health departments when needed for special studies of industrial wastes.

During the period from the summer of 1938 through 1940, pertinent data on the operation and on the amount and characteristics of plant wastes were obtained from all but two of the industries in the Valley which discharged liquid wastes. For purposes of this study the numerous small milk handling stations, local creameries, laundries, etc., were not considered of sufficient importance to warrant individual listing, since the wastes from such activities are constituents of normal domestic sewage from towns. Detailed studies were made of the wastes from twenty-two of the larger, typical, or unique plants in the Valley, and from the results of these studies conversion factors, usually in terms of population equivalents per unit of raw or finished material, were obtained which, with information obtained by studies elsewhere, permitted a relatively accurate estimate to be formed of the pollutional effect of most of the industries in the Valley. When the wastes were primarily chemical in nature and not amenable to such analytical procedure, complete chemical analyses of the wastes were made to determine their effects on the streams.

It is realized that there are logical arguments against the comparison of the effect on streams of industrial wastes with that of domestic sewage based upon the 5-day biochemical oxygen demand (B.O.D.). One of the chief criticisms against the method is the assumption that all wastes and sewages are oxidized at the same rate. In the studies of the industrial wastes in the Tennessee Valley rates of oxidations as low as one-third and others as high as three times the accepted rate for domestic sewage have been observed. The effect on streams of industrial wastes with low rates of oxidation will be much less than that of an equivalent amount of 5-day B.O.D. of domestic sewage. Also, the industrial wastes with high rates of oxidation will have more pronounced effects on streams

than an equivalent amount of domestic sewage. Other wastes have high immediate chemical oxygen demands followed by biochemical oxygen demands of varying rates depending upon the type of pollutional material. These facts should be appreciated in any comparison of industrial waste with domestic sewage and it should be realized that the "population equivalents" of industrial wastes used in this report are approximate only.

In the survey of the municipal sewerage systems, information was obtained from the state departments of health and from the municipalities themselves on the extent of sewered areas, connected populations, and types of treatment. This information made possible an accurate estimate of the amount and strength of domestic sewage reaching the streams in the Valley.

The presentation of the amounts of pollution from domestic sewage and industrial wastes in the tables indicates the estimation of these loads with a greater degree of accuracy than is warranted by the basic information. However, in order to maintain a system of reporting, this degree of accuracy has been used. It should be understood that the totals obtained by this method will be accurate perhaps to the third significant figure as shown in tables 3, 4, and 5.

The results of these studies are presented in this report in eight sections. Seven sections are devoted to the major tributaries, and the last section summarizes the pollution originating in the remainder of the Tennessee Valley and discusses general conditions which have developed in the Tennessee River with increased impoundage.

Sampling Procedures

In collecting the samples, care was taken to obtain a sufficient number of samples across the stream which, when composited, would represent the average conditions at the time. Usually three samples were collected, one at each quarter point. In the narrower streams, only two samples were collected.

Samples for bacteriological examinations were taken from near the surface of the stream at a depth of about six inches. All other samples were collected at mid-depth.

When necessary, accepted methods for the preservation of the samples were followed. Samples for bacteriological examinations and B.O.D. determinations were kept on ice in the interim between collection and examination, and samples for nitrogen determinations were preserved by the addition of sulphuric acid. Sodium hydroxide was used for the preservation of samples for phenol determinations.

Temperature, dissolved oxygen, and pH measurements were made in the field immediately after the samples were collected.

Analytical Procedure

Procedures outlined in "Standard Methods of Water Analysis, Eighth Edition 1936" were followed in all determinations with the exception of some determinations on certain industrial wastes where accepted modifications or other approved methods were necessary for the complete analyses.

As in the earlier work on the Tennessee River, reported in 1941, the densities of the coliform group are based upon the results of positive presumptive tests in lactose broth for the work done in the Norris laboratory, and on confirmation in brilliant green lactose bile broth for the work at the Wilson Dam laboratory.

Presentation of Analytical Results

Summaries of the analytical results are tabulated at the close of the discussion of each tributary. The information is presented in the following tables: (1) Mineral Analyses, (2) Solids, (3) Nitrogens, (4) Dissolved Oxygen and Biochemical Oxygen Demand, and (5) Bacteria.

These tables show in addition to the monthly averages, the seasonal averages for the summer and winter season. The period from June 15 through October 15 was considered the summer season; as it is during this period, in general, that higher temperatures and lower stream flows are experienced in the Valley. The winter season includes the remainder of the year. In these tables, the monthly results are the averages calculated from the individual observations during the month. The averages

for the total periods and for the seasons are also averages of the individual samples. The maximum and minimum results are the extreme values of individual observations during the indicated periods.

It is commonly known that in studies of this kind, abnormal amounts or "slugs" of pollutional material are occasionally included in samples, which, in addition to the usual experimental errors, will give results not representative of normal conditions. In the preparation of the tabulated material on dissolved oxygen and biochemical oxygen demand, Chauvenet's Criterion[1] was used to judge whether the variations of individual observations from the average of a series fell within acceptable limits. If the variation was too great, the particular observation was not included in determining the averages given in the tables. These studies resulted in the elimination of a number of observations which, if included in the calculations, would have resulted in data unduly influenced by single observations which were probably not representative of normal conditions.

The averages for the bacteria developing on agar and for the coliform group are geometric averages instead of arithmetic averages. This method of obtaining averages minimizes the effect of the extreme variants on the average, particularly if the data are "skewed" as is the case generally with bacteriological results.

All other averages are arithmetic averages on which no statistical analyses have been made.

The stream discharges given in the tables are the averages of the discharges at the approximate times the samples were collected. The individual discharges were estimated by the Hydraulic Data Division.

Discussion of Results

In the discussion of each tributary, the sources and extent of the pollution due to domestic sewage and industrial wastes are given and

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1. For discussions on the applications of Chauvenet's Criterion see:
C. B. Davenport and M. P. Ekas, Statistical Methods in Biology, Medicine and Psychology (4th ed.; New York: John Wiley & Sons, Inc., 1936);
W. M. Feldman, Biomathematics (2nd ed.; London: Charles Griffin & Company, Ltd., 1935).

correlated with the field and laboratory findings. The conditions observed in the streams and also those which can be expected under normal stream flow conditions are then described. In this report, the average flows given in the tables of mean monthly discharges are considered normal flows.

The period of the year during which the most critical conditions exist in the Tennessee River system includes the late summer and early fall months. It is during these months that the stream flows are at a minimum, and with the high temperatures promoting rapid biological activity conditions usually develop which degrade the streams to a greater extent than during any other period of the year. For this reason, the conditions existing during this critical period are used in describing the effects of pollution and in classifying streams, unless abnormal conditions are found which impose more severe burdens on the streams.

In describing the effects of pollution on streams, use is made of a system of classification based on the minimum acceptable qualities of water for municipal water supplies, swimming, and fish life. (For a complete discussion of the development of these requirements, see Appendix I).

In general, this system of classification is applied in the following manner. When the conditions in the streams are such that the water meets the requirements for Class A swimming areas and for domestic water supplies requiring only the minimum of treatment, the streams are described as being in a Class I condition. When the amount of pollution is slightly more than in Class I, but when the water can still meet the requirements for Class B and Class C swimming areas, or can be safely and satisfactorily treated for domestic use by normal water purification processes, the streams are described as being in a Class II condition. Under conditions of increased pollution from which safe, potable domestic water might be obtained with specialized purification processes, and in which the pollution is not too concentrated to seriously affect fish life, the streams are described as being in a Class III condition. When the amount of pollution is so great that the water cannot be satisfactorily treated to produce a safe, potable supply, or when conditions are generally unsuitable for the development of desirable fish life, the streams are described as being in a Class IV condition.

The limits of the stretches of the streams falling within the various classifications were determined from the results of the field and laboratory studies of the streams and from the data on the origins and amounts of domestic sewage and industrial wastes. Since the stations are so widely separated, the points at which the streams pass from one classification to the next are only approximate. To fix them more accurately would require studies at intermediate stations and knowledge of the times of flow between the stations for normal ranges of stream discharges. No basic information is available from which these times of flow in the tributaries can be estimated. Float studies, such as were carried out on the Tennessee River, were not attempted during the studies of the tributaries. Additional errors may have also been introduced in classifying the streams under conditions of normal flow from the observed conditions. These weaknesses should be appreciated and it should be realized that the classifications presented in this report are general in nature and subject to later revision and modification. However, it is believed that the descriptions present a fairly accurate picture of the conditions in the streams.

It will be noticed that considerable work has been done to secure information on the mineral constituents of the water in the tributaries and that little is said of these results in the discussions. To give a complete discussion of the changes in mineral content and their causes would require more space than can be justified in a report on pollution. The information is included for the purpose of completing the information on the streams and to provide information which may be of use in the selection of suitable water supplies. The mineral constituents are discussed only when markedly influenced by industrial wastes.

Additional Sources of Information

Geology

The discussions on the geology of the various areas have been taken from "Water Supply Papers Nos. 114 and 677" of the United States Geological Survey and from descriptions prepared by the Authority.

Precipitation

Data on precipitation were obtained from those assembled by the Hydraulic Data Division.

Stream Flows

Estimates of stream flows at the times samples were collected were made by the Hydraulic Data Division. Average stream discharges for the streams in the Valley were obtained from published records of the U.S. Geological Survey, Water Resources Branch.

Usually these average discharges are based on the fifteen-year period from 1920 to 1934, inclusive. As the discharges during this period are measures of the run-off from very dry seasons, as well as from those with excessive rainfall, it is felt that the averages obtained from these years are representative. Where records for this period are not available, the averages are based on records for other years.

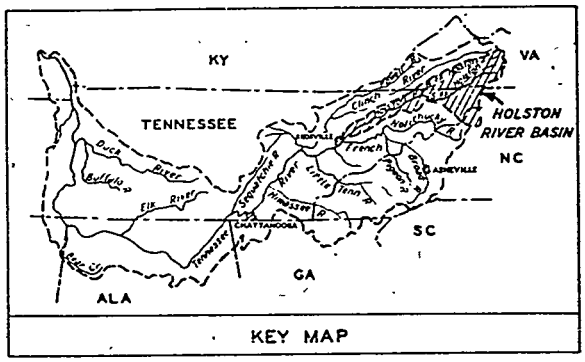
Population Estimates

Estimates of population in the areas were prepared from the 1940 reports of the U.S. Census.

Analytical Data

When available and when necessary to supplement the information obtained in these studies, the results of analyses made by other agencies have been incorporated in this report. This has been done in the case of the bacteriological examinations of raw water at the Bristol, Tenn., water plant. Mineral analyses of the North Fork Holston River at Saltville, Va., and the Clinch River at Speer Ferry, Va., were obtained from "Chemical Character of Surface Waters of Virginia," Bulletin No. 3, by the Division of Water Resources and Power, State Commission on Conservation and Development. Mineral analyses for the Little Tennessee River near Franklin, N.C., Nantahala River near Wesser, N.C., Cheoah River near Lopoco, N.C., and Nottely River near Murphy, N.C., were obtained from the "Chemical Quality of the Surface Waters of North Carolina with Relation to Industrial Use," Economic Paper No. 61, by the North Carolina Department of Conservation and Development.

Reference is frequently made to the results of studies on the tributaries which were made by the U.S.P.H.S. forces in their mobile laboratory. Use has been made of these data in describing the streams. The detailed results of these studies are given in "Ohio River Pollution Control," Part Two, Report of the United States Public Health Service, House Document No. 266, 1943.



VI
TEN

Chur

RIVER

Surgoinsville

Rogersville

Transition section from class IV through class III and class II to class I

St. Clair

Russellville

CHEROKEE DAM

HOLSTON

Morristown

Jefferson City

Mascot

John Sevier

French Broad River

KNOXVILLE

CHATTANOOGA DRAFTING SERVICE

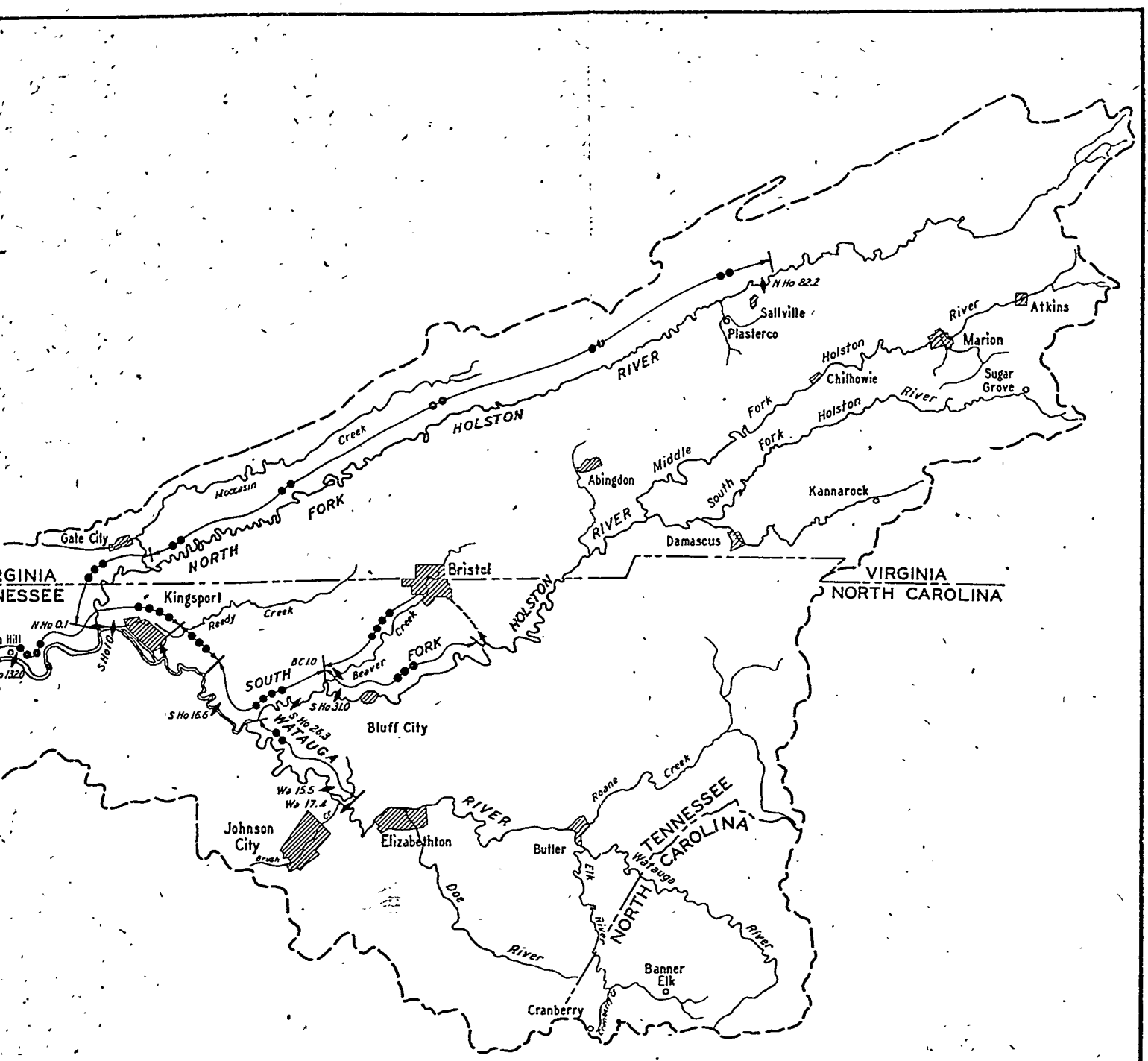


Figure 2

Scale 4 0 4 8 Miles

SYMBOLS:

- Class I – Class A swimming areas and water supplies with minimum treatment.
- Class II – Class B and C swimming areas and water supplies (normal filter plant operation).
- Class III – Water supplies (advanced treatment methods) and fish life.
- Class IV – Unsuitable for water supplies as defined under Class III or which do not support desirable fish fauna.
- Sampling stations
- Water supply intake

POLLUTION SURVEY

HOLSTON RIVER DRAINAGE BASIN

STREAM SANITATION PROGRAM
TENNESSEE VALLEY AUTHORITY
HEALTH AND SAFETY DEPARTMENT

SUBMITTED	RECOMMENDED	APPROVED

CHATTANOOGA	11-1-43	G	HS	306B507 R1

SECTION I

HOLSTON RIVER

SECTION I

HOLSTON RIVER

General

The Holston River and the French Broad River form the Tennessee River at Knoxville. The Holston River drains a wedge-shaped area, figure 2, which is rather narrow at the lower end but which widens abruptly above Morristown to include the areas drained by the North Fork and by the South Fork and its large tributary, the Watauga River. Both the South Fork and the North Fork extend up into the state of Virginia and the Watauga extends for a short distance into northwestern North Carolina. The Holston River is the third largest of the seven major tributaries, having a drainage area of 3,776 square miles divided among its tributaries as follows:

North Fork	729 square miles
South Fork (not including the Watauga River)	1,179 square miles
Watauga	869 square miles
Remainder of basin	999 square miles

While the area is largely agricultural, there is a considerable amount of industrial development. Textile, paper and pulp, and chemical industries are the predominating types of industry.

Geology

With the exception of the upper sections of the South Fork and Watauga Rivers, which rise in the Blue Ridge Mountain Region of resistant formations, the Holston River flows through what is known as the Valley of Eastern Tennessee. It should be realized that with the development of this valley since 1905, the pollution has increased to such an extent that the clear stream waters and wholesome springs described in the following discussion[1] outlining the effect of the geology of this section on the waters originating in the area are now almost entirely absent.

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1. L. C. Glenn, "Tennessee and Kentucky," in Underground Waters of Eastern United States, Water Supply and Irrigation Paper No. 114, United States Geological Survey, 1905, pp. 198-199.

"Description.--The so-called Valley of East Tennessee is that part of the great Appalachian Valley that extends southwestward across the eastern end of the State from the Virginia to the Georgia line. Its width varies from 45 to 60 miles. It is limited on the southeast by the Great Smoky Mountains along the North Carolina line, and on the northwest by the eastern scarp of the Cumberland Plateau. The floor of this valley has an elevation of 900 feet at Chattanooga and of 2,000 feet along the Virginia line. Many long, narrow, parallel ridges trending northeast-southwest in the same direction as the valley itself rise above its floor. They are separated by long, narrow, minor valleys. The ridges are formed by the hard, upturned, folded and faulted Cambrian, Silurian, and Devonian rocks, while the intervening valleys have been eroded in the limestone or soft shale.

"Water resources.--Along the eastern side of the valley the Great Smoky Range, which reaches an extreme height of over 6,500 feet, is carved along with its projecting spurs either from metamorphosed sediments of probably Cambrian age or from more ancient igneous rocks of various kinds. Among these spurs many bold freestone springs are found, and every ravine has its streamlet of pure, clear, and unfailing water. The region is rough and sparsely settled, and the springs furnish an abundant and satisfactory water supply.

"In the valley proper the streams are usually broad, shallow and rapid. Their waters are generally pure and clear, except after heavy rains. Innumerable springs are found throughout the valley. Because of the great variety in the rocks of the region the water of the springs varies greatly in character. From the limestones and dolomites large and bold springs of clear, hard but wholesome, water issue constituting the most common supply for household purposes. The waters often contain magnesian salts where the springs issue from the Knox dolomite. In general it may be said that their chief mineral contents are calcium, magnesium, and sodium carbonates, sulphates and chlorides, with occasionally iron sulphate and carbonate or aluminum sulphate or alum. Many sulphur, iron, and alum springs are found in the Devonian black shale. Sulphur waters are also found in the limestones and dolomites. Chalybeate waters occur in the sandstone and conglomerates, though freestone waters are more common. In several counties Epson springs are known.

"Some of these valley springs have earned a wide reputation for their medicinal qualities, and annually attract many visitors in search of health, recreation, or rest. A few ship their waters."

Precipitation

The average annual precipitation in the area is 45 inches. During the year of the study, from August 1937 to August 1938, the average was somewhat higher, approximately 51 inches.

Stream Flows

The mean monthly discharges for various streams in the valley are shown in table 6. For comparison with these discharges, the average discharges existing at each sampling station at the time samples were collected are shown in the tables presenting the results of analyses, (tables 11, 12, 13, 14, and 15).

Water Supplies

Because of the presence of so many large springs in the valley most of the municipal water supplies are drawn from such sources. Bristol, Kingsport, Morristown, John Sevier, and Mascot, Tenn., which obtain their water supplies from surface streams, provide the exceptions. Table 7 gives a list of the municipal supplies, their sources, and methods of purification.

TABLE 6

MEAN MONTHLY DISCHARGES IN CUBIC FEET PER SECOND

AT DESIGNATED POINTS ON HOLSTON RIVER

	South Holston River Bluff City Tenn.	Watauga River Elizabethton Tenn.	South Holston River Kingsport Tenn.	North Holston River Gate City Va.	Holston River Rogersville Tenn.	Holston River Strawberry Plains, Tenn.
Drainage Area Above Gage Sq. Mi.	813	692	1931	672	3,035	3,626
Period of Record	1920-1934	1926-1934	1926-1934	1932-1940	1920-1934	1931-1940
January cfs	1,580	1,170	2,790	1,580	5,660	6,870
February cfs	2,120	1,680	4,560	1,710	7,560	8,570
March cfs	2,050	1,710	4,480	1,910	7,360	8,870
April cfs	1,680	1,660	4,040	1,370	5,910	7,600
May cfs	1,360	1,400	3,340	753	4,950	4,390
June cfs	996	995	2,360	450	3,580	2,750
July cfs	697	767	1,770	454	2,610	2,900
August cfs	691	789	1,700	513	2,530	3,170
September cfs	493	628	1,370	220	1,770	1,760
October cfs	476	671	1,370	322	1,670	1,810
November cfs	596	800	1,660	283	2,160	1,870
December cfs	1,270	1,240	3,040	549	4,550	3,160
Mean Annual cfs	1,170	1,120	2,710	840	4,200	4,460
Maximum Flow cfs	28,000	75,100	68,800	23,700	70,900	62,900
Minimum Flow cfs	45	63	210	38	278	600

TABLE 7

WATER SUPPLIES

HOLSTON RIVER BASIN, 1937-1940

Municipality	Population	Source	Treatment[1]
Sugar Grove, Va.	350	Spring	N
Kannarock, Va.	300	Stream	N
Damascus, Va.	1,441	Springs	D
Atkins, Va.	95	Spring	N
Marion, Va.	5,177	Springs	D
Southwestern State Hospital	2,000	Spring	D
Chilhowie, Va.	889	Spring	N
Emory and Henry, Va.	500	Springs	D
Glade Springs, Va.	686	Springs	D
Abingdon, Va.	3,158	Springs	D
Bluff City, Tenn.	700	Springs	N
Bristol, Va.	9,768	(Springs	D
		(Stream	CFD
Bristol, Tenn.	14,004	South Fork, Holston	CFD
Blountville, Tenn.	250	Springs	D
Banner Elk, N. C.	720	Wells	N
Cranberry, N. C.	100	Springs	N
Elk Park, N. C.	467	Springs	N
Mountain City, Tenn.	1,021	Spring	D
Butler, Tenn.	608	Spring	N
Elizabethton, Tenn.	8,516	Spring	D
Johnson City, Tenn.	25,332	Springs	D
Kingsport, Tenn.	14,404	(Impounded and South	
		(Fork Holston	CFD
Saltville, Va.	2,650	Springs	D
Allison Gap, Va.	300	Saltville	
Henrytown, Va.	200	Saltville	
Plasterco, Va.	400	Spring	D
Meadow View, Va.	596	Spring	D
Mendota, Va.	173	Spring	N
Gate City, Va.	1,565	Springs	D
Rogersville, Tenn.	2,018	Wells and Spring	D
Morristown, Tenn.	8,050	Holston River	
		Spring and Well	CFD
Jefferson City, Tenn.	2,576	Spring	SD
Cherokee Dam, Tenn.	30	Spring	FD
Mascot, Tenn.	2,500	Mine and Flat Creek	CFD
John Sevier, Tenn.	700	Holston River	CFD

1. N = No Treatment
   C = Coagulation and Sedimentation
   D = Disinfection
   F = Filtration
   S = Softening

Population Estimates

The Holston River basin is the most densely populated of the large tributaries and ranks second among them with respect to population. Its population is 348,722, divided among the tributaries as follows:

North Fork	44,073
South Fork (not including the Watauga River)	123,296
Watauga	93,421
Remainder of basin	87,932

Sewerage Systems

Table 8 shows the municipalities in the Holston River basin which have sewerage systems and the types of treatment. Approximately 78 percent of the urban population and 24 percent of the total population is sewered. A reduction of approximately 5.2 percent in the amount of pollution by domestic sewage is accomplished by the six sewage treatment plants.

TABLE 8

SEWERAGE SYSTEMS

HOLSTON RIVER BASIN, 1937-1940

Municipality	Population (1940 U.S. Census)		Treatment
	Total	Sewered	
Damascus, Va.	1,441	220	None
Marion, Va.	5,177	7,000[a]	Imhoff Tank - Part of sewage chlorinated
Chilhowie, Va.	889	620	None
Abingdon, Va.	3,158	1,600	Imhoff Tank - Chlorination
Bluff City, Tenn.	700	350	None
Bristol, Va.	9,768	6,500	None
Bristol, Tenn.	14,004	9,800	None
Banner Elk, N. C.	724	550[b]	Imhoff Tank - Sprinkling Filter
Butler, Tenn.	608	240	None
Elizabethton, Tenn.	8,516	7,700	None
Johnson City, Tenn.	25,332	20,200	None
Kingsport, Tenn.	14,404	11,500	None
Saltville, Va.	2,650	1,320	None
Gate City, Va.	1,565	940	None
Rogersville, Tenn.	2,018	1,010	None
Morristown, Tenn.	8,050	5,250	None
Jefferson City, Tenn.	2,576	1,000	Imhoff Tank
Cherokee Dam, Tenn.	30	30	Septic Tank
Mascot, Tenn.	2,500	2,500	Septic Tank
Knoxville, Tenn.	6,530[c]	5,300	None
Total	110,640	83,630	

a. Includes inmates of Southwestern State Hospital.
b. Includes college students.
c. That portion of Knoxville tributary to the Holston River.

Industrial Plants

Table 9 gives the types and number of industrial plants in the basin, the disposition of their wastes, and comparative figures for the entire Tennessee Valley. This table is incomplete in that it does not list all the numerous small milk handling and processing plants in the area. Approximately 12.5 percent of the industries in the Valley are located in the basin, and these industries are responsible for 18.8 percent of the total industrial pollution.

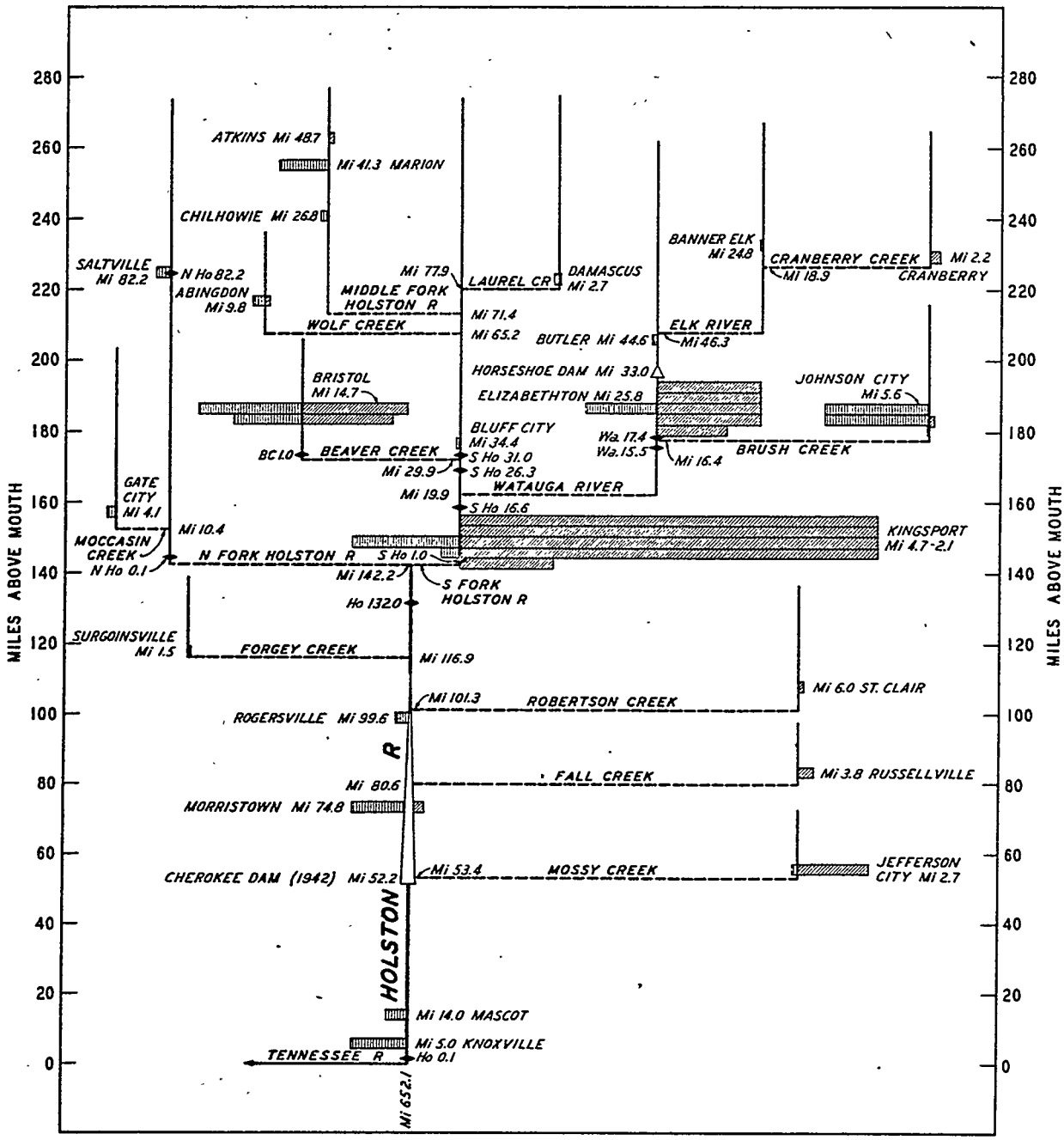
Very little reduction in the total industrial pollution is accomplished at the four plants in which the wastes receive some form of treatment. Two of these industries pond the wastes to equalize the flow. The small reduction in the population equivalent of industrial wastes reaching the river system is due to the discharge of wastes from a small industry into a dry run where it seeps into the soil. One of the large industries completed the installation of an efficient recovery plant just prior to the waste survey. The reduction in pollution effected by this treatment is not known since only general data on the character of the waste prior to treatment are available.

TABLE 9

INDUSTRIAL POLLUTION

HOLSTON RIVER BASIN, 1937-1940

Types of Industry	Number of Plants		Method of Disposal			Estimated Population Equivalents	
	Holston River Basin	Percent of Total in Tenn. Valley	Municipal Sewers	Stream	Some Correction	Holston River Basin	Percent of Total in Tenn. Valley
Canning	5	18.5	1	4	0	10,400	24.9
Cellulose	3	60.0	0	3	1	170,900	48.5
Chemical	4	15.4	0	4	2	560	2.1
Meat	1	5.3	0	1	0	100	0.2
Milk	3	8.8	1	2	0	900	6.3
Pulp and Paper	2	22.2	0	2	0	51,100	8.7
Tanning	1	11.1	0	1	0	430	0.5
Textiles	10	11.8	6	4	1	5,100	3.5
Miscellaneous	2	8.0	1	1	0	7,300	25.0
Total	31	12.5	9	22	4	246,790	18.8



SYMBOLS:

- Sampling station
- Population equivalent:
  - Domestic sewage
  - Industrial waste
- Dam and reservoir

Scale of population equivalent

0 10,000

NOTE:
Number at sampling station denotes miles above mouth of each stream.

Figure 3

HOLSTON RIVER SOURCES OF POLLUTION AND SAMPLING STATIONS

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Extent of Pollution

Table 10 shows the estimated amounts of pollution expressed in population equivalents due to domestic sewage and industrial wastes reaching the Holston River and its tributaries. The same information is shown graphically in figure 3. As it is impossible to measure the effects of the wastes from certain chemical industries in this manner, table 10 is incomplete. However, the effects of these chemical industries are clearly indicated by the results of the mineral analyses and will be discussed later. It is estimated that 17.6 percent of the total pollution received by the Tennessee River system originates in the Holston River basin.

TABLE 10

ESTIMATED POPULATION EQUIVALENT OF POLLUTION

REACHING HOLSTON RIVER SYSTEM, 1937-1940

Municipality	Receiving Stream	Estimated Population Equivalents		
		Domestic Sewage	Industrial Wastes	Total
Damascus, Va.	Laurel Creek	220	100	320
Atkins, Va.	Middle Fork	---	430	430
Marion, Va.	Middle Fork	4,550	---	4,550
Chilhowie, Va.	Middle Fork	620	---	620
Abingdon, Va.	Wolf Creek	1,040	500	1,540
Bluff City, Tenn.	South Holston River	350	---	350
Bristol, Va.-Tenn.	Beaver Creek	16,300	18,610	34,910
Banner Elk, N. C.	Elk River	110	---	110
Cranberry, N. C.	Cranberry Creek	---	1,000	1,000
Butler, Tenn.	Watauga River	240	---	240
Elizabethton, Tenn.	Watauga River	7,700	46,600	54,300
Johnson City, Tenn.	Brush Creek	20,200	450	20,650
Kingsport, Tenn.	South Holston River	11,500	168,950	180,450
Saltville, Va.	North Holston River	1,320	---	1,320
Gate City, Va.	North Holston River	940	---	940
Surgoinsville, Tenn.	Holston River	---	200	200
St. Clair, Tenn.	Holston River	---	500	500
Rogersville, Tenn.	Holston River	1,010	---	1,010
Russellville, Tenn.	Holston River	---	1,500	1,500
Morristown, Tenn.	Holston River	5,250	1,300	6,550
Jefferson City, Tenn.	Mossy Creek	650	6,600	7,250
Cherokee Dam, Tenn.	Holston River	20	---	20
Mascot, Tenn.	Holston River	2,000	---	2,000
Knoxville, Tenn.	Holston River	5,300	---	5,300
Total		79,320	246,740	326,060

Sampling and Sampling Stations

Sampling

Samples were collected at weekly intervals from the nine upper stations on the system from August 17, 1937, to August 11, 1938. The samples after collection were iced and taken to the laboratory at Norris, Tenn., for examination. Samples from the lower station were collected at weekly intervals from May 1936 to April 1937, and the results were reported in 1941.[1] The results have been summarized in this report in order to complete the data for this basin. Daily samples were collected and composited from June 1, 1930, to March 31, 1931, from the North Fork at Saltville, Va., and analyzed by the State Commission on Conservation and Development. The results of the bacteriological examinations at the Bristol, Tenn., water plant on the South Fork Holston River were obtained from plant records covering the period from August 1937 through June 1940.

Since the sampling trip for the nine stations required the greater part of two days, some of the samples were older than desirable when they reached the laboratory. However, since they were kept on ice during the time of transit, changes due to biological activity were reduced to a minimum.

Sampling Stations

The sampling stations were selected at a sufficient number of critical points to determine the significant changes in conditions brought about by pollution and natural recovery processes. The locations of the stations are given below. The numbers following the key letters for each station represent the distance in miles above the mouth of the stream to the station. (Figures 2 and 3)

South Fork Holston River, SHo 48.4: Bristol, Tenn., water purification plant.

South Fork Holston River, SHo 31.0: A bridge about a mile above the mouth of Beaver Creek and below Bluff City, Tenn.

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1. Studies of the Pollution of the Tennessee River System, I. A General Description of the Valley with Results of Studies on the Knoxville, Chattanooga, Decatur, and Tri-Cities Sections of the Tennessee River 1936-1937, Tennessee Valley Authority, Health and Safety Department, 1941.

Beaver Creek, BC 1.0:	A bridge one mile above the mouth. This stream carries the domestic sewage and a considerable amount of industrial pollution from Bristol, Tenn., and Bristol, Va.
South Fork Holston River, SHo 26.3:	A bridge about three miles below Beaver Creek and about 6.4 miles above Watauga River.
Watauga River, Wa 17.4:	A bridge at Watauga, Tenn. The station is below Elizabethton, Tenn., but above the mouth of Brush Creek which carries the sewage from Johnson City, Tenn.
Watauga River, Wa 15.5:	A bridge about one mile below the mouth of Brush Creek.
South Fork Holston River SHo 16.6:	A bridge about three miles below the mouth of Watauga River and above Kingsport, Tenn.
South Fork Holston River, SHo 1.0:	Below all pollution received at Kingsport, Tenn.
North Fork Holston River, NHo 82.2:	At Saltville, Va., but above the point at which the industrial wastes are discharged.
North Fork Holston River, NHo 0.1:	The bridge near the mouth of the river on U.S. Highway 11W.
Holston River, Ho 132.0:	A bridge near Church Hill, Tenn., about ten miles below the confluence of the North and South Forks.
Holston River, Ho 0.1:	Near the mouth of the river. About four miles above this point the river receives the domestic sewage from a small section of Knoxville, Tenn., having an estimated population of 6,530.

Discussion of Results

Stream Flows

In general the stream flow of the Holston River during the period of study was considerably above the average. At some stations

the flows during July were four times the average, and at a number of others the discharges at the time of the study were from two to three times the monthly average flow. In exception to these were the flows in the Watauga River, as approximately normal conditions existed in this stream during the summer of the study period.

Observed Conditions

The averages of the results of the routine bacteriological examinations at the Bristol, Tenn., water plant on the South Fork Holston River, at SHo 48.4, indicate that during June, July, and possibly August, Class III conditions exist in the stream at this point.

The results of the studies at SHo 31.0 indicate that the stream above Beaver Creek during the study period was Class II. The conditions as measured by the density of the coliform group and the 5-day B.O.D. places the stream in this classification although the dissolved oxygen is higher than might be expected. This condition will be true for most sections of the Holston River because of the excellent opportunities for reaeration afforded by rapid, comparatively shallow flow over rocky bottoms.

Beaver Creek with its load of domestic sewage and industrial wastes falls in Class IV. Here again the dissolved oxygen is higher than would be expected, but this station is located below a rapidly flowing section of the stream. In the pools in Beaver Creek septic conditions exist as evidenced by the ebullition of gases.

The effect of the pollution from Beaver Creek on the South Fork is to degrade the stream to Class III. The basis for this classification is primarily the concentration of coliform organisms since the concentration exceeds the allowable limits for Class II during six months of the year. Also, the 5-day B.O.D. was in excess of 2.0 ppm during October.

The Watauga River below Elizabethton and above the mouth of Brush Creek falls in Class II as determined by the number of bacteria and the 5-day B.O.D. There may be some basis for considering this section of the stream as Class IV owing to the presence of high concentrations of free ammonia originating in industrial wastes reaching the stream at Elizabethton. As shown in table 13, the free ammonia content during five summer

months averages 3.15 ppm with a maximum of 5.93 ppm.

Ellis[1] after the results of intensive surveys makes the following statements relative to the effect of free ammonia on fish life.

"---The good fish faunae showed a preference to waters containing less than 2 p.p.m. of dissolved ammonia as 79 percent of the cases of this group were found in water containing less than 1.9 p.p.m. dissolved ammonia. The remaining 21 percent were apparently thriving in waters containing between 2 and 3 p.p.m. dissolved ammonia,--- It must be noted that without exception those waters carrying 2 to 3 p.p.m. ammonia and at the same time supporting the good fish fauna were high in dissolved oxygen; that is, 5.5 to 7 p.p.m., were of low turbidity, and were flowing over good bottoms. Toleration of dissolved ammonia above 2 p.p.m. under field conditions was always associated with otherwise good to exceptionally favorable conditions."

"---However the existing literature and the data from our own experiments indicate that under average stream conditions with pH value 7.4 and pH 8.5, 2.5 p.p.m. of ammonia will be harmful to many individuals at least of the common aquatic species."

He concludes:

"Therefore, in view of the small amount of ammonia found in unpolluted natural flowing waters, 1.5 p.p.m. dissolved ammonia was considered the maximal amount of dissolved ammonia not suggestive of specific organic pollution. In flowing streams 2 to 3 p.p.m. were almost always associated with definite organic pollution and values above 3 p.p.m. in our field studies were always traceable to sewage or factory effluents."

Domestic sewage and the small amount of industrial wastes from Johnson City which enter by way of Brush Creek apparently have very little effect upon the condition of the Watauga River. The results, however, do indicate a slight increase in the 5-day B.O.D. and in the concentration of the coliform group.

In the South Fork Holston River below the mouth of the Watauga River there appears to be an increase in the 5-day B.O.D. which is unaccounted for by pollution in the Watauga River. It is quite possible that rapid decomposition follows the mixing of the high ammonia water of the Watauga River with the pollution carried by the South Fork. The free

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1. M. M. Ellis, Detection and Measurement of Stream Pollution, Bureau of Fisheries Bulletin No. 22, 1937, pp. 393-394.

ammonia found in the South Fork dropped to an average of 0.96 ppm at SHo 16.6 with a maximum of 2.0 ppm. Some of this reduction, however, can be attributed to dilution. Class III conditions were observed in the South Fork below the mouth of the Watauga River.

The domestic sewage and the large amounts of various types of industrial wastes received by the stream at Kingsport create conditions of such gross pollution that the water is unfit for most uses and is considered in Class IV.

No routine samples were collected from the North Fork Holston River above Saltville, Va., during this study; but since the river above this point does not receive any domestic sewage or industrial wastes, it should be comparatively clean. Its mineral content, as indicated by the results in table 11, is that normally expected from surface streams in this area.

At Saltville the stream receives the industrial wastes from a large chemical manufacturing plant. No information was obtained on the amount of these wastes or of their chemical contents. The results of the mineral analyses of samples collected from NHo 0.1, however, indicate large increases in calcium, sodium, and chlorides. The calcium materially increases the hardness of the Knoxville water supply. In January 1925 the effects of the wastes were felt as far downstream as Chattanooga. This was occasioned by the breaking of a dam which impounds the wastes, permitting a large slug of concentrated waste to enter the stream and resulting in salty water in the Knoxville and Chattanooga supplies.

The results of the studies on the North Fork at NHo 0.1 indicate that the stream at this station falls within Class II as determined by the coliform group and the 5-day B.O.D. It will be observed, however, that the chloride content exceeds the desirable limit of 250 ppm, during five months of the study period.

The effect of the relatively clean water for dilution from the North Fork on the pollution carried by the South Fork is an immediate improvement in the conditions of the stream below the confluence. At Ho 132.0, about 10 miles below the junction of the two large tributaries, the conditions have improved to such an extent that the stream falls

within the limits of Class III in all categories.

From this point to the mouth of the river, a general reduction in pollution was observed. The results of the studies in 1936-37 near the mouth of the river indicate that the stream at this point recovered to such an extent that it had returned to a Class II condition. However, at no place in the stream below Church Hill would conditions have been suitable for swimming unless the rate of recovery was more rapid than the assumed uniform rate shown in figure 3. It is probable that the recovery was more rapid than the assumed straight line and that the coliform group would decrease in numbers to such an extent that suitable conditions for swimming might have existed in the lower section of the river above the point which receives the small amount of domestic sewage from a section of Knoxville.

Studies[1] in October and November of 1941, which considered the locations and types of pollution from industrial wastes and from sewage, quantitative bottom-fauna, physico-chemical analyses of the water, presence or absence of different kinds of bottom organisms and fish netting data indicated that that section of the Holston River below Church Hill from mile 117.0 extending down to mile 104.0 would fall in the mesosaprobic or polluted zone, which has been defined as the second step toward the purification of grossly polluted waters. Below this section and extending down to mile 67.7, the conditions were such as to place the section at or near the transition of the mesosaprobic to the oligosaprobic or clear water zone.

Considerably more nitrogen, particularly ammonia nitrogen, was found during these studies than was observed during the 1937-38 studies and later observations in 1942. In the lower section between mile 104.0 and mile 67.7, concentrations of ammonia nitrogen varying from 2.4 ppm at the lower station to 6.6 ppm at the upper station were observed. Such evidence indicates a considerable variation in the amount of pollution which may be present at different times.

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1. F. Earle Lyman and Jack S. Dendy, "A Pre-Impoundment Bottom Fauna Study of Cherokee Reservoir Area (Tennessee)" (an unpublished report), Department of Forestry Relations, Tennessee Valley Authority.

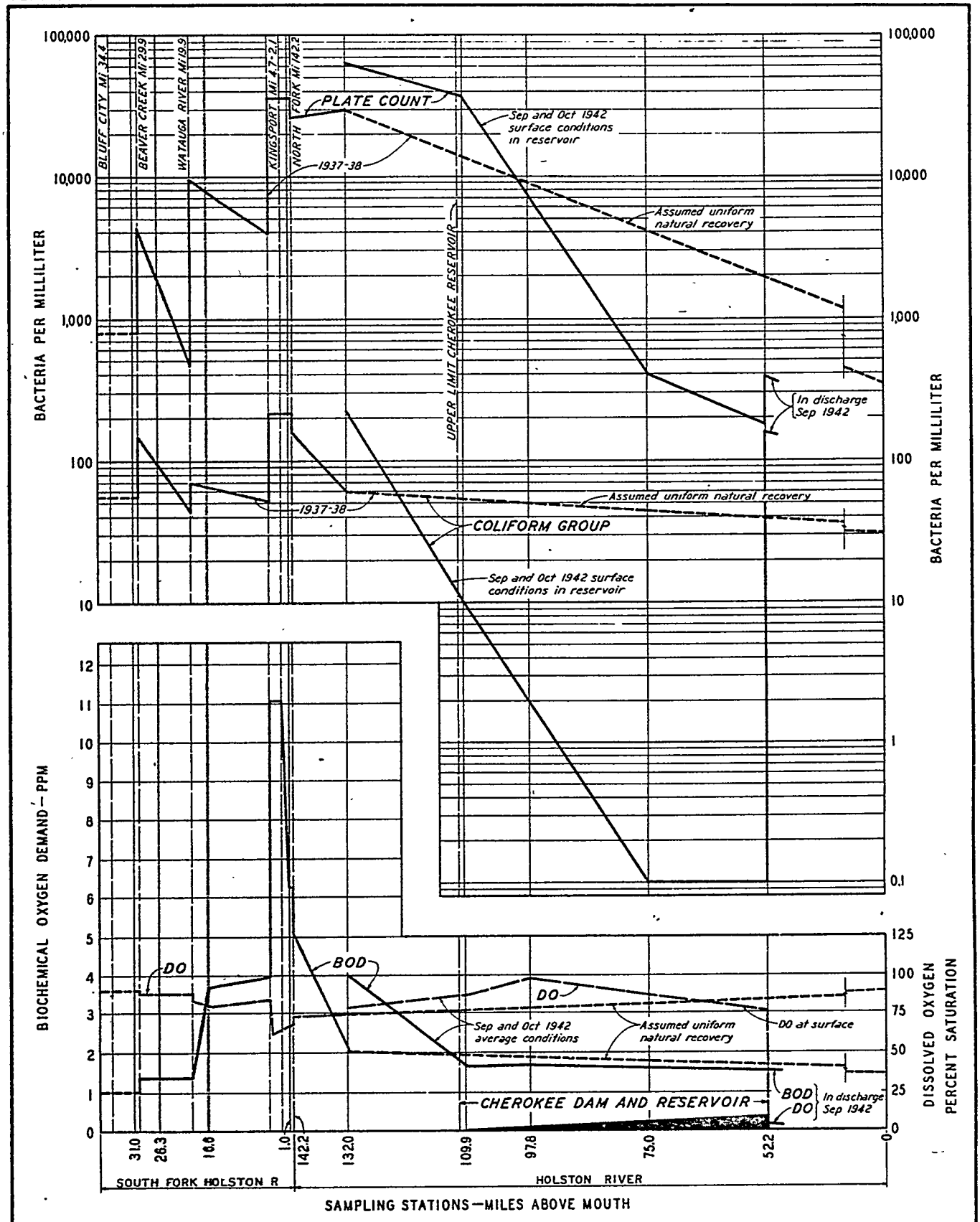
The general conditions in the South Fork and in the Holston River with respect to total bacteria, coliform group, dissolved oxygen, and 5-day B.O.D. are shown in figure 4. The curves shown on this figure illustrate the points mentioned above in the classification of this stream.

Figure 4 also shows the results of studies made on the Upper Holston River in 1942 after Cherokee Reservoir was impounded. These curves indicate a much larger pollutional load from Kingsport than the earlier studies and also very rapid recovery after the water enters Cherokee Reservoir. In fact, the recovery is so marked that the water in the epilimnion or that portion above the thermocline falls in Class I from a point just above Morristown to the dam. Below the dam the dissolved oxygen is quite low. This is to be expected, however, since water is drawn from below the thermocline.

Classification Based on Conditions of Normal Stream Flows

Because the stream flows during the period of study were considerably in excess of normal conditions, it appears desirable to base the classification of the Holston River system on conditions which would exist in periods of normal flow. This has been attempted, and the following classifications are shown on figure 2 as indicative of normal summertime conditions.

Under conditions of normal flow it might be expected that the effects of the pollution carried by the South Fork below the Bristol, Tenn., water supply intake and above Beaver Creek will result in those conditions existing in Class III streams. Beaver Creek will remain in Class IV. The effect of Beaver Creek on the South Fork will probably cause those conditions associated with Class IV, particularly during the late summer season. Since the flow in the Watauga River was approximately normal, no change is expected in the conditions of this stream. It is expected to remain in Class II except in the short section just below Elizabethton, with the reservation that high concentrations of ammonia might at times cause Class IV conditions. Below the mouth of the Watauga, it is expected that the Holston River under normal stream conditions will be degraded from Class III, as observed, to Class IV.



NOTE:
Curves for 1937-1938 based on averages of observations from August 17, 1937 through October 15, 1937 and from June 15, 1938 through August 10, 1938.

Figure 4
HOLSTON RIVER
STREAM CONDITIONS

CHATTANOOGA DRAFTING SERVICE

G HS 306A506-2

Class IV conditions will extend for some distance down the South Fork, but the natural purification processes will effect such improvements that Class III conditions will exist above Kingsport. That the river falls in Class III above Kingsport is indicated in part by the fact that a portion of Kingsport's water supply is obtained from the South Fork at mile 6.6 and can be treated without serious difficulty. It has been reported that at times phenolic tastes have been present and that the river at the intake has been dark brown and foamy because of industrial wastes. No results of routine bacteriological examinations made by the plant on the river water are available.

Less than two miles below the water works intake, the river receives its first waste from Kingsport; and from this point, Class IV conditions will exist to the mouth of the stream.

In the North Fork, Class II conditions with respect to organic pollution are expected. The high concentration of chlorides which were observed near the mouth of the river might be so intensified in concentration immediately below Saltville, due to lack of sufficient dilution, as to constitute sufficient grounds for classification in Class III or even, perhaps, Class IV. However, for this report, it will be placed in Class II with the reservation that it may be reclassified at a later date.

From Moccasin Creek, which carries the domestic sewage from Gate City, Class III conditions are anticipated to the mouth of the North Fork.

The dilution afforded the grossly polluted South Fork by the cleaner water from the North Fork, while improving conditions somewhat, will not be sufficient to result in Class III conditions in the upper end of the Holston River, and it will fall in Class IV. It is expected that the Holston River will remain Class IV until it reaches the upper end of Cherokee Reservoir. Here, with improved sedimentation and increased time of flow between the upper end of the reservoir and Morristown, it is expected that the natural purification processes will so reduce the pollutional load that the epilimnion of the lake below Morristown will meet the requirements outlined for Class I water. Below the dam and to the mouth of the river, Class II conditions might be expected during the greater portion of the time, since most of the discharge from Cherokee Reservoir will be drawn from the more highly polluted bottom waters.

Effects of Pollution

Mention has already been made of the conditions experienced with the South Fork water supply for Kingsport, Tenn. Acute phenol tastes have also been experienced in the Bristol, Tenn., supply. Very little information has been collected which illustrates the effect of pollution on the water supplies in the area. It might be pointed out, however, that the increased hardness of the water, caused by the wastes originating at Saltville, Va., results in an increased cost for soap for the consumers of all supplies taken from the Holston River and the upper Tennessee River.

Many of the springs and wells which now serve as water supplies will prove inadequate with any appreciable urban growth, and such communities will be forced to look elsewhere for water. In some cases, particularly for Bristol and Kingsport, the only available supply appears to be the South Fork, which is already in a rather serious condition.

TABLE 11

HOLSTON RIVER

MINERAL ANALYSES

South Fork Holston River - Station SHo 31.0 - below Bluff City, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Results of Mineral Analyses - Parts per Million										pH
				Fe Unfiltered	SiO_2	Ca	Mg	Na	SO_4	Cl	Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	Phenol	
1937	August	3	690	0.77	6	25.8	7.0	0.5	6.7	T	85	94	0.023	7.8
	September	4	1,480	2.64	6	27.2	6.8	1.9	7.9	T	90	96	.000	7.8
	October	3	1,230	1.05	6	23.5	6.9	1.4	6.6	2	79	87	.012	7.7
	November	4	660	.06	6	31.2	8.3	2.6	5.7	2	106	112	.018	7.8
	December	2	880	.20	7	24.9	7.2	2.0	5.4	2	85	92	.010	7.6
1938	January	3	1,180	.11	6	25.5	6.9	2.4	5.8	3	85	92	.008	7.7
	February	2	1,120	.27	6	25.3	6.6	.4	3.2	2	83	90	.008	7.8
	March	5	1,660	.95	6	20.8	5.6	3.5	8.0	2	70	75	.004	7.8
	April	4	1,590	.42	6	23.9	6.3	1.7	5.6	2	79	86	.008	7.9
	May	3	1,450	.39	6	23.9	6.4	4.4	4.5	4	85	86	.001	7.8
	June	5	1,280	1.08	7	23.8	6.2	2.5	4.3	3	81	86	.008	7.8
	July	3	750	2.83	6	26.2	7.5	1.9	5.5	3	89	97	.004	7.9
	August	2	1,640	.68	6	25.8	7.2	3.0	3.9	4	90	94	.008	7.8
	Average	43	1,230	0.94	6	25.1	6.8	2.3	5.8	2	85	91	0.009	7.8
	Maximum		4,550	10.00	7	33.4	9.3	10.8	18.8	4	118	119	.050	8.2
	Minimum		250	T	5	11.6	3.7	.0	2.6	0	43	45	.000	7.4

TABLE 11 (Continued)

HOLSTON RIVER

MINERAL ANALYSES

Beaver Creek - Station BC 1.0 - near mouth

Year	Month	Number Times Sampled	Discharge cfs	Results of Mineral Analyses - Parts per Million										pH
				Fe Unfiltered	SiO_2	Ca	Mg	Na	SO_4	Cl	Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	Phenol	
1937	August	3	250	1.67	7	49.2	12.8	5.1	10.1	7	163	176	0.023	7.7
	September	4	180	.95	7	50.6	12.6	7.0	9.0	10	167	178	.000	7.9
	October	3	260	4.97	7	50.0	13.3	6.3	7.0	13	163	180	.022	7.8
	November	4	90	.18	8	56.9	15.5	7.9	9.5	7	199	206	.056	7.9
	December	2	90	.30	8	52.6	15.0	9.2	11.8	12	181	193	.036	7.9
1938	January	3	160	.29	7	51.2	13.7	3.0	5.8	5	172	185	.027	7.8
	February	2	150	.36	8	52.9	14.4	4.6	7.4	10	176	192	.032	7.8
	March	5	250	1.26	7	46.8	12.7	2.7	8.1	5	156	169	.019	7.9
	April	4	160	.46	8	44.0	13.4	6.8	9.2	11	165	178	.033	7.8
	May	3	140	.28	7	53.1	14.6	11.4	7.3	18	182	193	.022	7.7
	June	5	160	.78	8	52.0	14.3	10.6	9.1	14	179	189	.043	7.8
	July	3	150	4.10	7	49.2	14.0	10.3	7.9	17	168	181	.040	7.8
	August	2	100	.30	7	55.4	15.5	8.9	8.4	20	182	202	.028	7.9
	Average	43	172	1.22	7	50.7	13.8	7.1	8.5	11	173	185	0.029	7.8
	Maximum		620	14.00	10	58.4	16.9	15.9	14.3	21	205	211	.094	8.0
	Minimum		30	.06	6	25.0	5.6	.0	1.0	0	93	103	.000	7.6

TABLE 11 (Continued)

HOLSTON RIVER

MINERAL ANALYSES

Watauga River - Station Wa 15.5 - below Johnson City, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Results of Mineral Analyses - Parts per Million										pH
				Fe Unfiltered	SiO_2	Ca	Mg	Na	SO_4	Cl	Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	Phenol	
1937	August	3	970	4.87	7	14.0	5.3	17.8	45.3	0	47	57	0.028	7.5
	September	4	650	1.80	7	13.7	4.8	15.9	53.0	2	50	54	.005	7.7
	October	3	970	2.56	7	11.7	5.2	18.9	39.9	3	45	51	.018	7.7
	November	4	790	1.44	7	12.0	4.4	19.1	36.4	3	45	48	.018	7.7
	December	2	490	.65	8	12.0	4.6	12.8	21.8	5	45	50	.012	7.8
1938	January	3	1,210	1.15	7	12.7	4.2	10.0	18.4	3	45	49	.013	7.5
	February	2	1,140	1.32	6	13.1	4.3	9.4	20.8	2	44	50	.018	7.6
	March	5	1,670	1.62	7	11.5	3.7	10.3	19.6	3	40	44	.007	7.6
	April	4	1,060	1.64	7	12.7	3.8	9.4	23.0	3	45	48	.015	7.8
	May	3	350	1.31	7	13.7	4.7	9.5	26.4	4	52	54	.002	7.8
	June	5	970	1.66	7	12.4	4.1	5.9	17.3	4	45	50	.014	7.7
	July	3	860	2.00	7	15.5	6.0	14.0	49.6	4	47	64	.029	7.5
	August	2	1,740	1.80	7	10.7	3.8	5.3	18.0	3	37	42	.016	7.5
	Average	43	1,000	1.84	7	12.8	4.5	12.2	30.1	3	45	51	0.014	7.7
	Maximum		2,150	11.00	8	19.0	7.5	28.8	91.0	6	64	75	.066	8.4
	Minimum		165	.10	6	8.8	2.8	2.5	9.5	0	30	35	.000	7.2

TABLE 11 (Continued)

HOLSTON RIVER

MINERAL ANALYSES

South Fork Holston River - Station SHo 1.0 - below Kingsport, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Results of Mineral Analyses - Parts per Million										pH
				Fe Unfiltered	SiO_2	Ca	Mg	Na	SO_4	Cl	Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	Phenol	
1937	August	3	2,360	1.63	7	27.9	6.9	10.0	31.9	4	74	98	0.053	7.5
	September	4	2,310	2.12	6	31.2	7.6	12.2	33.1	6	88	109	.036	7.5
	October	3	2,180	3.55	7	27.5	7.6	12.9	33.0	6	83	101	.088	7.5
	November	4	1,750	.63	7	28.0	7.4	11.3	21.7	4	93	101	.042	7.6
	December	2	2,380	.80	6	27.6	7.4	6.0	18.9	6	81	100	.032	7.6
1938	January	3	3,010	.45	7	26.7	6.8	5.3	11.8	4	85	95	.032	7.7
	February	2	3,210	.63	7	24.1	6.1	5.2	13.4	4	76	86	.026	7.7
	March	5	4,280	.88	7	24.5	6.2	4.4	11.2	4	76	87	.015	7.7
	April	4	3,010	.90	7	25.4	6.4	5.4	15.5	4	79	90	.041	7.7
	May	3	2,040	.72	7	26.9	6.8	6.3	16.6	6	83	95	.024	7.6
	June	5	2,980	1.70	7	24.6	6.4	6.2	12.7	5	77	88	.037	7.5
	July	3	2,160	3.70	7	28.8	7.6	5.8	17.7	4	87	104	.061	7.6
	August	2	3,720	.78	6	25.3	6.6	3.6	12.6	4	76	90	.020	7.4
	Average	43	2,750	1.45	7	26.8	6.9	7.4	19.2	5	82	96	0.039	7.6
	Maximum		6,100	10.00	8	36.4	8.7	25.1	52.3	11	105	126	.180	8.0
	Minimum		690	.10	5	19.8	5.0	1.4	6.1	1	65	70	T	7.4

TABLE 11 (Continued)

HOLSTON RIVER

MINERAL ANALYSES

North Fork Holston River - Station NHo 82.2 - Saltville, Va.

Year		1930-31
Month		*
Number times sampled		*
Discharge cfs		74.4
Fe (Filtered)	ppm	.04
SiO_2	"	6.7
Ca	"	29
Mg	"	12
Na	"	2.2
K	"	1.2
SO_4	"	12
Cl	"	1.5
Alkalinity as $CaCO_3$	"	109
Total Hardness as $CaCO_3$	"	120

*Average of determinations made on composites of daily samples from June 1, 1930, to March 31, 1931. Chemical Character of Surface Waters of Virginia, State Commission on Conservation and Development, Division of Water Resources and Power, Bulletin No. 3, 1932, pp. 138-139.

TABLE 11 (Continued)

HOLSTON RIVER

MINERAL ANALYSES

North Fork Holston River - Station NHo 0.1 - near mouth

Year	Month	Number Times Sampled	Discharge cfs	Results of Mineral Analyses - Parts per Million										pH
				Fe Unfiltered	SiO_2	Ca	Mg	Na	SO_4	Cl	Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	Phenol	
1937	August	3	600	0.13	4	221.0	7.1	127.8	13.0	556	62	582	0.023	7.8
	September	4	400	.26	4	214.4	7.4	161.6	14.5	578	69	554	.002	7.6
	October	3	620	1.63	5	156.0	10.1	68.2	13.2	343	82	447	-	7.6
	November	4	390	.14	6	183.8	10.6	86.1	13.9	408	98	503	.030	7.7
	December	2	680	.45	9	120.4	10.5	70.7	12.2	282	84	344	.002	7.6
1938	January	3	890	.17	6	94.9	6.9	28.1	11.9	155	94	268	.035	7.7
	February	2	820	.18	5	99.2	8.3	32.1	9.2	180	86	282	-	7.8
	March	5	1,540	1.84	6	67.4	7.2	18.3	8.3	104	81	198	-	7.9
	April	4	1,320	.56	5	89.2	7.0	27.7	9.2	158	78	252	-	8.1
	May	3	590	.17	3	99.6	8.4	41.2	10.5	197	83	284	-	8.1
	June	5	1,010	.80	6	78.5	7.8	39.0	9.2	156	81	228	.029	7.9
	July	3	1,500	8.53	5	96.0	7.7	43.1	9.9	199	74	272	.015	7.9
	August	2	850	.23	6	98.8	10.6	33.2	7.6	186	90	289	.010	7.9
	Average	43	896	1.17	5	123.7	8.2	60.1	11.0	268	81	343	0.016	7.8
	Maximum		3,670	25.00	12	372.8	13.5	283.9	20.2	1070	101	978	.050	8.3
	Minimum		150	.00	3	36.0	1.9	6.7	4.7	40	52	108	.000	7.4

TABLE 11 (Continued)

HOLSTON RIVER

MINERAL ANALYSES

Holston River - Station Ho 132.0 - Church Hill, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Results of Mineral Analyses - Parts per Million										pH
				Fe Unfiltered	SiO_2	Ca	Mg	Na	SO_4	Cl	Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	Phenol	
1937	August	3	2,900	1.17	6	57.1	7.4	39.3	29.1	106	75	173	-	7.7
	September	4	2,090	1.10	6	61.4	8.0	25.2	28.8	88	82	186	0.010	7.5
	October	3	2,830	.79	6	56.0	7.9	30.9	30.5	85	84	173	.057	7.6
	November	4	2,220	.48	6	56.2	7.8	19.0	19.6	70	92	171	.030	7.6
	December	2	2,980	.50	6	47.3	7.4	23.0	16.0	70	82	148	.012	7.6
1938	January	3	4,180	.40	7	42.4	6.7	13.6	11.4	44	86	134	.017	7.6
	February	2	4,070	.51	6	40.0	6.4	11.0	9.8	41	80	126	.021	7.7
	March	5	5,950	1.58	7	35.5	6.2	9.9	11.2	31	79	115	.006	7.7
	April	4	4,470	1.21	6	44.8	6.6	13.0	12.4	51	83	140	.014	7.8
	May	3	2,790	.42	6	43.2	7.1	19.1	12.8	57	87	137	.004	7.7
	June	5	4,120	.97	7	36.8	6.7	11.1	9.9	38	78	120	.016	7.7
	July	3	3,420	2.27	6	44.7	7.2	16.4	12.9	52	86	142	.017	7.7
	August	2	6,030	1.43	6	38.9	6.4	10.7	12.0	39	76	124	.013	7.6
	Average	43	3,720	1.02	6	46.4	7.1	18.2	16.6	58	82	145	0.018	7.6
	Maximum		8,660	6.00	7	77.8	10.2	55.6	45.6	142	99	237	.120	8.0
	Minimum		900	.10	5	27.6	4.7	5.5	5.7	18	67	89	.000	7.4

TABLE 11 (Continued)

HOLSTON RIVER

MINERAL ANALYSES

Holston River - Station Ho 0.1 - near mouth (1936-37)

	Number Times Sampled	Discharge cfs	Results of Mineral Analyses - Parts per Million										pH
			Fe Unfiltered	SiO_2	Ca	Mg	Na	SO_4	Cl	Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	Phenol	
Average	40	4,400	1.01	6	53.2	9.1	21.0	18.1	70	94	160	0.033	7.8
Maximum		27,600	10.00	9	115.8	14.2	64.4	42.3	266	110	330	.070	8.4
Minimum		980	T	3	28.4	4.2	.0	2.8	9	68	90	.000	7.4

Note: For complete report on this station see Studies of the Pollution of the Tennessee River System, I, February 1941.

TABLE 12

HOLSTON RIVER

SOLIDS

South Fork Holston River - Station SHo 31.0 - below Bluff City, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Solids - Parts per Million				
				Dissolved	Suspended	Volatile	Fixed	Total
1937	August	3	690	108	235	49	294	343
	September	4	1,480	114	317	68	363	431
	October	3	1,230	95	450	116	429	545
	November	4	660	117	24	64	77	141
	December	2	880	112	4	64	52	116
1938	January	3	1,180	109	16	50	75	125
	February	2	1,120	96	14	45	65	110
	March	5	1,660	92	49	45	96	141
	April	4	1,590	108	37	47	98	145
	May	3	1,450	100	31	42	89	131
	June	5	1,280	102	94	62	134	196
	July	3	750	107	114	46	175	221
	August	2	1,640	114	61	50	125	175
Summer[1]	Average	17	1,150	107	245	68	284	352
	Maximum		4,550	139	1,278	261	1,127	1,372
	Minimum		250	70	18	27	86	134
Winter[2]	Average	26	1,280	104	29	51	82	133
	Maximum	-	2,760	133	164	86	174	243
	Minimum		470	79	3	18	47	90
Beaver Creek - Station BC 1.0 - near mouth								
1937	August	3	250	211	365	148	428	576
	September	4	180	215	204	134	285	419
	October	3	260	209	148	117	240	357
	November	4	90	229	29	110	148	258
	December	2	90	223	31	136	118	254
1938	January	3	160	203	62	110	155	265
	February	2	150	208	34	106	136	242
	March	5	250	188	93	104	177	281
	April	4	160	213	49	122	140	262
	May	3	140	228	47	121	154	275
	June	5	160	222	80	131	171	302
	July	3	150	213	210	120	303	423
	August	2	100	257	31	104	184	288
Summer[1]	Average	17	184	218	190	126	282	408
	Maximum		620	272	966	212	894	1,106
	Minimum		30	132	23	76	121	273
Winter[2]	Average	26	164	213	56	117	152	269
	Maximum		420	241	273	155	318	411
	Minimum		75	138	13	78	99	222

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 12 (Continued)

HOLSTON RIVER

SOLIDS

South Fork Holston River - Station SHo 26.3 - below Beaver Creek

Year	Month	Number Times Sampled	Discharge cfs	Solids - Parts per Million				
				Dissolved	Suspended	Volatile	Fixed	Total
1937	August	3	940	119	258	79	298	377
	September	4	1,730	131	344	86	389	475
	October	3	1,390	115	200	73	242	315
	November	4	790	134	19	71	82	153
	December	2	1,000	116	32	72	76	148
1938	January	3	1,360	115	23	43	95	138
	February	2	1,280	110	9	59	60	119
	March	5	1,900	106	52	51	107	158
	April	4	1,780	116	37	60	93	153
	May	3	1,630	111	30	62	79	141
	June	5	1,420	116	74	53	137	190
	July	3	1,060	121	133	67	187	254
	August	2	1,820	127	38	35	130	165
Summer[1]	Average	17	1,370	122	204	70	256	326
	Maximum		5,370	148	1,294	137	1,243	1,380
	Minimum		330	85	5	26	71	124
Winter[2]	Average	26	1,450	116	33	58	91	149
	Maximum		3,150	142	166	75	209	258
	Minimum		600	86	2	10	48	110
Watauga River - Station Wa 17.4 - Watauga, Tenn.								
1937	August	3	950	132	138	41	229	270
	September	4	640	122	57	31	148	179
	October	3	960	100	53	37	116	153
	November	4	780	100	20	38	82	120
	December	2	540	98	6	61	43	104
1938	January	3	1,190	76	21	43	54	97
	February	2	1,120	71	32	17	86	103
	March	5	1,640	69	32	25	76	101
	April	4	1,030	88	21	32	77	109
	May	3	350	79	12	25	66	91
	June	5	940	81	52	38	95	133
	July	3	840	111	46	45	112	157
	August	2	1,710	80	50	27	103	130
Summer[1]	Average	17	893	108	69	35	142	177
	Maximum		1,940	162	343	68	395	463
	Minimum		160	52	3	14	88	116
Winter[2]	Average	26	1,040	83	24	35	72	107
	Maximum		2,100	113	66	64	103	139
	Minimum		170	56	2	5	40	69

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 12 (Continued)

HOLSTON RIVER

SOLIDS

Watauga River - Station Wa 15.5 - below Johnson City, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Solids - Parts per Million				
				Dissolved	Suspended	Volatile	Fixed	Total
1937	August	3	970	114	157	40	231	271
	September	4	650	125	59	38	146	184
	October	3	970	101	70	51	120	171
	November	4	790	98	17	39	76	115
	December	2	490	96	54	60	90	150
1938	January	3	1,210	79	20	44	55	99
	February	2	1,140	74	23	29	68	97
	March	5	1,670	71	36	27	80	107
	April	4	1,060	87	20	36	71	107
	May	3	350	95	8	20	83	103
	June	5	970	88	33	29	92	121
	July	3	860	127	29	39	117	156
	August	2	1,740	76	62	32	106	138
Summer[1]	Average	17	912	110	71	39	142	181
	Maximum		1,980	174	369	71	400	463
	Minimum		165	62	5	9	89	116
Winter[2]	Average	26	1,060	85	25	34	76	110
	Maximum		2,150	112	84	67	130	189
	Minimum		180	54	3	7	42	78
South Fork Holston River - Station SHo 16.6 - below Watauga River								
1937	August	3	2,320	133	300	73	360	433
	September	4	2,300	136	506	103	539	642
	October	3	2,430	113	134	63	184	247
	November	4	1,500	126	36	64	98	162
	December	2	1,600	112	37	75	74	149
1938	January	3	2,670	106	28	42	92	134
	February	2	2,600	102	8	42	68	110
	March	5	3,760	97	55	42	110	152
	April	4	2,730	108	33	51	90	141
	May	3	1,540	115	22	56	81	137
	June	5	2,570	112	59	46	125	171
	July	3	1,730	118	143	62	199	261
	August	2	3,750	111	40	34	117	151
Summer[1]	Average	17	2,370	124	236	68	292	360
	Maximum		6,200	165	1,919	277	1,727	2,004
	Minimum		730	85	2	27	82	133
Winter[2]	Average	26	2,520	109	35	52	92	144
	Maximum		5,500	150	169	84	208	255
	Minimum		900	80	1	12	59	93

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 12 (Continued)

HOLSTON RIVER

SOLIDS

South Fork Holston River - Station SHo 1.0 - below Kingsport, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Solids - Parts per Million				
				Dissolved	Suspended	Volatile	Fixed	Total
1937	August	3	2,360	158	264	84	338	422
	September	4	2,310	164	355	105	414	519
	October	3	2,180	143	284	103	324	427
	November	4	1,750	135	16	65	86	151
	December	2	2,380	129	70	99	100	199
1938	January	3	3,010	129	27	62	94	156
	February	2	3,210	110	30	58	82	140
	March	5	4,280	105	51	43	113	156
	April	4	3,010	121	51	68	104	172
	May	3	2,040	132	39	68	103	171
	June	5	2,980	118	71	64	125	189
	July	3	2,160	135	230	69	296	365
	August	2	3,720	126	60	48	138	186
Summer[1]	Average	17	2,470	145	239	82	302	384
	Maximum		5,800	215	1,191	162	1,150	1,312
	Minimum		690	105	14	29	84	153
Winter[2]	Average	26	2,940	121	42	64	99	163
	Maximum		6,100	152	122	127	152	221
	Minimum		1,400	95	7	33	30	121
North Fork Holston River - Station NHo 0.1 - near mouth								
1937	August	3	600	1,544	449	1,268	725	1,993
	September	4	400	1,308	376	785	899	1,684
	October	3	620	922	176	298	800	1,098
	November	4	390	961	17	288	690	978
	December	2	680	612	38	314	336	650
1938	January	3	890	437	23	163	297	460
	February	2	820	420	88	218	290	508
	March	5	1,540	329	156	200	285	485
	April	4	1,320	470	121	204	387	591
	May	3	590	518	151	308	361	669
	June	5	1,010	420	89	262	247	509
	July	3	1,500	541	601	451	691	1,142
	August	2	850	561	43	338	266	604
Summer[1]	Average	17	824	944	327	609	662	1,271
	Maximum		3,670	2,194	1,486	1,634	1,751	2,760
	Minimum		150	168	31	102	192	294
Winter[2]	Average	26	943	528	87	241	374	615
	Maximum		2,500	1,173	436	460	1,045	1,212
	Minimum		340	215	5	74	159	264

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 12 (Continued)

HOLSTON RIVER

SOLIDS

Holston River - Station Ho 132.0 - Church Hill, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Solids - Parts per Million				
				Dissolved	Suspended	Volatile	Fixed	Total
1937	August	3	2,900	385	269	292	362	654
	September	4	2,090	406	134	233	307	540
	October	3	2,830	367	24	203	188	391
	November	4	2,220	290	28	136	182	318
	December	2	2,980	228	31	141	118	259
1938	January	3	4,180	195	31	92	134	226
	February	2	4,070	193	23	96	120	216
	March	5	5,950	160	97	95	162	257
	April	4	4,470	224	62	130	156	286
	May	3	2,790	220	63	166	117	283
	June	5	4,120	185	86	119	152	271
	July	3	3,420	211	156	168	199	367
	August	2	6,030	182	87	92	177	269
Summer[1]	Average	17	3,300	305	138	194	249	443
	Maximum		7,790	577	715	389	731	1,120
	Minimum		900	129	6	58	98	185
Winter[2]	Average	26	4,000	214	53	123	144	267
	Maximum		8,660	311	292	203	344	445
	Minimum		1,800	123	7	42	84	170
Holston River - Station Ho 0.1 - near mouth (1936-37)[3]								
Summer[1]	Average	14	1,770	420	46	180	286	466
	Maximum		4,190	840	140	425	457	865
	Minimum		980	186	5	82	151	295
Winter[2]	Average	26	5,820	244	107	133	218	351
	Maximum		27,600	402	818	231	789	1,006
	Minimum		1,540	98	1	89	93	187

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.
3. For complete report on this station see Studies of the Pollution of the Tennessee River System, I, February 1941.

TABLE 13

HOLSTON RIVER

NITROGENS

South Fork Holston River - Station SHo 31.0 - below Bluff City, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Nitrogen - Parts per Million				
					Organic	Free Ammonia	Nitrite	Nitrate	Total
1938	April	3	1,840	16.5	0.26	0.012	0.001	0.35	0.62
	May	3	1,450	18.7	.31	.011	.003	.33	.65
	June	5	1,280	20.6	.32	.009	.003	.46	.79
	July	3	750	24.8	.53	.014	.004	.44	.98
	August	2	1,640	24.5	.34	T	.006	.56	.90
	Average	16	1,360	20.8	0.35	0.010	0.003	0.42	0.78
	Maximum		2,420	26.5	.80	.032	.011	.60	1.23
	Minimum		280	15.0	.19	.000	.000	.24	.52
Beaver Creek - Station BC 1.0 - near mouth									
1938	April	3	160	17.0	0.49	0.003	0.036	0.71	1.20
	May	3	140	18.7	.70	.000	.068	.84	1.54
	June	5	160	20.2	.49	.006	.046	.98	1.48
	July	3	150	23.5	.96	.000	.108	.85	1.81
	August	2	100	24.5	.48	.032	.050	.84	1.35
	Average	16	150	20.5	0.62	0.006	0.061	0.86	1.49
	Maximum		284	25.0	1.48	.064	.154	1.20	2.16
	Minimum		74	16.0	.29	.000	.002	.60	.94
South Fork Holston River - Station SHo 26.3 - below Beaver Creek									
1938	April	3	2,050	17.7	0.28	0.011	0.007	0.37	0.66
	May	3	1,630	19.5	.29	.000	.003	.40	.69
	June	5	1,420	21.6	.37	.004	.008	.46	.83
	July	3	1,060	25.5	.66	.000	.009	.45	1.11
	August	2	1,820	25.0	.41	.000	.010	.54	.95
	Average	16	1,560	21.6	0.40	0.003	0.008	0.44	0.84
	Maximum		2,680	27.5	1.20	.016	.014	.60	1.60
	Minimum		832	16.5	.11	.000	T	.32	.45
Watauga River - Station Wa 17.4 - Watauga, Tenn.									
1938	April	3	1,130	15.8	0.23	2.91	0.006	0.39	3.53
	May	3	350	18.2	.26	3.31	.008	.17	3.74
	June	5	940	20.2	.32	2.90	.014	.38	3.60
	July	3	840	23.7	.34	4.11	.008	.43	4.88
	August	2	1,710	22.0	.40	2.48	.010	.32	3.20
	Average	16	940	19.9	0.31	3.15	0.010	0.34	3.80
	Maximum		1,940	25.0	.51	5.93	.025	.56	7.00
	Minimum		284	13.5	.12	1.92	.002	.16	2.88

TABLE 13 (Continued)

HOLSTON RIVER

NITROGENS

Watauga River - Station Wa 15.5 - below Johnson City, Tenn.

Year	Month	Number Times Sampled	Dis-Charge cfs	Water Temper-ature °C	Nitrogen - Parts per Million				
					Organic	Free Ammonia	Nitrite	Nitrate	Total
1938	April	3	1,170	16.2	0.32	2.67	0.015	0.37	3.36
	May	3	350	18.7	.34	3.31	.024	.33	3.98
	June	5	970	20.4	.40	2.67	.024	.47	3.54
	July	3	860	24.2	.37	3.47	.042	.59	4.43
	August	2	1,740	22.2	.36	2.24	.022	.50	3.10
	Average	16	970	20.2	0.36	2.88	0.026	0.45	3.69
	Maximum		1,980	25.0	.60	5.12	.045	.68	6.39
	Minimum		301	14.0	.20	1.28	.010	.32	2.48
South Fork Holston River - Station SHo 16.6 - below Watauga River									
1938	April	3	3,080	17.5	0.28	1.00	0.023	0.48	1.76
	May	3	1,540	19.7	.28	1.52	.060	.63	2.43
	June	5	2,570	21.7	.41	.88	.059	.94	2.23
	July	3	1,730	25.5	.62	.59	.079	1.03	2.24
	August	2	3,750	25.0	.39	.77	.095	.82	1.98
	Average	16	2,460	21.7	0.40	0.96	0.061	0.80	2.16
	Maximum		4,580	27.5	1.08	2.00	.119	1.40	3.84
	Minimum		1,210	16.0	.22	.00	.005	.48	.80
South Fork Holston River - Station SHo 1.0 - below Kingsport, Tenn.									
1938	April	3	3,270	17.7	0.45	0.605	0.036	0.73	1.78
	May	3	2,040	20.6	.57	.907	.084	.91	2.39
	June	5	2,980	22.6	.51	.302	.077	1.22	2.03
	July	3	2,160	26.7	.68	.228	.190	1.47	2.38
	August	2	3,720	25.4	.52	.332	.175	1.20	2.05
	Average	16	2,800	22.4	0.54	0.462	0.104	1.12	2.12
	Maximum		4,640	29.5	1.20	1.600	.450	2.40	3.49
	Minimum		1,380	16.5	.30	.012	.006	.20	.61

TABLE 13 (Continued)

HOLSTON RIVER

NITROGENS

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Nitrogen - Parts per Million				
					Organic	Free Ammonia	Nitrite	Nitrate	Total
North Fork Holston River - Station NHo 0.1 - near mouth									
1938	April	3	1,550	17.8	0.28	0.019	0.005	0.28	0.58
	May	3	590	21.2	.91	.011	.004	.23	1.15
	June	5	1,010	23.0	.33	.018	.003	.40	.75
	July	3	1,500	27.3	.25	.013	.003	.27	.53
	August	2	850	27.0	.27	.000	.005	.18	.45
	Average	16	1,110	23.0	0.41	0.014	0.004	0.29	0.71
	Maximum		3,670	31.0	2.24	.056	.007	.68	2.53
	Minimum		222	16.5	.06	.000	T	.12	.31
Holston River - Station Ho 132.0 - Church Hill, Tenn.									
1938	April	3	4,960	18.2	0.42	0.707	0.034	0.56	1.69
	May	3	2,790	20.8	.30	.328	.068	.84	1.47
	June	5	4,120	23.0	.37	.056	.048	.65	1.08
	July	3	3,420	27.5	.50	.011	.091	1.28	1.79
	August	2	6,030	25.8	.66	.060	.074	1.02	1.74
	Average	16	4,140	22.9	0.43	0.221	0.060	0.83	1.48
	Maximum		7,790	30.0	.88	1.200	.135	1.80	2.48
	Minimum		1,850	16.5	.13	.000	.002	.04	.41
Holston River - Station Ho 0.1 - near mouth (1936-37)[1]									
Summer[2]	Average	14	1,770	25.8	0.36	0.035	0.023	1.23	1.62
	Maximum		4,190	29.0	.48	.320	.140	2.08	2.49
	Minimum		980	19.0	.24	.000	.005	.72	1.00
Winter[3]	Average	26	5,820	14.6	0.42	0.269	0.022	1.07	1.76
	Maximum		27,600	27.0	1.20	1.800	.080	1.68	4.08
	Minimum		1,540	4.0	.01	.000	.004	.56	.76

1. For complete report on this station see Studies of the Pollution of the Tennessee River System, I, February 1941.
2. Summer season from June 15 through October 15.
3. Winter season from October 16 through June 14.

TABLE 14

HOLSTON RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

South Fork Holston River - Station SHo 31.0 - below Bluff City, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Dissolved Oxygen		5-Day Oxygen Demand 20°C ppm	1000 Lb. per Day	
					ppm	% Saturation		Dissolved Oxygen	5-Day Oxygen Demand
1937	August	3	690	25.5	7.13	85.8	1.21	26.57	4.51
	September	4	1,480	21.1	8.40	93.5	1.17	67.13	9.35
	October	3	1,230	14.7	9.27	90.6	1.65	61.57	10.96
	November	4	660	7.5	12.02	100.0	.66	42.84	2.35
	December	2	880	4.0	12.85	97.7	.98	61.06	4.66
1938	January	3	1,180	6.3	12.17	98.3	.52	77.55	3.31
	February	2	1,120	8.5	11.80	100.5	.64	71.37	3.87
	March	5	1,660	11.9	10.80	99.5	.77	96.81	6.90
	April	4	1,590	15.4	9.59	89.6	.76	82.34	6.53
	May	3	1,450	18.7	8.78	93.3	.80	68.75	6.26
	June	5	1,280	20.6	8.24	91.0	.78	56.95	5.39
	July	3	750	24.8	7.62	90.6	.83	30.86	3.36
	August	2	1,640	24.5	7.70	91.1	1.03	68.19	9.12
Summer[1]	Average	17	1,150	22.4	7.95	89.9	1.03	49.37	6.40
	Maximum		4,550	28.0	10.10	101.6	2.23	-	-
	Minimum		250	15.0	6.60	76.0	.44	-	-
Winter[2]	Average	26	1,280	11.6	10.77	96.9	0.71	74.44	4.91
	Maximum		2,760	22.5	13.90	103.8	1.78	-	-
	Minimum		470	1.5	8.20	88.5	.30	-	-
Beaver Creek - Station BC 1.0 - near mouth									
1937	August	3	250	24.3	5.67	66.8	3.78	7.65	5.10
	September	4	180	20.4	7.58	83.3	2.52	7.37	2.45
	October	3	260	15.7	8.07	80.5	5.67	11.33	7.96
	November	4	90	8.6	10.85	92.7	3.62	5.27	1.76
	December	2	90	5.0	12.10	94.5	4.76	5.88	2.31
1938	January	3	160	8.2	10.67	90.1	2.26	9.22	1.95
	February	2	150	10.0	10.05	88.7	3.06	8.14	2.48
	March	5	250	12.4	9.92	92.4	2.01	13.39	2.71
	April	4	160	15.9	8.54	85.6	3.42	7.38	2.95
	May	3	140	18.7	7.83	83.2	3.36	5.92	2.54
	June	5	160	20.2	7.82	85.6	3.82	6.76	3.30
	July	3	150	23.5	6.55	76.2	3.04	5.31	2.46
	August	2	100	24.5	7.82	92.5	4.08	4.22	2.20
Summer[1]	Average	17	184	21.8	7.37	82.1	3.52	7.32	3.50
	Maximum		620	26.5	8.70	93.0	8.74	-	-
	Minimum		30	16.0	4.00	49.1	1.14	-	-
Winter[2]	Average	26	164	12.4	9.68	88.8	3.09	8.57	2.74
	Maximum		420	21.5	13.30	99.7	5.04	-	-
	Minimum		75	2.5	7.45	78.9	.78	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 14 (Continued)

HOLSTON RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

South Fork Holston River - Station SHo 26.3 - below Beaver Creek

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Dissolved Oxygen ppm	Dissolved Oxygen % Saturation	5-Day Oxygen Demand 20°C ppm	1000 Lb. per Day Dissolved Oxygen	1000 Lb. per Day 5-Day Oxygen Demand
1937	August	3	940	24.2	6.73	79.1	1.45	34.16	7.36
	September	4	1,730	20.6	8.22	90.7	1.44	76.79	13.45
	October	3	1,390	15.2	9.37	92.7	2.15	70.33	16.14
	November	4	790	7.8	12.32	103.2	.98	52.56	4.18
	December	2	1,000	4.0	13.35	101.6	1.05	72.09	5.67
1938	January	3	1,360	6.2	12.23	98.4	.84	89.82	6.17
	February	2	1,280	8.8	11.70	100.5	.84	80.87	5.81
	March	5	1,900	12.3	10.64	98.9	.85	109.17	8.72
	April	4	1,780	16.4	9.78	99.1	1.42	94.01	13.65
	May	3	1,630	19.5	8.87	95.8	1.03	78.07	9.07
	June	5	1,420	21.6	8.14	91.5	1.22	62.42	9.35
	July	3	1,060	25.5	7.55	91.0	.85	43.22	4.87
	August	2	1,820	25.0	7.88	94.0	.82	77.44	8.06
Summer[1]	Average	17	1,370	22.5	7.84	88.7	1.35	58.00	9.99
	Maximum		5,370	27.5	10.10	101.2	3.24	-	-
	Minimum		330	15.5	6.10	70.3	.32	-	-
Winter[2]	Average	26	1,450	12.0	10.86	98.5	0.99	85.03	7.75
	Maximum		3,150	23.5	14.50	110.5	2.33	-	-
	Minimum		600	1.0	8.25	88.0	.52	-	-
Watauga River - Station Wa 17.4 - Watauga, Tenn.									
1937	August	3	950	25.0	6.73	80.4	1.52	34.52	7.80
	September	4	640	21.2	7.48	83.5	1.25	25.85	4.32
	October	3	960	15.0	9.00	88.7	1.67	46.66	8.66
	November	4	780	7.5	11.32	94.2	1.72	47.68	7.24
	December	2	540	4.5	12.00	92.6	1.43	34.99	4.17
1938	January	3	1,190	5.8	11.50	91.6	.87	73.90	5.59
	February	2	1,120	8.0	11.00	92.7	.98	66.53	5.93
	March	5	1,640	11.0	10.44	94.4	.92	92.46	8.15
	April	4	1,030	14.6	9.20	89.8	1.11	51.17	6.17
	May	3	350	18.2	8.17	86.0	.79	15.44	1.49
	June	5	940	20.2	7.90	86.5	1.57	40.10	7.97
	July	3	840	23.7	7.12	83.0	1.07	32.30	4.85
	August	2	1,710	22.0	7.60	86.0	1.12	70.18	10.34
Summer[1]	Average	17	893	21.9	7.51	84.1	1.28	36.21	6.17
	Maximum		1,940	27.0	9.00	92.9	2.90	-	-
	Minimum		160	15.0	6.50	76.0	.40	-	-
Winter[2]	Average	26	1,040	11.2	10.20	90.9	1.16	57.28	6.51
	Maximum		2,100	21.5	13.10	97.3	1.90	-	-
	Minimum		170	2.0	7.65	85.4	.58	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 14 (Continued)

HOLSTON RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

Watauga River - Station Wa 15.5 - below Johnson City, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Dissolved Oxygen		5-Day Oxygen Demand 20°C ppm	1000 Lb. per Day	
					ppm	% Saturation		Dissolved Oxygen	5-Day Oxygen Demand
1937	August	3	970	25.5	6.43	77.5	1.44	33.68	7.54
	September	4	650	21.6	7.42	83.5	1.50	26.04	5.26
	October	3	970	15.2	8.83	87.2	1.77	46.25	9.27
	November	4	790	7.8	11.28	94.5	1.81	48.12	7.72
	December	2	490	4.2	11.70	89.5	1.55	30.96	4.10
1938	January	3	1,210	5.7	11.53	91.6	.95	75.34	6.21
	February	2	1,140	8.0	11.05	93.2	1.15	68.02	7.08
	March	5	1,670	11.1	10.20	92.3	.89	91.98	8.03
	April	4	1,060	14.9	9.28	91.4	1.80	53.12	10.30
	May	3	350	18.7	8.27	87.9	1.74	15.63	3.29
	June	5	970	20.4	7.76	85.3	3.92	40.65	20.53
	July	3	860	24.2	7.18	84.5	1.76	33.34	8.17
	August	2	1,740	22.2	7.55	85.8	.97	70.94	9.11
Summer[1]	Average	17	912	22.3	7.40	83.6	1.65	36.44	8.13
	Maximum		1,980	28.0	7.90	90.3	5.70	-	-
	Minimum		165	15.5	6.00	70.4	.82	-	-
Winter[2]	Average	26	1,060	11.2	10.29	91.4	1.45	58.90	8.30
	Maximum		2,150	21.5	13.00	97.7	6.14	-	-
	Minimum		180	2.0	7.50	83.4	.70	-	-
South Fork Holston River - Station SHo 16.6 - below Watauga River									
1937	August	3	2,320	24.3	5.77	68.2	3.73	72.29	46.73
	September	4	2,300	21.2	7.22	80.5	2.79	89.67	34.65
	October	3	2,430	15.7	9.00	89.8	3.00	118.10	39.37
	November	4	1,500	7.6	11.45	95.6	.98	92.74	7.94
	December	2	1,600	4.0	12.55	95.6	.90	108.43	7.78
1938	January	3	2,670	6.2	11.63	93.7	.70	167.68	10.09
	February	2	2,600	8.8	11.25	96.5	.95	157.95	13.34
	March	5	3,760	12.2	10.32	95.9	1.21	209.54	24.57
	April	4	2,730	16.4	9.30	94.2	1.83	137.10	26.98
	May	3	1,540	19.7	8.33	90.4	2.40	69.27	19.96
	June	5	2,570	21.7	7.48	84.2	3.70	103.81	51.35
	July	3	1,730	25.5	7.08	85.4	4.16	66.14	38.86
	August	2	3,750	25.0	6.75	80.5	3.58	136.69	72.50
Summer[1]	Average	17	2,370	22.8	7.02	79.7	3.67	89.84	46.97
	Maximum		6,200	27.5	9.30	96.2	7.42	-	-
	Minimum		730	16.0	4.80	58.5	.75	-	-
Winter[2]	Average	26	2,520	12.0	10.65	94.5	1.35	144.93	18.37
	Maximum		5,500	23.0	13.30	99.2	3.68	-	-
	Minimum		900	1.0	8.25	85.8	.51	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 14 (Continued)

HOLSTON RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Dissolved Oxygen ppm	Dissolved Oxygen % Saturation	5-Day Oxygen Demand 20°C ppm	1000 Lb. per Day Dissolved Oxygen	1000 Lb. per Day 5-Day Oxygen Demand
South Fork Holston River - Station SHo 1.0 - below Kingsport, Tenn.									
1937	August	3	2,360	26.3	4.57	55.9	6.82	58.24	86.91
	September	4	2,310	22.1	4.90	55.6	7.63	61.12	95.18
	October	3	2,180	15.2	7.43	73.4	8.58	87.47	101.00
	November	4	1,750	7.4	10.70	88.8	4.26	101.12	40.26
	December	2	2,380	4.0	11.60	88.2	3.64	149.08	46.78
1938	January	3	3,010	5.5	11.27	89.0	2.45	183.18	39.82
	February	2	3,210	8.5	10.55	89.8	2.84	182.87	49.23
	March	5	4,280	11.2	9.87	89.5	2.43	228.12	56.16
	April	4	3,010	16.8	8.64	98.3	2.83	140.43	46.00
	May	3	2,040	20.6	6.94	76.6	4.11	76.45	45.28
	June	5	2,980	22.6	6.69	76.5	3.31	107.66	53.26
	July	3	2,160	26.7	6.06	74.8	7.12	70.68	83.05
	August	2	3,720	25.4	5.96	71.6	4.48	119.72	89.99
Summer[1]	Average	17	2,470	23.7	5.78	66.7	6.26	77.09	83.50
	Maximum		5,800	29.5	7.50	79.6	12.95	-	-
	Minimum		690	15.5	2.40	29.2	3.16	-	-
Winter[2]	Average	26	2,940	11.9	9.59	86.4	3.22	152.25	51.12
	Maximum		6,100	24.5	13.50	97.5	4.98	-	-
	Minimum		1,400	1.0	6.52	75.5	1.90	-	-
North Fork Holston River - Station NHo 0.1 - near mouth									
1937	August	3	600	27.0	7.50	92.9	0.98	24.30	3.18
	September	4	400	20.4	7.92	87.1	1.00	17.11	2.16
	October	3	620	14.0	9.30	89.7	1.52	31.14	5.09
	November	4	390	5.5	11.75	93.0	1.15	24.75	2.42
	December	2	680	2.5	12.40	90.8	.79	45.53	2.90
1938	January	3	890	4.5	11.90	91.8	.71	57.19	3.41
	February	2	820	7.0	11.20	92.1	.82	49.59	3.63
	March	5	1,540	10.6	10.50	93.9	1.10	87.32	9.15
	April	4	1,320	17.0	10.59	108.9	.74	75.49	5.27
	May	3	590	21.2	9.40	105.0	.76	29.95	2.42
	June	5	1,010	23.0	8.57	98.7	1.22	46.74	6.65
	July	3	1,500	27.3	7.52	93.7	1.99	60.91	16.12
	August	2	850	27.0	7.98	99.0	.56	36.63	2.57
Summer[1]	Average	17	824	23.6	7.95	91.7	1.16	35.37	5.16
	Maximum		3,670	31.0	9.40	112.3	3.14	-	-
	Minimum		150	13.5	6.15	70.8	.43	-	-
Winter[2]	Average	26	943	11.3	10.78	94.9	0.87	54.89	4.43
	Maximum		2,500	25.0	13.90	124.8	1.91	-	-
	Minimum		340	.0	8.35	86.0	.38	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 14 (Continued)

HOLSTON RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

Holston River - Station Ho 132.0 - Church Hill, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Dissolved Oxygen ppm	Dissolved Oxygen % Saturation	5-Day Oxygen Demand 20°C ppm	1000 Lb. per Day Dissolved Oxygen	1000 Lb. per Day 5-Day Oxygen Demand
1937	August	3	2,900	27.3	5.80	72.4	2.21	90.83	34.61
	September	4	2,090	21.2	5.90	65.8	2.18	66.59	24.60
	October	3	2,830	14.7	9.20	89.8	2.23	140.59	34.08
	November	4	2,220	6.6	10.78	87.7	1.51	129.23	18.10
	December	2	2,980	3.8	11.50	87.1	1.34	185.06	21.56
1938	January	3	4,180	5.3	11.37	89.5	.90	256.64	20.31
	February	2	4,070	8.0	10.45	88.0	1.13	229.67	24.84
	March	5	5,950	10.8	10.16	91.3	1.45	326.44	46.59
	April	4	4,470	17.1	8.70	89.6	1.70	210.00	41.03
	May	3	2,790	20.8	7.58	84.0	1.56	114.20	23.50
	June	5	4,120	23.0	7.19	82.8	1.47	159.96	32.70
	July	3	3,420	27.5	6.88	86.1	2.11	127.06	38.97
	August	2	6,030	25.8	6.18	75.0	3.30	201.23	107.45
Summer[1]	Average	17	3,300	23.9	6.50	75.4	2.01	115.83	35.82
	Maximum		7,790	30.5	8.50	97.9	4.39	-	-
	Minimum		900	14.0	4.70	57.2	1.19	-	-
Winter[2]	Average	26	4,000	11.8	9.74	87.6	1.41	210.38	30.46
	Maximum		8,660	25.0	13.00	108.6	2.91	-	-
	Minimum		1,800	1.0	6.60	78.8	.74	-	-
Holston River - Station Ho 0.1 - near mouth (1936-37)[3]									
Summer[1]	Average	14	1,770	25.8	7.14	86.4	1.11	68.24	10.61
	Maximum		4,190	29.0	8.30	96.4	2.05	-	-
	Minimum		980	19.0	6.35	78.0	.45	-	-
Winter[2]	Average	26	5,820	14.6	9.34	88.7	1.44	293.54	45.26
	Maximum		27,600	27.0	11.35	98.5	2.90	-	-
	Minimum		1,540	4.0	7.45	77.4	.70	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.
3. For complete report on this station see Studies of the Pollution of the Tennessee River System, I, February 1941.

TABLE 15

HOLSTON RIVER

BACTERIA

South Fork Holston River - Station SHo 48.4 - Bristol, Tenn., Water Supply

Year	Month	Number Times Sampled	Coliform Group M.P.N. per Milliliter Average
August 1937 through June 1940	January	85	13
	February	79	21
	March	86	21
	April	81	46
	May	84	16
	June	80	70
	July	57	160
	August	89	50
	September	86	21
	October	84	28
	November	64	30
	December	83	11
Summer[1]	Average	396	60
	Maximum		2400
	Minimum		0.2
Winter[2]	Average	562	22
	Maximum		2400
	Minimum		0

1. Summer season from June through October.
2. Winter season November through May.

Note: Summarized from plant records.

TABLE 15 (Continued)

HOLSTON RIVER

BACTERIA

South Fork Holston River - Station SHo 31.0 - below Bluff City, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Bacteria Per Milliliter		Quantity Units (Bacteria x 1000 cfs)	
					On Agar 37°C for 24 Hours	Coliform Group M.P.N.	On Agar 37°C for 24 hours	Coliform Group M.P.N.
1937	August	3	690	25.5	750	75	518	52
	September	4	1,480	21.1	550	27	814	40
	October	3	1,230	14.7	400	55	492	68
	November	4	660	7.5	27	2.8	18	1.8
	December	2	880	4.0	300	3.9	264	3.4
1938	January	3	1,180	6.3	25	3.8	30	4.5
	February	2	1,120	8.5	33	4.7	37	5.3
	March	5	1,660	11.9	70	5.9	116	9.8
	April	4	1,590	15.4	75	9.1	119	14
	May	3	1,450	18.7	95	24	138	35
	June	5	1,280	20.6	300	55	384	70
	July	3	750	24.8	850	32	638	24
	August	2	1,640	24.5	3,800	46	6,232	75
Summer[1]	Average	17	1,150	22.4	800	55	920	63
	Maximum		4,550	28.0	13,000	2,400	-	-
	Minimum		250	15.0	90	2.3	-	-
Winter[2]	Average	26	1,280	11.6	65	6.8	83	8.7
	Maximum		2,760	22.5	4,200	110	-	-
	Minimum		470	1.5	10	0.6	-	-
Beaver Creek - Station BC 1.0 - near mouth								
1937	August	3	250	24.3	25,000	850	6,250	213
	September	4	180	20.4	29,500	600	5,310	108
	October	3	260	15.7	19,000	1,200	4,940	312
	November	4	90	8.6	1,100	375	99	34
	December	2	90	5.0	1,200	160	108	14
1938	January	3	160	8.2	950	140	152	22
	February	2	150	10.0	800	200	120	30
	March	5	250	12.4	1,000	100	250	25
	April	4	160	15.9	3,600	500	576	80
	May	3	140	18.7	18,500	900	2,590	126
	June	5	160	20.2	16,000	700	2,560	112
	July	3	150	23.5	24,000	1,800	3,600	270
	August	2	100	24.5	17,500	800	1,750	80
Summer[1]	Average	17	184	21.8	27,000	850	4,968	156
	Maximum		620	26.5	120,000	7,000	-	-
	Minimum		30	16.0	4,000	60	-	-
Winter[2]	Average	26	164	12.4	2,100	300	344	49
	Maximum		420	21.5	32,500	1,600	-	-
	Minimum		75	2.5	275	36	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 15 (Continued)

HOLSTON RIVER

BACTERIA

South Fork Holston River - Station SHo 26.3 - below Beaver Creek

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Bacteria Per Milliliter		Quantity Units (Bacteria x 1000 cfs)	
					On Agar 37°C for 24 Hours	Coliform Group M.P.N.	On Agar 37°C for 24 Hours	Coliform Group M.P.N.
1937	August	3	940	24.2	1,900	75	1,786	70
	September	4	1,730	20.6	1,800	120	3,114	208
	October	3	1,390	15.2	1,500	110	2,085	153
	November	4	790	7.8	70	8.3	55	6.6
	December	2	1,000	4.0	120	21	120	21
1938	January	3	1,360	6.2	90	13	122	18
	February	2	1,280	8.8	47	29	60	37
	March	5	1,900	12.3	170	19	323	36
	April	4	1,780	16.4	275	42	490	75
	May	3	1,630	19.5	1,500	140	2,445	228
	June	5	1,420	21.6	1,400	85	1,988	121
	July	3	1,060	23.5	1,700	130	1,802	138
	August	2	1,820	25.0	1,900	29	3,458	53
Summer[1]	Average	17	1,370	22.5	1,900	95	2,603	130
	Maximum		5,370	27.5	16,000	2,400	-	-
	Minimum		330	15.5	300	6.0	-	-
Winter[2]	Average	26	1,450	12.0	210	27	304	39
	Maximum		3,150	23.5	1,000	400	-	-
	Minimum		600	1.0	20	2.3	-	-
Watauga River - Station Wa 17.4 - Watauga, Tenn.								
1937	August	3	950	25.0	39,000	45	37,050	43
	September	4	640	21.2	22,500	28	14,400	18
	October	3	960	15.0	11,000	26	10,560	25
	November	4	780	7.5	70	2.5	55	2
	December	2	540	4.5	475	1.2	256	0.6
1938	January	3	1,190	5.8	26	5.2	31	6.2
	February	2	1,120	8.0	35	4.2	39	4.7
	March	5	1,640	11.0	160	8.9	262	15
	April	4	1,030	14.6	300	7.2	309	7.4
	May	3	350	18.2	5,000	9.8	1,750	3.4
	June	5	940	20.2	8,900	34	8,366	32
	July	3	840	23.7	48,500	21	40,740	18
	August	2	1,710	22.0	59,000	120	100,890	205
Summer[1]	Average	17	893	21.9	27,000	21	24,111	19
	Maximum		1,940	27.0	88,000	700	-	-
	Minimum		160	15.0	5,700	0.2	-	-
Winter[2]	Average	26	1,040	11.2	275	6.1	286	6.3
	Maximum		2,100	21.5	10,500	36	-	-
	Minimum		170	2.0	18	0.4	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 15 (Continued)

HOLSTON RIVER

BACTERIA

Watauga River - Station Wa 15.5 - below Johnson City, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Bacteria Per Milliliter		Quantity Units (Bacteria x 1000 cfs)	
					On Agar 37°C for 24 Hours	Coliform Group M.P.N.	On Agar 37°C for 24 Hours	Coliform Group M.P.N.
1937	August	3	970	25.5	18,500	55	17,945	53
	September	4	650	21.6	21,000	8.6	13,658	5.6
	October	3	970	15.2	14,000	44	13,580	43
	November	4	790	7.8	95	2.6	75	2.1
	December	2	490	4.2	900	21	441	10
1938	January	3	1,210	5.7	45	10	54	12
	February	2	1,140	8.0	55	8.3	63	9.5
	March	5	1,670	11.1	180	12	301	20
	April	4	1,060	14.9	425	10	451	11
	May	3	350	18.7	4,100	21	1,435	7.4
	June	5	970	20.4	10,500	31	10,185	30
	July	3	860	24.2	29,000	43	24,940	37
	August	2	1,740	22.2	32,000	65	55,680	113
Summer[1]	Average	17	912	22.3	21,000	33	19,152	30
	Maximum		1,980	28.0	54,000	700	-	-
	Minimum		165	10.0	8,300	1.1	-	-
Winter[2]	Average	26	1,060	11.2	350	11	371	12
	Maximum		2,150	21.5	11,500	70	-	-
	Minimum		180	2.0	23	0.6	-	-
South Fork Holston River - Station SHo 16.6 - below Watauga River								
1937	August	3	2,320	24.3	28,500	170	66,120	394
	September	4	2,300	21.2	8,600	33	19,780	76
	October	3	2,430	15.7	6,300	50	15,309	122
	November	4	1,500	7.6	55	1.7	82	2.6
	December	2	1,600	4.0	65	7.9	104	13
1938	January	3	2,670	6.2	42	11	112	29
	February	2	2,600	8.8	50	6.2	130	16
	March	5	3,760	12.2	275	26	1,034	98
	April	4	2,730	16.4	275	12	751	33
	May	3	1,540	19.7	850	21	1,309	32
	June	5	2,570	21.7	3,600	60	9,252	154
	July	3	1,730	25.5	210	60	363	104
	August	2	3,750	25.0	5,100	140	19,125	525
Summer[1]	Average	17	2,370	22.8	7,900	65	18,723	154
	Maximum		6,200	27.5	130,000	3,600	-	-
	Minimum		730	16.0	375	2.3	-	-
Winter[2]	Average	26	2,520	12.0	70	12	176	30
	Maximum		5,500	23.0	2,100	110	-	-
	Minimum		900	1.0	14	0.6	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 15 (Continued)

HOLSTON RIVER

BACTERIA

South Fork Holston River - Station SHo 1.0 - below Kingsport, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Bacteria Per Milliliter		Quantity Units (Bacteria x 1000 cfs)	
					On Agar 37°C for 24 Hours	Coliform Group M.P.N.	On Agar 37°C for 24 Hours	Coliform Group M.P.N.
1937	August	3	2,360	26.3	76,000	600	179,360	1,416
	September	4	2,310	22.1	35,500	170	82,005	393
	October	3	2,180	15.2	19,500	130	42,510	283
	November	4	1,750	7.4	250	12	438	21
	December	2	2,380	4.0	180	8.2	428	20
1938	January	3	3,010	5.5	230	6.2	692	19
	February	2	3,210	8.5	240	16	770	51
	March	5	4,280	11.2	750	40	3,210	171
	April	4	3,010	16.8	2,000	41	6,020	123
	May	3	2,040	20.6	7,200	70	14,688	143
	June	5	2,980	22.6	18,000	95	53,640	283
	July	3	2,160	26.7	27,000	100	58,320	216
	August	2	3,720	25.4	38,000	350	141,360	1,302
Summer[1]	Average	17	2,470	23.7	35,000	210	86,450	519
	Maximum		5,800	29.5	120,000	2,400	-	-
	Minimum		690	15.5	9,800	6.2	-	-
Winter[2]	Average	26	2,940	11.9	950	27	2,793	79
	Maximum		6,100	24.5	16,000	190	-	-
	Minimum		1,400	1.0	60	1.6	-	-
North Holston River - Station NHo 0.1 - near mouth								
1937	August	3	600	27.0	950	21	570	13
	September	4	400	20.4	800	20	320	8
	October	3	620	14.0	1,100	110	682	68
	November	4	390	5.5	110	2.7	43	1.1
	December	2	680	2.5	90	7.6	61	5.2
1938	January	3	890	4.5	40	6.2	36	5.5
	February	2	820	7.0	55	6.2	45	5.1
	March	5	1,540	10.6	190	8.2	293	13
	April	4	1,320	17.0	50	5.1	66	6.7
	May	3	590	21.2	90	14	53	8.3
	June	5	1,010	23.0	220	20	222	20
	July	3	1,500	27.3	700	55	1,050	82
	August	2	850	27.0	450	20	382	17
Summer[1]	Average	17	824	23.6	750	34	618	28
	Maximum		3,670	31.0	12,500	2,400	-	-
	Minimum		150	13.5	50	2.3	-	-
Winter[2]	Average	26	943	11.3	90	6.9	85	6.5
	Maximum		2,500	25.0	1,200	240	-	-
	Minimum		340	.0	15	0.6	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 15 (Continued)

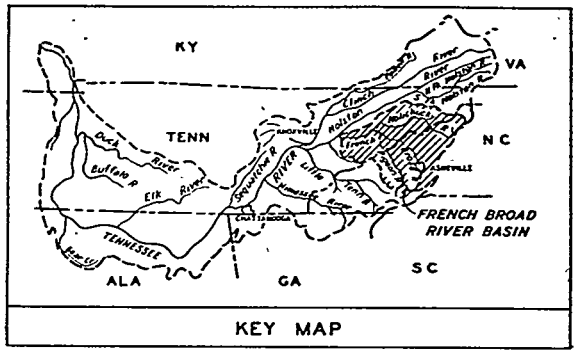
HOLSTON RIVER

BACTERIA

Holston River - Station Ho 132.0 - Church Hill, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Bacteria Per Milliliter		Quantity Units (Bacteria x 1000 cfs)	
					On Agar 37°C for 24 Hours	Coliform Group M.P.N.	On Agar 37°C for 24 Hours	Coliform Group M.P.N.
1937	August	3	2,900	27.3	68,000	55	197,200	160
	September	4	2,090	21.2	31,000	32	64,790	67
	October	3	2,830	14.7	13,000	50	36,790	142
	November	4	2,220	6.6	800	3.3	1,776	7.3
	December	2	2,980	3.8	400	21	1,192	63
1938	January	3	4,180	5.3	180	3.9	752	16
	February	2	4,070	8.0	120	1.8	488	7.3
	March	5	5,950	10.8	800	14	4,760	83
	April	4	4,470	17.1	1,400	8.6	6,258	38
	May	3	2,790	20.8	6,000	17	16,740	47
	June	5	4,120	23.0	12,000	35	49,440	144
	July	3	3,420	27.5	19,000	60	64,980	205
	August	2	6,030	25.8	27,000	350	162,810	2,111
Summer[1]	Average	17	3,300	23.9	29,000	60	95,700	198
	Maximum		7,790	30.5	110,000	1,100	-	-
	Minimum		900	14.0	4,400	3.6	-	-
Winter[2]	Average	26	4,000	11.8	950	8.8	3,800	35
	Maximum		8,660	25.0	11,000	240	-	-
	Minimum		1,800	1.0	70	0.6	-	-
Holston River - Station Ho 0.1 - near mouth (1936-37)[3]								
Summer[1]	Average	14	1,770	25.8	80	12	142	21
	Maximum		4,190	29.0	210	36	-	-
	Minimum		980	19.0	24	3.6	-	-
Winter[2]	Average	26	5,820	14.6	110	5.2	640	30
	Maximum		27,600	27.0	5,300	60	-	-
	Minimum		1,540	4.0	14	0.2	-	-

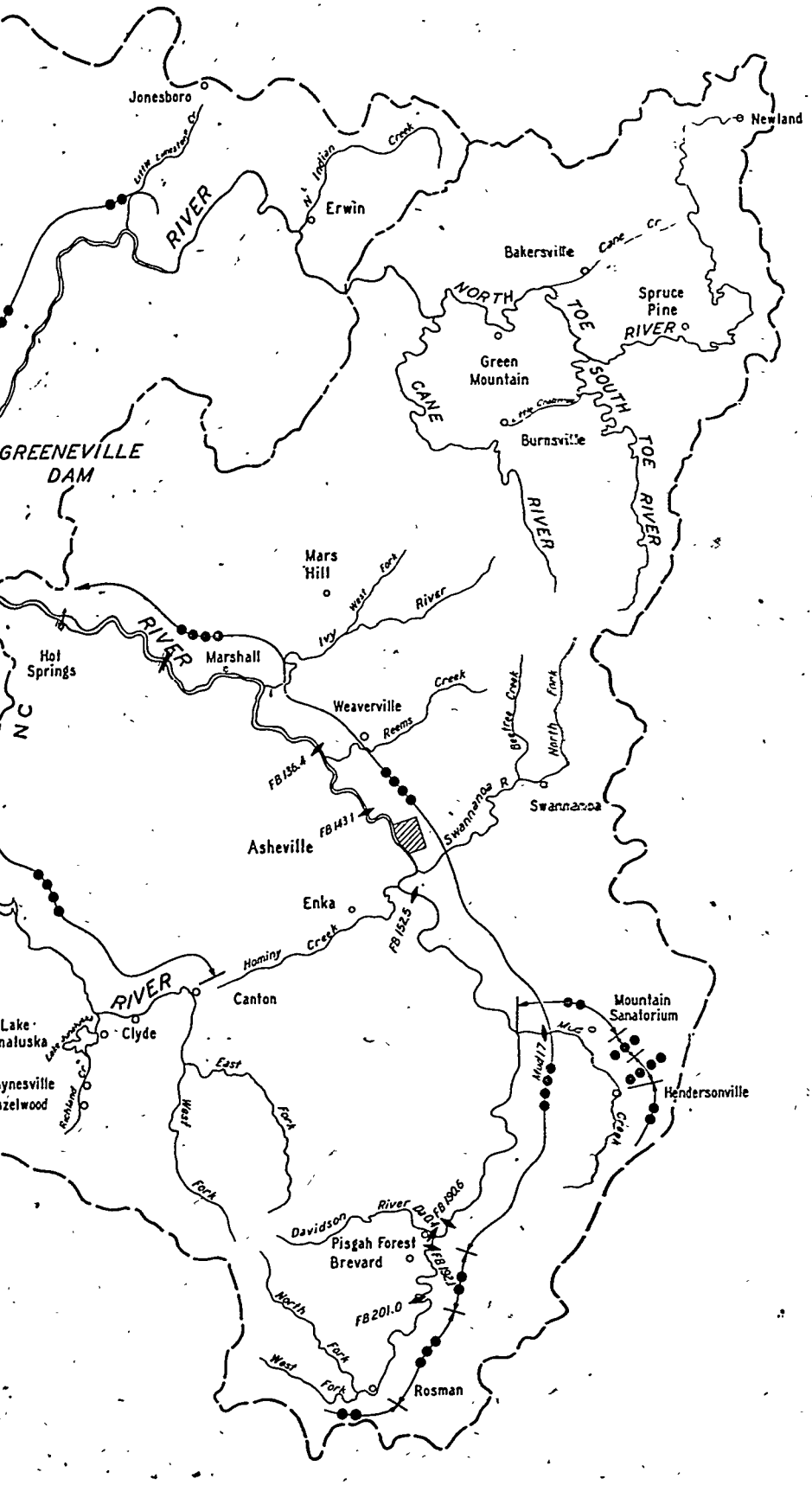
1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.
3. For complete report on this station see Studies of the Pollution of the Tennessee River System, 1, February 1941.



KEY MAP

Mosheim
Greeneville
Rockland Co
NOLICHUCKY
No 36.8
BROAD
Oak Grove
Indefinite classification
Dandridge
FB 78.4
Pi 5.6
Pi 6.7
Newport
DOUGLAS DAM
Chestnut Hill
FRENCH
RIVER
FB 0.4
TENNESSEE
LITTLE PIGEON RIVER
Sevierville
West Fork
Gatlinburg
Waterville
PIGEON
WATERVILLE DAM

CHATTANOOGA DRAFTING SERVICE



SYMBOLS:

- Class I – Class A swimming areas and water supplies with minimum treatment.
- Class II – Class B and C swimming areas and water supplies (normal filter plant operation).
- Class III – Water supplies (advanced treatment methods) and fish life.
- Class IV – Unsuitable for water supplies as defined under class III or which do not support desirable fish fauna.
- Sampling stations

Figure 5

Scale 4 0 4 8 Miles

POLLUTION SURVEY				
FRENCH BROAD RIVER DRAINAGE BASIN				
STREAM SANITATION PROGRAM TENNESSEE VALLEY AUTHORITY HEALTH AND SAFETY DEPARTMENT				
SUBMITTED	RECOMMENDED			APPROVED
CHATTANOOGA	9-24-43	G	HS	306B509 R1

SECTION II

FRENCH BROAD RIVER

SECTION II

FRENCH BROAD RIVER

General

The French Broad River basin is the largest of the major tributaries in the Tennessee River system. It drains an area of 5,124 square miles, roughly rectangular in shape, extending from the South Carolina state line up through western North Carolina to Knoxville, Tennessee, figure 5. The areas drained by its principal tributaries are as follows:

Pigeon	689 square miles
Nolichucky	1,756 square miles
Little Pigeon	381 square miles
Remainder of basin	2,298 square miles

The area is mostly mountainous, particularly in North Carolina. That portion of the area near the mouth which lies within the Great Valley is less rugged. The French Broad River and its tributary, the Pigeon River, in general are the most highly polluted streams in the Tennessee Valley. This pollution originates at pulp and paper, and cellulose industries in North Carolina.

Geology

That portion of the drainage area in Tennessee to within about 15 miles of the North Carolina state line lies in the Great Valley, which has been described in the section on the Holston River. The remainder of the area drains a portion of what is known as the Blue Ridge Region. This has been described as follows:[1]

"The Blue Ridge Region straddles the Tennessee-North Carolina boundary and is an integral part of the Appalachian Mountains. The most prominent parts are the Unaka, the Iron, and the Great Smoky mountains.

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1. Industrial Water Supplies of the Tennessee Valley Region, Tennessee Valley Authority, Commerce Department and Health and Safety Department, 1943, p. 5.

"This mountainous area varies in elevation from 2,500 feet along the eastern front to over 6,600 feet on the western front. It is underlain, for the most part, by a series of crystalline rocks (gneisses, schists, etc.) of pre-Cambrian age, cut by granites and basic igneous intrusions. Highly metamorphosed sedimentary rocks such as slate, quartzite, marble and conglomerates occur as inliers and along the western front of the area.

"The upper slopes and crests of the serrated ridges usually have a thick covering of soil and weathered rock. The underlying rocks, broadly speaking, are siliceous and not easily dissolved by ground waters. Surface drainage is rapid; vadose waters follow joints and bedding and fracture planes rather than solution channels. Consequently the water contains little dissolved mineral constituents.

"Below the zone just described, the topography is less rugged. There is a thicker covering of comparatively porous residual soil, and in places, talus. Surface drainage is less rapid than in the upper slopes. There is a large reservoir of ground water and springs are numerous. The water is not heavily charged with mineral matter.

"The lower slopes and outwash plains have coarse, loose soils. The water in this zone is more mineralized than that in the other zones of the Blue Ridge since it is charged with the dissolved constituents accumulated in its downward passage from the upper mountain slopes. The water in the lowest zone is often mineralized, containing iron and alum in solution as well as other constituents."

Precipitation

The precipitation on the drainage area varies more widely than on any of the other tributaries. The annual precipitation in the upper section near the South Carolina state line is 77 inches per year, while near the mouth of the river it drops to about 36 inches. The average for the entire area is approximately 50 inches. During the year of study in 1937-1938 the precipitation was 53 inches.

Stream Flows

Table 16 gives the mean monthly discharges, period of record, and extent of drainage areas for three points on the French Broad River and for two of its tributaries. It will be noticed that the summer flows for the period of study was considerably greater than the average discharges, tables 21, 22, 23, 24, and 25.

TABLE 16

MEAN MONTHLY DISCHARGES IN CUBIC FEET PER SECOND

AT DESIGNATED POINTS ON THE FRENCH BROAD RIVER SYSTEM

	French Broad River Asheville, N. C.	French Broad River Newport, Tenn.	Pigeon River Hartford, Tenn.	Nolichucky River Morristown, Tenn.	French Broad River Dandridge, Tenn.
Drainage Area Above Gage Sq. Mi.	945	1,858	547	1,686	4,446
Period of Record	1920-1934	1921-1934	1926-1934	1921-1934	1920-1934
January cfs	2,240	3,380	1,120	2,780	7,980
February cfs	2,210	3,690	1,300	3,840	9,880
March cfs	2,630	4,210	1,600	3,800	10,710
April cfs	2,540	3,650	1,270	3,020	9,160
May cfs	2,170	3,470	1,260	2,790	8,000
June cfs	1,710	2,520	879	1,940	5,830
July cfs	1,455	2,140	698	1,810	5,090
August cfs	1,560	2,150	689	1,620	5,030
September cfs	1,470	1,920	624	1,170	3,920
October cfs	1,430	1,880	577	1,120	3,640
November cfs	1,470	1,950	647	1,310	4,080
December cfs	2,070	2,880	1,140	2,230	6,880
Mean Annual cfs	1,910	2,820	983	2,290	6,710
Maximum Flow cfs	110,000	76,300	38,600	61,900	95,000
Minimum Flow cfs	239	210	11	22	360

Water Supplies

Because of the presence of large numbers of mountain streams, relatively free of mineral matter and turbidity, most towns in the valley obtain their water supplies from such sources. Many of these supplies receive no treatment whatever, although the greater part of them are chlorinated. Only eight supplies have water purification plants. Table 17 gives the water supplies, their sources, and methods of purification.

TABLE 17

WATER SUPPLIES

FRENCH BROAD RIVER BASIN, 1937-1940 -

Municipality	Population	Source	Treatment[1]
Rosman, N. C.	529	Spring and Stream	N
Transylvania County State Prison Camp	100	Well	N
Brevard, N. C.	5,000	Stream	D
Hendersonville, N. C.	10,762	Stream	D
Flat Rock	2,000	Hendersonville	
E. Flat Rock	1,103	"	
Laurel Park	500	"	
David Hills San. Dist.	500	"	
Balfour	450	"	
Mountain Home, N. C.	400	Spring and Wells	N
Biltmore Estate, N. C.	300	Stream	CFD
Mt. Sanatorium, N. C.	200	Well and Stream	N
Asheville, N. C.	51,310	Streams	D
S. Bumcombe Water Dist.	2,500	Asheville	
Venable Water Dist.	500	"	
Biltmore Forest	476	"	
Enka	800	"	
Caney Valley San. Dist.	510	"	
Swannanoa San. Dist.	2,600	"	
Hazel Water Dist.	1,250	"	
Beaver Dam San. Dist.	650	"	
Candler Heights, N. C.	200	Well	N
Candler, N. C.	150	Springs	N
Ridgecrest, N. C.	1,600	Stream	D
Montreat, N. C.	2,000	Piney Branch	D
WNC State Sanatorium	430	Asheville	
Black Mountain, N. C.	2,000	Stream	D
Blue Ridge, N. C.	350	Stream	D

1. N = No Treatment
   C = Coagulation and Sedimentation
   D = Disinfection
   F = Filtration

TABLE 17 (Continued)

WATER SUPPLIES

FRENCH BROAD RIVER BASIN

Municipality	Population	Source	Treatment[1]
Swannanoa, N. C.	1,800	Stream and Asheville	D
U. S. Veterans Hospital	1,225	Asheville	
Deaver View Park, N. C.	200	Springs	N
Fairview San. Dist. N. C.	300	Asheville	
Woodfin San. Dist. N. C.	4,000	Reems Creek	D
Weaverville, N. C.	1,000	Streams	D
Mars Hill, N. C.	1,100	Laurel Creek	D
Marshall, N. C.	1,160	Streams	D
Hot Springs, N. C.	773	Cascade Branch	D
Canton, N. C.	5,037	(Rough Creek	FD
		(Pigeon River	CFD
Clyde, N. C.	516	Canners Branch	CFD
Hazelwood, N. C.	1,508	Waynesville	
Waynesville, N. C.	2,940	Allen Creek	FD
Lake Junaluska, N. C.	5,000	Waynesville	
Waterville, N. C.	100	Big Creek	FD
Newport, Tenn.	3,575	Wells and Springs	D
Newland, N. C.	471	Well	N
Spruce Pine, N. C.	1,968	Streams	D
Burnsville, N. C.	997	Bowling Creek	CFD
Bakersville, N. C.	437	Springs	N
Yancey County State Prison Camp	100	Well	N
Erwin, Tenn.	3,350	Springs	D
Jonesboro, Tenn.	976	Springs	D
Greeneville, Tenn.	6,784	Spring and Nolichucky R.	CFD
Mosheim, Tenn.	400	Spring	N
Dandridge, Tenn.	488	Spring	D
Gatlinburg, Tenn.	200	Springs	D
Sevierville, Tenn.	1,161	Wells	D

1. N = No Treatment
   C = Coagulation and Sedimentation
   D = Disinfection
   F = Filtration

Note: Where population of municipality is significantly increased by summer tourists, the estimate of population at this season is shown.

Sources of Pollution

Population Estimates

While this drainage area is the largest in the system and has the largest population, it is not so densely populated as is the Holston River valley. This, of course, is to be expected from the rugged nature of the valley. Its population, particularly in most of western North Carolina, is subject to a considerable annual variation due to the influx of tourists and vacationers during the summer season. In this section the populations of some of the towns are from two to three times as large in the summer as they are during the rest of the year. Its population is 388,506, divided among the tributaries as follows:

Pigeon	48,295
Nolichucky	114,176
Little Pigeon	18,090
Remainder of basin	207,945

Sewerage Systems

Table 18 shows the municipalities in the French Broad River basin which have sewerage systems and the types of treatment. Approximately 96 percent of the urban population is connected to sewers. The extent of sewage treatment facilities is rather small. The reduction in load resulting from sewage treatment is less than 6 percent of the total.

Industrial Plants

Table 19 gives the types and number of industrial plants in the basin, disposition of the wastes, and comparative figures for the entire Tennessee Valley. It should be noted that while less than 18 percent of the number of industries are located in this basin, the population equivalent of the wastes is 34 percent of the total. The principal sources of the pollutional material are pulp and paper, tanning, and cellulose industries.

It will be noted that the wastes of only six industrial plants receive some form of treatment or correction and that reduction in population equivalent due to such treatment is relatively small. The treatment

shown for the two canning plants consists of the discharge of the wastes into dry streams, from which it is rather doubtful that any of the wastes reach the river system. At two of the tanneries lagoons serve as sedimentation basins for the partial removal of pollutional material. Some reduction in pollution by milk wastes is accomplished by municipal sewage treatment plants.

TABLE 18

SEWERAGE SYSTEMS

FRENCH BROAD RIVER BASIN, 1937-1940

Municipality	Population (1940 U.S. Census)		Treatment
	Total	Sewered	
Transylvania County State Prison Camp	100	100	Septic Tank - Sand Filter
Brevard, N. C.	5,000	4,800	None
Hendersonville, N. C.[1]	12,212	11,760	None
Mt. Sanatorium, N. C.	200	150	Septic Tank - Sand Filter
S. Buncombe County San. Dist.	2,500	2,500	Septic Tanks - Sand Filters
Enka, N. C.	800	800	None
Swannanoa San. Dist. N. C.	12,315	11,660	None
Asheville, N. C.[1]	57,246	56,240	None
Weaverville, N. C.	1,000	750	None
Mars Hill and College, N. C.	1,100	600	Septic Tank
Marshall, N. C.	1,160	1,090	None
Hot Springs, N. C.	773	560	None
Canton, N. C.	5,037	5,030	None
Clyde, N. C.	516	390	None
Waynesville, N. C. Interceptor[2]	9,448	9,280	None
Waterville, N. C.	100	100	None
Newport, Tenn.	3,575	2,500	None
Newland, N. C.	471	380	Imhoff Tank
Spruce Pine, N. C.	1,968	1,180	None
Burnsville, N. C.	997	700	None
Bakersville, N. C.	437	30	None
Yancey County State Prison Camp	100	100	Septic Tank - Sand Filter
Erwin, Tenn.	3,350	3,180	None
Jonesboro, Tenn.	976	590	Imhoff Tank
Greeneville, Tenn.	6,784	6,400	Sedimentation - Sprinkling Filter
Dandridge, Tenn.	488	300	None
Sevierville, Tenn.	1,161	460	None
Total	129,814	121,630	

1. 1940 U.S. Census plus small adjacent suburbs.
2. Hazelwood, Waynesville, and Lake Junaluska.

Note: When population of municipality is significantly increased by summer tourists, the estimates of population at this season is shown.

TABLE 19

INDUSTRIAL POLLUTION

FRENCH BROAD RIVER BASIN, 1937-1940

Types of Industry	Number of Plants		Method of Disposal			Estimated Population Equivalents	
	French Broad River Basin	Percent of Total in Tenn. Valley	Municipal Sewers	Stream	Some Correction	French Broad River Basin	Percent of Total in Tenn. Valley
Canning	9	33.4	2	7	2	17,700	42.4
Cellulose	1	20.0	0	1	0	49,500	14.0
Chemical	2	7.7	0	2	0	2,500	9.3
Meat	2	10.5	1	1	0	3,300	8.2
Milk	4	11.8	3	1	2	2,100	14.8
Mining[1]	3	30.0	0	3	0	-	-
Pulp and Paper	2	22.2	0	2	0	296,400	50.8
Tanning	5	55.5	2	3	2	51,700	64.7
Textiles	15	17.6	11	4	0	22,500	15.7
Miscellaneous	1	4.0	0	1	0	400	1.4
Total	44	17.7	19	25	6	446,100	34.0

1. This does not include an undetermined number of kaolin and mica mines in the Toe River Valley.

Extent of Pollution

The estimated amounts of pollution due to domestic sewage and industrial wastes which reach the French Broad River and its tributaries are shown in table 20 expressed in population equivalents. The same information is shown graphically in figure 6.

TABLE 20
ESTIMATED POPULATION EQUIVALENT OF POLLUTION
REACHING FRENCH BROAD RIVER SYSTEM, 1937-1940

Municipality	Receiving Stream	Estimated Population Equivalents		
		Domestic Sewage	Industrial Wastes	Total
Rosman, N. C.	French Broad River	-	7,200	7,200
Transylvania County State Prison Camp	Galloway Creek	10	-	10
Brevard, N. C.	French Broad River	4,800	2,880	7,680
Pisgah Forest, N. C.	Davidson River	-	41,400	41,400
Hendersonville, N. C.	Mud Creek	11,760	1,600	13,360
Mt. Sanatorium, N. C.	Byers Creek	90	-	90
S. Buncombe County San. Dists.	French Broad River	1,200	-	1,200
Enka, N. C.	Hominy Creek	800	49,500	50,300
Swannanoa San. Dist., N. C.	French Broad River	11,660	3,050	14,710
Asheville, N. C.	French Broad River	56,240	31,300	87,540
Weaverville, N. C.	Reems Creek	750	-	750
Mars Hill, N. C.	Gabriels Creek	450	-	450
Marshall, N. C.	French Broad River	1,090	-	1,090
Hot Springs, N. C.	French Broad River	560	-	560
Canton, N. C.	Pigeon River	5,030	255,000	260,030
Clyde, N. C.	Pigeon River	390	-	390
Waynesville, N. C. Interceptor	Pigeon River	9,280	9,780	19,060
Waterville, N. C.	Pigeon River	100	-	100
Newport, Tenn.	Pigeon River	2,500	29,700	32,200
Newland, N. C.	North Toe River	250	-	250
Spruce Pine, N. C.	North Toe River	1,180	200	1,380
Burnsville, N. C.	Little Crabtree Cr.	350	-	350
Burnsville, N. C.	Pine Swamp Branch	350	-	350
Bakersville, N. C.	Cane Creek	30	-	30
Green Mountain, N. C.	North Toe River	-	400	400
Yancey County State Prison Camp	Cane River	10	-	10
Erwin, Tenn.	North Indian Creek	3,180	-	3,180
Jonesboro, Tenn.	Little Limestone Cr.	380	60	440
Greeneville, Tenn.	Richland Creek	1,280	990	2,270
Oak Grove, Tenn.	Spring Creek	-	1,300	1,300
Dandridge, Tenn.	French Broad River	300	-	300
Chestnut Hill, Tenn.	Clear Creek	-	2,300	2,300
Sevierville, Tenn.	Little Pigeon River	460	2,900	3,360
Total		114,480	439,560	554,040

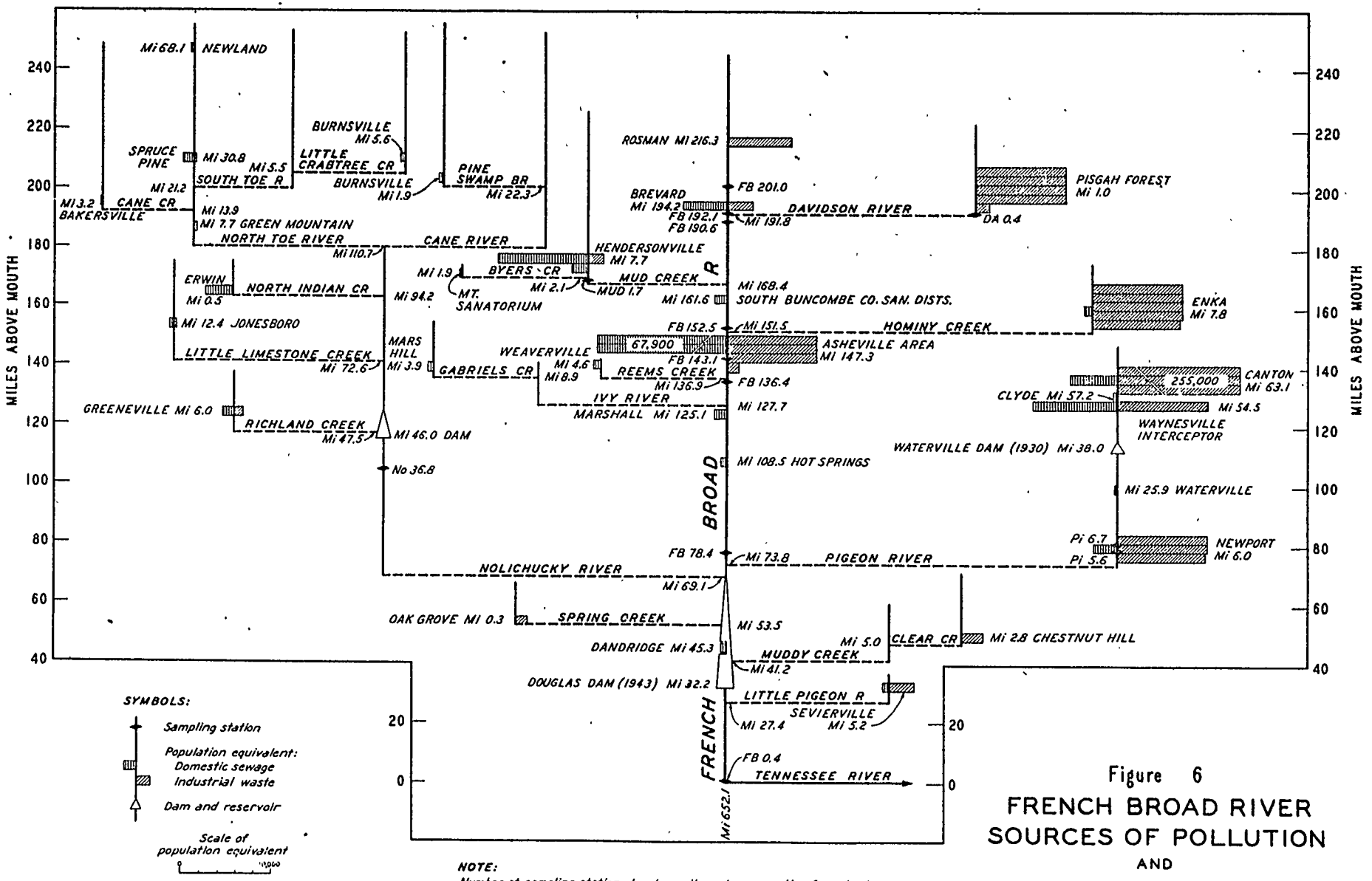

Figure 6

FRENCH BROAD RIVER SOURCES OF POLLUTION AND SAMPLING STATIONS

Sampling and Sampling Stations

Sampling

The sampling and field observations at the six upper stations on the French Broad River and on Davidson River and Mud Creek were carried out at weekly intervals from September 22, 1938, to November 10, 1938, inclusive, by representatives of the North Carolina State Board of Health. Samples for B.O.D. determinations and bacteriological examinations were iced and sent to the state laboratory. Samples for mineral analyses were expressed to the TVA laboratory at Norris, Tennessee.

Samples from FB 78.4, Pi 6.7, Pi 5.6 and No 36.8 were collected at weekly intervals from August 17, 1937, to August 11, 1938, by the Authority, and taken to the Norris laboratory for examination.

The samples from the lower station on the French Broad River (FB 0.4) were collected at weekly intervals from May 1936 to April 1937 and reported in 1941.[1]

The samples from the French Broad, Pigeon, and Nolichucky Rivers in 1937-1938 were collected on the same trips during which samples were collected from the Holston River. As explained in the section discussing the Holston River, some of the samples were two days old when they reached the laboratory; but since they were kept on ice during this time, it is believed that changes due to biological activities were not significant.

Sampling Stations

The routine samples were collected from a total of 13 sampling stations. A number of other sampling stations were used for short periods of time on the French Broad River below the mouth of the Pigeon River, but since detailed analytical results of these studies are not shown in this report, these stations are not described. As in the case of the other tributaries, the numbers following the letters for each station

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1. Studies of the Pollution of the Tennessee River System, I. A General Description of the Valley with Results of Studies on the Knoxville, Chattanooga, Decatur, and Tri-Cities Sections of the Tennessee River 1936-1937, Tennessee Valley Authority, Health and Safety Department, 1941.

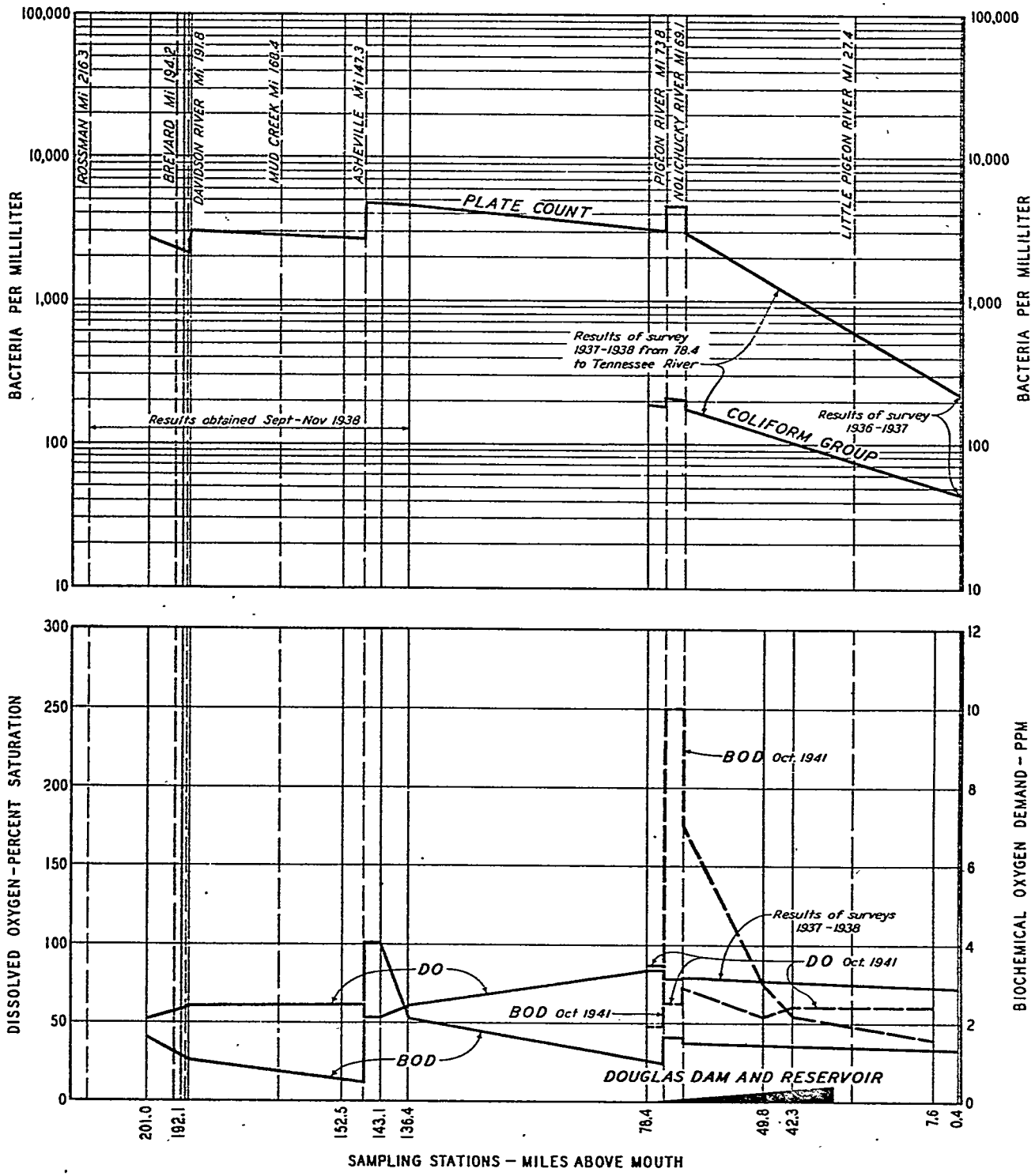
represent the distance in miles above the mouth of the stream in question to the station (figures 5 and 6).

French Broad River, FB 201.0:	A bridge above Brevard, N.C., but below the pollution from the industries at Rosman, N.C.
French Broad River, FB 192.1:	Dunns Rock Bridge below Brevard and above the mouth of Davidson River.
Davidson River, Da 0.4:	The bridge on U.S. Highway No. 64 below Pisgah Forest, N.C.
French Broad River, FB 190.6:	Patton Bridge just below the mouth of Davidson River.
Mud Creek, Mud 1.7:	The bridge on U.S. Highway No. 25 below Hendersonville, N.C.
French Broad River, FB 152.5:	Biltmore Ferry above the mouth of Hominy Creek and the sources of pollution at Asheville, N.C.
French Broad River, FB 143.1:	The bridge at Craggy, N.C., below the pollution from the vicinity of Asheville.
French Broad River, FB 136.4:	The bridge at Alexander, N.C.
French Broad River, FB 78.4:	The bridge on State Highway No. 35 at Oldtown, Tenn., just above the mouth of Pigeon River.
Pigeon River, Pi 6.7:	The bridge on U.S. Highway No. 25 and No. 70 just above Newport, Tenn.
Pigeon River, Pi 5.6:	The bridge on State Highway No. 35 at Newport, Tenn.
Nolichucky River, No 36.8:	Love Bridge on State Highway No. 35 southwest of Greeneville, Tenn.
French Broad River, FB 0.4:	Just below Pickles Island near the mouth of the river.

Discussion of Results

Stream Flows

The stream flows for the upper portion of the river during the period of study in September and October 1938 were considerably lower than



NOTE:
Curves for 1937-1938 based on averages of observations from August 17, 1937 through October 15, 1937 and from June 15, 1938 through August 11, 1938.

Figure 7

FRENCH BROAD RIVER
STREAM CONDITIONS

the average. The discharges experienced at the lower stations on the French Broad and on the Pigeon were somewhat greater than normal. The summer flows for the Nolichucky River were slightly below normal during the study period.

The period of the year during which the most critical stream conditions occur in the French Broad River is, as is the case for the remainder of the Tennessee River system, during the late summer and early fall months. The Pigeon River is an exception, as the amount of water flowing in the stream is dependent on the amount released at the hydroelectric station below Waterville Lake.

As might be expected in mountainous streams, the velocities in the French Broad River system, particularly in the Blue Ridge region, are high and the streams flow over boulder-strewn channels. Consequently the amounts of dissolved oxygen are quite high.

Observed Conditions

In discussing the conditions observed in the upper section of the French Broad River during the studies in 1938 it should be pointed out that the classification is based primarily upon the biochemical oxygen demand results. The bacteriological determinations made by the state laboratory on samples collected from this section of the stream were not suitable to permit an estimation of the density of the coliform group. The dissolved oxygen results, also, are consistently lower than might be expected from a rapidly flowing stream carrying no more pollution than was discharged from the sources of pollution which existed in this area at the time of the study.

This lack of information, however, does not offer a serious handicap in the description of this stream since some additional information was obtained by a trailer laboratory force operated by the U.S. Public Health Service during February and March 1941. From the results of these studies[1], along with the tabulated results shown in tables 21, 22, 23, 24, and 25 and illustrated in figure 7, it is possible to present a fairly accurate description of the conditions in the French Broad River.

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1. Ohio River Pollution Control, Part Two, Report of the United States Public Health Service, House Document No. 266, 78th Congress 1st Session, August 27, 1943, pp. 836-837.

The results obtained by the U.S. Public Health Service indicate that the French Broad River immediately above Rosman, N.C., has received a sufficient amount of pollution, supposedly from surface wash, to place it in Class II.

The industrial pollution received at Rosman is sufficient to degrade the stream to Class III. By the time the stream flows the 15 miles to the upper station, FB 201.0, the recovery process has returned the stream to Class II conditions.

At Brevard, N.C., the stream receives an additional load of pollution from industrial wastes and domestic sewage. The tabulated results of B.O.D. for station FB 192.1 below Brevard, table 24, indicate that the stream at this point falls in Class II and is very little affected by the wastes from Brevard. That a decrease in B.O.D. between FB 201.0 and FB 192.1 is found seems rather unusual; however, the majority of the samples were collected from FB 192.1 early in the morning and may not have contained representative amounts of pollutional material from Brevard. The samples collected from this station by the U. S. Public Health Service, however, also gave a low B.O.D.--all of which may indicate that the pollutional load received from Brevard has little effect on the stream.

The tabulated results for Davidson River indicate Class I conditions, as might be expected in a clear mountain stream receiving no pollution.

The French Broad River at FB 190.6 below Davidson River remains in Class II and perhaps does not change materially between this point and the mouth of Mud Creek.

At the sampling station Mud 1.7 on Mud Creek six miles below Hendersonville, N.C., Class II conditions with respect to B.O.D. were observed in 1938. Studies by the U.S. Public Health Service in 1941 indicate that Class II conditions existed in Mud Creek above Hendersonville. Immediately below Hendersonville the stream was degraded to Class IV, and two miles below Hendersonville it had recovered to Class III. In this section of Mud Creek is demonstrated extreme pollution from domestic sewage along with rather rapid recovery before the stream discharges into the French Broad River.

Below the mouth of Mud Creek the French Broad River continues as a Class II stream until it receives the pollution from Hominy Creek and the Asheville area. At FB 143.1 immediately below these points of pollution the French Broad River is degraded to Class IV. A few miles downstream, at FB 136.4, conditions are improved somewhat to Class III. Between FB 136.4 and FB 78.4 the stream receives no significant amount of pollution and flows rapidly over a very rocky bottom, which provides ample aeration.

The results of studies during the summer months at FB 78.4 indicate rather high densities of the coliform group. Densities are so high for two of the months that they exceed the upper limits for Class III streams, and for the remaining summer months the results fall in Class III. On the other hand high dissolved oxygen concentrations were observed, and the B.O.D. was low enough to meet the requirements of Class II streams. Despite the favorable results of dissolved oxygen and B.O.D., it is believed that this stream should properly be classified as Class III rather than as Class II.

At mile 73.8 the French Broad River receives the discharge of Pigeon River. This stream receives the untreated domestic sewage from Canton and Waynesville, N.C., and Newport, Tenn., along with a large load of industrial wastes originating from a pulp and paper mill, tanneries, tannic acid plants, and a cannery. The total population equivalent of the pollution received from this area at Canton and Waynesville at the time of the study was 279,480. Since the average summer discharge of Pigeon River at Canton, N.C., is less than 200 cfs with many periods when the flow is less than 100 cfs, it is obvious that this stream is grossly polluted. Normally, from 1000 to 1500 cfs would be required for adequate dilution of such amounts of pollution in a rapidly flowing stream. In the case of wastes from paper and pulp mills, this dilution would not be sufficient to permit the reuse of the water for domestic uses because of the extreme difficulty with which the pollutional matter is removed.

The analytical results of studies which have been made for a short period on this stream are not shown in the report; but in all of the categories of classification, results indicate very serious pollution. The stream is black, is covered with foam, and has a high B.O.D. All sections of free flow have appreciable amounts of dissolved oxygen resulting from rapid reaeration due to high velocities over rocky bottoms.

As the stream enters Waterville Lake, the velocities are reduced to such an extent that deposition takes place, resulting in the formation of extensive sludge blankets on the floor of the reservoir. Surface reaeration is not sufficient to maintain appreciable amounts of oxygen in the water even near the surface, and below the thermocline no oxygen is found.

Below the discharge of the hydroelectric station the stream resumes its way down the mountain at high velocities and recovers a fairly satisfactory dissolved oxygen content. At mile 7.6 the river receives the wastes from a tannic acid plant and a tannery which, however, do not cause any significant changes in stream conditions. The results at Pi 6.7 indicate that the sedimentation and storage in Waterville Lake followed by subsequent reaeration do not provide sufficient natural treatment to enable the stream to meet Class III conditions.

Between Pi 6.7 and Pi 5.6 the stream receives the domestic sewage and industrial wastes from Newport and then enters the French Broad River in a grossly polluted state.

In the winter of 1939-1940 and to a lesser extent in the following winter season when the stream flows in the French Broad River were below normal, and at times when unusual amounts of water were discharged from Waterville Lake, the effect of pollution carried by Pigeon River extended down the French Broad River in such concentrations as to seriously affect the Knoxville water supply. It was not possible by the normal operation of the filter plant to remove all the color and taste producing substances in these wastes, and the chlorine demand of the water was so high as to overtax the capacity of the chlorinating equipment.[1]

The results of this pollution on aquatic life in the Pigeon and French Broad Rivers were studied in November 1941.[2] On the basis of their observations, the authors conclude that the Pigeon River above Canton is a typical clean water stream with an abundance of clean water organisms.

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1. Unpublished reports by J. J. Quinn, Bureau of Water, Knoxville Electric Power and Water Board; and F. W. Kittrell, Division of Sanitary Engineering, Tennessee Department of Public Health.

2. Unpublished report by Dr. A. D. Hess and Dr. C. M. Tarzwell, Tennessee Valley Authority.

Below this point the stream is grossly polluted with only pollutional or very tolerant forms of organisms present. "Waterville Lake appears to be an immense septic tank, with an abundance of rat-tailed maggots and other pollutional forms..." Some biological recovery was found below the lake and a few of the coarser types of fish were reported. At no point in the lower section were conditions suitable for any but the most tolerant forms of fish life. The French Broad River below the mouth of the Pigeon River was highly colored. Clean water organisms were more abundant in the French Broad River above the mouth of the Pigeon than below. Their studies were not sufficient to determine the effects of this pollution on fish life in the French Broad River.

The results obtained from studies of the Nolichucky River indicate that it is a Class II stream at No 36.8. No studies of stream conditions were made above this point; but with the small amount of domestic sewage which the stream receives and with almost complete absence of organic industrial wastes, it is assumed that Class II conditions exist throughout the entire length of the stream except the upper portion, which might meet the requirements of Class I streams. In western North Carolina the stream does receive the silt-laden water from ore washing operations, which might possibly have some effect upon the development of certain types of fish.

No studies were made on the French Broad River below the mouth of Nolichucky River in 1937 and 1938; however, studies were carried out in October 1941 which indicated that with the flow of approximately 1200 cfs at FB 49.8, 24 miles below the mouth of Pigeon River, the B.O.D. was 3.0 ppm and the dissolved oxygen content averaged 4.8 ppm with a minimum observation of 3.0 ppm. The water had a very high color exceeding at times 200 ppm with an average of 153 ppm. Below this point at FB 42.3 the B.O.D. had reduced somewhat to 2.2 ppm with no appreciable increase in dissolved oxygen and no reduction in color. By the time the stream had reached FB 7.6 the B.O.D. had been reduced to 1.6 ppm, the dissolved oxygen had increased to 5.2 ppm with a minimum of 4.2 ppm, but the average color remained high at 168 ppm.

The conditions which were found at the mouth of the river at FB 0.4 during the 1936-1937 studies indicate that the French Broad River

at that time met the requirements for Class II. However, because of the nature of the wastes which the French Broad River carries below the mouth of Pigeon River and the difficulty experienced in the Knoxville water plant with the treatment of these wastes even diluted with water from the Holston River, it is logical to assume that the undiluted water of the French Broad River from the mouth of the Pigeon River to the Tennessee River is unsuitable for domestic water supplies even if treated by the most modern purification processes. Also, at certain times it appears that the dissolved oxygen in the river is not adequate for the development of desirable fish fauna. For these reasons, therefore, this section of the river below the mouth of Pigeon River does not meet the requirements for Class III streams and is placed in Class IV.

Classification Based on Conditions of Normal Stream Flows

In discussing the effect of pollution on the French Broad River system during periods of normal flow, consideration is also given to increased pollution originating from new developments in the area and to increased activities of the existing industries.

It is estimated that the normal conditions of the French Broad River immediately above Rosman meet the requirements outlined for Class II streams. The effect of the pollution received at Rosman degrades the stream to Class III and by the time the stream reaches FB 201.0 it recovers to meet conditions outlined for Class II. These classifications represent no change in conditions from those which were found during the studies.

Below Brevard, a large paper mill was constructed and began operation sometime between 1938 and the summer of 1940. In September 1940, studies were made of its waste and its effect upon the Davidson River and the French Broad River. The short section of Davidson River below the plant outfall was very seriously polluted with the wastes. These wastes caused Class IV conditions in the French Broad River at FB 190.6, and gave the river a black color from this point downstream to some point well below Asheville. Information from plant officials, which was received in the spring of 1943, indicates that the production of the plant had increased to two and one-half times that at the time of the study in 1940. Recent information from sport clubs in the area discloses that large numbers of fish have been killed below Davidson River and above Asheville. For

these reasons it is expected that Class IV conditions exist in the French Broad River from the mouth of Davidson River to some point below Asheville.

It is assumed that the conditions which were observed in Mud Creek were representative of normal stream conditions. Above Hendersonville Class II conditions exist. The domestic sewage from Hendersonville degrades the stream to Class IV, but rapid recovery processes improve the stream to Class II by the time it reaches the French Broad River.

Below Asheville and before the French Broad River reaches FB 78.4 conditions improve somewhat until the stream meets requirements of Class III. However, below the mouth of the Pigeon River in the upper end of Douglas Reservoir Class IV can be expected under normal conditions of stream flow.

Class IV conditions in the extreme exist in the Pigeon River below Canton, N.C. It is expected that conditions in 1943 were more serious than the previous studies indicated, as a considerable increase in production has been reported by some of the industries.

No change is expected in the classification of the Nolichucky River. This stream should meet the requirements for Class II streams throughout the major portion of its length unless aquatic life is seriously affected by silt from the ore washing operations in western North Carolina.

Studies of Douglas Reservoir, which was impounded in the spring of 1943, have not been sufficient to determine the purification effected by storage and sedimentation. The results of the few observations which have been made indicate Class II conditions with respect to color, D.O., and B.O.D. in the epilimnion just above Douglas Dam. Below a depth of 20 to 30 feet, or in the hypolimnion the water is almost devoid of dissolved oxygen, the B.O.D. exceeds 3 ppm, and the color is above 100 ppm in the lower levels. As the water for the operation of the turbines will be taken from these lower levels, Class IV conditions are expected to exist in the river below the dam.

The above classifications are those shown on figure 5.

Effects of Pollution

With the exception of the effect of the industrial wastes on the Knoxville water supply, which has been discussed, the pollution carried by the French Broad River system has no effect on existing water supplies, since all other municipalities obtain their supplies from unpolluted sources.

The extent of pollution in the French Broad River below Brevard and in the Pigeon River below Canton is such as to render the water from these points throughout the entire remaining section of the two rivers unsuitable for any industrial uses which require clean water. Most of the pollutional materials are soluble, produce high color in the stream, undergo bacteriological decomposition relatively slowly, and are extremely difficult and expensive to remove by coagulation and other water-treatment processes.

These two rivers are spoiled for normal recreational activities. The waters are unsuitable for swimming. Fish are unable to live in the Pigeon River and in the upper section of the French Broad River. It is expected that coarse fish only are able to survive in the lower section of the French Broad River.

With the filling of Douglas Reservoir improved conditions may be expected in the epilimnion of the lake. More desirable types of fish may be able to exist, especially in the bays and at the mouths of the small tributaries. However, below Douglas Dam, since the larger portion of the release will be drawn from the bottom of the lake, it is expected that Class IV conditions will exist to the mouth of the river.

TABLE 21

FRENCH BROAD RIVER

MINERAL ANALYSES

French Broad River - Station FB 190.6 - below Pisgah Forest, N. C.

Year	Number Times Sampled	Discharge cfs	Results of Mineral Analyses - Parts per Million											pH
			Fe	SiO_2	Ca	Mg	Na	SO_4	Cl	F	Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	Phenol	
1938	4^1_2	360	0.36	8	1.7	1.0	4.8	3.3	4	0.00	10	9	0.005	6.7
	4^2	283	.34	9	1.5	.8	3.5	1.6	3	.00	9	7	-	6.8
French Broad River - Station FB 136.4 - Alexander, N. C.														
1938	4^1_2	970	0.40	10	2.7	1.7	11.5	16.6	5	0.00	14	14	0.023	6.7
	4^2	820	.40	IO	3.2	1.4	13.8	17.6	6	.10	15	14	-	7.0

1. Composite of samples collected in September and October.
2. Composite of samples collected in October and November.

TABLE 21 (Continued)

FRENCH BROAD RIVER

MINERAL ANALYSES

French Broad River - Station FB 78.4 - near Newport, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Results of Mineral Analyses - Parts per Million										pH
				Fe Unfiltered	SiO_2	Ca	Mg	Na	SO_4	Cl	Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	Phenol	
1937	August	3	3,670	34.53	8	4.7	1.2	3.6	4.6	1	17	17	0.023	7.0
	September	4	1,960	2.35	7	4.3	1.0	4.6	6.7	1	16	15	.000	7.2
	October	3	3,890	3.16	8	3.7	1.6	5.8	6.2	4	16	16	.005	6.9
	November	3	1,980	.44	8	3.9	1.0	6.6	5.3	3	16	14	.025	6.9
	December	3	1,770	.40	8	3.8	1.1	6.6	5.5	5	15	14	.018	6.9
1938	January	3	2,290	.27	8	3.9	1.3	4.2	4.3	3	14	15	.012	6.9
	February	2	2,370	.66	8	5.0	1.2	4.2	5.0	3	16	18	.014	7.1
	March	5	5,330	8.54	7	4.1	1.3	4.9	5.3	3	15	16	.003	7.0
	April	4	2,540	.97	8	3.9	1.1	5.6	4.3	3	17	14	.010	7.1
	May	3	1,770	.43	7	6.3	1.1	5.6	5.6	4	20	21	.001	7.2
	June	5	2,600	3.72	8	3.7	1.2	6.1	4.6	4	17	14	.006	7.1
	July	3	8,960	51.66	8	3.7	1.2	5.8	6.9	3	14	14	.017	7.1
	August	2	4,120	5.20	8	3.3	1.5	4.4	5.2	4	14	15	.015	7.0
	Average	43	3,340	8.35	8	4.1	1.2	5.3	5.3	3	16	16	0.011	7.1
	Maximum		19,000	150.00	9	11.2	1.9	9.9	9.0	6	24	32	.050	7.3
	Minimum		1,330	.02	6	2.9	.6	.9	2.7	0	10	11	.000	6.8

TABLE 21 (Continued)

FRENCH BROAD RIVER

MINERAL ANALYSES

Pigeon River - Station Pi 5.6 - Newport, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Results of Mineral Analyses - Parts per Million										pH
				Fe Unfiltered	SiO_2	Ca	Mg	Na	SO_4	Cl	Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	Phenol	
1937	August	3	580	1.17	6	25.3	2.6	11.9	5.9	20	63	74	0.068	7.2
	September	4	630	1.19	6	23.2	1.7	6.4	4.7	16	50	65	.015	7.3
	October	3	1,200	1.37	7	21.4	2.0	9.5	5.1	18	51	62	-	7.4
	November	3	600	.76	6	19.5	1.4	7.4	6.7	13	43	55	-	7.1
	December	3	520	1.32	6	20.5	2.2	9.3	9.0	19	43	61	-	7.1
1938	January	3	1,470	.37	6	14.5	1.7	6.6	6.0	12	33	43	-	7.1
	February	2	1,230	.68	6	13.4	1.2	6.0	4.9	10	32	40	-	7.2
	March	5	2,420	1.56	7	12.4	1.4	3.4	5.3	7	27	37	-	7.2
	April	4	1,060	.72	8	14.0	1.8	5.2	5.7	10	34	42	-	7.2
	May	3	860	1.06	7	18.0	2.1	6.4	6.9	14	40	54	-	7.3
	June	5	850	1.04	7	12.6	1.9	6.8	4.7	11	32	39	-	7.2
	July	3	1,120	2.10	8	11.5	1.6	6.7	3.4	10	32	36	-	7.2
	August	2	1,180	.33	10	11.3	1.9	6.8	6.7	10	28	36		7.2
	Average	43	1,090	1.12	7	16.6	1.8	6.9	5.7	13	39	49	-	7.2
	Maximum		5,280	4.50	12	26.8	3.2	15.0	9.7	24	68	80	0.150	7.8
	Minimum		180	.08	4	6.0	.5	.0	1.8	3	16	20	.000	7.0

TABLE 21 (Continued)

FRENCH BROAD RIVER

MINERAL ANALYSES

Nolichucky River - Station No 36.8 - below Greeneville, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Results of Mineral Analyses - Parts per Million										pH
				Fe Unfiltered	SiO_2	Ca	Mg	Na	SO_4	Cl	Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	Phenol	
1937	August	3	1,020	0.90	7	13.5	2.7	0.9	2.5	0	43	45	0.025	7.4
	September	4	290	.94	7	11.0	2.6	1.6	1.8	1	38	42	.000	7.4
	October	3	1,580	1.13	7	12.2	2.9	2.4	2.5	2	41	42	.010	7.3
	November	3	220	.57	7	13.0	2.6	4.6	2.8	3	44	43	-	7.3
	December	3	130	.40	8	13.4	2.8	4.1	3.1	4	44	45	-	7.3
1938	January	3	1,730	.43	7	16.1	3.4	3.6	3.2	3	51	54	-	7.4
	February	2	2,210	.58	6	14.9	2.8	2.0	2.0	2	46	49	-	7.4
	March	5	2,670	1.43	7	15.0	2.9	2.2	3.2	3	45	50	-	7.5
	April	4	1,120	.41	8	15.4	3.3	3.4	3.2	3	48	52	-	7.5
	May	3	550	.27	7	16.5	3.3	4.9	3.4	4	55	55	-	7.4
	June	5	360	.72	7	13.6	2.9	3.9	2.4	3	47	47	-	7.5
	July	3	1,100	1.77	7	15.0	3.2	3.2	3.4	3	49	51	-	7.5
	August	2	2,620	2.70	6	11.4	2.6	1.7	2.2	2	36	40	-	7.4
	Average	43	1,150	0.91	7	14.0	2.9	3.0	2.8	3	46	48	-	7.4
	Maximum		4,070	4.00	9	18.1	4.5	6.2	5.2	5	57	59	0.050	7.5
	Minimum		85	.10	5	8.9	1.4	.0	.8	0	31	33	.000	7.2

TABLE 21 (Continued)

FRENCH BROAD RIVER

MINERAL ANALYSES

French Broad River - Station FB 0.4 - near mouth (1936-37)

	Number Times Sampled	Discharge cfs	Results of Mineral Analyses - Parts per Million										pH
			Fe	SiO_2	Ca	Mg	Na	SO_4	Cl	Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	Phenol	
Average	40	7,600	3.0	9	13.5	2.7	5.6	6.5	6	42	45	0.037	7.3
Maximum		30,200	20	14	17.8	5.3	11.7	10.7	11	66	60	.120	7.6
Minimum		1,900	T	6	7.8	.6	0.9	2.3	2	21	23	.000	6.9

Note: For complete report on this station see Studies of the Pollution of the Tennessee River System, I, February 1941.

TABLE 22

FRENCH BROAD RIVER

SOLIDS

French Broad River - Station FB 190.6 - below Pisgah Forest, N. C.

Year	Number Times Sampled	Discharge cfs	Solids - Parts per Million		
			Volatile	Fixed	Total
1938	4[1] 4[2]	360 283	24 18	18 13	42 31
French Broad River - Station FB 136.4 - Alexander, N. C.					
1938	4[1] 4[2]	970 820	44 48	40 39	84 87

1. Composite of samples collected in September and October.
2. Composite of samples collected in October and November.

TABLE 22 (Continued)

FRENCH BROAD RIVER

SOLIDS

French Broad River - Station FB 78.4 - near Newport, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Solids - Parts per Million				
				Dissolved	Suspended	Volatile	Fixed	Total
1937	August	3	3,670	50	967	128	889	1,017
	September	4	1,960	39	180	36	183	219
	October	3	3,890	30	176	55	151	206
	November	3	1,980	39	22	37	24	61
	December	3	1,770	35	9	22	22	44
1938	January	3	2,290	37	16	23	30	53
	February	2	2,370	36	22	14	44	58
	March	5	5,330	36	260	47	249	296
	April	4	2,540	44	30	35	39	74
	May	3	1,770	39	28	41	26	67
	June	5	2,600	45	274	51	268	319
	July	3	8,960	41	1,526	176	1,391	1,567
	August	2	4,120	47	148	29	166	195
Summer[1]	Average	17	3,840	41	570	80	531	611
	Maximum		19,000	54	4,336	476	3,901	4,377
	Minimum		1,330	27	10	3	35	53
Winter[2]	Average	26	3,010	39	92	37	94	131
	Maximum		14,000	63	681	108	615	723
	Minimum		1,390	26	1	1	12	34
Pigeon River - Pi 6.7 - Newport, Tenn.								
1937	August	3	580	207	92	142	157	299
	September	4	630	180	75	132	123	255
	October	3	1,200	166	38	115	89	204
	November	3	600	151	21	107	65	172
	December	3	520	172	26	108	90	198
1938	January	3	1,470	101	24	60	65	125
	February	2	1,230	91	31	70	52	122
	March	5	2,420	77	97	69	105	174
	April	4	1,060	99	22	72	49	121
	May	3	860	100	32	71	61	132
	June	5	850	102	31	68	65	133
	July	3	1,120	64	48	45	67	112
	August	2	1,180	80	16	36	60	96
Summer[1]	Average	17	734	141	53	97	97	194
	Maximum		2,230	224	168	175	224	373
	Minimum		180	46	5	34	26	83
Winter[2]	Average	26	1,320	109	41	77	73	150
	Maximum		5,280	186	337	129	317	381
	Minimum		240	44	8	43	29	113

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 22 (Continued)

FRENCH BROAD RIVER

SOLIDS

Pigeon River - Pi 5.6 - Newport, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Solids - Parts per Million				
				Dissolved	Suspended	Volatile	Fixed	Total
1937	August	3	580	191	121	140	172	312
	September	4	630	163	66	108	121	229
	October	3	1,200	155	38	113	80	193
	November	3	600	148	21	104	65	169
	December	3	520	170	31	130	71	201
1938	January	3	1,470	103	27	68	62	130
	February	2	1,230	96	21	58	59	117
	March	5	2,420	78	101	57	122	179
	April	4	1,060	97	16	66	47	113
	May	3	860	102	31	78	55	133
	June	5	850	96	23	55	64	119
	July	3	1,120	61	51	49	63	112
	August	2	1,180	75	15	34	56	90
Summer[1]	Average	17	734	130	55	89	96	185
	Maximum		2,230	207	207	151	269	397
	Minimum		180	46	11	16	12	83
Winter[2]	Average	26	1,320	109	41	76	74	150
	Maximum		5,280	199	375	145	383	422
	Minimum		240	47	3	38	38	102
Nolichucky River - No 36.8 - below Greeneville, Tenn.								
1937	August	3	1,020	67	141	36	172	208
	September	4	290	59	133	34	158	192
	October	3	1,580	52	60	41	71	112
	November	3	220	62	36	39	59	98
	December	3	130	62	17	39	40	79
1938	January	3	1,730	70	24	36	58	94
	February	2	2,210	60	20	15	65	80
	March	5	2,670	62	134	39	157	196
	April	4	1,120	70	25	40	55	95
	May	3	550	79	6	50	37	87
	June	5	360	70	20	30	60	90
	July	3	1,100	68	62	27	103	130
	August	2	2,620	62	136	36	162	198
Summer[1]	Average	17	865	63	92	33	122	155
	Maximum		3,020	82	414	67	399	466
	Minimum		85	46	8	6	44	73
Winter[2]	Average	26	1,340	66	46	38	74	112
	Maximum		4,070	93	483	74	476	544
	Minimum		110	53	1	4	11	70

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 22 (Continued)

FRENCH BROAD RIVER

SOLIDS

French Broad River - Station FB 0.4 - near mouth (1936-37)[1]

		Number Times Sampled	Discharge cfs	Solids - Parts per Million				
				Dissolved	Suspended	Volatile	Fixed	Total
Summer[2]	Average	14	4,280	81	390	73	398	471
	Maximum		12,000	98	1,286	151	1,207	1,358
	Minimum		1,900	44	60	37	82	153
Winter[3]	Average	26	9,360	68	127	77	118	195
	Maximum		30,200	88	656	99	549	720
	Minimum		3,660	38	5	12	35	81

1. For complete report on this station see Studies of the Pollution of the Tennessee River System, I, February 1941.
2. Summer season from June 15 through October 15.
3. Winter season from October 16 through June 14.

TABLE 23

FRENCH BROAD RIVER

NITROGENS

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Nitrogen - Parts per Million				
					Organic	Free Ammonia	Nitrite	Nitrate	Total
French Broad River - Station FB 78.4 - near Newport, Tenn.									
1938	April	3	2,520	17.8	0.25	0.004	0.002	0.20	0.45
	May	3	1,770	19.0	.23	.003	.002	.11	.34
	June	5	2,600	21.4	.59	.002	.001	.30	.89
	July	3	8,960	25.0	3.56	.032	.002	.31	3.90
	August	2	4,120	24.5	.47	.002	.003	.16	.63
	Average	16	3,810	21.3	1.00	0.008	0.002	0.23	1.24
	Maximum		19,000	27.0	10.00	.096	.005	.48	10.58
	Minimum		1,420	16.0	.22	.000	.000	.08	.30
Pigeon River - Station Pi 6.7 - Newport, Tenn.									
1938	April	3	890	15.0	0.33	0.021	T	0.11	0.46
	May	3	860	17.7	.55	.039	0.000	.21	.80
	June	5	850	19.9	.52	.117	.001	.13	.77
	July	3	1,120	22.8	.43	.077	.007	.08	.59
	August	2	1,180	22.5	.39	.052	.007	.04	.48
	Average	16	950	19.4	0.46	0.069	0.003	0.12	0.65
	Maximum		2,230	24.0	.76	.320	.014	.44	1.28
	Minimum		460	13.0	.26	.000	.000	.04	.32
Pigeon River - Station Pi 5.6 - Newport, Tenn.									
1938	April	3	890	14.8	0.35	0.011	0.001	0.11	0.47
	May	3	860	17.7	.42	.011	.000	.11	.54
	June	5	850	19.8	.41	.002	.001	.20	.61
	July	3	1,120	22.5	.31	.004	.006	.08	.39
	August	2	1,180	22.5	.26	T	.006	.12	.38
	Average	16	950	19.3	0.36	0.006	0.002	0.13	0.50
	Maximum		2,230	24.0	.56	.016	.009	.48	.76
	Minimum		460	12.5	.22	.000	.000	.04	.27
Nolichucky River - Station No 36.8 - below Greeneville, Tenn.									
1938	April	3	1,190	15.5	0.15	0.011	0.002	0.36	0.52
	May	3	550	18.7	.59	.011	.004	.29	.89
	June	5	360	22.3	.18	.011	.003	.30	.49
	July	3	1,100	25.0	.28	T	.006	.33	.61
	August	2	2,620	25.0	.32	.000	.001	.32	.64
	Average	16	970	21.2	0.29	0.008	0.003	0.32	0.62
	Maximum		3,020	26.0	1.60	.024	.009	.56	1.90
	Minimum		85	13.0	.02	.000	.000	.20	.30

TABLE 23 (Continued)

FRENCH BROAD RIVER

NITROGENS

French Broad River - Station FB 0.4 - near mouth (1936-37)[1]

		Number Times Sampled	Discharge cfs	Water Temperature °C	Nitrogen -Parts per Million				
					Organic	Free Ammonia	Nitrite	Nitrate	Total
Summer[2]	Average	14	4,280	25.6	0.72	0.003	0.004	0.32	1.04
	Maximum		12,000	30.0	1.60	.016	.019	.70	2.24
	Minimum		1,900	18.0	.24	.000	.001	.14	.42
Winter[3]	Average	26	9,360	14.2	0.39	0.005	0.001	0.27	.66
	Maximum		30,200	26.0	1.28	.032	.003	.56	1.78
	Minimum		3,660	3.5	.05	.000	.000	.04	.18

1. For complete report on this station see Studies of the Pollution of the Tennessee River System, I, February 1941.
2. Summer season from June 15 through October 15.
3. Winter season from October 16 through June 14.

TABLE 24

FRENCH BROAD RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

Date	Discharge cfs	Water Temperature °C	Dissolved Oxygen ppm	Dissolved Oxygen % Saturation	5-Day Oxygen Demand 20°C ppm	1000 Lb. per Day Dissolved Oxygen	1000 Lb. per Day 5-Day Oxygen Demand
French Broad River - Station FB 201.0 - above Brevard, N. C.							
9-22-38	266	11.0	5.20	46.8	1.06	7.47	1.52
9-29-38	253	16.5	5.90	59.9	.85	8.06	1.16
10-6-38	226	14.0	6.50	62.7	1.70	7.93	2.07
10-13-38	215	10.5	6.00	53.5	2.24	6.97	2.60
10-20-38	202	13.0	4.70	44.3	1.74	5.13	1.90
10-27-38	196	9.0	5.40	46.6	2.54	5.72	2.69
11-3-38	186	8.0	5.60	47.2	1.92	5.62	1.93
11-10-38	344	7.0	6.00	49.3	1.15	11.15	2.14
Average	236	11.1	5.66	51.2	1.65	7.21	2.10
Maximum	344	16.5	6.50	62.7	2.54	11.15	2.69
Minimum	186	7.0	4.70	44.3	.85	5.13	1.16
French Broad River - Station FB 192.1 - below Brevard, N. C.							
9-22-38	301	12.0	6.20	57.2	0.48	10.08	0.78
9-29-38	313	16.0	5.80	58.3	.66	9.80	1.12
10-6-38	261	15.0	7.40	72.8	1.10	10.43	1.55
10-13-38	250	12.0	5.00	46.2	.99	6.75	1.34
10-20-38	237	14.0	4.70	45.3	1.16	6.02	1.48
10-27-38	225	9.0	8.00	69.0	2.47	9.72	3.00
11-3-38	211	9.0	8.40	72.5	.58	9.57	.66
11-10-38	414	8.0	5.50	46.3	1.83	12.30	4.09
Average	276	11.9	6.38	58.7	1.16	9.51	1.73
Maximum	414	16.0	8.40	72.8	2.47	12.30	4.09
Minimum	211	8.0	4.70	45.3	.48	6.02	.66
Davidson River - Station Da 0.4 - U.S. Highway No. 64							
9-22-38	59	10.0	5.70	50.3	0.54	1.82	0.17
9-29-38	57	15.5	8.20	81.6	.79	2.52	.24
10-6-38	49	15.0	5.70	56.2	.44	1.51	.12
10-13-38	42	11.0	5.60	50.6	.58	1.27	.13
10-20-38	39	13.5	5.10	48.6	.34	1.07	.07
10-27-38	39	8.5	6.60	56.2	.94	1.39	.20
11-3-38	35	8.5	6.60	56.2	.30	1.25	.06
11-10-38	66	7.0	6.40	52.6	1.14	2.28	.41
Average	48	11.1	6.24	56.4	0.63	1.62	0.16
Maximum	66	15.5	8.20	81.6	1.14	2.52	.41
Minimum	35	7.0	5.10	48.6	.30	1.07	.06

TABLE 24 (Continued)

FRENCH BROAD RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

Date	Discharge cfs	Water Temperature °C	Dissolved Oxygen ppm	Dissolved Oxygen % Saturation	5-Day Oxygen Demand 20°C ppm	1000 Lb. per Day Dissolved Oxygen	1000 Lb. per Day 5-Day Oxygen Demand
French Broad River - Station FB 190.6 - below Pisgah Forest, N. C.							
9-22-38	363	12.5	7.10	66.2	0.52	13.92	1.02
9-29-38	398	16.5	7.70	78.2	.99	16.55	2.13
10-6-38	321	13.0	8.40	79.2	.34	14.56	.59
10-13-38	310	13.0	5.40	50.9	1.28	9.04	2.14
10-20-38	290	14.0	5.00	48.2	1.10	7.83	1.72
10-27-38	275	10.0	6.50	57.3	1.60	9.65	2.38
11-3-38	256	11.0	6.80	61.3	1.69	9.40	2.34
11-10-38	507	8.0	5.80	48.9	.97	15.88	2.66
Average	340	12.2	6.59	61.1	1.06	12.10	1.95
Maximum	507	16.5	8.40	79.2	1.69	16.55	2.66
Minimum	256	8.0	5.00	48.2	.34	7.83	.59
Mud Creek - Station Mud 1.7 - below Hendersonville, N. C.							
9-22-38	74	13.0	5.80	54.7	1.63	2.32	0.65
9-29-38	75	17.5	7.20	74.7	1.18	2.92	.48
10-6-38	68	19.0	6.50	69.5	.42	2.39	.15
10-13-38	65	14.5	5.20	50.7	.66	1.82	.23
10-20-38	63	16.0	4.70	47.3	1.55	1.60	.53
10-27-38	65	11.0	5.20	46.8	1.28	1.82	.45
11-3-38	62	13.0	5.20	49.1	3.38	1.74	1.13
11-10-38	90	9.0	7.20	62.2	1.16	3.50	.56
Average	70	14.1	5.88	56.8	1.41	2.22	0.53
Maximum	90	19.0	7.20	74.7	3.38	3.50	1.13
Minimum	62	9.0	4.70	46.8	.42	1.60	.15
French Broad River - Station FB 152.5 - above Asheville, N. C.							
9-22-38	466	14.5	6.40	62.3	0.70	15.41	1.69
9-29-38	467	17.5	5.10	52.8	.16	12.86	.40
10-6-38	432	18.0	6.40	67.1	.60	14.93	1.40
10-13-38	417	15.0	4.90	48.3	.47	11.03	1.06
10-20-38	398	15.5	4.60	45.8	1.10	9.89	2.36
10-27-38	398	11.0	6.10	55.1	.10	13.11	.21
11-3-38	366	12.0	9.60	88.6	.34	18.97	.67
11-10-38	583	10.0	7.60	67.1	1.04	23.93	3.27
Average	438	14.2	6.34	61.4	0.56	15.00	1.32
Maximum	583	18.0	9.60	88.6	1.10	23.93	3.27
Minimum	366	10.0	4.60	45.8	.10	9.89	.21

TABLE 24 (Continued)

FRENCH BROAD RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

Date	Discharge cfs	Water Temperature °C	Dissolved Oxygen ppm	Dissolved Oxygen % Saturation	5-Day Oxygen Demand 20°C ppm	1000 Lb. per Day Dissolved Oxygen	1000 Lb. per Day 5-Day Oxygen Demand
French Broad River - Station 143.1 - below Asheville, N. C.							
9-22-38	867	14.5	5.20	50.7	2.64	24.35	12.36
9-29-38	983	17.5	4.50	46.7	2.87	23.89	15.23
10-6-38	867	21.0	5.50	61.2	4.58	25.75	21.44
10-13-38	811	17.0	4.20	43.2	3.08	18.39	13.49
10-20-38	756	17.0	4.10	42.1	4.68	16.74	19.11
10-27-38	756	13.0	7.00	66.1	4.50	28.58	18.37
11-3-38	655	14.0	6.00	57.8	6.37	21.22	22.53
11-10-38	1,490	12.0	7.00	64.6	3.92	56.32	31.54
Average	898	15.8	5.44	54.5	4.08	26.38	19.78
Maximum	1,490	21.0	7.00	66.1	6.37	56.32	31.54
Minimum	655	12.0	4.10	42.1	2.64	16.74	12.36
French Broad River - Station FB 136.4 - Alexander, N. C.							
9-22-38	955	16.5	6.00	60.9	2.33	30.94	12.02
9-29-38	1,020	17.8	6.00	62.6	2.06	33.05	11.35
10-6-38	955	21.0	5.40	60.1	1.30	27.85	6.70
10-13-38	894	17.0	5.80	59.6	1.66	28.00	8.01
10-20-38	833	17.0	5.00	51.3	2.40	22.49	10.80
10-27-38	833	12.0	9.90	91.3	3.14	44.53	14.12
11-3-38	722	14.0	5.20	50.2	3.90	20.27	15.21
11-10-38	1,640	13.0	5.90	55.7	2.22	52.25	19.66
Average	982	16.0	6.15	61.8	2.38	32.61	12.62
Maximum	1,640	21.0	9.90	91.3	3.90	52.25	19.66
Minimum	722	12.0	5.00	50.2	1.30	20.27	6.70

TABLE 24 (Continued)

FRENCH BROAD RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Dissolved Oxygen ppm	Dissolved Oxygen % Saturation	5-Day Oxygen Demand 20°C ppm	1000 Lb. per Day Dissolved Oxygen	1000 Lb. per Day 5-Day Oxygen Demand
French Broad River - Station FB 78.4 - near Newport, Tenn.									
1937	August	3	3,670	24.8	6.57	78.1	1.35	130.20	26.75
	September	4	1,960	20.5	7.88	86.8	.89	83.40	9.42
	October	3	3,890	15.2	8.43	83.3	1.44	177.08	30.25
	November	3	1,980	6.3	11.80	95.2	1.08	126.17	11.55
	December	3	1,770	3.6	12.23	92.4	.96	116.89	9.18
1938	January	3	2,290	5.3	11.63	91.6	1.01	143.82	12.49
	February	2	2,370	9.2	10.90	94.4	1.04	139.50	13.31
	March	5	5,330	11.7	9.86	90.5	1.12	283.79	32.24
	April	4	2,540	16.6	8.97	91.2	1.06	123.03	14.54
	May	3	1,770	19.0	8.20	87.6	.93	78.38	8.89
	June	5	2,600	21.4	7.53	84.3	1.15	105.72	16.15
	July	3	8,960	25.0	6.00	71.6	1.29	290.30	62.42
	August	2	4,120	24.5	7.08	83.8	.84	157.52	18.69
Summer[1]	Average	17	3,840	22.4	7.38	83.3	1.01	153.03	20.94
	Maximum		19,000	27.0	9.30	93.4	2.74	-	-
	Minimum		1,330	15.0	5.05	57.2	.44	-	-
Winter[2]	Average	26	3,010	11.5	10.20	90.7	1.05	165.79	17.07
	Maximum		14,000	23.0	14.10	97.8	1.92	-	-
	Minimum		1,390	.2	7.45	81.1	.58	-	-
Pigeon River - Station Pi 6.7 - Newport, Tenn.									
1937	August	3	580	23.5	1.00	11.6	10.22	3.13	32.01
	September	4	630	21.1	3.08	34.3	9.25	10.48	31.47
	October	3	1,200	16.5	4.93	50.0	13.51	31.95	87.54
	November	3	600	8.8	8.40	72.1	14.31	27.22	46.36
	December	3	520	4.8	8.70	67.6	18.05	24.43	50.68
1938	January	3	1,470	5.3	9.93	78.1	11.28	78.82	89.54
	February	2	1,230	9.2	9.20	79.7	7.81	61.11	51.87
	March	5	2,420	10.6	9.28	83.2	6.02	121.27	78.67
	April	4	1,060	14.2	7.52	72.7	5.66	43.04	32.40
	May	3	860	17.7	5.82	60.6	11.89	27.03	55.22
	June	5	850	19.9	6.55	71.3	8.04	30.06	36.90
	July	3	1,120	22.8	7.22	82.8	4.88	43.67	29.51
	August	2	1,180	22.5	7.08	81.0	5.88	45.11	37.47
Summer[1]	Average	17	734	21.7	4.29	48.1	8.80	17.00	34.88
	Maximum		2,230	24.0	7.55	84.0	16.44	-	-
	Minimum		180	17.5	.60	7.0	3.80	-	-
Winter[2]	Average	26	1,320	11.0	8.35	74.1	10.01	59.52	71.35
	Maximum		5,280	19.5	10.50	84.8	19.61	-	-
	Minimum		240	4.0	5.75	58.4	3.45	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 24 (Continued)

FRENCH BROAD RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

Pigeon River - Station Pi 5.6 - Newport, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Dissolved Oxygen ppm	Dissolved Oxygen % Saturation	5-Day Oxygen Demand 20°C ppm	1000 Lb. per Day Dissolved Oxygen	1000 Lb. per Day 5-Day Oxygen Demand
1937	August	3	580	23.7	0.87	10.2	7.67	2.72	24.02
	September	4	630	21.1	2.50	27.8	6.25	8.50	21.26
	October	3	1,200	16.2	4.10	41.4	10.01	26.57	64.86
	November	3	600	8.8	7.57	65.0	12.13	24.53	39.30
	December	3	520	4.7	8.70	67.4	14.79	24.43	41.53
1938	January	3	1,470	5.3	9.50	74.8	10.53	75.41	83.59
	February	2	1,230	9.0	8.90	76.8	6.70	59.11	44.50
	March	5	2,420	10.5	8.80	78.4	6.02	115.00	78.67
	April	4	1,060	14.1	7.45	72.0	4.60	42.64	26.33
	May	3	860	17.7	5.53	57.8	6.61	25.68	30.70
	June	5	850	19.8	6.30	68.4	5.00	28.92	22.95
	July	3	1,120	22.5	6.98	79.8	1.59	42.22	9.62
	August	2	1,180	22.5	7.12	81.3	2.30	45.37	14.66
Summer[1]	Average	17	734	21.6	3.95	44.1	4.74	15.66	13.79
	Maximum		2,230	24.0	7.50	84.2	13.90	-	-
	Minimum		180	17.0	.70	8.1	.94	-	-
Winter[2]	Average	26	1,320	10.9	7.98	70.7	7.94	56.95	56.60
	Maximum		5,280	19.5	9.80	30.0	18.08	-	-
	Minimum		240	4.0	5.45	56.8	1.66	-	-
Nolichucky River - Station No 36.8 - below Greeneville, Tenn.									
1937	August	3	1,020	25.3	6.40	76.8	1.37	35.25	7.55
	September	4	290	21.5	7.30	81.9	.62	11.43	.97
	October	3	1,580	13.8	9.07	87.0	.97	77.39	8.28
	November	3	220	8.2	10.83	91.8	.64	12.87	.76
	December	3	130	4.7	11.87	92.0	.61	8.33	.43
1938	January	3	1,730	5.2	11.30	88.7	.65	105.56	6.07
	February	2	2,210	9.8	10.40	91.4	.72	124.11	8.59
	March	5	2,670	10.9	10.24	92.1	.82	147.64	11.82
	April	4	1,120	14.8	8.80	86.6	.92	53.22	5.56
	May	3	550	18.7	7.87	83.6	.54	23.37	1.60
	June	5	360	22.3	7.35	84.0	.78	14.29	1.52
	July	3	1,100	25.0	6.78	80.9	.56	40.27	3.33
	August	2	2,620	25.0	6.90	82.3	4.68	97.62	66.21
Summer[1]	Average	17	865	22.9	7.10	80.9	0.92	33.16	4.30
	Maximum		3,020	26.5	8.60	86.4	6.72	-	-
	Minimum		85	12.0	6.20	73.9	.24	-	-
Winter[2]	Average	26	1,340	11.3	10.11	89.7	0.68	73.16	4.92
	Maximum		4,070	21.5	12.20	94.3	1.72	-	-
	Minimum		110	4.0	7.50	80.2	.40	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 24 (Continued)

FRENCH BROAD RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

French Broad River - Station FB 0.4 - near mouth (1936-37)[1]

		Number Times Sampled	Discharge cfs	Water Temperature °C	Dissolved Oxygen		5-Day Oxygen Demand 20°C ppm	1000 Lb. per Day	
					ppm	% Saturation		Dissolved Oxygen	5-Day Oxygen Demand
Summer[2]	Average	14	4,280	25.6	5.90	71.5	1.36	136.36	31.43
	Maximum		12,000	30.0	6.70	77.5	3.50	-	-
	Minimum		1,900	18.0	5.18	66.0	.40	-	-
Winter[3]	Average	26	9,360	14.2	8.81	83.9	1.40	445.29	70.76
	Maximum		30,200	26.0	11.00	90.2	2.40	-	-
	Minimum		3,660	3.5	6.12	81.1	.45	-	-

1. For complete report on this station see Studies of the Pollution of the Tennessee River System, I, February 1941.
2. Summer season from June 15 through October 15.
3. Winter season from October 16 through June 14.

TABLE 25

FRENCH BROAD RIVER

BACTERIA

French Broad River - Station FB 201.0 - above Brevard, N. C.

Date	Discharge cfs	Water Temperature °C	Bacteria per Milliliter on Agar 37°C for 24 Hours	Quantity Units (Bacteria x 1000 cfs)
9-22-38	266	11.0	5,000	1,330
9-29-38	253	16.5	4,000	1,012
10-6-38	226	14.0	2,500	565
10-13-38	215	10.5	5,000	1,075
10-20-38	202	13.0	4,500	909
10-27-38	196	9.0	180	35
11-3-38	186	8.0	5,500	1,023
11-10-38	344	7.0	2,500	860
Average	236	11.1	2,700	637
Maximum	344	16.5	5,500	1,330
Minimum	186	7.0	180	35
French Broad River - Station FB 192.1 - below Brevard, N. C.				
9-22-38	301	12.0	4,500	1,354
9-29-38	313	16.0	2,000	626
10-6-38	261	15.0	1,100	287
10-13-38	250	12.0	4,000	1,000
10-20-38	237	14.0	2,000	474
10-27-38	225	9.0	900	202
11-3-38	211	9.0	4,500	950
11-10-38	414	8.0	2,000	828
Average	276	11.9	2,200	607
Maximum	414	16.0	4,500	1,354
Minimum	211	8.0	900	202
Davidson River - Station Da 0.4 - U. S. Highway No. 64				
9-22-38	59	10.0	1,800	106
9-29-38	57	15.5	300	17
10-6-38	49	15.0	2,000	98
10-13-38	42	11.0	1,000	42
10-20-38	39	13.5	1,000	39
10-27-38	39	8.5	300	12
11-3-38	35	8.5	4,000	140
11-10-38	66	7.0	4,000	264
Average	48	11.1	1,200	58
Maximum	66	15.5	4,000	264
Minimum	35	7.0	300	12

TABLE 25 (Continued)

FRENCH BROAD RIVER

BACTERIA

Date	Discharge cfs	Water Temperature °C	Bacteria per Milliliter on Agar 37°C for 24 Hours	Quantity Units (Bacteria x 1000 cfs)
French Broad River - Station FB 190.6 - below Pisgah Forest, N. C.				
9-22-38	363	12.5	3,000	1,089
9-29-38	398	16.5	-	-
10-6-38	321	13.0	1,800	578
10-13-38	310	13.0	7,500	2,325
10-20-38	290	14.0	3,500	1,015
10-27-38	275	10.0	3,000	825
11-3-38	256	11.0	5,000	1,280
11-10-38	507	8.0	1,200	608
Average	340	12.2	3,000	1,020
Maximum	507	16.5	7,500	2,325
Minimum	256	8.0	1,200	578
Mud Creek - Station Mud 1.7 - below Hendersonville, N. C.				
9-22-38	74	13.0	5,000	370
9-29-38	75	17.5	3,500	262
10-6-38	68	19.0	1,200	82
10-13-38	65	14.5	4,500	292
10-20-38	63	16.0	2,500	158
10-27-38	65	11.0	1,000	65
11-3-38	62	13.0	5,000	310
11-10-38	90	9.0	3,500	315
Average	70	14.1	2,800	196
Maximum	90	19.0	5,000	370
Minimum	62	9.0	1,000	65
French Broad River - Station FB 152.5 - above Asheville, N. C.				
9-22-38	446	14.5	2,500	1,115
9-29-38	467	17.5	4,000	1,868
10-6-38	432	18.0	2,500	1,080
10-13-38	417	15.0	2,500	1,042
10-20-38	398	15.5	3,500	1,393
10-27-38	398	11.0	2,500	995
11-3-38	366	12.0	5,000	1,830
11-10-38	583	10.0	1,000	583
Average	438	14.2	2,700	1,183
Maximum	583	18.0	5,000	1,868
Minimum	366	10.0	1,000	583

TABLE 25 (Continued)

FRENCH BROAD RIVER

BACTERIA

French Broad River - Station FB 143.1 - below Asheville, N. C.

Date	Discharge cfs	Water Temperature °C	Bacteria per Milliliter on Agar 37°C for 24 Hours	Quantity Units (Bacteria x 1000 cfs)
9-22-38	867	14.5	3,000	2,601
9-29-38	983	17.5	4,500	4,424
10-6-38	867	21.0	1,800	1,561
10-13-38	811	17.0	6,000	4,866
10-20-38	756	17.0	7,000	5,292
10-27-38	756	13.0	7,500	5,670
11-3-38	655	14.0	8,500	5,568
11-10-38	1,490	12.0	4,500	6,705
Average	898	15.8	4,800	4,310
Maximum	1,490	21.0	8,500	6,705
Minimum	655	12.0	1,800	1,561
French Broad River - Station FB 136.4 - Alexander, N. C.				
9-22-38	955	16.5	4,500	4,298
9-29-38	1,020	17.8	3,500	3,570
10-6-38	955	21.0	3,000	2,865
10-13-38	894	17.0	10,000	8,940
10-20-38	833	17.0	6,000	4,998
10-27-38	833	12.0	4,500	3,748
11-3-38	722	14.0	4,500	3,249
11-10-38	1,640	13.0	4,500	7,380
Average	982	16.0	4,700	4,615
Maximum	1,640	21.0	10,000	8,940
Minimum	722	12.0	3,000	2,865

TABLE 25 (Continued)

FRENCH BROAD RIVER

BACTERIA

French Broad River - Station FB 78.4 - near Newport, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Bacteria per Milliliter		Quantity Units (Bacteria x 1000 cfs)	
					On Agar 37°C for 24 Hours	Coliform Group M.P.N.	On Agar 37°C for 24 Hours	Coliform Group M.P.N.
1937	August	3	3,670	24.8	3,100	275	11,377	1,009
	September	4	1,960	20.5	3,000	120	5,880	235
	October	3	3,890	15.2	1,500	210	835	817
	November	3	1,980	6.3	1,300	80	2,574	158
	December	3	1,770	3.6	900	85	1,593	150
1938	January	3	2,290	5.3	450	45	1,030	103
	February	2	2,370	9.2	375	75	889	178
	March	5	5,330	11.7	1,900	140	10,127	746
	April	4	2,540	16.6	700	60	1,778	152
	May	3	1,770	19.0	350	24	620	42
	June	5	2,600	21.4	3,900	170	10,140	442
	July	3	8,960	25.0	2,700	110	24,192	986
	August	2	4,120	24.5	7,400	650	30,488	2,678
Summer[1]	Average	17	3,840	22.4	3,100	190	11,904	730
	Maximum		19,000	27.0	23,500	2,400	-	-
	Minimum		1,330	15.0	400	23	-	-
Winter[2]	Average	26	3,010	11.5	950	75	2,860	226
	Maximum		14,000	23.0	17,000	600	-	-
	Minimum		1,390	.2	60	11	-	-
Pigeon River - Station Pi 6.7 - Newport, Tenn.								
1937	August	3	580	23.5	8,600	275	4,988	160
	September	4	630	21.1	10,000	80	6,300	50
	October	3	1,200	16.5	10,000	110	12,000	132
	November	3	600	8.8	2,400	29	1,440	17
	December	3	520	4.8	850	33	442	17
1938	January	3	1,470	5.3	2,100	13	3,087	19
	February	2	1,230	9.2	325	4.7	400	5.8
	March	5	2,420	10.6	850	18	2,057	44
	April	4	1,060	14.2	800	35	848	37
	May	3	860	17.7	5,100	70	4,386	60
	June	5	850	19.9	3,100	65	2,635	55
	July	3	1,120	22.8	4,700	55	5,264	62
	August	2	1,180	22.5	2,000	60	2,360	71
Summer[1]	Average	17	734	21.7	5,800	85	4,257	62
	Maximum		2,230	24.0	23,000	1,600	-	-
	Minimum		180	17.5	650	23	-	-
Winter[2]	Average	26	1,320	11.0	1,500	28	1,980	37
	Maximum		5,280	19.5	17,500	600	-	-
	Minimum		240	4.0	150	3.6	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 25 (Continued)

FRENCH BROAD RIVER

BACTERIA

Pigeon River - Station Pi 5.6 - Newport, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Bacteria Per Milliliter		Quantity Units Bacteria x 1000 cfs	
					On Agar 37°C for 24 Hours	Coliform Group M.P.N.	On Agar 37°C for 24 Hours	Coliform Group M.P.N.
1937	August	3	580	23.7	30,000	1,500	17,400	870
	September	4	630	21.1	15,000	130	9,450	82
	October	3	1,200	16.2	27,000	180	32,400	216
	November	3	600	8.8	2,700	27	1,620	16
	December	3	520	4.7	1,000	4.3	520	2.2
1938	January	3	1,470	5.3	240	8.6	353	13
	February	2	1,230	9.0	275	24	338	30
	March	5	2,420	10.5	600	24	1,452	58
	April	4	1,060	14.1	325	27	344	29
	May	3	860	17.7	4,800	95	4,128	82
	June	5	850	19.8	5,800	425	4,930	361
	July	3	1,120	22.5	8,800	375	9,856	420
	August	2	1,180	22.5	4,800	46	5,664	54
Summer[1]	Average	17	734	21.6	12,000	300	8,808	202
	Maximum		2,230	24.0	110,000	3,900	-	-
	Minimum		180	17.0	1,000	23	-	-
Winter[2]	Average	26	1,320	10.9	1,000	28	1,320	37
	Maximum		5,280	19.5	33,500	600	-	-
	Minimum		240	4.0	120	3.6	-	-

Nolichucky River - Station No 36.8 - below Greeneville, Tenn.

1937	August	3	1,020	25.3	900	60	918	61
	September	4	290	21.5	750	21	218	6.1
	October	3	1,580	13.8	275	20	434	32
	November	3	220	8.2	110	6.8	24	1.5
	December	3	130	4.7	325	9.3	42	1.2
1938	January	3	1,730	5.2	55	13	95	22
	February	2	2,210	9.8	65	9.3	144	21
	March	5	2,670	10.9	250	21	668	56
	April	4	1,120	14.8	95	17	106	19
	May	3	550	18.7	55	13	30	7.2
	June	5	360	22.3	350	24	126	8.6
	July	3	1,100	25.0	750	17	825	19
	August	2	2,620	25.0	700	600	1,834	1,572
Summer[1]	Average	17	865	22.9	550	33	476	29
	Maximum		3,020	26.5	11,000	1,100	-	-
	Minimum		85	12.0	60	2.3	-	-
Winter[2]	Average	26	1,340	11.3	140	15	188	20
	Maximum		4,070	21.5	3,200	240	-	-
	Minimum		110	4.0	23	3.6	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 25 (Continued)

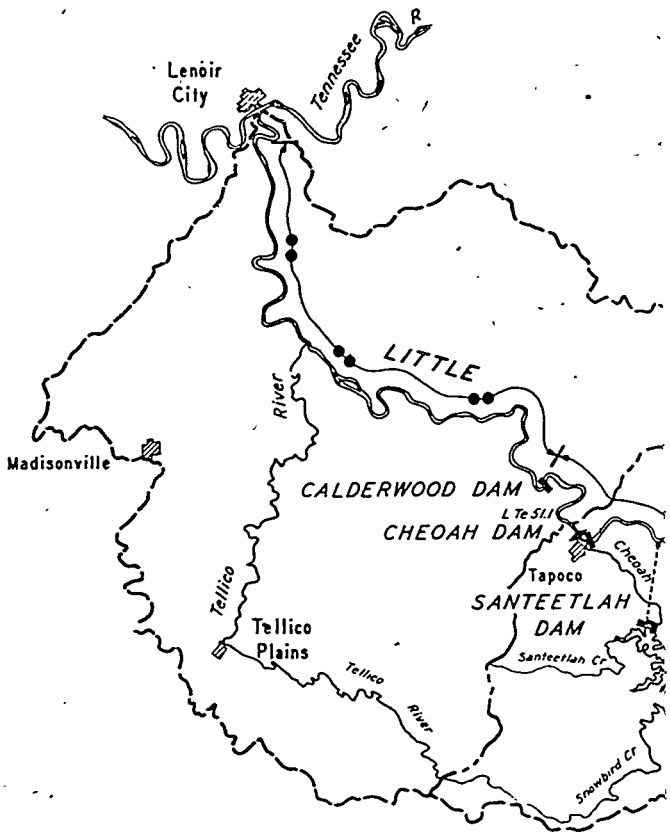
FRENCH BROAD RIVER

BACTERIA

French Broad River - Station FB 0.4 - near mouth (1936-37)[1]

		Number Times Sampled	Discharge cfs	Water Temperature °C	Bacteria per Milliliter		Quantity Units (Bacteria x 1000 cfs)	
					On Agar 37°C for 24 Hours	Coliform Group M.P.N.	On Agar 37°C for 24 Hours	Coliform Group M.P.N.
Summer[2]	Average	14	4,280	25.6	210	44	899	188
	Maximum		12,000	30.0	7,600	700	-	-
	Minimum		1,900	18.0	35	6.2	-	-
Winter[3]	Average	26	9,360	14.2	190	26	1,778	243
	Maximum		30,200	26.0	16,000	400	-	-
	Minimum		3,660	3.5	28	0.9	-	-

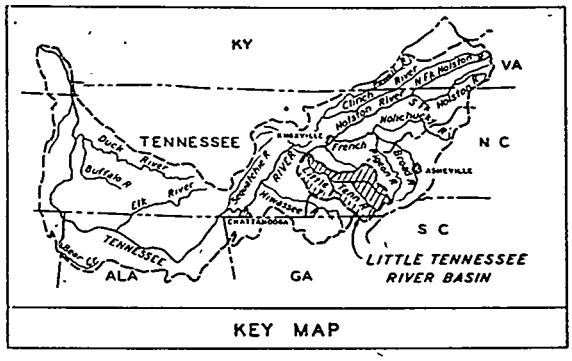
1. For complete report on this station see Studies of the Pollution of the Tennessee River System, I, February 1941.
2. Summer season from June 15 through October 15.
3. Winter season from October 16 through June 14.



SYMBOLS:

- Class I – Class A swimming areas and water supplies with minimum treatment.
- Class II – Class B and C swimming areas and water supplies (normal filter plant operation).
- Class III – Water supplies (advanced treatment methods) and fish life.
- Class IV – Unsuitable for water supplies as defined under class III or which do not support desirable fish fauna.
- Sampling stations

CHATTANOOGA DRAFTING SERVICE



KEY MAP

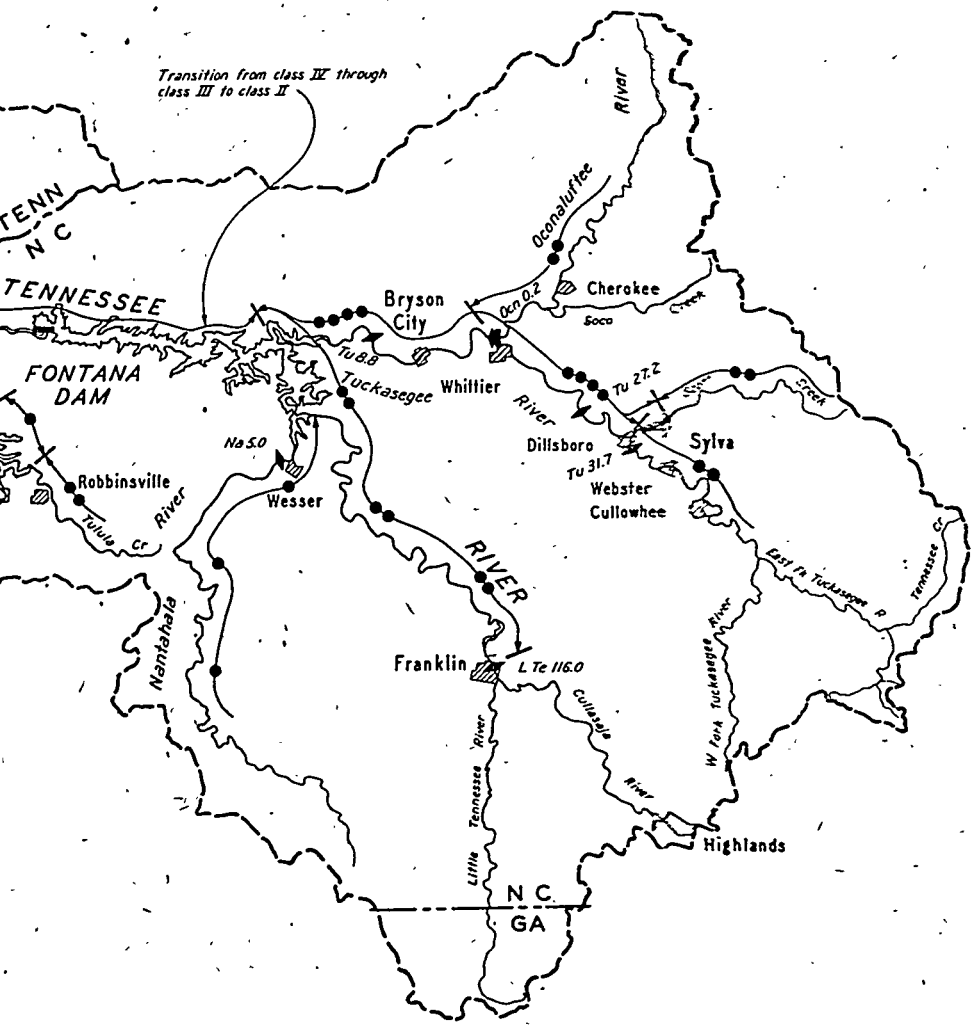


Figure 8

Scale 4 0 4 8 Miles

POLLUTION SURVEY

LITTLE TENNESSEE RIVER DRAINAGE BASIN

STREAM SANITATION PROGRAM
TENNESSEE VALLEY AUTHORITY
HEALTH AND SAFETY DEPARTMENT

SUBMITTED	RECOMMENDED	APPROVED

CHATTANOOGA	10-1-43	G	HS	306B508	R1

SECTION III

LITTLE TENNESSEE RIVER

SECTION III

LITTLE TENNESSEE RIVER

General

The Little Tennessee River drainage area, figure 8, is a long, relatively narrow area lying just south of the French Broad River basin and extending from northern Georgia and the South Carolina state line northwestwardly to the Tennessee River at Lenoir City. It is the sixth in size of the seven larger tributaries to the Tennessee River and has an area of 2,627 square miles. The areas drained by its principal tributaries are as follows:

Nantahala	175 square miles
Tuckasegee	734 square miles
Cheoah	215 square miles
Remainder of basin	1,503 square miles

The area is largely mountainous in character, containing only a few industries. Agriculture is the principal industry in the upper section of the valley, as it is here that most of the land suitable for agriculture is found. Most of the area below Bryson City is too mountainous and rugged to be suitable for farming.

The streams in general are very crooked, winding down narrow valleys. The nature of the valleys, along with abundant stream flows, provides exceptionally favorable conditions for hydroelectric projects. There were five hydroelectric plants operating in the valley in 1943 and another was completed in 1944.

Geology

With the exception of a very small portion of the valley near the mouth of the river, the drainage area lies in the Blue Ridge section which has been described under the French Broad River.

Precipitation

The average annual precipitation in the drainage area is the highest that occurs on the main tributaries. It ranges from 44 inches near the mouth of the river to 85 inches in the upper section, with an average of approximately 58 inches.

Stream Flows

Table 26 gives the mean monthly discharges and period of record for the Little Tennessee River and its major tributary, the Tuckasegee River.

TABLE 26

MEAN MONTHLY DISCHARGES IN CUBIC FEET PER SECOND

AT DESIGNATED POINTS ON LITTLE TENNESSEE RIVER

	Little Tennessee River Judson, N. C.	Tuckasegee River Bryson, N. C.	Little Tennessee River McGhee, Tenn.
Drainage Area Above Gage Sq. Mi.	664	655	2443
Period of Record	1920-1934	1920-1934	1925-1934
January cfs	2,210	1,940	6,570
February cfs	2,220	2,040	7,320
March cfs	2,600	2,360	8,420
April cfs	2,320	2,140	6,680
May cfs	2,060	1,890	6,420
June cfs	1,450	1,380	4,410
July cfs	1,120	1,100	3,320
August cfs	1,080	1,070	3,160
September cfs	940	880	3,050
October cfs	818	756	2,590
November cfs	1,080	998	3,800
December cfs	1,940	1,660	6,480
Mean Annual cfs	1,650	1,520	5,180
Maximum Flow cfs	40,800	61,600	92,000
Minimum Flow cfs	165	31	480

Water Supplies

As there are no large municipalities in the area, most of the water supplies are small and are obtained principally from springs and surface streams. Only three of the supplies have filter plants. Chlorination is relied upon for treatment for all but four of the remainder. Table 27 gives the water supplies in the valley, their sources, and methods of purification.

TABLE 27

WATER SUPPLIES

LITTLE TENNESSEE RIVER BASIN, 1937-1940

Municipality	Population	Source	Treatment[1]
Highlands, N. C.	1,500	West Prong of Cullasaja River	D
Franklin, N. C.	2,500	Wells	N
Macon County State Prison Camp	100	Well	N
Cullowhee, N. C.	1,200	Streams	FD
Webster, N. C.	84	Springs	D
Sylva, N. C.	1,409	Fisher Creek	D
Dillsboro, N. C.	400	Dills Branch	D
Jackson County State Prison Camp	100	Well	N
Whittier, N. C.	587	Spring	N
Cherokee Indian Reservation	1,100	Mingus Creek	D
Bryson, N. C.	2,000	Lands Creek	D
Robbinsville, N. C.	800	Long Branch	D
Tapoco, N. C.	200	Yellow Hammer Cr.	D
Calderwood, Tenn.	190	First Creek	FD
Tellico Plains, Tenn.	899	Wells	D
Madisonville, Tenn.	965	Spring	CFD

1. N = No Treatment
   C = Coagulation and Sedimentation
   D = Disinfection
   F = Filtration
   S = Softening

SOURCES OF POLLUTION

Population Estimates

The population in the drainage area is the smallest in the seven major tributaries. It is estimated that the population of the valley in 1940 was 83,354. Like the upper section of the French Broad River valley, the upper section of the Little Tennessee River valley is a popular summer playground. Accordingly, the summer population in this area is considerably greater than the winter population.

Sewerage Systems

Table 28 lists the sewered municipalities in the drainage area along with the type and extent of treatment which the sewage receives before being discharged.

Five of the 13 systems have treatment plants which reduce the total pollutional load caused by domestic sewage about 11 percent.

TABLE 28

SEWERAGE SYSTEMS

LITTLE TENNESSEE RIVER BASIN, 1937-1940

Municipality	Population (1940 U.S. Census)		Treatment
	Total	Sewered	
Highlands, N. C.	1,500[a]	500	Septic Tank
Franklin, N. C.	2,500[a]	1,500	Imhoff Tank
Macon County State Prison Camp	100[b]	100	(Septic Tank - (Sand Filters
Cullowhee, N. C.	1,200	1,200	None
Sylva, N. C.	1,409	920	None
Dillsboro, N. C.	400[a]	400	None
Jackson County State Prison Camp	100	100	(Septic Tank - (Sand Filters
Whittier, N. C.	587[c]	370	None
Cherokee Indian Reservation	1,100	500	(Imhoff Tank - (Chlorination
Bryson City, N. C.	2,000[a]	1,500	None
Robbinsville, N. C.	800[a]	700	None
Tapoco, N. C.	200[a]	200	None
Calderwood, Tenn.	190	190	None
Total	12,086	8,180	

a. Summer population
b. Includes W.N.C. Teacher College
c. Includes Swain County School

Industrial Plants

Table 29 gives the number and types of industrial plants in the area. Only 1.6 percent of the total number of industries are located in the area, whereas these industries discharge 7.6 percent of the total industrial pollution. Although the valley is one of the smallest of the major tributaries, it is third in the list on the basis of the total amount of industrial wastes.

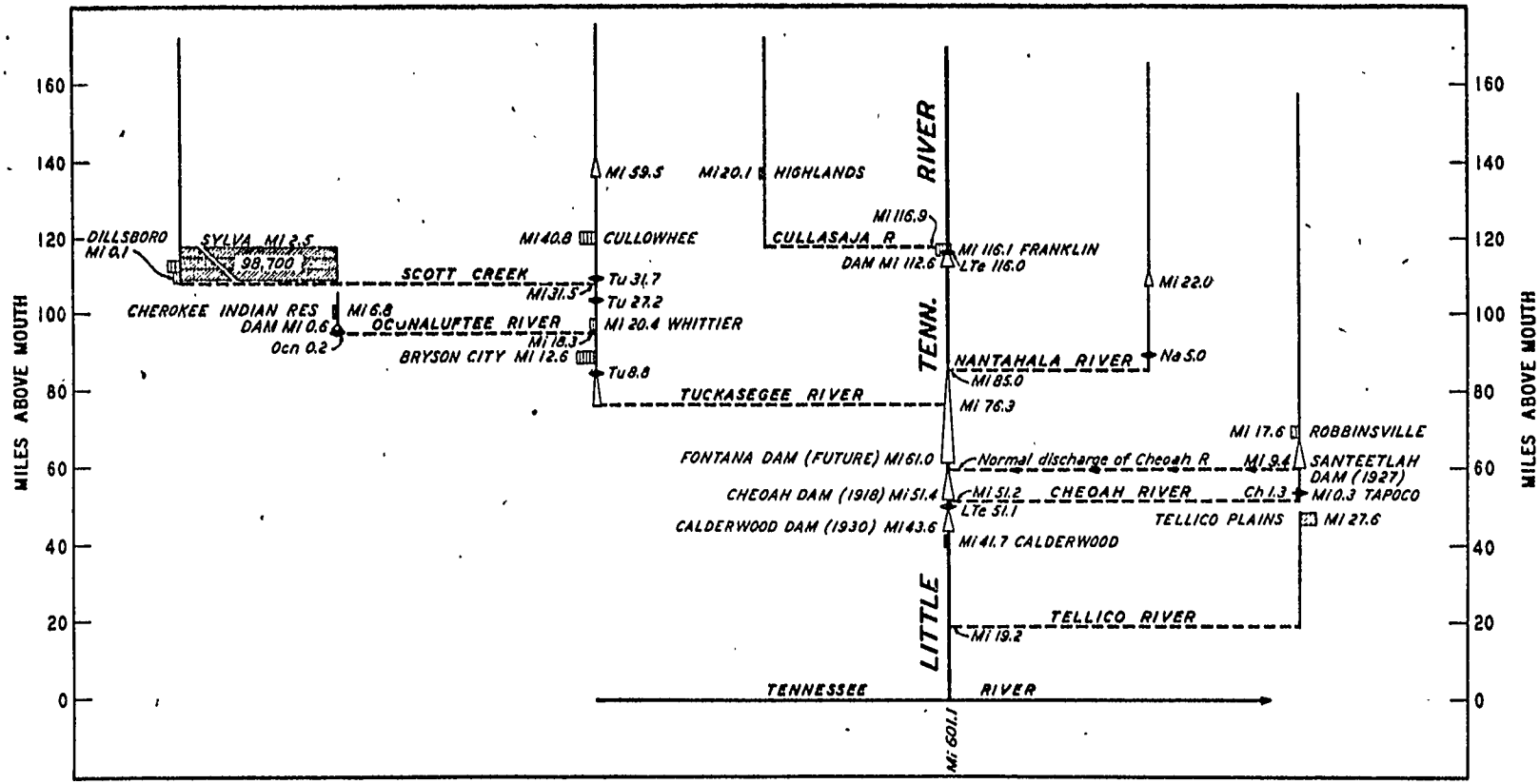
It will be noted that there is no significant decrease in the amount of industrial pollution due to corrective measures. The wastes from one small milk plant only receive partial treatment in a municipal sewage treatment.

TABLE 29

INDUSTRIAL POLLUTION

LITTLE TENNESSEE RIVER BASIN, 1937-1940

Types of Industry	Number of Plants		Method of Disposal			Estimated Population Equivalents	
	Little Tennessee River Basin	Percent of Total in Tenn. Valley	Municipal Sewers	Stream	Some Correction	Little Tennessee River Basin	Percent of Total in Tenn. Valley
Canning	1	3.7	0	1	0	1,300	3.1
Milk	1	2.9	1	0	1	100	.7
Pulp and Paper	1	11.1	0	1	0	85,000	14.6
Tanning	1	11.1	0	1	0	13,700	17.2
Total	4	1.6	1	3	1	100,100	6



SYMBOLS:

- Sampling station
- Population equivalent:
  - Domestic sewage
  - Industrial waste
- Dam and reservoir

Scale of population equivalent

NOTE:
Number at sampling station denotes miles above mouth of each stream.

Figure 9

LITTLE TENNESSEE RIVER SOURCES OF POLLUTION AND SAMPLING STATIONS

Extent of Pollution

The estimated amounts of pollution due to domestic sewage and industrial wastes which reach the streams in the valley are shown in table 30. The same information is shown graphically in figure 9.

TABLE 30

ESTIMATED POPULATION EQUIVALENT OF POLLUTION

REACHING LITTLE TENNESSEE RIVER SYSTEM, 1937-1940

Municipality	Receiving Stream	Estimated Population Equivalents		
		Domestic Sewage	Industrial Wastes	Total
Highlands, N. C.	Cullasaja River	400	-	400
Franklin, N. C.	Little Tenn. River	980	60	1,040
Macon County State Prison Camp	Little Tenn. River	10	-	10
Cullowhee, N. C.	Tuckasegee River	1,200	-	1,200
Sylva, N. C.	Scott Creek	920	98,700	99,620
Dillsboro, N. C.	Scott Creek	400	-	400
Jackson County State Prison Camp	Tuckasegee River	10	-	10
Whittier, N. C.	Tuckasegee River	370	-	370
Cherokee Indian Reservation	Oconaluftee River	320	-	320
Bryson City, N. C.	Tuckasegee River	1,500	-	1,500
Robbinsville, N. C.	Cheoah River	700	-	700
Tapoco, N. C.	Cheoah River	200	-	200
Calderwood, Tenn.	Little Tenn. River	190	-	190
Tellico Plains, Tenn.	Tellico River	-	1,300	1,300
Total		7,200	100,060	107,260

Sampling and Sampling Stations

Sampling

No long-period routine studies have been made of the Little Tennessee River. However, daily samples were collected from nine stations on the Tuckasegee River system for a period of seven days during August 1938. These samples were collected with the assistance of the district engineer of North Carolina State Board of Health and delivered to the laboratory at Norris, Tennessee, for examination. The results of the studies on four of these nine stations are included in this report. During the same period of study, five samples were collected from the Little Tennessee River below Cheoah Dam. The information tabulated for the remainder of the stations was obtained from studies carried out by the North Carolina Department of Conservation and Development.

Sampling Stations

The locations of the sampling stations for which information is listed are as follows:

Little Tennessee River - LTe 116.0:	The upper end of Lake Emory near Franklin, N. C.
Nantahala River - Na 5.0:	Near the town of Wesser on U. S. Highway No. 19.
Tuckasegee River - Tu 31.7:	A bridge on U.S. Highway No. 23 at Dillsboro, N. C.
Tuckasegee River - Tu 27.2:	A bridge at Barkers Creek, N. C., below the mouth of Scott Creek.
Oconaluftee River - Ocn 0.2:	A bridge at the mouth of the river just below the dam.
Tuckasegee River - Tu 8.8:	A footbridge just below Bryson City and above the mouth of Peachtree Creek.
Little Tennessee River - LTe 51.1:	The bridge on U.S. Highway No.129, just below Cheoah Dam.

Discussion of Results

Stream Flows

The discharges were not available at the time the samples were collected from the stations which were studied by the Department of Conservation and Development. During the period in which the studies were made on the Tuckasegee River in August 1938, the stream flows were considerably below the average for that season of the year.

Observed Conditions

In general, with the exception of Scott Creek below Sylva, N.C., the Tuckasegee River, and the Little Tennessee River below the mouth of the Tuckasegee, all the streams in the valley are clean water streams receiving very little pollution from domestic sewage and no industrial waste.

While no studies have been made in the upper end of the Little Tennessee River, it is logical to assume that Class II conditions exist for a considerable distance above the mouth of the Tuckasegee River. The extreme upper portion should meet the requirements of Class I.

Class I conditions should exist on all but the lower end of the Nantahala River, as this stream drains an extremely mountainous section.

The upper section of the Tuckasegee River as measured by th conditions observed at Tu 31.7 meets the requirement of Class II, and it is logical to assume that these conditions exist throughout the major portion of the upper section.

From Scott Creek the Tuckasegee River receives a heavy load of industrial wastes from a tannery and a paperboard mill located at Sylva, N.C. The domestic sewage and these wastes increase the densities of the coliform group and the B.O.D. to such an extent that the Tuckasegee River below Scott Creek is degraded to Class IV.

About 13 miles below the mouth of Scott Creek the Tuckasegee River receives added dilution from Oconaluftee River. The density of the

coliform group is low in this stream, but the results indicate a rather high B.O.D. It is possible that the water at this station was drawn through the turbines from near the bottom of the lake; and, if such was the case, the B.O.D. would have been higher than if the water had been taken from the upper section. Class II conditions are expected to exist in the Oconaluftee River above the lake.

Below the Oconaluftee River the coliform group is reduced in number, and the B.O.D. falls just slightly below 4.0 ppm. However, since the pollutional materials are extremely difficult and expensive to remove, the stream is unsuitable as a source of domestic water and still remains a Class IV stream.

At Bryson City the stream receives a relatively small pollutional load of domestic sewage, and at the lower station, Tu 8.8, which was examined at this time, Class III conditions with respect to B.O.D. and the coliform group were observed with relatively high concentrations of dissolved oxygen.

The industrial wastes carried by the Tuckasegee River make the Little Tennessee River dark in appearance with a considerable amount of white foam on the surface. About 16 miles below the mouth of the Tuckasegee River the Little Tennessee River enters the Cheoah Reservoir and at the same time receives the discharge from the turbines operating on the lower end of the penstock from Santeetlah Dam on the Cheoah River.

The Cheoah River drains a relatively small valley in the Great Smoky Mountains and receives the domestic sewage from the small town of Robbinsville, just above the upper end of Santeetlah Lake. This water should be relatively clean, at least meeting the requirements for Class II. It is quite probable that the epilimnion of Santeetlah Lake will meet the requirements for Class I.

The added dilution received at the upper end of Cheoah Dam and the retention period through Cheoah Lake and Calderwood Lake, immediately below, considerably improve the conditions of the Little Tennessee River. At LTe 51.1, just below Cheoah Dam, the results indicate a low B.O.D. meeting the requirements for Class I. No bacteriological examinations were

made on samples collected from this station. From visual observations of the Little Tennessee River between Calderwood Dam and its mouth, it is apparent that the stream still contains a considerable amount of coloring material and at times is somewhat frothy. The river from this point to the mouth is considered a Class II stream.

With the completion of Fontana Dam at mile 61.0 it can be expected that a considerable amount of recovery will take place in the Fontana Reservoir. In the future, it is expected that the Tuckasegee River below Scott Creek will be a Class IV stream until it enters the Fontana Reservoir. Here recovery will take place, particularly in the epilimnion, to such an extent that conditions will be favorable for the development of fish, particularly near the lower end, even though septic conditions may exist in the upper end of the reservoir and in the hypolimnion. The Little Tennessee and Nantahala arms of the reservoir should be clean water. Below Fontana Dam, with the removal of water from the hypolimnion, it is expected that conditions unfavorable for fish life will exist in the upper end of Cheoah Lake. The total result of this added retention and storage on the Little Tennessee River should improve conditions in the river below Calderwood Dam somewhat, but it is doubtful that conditions in this section of the stream will ever meet requirements for Class I.

These classifications, as modified by the expected effect of Fontana Reservoir, are shown in figure 8.

TABLE 31

LITTLE TENNESSEE RIVER

MINERAL ANALYSES AND SOLIDS

		Station							
		LTe 116.0 (1)(2)	Na 5.0 (1)(3)	Tu 31.7 (4)	Tu 27.2 (5)	Ocn 0.2 (6)	Tu 8.8 (7)	Ch 1.3 (1)(8)	LTe 51.1 (9)
Year		1927	1927	1938	1938	1938	1938	1924	1938
Month		August	August	August	August	August	August	April	August
Number times sampled		1	1	7**	7**	7**	7**	1	5**
Discharge cfs		-	-	463	567	370	1,050	-	4,840
Fe (unfiltered)	ppm	0.2*	.25*	.2	.16	.19	.24	0.2*	.73
SiO_2	ppm	8.5	9.5	8	11	7	10	5.3	8
Ca	ppm	2.3	1.6	2.3	2.9	2.3	2.2	1.0	2.2
Mg	ppm	.9	.8	.5	.9	.2	.4	.6	.7
Na	ppm	2.4	2.5	3	3.4	3	3.9	1.4	1.9
SO_4	ppm	1.8	1.4	.6	2.4	.8	.7	1.7	1.0
Cl	ppm	1.0	.6	2	2	2	2	.3	2
F	ppm	-	-	.16	.48	.13	.30	-	.07
Alkalinity as $CaCO_3$	ppm	10	7.5	10	13	9	11	4	9
Total Hardness as $CaCO_3$	ppm	9.4	7.4	8	12	7	7	5	8
Phenol	ppm	-	-	.004	.005	.002	.004	-	.008
pH		-	-	7.0	6.9	6.9	7.1	-	-
Color	ppm	12	25	16	44	9	30	9	36
Tannins	ppm	-	-	.2	4.7	.3	2.0		.1
Solids									
Dissolved	ppm	29.3	26.9	28	41	23	29	16	26
Suspended	ppm	8	12	15	16	16	14	10	34
Volatile	ppm	-	-	19	26	14	17	-	16
Fixed	ppm	-	-	24	31	25	26	-	44
Total	ppm	37.3	38.9	43	57	39	43	36	60

*Made on filtered samples. **Results shown are averages for the number of days corresponding to the number of samples.

(1) Chemical Quality of the Surface Waters of North Carolina with Relation to Industrial Use. Economic Paper Number 61, North Carolina Department of Conservation and Development, pp. 30-31.

(2) Lake Emory on Little Tennessee River near Franklin, No. 107.

(3) Nantahala River, near town of Wesser, No. 108. (4) Tuckasegee River - just above the mouth of Scott Creek.

(5) Tuckasegee River - below the mouth of Scott Creek. (6) Oconaluftee River - near mouth.

(7) Tuckasegee River - below Bryson City. (8) Cheoah River, 1 mile above mouth at Tapoco, No. 109.

(9) Little Tennessee River - just below Cheoah Dam.

TABLE 32

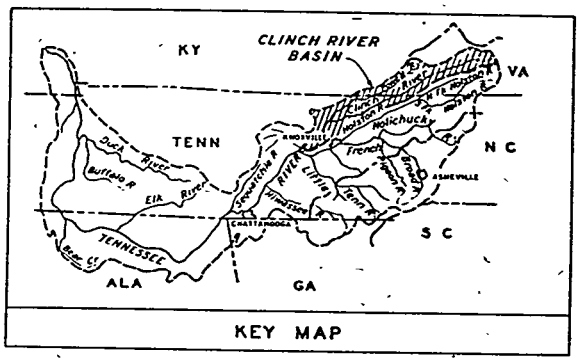
LITTLE TENNESSEE RIVER

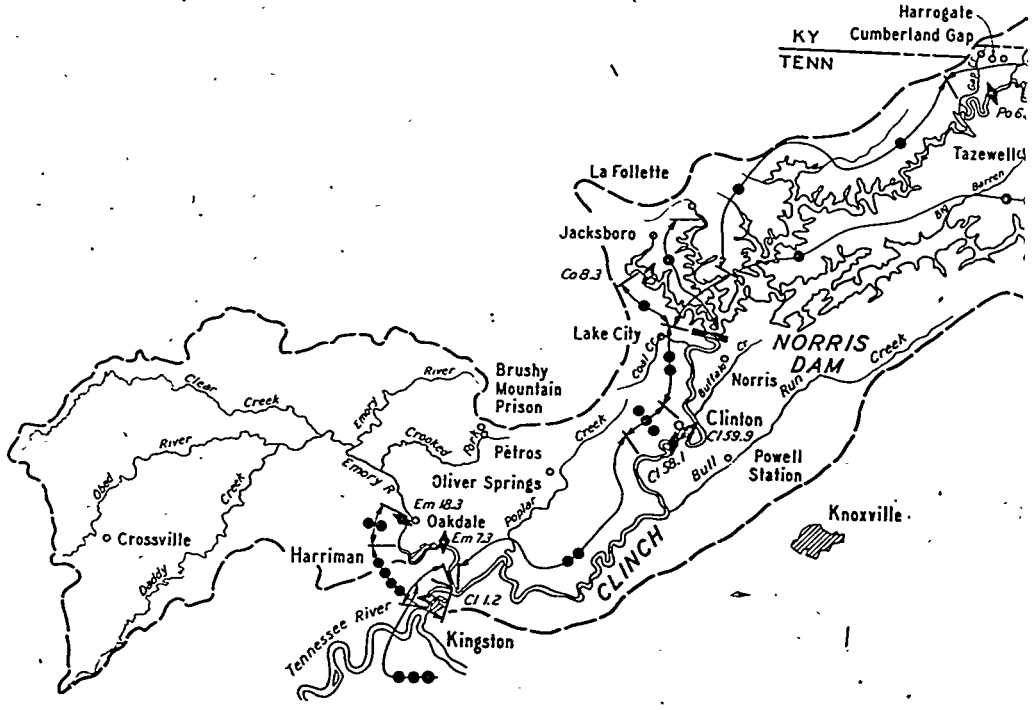
DISSOLVED OXYGEN, BIOCHEMICAL OXYGEN DEMAND, AND BACTERIA

	Station				
	Tu 31.7 (1)	Tu 27.2 (2)	Ocn 0.2 (3)	Tu 8.8 (4)	LTe 51.1 (5)
Year	1938	1938	1938	1938	1938
Month	August	August	August	August	August
Number of Times Sampled	7*	7*	7*	7*	5*
Discharge cfs	463	567	370	1,050	4,840
Water Temperature °C	23.0	23.8	22.7	26.2	23.9
Dissolved Oxygen					
Parts per Million	7.02	5.95	6.98	6.33	-
Percent Saturation	80.9	69.5	80.1	77.4	-
5-Day Oxygen Demand					
20°C ppm	1.47	4.25	3.24	3.35	.38
1000 Lb. per Day					
Dissolved Oxygen	17.55	18.22	13.95	35.89	-
5-Day Oxygen Demand	3.68	13.01	6.47	18.99	9.93
Bacteria per Milliliter					
On Agar 37°C for 24 hrs.	850	11,500	600	7,100	-
Coliform Group M.P.N.	46	300	36	150	-
Bacteria Quantity Units					
On Agar 37°C for 24 hrs.	394	6,520	222	7,455	-
Coliform Group M.P.N.	21	170	13	158	-

*Results shown are the averages for the period of study covering the number of days corresponding to number of samples.

(1) Tuckasegee River - just above the mouth of Scott Creek.
(2) Tuckasegee River - below the mouth of Scott Creek.
(3) Oconaluftee River - near mouth.
(4) Tuckasegee River - below Bryson City.
(5) Little Tennessee River - just below Cheoah Dam.





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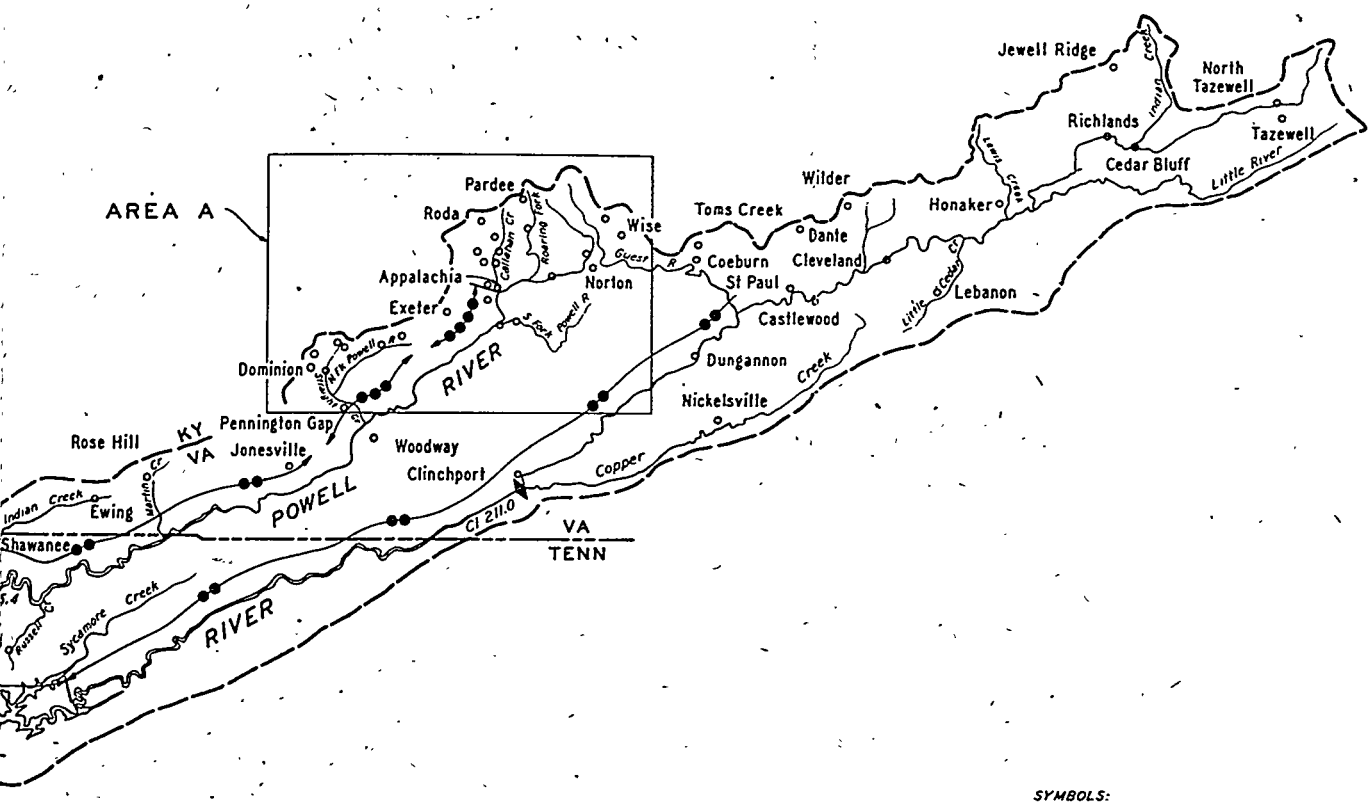
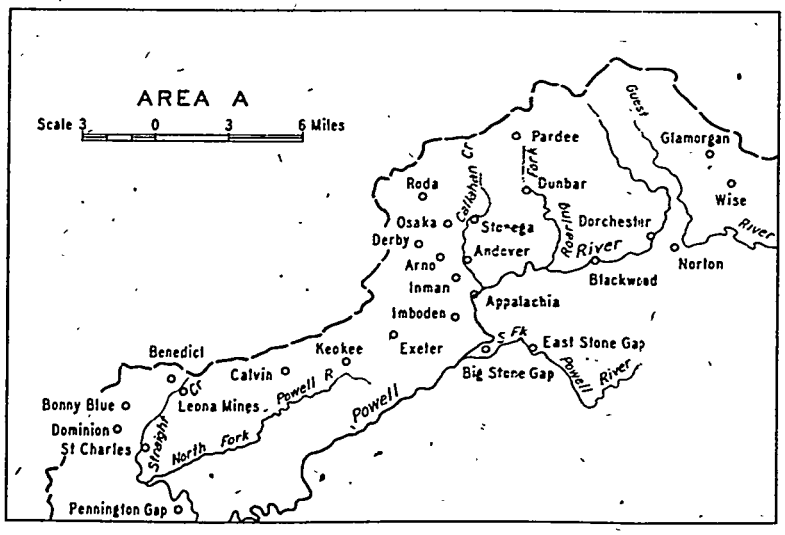
CHATTANOOGA DRAFTING SERVICE





SYMBOLS:

- Class I – Class A swimming areas and water supplies with minimum treatment.
- Class II – Class B and C swimming areas and water supplies (normal filter plant operation).
- Class III – Water supplies (advanced treatment methods) and fish life.
- Class IV – Unsuitable for water supplies as defined under Class III or which do not support desirable fish fauna.
- Sampling stations

Figure 10

Scale 5 0 5 10 15 20 25 Miles

POLLUTION SURVEY

CLINCH RIVER DRAINAGE BASIN

STREAM SANITATION PROGRAM
TENNESSEE VALLEY AUTHORITY
HEALTH AND SAFETY DEPARTMENT

SUBMITTED	RECOMMENDED	APPROVED

CHATTANOOGA	10-15-43	G	HS	306B511 R1

SECTION IV

CLINCH RIVER

SECTION IV

CLINCH RIVER

General

The Clinch River drainage basin, figure 10, is a long, slender area lying between the Holston River valley on the south and the Kentucky state line on the north and extending from just above Tazewell, Va., to the Tennessee River near Kingston, Tenn., at mile 567.7. The Powell River, its largest tributary, flows in a long, narrow valley parallel to the Clinch River. The next largest tributary, the Emory River, drains a short broad area near the mouth of the Clinch.

The Clinch River is the second largest tributary to the Tennessee River, having an area of 4,413 square miles. The areas of the principal tributaries are as follows:

Powell River	938 square miles
Emory River	865 square miles
Remainder of basin	2,610 square miles

The area on the northern edge of the basin is mountainous with coal mining as its chief industry. Agriculture is the principal industry in the main valley. In addition, there are a number of textile plants and one pulp and paper plant.

Geology

The area lies mainly in the great Valley, which has been described in the section on the Holston River. The Cumberland Plateau, which forms the northern boundary of the basin, has been described as follows:[1]

"Description.--The Cumberland Plateau crosses Tennessee in a northeast-southwest direction, and varies in width from about 35 miles near the Alabama line to about 50 miles near the Kentucky line. Its elevation is 1,500 feet on the Alabama line, 2,000 feet in the center of the State, and 3,500 feet near Cumberland Gap. The plateau surface stands about 1,000 feet above the adjacent region on either side. The eastern edge is an abrupt scarp that is straight for miles. The western edge is an equally abrupt scarp, but is notched by the headwaters of streams that have eaten into the plateau from the west. The surface, while measurably flat, is diversified by shallow valleys and low ridges.

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1. L. C. Glenn, "Tennessee and Kentucky," in Underground Waters of Eastern United States, Water Supply and Irrigation Paper No. 114, United States Geological Survey 1905, pp. 199-200.

"Water Resources--The rocks of the plateau are of Carboniferous age. Much of the surface is underlain by sandstone, which forms an open porous soil if well drained. From this sandstone issue the numerous freestone springs that furnish so large a part of the water supply of the region. During summer and fall droughts sometimes occur, and many springs and streams decrease in volume or go entirely dry, so that water for household use and for stock becomes scarce while the small mills for grinding corn remain idle until rains set in. Open wells supplement the springs in many instances.

"Supplies of water may be obtained by drilling a few hundred feet into the thick sandstone beds that underlie the larger part of the plateau. Such waters will not usually flow, but will rise within easy pumping distance of the surface. They may contain more or less iron from the sandstones or sulphur from the interbedded shales and coals. Wells drilled deeper into the underlying Mississippian or Silurian limestones or into the Devonian black shale usually obtain salt water, with greater or less amounts of natural gas or petroleum.

"There are numerous chalybeate springs on the plateau, some of which are of local repute as summer resorts. Although none have been improved to any extent, the clear, cold, freestone waters, combined with the elevation and delightful summer temperature, bring many visitors from the lowlands during the heated season.

"Much of the plateau is underlain by workable coal and mines are being opened at numerous places, each of which becomes the nucleus for the development of a mining town. With its growth the quality of its water supply, usually taken from open wells and springs, will deteriorate."

Precipitation

The precipitation in the area varies from 36 to 58 inches a year, with the average being approximately 47 inches. The average rainfall during the period of study in 1937 and 1938 was approximately 51 inches.

Stream Flow

Table 33 gives the mean monthly discharges and periods of record for the Clinch River and its largest tributaries at selected points.

TABLE 33

MEAN MONTHLY DISCHARGES IN CUBIC FEET

PER SECOND AT DESIGNATED POINTS ON CLINCH RIVER

	Clinch River Cleveland, Va.	Clinch River Speers Ferry, Va.	Powell River Arthur, Tenn.	Clinch River Lake City, Tenn.	Emory River Oakdale, Tenn.
Drainage Area Above Gage Sq. Mi.	528	1,126	685	2,960	764
Period of Record	1921-1934	1920-1934	1920-1934	1927-1934	1930-1934
January cfs	1,230	2,530	1,920	5,890	2,050
February cfs	1,410	3,130	2,340	7,730	3,070
March cfs	1,330	3,090	2,310	9,490	2,810
April cfs	923	2,250	1,660	6,380	1,670
May cfs	839	1,980	1,390	6,100	906
June cfs	598	1,190	833	3,330	166
July cfs	304	808	614	2,590	156
August cfs	313	773	533	1,740	233
September cfs	257	495	316	1,270	190
October cfs	225	475	290	1,080	172
November cfs	399	928	763	2,650	380
December cfs	878	2,030	1,510	3,650	1,710
Mean Annual cfs	726	1,640	1,210	4,140	1,120
Maximum Flow cfs	22,500	37,200	27,800	70,000	100,000
Minimum Flow cfs	39	42	47	5.4	0.4

Water Supplies

As will be noticed in table 34, there are 64 individual water supplies in the valley. Most of these are small and are obtained from wells and springs. Only 15 have purification plants. Disinfection only is practiced at a number. No treatment is given to 24 of the supplies.

TABLE 34

WATER SUPPLIES

CLINCH RIVER BASIN, 1937-1940

Municipality	Population	Source	Treatment[1]
Tazewell, Va.	1,374	Cox Branch	D
North Tazewell, Va.	688	Springs	D
Cedar Bluff, Va.	823	Springs	N
Richlands, Va.	2,203	(Spring	D
		(Clinch River	CFD
Jewell Ridge, Va.	1,000	Abandoned Mine	CFD
Red Ash, Va.	3,000	Wells and Mine	N
Honaker, Va.	851	Well	D
Lebanon, Va.	622	Spring	D
Cleveland, Va.	500	Spring	D
Wilder, Va.	200	Well	D
Castlewood, Va.	200	Spring	N
Dante, Va.	2,600	Well and Mines	D
St. Paul, Va.	746	Clinch River	CFD
Glamorgan, Va.	800	Well	N
Norton, Va.	4,006	Stream	CFD
Wise, Va.	1,226	Well	FD
Toms Creek, Va.	1,500	(Stream	CFD
		(Well	D
Coeburn, Va.	764	Wells	CFD
Dungannon, Va.	333	Spring	N
Clinchport, Va.	346	Springs	N
Nickelsville, Va.	256	Spring	N
New Tazewell, Tenn.	621	Wells	N
Dorchester, Va.	300	Norton	
Blackwood, Va.	600	Stream	N
Dunbar, Va.	800	Well	N
Pardee, Va.	900	Well	N
Stonega, Va.	900	Appalachia	
Roda, Va.	1,500	Stream and Well	N

1. N = No Treatment
   C = Coagulation and Sedimentation
   D = Disinfection
   F = Filtration

TABLE 34 (Continued)

WATER SUPPLIES

CLINCH RIVER BASIN

Municipality	Population	Source	Treatment[1]
Osaka, Va.	500	Appalachia	
Arno, Va.	300	Appalachia	
Andover, Va.	800	Appalachia	
Inman, Va.	300	Wells	N
Derby, Va.	400	Appalachia	
Appalachia, Va.	3,010	Stream	CFD
Exeter, Va.	1,200	Wells	D
Imboden, Va.	1,200	Well	N
East Stone Gap, Va.	700	Big Stone Gap	
Big Stone Gap, Va.	4,331	South Fork Powell R.	D
Keokee, Va.	575	Stream	N
Calvin, Va.	400	North Fork Powell R.	CFD
Virginia Lee, Va.	400	Spring	N
Bonny Blue, Va.	3,000	Wells	N
Dominion, Va.	400	Mine	N
Leona Mines, Va.	112	Mine	N
Benedict, Va.	900	Mine	D
Pennington Gap, Va.	1,990	Spring	D
Woodway, Va.	200	Spring	N
Jonesville, Va.	588	Springs	D
Rose Hill, Va.	500	Spring	D
Tazewell, Tenn.	800	Springs	D
Ewing, Va.	350	Spring	D
Shawnee, Tenn.	475	Springs	N
Cumberland Gap, Tenn.	409	Harrogate	
Harrogate, Tenn.	700	Spring	D
La Follette, Tenn.	4,010	Wells and Stream	CFD
Jacksboro, Tenn.	834	Springs	N
Lake City, Tenn.	1,520	Springs	D
Norris, Tenn.	1,300	Spring	D
Clinton, Tenn.	2,761	Spring	FD
South Clinton, Tenn.	250	Spring	D
Powell Station, Tenn.	400	Spring	D
Oliver Springs, Tenn.	855	Well and Spring	CD
Crossville, Tenn.	1,511	Stream	CFD
Brushy Mountain Prison, Tenn.	1,000	Mine	D
Oakdale, Tenn.	900	Emory River	CFD
Harriman, Tenn.	5,620	Emory River	CFD
Kingston, Tenn.	880	Spring	D

1. N = No Treatment
   C = Coagulation and Sedimentation
   D = Disinfection
   F = Filtration

Sources of Pollution

Population Estimates

The population in the basin is the third largest of the seven main tributaries. The 1940 census for the area is 277,891.

Sewerage Systems

Table 35 lists the sewered municipalities in the drainage area along with the types of treatment. Seven of the 44 systems have treatment of some form which reduces the pollutional load about 7.7 percent.

Industrial Plants

Table 36 gives the number and types of industrial plants in the area. Only eight industries are listed, or 3.2 percent of those in the Tennessee Valley, which contribute 6.5 percent of the total industrial pollution.

The information on industries is incomplete inasmuch as it does not list the coal mining operations. It has been estimated[1] that before the program of sealing abandoned coal mines by WPA under the supervision of the U.S. Public Health Service, approximately 209,000 pounds of acid as $CaCO_3$ were discharged from the mines in the Tennessee River basin. The information is not broken down into tributaries, but the major portion of these wastes originated at the mines in the Clinch River area, with the remainder scattered along the Cumberland Plateau to the south. It was further estimated that after the program this acid load was reduced to 120,000 pounds of acid as $CaCO_3$ per day.

It will be noted that there is no significant decrease in other industrial pollution due to corrective measures. The wastes from one milk plant are treated in a septic tank with a tile disposal field, and wastes from a small canning plant are discharged on the open ground, where they seep into the soil and do not reach a stream.

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1. "Acid Mine Drainage," Ohio River Pollution Control, Supplements to Part Two, Report of the United States Health Service, House Document No. 266, 78th Congress, 1st Session, August 27, 1943, p. 1009.

TABLE 35

SEWERAGE SYSTEMS

CLINCH RIVER BASIN, 1937-1940

Municipality	Population (1940 U.S. Census)		Treatment
	Total	Sewered	
Tazewell, Va.	1,374	340	Septic Tanks
North Tazewell, Va.	688	170	None
Cedar Bluff, Va.	823	200	None
Richlands, Va.	2,203	1,650	None
Honaker, Va.	851	90	None
Lebanon, Va.	622	370	None
Cleveland, Va.	500	400	None
St. Paul, Va.	746	520	None
Glamorgan, Va.	800	40	None
Norton, Va.	4,006	3,200	None
Wise, Va.	1,226	740	None
Toms Creek, Va.	1,500	150	None
Coeburn, Va.	764	380	None
Clinchport, Va.	346	210	None
Dorchester, Va.	300	30	None
Dunbar, Va.	800	80	None
Stonega, Va.	900	450	None
Roda, Va.	1,500	220	None
Osaka, Va.	500	100	None
Arno, Va.	300	60	None
Andover, Va.	800	680	None
Appalachia, Va.	3,010	2,100	None
Exeter, Va.	1,200	120	None
Imboden, Va.	1,200	120	None
East Stone Gap, Va.	700	70	None
Big Stone Gap, Va.	4,331	3,200	None
Bonny Blue, Va.	3,000	200	None
St. Charles, Va.	482	200	None
Pennington Gap, Va.	1,990	1,200	None
Jonesville, Va.	588	350	To Cave
Rose Hill, Va.	500	100	None
Ewing, Va.	350	50	None
Cumberland Gap, Tenn.	409	310	None
Harrogate, Tenn.	700	630	Imhoff Tank, Trickling Filter
La Follette, Tenn.	4,010	1,400	None
Jacksboro, Tenn.	834	170	None
Norris Dam, Tenn.	200	200	Septic Tanks
Lake City, Tenn.	1,520	760	Imhoff Tank
Norris, Tenn.	1,100	1,100	Imhoff Tank, Activated Sludge
Clinton, Tenn.	2,761	2,350	None
Crossville, Tenn.	1,511	530	Imhoff Tanks
Brushy Mountain Prison, Tenn.	1,000	1,000	Imhoff Tank
Harriman, Tenn.	5,620	3,650	None
Kingston, Tenn.	880	350	None
Total	59,445	30,240	

TABLE 36

INDUSTRIAL POLLUTION

CLINCH RIVER BASIN, 1937-1940

Types of Industry	Number of Plants		Method of Disposal			Estimated Population Equivalents	
	Clinch River Basin	Percent of Total in Tenn. Valley	Municipal Sewers	Stream	Some Correction	Clinch River Basin	Percent of Total in Tenn. Valley
Canning	2	7.4	0	2	1	3,600	8.6
Milk	1	2.9	0	1	1	400	2.8
Pulp and Paper	1	11.1	0	1	0	76,000	13.0
Textiles	4	4.7	1	3	0	5,300	3.7
Total	8	3.2	1	7	2	85,300	6.5

Extent of Pollution

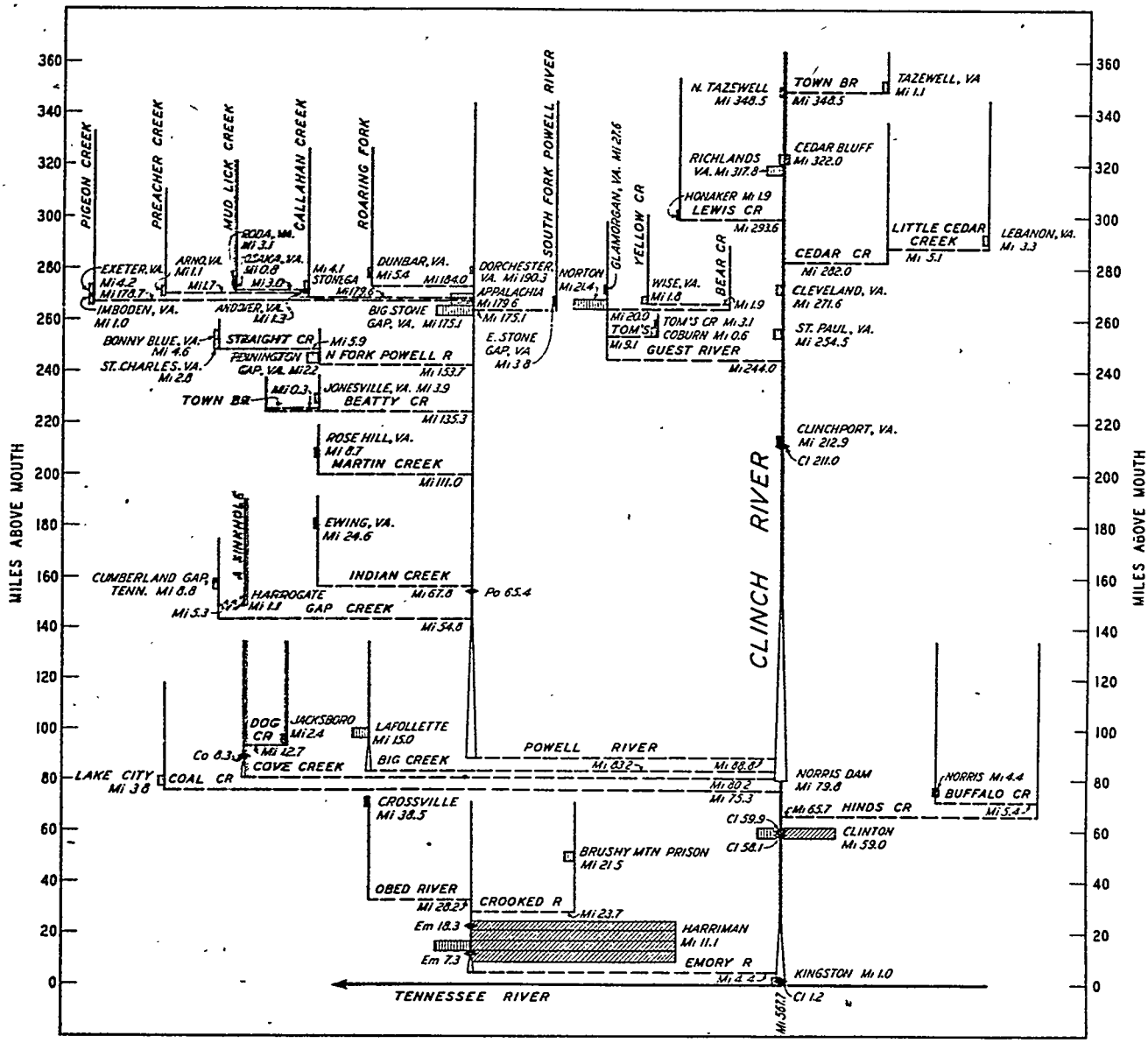
The estimated amounts of pollution due to domestic sewage and industrial wastes which reach the streams in the valley are shown in table 37. The same information is shown graphically in figure 11.

TABLE 37

ESTIMATED POPULATION EQUIVALENT OF POLLUTION

REACHING CLINCH RIVER SYSTEM, 1937-1940

Municipality	Receiving Stream	Estimated Population Equivalents		
		Domestic Sewage	Industrial Wastes	Total
Tazewell, Va.	Town Branch	270	-	270
North Tazewell, Va.	Clinch River	170	-	170
Cedar Bluff, Va.	Clinch River	200	300	500
Richlands, Va.	Clinch River	1,650	-	1,650
Honaker, Va.	Lewis Creek	90	-	90
Lebanon, Va.	Little Cedar Creek	370	-	370
Cleveland, Va.	Clinch River	400	-	400
St. Paul, Va.	Clinch River	520	-	520
Glamorgan, Va.	Guest River	40	-	40
Norton, Va.	Guest River	3,200	-	3,200
Wise, Va.	Yellow Creek	740	-	740
Toms Creek, Va.	Toms Creek	150	-	150
Coeburn, Va.	Toms Creek	380	-	380
Clinchport, Va.	Clinch River	210	-	210
Dorchester, Va.	Powell River	30	--	30
Dunbar, Va.	Roaring Fork	80	-	80
Stonega, Va.	Callahan Creek	450	-	450
Roda, Va.	Mud Lick Creek	220	-	220
Osaka, Va.	Mud Lick Creek	100	-	100
Arno, Va.	Preacher Creek	60	-	60
Andover, Va.	Callahan Creek	680	-	680
Appalachia, Va.	Powell River	2,100	-	2,100
Exeter, Va.	Pigeon Creek	120	-	120
Imboden, Va.	Pigeon Creek	120	-	120
East Stone Gap, Va.	South Fork Powell River	70	-	70
Big Stone Gap, Va.	Powell River	3,200	-	3,200
Bonny Blue, Va.	Straight Creek	200	-	200
St. Charles, Va.	Straight Creek	200	-	200
Pennington Gap, Va.	N. Fork Powell River	1,200	-	1,200
Jonesville, Va.	Cave (Town Branch)	350	-	350
Rose Hill, Va.	Martin Creek	100	-	100
Ewing, Va.	Indian Creek	50	-	50
Cumberland Gap, Tenn.	Gap Creek	310	-	310
Harrogate, Tenn.	Gap Creek	130	-	130
La Follette, Tenn.	Big Creek	1,400	-	1,400
Jacksboro, Tenn.	Dog Creek	170	-	170
Norris Dam, Tenn.	Clinch River	160	-	160
Lake City, Tenn.	Coal Creek	490	-	490
Norris, Tenn.	Buffalo Creek	110	200	310
Clinton, Tenn.	Clinch River	2,350	5,200	7,550
Crossville, Tenn.	Obed River	340	-	340
Brushy Mountain Prison	Crooked Fork	700	-	700
Harriman, Tenn.	Emory River	3,650	79,400	83,050
Kingston, Tenn.	Clinch River	350	-	350
Total		27,880	85,100	112,980



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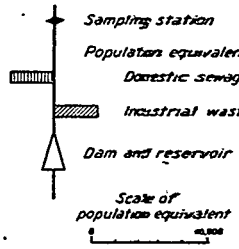


NOTE:
Number at sampling station denotes miles above mouth of each stream.

Figure 11
CLINCH RIVER
SOURCES OF POLLUTION
AND
SAMPLING STATIONS

Sampling and Sampling Stations

Sampling

Routine weekly samples were collected over a period of one year, from August 1937 to August 1938, from the Clinch River at Cl 1.2 and the Emory River at Em 18.3 and Em 7.3. The Authority also collected grab samples from the Powell River and Cove Creek, and made special studies of the Clinch River at Cl 59.9 and 58.1 over a period of 2 days.

The mineral analyses given for the Clinch River at Cl 211.0 cover a study of one year made by the Virginia Division of Water Resources and Power.

Sampling Stations

The stations and their locations were:

Clinch River, Cl 211.0:	Speers Ferry, Va.
Powell River, Po 65.4:	A bridge on U.S. Highway No. 25E near Arthur, Tenn.
Cove Creek, Co 8.3:	Cove Creek arm of Norris Lake below Caryville, Tenn.
Clinch River, Cl 59.9:	Above Clinton, Tenn.
Clinch River, Cl 58.1:	Below Clinton, Tenn.
Emory River, Em 18.3:	A bridge at Oakdale, Tenn.
Emory River, Em 7.3:	Below Harriman, Tenn.
Clinch River, Cl 1.2:	The old Highway Bridge at Kingston, Tenn., about three miles below the mouth of Emory River.

Discussion of Results

Since no comprehensive sampling program was carried out on the Powell River and the upper end of the Clinch River, it will be impossible to describe conditions in detail. Some information on conditions in the Powell River in the vicinity of Big Stone Gap, Va., was obtained by the U.S.P.H.S. mobile laboratory in March 1941. The results of these studies are used in the description of this section of the Powell River. As no

large amounts of domestic sewage or industrial wastes are discharged into the streams in the remainder of the Powell and upper Clinch Rivers, estimates sufficiently accurate for the purpose of this report can be made on the conditions in these sections.

It will be noticed from figure 11 that the Powell River in the short section around Appalachia and Big Stone Gap receives a considerable amount of domestic sewage. The river between these two municipalities contains sufficient pollution to be classified as Class IV. This condition continues for a short distance below Big Stone Gap. At a point about 15 miles north of the Tennessee-Virginia state line analyses indicated that the stream has recovered sufficiently to be classified as Class II. There is a transition section between these two sections that will be Class III.

From the results of studies of the amounts of domestic sewage and industrial wastes, it appears safe to assume that the Clinch River above Norris Lake is a Class II stream. As the Powell and Clinch Rivers enter Norris Reservoir purification reaches the advanced stages, and Class I conditions have been observed over the major portion of the lake.

The results of the mineral analyses would indicate that the effect of the acid mine drainage on the upper Powell and the Clinch are not so serious as might be expected when the results of the analyses are compared with those from the South Holston River below Bluff City, Tenn. The amount of the sulphate, while not excessive (13-14 ppm), is about 2-1/2 times that found in the South Holston River. The alkalinity in the Powell River is somewhat lower than in the Clinch, but both have more alkalinity than the South Holston. On the whole, the results are comparable to those found in the North Holston River above Saltville, Va.

Below Norris Dam conditions are favorable for the growth and development of trout, and this section of the stream probably meets the requirements of Class I streams with the exception of the bacterial requirements. Surface drainage increases the bacterial density to such an extent that Class II conditions exist in the stream above Clinton, Tenn.,

where additional pollution from domestic sewage and industrial wastes degrade the stream to Class III for a short distance, and then it recovers to Class II. This recovery was not demonstrated by examination immediately below Clinton but by the results at Cl 1.2 below the mouth of Emory River, where even with this added pollution Class II conditions were observed.

The Emory River at Oakdale, while having Class I conditions with respect to B.O.D. and dissolved oxygen, contained rather high amounts of coliform organisms and so is placed in Class II. At Harriman the stream receives such a large load of industrial wastes that it is degraded to a Class IV stream. From this point to its mouth the Emory River is black and devoid of oxygen during periods of low stream flow.

As pointed out above, the effects of these wastes upon the Clinch River did not seriously pollute the stream as measured by the tests; however, it is known that these wastes are very difficult to treat in a water purification plant, and for that reason the section of Clinch River below the mouth of Emory River is considered as Class III.

TABLE 38

CLINCH RIVER

MINERAL ANALYSES

		Station				
		Cl 211.0 (1)(6)	Po 65.4 (2)	Co 8.3 (3)	Cl 59.9 (4)	Cl 58.1 (5)
Year		1930-31	1936	1937	1937	1937
Month		(6)	April	Feb.	May	May
Number Times Sampled		(6)	1	1	17	17
Discharge cfs		565	1,030	-	206	208
Fe (Unfiltered)	ppm	.03*	.04*	.42	.80	.40
SiO_2	ppm	5.7	6	7	6	7
Ca	ppm	32	23.8	17.3	25.2	25.7
Mg	ppm	11	8.4	6.3	7.5	7.5
Na	ppm	4.8**	5.5	1.7	7.3	7.3
SO_4	ppm	13	14.1	9.2	15.9	17.3
Cl	ppm	2.3	0	2	2	2
Alkalinity as $CaCO_3$	ppm	111	89	61	90	90
Total Hardness as $CaCO_3$	ppm	123	94	69	94	95
Phenol	ppm	-	-	-	.032	.042
pH		-	7.7	-	7.7	7.7

*Filtered sample
**Sodium plus potassium

(1) Clinch River - at Speers Ferry, Va.
(2) Powell River - near Arthur, Tenn.
(3) Cove Creek - below Caryville, Tenn.
(4) Clinch River - above Clinton, Tenn.
(5) Clinch River - below Clinton, Tenn.
(6) Averages of determinations made on composites of daily samples from April 1, 1930, to March 31, 1931, Chemical Character of Surface Waters of Virginia, State Commission on Conservation and Development, Division of Water Resources and Power, Bulletin No. 3, 1932, pp. 144-145.

TABLE 38 (Continued)

CLINCH RIVER

MINERAL ANALYSES

Emory River - Station Em 7.3 - below Harriman, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Results of Mineral Analyses - Parts per Million										pH
				Fe Unfiltered	SiO_2	Ca	Mg	Na	SO_4	Cl	Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	Phenol	
1937	August	2	280	0.30	4	8.0	1.6	3.8	6.4	T	27	26	0.030	6.8
	September	5	40	.41	4	12.3	3.2	10.9	15.8	1	51	44	.011	6.8
	October	3	160	.46	3	9.7	2.2	9.4	17.2	4	24	33	.020	6.8
	November	3	100	.25	5	8.7	1.5	10.0	16.3	4	25	28	.050	6.8
	December	3	560	.27	5	6.1	2.4	9.3	14.0	7	20	25	.033	6.8
1938	January	3	1,060	.11	5	4.1	1.2	3.2	6.1	2	10	15	.043	6.9
	February	2	1,280	.28	6	4.3	1.0	2.0	5.4	2	10	15	.016	6.8
	March	5	2,000	.41	6	4.0	1.0	2.3	4.5	3	10	14	.017	6.9
	April	4	1,770	.25	7	4.6	1.5	2.0	4.8	3	12	18	.028	6.8
	May	4	2,140	.50	6	4.0	1.1	2.5	4.4	4	10	15	.016	6.8
	June	4	650	.48	7	6.0	2.0	2.8	5.8	4	16	24	.034	6.9
	July	3	1,790	1.50	6	6.7	1.3	5.5	6.8	4	20	22	.022	6.8
	August	2	5,760	1.40	6	4.8	4.4	4.6	8.6	2	14	18	.010	6.8
	Average	43	1,260	0.48	6	6.5	1.7	5.3	8.9	3	20	23	0.025	6.8
	Maximum		10,000	4.00	8	25.0	6.4	28.1	23.6	9	81	89	.066	7.0
	Minimum		8	.04	2	2.6	.3	.0	.0	0	7	12	.000	6.7

TABLE 38 (Continued)

CLINCH RIVER

MINERAL ANALYSES

Clinch River - Station Cl 1.2 - Kingston, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Results of Mineral Analyses - Parts per Million										pH
				Fe Unfiltered	SiO_2	Ca	Mg	Na	SO_4	Cl	Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	Phenol	
1937	August	2	2,080	0.75	6	23.9	6.6	2.4	9.4	2	78	86	-	7.4
	September	5	3,800	.24	5	22.0	6.3	2.1	7.8	T	76	79	-	7.6
	October	3	5,460	.52	5	27.0	6.9	3.8	8.1	2	91	96	-	7.5
	November	3	14,500	.32	5	28.1	6.9	4.7	7.5	3	95	98	-	7.5
	December	3	6,930	.20	5	26.8	7.6	5.4	9.3	4	92	99	-	7.5
1938	January	3	4,200	.11	5	18.7	5.2	3.9	8.2	3	62	68	-	7.4
	February	2	2,030	.34	4	11.6	4.0	1.6	8.0	3	36	46	-	7.2
	March	5	3,900	.82	6	12.5	3.0	3.1	6.0	3	39	44	-	7.2
	April	4	3,430	.47	6	12.3	3.6	3.3	7.1	3	40	46	-	7.2
	May	4	4,530	1.48	5	12.6	3.8	3.4	6.8	4	41	47	-	7.3
	June	4	4,960	.58	6	24.0	5.8	5.8	7.8	4	81	84	-	7.6
	July	3	4,830	.79	6	25.6	6.2	4.6	8.6	5	81	90	-	7.4
	August	2	14,000	.60	6	23.7	5.2	4.8	7.6	5	74	78	-	7.4
	Average	43	5,450	0.57	6	20.1	5.3	3.7	7.7	3	67	72	-	7.4
	Maximum		16,650 Q	4.50	7	29.6	8.2	11.7	11.1	7	99	108	-	7.8
	Minimum		660	.04	3	8.4	2.2	.2	4.5	0	28	30	-	7.1

TABLE 39

CLINCH RIVER

SOLIDS

	Station				
	Cl 211.0 (1)(6)	Po 65.4 (2)	Co 8.3 (3)	Cl 59.9 (4)	Cl 58.1 (5)
Year	1930-31	1936	1937	1937	1937
Month	(6)	April	Feb.	May	May
Number Times Sampled	(6)	1	1	17	17
Discharge cfs	565	1,030	-	206	208
Solids, Parts per Million					
Dissolved	106	113	82	134	135
Suspended	31	7	-	69	53
Volatile	-	-	-	79	52
Fixed	-	-	-	124	136
Total	137	120	-	203	188

(1) Clinch River - at Speers Ferry, Va.
(2) Powell River - near Arthur, Tenn.
(3) Cove Creek - below Caryville, Tenn.
(4) Clinch River - above Clinton, Tenn.
(5) Clinch River - below Clinton, Tenn.
(6) Average of determinations made on composites of daily samples from April 1, 1930, to March 31, 1931, Chemical Character of Surface Waters of Virginia, State Commission on Conservation and Development, Division of Water Resources and Power, Bulletin No. 3, 1932, pp. 144-145.

TABLE 39 (Continued)

CLINCH RIVER

SOLIDS

Emory River - Station Em 18.3 - Oakdale, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Solids - Parts per Million				
				Dissolved	Suspended	Volatile	Fixed	Total
1937	August	2	260	40	20	26	34	60
	September	5	40	28	14	20	22	42
	October	3	150	45	12	24	33	57
	November	3	100	39	19	29	29	58
	December	3	510	45	6	17	34	51
1938	January	3	990	23	8	16	15	31
	February	2	1,220	25	6	8	23	31
	March	5	1,940	21	26	18	29	47
	April	4	1,660	24	2	10	16	26
	May	4	2,140	22	38	13	47	60
	June	4	600	36	4	22	18	40
	July	3	1,690	30	90	21	99	120
	August	2	5,070	25	128	31	122	153
Summer[1]	Average	16	1,060	33	42	24	51	75
	Maximum		9,490	55	247	53	239	277
	Minimum		7	20	2	9	11	35
Winter[2]	Average	27	1,260	29	15	16	28	44
	Maximum		4,520	51	63	65	70	84
	Minimum		80	18	0	3	6	23
Emory River - Station Em 7.3 - below Harriman, Tenn.								
1937	August	2	280	86	17	62	41	103
	September	5	40	171	34	119	86	205
	October	3	160	85	30	64	51	115
	November	3	100	102	26	68	60	128
	December	3	560	75	33	57	51	108
1938	January	3	1,050	28	17	25	20	45
	February	2	1,280	31	9	16	24	40
	March	5	2,000	26	41	31	36	67
	April	4	1,770	34	4	12	26	38
	May	4	2,140	23	34	23	34	57
	June	4	650	44	18	20	42	62
	July	3	1,790	52	88	35	105	140
	August	2	5,760	38	104	34	108	142
Summer[1]	Average	16	1,180	97	47	68	76	144
	Maximum		10,000	344	228	214	224	356
	Minimum		8	31	2	12	28	53
Winter[2]	Average	27	1,300	44	25	32	37	69
	Maximum		4,120	152	90	157	71	196
	Minimum		85	17	0	3	9	30

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 39 (Continued)

CLINCH RIVER

SOLIDS

Clinch River - Station Cl 1.2 - Kingston, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Solids - Parts per Million				
				Dissolved	Suspended	Volatile	Fixed	Total
1937	August	2	2,080	124	66	69	121	190
	September	5	3,800	99	39	54	84	138
	October	3	5,460	110	43	57	96	153
	November	3	14,500	120	42	72	90	162
	December	3	6,930	118	34	71	81	152
1938	January	3	4,200	79	12	44	47	91
	February	2	2,030	54	12	22	44	66
	March	5	3,900	61	79	46	94	140
	April	4	3,430	67	11	24	54	78
	May	4	4,530	59	116	31	144	175
	June	4	4,960	114	30	69	75	144
	July	3	4,830	109	36	41	104	145
	August	2	14,000	100	39	40	99	139
Summer[1]	Average	16	5,050	109	41	57	93	150
	Maximum		16,600	131	100	112	154	231
	Minimum		660	67	4	19	51	107
Winter[2]	Average	27	5,680	81	48	45	84	129
	Maximum		16,600	129	387	116	401	469
	Minimum		1,560	40	3	9	33	55

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 40

CLINCH RIVER

NITROGENS

Emory River - Station Em 18.3 - Oakdale, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Nitrogen - Parts per Million				
					Organic	Free Ammonia	Nitrite	Nitrate	Total
1938	April	3	1,970	15.2	0.18	0.005	T	0.15	0.34
	May	4	2,140	18.8	.25	.000	0.001	.11	.36
	June	4	600	22.1	.47	.006	T	.13	.61
	July	3	1,690	23.8	.37	.000	.001	.24	.61
	August	2	5,070	24.5	.46	.000	.001	.03	.49
	Average	16	2,000	20.6	0.34	0.002	0.001	0.14	0.48
	Maximum		9,490	27.0	1.26	.016	.004	.40	1.39
	Minimum		318	11.0	.10	.000	.000	T	.10
Emory River - Station Em 7.3 - below Harriman, Tenn.									
1938	April	3	2,090	16.0	0.27	0.011	0.002	0.13	0.41
	May	4	2,140	19.4	.27	.000	.001	.09	.36
	June	4	650	24.2	.34	.008	.001	.14	.49
	July	3	1,790	25.8	.40	.000	.003	.19	.59
	August	2	5,760	25.0	.41	.000	.001	.05	.46
	Average	16	2,140	21.9	0.33	0.004	0.001	0.12	0.45
	Maximum		10,000	27.5	.80	.024	.005	.32	.96
	Minimum		340	11.5	.10	.000	.000	.04	.18
Clinch River - Station Cl 1.2 - Kingston, Tenn.									
1938	April	3	4,050	16.1	0.30	0.011	0.001	0.31	0.62
	May	4	4,530	19.8	.35	.000	.002	.23	.58
	June	4	4,960	18.5	.26	.004	.002	.28	.54
	July	3	4,830	19.5	.25	.000	.004	.61	.86
	August	2	13,990	18.6	.23	.000	.001	.54	.77
	Average	16	5,790	18.6	0.29	0.003	0.002	0.37	0.66
	Maximum		16,650	21.5	.80	.016	.005	.88	1.28
	Minimum		1,900	12.7	.10	.000	.000	.06	.28

TABLE 41

CLINCH RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

	Station		
	Po 65.4 (1)	Cl 59.9 (2)	Cl 58.1 (3)
Year	1936	1937	1937
Month	April	May	May
Number of Times Sampled	1	17	17
Discharge cfs	1,030	206	208
Water Temperature °C	14.5	21.4	21.6
Dissolved Oxygen			
Parts per Million	9.40	7.37	7.38
Percent Saturation	91.6	82.5	83.1
5-Day Oxygen Demand 20°C ppm	1.3	.96	1.4
1000 Lb. per Day			
Dissolved Oxygen	52.28	8.20	8.29
5-Day Oxygen Demand	7.23	1.07	1.57

(1) Powell River - near Arthur, Tenn.
(2) Clinch River - above Clinton, Tenn.
(3) Clinch River - below Clinton, Tenn.

TABLE 41 (Continued)

CLINCH RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

Emory River - Station Em 18.3 - Oakdale, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Dissolved Oxygen ppm	Dissolved Oxygen % Saturation	5-Day Oxygen Demand 20°C ppm	1000 Lb. per Day Dissolved Oxygen	1000 Lb. per Day 5-Day Oxygen Demand
1937	August	2	260	27.0	6.80	84.2	1.19	9.55	1.67
	September	5	40	24.8	7.52	89.4	.57	1.62	.12
	October	3	150	16.3	9.33	94.4	.96	7.56	.78
	November	3	100	7.2	11.73	96.8	.55	6.33	.30
	December	3	510	3.8	12.50	94.7	.86	34.42	2.37
1938	January	3	990	4.7	11.90	92.2	.25	63.62	1.34
	February	2	1,220	9.8	10.80	95.0	.50	71.15	3.29
	March	5	1,940	12.0	10.44	96.3	.47	109.37	4.92
	April	4	1,660	14.9	9.65	95.0	.37	86.50	3.32
	May	4	2,140	18.8	8.50	90.5	.58	98.23	6.70
	June	4	600	22.1	7.82	88.8	.52	25.34	1.68
	July	3	1,690	23.8	7.10	82.9	.69	64.79	6.30
	August	2	5,070	24.5	7.30	86.4	.94	199.86	25.74
Summer[1]	Average	16	1,060	23.7	7.47	86.3	0.76	42.76	4.35
	Maximum		9,490	28.5	9.40	95.5	1.50	-	-
	Minimum		7	16.0	6.40	78.1	.38	-	-
Winter[2]	Average	27	1,260	11.7	10.52	94.4	0.52	71.58	3.54
	Maximum		4,520	23.0	13.50	98.6	1.13	-	-
	Minimum		80	1.0	7.95	85.4	.12	-	-
Emory River - Station Em 7.3 - below Harriman, Tenn.									
1937	August	2	280	28.2	2.55	32.4	6.70	3.86	10.13
	September	5	40	26.4	.86	10.5	19.59	.19	4.23
	October	3	160	17.8	4.33	45.3	9.48	3.74	8.19
	November	3	100	9.2	5.90	51.1	9.32	3.19	5.03
	December	3	560	5.0	10.10	78.8	6.14	30.54	18.57
1938	January	3	1,060	5.3	11.60	91.4	2.05	66.40	11.73
	February	2	1,280	10.0	10.05	88.5	1.04	69.47	7.19
	March	5	2,000	12.7	9.94	93.3	1.25	107.35	13.50
	April	4	1,770	15.5	9.02	89.7	1.13	86.21	10.80
	May	4	2,140	19.4	8.20	88.3	.70	94.76	8.09
	June	4	650	24.2	6.32	74.4	4.40	22.18	15.44
	July	3	1,790	25.8	5.67	68.8	1.94	54.81	18.75
	August	2	5,760	25.0	6.35	75.8	5.52	197.51	171.69
Summer[1]	Average	16	1,180	25.4	3.42	41.3	7.42	21.79	47.28
	Maximum		10,000	30.0	7.30	83.5	48.75	-	-
	Minimum		8	18.0	.00	.0	.44	-	-
Winter[2]	Average	27	1,300	12.6	9.22	85.5	2.17	64.72	15.23
	Maximum		4,120	24.0	12.10	99.2	14.36	-	-
	Minimum		85	1.5	4.30	37.1	.30	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 41 (Continued)

CLINCH RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

Clinch River - Station Cl 1.2 - Kingston, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Dissolved Oxygen		5-Day Oxygen Demand 20°C ppm	1000 Lb. per Day	
					ppm	% Saturation		Dissolved Oxygen	5-Day Oxygen Demand
1937	August	2	2,080	22.0	6.02	68.3	3.49	67.62	39.20
	September	5	3,800	21.9	8.09	91.3	1.11	166.01	22.78
	October	3	5,460	13.9	9.15	88.1	1.38	269.78	40.69
	November	3	14,500	12.7	10.00	93.8	1.11	784.62	87.09
	December	3	6,930	6.9	11.13	91.2	1.27	416.51	47.53
1938	January	3	4,200	6.0	11.32	91.0	.81	256.74	18.37
	February	2	2,030	10.2	10.24	91.0	.74	112.25	8.11
	March	5	3,900	12.7	9.41	88.4	1.15	198.17	24.22
	April	4	3,430	15.6	8.82	87.8	.99	163.36	18.34
	May	4	4,530	19.8	7.84	85.0	.93	191.78	22.75
	June	4	4,960	18.5	8.41	89.1	1.04	225.25	27.86
	July	3	4,830	19.5	7.69	83.0	1.65	200.57	43.04
	August	2	14,000	18.6	8.28	87.8	1.73	625.52	130.69
Summer[1]	Average	16	5,050	19.6	8.63	85.5	1.36	235.34	37.09
	Maximum		16,600	26.5	10.10	97.4	5.82	-	-
	Minimum		660	13.5	4.53	48.0	.58	-	-
Winter[2]	Average	27	5,680	13.0	9.59	89.3	0.98	294.14	30.06
	Maximum		16,600	21.5	11.67	97.1	2.16	-	-
	Minimum		1,560	3.8	7.22	78.6	.52	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 42

CLINCH RIVER

BACTERIA

	Station		
	Po 65.4 (1)	Cl 59.9 (2)	Cl 58.1 (3)
Year	1936	1937	1937
Month	April	May	May
Number Times Sampled	1	17	17
Discharge cfs	1,030	206	208
Water Temperature °C	14.5	21.4	21.6
Bacteria per Milliliter			
On Agar 37°C for 24 hours	74	160	800
Coliform Group M.P.N.	0.4	7.8	90
Bacteria, Quantity Units			
On Agar 37°C for 24 hours	76	33	166
Coliform Group M.P.N.	0.4	1.6	19

(1) Powell River - near Arthur, Tenn.
(2) Clinch River - above Clinton, Tenn.
(3) Clinch River - below Clinton, Tenn.

TABLE 42 (Continued)

CLINCH RIVER

BACTERIA

Emory River - Station Em 18.3 - Oakdale, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Bacteria Per Milliliter		Quantity Units (Bacteria x 1000 cfs)	
					On Agar 37°C for 24 Hours	Coliform Group M.P.N.	On Agar 37°C for 24 Hours	Coliform Group M.P.N.
1937	August	2	260	27.0	650	38	169	9.9
	September	5	40	24.8	400	26	16	1.0
	October	3	150	16.3	130	13	20	2.0
	November	3	100	7.2	17	4.1	1.7	0.4
	December	3	510	3.8	55	12	28	6.1
1938	January	3	990	4.7	7.8	0.2	7.7	0.2
	February	2	1,220	9.8	50	2.2	61	2.7
	March	5	1,940	12.0	85	6.2	165	12
	April	4	1,660	14.9	17	1.5	28	2.5
	May	4	2,140	18.8	140	11	300	24
	June	4	600	22.1	75	20	45	12
	July	3	1,690	23.8	600	29	1,014	49
	August	2	5,070	24.5	650	29	3,296	147
Summer[1]	Average	16	1,060	23.7	400	28	424	30
	Maximum		9,490	28.5	4,100	240	-	-
	Minimum		7	16.0	85	3.6	-	-
Winter[2]	Average	27	1,260	11.7	38	3.7	48	4.7
	Maximum		2,820	23.0	450	70	-	-
	Minimum		80	1.0	3	0.1	-	-
Emory River - Station Em 7.3 - below Harriman, Tenn.								
1937	August	2	280	28.2	4,100	120	1,148	34
	September	5	40	26.4	34,500	425	1,380	17
	October	3	160	17.8	21,500	325	3,440	52
	November	3	100	9.2	1,500	150	150	15
	December	3	560	5.0	650	140	364	78
1938	January	3	1,060	5.3	550	26	583	28
	February	2	1,280	10.0	375	46	480	59
	March	5	2,000	12.7	600	55	1,200	110
	April	4	1,770	15.5	300	25	531	44
	May	4	2,140	19.4	950	85	2,033	182
	June	4	650	24.2	2,000	210	1,300	136
	July	3	1,790	25.8	4,100	170	7,339	304
	August	2	5,760	25.0	3,400	190	19,584	1,094
Summer[1]	Average	16	1,180	25.4	12,000	250	14,160	295
	Maximum		10,000	30.0	110,000	7,000	-	-
	Minimum		8	18.0	2,200	23	-	-
Winter[2]	Average	27	1,300	12.6	650	70	845	91
	Maximum		4,120	24.0	3,200	350	-	-
	Minimum		85	1.5	30	11	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 42 (Continued)

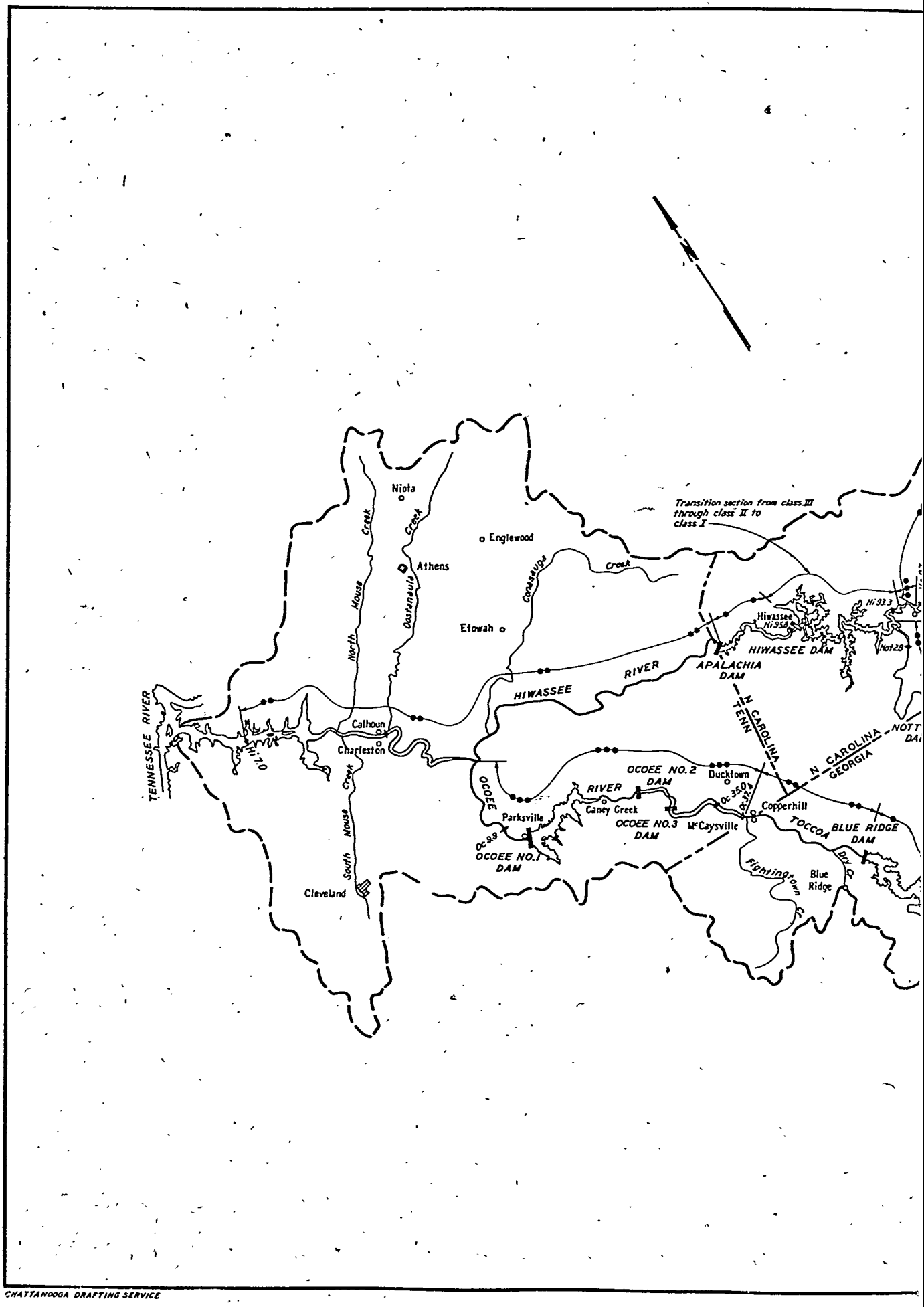
CLINCH RIVER

BACTERIA

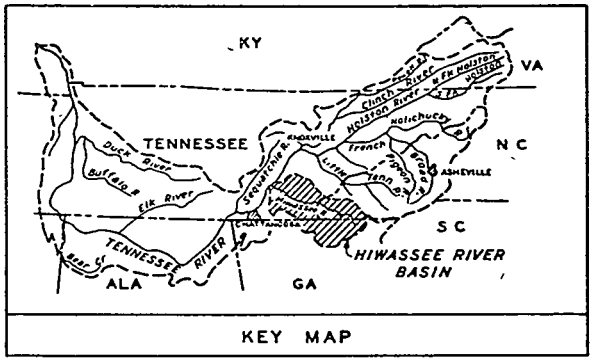
Clinch River - Station Cl 1.2 - Kingston, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Bacteria per Milliliter		Quantity Units (Bacteria x 1000 cfs)	
					On Agar 37°C for 24 Hours	Coliform Group M.P.N.	On Agar 37°C for 24 Hours	Coliform Group M.P.N.
1937	August	2	2,080	22.0	600	65	1,248	135
	September	5	3,800	21.9	700	9.2	2,660	35
	October	3	5,460	13.9	300	17	1,638	93
	November	3	14,500	12.7	85	5.1	1,232	74
	December	3	6,930	6.9	48	2.5	333	17
1938	January	3	4,200	6.0	75	14	315	59
	February	2	2,030	10.2	110	21	223	43
	March	5	3,900	12.7	600	30	2,340	117
	April	4	3,430	15.6	250	38	858	130
	May	4	4,530	19.8	700	60	3,171	272
	June	4	4,960	18.5	850	65	4,216	322
	July	3	4,830	19.5	1,600	80	7,728	386
	August	2	14,000	18.6	3,100	90	43,400	1,260
Summer[1]	Average	16	5,050	19.6	950	34	4,798	172
	Maximum		16,650	26.5	14,500	700	-	-
	Minimum		660	13.5	95	1.8	-	-
Winter[2]	Average	27	5,680	13.0	210	19	1,193	108
	Maximum		16,600	21.5	3,300	475	-	-
	Minimum		1,560	3.8	15	0.8	-	-

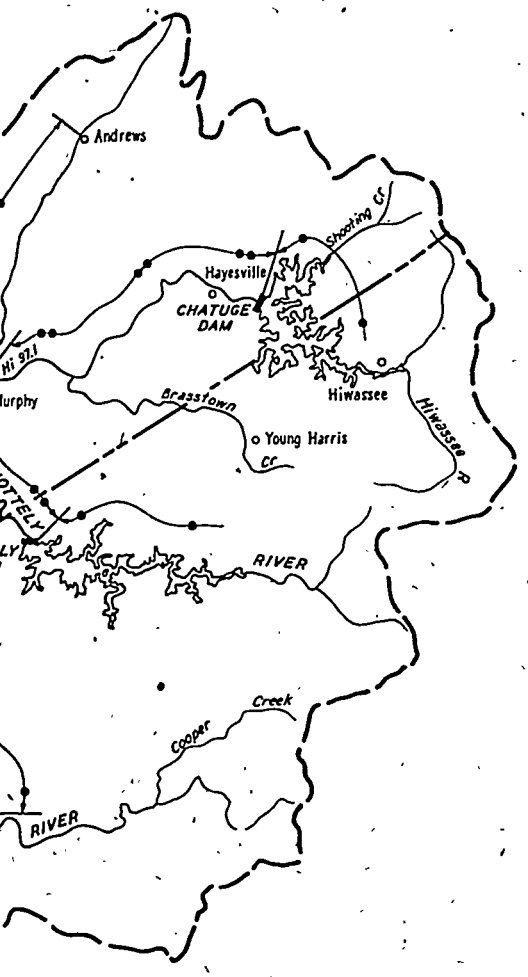
1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.



CHATTANOOGA DRAFTING SERVICE



KEY MAP



SYMBOLS:

- *Class I – Class A swimming areas and water supplies with minimum treatment.*
- *Class II – Class B and C swimming areas and water supplies (normal filter plant operation).*
- *Class III – Water supplies (advanced treatment methods) and fish life.*
- *Class IV – Unsuitable for water supplies as defined under Class III or which do not support desirable fish fauna.*
- *Sampling stations*

Figure 12

Scale 5 0 5 Miles

POLLUTION SURVEY

HIWASSEE RIVER DRAINAGE BASIN

STREAM SANITATION PROGRAM
TENNESSEE VALLEY AUTHORITY
HEALTH AND SAFETY DEPARTMENT

SUBMITTED	RECOMMENDED	APPROVED

CHATTANOOGA	10-12-43	G	HS	306B510 R1

SECTION V

HIWASSEE RIVER

SECTION V

HIWASSEE RIVER

General

The Hiwassee River, figure 12, drains a basin roughly rectangular in shape, lying south of the Little Tennessee River drainage basin and extending from the northern part of Georgia to the Tennessee River at mile 499.4. It has two large tributaries, the Nottely River and the Ocoee River. The drainage basin is fifth in order of the seven large tributaries and has an area of 2,700 square miles. The areas of the tributaries are as follows:

Nottely River	287 square miles
Ocoee River	639 square miles
Remainder of basin	1,774 square miles

The area is principally mountainous with agriculture as the chief industry in the valleys and uplands. Extensive copper mining and refining operations are carried on in a section of the Ocoee River watershed.

The streams are turbulent and flow rapidly over rocky bottoms with steep gradients. There are six hydroelectric plants and two storage reservoirs on the main river and its tributaries.

Geology

The lower end of the drainage basin lies in the Great Valley, while the upper section is in the Blue Ridge region. The geology of the Great Valley has been described under the Holston River, and the Blue Ridge region has been discussed under the French Broad River.

Precipitation

The annual precipitation varies from 45 inches to 78 inches. The average for the entire area is approximately 56 inches a year.

Stream Flows

The average monthly discharges at two points on the Hiwassee River and at one point on the Ocoee River are shown in table 43. The discharges in both streams are now controlled by the operation of hydroelectric plants.

TABLE 43

MEAN MONTHLY DISCHARGES IN CUBIC FEET PER SECOND

AT DESIGNATED POINTS ON HIWASSEE RIVER

	Hiwassee River Murphy, N. C.[1]	Hiwassee River Charleston, Tenn.[2]	Ocoee River Parksville, Tenn.[2]
Drainage Area Above Gage Sq. Mi.	421	2,298	595
Period of Record	1920-1934	1920-1934	1921-1934
January cfs	1,240	6,090	1,550
February cfs	1,260	6,560	1,520
March cfs	1,481	7,840	1,710
April cfs	1,290	7,020	1,720
May cfs	1,140	5,930	1,680
June cfs	794	4,090	1,240
July cfs	628	3,460	1,130
August cfs	582	3,260	890
September cfs	492	2,750	937
October cfs	402	2,050	771
November cfs	604	3,170	1,030
December cfs	1,130	5,170	1,220
Mean Annual cfs	921	4,750	1,280
Maximum Flow cfs	23,100	55,800	19,000
Minimum Flow cfs	10	260	6

1. Uncontrolled discharge.
2. Controlled by operation of hydroelectric plants on the Ocoee River.

Water Supplies

There are 22 municipal water supplies in the valley. Five of these supplies have filter plants, ten supplies are chlorinated, and seven have no treatment, table 44.

TABLE 44

WATER SUPPLIES

HIWASSEE RIVER BASIN, 1937-1940

Municipality	Population	Source	Treatment[1]
Hiwassee, Ga.	163	Spring	N
Hayesville, N. C.	336	Springs	D
Young Harris, Ga.	820	Springs	N
Cherokee County State Prison Camp	100	Well	N
Murphy, N. C.	5,000	(Marble Creek	D
		(Hiwassee River	CFD
Andrews, N. C.	2,500	Beaver Creek	D
Hiwassee Dam, N. C.	600	Hiwassee River	CFD
Etowah, Tenn.	3,362	(Well	N
		(Spring	D
Blue Ridge Dam, Ga.	20	Spring	D
Blue Ridge, Ga.	1,300	Spring Branch	CFD
McCaysville, Ga.	1,832	Copperhill	
Copperhill, Tenn.	1,005	Springs	N
Ducktown, Tenn.	1,526	Springs	N
Caney Creek, Tenn.	40	Big Creek	FD
Parksville, Tenn.	40	Spring	D
Englewood, Tenn.	1,342	Wells	D
Athens, Tenn.	6,930	Springs	CFD
Calhoun, Tenn.	275	Well	N
Charleston, Tenn.	480	Well	D
Cleveland, Tenn.	11,351	Spring	D
Niota, Tenn.	623	Spring and Well	D

1. N = No Treatment
   C = Coagulation and Sedimentation
   D = Disinfection
   F = Filtration

Sources of Pollution

Population Estimates

The population in the drainage basin as given by the 1940 United States Census is 129,432. The basin is fifth in size with regard to population, as well as being fifth with respect to area.

Sewerage Systems

Table 45 shows the sewerage systems in the basin. There are 15 systems, six of which have some form of treatment. The total effect of this treatment is to reduce the amount of pollution by domestic sewage 28.6 percent.

TABLE 45

SEWERAGE SYSTEMS

HIWASSEE RIVER BASIN, 1937-1940

Municipality	Population (1940 U.S. Census)		Treatment
	Total	Sewered	
Hayesville, N. C.	336	100	None
Young Harris, Ga.	820[a]	500	None
Cherokee County State Prison Camp	100	100	Septic Tank - Sand Filters Chlorination
Murphy, N. C.	5,000[b]	2,900	None
Andrews, N. C.	2,500[b]	2,400	None
Hiwassee Dam, N. C.	600	600	Septic Tank
Etowah, Tenn.	3,362	2,600	Imhoff Tank
Blue Ridge Dam, Ga.	20	20	Septic Tank
Blue Ridge, Ga.	1,300[c]	450	None
McCaysville, Ga.	1,832	200	Septic Tank
Copperhill, Tenn.	1,005	1,000	None
Caney Creek, Tenn.	40	40	None
Parksville, Tenn.	40	40	None
Athens, Tenn.	6,930	5,700	None
Cleveland, Tenn.	11,351	7,000	Imhoff Tank - Sprinkling Filters
Total	35,236	23,650	

a. Includes Young Harris College
b. Summer population
c. That portion of Blue Ridge draining into Tennessee River system

Industrial Plants

The industrial plants in the basin are shown in table 46. While 6.8 percent of the industries in the Tennessee Valley are located in the Hiwassee River drainage basin, these industries are responsible for only 0.7 percent of the industrial organic pollution.

TABLE 46

INDUSTRIAL POLLUTION

HIWASSEE RIVER BASIN, 1937-1940

Types of Industry	Number of Plants		Method of Disposal			Estimated Population Equivalents	
	Hiwassee River Basin	Percent of Total in Tenn. Valley	Municipal Sewers	Stream	Some Correction	Hiwassee River Basin	Percent of Total in Tenn. Valley
Canning	1	3.7	1	0	0	400	1.0
Chemical	4	15.4	0	4	1	2,200	8.2
Meat	1	5.3	0	1	0	600	1.5
Milk	1	2.9	0	1	1	50	.4
Mining[1]	1	10.0	0	1	0	-	-
Textiles	8	9.4	1	7	0	6,050	4.2
Miscellaneous[2]	1	4.0	0	1	0	-	-
Total	17	6.8	2	15	2	9,300	0.7

1. Copper mines discharging acid drainage.
2. Stove plant discharging 150 gpd acid pickle liquor.

Extent of Pollution

The estimated amounts of pollution due to domestic sewage and industrial wastes which reach the streams in the valley are shown in table 47. The same information is shown graphically in figure 13. This information does not take into consideration the effects of the wastes from the mining and refining operations at Copperhill, Tenn., on the Ocoee River, since the effects of these wastes are chemical and cannot be expressed in terms of population equivalents. A large amount of silt, resulting from erosion of the denuded area around Copperhill and Ducktown, is carried by the Ocoee River. Since this silt settles out in Parksville Reservoir, the concentrations are not indicated by the results obtained on the samples collected below Ocoee Dam No. 1.

TABLE 47

ESTIMATED POPULATION EQUIVALENT OF POLLUTION

REACHING HIWASSEE RIVER SYSTEM, 1937-1940

Municipality	Receiving Stream	Estimated Population Equivalents		
		Domestic Sewage	Industrial Wastes	Total
Hayesville, N. C.	Hiwassee River	100	-	100
Young Harris, Ga.	Brasstown Creek	500	-	500
Cherokee County State Prison Camp	Hiwassee River	10	-	10
Murphy, N. C.	Hiwassee River	2,900	450	3,350
Andrews, N. C.	Valley River	2,400	2,100	4,500
Hiwassee Dam, N. C.	Hiwassee River	480	-	480
Etowah, Tenn.	Cane Creek	1,700	-	1,700
Blue Ridge Dam, Ga.	Toccoa River	20	-	20
Blue Ridge, Ga.	Dry Creek	450	-	450
McCaysville, Ga.	Toccoa River	160	-	160
Copperhill, Tenn.	Ocoee River	1,000	-	1,000
Caney Creek, Tenn.	Ocoee River	40	-	40
Parksville, Tenn.	Ocoee River	40	-	40
Athens, Tenn.	Oostanaula Creek	5,700	600	6,300
Charleston, Tenn.	Hiwassee River	-	600	600
Cleveland, Tenn.	S. Mouse Creek	1,400	5,300	6,700
Niota, Tenn.	N. Mouse Creek	-	200	200
Total		16,900	9,250	26,150

Sampling and Sampling Stations

Sampling

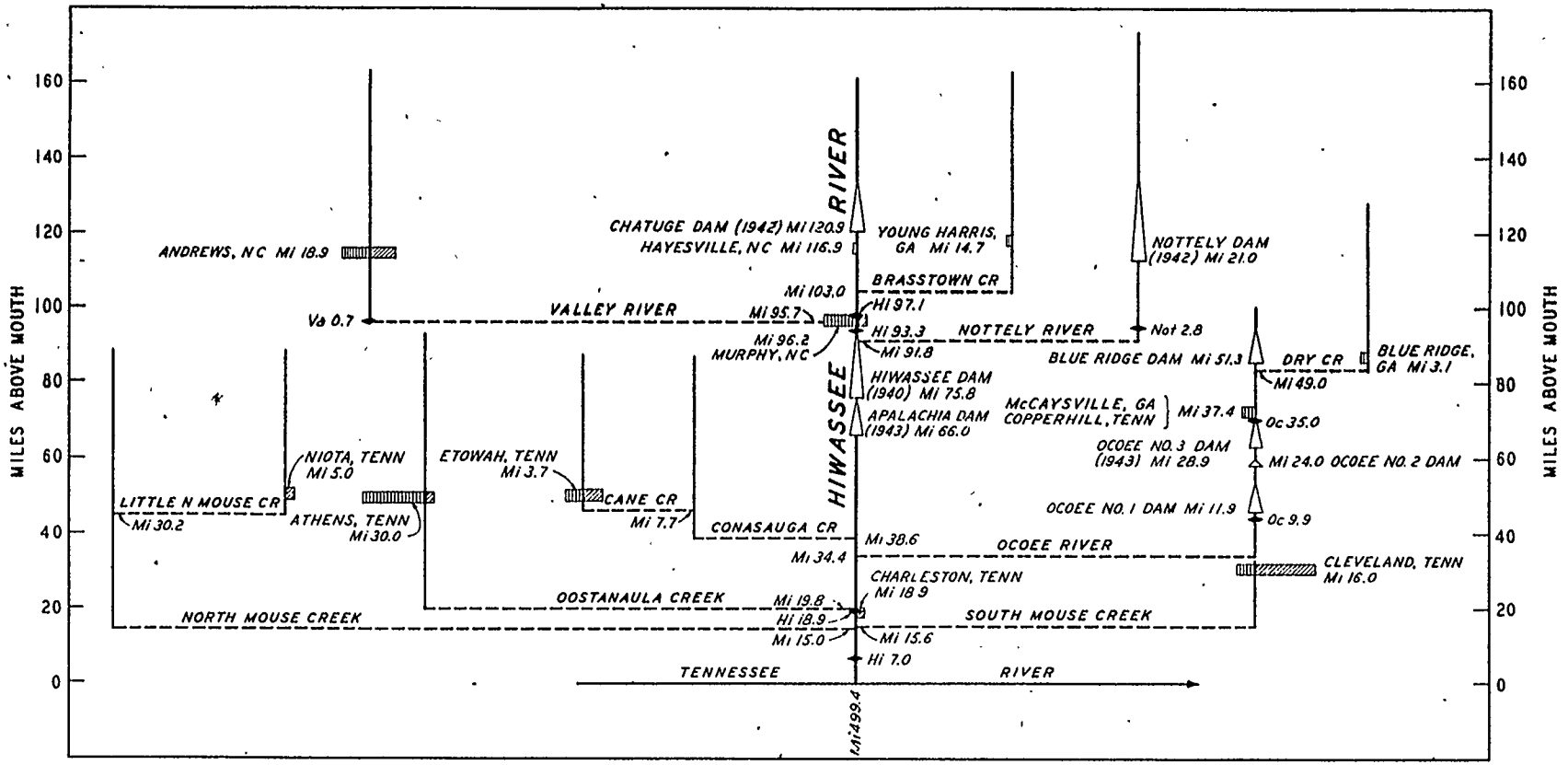
No extensive routine studies have been made of the Hiwassee River and its tributaries. Special studies covering a period of one week were made on the Hiwassee River at Murphy, N.C., and of the Valley River below Andrews, N. C. Bacteriological results obtained in the routine examination of the water supplies for Hiwassee Village throughout 1942 have been tabulated to illustrate the condition of the lower end of Hiwassee Lake.

The mineral constituents of the water in the Ocoee River are shown by the results of analyses of a number of samples collected at infrequent intervals. The character of the water in the Nottely River is shown by the results of analyses by the North Carolina Department of Conservation and Development.

Sampling Stations

The sampling stations and their locations were:

Hiwassee River, Hi 97.1:	Above Murphy, N. C.
Valley River, Va 0.7:	Bridge on U.S. Highway No. 19, near mouth Valley River at Murphy, N. C.
Hiwassee River, Hi 93.3:	Below the mouth of Valley River at Murphy, N. C.
Nottely River, Not 2.8:	Above King Creek.
Hiwassee River, Hi 75.8:	Hiwassee Dam.
Ocoee River, Oc 37.4:	Bridge at Copperhill, Tenn.
Ocoee River, Oc 35.0:	Rogers Bridge below Copperhill, Tenn.
Ocoee River, Oc 9.9:	Bridge on U.S. Highway No. 64, below Ocoee Dam No. 1.
Hiwassee River, Hi 18.9:	Old bridge on U.S. Highway No. 11 at Charleston.
Hiwassee River, Hi 7.0:	Russells Bridge on State Highway No. 58.



SYMBOLS:

Sampling station

Population equivalent:
Domestic sewage
Industrial waste

Dam and reservoir

Scale of population equivalent

0 10,000

NOTE:
Number at sampling station denotes miles above mouth of each stream

Figure 13

HIWASSEE RIVER SOURCES OF POLLUTION AND SAMPLING STATIONS

Discussion of Results

The examinations of the seven samples collected from the Hiwassee River immediately above Murphy, N. C., indicate that the coliform group are present in such unusually high numbers that on this criterion alone the stream falls in Class IV. On the other hand, the dissolved oxygen is high and the 5-day B.O.D. is low, indicating Class II conditions. Because of the absence of any great amount of pollution entering the Hiwassee River above Murphy, it seems logical that the stream in this section meets the requirements of Class II.

The Valley River near its mouth, with the exception of the high densities of the coliform group, meets the requirements for Class II streams. However, since the studies were made when the stream flow was about three times the normal flow and since this stream receives industrial wastes from Andrews, N. C., which make this water difficult to treat for a municipal water supply, the stream is considered as Class IV from Andrews to its mouth. The studies which were made on the Hiwassee River near Murphy were carried out before the completion of Hiwassee Dam, and for this reason the results at Hi 93.3 a few miles below the upper end of Hiwassee Reservoir do not indicate present conditions. Even though the results indicate that the pollution carried by the Valley River or that due to domestic sewage from Murphy has very little effect upon the Hiwassee River, it is assumed that Class III conditions exist in the immediate vicinity of Murphy with Class II conditions developing as sedimentation and natural purification agencies reduce the pollution in the upper end of the lake.

The results of the bacteriological examinations of the samples collected from the water supply at Hiwassee Dam indicate that Class I conditions are reached by the time the water reacnes the dam.

No sanitary studies were made of the Nottely River; but since the stream receives only surface wash and no domestic sewage or industrial wastes, it is logical to assume that the major portion of Nottely Reservoir is Class I and that the stream below Nottely Dam meets the requirements for Class II streams.

Below Hiwassee Dam the river immediately enters the newly formed Apalachia Reservoir after receiving a small amount of domestic sewage from Hiwassee Village; but the effect of this pollution should not materially degrade the stream. It is expected that Class I conditions exist throughout the major portion of Apalachia Reservoir.

Below Apalachia Dam the river flows through rugged, comparatively uninhabited country receiving no major side drainage until it reaches Conasauga Creek, which carries a small amount of domestic sewage from Etowah, Tenn.

The Ocoee River above Blue Ridge Dam should meet the requirements of Class I streams since it receives no pollution other than surface wash. Below Blue Ridge Dam it receives a small amount of domestic sewage which, with surface wash, causes Class II conditions in the stream until the Copperhill area is reached. Here the stream receives a small amount of domestic sewage and a considerable amount of acid industrial wastes. A comparison of mineral analyses of samples collected at Oc 37.4 and Oc 35.0 indicate the effects of these industrial wastes upon the stream. At the time these samples were collected the amount of acid being discharged was not as large as amounts which have been discharged at other periods, as the pH at Oc 35.0 is not much lower than at Oc 37.4. Samples have been collected below this station from Parksville Reservoir indicating hydrogen-ion concentrations as low as 4.2 as contrasted with 6.4, which was found at Oc 35.0 in October 1940. Because of these acid wastes it is estimated that the effect of pollution added at Copperhill, Tenn., is to create Class III conditions in the stream. It might also be considered that Class IV conditions exist at times in the stream when measured by the effects of these wastes upon fish life.

The acid wastes are neutralized to a great extent when the Ocoee River empties into the Hiwassee River. Class II conditions are expected throughout the Hiwassee River from Apalachia Dam to some point below Hi 7.0. At Charleston at Hi 18.9 the stream receives a small amount of industrial wastes from a packing plant and the pollution from Athens, Tenn., carried by Oostanaula Creek. This pollution, however, does not cause the density of the coliform group to increase sufficiently to degrade the

stream to Class III conditions. However, this pollution, with that received from Cleveland, Tenn., by way of South Mouse Creek at mile 15.6, prevents this arm of Chickamauga Lake from recovering to Class I conditions at Hi 7.0. Studies of this arm of the lake in 1940 indicated Class II conditions with respect to coliform organisms. In fact the water met the requirements for Class B swimming areas (appendix I).

These classifications are shown on the map in figure 12.

Effects of Pollution

No water supplies are affected by the pollution in the Hiwassee River system. The most serious effects of pollution are the silting up of the reservoirs on the Ocoee River by silt eroded from the Ducktown and Copperhill area, and the unfavorable conditions for fish life and the possible corrosion of hydroelectric installations caused by the industrial wastes from Copperhill, Tenn.

TABLE 48

HIWASSEE RIVER

MINERAL ANALYSES AND SOLIDS

		Station					
		Hi 97.1 (1)	Va 0.7 (2)	Not 2.8 (3)	Oc 37.4 (4)	Oc 35.0 (5)	Oc 9.9 (6)
Year		1938	1938	1927	1940	1940	1938 & 1940
Month		August	August	August	October	October	Aug. & Feb.
Number Times Sampled		7*	7*	1	1	1	6*
Discharge cfs		1,520	432	-	1,940	1,940	-
Fe (Unfiltered)	ppm	2.02	0.59	0.2**	4.2	33.5	0.6
SiO_2	ppm	8	8	9.4	10	17	7
Ca	ppm	1.8	2.4	3.4	3.5	19.6	6.0
Mg	ppm	.6	.7	1.1	3.8	12.2	2.5
Na	ppm	2.4	2.5	3.2	-	-	2.2
SO_4	ppm	.9	1.2	2.0	14.2	67.4	20.8
Cl	ppm	2	3	2.1	-	-	3
F	ppm	.08	.07	-	-	-	.30
Alkalinity as $CaCO_3$	ppm	8	10	15	12	12	4
Total Hardness as $CaCO_3$	ppm	7	9	13	24	99	25
Phenol	ppm	.009	.012	-	-	-	-
pH		-	-	-	6.7	6.4	6.4
Color	ppm	22	14	15	-	-	10
Tannins	ppm	.00	.35	-	-	-	-
Solids							
Dissolved	ppm	22	21	39.8	28	49	46
Suspended	ppm	80	29	30	32	58	7
Volatile	ppm	82	34	-	4	12	9
Fixed	ppm	20	16	-	56	95	44
Total	ppm	102	50	69.8	60	107	53

(1) Hiwassee River - above Murphy, N. C.
(2) Valley River - above Murphy, N. C.
(3) Nottely River - above mouth of Crane Creek near Murphy, N. C.
Economic Paper Number 61, Chemical Quality of the Surface Waters of North Carolina with Relation to Industrial Use, North Carolina Department of Conservation and Development, pp. 30-31.
(4) Ocoee River - Bridge at Copperhill, Tenn.
(5) Ocoee River - below Copperhill, Tenn.
(6) Ocoee River - below Ocoee Dam No. 1.

*Results shown are averages for the samples which were collected on the number of days corresponding to number of samples.
**Made on filtered sample.

TABLE 49

HIWASSEE RIVER

DISSOLVED OXYGEN, BIOCHEMICAL OXYGEN DEMAND, AND BACTERIA

	Hi 97.1 (1)	Va 0.7 (2)	Hi 93.3 (3)	Hi 18.9 (4)	Hi 7.0 (5)
Year	1938	1938	1938	1940	1940
Month	August	August	August	Summer	Summer
No. Times Sampled	7*	7*	7*	11**	11**
Discharge cfs	1,520	432	1,880	2,190	2,290
Water Temperature °C	23.6	22.2	23.6		
Dissolved Oxygen					
Parts per million	7.39	7.46	7.54		
Percent Saturation	86.0	84.8	87.8		
5-Day Oxygen Demand					
20°C ppm	1.15	1.00	.87		
1000 lb. per Day					
Dissolved Oxygen	60.66	17.40	76.55		
5-Day Oxygen Demand	9.44	2.33	8.83		
Bacteria per Milliliter					
On Agar 37°C for 24 hrs.	4,000	4,000	4,500	-	-
Coliform Group M.P.N.	375	250	300	12	1.8
Bacteria Quantity Units					
On Agar 37°C for 24 hrs.	6,080	1,728	8,460	-	-
Coliform Group M.P.N.	570	108	564	26	4.1

(1) Hiwassee River - above Murphy, N. C.
(2) Valley River - above Murphy, N. C.
(3) Hiwassee River - below Murphy, N. C.
(4) Hiwassee River - above Charleston, Tenn.
(5) Hiwassee River - Bridge State Highway No. 58

*Results shown are averages for the samples which were collected on seven consecutive days.

**Results shown are averages for the eleven samples collected at weekly intervals.

TABLE 50

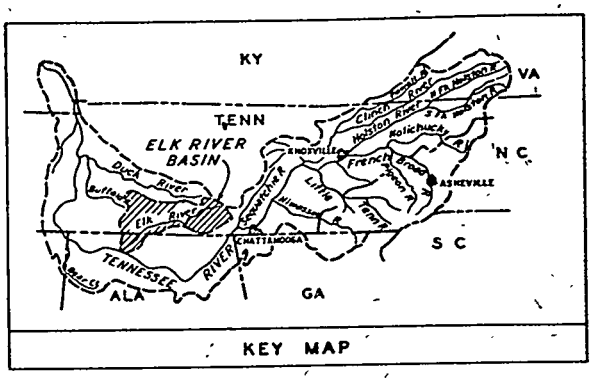
HIWASSEE RIVER

BACTERIA

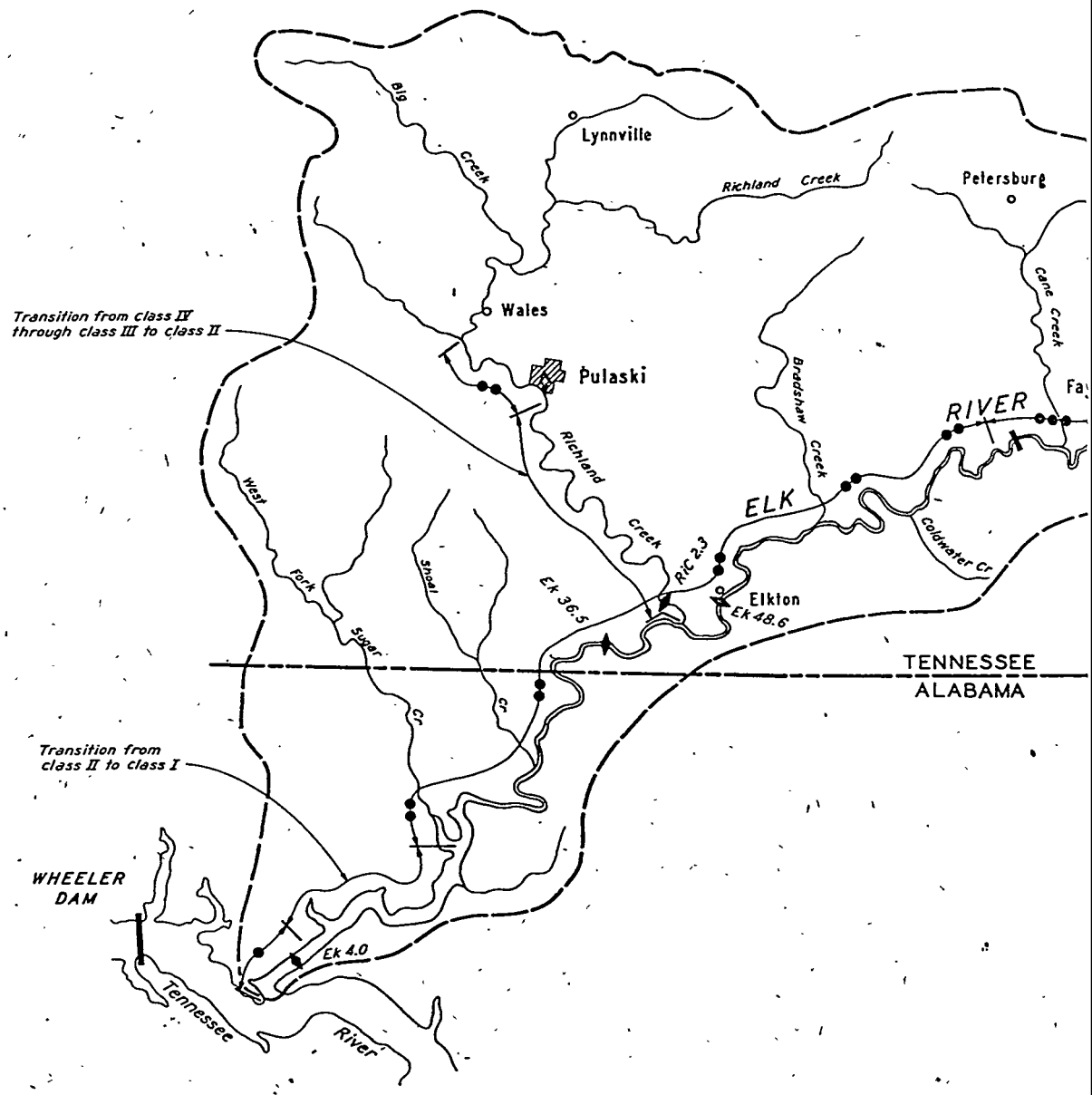
Hiwassee River - Station Hi 75.8 - Hiwassee Dam

Year	Month	No. Times Sampled	Bacteria per Milliliter	
			On Agar 37°C for 24 Hours	Coliform Group M.P.N.
1942	January	3	550	0.2
	February	3	475	0.2
	March	4	300	0.3
	April	3	1,300	0.2
	May	3	1,200	0.3
	June	4	2,600	0.8
	July	3	16,500	1.2
	August	3	650	0.1
	September	3	2,000	0.4
	October	3	1,200	0.4
	November	3	425	0.1
	December	3	350	0.5
Summer[1]	Average	13	2,800	0.5
	Maximum		57,000	6.2
	Minimum		8	0.0
Winter[2]	Average	25	600	0.2
	Maximum		8,800	2.4
	Minimum		4	0.05

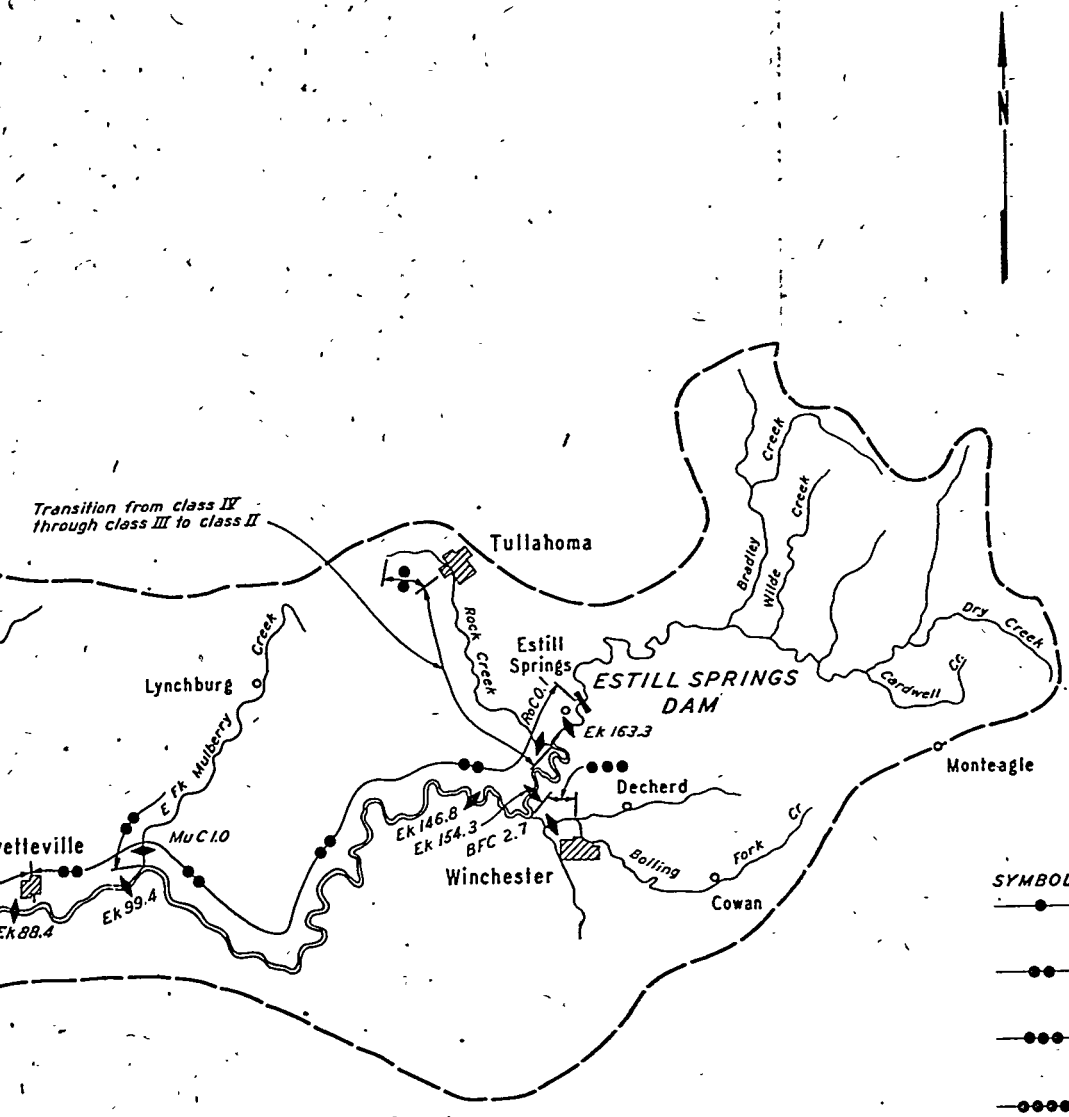
1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.



KEY MAP



CHATTANOOGA DRAFTING SERVICE



SYMBOLS:

- Class I - Class A swimming areas and water supplies with minimum treatment.
- Class II - Class B and C swimming areas and water supplies (normal filter plant operation).
- Class III - Water supplies (advanced treatment methods) and fish life.
- Class IV - Unsuitable for water supplies as defined under class III or which do not support desirable fish fauna.
- Sampling station
- Water supply intake

Figure 14

Scale 4 0 4 8 Miles

POLLUTION SURVEY

ELK RIVER DRAINAGE BASIN

STREAM SANITATION PROGRAM
TENNESSEE VALLEY AUTHORITY
HEALTH AND SAFETY DEPARTMENT

SUBMITTED	RECOMMENDED	APPROVED

CHATTANOOGA | 10-21-43 | G | HS | 306B512 R1

SECTION VI

ELK RIVER

SECTION VI

ELK RIVER

General

The Elk River is the smallest of the seven major tributaries, figure 14. It drains a long, narrow area of 2,249 square miles parallel to the Tennessee-Alabama state line, lying mostly in Tennessee but extending into Alabama at its mouth as it joins the Tennessee River at mile 284.3. The valley is predominantly rural. Pulaski, its largest municipality, has a population of 5,314. Very little manufacturing exists and agriculture is the principal industry. There are a few phosphate ore mines in the northwestern section of the valley. There are two low power dams on the river, one near the upper end at Estill Springs and the other downstream near Fayetteville, Tenn.

Geology

The headwaters in the eastern margin originate in the Cumberland Plateau but soon drop to the Highland Plain. Most of the drainage below these formations comes from the Nashville or Central Basin. The Cumberland Plateau has been discussed in Section III, Clinch River. The Highland Plain and the Nashville Basin have been described as follows:[1]

"Highland Plain

"West of the Cumberland Plateau lies the Highland Plain, which extends westward to Tennessee River. The width of this plain is about 175 miles along the Kentucky line and 105 miles along the Alabama line. Its average elevation is approximately 1,000 feet. Viewed broadly, its surface is level; viewed in detail, it is gently undulating or cut by small streams into narrow but sometimes steep-sided valleys. In a few places the larger rivers, including the Cumberland, Duck, and Elk, have cut steep-walled valleys 300 or 400 feet deep and have eroded out of the very center of the Highland Plain a great oval basin 120 miles long and 50 broad, whose comparatively flat bottom is 300 to 400 feet below the encircling plain. This basin is known as the Nashville or Central Basin and will be discussed in a subsequent paragraph.

---

1. L. C. Glenn, "Tennessee and Kentucky," Underground Waters of Eastern United States, Water Supply and Irrigation Paper No. 114, United States Geological Survey, 1905, pp. 200-202.

"Plateau Region

"Description.--The siliceous beds of the Mississippian form the surface of the Highland Plain. These beds consist of limestones, siliceous shales, and chert. As they form the surface of this plain they have been exposed to the leaching action of the water so long that the calcareous matter has been removed to a considerable depth and the surface is a disintegrated mass of reddish clay and porous chert.

"Water resources.--The waters of the Highland Plain are mostly of the clear freestone type, although some are chalybeate from the iron contained in the chert. Where the lime has not yet been entirely leached from the rocks the waters may be hard. Many springs are found on the Highland, although in numerous areas springs are weak or wanting, or fail during dry seasons. Many of the smaller streams dry up also. In such places deep drilling generally gives a water containing objectionable quantities of calcium and magnesium carbonates and sulphates, hence the main dependence for potable water in such cases must be cisterns, of which many are in use.

"Along the eastern margin of the Highland Plain at the foot of the escarpment which rises to the Cumberland Plateau many very large springs flow from the outcrop of the flat-lying Mississippian limestones underlying the sandstones of the plateau. These limestones receive a considerable part of the drainage which emerges along the edge of the Highland Plain in streams, many of which are large enough to turn a mill where they issue from their underground channels.

"In the portion of the Highland area adjacent to the central basin are many sulphur springs, while on the steep slopes between the two the springs from the outcropping black Devonian shale contain sulphur, iron, and in some cases alum. No extensive area of this slope is made up of black shale, however, as it varies from only a few feet to 20 or 30 feet in thickness. Some of the sulphur and other mineral springs on the Highland and on the slope into the basin have been improved and have considerable reputation as summer resorts.

"Nashville Basin

"Description.--The strata of the central portion of the Highland Plain have been arched into a low oblong dome which Elk, Duck, and Cumberland rivers have eroded until they have cut through the Mississippian and Devonian and into the softer limestones and shales of the Silurian. These have been in turn eroded, resulting in the undermining of the overlying rocks of the Highland Plain and the final formation of a basin of the dimensions already given. The bottom of this basin is flat or gently rolling. It slopes somewhat toward the Cumberland and other main streams and has some isolated knobs that rise to nearly the height of the adjacent Highland, while from the rim spurs project into the basin.

"Water resources.--The Silurian limestones that form the floor of the Nashville basin dip away from its center in all directions, but at such a low angle that they appear nearly flat. Many springs are found in these limestones, some of them being very large. They furnish clear, cold, hard water as a rule, though some of them contain sulphur. During the dry seasons many of the weaker springs and smaller streams go dry and difficulty is found in securing water supplies. Cisterns are extensively used, especially for household purposes, while ponds are dug or small streams dammed to secure water for stock. This region is the most fertile

and most thickly populated in the State. Some cities, such as Nashville, get their water supply from rivers, others obtain water from deep wells which are pumped, while others without waterworks depend mainly on cisterns.

"No persistent horizon of potable deep waters is known to underlie the basin surface. Water may be obtained almost anywhere by drilling a few hundred feet, but it is usually strongly impregnated with sulphur or is salty. In the lowest part of the basin the deep wells may flow. Several of the deep wells in Nashville are strongly sulphurous. Wells in other parts of the basin sometimes give off small quantities of natural gas, or are greatly injured by a slight exudation of petroleum. Many other wells, especially if not deep, furnish good water."

Precipitation

The average annual precipitation in the Elk River valley is about 52.2 inches. The annual precipitation over the valley during 1938 was approximately 53 inches. During the seven months of the study the rainfall was about four inches more than normal. Excess rainfall occurred during May, June, July, and November. October was a very dry month with a deficiency of about three inches.

Stream Flows

The mean monthly discharges at two points on the stream are shown in table 51. As a comparison with these average discharges, the estimated discharges at each sampling station at the times the samples were collected are shown in the tables presenting the results of analyses, tables 56, 57, 58, 59, and 60.

Water Supplies

Table 52 shows that there are 10 municipal water supplies in the basin. Only one supply is taken from a surface stream. The rest are obtained from wells and springs. Three supplies have purification plants and all but one of the remainder of the supplies are chlorinated.

TABLE 51

MEAN MONTHLY DISCHARGES IN CUBIC FEET PER SECOND

AT DESIGNATED POINTS ON ELK RIVER

		Elk River Estill Springs, Tenn.	Elk River, Rogersville, Ala.
Drainage Area Above Gage Sq. Mi.		281	2,239
Period of Record		1921-1934	1928-1934
January	cfs	696	5,070
February	cfs	923	7,070
March	cfs	1,063	9,180
April	cfs	800	4,980
May	cfs	491	4,840
June	cfs	274	2,350
July	cfs	180	1,630
August	cfs	162	920
September	cfs	116	798
October	cfs	111	1,330
November	cfs	320	2,570
December	cfs	634	3,900
Mean Annual	cfs	481	3,720
Maximum Flow	cfs	22,900	61,600
Minimum Flow	cfs	10	85

TABLE 52

WATER SUPPLIES

ELK RIVER BASIN, 1937-1940

Municipality	Population	Source	Treatment[1]
Monteagle, Tenn.	1,000[2]	Wells	F
Tullahoma, Tenn.	4,549	Wells and Springs	D
Cowan, Tenn.	1,461	Springs	D
Decherd, Tenn.	868	Wells	D
Winchester, Tenn.	2,760	Springs	CD
Lynchburg, Tenn.	390	Springs	N
Fayetteville, Tenn.	4,684	Springs	D
Petersburg, Tenn.	581	Wells	D
Lynnville, Tenn.	374	Wells and Springs	D
Pulaski, Tenn.	5,314	Richland Creek	CFD

1. N = No Treatment
   C = Coagulation and Sedimentation
   D = Disinfection
   F = Filtration
   S = Softening
2. Monteagle: Summer population.

Sources of Pollution

Population Estimates

The estimated population for the Elk River basin in 1940 was 101,752. The basin is sixth in order with respect to population.

Sewerage Systems

Table 53 shows the municipalities having sewerage systems, population sewered, and types of sewage treatment. There are eight systems; seven have some form of treatment, one of which discharges a portion of the sewage into a sink hole. The effect of this treatment, however, is to reduce the pollution due to domestic sewage by only 15.4 percent.

TABLE 53

SEWERAGE SYSTEMS

ELK RIVER BASIN, 1937-1940

Municipality	Population (1940 U.S. Census)		Treatment
	Total	Sewered	
Monteagle, Tenn.	1,000[a]	800	Septic Tank - Chlorination
Tullahoma, Tenn.	4,549	2,730	Septic Tank
State Vocational School for Girls	200	200	Imhoff Tank
Cowan, Tenn.	1,461	440	Septic Tank - Imhoff Tank
Decherd, Tenn.	868	650	Imhoff Tank
Winchester, Tenn.	2,760	(650 (1,610	To Sink Hole Septic Tank
Fayetteville, Tenn.	4,684	3,600	Septic Tank
Pulaski, Tenn.	5,314	3,200	None
Total	20,836	13,880	

a. Summer population, 1,000; winter population 300.

Industrial Plants

Table 54 gives the type and number of industrial plants in the basin and the disposition of the resulting wastes. The basin contains 5.2 percent of the industries in the Valley. These industries are responsible for only 0.6 percent of the industrial pollution. Milk processing is the principal industry.

TABLE 54

INDUSTRIAL POLLUTION

ELK RIVER BASIN, 1937-1940

Types of Industry	Number of Plants		Method of Disposal			Estimated Population Equivalents	
	Elk River Basin	Percent of Total in Tenn. Valley	Municipal Sewers	Stream	Some Correction	Elk River Basin	Percent of Total in Tenn. Valley
Canning	1	3.7	1	0	1	900	2.2
Chemical	1	3.9	0	1	0	-	0
Milk	7	20.6	6	1	4	3,400	23.9
Mining	1	10.0	0	1	1	-	0
Tanning	1	11.1	0	1	0	2,800	3.5
Textiles	1	1.2	0	1	0	100	.1
Miscellaneous	1	4.0	0	1	0	900	3.1
Total	13	5.2	7	6	6	8,100	0.6

Extent of Pollution

In table 55 are shown the estimated amounts of pollution by domestic sewage and industrial wastes originating in the various municipalities in the basin. The same information along with the points of discharge and the locations of the sampling stations is shown graphically in figure 15.

Table 55 and figure 15 do not show the chemical and mining industries at Wales, Tenn., since the effect of these wastes can not be expressed in terms of population equivalents.

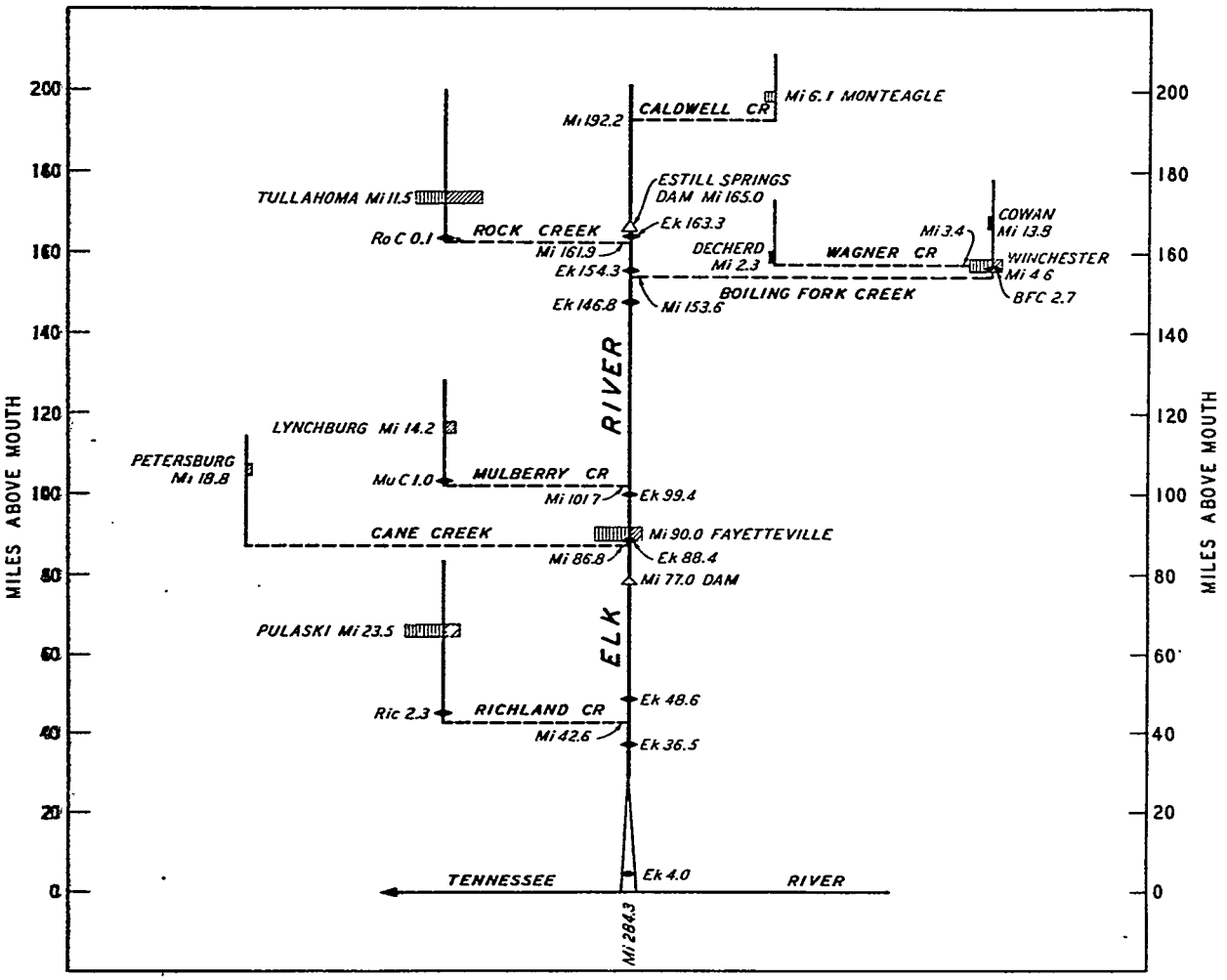
TABLE 55

ESTIMATED POPULATION EQUIVALENT OF POLLUTION

REACHING ELK RIVER SYSTEM, 1937-1940

Municipality	Receiving Stream	Estimated Population Equivalents		
		Domestic Sewage	Industrial Wastes	Total
Monteagle, Tenn.	Caldwell Creek	640	-	640
Tullahoma, Tenn.[1]	Rock Creek	2,330	3,220	5,550
Cowan, Tenn.	Boiling Fork Creek	310	-	310
Decherd, Tenn.	Wagner Creek	420	-	420
Winchester, Tenn.	Boiling Fork Creek	1,950	800	2,750
Lynchburg, Tenn.	Mulberry Creek	-	900	900
Fayetteville, Tenn.	Elk River	2,900	960	3,860
Petersburg, Tenn.	Cane Creek	-	500	500
Pulaski, Tenn.	Richland Creek	3,200	1,200	4,400
Total		11,750	7,580	19,330

1. Includes State Vocational School for Girls.



SYMBOLS:

- Sampling station
- Population equivalent:
  - Domestic sewage
  - Industrial waste
- Dam and reservoir
- Scale of population equivalent

NOTE:
Number at sampling station denotes miles above mouth of each stream.

Figure 15
ELK RIVER
SOURCES OF POLLUTION
AND
SAMPLING STATIONS

Sampling and Sampling Stations

Sampling

Samples were collected in 1938 at biweekly intervals between May and November. Twelve sets of samples were collected during this period.

Sampling Stations

The stations and their descriptions follow:

Elk River, Ek 163.3:	Highway bridge downstream from the N. C. & St. L. Railroad bridge; 1.7 miles downstream from Estill Springs power dam.
Rock Creek, RoC 0.1:	Below Tullahoma at the bridge 0.1 mile above the mouth of Rock Creek.
Elk River, Ek 154.3:	Lee Ford Bridge northwest of Winchester, on State Highway No. 16.
Boiling Fork Creek, BFC 2.7:	A bridge on State Highway No. 16 below Winchester.
Elk River, Ek 146.8:	Owl Hollow Highway Bridge.
Mulberry Creek, MuC 1.0:	Bridge near mouth of Mulberry Creek.
Elk River, Ek 99.4:	U.S. Highway No. 64 bridge, above Fayetteville.
Elk River, Ek 88.4:	Bridge about one mile below Fayetteville.
Elk River, Ek 48.6:	U.S. Highway No. 31 bridge at Elkton.
Richland Creek, RiC 2.3:	Bridge at Kelley Cemetery.
Elk River, Ek 36.5:	Highway bridge about 700 feet upstream from the L. & N. R.R. bridge south of Prospect.

Discussion of Results

Observed Conditions

Elk River is a relatively clean stream (tables 56 to 60 inclusive and figure 16). In general, the dissolved oxygen will meet the requirements for Class I waters. The B.O.D. for the main stream also usually meets the requirements for the cleaner waters. The average

B.O.D.'s for Mulberry Creek and Richland Creek at the points sampled indicate that the waters in these two streams contain sufficient amounts of pollution to be placed in Class II.

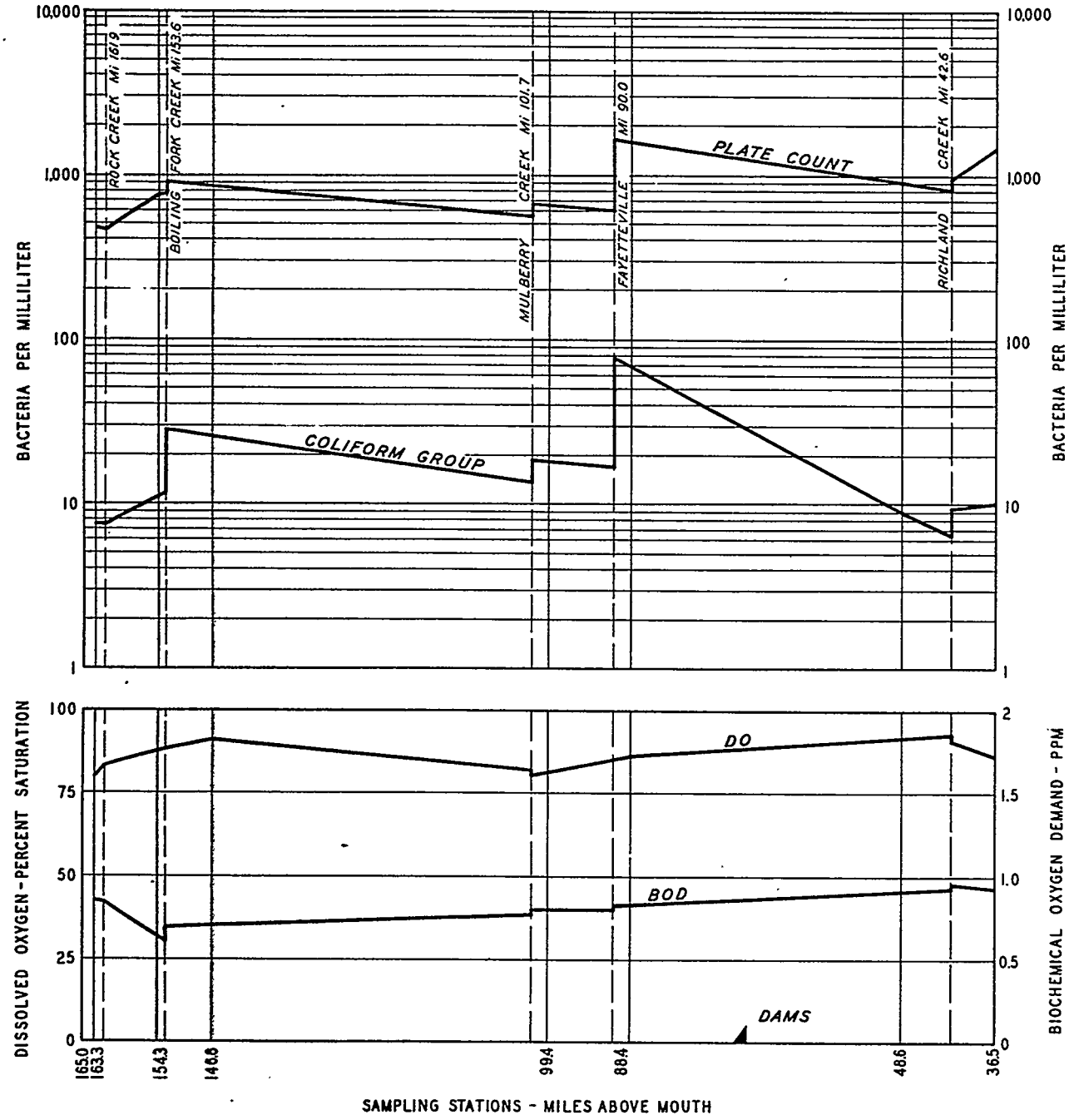
The results of the bacteriological examinations vary somewhat more than the results of the dissolved oxygen and B.O.D. and indicate more clearly the effects of the small amounts of pollution received by the stream. For this reason the classification of the stream will be based primarily upon the results of the bacteriological examinations and upon information concerning the origin and extent of the pollution.

Elk River below Estill Springs and Rock Creek near its mouth meet the requirements of Class II. Although no detailed studies were made on Rock Creek immediately below Tullahoma, Tenn., three samples collected above and below Tullahoma by the U.S.P.H.S. in 1941 indicate Class II conditions above town and Class IV conditions below. The pollution received from Winchester is sufficient to cause Class III conditions in Boiling Fork Creek. However, the effect of this pollution is not sufficient to change Elk River from Class II to Class III below the mouth of Boiling Fork Creek. Elk River continues as Class II until it receives the wastes from Fayetteville. Mulberry Creek which enters just above Fayetteville is also a Class II stream near its mouth.

At Fayetteville, the amount of pollution is sufficient to cause Class III conditions. The stream recovers to Class II conditions at approximately mile 75.0. From this point on, the stream receives no additional pollution sufficient to degrade it.

Richland Creek with its comparatively large load of pollution from Pulaski has recovered to Class II conditions at its mouth. Studies made by the U.S.P.H.S. in 1941 indicate that Class II conditions exist in Richland Creek above Pulaski, and Class IV conditions immediately below town.

Below Richland Creek conditions should improve in the Elk River, and upon entering the Elk River arm of Wheeler Reservoir at about mile 29.0 the rate of improvement should increase because conditions are more



NOTE:
Curves based on averages of all observations from May 20, 1938 through November 16, 1938.

Figure 16

ELK RIVER
STREAM CONDITIONS

favorable for rapid purification than in the running stream. Bacteriological examinations carried out on the Elk River arm of Wheeler Lake in 1940 at Ek 4.0 indicate Class I conditions in the upper surface of the lake.

The above classifications are shown graphically on figure 14.

Effects of Sewage from Camp Forrest

The classifications discussed above are based upon conditions prior to the construction and operation of Camp Forrest near Tullahoma. No information is available on the number of men in the camp. It is understood that the sewage receives complete treatment before it is discharged into Rock Creek. However, even with such treatment, more serious conditions of pollution than were described for Rock Creek undoubtedly exist, and the pollution may affect somewhat the classification of the upper section of Elk River below Estill Springs.

TABLE 56

ELK RIVER

MINERAL ANALYSES

Elk River - Station Ek 163.3 - Estill Springs, Tenn.

Date	Discharge cfs	Results of Mineral Analyses - Parts per Million											pH
		Fe		SiO_2	Ca	Mg	Na	SO_4	Cl	F	Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	
		Unfiltered	Filtered										
6-27-38	720	3.30	0.00	7	25.6	3.0	0.7	3.9	5	0.42	65	76	7.3
7-15-38	432	.80	.00	7	27.2	3.4	4.6	4.0	10	.00	73	82	7.2
7-27-38	565	1.00	.00	6	23.4	3.1	3.7	2.2	6	.18	68	72	7.1
8-10-38	449	.40	-	7	24.4	3.0	1.6	2.0	2	.14	71	74	7.1
8-25-38	65	.30	.00	7	30.2	3.9	1.8	3.0	3	.10	87	92	7.2
9-15-38	65	.30	-	7	31.6	4.8	.9	3.8	2	.50	90	99	7.0
9-27-38	55	.60	T	8	28.8	4.3	3.7	4.2	2	.50	89	90	7.0
10-12-38	55	.36	.06	7	28.4	6.1	1.4	6.2	2	.34	88	96	7.1
10-27-38	61	.60	T	7	29.0	5.6	2.5	4.0	8	.00	88	96	7.1
11-16-38	54	1.00	T	7	27.8	5.3	2.5	4.9	2	.10	89	92	7.1
Average	252	0.87	T	7	27.6	4.2	2.3	3.8	4	0.23	81	87	7.2
Maximum	720	3.30	0.06	8	31.6	6.1	4.6	6.2	10	.50	90	99	7.4
Minimum	54	.30	.00	6	23.4	3.0	.7	2.0	2	.00	65	72	7.0

TABLE 56 (Continued)

ELK RIVER

MINERAL ANALYSES

Elk River - Station Ek 36.5 - Prospect, Tenn.

Date	Discharge cfs	Results of Mineral Analyses - Parts per Million											pH
		Fe		SiO_2	Ca	Mg	Na	SO_4	Cl	F	Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	
		Unfiltered	Filtered										
6-27-38	2,060	3.30	0.00	7	34.0	4.4	2.5	6.4	6	0.42	92	103	7.6
7-15-38	1,250	1.33	.00	6	28.6	4.2	1.4	3.5	4	.16	81	89	7.3
7-27-38	1,750	1.40	.00	7	26.6	2.0	4.1	2.6	3	.54	75	75	7.3
8-10-38	1,670	.90	-	7	28.7	3.7	1.4	4.3	2	.44	81	88	7.4
8-25-38	508	.60	.00	7	33.8	3.1	5.1	5.9	3	.44	96	97	7.4
9-15-38	453	.70	-	6	33.6	4.2	.2	3.8	2	.60	93	101	7.2
9-28-38	357	1.60	.00	8	34.2	3.8	3.5	5.8	2	.52	98	101	7.4
10-13-38	299	1.00	.02	6	33.4	4.9	.2	5.7	2	.36	95	104	7.3
10-27-38	304	1.60	T	6	34.6	5.1	1.8	4.8	4	.70	103	108	7.3
11-16-38	408	2.66	.10	7	30.4	4.7	3.0	5.0	3	.70	90	96	7.3
Average	906	1.51	0.01	7	31.8	4.0	2.3	4.8	3	0.49	90	96	7.4
Maximum	2,060	3.30	.10	8	34.6	5.1	5.1	6.4	6	.70	103	108	7.6
Minimum	299	.60	.00	6	26.6	2.0	.2	2.6	2	.16	75	75	7.2

TABLE 57

ELK RIVER

TURBIDITY AND SOLIDS

Elk River - Station Ek 163.3 - Estill Springs, Tenn.

Date	Discharge cfs	Turbidity ppm	Solids - Parts per Million				
			Dissolved	Suspended	Volatile	Fixed	Total
6-27-38	720	240	87	171	70	188	258
7-15-38	432	65	103	46	34	115	149
7-27-38	565	45	96	33	42	87	129
8-10-38	449	50	98	23	31	90	121
8-25-38	65	35	111	24	37	98	135
9-15-38	65	30	132	5	71	66	137
9-27-38	55	35	108	12	43	77	120
10-12-38	55	15	110	7	6	111	117
10-27-38	61	25	121	38	54	105	159
11-16-38	54	30	-	-	43	84	127
Average	252	55	106	39	43	102	145
Maximum	720	240	132	171	71	188	258
Minimum	54	15	87	5	6	66	117

Elk River - Station Ek 36.5 - Prospect, Tenn.

6-27-38	2,060	150	130	164	79	215	294
7-15-38	1,250	110	99	90	46	143	189
7-27-38	1,750	125	103	165	63	205	268
8-10-38	1,670	200	108	167	75	200	275
8-25-38	508	60	122	56	36	142	178
9-15-38	453	100	132	70	63	139	202
9-28-38	357	90	110	71	77	104	181
10-13-38	299	90	115	68	42	141	183
10-27-38	304	75	121	85	100	106	206
11-16-38	408	100	-	-	90	110	200
Average	906	110	115	103	67	151	218
Maximum	2,060	200	132	167	100	215	294
Minimum	299	60	99	56	36	104	178

TABLE 58

ELK RIVER

NITROGENS

Elk River - Station Ek 163.3 - Estill Springs, Tenn.

Date	Discharge cfs	Water Temperature °C	Nitrogen - Parts per Million				
			Organic	Free Ammonia	Nitrite	Nitrate	Total
6-27-38	720	20.5	0.64	0.008	0.000	0.40	1.05
7-15-38	432	20.5	.87	.176	.002	.48	1.53
7-27-38	565	21.0	.29	.024	.001	.32	.63
8-10-38	449	22.0	.56	.120	.001	.48	1.16
8-25-38	65	23.0	.34	.016	.002	.48	.84
9-15-38	65	22.0	.00	.120	.001	1.12	1.24
9-27-38	55	20.0	.28	.006	.002	.48	.77
10-12-38	55	19.0	.32	.016	.001	.52	.86
10-27-38	61	14.5	.61	1.120	.002	.36	2.09
11-16-38	54	11.5	.20	.012	.002	.20	.41
Average	252	19.4	0.41	0.162	0.001	0.48	1.05
Maximum	720	23.0	.87	1.120	.002	1.12	2.09
Minimum	54	11.5	.00	.006	.000	.20	.41
Rock Creek - Station RoC 0.1 - near Estill Springs, Tenn.							
6-27-38	149	20.5	0.02	0.072	0.000	0.28	0.37
7-15-38	64	22.0	.33	.304	.003	.20	.83
7-27-38	78	21.0	.27	.096	.001	.48	.85
8-10-38	62	22.0	.37	.220	T	.36	.95
8-25-38	17	24.0	.26	.032	.003	.48	.77
9-15-38	26	21.0	.12	.376	.002	.32	.82
9-27-38	15	19.0	.23	.000	.001	.24	.47
10-12-38	8	18.0	.29	.032	.001	.44	.76
10-27-38	9	12.0	.80	1.000	.002	.36	2.16
11-16-38	8	9.0	.14	.024	.001	.16	.32
Average	44	18.8	0.28	0.216	0.001	0.33	0.83
Maximum	149	24.0	.80	1.000	.003	.48	2.16
Minimum	8	9.0	.02	.000	.000	.16	.32

TABLE 58 (Continued)

ELK RIVER

NITROGENS

Elk River - Station Ek 154.3 - above Winchester, Tenn.

Date	Discharge cfs	Water Temperature °C	Nitrogen - Parts per Million				
			Organic	Free Ammonia	Nitrite	Nitrate	Total
6-27-38	763	20.5	0.03	0.000	0.000	0.40	0.43
7-15-38	530	20.5	.22	.000	.003	.40	.62
7-27-38	704	21.0	.30	.040	.002	.44	.78
8-10-38	530	22.5	.12	.090	.001	.48	.69
8-25-38	103	23.0	.26	.048	.003	.88	.19
9-15-38	162	22.0	.00	.480	T	.40	.88
9-27-38	162	20.5	.04	.000	.001	.24	.28
10-12-38	67	19.0	-	-	-	-	-
10-27-38	75	13.0	.40	.280	.002	.32	1.00
11-16-38	67	10.5	.19	.004	.001	.12	.31
Average	316	19.2	0.17	0.105	0.001	0.41	0.68
Maximum	763	23.0	.40	.480	.003	.88	1.19
Minimum	67	10.5	.00	.000	.000	.12	.28
Boiling Fork Creek - BFC 2.7 - Winchester, Tenn.							
6-27-38	279	21.0	T	0.000	0.000	0.92	0.92
7-15-38	120	19.0	0.18	.000	.002	.88	1.06
7-27-38	145	19.0	.26	.072	T	1.04	1.37
8-10-38	116	19.5	.28	.070	T	1.12	1.47
8-25-38	32	19.0	.22	.072	.002	1.12	1.41
9-15-38	49	19.0	.00	.064	.002	1.16	1.22
9-27-38	29	19.5	.33	.088	.005	1.32	1.74
10-12-38	15	18.0	1.20	1.400	.001	.96	3.56
10-27-38	17	15.0	.72	.672	.003	1.20	2.59
11-16-38	15	11.0	.32	.032	.004	.92	1.27
Average	82	18.0	0.35	0.247	0.002	1.06	1.66
Maximum	279	21.0	1.20	1.400	.005	1.32	3.56
Minimum	15	11.0	.00	.000	.000	.88	.92

TABLE 58 (Continued)

ELK RIVER

NITROGENS

Elk River - Station Ek 146.8 - below Winchester, Tenn.

Date	Discharge cfs	Water Temperature °C	Nitrogen - Parts per Million				
			Organic	Free Ammonia	Nitrite	Nitrate	Total
6-27-38	944	21.0	0.11	0.008	0.000	0.48	0.60
7-15-38	717	22.0	.22	.040	.003	.48	.74
7-27-38	967	22.0	.40	.240	T	.60	1.24
8-10-38	813	23.0	.38	.080	.001	.48	.94
8-25-38	290	24.0	.26	.000	.002	.48	.74
9-15-38	367	24.0	.00	.096	.002	.40	.50
9-27-38	461	20.5	.27	.064	.002	.60	.93
10-12-38	94	19.0	.72	.024	.001	.60	1.34
10-27-38	104	13.0	.28	.032	.001	.16	.47
11-16-38	89	10.0	.18	.024	.002	.32	.52
Average	485	19.8	0.28	0.061	0.001	0.46	0.80
Maximum	967	24.0	.72	.240	.003	.60	1.34
Minimum	89	10.0	.00	.000	.000	.16	.47
Mulberry Creek - Station MuC 1.0 - below Lynchburg, Tenn.							
6-27-38	173	22.0	0.70	0.184	0.000	0.56	1.44
7-15-38	111	25.0	.45	.304	.003	.56	1.31
7-27-38	148	23.5	.72	.096	T	1.04	1.86
8-10-38	132	25.0	.37	.030	T	.76	1.16
8-25-38	44	25.0	.32	.080	.002	.40	.80
9-15-38	50	24.0	.05	T	.004	.20	.25
9-28-38	27	20.0	.30	.064	.003	.52	.88
10-13-38	25	17.0	2.00	.416	.001	.12	2.54
10-27-38	23	14.0	.77	.800	.004	.04	1.61
11-16-38	28	9.5	.45	.032	.001	.40	.88
Average	76	20.5	0.61	0.201	0.002	0.46	1.27
Maximum	173	25.0	2.00	.800	.004	1.04	2.54
Minimum	23	9.5	.05	T	.000	.04	.25

TABLE 58 (Continued)

ELK RIVER

NITROGENS

Elk River - Station Ek 99.4 - above Fayetteville, Tenn.

Date	Discharge cfs	Water Temperature °C	Nitrogen - Parts per Million				
			Organic	Free Ammonia	Nitrite	Nitrate	Total
6-27-38	1,440	22.0	0.06	0.008	0.000	0.56	0.63
7-15-38	923	24.0	.87	.391	.003	.52	1.78
7-27-38	1,230	23.5	.43	.176	.250	.60	1.21
8-10-38	1,080	24.5	.84	.470	.002	.56	1.87
8-25-38	341	26.0	.46	.184	.003	.28	.92
9-15-38	405	25.0	.00	.432	.002	.40	.83
9-28-38	204	19.5	.23	.002	.001	.48	.71
10-13-38	204	18.0	1.60	1.000	.002	.16	2.76
10-27-38	192	13.0	.18	.016	.002	.08	.28
11-16-38	231	10.0	.30	.000	.001	.12	.42
Average	625	20.6	0.50	0.268	0.027	0.38	1.15
Maximum	1,440	26.0	1.60	1.000	.250	.60	2.76
Minimum	192	10.0	.06	.000	.000	.08	.28
Elk River - Station Ek 88.4 - Fayetteville, Tenn.							
6-27-38	1,690	23.0	0.72	0.012	0.000	0.48	1.21
7-15-38	1,010	25.0	.45	.008	.003	.48	.94
7-27-38	1,370	24.0	.40	.024	.002	.32	.74
8-10-38	1,230	25.0	.74	.480	T	.48	1.70
8-25-38	408	27.0	.43	.080	.004	.48	.99
9-15-38	383	25.0	.67	.232	.003	.32	1.22
9-28-38	226	21.0	.34	.064	.003	.20	.60
10-13-38	239	18.0	.45	.184	.002	.12	.75
10-27-38	209	14.0	.45	.560	.010	.12	1.13
11-16-38	242	10.5	.45	.024	.001	.12	.59
Average	701	21.2	0.51	0.167	0.003	0.31	0.99
Maximum	1,690	27.0	.74	.560	.010	.48	1.70
Minimum	209	10.5	.34	.008	.000	.12	.59

TABLE 58 (Continued)

ELK RIVER

NITROGENS

Elk River - Station Ek 48.6 - Elkton, Tenn.

Date	Discharge cfs	Water Temperature °C	Nitrogen - Parts per Million				
			Organic	Free Ammonia	Nitrite	Nitrate	Total
6-27-38	1,860	23.0	1.00	0.016	0.000	0.48	1.50
7-15-38	1,070	25.5	.38	.008	.004	.40	.79
7-27-38	1,520	25.0	.35	.024	.001	.52	.89
8-10-38	1,450	25.5	.47	.100	.002	.48	1.05
8-25-38	444	28.0	.59	.320	.004	.60	1.51
9-15-38	413	25.0	.32	.160	.003	.48	.96
9-28-38	316	22.0	.34	.048	.004	.36	.75
10-13-38	270	19.0	-	-	-	-	-
10-27-38	258	15.0	.34	.040	.003	.12	.50
11-16-38	337	11.5	.56	.000	.002	.24	.80
Average	794	22.0	0.48	0.080	0.003	0.41	0.97
Maximum	1,860	28.0	1.00	.320	.004	.60	1.51
Minimum	258	11.5	.32	.000	.000	.12	.50
Richland Creek - Station RiC 2.3 - near Elkton, Tenn.							
6-27-38	294	24.0	0.51	0.080	0.002	0.68	1.27
7-15-38	130	26.5	.30	.000	.090	.80	1.10
7-27-38	144	27.0	.53	.480	.001	.84	1.85
8-10-38	130	28.0	.48	.040	T	.72	1.24
8-25-38	58	28.0	.51	.024	.003	.20	.73
9-15-38	62	25.0	.51	.040	.002	.40	.95
9-28-38	42	21.0	.31	.024	.002	.04	.37
10-13-38	45	20.0	.80	.800	.001	.12	1.72
10-27-38	50	15.0	.54	.656	.003	.16	1.36
11-16-38	66	11.0	.61	.008	.001	.12	.74
Average	102	22.6	0.51	0.215	0.010	0.41	1.13
Maximum	294	28.0	.80	.800	.090	.84	1.85
Minimum	42	11.0	.30	.000	T	.04	.37

TABLE 58 (Continued)

ELK RIVER

NITROGENS

Elk River - Station Ek 36.5 - Prospect, Tenn.

Date	Discharge cfs	Water Temperature °C	Nitrogen - Parts per Million				
			Organic	Free Ammonia	Nitrite	Nitrate	Total
6-27-38	2,060	24.0	0.51	0.056	0.000	0.40	0.97
7-15-38	1,250	26.0	.75	.024	.005	.40	1.17
7-27-38	1,750	25.0	.46	.032	T	.60	1.09
8-10-38	1,670	27.0	.48	.020	.002	.60	1.10
8-25-38	508	28.0	.53	.064	.004	.60	1.19
9-15-38	453	25.0	.61	.120	T	.52	1.25
9-28-38	357	22.0	.43	.032	.003	.44	.90
10-13-38	299	21.0	.59	.152	.003	.20	.94
10-27-38	304	15.0	.56	.720	.002	.12	1.40
11-16-38	408	11.5	.56	.016	.003	.64	1.22
Average	906	22.4	0.55	0.124	0.002	0.45	1.12
Maximum	2,060	28.0	.75	.720	.005	.64	1.40
Minimum	299	11.5	.43	.016	.000	.12	.90

TABLE 59

ELK RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

Elk River - Station Ek 163.3 - Estill Springs, Tenn.

Date	Discharge cfs	Water Temperature °C	Dissolved Oxygen		5-Day Oxygen Demand 20°C ppm	1000 Lb. per Day	
			ppm	% Saturation		Dissolved Oxygen	5-Day Oxygen Demand
5-20-38	270	20.5	7.70	84.8	0.60	11.23	0.87
6-6-38	670	17.5	-	-	.87	-	3.15
6-27-38	720	20.5	7.70	84.8	1.14	29.94	4.43
7-15-38	432	20.5	7.50	82.6	1.49	17.50	3.48
7-27-38	565	21.0	7.50	83.4	.48	22.88	1.46
8-10-38	449	22.0	7.40	83.8	.48	17.94	1.16
8-25-38	65	23.0	5.10	58.8	.75	1.79	.26
9-15-38	65	22.0	6.90	78.2	1.02	2.42	.36
9-27-38	55	20.0	-	-	.62	-	.18
10-12-38	55	19.0	5.40*	57.8*	1.14	1.60	.34
10-27-38	61	14.5	8.60	83.8	.77	2.83	.25
11-16-38	54	11.5	8.50	77.6	2.56*	2.48	.75
Average	288	19.3	7.43	79.8	0.85	11.56	1.32
Maximum	720	23.0	8.60	84.8	2.56	29.94	4.43
Minimum	54	11.5	5.10	57.8	.48	1.60	.18
Rock Creek - Station RoC 0.1 - near Estill Springs, Tenn.							
5-20-38	44	20.0	8.80	96.0	0.70	2.09	0.17
6-6-38	91	17.0	8.30	85.2	.38	4.08	.19
6-27-38	149	20.5	8.20	90.3	.72	6.60	.58
7-15-38	64	22.0	7.60	86.1	1.05	2.63	.36
7-27-38	78	21.0	7.50	83.4	.91	3.16	.38
8-10-38	62	22.0	7.00	79.3	.68	2.34	.23
8-25-38	17	24.0	7.00	82.1	1.78*	.64	.16
9-15-38	26	21.0	10.40*	115.7*	.91	1.46	.13
9-27-38	15	19.0	8.50	90.8	.34	.69	.03
10-12-38	8	18.0	4.40*	46.1*	1.05	.19	.05
10-27-38	9	12.0	9.00	83.1	.62	.44	.03
11-16-38	8	9.0	10.00	86.3	1.34	.43	.06
Average	48	18.8	8.19	86.3	0.79	2.12	0.20
Maximum	149	24.0	10.40	115.7	1.78	6.60	.58
Minimum	8	9.0	4.40	46.1	.34	.19	.03

*Value omitted from average according to Chauvenet's criterion.

TABLE 59 (Continued)

ELK RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

Elk River - Station Ek 154.3 - above Winchester, Tenn.

Date	Discharge cfs	Water Temperature °C	Dissolved Oxygen ppm	Dissolved Oxygen % Saturation	5-Day Oxygen Demand 20°C ppm	1000 Lb. per Day Dissolved Oxygen	1000 Lb. per Day 5-Day Oxygen Demand
5-20-38	326	20.0	8.30	90.5	0.84	14.61	1.48
6-6-38	822	19.0	8.40	89.8	.50	37.29	2.22
6-27-38	763	20.5	7.80	85.9	1.12	32.14	4.61
7-15-38	530	20.5	7.70	84.8	.48	22.04	1.37
7-27-38	704	21.0	7.60	84.5	.88	28.89	3.35
8-10-38	530	22.5	7.30	83.4	.30	20.89	.86
8-25-38	103	23.0	4.10*	47.2*	.34	2.28	.19
9-15-38	162	22.0	7.80	88.3	.44	6.82	.38
9-27-38	162	20.5	8.60	94.7	.48	7.52	.42
10-12-38	67	19.0	8.10	86.6	.86	2.93	.31
10-27-38	75	13.0	9.50	89.6	.84	3.85	.34
11-16-38	67	10.5	9.70	86.5	.44	3.51	.16
Average	359	19.2	8.25	87.7	0.63	15.99	1.22
Maximum	822	23.0	9.70	94.7	1.12	37.29	4.61
Minimum	67	10.5	4.10	47.2	.30	2.28	.16
Boiling Fork Creek - Station BFC 2.7 - Winchester, Tenn.							
5-20-38	82	19.0	9.40	100.5	0.76	4.16	0.34
6-6-38	170	18.0	9.00	94.3	.50	8.26	.46
6-27-38	279	21.0	8.00	89.0	2.20	12.05	3.31
7-15-38	120	19.0	8.70	93.0	.48	5.64	.31
7-27-38	145	19.0	8.60	92.0	.68	6.73	.53
8-10-38	116	19.5	8.80	95.0	-	5.51	-
8-25-38	32	19.0	5.90	63.1	.52	1.02	.09
9-15-38	49	19.0	-	-	.48	-	.13
9-27-38	29	19.5	7.90	85.3	.68	1.24	.11
10-12-38	15	18.0	6.60	69.2	.76	.53	.06
10-27-38	17	15.0	11.00	108.3	.68	1.01	.06
11-16-38	15	11.0	8.50	76.8	2.48	.69	.20
Average	89	18.1	8.40	87.9	0.77	4.04	0.37
Maximum	279	21.0	11.00	108.3	2.48	12.05	3.31
Minimum	15	11.0	5.90	63.1	.48	.53	.06

*Value omitted from average according to Chauvenet's criterion.

TABLE 59 (Continued)

ELK RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

Elk River - Station Ek 146.8 - below Winchester, Tenn.

Date	Discharge cfs	Water Temperature °C	Dissolved Oxygen		5-Day Oxygen Demand 20°C ppm	1000 Lb. per Day	
			ppm	% Saturation		Dissolved Oxygen	5-Day Oxygen Demand
5-20-38	438	21.5	8.50	95.4	0.22	20.10	0.52
6-6-38	1,143	19.0	8.50	90.9	.80	52.46	4.94
6-27-38	944	21.0	7.80	86.8	.94	39.76	4.79
7-15-38	717	22.0	7.70	87.2	.58	29.81	2.25
7-27-38	967	22.0	7.80	88.3	.72	40.73	3.76
8-10-38	813	23.0	7.50	86.4	.34	32.93	1.49
8-25-38	290	24.0	4.70*	55.1*	.38	7.36	.60
9-15-38	367	24.0	8.60	100.8	.48	17.04	.95
9-27-38	461	20.5	8.60	94.7	.38	21.41	.95
10-12-38	94	19.0	9.30	99.5	1.12	4.72	.57
10-27-38	104	13.0	9.90	93.3	1.12	5.56	.63
11-16-38	89	10.0	9.80	86.5	1.34	4.71	.64
Average	536	19.9	8.55	91.8	0.70	24.75	2.03
Maximum	1,143	24.0	9.90	100.8	1.34	52.46	4.94
Minimum	89	10.0	4.70	55.1	.22	4.71	.52
Mulberry Creek - Station MuC 1.0 - below Lynchburg, Tenn.							
5-20-38	108	24.5	8.60	101.8	1.28	5.02	0.75
6-6-38	192	20.0	7.70	84.0	.97	7.98	1.01
6-27-38	173	22.0	7.70	87.2	1.66	7.19	1.55
7-15-38	111	25.0	6.90	82.3	1.26	4.14	.76
7-27-38	148	23.5	6.40	74.4	1.27	5.11	1.01
8-10-38	132	25.0	7.00	83.5	1.01	4.99	.72
8-25-38	44	25.0	-	-	1.42	-	.34
9-15-38	50	24.0	7.20	84.4	1.16	1.94	.31
9-28-38	27	20.0	6.90	75.2	.54	1.01	.08
10-13-38	25	17.0	4.70*	48.2*	1.26	.63	.17
10-27-38	23	14.0	-	-	.66	-	.08
11-16-38	28	9.5	10.00	87.3	1.22	1.51	.18
Average	88	20.8	7.60	84.5	1.14	3.61	0.54
Maximum	192	25.0	10.00	101.8	1.66	7.98	1.55
Minimum	23	9.5	4.70	48.2	.54	.63	.08

*Value omitted from average according to Chauvenet's criterion.

TABLE 59 (Continued)

ELK RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

Elk River - Station Ek 99.4 - above Fayetteville, Tenn.

Date	Discharge cfs	Water Temperature °C	Dissolved Oxygen		5-Day Oxygen Demand 20°C ppm	1000 Lb. per Day	
			ppm	% Saturation		Dissolved Oxygen	5-Day Oxygen Demand
5-20-38	974	23.0	7.90	91.0	1.10	41.55	5.79
6-6-38	1,600	20.0	8.10	88.3	.48	69.98	4.15
6-27-38	1,440	22.0	7.60	86.1	1.53	59.10	11.90
7-15-38	923	24.0	7.30	85.6	.86	36.38	4.29
7-27-38	1,230	23.5	7.20	83.7	.44	47.82	2.92
8-10-38	1,080	24.5	7.00	82.8	.74	40.82	4.32
8-25-38	341	26.0	6.00	73.0	.90	11.05	1.66
9-15-38	405	25.0	6.20	73.9	.78	13.56	1.71
9-28-38	204	19.5	7.70	83.2	.44	8.48	.48
10-13-38	204	18.0	5.60	58.7	1.00	6.17	1.10
10-27-38	192	13.0	10.20	96.2	.92	10.58	.95
11-16-38	231	10.0	9.70	85.6	1.14	12.10	1.42
Average	735	20.7	7.54	82.3	0.80	29.93	3.18
Maximum	1,600	26.0	10.20	96.2	1.53	69.98	11.90
Minimum	192	10.0	5.60	58.7	.44	6.17	.48
Elk River - Station Ek 88.4 - Fayetteville, Tenn.							
5-20-38	1,060	23.0	7.70	88.7	0.76	44.07	4.35
6-6-38	1,800	20.5	8.00	88.0	.54	77.76	5.25
6-27-38	1,690	23.0	7.50	86.4	.88	68.44	8.03
7-15-38	1,010	25.0	7.30	87.1	.61	39.81	3.33
7-27-38	1,370	24.0	7.20	84.4	1.06	53.27	7.84
8-10-38	1,230	25.0	7.00	83.5	.65	46.49	4.32
8-25-38	408	27.0	6.80	84.3	1.95*	14.98	4.30
9-15-38	383	25.0	8.40	100.1	.65	17.37	1.34
9-28-38	226	21.0	7.50	83.4	.61	9.15	.74
10-13-38	239	18.0	5.30*	55.6*	.57	6.84	.74
10-27-38	209	14.0	9.80	94.5	.81	11.06	.91
11-16-38	242	10.5	9.60	85.6	1.79	12.55	2.34
Average	822	21.3	7.90	87.8	0.81	35.07	3.60
Maximum	1,800	27.0	9.80	100.1	1.95	77.76	8.03
Minimum	209	10.5	5.30	55.6	.54	6.84	.74

*Value omitted from average according to Chauvenet's criterion.

TABLE 59 (Continued)

ELK RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

Elk River - Station Ek 48.6 - Elkton, Tenn.

Date	Discharge cfs	Water Temperature °C	Dissolved Oxygen ppm	Dissolved Oxygen % Saturation	5-Day Oxygen Demand 20°C ppm	1000 Lb. per Day: Dissolved Oxygen	1000 Lb. per Day: 5-Day Oxygen Demand
5-20-38	1,120	23.0	8.10	93.3	0.58	48.99	3.51
6-6-38	2,230	22.0	8.40	95.1	.40	101.15	4.82
6-27-38	1,860	23.0	7.80	89.9	1.28	78.34	12.86
7-15-38	1,070	25.5	7.40	89.2	.62	42.76	3.58
7-27-38	1,520	25.0	7.60	90.7	.48	62.38	3.94
8-10-38	1,450	25.5	7.60	91.7	-	59.51	-
8-25-38	444	28.0	8.60*	108.5*	.80	20.62	1.92
9-15-38	413	25.0	7.70	91.8	.67	17.17	1.49
9-28-38	316	22.0	8.00	90.6	1.27	13.65	2.17
10-13-38	270	19.0	6.50*	69.5*	1.21	9.48	1.76
10-27-38	258	15.0	9.80	96.5	1.51	13.65	2.10
11-16-38	337	11.5	9.80	89.4	1.17	17.83	2.13
Average	941	22.0	8.22	91.8	0.91	41.77	4.62
Maximum	2,230	28.0	9.80	108.5	1.51	101.15	12.86
Minimum	258	11.5	6.50	69.5	.40	9.48	1.49
Richland Creek - Station RiC 2.3 - near Elkton, Tenn.							
5-20-38	172	24.0	8.10	95.0	1.04	7.52	0.97
6-6-38	213	23.0	8.40	96.8	.86	9.66	.99
6-27-38	294	24.0	7.40	86.8	.97	11.75	1.54
7-15-38	130	26.5	6.70	82.4	.78	4.70	.55
7-27-38	144	27.0	7.00	86.8	1.10	5.44	.86
8-10-38	130	28.0	7.20	91.0	1.04	5.05	.73
8-25-38	58	28.0	4.50	56.9	1.38	1.41	.43
9-15-38	62	25.0	6.00	71.6	.96	2.01	.32
9-28-38	42	21.0	8.60	95.7	1.72	1.95	.39
10-13-38	45	20.0	3.80*	41.4*	1.51	.92	.37
10-27-38	50	15.0	9.70	95.5	1.08	2.62	.29
11-16-38	66	11.0	8.80	79.4	1.67	3.14	.60
Average	117	22.7	7.50	85.3	1.18	4.74	0.75
Maximum	294	28.0	9.70	96.8	1.72	11.75	1.54
Minimum	42	11.0	3.80	41.4	.78	.92	.29

*Value omitted from average according to Chauvenet's criterion.

TABLE 59 (Continued)

ELK RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

Elk River - Station Ek 36.5 - Prospect, Tenn.

Date	Discharge cfs	Water Temperature °C	Dissolved Oxygen		5-Day Oxygen Demand 20°C ppm	1000 Lb. per Day	
			ppm	% Saturation		Dissolved Oxygen	5-Day Oxygen Demand
5-20-38	1,320	23.0	8.10	93.3	0.74	57.74	5.27
6-6-38	2,610	22.5	8.00	91.4	1.00	112.75	14.09
6-27-38	2,060	24.0	7.70	90.3	.68	85.65	7.56
7-15-38	1,250	26.0	7.30	88.9	.72	49.28	4.86
7-27-38	1,750	25.0	7.20	86.0	.78	68.04	7.37
8-10-38	1,670	27.0	7.00	86.7	1.04	63.13	9.38
8-25-38	508	28.0	6.00	75.8	.76	16.46	2.08
9-15-38	453	25.0	5.70	68.0	.92	13.94	2.25
9-28-38	357	22.0	8.00	90.6	1.25	15.42	2.41
10-13-38	299	21.0	3.70*	41.2*	.86	5.97	1.39
10-27-38	304	15.0	9.40	92.6	1.12	15.43	1.84
11-16-38	408	11.5	9.20	83.9	1.27	20.27	2.80
Average	1,082	22.5	7.60	86.1	0.93	44.41	5.43
Maximum	2,610	28.0	9.40	93.3	1.27	112.75	14.09
Minimum	299	11.5	3.70	41.2	.72	5.97	1.39

*Value omitted from average according to Chauvenet's criterion.

TABLE 60

ELK RIVER

BACTERIA

Elk River - Station Ek 163.3 - Estill Springs, Tenn.

Date	Discharge cfs	Water Temperature °C	Bacteria per Milliliter		Quantity Units (Bacteria x 1000 cfs)	
			On Agar 37°C for 24 hours	Coliform Group M.P.N.	On Agar 37°C for 24 hours	Coliform Group M.P.N.
5-20-38	270	20.5	140	0.9	38	0.2
6-6-38	670	17.5	350	50	234	34
6-27-38	720	20.5	2,000	600	1,440	432
7-15-38	432	20.5	3,000	9.3	1,296	4
7-27-38	565	21.0	250	6.2	141	4
8-10-38	449	22.0	450	36	202	16
8-25-38	65	23.0	950	6.2	62	0.4
9-15-38	65	22.0	300	46	20	3
9-27-38	55	20.0	400	1.6	22	0.1
10-12-38	55	19.0	200	1.1	11	0.1
10-27-38	61	14.5	350	1.6	21	0.1
11-16-38	54	11.5	500	0.6	27	0.05
Average	288	19.3	475	7.4	137	2
Maximum	720	23.0	3,000	600	1,440	432
Minimum	54	11.5	140	0.6	11	0.05
Rock Creek - Station RoC 0.1 - near Estill Springs, Tenn.						
5-20-38	44	20.0	85	1.6	4	0.1
6-6-38	91	17.0	700	5.2	64	0.5
6-27-38	149	20.5	500	60	74	9
7-15-38	64	22.0	4,500	16	288	1
7-27-38	78	21.0	-	-	-	-
8-10-38	62	22.0	2,000	1.1	124	0.1
8-25-38	17	24.0	300	9.3	5	0.2
9-15-38	26	21.0	275	210	7	5
9-27-38	15	19.0	150	3.6	2	0.1
10-12-38	8	18.0	210	9.3	2	0.1
10-27-38	9	12.0	220	5.2	2	0.05
11-16-38	8	9.0	250	1.1	2	0.05
Average	48	18.8	400	7.3	19	0.4
Maximum	149	24.0	4,500	210	288	9
Minimum	8	9.0	85	1.1	2	0.05

TABLE 60 (Continued)

ELK RIVER

BACTERIA

Elk River - Station Ek 154.3 - above Winchester, Tenn.

Date	Discharge cfs	Water Temperature °C	Bacteria per Milliliter		Quantity Units (Bacteria x 1000 cfs)	
			On Agar 37°C for 24 hours	Coliform Group M.P.N.	On Agar 37°C for 24 hours	Coliform Group M.P.N.
5-20-38	326	20.0	250	0	82	0
6-6-38	822	19.0	28,000	24,000	23,016	19,728
6-27-38	763	20.5	4,200	950	3,205	725
7-15-38	530	20.5	3,000	110	1,590	58
7-27-38	704	21.0	120	11	84	8
8-10-38	530	22.5	Spreader	2.3	-	1
8-25-38	103	23.0	350	6.2	36	0.6
9-15-38	162	22.0	275	36	45	6
9-27-38	162	20.5	425	2.3	69	0.4
10-12-38	67	19.0	350	2.3	23	0.2
10-27-38	75	13.0	350	0.6	26	0.05
11-16-38	67	10.5	600	0.6	40	0.05
Average	359	19.2	750	11	269	4
Maximum	822	23.0	28,000	24,000	23,016	19,728
Minimum	67	10.5	120	0	23	0
Boiling Fork Creek - Station BFC 2.7 - Winchester, Tenn.						
5-20-38	82	19.0	800	160	66	13
6-6-38	170	18.0	600	21	102	4
6-27-38	279	21.0	5,900	1,600	1,646	446
7-15-38	120	19.0	1,600	60	192	7
7-27-38	145	19.0	400	36	58	5
8-10-38	116	19.5	2,200	1.1	255	0.1
8-25-38	32	19.0	900	160	29	5
9-15-38	49	19.0	4,100	2,400	201	118
9-27-38	29	19.5	900	36	26	1
10-12-38	15	18.0	350	350	5	5
10-27-38	17	15.0	500	95	8	2
11-16-38	15	11.0	550	350	8	5
Average	89	18.1	1,200	110	107	10
Maximum	279	21.0	5,900	2,400	1,646	446
Minimum	15	11.0	350	1.1	5	0.1

TABLE 60 (Continued)

ELK RIVER

BACTERIA

Elk River - Station Ek 146.8 - below Winchester, Tenn.

Date	Discharge cfs	Water Temperature °C	Bacteria per Milliliter		Quantity Units (Bacteria x 1000 cfs)	
			On Agar 37°C for 24 hours	Coliform Group M.P.N.	On Agar 37°C for 24 hours	Coliform Group M.P.N.
5-20-38	438	21.5	190	95	83	42
6-6-38	1,143	19.0	1,700	11	1,943	13
6-27-38	944	21.0	4,400	350	4,154	330
7-15-38	717	22.0	3,800	160	2,725	115
7-27-38	967	22.0	70	1.6	68	2
8-10-38	813	23.0	1,900	2.3	1,545	2
8-25-38	290	24.0	220	24	64	7
9-15-38	367	24.0	3,800	2,200	1,395	807
9-27-38	461	20.5	180	6.2	83	3
10-12-38	94	19.0	350	110	33	10
10-27-38	104	13.0	700	9.3	73	1
11-16-38	89	10.0	5,400	2.1	481	0.2
Average	536	19.9	850	27	456	14
Maximum	1,143	24.0	5,400	2,200	4,154	807
Minimum	89	10.0	70	1.6	33	0.2
Mulberry Creek - Station MuC 1.0 - below Lynchburg, Tenn.						
5-20-38	108	24.5	200	6.2	22	0.7
6-6-38	192	20.0	1,800	60	346	12
6-27-38	173	22.0	7,600	2,200	1,315	381
7-15-38	111	25.0	5,500	16	610	2
7-27-38	148	23.5	250	24	37	4
8-10-38	132	25.0	850	60	112	8
8-25-38	44	25.0	1,600	6.2	70	0.3
9-15-38	50	24.0	23,500	24,000	1,175	1,200
9-28-38	27	20.0	350	13	9	0.4
10-13-38	25	17.0	2,900	130	72	3
10-27-38	23	14.0	170	1.6	4	0.05
11-16-38	28	9.5	1,200	50	34	1
Average	88	20.8	1,300	50	114	4
Maximum	192	25.0	23,500	24,000	1,315	1,200
Minimum	23	9.5	170	1.6	4	0.05

TABLE 60 (Continued)

ELK RIVER

BACTERIA

Elk River - Station Ek 99.4 - above Fayetteville, Tenn.

Date	Discharge cfs	Water Temperature °C	Bacteria per Milliliter		Quantity Units (Bacteria x 1000 cfs)	
			On Agar 37°C for 24 hours	Coliform Group M.P.N.	On Agar 37°C for 24 hours	Coliform Group M.P.N.
5-20-38	974	23.0	240	21	234	20
6-6-38	1,600	20.0	1,400	50	2,240	80
6-27-38	1,440	22.0	3,300	350	4,752	504
7-15-38	923	24.0	1,300	36	1,200	33
7-27-38	1,230	23.5	600	24	738	30
8-10-38	1,080	24.5	2,200	36	2,376	39
8-25-38	341	26.0	375	3.6	128	1
9-15-38	405	25.0	1,000	275	405	111
9-28-38	204	19.5	275	6.2	56	1
10-13-38	204	18.0	-	-	-	-
10-27-38	192	13.0	260	0.6	50	0.1
11-16-38	231	10.0	180	80	42	18
Average	735	20.7	650	26	478	19
Maximum	1,600	26.0	3,300	350	4,752	504
Minimum	192	10.0	180	0.6	42	0.1
Elk River - Station Ek 88.4 - Fayetteville, Tenn.						
5-20-38	1,060	23.0	1,700	36	1,802	38
6-6-38	1,800	20.5	700	240	1,260	432
6-27-38	1,690	23.0	3,000	600	5,070	1,014
7-15-38	1,010	25.0	7,300	600	7,373	606
7-27-38	1,370	24.0	600	240	822	329
8-10-38	1,230	25.0	5,400	2.3	6,642	3
8-25-38	408	27.0	2,600	60	1,061	24
9-15-38	383	25.0	1,300	95	498	36
9-28-38	226	21.0	2,400	0	542	0
10-13-38	239	18.0	475	50	114	12
10-27-38	209	14.0	1,100	550	230	115
11-16-38	242	10.5	1,500	350	363	85
Average	822	21.3	1,700	70	1,397	58
Maximum	1,800	27.0	7,300	600	7,373	1,014
Minimum	209	10.5	475	0	114	0

TABLE 60 (Continued)

ELK RIVER

BACTERIA

Elk River - Station Ek 48.6 - Elkton, Tenn.

Date	Discharge cfs	Water Temperature °C	Bacteria per Milliliter		Quantity Units (Bacteria x 1000 cfs)	
			On Agar 37°C for 24 hours	Coliform Group M.P.N.	On Agar 37°C for 24 hours	Coliform Group M.P.N.
5-20-38	1,120	23.0	600	0	672	0
6-6-38	2,230	22.0	2,100	60	4,683	134
6-27-38	1,860	23.0	2,500	1,600	4,650	2,976
7-15-38	1,070	25.5	11,000	11	11,700	12
7-27-38	1,520	25.0	40	2.1	61	3
8-10-38	1,450	25.5	4,200	110	6,090	160
8-25-38	444	28.0	650	3.6	289	2
9-15-38	413	25.0	1,600	95	661	39
9-28-38	316	22.0	500	0.6	158	0.2
10-13-38	270	19.0	550	11	148	3
10-27-38	258	15.0	350	0.6	90	0.2
11-16-38	337	11.5	450	9.3	152	3
Average	941	22.0	900	9	847	8
Maximum	2,230	28.0	11,000	1,600	11,770	2,976
Minimum	258	11.5	40	0	61	0
Richland Creek - Station RiC 2.3 - near Elkton, Tenn.						
5-20-38	172	24.0	180	0	31	0
6-6-38	213	23.0	2,200	24,000	469	5,112
6-27-38	294	24.0	1,600	36	470	11
7-15-38	130	26.5	4,400	24	572	3
7-27-38	144	27.0	1,200	24	173	3
8-10-38	130	28.0	800	3.6	104	0.5
8-25-38	58	28.0	600	50	35	3
9-15-38	62	25.0	400	3.6	25	0.2
9-28-38	42	21.0	475	3.6	20	0.2
10-13-38	45	20.0	400	6.2	18	0.3
10-27-38	50	15.0	350	1.3	18	0.1
11-16-38	66	11.0	550	160	36	11
Average	117	22.7	750	15	88	2
Maximum	294	28.0	4,400	24,000	572	5,112
Minimum	42	11.0	180	0	18	0

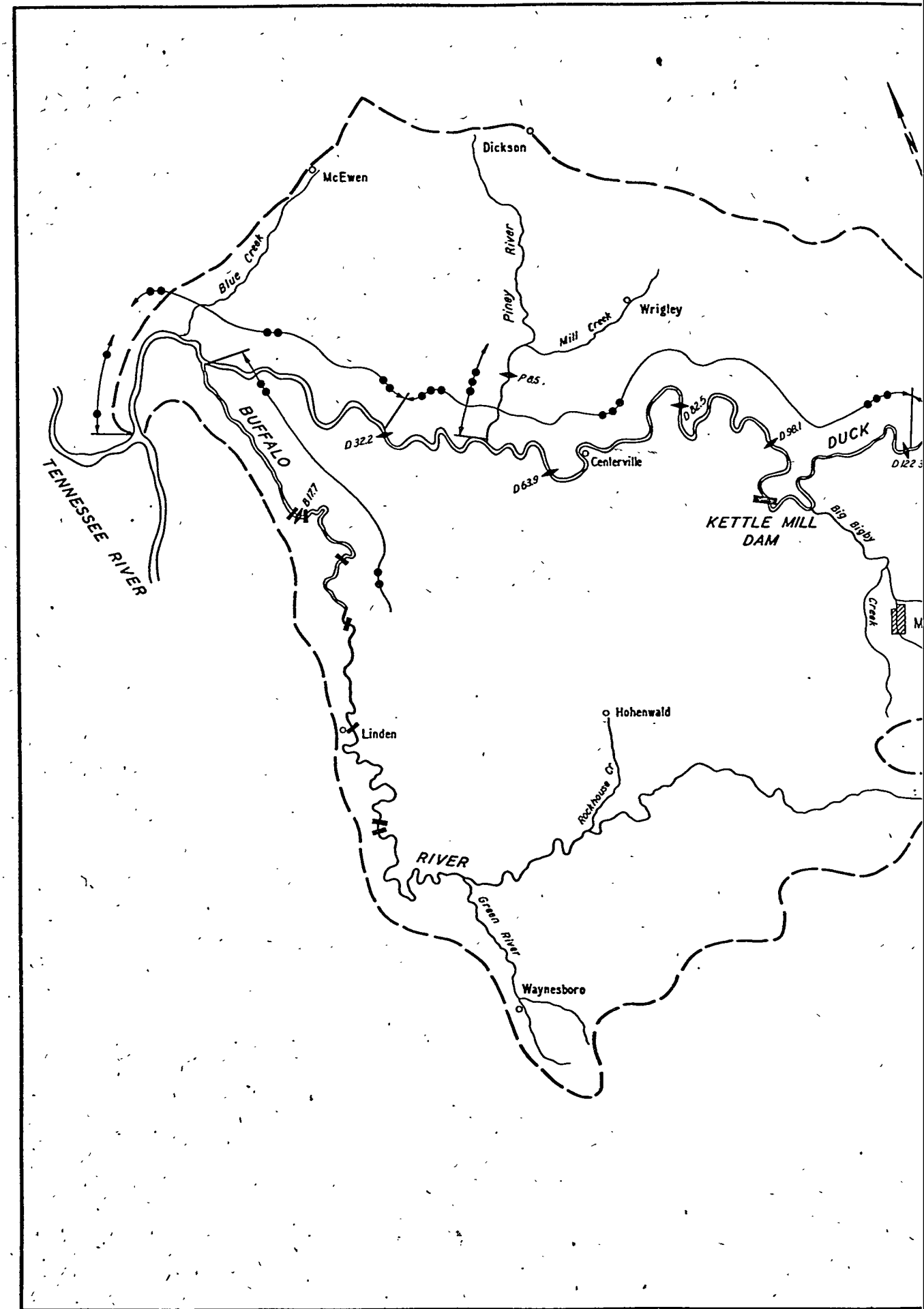
TABLE 60 (Continued)

ELK RIVER

BACTERIA

Elk River - Station Ek 36.5 - Prospect, Tenn.

Date	Discharge cfs	Water Temperature °C	Bacteria per Milliliter		Quantity Units (Bacteria x 1000 cfs)	
			On Agar 37°C for 24 hours	Coliform Group M.P.N.	On Agar 37°C for 24 hours	Coliform Group M.P.N.
5-20-38	1,320	23.0	1,200	11	1,584	15
6-6-38	2,610	22.5	2,600	11	6,786	29
6-27-38	2,060	24.0	4,000	60	8,240	124
7-15-38	1,250	26.0	5,900	16	7,375	20
7-27-38	1,750	25.0	3,200	36	5,600	63
8-10-38	1,670	27.0	3,100	9.3	5,177	16
8-25-38	508	28.0	750	3.6	381	2
9-15-38	453	25.0	400	6.2	181	3
9-28-38	357	22.0	1,500	13	536	5
10-13-38	299	21.0	700	2.3	209	0.7
10-27-38	304	15.0	475	1.1	144	0.3
11-16-38	408	11.5	500	60	204	24
Average	1,082	22.5	1,400	10	1,515	11
Maximum	2,610	28.0	5,900	60	8,240	124
Minimum	299	11.5	400	1.1	144	0.3



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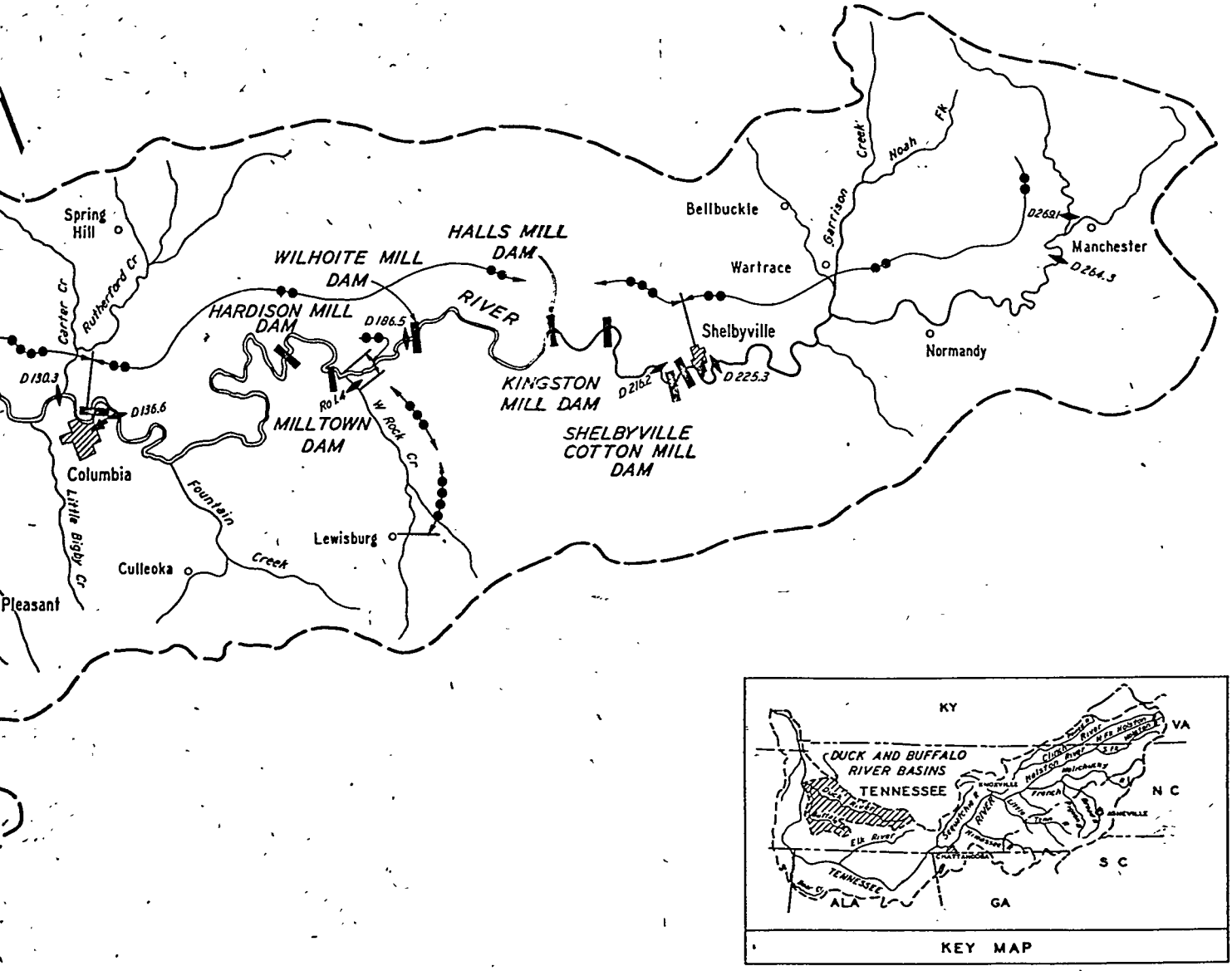


KEY MAP

SYMBOLS:

- Class I – Class A swimming areas and water supplies with minimum treatment.
- Class II – Class B and C swimming areas and water supplies (normal filter plant operation).
- Class III – Water supplies (advanced treatment methods) and fish life.
- Class IV – Unsuitable for water supplies as defined under class III or which do not support desirable fish fauna.
- Sampling stations.
- Water supply intake

Figure 17

Scale 4 0 4 8 Miles

POLLUTION SURVEY

DUCK RIVER DRAINAGE BASIN

STREAM SANITATION PROGRAM
TENNESSEE VALLEY AUTHORITY
HEALTH AND SAFETY DEPARTMENT

SUBMITTED	RECOMMENDED	APPROVED

CHATTANOOGA	10-29-43	G	HS	3068516 R1

SECTION VII

DUCK RIVER

SECTION VII

DUCK RIVER

General

The Duck River drains a long, narrow valley in middle Tennessee along the northern edge of the Tennessee Valley extending from the Cumberland Plateau on the east to the Tennessee River on the west, figure 17. It is the lowest large tributary of the Tennessee River, discharging into the river 110.7 miles above its mouth.

It is the fourth in size of the larger tributaries, and has a drainage area of 3,500 square miles. It has two large tributaries, the Buffalo River and the Piney River. The sizes of these drainage areas are as follows:

Piney River	223 square miles
Buffalo River	764 square miles
Remainder of basin	2,513 square miles

The area is predominantly rural in character, having no large cities. Columbia, the largest municipality, having a population of 10,579, is located approximately in the center of the basin. Agriculture is the chief industry, with the mining and processing of phosphate ore in the vicinity of Columbia perhaps next in importance. There are two power dams, eight mill dams, and one dam forming a recreational lake on Duck River. The power dams are located at Shelbyville and Columbia.

Geology

The drainage area of the Duck River lies within that area of central Tennessee designated as the Highland Plain, with the midportion in the southern section of the Nashville Basin. The geology of these areas has been discussed under the Elk River.

As a result of the geological formations and physical structures the main river is a series of deep sluggish pools connected with sections of shallow depth and higher velocities over rocky bottoms. During periods of normal flows the stream is relatively clear; but during flood stage it carries a large amount of silt.

Precipitation

The average annual precipitation in the Duck River basin varies between 47 and 56 inches with an average of about 52 inches for the area. During the year's sampling survey the average precipitation over the entire area was 51 inches.

Stream Flows

The mean monthly discharges, along with the periods of record and extent of drainage areas, at various points on the Duck River and its main tributaries are shown in table 61. Low flows below Columbia and Shelbyville are completely regulated by the power dams.

As a comparison with these monthly discharges, the average discharges existing at each sampling station at the time samples were taken are shown in the tables presenting the results of analyses (tables 66-70).

TABLE 61

MEAN MONTHLY DISCHARGES IN CUBIC FEET PER SECOND

AT DESIGNATED POINTS ON THE DUCK, PINEY, AND BUFFALO RIVERS

	Duck River Columbia, Tenn.	Duck River Centerville, Tenn.	Duck River Hurricane Mills, Tenn.	Piney River Vernon, Tenn.	Buffalo River Lobelville, Tenn.
Drainage Area Above Gage Sq. Mi.	1,208	2,048	2,571	193	707
Period of Record	1920-1934	1920-1934	1926-1934	1926-1934	1928-1934
January cfs	2,980	4,750	6,020	484	1,730
February cfs	3,830	6,070	7,100	538	2,200
March cfs	4,430	7,220	9,020	627	2,460
April cfs	2,980	5,100	6,210	525	1,730
May cfs	2,000	3,350	4,450	424	1,620
June cfs	1,060	1,710	2,240	245	712
July cfs	530	930	1,480	138	682
August cfs	712	1,170	1,260	117	372
September cfs	384	719	890	89	375
October cfs	524	788	1,190	100	532
November cfs	1,260	1,730	2,240	125	554
December cfs	2,650	3,900	5,300	370	1,100
Mean Annual cfs	2,010	3,100	3,950	315	1,170
Maximum Flow cfs	43,800	51,700	65,000	32,500	31,600
Minimum Flow cfs	0	68	185	35	142

Water Supplies

As shown in table 62, most of the municipal water supplies are obtained from springs. Four of the supplies receive treatment in filter plants and all but one of the remainder of the supplies are chlorinated.

TABLE 62

WATER SUPPLIES

DUCK RIVER BASIN, 1937-1940

Municipality	Population 1940	Source	Treatment[1]
Manchester, Tenn.	1,715	Spring	D
Normandy, Tenn.	163	Wartrace	
Bellbuckle, Tenn.	355	Wartrace	
Wartrace, Tenn.	552	Spring	D
Shelbyville, Tenn.	6,537	Duck River	CFD
Shelbyville Mills, Tenn.	700	Shelbyville	
Lewisburg, Tenn.	3,582	Impounding reservoir	ACFD
Columbia, Tenn.	10,579	Duck River	CFD
Spring Hill, Tenn.	543	Wells and Spring	D
Mt. Pleasant, Tenn.	3,089	Springs	D
Centerville, Tenn.	1,030	Spring	D
Dickson, Tenn.	3,504	Impounding reservoir	CFD
Wrigley, Tenn.	733	Spring	D
Hohenwald, Tenn.	1,086	Spring	N
Waynesboro, Tenn.	768	Springs	AD
Linden, Tenn.	641	Spring	D
McEwen, Tenn.	617	Well	D

1. N = No Treatment
   C = Coagulation and Sedimentation
   D = Disinfection
   F = Filtration
   A = Aeration

Sources of Pollution

Population Estimates

The total population for the Duck River basin in 1940 was 130,344.

Sewerage Systems

Table 63 shows the municipalities having sewerage systems and the types of sewage treatment. The three sewage treatment plants effect a reduction of 13.5 percent in the amount of pollution from domestic sewage.

TABLE 63

SEWERAGE SYSTEMS

DUCK RIVER BASIN, 1937-1940

Municipality	Population (1940 U.S. Census)		Treatment
	Total	Sewered	
Shelbyville, Tenn.	6,537	3,270	None
Shelbyville Mills, Tenn.	700	700	None
Lewisburg, Tenn.	3,582	2,150	Imhoff Tanks, Trickling Filter, Secondary-Settling
Columbia, Tenn.	10,579	7,410	None
Centerville, Tenn.	1,030	820	None
Dickson, Tenn.	1,930*	1,450	Septic Tank
Hohenwald, Tenn.	1,086	540	Imhoff Tank
Total	25,444	16,340	

*Dickson total population 3,504; 55± percent in Duck River basin and 45± percent in Cumberland basin.

Industrial Plants

Table 64 gives the types and numbers of industrial plants in the basin, the disposition of their wastes, and comparative figures for the entire Tennessee Valley.

TABLE 64

INDUSTRIAL POLLUTION

DUCK RIVER BASIN, 1937-1940

Types of Industry	Number of Plants		Method of Disposal			Estimated Population Equivalents	
	Duck River Basin	Percent of Total in Tenn. Valley	Municipal Sewers	Stream	Some Correction	Duck River Basin	Percent of Total in Tenn. Valley
Canning	3	11.1	1	2	1	4,300	10.3
Chemical[1]	6	23.0	0	6	5	19,300	71.6
Meat	2	10.5	0	2	0	2,200	5.5
Milk	10	29.4	9	1	3	5,850	41.3
Mining[2]	5	50.0	0	5	5	-	0
Textile	3	3.5	2	1	0	300	.2
Total	29	11.7	12	17	14	31,950	2.4

1. Five of the six industries discharge wastes containing mineral matter and inorganic solids in solution and suspension. No information on the population equivalent of these wastes is available. Acid wastes are neutralized and ponds are provided for removal of grosser solids.

2. Wastes from phosphate mining and refining operations contain large concentrations of silt at times. Wastes are usually settled in ponds prior to discharge.

Extent of Pollution

Table 65 shows the estimated amounts of pollution by domestic sewage and industrial wastes originating in the municipalities in the basin. The same information is shown graphically in figure 18. No attempt has been made to measure the effect of the phosphate mining and manufacturing plants in either table 65 or figure 18, as it is not possible to measure such wastes by this method.

TABLE 65

ESTIMATED POPULATION EQUIVALENT OF POLLUTION

REACHING DUCK RIVER SYSTEM, 1937-1940

Municipality	Receiving Stream	Estimated Population Equivalents		
		Domestic Sewage	Industrial Wastes	Total
Wartrace, Tenn.	Wartrace Creek	-	400	400
Shelbyville, Tenn.	Duck River	3,270	1,200	4,470
Shelbyville Mills	Duck River	700	-	700
Lewisburg, Tenn.	West Rock Creek	430	520	950
Culleoka, Tenn.	Fountain Creek	-	1,500	1,500
Columbia, Tenn.	Duck River	6,170	6,200	12,370
Columbia, Tenn.	Little Bigby Creek	1,240	-	1,240
Centerville, Tenn.	Duck River	820	-	820
Dickson, Tenn.	Piney River	1,160	40	1,200
Wrigley, Tenn.	Mill Creek	-	19,300	19,300
Hohenwald, Tenn.	Buffalo River	350	-	350
McEwen, Tenn.[1]	Blue Creek	-	200	200
Total		14,140	29,360	43,500

1. Industrial wastes from one plant at McEwen are discharged into a dry ditch. It is rather doubtful that any of this waste reaches the main river.

Sampling and Sampling Stations

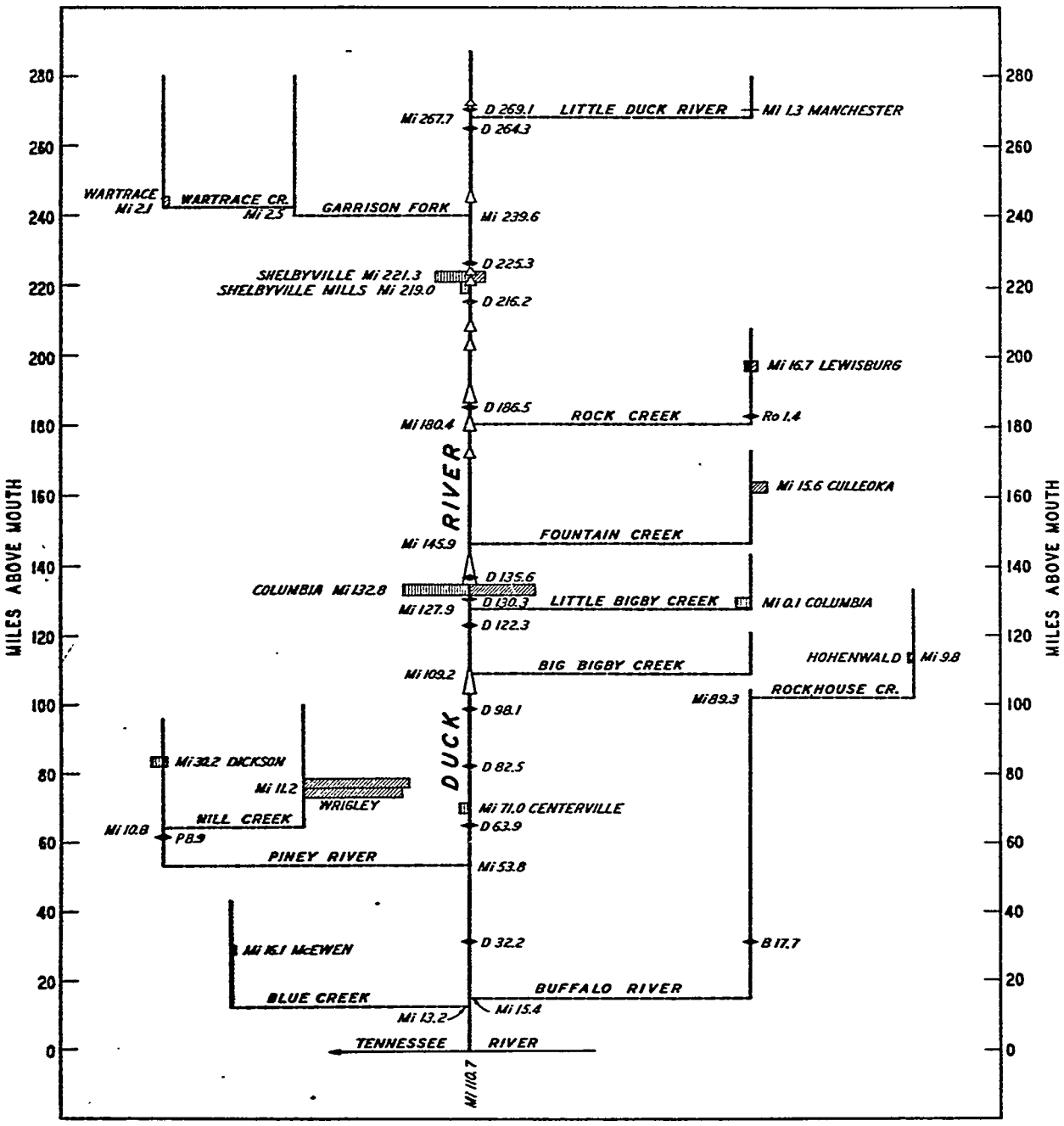
Sampling

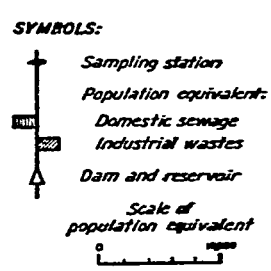
Samples were collected by the Tennessee Department of Public Health from 15 stations during the period from February 15, 1938, to February 1, 1939. Originally it was intended to collect samples at weekly intervals from all stations; however, lack of time made it impossible to carry out such a schedule. Weekly samples were collected from the stations in the central section above and below Columbia, with less frequent collections from the upper and lower stations where the pollution problem was not considered acute enough to warrant the detailed survey. The state made the following determinations: temperature, dissolved oxygen, pH B.O.D., alkalinity, chlorides, and turbidity. The remainder of the determinations were made by the Authority on samples expressed to the laboratory at Norris.

Sampling Stations

The sampling stations and their locations were:

Duck River, D 269.1:	U.S. Highway No. 41 bridge above Manchester.
Duck River, D 264.3:	About three miles below the mouth of Little Duck River.
Duck River, D 225.3:	State Highway No. 16 bridge upstream from Shelbyville.
Duck River, D 216.2:	Sims Bridge, west of Shelbyville.
Duck River, D 186.5:	About 35 miles downstream from Shelbyville, above Rock Creek.
Big Rock Creek, Ro 1.4:	Cheek Bridge below mouth of East Rock Creek.
Duck River, D 136.6:	Bridge just above dam at Columbia.
Duck River, D 130.3:	Godwin Bridge, north and downstream from Columbia. All of the industrial wastes and 83 percent of the domestic sewage from Columbia enter the river above this station.
Duck River, D 122.3:	Hughs Bridge below Green Lick Creek.
Duck River, D 98.1:	Gordon Ferry Bridge; Big Bigby Creek enters the Duck River about 11 miles upstream.





NOTE:
Number at sampling station denotes miles above mouth of each stream.

Figure 18

DUCK RIVER
SOURCES OF POLLUTION
AND
SAMPLING STATIONS

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Duck River, D 82.5: Totty's Bend Bridge above Centerville.

Duck River, D 63.9: Huddleston Bridge on State Highway No. 50 below Centerville.

Piney River, P 8.5: Vernon Bridge at Vernon.

Duck River, D 32.2: About 22 miles below the mouth of Piney River near Only, Tenn.

Buffalo River, B 17.7: Standing Rock Bridge on State Highway No. 13.

Discussion of Results

The detailed results of the studies are shown in tables 66 to 70, inclusive, and the bacterial results, dissolved oxygen, and B.O.D. are shown graphically in figure 19.

The results indicate that Duck River above D 269.1 is in a Class II condition. The effect of Manchester with no municipal sewerage system is very slight, as indicated by the results obtained at D 264.3. The river continues as a Class II stream until it reaches Shelbyville. Here the domestic sewage and industrial wastes degrade the stream to Class III, as indicated by the results at D 216.2. It recovers from this pollution at some point above D 186.5, perhaps about mile 200, as indicated on figure 19 with respect to the coliform group.

Rock Creek enters at mile 180.4 in a Class II condition. This represents a remarkable recovery in the stream as the State Department of Public Health has observed Class IV conditions in the west fork of Rock Creek below Lewisburg, about 15 miles upstream.

Below Rock Creek Class II conditions exist in the stream to Columbia. The cause of the increase in the nitrogen content and B.O.D. observed at D 136.6 has not been determined.

The effect of the domestic sewage and industrial wastes from Columbia is to degrade the stream to Class IV. From the results of the studies it appears that the stream recovers to Class III conditions by the time it reaches D 122.3. However, the method of operation and the

amount of discharge from the hydroelectric plant at Columbia will govern the rate of recovery from this load of pollution. With low discharges it is possible for Class IV conditions to extend downstream well below the mouth of Big Bigby Creek.

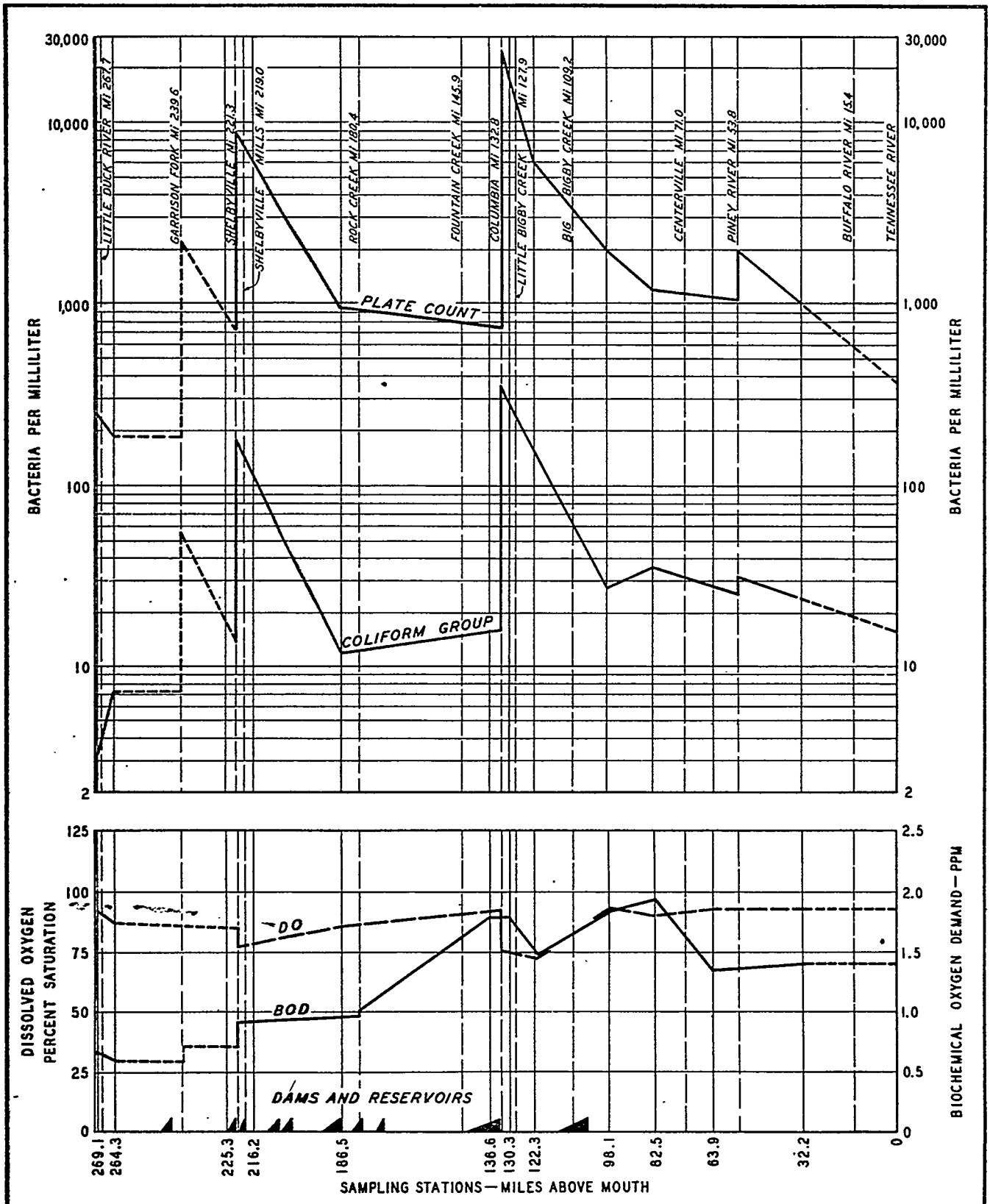
The effects of the wastes from the phosphate mining and refining operations carried by Big Bigby Creek, as shown by the results at D 98.1, are to increase the suspended solids and turbidities. There also appears to be an increase in fluoride content in the stream, and while no tests were made for phosphorus compounds, it is logical to assume that such compounds will be increased by the activities in the stream below Columbia.

This possible increase of phosphates along with the increase of nitrogen compounds which are received above Columbia might serve as food for bacteria. If so it would offer a possible explanation for the unexpected high concentrations of bacteria which were found in Duck River all the way from Columbia to D 63.9. Below D 122.3 Class III conditions with respect to bacteria and dissolved oxygen were observed during a considerable portion of the year, whereas the B.O.D. results indicated a cleaner stream. At mile 71.0 the stream receives a small amount of domestic sewage from Centerville which has no apparent effect on the stream.

Piney River enters Duck River at mile 53.8 in a Class III condition as measured by high bacterial results. The source of this high concentration is undetermined, as the only domestic sewage received by the stream originates from a portion of Dickson, Tenn. There are considerable amounts of industrial wastes originating at Wrigley, Tenn., which seriously pollute Mill Creek.

Buffalo River enters the Duck River at mile 15.4 in a Class II condition. This is a relatively clean stream throughout as it receives no industrial waste and only a small amount of domestic sewage from Hohenwald, Tenn.

Below D 32.2 it is estimated that Duck River continues as Class II to the mouth. It is estimated that when Kentucky Reservoir is filled, recovery will be more rapid; and it is expected that Class I conditions will exist in this arm of Kentucky Reservoir in the mouth of the river.



NOTE:

Curves based on averages of observations from June 15, 1938 through October 15, 1938.

Figure 19

DUCK RIVER
STREAM CONDITIONS

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The classifications as discussed above are shown on figure 17.

Effects of Pollution

The small amount of organic pollution does not seriously affect any of the municipal water supplies obtained from surface streams.

There have been several reports that fish were killed by wastes from the phosphate ore mining and processing operations in the area below Columbia. However, at no time when samples have been collected were conditions observed which were recognized as toxic to fish. High concentrations of turbidities have been observed. This material on settling would form silt banks which might prevent spawning but concentrations of turbidity which were observed should not kill fish. Since very low flows have been experienced for short periods below Columbia due to the operation of the hydroelectric plant, it would seem more logical to assume that insufficient amounts of oxygen in the trough of low flow as it progresses downstream might be the cause of the death of the fish. It is also possible that elemental phosphorus resulting from accidental spills at the processing plants has caused the death of fish.

TABLE 66

DUCK RIVER

MINERAL ANALYSES[1]

Duck River - Station D 225.3 - above Shelbyville, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Results of Mineral Analyses - Parts per Million											pH
				Fe		SiO_2	Ca	Mg	Na	SO_4	Cl	F	Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	
				Unfiltered	Filtered										
1938	June	3	675	1.60	0.00	6	26.8	3.3	0.7	3.0	4	0.42	72	82	7.5
	July	2	322	1.60	.00	7	24.6	1.7	4.1	2.5	2	.44	71	69	7.4
	August	2	135	.92	T	9	27.8	1.8	11.5	3.4	11	.40	82	77	7.6
	September	2	166	1.20	.00	9	28.4	4.3	4.4	5.3	8	.84	85	89	7.6
	October	2	64	.90	.06	7	26.6	4.0	4.4	3.2	4	.40	84	83	7.6
	November	3	273	.44	.04	7	29.6	4.0	3.2	4.2	3	T	86	91	7.5
	Average		300	1.11	0.02	7	27.3	3.2	4.7	3.6	5	0.42	80	82	7.5
	Maximum		1,380	1.60	.06	9	29.6	4.3	11.5	5.3	11	.84	86	91	7.6
	Minimum		34	.44	.00	6	24.6	1.7	.7	2.5	2	T	71	69	7.4

1. Based on monthly composites.

TABLE 66 (Continued)

DUCK RIVER

MINERAL ANALYSES[1]

Duck River - Station D 136.6 - above Columbia, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Results of Mineral Analyses - Parts per Million											pH
				Fe		SiO_2	Ca	Mg	Na	SO_4	Cl	F	Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	
				Unfiltered	Filtered										
1938	June	5	875	1.00	0.00	7	41.0	3.8	2.0	3.5	4	0.46	110	119	7.7
	July	4	1,810	3.50	.00	7	38.2	2.4	4.8	3.8	3	.44	107	106	7.6
	August	5	1,160	1.20	T	8	43.4	2.7	2.5	4.4	3	.30	119	120	7.8
	September	4	187	.60	.02	8	38.0	4.6	2.3	5.1	3	.64	109	114	7.9
	October	4	115	1.00	T	7	37.9	2.2	.9	4.3	4	.40	102	104	8.4
	November	5	841	.82	.02	7	39.8	3.9	1.8	4.7	3	.01	107	116	7.5
	December	4	1,440	1.52	.02	7	49.0	5.0	.9	9.4	3	.24	132	143	7.6
1939	January	4	2,310	1.40	.02	7	47.8	3.7	.7	8.2	4	.20	122	135	7.5
	Average		1,080	1.38	0.01	7	41.9	3.5	2.0	5.4	3	0.34	114	120	7.8
	Maximum		4,570	3.50	.02	8	49.0	5.0	4.8	9.4	4	.64	132	143	8.4
	Minimum		91	.60	.00	7	37.9	2.2	.7	3.5	3	.01	102	104	7.4

1. Based on monthly composites.

TABLE 66 (Continued)

DUCK RIVER

MINERAL ANALYSES[1]

Duck River - Station D 98.1 - below Big Bigby Creek

Year	Month	Number Times Sampled	Discharge cfs	Results of Mineral Analyses - Parts per Million											pH
				Fe		SiO_2	Ca	Mg	Na	SO_4	Cl	F	Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	
				Unfiltered	Filtered										
1938	June	5	1,540	3.50	0.00	7	41.6	3.2	3.7	6.8	4	0.48	110	119	7.7
	July	4	2,160	16.50	.00	6	42.0	2.8	3.9	6.9	4	.50	111	117	7.6
	August	5	1,300	1.24	.00	8	45.0	2.2	3.4	6.1	3	.40	121	122	7.7
	September	4	310	1.20	.02	8	37.6	3.9	1.6	5.1	4	1.02	102	110	7.6
	October	4	198	1.20	.00	7	42.2	4.4	.7	5.8	4	.70	118	124	7.8
	November	5	980	1.08	.02	8	42.0	3.7	2.3	5.4	4	.12	113	121	7.5
	December	4	1,160	1.68	.04	7	50.8	4.5	1.8	9.8	4	.50	136	146	7.6
1939	January	4	2,940	4.50	T	7	48.4	3.9	3.0	10.1	4	.56	123	137	7.6
	Average		1,320	3.86	0.01	7	43.7	3.6	2.6	7.0	4	0.54	117	124	7.6
	Maximum		4,730	16.50	.04	8	50.8	4.5	3.9	10.1	4	1.02	136	146	8.3
	Minimum		177	1.08	.00	6	37.6	2.2	.7	5.1	3	.12	102	110	7.4

1. Based on monthly composites.

TABLE 67

DUCK RIVER

SOLIDS[1]

Duck River - Station D 225.3 - above Shelbyville, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Turbidities	Solids - Parts per Million				
					Dissolved	Suspended	Volatile	Fixed	Total
1938	June	3	675	100	101	122	50	173	223
	July	2	322	120	99	79	62	116	178
	August	2	135	50	124	27	27	124	151
	September	2	166	50	108	50	97	61	158
	October	2	64	45	109	82	112	79	191
	November	3	273	25	103	22	54	71	125
	Average		300	65	107	64	67	104	171
	Maximum		1,380	120	124	122	112	173	223
	Minimum		34	25	99	22	27	61	125
Duck River - Station D 136.6 - above Columbia, Tenn.									
1938	June	5	875	110	148	51	33	166	199
	July	4	1,810	450	135	198	96	237	333
	August	5	1,160	110	151	97	49	199	248
	September	4	187	60	128	18	31	115	146
	October	4	115	40	119	45	73	91	164
	November	5	841	50	132	38	61	109	170
	December	4	1,440	75	159	63	43	179	222
1939	January	4	2,310	80	145	59	63	141	204
	Average		1,080	122	140	71	56	155	211
	Maximum		4,570	450	159	198	96	237	333
	Minimum		91	40	119	18	31	91	146
Duck River - Station D 98.1 - below Big Bigby Creek									
1938	June	5	1,540	340	149	413	58	504	562
	July	4	2,160	600	150	616	113	653	766
	August	5	1,300	160	160	106	61	205	266
	September	4	310	90	128	82	61	149	210
	October	4	198	55	127	41	73	95	168
	November	5	980	85	147	69	45	171	216
	December	4	1,160	80	172	57	55	174	229
1939	January	4	2,940	200	157	137	77	217	294
	Average		1,320	201	149	190	68	271	339
	Maximum		4,730	600	172	616	113	653	766
	Minimum		177	55	127	41	45	95	168

1. Based on monthly composites.

TABLE 68

DUCK RIVER

NITROGENS[1]

Duck River - Station D 269.1 - above Manchester, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Nitrogen - Parts per Million				
					Organic	Free Ammonia	Nitrite	Nitrate	Total
1938	June	1	47	21.0	0.56	0.168	T	0.40	1.13
	July	1	26	24.0	.40	.179	0.002	.32	.90
	August	1	34	24.0	.06	.184	.002	.12	.36
	September	1	20	23.5	1.16	.704	.002	.04	1.90
	October	1	18	18.0	.32	.280	.002	.12	.72
	Average		29	22.1	0.50	0.303	0.002	0.20	1.00
	Maximum		47	24.0	1.16	.704	.002	.40	1.90
	Minimum		18	18.0	.06	.168	T	.04	.36
Duck River - Station D 264.3 - below Manchester, Tenn.									
1938	June	1	92	21.0	0.43	0.096	T	0.32	0.85
	July	1	51	24.0	.24	.096	0.001	.40	.70
	August	1	66	25.0	.51	.112	.003	.16	.78
	September	1	38	24.0	.33	.216	.001	3.68	4.23
	October	1	35	19.0	.45	.400	.002	.12	.97
	Average		56	22.6	0.39	0.184	0.001	0.94	1.51
	Maximum		92	25.0	.51	.400	.003	3.68	4.23
	Minimum		35	19.0	.24	.096	T	.12	.70
Duck River - Station D 225.3 - above Shelbyville, Tenn.									
1938	June	3	675	21.7	0.88	0.400	0.003	0.80	2.08
	July	2	322	26.0	.58	.184	.001	.48	1.24
	August	2	135	27.2	.36	.032	.002	.24	.63
	September	2	166	21.8	.67	1.360	.005	.32	2.35
	October	2	64	19.8	.53	.480	.002	.28	1.29
	Average		309	23.1	0.61	0.491	0.003	0.42	1.52
	Maximum		1,380	28.5	.88	1.360	.005	.80	2.35
	Minimum		34	18.0	.36	.032	.001	.24	.63

1. Based on monthly composites.

TABLE 68 (Continued)

DUCK RIVER

NITROGENS[1]

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Nitrogen - Parts per Million				
					Organic	Free Ammonia	Nitrite	Nitrate	Total
Duck River - Station D 216.2 - below Shelbyville, Tenn.									
1938	June	3	711	22.3	0.88	1.000	0.002	0.80	2.68
	July	2	318	26.5	.84	.304	.001	.52	1.66
	August	2	184	27.8	.67	.510	.008	.32	1.50
	September	2	139	22.5	.92	1.020	.003	.44	2.38
	October	2	74	20.2	1.20	1.400	.002	.12	2.72
	Average		324	23.7	0.90	0.847	0.003	0.44	2.19
	Maximum		1,465	29.0	1.20	1.400	.008	.80	2.72
	Minimum		16	19.0	.67	.304	.001	.12	1.50
Duck River - Station D 186.5 - above Rock Creek									
1938	June	1	364	24.0	0.88	0.180	0.003	0.60	1.66
	July	1	469	27.0	.51	.144	T	.60	1.25
	August	1	213	27.0	.92	.344	.002	.36	1.62
	September	1	143	19.5	1.08	.640	.002	.32	2.04
	October	1	173	20.0	1.20	2.000	.001	.12	3.32
	Average		272	23.5	0.92	0.662	0.002	0.40	1.98
	Maximum		469	27.0	1.20	2.000	.003	.60	3.32
	Minimum		143	19.5	.51	.144	T	.12	1.25
Rock Creek - Station Ro 1.4 - near mouth									
1938	June	1	59	23.5	0.76	0.400	0.002	1.00	2.16
	July	1	34	24.0	.42	.048	.000	1.16	1.63
	August	1	17	28.5	.43	.096	.002	.48	1.01
	September	1	14	19.0	1.76	.784	.002	.04	2.58
	October	1	12	19.5	1.00	.152	.002	.12	1.27
	Average		27	22.9	0.87	0.296	0.002	0.56	1.73
	Maximum		59	28.5	1.76	.784	.002	1.16	2.58
	Minimum		12	19.0	.42	.048	.000	.04	1.01

1. Based on monthly composites.

TABLE 68 (Continued)

DUCK RIVER

NITROGENS[1]

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Nitrogen - Parts per Million				
					Organic	Free Ammonia	Nitrite	Nitrate	Total
Duck River - Station D 136.6 - above Columbia, Tenn.									
1938	June	5	875	25.1	0.48	0.069	0.003	0.96	1.51
	July	4	1,810	27.2	.96	.240	.000	.60	1.80
	August	5	1,160	28.6	2.00	1.200	.004	.56	3.76
	September	4	187	24.6	.84	.328	.001	.32	1.49
	October	4	115	20.5	1.80	1.800	.002	.12	3.72
	Average		848	25.4	1.22	0.727	0.002	0.51	2.46
	Maximum		5,540	31.0	2.00	1.800	.004	.96	3.76
	Minimum		91	17.0	.48	.069	.000	.12	1.49
Duck River - Station D 130.3 - below Columbia, Tenn.									
1938	June	5	840	24.9	0.56	1.030	0.015	1.08	2.67
	July	4	1,820	27.1	1.20	.184	.000	.48	1.86
	August	5	1,180	28.4	1.00	.480	.005	.40	1.88
	September	4	203	24.4	.96	.576	.001	.12	1.66
	October	4	117	19.6	1.12	1.400	.002	.24	2.76
	Average		849	25.0	0.97	0.734	0.005	0.46	2.16
	Maximum		5,230	30.0	1.20	1.400	.015	1.08	2.76
	Minimum		63	15.5	.56	.184	.000	.12	1.66
Duck River - Station D 122.3 - below Green Lick Creek									
1938	June	5	1,230	24.2	0.80	0.618	0.003	1.08	2.50
	July	4	2,230	27.3	1.84	.384	.000	.60	2.82
	August	5	1,400	28.4	1.00	1.200	.004	.48	2.68
	September	4	216	24.1	.66	.496	.002	.48	1.64
	October	4	124	19.4	.72	.224	.003	.32	1.26
	Average		1,064	24.8	1.00	0.584	0.002	0.59	2.17
	Maximum		6,460	30.5	1.84	1.200	.004	1.08	2.82
	Minimum		92	15.0	.66	.224	.000	.32	1.26

1. Based on monthly composites.

TABLE 68 (Continued)

DUCK RIVER

NITROGENS[1]

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Nitrogen - Parts per Million				
					Organic	Free Ammonia	Nitrite	Nitrate	Total
Duck River - Station D 98.1 - below Big Bigby Creek									
1938	June	5	1,540	25.0	0.96	0.364	0.003	1.08	2.40
	July	4	2,160	28.1	1.68	.248	.000	.68	2.61
	August	5	1,300	28.3	1.20	1.600	.005	.80	3.60
	September	4	310	24.1	.88	.376	.001	.60	1.86
	October	4	198	19.1	1.20	1.400	.002	.16	2.76
	Average		1,131	25.1	1.18	0.798	0.002	0.66	2.64
	Maximum		6,020	30.5	1.68	1.600	.005	1.08	3.60
	Minimum		177	14.0	.88	.248	.000	.16	1.86
Duck River - Station D 82.5 - above Centerville, Tenn.									
1938	June	2	1,250	25.2	1.00	0.168	0.001	0.88	2.05
	July	2	1,530	27.8	1.32	.176	.006	.56	2.06
	August	3	2,150	27.3	.76	.800	.007	.56	2.12
	September	2	336	24.2	1.08	.328	.001	.44	1.85
	October	2	206	18.0	1.00	1.000	.002	.20	2.20
	Average		1,192	24.8	1.03	0.494	0.003	0.53	2.05
	Maximum		5,140	29.5	1.32	1.000	.007	.88	2.20
	Minimum		193	15.0	.76	.168	.001	.20	1.85
Duck River - Station D 63.9 - below Centerville, Tenn.									
1938	June	2	1,400	24.8	0.67	0.288	0.001	0.68	1.64
	July	2	1,310	27.2	1.82	.462	.006	.76	3.04
	August	3	2,970	26.8	1.08	.920	.007	.48	2.48
	September	2	401	24.5	.74	.248	.001	.48	1.47
	October	2	231	17.8	.80	.608	.002	.20	1.61
	Average		1,417	24.5	1.02	0.505	0.003	0.52	2.05
	Maximum		7,320	28.5	1.82	.920	.007	.76	3.04
	Minimum		212	15.0	.74	.248	.001	.20	1.47

1. Based on monthly composites.

TABLE 68 (Continued)

DUCK RIVER

NITROGENS[1]

Piney River - Station P 8.5 - at Vernon, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Nitrogen - Parts per Million				
					Organic	Free Ammonia	Nitrite	Nitrate	Total
1938	June	2	202	21.2	0.34	0.120	T	0.02	0.48
	July	2	176	23.8	.56	.096	0.003	.52	1.18
	August	3	186	23.3	.64	.640	.002	.36	1.64
	September	2	101	22.0	.70	.672	.001	.08	1.45
	October	2	68	15.8	1.60	1.600	.002	.16	3.36
	Average		150	21.4	0.77	0.626	0.002	0.23	1.63
	Maximum		308	24.0	1.60	1.600	.003	.52	3.36
	Minimum		66	13.5	.34	.096	T	.02	.48
Duck River - Station D 32.2 - below Piney River									
1938	June	2	1,960	24.8	0.80	0.400	T	0.84	2.04
	July	2	1,940	27.0	.18	.244	.003	.76	1.18
	August	3	3,240	26.2	1.00	2.000	.005	.40	3.40
	September	2	770	24.0	1.08	.272	.001	.20	1.55
	October	2	436	17.0	.80	1.800	.002	.08	2.68
	Average		1,813	24.0	0.77	0.943	0.002	0.46	2.17
	Maximum		7,820	28.0	1.08	2.000	.005	.84	3.40
	Minimum		418	14.5	.18	.244	T	.08	1.18
Buffalo River - Station B 17.7 - below Lobelville, Tenn.									
1938	June	1	980	24.0	0.45	0.216	T	0.48	1.15
	July	1	670	26.0	1.01	.024	0.002	.32	1.35
	August	1	443	27.0	.43	.160	.001	.20	.79
	September	1	300	26.0	1.12	.152	.001	.04	1.31
	October	1	219	19.5	.56	1.400	.003	.10	2.06
	Average		522	24.5	0.71	0.390	0.001	0.23	1.33
	Maximum		980	27.0	1.12	1.400	.003	.48	2.06
	Minimum		219	19.5	.43	.024	T	.04	.79

1. Based on monthly composites.

TABLE 69

DUCK RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

Duck River - Station D 269.1 - above Manchester, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Dissolved Oxygen		5-Day Oxygen Demand 20°C ppm	1000 Lb. per Day	
					ppm	% Saturation		Dissolved Oxygen	5-Day Oxygen Demand
1938	February	1	55	11.0	9.10	82.1	1.45	2.70	0.43
	March	3	59	12.2	9.33	86.5	.55	2.97	.18
	April	2	88	15.5	9.18	91.4	.57	4.36	.27
	May	1	43	18.5	9.20	97.4	.72	2.14	.17
	June	1	47	21.0	8.10	90.1	1.00	2.06	.25
	July	1	26	24.0	7.90	92.6	.75	1.11	.11
	August	1	34	24.0	7.70	90.3	.55	1.41	.10
	September	1	20	23.5	7.70	89.6	.70	.83	.08
	October	1	18	18.0	9.40	98.5	.28	.91	.03
	November	2	90	9.2	11.38	98.6	.61	5.53	.30
Summer[1]	Average	5	29	22.1	8.16	92.2	0.66	1.28	0.10
	Maximum		47	24.0	9.40	98.5	1.00	-	-
	Minimum		18	18.0	7.70	89.6	.28	-	-
Winter[2]	Average	9	70	12.8	9.71	90.6	0.59	3.67	0.22
	Maximum		163	18.5	12.40	99.8	1.45	-	-
	Minimum		17	4.5	8.60	82.0	.30	-	-
Duck River - Station D 264.3 - below Manchester, Tenn.									
1938	February	1	104	11.0	9.50	85.7	1.50	5.34	0.84
	March	3	117	11.3	9.27	84.3	.69	5.86	.44
	April	2	171	15.8	9.25	92.6	.70	8.54	.65
	May	1	83	18.0	9.05	94.9	1.12	4.06	.50
	June	1	92	21.0	8.00	89.0	.68	3.97	.34
	July	1	51	24.0	7.55	88.5	.30	2.08	.08
	August	1	66	25.0	6.95	82.9	.22	2.48	.08
	September	1	38	24.0	6.85	80.3	.90	1.41	.18
	October	1	35	19.0	8.55	91.5	.78	1.62	.15
	November	2	174	8.5	11.30	96.3	.55	10.62	.52
Summer[1]	Average	5	56	22.6	7.58	86.4	0.58	2.29	0.18
	Maximum		92	25.0	8.55	94.9	.90	-	-
	Minimum		35	19.0	6.85	80.3	.22	-	-
Winter[2]	Average	9	136	12.4	9.72	89.6	0.80	7.14	0.59
	Maximum		315	18.0	12.90	98.3	1.50	-	-
	Minimum		32	4.0	8.50	80.2	.15	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 69 (Continued)

DUCK RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

Duck River - Station D 225.3 - above Shelbyville, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Dissolved Oxygen ppm	Dissolved Oxygen % Saturation	5-Day Oxygen Demand 20°C ppm	1000 Lb. per Day Dissolved Oxygen	1000 Lb. per Day 5-Day Oxygen Demand
1938	February	1	376	11.5	8.90	81.3	1.85	18.07	3.76
	March	3	519	12.2	8.98	83.3	.85	25.17	2.38
	April	2	849	17.5	8.62	89.5	.62	39.52	2.84
	May	1	376	20.0	8.40	91.6	.60	17.06	1.22
	June	3	675	21.7	7.58	85.4	1.71	27.63	6.23
	July	2	322	26.0	6.78	82.5	.76	11.79	1.32
	August	2	135	27.2	6.88	85.6	.59	5.02	.43
	September	2	166	21.8	7.55	85.2	.88	6.77	.79
	October	2	64	19.8	8.05	87.4	.60	2.78	.21
	November	3	273	9.7	10.55	92.4	1.03	15.55	1.52
Summer[1]	Average	9	220	24.0	7.28	85.1	0.75	8.65	0.89
	Maximum		403	28.5	8.45	89.9	1.28	-	-
	Minimum		94	18.0	6.60	80.3	.25	-	-
Winter[2]	Average	12	520	14.2	9.23	86.9	0.90	25.92	2.53
	Maximum		1,380	20.0	12.40	96.9	3.40	-	-
	Minimum		34	5.0	7.40	71.4	.58	-	-
Duck River - Station D 216.2 - below Shelbyville, Tenn.									
1938	February	1	476	12.0	9.50	87.7	1.80	24.42	4.63
	March	3	768	13.2	9.75	92.4	.77	40.44	3.19
	April	2	1,052	17.8	9.20	96.1	.67	52.26	3.80
	May	1	455	19.0	8.35	89.3	.92	20.52	2.26
	June	3	711	22.3	7.68	87.4	1.36	29.49	5.22
	July	2	318	26.5	6.20	76.2	1.18	10.65	2.03
	August	2	184	27.8	6.22	78.3	.55	6.18	.55
	September	2	139	22.5	6.72	76.8	1.13	5.04	.85
	October	2	74	20.2	6.95	76.2	1.00	2.78	.40
	November	3	276	10.8	10.32	92.8	.98	15.38	1.46
Summer[1]	Average	9	231	24.6	6.67	78.9	0.95	8.32	1.18
	Maximum		485	29.0	7.45	88.2	1.35	-	-
	Minimum		72	19.0	5.90	71.8	.50	-	-
Winter[2]	Average	12	637	14.8	9.31	90.3	0.92	32.02	3.16
	Maximum		1,465	20.0	12.90	100.7	2.40	-	-
	Minimum		16	5.0	6.75	72.9	.38	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 69 (Continued)

DUCK RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

Duck River - Station D 186.5 - above Rock Creek

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Dissolved Oxygen ppm	Dissolved Oxygen % Saturation	5-Day Oxygen Demand 20°C ppm	1000 Lb. per Day Dissolved Oxygen	1000 Lb. per Day 5-Day Oxygen Demand
1938	March	3	665	13.0	9.75	92.0	1.19	35.01	4.27
	April	2	974	17.2	9.05	93.3	.84	47.60	4.42
	May	1	305	19.5	8.30	89.6	.85	13.67	1.40
	June	1	364	24.0	7.35	86.2	1.00	14.45	1.97
	July	1	469	27.0	7.10	88.0	1.10	17.98	2.79
	August	1	213	27.0	7.05	87.4	.85	8.11	.98
	September	1	143	19.5	7.90	85.3	.98	6.10	.76
	October	1	173	20.0	8.05	87.8	.82	7.52	.77
	November	1	98	11.0	9.60	86.6	.30	5.08	.16
Summer[1]	Average	4	297	24.4	7.35	86.7	0.98	11.79	1.57
	Maximum		469	27.0	7.90	88.0	1.10	-	-
	Minimum		143	19.5	7.05	85.3	.85	-	-
Winter[2]	Average	8	565	15.5	9.16	90.7	0.80	27.95	2.44
	Maximum		1,020	20.0	10.80	94.9	1.62	-	-
	Minimum		98	8.5	8.05	86.6	.30	-	-
Rock Creek - Station Ro 1.4 - near mouth									
1938	February	1	95	11.0	8.90	80.3	1.75	4.57	0.90
	March	3	139	12.8	9.28	87.2	.89	6.97	.67
	April	2	236	17.8	9.10	94.9	1.38	11.60	1.76
	May	1	45	19.0	7.30	78.1	.82	1.77	.20
	June	1	59	23.5	7.15	83.1	1.00	2.28	.32
	July	1	34	24.0	7.50	87.9	1.05	1.38	.19
	August	1	17	28.5	8.95	114.2	2.12	.82	.19
	September	1	14	19.0	13.40	143.3	-	1.01	-
	October	1	12	19.5	4.60	49.7	2.28	.30	.15
	November	1	20	11.0	4.40	39.7	2.72	.48	.29
Summer[1]	Average	4	31	23.8	7.32	85.5	1.39	1.22	0.23
	Maximum		59	28.5	13.40	143.3	2.12	-	-
	Minimum		14	19.0	7.15	83.1	1.00	-	-
Winter[2]	Average	9	118	14.9	7.92	77.6	1.44	5.05	0.92
	Maximum		242	19.5	10.10	97.5	2.72	-	-
	Minimum		12	9.0	4.40	39.7	.80	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 69 (Continued)

DUCK RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

Duck River - Station D 136.6 - above Columbia, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Dissolved Oxygen ppm	Dissolved Oxygen % Saturation	5-Day Oxygen Demand 20°C ppm	1000 Lb. per Day Dissolved Oxygen	1000 Lb. per Day 5-Day Oxygen Demand
1938	February	1	960	12.5	7.80	72.8	1.70	40.44	8.81
	March	3	1,510	13.7	9.45	90.5	1.03	77.06	8.40
	April	2	2,140	17.5	8.30	86.1	.92	95.91	10.63
	May	2	573	20.5	7.15	78.8	.66	22.12	2.04
	June	5	875	25.1	7.26	86.8	1.55	34.30	7.32
	July	4	1,810	27.2	8.10	100.7	1.94	79.17	18.96
	August	5	1,160	28.6	7.46	95.3	1.79	46.73	11.21
	September	4	187	24.6	7.58	89.8	2.18	7.65	2.20
	October	4	115	20.5	8.14	89.6	3.14	5.05	1.95
	November	5	841	11.7	9.19	84.2	1.67	41.74	7.58
	December	4	1,440	6.8	11.44	93.5	.89	88.96	6.92
1939	January	4	2,310	8.9	10.92	94.0	.76	136.22	9.48
	February	1	5,060	8.5	10.55	90.0	1.90	288.27	51.92
Summer[1]	Average	18	886	26.3	7.40	89.2	1.91	35.40	9.14
	Maximum		5,540	31.0	12.20	162.7	4.30	-	-
	Minimum		95	22.0	4.85	62.4	.85	-	-
Winter[2]	Average	26	1,460	13.2	9.38	86.7	1.22	73.95	9.62
	Maximum		5,060	25.0	12.70	100.5	3.20	-	-
	Minimum		91	5.5	5.25	58.4	.45	-	-
Duck River - Station D 130.3 - below Columbia, Tenn.									
1938	February	1	1,080	12.0	8.90	82.2	1.55	51.90	9.04
	March	3	1,730	13.7	9.23	88.4	1.51	86.23	14.11
	April	2	2,320	18.0	8.80	93.2	1.15	110.25	14.41
	May	2	772	20.5	7.42	81.7	1.06	28.93	4.13
	June	5	840	24.9	6.73	80.2	1.75	30.53	7.94
	July	4	1,820	27.1	8.01	99.5	2.52	78.72	24.77
	August	5	1,180	28.4	5.70	72.6	1.69	36.32	10.77
	September	4	203	24.4	5.92	69.9	1.89	6.49	2.07
	October	4	117	19.6	6.04	65.4	2.29	3.82	1.45
	November	5	847	11.7	8.90	81.7	2.19	40.71	10.02
	December	4	1,830	6.8	11.56	94.5	1.70	114.24	16.80
1939	January	4	2,440	8.6	11.29	96.5	1.14	148.76	15.02
	February	1	5,400	9.0	11.25	97.1	2.48	328.05	72.32
Summer[1]	Average	18	866	26.1	6.24	75.5	1.91	29.18	8.93
	Maximum		5,230	30.0	11.45	150.2	3.60	-	-
	Minimum		63	21.0	4.80	61.2	.98	-	-
Winter[2]	Average	26	1,620	13.1	9.46	87.2	1.50	82.76	13.12
	Maximum		5,650	24.0	12.20	101.5	3.22	-	-
	Minimum		94	5.5	4.20	45.8	.70	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 69 (Continued)

DUCK RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Dissolved Oxygen ppm	Dissolved Oxygen % Saturation	5-Day Oxygen Demand 20°C ppm	1000 Lb. per Day Dissolved Oxygen	1000 Lb. per Day 5-Day Oxygen Demand
Duck River - Station D 122.3 - below Green Lick Creek									
1938	February	1	1,198	13.0	9.50	89.6	1.25	61.46	8.09
	March	3	1,920	13.5	9.15	87.4	2.06	94.87	21.36
	April	2	2,480	18.2	8.60	90.6	1.04	115.17	13.93
	May	2	833	20.5	7.08	78.0	1.12	31.85	5.04
	June	5	1,230	24.2	6.97	82.0	1.79	46.29	11.89
	July	4	2,230	27.3	7.22	90.1	2.66	86.94	32.03
	August	5	1,400	28.4	5.94	75.6	1.41	44.91	10.66
	September	4	216	24.1	5.44	64.0	1.62	6.35	1.89
	October	4	124	19.4	6.39	68.8	1.54	4.28	1.03
	November	5	962	11.5	8.95	81.7	1.83	46.49	9.51
	December	4	1,760	6.4	11.26	91.1	.97	107.02	9.22
1939	January	4	2,680	8.9	11.06	95.2	.76	160.06	11.00
	February	1	6,130	9.0	10.55	91.1	2.38	349.23	78.78
Summer[1]	Average	18	1,102	25.9	6.10	74.0	1.49	36.30	8.87
	Maximum		6,460	30.5	9.35	120.3	4.20	-	-
	Minimum		92	21.0	4.70	57.8	1.05	-	-
Winter[2]	Average	26	1,760	13.0	9.36	86.5	1.37	88.96	13.02
	Maximum		6,130	23.0	12.20	105.5	3.52	-	-
	Minimum		100	5.5	6.40	62.5	.50	-	-
Duck River - Station D 98.1 - below Bigby Creek									
1938	February	1	1,440	12.5	9.00	84.0	1.15	69.98	8.94
	March	3	3,080	13.5	9.27	88.5	1.36	154.18	22.62
	April	2	2,480	19.2	8.30	89.2	.88	111.15	11.78
	May	1	774	21.0	8.10	90.1	.88	33.85	3.68
	June	5	1,540	25.0	7.94	94.7	2.08	66.03	17.30
	July	4	2,160	28.1	7.84	99.3	2.22	91.45	25.89
	August	5	1,300	28.3	7.39	93.9	1.46	51.88	10.25
	September	4	310	24.1	6.75	79.3	1.56	11.30	2.61
	October	4	198	19.1	9.45	101.3	2.81	10.10	3.00
	November	5	980	11.3	9.76	88.7	1.60	51.65	8.47
	December	4	1,160	6.0	11.61	93.1	.95	72.73	5.95
1939	January	4	2,940	8.2	11.10	94.0	.88	176.22	13.97
	February	1	7,170	9.0	10.75	92.8	2.15	416.22	83.24
Summer[1]	Average	18	1,100	26.2	7.62	92.5	1.84	45.26	10.93
	Maximum		6,020	30.5	10.90	144.2	3.28	-	-
	Minimum		177	21.0	5.35	66.3	.82	-	-
Winter[2]	Average	25	2,000	12.6	9.75	90.0	1.32	105.30	14.26
	Maximum		7,170	24.0	12.50	101.8	4.60	-	-
	Minimum		182	4.5	7.40	78.3	.58	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 69 (Continued)

DUCK RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Dissolved Oxygen ppm	Dissolved Oxygen % Saturation	5-Day Oxygen Demand 20°C ppm	1000 Lb. per Day Dissolved Oxygen	1000 Lb. per Day 5-Day Oxygen Demand
Duck River - Station D 82.5 - above Centerville, Tenn.									
1938	February	1	1,680	12.5	9.60	89.6	1.35	87.09	12.25
	March	3	3,020	13.3	9.22	87.6	1.71	150.36	27.89
	April	2	2,850	18.2	8.35	87.8	.98	128.51	15.08
	May	1	953	21.0	8.15	90.7	1.10	41.94	5.66
	June	2	1,250	25.2	7.60	91.1	1.59	51.30	10.73
	July	2	1,530	27.8	7.92	99.7	2.30	65.44	19.00
	August	3	2,150	27.3	7.17	89.3	1.87	83.24	21.71
	September	2	336	24.2	7.28	85.7	1.53	13.21	2.78
	October	2	206	18.0	9.48	99.3	1.52	10.55	1.69
	November	2	2,130	13.5	9.32	89.0	2.36	107.20	27.14
	December	4	1,110	6.0	11.78	94.4	.95	70.61	5.69
1939	January	4	3,050	8.5	11.02	94.0	.84	181.50	13.83
	February	1	8,690	8.5	10.62	90.4	2.00	498.35	93.85
Summer[1]	Average	9	1,260	25.9	7.48	90.0	1.92	50.89	13.06
	Maximum		5,140	29.5	9.30	120.8	2.50	-	-
	Minimum		193	21.0	6.05	73.6	1.32	-	-
Winter[2]	Average	20	2,440	12.1	9.88	90.3	1.18	130.18	15.55
	Maximum		8,690	24.0	12.55	102.8	3.20	-	-
	Minimum		269	5.0	7.25	82.1	.40	-	-
Duck River - Station D 63.9 - below Centerville, Tenn.									
1938	February	1	1,700	12.5	9.70	90.5	2.00	89.05	18.36
	March	3	3,730	14.8	9.42	92.4	1.45	189.74	29.21
	April	2	4,160	18.8	8.38	89.3	1.01	188.25	22.69
	May	1	940	21.0	8.30	92.4	.78	42.13	3.96
	June	2	1,400	24.8	7.55	89.8	1.10	57.08	8.32
	July	2	1,310	27.2	7.38	91.7	1.70	52.21	12.03
	August	3	2,970	26.8	7.48	92.3	1.77	119.96	28.39
	September	2	401	24.5	7.62	90.2	1.26	16.50	2.73
	October	2	231	17.8	9.15	95.5	.99	11.41	1.23
	November	2	2,750	13.5	9.25	88.3	2.31	137.36	34.30
Summer[1]	Average	9	1,510	25.6	7.70	92.7	1.33	62.78	10.84
	Maximum		7,320	28.5	9.00	103.5	2.88	-	-
	Minimum		212	20.5	6.60	80.3	.80	-	-
Winter[2]	Average	11	2,690	16.5	8.90	90.4	1.21	129.28	17.58
	Maximum		6,790	24.0	10.55	95.1	3.52	-	-
	Minimum		250	11.0	7.35	86.2	.48	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 69 (Continued)

DUCK RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

Piney River - Station P 8.5 - at Vernon, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Dissolved Oxygen ppm	Dissolved Oxygen % Saturation	5-Day Oxygen Demand 20°C ppm	1000 Lb. per Day Dissolved Oxygen	1000 Lb. per Day 5-Day Oxygen Demand
1938	February	1	239	12.0	10.00	92.3	1.45	12.91	1.87
	March	3	494	14.5	9.45	92.0	1.30	25.21	3.47
	April	2	269	19.2	9.75	104.8	1.31	14.16	1.90
	May	1	203	21.0	7.70	85.7	2.98	8.44	3.27
	June	2	202	21.2	7.68	85.7	.90	8.38	.98
	July	2	176	23.8	6.78	79.2	2.00	6.44	1.90
	August	3	186	23.3	7.23	83.8	.97	7.26	.97
	September	2	101	22.0	7.80	88.3	.78	4.25	.43
	October	2	68	15.8	9.10	91.1	.65	3.34	.24
	November	2	84	12.5	9.38	87.6	1.12	4.25	.51
Summer[1]	Average	9	147	22.4	7.40	84.1	0.86	5.87	0.68
	Maximum		308	24.0	9.70	95.7	3.02	-	-
	Minimum		66	13.5	6.45	75.0	.65	-	-
Winter[2]	Average	11	269	15.8	9.21	90.8	1.25	13.38	1.82
	Maximum		954	21.0	10.20	111.2	1.60	-	-
	Minimum		70	11.5	8.55	81.1	.90	-	-
Duck River - Station D 32.2 - below Piney River									
1938	February	1	2,280	12.5	9.90	92.4	0.80	121.89	9.85
	March	3	4,610	15.5	8.83	87.9	1.72	219.81	42.82
	April	2	4,370	19.2	8.38	90.0	1.12	197.75	26.43
	May	1	1,270	22.0	8.30	94.0	5.20	56.92	35.66
	June	2	1,960	24.8	8.72	103.7	.99	92.29	10.48
	July	2	1,940	27.0	7.92	98.2	1.38	82.97	14.46
	August	3	3,240	26.2	7.47	91.1	1.55	130.70	27.12
	September	2	770	24.0	7.52	88.2	1.22	31.27	5.07
	October	2	436	17.0	9.35	96.0	1.51	22.01	3.56
	November	2	3,630	13.2	9.05	85.8	2.85	177.39	55.86
Summer[1]	Average	9	1,880	25.1	7.81	93.4	1.39	79.29	14.11
	Maximum		7,820	28.0	9.20	110.5	1.82	-	-
	Minimum		418	19.5	6.45	78.5	.78	-	-
Winter[2]	Average	11	3,310	16.7	8.90	89.3	1.62	159.08	28.96
	Maximum		6,820	23.0	9.95	112.8	5.20	-	-
	Minimum		454	12.0	7.90	84.0	.80	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 69 (Continued)

DUCK RIVER

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

Buffalo River - Station B 17.7 - below Lobelville, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Dissolved Oxygen		5-Day Oxygen Demand 20°C ppm	1000 Lb. per Day	
					ppm	% Saturation		Dissolved Oxygen	5-Day Oxygen Demand
1938	February	1	710	12.0	9.80	90.5	0.75	37.57	2.88
	March	3	1,900	15.3	9.63	95.4	.75	98.80	7.70
	April	2	1,460	18.5	8.55	90.5	.53	67.41	4.18
	May	1	528	22.0	8.80	99.7	.98	25.09	2.79
	June	1	980	24.0	7.40	86.8	.38	39.16	2.01
	July	1	670	26.0	7.30	88.8	.78	26.41	2.82
	August	1	443	27.0	7.30	90.5	.62	17.46	1.48
	September	1	300	26.0	6.90	83.9	.82	11.18	1.33
	October	1	219	19.5	8.50	91.8	.52	10.05	.61
	November	1	337	13.5	8.65	82.5	.75	15.74	1.36
Summer[1]	Average	5	522	24.5	7.48	88.4	0.62	21.08	1.75
	Maximum		980	27.0	8.50	91.8	.82	-	-
	Minimum		219	19.5	6.90	83.9	.38	-	-
Winter[2]	Average	8	1,270	16.3	9.16	92.3	0.80	62.82	5.49
	Maximum		3,240	22.0	10.65	101.5	.98	-	-
	Minimum		337	12.0	8.05	82.5	.18	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 70

DUCK RIVER

BACTERIA

Duck River - Station D 269.1 - above Manchester, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Bacteria Per Milliliter		Quantity Units (Bacteria x 1000 cfs)	
					On Agar 37°C for 24 Hours	Coliform Group M.P.N.	On Agar 37°C for 24 Hours	Coliform Group M.P.N.
1938	February	1	55	11.0	-	2.3	-	0.1
	March	3	59	12.2	48	0.5	2.8	0.05
	April	2	88	15.5	2,200	0.7	194	.1
	May	1	43	18.5	55	11	2.4	0.5
	June	1	47	21.0	120	11	5.6	0.5
	July	1	26	24.0	150	11	3.9	0.3
	August	1	34	24.0	600	3.6	20	0.1
	September	1	20	23.5	800	2.3	16	0.1
	October	1	18	18.0	110	0.3	2.0	0.05
	November	2	90	9.2	44	0.8	4.0	0.1
Summer[1]	Average	5	29	22.1	250	3.1	7.2	0.1
	Maximum		47	24.0	800	11	-	-
	Minimum		18	18.0	110	0.3	-	-
Winter[2]	Average	9	70	12.8	120	1.0	8.4	0.1
	Maximum		163	18.5	5,000	11	-	-
	Minimum		17	4.5	18	0.1	-	-
Duck River - Station D 264.3 - below Manchester, Tenn.								
1938	February	1	104	11.0	-	2.3	-	0.2
	March	3	117	11.3	65	1.5	7.6	0.2
	April	2	171	15.8	1,400	5.6	239	1.0
	May	1	83	18.0	42	36	3.5	3.0
	June	1	92	21.0	140	36	13	3.3
	July	1	51	24.0	75	6.2	3.8	0.3
	August	1	66	25.0	550	2.3	36	0.2
	September	1	38	24.0	800	36	30	1.4
	October	1	35	19.0	50	1.1	1.8	.05
	November	2	174	8.5	46	1.3	8.0	0.2
Summer[1]	Average	5	56	22.6	190	7.3	11	0.4
	Maximum		92	25.0	800	36	-	-
	Minimum		35	19.0	50	1.1	-	-
Winter[2]	Average	9	136	12.4	120	2.9	16	0.4
	Maximum		315	18.0	8,000	36	-	-
	Minimum		32	4.0	24	0.2	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 70 (Continued)

DUCK RIVER

BACTERIA

Duck River - Station D 225.3 - above Shelbyville, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Bacteria Per Milliliter		Quantity Units (Bacteria x 1000 cfs)	
					On Agar 37°C for 24 Hours	Coliform Group M.P.N.	On Agar 37°C for 24 Hours	Coliform Group M.P.N.
1938	February	1	376	11.5	-	2.3	-	0.9
	March	3	519	12.2	250	4.9	130	2.5
	April	2	849	17.5	600	9.5	509	8.1
	May	1	376	20.0	150	6.2	56	2.3
	June	3	675	21.7	900	95	608	64
	July	2	322	26.0	1,300	24	419	7.7
	August	2	135	27.2	900	10	122	1.4
	September	2	166	21.8	650	19	108	3.2
	October	2	64	19.8	250	4.7	16	0.3
	November	3	273	9.7	110	6.1	30	1.7
Summer[1]	Average	9	220	24.0	900	18	198	4.0
	Maximum		403	28.5	2,000	60	-	-
	Minimum		94	18.0	450	6.2	-	-
Winter[2]	Average	12	520	14.2	220	8.1	114	4.2
	Maximum		1,380	20.0	3,000	600	-	-
	Minimum		34	5.0	90	2.3	-	-
Duck River - Station D 216.2 - below Shelbyville, Tenn.								
1938	February	1	476	12.0	-	24	-	11
	March	3	768	13.2	750	49	576	38
	April	2	1,052	17.8	550	75	579	79
	May	1	455	19.0	130	240	59	109
	June	3	711	22.3	3,100	160	2,204	114
	July	2	318	26.5	11,000	275	3,498	87
	August	2	184	27.8	8,900	110	1,638	20
	September	2	139	22.5	5,600	130	778	18
	October	2	74	20.2	1,400	46	104	3.4
	November	3	276	10.8	950	60	262	17
Summer[1]	Average	9	231	24.6	6,100	120	1,409	28
	Maximum		485	29.0	22,500	350	-	-
	Minimum		72	19.0	2,600	36	-	-
Winter[2]	Average	12	637	14.8	700	75	446	48
	Maximum		1,465	20.0	4,300	600	-	-
	Minimum		16	5.0	130	24	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 70 (Continued)

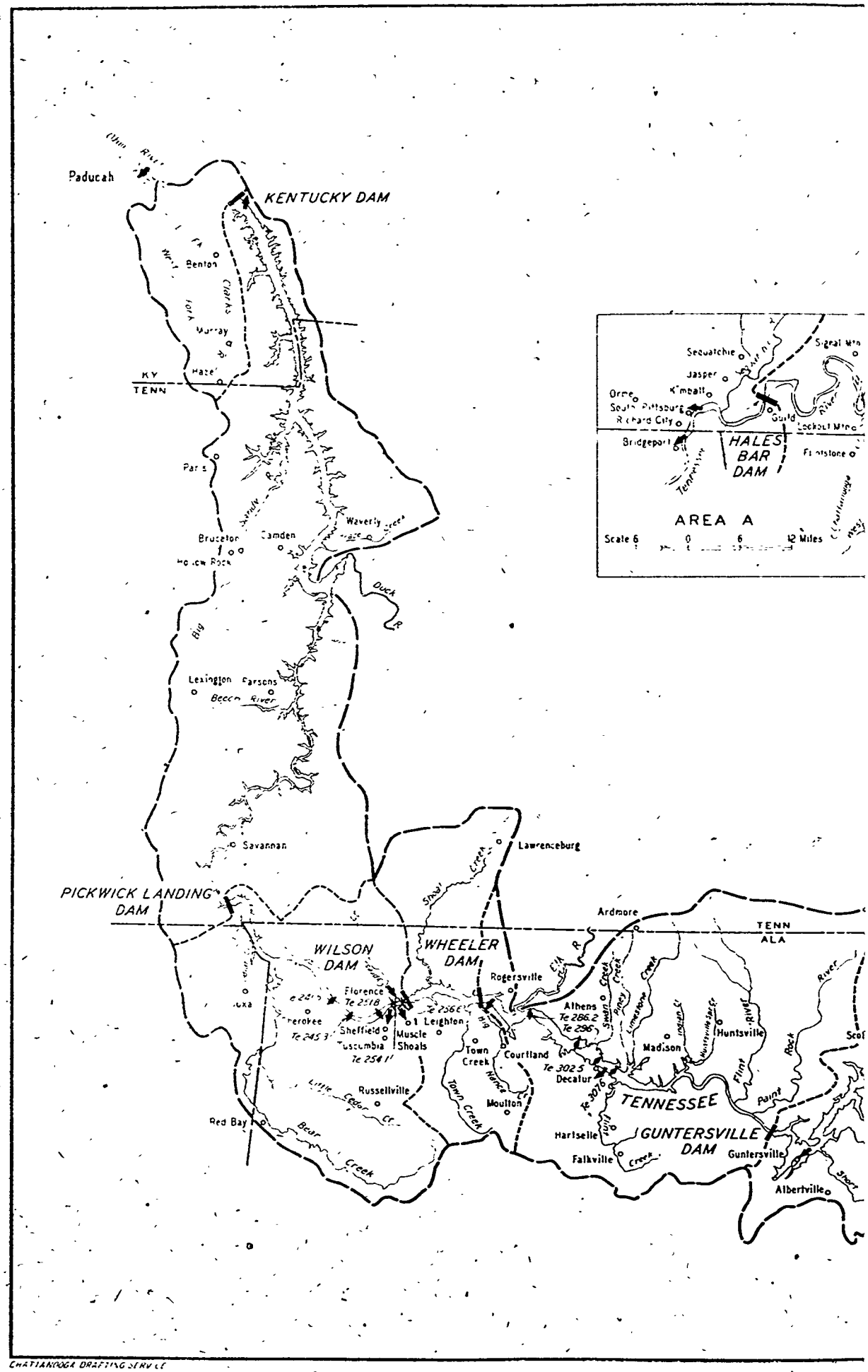
DUCK RIVER

BACTERIA

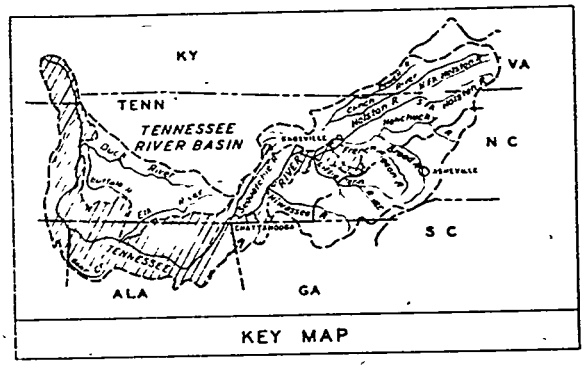
Duck River - Station D 186.5 - above Rock Creek

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Bacteria per Milliliter		Quantity Units (Bacteria x 1000 cfs)	
					On Agar 37°C for 24 Hours	Coliform Group M.P.N.	On Agar 37°C for 24 Hours	Coliform Group M.P.N.
1938	March	3	665	13.0	450	7.0	299	4.6
	April	2	974	17.2	1,300	11	1,266	11
	May	1	305	19.5	450	110	137	34
	June	1	364	24.0	1,600	60	582	22
	July	1	469	27.0	1,700	24	797	11
	August	1	213	27.0	600	3.6	128	0.8
	September	1	143	19.5	500	3.6	72	0.5
	October	1	173	20.0	28	3.6	4.8	0.6
	November	1	98	11.0	300	2.3	29	0.2
Summer[1]	Average	4	297	24.4	950	12	282	3.6
	Maximum		469	27.0	1,700	60	-	-
	Minimum		143	19.5	500	3.6	-	-
Winter[2]	Average	8	565	15.5	400	8.9	226	5.0
	Maximum		1,020	20.0	2,000	110	-	-
	Minimum		98	8.5	28	0.6	-	-
Rock Creek - Station Ro 1.4 - near mouth								
1938	February	1	95	11.0	-	240	-	23
	March	3	139	12.8	180	8.2	25	1.1
	April	2	236	17.8	850	18	201	4.2
	May	1	45	19.0	250	36	11	1.6
	June	1	59	23.5	750	6.2	44	0.4
	July	1	34	24.0	1,600	24	54	0.8
	August	1	17	28.5	275	3.6	4.7	0.1
	September	1	14	19.0	1,100	2.3	15	0.05
	October	1	12	19.5	400	2.3	4.8	0.05
	November	1	20	11.0	180	1.1	3.6	0.05
Summer[1]	Average	4	31	23.8	800	5.9	25	0.2
	Maximum		59	28.5	1,600	24	-	-
	Minimum		14	19.0	275	2.3	-	-
Winter[2]	Average	9	118	14.9	300	12	35	1.4
	Maximum		242	19.5	1,500	240	-	-
	Minimum		12	9.0	50	0.6	-	-

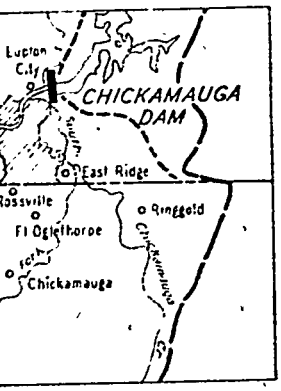
1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

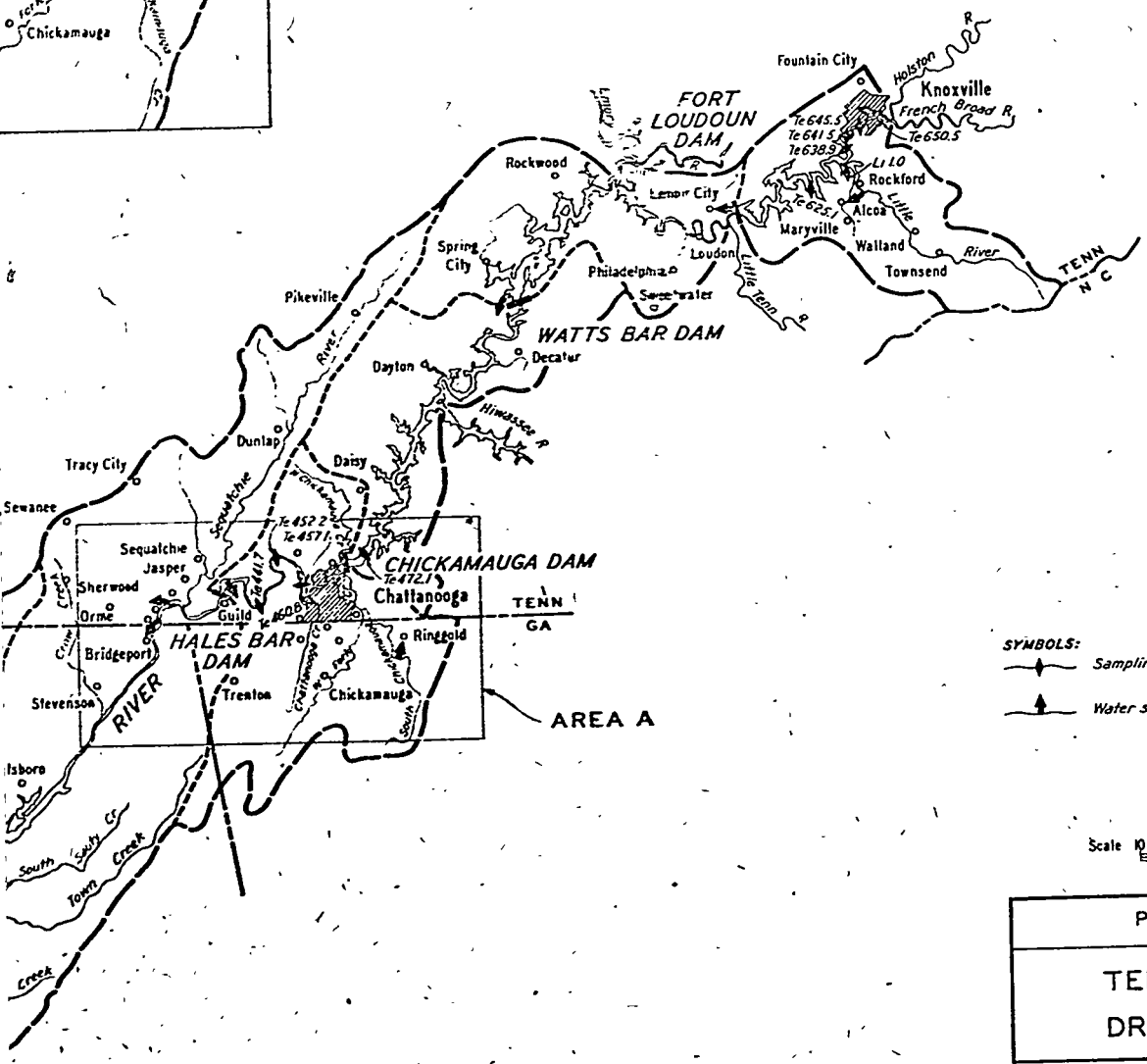


CHATTANOOGA DRAFTING SERVICE



KEY MAP





SYMBOLS:

Sampling station

Water supply intake

Figure 20

Scale 10 0 10 20 Miles

POLLUTION SURVEY

TENNESSEE RIVER DRAINAGE BASIN

STREAM SANITATION PROGRAM
TENNESSEE VALLEY AUTHORITY
HEALTH AND SAFETY DEPARTMENT

SUBMITTED	RECOMMENDED	APPROVED

CHATTANOOGA	11-2-43	G	HS	306B519

TABLE 70 (Continued)

DUCK RIVER

BACTERIA

Duck River - Station D 136.6 - above Columbia, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Bacteria per Milliliter: On Agar 37°C for 24 Hours	Bacteria per Milliliter: Coliform Group M.P.N.	Quantity Units (Bacteria x 1000 cfs): On Agar 37°C for 24 Hours	Quantity Units (Bacteria x 1000 cfs): Coliform Group M.P.N.
1938	February	1	960	12.5	-	2.3	-	2.2
	March	3	1,510	13.7	350	44	528	66
	April	2	2,640	17.5	300	13	792	34
	May	2	573	20.5	475	24	272	14
	June	5	875	25.1	700	55	612	48
	July	4	1,810	27.2	1,800	42	3,258	76
	August	5	1,160	28.6	1,100	18	1,276	21
	September	4	187	24.6	425	4.9	79	0.9
	October	4	115	20.5	120	2.3	14	0.3
	November	5	841	11.7	350	5.8	294	4.9
	December	4	1,440	6.8	140	1.9	202	2.7
1939	January	4	2,310	8.9	210	28	485	65
	February	1	5,060	8.5	6,800	60	34,408	304
Summer[1]	Average	18	886	26.3	750	16	644	14
	Maximum		5,540	31.0	12,000	1,400	-	-
	Minimum		95	22.0	40	1.1	-	-
Winter[2]	Average	26	1,460	13.2	300	11	438	16
	Maximum		5,060	25.0	6,800	700	-	-
	Minimum		91	5.5	40	0.3	-	-
Duck River - Station D 130.3 - below Columbia, Tenn.								
1938	February	1	1,080	12.0	-	24	-	26
	March	3	1,730	13.7	1,400	70	2,422	121
	April	2	2,320	18.0	2,200	70	5,104	162
	May	2	722	20.5	3,900	350	2,816	253
	June	5	840	24.9	16,000	475	13,440	399
	July	4	1,820	27.1	14,500	450	26,390	819
	August	5	1,180	28.4	35,500	500	41,890	590
	September	4	203	24.4	13,000	275	2,639	56
	October	4	117	19.6	7,600	100	889	12
	November	5	847	11.7	4,300	325	3,642	275
	December	4	1,830	6.8	1,100	160	2,013	293
1939	January	4	2,440	8.6	550	85	1,342	207
	February	1	5,400	9.0	5,000	700	27,000	3,780
Summer[1]	Average	18	839	26.1	18,000	300	15,102	252
	Maximum		5,230	30.0	130,000	7,000	-	-
	Minimum		63	21.0	500	2.3	-	-
Winter[2]	Average	26	1,620	13.1	2,300	170	3,726	275
	Maximum		5,650	24.0	18,000	1,400	-	-
	Minimum		94	5.5	350	24	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 70 (Continued)

DUCK RIVER

BACTERIA

Duck River - Station D 122.3 - below Green Lick Creek

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Bacteria per Milliliter		Quantity Units (Bacteria x 1000 cfs)	
					On Agar 37°C for 24 Hours	Coliform Group M.P.N.	On Agar 37°C for 24 Hours	Coliform Group M.P.N.
1938	February	1	1,198	13.0	-	24	-	29
	March	3	1,920	13.5	2,500	40	4,800	77
	April	2	2,480	18.2	2,700	130	6,696	322
	May	2	833	20.5	2,600	46	2,166	38
	June	5	1,230	24.2	5,200	425	6,396	523
	July	4	2,230	27.3	13,500	200	30,105	446
	August	5	1,400	28.4	6,000	190	8,400	266
	September	4	216	24.1	7,700	190	1,663	41
	October	4	124	19.4	1,300	35	161	4.3
	November	5	962	11.5	2,200	110	2,116	106
	December	4	1,760	6.4	900	60	1,584	106
1939	January	4	2,680	8.9	600	32	1,608	86
	February	1	6,130	9.0	4,700	36	28,811	211
Summer[1]	Average	18	1,102	25.9	6,400	160	7,053	176
	Maximum		6,460	30.5	65,000	2,400	-	-
	Minimum		92	21.0	1,100	11	-	-
Winter[2]	Average	26	1,760	13.0	1,600	70	2,816	123
	Maximum		6,130	23.0	15,000	2,400	-	-
	Minimum		100	5.5	220	1.3	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 70 (Continued)

DUCK RIVER

BACTERIA

Duck River - Station D 98.1 - below Bigby Creek

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Bacteria per Milliliter		Quantity Units (Bacteria x 1000 cfs)	
					On Agar 37°C for 24 Hours	Coliform Group M.P.N.	On Agar 37°C for 24 Hours	Coliform Group M.P.N.
1938	February	1	1,440	12.5	-	24	-	35
	March	3	3,080	13.5	2,300	44	7,084	136
	April	2	2,480	19.2	1,300	41	3,224	102
	May	1	774	21.0	650	24	503	19
	June	5	1,540	25.0	1,800	60	2,772	92
	July	4	2,160	28.1	3,700	75	7,992	162
	August	5	1,300	28.3	1,800	41	2,340	53
	September	4	310	24.1	2,200	31	682	9.6
	October	4	198	19.1	700	3.7	139	0.7
	November	5	980	11.3	800	7.1	784	7.0
	December	4	1,160	6.0	140	6.9	162	8.0
1939	January	4	2,940	8.2	600	31	1,764	91
	February	1	7,170	9.0	3,800	60	27,246	430
Summer[1]	Average	18	1,100	26.2	2,000	27	2,200	30
	Maximum		6,020	30.5	34,500	3,900	-	-
	Minimum		177	21.0	250	2.3	-	-
Winter[2]	Average	25	2,000	12.6	750	21	1.500	42
	Maximum		7,170	24.0	10,000	2,400	-	-
	Minimum		182	4.5	31	2.4	-	-

Duck River - Station D 82.5 - above Centerville, Tenn.

1938	February	1	1,680	12.5	-	2.3	-	3.9
	March	3	3,020	13.3	1,400	110	4,228	332
	April	2	2,850	18.2	3,100	70	8,835	200
	May	1	953	21.0	140	110	133	105
	June	2	1,250	25.2	1,000	210	1,250	262
	July	2	1,530	27.8	1,200	28	1,836	43
	August	3	2,150	27.3	2,100	85	4,515	183
	September	2	336	24.2	1,500	29	504	9.7
	October	2	206	18.0	275	2.4	57	0.5
	November	2	2,130	13.5	1,700	21	3,621	45
	December	4	1,110	6.0	130	8.5	144	9.4
1939	January	4	3,050	8.5	550	37	1,678	113
	February	1	8,690	8.5	2,000	110	17,380	956
Summer[1]	Average	9	1,260	25.9	1,200	36	1,512	45
	Maximum		5,140	29.5	14,500	1,100	-	-
	Minimum		193	21.0	95	2.3	-	-
Winter[2]	Average	20	2,440	12.1	650	31	1,586	76
	Maximum		8,690	24.0	8,000	400	-	-
	Minimum		269	5.0	37	2.3	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 70 (Continued)

DUCK RIVER

BACTERIA

Duck River - Station D 63.9 - below Centerville, Tenn.

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Bacteria per Milliliter		Quantity Units (Bacteria x 1000 cfs)	
					On Agar 37°C for 24 Hours	Coliform Group M.P.N.	On Agar 37°C for 24 Hours	Coliform Group M.P.N.
1938	February	1	1,700	12.5	-	2.3	-	3.9
	March	3	3,730	14.8	1,000	75	3,730	280
	April	2	4,160	18.8	1,000	70	4,160	291
	May	1	940	21.0	190	6.2	179	5.8
	June	2	1,400	24.8	900	80	1,260	112
	July	2	1,310	27.2	650	50	852	66
	August	3	2,970	26.8	2,500	85	7,425	252
	September	2	401	24.5	900	16	361	6.4
	October	2	231	17.8	425	3.8	98	.9
	November	2	2,750	13.5	2,200	50	6,050	138
Summer[1]	Average	9	1,510	25.6	1,100	29	1,661	44
	Maximum		7,320	28.5	30,000	1,600	-	-
	Minimum		212	20.5	60	2.3	-	-
Winter[2]	Average	11	2,690	16.5	900	37	2,421	100
	Maximum		6,790	24.0	4,600	400	-	-
	Minimum		250	11.0	170	2.3	-	-
Piney River - Station P 8.5 - at Vernon, Tenn.								
1938	February	1	239	12.0	-	240	-	57
	March	3	494	14.5	1,400	5.5	692	2.7
	April	2	269	19.2	2,200	7.0	592	1.9
	May	1	203	21.0	11,500	60	2,334	12
	June	2	202	21.2	6,500	95	1,313	19
	July	2	176	23.8	8,300	65	1,461	11
	August	3	186	23.3	2,400	220	446	41
	September	2	101	22.0	13,500	37	1,364	3.7
	October	2	68	15.8	1,200	2.3	82	0.2
	November	2	84	12.5	2,000	21	168	1.8
Summer[1]	Average	9	147	22.4	11,500	65	1,690	9.6
	Maximum		308	24.0	51,000	1,100	-	-
	Minimum		66	18.0	1,400	2.3	-	-
Winter[2]	Average	11	269	15.8	2,100	14	565	3.8
	Maximum		954	21.0	11,500	240	-	-
	Minimum		70	11.5	350	0.1	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

TABLE 70 (Continued)

DUCK RIVER

BACTERIA

Duck River - Station D 32.2 - below Piney River

Year	Month	Number Times Sampled	Discharge cfs	Water Temperature °C	Bacteria per Milliliter		Quantity Units (Bacteria x 1000 cfs)	
					On Agar 37°C for 24 Hours	Coliform Group M.P.N.	On Agar 37°C for 24 Hours	Coliform Group M.P.N.
1938	February	1	2,280	12.5	-	240	-	547
	March	3	4,610	15.5	1,200	49	5,532	226
	April	2	4,370	19.2	600	9.5	2,622	42
	May	1	1,270	22.0	5,400	36	6,858	46
	June	2	1,960	24.8	1,400	60	2,744	118
	July	2	1,940	27.0	1,700	19	3,298	37
	August	3	3,240	26.2	1,500	45	4,860	146
	September	2	770	24.0	1,000	20	770	15
	October	2	436	17.0	190	2.4	83	1
	November	2	3,630	13.2	1,000	75	3,630	272
Summer[1]	Average	9	1,880	25.1	1,000	24	1,880	45
	Maximum		7,820	28.0	14,000	1,300	-	-
	Minimum		418	19.5	350	3.6	-	-
Winter[2]	Average	11	3,310	16.7	1,000	33	3,310	109
	Maximum		6,820	23.0	6,000	240	-	-
	Minimum		454	12.0	100	1.6	-	-
Buffalo River - Station B 17.7 - below Lobelville, Tenn.								
1938	February	1	710	12.0	-	0.2	-	0.1
	March	3	1,900	15.3	325	3.1	618	5.9
	April	2	1,460	18.5	325	7.0	474	10
	May	1	528	22.0	90	3.6	48	1.9
	June	1	980	24.0	750	240	735	235
	July	1	670	26.0	500	36	335	24
	August	1	443	27.0	700	60	310	27
	September	1	300	26.0	350	6.0	105	1.8
	October	1	219	19.5	300	0.9	66	0.2
	November	1	337	13.5	1,200	39	404	13
Summer[1]	Average	5	522	24.5	500	19	261	9.9
	Maximum		980	27.0	750	240	-	-
	Minimum		219	19.5	300	0.9	-	-
Winter[2]	Average	8	1,270	16.3	325	3.8	413	4.8
	Maximum		3,240	22.0	1,200	240	-	-
	Minimum		337	12.0	50	0.2	-	-

1. Summer season from June 15 through October 15.
2. Winter season from October 16 through June 14.

SECTION VIII

TENNESSEE RIVER

SECTION VIII

TENNESSEE RIVER

General

Sections I through VII have discussed the seven larger tributaries in the Tennessee Valley. This section of the report deals with the remainder of the basin and includes the minor tributary streams and the area that drains directly to the Tennessee River, exclusive of the previously discussed drainage areas. This section of the Tennessee Valley contains 16,521 square miles, or 40.4 percent of the entire Valley. The distribution of this area among the nine Tennessee reservoirs is shown in table 71.

With the exception of the industrial areas at Knoxville, Chattanooga, Huntsville, Decatur, and Wilson Dam, the area is largely rural and agricultural. These industrial areas contribute the only significant amounts of pollution which are discharged directly into the river.

Geology

The Tennessee River from Knoxville to Chattanooga flows through the Valley of Eastern Tennessee, which has already been discussed in section I, Holston River. Below Chattanooga the river cuts through the Cumberland Plateau, which is discussed in section IV, Clinch River. The remainder of the river flows through the southern and western edge of the Highland Plain, which is discussed in section VI, Elk River. The Mississippi Embayment borders the western edge of the Valley and has been described as follows:[1]

> "The westernmost physiographic division of the TVA region is the Mississippi Embayment. This province is a broad west-sloping plain extending from the western valley of the Tennessee River to and beyond the Mississippi River. Although the region as a whole constitutes a sloping plane, the general surface is marked by numerous small ridges and drainage divides caused by stream erosion.

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1. Industrial Water Supplies of the Tennessee Valley Region, Tennessee Valley Authority, Commerce Department and Health and Safety Department, 1943, p. 11.

TABLE 71

DRAINAGE AREAS

TENNESSEE RIVER

Reservoir	Location of Dam--Miles Above Mouth	Tributary Area	Drainage Area Sq. Mi.	Total Area Above Dam Sq. Mi.
Fort Loudoun	602.3	Immediate Area*	271	9,550
		Holston River	3,776	
		French Broad River	5,124	
		Little River	379	
		Total	9,550	
Watts Bar	529.9	Immediate Area*	720	17,310
		Little Tennessee River	2,627	
		Clinch River	4,413	
		Total	7,760	
Chickamauga	471.0	Immediate Area*	780	20,790
		Hiwassee River	2,700	
		Total	3,480	
Hales Bar	431.1	Immediate Area*	461	21,790
		S. Chickamauga Creek	464	
		Chattanooga Creek	75	
		Total	1,000	
Guntersville	349.0	Immediate Area*	2,073	24,450
		Sequatchie River	587	
		Total	2,660	
Wheeler	274.9	Immediate Area*	1,865	29,590
		Paint Rock River	458	
		Flint River	568	
		Elk River	2,249	
		Total	5,140	
Wilson	259.4	Immediate Area*	665	30,750
		Shoal Creek	495	
		Total	1,160	
Pickwick	206.7	Immediate Area*	1,124	32,820
		Bear Creek	946	
		Total	2,070	
Kentucky	22.4	Immediate Area*	3,251	40,200
		Duck River	3,500	
		Big Sandy River	629	
		Total	7,380	
From Kentucky Dam To Mouth of River		Immediate Area*	164	40,910**
		Clark River	546	
		Total	710	

*Immediate Area is the area draining directly to the reservoir not including the area of the tributaries which are named.

**Total Area Tennessee River drainage basin.

"The underlying formations consist of a thick series of essentially unconsolidated sands, gravel, silt, and clays from Cretaceous to Recent in age. These unconsolidated materials constitute an excellent catchment basin and reservoir for underground waters. The supply of water in shallow wells is seldom great but ordinarily sufficient for domestic purposes. Such water generally contains little mineral matter in solution. It is sometimes contaminated by surface drainage, however, and at some places it carries considerable iron. Deep wells usually furnish uncontaminated water, but some of these wells may be charged with saline materials."

Precipitation

The average annual precipitation in the valley of the Tennessee River varies from 47 to 55 inches. One of the minor tributaries, Little River, has a rainfall as high as 63 inches. The average for the entire area included in this section is about 52 inches.

Stream Flows

Table 72 gives the estimated flows that may be expected in the Tennessee River after the completion of Fontana Dam. Multiple-purpose reservoir operation and a repetition of stream flow similar to that experienced in past dry years or average flow years have been assumed in the preparation of these data.

TABLE 72

EXPECTED FLOWS IN CUBIC FEET PER SECOND AT DESIGNATED POINTS ON TENNESSEE RIVER FOR THE PERIOD MAY THROUGH SEPTEMBER

Location	Miles Above Mouth	Dry-Type Year		Average-Type Year
		Average of Lowest 5 Consecutive Weeks	Average for Period	Average for Period
Knoxville	648.0	4,500	9,000	12,000
Fort Loudoun Dam	602.3	5,000	10,000	13,000
Watts Bar Dam	529.9	12,000	22,000	25,000
Chickamauga Dam	471.0	18,000	26,000	32,000
Hales Bar Dam	431.1	19,000	27,000	33,000
Guntersville Dam	349.0	20,000	28,000	35,000
Wheeler Dam	274.9	21,000	30,000	39,000
Wilson Dam	259.4	22,000	31,000	40,000
Pickwick Landing Dam	206.7	24,000	32,000	42,000
Kentucky Dam	22.4	28,000	37,000	56,000

Water Supplies

Table 73 lists the public water supplies, their sources, and methods of purification in this section of the Tennessee Valley. Although the majority of the supplies are obtained from wells and springs, the larger cities, in general, use surface streams as a source. All supplies using surface sources are provided with purification plants. A number of the smaller supplies do not provide treatment.

Sources of Pollution

With the exception of the Knoxville, Chattanooga, Huntsville, and Tri-Cities (Florence, Sheffield, and Tuscumbia) sections, there are no large sources of pollution in the area. The sewage and industrial wastes from the remaining sources are discharged at isolated points and are not in large enough quantities to affect the Tennessee River seriously for any distance, although some of the smaller tributaries are severely damaged. This area contributes 51.5 percent of the pollution due to domestic sewage and 29.4 percent of the pollution from the industries in the Tennessee Valley.

The results of studies on the Knoxville, Chattanooga, Decatur, and Tri-Cities sections of the Tennessee River in 1936-1937 were presented in a previous report.[1]

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1. Studies of the Pollution of the Tennessee River System, I. A General Description of the Valley with Results of Studies on the Knoxville, Chattanooga, Decatur, and Tri-Cities Sections of the Tennessee River 1936-1937, Tennessee Valley Authority, Health and Safety Department, 1941.

TABLE 73

WATER SUPPLIES

TENNESSEE RIVER, 1937-1940

Municipality	Population	Source	Treatment[1]
Fort Loudoun Reservoir			
Fountain City, Tenn.	6,700	Springs	D
Knoxville, Tenn.	111,580	Tennessee River	CFD
Eastern State Hospital, Tenn	1,740	Spring	D
Townsend, Tenn.	378	Well	N
Walland, Tenn.	175	Well	N
Maryville, Tenn.	5,609	Wells	D
Alcoa, Tenn.	5,131	(Little River	CFD
		(Springs	D
Rockford, Tenn.	350	Wells	N
Watts Bar Reservoir			
Fort Loudoun Dam, Tenn.	40	Lenoir City	
Lenoir City, Tenn.	4,373	(Tennessee River	CFD
		(Little Tennessee River	
Loudon, Tenn.	3,017	Spring	D
Sweetwater, Tenn.	2,593	Spring	D
Rockwood, Tenn.	3,981	Springs	D
Spring City, Tenn.	1,569	Springs	D
Watts Bar Dam, Tenn.	500	Tennessee River	CFD
Chickamauga Reservoir			
Dayton, Tenn.	1,870	(Richland Creek	CFD
		(Spring	
Hales Bar Reservoir			
Chickamauga Dam, Tenn.	40	Chattanooga	
Lupton City, Tenn.	200	Wells	N
Ringgold, Ga.	882	S. Chickamauga Creek	CFD
Chickamauga, Ga.	1,665	Spring	CFS
Ft. Oglethorpe, Ga.	500	Chattanooga	
East Ridge, Tenn.	2,939	Chattanooga	
Chattanooga, Tenn.	128,163	Tennessee River	CFD
Rossville, Ga.	3,538	Chattanooga	
Trenton, Ga.	570	Spring	D
Lookout Mt., Tenn.	1,545	Chattanooga	
Signal Mt., Tenn.	1,308	Chattanooga	
Hales Bar Dam, Tenn.	120	Tennessee River	CFD

1. N = No treatment D = Disinfection S = Softening
C = Coagulation and Sedimentation F = Filtration

TABLE 73 (Continued)

WATER SUPPLIES

TENNESSEE RIVER

Municipality	Population	Source	Treatment[1]
Guntersville Reservoir			
Pikeville, Tenn.	759	Springs and Well	D
Dunlap, Tenn.	721	Springs	D
Sequatchie, Tenn.	300	Springs	N
Jasper, Tenn.	1,251	Spring	D
Tracy City, Tenn.	1,500	Wells	N
Kimball, Tenn.	150	Springs	N
South Pittsburg, Tenn.	2,285	Tennessee River	CFD
Richard City, Tenn.	1,008	South Pittsburg	
Bridgeport, Ala.	2,031	(Tennessee River	CFD
		(Springs	D
Orme, Tenn.	277	Spring	N
Sewanee, Tenn.	700	Springs and Wells	N
Sherwood, Tenn.	600	Spring	N
Stevenson, Ala.	793	Springs and Well	D
Scottsboro, Ala.	2,834	Springs and Wells	D
Albertville Ala.	3,651	Short Creek	CFD
Guntersville, Ala.	4,398	Tennessee River	CFD
Wheeler Reservoir			
Guntersville Dam, Ala.	30	Springs	D
Huntsville, Ala.	13,050	Springs	D
Madison, Ala.	455	Springs	D
Falkville, Ala.	567	Well	N
Hartselle, Ala.	2,584	Well and Spring	D
Decatur, Ala.	16,604	Tennessee River	CFD
Athens, Ala.	4,342	Springs	D
Rogersville, Ala.	508	Well	D
Wheeler Dam, Ala.	120	Tennessee River	CFD
Wilson Reservoir			
Moulton, Ala.	490	Spring	CFD
Courtland, Ala.	454	Well	FD
Town Creek, Ala.	637	Well	D
Lawrenceburg, Tenn.	3,807	Spring	D
Leighton, Ala.	810	Well	D
Village 3, Wilson Dam, Ala.	200	Wilson Dam, Village 2	

1. N = No treatment
   C = Coagulation and Sedimentation
   D = Disinfection
   F = Filtration
   S = Softening

TABLE 73 (Continued)

WATER SUPPLIES

TENNESSEE RIVER

Municipality	Population	Source	Treatment[1]
Pickwick Reservoir			
Village 2, Wilson Dam, Ala.	3,300	Tennessee River	CFD
Florence, Ala.	15,043	Cypress Creek	CFD
Sheffield, Ala.	7,933	Tennessee River	CFD
Tuscumbia, Ala.	5,515	Sheffield	
Village 1, Wilson Dam, Ala.	350	Sheffield	
Russellville, Ala.	3,510	Cedar Creek	CFD
Red Bay, Ala.	1,560	Spring	D
Cherokee, Ala.	786	Well	SD
Iuka, Miss.	1,664	Well	D
Kentucky Reservoir			
Pickwick Dam, Tenn.	100	Wells	FD
Savannah, Tenn.	1,504	Wells	D
Lexington, Tenn.	2,526	Wells	N
Parsons, Tenn.	1,079	Wells	D
Waverly, Tenn.	1,318	Wells	D
Camden, Tenn.	992	Wells	D
Hollow Rock, Tenn.	422	Well	D
Bruceton, Tenn.	1,003	Wells	N
Paris, Tenn.	6,395	Wells	CD
Area below Kentucky Dam			
Kentucky Dam (Temporary)	200	Tennessee River	CFD
Kentucky Dam Camp, Ky.	800	Well	CFDS
Hazel, Ky.	396	Well	D
Murray, Ky.	3,773	Wells	CD
Benton, Ky.	1,906	Wells	N

1. N = No Treatment
   C = Coagulation and Sedimentation
   D = Disinfection
   F = Filtration
   S = Softening

Population Estimates

The distribution of the population in this section of the Tennessee Valley is given in table 74.

TABLE 74

POPULATION

TENNESSEE VALLEY

Reservoir	Population (1940 U.S. Census)		
	Rural	Urban	Total
Fort Loudoun	59,365	115,790	175,155
Watts Bar	28,497	13,964	42,461
Chickamauga	39,043	0	39,043
Hales Bar	68,085	134,640	202,725
Guntersville	105,842	10,883	116,725
Wheeler	141,539	36,580	178,119
Wilson	55,734	3,807	59,541
Pickwick	64,642	32,001	96,643
Kentucky	105,708	8,921	114,629
Below Kentucky Dam	30,593	3,773	34,366
Total	699,048	360,359	1,059,407

Sewerage Systems

Table 75 shows the municipalities in this section of the Valley which have sewerage systems and the types of treatment. Totals are shown for each reservoir area as well as the percentage of sewage treatment and the percentage of reduction accomplished. It is estimated that 21.3 percent of the sewage receives treatment which reduces the amount of pollution by domestic sewage 6.5 percent.

TABLE 75

SEWERAGE SYSTEMS

TENNESSEE VALLEY, 1937-1940

Municipality	Population (1940 U.S. Census)		Treatment		
	Total	Sewered	Type	Percent of Sewage Treated	Reduction Accomplished --Percent of Sewered Population
Fort Loudoun Reservoir					
Knoxville, Tenn.	105,050[a]	85,080[b]	None		
Eastern State Hospital	1,740	1,740	None		
Maryville, Tenn.	5,609	5,800	Sedimentation		
Alcoa, Tenn.	5,131	4,620	Septic Tank, Trickling Filter		
Total	117,530	97,240		10.7	5.9
Watts Bar Reservoir					
Fort Loudoun Dam, Tenn.	40	40	Septic Tank		
Lenoir City, Tenn.	4,373	2,190	Septic Tanks		
Loudon, Tenn.	3,017	1,500	None		
Sweetwater, Tenn.	2,593	2,400	Septic Tanks		
Rockwood, Tenn.	3,981	1,990	Imhoff Tank		
Watts Bar Dam, Tenn.	250	250	Septic Tank		
Total	14,254	8,370		72.6	18.2
Chickamauga Reservoir					
Watts Bar Dam, Tenn.	250	250	Septic Tanks		
Dayton, Tenn.	1,870	1,120	Imhoff Tank		
Total	2,120	1,370		100.0	32.0

a. That portion of Knoxville tributary to Tennessee River. Total Population 111,580.

b. That portion of Knoxville tributary to Tennessee River. Total Sewered 90,380.

TABLE 75 (Continued)

SEWERAGE SYSTEMS

TENNESSEE VALLEY

Municipality	Population (1940 U.S. Census)		Treatment		
	Total	Sewered	Type	Percent of Sewage Treated	Reduction Accomplished --Percent of Sewered Population
Hales Bar Reservoir					
Chickamauga Dam	40	40	Septic Tank		
Lupton City, Tenn.	200	200	Septic Tank		
Ringgold, Ga.	882	100	Imhoff Tank		
Chickamauga, Ga.	1,665	1,200	Septic Tank		
Ft. Oglethorpe, Ga.	500	500[a]	Septic Tank - Trickling Filter		
Chattanooga, Tenn.	128,163	5,000[b]	Seasonal Chlorination		
		5,000[c]	Septic Tanks		
		92,530	None		
Rossville, Ga.	3,538	2,000	Imhoff Tank		
Hales Bar Dam, Tenn.	120	120	None		
Total	135,108	106,690		13.1	2.3
Guntersville Reservoir					
South Pittsburg, Tenn.	2,285	1,260	None		
Bridgeport, Ala.	2,031	1,000	Septic Tank		
Sewanee, Tenn.	700	700	Septic Tanks		
Scottsboro, Ala.	2,834	1,140	Imhoff Tank		
Albertville, Ala.	3,651	3,100	Imhoff Tank - Settling Tank		
Guntersville, Ala.	4,398	3,000	None		
Total	15,899	10,200		51.0	16.4

a. Approximate normal population.
b. Tributary to South Chickamauga Creek.
c. St. Elmo and Alton Park Districts. In addition St. Elmo has overloaded contact beds following the septic tank.

TABLE 75 (Continued)

SEWERAGE SYSTEMS

TENNESSEE RIVER

Municipality	Population (1940 U.S. Census)		Treatment		
	Total	Sewered	Type	Percent of Sewage Treated	Reduction Accomplished --Percent of Sewered Population
Wheeler Reservoir					
Guntersville Dam, Ala.	40	40	Septic Tanks		
Huntsville, Ala.	13,050	19,100[a]	None		
Merrimack Mills, Ala.	3,500	3,500	Septic Tanks		
Hartselle, Ala.	2,584	2,000	Sedimentation		
Decatur, Ala.	16,604	14,000	None		
Athens, Ala.	4,342	3,500	None		
Total	40,120	42,140		17.9	3.3
Wilson Reservoir					
Wheeler Dam, Ala.	120	120	Imhoff Tank		
Moulton, Ala.	752	750	Imhoff Tank		
Lawrenceburg, Tenn.	3,807	3,600	Imhoff Tank (Chlorination in Summer)		
Wilson Dam, Village 3	200	200	Septic Tank		
Total	4,879	4,670		100.0	34.0

a. Huntsville includes mill villages outside city.

TABLE 75 (Continued)

SEWERAGE SYSTEMS

TENNESSEE RIVER

Municipality	Population (1940 U.S. Census)		Treatment		
	Total	Sewered	Type	Percent of Sewage Treated	Reduction Accomplished --Percent of Sewered Population
Pickwick Reservoir					
Village 2, Wilson Dam, Ala.	3,300[a]	3,300	Imhoff Tank		
Florence, Ala.	15,043	8,300	See Note[b]		
Sheffield, Ala.	7,933	5,000	None		
Tuscumbia, Ala.	5,515	3,000	None (Septic Tank 300)		
Village 1, Wilson Dam, Ala.	350	350	None		
Russellville, Ala.	3,510	1,020	Septic Tank		
Iuka, Miss.	1,664	700	None		
Total	37,315	21,670		28.8	8.8
Kentucky Reservoir					
Pickwick Dam, Tenn.	100	100	Imhoff Tank		
Savannah, Tenn.	1,504	700	None		
Lexington, Tenn.	2,526	1,640	None		
Parsons, Tenn.	1,079	430	Imhoff Tank		
Camden, Tenn.	992	700	Imhoff Tank		
Bruceton, Tenn.	1,003	500	None		
Paris, Tenn.	6,395	5,560	Septic Tank		
Total	13,599	9,630		70.5	16.0

a. Includes offices and plant.
b. Septic Tanks, 300; Imhoff Tank, 1,325; None, 6,675.

TABLE 75 (Continued)

SEWERAGE SYSTEMS

TENNESSEE RIVER

Municipality	Population (1940 U.S. Census)		Treatment		
	Total	Sewered	Type	Percent of Sewage Treated	Reduction Accomplished --Percent of Sewered Population
Area below Kentucky Dam					
Kentucky Dam, Ky.	1,000	1,000	Part Imhoff Tank		
Murray, Ky.	3,773	3,400	Imhoff Tank		
Benton, Ky.	1,906	1,240	Septic Tank		
Total	6,679	5,640		94.1	29.6
Total Tennessee River	387,503	307,620		21.3	6.5

Industrial Plants

Table 76 gives the types and number of industrial plants in the section, the disposition of their wastes, and comparative figures for the entire Tennessee Valley. These industries are listed for each of the reservoir areas. Approximately 41.4 percent of the industries in the Valley are located in this section, and these industries are responsible for 29.4 percent of the total industrial pollution.

In Fort Loudoun Reservoir area wastes from the cannery and from one of the meat plants receive primary treatment in a municipal sewage treatment plant. Acid wastes from the chemical plant are neutralized with lime and settled in a pond before being discharged to the stream.

None of the industries in the Watts Bar Reservoir area report any treatment of wastes.

In the Chickamauga Reservoir area, treatment is provided for three of the four industries in municipal sewage treatment plants. In addition to these industrial wastes, there is a large munitions plant which discharges an acid waste, highly colored and containing large amounts of chemicals. Some of the wastes after partial neutralization are discharged into the reservoir in the Chattanooga Rod and Gun Club embayment.

Only one of the 45 industries in the Hales Bar Reservoir area reports any reduction in its wastes. This metal plating plant reports that its industrial wastes, which consist of spent hydrofluoric and sulphuric acid, seep into the ground and do not reach the stream.

The wastes from three of the four plants in the Guntersville Reservoir area receive some form of treatment. The wastes from the milk plant are treated in a septic tank with a tile disposal field and do not reach the stream. Wastes from two of the textile industries are treated in a municipal sewage treatment plant.

Treatment of industrial waste is not provided for the plants in the Guntersville Reservoir area. In addition to the industries listed in table 76, a large munitions plant has been constructed near Huntsville since 1940 and discharges chemical wastes to Indian Creek.

TABLE 76

INDUSTRIAL POLLUTION

TENNESSEE RIVER, 1937-1940

Types of Industry	Number of Plants		Methods of Disposal			Estimated Population Equivalents	
	In Area	Percent of Total in Tenn. Valley	Municipal Sewers	Stream	Some Correction	In Area	Percent of Total in Tenn. Valley
Fort Loudoun Reservoir							
Canning	1	3.7	1	0	1	50	0.1
Chemical	2	7.7	1	1	1	100	0.4
Meat	5	26.3	3	2	1	22,050	54.8
Pulp and Paper	1	11.1	1	1	0	49,000	8.4
Textiles	5	5.9	5	0	0	8,800	6.1
Miscellaneous	3	12.0	0	3	0	1,100	3.8
Total	17	6.8	11	7	3	81,100	6.2
Watts Bar Reservoir							
Canning	1	3.7	0	1	0	1,500	3.6
Milk	2	5.9	1	1	0	400	2.8
Textiles	7	8.2	1	6	0	18,700	13.0
Total	10	4.0	2	8	0	20,600	1.6
Chickamauga Reservoir							
Canning	1	3.7	1	0	1	1,500	3.6
Textiles	3	3.5	2	1	2	250	0.2
Total	4	1.6	3	1	3	1,750	0.1
Hales Bar Reservoir							
Cellulose	1	20.0	0	1	0	132,000	37.5
Chemical	4	15.4	1	3	0	600	2.2
Meat	4	21.0	4	0	0	7,100	17.7
Pulp and Paper	2	22.2	1	1	0	26,300	4.5
Tanning	1	11.1	0	1	0	11,300	14.1
Textiles	23	27.1	7	16	0	74,600	51.9
Miscellaneous	10	40.0	3	7	1	18,400	63.1
Total	45	18.1	16	29	1	270,300	20.6

TABLE 76 (Continued)

INDUSTRIAL POLLUTION

TENNESSEE RIVER

Types of Industry	Number of Plants		Methods of Disposal			Estimated Population Equivalents	
	In Area	Percent of Total in Tenn. Valley	Municipal Sewers	Stream	Some Correction	In Area	Percent of Total in Tenn. Valley
Guntersville Reservoir							
Milk	1	2.9	1	0	1	0	0
Textiles	3	3.5	3	0	2	400	.3
Total	4	1.6	4	0	3	400	.05
Wheeler Reservoir							
Chemical	1	3.9	0	1	0	1,600	6.0
Meat	2	10.5	2	0	0	2,300	5.7
Milk	2	5.9	1	1	0	700	4.9
Textiles	1	1.2	0	1	0	400	.3
Miscellaneous	2	8.0	1	1	0	200	.7
Total	8	3.2	4	4	0	5,200	0.4
Wilson Reservoir							
Cannery	1	3.7	0	1	1	50	0.1
Milk	1	2.9	1	0	1	200	1.4
Miscellaneous	1	4.0	0	1	0	800	2.7
Total	3	1.2	1	2	2	1,050	0.1
Pickwick Reservoir							
Chemical	2	7.7	0	2	1	50	0.2
Meat	1	5.3	1	0	0	2,500	6.2
Textiles	1	1.2	1	0	0	1,100	.8
Miscellaneous	4	16.0	0	4	0	50	.2
Total	8	3.2	2	6	1	3,700	0.3

TABLE 76 (Continued)

INDUSTRIAL POLLUTION

TENNESSEE RIVER

Types of Industry	Number of Plants		Methods of Disposal			Estimated Population Equivalents	
	In Area	Percent of Total in Tenn. Valley	Municipal Sewers	Stream	Some Correc-tion	In Area	Percent of Total in Tenn. Valley
Kentucky Reservoir							
Canning	1	3.7	0	1	0	50	0.1
Total	1	0.4	0	1	0	50	.05
Area below Kentucky Dam							
Meat	1	5.3	0	1	0	100	0.2
Milk	1	2.9	0	1	0	100	.7
Textiles	1	1.2	0	1	0	100	.1
Total	3	1.2	0	3	0	300	.05
Total Tennessee River	103	41.4	43	61	13	384,450	29.4

Wastes from two of the three plants in the Wilson Reservoir area receive some form of correction. Wastes from the milk plant are treated with municipal sewage in the city treatment plant, and wastes from the cannery are disposed on the ground and do not flow directly to the stream.

One chemical plant in the Pickwick Reservoir area provides aeration and sedimentation to oxidize phosphorous wastes before discharge to the river. Since the survey in 1940, the aluminum plants in Muscle Shoals City have been placed in operation and considerably enlarged over the original expected capacity. Industrial wastes consisting primarily of oils, and additional domestic sewage are discharged to the Pickwick Reservoir just below Wilson Dam.

Only one industry is located in the Kentucky Reservoir area. Treatment is not provided for the industrial wastes.

No treatment of industrial waste is provided in the area below Kentucky Dam.

Extent of Pollution

Table 77 shows the estimated amounts of pollution expressed in population equivalents due to domestic sewage and industrial wastes reaching the reservoirs on the Tennessee River. This same information is shown graphically in figure 21. It is estimated that 36.1 percent of the total pollution received by the Tennessee River system originates in this section. This does not consider the full effect of the chemical and miscellaneous types of industries which discharge wastes that cannot be expressed in terms of population equivalents. Estimates have not been made of the increased domestic sewage pollution which has resulted from population increases in many areas.

Since the survey a large munitions plant has been located on the bank of Chickamauga Reservoir. After partial neutralization, some of its wastes are discharged to Chickamauga Reservoir. The remainder of the wastes and the domestic sewage, which is given complete treatment followed by chlorination, reaches Hales Bar Reservoir by way of South Chickamauga Creek. No detailed studies have been made of the wastes from this munitions plant, but the dilution is sufficient to protect the Chattanooga

water supply and to prevent the development of a serious condition in the main reservoir below the point of discharge.

Detailed studies have not been made of the wastes from the munitions plant that discharges chemical wastes to Indian Creek in the Wheeler Reservoir area. Estimates of the strength of these wastes are not included in table 77.

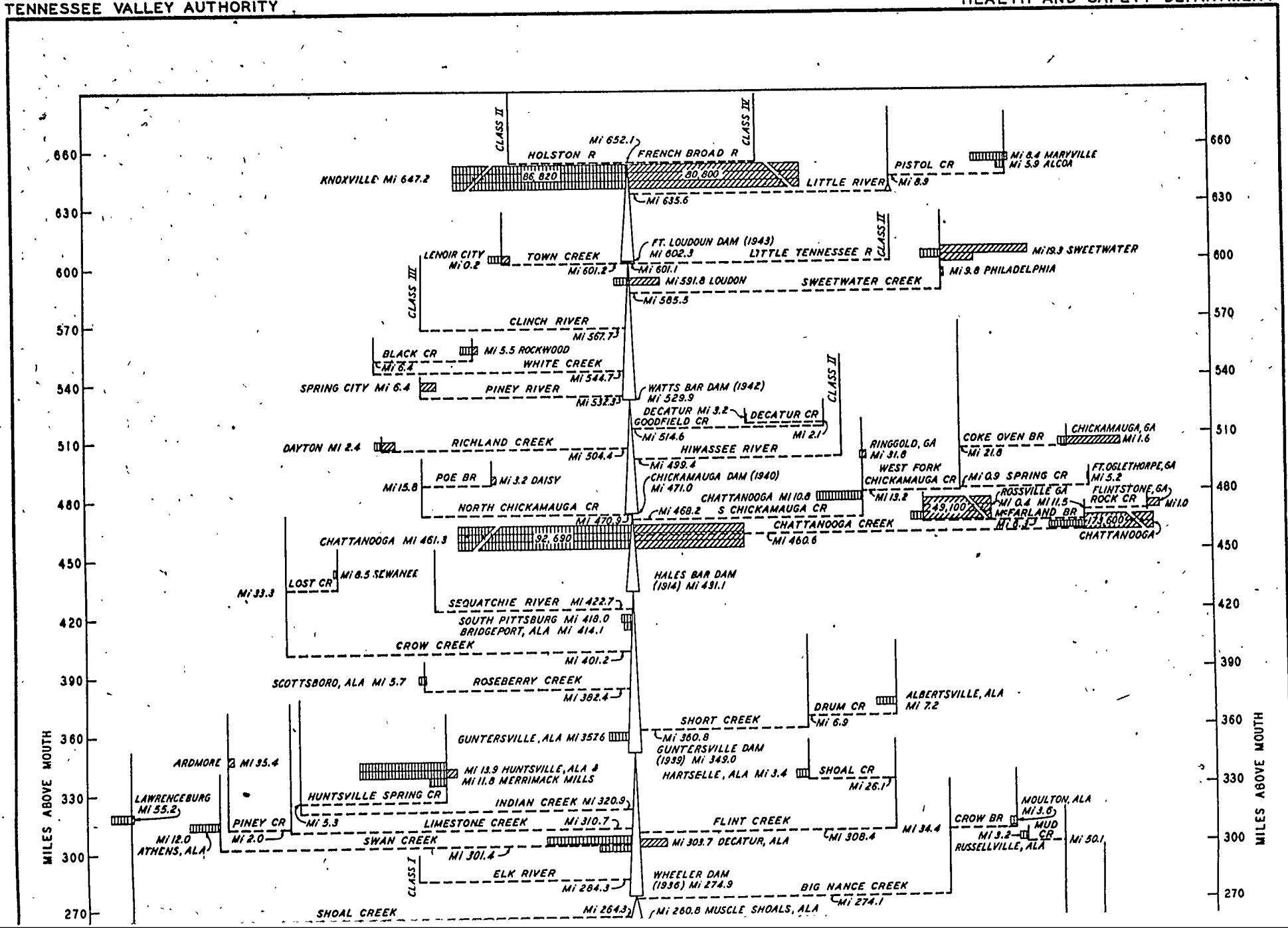
Additional pollution also not included originates at the Southern Aviation Training School, north of Decatur. Sewage is treated in a septic tank and discharged into an arm of Wheeler Reservoir at the mouth of Pryor Branch, opposite Decatur and downstream from the Decatur water supply intake. It is estimated that this pollution has a population equivalent of about 560.

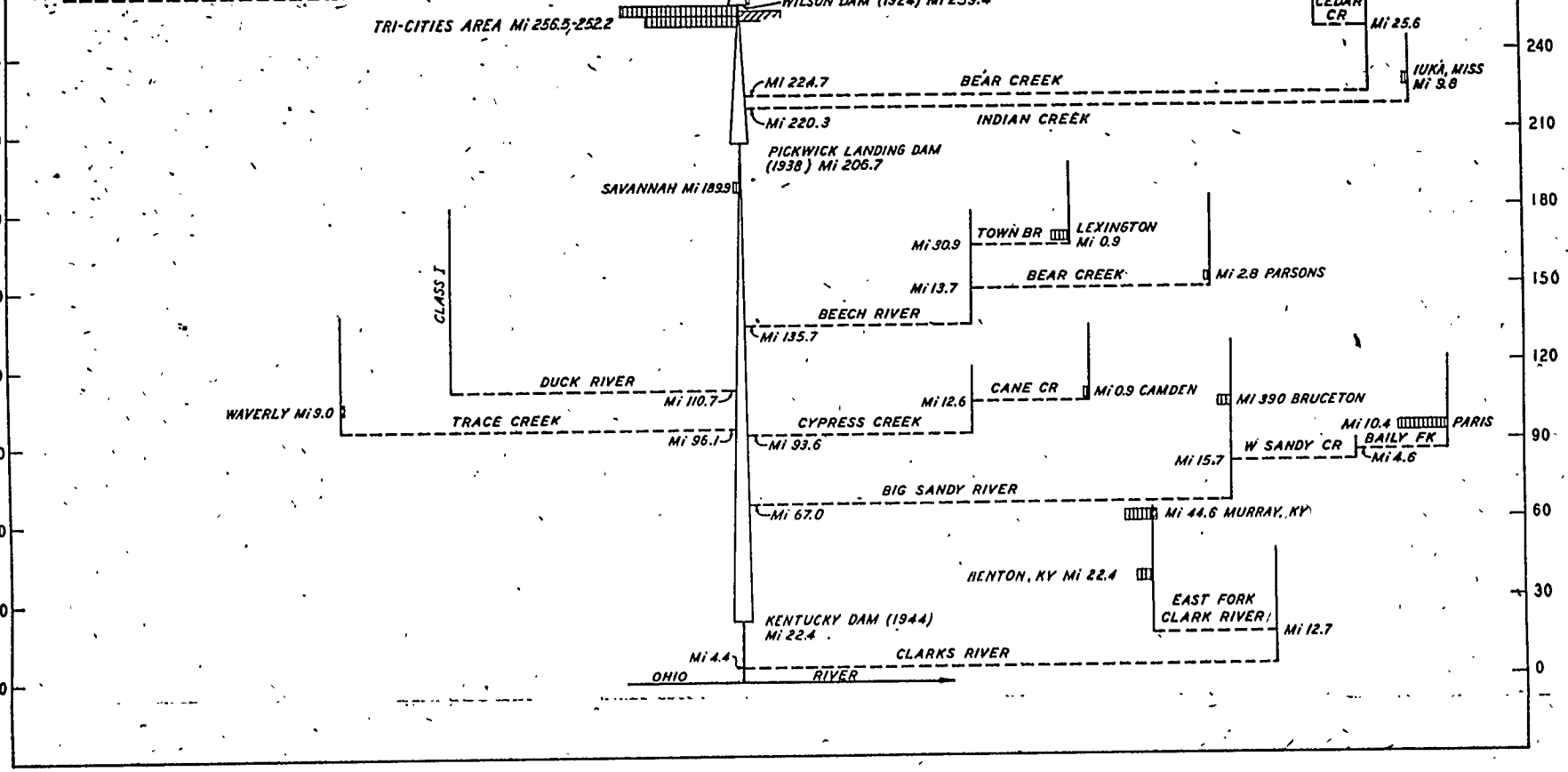
Sewage from the recently constructed Courtland Air Base receives primary treatment in a sedimentation tank and secondary treatment on a trickling filter. The effluent is discharged into Big Nance Creek which enters Wilson Reservoir at mile 274.1.

The total effect of the chemical and miscellaneous industries which discharge wastes to the upper end of Pickwick Reservoir cannot be expressed in terms of population equivalents. Wastes from these plants contain oils and chemicals which have been detected in the main river and have caused occasional troubles in the use of the raw water for industrial purposes.

TENNESSEE VALLEY AUTHORITY

HEALTH AND SAFETY DEPARTMENT





SYMBOLS:

Population equivalent:
Domestic sewage
Industrial waste

Dam and reservoir

Scale of population equivalent
0 — 10,000

Figure 21

TENNESSEE RIVER
SOURCES OF POLLUTION

155

CHATTANOOGA DRAFTING SERVICE

G HS 306B520-1 RI

TABLE 77

ESTIMATED POPULATION EQUIVALENT OF POLLUTION

REACHING TENNESSEE RIVER, 1937-1940

Municipality	Receiving Stream	Estimated Population Equivalents			
		Domestic Sewage	Industrial Wastes	Total	Percent of Total in Tenn. Valley
Fort Loudoun Reservoir					
Knoxville, Tenn.	Tennessee River	85,080	80,800	165,880	
Eastern State Hosp.	Tennessee River	1,740	-	1,740	
Maryville, Tenn.	Pistol Creek	3,770	260	4,030	
Alcoa, Tenn.	Pistol Creek	920	-	920	
Total		91,510	81,060	172,570	9.3
Watts Bar Reservoir					
Ft. Loudoun Dam, Tenn.	Tennessee River	30	-	30	
Lenoir City, Tenn.	Town Creek	1,750	1,000	2,750	
Loudon, Tenn.	Tennessee River	1,500	3,600	5,100	
Sweetwater, Tenn.	Sweetwater Creek	2,080	13,600	15,680	
Philadelphia, Tenn.	Sweetwater Creek	-	200	200	
Rockwood, Tenn.	Black Creek	1,290	600	1,890	
Spring City, Tenn.	Piney River	-	1,600	1,600	
Watts Bar Dam, Tenn.	Tennessee River	200	0	200	
Total		6,850	20,600	27,450	1.5
Chickamauga Reservoir					
Watts Bar Dam, Tenn.	Tennessee River	200	-	200	
Decatur, Tenn.	Goodfield Creek	-	50	50	
Dayton, Tenn.	Richland Creek	730	1,110	1,840	
Total		930	1,160	2,090	0.1

TABLE 77 (Contintued)

ESTIMATED POPULATION EQUIVALENT OF POLLUTION

REACHING TENNESSEE RIVER

Municipality	Receiving Stream	Estimated Population Equivalents			
		Domestic Sewage	Industrial Wastes	Total	Percent of Total in Tenn. Valley
Hales Bar Reservoir					
Chickamauga Dam	Tennessee River	30	-	30	
Daisy, Tenn.	N. Chickamauga Creek	-	300	300	
Ringgold, Ga.	S. Chickamauga Creek	60	300	360	
Chickamauga, Ga.	West Fork South Chickamauga Creek	960	6,400	7,360	
Ft. Oglethorpe, Ga.	Spring Creek	100	-	100	
Chattanooga, Tenn.	S. Chickamauga Creek	5,000	-	5,000	
	Tennessee River	92,690[1]	39,400	132,090	
	Chattanooga Creek	4,000	173,600	177,600	
Flintstone, Ga.	Chattanooga Creek	-	1,200	1,200	
Rossville, Ga.	Chattanooga Creek	1,300	49,100	50,400	
Hales Bar Dam, Tenn.	Tennessee River	120	-	120	
Total		104,260	270,300	374,560	20.0
Guntersville Reservoir					
South Pittsburg, Tenn.	Tennessee River	1,260	-	1,260	
Bridgeport, Ala.	Tennessee River	950	100	1,050	
Sewanee, Tenn.	Lost Creek	560	-	560	
Scottsboro, Ala.	Roseberry Creek	740	200	940	
Albertville, Ala.	Drum Creek	2,020	-	2,020	
Guntersville, Ala.	Tennessee River	3,000	-	3,000	
Total		8,530	300	8,830	0.5
Wheeler Reservoir					
Guntersville Dam, Ala.	Tennessee River	30	-	30	
Huntsville, Ala.	Huntsville Spr. Cr.	19,100	1,100	20,200	
Merrimack Mills, Ala.	Huntsville Spr. Cr.	2,800	-	2,800	
Ardmore, Tenn.	Piney Creek	-	600	600	
Hartselle, Ala.	Shoal Creek	1,300	-	1,300	
Decatur, Ala.	Tennessee River	14,000	3,500	17,500	
Athens, Ala.	Swan Creek	3,500	-	3,500	
Total		40,730	5,200	45,930	2.5

1. Includes Lupton City.

TABLE 77 (Continued)

ESTIMATED POPULATION EQUIVALENT OF POLLUTION

REACHING TENNESSEE RIVER

Municipality	Receiving Stream	Estimated Population Equivalents			
		Domestic Sewage	Industrial Wastes	Total	Percent of Total in Tenn. Valley
Wilson Reservoir					
Wheeler Dam, Ala.	Tennessee River	80	-	80	
Moulton, Ala.	Crow Creek	490	-	490	
Lawrenceburg, Tenn.	Shoal Creek	2,340	130	2,470	
Muscle Shoals, Ala.	Tennessee River	-	800	800	
Village 3, Wilson Dam	Tennessee River	160	-	160	
Total		3,070	930	4,000	0.2
Pickwick Reservoir					
Village 2, Wilson Dam	Tennessee River	2,140	50	2,190	
Florence, Ala.	Tennessee River	7,780	3,600	11,380	
Sheffield, Ala.	Tennessee River	5,000	50	5,050	
Tuscumbia, Ala.	Spring Creek	2,940	-	2,940	
Village 1, Wilson Dam	Tennessee River	350	-	350	
Russellville, Ala.	Bear Creek	850	-	850	
Iuka, Miss.	Indian Creek	700	-	700	
Total		19,760	3,700	23,460	1.3
Kentucky Reservoir					
Pickwick Dam, Tenn.	Tennessee River	70	-	70	
Savannah, Tenn.	Tennessee River	700	-	700	
Lexington, Tenn.	Beech River	1,640	-	1,640	
Parsons, Tenn.	Bear Creek	280	-	280	
Waverly, Tenn.	Trace Creek	-	50	50	
Camden, Tenn.	Cypress Creek	460	-	460	
Bruceton, Tenn.	Big Sandy River	500	-	500	
Paris, Tenn.	Bailey Fork	4,450	-	4,450	
Total		8,100	50	8,150	0.4
Below Kentucky Dam					
Kentucky Dam, Ky.	Tennessee River	770	-	770	
Murray, Ky.	E. Fork Clarks River	2,210	300	2,510	
Benton, Ky.	E. Fork Clarks River	900	-	990	
Total		3,970	300	4,270	0.2
Total Tennessee River		287,710	383,600	671,310	36.1

Sampling and Sampling Stations

Extensive studies were made of the Tennessee River in the vicinity of Knoxville, Chattanooga, Decatur, and Wilson Dam, and the results were reported in 1941.[1] These results will not be repeated here.

Studies have continued on Fort Loudoun Reservoir, and although the results are used in describing the reservoir conditions, they will not be reported in detail until the studies have been completed.

During the summer of 1940 bacteriological samples were collected from Chickamauga, Hales Bar, Guntersville, Wheeler, Wilson, and Pickwick Reservoirs in connection with the selection of recreational areas. Additional samples have been collected at various points throughout the reservoirs at proposed recreational areas. These data are also used in the discussion of reservoir conditions.

A study was made of Chattanooga Creek in 1937 to determine the effects of this stream on Hales Bar Reservoir.

Reservoir Conditions

Fort Loudoun Reservoir

Fort Loudoun Reservoir was impounded in the fall of 1943. Studies on the river were started prior to that time and have continued; however, reservoir conditions cannot be described until the results of the various methods of reservoir operation have been determined. The major portion of flow into this reservoir is controlled by discharges from Cherokee and Douglas Dams on the Holston and French Broad Rivers.

The sewage from an estimated population of 85,080 and industrial wastes having an estimated population equivalent of 80,800 are discharged by Knoxville to the mixture of the Class II Holston River and the Class IV French Broad River waters. The resulting conditions cannot be predicted throughout the reservoir, but it is expected that Class III conditions will exist in the upper end of the reservoir above Knoxville.

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1. Studies of the Pollution of the Tennessee River System, I. A General Description of the Valley with Results of Studies on the Knoxville, Chattanooga, Decatur, and Tri-Cities Sections of the Tennessee River, 1936-1937, Tennessee Valley Authority, Health and Safety Department, 1941.

In 1937 the mouth of Little River was in Class II condition. Flows at the time the studies were made were greater than normal. Additional pollution is now reaching the stream from Maryville and Alcoa, and the stream is probably Class III.

The Knoxville water supply is obtained from the upper end of Fort Loudoun Reservoir, upstream from Knoxville. Considerable difficulty has been experienced in treating this water because of the large amounts of pollution which originate in the French Broad River basin. The hardness of the water is also increased by the mineral matter carried by the Holston River, as has been pointed out in section I.

Watts Bar Reservoir

Watts Bar Reservoir was impounded in the spring of 1942. While extensive studies have not been carried out on this reservoir, the sources of pollution are known and the general conditions of the surface water can be described.

Water enters the upper end of the reservoir from Fort Loudoun Dam and the Little Tennessee River. The Little Tennessee has been classified as Class II at its mouth. The upper reservoir has not yet been classified, but when water is being released through the turbines, Class III conditions will probably exist for a short distance below the dam.

The Clinch River which enters the main reservoir at Kingston is Class III.

The lower section of the reservoir and the principal embayments are generally in Class I condition in the epilimnion and are therefore suitable for swimming. All sections of the reservoir are suitable for other forms of recreation.

At the present time part of the industrial waste from a pulp and paper mill on the Emory River is barged to the main reservoir and discharged below Kingston. This may have some effect on the reservoir for an undetermined distance downstream.

Chickamauga Reservoir

Chickamauga Reservoir is a relatively clean body of water that receives no large quantity of pollution. The main reservoir is Class I while some of the bays are Class II or III because of local pollution reaching the streams. Recreational areas at which swimming in the lake is featured should not be considered at present in these bays. In general, conditions are suitable for this type of recreation throughout the entire section of the main reservoir with the exception of the area affected by the industrial wastes from the munitions plant just above the dam.

Hales Bar Reservoir

Hales Bar Reservoir is a relatively shallow and narrow reservoir that does not have a large storage capacity. South Chickamauga Creek enters the reservoir at mile 468.2, upstream from the Chattanooga water supply intake. In addition to the pollution of an undetermined amount from the munitions plant in the lower end of the Chickamauga area, South Chickamauga Creek receives a pollutional load having an estimated population equivalent of 12,820. This pollution is diluted by water from Chickamauga Dam and is not sufficient to affect seriously the Chattanooga water supply; however, an increase in bacterial densities in the raw water has been observed to parallel the population growth in the area.

Pollution having an estimated population equivalent of 132,090 is discharged directly to the river from Chattanooga, and an additional amount having a population equivalent of 229,200 originating in Chattanooga, Rossville, and Flintstone is discharged from Chattanooga Creek. This combined pollution is sufficient to degrade Hales Bar Reservoir to Class IV below Chattanooga. Natural purification is sufficient to improve the lower end of the lake to Class III at some undetermined point before reaching Hales Bar Dam.

Chattanooga Creek is so grossly polluted that it cannot be used as a source of water supply. One plant located near the Georgia state

line uses creek water for quenching coke and reports it satisfactory for such purposes.

The water plant at Hales Bar Dam is able to treat the lake water to produce a potable, safe water supply. The reservoir at the dam is Class III based upon results of bacteriological examinations of raw water samples collected weekly at the water plant.

The City Water Company supplies domestic water to Chattanooga, Rossville, and other near-by municipalities. It also furnishes water for industrial use to many industries in the area, one of which requires a water of low color. The water plant is able to furnish this premium quality water with no changes in plant operation.

Guntersville Reservoir

Water enters Guntersville Reservoir from Hales Bar Reservoir in a Class III condition and recovers sufficiently to meet Class II requirements by the time it reaches mile 407.6 about 24 miles below Hales Bar Dam. The reservoir remains Class II and is unsuitable for swimming for some distance downstream. At mile 362.0 upstream from Guntersville, Class I conditions based upon bacteriological results were observed. Class III conditions exist in the immediate vicinity of the Guntersville sewer outfall, but recovery is rapid and clean water should be found at Guntersville Dam.

The Sequatchie River is Class I at its mouth based on information obtained by the U.S.P.H.S. trailer laboratory in February 1941.[1]

Wheeler Reservoir

Studies indicate that Wheeler Reservoir upstream from Indian Creek is Class II and will meet the requirements for Class B swimming areas. The section of the reservoir between Indian Creek and Elk River is Class II, but is not suitable for swimming because of the pollution added to

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1. Ohio River Pollution Control, Part Two, Report of the United States Public Health Service, House Document No. 266, 78th Congress, 1st Session, August 27, 1943, p. 841.

the reservoir by Huntsville and Decatur. At times wastes from Indian Creek may degrade the area below its mouth to Class III or IV; however, no studies have been made on this section of the reservoir above Decatur.

Elk River enters the reservoir in Class I condition. This dilution combined with natural purification in the lake results in Class I conditions between Elk River and Wheeler Dam.

The amount of pollution in Wheeler Reservoir does not seriously affect either of the two municipal supplies obtained from it. The Decatur supply, which is drawn from the reservoir about 17 miles below the mouth of Indian Creek, can be treated satisfactorily. The clean water at Wheeler Dam offers no problems of treatment for that supply.

Wilson Reservoir

Water enters Wilson Reservoir from Wheeler Dam in a Class I condition. Shoal Creek is Class II but is not suitable for swimming. Wilson Lake will meet the requirements for Class B swimming in the main section of the lake and below Big Nance Creek after recovery from the pollution carried by that stream. A small amount of sewage is discharged to the lake on the right bank near Wilson Dam, and this section near the sewer outfall is often Class III based on the coliform densities. The left and center sections of the lake near the dam are Class II.

Wastes with an estimated population equivalent of 800 enter the reservoir at mile 260.8 from an industrial plant located on the south bank of Wilson Lake. These wastes contain a black suspended material that resembles finely divided carbon. This material has collected in bays on the left bank and has been objectionable to recreational uses. Chemical analyses on this waste indicate only a small increase in B.O.D. and suspended solids over that contained in the lake water.

Pickwick Reservoir

Water enters Pickwick Reservoir from Wilson Reservoir in a Class II condition. Pollution from the Tri-Cities area degrades the stream to Class III and at times to Class IV in the immediate vicinity of the industrial waste outfall; however, the reservoir returns to Class II before

reaching mile 226.0 above Bear Creek. Bear Creek receives no large amount of pollution and is Class I near its mouth. In general, the lower end of Pickwick Reservoir from Bear Creek to the dam is Class I.

Wastes from chemical industries are discharged into the upper end of Pickwick Reservoir and have been in sufficient quantities to kill fish. These wastes also promote the growth of microscopic taste-producing organisms which have caused operating difficulties at the Wilson Dam and Sheffield water supplies.

Sewage and industrial wastes are discharged from Florence on the right bank of the reservoir upstream from the Sheffield water supply intake, which is on the left bank. Coliform densities were observed in the section prior to and after impoundage to observe changes in water quality. The studies indicate that the pollution follows the right bank downstream and seldom crosses the reservoir to the intake. No operating difficulties have been observed with the exception of the tastes and odors due to microscopic organisms.

Kentucky Reservoir

Water enters Kentucky Reservoir from Pickwick Dam in a Class I condition. The mouth of the Duck River is also estimated to be Class I. As no large amounts of pollution are added directly to the reservoir the only sources of pollution will be from surface run-off. From observations in other reservoirs, it is expected that when this reservoir is impounded in 1944 the main section will be in a Class I condition. The bays receive varying amounts of pollution and cannot be classified until studies are made after the filling of the reservoir.

Area Below Kentucky Dam

It is expected that Class I conditions will exist below Kentucky Dam following impoundage. Class II conditions may exist below Clarks River.

APPENDIX I

QUALITIES OF WATER USED IN THE DESCRIPTION OF STREAMS IN THE TENNESSEE VALLEY

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QUALITIES OF WATER USED IN THE DESCRIPTION OF STREAMS IN THE TENNESSEE VALLEY

The clarity of any description depends upon the use of adequate and suitable standards of measurement and comparison. The need for such standards in the description of the conditions and of the extent of pollution of inland waters is no exception. While adequate results of a large number of field and laboratory tests, which measure the degree or extent of pollution, may be available for such description, they must be brought to a focus in order to clarify the net effects and interlocking relationships of the individual variants measured by the numerous tests.

There have been numerous attempts to establish such criteria for the description of stream conditions, varying in specificity from those concerned with hardly more than superficial appearance to others based on the interpretation of extensive quantitative and qualitative tests. Some of these were reviewed to determine their applicability to the Tennessee River system, and those developed by the U.S. Public Health Service[1] for the Ohio Valley were critically examined to determine whether they might apply with or without certain modifications.

The lack of suitable standards and the difficulty of establishing them for uniform application have been realized by the Special Advisory Committee on Water Pollution of the National Resources Committee.[2]

"Three factors make it wholly impracticable to establish standards of water quality on a national scale.

"Stream systems are Nature's sewers. They carry excess water from the land and in so doing transport mineral and vegetable wastes. In their natural state some streams are so heavily laden with salts and other substances that they are unpalatable and support only a meager

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1. Ohio River Pollution Control, Part Two, Report of the United States Public Health Service, House Document No. 266, 78th Congress, 1st Session, August 27, 1943, pp. 168-178.

2. Water Pollution in the United States, Third Annual Report of the Special Advisory Committee on Water Pollution, National Resources Committee, 1939, pp. 56-57.

aquatic life. Others naturally have a high silt content. No stream has pure water in a strict sense; pure water is found only in the laboratory. Water as man finds it in nature is H_2O plus other chemical elements or compounds and a population of micro-organisms. It varies from one drainage area to another in hardness, iron content, calcium content, color, suspensoids, and in several score of other respects. The elimination of all pollution would not return the country's water bodies to a uniformly 'pure' state, but rather to a natural state which in some areas would be fully as objectionable from a human standpoint as the present polluted state.

"Stream systems change greatly in volume from time to time, so that flows which in some months or years are adequate to dilute all natural and man-made wastes, may be wholly inadequate at other times.

"Human use of water and adjacent land varies as much as within drainage basins and from one basin to another as do the quality and quantity of water. The predominant demand for water in one area may be for domestic use, in another for industrial use, and in still another for fish production.

"For these reasons--the differences in natural water quality, the variations in stream flow, and the differences in human requirements--abatement of water pollution in the United States could not be advanced appreciably by setting up rigid or uniform standards of water quality. On the contrary, it would be greatly retarded by such a procedure. No single standard is applicable generally, but it is practicable and desirable to set standards for selected portions of drainage basins with due regard for the natural condition of the water and for its present and potential use. The key problem in planning for pollution abatement is to find the standards in each section of a stream which express the best balance between the stream's use for receiving and assimilating sewage and other waste and its use for other purposes, aesthetic and economic.

"At the time of its 1935 report the committee noted the absence of standards of water quality except for drinking water and water from which shellfish are taken. Standards for industrial, bathing, and agricultural use, and for propagation of aquatic life, were deficient in large measure and extensive research in those fields was recommended. Since then the understanding of standards has been improved in two respects; first, interstate organizations have agreed upon standards for water zones in two large areas having severe pollution problems--the New York-New Jersey coastal waters and the Delaware Basin; second, criteria of water quality from the standpoint of fresh-water fish production have been formulated. These advances are reported here to illustrate the complexity of the problem and the progress of research in that field."

As it was realized that a considerable amount of care should be observed in the preparation of the criteria for comparison, not only to provide the most suitable measures for the description of existing conditions, but for possible future use in the control of the streams in the

Valley, tentative water qualities were proposed which have been examined and approved by the collaborating states, the U.S. Public Health Service, and the Authority's consultants.

For simplicity in preparing the criteria, the qualities of water necessary for public water supplies, swimming, and fish fauna were primary considerations. It was felt that if the criteria for these three uses were clear, other needs might be related to them without detailed and laborious calculations. While it may be argued that it is impossible to correlate satisfactorily all of the needs of fish with those of public water supplies and swimming, it is believed that if a water is acceptable for such uses it will provide, generally, a suitable environment for fish.

In this study the requirements for water supplies with respect to densities of the coliform group of bacteria, mineral content, and other general characteristics are based upon generally accepted requirements.[1] The permissible limits of dissolved oxygen and 5-day biochemical oxygen demand were determined by studies (described later) of conditions which have been observed in the Tennessee River system.

The recommendations of the Authority's consultants on environmental sanitation were followed in outlining the bacteriological desirabilities for swimming areas. The permissible limits of dissolved oxygen and 5-day biochemical oxygen demand, as in the case for water supply requirements, were based on observed conditions. The color and turbidity requirements listed as desirable are offered for discussion without any basic reason other than a desire to limit such conditions as much as possible without hindering the development of swimming areas in logical sites.

The recommendations of the consultants for the classification of swimming areas are as follows:

> "Based on our review of the origin and use of such standards, and on the Tennessee Valley situation itself, the following interpretation of the coli-aerogenes densities is suggested as a collateral criterion for the selection of public swimming areas on the Tennessee Valley reservoirs. (The term 'coli-aerogenes densities', refers to an average of the most probable numbers of organisms of

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1. Public Health Service Drinking Water Standards and Manual of Recommended Water Sanitation Practice, Public Health Reports, Vol. 58, No. 3, January 15, 1943, pp. 69-111.

the coli-aerogenes (coliform) group per 100 ml. in the water of the swimming area as determined by Standard Methods of Examination[1] in representative samples of reasonable frequency.)

"Coli-Aerogenes Densities (per 100 milliliters)	Suggested Application or Interpretation
0 to 50	Indicates a preferred classification. Not generally attainable, except where direct sewage pollution is absent and long periods of sedimentation and self-purification are available. If later investigations disclose that areas having a coli-aerogenes density in this class exist, and in the absence of definitely adverse sanitary survey or epidemiological evidence, they may be selected for swimming areas without question.
50 to 500	Indicates a state of contamination presumably normal for inland streams which are free of detrimental sewage pollution but are subject to surface wash. In the absence of convincing adverse sanitary survey or epidemiological evidence the selection of swimming areas in this classification should be permitted.
500 to 1000	Indicates a water of suspicious quality which should be considered dangerous in proximity to fresh sewage pollution. However, such densities might be due to non-human or to distant pollution and under such conditions swimming areas may be selected provided a careful sanitary survey does not disclose unfavorable or dangerous conditions.

"If the coli-aerogenes densities, as previously defined, are above 1000 per 100 ml., the area should be viewed with suspicion, and not selected for swimming until further sanitary survey information discloses the origin of the high densities and that they are not due to fresh sewage contamination.

"In event of the development of sanitary survey evidence or epidemiological data which dispute the validity of the interpretations outlined above, it may be necessary to substitute more stringent

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1. Standard Methods for the Examination of Water and Sewage, 8th Edition, 1936, American Public Health Association, New York, N. Y.

limits of bacterial quality. Furthermore, these interpretations of coli-aerogenes densities are recommended primarily as a guide in the selection of relatively open areas in which, by natural exchanges of water, adjacent portions of the main reservoir will exercise a predominant influence. They should be used with greater discretion in the selection of restricted areas, such as embayments or coves, where the influence of the main reservoirs may be so subdued that conditions similar to those which obtain in semi-artificial swimming pools might result."

M. M. Ellis states:[1] "Water standards for fishes and other aquatic organisms, moreover, are not identical with those standards which will define water as potable for human beings or satisfactory for industrial use." He finds that in natural waters, the conditions of pollution as affecting fish life can be determined by measuring the (1) dissolved oxygen, (2) pH, (3) ionizable salts, (4) carbon dioxide, fixed and free, (5) total ammonia, and (6) suspensoids. The data should be sufficient to define daily and seasonal variations and to determine the maximum and minumum conditions, as these extremes may be the factors preventing or permitting the development of desirable fauna.

While such detailed information may be desirable for the complete definition of conditions affecting fish life, it appears that for simplicity and for general application to this Valley the definition might be based upon the pH and the amount of dissolved oxygen, except in the case of certain toxic mineral pollutants and perhaps silt in a few instances. In this connection, it is interesting to note that the monthly average dissolved oxygen content of 5.5 ppm observed in waters of the system having coliform group densities sufficiently low to be classed as suitable for water supplies is slightly more than the minimum of 5.0 ppm, which Ellis finds as necessary for maintenance of native fish life. The minimum observed dissolved oxygen which might be expected in at least 10 percent of the daytime observations when the monthly average is 5.5 ppm is about 4.5, or slightly lower than the desirable limit. However, in view of the fact that generally there will be no obstacle to migration, and since fish can tolerate lower concentrations of dissolved oxygen for short periods of time, it would appear that the requirements for water supplies might safely be related to certain criteria of the requirements for fish life. There might also be a satisfactory correlation between the

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1. M. M. Ellis, Detection and Measurement of Stream Pollution, Bureau of Fisheries, Bulletin No. 22, 1937, p. 367.

amount of certain industrial wastes of chemical origin which can be treated safely by a water purification plant and the amount which can be tolerated by fish. In this connection, it was found that the dilution of yellow liquor from TNT plants required for water supplies was more than necessary to protect fish life.

The results of studies on these criteria have been summarized and are presented in table 78, "Minimum Acceptable Qualities of Water for Various Uses Proposed for Surface Waters in the Tennessee Valley."

Care must be exercised in the application of these criteria in the description of stream conditions. Information collected during sanitary surveys must be considered and in some instances may take precedence over the analytical data.

In arriving at the permissible limits of 5-day biochemical oxygen demand and of dissolved oxygen, studies were carried out to determine the range of these parameters in the Tennessee River system for given densities of the coliform group. Figure 22 illustrates the relationship found between the monthly average density of the coliform group and the monthly average 5-day B.O.D. in the tributaries of the Tennessee River, and figure 23; the relationship between the coliform group and the dissolved oxygen. In the preparation of these curves, the geometric averages were obtained for the densities of the coliform group. The data available for the 5-day B.O.D. curves included approximately 400 observation months, and for the dissolved oxygen curves, slightly more than 300 observation months. While additional data on the main river might have been made available for this comparison by obtaining the geometric averages of coliform densities, it was felt that the information which was used would result in quite stable curves.

Figures 22 and 23 also show the average monthly limits tentatively selected for the various classifications. In the case of dissolved oxygen, it will be noted that the lower limit is such as might be expected to be exceeded 90 percent of the time. The effect of industrial wastes on the 5-day B.O.D. observations produced such erratic results near the extremes of the data that the curve defining the limits including 90 percent

TABLE 78

MINIMUM ACCEPTABLE QUALITIES OF WATER FOR VARIOUS USES

PROPOSED FOR SURFACE WATERS IN THE TENNESSEE VALLEY

Stream Conditions	Required Conditions				
	Class I	Class II		Class III	Class IV
	Class A Swimming Areas and Water Supplies with Minimum Treatment	Class B Swimming Areas II-B Class C Swimming Areas II-C	Water Supplies (Normal Filter Plant Operation)	Water Supplies (Advanced Treatment Methods) and Aquatic Life	Unsuitable for Water Supplies and Will not Support Desirable Aquatic Life
Appearance: Oils, tars, greases, floating solids, scum or debris except from natural sources	None	None		Moderate - localized	This class to apply to all waters which are unsuitable for water supplies as defined under Class III; which do not support desirable aquatic life; where generalized nuisances of appearance and odor exist; where conditions cause interference with such other uses as navigation and power, and deterioration of submerged structure and equipment; and where the water is unsuitable for stock watering or other agricultural purposes.
Color, ppm:	20 (Desirable)	20 (Desirable)	Amount of color and turbidity allowed which can be removed with normal equipment by standard practices	Amount of color and turbidity allowed which can be removed economically by advanced methods	
Turbidity, ppm:	10 (Desirable)	25 (Desirable)			
Sludge Deposits and Offensive Odors	None	None		Moderate - localized	
5-Day Biochemical Oxygen Demand:					
Monthly Average, ppm	1.0	1.5	2.0	4.0	
Maximum Observation, ppm	2.0	3.0	4.0	6.0	
Dissolved Oxygen:					
Monthly Average, ppm		7.0	6.5	5.5	
Minimum Observation, ppm	7.0*	5.5	5.0	4.0	
Coliform Group					
Monthly Average M.P.N. per Ml.	0.50	(II-B) 5.0 (II-C) 10.0	50	200	
pH	6.5-8.6	6.5-8.6		5.0-9.5	
Other Conditions: Toxic substances, free acid, taste and odor producing materials and other chemicals	Water shall not be irritating or toxic to swimmers for classes I, II-B, and II-C. Water when treated shall meet standards of physical and chemical characteristics as outlined in "Public Health Service, Drinking Water Standards," Reprint No. 2440 Public Health Reports--Jan. 15, 1943.				

*In upper layers of lakes and pools.

of the data could not be indicated satisfactorily. The limits of classification, however, were established well above the values below which 75 percent of the results were observed.

Figure 24 shows the relationship which was observed between the monthly average and maximum observed 5-day B.O.D. The 90 percent expectancy curve was used in establishing the maximum permissible observation with the exception of the value for Class III, which was taken from the 75 percent curve.

Figure 25 illustrates the relationship found between the monthly average dissolved oxygen and the minimum observation. The tentative minimum observations shown in the tabulation fall well below that which might be expected to be exceeded 90 percent of the time.

The data used in the preparation of the curves shown in figures 24 and 25 include results from the entire Tennessee River system, covering 560 observation months having from two to five observations a month.

STREAM SANITATION SURVEY

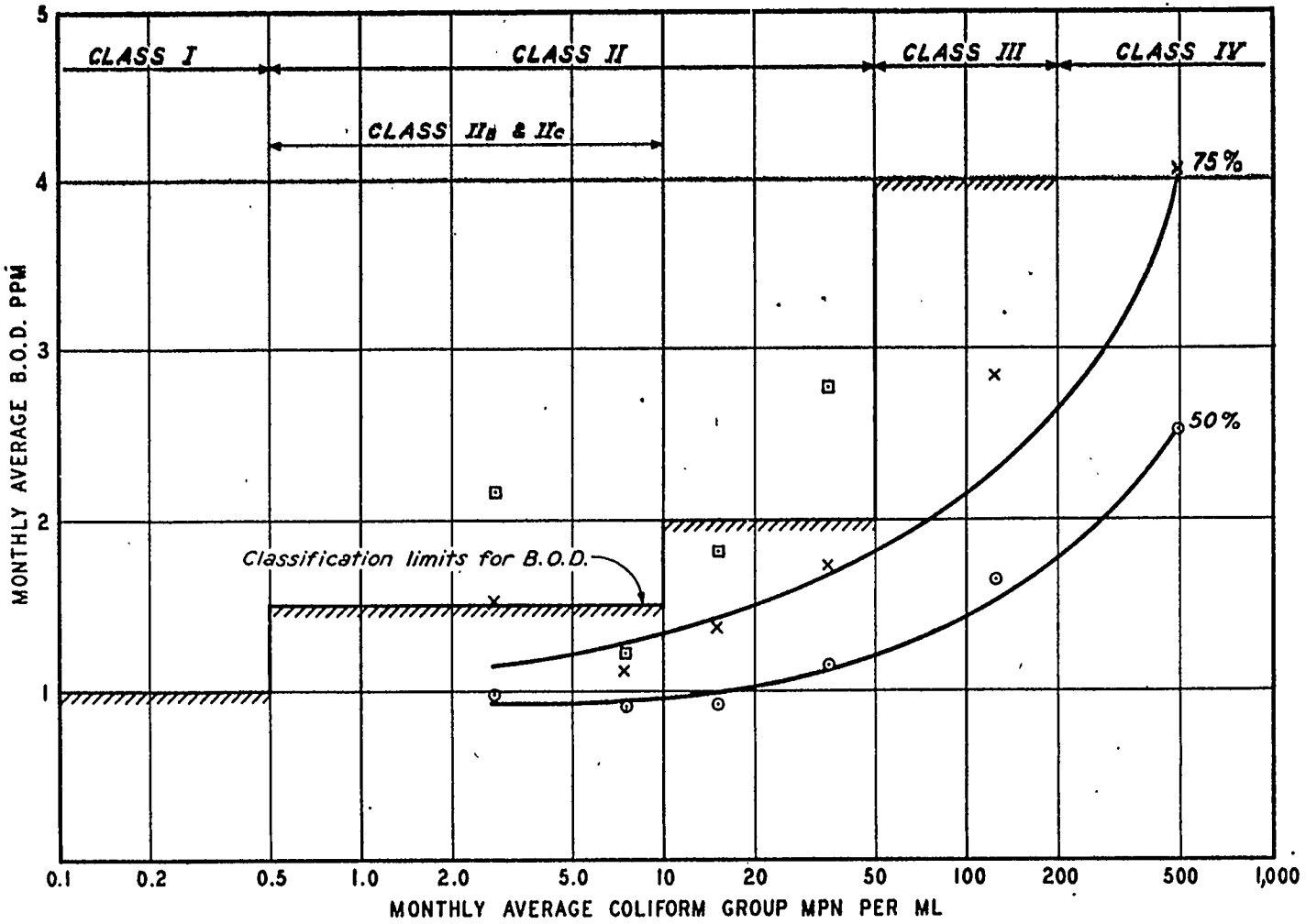


Figure 22

SYMBOLS:

50 % of expected B.O.D. less than —⊙—⊙—

75 % " " " " " —×—×—

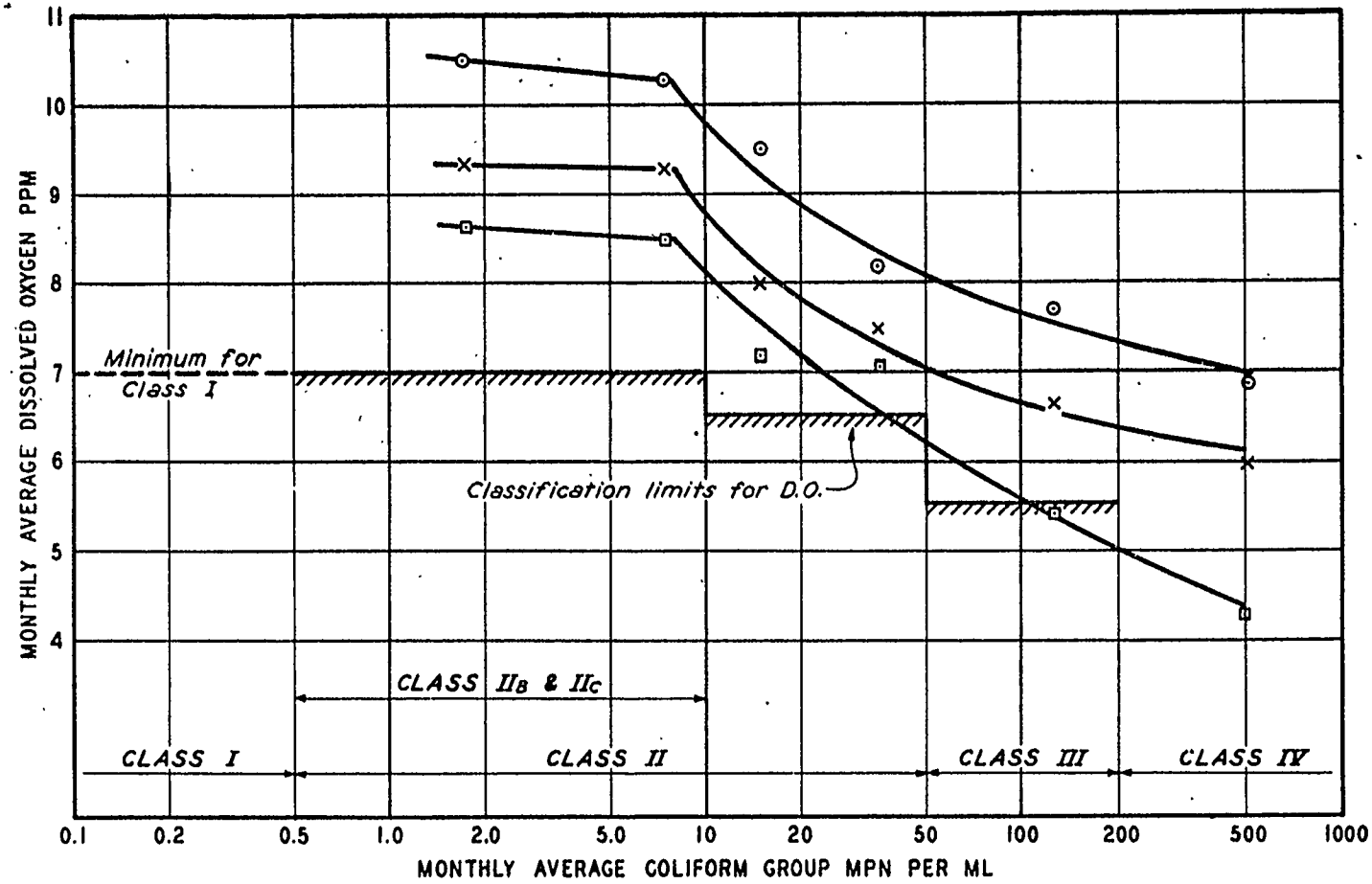
90 % " " " " " ⊡

TENNESSEE VALLEY AUTHORITY
HEALTH AND SAFETY DEPARTMENT

RELATIONSHIP BETWEEN
MONTHLY AVERAGE DENSITY OF COLIFORM GROUP
AND
MONTHLY AVERAGE 5 DAY B.O.D.
IN THE TRIBUTARIES OF THE TENNESSEE RIVER

G HS 306 A 501 RI

STREAM SANITATION SURVEY



SYMBOLS:

50 % of expected D.O. greater than —⊙—⊙—

75 % " " " " " —×—×—

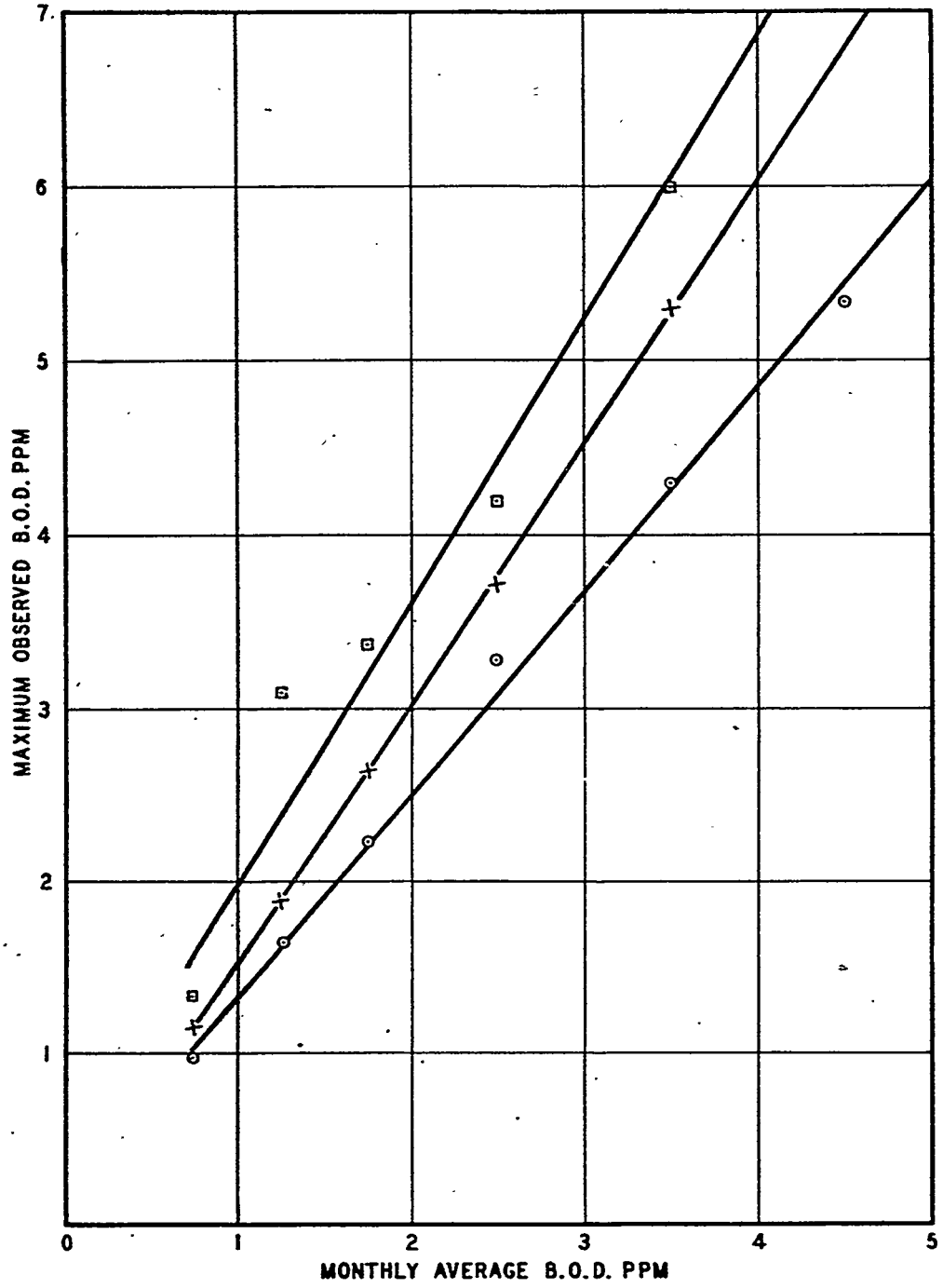
90 % " " " " " —⊡—⊡—

Figure 23

TENNESSEE VALLEY AUTHORITY
HEALTH AND SAFETY DEPARTMENT

RELATIONSHIP BETWEEN
MONTHLY AVERAGE DENSITY OF COLIFORM GROUP
AND
MONTHLY AVERAGE DISSOLVED OXYGEN
IN THE TRIBUTARIES OF THE TENNESSEE RIVER

G HS 306 A 502 R1



SYMBOLS:

50% of expected maximum B.O.D. less than —⊙—

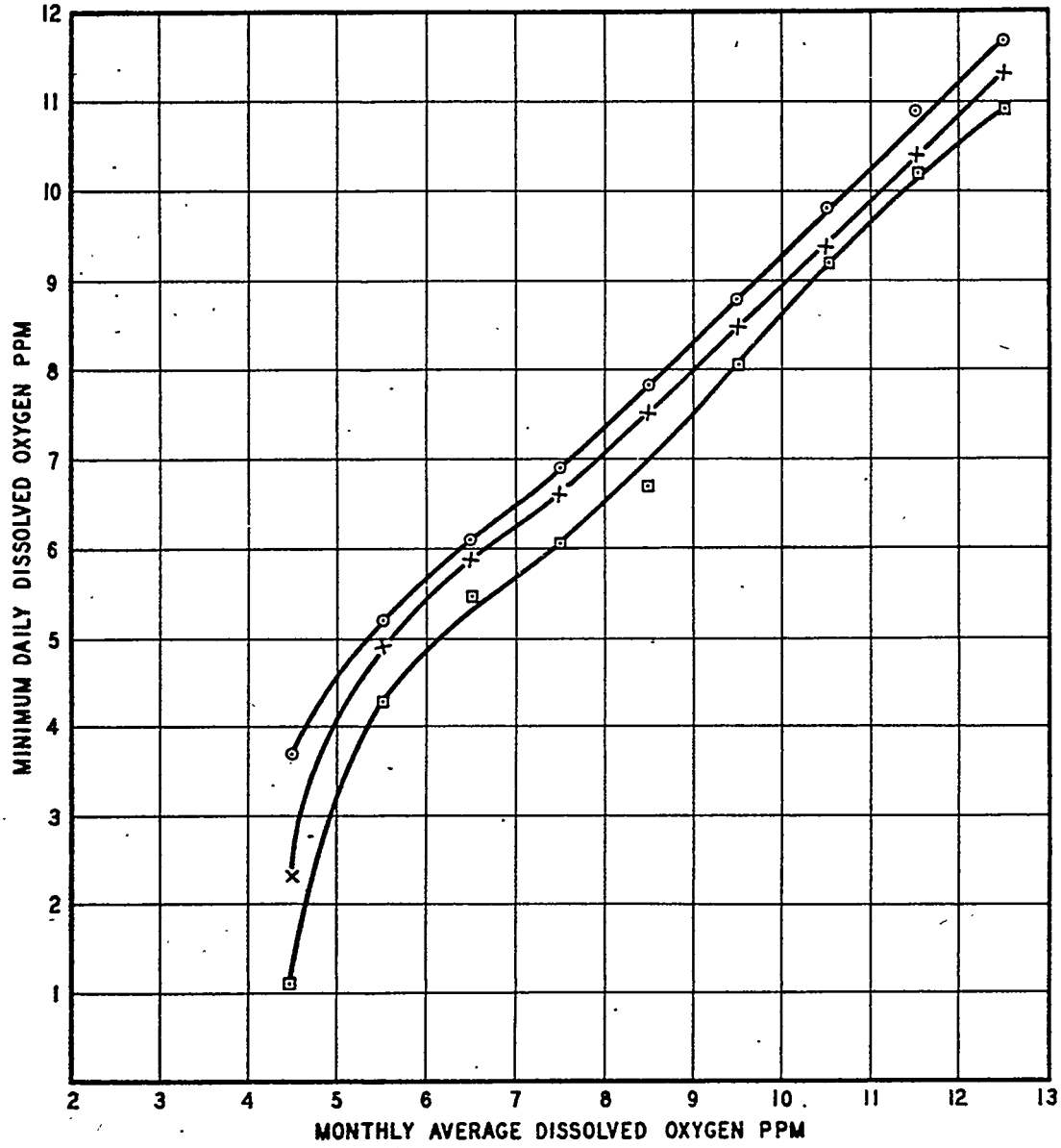
75% of expected maximum B.O.D. less than —×—

90% of expected maximum B.O.D. less than —⊡—

Figure 24

TENNESSEE VALLEY AUTHORITY
HEALTH AND SAFETY DEPARTMENT

RELATIONSHIP BETWEEN
MONTHLY AVERAGE
AND
MAXIMUM OBSERVED 5 DAY B.O.D.
IN THE TENNESSEE RIVER AND ITS TRIBUTARIES



SYMBOLS:

50% of expected minimum D.O. greater than —⊙—

75% of expected minimum D.O. greater than —×—

90% of expected minimum D.O. greater than —⊡—

Figure 25

TENNESSEE VALLEY AUTHORITY
HEALTH AND SAFETY DEPARTMENT

RELATIONSHIP BETWEEN
MONTHLY AVERAGE
AND
OBSERVED MINIMUM DAILY DISSOLVED OXYGEN
IN THE TENNESSEE RIVER AND ITS TRIBUTARIES