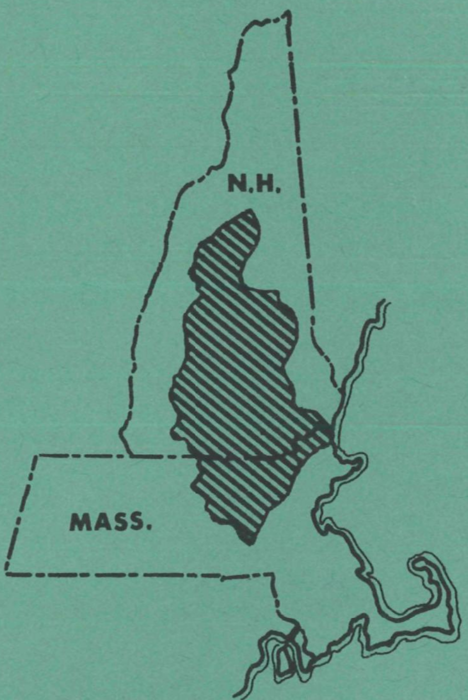
REPORT ON POLLUTION OF THE MERRIMACK RIVER AND CERTAIN TRIBUTARIES —

part V - Nashua River



U. S. DEPARTMENT OF THE INTERIOR

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

Merrimack River Project - Northeast Region

Lawrence, Massachusetts

August 1966

REPORT ON POLLUTION OF

THE MERRIMACK RIVER

AND CERTAIN TRIBUTARIES

PART V - NASHUA RIVER

U. S. Department of the Interior
Federal Water Pollution Control Administration
Northeast Region
Merrimack River Project
Lawrence, Massachusetts

August 1966

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INTRODUCTION

In accordance with the written request to the Secretary of Health, Education, and Welfare from the former Governor Endicott Peabody of Massachusetts, dated February 12, 1963, and on the basis of reports, surveys or studies, the Secretary of Health, Education, and Welfare, on September 23, 1963, called a conference under the provisions of the Federal Water Pollution Control Act (33 U. S. C. 466 et seq.), in the matter of pollution of the interstate waters of the Merrimack and Nashua Rivers and their tributaries (Massachusetts-New Hampshire) and the intrastate portions of those waters within the State of Massachusetts. The conference was held February 11, 1964, in Faneuil Hall, Boston, Massachusetts.

In February 1964, the U. S. Department of Health, Education, and Welfare established the Merrimack River Project to evaluate the adequacy of the pollution abatement program for the Merrimack River and to obtain supplemental water quality data in certain portions of the Merrimack River Basin. The Nashua River is included in this study. Headquarters for the Project are located at the Lawrence Experiment Station of the Commonwealth of Massachusetts in Lawrence, Massachusetts.

Subsequent to the conference, the Secretary of Health, Education, and Welfare recommended appropriate pollution abatement action. Specifically, he recommended that a pollution abatement program commensurate with that on the Merrimack River be established for Massachusetts communities and industries in the Massachusetts portion of the Nashua River Valley with all preliminary plans completed and submitted to the Massachusetts Department of Public Health not later than September 1965.

This report is based on data, reports and other materials furnished by the Massachusetts Department of Public Health, the New Hampshire Water Pollution Commission and the New England Interstate Water Pollution Control Commission; data furnished by the National Council for Stream Improvement (of the Pulp, Paper, and Paperboard Industries), Incorporated; information furnished by other interested federal agencies; information from the Nashua River Study Committee and other citizens living in the Nashua River Basin; official records of the Federal Water Pollution Control Administration; and data obtained by the Merrimack River Project through field surveys. The cooperation of the numerous agencies and individuals is gratefully acknowledged.

BACKGROUND

The Nashua River is formed by the confluence of the North and South Branches of the Nashua River at Lancaster, Massachusetts, from which it flows in a northerly direction for approximately twenty-six miles. At the New Hampshire-Massachusetts state line, it flows north-easterly for about ten miles to Nashua, New Hampshire, where it joins the Merrimack River (Figure 1). It has a drainage area of 530 square miles, of which 132 square miles are drained by the North Nashua River. The North Nashua has an average slope of twenty feet per mile, while the slope of the slower moving Nashua River averages only four feet per mile, much of which is utilized by several dams.

The industrial value of the North Nashua River was recognized in the first decade of the nineteenth century when General Leonard Burbank established a paper mill and dam at Fitchburg, Massachusetts. Later, cotton mills, saw mills and additional paper mills were established. Today, approximately 27 per cent of the production of paper and board in Massachusetts come from plants in the Nashua River Basin.

SOURCES OF POLLUTION

GENERAL

Sewage and industrial wastes contain a variety of obnoxious components which can damage water quality and restrict its use. Oxygen-demanding materials can limit or destroy fish, fish food organisms and other desirable aquatic life by removing dissolved oxygen from the river. Greasy substances can form objectionable surface scums, settleable solids can create sludge deposits, and suspended materials can make once attractive waters appear turbid.

Industrial wastes may also contain additional objectionable chemicals and toxic substances that can kill aquatic life, taint fish flesh or promote slime growths in the receiving waters. Heat from industrial processes or steam-electric generating plants can magnify the adverse effects of other decomposing wastes and, if excessive, can injure or kill fish and other aquatic life.

Sewage contains astronomical numbers of intestinal bacteria which were released in man's excretions. Some of these, such as the Salmonella bacteria, may be pathogens which can reinfect man with a variety of diseases.

The 5-day biochemical oxygen demand test of sewage and industrial wastes measures the potential of these materials for reducing the dissolved oxygen content of the river waters. The coliform bacteria content of raw and treated sewage indicates the density of sewage-associated bacteria, which may include disease-producing pathogens, discharged to the river. Oxygen-demanding loads are expressed as population equivalents (PE) of 5-day biochemical oxygen demand (BOD), and the bacterial loads are expressed as bacterial population equivalents (BPE) of total coliform bacteria. Each PE or BPE unit represents the average amount of oxygen demand or coliform bacteria normally contained in sewage contributed by one person in one day. (One PE equals one-sixth pound per day of 5-day BOD and one BPE equals about 250 billion coliform bacteria per day).

The amount of such pollutional components in sewage that can be removed by sewage treatment works depends upon the type and capacity of the plants and the skill of the operators. Types of sewage treatment plants in this area are generally identified as primary or secondary—with or without chlorination.

Primary treatment plants, which consist essentially of settling tanks and sludge digesters, can remove most of the scum and settleable solids, about one-third of the oxygen-demanding materials and approximately fifty per cent of the bacteria. Secondary plants consist of biological treatment units, such as trickling filters, activated sludge or oxidation lagoons. Such plants can remove about 90-95 per cent of the BOD, suspended solids and coliform bacteria. Chlorination facilities for disinfection of properly treated sewage plant effluents can destroy more than 99 per cent of the sewage bacteria. To accomplish these reductions, however, treatment facilities must be properly designed and skillfully operated.

Estimates have been made of the waste discharges to the Nashua

River and its tributaries within Massachusetts. These estimates, based primarily on surveys taken by the Massachusetts Department of Public Health and 1963 surveys by the National Council for Stream Improvement (of the Pulp, Paper, and Paperboard Industries), are summarized in Table 1.

BACTERIA

Sewage is the principal source of bacterial pollution in the Nashua River Basin. Tests were not carried out to determine whether or not favorable environmental conditions in the paper machines increased the bacterial densities in the process water used by the paper industries and, subsequently, in the receiving stream. Although practically all the sewage in the Basin receives treatment before being discharged, an inadequate sewage collection system at Fitchburg, Massachusetts, results in overflows of raw sewage directly to the North Nashua River. This source, accounting for approximately 18,900 bacterial population equivalents, represents nearly 78 per cent of the total bacterial load entering the Nashua River and its tributaries.

Leominster, with part of its sewage receiving secondary treatment and a small amount being by-passed at the time of this report, accounts for 12.4 per cent of the total bacterial load to the river, while treated sewage from Clinton represents 5.4 per cent of the total. The prechlorination facilities at Leominster are not used. Raw sewage from approximately 200 persons is discharged by East Pepperell, while lesser amounts are discharged by Lancaster and Shirley. These three discharges represent less than 2 per cent of the total bacterial loading.

TABLE 1

ESTIMATED CHARACTERISTICS OF SEWAGE AND INDUSTRIAL WASTES DISCHARGED TO THE NASHUA RIVER AND TRIBUTARIES WITHIN MASSACHUSETTS

Discharge	Treatment and Waste Reduction Measures	Population Equivalents Discharged					
		Bacterial		Suspended Solids		Oxygen Demand	
		Number	% Total	Number	% Total	Number	% Total
Cushing Academy	Secondary with Cl_2	3	0.01	45	0.01	30	0.02
State Hospital (Gardner)	Secondary with Cl_2	16	0.07	80	0.01	80	0.05
Weyerhaeuser Paper Company	Save-alls, wastes recirculated, starch substitution, settling	--	--	184,600	33.19	39,650	22.30
Fitchburg Paper Co.	Save-alls, wastes recirculated, retention aids	--	--	108,200	19.45	37,060	20.84
Simonds Saw and Steel Company	None	--	--	--	--	5,800	3.26
Falulah Paper Company	Wastes recirculated, chemical precipitation, vacuum filtration of sludge	--	--	115,400	20.75	27,940	15.71
Fitchburg	Inadequate secondary	18,900	77.85	20,700	3.72	19,500	10.97
Mead Corporation	Starch substitution, wastes recirculated	--	--	30,300	5.45	5,700	3.21
Foster Grant Company	Lagoon	--	--	16,600	2.98	2,500	1.41
Leominster	Partly secondary, partly raw	3,000	12.36	5,200	0.94	12,140	6.82
Atlantic Union College	Partly primary, partly secondary	210	0.87	210	0.04	280	0.16
Lancaster	None	150	0.62	150	0.03	150	0.08

TABLE 1 (Continued)

Discharge	Treatment and Waste Reduction Measures	Population Equivalents Discharged					
		Bacterial		Suspended Solids		Oxygen Demand	
		Number	% Total	Number	% Total	Number	% Total
Blackstone Mills, Inc.	None	--	--	--	--	150	0.08
Clinton	Secondary	1,300	5.35	1,560	0.28	1,040	0.58
Girls Industrial School	Secondary	15	0.06	18	--	18	0.01
Shirley	None	100	0.41	100	0.02	100	0.06
Ayer	Secondary	375	1.55	750	0.13	500	0.28
Hollingsworth and Vose Company	Settling, wastes recirculated	--	--	1,470	0.26	6,650	3.74
Groton Leather Board Company	Settling, wastes recirculated	--	--	5,880	1.06	2,120	1.19
Groton School	Secondary	8	0.03	10	--	10	0.01
St. Regis Paper Company	Save-alls, wastes recirculated	--	--	64,700	11.64	16,200	9.11
Pepperell	None	200	0.82	200	0.04	200	0.11
TOTAL		24,277	100.00	556,173	100.00	177,818	100.00

Supplementary Data:

Borden Chemical Company, Leominster, Massachusetts, having no treatment measures, discharges suspended solids population equivalents of 2,000 and oxygen demand population equivalents of 11,000.

Sewage from Fort Devens, a federal installation at Ayer, Massachusetts, passes through Imhoff tanks with the effluent being discharged to leaching beds where it seeps into the ground away from the Nashua River.

SUSPENDED SOLIDS

Discharges of suspended solids create a severe problem in the Nashua River. Most of the solids are discharged by the paper mills in the Basin. For example, almost 92 per cent of the 556,000 suspended solids population equivalents (SSPE) discharged come from the paper mills. By far the largest loadings emanate from the three paper industries of Fitchburg, Massachusetts, where 408,200 SSPE or 73.4 per cent of the total originate. The St. Regis Paper Company in Pepperell, Massachusetts, discharges wastes with a suspended solids population equivalent of 64,700, or 11.6 per cent of the total, 3.5 miles above the Massachusetts-New Hampshire state line. Figure 2 presents the data in graphical form.

BIOCHEMICAL OXYGEN DEMAND

Sewage and industrial wastes presently discharged to the Nashua River have an estimated biochemical oxygen demand (BOD) population equivalent of 177,800. The paper industries contribute 76.1 per cent of the total. Of the municipalities, Fitchburg contributes approximately 19,500 BOD population equivalents or 11 per cent of the 177,800. Other sources, accounting for the remaining 12.9 per cent, ranged from 0.01 to 6.8

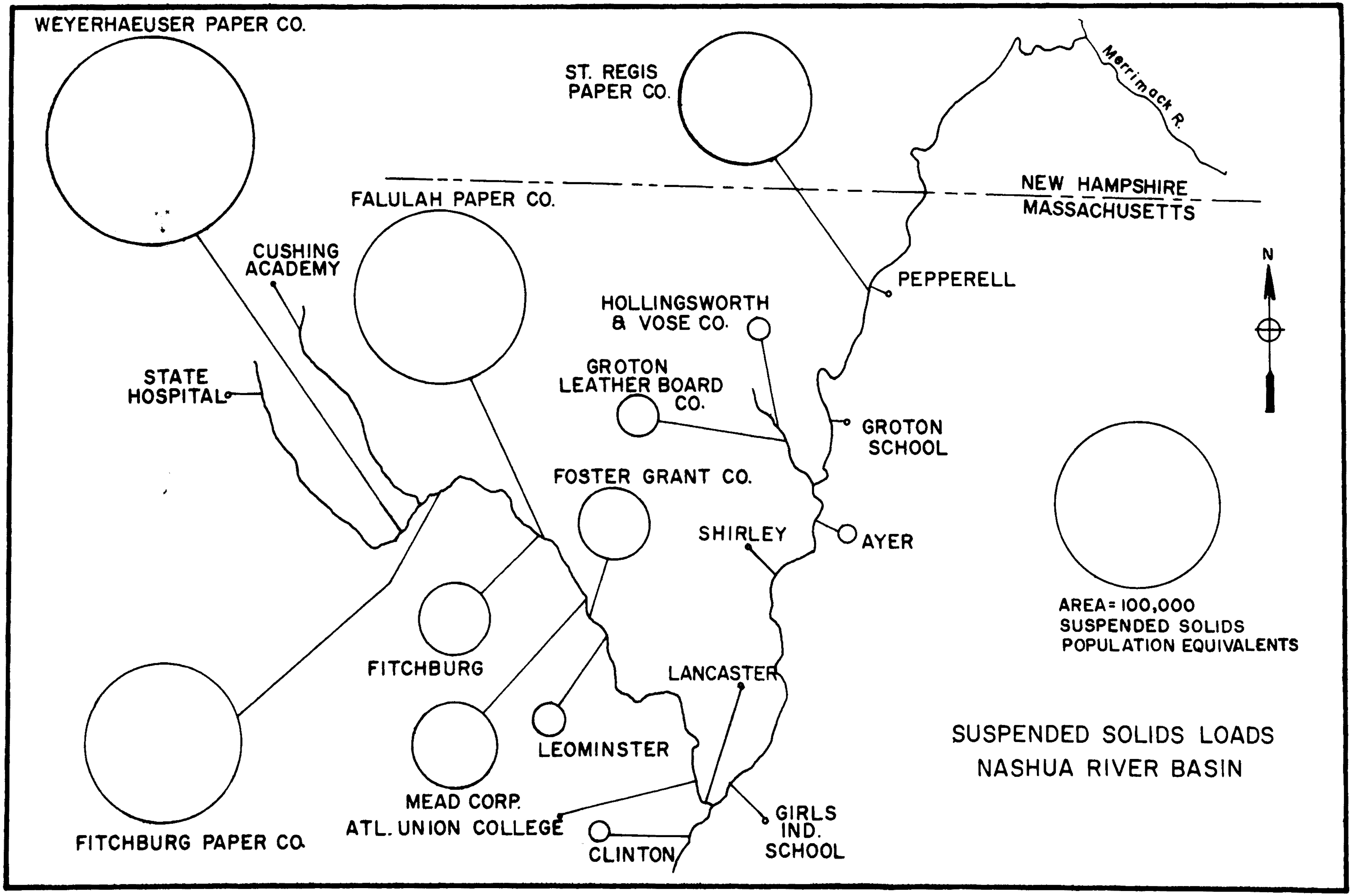
per cent of the total each, with the effluent from Leominster being responsible for the higher value (Figure 3).

NUTRIENTS

Treated and untreated sewage discharged to the Nashua River contributes a significant amount of phosphates to the stream. Considering data from river sampling and the sewered population, it was estimated that 128,000 population equivalents of orthophosphates, which are readily available for growth of algae or other aquatic vegetation, are discharged to the Nashua River. The three largest sources are Leominster with 51 per cent, Fitchburg with 34 per cent and Clinton with 8 per cent.

APPARENT COLOR

At the end of a paper machine run, batches of the residual liquid containing pigments or dyes are discharged by some of the paper mills. When this happens, the river is turned red, green, blue or whatever color is discharged. In addition, white suspended matter, due to materials such as titanium dioxide which are used to give the paper a whiter appearance, is routinely released to the Nashua River.



WEYERHAEUSER PAPER CO.
ST. REGIS PAPER CO.
Merrimack R.
NEW HAMPSHIRE
MASSACHUSETTS
FALULAH PAPER CO.
CUSHING ACADEMY
PEPPERELL
N
HOLLINGSWORTH & VOSE CO.
STATE HOSPITAL
GROTON LEATHER BOARD CO.
GROTON SCHOOL
FOSTER GRANT CO.
SHIRLEY
AYER
AREA = 100,000 SUSPENDED SOLIDS POPULATION EQUIVALENTS
FITCHBURG
LANCASTER
LEOMINSTER
SUSPENDED SOLIDS LOADS NASHUA RIVER BASIN
MEAD CORP.
ATL. UNION COLLEGE
GIRLS IND. SCHOOL
FITCHBURG PAPER CO.
CLINTON

FIGURE 2

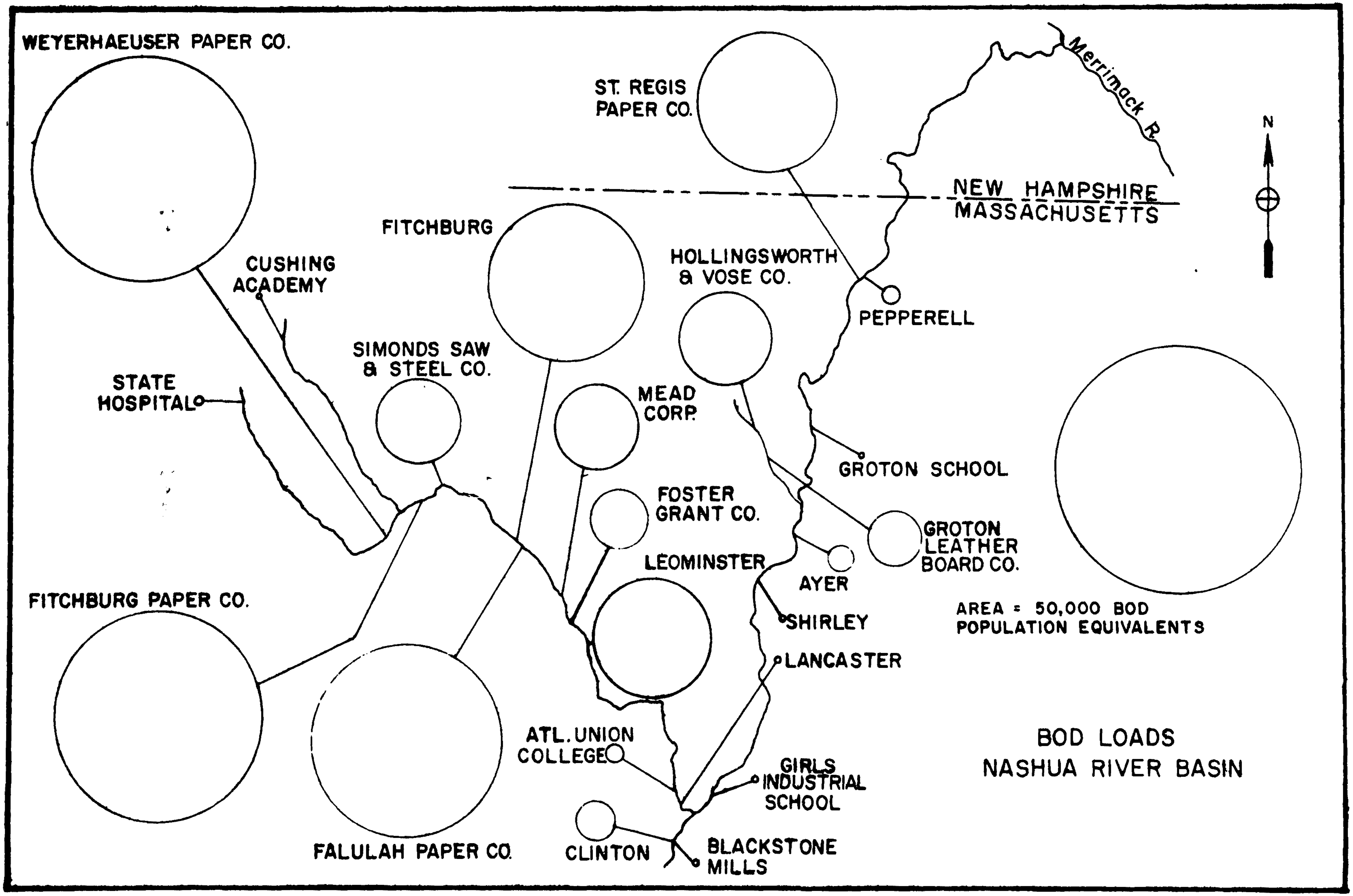

WEYERHAEUSER PAPER CO.
ST. REGIS PAPER CO.
Merrimack R.
N
NEW HAMPSHIRE
MASSACHUSETTS
FITCHBURG
CUSHING ACADEMY
HOLLINGSWORTH & VOSE CO.
PEPPERELL
SIMONDS SAW & STEEL CO.
STATE HOSPITAL
MEAD CORP.
GROTON SCHOOL
FOSTER GRANT CO.
GROTON LEATHER BOARD CO.
LEOMINSTER
AYER
FITCHBURG PAPER CO.
SHIRLEY
AREA = 50,000 BOD POPULATION EQUIVALENTS
LANCASTER
ATL. UNION COLLEGE
GIRLS INDUSTRIAL SCHOOL
BOD LOADS NASHUA RIVER BASIN
CLINTON
BLACKSTONE MILLS
FALULAH PAPER CO.

FIGURE 3

WATER USES

Several Nashua River Basin communities obtain their municipal water supplies from surface sources. These supplies are obtained from unpolluted tributaries or headwaters in the Basin. In addition, the Metropolitan District Commission obtains water for Greater Boston from the Wachusett Reservoir on the South Branch Nashua River. No municipal water is obtained from the polluted sections of the Nashua River.

During the past few years, there has been a critical shortage of municipal water supplies in Fitchburg and Leominster, Massachusetts. Emergency water lines had to be laid to new sources, and severe restrictions on the use of water were put into effect.

Approximately 28 million gallons per day are used from the Nashua River Basin by the paper industries for process water. In some cases, the river containing upstream waste discharges is diverted for use by a downstream mill. When necessary to precondition the water, facilities ranging from sand filters to ion exchange processes are used.

Nashua River water is used for irrigation of truck crops in some areas. During drought periods, the stream may be of considerable benefit to nearby farmers.

At the present time the Nashua River is populated by various types of coarse fish in the Pepperell reservoir and in the New Hampshire section. Based on the character of the stream, it appears that recreational fishing would be possible in the entire North Nashua and Nashua River system if the water quality were improved. In addition, improved water quality would enhance the important waterfowl area in the Lancaster-Bolton, Massachusetts, section. At the present time, a small amount of boating takes place in the reservoir at Pepperell. Demands for all types of water oriented recreation in the Nashua River Basin are heavy and are expected to increase in the future.

The Nashua River can be used at the Fort Devens Military Reservation for training exercises involving streams and for recreation when pollution is controlled. The sections of the river forming the post boundary could be used for public recreation, while the sections entirely within the reservation could be used for recreation by post personnel or by the public by permit.

EFFECTS OF POLLUTION ON WATER QUALITY AND USES

Previous reports have described the polluted conditions in the Nashua River. The Nashua Valley Water Supply and Sewerage Project of the W. P. A. concluded in 1936 that: "There is no question but that the Nashua River is polluted in portions of its course both by domestic and industrial wastes. This condition exists from Fitchburg to the Massachusetts-New Hampshire state line." The Project added that the removal of polluted wastes "...would be an asset to both communities and industries, and would encourage further industrial and recreational development." In 1954 the report of the New England-New York Inter-Agency Committee on the resources of the region cited the Nashua River as being "outstanding for its absolute worthlessness as a fish stream" in its present condition.

During the summers of 1962 and 1963, studies were made by the National Council for Stream Improvement (of the Pulp, Paper, and Paperboard Industries) and the Massachusetts Department of Public Health of the paper mill waste loads and the water quality conditions of the receiving streams. Severe pollution was found from Fitchburg, Massachusetts, to Nashua, New Hampshire.

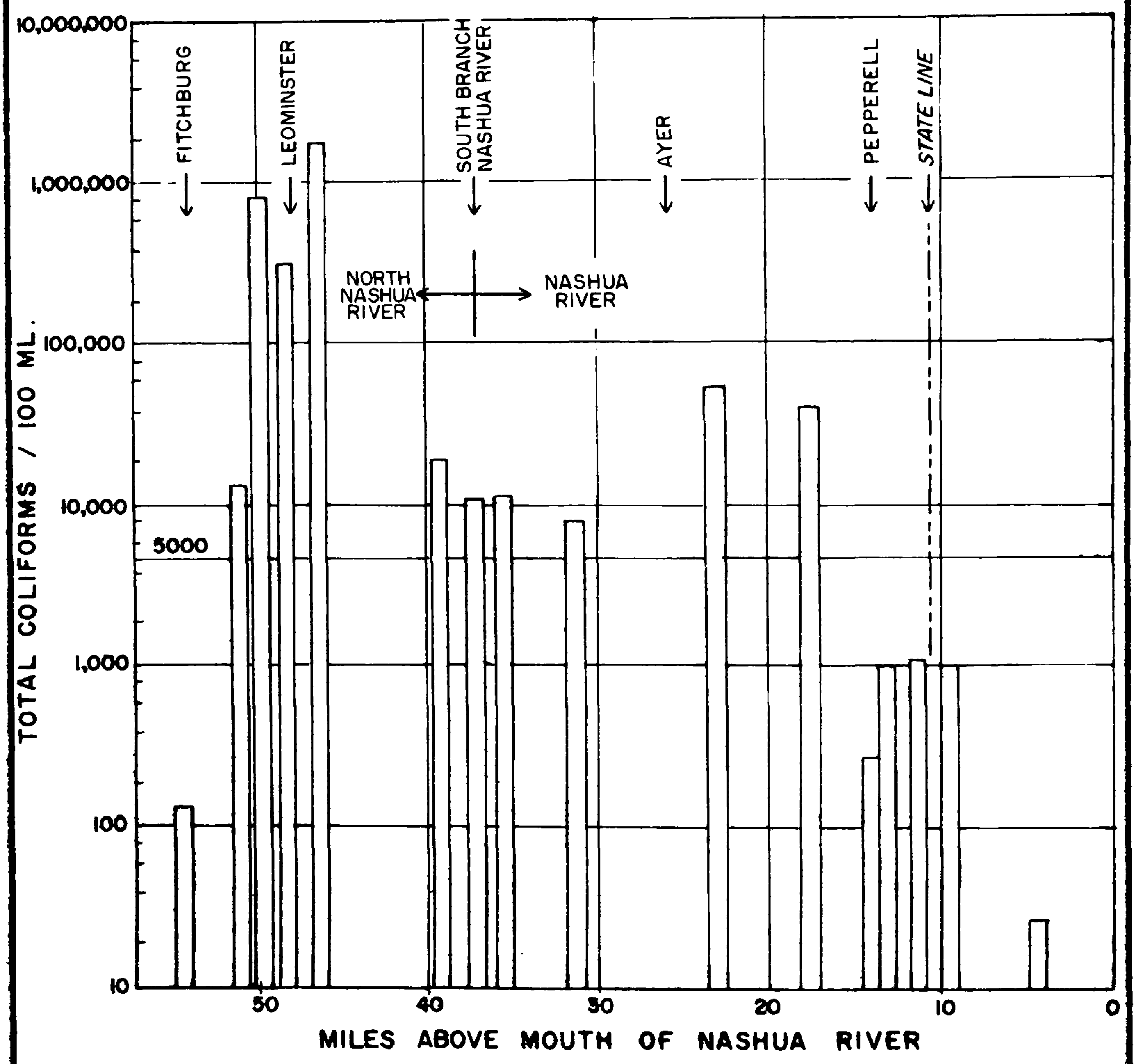
BACTERIAL POLLUTION

Water polluted by sewage frequently contains pathogenic bacteria which, if ingested, can cause gastrointestinal diseases such as typhoid fever, dysentery, and diarrhea. The infectious hepatitis virus, and other viruses may also be present. Body contact with sewage-polluted water can cause eye, ear, nose, throat or skin infections. Therefore, excessive bacterial pollution of a river presents a health hazard to all who come in contact with the water.

Sewage also contains bacteria of the coliform group, which typically occur in excreta or feces and are readily detectable. Although most are harmless in themselves, coliform bacteria are always present in sewage-polluted water and are considered indicators of the probable presence of pathogenic bacteria. Many state and interstate water pollution control agencies evaluate water quality on the basis of sanitary survey findings and total coliform content. Recently, refined methods for isolation and detection of Salmonella organisms have made it practical to test for these specific infectious disease bacteria.

Both Massachusetts and New Hampshire have bacteriological standards for bathing waters. The total coliform limit in Massachusetts bathing waters is 2,400 per 100 ml, while the limit in New Hampshire is 240 per 100 ml. Neither state has adopted a total coliform standard of water quality for the recreational uses of fishing and boating. Where such an objective has been adopted in other states, the commonly used limit is 5,000 per 100 ml. A commonly accepted upper limit for waters involving whole body contact uses, such as swimming and water skiing, is 1,000 coliform bacteria per 100 ml.

A bacteriological study was made by the Merrimack River Project on the Nashua River during the period June 15-17, 1965. The results are presented in Figure 4. Most of the length of the North Nashua and Nashua



COLIFORMS IN NORTH
NASHUA & NASHUA RIVERS
JUNE 15-17, 1965

FIGURE 4.

Rivers in Massachusetts had a coliform density which exceeded 5,000 per 100 ml.

The total coliforms increased from an average of 110 per 100 ml in the Whitman River near its mouth to an average of 824,000 per 100 ml. below Fitchburg. Maximum coliform values recorded during the period were 270 and 1,140,000 per 100 ml, respectively. After an initial decrease, the average number of coliforms increased to 1,830,000 per 100 ml below Leominster. At this location, a maximum coliform density of 3,400,000 per 100 ml was obtained during the June sampling. This density was 680 times the commonly used limit for fishing waters. Apparently the secondary sewage treatment plant at Leominster was not operating properly, since the increase was much higher than would be expected. Around-the-clock sampling during the period August 31 to September 2, 1965, in the North Nashua River below Leominster and the upper Nashua River indicated that the coliform densities were the same order of magnitude as those found during the June survey. The coliforms were again found to be as high as 3,400,000 per 100 ml below Leominster.

Although coliforms below the Clinton, Massachusetts, treated sewage discharge increased to an average of 372,000 per 100 ml in the South Branch Nashua River, the low flow and long detention resulted in a decrease to 14,400 just above the mouth. Treated sewage from the Ayer, Massachusetts, area resulted in an increase in the average coliform value to 55,000 per 100 ml in the Nashua River. After the coliform die-off in Pepperell reservoir, an increase again took place as the raw sewage from East Pepperell was discharged to the river.

During November and December, 1965, special Salmonella bacteria detection studies were conducted on the North Nashua and the South Branch Nashua Rivers in Lancaster, Massachusetts. While coliform densities indicate the magnitude of fecal pollution which may contain disease-producing organisms, detection of pathogenic Salmonella bacteria in river water is positive proof that these infectious disease-producing organisms are actually present.

Salmonellosis, the disease caused by various species of Salmonella bacteria, includes typhoid fever, gastroenteritis and diarrhea. There are more than 900 known serological types of Salmonella. During 1964 there were over 21,000 Salmonella isolations from humans in the United States; fifty-seven known deaths resulted from Salmonellosis. Table 2 lists the ten most common salmonella serotypes isolated from human specimens in the United States during 1964.

In the work conducted by the Merrimack River Project, six different serotypes were found in the river in Lancaster. Salmonella new brunswick and S. montevideo were isolated from the North Nashua River, while S. livingstone, S. typhimurium, S. blockley, and S. typhimurium var. copenhagen were found in the South Branch Nashua River.

The presence of pathogenic organisms in the stream emphasizes the need for adequate pollution abatement and reaffirms the necessity for continuous and effective waste treatment which will remove Salmonellae and other pathogenic bacteria.

The high bacterial densities in the Nashua River Basin present a health hazard to anyone who may ingest the water. In addition, there

TABLE 2

MOST FREQUENT SALMONELLA ISOLATIONS, 1964

RANK	SEROTYPE	NUMBER	PERCENT
1.	S. typhimurium & S. typhimurium v. cop.	5,862	27.8
2.	S. derby	2,360	11.2
3.	S. heidelberg	1,717	8.1
4.	S. infantis	1,523	7.2
5.	S. newport	1,036	4.9
6.	S. enteritidis	801	3.8
7.	S. typhi	703	3.3
8.	S. saint-paul	645	3.1
9.	S. oranienburg	550	2.6
10.	S. montevideo	524	2.5
TOTAL		15,721	74.5
TOTAL (all serotypes)		21,113	100.0

SOURCE: Salmonella Surveillance Report, Annual Summary-1964, Communicable Disease Center, U. S. Department of Health, Education, and Welfare, Atlanta, Georgia is a hazard to the health of persons who eat truck crop produce irrigated by polluted Nashua River water. Much truck crop produce is eaten without being cooked.

SUSPENDED SOLIDS

Excessive suspended solids in a stream diminish the beauty of the water and settle to the stream bottom where they form sludge deposits. These deposits can deplete the stream's oxygen supply and produce offensive odors. They blanket the stream bottom and smother the aquatic life upon which fish feed. The sludge deposits decompose, and in many cases the gases from decomposition buoy up the sludge which then will float on the stream surface, causing unsightly conditions.

Ideally, a stream bottom should be free of pollutants that will adversely alter the composition of the bottom fauna, interfere with the spawning of fish or with their eggs, or adversely change the physical or chemical nature of the bottom. The Nashua River is far from meeting these conditions.

Deposits of sludge two to six inches deep exist throughout most of North Nashua and Nashua Rivers. Along the river banks, sludge depths one to two feet deep are common, while in parts of the Pepperell reservoir, sludge deposits at least thirty inches deep were located. Behind the dam near the Ayer Ice Company, sludge extends nearly to the top of the dam. Similar conditions exist behind several other dams along the North Nashua and Nashua Rivers.

Many obnoxious, black, floating sludge rafts, which have been lifted up from the bottom, may be observed in the Nashua River. Most of the clumps are a few inches in diameter, but floating sludge over three feet in diameter has been seen. In July 1966, a solid blanket of sludge over 600 feet long coated the top of the Nashua River behind the Ayer Ice Company dam.

In the summer of 1965, the Merrimack River Project received a letter from a family living near the Nashua River in Pepperell. The letter described the Nashua and read in part "...There are giant clumps of solids that look and smell like cow manure, only it can't be I don't think. What ever it is, it sure smells awful...I've never seen it (the river) so bad as now and never has it smelled like now. You'll need a gas mask if you come to town."

Clean rivers are an asset to property values and a joy to persons living nearby. Waste treatment measures should be taken long before a river is so polluted that nearby families can no longer tolerate the foul stench.

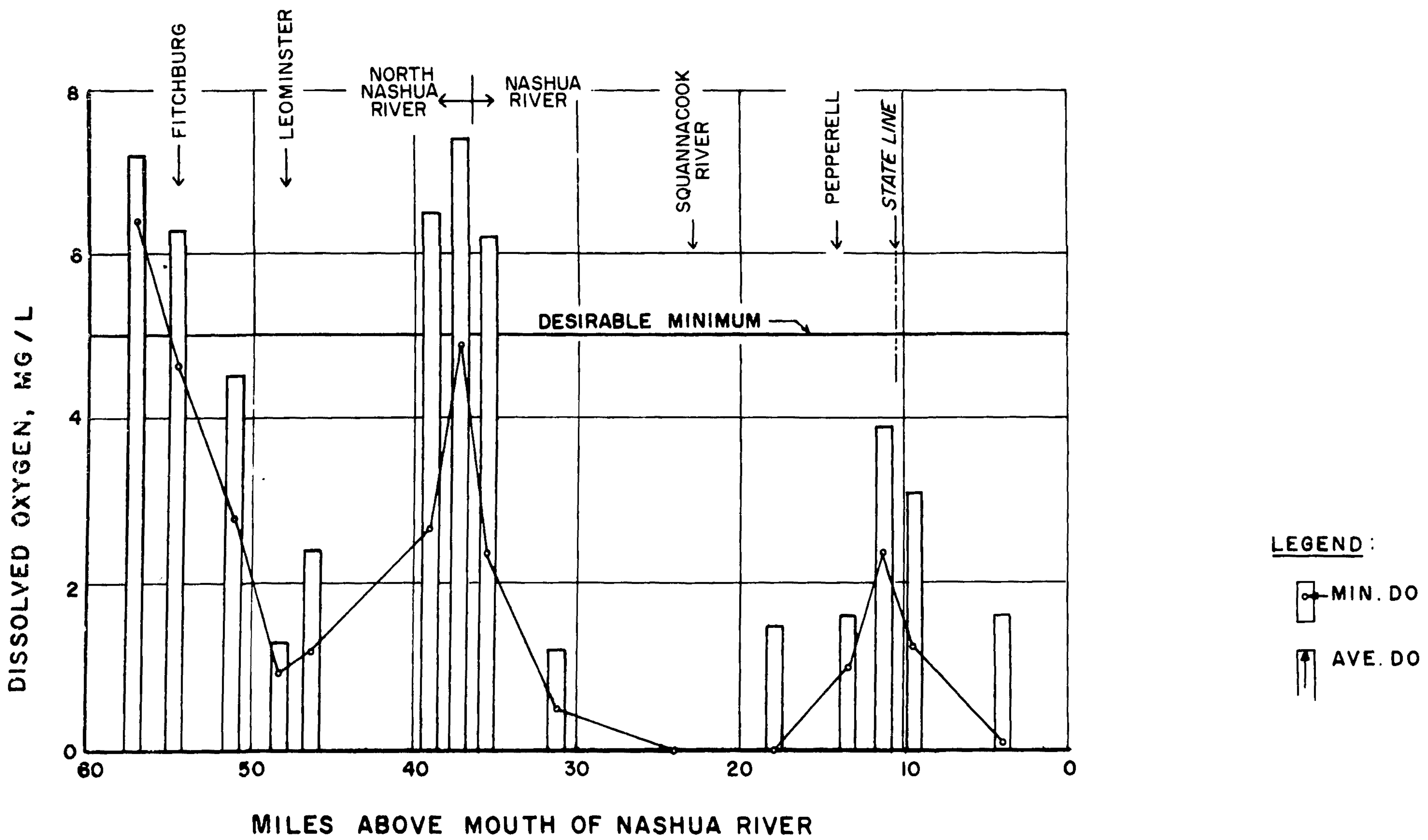
DISSOLVED OXYGEN

Sewage and many industrial wastes contain organic matter which decomposes and exerts a demand on the dissolved oxygen in the receiving stream. When the dissolved oxygen (D.O.) is reduced below an adequate level, the fish population and the aquatic life on which the fish feed are killed or driven out of the area. Most water pollution control agenices have adopted a minimum mg/l D.O. objective to maintain the maximum potential warm water sport fish population.

When the dissolved oxygen becomes totally depleted, obnoxious odors, mostly from hydrogen sulfide, result, causing an unpleasant environment for persons living or working nearby. The hydrogen sulfide given off by the stream may turn nearby houses, bridges and other painted structures black.

Figure 5 illustrates the substantial reduction in D.O. in the North Nashua River during the period June 15-17, 1965, caused by the waste discharges followed by only partial recovery. It also shows the effect of sludge deposits, along with the residual biochemical oxygen demand from the upstream discharges, on D.O. of the Nashua River, where the stream velocity was much lower than in the North Nashua and reaeration was less rapid. Oxygen values at or near zero were common. In fact, just upstream of the Squannacook River, zero D.O. occurred in every sample obtained. At this point the disgusting septic odor was prevalent 200 feet from the Nashua River. The dissolved oxygen was slightly above zero in the free flowing section below the dam at Pepperell, Massachusetts, but the oxygen decreased again in New Hampshire. At the Everett Turnpike in Nashua, New Hampshire, the average D.O. was only 1.65 mg/l, with a minimum of 0.1 mg/l being recorded. Of the fifty-three miles of stream sampled, the average dissolved oxygen was below the desirable minimum of 5 mg/l in approximately forty miles, while the minimum dissolved oxygen levels recorded were below the desired lower limit at every sampling station except the background station above Fitchburg.

Additional sampling was carried out by the Merrimack River



DISSOLVED OXYGEN
NORTH NASHUA & NASHUA RIVERS
JUNE 15-17, 1965

FIGURE 5

Project during the period August 31 to September 3, 1965, in the North Nashua River below Leominster and in the Nashua River from Lancaster to Still River Station at river mile 31.3. Average dissolved oxygen values were approximately half the values obtained during the June sampling. Minimum values of zero were obtained in the North Nashua at the bridge near the old Ponakin Mill in North Lancaster and in the Nashua River at Still River Station.

With few exceptions, the dissolved oxygen levels in the North Nashua and Nashua Rivers have been inadequate to support fish life. Non-game fish find their way into the Pepperell reservoir and into the New Hampshire section of the Nashua River; but even these fish are killed by the pollution.

During the period June 30-July 3, 1965, an estimated 7,000 non-game fish were killed in Pepperell reservoir when the Hollingsworth and Vose Paper Company pumped a large batch of sludge to the Squannacook River instead of to sludge drying beds. This black slurry totally depleted the dissolved oxygen of the Nashua River and killed all the fish in its path, as it flowed downstream.

Low dissolved oxygen was also the cause of a large fish kill in the lower Nashua River during the period July 14-24, 1963, when thousands of non-game fish died. The effected reach covered over fifteen miles of stream in Massachusetts and New Hampshire.

Fish kills are not limited to the summer period. On March 10, 1966, numerous non-game fish were killed in the Pepperell reservoir.

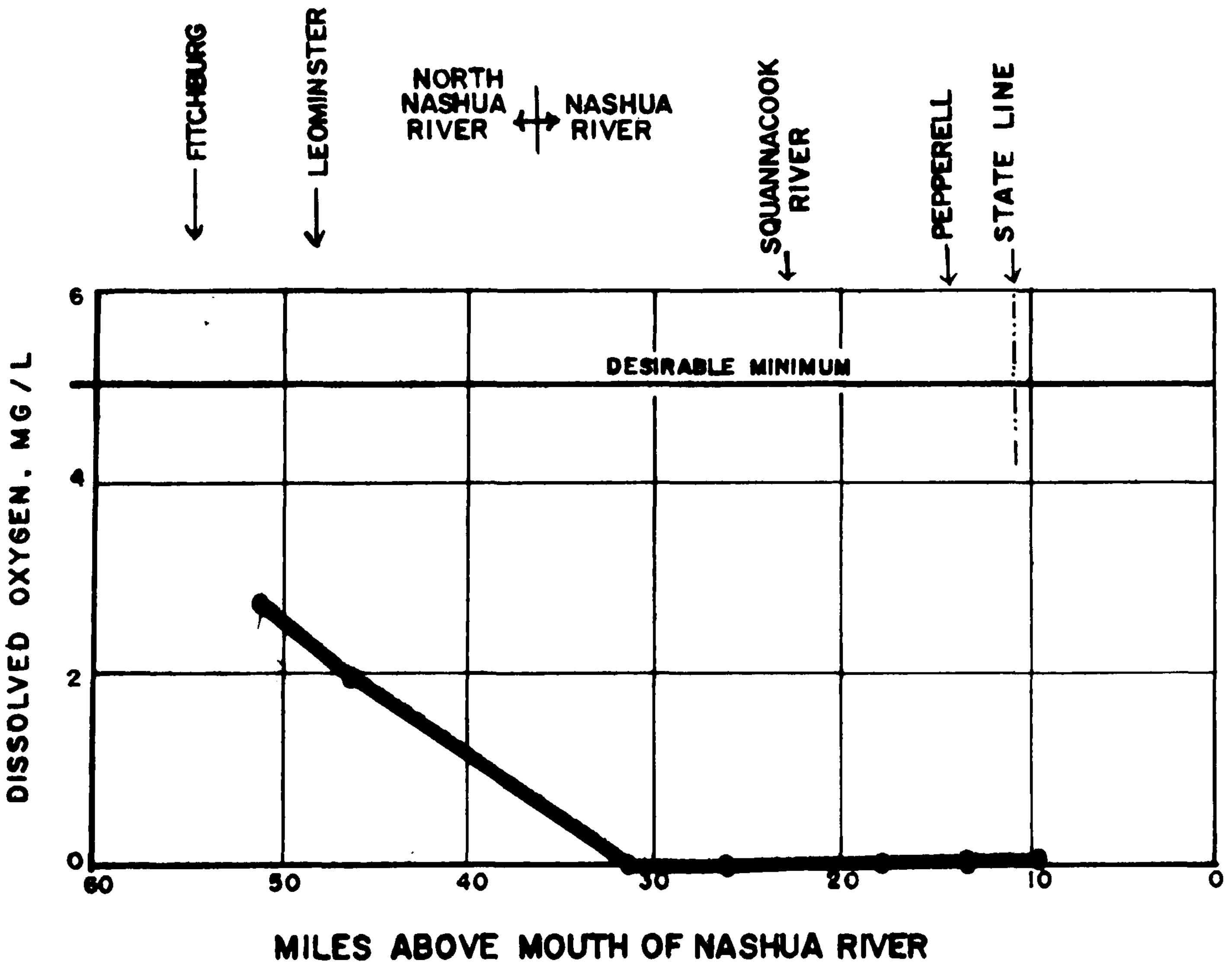
Despite the very low dissolved oxygen conditions in the Nashua

River over the past years, probably the worst condition was reached during the summer of 1966. Figure 6 shows the results of a spot check made of the dissolved oxygen in the North Nashua and Nashua Rivers on July 1, 1966. The Nashua River contained no dissolved oxygen whatsoever at each point sampled from Still River Station to Hollis, New Hampshire. The river was grayish-black in color and had a strong septic odor.

As a result of the obnoxious odor, the people living in towns bordering the Nashua River initiated a purewater campaign. The movement began in Hollis, New Hampshire, where the odor from the river was reported to be so strong that the people could not sleep at night. Petitions containing more than 600 signatures from the small town of Hollis were sent to the Governor of New Hampshire with the request to "take whatever action you deem will be the most effective in restoring the Nashua River to something resembling its natural state." The petition also stated that the people of Hollis, New Hampshire, "are distressed by the wanton pollution of the Nashua River with the resultant loss of health, recreation and esthetic benefits."

The movement spread to Massachusetts. On August 17, 1966, a large number of state legislators and officials from ten communities bordering the Nashua River presented petitions listing over 6,000 names to the Governor of Massachusetts and requested action in cleaning up the Nashua River. Their statement concluded:

"The message is exceedingly clear. Commonwealth officials and politicians should listen: The citizens in the towns along the Nashua River can no longer be pacified by descriptions of impending



DISSOLVED OXYGEN
NORTH NASHUA & NASHUA RIVERS
JULY 1, 1966

FIGURE 6

legislation, promises and generalities. They are quite tired of hearing politicians tell them about what is going to happen. Patience has been exhausted. The willingness to suffer industrial and municipal waste has run out. They will not be satisfied until pure water again flows in their river."

BIOLOGICAL

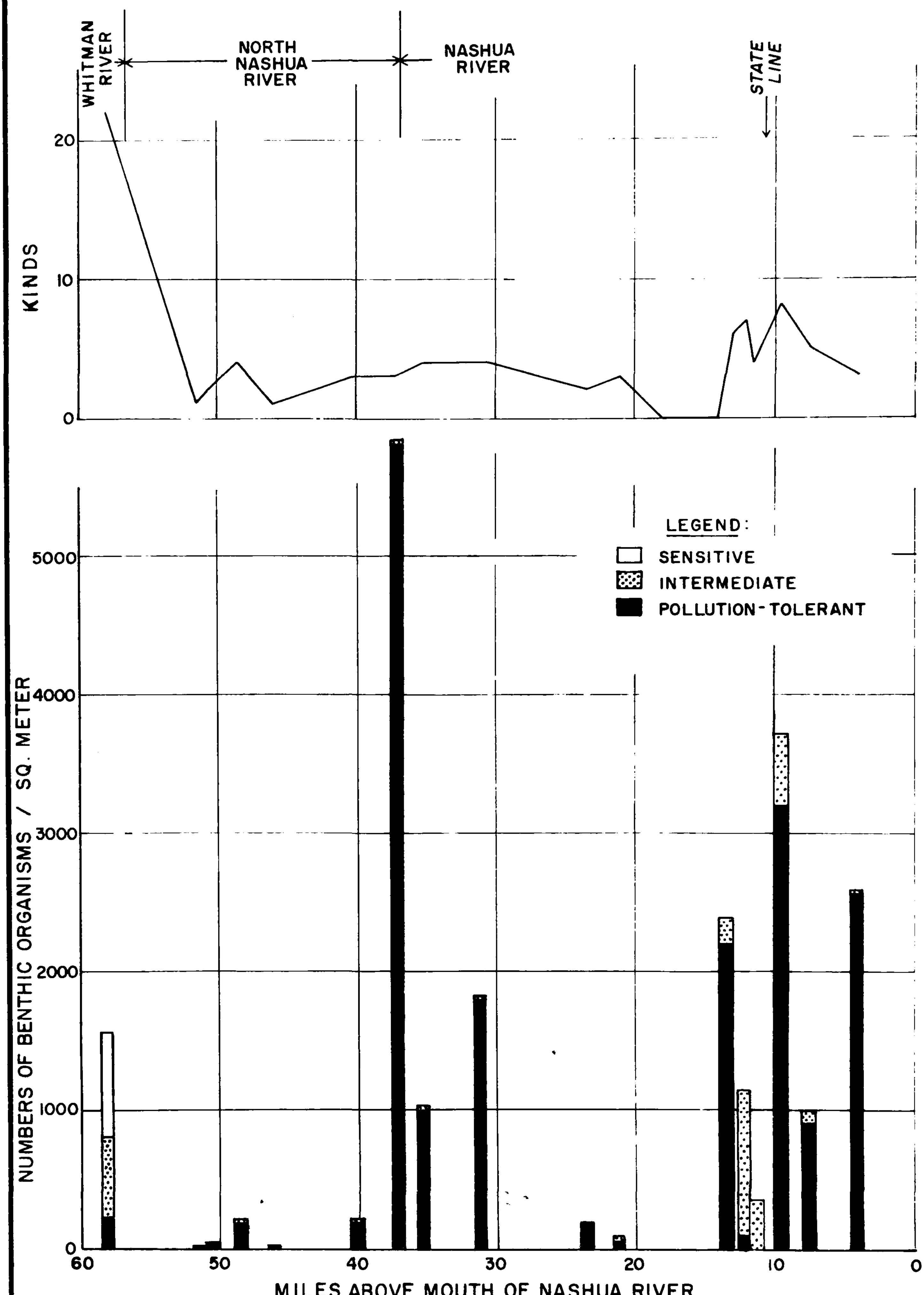
Environments in which aquatic organisms live can be modified by the introduction of man-produced pollution. Unpolluted watercourses support many kinds of clean-water-associated bottom organisms such as mayflies, stoneflies, alderflies, certain beetles and caddisflies. Certain kinds of benthic fauna generally found in moderately polluted environs include such forms as snails, craneflies, sowbugs and certain midges and may be considered as forms of life intermediate in their tolerance of pollution. Pollution-tolerant organisms, consisting of sludgeworms, certain leeches, and midges with special respiratory structures usually markedly increase in areas severely polluted with organic wastes such as sewage. Stream conditions that permit the development of an assemblage of clean-water-associated forms provide food for fishes and prevent development of nuisance organisms in large numbers.

Responses of aquatic organisms to domestic and industrial wastes depend largely on the amounts and kinds of such materials entering the environment of these organisms. One response is manifest by the loss of a few kinds of organisms that thrive only in clean water environments, while those associated with mildly polluted waters increase slightly in numbers. A more drastic response causes the disappearance of all clean-water-associated forms and the development of pollution-tolerant organisms often associated with sludges and slimes.

The results of biological surveys in the Nashua River Basin, conducted in June and July of 1965, are shown in Figure 7.

The Whitman River upstream of Snows Mill Pond and above any significant waste discharges exhibited many clean-water-associated bottom organisms and showed that the stream was an excellent environment for aquatic life. Downstream from the first series of paper mills, the bottom of the North Nashua River was completely covered with paper fibers, and the benthic organisms were drastically reduced from the pollution-sensitive kinds found upstream of the paper mills to low populations of pollution-tolerant organisms downstream (see Figure 7). This condition existed until just upstream of the confluence with the South Branch of the Nashua River where organisms tolerant to pollution began to increase.

Certain bacterial slimes (Sphaerotilus sp.) were found growing in the North Nashua River. Under favorable conditions, these organisms attach themselves to an underwater solid surface and grow as chains, or filaments, of cells surrounded by a sheath. The filaments are encased in gelatinous capsular material. A characteristic of the slimes is the tendency of the gelatinous masses to become entwined with and cling tightly to objects with which they come in contact in the stream, including aquatic forms of life. In the absence of pollution by organic materials, slime infestations will not occur.



NUMBERS AND KINDS OF BENTHIC ORGANISMS, JUNE-JULY, 1965

FIGURE 7

The South Branch below Clinton, Massachusetts, had 9,680 pollution-tolerant benthic organisms per square meter, reflecting the existence of organic pollution from the Clinton sewage treatment plant.

Benthic fauna found in the Nashua River from Lancaster to the Squannacook River indicated that this reach was grossly polluted. Only a few kinds of pollution-tolerant organisms predominated.

Fourteen different kinds of benthic fauna were found on the bottom of the Squannacook River upstream of the paper mills, the majority of which types were sensitive to pollution. Downstream of the paper mills no benthic organisms of any kind were found. The dissolved oxygen of the overlying water was 2.3 mg/l and the pH was 10.7 at the time of sampling. This pH indicates an excessively alkaline condition.

With one exception at river mile 20.6, bottom samples in the main channel between the Squannacook River and the St. Regis Paper Company dam at East Pepperell contained no benthic organisms whatsoever. Dredging generally released large volumes of gas from bottom sludges. Some sheltered inlets to Pepperell reservoir, however, contained moderate numbers of forms tolerant to organic pollution.

Six kinds of benthic fauna and 2,387 individuals were found per square meter of stream bed in a riffle area, river mile 13.6, downstream of the St. Regis Paper Company, East Pepperell. Bottom sediments here contained mostly sludgeworms and a few midgefly larvae, snails and leeches. Red fibers blanketed the stream bed. Fibers such as these clog respiratory surfaces, causing death by suffocation of certain benthic fauna, such as caddisflies, mayflies and waterpennies, normally found in the sediments of unpolluted riffle areas of this type.

Fibrous matter in the river 1.4 miles upstream of the Massachusetts-New Hampshire state line was so abundant that the river resembled a thick grey soup. Two to three inches of sludge covered the stream bed and piled up to four inches high along the banks. Fibers like these clog the gills of suspension feeders, such as mussels, clams and snails, leading to eventual death by starvation and suffocation. Certain burrowing insect fauna such as caddisflies and mayflies cannot tolerate such low oxygen levels as found here (D.O. was 2.7 mg/l). Only a few midgefly larvae (356 per square meter of stream bed) were found. Gross organic pollution, in this portion of the Nashua River, prevented the development of all the different kinds of benthic fauna normally found in a riffle area such as this, except for the few midgefly larvae.

In a rapids area, river mile 9.9, four-tenths of a mile downstream of the Massachusetts-New Hampshire state line, sludges accumulated along the banks and to a depth of six inches in pools below the falls at Hollis Depot. Large numbers of benthic fauna, mostly sludgeworms (3,110 worms per square meter), were found in sediments taken from this area. There were eight different kinds of bottom life in these sediments, including midgefly larvae, scuds, snails, leeches and sludgeworms. Although this portion of the stream was still grossly polluted, there was a greater variety of benthic fauna here than at the next upstream reach in Massachusetts. Insect fauna such as certain stoneflies, caddisflies, mayflies and certain beetles were not found in sediments here. Benthic fauna of this type cannot tolerate the low oxygen levels (D.O. was 3.1

mg/l) found here or the blanketing by the fibrous matter found in abundance at this location.

During dredging of a ponded area, river mile 8.0, of the river, 2.3 miles downstream of the state line, sludge rafts and gases of anaerobic decomposition rose from the stream bed. The water was slightly acid (pH 6.75), and the dissolved oxygen concentration was 1.4 mg/l. This portion of the Nashua River was in a zone of active decomposition. The septic environment limited the benthic population to five kinds of fauna and 1,002 individuals per square meter of stream bed. Midgefly larvae and sludgeworms were the only kinds of bottom life found in stream bed sediments. Certain rotifers (Conochiloides sp.) were found in large numbers attached to the body surfaces of these midgefly larvae. By decreasing respiratory surface area, these rotifers posed an additional hazard to survival to even these pollution tolerant fauna. Rotifers such as these were found on benthic fauna dredged from several sections of the Merrimack River stream bed known to be grossly contaminated with organic pollution.

Septic conditions also prevailed at river mile 3.9, and the benthic population consisted of 2,624 midgefly larvae and sludgworms per square meter of stream bed. No other kinds of benthic fauna were found in the bottom sediments. The water appeared grey-black, and bottom sediments were black with a septic odor.

From an over-all biological standpoint, over sixty miles of the North Nashua, Nashua, South Branch, and Squannacook Rivers are grossly polluted. Not one organism sensitive to pollution was found in these reaches, as the present condition of the stream prevents the development and growth of the sensitive forms. Even the pollution-tolerant forms occur in limited numbers. Survival for benthic organisms in the sludges, and on the sand and rocks of this river is an arduous task for the hardy, and nearly an impossibility for those benthic fauna such as certain mayflies, caddisflies and beetles which cannot resist such excessive pollution.

Fish depend on bottom organisms for their food. If the fish have not been killed or limited in their development directly by the pollution, the lack of organisms that serve as fish food will limit the fish indirectly. Sport fish depend on the type of organisms that grow only in relatively clean waters.

In addition to the effect on the bottom fauna, the pollution affects waterfowl in the Lancaster-Bolton area. There is much duck hunting in the area but the birds are hunted mainly for sport. Few ducks are eaten because of their bad taste, brought about by ingesting pollutional materials. During the higher spring flows, the river overflows into the adjacent lowlands and deposits paper fibers. These fibers tend to retard or smother the vegetation. Waterfowl development in the area is, therefore, retarded because of the adverse environmental conditions.

NUTRIENTS

With proper environmental conditions, a nuisance can be created in a stream by large growths of algae or other aquatic vegetation. Aquatic plants can become so thick as to be esthetically displeasing and to render the stream unfit for many uses. At times the algal growths are killed and decay within or along the banks of the river, causing very unpleasant odors. Dense growths of algae may not only have a direct effect on water uses of a river, but may also reduce the dissolved oxygen to levels that are below the minimum required by aquatic life.

Oxygen is generated by the algae when there is sunlight, but in the absence of sunlight, algal respiration depresses the oxygen levels to low values. This may occur not only at night but also on cloudy days.

Algae and other aquatic plants tend to develop in slow moving streams when the concentrations of key nutrients that are required for growth are present in sufficient amounts. Among the nutrients, nitrogen and phosphorus have dominant roles.

A study of nutrient levels was carried out in the Nashua River Basin during the period September 7-9, 1965. The results are shown in Figures 8 and 9. Nitrogen and orthophosphate concentrations of the North Nashua River increased substantially from wastes discharged in Fitchburg and Leominster. Orthophosphate levels reached 8.1 mg/l as PO_4 below Leominster, while total nitrogen increased to 5.2 mg/l as N. As was to be expected in a stream of this type since these nutrient levels were far in excess of minimum concentrations needed to trigger blooms, dense growths of algae and other aquatic vegetation occurred. The algae began to grow in abundance in the Nashua River shortly downstream of the confluence of the North Nashua and South Branch Nashua

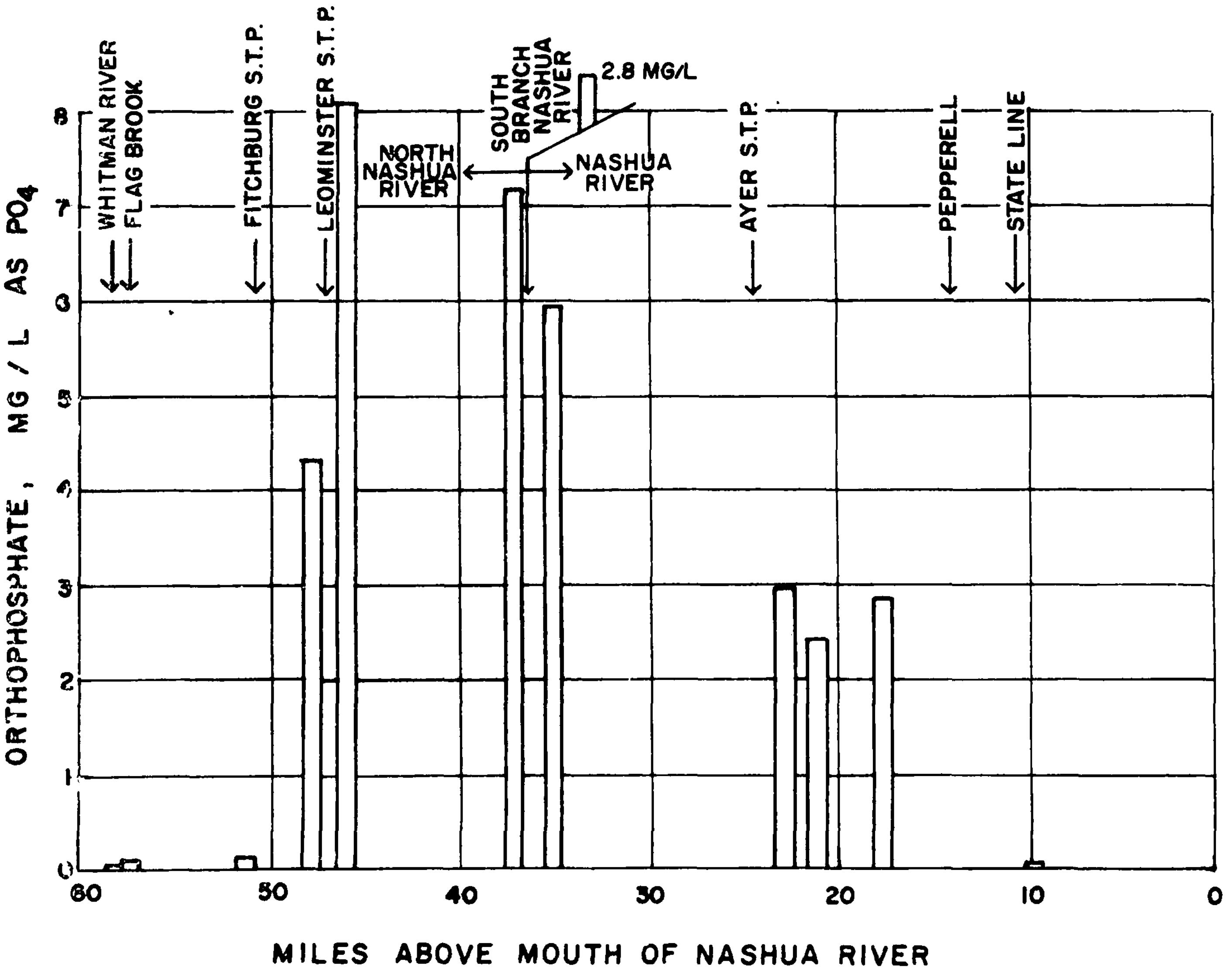
Rivers and persisted all the way to the Nashua River mouth in Nashua, New Hampshire. In Pepperell Pond and in the section of the Nashua River near the state line, considerable Lemna minor were found. These free floating plants, commonly known as duckweed, form green blankets over the water. As the nutrients are utilized by the algae and other aquatic plants, the concentrations of the nutrients tend to be reduced.

The effect of algal growths on dissolved oxygen levels was vividly demonstrated on the dark, rainy afternoon of August 30, 1964. Samples were taken at a number of locations from the Squannacook River to the mouth of the Nashua. Algal growths were observed throughout this reach and at the majority of locations, the river was completely devoid of oxygen.

To prevent excessive growths in the Nashua River, it is necessary to sufficiently reduce at least one nutrient, such as phosphate, necessary in the life cycle of the algae. Phosphates can be removed by special treatment methods, from wastes discharged to the river.

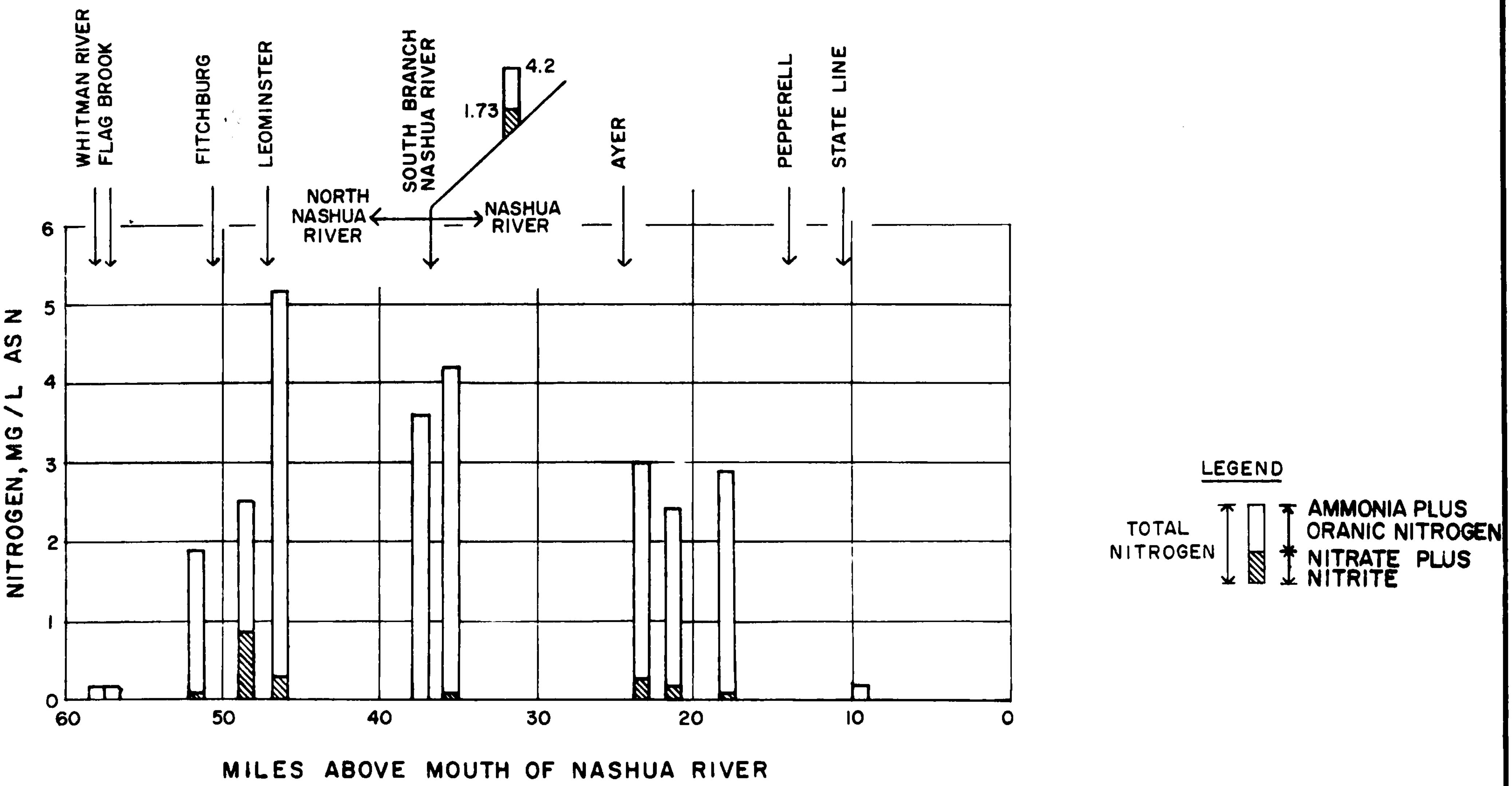
APPARENT COLOR

Inorganic materials used to impart a whiteness to paper products cause turbidity in the receiving stream. This results in a milky appearance of the river for many miles. In addition, some paper mills discharge batches of wastes containing pigments or dyes which cause unnatural stream colors. These materials completely destroy the beauty of the stream from Fitchburg well into New Hampshire.



ORTHOPHOSPHATE
NORTH NASHUA & NASHUA RIVERS
SEPTEMBER 7-9, 1965

FIGURE 8



NITROGEN
NORTH NASHUA & NASHUA RIVERS
SEPTEMBER 7-9, 1965

FIGURE 9

BOTTOM SEDIMENTS IN PEPPERELL POND

From Lancaster, Massachusetts, to the Massachusetts-New Hampshire state line, the Nashua River flows through two impoundments. One impoundment is formed behind the dam located near Ayer, Massachusetts. The other impoundment is formed behind the dam located in Pepperell, Massachusetts. This latter impoundment is generally known as Pepperell Pond (Figure 10). The dam is located at river mile 13.9, and the impoundment extends upriver nearly to the mouth of the Squannacook River at river mile 22.9.

VOLUME OF SEDIMENT

In July 1965, a Peterson dredge was used to collect shallow benthal sediments in Pepperell Pond from the Squannacook River to Pepperell Dam. When the sediment depths exceeded two or three inches a core sampler was used. The core sampler could measure depth up to four feet.

Pepperell Pond was divided into seven sections, as shown in Figure 10. Four sections were selected in the main channel on the basis of similar benthal sediments. The other three areas, including the Ox Bow, were selected because they would have a small effect on the dissolved oxygen (D.O.) in the pond. The Ox Bow area studied included only the water area around Boutwell Island since the remaining part of the Ox Bow is very shallow and stagnant, and has little effect on the water passing through Pepperell Pond during lower flows.

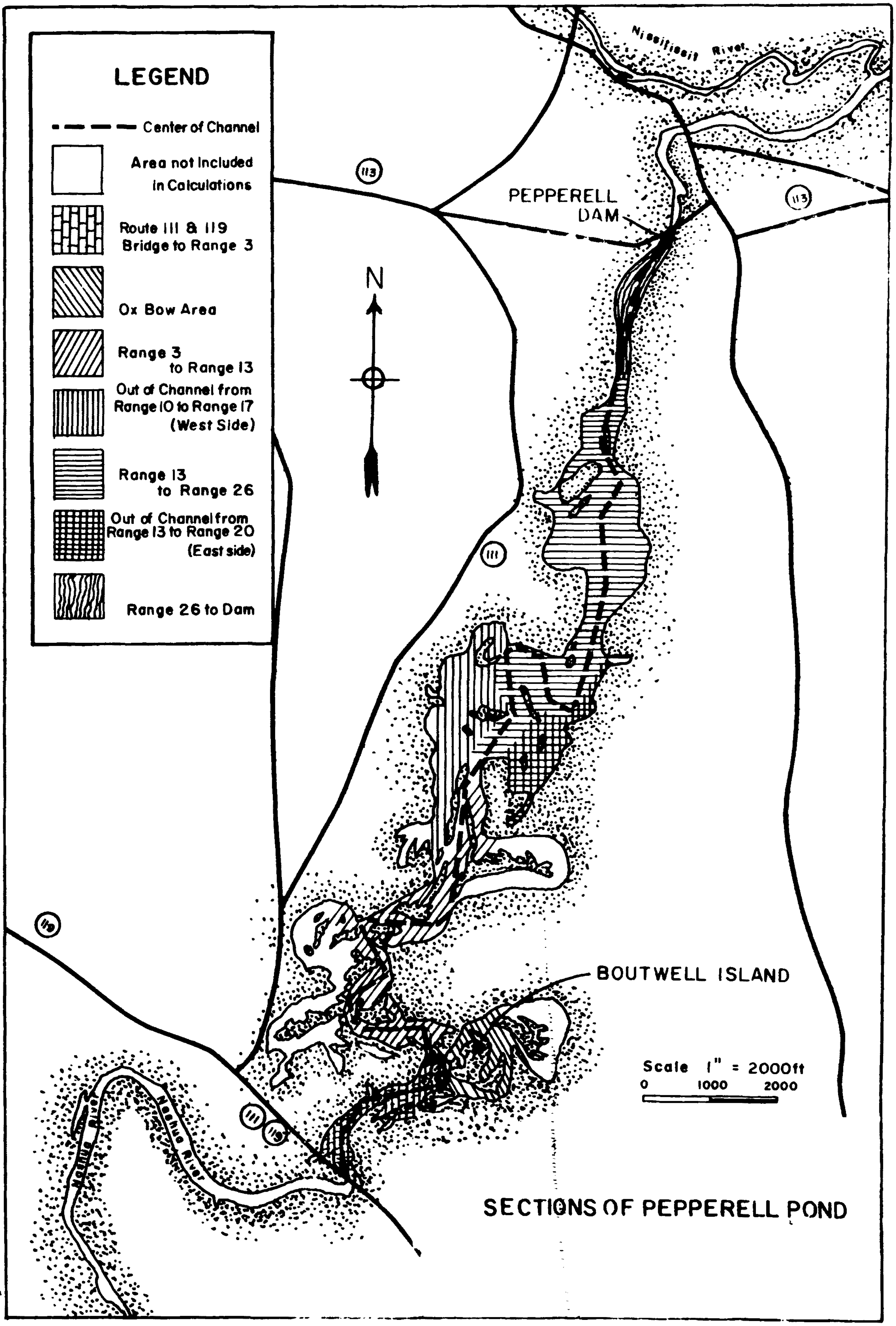
A total of thirty cross sections were taken from the Route 111 and 119 bridge to Pepperell Dam. At most of these ranges, the depth of benthal sediments, as well as the hydraulic depth, was determined.

Additional work upstream of Route 111 and 119 showed that there was very little organic material deposited between this location and the Squannacook River, except along the banks where depths of one-fourth inch were generally found. As the river made its way downstream and the pond widened, the depth of benthal sediments increased, reaching a maximum of three feet in the channel midway to the dam. The total volume of sediment in Pepperell Pond was estimated to be 17 million cubic feet. Table 3 breaks down this volume by sections.

OXYGEN UTILIZATION BY SEDIMENTS

Sediment samples were collected at various points throughout the pond. Specific gravity, per cent moisture, per cent volatile solids and the Warburg oxygen demand were determined for each sample and averaged for each section. The values appear in Table 4.

The benthal sediments from Pepperell Pond had an oxygen demand in a laboratory Warburg apparatus of 4 to 7 milligrams O_2 per gram initial volatile solids per day. These values were of the same magnitude as obtained on aged sediment deposits in the Merrimack River. Other work with Merrimack River sediments indicated that sediments that had been in place for a period of time had an oxygen demand of approximately 1.0 gram per square meter per day. This value appears to be reasonable for determining the affect of benthal sediments in Pepperell Pond on overlying waters.



LEGEND
Center of Channel
Area not Included in Calculations
Route 111 & 119 Bridge to Range 3
Ox Bow Area
Range 3 to Range 13
Out of Channel from Range 10 to Range 17 (West Side)
Range 13 to Range 26
Out of Channel from Range 13 to Range 20 (East side)
Range 26 to Dam
N
Nissitissit River
113
PEPPERELL DAM
111
119
BOUTWELL ISLAND
Scale 1" = 2000ft
0 1000 2000
Nashua River
SECTIONS OF PEPPERELL POND

FIGURE 10

TABLE 3

SEDIMENT DEPOSITS IN PEPPERELL POND

SECTION AND RIVER MILE	SURFACE AREA $FT^2 \times 10^3$	AVERAGE HYDRAULIC DEPTH, FT.	AVERAGE SEDIMENT DEPTH, FT.	AVERAGE SEDIMENT VOLUME $FT^3 \times 10^6$
Rt. 111 & 119 (RM 17.7) to Range 3 (RM 17.3)	453	7.5	0.25	0.11
Ox Bow area (near RM 17.3)	391	7.5	3.5	1.4
Range 3 (RM 17.3) to Range 13 (RM 15.8)	1,825	10.0	0.33	0.60
West of Channel from Range 10 (RM 16.3) to Range 17 (RM 15.5)	1,480	6.0	2.0	3.0
East of Channel from Range 13 (RM 15.8) to Range 20 (RM 15.2)	830	3.0	0.17	0.14
In Channel from Range 13 (RM 15.8) to Range 26 (RM 14.3)	3,800	7.5	3.0	11.
Range 26 (RM 14.3) to Dam (RM 13.9)	542	12.5	1.0	.54

TABLE 4

OXYGEN DEMAND BY PEPPERELL POND SEDIMENTS

SECTION AND RIVER MILE	AVERAGE SPECIFIC GRAVITY	AVERAGE % MOISTURE	AVERAGE % VOLATILE SOLIDS	TOTAL O_2 DEMAND, mg/gm I.V.S.	TOTAL O_2 DEMAND IN REACH, gm x 10^6	TIME TO OXIDIZE SEDIMENTS, YEARS*	OXYGEN DEMAND ON OVERLYING WATERS, ppm/day*	CHEMICAL OXYGEN DEMAND OF SEDIMENTS, gm x 10^6
Rt. 111 & 119 (RM 17.7) to Range 3 (RM 17.3)	1.44	49.0	5.2	90	11	0.7	0.5	210
Ox Bow area (near RM 17.3)	1.17	76.0	23.3	50	127	9.6	0.5	3,300
Range 3 (RM 17.3) to Range 13 (RM 15.8)	1.12	78.0	22.2	95	88	1.4	0.4	900
West of Channel from Range 10 (RM 16.3) to Range 17 (RM 15.5)	1.14	79.0	22.0	55	243	4.8	0.6	4,700
East of Channel from Range 13 (RM 15.8) to Range 20 (RM 15.2)	1.16	72.0	13.9	60	10.6	0.4	1.1	240
In Channel from Range 13 (RM 15.8) to Range 26 (RM 14.3)	1.19	72.0	18.5	55	1090	8.5	0.5	20,000
Range 26 (RM 14.3) to Dam (RM 13.9)	1.17	73.4	12.1	60	34.7	1.9	0.3	1,800

*Based on rate of 1 gram O_2 per square meter per day.

The cumulative Warburg oxygen demand was plotted against time for each day over a ten day period. Based on the shape of the curve, it could then be extended to approximate the ultimate oxygen demand. This total oxygen demand is shown in Table 4 for each section, along with an estimate of the time it would take to oxidize substantially all these sediments. This time period ranges from 0.4 to 9.6 years.

In arriving at these estimates, further assumptions were made that no more organic material would be deposited and that floods would not scour the deposits from the bottom. Although the effect of present sediment deposits would still be measurable for almost ten years after a pollution abatement program, it is anticipated that a substantial improvement will be apparent after two or three years.

In addition to the biochemical oxygen demand as found by the Warburg test, the chemical oxygen demand of the sediments was determined. The latter values include both biologically decomposible organic material and biologically inert organic material. The chemical oxygen demand was approximately twenty times greater than the Warburg values, indicating that a substantial portion of the organic sediments are not biologically degradeable and, therefore, will probably not exert an oxygen demand.

Using a rate of 1.0 $gm/m^2/day$, the oxygen utilized from overlying waters varies from 0.3 to 1.1 parts per million per day, with an overall value of approximately 0.5 ppm/day (Table 4). If there were no fresh deposits after the installation of upstream waste treatment facilities, the oxygen utilized would tend to decrease slowly with time because of the decomposition of the organic materials in the sediments. Therefore, if Nashua River water entered Pepperell Pond with a satisfactory dissolved oxygen level, the sediments would probably not reduce the oxygen below the desirable minimum.

NUTRIENTS CONTAINED IN SEDIMENTS

The samples of bottom sediments obtained from Pepperell Pond were analyzed for nitrogen and phosphate. The results are tabulated in Table 5. Values are averages for each section. Dry weight nitrogen ranged from 0.19 to 0.95 per cent, while phosphate ranged from 0.22 to 0.45 per cent on a dry weight basis. The nitrogen-phosphate ratio was 0.9 to 3.8.

While the nitrogen values are of the same order of magnitude as those commonly found in the sediments of lakes or ponds, the phosphate content of Pepperell Pond sediments appears to be higher than normal for bottom sediments. Some of the nutrients contained in the sediments could diffuse into the overflowing waters and increase the concentrations of these nutrients in the water.

TABLE 5

NUTRIENTS IN BENTHAL DEPOSITS OF PEPPERELL POND

SECTION AND RIVER MILE	NITROGEN, % DRY WEIGHT	PHOSPHATE, % DRY WEIGHT	$\frac{N}{P}$
Rt. 111 & 119 (RM 17.7) to Range 3 (RM 17.3)	.19	.22	0.9
Ox Bow area (near RM 17.3)	.70	.39	1.8
Range 3 (RM 17.3) to Range 13 (RM 15.8)	.79	.45	1.8
West of Channel from Range 10 (RM 16.3) to Range 17 (RM 15.5)	.95	.25	3.8
East of Channel from Range 13 (RM 15.8) to Range 20 (RM 15.2)	.46	.27	1.7
In Channel from Range 13 (RM 15.8) to Range 26 (RM 14.3)	.55	.27	2.0
Range 26 (RM 14.3) to Dam (RM 13.9)	.36	.28	1.3

FUTURE WATER QUALITY

Citizens living downstream from the sources of pollution requested improvement of the water quality in the Nashua River Basin. At a public meeting held September 17, 1964, at Lancaster, Massachusetts, the Nashua River Study Committee pointed out that the people of the area wish to use the Nashua River for recreational purposes. A communication, shown in the Appendix, expresses the conclusions of the group and the officials of the Town of Lancaster, Massachusetts, concerning the water quality objectives for the Nashua River.

A typical reaction was expressed in a letter from a Leominster Councillor to his United States Senator and Representative. The contents of this letter, also shown in the Appendix, describe the obnoxious conditions in the North Nashua River, which are a menace to the families of North Leominster that live along the banks of this river. It was the request of the Councillor that the river should be cleaned up immediately.

The campaign of the citizens of the Nashua River Valley in New Hampshire and Massachusetts during the summer of 1966 has already been reviewed. These people who live near the river have demanded that a high state of water quality be achieved.

At a meeting held November 12, 1964, in Nashua, New Hampshire, the Technical Subcommittee of the New England Interstate Water Pollution Control Commission discussed the existing water quality of the Nashua River. It was agreed that the North Nashua River was Class E, in nuisance condition, from the Weyerhaeuser Paper Company discharge to the confluence of the north and south branches of the Nashua River. It was further agreed that the Nashua River was in Class E condition from this confluence to Hollis Depot, New Hampshire, and in Class D condition from Hollis Depot to the mouth of the Nashua River. A chart showing the classification system is presented in the Appendix.

On April 27, 1965, the Commonwealth of Massachusetts, the New Hampshire Water Pollution Commission, and the New England Interstate Water Pollution Control Commission agreed on a classification of the Nashua River for future highest use. Flag Brook and Whitman River were classified "B". The North Nashua River from the junction of Flag Brook and Whitman River to the confluence of the north and south branches was set at Class D for future highest use. The Nashua River was classified "D" from the confluence of the north and south branches to the Harvard-Bolton town line, 3.8 miles below the confluence. This river was then classified "C" with the dissolved oxygen modified to four parts per million from the Harvard-Bolton line to Unkety Brook, 0.9 miles upstream of the Massachusetts-New Hampshire state line. The Nashua River was classified "C", without modification, from Unkety Brook to its mouth.

With Class D waters only a minimum amount of dissolved oxygen would be required to avoid septic conditions. According to the New England Interstate Water Pollution Control Commission classification system, the Class D section of the river would not be suitable for recreational use but would be suitable for transportation of sewage and industrial wastes without nuisance. In addition, the Class C section would restrict several uses. Therefore, if the stream is not better than the classification set by the state and interstate agencies, the Nashua River system would be unsuitable for the uses desired by the people of the towns along the river.

Some persons believe that, since the Nashua River flows through the Fort Devens Military Reservation, there is little need to improve the water quality in this reach. However, the Department of the Army has indicated that use could be made of the Nashua River at Fort Devens if the water quality were suitable. Because of the pollution, the Army cannot make use of the river at the present time.

In considering the water quality of a stream, attention should be given not only to present population, industrial discharges, and water uses but also to future population, expansion of industrial capacity, the possible introduction of new industries into the area, and potential water uses expected to develop. Water quality should be sufficiently high and waste loadings must be sufficiently low enough that economic growth is not hindered and the maximum beneficial use is made of the stream.

It is not acceptable to assign a portion of the Nashua River system to a status where it is only "suitable for transportation of sewage and industrial wastes without nuisance." This is especially so since means are presently available to correct the pollution problem. Waste discharges should, therefore, be controlled to allow economic growth of the area and recreational use of the river. To achieve these objectives, the principal controls should be placed on discharges of suspended solids, materials causing biochemical oxygen demand, bacteria, phosphates, and true and apparent color. In addition, water quality requirements which more truly reflect the future uses of the stream should be applied.

Water uses which should be protected in the Nashua River from Lancaster, Massachusetts, to the mouth in Nashua, New Hampshire, and the South Branch Nashua River from Wachusett Reservoir to its mouth in Lancaster, Massachusetts, include:

Industrial Water - Processing and Cooling

Recreation - Whole Body Contact

Recreation - Limited Body Contact

Military Training Exercises

Fish and Wildlife

Irrigation

Esthetics

Water uses which should be protected in the North Nashua River from the confluence of Flag Brook and the Whitman River to the mouth at Lancaster, Massachusetts, and the Squannacook River from the paper mill dam at Vose Village to the mouth include:

Industrial Water - Processing and Cooling

Recreation - Limited Body Contact

Fish and Wildlife

Irrigation

Esthetics

If the recommendations of this report (Part I — Summary, Conclusions and Recommendations) are followed, water quality of sufficient purity to accommodate the various water uses will be attained.

SUMMARY AND CONCLUSIONS

In accordance with the written request to the Secretary of Health, Education, and Welfare from the former Governor Endicott Peabody of Massachusetts, dated February 12, 1963, and on the basis of reports, surveys, or studies, the Secretary of Health, Education, and Welfare, on September 23, 1963, called a Conference under the provisions of the Federal Water Pollution Control Act (33 U.S.C. 466 et seq.), in the matter of pollution of the interstate waters of the Merrimack and Nashua Rivers and their tributaries (Massachusetts-New Hampshire) and the intrastate portions of those waters within the State of Massachusetts. The conference was held February 11, 1964, in Faneuil Hall, Boston, Massachusetts.

Serious pollution exists in the North Nashua River from the outfall of the Weyerhaeuser Paper Company, Fitchburg, Massachusetts, to the confluence of the north and south branches of the Nashua River at Lancaster, Massachusetts; in the Nashua River from Lancaster to the mouth of the Nashua River in New Hampshire; in the Squannacook River below the dam at Vose Village; and in the South Branch Nashua River below Clinton, Massachusetts. This pollution affects present and potential water uses.

Discharges from paper mills result in suspended solids, organic matter causing biochemical oxygen demand, and materials causing apparent color in the stream. By far the largest loadings emanate from the three paper industries of Fitchburg, Massachusetts. Inadequate sewage treatment, particularly at Fitchburg and Leominster, Massachusetts, contributes to the problem by causing excessive bacterial densities, suspended solids, nutrients, and organic matter causing biochemical oxygen demand. Plastics and metal fabrication industries also add suspended solids and materials that cause biochemical oxygen demand.

Bacteria equivalent to those in the raw sewage of approximately 24,000 persons are discharged to the streams at present. Fitchburg and Leominster, Massachusetts, contribute 90 per cent of the total. The coliform bacteria in the North Nashua River were as high as 680 times the recommended maximum value of 5,000 per 100 ml for this stream. Pathogenic bacteria were isolated in both the North Nashua and South Branch Nashua Rivers.

Discharges of suspended solids create a severe problem in the Nashua River. These materials cause deep sludge deposits which deplete the stream oxygen supply, produce offensive odors and reduce or eliminate aquatic life which serves as food for fishes. The suspended matter also makes these once attractive waters appear turbid. Suspended solids discharged to the Nashua River Basin are equivalent to those in the raw sewage of 556,000 persons. Of these, nearly 92 per cent come from the paper mills. It was estimated that 17 million cubic feet of sediments have accumulated in Pepperell Pond alone.

Sewage and industrial wastes presently discharged have an estimated biochemical oxygen demand population equivalent of 178,000, of which the paper industries contribute 76 per cent of the total. As a result of the reduction in dissolved oxygen, fish, fish food organisms and other desirable forms of aquatic life are destroyed. In addition, when dissolved oxygen is reduced to zero, obnoxious odors are given off by the stream.

Nutrients discharged to the Nashua River Basin result in excessive densities of algae and other aquatic plants, creating a nuisance. These plants may die and decompose, causing unsightly conditions, obnoxious odors and depletion of dissolved oxygen. In addition, in the absence of sunlight, the algal respiration depresses the dissolved oxygen to low levels—at times to zero. Estimates based on sewered population and stream analyses indicate that 128,000 population equivalents of ortho-phosphates are discharged to the Nashua River. Phosphates are key nutrients which are readily available for the growth of algae and other aquatic plants.

As a result of the severely polluted condition of the Nashua River, the people who live in the towns bordering the river in New Hampshire and Massachusetts petitioned the governors of the two states to take immediate abatement action. The people demanded that the river be restored to a high state of water quality.

The Nashua River system has been classified for future highest use by the state and interstate agencies. The classification of the North Nashua River and part of the Nashua River was set at Class D. This will only permit the river to be used for transportation of sewage and industrial wastes without nuisance. Other portions of the river were set at Class C. However, these classifications are not adequate as they do not permit the development of recreational uses of the river that are desired by citizens of the area, nor do they permit the quality needed by most industrial uses.

In addition to many other uses, the Nashua River can be used at the Fort Devens Military Reservation for training exercises involving rivers and for recreation when pollution is controlled. The sections of the river forming the post boundary could be used for public recreation, while the sections entirely within the reservation could be used for recreation either by post personnel or by the public by permit.

Water quality requirements have been developed for various sections of the Nashua River Basin. When these requirements are met, additional use could be made of the waters of the area. Water uses that would be permitted in the Nashua River from Lancaster, Massachusetts, to the mouth in Nashua, New Hampshire, and the South Branch Nashua River from Wachusett Reservoir to its mouth in Lancaster, Massachusetts, include:

Industrial Water - Processing and Cooling

Recreation - Whole Body Contact

Recreation - Limited Body Contact

Military Training Exercises

Fish and Wildlife

Irrigation

Esthetics

Water uses that would be permitted in the North Nashua River from the confluence of Flag Brook and the Whitman River to the mouth at Lancaster, Massachusetts, and the Squannacook River from the paper mill dam at Vose Village to the mouth include:

Industrial Water - Processing and Cooling

Recreation - Limited Body Contact

Fish and Wildlife

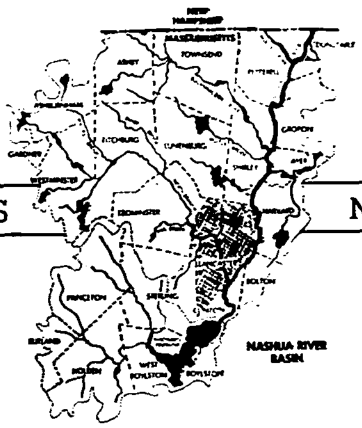
Irrigation

Esthetics

If the recommendations of this report (Part I -- Summary, Conclusions and Recommendations) are followed, water quality of sufficient purity to accommodate the various water uses will be attained.

APPENDICES

TOWN OF LANCASTER, MASSACHUSETTS



NASHUA RIVER STUDY COMMITTEE

1 Buttonwood Lane
Lancaster, Mass.
April 1, 1965

Mr. Herbert R. Pahren, Director
Merrimack River Project, DWSPC
U. S. Public Health Service
37 Shattuck Street
Lawrence, Massachusetts 01843

Dear Mr. Pahren:

We have received a letter from Mrs. Mildred E. Smith, Sanitary Engineer of the Water Supply and Pollution Control Branch of the Department of Health, Education and Welfare, in which she has stated that the department is interested in the statement of the desired objectives for water quality of the Nashua River.

After meeting with the Board of Selectmen of Lancaster, and in consequence of earlier meetings with other officials of the Department of Public Health, our committee has concluded that our ultimate objective would be Classification B for the Nashua River. Our efforts along with proposed combined efforts of other towns in the Nashua River Basin will be toward that objective. It may interest you to know at this time that our committee is presently attempting to organize on a regional basis, similar committees in all towns in the Nashua River Basin with a view toward disseminating information regarding pollution control and steps to be taken on the local level which will be helpful in improving the condition of this River.

We would appreciate being advised of any new developments along pollution control lines so that we may alert interested parties through our proposed newspaper releases.

Thanking you for any assistance you can provide us in this regard, I remain,

Very truly yours,

John E. Burgoyne

John E. Burgoyne
Chairman

JEB:cp

<u>C O P Y</u>

93 Tolman Ave.
Leominster, Massachusetts 01453
February 7, 1966

Senator Edward M. Kennedy
Washington, D. C.

Congressman Philip J. Philbin
2372 Rayburn House Office Building
Washington, D. C. 20515

Dear Senator and Represenative,

A very serious and vexing problem has plagued this Monachusett region for years and this is the Nashua River. When you mention Nashua River to anybody in this area their immediate reaction is to turn their head the other way and rightfully so, because the obnoxious and vile smell that emanates from this river would turn anybody's head.

A wide selection of colors is available in this highly polluted stream as it meander's its way through Leominster and the surrounding towns and the coloring in this water will change almost as fast as the weather here in New England. A very serious menace to one's health exists all along this highly contaminated river, and especially in those areas where families live almost on the banks of this river, such as the Crawford, Hamilton, and River St. complex in North Leominster.

A very large, new, shopping center, "Sear's Town," is about to emerge on the banks of this once beautiful river and I know that the business men who will occupy this area will be vitally interested in seeing that something is being done about cleaning up and purifying this river. In the past ten years or so, all kinds of plans were presented to cleanse this river and to eliminate this unhealthy situation, but as yet the results if any have been impossible to see.

In the past few weeks on radio, television, and the other news media the word has been "CLEAN UP OUR POLLUTED RIVERS AND STREAMS."

I know of no better river to start with than the Nashua and it is my desire and the people of Leominster's that the time to start is now.

After three years of drought here in the northeastern part of our country, it seems a shame that so much water is wasted because of contamination. I urgently request that you give this matter your most serious attention.

I sincerely hope you will contact me on any progress and feel free to call on me if I can be of any assistance, such as a tour or anything else that would help in the solution of this perplexing problem.

Sincerely yours,

John B. McLaughlin
Councillor, Ward 1

MASSACHUSETTS WATER USE CLASSIFICATION AND QUALITY STANDARDS

	CLASS A	CLASS B	CLASS C	CLASS D
	Suitable for any water use. Character uniformly excellent.	Suitable for bathing and recreation, irrigation and agricultural uses; good fish habitat; good aesthetic value. Acceptable for public water supply with filtration and disinfection.	Suitable for recreational boating, irrigation of crops not used for consumption without cooking; habitat for wildlife and common food and game fishes indigenous to the region; industrial cooling and most industrial process uses.	Suitable for transportation of sewage and industrial wastes without nuisance, and for power, navigation and certain industrial uses.
Standards of Quality				
Dissolved oxygen	Not less than 75% sat.	Not less than 75% sat.	Not less than 5 ppm	Present at all times
Oil and grease	None	No appreciable amount	Not objectionable	Not objectionable
Odor, scum, floating solids, or debris	None	None	None	Not objectionable
Sludge deposits	None	None	None	Not objectionable
Color and turbidity	None	Not objectionable	Not objectionable	Not objectionable
Phenols or other taste producing substances	None	None	None	
Substances potentially toxic	None	None	Not in toxic concentrations or combinations	Not in toxic concentrations or combinations
Free acids or alkalies	None	None	None	Not in objectionable amounts
Radioactivity	Within limits approved by the appropriate State agency with consideration of possible adverse effects in downstream waters from discharge of radioactive wastes; limits in a particular watershed to be resolved when necessary after consultation between States involved.			
Coliform bacteria	* Within limits approved by State Department of Health for uses involved.	Bacterial content of bathing waters shall meet limits approved by State Department of Health and acceptability will depend on sanitary survey.		

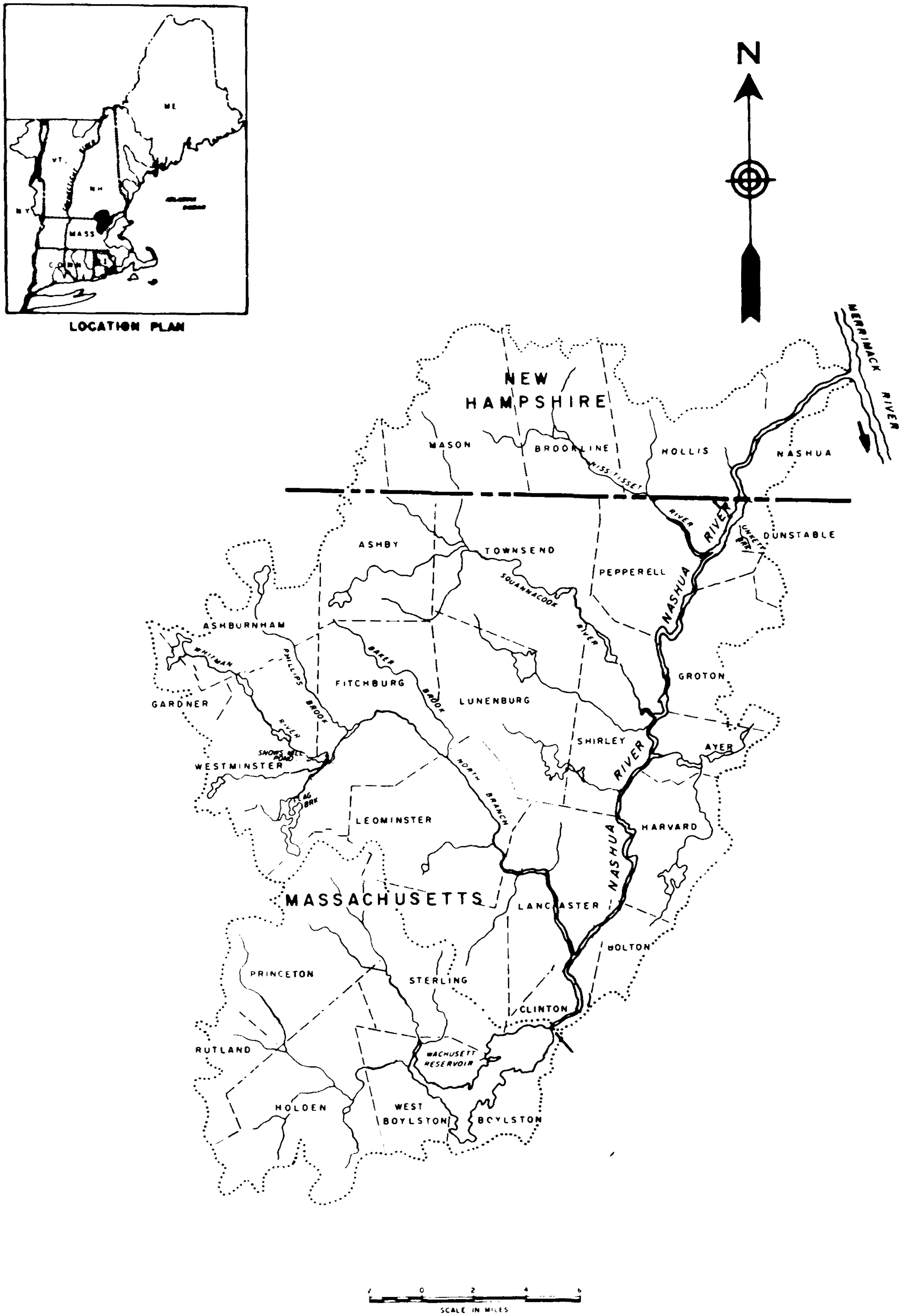
* Sea waters used for the taking of market shellfish shall not have a median coliform content in excess of 70 per 100 ml.

NOTE: Waters falling below these descriptions are considered as unsatisfactory and as Class E.
These standards do not apply to conditions brought about by natural causes.
For purpose of distinction as to use, waters used or proposed for public water supply shall be so designated.

NEW HAMPSHIRE WATER USE CLASSIFICATION
AND QUALITY STANDARDS

	CLASS A	CLASS B		CLASS C	CLASS D
		B-1	B-2		
	Potentially acceptable for public water supply after disinfection. (Quality uniformly excellent.)	Acceptable for bathing and recreation, fish habitat and public water supply after adequate treatment. (High esthetic value.)	Acceptable for recreational boating, fish habitat, industrial and public water supplies after adequate treatment. (High esthetic value.)	Acceptable for recreational boating, fish habitat, and industrial water supply. (Third highest quality.)	Devoted to transportation of sewage or industrial waste without nuisance. (Lowest classification.)
Dissolved oxygen	Not less than 75% sat.	Not less than 75% sat.	Not less than 75% sat.	Not less than 5 p.p.m.	Present at all times
Coliform bacteria MPN/100 ml.	Not more than 50	Not more than 240	Not more than 1,000	Not specified	Not specified
pH	5.0 - 8.5	5.0 - 8.5	5.0 - 8.5	5.0 - 8.5	Not specified
Substances potentially toxic	None	Not in toxic concentrations or combinations.	Not in toxic concentrations or combinations.	Not in toxic concentrations or combinations.	Not in toxic concentrations or combinations.
Sludge deposits	None	Not in objectionable amounts.	Not in objectionable amounts.	Not in objectionable amounts.	Not in objectionable amounts.
Oil and grease	None	None	Not in objectionable amounts.	Not in objectionable amounts.	Not of unreasonable quantity or duration.
Color and turbidity	Not in objectionable amounts.	Not in objectionable amounts	Not in objectionable amounts.	Not in objectionable amounts.	Not of unreasonable quantity or duration.
Slick, odors and surface-floating solids	None	None	Not in objectionable amounts.	Not in objectionable amounts.	Not of unreasonable quantity or duration.

NOTE: The waters in each classification shall satisfy all provisions of all lower classifications.



NASHUA RIVER BASIN

FIGURE 1