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Walter R. Whitworth
University of Connecticut

David H. Bennett
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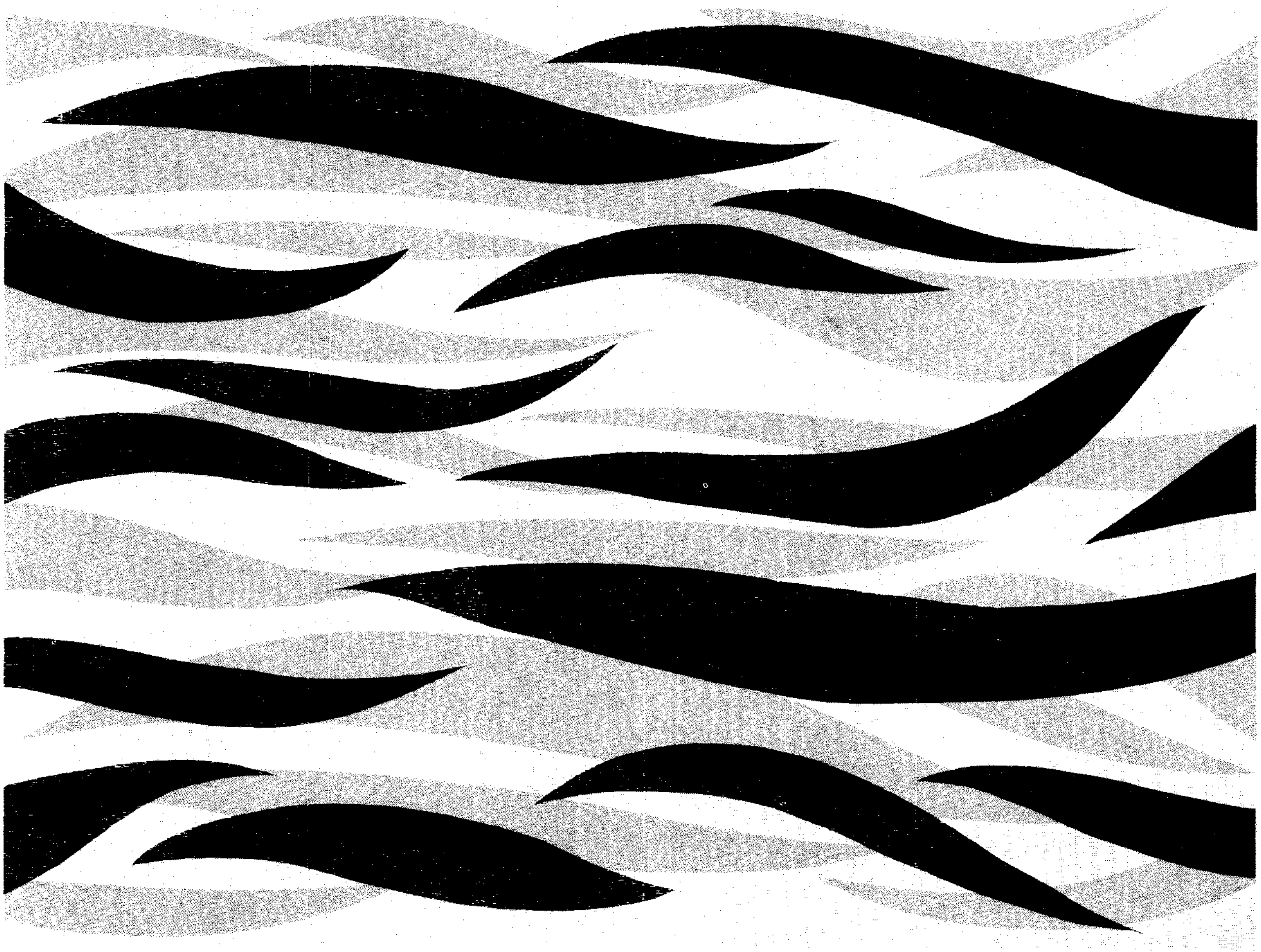

INSTITUTE OF WATER RESOURCES
The University of Connecticut

Report No. 9

February 1970

A LIMNOLOGICAL STUDY OF THE LOWER FARMINGTON RIVER WITH SPECIAL REFERENCE TO THE ABILITY OF THE RIVER TO SUPPORT AMERICAN SHAD[1]

WALTER R. WHITWORTH, *Associate Professor, Fisheries*
and
DAVID H. BENNETT, *Graduate Research Assistant, Fisheries*

The University of Connecticut
Storrs, Connecticut

1. Contribution No. 402, Storrs Agricultural Experiment Station, College of Agriculture and Natural Resources, University of Connecticut, Storrs.

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INTRODUCTION

The major objectives of this study were to determine (1) if adult American shad, *Alosa sapidissima* (Wilson), transferred from the Connecticut River, spawned successfully in a section of the lower Farmington River, and (2) if eggs of American shad (obtained from adults seined in the Connecticut River) would hatch and grow in a section of the lower Farmington River. Secondary objectives were to estimate (1) the effects of selected municipal and industrial effluents and the Pequabuck River on temperature, total alkalinity, specific conductance, pH, rate of plate colonization, community metabolism, and populations of bottom fauna, plankton, and fish in this section of the lower Farmington River, and (2) the productivity of this section of the Farmington River by frequent measurements of the bottom fauna, plankton, fish, and community metabolism.

Similar studies concerning the reintroduction of American shad have been conducted in other rivers of the East Coast, i.e., the Delaware (Chittenden, unpublished data; Barker, 1965), and the Susquehanna (Carlson *et al.*, 1968). The Board of Fisheries and Game and the Farmington River Watershed Association have shown an active interest in research concerning the Farmington River. The Board of Fisheries and Game has stocked eggs and adult specimens of American shad in various areas of the Farmington River below Collinsville and above Rainbow Dam since 1962. Results obtained indicated eggs did hatch (unpublished data, Board of Fisheries and Game). The Farmington River Watershed Association has helped sponsor or cooperated with other studies in "their" river, the most comprehensive being a water resources planning study of the Farmington Valley (Bock, *et al.*, 1965).

ACKNOWLEDGMENTS

This study was supported, in part, by monies provided by the Connecticut Research Commission (Grant No. RSA 66-5). The Board of Fisheries and Game, especially Messrs. Robert Jones, Richard Hames, Matthew Banach, John Orintas, Edward Leavy, and Chester Dynick, assisted the study and furnished some much needed supplies, equipment, and personnel. The Farmington River Watershed Association (Mr. Harold Peters, Executive Secretary) provided some financial and much moral support. Messrs. John Horton and Fred Ruggles, U. S. Geological Survey, generously allowed use of their discharge data and a current meter; Mr. Robert Taylor, Water Resources Commission, provided helpful information concerning water quality in the Farmington River; Mr. Joseph Brumbach, ESSA State Climatologist, provided access to state precipitation data; the Connecticut Sand and Gravel Co. graciously authorized travel over its property and excavated an access area to the gravel pit; many other private and industrial landowners permitted travel over their lands and allowed sampling stations to be established on their property; personnel at the effluent sources allowed us to collect effluent samples on their properties, viz., Mr. King Brooks, Jr. (Charles W. House and Sons, Inc.), Mr. Joseph Martinelli, Sr. (Pioneer Steel Ball Co., Inc.), Mr. Arnold Storrs (Ensign-Bickford Co.), Mr. Reynold L. Hoover (Combustion Engineering), Mr. Arthur Hayes (Tariffville Municipal Sewage Treatment Plant), and Mr. Banker (Farmington Municipal Sewage Treatment Plant); Mr. Arthur Krueger conducted the B.O.D. tests; Messrs. Charles Surprenant, Gary Smith, Richard Biggins, Walter Keller, Peter Berrien, Donald Dorfman, Arthur Krueger, William Lutzen, James Ewen, John Merwin, Richard Carlson, and Richard Voyer assisted with some phases of the field and laboratory work; Mr. Paul Jacobson assisted with much of the field work and obtained the daily estimates of community metabolism; Messrs. Wayne Swingle and John Castleman, and Miss Peggy Marsh wrote computer programs to perform certain analysis; Mr. Mark Chittenden kindly made the progress reports concerning his studies of American shad in the Delaware River available to us.

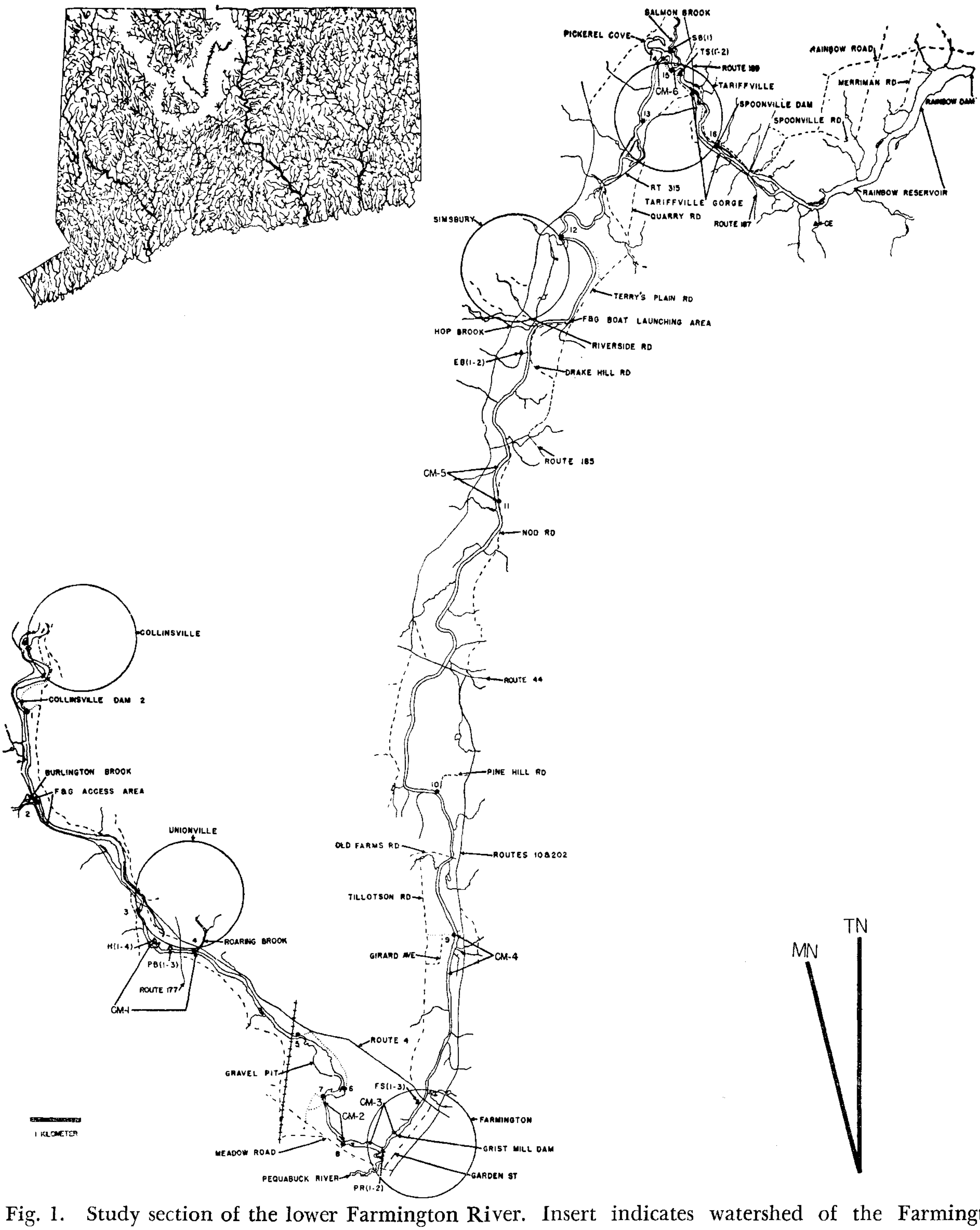

Fig. 1. Study section of the lower Farmington River. Insert indicates watershed of the Farmington River in Connecticut and the study section. Primary stations are numbered and denoted with closed circles; effluent stations are indicated with closed triangles. Abbreviations of the effluents are H (Charles W. House & Sons, Inc.), PB (Pioneer Steel Ball Co., Inc.), PR (Pequabuck River), FS (Farmington Municipal Sewage Treatment Plant), EB (Ensign-Bickford Co.), SB (Salmon Brook), TS (Tariffville Municipal Sewage Treatment Plant), and CE (Combustion Engineering). Community metabolism areas are shown by CM (1-6) and arrows.

MATERIALS AND METHODS

STUDY AREA

The Farmington River has a watershed of approximately 1,559 km^2 (602 $miles^2$) in north-central Connecticut and south-central Massachusetts. Its watershed in Connecticut and the study area from Collinsville to Rainbow (47.8 km = 30.3 miles) are shown in Fig. 1. The region through which the river flowed from Collinsville to Unionville was stony, hilly land of light textured glacial till soils; Unionville to Farmington was valley land of irregular surface and gravelly and sandy soils; and Farmington to Tariffville was bottom land of light textured, imperfectly drained alluvial soils (Morgan, 1939).

The Farmington River from Collinsville to the gravel pit in Farmington was characterized by a steep gradient with alternating pools and riffles that varied in depth from about 0.5 to 2.0 m. Many *Potamogeton* sp. grew on the silt bottom of the pools. *Anacharis* sp. and attached algae (*Ulothrix* sp, and *Cladophora* sp.) grew on the bedrock, large boulder, and rock bottoms of the riffles. Effluent from Charles W. House & Sons, Inc. left a lagoon, flowed through a channel (about 1 m wide) over a sand and small gravel bottom and (1) entered the main river during times of low river flow (<2.0 m^3/sec) or (2) entered a secondary channel of the river that joined the main stream about 300 m downstream during high river discharges (>2.0 m^3/sec). Effluent from Pioneer Steel Ball Co., Inc. also entered in this section about 3.3 km upstream from the gravel pit and about 320 m downstream from the main effluent entrance of Charles W. House & Sons, Inc. This effluent entered the river through three pipes (approximately 1.5 cm diam.) in 1966 and over a gravel ditch from settling beds in 1967.

The gravel pit was about 10 m deep and water was often turbid up to 5.2 km below the active dredging operations. The section below the gravel pit to station 8 was of lower gradient with fewer riffles and shallow pools (0.5 to 1.5 m). Thick beds of *Potamogeton* sp. grew on the silty, sandy bottom. The bottom types of the riffles, rubble and large gravel, supported large populations of attached *Microspora* sp. and either *Binularia* sp. or *Cylindrocapsa* sp. The river downstream to the Pequabuck River had a similar gradient and was shallow (to 1 m deep). The fine gravel and sand bottom supported thick beds of *Potamogeton* sp. The Pequabuck River, which flowed over a mucky organic bottom, contributed a turbid water mass to the Farmington River.

The area from the Pequabuck River to the gristmill dam (about 2 to 3 m deep), had hardpan (clay), mud and detritus bottom types. Below the gristmill dam to station 9 the river became shallow (about 0.5 to 1.5 m) with a low gradient. The gravel bottoms of the few riffles were generally of finer materials. The prevalent bottom type of sand supported many large beds of *Potamogeton* sp. The effluent from the Farmington Municipal Sewage Treatment Plant, about 0.85 km downstream from the gristmill dam, entered midriver from a cement structure (approximately 1.02 m^2) 1.5 m above the river bottom. The effluent was discharged above water level at times of low river discharges (about 2.0 m^3/sec) and below water level at higher discharges. The effluent entrance was closely followed by a few riffles with a gravel bottom. The section below station 9 to approximately 0.2 km upstream from station 13 was generally shallow (approximately 1.5 m) and had a sandy bottom; a few deeper sections (about 2.0 m) had substantial amounts of organic matter on the bottom. The numbers of *Potamogeton* sp. beds were reduced, but thick *Anacharis* sp. growths were found approximately 0.5 km upstream from station 13. The water was 2 to 3 m deep from this section downstream to Tariffville (approximately 0.2 km downstream from station 15); there was little submerged vegetation observed and the bottom types were organic matter, sand, and silt. Salmon Brook entered about 0.2 km upstream from station 15 over a sandy bottom and contributed a clear inflow to the Farmington River.

The river from Tariffville to station 16 differed from the upper section (stations 1 to 5) by having a steeper gradient, fewer but deeper pools (about 2 to 3 m) and much less vegetation. The effluent from Tariffville Municipal Sewage Treatment Plant gravitated through a cement conduit and entered the river underwater in this section. The river became deeper (approximately 2.5 m) for about 0.3 km downstream from station 16, then changed to shallow riffles (approximately 0.2 to 0.5 m) with gravel bottoms and a few scattered beds of *Potamogeton* sp., until it became Rainbow Reservoir.

TABLE 1. DISTANCE*BETWEEN PRIMARY SAMPLING STATIONS ON THE LOWER FARMINGTON RIVER.**

Stations			*Distance between stations (km)*	*Cumulative distance (km)*
2nd Collinsville Dam	to	1	0.3	0.3
1	to	2	1.8	2.1
2	to	3	3.2	5.3
3	to	4	1.4	6.7
4	to	5	2.7	9.4
5	to	6	1.3	10.7
6	to	7	0.1	10.8
7	to	8	1.0	11.8
8	to	9	4.1	15.9
9	to	10	4.2	20.1
10	to	11	6.7	20.8
11	to	12	6.1	32.9
12	to	13	2.5	35.4
13	to	14	1.9	37.3
14	to	15	0.2	37.5
15	to	16	1.9	39.4
16	to	Rainbow Dam	6.8	46.2

* 1 kilometer = .62137 miles
** Estimated from topographic sheets

TABLE 2. SELECTED MORPHOMETRIC CHARACTERISTICS OF THE LOWER FARMINGTON RIVER.

Area	Stations included	Length (M) mean & range	Cross Section (M^2) mean & range	Date measured
2nd Collinsville Dam to HW 177 Bridge Unionville	1-4	29.31 (20.0-36.54)	15.74 (5.71-26.12)	7- 7-66
HW 177 Bridge Unionville to HW 4 Bridge Farmington	5-8	23.29 (13.2-34.2)	17.10 (7.52-32.77)	7- 7-66
HW 4 Bridge Farmington to HW 315 Bridge Simsbury	9-12	37.02 (25.12-44.0)	27.11 (21.10-41.22)	7-7 to 7-8-66
HW 315 Bridge Simsbury to Tariffville	13-15	45.25 (35.54-52.38)	64.94 (55.59-72.80)	7-11-66
Tariffville to Highway 189 Bridge	16	26.19	33.08	7-11-66

SAMPLING AREAS

Sixteen primary stations, representative of all habitats within the study area, were established which were generally accessible during most weather conditions. Distances (approximate water) between the primary stations and characteristics of the river at the primary stations are shown in Tables 1 and 2. Additional stations were (1) upstream, in, and up to 100 m downstream from each of the seven effluent sources, (2) six areas selected for estimates of community metabolism (Fig. 1 and Table 3), and (3) at random areas in the river.

SAMPLING-FISHES

Five and 6 mm mesh knotless nylon seines (0.9 to 9.2 m long x 0.9 to 3.1 m deep) and a 6 mm mesh cotton bag seine (15.2 x 2.0 m deep) were used to sample fish (1) at irregular times and places throughout the study area from July 1966 to October 1967, and (2) at least once a week during August to October 1966 and 1967, in random areas from the gravel pit to Tariffville. Four nighttime electrofishing samples (August to October, 1966) were obtained with the Board of Fisheries and Game's a-c, d-c boat shocker (twice in the gravel pit, once in Rainbow Reservoir, and once from the Simsbury boat launching site to the Highway 315 bridge), and one daytime sample (October) in 1967 (station 12 to 15). Gill nets (12 and 35 mm^2 mesh, 5 to 30 m long x 2 m deep) were set at irregular intervals in random areas from station 8 to Rainbow Reservoir in August through October 1966 and 1967. Powdered rotenone was introduced in three areas of the river in October 1967. Only enough rotenone was added in a small area (approximately 5 m wide by 20 m long) to effect surfacing in fish. The areas sampled were the backwater area at station 7, the pool above the gristmill dam, and a small section of the Tariffville "gorge." Observations of fishes were made every time the river was visited (an average of three to four times a week including Saturdays and Sundays from June 1966 to October 1967 (this included three canoe trips and two boat trips of the entire area and many short voyages).

Random samples of fishes obtained from seine hauls were preserved in 10% formalin in August and October of 1966 and 1967, and their stomach contents analyzed (qualitative). Results were expressed as the percent occurrence of each food item in the total number of specimens of each species examined that had any food in its stomach.

Scale samples were taken from random samples of fish collected by all methods from July 1966 through October 1967, from the area between the lateral line and the anterior base of the dorsal fin on the left side of the fish. Scales were interpreted by placing them between glass slides and magnifying them with a micro-projector. Total scale length (center of focus to center of anterior scale margin) and length from the center of the focus to each annulus (along the same center line) were measured in mm. A computer (IBM 360) then performed the back calculations as follows:

(1) Total fish length (cm) was plotted against total scale (mm) and a regression line fitted, i.e., total fish length $=$ a $+$ b total scale length.

(2) The constants just obtained (a and b) were then used to calculate total fish length at each age, i.e.

$$\text{total fish length at age } 1 = a + b \text{ annulus length at age } 1.$$

Total (most anterior part of the head to the most posterior part of the caudal fin when the caudal rays are squeezed together) and standard (most anterior part of the head to the structural base of the caudal peduncle, which is located by bending the caudal fin laterally) lengths (cm) were measured on random samples of fishes obtained by all methods from July 1966 through October 1967, and the relationship between total length and standard length calculated (IBM 360 computer) by fitting the data to the following equation and obtaining values for a and b.

$$\text{Total length} = a + b \text{ standard length}$$

Random samples of the fishes preserved were weighed to the nearest 0.1 gram on a direct reading balance and total length-weight relationships calculated (IBM 360 computer) by fitting the data to the equation (weight $= aX^b$; a and b are constants and $X =$ total length in cm) and obtaining values for a and b. These constants were then substituted in the same equation and the weight calculated for each 1 cm ($\pm$ 0.5) total length class. The average weight and condition index

$$\text{condition index} = \frac{\text{weight} \times 10^2}{\text{length}^3}$$

for each total length (cm) class was obtained. The constant 10^2 was selected to bring the condition indexes near 1.

Relative abundance of fishes was estimated from all methods and expressed as common, abundant, or rare for general areas of the study section.

TABLE 3. SELECTED CHARACTERISTICS OF THE AREAS IN WHICH COMMUNITY METABOLISM WAS ESTIMATED IN THE LOWER FARMINGTON RIVER.

Area	Predominant Bottom type	Ave. cross-section (m^2)	Ave. width (m)	Ave. depth (m)	Length (m)	Est. vol. (m^3)	Inflows in area	Inflows above area
CM 1	Rock	13.03	36.61	0.36	800	10,424	Charles W. House & Sons, Inc. Pioneer Steel Ball Co., Inc.	N.A.
CM 2	Rock	15.40	32.50	0.37	955	14,707		Charles W. House & Sons, Inc. Pioneer Steel Ball Co., Inc.
CM 3	Mud & detritus	63.31	59.64	1.06	740	46,849	Pequabuck River	Charles W. House & Sons, Inc. Pioneer Steel Ball Co., Inc.
CM 4	Sand	29.03	41.08	0.71	620	17,998		Charles W. House & Sons, Inc. Pioneer Steel Ball Co., Inc. Pequabuck River Farmington Municipal Sewage Treatment Plant
CM 5	Sand	62.07	49.00	1.24	800	49,656		Charles W. House & Sons, Inc. Pioneer Steel Ball Co., Inc. Pequabuck River Farmington Municipal Sewage Treatment Plant Ensign-Bickford Co.
CM 6	Mud & detritus	71.60	46.33	1.55	740	41,886	Salmon Brook	Charles W. House & Sons, Inc. Pioneer Steel Ball Co., Inc. Pequabuck River Farmington Municipal Sewage Treatment Plant Ensign-Bickford Co. Salmon Brook

SAMPLING-PLANKTON

Samples of plankton were usually obtained at each of the primary stations at least once a month from July 1966 to August 1967; other areas were occasionally sampled. Twelve liters of river water were taken at random and poured into a No. 20 mesh plankton net. Concentrates (7-150 ml) were drained into small glass containers, returned to the laboratory, refrigerated overnight, and usually analyzed the next day. Plankton numbers were estimated by counting ten fields of a calibrated Whipple disc of each of two 1 ml samples in a Sedgwick Rafter using a monocular microscope of 160x (APHA *et al.* 1965). The populations were estimated as follows:

$$\#CC = \left\{ \frac{\text{ml of concentrate}}{\text{ml of original sample}} \times \frac{\text{\# fields in counting cell}}{\text{\# of fields counted}} \right\} \times \text{\# organisms counted}$$

No attempt was made to identify zooplankton. Phytoplankton were identified using Smith (1950), Palmer (1962), and Prescott (1962).

SAMPLING-BOTTOM FAUNA

The bottom fauna was usually sampled at least once a month from July 1966 to August 1967 at each of the primary stations; other areas were occasionally sampled. Two samples were usually collected at random areas at stations 1 to 10, 16, and stations associated with the Charles W. House & Sons, Inc. and Pioneer Steel Ball Co., Inc. effluents by a modified Surber sampler (modified by wire mesh replacing the triangular cloth wings and having a replaceable sample bottle). One sample was usually collected at stations 11 to 15, and the stations associated with the Pequabuck River, Salmon Brook, and the Farmington Municipal Sewage Treatment Plant and Ensign-Bickford Co. effluents with an Ekman (July 1966 to October 1966) and Ponar (October 1966 to October 1967) sampler (0.0137 and $0.052m^2$ respectively). All materials retained by a fine mesh screen were transferred to glass bottles or plastic bags, returned to the laboratory, refrigerated overnight (usually) and analyzed the next day. Samples were emptied into white porcelain pans and separated from the stones and detritus. A binocular zoom microscope of varying magnification was used to identify smaller organisms. Identifications were made according to Needham and Needham (1965), Usinger (1963), APHA *et al.* (1965) and Ward and Whipple (1966). Number of organisms were expressed as $\#/m^2$.

SAMPLING-WATER

Water samples (0.1 to 1.0 liter) were usually collected at random at the same times and places that bottom fauna and plankton samples were obtained. Analyses were made either upon return to the laboratory or the following day; samples were held at 15 to 25 C. A Corning pH meter was used to measure the pH of 100 ml of water. This same sample was then titrated to a pH of 4.3 with 0.02 N sulfuric acid to measure total alkalinity, expressed as mg/liter of equivalent $CaCo_3$ (APHA *et al.* 1965). A wheatstone bridge was used to measure the specific resistance in ohms. This was corrected to 25 C and converted to specific conductance as follows, where t = temperature at which the reading was measured, a = 0.0226, a constant calibrated for the Farmington River, and MR = measured resistance.

$$\text{corrected conductance (mhos} \div 10^{-6} = \text{micromhos)} = \frac{1}{MR[1 + a(t - 25)]}$$

TEMPERATURE MEASUREMENT

Four Ryan thermographs were used to measure temperatures at all of the primary stations except 3, 5, 10, and 15 and the effluent sources of the Pequabuck River, Charles W. House and Sons, Inc., Farmington Municipal Sewage Treatment Plant and the Tariffville Municipal Sewage Treatment Plant from August 1966 to November 1967. The thermographs were placed on the bottom in .03 to 1.0 m of water and either anchored in place with a rock or tied to a stake. After tapes from the thermographs were read (hourly) by taking the average distance the tapes moved/hour, the mean weekly and daily temperatures (C) were calculated for each thermograph and for all thermographs combined. Thermographs were calibrated in the laboratory and the errors for slow ($\pm$ 1 C) and rapid ($> \pm$ 1 C) changes measured. A standard field thermometer was usually used to measure the temperature at the areas visited and comparisons were made in temperatures felt when wading and swimming in the river and in each effluent.

PRECIPITATION

Precipitation data was obtained from U. S. Climatological Data, New England (1966, 1967). All reporting stations in the Farmington River Watershed (8) and from West Hartford, Bloomfield, Hartford WB Airport, and Hartford Brainard Field were averaged by weekly periods.

AREA, VELOCITY, AND VOLUME MEASUREMENTS

Cross sectional areas were calculated from width and depth measurements made at each of the primary stations, the community metabolism stations, and at random areas in the study area. A wire line with 1 m markings was stretched across the river, the width was recorded and the depth measured at each marking. Cross sectional area was calculated as follows:

CS (m^2) = ½ 1st depth + second depth +. . . . + last depth + ½ last depth
x distance to shore

Railroad spikes, and pipes were driven into the river's edge at water level. Cross sectional estimates were subsequently changed by measuring from these markers and adding or subtracting the area encompassed by the new measurements from the original cross section. Velocity measurements were obtained at least once a month at stations 1 to 16 in July and August 1966, at stations 7 and 8 in November 1966, and at station 2 in February 1967, by averaging three one-minute velocity readings taken at 1/3 width intervals 1/6 the depth from the top of the water with a Gurley current meter. Velocity was measured at least four days in August 1967 at the Charles W. House & Sons, Inc. effluent source with a direct-reading Gurley current meter connected to a Rustrak recorder. This instrument was calibrated in the laboratory prior to use in the field. Volume estimates for the primary stations and the Charles W. House & Sons, Inc. effluent were calculated from velocity and cross sectional measurements (volume = velocity x cross section). Volume estimates at the Pequabuck River, Salmon Brook, and the Farmington River at Collinsville and Rainbow were obtained from the U. S. Geological Survey (1965, 1966, and unpublished data from 1967) in ft^3/sec and converted to m^3/sec. Estimates of the other effluent discharges were made by comparing their discharges with those of the Charles W. House & Sons, Inc. effluents.

ESTIMATES OF COMMUNITY METABOLISM

The six community metabolism areas (shown in Fig. 1 and characterized in Table 3) were so delineated (September, 1966) that the water mass entering the upstream station would leave the downstream station in not less than 30 or more than 90 minutes. Initial calculation of retention

$$\text{time} \left\{ \frac{\text{volume } (m^3) \text{ between station}}{\text{flow } (m^3/sec)} \right\} \text{was based}$$

on the average of three Gurley current meter readings measured at intervals across the river at the upstream end of the area. Each time community metabolism was estimated in an area the average cross section and volume (Table 3) were corrected by measuring the vertical and horizontal differences in length and depth at the upstream and downstream stations and adjusting the volume and retention time accordingly.

Community metabolism was estimated once in each area except CM-3 from October to December 1966. Dissolved oxygen and temperature were measured at the upstream station every three hours, beginning at 1600 to 1900 hours, for one 24-hour period. Another oxygen sample was obtained at the downstream station when the water previously sampled at the upstream station theoretically passed the downstream station. A Kemerrer sampler was used to obtain three samples of water at intervals across the stream one to two feet under the surface of the water and dissolved oxygen measured by the Alsterberg modification of the Winkler method (APHA *et al.* 1965). Temperature was measured by a standard mercury thermometer. The averaged dissolved oxygen and temperature obtained at each sampling time were plotted on graph paper (downstream values plotted directly underneath the corresponding upstream value at each time) and the hourly values interpolated. Saturation values of dissolved oxygen were obtained from Truesdale, Downing, and Lowden (1955). Four estimates of community metabolism were made each day. One followed Odum (1956) except that the diffusion constant was selected to yield the smallest value. Another drew the respiration line as reported in Copeland and Dorris (1962) and selected the diffusion constant similarly. The final two estimates were similar to the previous two except the diffusion constant was fixed at 0.1 $g/m^3/hr$ (Whitworth and Lane, 1969). All computations

were performed by an IBM 360 computer. The estimates were left in concentration units and not changed to areal measurements.

Community metabolism was estimated at least five times (in sequences of two to seven days) from June to November 1967. Dissolved oxygen and temperature were continuously measured, temperature by a Ryan thermograph located at either the upstream or downstream stations or both. Dissolved oxygen was measured by a Precision Scientific oxygen probe located one to two feet below the surface of the water at each station. The probes were connected to Rustrak recorders housed in detachable plywood boxes attached to galvanized metal pipes driven into the river bottom. The oxygen probes and temperature recorders were usually attached to the pipe. Resistors of 15,000 ohms were attached to the recorders during the summer to compensate for the excessive microamps produced by the probes at the high temperatures. The oxygen probes were calibrated, and the recorders marked every two to four days during each sequence of tests; probes were calibrated by comparing with the average of three oxygen samples taken at probe depth and analyzed by the Alsterberg modification of the Winkler method (APHA *et al.* 1965). Oxygen values were obtained following the instructions with the probes. Hourly sensitivity coefficients were obtained by dividing the difference between the sensitivity coefficients obtained when the probes were calibrated assuming a constant change in factors, by the time. Temperature records for each hour were interpreted from the thermograph tapes as previously described.

B.O.D. TESTS

Biochemical oxygen demand tests were conducted in September 1966, on samples obtained from the Pequabuck River, Farmington Municipal Sewage Treatment Plant, Ensign-Bickford Co., and Tariffville Municipal Sewage Plant. Effluent samples were collected in plastic bags, transported to the Engineering Department at The University of Connecticut, and analyzed following standard methods (APHA *et al.* 1965). Results were expressed in mg/liter.

RATE OF SLIDE COLONIZATION TESTS

Four rate of slide colonization tests of three to fifteen days in length were conducted between August and October 1967 at all primary stations and in areas above and below effluent inflows in the Farmington River. Glass slides (7.7 x 2.54 and 13 x 13 cm) were used as substrates. Horizontal cuts were made in various sized wooden stakes and the stakes driven into the river bottom with the cuts facing upstream. The slides were inserted in cuts about halfway between the bottom and the surface in shallow areas (up to 0.5 m) and approximately 0.2 m below the surface in deeper waters ($>$0.5 m). After the slides were removed from the stakes they were rinsed in the river to remove silt and other debris and taken to shore. The surface most heavily colonized was immediately placed side up on a binocular microscope of 120X and all of the twenty-five center squares in a Whipple Disc that were more than 50% covered by organisms were counted. Twenty-five random areas of the slides were counted by each of two observers. Each observer counted first every other station. The average number of all counts was expressed as the per cent (total count/625 x 100) of the slide colonized (625 represents 100% colonization).

LABORATORY BIOASSAY OF EFFLUENTS

Laboratory bioassays of selected effluents were conducted from July 1966 to December 1966. Effluent samples were collected in plastic bags, transported to the laboratory, and held at constant temperatures (10, 12, 21, and 23 C). The following fish were seined at the respective areas, transported to the laboratory, and acclimated to selected temperatures (10, 12, 21, and 23 C): *Rhinichthys atratulus* (Herman), blacknose dace, Coginchaug River, Durham, Conn. and Blackberry River, Winsted, Conn.; *Rhinichthys cataractae* (Valenciennes), longnose dace, Blackberry River, Winsted, Conn.; *Notropis bifrenatus* (Cope), bridled shiner, Saugatuck River, Saugatuck, Conn.; and *Notropis cornutus* (Mitchill), common shiner, Farmington River, Farmington, Conn. Concentrations of each effluent (reconstituted water used for dilution) were poured (2 liters) into glass jars. Reconstituted water was made by passing tap water through deionizers and adding salts (Lennon and Walker, 1966). Two or three fish were added to each jar; window screening was placed on top of the jars to prevent fish from escaping. Observations on mortality were made at least once a day for 96 hours. Twenty-four and 96 hour TLms were calculated for each effluent by straight line graphical interpolation (APHA *et al.* 1965).

Exposure tests (survival of fish exposed to different concentrations of effluent for varying periods of time, then transferred to reconstituted water) were conducted in the laboratory with the effluents from the Charles W. House & Sons, Inc. and Tariffville Municipal Sewage Treatment Plant in September 1967. Effluent samples were collected in plastic bags, transported to the laboratory, and held at 10 C. Concentrations tested were 100% (12 liters of effluent in 19.4 liter capacity glass jars) and 50% effluent (6 liters of reconstituted water and 6 liters of effluent in the same sized jar). *Notropis cornutus* and *Fundulus diaphanus* (LeSueur) banded killifish, were collected by seining (station 5 and Ball Pond, New Fairfield, Conn., respectively), transported to the laboratory, and acclimated to 10 C in reconstituted water for 1-10 days before exposure to an effluent. Specimens of *Salvelinus fontinalis* (Mitchill), brook trout, were raised from the egg stage in the laboratory in reconstituted water in 10 C. Sixteen to 32 specimens were placed in a 19.4 liter test vessel containing an effluent solution. Two to four fish were removed at selected intervals (with a small net or by hand) transferred to 3.7 liter glass jars with 2 liters of reconstituted water. These vessels were placed into a water bath (10 C) and fish were checked frequently during the first day and then at least once a day for 96 hours. Numbers surviving each check were recorded and the dead fish removed.

FIELD BIOASSAY OF EFFLUENTS

Field bioassays were conducted three times during July-August 1967 at all primary stations and in areas above and below selected effluent inflows into the Farmington River. Cages (25 cm^2) were constructed with No. 9 wire and covered with 6 mm knotless mesh bags that had a draw tie to add and remove fish. Cages were anchored to rocks, pipes, or metal pegs driven into the river bottom. Fishes were collected in the Farmington River by seining at stations 3, 6, 7, and 9. Species utilized were *Notropis cornutus, Notropis hudsonius* (Clinton), spottail shiner, and *Semotilus* sp. (probably *S. corporalis*). Although all specimens examined were *Semotilus corporalis* (Mitchill), fallfish, *S. atromaculatus* (Mitchill), creek chub, is found in the river and positive identification requires examination of each specimen. One to seven fish were either placed in the test cages the same day they were obtained or one day after collection. The latter fish were held overnight in cages in the river. The cages were checked at least once a day for four days and the number of dead and living fish recorded. Effects of the effluents on fish were characterized as (1) definite effect, (2) partial effect, (3) possible effect, and (4) no effect, by comparing effects at the primary stations and selected areas upstream from the entrance of the effluents to the effluent inflow and below the inflow. Factors considered in evaluating these effects were (1) deaths of fish due to parasites and diseases, (2) fluctuations of velocities and water levels in the river and effluents, (3) size of the fish, (4) losses due to damaged cages, and (5) temperature changes.

STOCKING OF ADULT AMERICAN SHAD

Adult American shad were seined by personnel of the Board of Fisheries and Game during May and June of 1966, and transported to the Farmington River. They were released at the gravel pit and at the Simsbury boat launching area (Board of Fisheries and Game, personal communication).

AMERICAN SHAD EGGS, FIELD STUDIES

Eggs were obtained from adult American shad from June 6 to 28, 1967. Adults were obtained by night collecting with a 190 x 2 m (approximate) seine. Ripe fish were stripped shortly after removal from the seine. Eggs were fertilized, washed with river water and allowed to water harden for approximately one hour. One sample of eggs was preserved in 10% formalin after water hardening; number of eggs/ounce was estimated from this sample, by counting 10-100ml samples and calculations based on the average diameter of the eggs. The eggs were measured volumetrically (after water hardening) and 6-32 ounces (usually 16) placed in a plastic bag containing about 5 liters of river water. An oxygen atmosphere was introduced, the bag sealed with rubber bands, and the eggs immediately taken to the Farmington River and placed in egg boxes (all eggs were in boxes by 2 A.M. to 5 A.M.), broadcast in the river, or returned to the laboratory. Egg boxes (similar to those described by Carlson *et al.*, 1968) were usually placed in the river before eggs were obtained. Egg boxes were checked once a day until hatching and usually once a day thereafter. Some of the eggs were held in egg boxes until the following morning, broadcast, and their movement downstream followed by an observer with scuba gear. Samples of fry were removed about every 7-14 days

from one of the boxes in which eggs were collected on the same night. Boxes were moved daily and adjusted for the existing volume and velocity characteristics of the river and for the expected changes during the next 24 hours.

AMERICAN SHAD EGGS, LABORATORY STUDIES

Samples of American shad eggs obtained in 1966 (two tests) and 1967 (five tests) were sorted with the aid of a binocular dissecting scope, into groups of 10-50 eggs of approximately the same developmental stage the morning after they were obtained. Any egg that did not appear to be developing "normally" was discarded. Each group was then placed into a 100 or 150 ml lead solution (some groups were held in reconstituted water until the next day and then introduced into the lead solutions). All waters, except those used in the preparation of stock solutions, were reconstituted as described under laboratory bioassay of effluents. Lead solutions were made with ACS grade lead nitrate (10 g lead nitrate and 1 ml nitric acid diluted to 1 liter with deionized water) and held in either a glass or plastic covered dish of approximately 350 ml capacity at room temperature (20-25 C). All eggs were inspected once a day for four days and the number of dead embryos recorded and removed at each inspection period.

Samples of some of the eggs obtained in 1966 were introduced in the experimental apparatus described by Whitworth (1968) to measure the effects of fluctuating levels of dissolved oxygen on hatching. Waters, maintained at 19.2 (19.0-19.6) C by an immersion cooler were pumped from a 500 liter reservoir to the top of two marble-filled columns at a rate sufficient to keep them full; excess returned to the reservoir through overflows. Dissolved oxygen was reduced in one of the stripping columns by displacement with nitrogen gas, introduced at the base. The amount of oxygen removed was controlled by varying the rate of nitrogen and water flow. Diurnal fluctuations of dissolved oxygen were obtained by a device that alternately opened and closed nitrogen flow to the column. This resulted in low dissolved oxygen levels from 6 P.M. to 8 A.M. and air saturation levels from 10 A.M. to 4 P.M. Waters from the bases of the columns flowed to equilibrium chambers in water baths, then to ten 3.7 liter test chambers (five chambers received waters of approximately air saturation and five received waters having a diurnal fluctuation of dissolved oxygen). Water flow through the chambers averaged 107 ml/min (88-127). One experiment was performed from June 16 to June 24, 1966. The experimental design was a randomized complete block with two levels of oxygen, five replications and fifty eggs per replication. The temperature and oxygen levels selected were chosen arbitrarily.

Samples of some eggs brought back to the laboratory in 1967 were hatched in Heath hatching trays in recirculating waters maintained at 19.8-21.0 C by an immersion cooler. Other eggs were introduced into the same apparatus described above and exposed to diurnal fluctuations of dissolved oxygen and a daily slug dose of lead. Five groups of twenty eggs collected June 14, 1967 were placed in the test vessels the morning of June 15. Dissolved oxygen fluctuated between 10.6 (9.7-11.5) and 4.5 (4.2-4.9) mg/liter and the temperature was 9.5 C (9.0-10.0). Five solutions of lead were prepared as described above (concentrations of 0, 1.66, 8.33, 16.66, and 25.0 mg/liter). Solutions of lead were given daily at 1300 from June 16 - June 26 and provided an instantaneous concentration that was immediately diluted; average theoretical elimination time was 106 min. Eggs were inspected once a day until June 27, 1967.

TABLE 4. SUMMARY OF AMERICAN SHAD EGGS PLACED IN HATCHING BOXES AND BROADCAST IN THE LOWER FARMINGTON RIVER.*

Area	# egg boxes	# eggs/box	Total # eggs	Times introduced	% mortality at time of hatching	Days to 99% hatch	Days from intro. to box overturned	# eggs broadcast	# times eggs broadcast	Time broadcast	Approx. # eggs in overturned boxes	Total # eggs free in river
2nd Collinsville Dam to Unionville, Hgwy. 177 Bridge	8	11,500-18,400	126,500	6-7 to 6-15-67	10-100	4-7	7-15	34,500	1	6-12-67	66,700	101,200
Unionville Bridge to Hgwy. 4 Bridge in Farmington	15	6,900-36,800	239,200	6-7 to 6-23-67	10-100	4-6	3-48	315,100	5	6-12 to 6-23-67	165,600	480,700
Highway 4 Bridge, Farmington to Tariffville	20	6,900-27,600	289,800	6-7 to 6-28-67	10-100	4-7	3-32	374,900	7	6-12 to 6-28-67	241,500	616,400
Tariffville to Hgwy. 189 Bridge	6	6,900-18,400	57,500	6-7 to 6-28-67	10-100	4-6	5-42				36,800	36,800
Total	49	6,900-36,800	713,000					724,500	13		510,600	1,235,100

* Numbers of eggs based on 1150 eggs/ounce.

AMERICAN SHAD STUDIES

No live adult specimens of American shad were observed or collected after we began visiting the river (June 20, 1966). Twenty to 30 dead adults were seen at random areas from station 6 (at the lower end of the gravel pit) to the boat launching area, Rainbow Reservoir. Many area residents reported dead adults throughout the same area, especially Rainbow Reservoir. Since adult shad were seen dead in or close to Rainbow Reservoir within a relatively short time after their release, it would appear that they either spawned shortly after their release or didn't spawn at all and immediately moved downstream. Unfortunately, we do not know where any of the fish that reached Rainbow Reservoir were initially stocked.

Two young specimens (6.5 and 8.0 cm, total length) were captured in a seine haul at station 7 August 4, 1966, with many young *Semotilus corporalis, Notropis cornutus, Notropis hudsonius, Etheostoma olmstedi, Ambloplites rupestris, Micropterus salmoides, Micropterus dolomieui* and *Catostomus commersoni.* These young American shad may have been either feeding in this area or beginning their downstream emigration, probably from the gravel pit. These two juveniles were the progeny of adults released in the gravel pit; spawning area was probably above the gravel pit between stations 4 and 5.

No young American shad, except those contained in egg boxes, were observed or collected in the river in 1967. Possible reasons why we captured none of them are (1) few of them survived, or (2) chance, e.g., applying a 0.1% survival estimate to the time of downstream migration there were approximately 1,000 fry left of the approximately 1,000,000 eggs "free" in the river (Table 4). The two most probable reasons for low survival would be (1) *Notropis cornutus, Notropis hudsonius, Semotilus corporalis, Catostomus commersoni, Lepomis gibbosus, Micropterus salmoides,* and *Etheostoma olmstedi* competed directly with young American shad for food (Table 5), and (2) predation of eggs and fry by most of the abundant fishes in the river, i.e., other studies in Connecticut (unpublished data, Thames River) reveal that most of these fishes eat large numbers of eggs and larval fish. The food habits of young American shad in the Connecticut River, reported by Mitchell *et al.* (1925) also indicate that the young American shad would be competing with most fishes in the Farmington River for food.

Most sites at which eggs were stocked in boxes produced a successful hatching (Table 4). Fluctuations in river discharge (Table 6) probably increased loss of the eggs in many boxes by (1) insufficient or excessive agitation, (2) increased temperature, or (3) washing the eggs out of the boxes. The number of eggs per ounce used in all calculations reported was estimated to be 1150 (Table 7). Our attempts to follow the downstream movements of the eggs broadcast were not successful because high waters came either during or after each broadcasting. We were able to follow the movement of the eggs until they sank and apparently lodged (about 5 to 35 m after being released); other investigators also noted that the eggs moved only a short distance away from the point of release before lodging (Barker, 1965; Carlson *et al.,* 1968; Chittenden, unpublished data). Subsequently, when the diver got close enough to the lodged egg to view it clearly (visibility was usually less than 0.3m) the motion of his body or air bubbles was enough to start the egg in motion again. Downstream drifting by the diver to observe lodged eggs produced the same results. This technique cannot be used effectively unless visibility is better or water is deeper than 2.0 m.

All hatching (five times) in the laboratory at 19.8 to 25.6 C took four to six days. Temperatures measured in the field at irregular intervals all were in this range and hatching times were similar (Table 4). These results were similar to those reported by Carlson *et al.,* (1968).

Since (1) the toxic level of lead (administered as a slug dose once a day while oxygen fluctuated between 10.7 to 4.5 mg/liter at 9.5 C) was probably between 1.66 and 8.33 mg/liter (Table 8), (2) fluctuating oxygen levels from 7.7 to 3.0 mg/liter at 19.8 to 21.0 C were not tolerated by developing American shad eggs (Table 9), and (3) shad eggs exposed continually to lead solutions revealed the lethal level of lead to be around 5 mg/liter (Table 10), the eggs of American shad would probably be able to survive oxygen levels (4.5 mg/liter was the lowest level recorded at the downstream community metabolism station below the mouth of the Pequabuck River in August, 1967), temperatures (Table 11), and lead pollution (lead was negligible in all areas checked), in most areas of the lower Farmington River.

TABLE 5. PERCENTAGE OCCURRENCE OF SELECTED FOOD ITEMS OF ALL FISH EXAMINED IN THE LOWER FARMINGTON RIVER DURING AUGUST AND OCTOBER, 1966 AND 1967.

Species	Number of stomachs examined	Empty stomachs	Plants: Filamentous green algae	Plants: Other algae	Plants: Vascular aquatics	Animals: Mollusks	Animals: Oligochaetes	Animals: Hydropsychids	Animals: Tendipedids	Animals: Other insects	Animals: Arthropods (gen)	Animals: Fish	Animals: Miscellaneous	Grit
Alosa sapidissima	2			50	50				50	50	50			
Esox americanus	1												100	
E. niger	9						11				11	44	33	
Notemigonus crysoleucas	11	27	9	45	18								27	18
Notropis bifrenatus	7	10		10	10	10			30	20			50	20
N. cornutus	35	6	28	51	17	3	3	11	26	17	14		11	23
N. hudsonius	39	8	13	36	28			2	15	28	12		15	41
Rhinichthys atratulus	5			60				40	40					
R. cataractae	1							100	100	100				
Semotilus atromaculatus	2			50	50									
S. corporalis	10	10	30	10	30			30	20	22	30		40	50
Catostomus commersoni	21	5	5	24	5	10		5	43	14	43		28	19
Ictalurus nebulosus	4		25	25	25		25		75	25	25		25	25
Fundulus diaphanus	3		67						33				67	33
Ambloplites rupestris	9							11		11	78			
Lepomis auritus	8		12	12				12	88	25	25		25	
L. gibbosus	31			13	10	10		6	45	13	26		29	39
L. macrochirus	6	17					17	67			33		17	50
Micropterus dolomieui	2										100			
M. salmoides	21		5					5	19	24	33	14	33	14
Etheostoma olmstedi	23	13					4		52	13			22	26
Perca flavescens	10				40		10		30	10	60			

PRODUCTIVITY ESTIMATES OF THE LOWER FARMINGTON RIVER

Relatively small numbers of game fishes were observed (Table 12). Their growth (Table 13) compared with general growth reported by the State Board of Fisheries and Game (1942 and 1959) and their length-weight relationships (Table 14) compared with data summarized in Carlander (1953), appeared to be much lower than expected. (Table 15 contains the constants required to change total lengths to standard lengths, if desired.) Condition indexes (Table 14) were generally higher for the larger fishes suggesting intraspecific competition and dense populations. Greatest diversity (Table 12) and largest populations of game fishes were observed and collected from Collinsville to station 8. Some were apparently restricted to this area, probably because of their habitat preferences for rocky bottoms and waters of higher velocities with higher dissolved oxygen levels, i.e., *Salmo trutta, Salvelinus fontinalis, Rhinichthys cataractae, Ambloplites rupestris,* and *Micropterus dolomieui.* The largest populations of forage fishes were collected and observed from Station 8 to station 12. Possible reasons for the small number of game fishes might be (1) competition with the large numbers of forage fishes for food (Table 7), (2) predation by forage fishes on the eggs of game fishes (3) deposition of silt on centrarchid nests by the turbid water runoff from the watershed and the operations at Colebrook Dam (particularly bad in 1967) and the gravel pit, (4) fluctuations of water levels that periodically exposed nests of centrarchids and eggs of pickerels, and (5) high waters in the "drifting" sands area from Farmington to the highway 315 bridge that periodically rearranged the bottom destroying the nests of game fishes.

Plankton populations (Table 16), although they varied with the seasons, were certainly capable of supporting large populations of fishes. Bottom fauna populations (Table 17), were difficult to compare to each other because some organisms were living in, and others on, the bottom. The smaller numbers of organisms in most of the areas between stations 1-5 and at 16 were of more value to fish than were the larger numbers of "worms" in many remaining sections of the river.

EFFECTS OF EFFLUENTS ON THE FARMINGTON RIVER

CHARLES W. HOUSE & SONS. INC.

This effluent discharge varied greatly throughout the day (negligible to 0.12m^3/sec.); typical hourly changes in velocity are shown in Table 18. Mixing zones are shown in Fig. 2. Area A was estimated by changes in pH and visual observation to extend about 85 m downstream in the main river, and Area B was estimated, by visual observation and total alkalinity changes, somewhere between the point of entry to the main river and approximately 400 m downstream.

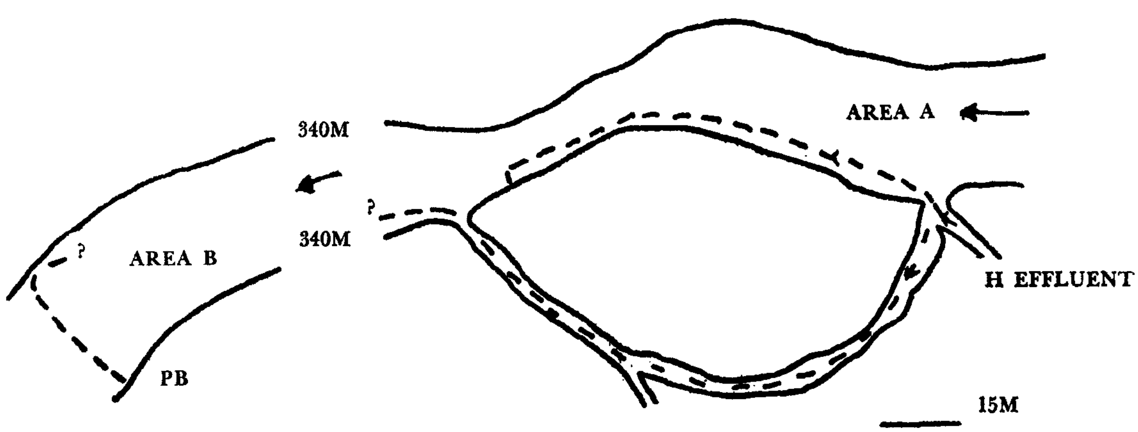

Fig. 2. Estimated mixing zones of the Charles W. House & Sons effluent in the lower Farmington River.

The high temperatures of the effluent occasionally increased temperatures about 6 m downstream in both areas A (Tables 19 and 20) and B. Plankton populations in the main river increased slightly after the addition of the effluent, probably because large populations were added from area B (Table 21); there was no effect from this effluent on the rate of colonization of glass slides (Table 21). Numbers of bottom fauna were reduced 50 m downstream in Area A, although the predominant taxons in the area (Tendipedidae, Oligochaeta, Hydropsychidae, Mollusca, and Ephemeroptera) apparently were not affected because populations were similar above (stations 1-3), below (stations 4-5), and in the effluent stream. Although 96-hour field (Table 22) and laboratory (Table 23) toxicity bioassays were toxic to fish, there were no differences in species observed above (stations 1-3), below (stations 4-5), and in the area effected by the effluent. Fish were observed numerous times swimming into and out of the effluent stream. Almost all specimens of two species (*Notropis cornutus* and *Fundulus diaphanus*) exposed to samples of the effluent in the laboratory then placed in reconstituted water survived (Tables 24 and 25); all species lost equilibrium in two minutes or less. All *Salvelinus fontinalis,* already in poor condition, died when exposed to 100% effluent longer than six minutes (up to fifteen minutes).

PIONEER STEEL BALL COMPANY

This effluent had no measurable effect on bottom fauna, plankton, specific conductance, total alkalinity, rate of glass slide colonization and fish (Table 22 and observations). Its volume (estimated at less than 0.1 m^3/sec.) contained an oily material in 1966 that settled on the bottom of the river up to 39 m downstream, whereas in 1967, the effluent was immediately mixed and the deposited material was no longer detectable. There were no temperature differences felt in the Farmington River at the entrance of this effluent in either year.

PEQUABUCK RIVER

The waters from the Pequabuck River (0.40-12.2 m^3/sec.) were apparently diluted by the Farmington River, within 25 m downstream, (Fig. 3), i.e., differences in color, temperature (Table 26 and felt while swimming), and pH, plankton, and mean rate of colonization of glass slides (Table 21) between the Farmington River and the Pequabuck River were measured only to this point. This effluent probably increased total alkalinity and specific conductance (Table 21) downstream (combined with the effluent from the Farmington Sewage Treatment Plant) to station 10. The Pequabuck River had no effect on bottom fauna or its composition, because similar taxons were found at other stations (13-15) with similar bottom types. This effluent had variable effects on fish because (1) fish survived 100% in laboratory toxicity bioassays (Table 23), (2) many fish were often observed swimming into and out of the area of little or no dilution, and (3) fish in 96-hour field bioassays (Table 22) were usually effected for at least 6 m downstream. There were no differences in species observed above (station 8), below (station 9), and in the area affected by the effluent.

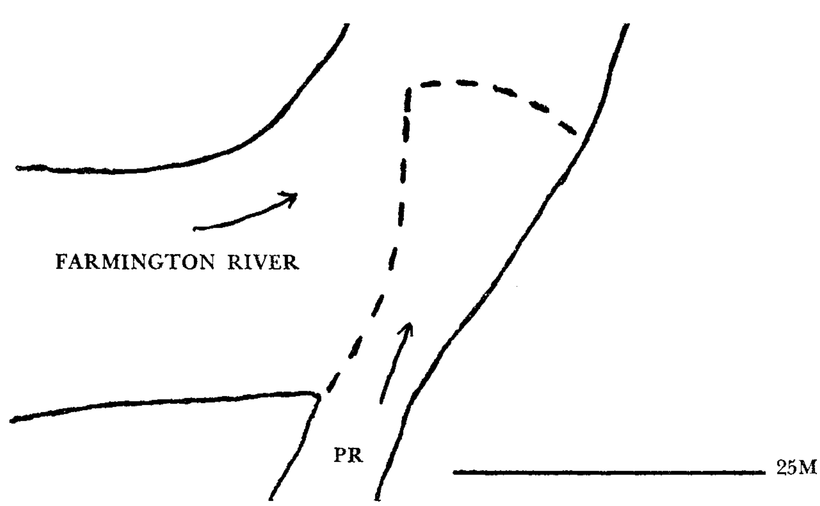

Fig. 3. Estimated mixing zone of the discharge of the Pequabuck River in the lower Farmington River.

FARMINGTON MUNICIPAL SEWAGE TREATMENT PLANT

This discharge (less than 0.15 m^3/sec.) was often cooler than the main river in the summer (Table 26). The mixing zone in the main stream (Fig. 4) extended downstream about 25 m and was estimated by color and temperature (felt) comparisons between the main river and the effluent. This effluent probably increased total alkalinity, specific conductance (Table 21) downstream (combined with the Pequabuck River) to station 10, and diluted plankton (Table 21) for 6 m downstream. Plankton populations at the lower end of the mixing zone returned to what were probably "normal" after the mixing of the Pequabuck River with the Farmington River. The combined effluents from the Pequabuck River and the Farmington River must have contained some of the elements considered necessary for plankton growth (N, P, Ca, Mg, Na, K, S, Fe, Mn, Cu, Zn, Mo, B, Cl, Co, and V) because plankton populations increased downstream from this point. There were no effects from this effluent on pH (Table 21) and bottom fauna. Rate of colonization of glass slides was affected approximately 6 m downstream but was not measurable at the entrance to the river (Table 21). This effluent had little effect on fish because (1) fish survived 100% effluent in laboratory toxicity tests (Table 23), (2) many fish were observed swimming into and out of the area of little or no dilution, and (3) fish in 96-hour field toxicity bioassay studies (Table 22) showed only slight effects of this effluent. There were no differences observed in species composition in stations above (8), below (9), and in the area affected.

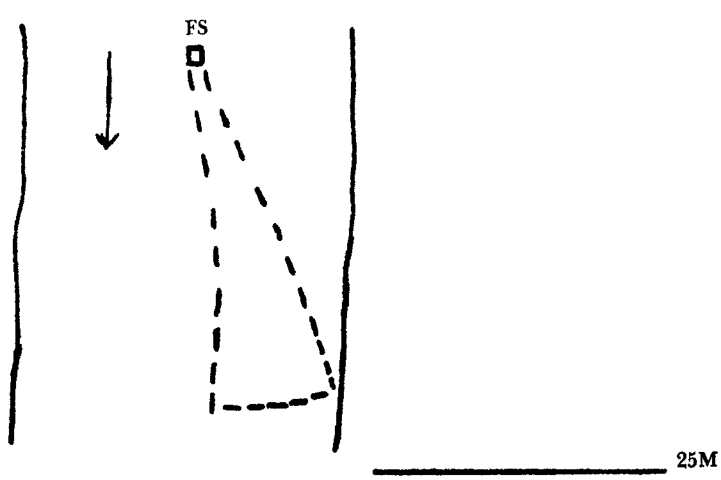

Fig. 4. Estimated mixing zone of the Farmington Sewage Treatment Plant effluent in the lower Farmington River.

ENSIGN-BICKFORD COMPANY

The small stream (less than 0.10 m^3/sec.) in which this effluent entered the Farmington River was apparently diluted 10 m downstream (Fig. 5) because differences in temperature (felt), pH, specific conductance, and plankton (Table 21) were measured to this point. This small stream probably increased total alkalinity in the main river downstream to station 12 (Table 21). There were no effects on the rate of colonization of glass slides, (Table 21) bottom fauna and probably no effects on fish; populations observed upstream (stations 10 and 11), downstream (station 12) and swimming into and out of the effluent stream were similar.

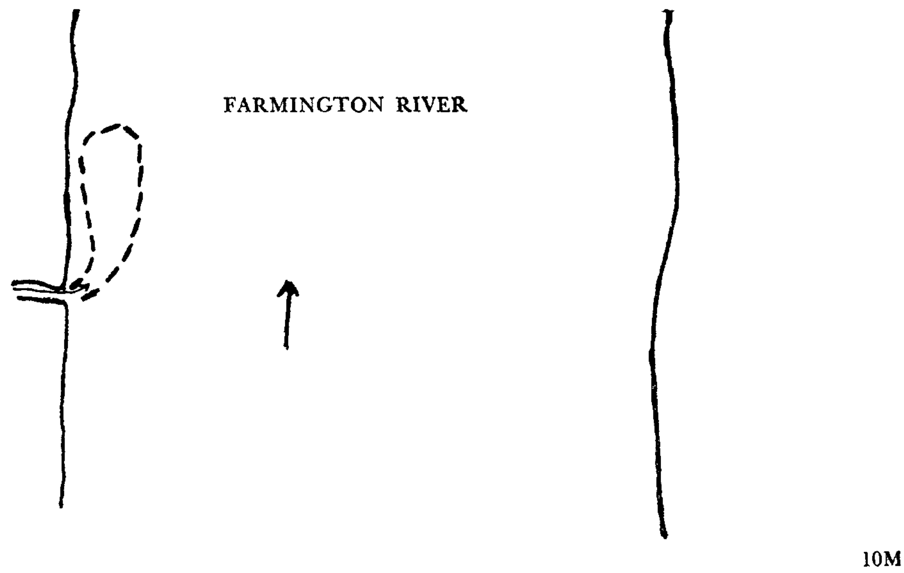

Fig. 5. Estimated mixing zone of the little stream that received the Ensign-Bickford effluent in the lower Farmington River.

SALMON BROOK

This discharge (0.20-6.4 m^3/sec.) was clearer and cooler than the Farmington River. The area in which the effluent apparently mixed with the main river extended about 25 m downstream (Fig. 6) because differences in temperature (felt while swimming) and color were observed to this point. The discharge had no effect on bottom fauna, pH (Table 21), and fish. Plankton populations were diluted downstream to the entrance of the Tariffville Municipal Sewage Treatment plant and total alkalinity and specific conductance (Table 21) were temporarily decreased (not measurable approximately 280 m downstream).

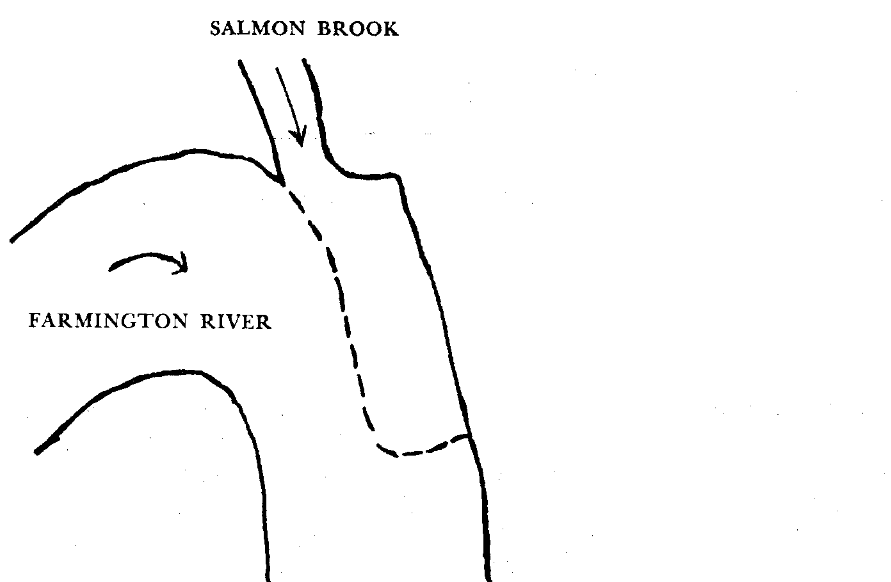

Fig. 6. Estimated mixing zone of the Salmon Brook discharge in the lower Farmington River.

TARIFFVILLE MUNICIPAL SEWAGE TREATMENT PLANT

The area in which this discharge (less than 0.10 m^3/sec.) was diluted by the Farmington River extended 10 m downstream (shown in Fig. 7) i.e., differences in temperature (Table 26), plankton, total alkalinity, and specific conductance (Table 21) between it and the Farmington were only measured downstream to this point. This effluent affected the rate of colonization of glass slides approximately 10 m downstream but not at its entrance to the river (Table 21); it had no effect on pH (Table 21). Both 96-hour field (Table 22) and laboratory (Table 23) toxicity bioassays showed variable toxicity to fish. *Salvelinus fontinalis,* already in poor condition, placed in 100% effluent then placed in reconstituted water died in all exposures (6.5 to 12 minutes), whereas similar exposures had no effect on *Fundulus diaphanus;* all *Fundulus diaphanus* and *Salvelinus fontinalis* (in poor condition) lost equilibrium after 1.5 minutes exposure.

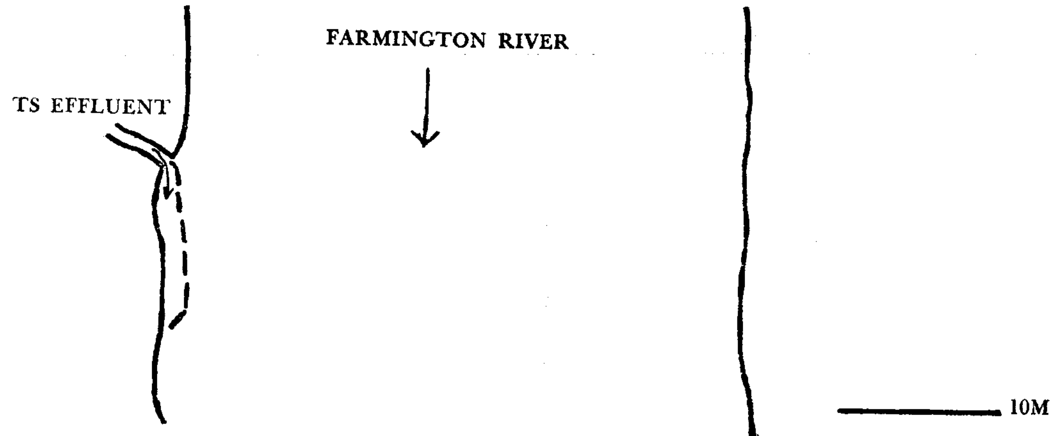

Fig. 7. Estimated mixing zone of the Tariffville Sewage discharge in the lower Farmington River.

COMBUSTION ENGINEERING

The small stream that received this effluent discharge (less than 0.20 m^3/sec.) was clearer and felt cooler than the water in Rainbow Reservoir. The effluent itself did not affect fish (Table 23).

GENERAL EFFECTS OF THE EFFLUENTS

The combined effects of the effluents on the river were probably responsible for the downstream changes in community metabolism (Table 28) and the downstream increases in plankton (Table 16), total alkalinity (Table 27) and specific conductance (Table 29); higher ionic concentrations and reduced velocities were probably responsible for higher plankton numbers. Increased precipitation and discharges of the river (Table 5) reduced the effects of the effluents on the river by decreasing total alkalinity (Table 27) and specific conductance (Table 29) whereas reduced precipitation and discharges reversed these effects. The effluents had no measurable effect on the pH of the river (Table 21). Changes in numbers of bottom fauna (Table 17), fishes (Table 12) and rate of colonization of glass slides (Table 21) downstream were probably not influenced by the effluents.

The apparent effect of both domestic effluents (Farmington Municipal Sewage Treatment Plant, Tariffville Municipal Sewage Treatment Plant) on the rate of colonization of glass slides was contrary to that reported by Butcher (1947), who found reduced colonization at the entrance of a sewage effluent. Since the areas affected were relatively small (beginning about 6-10 m downstream from the effluent and ending at less than 20-1680 m), more work should be done to determine if this really was an effect of the effluents or was due to experimental error.

Fish populations observed at some effluent sources may have been seeking cooler temperatures (Farmington Municipal Sewage Treatment Plant, Pequabuck River, Ensign- Bickford Co.) in the summer, or organic matter for food (Farmington Municipal Sewage Treatment Plant). Moore (1932) observed fish feeding at the entrance of sewage effluents to receiving waters. The fishes exposed to effluents may be more susceptible to predation or to infestation with diseases and parasites, or may have reduced growth and fecundity.

TABLE 6. AVERAGE WEEKLY PRECIPITATION IN THE FARMINGTON RIVER WATERSHED AND MEANS AND RANGES OF DISCHARGES IN THE LOWER FARMINGTON RIVER.

Week	Average Precipitation (CM)	Collinsville Discharge M³/sec.		Rainbow Discharge M³/sec.	
7-18-66	3.1	2.2	(0.91- 5.62)	3.00	(1. 0-57.09)
7-25-66	1.7	1.6	(1.16- 2.32)	2.19	(1.22-57.77)
8-1-66	0.1	1.5	(0.17-23.79)	2.12	(1.22-57.77)
8-8-66	2.1	1.3	(0.20-12.65)	2.26	(1.16-60.82)
8-15-66	2.6	1.0	(0.16-12.03)	2.90	(.85-60.82)
8-22-66	1.2	1.1	(0.26- 2.32)	1.84	(.85-59.81)
8-29-66	2.8	0.93	(0.62- 3.23)	2.19	(1.16-62.52)
9-5-66	2.2	3.1	(1.30-11.86)	3.20	(1. 0-61.84)
9-12-66	3.6	1.6	(1.16- 3.28)	3.00	(.75-60.48)
9-19-66	6.5	4.8	(1.22-21.31)	7.36	(.64-61.50)
9-26-66	3.9	3.1	(2.12-26.34)	4.42	(.75-60.82)
10-3-66	0.1	10.15	(6.74-20.25)	7.08	(.57-66.60)
10-10-66	0.9	5.37	(5.14- 6.36)	3.51	(.59-60.82)
10-17-66	6.4	20.21	(4.14-52.39)	18.29	(.48-65.92)
10-24-66	0	11.69	(6.74-49.02)	6.94	(.51-59.81)
10-31-66	6.6	19.96	(6.74-49.02)	23.22	(.54-70.64)
11-7-66	2.2	24.98	(17.42-37.12)	26.62	(.57-72.04)
11-14-66	0.2	13.86	(11.18-17.42)	12.63	(.54-57.77)
11-21-66	0.2	10.76	(5.62-21.63)	8.38	(.51-57.77)
11-28-66	1.9	15.39	(5.62-21.63)	12.43	(.57-68.98)
12-5-66	0.6	13.67	(5.62-21.63)	10.25	(.57-59.13)
12-12-66	1.3	11.93	(7.82-16.42)	8.89	(.57-57.77)
12-19-66	2.6	12.03	(8.89-16.03)	7.08	(.54-70.34)
12-26-66	3.2	15.48	(11.58-23.79)	12.03	(.57-69.32)
1-2-67	1.1	7.69	(3.39-13.41)	7.87	(.54-56.75)
1-9-67	0.3	9.96	(5.69-16.99)	9.85	(.51-68.30)
1-16-67	0	5.77	(2.68- 9.70)	5.66	(.57-56.41)
1-23-67	2.3	19.11	(5.33-26.34)	21.52	(.64-69.66)
1-30-67	1.1	11.78	(9.91-15.63)	13.42	(.54-67.62)
2-6-67	2.1	8.05	(4.99-11.04)	8.38	(.54-68.98)
2-13-67	0.1	8.55	(4.29-16.14)	8.38	(.54-55.73)
2-20-67	2.3	7.04	(9.39-10.02)	5.55	(.54-55.05)
2-27-67	1.4	6.98	(4.47- 8.38)	6.37	(.57-55.05)
3-6-67	6.1	11.64	(4.92-24.13)	15.91	(.54-67.62)
3-13-67	2.5	18.43	(7.20-29.39)	29.73	(.57-55.73)
3-20-67	1.8	9.48	(8.38-16.14)	13.42	(.54-55.05)
3-27-67	1.1	34.46	(9.39-54.37)	46.55	(.57-68.30)
4-3-67	2.4	51.65	(40.49-63.88)	79.85	(67.28-114.63)
4-10-67	3.6	37.54	(45.45-52.90)	46.89	(.57-66.26)
4-17-67	3.4	45.39	(31.97-49.02)	68.30	(3.0-112.65)
4-24-67	1.1	25.00	(15.01-33.63)	32.08	(.57-66.94)
5-1-67	3.1	21.49	(9.74-32.15)	24.92	(.57-67.96)
5-8-67	3.6	29.73	———	44.51	(.57-66.26)
5-15-67	0.9	21.12	(14.37-25.14)	26.62	(.59-64.22)
5-22-67	5.1	26.12	(10.04-39.50)	31.77	(.59-66.94)
5-29-67	0	15.48	(8.71-23.79)	15.01	(.59-54.71)

TABLE 6— (continued)

6-5-67	0.1	7.59	(4.94- 9.74)	6.65	(.59-55.05)
6-12-67	2.9	8.21	(6.59-18.41)	7.22	(.70-56.41)
6-19-67	6.4	20.90	(13.86-35.54)	21.52	(.57-55.05)
6-26-67	1.5	13.63	(9.07-24.81)	10.65	(.59-55.05)
7-3-67	3.1	8.77	(5.48-16.03)	8.04	(.70-55.73)
7-10-67	2.4	7.50	(4.62-12.03)	6.51	(.57-61.16)
7-17-67	0.9	9.22	(4.94-29.58)		
7-24-67	3.4	10.50	(9.44-22.26)		
7-31-67	2.9	6.51	(4.50- 8.89)		
8-7-67	1.9	6.85	(5.97- 9.17)		
8-14-67	0.6	3.73	(1.87-11.89)		
8-21-67	4.9	3.84	(2.49- 7.56)		
8-28-67	1.2	5.59	(2.86-10.9)		
9-4-67	0.6	5.97	(2.32- 6.29)		
9-11-67	0.2	2.20	(1.95- 4.50)		
9-18-67	1.4	2.15	(1.98- 3.34)		
9-25-67	2.0				
10-2-67	0.3				
10-9-67	2.0				
10-16-67	3.1				
10-23-67	3.9				
10-30-67	2.2				

TABLE 7. SUMMARY OF ESTIMATES OF THE NUMBER OF AMERICAN SHAD EGGS/VOLUMETRIC OUNCE.

Preservative	Method of Counting	Average	Range	# Counts
10% formalin	direct count in 10-100 mls	1151	956-1375	15
10% formalin	von Bayer egg table	1340		
10% formalin	calculation based on 2.95 mm average diameter/egg	1152		

TABLE 8. PER CENT SURVIVAL OF EGGS OF AMERICAN SHAD* EXPOSED TO DAILY SLUG-DOSES OF LEAD**

Day	Lead (mg/liter) 0	1.66	8.33	16.66	25.0
6-16-67	95	90	60	10	0
6-17-67	90	90	0	0	0
6-18-67	90	70	↓	↓	↓
6-19-67	75	45			
6-20-67	75	25			
6-21-67	70	25			
6-22-67	60	25			
6-23-67	50	25			
6-24-67	40	20			
6-25-67	40	20			
6-26-67	40	20			

* Eggs introduced 6-15-67

** Dissolved oxygen had a diurnal fluctuation between 4.5-11.0 mg/liter, temperature was 9.5C.

TABLE 9. EFFECTS OF FLUCTUATING OXYGEN LEVELS ON DEVELOPMENT OF AMERICAN SHAD EGGS*

Oxygen (mg/liter)	# Eggs	Per cent survival at selected hours after test started 24	48	72	96
7.7	250	63.6	52.4	25.0	16.0
7.7-3.0	250	0	0	0	0

* Eggs collected June 15, 1966; tests began June 16, 1966.

TABLE 10. PER CENT SURVIVAL* OF AMERICAN SHAD EGGS** EXPOSED CONTINUALLY TO THE SAME LEAD SOLUTION.

Lead (mg/liter)	# of Fish	Per cent survival at selected hours after exposure 24	48	72	96
0	90	67.8	44.4	23.3	13.3
0(+5ml/liter HNO_3)	20	65.0	60.0	45.0	0
.0001	10	100.0	100.0	30.0	30.0
.0005	10	100.0	100.0	20.0	20.0
.001	20	100.0	95.0	85.0	80.0
.01	10	100.0	100.0	100.0	100.0
0.1	30	60.0	53.3	36.7	0
0.5	20	95.0	75.0	5.0	0
1.0	30	63.0	56.7	46.7	20.0
1.67	40	47.5	40.0	0	0
2.0	30	53.3	23.3	13.3	0
3.34	40	30.0	17.5	5.0	0
5.0	60	23.3	11.6	6.6	3.3
10.0	20	0	0	0	0
15.0	20	0	0	0	0
20.0	20	0	0	0	0
25.0	20	0	0	0	0

* All test combined; temperature range 20-25 C.
** Eggs collected June 15, 1966 and June 14, 15, 16, and 17, 1967.

TABLE 11. WEEKLY MEANS AND RANGES OF TEMPERATURES IN THE LOWER FARMINGTON RIVER.

Week	Temp. (C)		Week	Temp. (C)	
8-22-66	23.2	(20.6-27.2)	4-10-67	8.8	(3.9- 5.6)
8-29-66	24.2	(19.4-27.8)	4-17-67	7.1	(4.4- 9.4)
9-5-66	20.6	(17.8-23.3)	4-24-67	8.9	(5.6-13.3)
9-12-66	18.8	(16.1-21.1)	5-1-67	13.1	(11.7-15.0)
9-19-66	16.4	(13.9-20.0)	5-8-67	9.7	(8.9-11.7)
9-26-66	14.6	(11.7-20.0)	5-15-67	14.9	(11.1-22.2)
10-3-66	17.2	(11.7-13.7)	5-22-67	16.7	(10.0-21.1)
10-10-66	12.8	(10.0-15.0)	5-29-67	17.8	(14.4-21.1)
10-17-66	11.1	(10.0-13.3)	6-5-67	21.4	(20.0-26.7)
10-24-66	10.6	(7.8-12.2)	6-12-67	22.8	(18.9-26.7)
10-31-66	9.4	(6.7-12.2)	6-19-67	19.8	(17.2-23.9)
11-7-66	8.1	(7.8- 9.4)	6-26-67	21.7	(18.9-25.0)
11-14-66	—	———	7-3-67	21.7	(19.4-24.4)
11-21-66	5.0	(4.4- 6.1)	7-10-67	24.0	(21.7-26.1)
11-28-66	6.3	(2.2- 7.8)	7-17-67	23.6	(21.7-25.6)
12-5-66	2.8	(-0.6- 7.2)	7-24-67	24.0	(20.6-27.2)
12-12-66	3.6	(2.8- 7.2)	7-31-67	24.0	(22.2-26.7)
12-19-66	1.4	(0.6- 3.3)	8-7-67	23.1	(18.9-26.7)
12-26-66	1.1	(0.0- 2.2)	8-14-67	23.3	(18.9-26.7)
1-2-67	1.1	(0.0- 1.7)	8-21-67	20.6	(17.8-22.8)
1-9-67	0.9	(0.0- 2.2)	8-28-67	20.6	(16.1-23.9)
1-16-67	1.1	(0.0- 2.8)	9-4-67	20.0	(16.7-23.9)
1-23-67	1.9	(0.0- 3.9)	9-11-67	18.6	(15.6-22.8)
1-30-67	0.6	(-0.6- 2.2)	9-18-67	17.2	(15.6-23.3)
2-6-67	0.0	(-0.6- 0.9)	9-25-67	16.7	(13.9-20.0)
2-13-67	0.3	(-0.6- 1.6)	10-2-67	16.7	(12.2-20.0)
2-20-67	0.8	(-0.6- 2.2)	10-9-67	13.9	(11.7-16.1)
2-27-67	0.6	(-0.6- 2.2)	10-16-67	13.6	(10.0-16.1)
3-6-67	0.6	(-1.1- 2.2)	10-23-67	9.9	(9.4-11.7)
3-13-67	0.8	(0.0- 2.2)	10-30-67	—	———
3-20-67	0.8	(0.0- 4.4)	11-6-67	—	———
3-27-67	4.0	(2.8- 5.6)	11-13-67	4.4	(3.3- 8.9)
4-3-67	4.2	(2.8- 5.6)			

TABLE 12. FISHES* COLLECTED AND OBSERVED IN THE LOWER FARMINGTON RIVER.

	Areas							
	1-Gravel pit	Gravel-pit	Gravel-pit - 8	8 - 9	9-12	12-15	15 to Rainbow Reservoir	Rainbow Reservoir
Alosa sapidissima (Wilson)			X					
Salmo trutta Linnaeus	XX		XX					
Salvelinus fontinalis (Mitchill)	XX							
Esox americanus (Gmelin)	X		X					
Esox niger LeSueur	XX	XX	XX	XX	XX	XXX	X	X
Cyprinus carpio Linnaeus					X	XXX		XX
Notemigonus crysoleucas (Mitchill)	XX	X	X	X		XX		XXX
Notropis bifrenatus (Cope)	XXX		XX	X	X			
Notropis cornutus (Mitchill)	XXX	XXX	XXX	XXX	XXX	XXX	XX	XXX
Notropis hudsonius (Clinton)	XXX	XXX	XXX	XXX	XXX	XXX	XX	XX
Rhinichthys atratulus (Hermann)	XX		XX					
Rhinichthys cataractae (Valenciennes)	XX		XX					
Semotilus atromaculatus (Mitchill)		X				XX		
Semotilus corporalis (Mitchill)	XXX	XXX	XXX	XXX	XXX	XXX	XX	XX
Catostomus commersoni (Lacépède)	XXX	XXX	XXX	XXX	XX	XXX	XXX	XXX
Ictalurus nebulosus (LeSueur)	X	XX	XX	XX				
Anguilla rostrata (LeSueur)	XX	XXX	X			XXX		XXX
Fundulus diaphanus (LeSueur)	XX	XX	XX	XX	XX	XX	XX	
Ambloplites rupestris Rafinesque	XXX	XX	XXX	XX				
Lepomis auritus Linnaeus	XX	XX	XX	XX	XX			
Lepomis gibbosus (Linnaeus)	XXX	XXX	XXX	XXX	XX	XX	XXX	XX
Lepomis macrochirus Rafinesque	XXX	XXX	XXX	XX	XX	XX		
Micropterus dolomieui (Lacépède)	XX		XX					
Micropterus salmoides (Lacépède)	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XX
Pomoxis nigromaculatus (LeSueur)			X					
Etheostoma olmsteadi (Storer)	XXX	XXX	XXX	XXX	XXX	XXX	XXX	
Perca flavescens (Mitchill)	XX	XX	XX	XX	XX	XXX	XX	XX
Totals	23	17	24	16	14	15	10	11

* X = Rare, XX = Common, XXX = Abundant

TABLE 13. CALCULATED LENGTH (CM) OF SELECTED FISHES COLLECTED IN THE LOWER FARMINGTON RIVER.

ESOX NIGER

Age	Calculated total length: All fish	Age 1	Age 2	Age 3	Age 4	Age 5	Mean Actual length	No. of fish
0	——	——	——	——	——	——	12.90	1
1	13.92	13.74	——	——	——	——	13.83	3
2	17.97	14.02	15.35	——	——	——	24.30	1
3	21.28	——	——	——	——	——	——	——
4	24.01	——	——	——	——	——	——	——
5	27.82	14.14	19.29	21.28	24.01	27.82	28.20	2

Calculated regression coefficients a = 103.92 b = 1.21

NOTEMIGONUS CRYSOLEUCAS

Age	Calculated total length: All fish	Age 1	Age 2	Age 3	Age 4	Age 5	Mean Actual length	No. of fish
0	——	——	——	——	——	——	7.00	2
1	6.42	4.50	——	——	——	——	7.20	1
2	9.75	5.66	6.82	——	——	——	7.46	3
3	13.66	7.05	10.44	12.00	——	——	14.13	3
4	17.53	5.46	10.72	14.43	15.26	——	17.30	1
5	20.28	9.64	15.50	17.89	19.81	20.28	19.10	1

Calculated regression coefficients a = 30.74 b = 1.19

NOTROPIS CORNUTUS

Age	Calculated total length: All fish	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Mean Actual length	No. of fish
0	——	——	——	——	——	——	——	——	——	8.80	1
1	5.58	6.23	——	——	——	——	——	——	——	8.78	6
2	6.89	5.78	7.29	——	——	——	——	——	——	8.62	17
3	7.19	4.92	6.10	7.16	——	——	——	——	——	7.85	4
4	8.07	4.78	6.26	6.99	8.02	——	——	——	——	8.76	3
5	8.52	5.08	6.90	7.84	8.74	9.20	——	——	——	9.10	3
6	7.05	——	——	——	——	——	——	——	——	——	——
7	7.32	——	——	——	——	——	——	——	——	——	——
8	7.68	4.60	5.05	5.96	6.23	6.51	7.05	7.32	7.68	6.70	1

Calculated regression coefficients a = 36.97 b = 0.90

TABLE 13—(continued)

NOTROPIS HUDSONIUS

Age	Calculated total length All fish	Age 1	Age 2	Age 3	Age 4	Mean Actual length	No. of fish
0	—	—	—	—	—	—	—
1	4.42	4.90	—	—	—	6.77	8
2	5.72	4.48	5.93	—	—	7.89	17
3	7.07	4.16	5.53	7.15	—	8.27	15
4	7.15	3.26	4.89	5.86	7.15	8.40	1

Calculated regression coefficients a = 25.12 b = 1.08

CATOSTOMUS COMMERSONI

Age	Calculated total length All fish	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Mean Actual length	No. of fish
0	—	—	—	—	—	—	—	8.30	4
1	8.57	5.56	—	—	—	—	—	6.20	2
2	14.83	9.70	15.15	—	—	—	—	14.10	3
3	17.99	9.44	14.82	17.81	—	—	—	20.37	11
4	20.91	—	—	—	—	—	—	—	—
5	23.20	5.44	14.52	17.32	19.79	22.03	—	29.95	2
6	26.96	8.25	14.74	19.67	22.03	24.38	26.96	30.25	2

Calculated regression coefficients a = 27.61 b = 2.24

LEPOMIS AURITUS

Age	Calculated total length All fish	Age 1	Age 2	Age 3	Mean Actual length	No. of fish
0	—	—	—	—	3.20	1
1	4.67	4.67	—	—	5.33	3
2	8.44	4.48	8.82	—	8.30	2
3	9.79	4.87	8.05	9.79	12.30	2

Calculated regression coefficients a = 6.20 b = 1.93

LEPOMIS MACROCHIRUS

Age	Calculated total length All fish	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Mean Actual length	No. of fish
0	—	—	—	—	—	—	—	—	—
1	4.25	3.87	—	—	—	—	—	5.16	3
2	7.67	4.38	7.92	—	—	—	—	8.26	3
3	9.69	5.15	6.84	9.76	—	—	—	9.00	1
4	11.46	—	—	—	—	—	—	—	—
5	12.53	—	—	—	—	—	—	—	—
6	14.22	4.08	7.77	9.61	11.46	12.53	14.22	16.10	1

Calculated regression coefficients a = 13.15 b = 1.53

TABLE 13—(continued)

MICROPTERUS SALMOIDES

Age	All fish	Calculated total length Age 1	Age 2	Age 3	Age 4	Age 5	Mean Actual length	No. of fish
0	—	—	—	—	—	—	5.80	1
1	5.39	6.33	—	—	—	—	7.07	8
2	6.58	4.85	6.33	—	—	—	7.36	9
3	8.41	4.28	5.93	7.52	—	—	7.96	3
4	10.98	5.71	10.32	11.30	12.62	—	13.40	1
5	11.96	5.71	7.02	8.18	9.33	11.96	13.30	1

Calculated regression coefficients a = 24.21 b = 1.64

AMBLOPLITES RUPESTRIS

Age	All fish	Calculated total length Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Mean Actual length	No. of fish
0	—	—	—	—	—	—	—	—	—	—	—
1	5.59	2.59	—	—	—	—	—	—	—	2.95	2
2	9.37	—	—	—	—	—	—	—	—	—	—
3	11.32	8.27	11.18	12.69	—	—	—	—	—	15.06	3
4	11.32	4.36	5.69	7.68	9.33	—	—	—	—	9.00	1
5	14.64	—	—	—	—	—	—	—	—	—	—
6	16.02	6.35	9.89	12.43	13.09	16.85	18.51	—	—	17.30	1
7	15.08	—	—	—	—	—	—	—	—	—	—
8	16.96	4.03	7.12	9.78	11.54	12.43	13.53	15.08	16.96	17.10	1

Calculated regression coefficients a = 19.31 b = 1.10

LEPOMIS GIBBOSUS

Age	All fish	Calculated total length Age 1	Age 2	Age 3	Age 4	Mean Actual length	No. of fish
0	—	—	—	—	—	3.80	1
1	6.97	7.20	—	—	—	6.95	8
2	7.91	6.69	7.67	—	—	8.06	8
3	8.72	7.15	8.30	9.00	—	9.38	10
4	8.18	6.50	7.25	7.80	8.18	9.93	3

Calculated regression coefficients a = 56.47 b = 0.44

TABLE 13—(continued)

RHINICHTHYS ATRATULUS

Age	Calculated total length All fish	Age 1	Age 2	Mean Actual length	No. of fish
0	—	—	—	—	—
1	3.37	3.10	—	5.70	2
2	4.82	3.65	4.82	6.30	2

Calculated regression coefficients a = 15.36 b = 1.56

SEMOTILUS CORPORALIS

Age	Calculated total length All fish	Age 1	Age 2	Age 3	Age 4	Age 5	Mean Actual length	No. of fish
0	—	—	—	—	—	—	—	—
1	9.16	9.45	—	—	—	—	12.40	1
2	10.94	8.96	11.08	—	—	—	8.70	2
3	12.67	8.66	11.05	12.93	—	—	16.10	3
4	15.38	8.47	9.40	10.54	12.83	—	13.90	1
5	18.40	10.30	11.41	13.34	16.66	18.40	19.35	2

Calculated regression coefficients a = 69.59 b = 0.54

ETHEOSTOMA OLMSTEDI

Age	Calculated total length All fish	Age 1	Age 2	Mean Actual length	No. of fish
0	—	—	—	4.32	7
1	4.26	4.17	—	5.14	12
2	5.28	4.49	5.28	5.91	5

Calculated regression coefficients a = 33.86 b = 0.73

PERCA FLAVESCENS

Age	Calculated total length All fish	Age 1	Age 2	Age 3	Mean Actual length	No. of fish
0	—	—	—	—	—	—
1	5.06	3.39	—	—	6.50	1
2	7.82	4.54	6.90	—	8.42	7
3	11.48	7.72	11.05	11.48	14.35	2

Calculated regression coefficients a = 17.99 b = 1.44

TABLE 14. LENGTH-WEIGHT RELATIONSHIPS AND CONDITION INDEXES OF FISHES COLLECTED IN THE LOWER FARMINGTON RIVER.

Length group (cm)	Calculated weight (g)	Actual weight (g)	# Fish	Condition index
		ESOX NIGER		
1				
2				
3	.1			
4	.2			
5	.5			
6	.9			
7	1.5			
8	2.5			
9	3.7			
10	5.4			
11	7.6			
12	10.3	9.8	1	.58
13	13.7	15.1	2	.68
14	17.7			
15	22.6			
16	28.4	27.5	1	.62
17	35.2			
18	43.1			
19	52.1			
20	62.4			
21	74.1			
22	87.4			
23	102.2			
24	118.7	98.8	1	.69
25	137.1			
26	157.4			
27	179.9			
28	204.4	208.1	1	.98
29	231.4	261.0	1	1.10
30	260.8			
		NOTROPIS BIFRENATUS		
1				
2	.1			
3	.2			
4	.6	.7	4	.93
5	1.2	1.1	6	.98

TABLE 14—(continued)

Length group (cm)	Calculated weight (g)	Actual weight (g)	# Fish	Condition index
		LEPOMIS MACROCHIRUS		
1				
2	.1			
3	.5			
4	1.1	1.2	2	1.74
5	2.3			
6	4.0			
7	6.5	7.1	1	1.83
8	9.9	11.3	3	1.99
9	14.4	15.2	1	2.09
10	20.0			
11	29.9			
12	35.4			
13	45.6			
14	57.3			
15	71.2			
16	87.1	84.5	1	2.02
17	105.4			
18	126.1			
19	149.4			
20	175.4			
		MICROPTERUS SALMOIDES		
1				
2	.1			
3	.3			
4	.8	.7	2	1.18
5	1.6	1.6	5	1.24
6	2.9	3.3	4	1.48
7	4.9	5.0	4	1.52
8	7.5	7.8	2	1.52
9	11.1	8.8	1	1.43
10	15.7	12.5	4	1.43
11	21.6			
12	28.7			
13	37.4	39.5	3	1.77
14	47.7			
15	59.9			

TABLE 14–(continued)

Length group (cm)	Calculated weight (g)	Actual weight (g)	# Fish	Condition index
		ETHEOSTOMA OLMSTEDI		
1				
2	.1			
3	.2			
4	.6	.5	5	.90
5	1.1	1.1	13	.90
6	1.9	1.8	4	.86
7	3.0	3.1	2	.94
8	4.4			
		PERCA FLAVESCENS		
1				
2	.1			
3	.2			
4	.6			
5	1.2			
6	2.3			
7	3.7	3.1	6	1.02
8	5.8			
9	8.5			
10	12.0			
11	16.4	22.6	1	1.95
12	21.8	24.4	1	1.41
13	28.4	35.0	1	1.56
14	36.1			
15	45.3			
16	55.9			
17	68.2			
18	82.2	51.7	1	.93
19	98.1			
20	116.0			

TABLE 14—(continued)

Length group (cm)	Calculated weight (g)	Actual weight (g)	# Fish	Condition index
		NOTEMIGONUS CRYSOLEUCAS		
1				
2				
3	.2			
4	.5			
5	1.0			
6	1.9			
7	3.2	3.3	4	.92
8	5.0	5.6	1	.98
9	7.5			
10	10.7			
11	14.8			
12	19.9	23.1	2	1.27
13	26.2			
14	33.7			
15	42.6			
16	53.0			
17	65.2			
18	79.1	67.3	1	1.15
19	95.1	102.2	1	1.47
20	113.2			
		NOTROPIS CORNUTUS		
1				
2	.1			
3	.2			
4	.5			
5	1.2			
6	2.1			
7	3.5	3.7	11	1.07
8	5.5	5.2	7	1.02
9	8.1	8.1	9	1.11
10	11.5	11.5	7	1.15
11	15.8	18.3	2	1.38
12	21.1			
13	27.5			
14	35.1			
15	44.2			

TABLE 14—(continued)

Length group (cm)	Calculated Weight (g)	Actual Weight (g)	# Fish	Condition index
		NOTROPIS HUDSONIUS		
1				
2	.1			
3	.3			
4	.6			
5	1.2	1.1	6	.97
6	2.0	2.0	5	.88
7	3.1	3.0	4	.93
8	4.6	4.7	10	.91
9	6.5	5.9	6	.87
10	8.8	8.9	8	.92
11	11.6	9.9	2	.82
12	15.0			
13	18.9			
14	23.3			
15	28.7			
		RHINICHTHYS ATRATULUS		
1				
2	.1			
3	.3			
4	.7	.9	1	1.09
5	1.4	1.6	1	1.20
6	2.6			
7	4.4	4.4	1	1.23
8	6.7	5.6	1	1.33
		ICTALURUS NEBULOSUS		
1				
2	.1			
3	.4			
4	.9	.8	1	1.48
5	1.6	2.3	1	1.53
6	2.7			
7	4.0			
8	5.8			
9	7.9			
10	10.5			
11	13.5			
12	17.1	9.4	1	.51
13	21.1			
14	25.8			
15	31.0			
16	36.9			
17	43.4			
18	50.5	80.3	1	1.38
19	58.4			
20	67.0			

TABLE 14—(continued)

Length group (cm)	Calculated Weight (g)	Actual Weight (g)	# Fish	Condition index
		CATOSTOMUS COMMERSONI		
1				
2	.1			
3	.3			
4	.7			
5	1.4			
6	2.4	2.9	3	1.24
7	3.8			
8	5.6			
9	8.0	8.5	3	1.15
10	10.8			
11	14.4			
12	18.6			
13	23.5	9.6	1	.49
14	29.2	26.7	2	.96
15	35.8			
16	43.3	47.0	3	1.16
17	51.8			
18	61.3			
19	71.9			
20	83.7	87.7	2	1.14
21	89.6	92.8	2	1.02
22	110.8	120.0	1	1.19
23	126.3			
24	143.2	145.5	1	1.07
25	161.5	149.9	1	.95
26	181.3	166.0	1	.93
27	202.6	185.5	1	1.00
28	225.5			
29	250.1	322.6	1	1.28
30	276.4			
31	304.4	351.5	1	1.23
32	334.3			
33	336.0			
34	399.7	361.7	1	.92
35	435.3			
		FUNDULUS DIAPHANUS		
1				
2	.1			
3	.3			
4	.6	.7	1	1.10
5	1.3			
6	2.4			
7	3.9	3.0	1	1.08
8	5.9	4.9	1	1.16
9	8.6			
10	12.1			

TABLE 14—(continued)

Length group (cm)	Calculated Weight (g)	Actual Weight (g)	# Fish	Condition index
		SEMOTILUS CORPORALIS		
1				
2	.1			
3	.2			
4	.6			
5	1.1			
6	2.0			
7	3.2			
8	4.8	5.2	1	.91
9	7.0	7.8	1	1.04
10	9.7			
11	13.0			
12	17.1	20.2	1	1.06
13	22.0			
14	27.6	21.5	2	.84
15	34.3	41.4	1	1.23
16	41.9	46.5	1	1.11
17	50.6			
18	60.5	50.0	1	.93
19	71.6	77.2	1	1.18
20	84.1			
21	97.9	96.7	1	1.01
22	113.2			
23	130.0			
24	148.5			
25	168.6			
		AMBLOPLITES RUPESTRIS		
1				
2	.1			
3	.5	.5	2	1.77
4	1.2			
5	2.5			
6	4.5			
7	7.2			
8	11.0	10.7	1	2.44
9	15.9	18.0	1	2.47
10	22.2			
11	23.0			
12	39.3			
13	50.6			
14	63.9	65.2	1	2.33
15	79.3			
16	97.1	84.3	2	2.24
17	117.5	119.6	2	2.35
18	140.6			
19	166.7			
20	195.8			

TABLE 14—(continued)

Length group (cm)	Calculated Weight (g)	Actual Weight (g)	# Fish	Condition index
		LEPOMIS AURITUS		
1				
2	.1			
3	.5	.6	1	1.89
4	1.2	.7	1	1.57
5	2.5			
6	4.5	4.7	1	2.29
7	7.3	5.9	1	2.05
8	11.2	10.7	1	2.09
9	16.4	17.6	2	2.46
10	23.0			
11	31.3			
12	41.4			
13	53.5			
14	67.9			
15	84.8	81.5	1	2.28
16	104.3			
17	126.8			
18	152.4			
19	181.3			
20	213.8			
		LEPOMIS GIBBOSUS		
1				
2	.2			
3	.5	.5	1	1.68
4	1.2	1.0	1	1.82
5	2.4	2.7	3	1.92
6	4.2	4.3	3	1.96
7	6.7	6.0	1	2.09
8	9.9	11.2	4	2.20
9	14.2	14.9	11	2.10
10	19.4	16.9	4	1.84
11	25.9	19.3	2	1.43
12	33.6			
13	42.8	50.8	1	2.54
14	53.4			
15	65.8			
16	79.8			
17	95.8			
18	113.8			
19	133.9			
20	156.2			

TABLE 15. TOTAL LENGTH – STANDARD LENGTH RELATIONSHIPS[1] OF FISHES COLLECTED IN THE LOWER FARMINGTON RIVER.

Species	Number	a	b	Correlation Coefficient
Esox niger	4	–0.28	1.19	.99869
Notemigonus crysoleucas	9	0.23	1.25	.99857
Notropis bifrenatus	10	0.79	1.02	.92293
Notropis cornutus	36	–0.08	1.26	.97652
Notropis hudsonius	41	–0.06	1.27	.99587
Rhinichthys atratulus	4	0.28	1.14	.99847
Semotilus corporalis	10	0.08	1.26	.99825
Catostomus commersoni	24	0.23	1.23	.99863
Ictalurus nebulosus	4	–0.13	1.26	.99891
Ambloplites rupestris	9	–0.08	1.28	.99964
Lepomis auritus	8	–0.15	1.29	.99856
Lepomis gibbosus	31	–0.12	1.30	.99715
Lepomis macrochirus	8	0.08	1.28	.99796
Micropterus salmoides	25	0.08	1.20	.99904
Etheostoma olmstedi	24	0.16	1.17	.98797
Perca flavescens	10	0.32	1.19	.99731

[1] Total length = a + b standard length

TABLE 16. MEANS AND RANGES OF PLANKTON POPULATIONS IN THE LOWER FARMINGTON RIVER.

	Stations 1-5		Stations 6-8		Stations 9-12		Stations 13-15		Station 16		All
Month	# Obs.	#/CC	# Obs.	#/CC	# Obs.	#/CC	# Obs.	#/CC	# Obs.	#/CC	Average
7/66	5	21.4	3	6.8	3	27.2	3	16.5	1	17.9	18.6
		(12.6–27.8)		(3.1–9.4)		(21.6–35.9)		(1.2–30.4)			
8/66	10	10.0	6	2.9	8	23.0	6	15.3	2	30.9	14.2
		(1.0–25.0)		(.3–8.3)		(7.5–33.8)		(1.4–33.3)		(13.0–48.8)	
9/66	5	6.6	3	6.2	4	3.8	3	3.4	1	6.5	5.2
		(.5–15.0)		(.2–13.3)		(2.3–6.2)		(1.3–5.7)			
10/66	10	2.1	6	1.8	8	1.3	6	2.4	2	2.7	1.5
		(.3–7.2)		(.3-4.30)		(0–4.2)		(0–9.2)		(1.7–3.6)	
11/66	10	5.7	6	.6	8	0.5	6	1.0	2	.6	2.2
		(0–43.8)		(.3–7)		(.2–1.2)		(.2–2.3)		(.4–.8)	
12/66	5	1.7	3	.1	4	1.1	3	2.8	1	.7	1.5
		(.7–2.8)		(.2–1.5)		(.5–2.3)		(.2–7.8)			
1/67	7	0	5	0	4	0	2	0	1	0	0
		(0–0.2)		(0–0.2)							
2/67	5	1.4	3	.7	4	.3	3	0	—	—	0.7
		(0–4.7)		(.6–.8)		(.2–.5)					
3/67	10	21.5	4	4.5	8	2.0	6	5.0	1	2.7	9.7
		(1.7–73.5)		(.7-11.8)		(0–6.7)		(.8–14.6)			
4/67	10	4.4	6	1.5	8	2.9	6	7.1	2	2.2	3.8
		(.8–8.9)		(0–2.5)		(1.0–5.9)		(.9–22.6)		(1.8–2.5)	
5/67	10	57.8	6	19.6	8	59.4	6	33.9	2	31.2	44.8
		(13.2–255.4)		(4.6–44.2)		(4.1–306.4)		(5.8–94.9)		(9.6–52.8)	
6/67	10	11.2	5	11.1	8	10.9	6	19.1	2	12.1	12.7
		(0–24.7)		(3.9–21.0)		(1.7–20.9)		(10.2–28.8)		(7.3–16.9)	
7/67	10	11.6	6	11.3	8	20.7	6	31.8	2	18.3	18.0
		(1.0–22.1)		(2.2–27.5)		(4.5–49.8)		(11.7–65.2)		(2.4–34.2)	
8/67	15	10.2	9	8.8	12	25.8	8	19.7	2	24.5	16.3
		(.5–33.4)		(1.0–28.5)		(3.8–86.7)		(4.0–34.2)		(8.8–40.1)	
9/67	5	1.0	3	3.2	4	111.0	3	33.3	1	61.3	38.7
		(0–2.40)		(2.0–4.1)		(20.2–322.5)		(8.0–65.6)			
10/67	5	2.3	3	3.6	4	1.6	3	1.7	1	1.6	2.2
		(.7–4.9)		(2.5-5.2)		(.6–3.3)		(1.2–2.8)			
Means											
All dates		11.9		5.6		18.7		13.7		14.3	

TABLE 17. MEANS AND RANGES OF BOTTOM FAUNA POPULATIONS IN THE LOWER FARMINGTON RIVER.

	Stations 1-5		Stations 6-8		Stations 9-12		Stations 13-15		Station 16		All
Month	# Obs.	#/M²	# Obs.	#/M²	# Obs.	#/M²	# Obs.	#/M²	# Obs.	#/M²	Average
7/66	4	372.4	3	830.7	3	1396.7	3	3530.7	1	490	1,375.3
		(976–846)		(438–1284)		(73–4018)		(1607–5844)			
8/66	10	622.0	6	3126.3	8	496.6	6	233.3	2	1103	876.8
		(85–1926)		(157–6049)		(110–1497)		(105–438)		(998–1208)	
9/66	5	166.0	3	166.0	4	780.0	3	681.7	1	192	417.8
		(8–358)		(140–201)		(183–1476)		(37–1570)			
10/66	10	141	6	385.2	8	563.5	6	700.0	—	—	414.3
		(0–770)		(0–1313)		(35–1838)		(36–2045)			
11/66	10	56.1	6	21.8	8	654.5	6	641.5	2	113.5	312.6
		(0–219)		(0–44)		(0–1934)		(186–1095)		(17–210)	
12/66	5	15.6	3	3	4	2331.3	3	6317.3	1	9.0	1,773.3
		(9–26)		(0–9)		(0–5598)		(130–10,564)			
1/67	7	31.3	5	47.4	3	155.7	3	3656.0	2	44.0	599.0
		(0–96)		(0–158)		(35–394)		(206–10,350)		(18–70)	
2/67	5	16.8	3	57.0	4	570.5	3	3317.3	—	—	780.6
		(0–34)		(26–94)		(17–1387)		(1444–4758)			
3/67	5	46.4	1	86	3	40.3	3	291.3	1	17	102.3
		(9–154)				(0–112)		(130–409)			
4/67	—	—	—	—	—	—	—	—	—	—	—
5/67	5	5.4	3	6	4	181.0	2	1357.5	1	9	232.9
		(0–9)		(0–18)		(0–715)		(223–2492)			
6/67	10	49.2	5	211.8	7	108.7	4	376.8	1	79	144.4
		(0–140)		(17–595)		(0–260)		(0–930)			
7/67	10	112.5	6	104.2	8	217.5	6	607.8	2	505	262.2
		(61–270)		(35–287)		(0–632)		(205–1153)		(9–92)	
8/67	15	127.1	9	541.9	11	532.1	7	720.3	1	53	412.4
		(34–1355)		(18–2444)		(9–2585)		(93–1990)			
9/67	5	58.4	3	282.7	4	208.8	1	316.0	1	86	169.8
		(17–94)		(34–737)		(9–558)					
10/67	5	43.0	3	880.3	4	143.3	—	—	1	43	267.1
		(0–86)		(334–1235)		(34–205)					
Means											
All dates		167.3		534.8		526.6		1358.2		162.5	

TABLE 18. MEAN HOURLY VELOCITIES (M/SEC) OF THE C. W. HOUSE & SONS, INC. EFFLUENT.

Time	8-22-67	8-23-67	8-24-67	8-25-67	8-26-67
0100		0.00		0.00	0.00
0200		0.00		0.00	0.00
0300		0.00		0.00	0.00
0400		0.00		0.00	0.00
0500		0.00		0.00	0.00
0600		0.00		0.00	0.00
0700		0.05		0.00	0.00
0800		0.16		0.00	0.00
0900		0.20		0.50	0.00
1000	0.15	0.30	0.10	0.12	0.00
1100	0.15	0.19	0.10	0.00	0.13
1200	0.15		0.00	0.12	0.10
1300	0.15		0.20	0.15	0.00
1400	0.14		0.00	0.14	0.00
1500	0.15		0.00	0.15	0.00
1600	0.18		0.00	0.00	0.00
1700	0.19		0.00	0.00	
1800	0.20		0.00	0.00	
1900	0.14		0.00	0.00	
2000	0.07		0.00	0.00	
2100	0.02		0.00	0.02	
2200	0.00		0.00	0.10	
2300	0.00		0.00	0.04	
2400	0.00		0.00	0.00	

TABLE 19. DAILY MEANS AND RANGES OF TEMPERATURE (C) IN THE FARMINGTON RIVER AT THE DISCHARGE OF THE EFFLUENT OF THE C. W. HOUSE & SONS EFFLUENT.

Date	5 m across effluent stream		6 m downstream in effluent stream	
3-13-67	1.0	(0- 2.2)	1.7	(1.1- 2.8)
3-20-67	1.1	(0- 3.9)	4.8	(1.7-15.0)
3-27-67	4.2	(2.8- 6.1)	5.5	(3.3-19.4)
4-3-67	4.1	(3.3- 5.6)	4.7	(3.3- 6.1)
4-10-67	6.3	(3.9- 8.9)	7.4	(5.0-10.6)
4-17-67	7.2	(5.6- 9.4)	7.4	(5.6-10.0)
4-24-67	8.8	(6.1-13.3)	9.8	(6.1-13.3)
5-1-67	13.1	(11.7-15.0)	12.6	(10.6-19.4)
5-8-67	9.7	(8.9-11.9)	10.8	(8.9-12.2)
5-15-67	13.2	(11.1-17.2)	14.0	(11.1-21.1)
5-22-67	14.7	(10.0-15.6)	16.3	(13.3-22.2)
10-2-67	16.7	(12.8-20.0)	18.1	(8.3-26.7)
10-9-67	14.2	(11.7-16.1)	17.8	(11.1-25.0)
10-16-67	13.8	(6.6-16.1)	16.4	(6.7-20.6)
10-23-67	9.9	(5.9-11.7)	13.3	(5.6-20.6)

TABLE 20. MEAN HOURLY TEMPERATURES (C) IN THE FARMINGTON RIVER AT THE DISCHARGE OF THE C. W. HOUSE & SONS EFFLUENT.

Time	3-16		3-17		3-18		3-19		10-20		10-21		10-22		10-23	
	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b
0100	0.0	1.7	0.6	1.1	0.6	1.6	0.6	1.6	13.9	15.6	12.8	11.7	11.7	9.4	11.7	6.1
0200	0.0	1.1	0.6	1.1	—	2.8	0.6	1.6	13.9	15.6	12.8	11.7	11.7	9.4	11.1	5.6
0300	0.0	1.1	0.6	1.7	—	4.4	0.6	1.6	13.9	15.6	12.2	11.7	11.7	9.4	10.6	5.6
0400	0.0	2.8	0.6	2.2	—	7.1	0.6	1.7	13.9	15.6	12.2	11.7	11.7	9.4	10.6	6.1
0500	0.0	3.3	0.6	2.8	—	12.2	0.6	2.2	13.3	15.6	12.2	11.7	11.7	9.4	10.6	8.3
0600	0.0	3.9	0.6	3.9	—	10.0	0.6	2.2	13.3	15.0	12.2	12.2	11.1	11.1	10.6	12.2
0700	0.6	3.9	0.6	5.6	—	5.6	0.6	2.2	13.3	15.0	12.2	13.3	11.1	12.8	10.0	15.6
0800	0.6	5.0	0.6	5.6	—	4.4	0.6	2.2	13.3	15.0	12.2	13.9	10.6	14.4	9.4	17.7
0900	0.6	5.0	0.6	6.1	—	3.3	0.6	2.2	13.3	15.0	12.2	13.9	10.6	14.4	9.4	19.4
1000	1.1	5.0	0.6	5.6	—	3.3	0.6	2.2	13.3	15.0	12.2	13.9	10.6	15.6	9.4	19.8
1100	1.1	4.4	0.6	5.0	—	2.2	0.6	2.2	13.3	15.6	12.2	14.4	10.6	15.6	9.4	20.6
1200	1.1	4.4	0.6	3.9	—	1.6	0.6	2.2	13.3	15.6	12.2	15.0	10.6	15.6	9.4	20.6
1300	1.1	2.8	0.6	2.2	—	1.6	0.6	2.2	13.9	15.6	12.2	15.0	10.6	14.4	9.4	20.4
1400	1.1	1.7	0.6	1.6	0.6	1.6	1.1	1.6	13.9	15.6	12.2	15.0	10.6	13.3	9.4	19.8
1500	1.1	1.7	0.6	1.6	1.1	1.6	1.1	1.6	13.9	16.1	12.2	14.4	11.1	12.2	9.4	18.3
1600	0.6	1.7	0.6	1.6	1.1	1.6	1.1	1.6	13.9	16.1	12.2	13.9	11.1	11.1	9.4	15.6
1700	0.6	1.7	0.6	1.6	1.1	1.6	1.1	1.6	13.9	16.1	12.8	12.1	12.2	10.6	9.4	13.3
1800	0.6	1.7	0.6	1.6	1.1	1.6	1.1	1.6	13.9	16.1	12.8	11.7	12.2	9.4	—	12.0
1900	0.6	1.7	0.6	1.6	1.1	1.6	1.1	1.6	13.9	15.6	12.8	11.1	12.2	9.4	—	11.7
2000	0.6	1.7	0.6	1.6	1.1	1.6	1.1	1.6	13.9	13.9	12.8	10.6	12.2	8.3	—	10.6
2100	0.6	1.7	0.6	1.6	0.6	1.6	0.6	1.6	13.3	13.9	12.8	10.6	12.2	7.8	—	10.6
2200	0.6	1.7	0.6	1.6	0.6	1.6	0.6	1.6	12.8	12.8	12.8	10.6	11.7	7.2	—	9.4
2300	0.6	1.1	0.6	1.6	0.6	1.6	0.6	1.6	12.8	12.2	12.2	10.6	11.7	6.7	—	8.9
2400	0.6	1.1	0.6	1.6	0.6	1.6	—	1.6	12.8	11.7	11.7	10.0	11.7	6.1	—	8.3

a = 5 m across effluent stream
b = 6 m downstream in effluent stream

TABLE 21. EFFECTS OF SELECTED EFFLUENTS ON SPECIFIC CONDUCTANCE, TOTAL ALKALINITY, pH, RATE OF COLONIZATION OF GLASS SLIDES, AND POPULATIONS OF PLANKTON IN THE LOWER FARMINGTON RIVER.

				H				PB							
Dates	Station 1	Station 2	Station 3	Source	50m below	85m below	100m below	Source	18m below	85m below	Station 4	Station 5	Station 6	Station 7	Station 8
Specific conductance (μmho/cm)															
8-22-67	116	116	118	165	134	130	196	148	130	126	112	120	145	112	134
8-24-67	152	138	146	353	138	149	268	156	146	149	134	146	134	134	143
9-26-67	175	157	156	205	192	189	236	197	182	197	177	170	180	178	153
10-31-67	120	122	124	131	137	361	127	139	133	125	122	131	121	128	135
Average	141	133	136	214	150	207	207	160	148	149	136	142	145	138	141
Total alkalinity (mg/liter as equivalent $CaCo_3$)															
8-22-67	19	16	20	5	20	20	27	20	20	21	20	20	20	21	20
8-24-67	22	18	22	0	18	20	38	20	22	23	22	23	22	11	21
9-26-67	20	18	20	22	17	19	26	22	21	20	21	22	22	23	22
10-31-67	13	12	13	8	9	9	11	12	13	13	13	13	14	13	14
Average	19	16	19	8	16	17	26	18	19	19	19	20	19	17	19
pH															
8-22-67	6.5	6.5	6.5	5.5	6.4	6.6	6.4	6.4	6.4	6.4	6.7	8.4	6.6	6.6	6.6
8-24-67	6.5	6.6	6.7	3.6	6.5	6.7	6.6	6.6	6.6	6.8	6.8	6.9	6.5	6.7	6.7
9-26-67	6.9	6.6	7.0	7.0	6.4	6.6	6.7	6.7	7.2	6.9	6.8	8.0	6.7	6.7	6.9
10-31-67	6.3	6.4	6.5	6.0	6.3	6.3	6.5	6.5	6.5	6.4	6.3	6.5	6.4	6.3	6.4
Average	6.6	6.3	6.7	5.5	6.1	6.6	6.5	6.5	6.7	6.6	6.6	7.4	6.6	6.6	6.6
Percent slide colonization															
8-29-67	08	—	—	08	24	54	—	38	55	47	—	43	51	24	23
9-6-67	—	—	—	08	—	—	—	100	100	100	61	45	56	—	49
9-29-67	03	05	04	03	—	01	02	02	07	02	05	05	20	38	16
10-31-67	02	04	03	—	03	03	06	—	—	01	02	02	02	02	04
Average	04	04	04	06	14	19	04	47	54	38	23	24	32	31	23
Plankton population (#/CC)															
8-22-67	33	28	17	41	54	3	9	72	69	87	4	12	3	29	27
8-24-67	2	4	1	5	14	16	297	44	22	12	31	9	4	1	9
9-26-67	2	0	0	1	1	1	1	3	1	2	1	1	2	4	4
10-31-67	3	5	1	2	5	1	1	2	2	1	1	1	2	3	5
Average	10	9	5	13	18	5	77	30	24	25	9	6	3	9	11

	PR		FS						EB					SB		TS		
Dates	Source	25m below	Source	6m below	26m below	Station 9	Station 10	Station 11	Source	10m below	Station 12	Station 13	Station 14	Source	Station 15	Source	10m below	Station 16
Specific conductance (μmho/cm)																		
8-22-67	136	129	178	178	182	174	157	174	176	196	184	—	158	174	176	174	176	158
8-24-67	160	126	162	168	117	160	160	176	268	160	160	160	176	160	147	315	163	184
9-26-67	198	237	275	247	218	250	227	258	224	236	221	215	215	—	224	209	246	239
10-31-67	379	253	154	151	151	141	151	148	143	139	142	152	155	177	155	160	153	147
Average	218	186	192	186	167	181	174	189	202	182	178	176	176	170	176	215	185	182
Total alkalinity (mg/liter as equivalent $CaCo_3$)																		
8-22-67	23	22	26	26	24	29	27	30	41	30	30	—	30	29	31	31	34	30
8-24-67	16	10	19	18	18	18	18	18	54	18	19	20	20	19	21	80	21	30
9-26-67	22	33	39	34	30	34	34	29	33	32	33	35	34	—	32	35	33	30
10-31-67	62	44	18	18	16	17	17	17	17	17	18	20	19	20	19	21	20	19
Average	31	27	25	24	22	24	24	23	36	24	25	25	26	23	26	42	27	27
pH																		
8-22-67	6.6	6.6	6.5	6.3	6.5	6.3	6.8	6.5	6.7	6.5	6.7	—	6.8	6.8	6.7	6.7	6.6	6.6
8-24-67	6.7	8.3	6.9	6.9	6.8	6.7	6.8	7.0	6.9	7.3	7.1	6.9	6.9	6.9	6.6	6.9	7.1	6.6
9-26-67	7.0	7.1	7.1	7.1	7.0	7.0	6.9	7.0	7.6	7.5	6.8	6.6	7.0	—	6.8	6.6	6.7	7.0
10-31-67	6.9	6.9	6.6	6.5	6.5	6.6	6.5	6.5	6.4	6.5	6.4	6.4	6.5	6.5	6.4	6.6	6.6	6.5
Average	6.8	7.2	6.8	6.7	6.7	6.6	6.8	6.8	6.9	7.0	6.8	6.6	6.8	6.7	6.6	6.7	6.7	6.7
Percent slide colonization																		
8-29-67	14	53	04	08	11	23	22	—	18	08	32	20	19	—	—	20	—	20
9-6-67	31	12	—	15	—	—	68	—	53	94	—	44	—	—	—	71	—	—
9-29-67	—	—	59	11	29	28	12	29	08	31	23	13	15	—	22	22	09	20
10-31-67	04	—	02	0	04	—	04	—	04	10	06	—	08	—	08	12	03	03
Average	16	32	22	08	15	26	26	29	21	36	20	26	14	—	15	31	06	12
Plankton population (#/CC)																		
8-22-67	8	10	13	5	106	9	28	12	42	32	87	18	34	—	18	37	58	40
8-24-67	8	9	10	10	58	74	15	30	18	4	12	25	33	3	8	18	6	23
9-26-67	3	4	4	1	4	20	41	60	110	84	322	66	26	—	1	43	36	61
10-31-67	6	1	.5	0	3	3	1	1	1	4	1	1	1	2	3	1	4	1
Average	6	6	7	4	43	27	21	26	43	31	105	27	24	2	9	24	26	31

H = Charles W. House & Sons, Inc.
PB = Pioneer Steel Ball Company
PR = Pequabuck River
FS = Farmington Municipal Sewage Treatment Plant
TS = Tariffville Municipal Sewage Treatment Plant
EB = Ensign-Bickford Company
SB = Salmon Brook

TABLE 22. TOXIC EFFECTS ON FISHES CONFINED FOR 96 HOURS IN AND DOWNSTREAM FROM SELECTED EFFLUENTS IN THE LOWER FARMINGTON RIVER.

Effluent	Period ending 7 - 14 - 67	Period ending 7 - 18 - 67	Period ending 8 - 22 - 67
Charles W. House & Sons		Definite effects to 100 m downstream	Definite effects to 85 m downstream
Pioneer Steel Ball	No effect		
Pequabuck River	Definite effects to 30 m downstream	Definite effects to 6 m downstream	Partial effects to 6 m downstream
Farmington Municipal Sewage Plant	No effect	Possible effects to 0.5 m downstream	No effect
Ensign-Bickford Co.	Possible effect at effluent entrance	Partial effect at effluent entrance	No effect
Salmon Brook			No effect
Tariffville Sewage Treatment Plant	Possible effect at effluent entrance	Definite effect at effluent entrance	No effect

TABLE 23. TWENTY-FOUR AND 96 HOUR TLms AND BOD OF SELECTED EFFLUENTS IN THE LOWER FARMINGTON RIVER.

Effluent collected	7-66 *Rhinichthys atratulus*	7-66 *Rhinichthys atratulus*	8-66 *Rhinichthys atratulus*	9-66 *Notropis cornutus*	11-66 *Notropis bifrenatus*	11-66 *Notropis bifrenatus*	12-66 *Notropis bifrenatus*	9-16-66 BOD
Charles W. House & Sons	<1/ 22.8	3.2/3.2 21.1			>10/6 10	3.9/1.7 10	>5/>5 10	
Pioneer Steel Ball		>100/>100 (3 effluents) 21.1						
Pequabuck River	>100/>100 22.8		>100/>100 21.1					40
Farmington Municipal Sewage Plant	96/96 22.8							32
Ensign-Bickford Company	>100/>100 17.2 + 22.8							7
Tariffville Municipal Sewage Treatment Plant	63.5/ 22.8		<70/<70 21.1	7/7 21.1				120
Combustion Engineering	>100/>100 22.8			>100/94 21.1				

TLm 24/96 over Temperature (C)

TABLE 24. RESPONSES OF *NOTROPIS CORNUTUS* TO THE C. W. HOUSE & SONS, INC. EFFLUENT.*

# Fish	Exposure time (min.) a	Exposure time (min.) b	% survival (24 hr.) a	% survival (24 hr.) b	% survival (48 hr.) a	% survival (48 hr.) b	% survival (72 hr.) a	% survival (72 hr.) b	% survival (96 hr.) a	% survival (96 hr.) b
2	2:00	0:40	50	100	50	100	50	100	50	100
2	3:40	1:35	50	100	50	100	50	100	50	100
2	5:25	2:17	100	100	100	100	100	100	100	100
2	9:30	3:12	100	100	100	100	100	100	100	100
2	16:10	4:52	100	100	100	100	100	100	50	100
2	18:25	5:55	100	100	50	100	50	100	50	100
2	21:37	6:42	100	50	100	50	100	50	50	50
2	24:18	7:00	100	100	100	100	100	100	100	100
2	32:00	7:55	100	100	100	100	100	100	100	100
1		10:07		100		100		100		100
1		10:45		100		100		100		100

* Effluent collected 9-8-67 a = 50% effluent; b = 100% effluent

TABLE 25. RESPONSES OF *FUNDULUS DIAPHANUS* TO THE C. W. HOUSE & SONS, INC. EFFLUENT.*

Number of Fish	Exposure Time (minutes)	Recovery Time (minutes)
4	11:24	17–53
4	12:51	51–105
4	14:02	50–104
4	15:00	14–101
4	16:09	48–99
4	16:30	12–99
4	16:42	47–101
4	17:57	180–295
4	19:30	178–293
4	20:00	9–96
3	22:15	176–291
4	23:00	6–93
4	25:15	91–1140
4	27:00	2–89
4	29:00	87–1138
4	32:00	84–1134

* Effluent collected 9-22-67

TABLE 26. MEAN DAILY TEMPERATURES (C) OF AREAS AFFECTED BY SELECTED EFFLUENTS IN THE LOWER FARMINGTON RIVER.

Effluent	Date	Upstream 2 m	Upstream 0.5 m	Entrance effluent	Downstream 0.5 m	Downstream 5 m	Downstream 10 m
Farmington Municipal Sewage Treatment Plant	7-19-67	25.7			23.5		
	7-20-67	24.8			23.6		
	7-21-67	25.2			23.6		
	7-22-67	25.0			23.4		
	7-23-67	24.7			23.5		
	7-24-67	24.1			23.1		
	7-25-67	24.5			23.5		
Tariffville Municipal Sewage Treatment Plant	9-12-67		17.5	20.6			17.2
	9-13-67		16.5	20.6			16.5
	9-14-67		17.0	20.6			17.1
	9-15-67		17.4	20.6			17.9
	9-16-67		18.1	21.0			18.3
	9-17-67		19.0	21.0			19.1
	9-18-67		19.7	21.1			20.0
	9-19-67		20.1	20.6			20.4
Pequabuck River	9-19-67	20.6				21.1	
	9-20-67	20.3				19.6	
	9-21-67	19.6				20.6	
	9-22-67	20.0				20.6	
	9-23-67	18.8				18.9	
	9-24-67	17.7				17.1	
	9-25-67	16.2				15.4	
	9-26-67	16.2				14.6	
	9-27-67	16.4				15.0	
	9-28-67	16.6				16.8	
	9-29-67	17.2				18.4	

TABLE 27. MEANS AND RANGES OF TOTAL ALKALINITY IN THE LOWER FARMINGTON RIVER.

	Stations 1-5		Stations 6-8		Stations 9-12		Stations 13-15		Station 16		All
Month	# Obs.	mg/liter*	# Obs.	mg/liter*	# Obs.	mg/liter*	# Obs.	mg/liter*	# Obs.	mg/liter*	Average
7/66	5	27.8	3	31.6	3	35.3	3	32.7	1	30	31.4
		(24–48)		(24–37)		(31–40)		(31–35)			
8/66	10	25.6	6	35.3	8	33.8	6	36.3	2	30	31.8
		(18–33)		(23–58)		(31–38)		(31–39)			
9/66	5	18.4	3	21.3	4	32.0	3	31.7	1	27	25.4
		(11–22)		(20–24)		(23–36)		(29–35)			
10/66	10	15.1	6	16.9	8	19.2	6	19.4	2	15.5	17.4
		(12–22)		(14–23)		(15–24)		(16–25)		(14–17)	
11/66	10	12.6	6	12.7	8	16.9	6	19.0	2	18.9	15.1
		(10–15.4)		(10.5–14.8)		(15.3–18.2)		(16.0–18.5)		(17.8–20.0)	
12/66	5	11.9	3	12.4	4	16.2	3	17.0	1	16.3	14.3
		(11.4–14.2)		(12.3–12.6)		(16.0–17.1)		(16.4–17.7)			
1/67	7	12.2	5	12.7	4	18.3	—	—	1	18.3	13.1
		(11.9–12.4)		(12.2–13.2)		(17.1–19.4)					
2/67	5	11.0	3	15.2	4	20.4	3	21.1	1	20.2	16.6
		(0–15.1)		(14.5–15.8)		(20.0–21.2)		(20.8–21.5)			
3/67	10	10.2	4	11.3	8	14.4	6	12.6	2	14.9	13.2
		(6.1–12.7)		(11.1–11.8)		(13.5–15.7)		(10.6–17.2)		(14.2–15.6)	
4/67	10	7.2	6	8.8	8	10.4	6	11.5	2	11.6	9.2
		(0–9.2)		(7.8–9.8)		(9.0–13.0)		(10.2–13.0)		(10.2–13.0)	
5/67	10	9.8	6	11.0	8	14.2	6	14.8	2	15.1	13.3
		(7.7–12.0)		(9.0–13.5)		(11.1–17.3)		(11.9–17.8)		(12.2–18.0)	
6/67	10	13.7	5	14.3	8	18.3	6	20.5	2	21.1	16.4
		(10.8–14.6)		(13.8–14.8)		(15.0–20.8)		(20.1–20.8)		(20.6–21.6)	
7/67	10	16.7	6	17.5	8	21.5	6	21.6	2	22.4	19.2
		(14.7–18.0)		(18.0–20.0)		(18.0–25.1)		(18.6–28.8)		(19.8–25.0)	
8/67	15	19.7	9	22.3	12	32.2	8	33.6	1	29.5	26.7
		(16.3–22.8)		(21.8–23.1)		(29.0–33.6)		(32–35.3)			
9/67	5	20.1	3	20.5	4	24.1	3	25.7	2	28.9	22.3
		(17.8–22)		(11.7–26.7)		(17.5–30.6)		(19.0–30.5)		(27.0–30.1)	
10/67	5	12.9	3	13.3	4	17.3	3	19.4	1	18.5	15.6
		(12.2–13.7)		(12.8–13.7)		(16.5–18.3)		(18.5–20.2)			
Means											
All date		15.2		17.4		21.3		22.2		24.8	

* Equivalent $CaCO_3$

TABLE 28. MEAN GROSS ESTIMATES OF COMMUNITY METABOLISM* IN THE LOWER FARMINGTON RIVER.

Method of Calculation: Respiration Line	Method of Calculation: Diffusion Constant	Time	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6
Odum (1956)	Odum (1956)	Oct-Dec 1966	3.5/0.5	3.9/4.9	—	6.8/14.6	2.4/2.2	2.5/2.9
		June-Nov 1967	15.0/5.2	8.5/11.6	4.7/20.7	6.5/10.9	9.9/13.8	4.3/2.3
Odum (1956)	Whitworth & Lane (1969)	Oct-Dec 1966	3.9/1.4	8.3/25.0	—	16.8/32.3	71.0/34.6	2.8/6.2
		June-Nov 1967	23.1/4.5	11.2/17.7	13.6/45.2	14.9/42.1	10.3/18.2	5.2/21.4
Copeland & Dorris (1962)	Odum (1956)	Oct-Dec 1966	9.2/3.8	7.5/7.1	—	23.0/24.7	8.0/5.2	5.9/4.7
		June-Nov 1967	50.3/16.6	22.8/22.2	30.4/64.0	40.8/55.2	21.1/23.2	10.8/4.1
Copeland & Dorris (1962)	Whitworth & Lane (1969)	Oct-Dec 1966	10.0/4.7	16.4/28.8	—	41.3/46.3	12.5/36.7	6.3/8.1
		June-Nov 1967	34.2/13.6	19.1/16.0	19.1/16.0	20.2/20.8	20.5/18.8	12.6/26.0
# Daily Estimates		Oct-Dec 1966	1	1	0	1	1	1
		June-Nov 1967	5	5	15	10	11	18

* production/respiration in g/m^3/day

TABLE 29. MONTHLY MEANS AND RANGES OF SPECIFIC CONDUCTANCE* IN THE LOWER FARMINGTON RIVER.

Month	Stations 1 - 5 # Obs.	Stations 1 - 5 Mg/liter	Stations 6 - 8 # Obs.	Stations 6 - 8 Mg/liter*	Stations 9 - 12 # Obs.	Stations 9 - 12 Mg/liter*	Stations 13 - 15 # Obs.	Stations 13 - 15 Mg/liter*	Station 16 # Obs.	Station 16 Mg/liter*	All Average
11/66	5	108	3	105	4	131	3	126	1	127	118
		(107-112)		(99-112)		(119-140)		(118-134)		—	
12/66	5	103	3	128	1	130	–	–	–	–	114
		(98-112)		(109-153)		—		—		—	
1/67	–	–	–	–	–	–	–	–	–	–	–
2/67	5	164	2	152	4	222	3	203	1	206	188
		(132-238)		(151-152)		(209-236)		(194-208)		—	
3/67	10	146	4	152	6	185	6	184	2	157	164
		(103-174)		(130-176)		(158-212)		(162-206)		(153-161)	
4/67	9	112	6	116	8	134	6	140	2	142	126
		(103-118)		(104-125)		(124-144)		(129-151)		(133-151)	
5/67	5	111	3	125	4	149	3	157	1	160	135
		(104-119)		(110-147)		(130-160)		(151-162)		—	
6/67	10	124	5	136	8	159	6	159	2	170	145
		(114-138)		(129-143)		(136-176)		(143-176)		(164-175)	
7/67	10	126	6	132	7	144	6	159	2	147	139
		(112-137)		(122-140)		(126-156)		(155-169)		(134-160)	
8/67	5	123	3	140	4	150	3	163	1	133	141
		(112-129)		(128-158)		(140-156)		(159-167)		—	
Mean All Dates		125		131		157		161		155	

*micromhos/cm at 25C

CONCLUSIONS

We conclude that (1) the lower Farmington River appears capable of supporting a significant run of American shad, (2) productivity of the river is influenced by the effluents entering the river, and (3) existing populations of game fishes are not using the energy source of forage fishes available in the river.

The river from Collinsville to the gravel pit is currently the most productive ("game" fish) section of the lower Farmington River and, although American shad should be able to spawn and grow in many areas of this section, American shad interests should be second to those of smallmouth bass (natural reproduction) and trout (stocked). The gravel pit is often turbid but is probably a suitable area for young American shad to grow; young spawned in sites above the gravel pit would probably not compete with the smallmouth bass and trout populations. The increase in (1) turbidity caused by the gravel pit, (2) turbidity and ions added by the discharge of the Pequabuck River, and (3) ions added by the Farmington Municipal Sewage Treatment Plant, combined with the change to a lower gradient and shifting sand bottom that predominates from Farmington to Tariffville increases the chances of occasional catastrophies to fish in this section. Temperature and pollution changes in this area could be quite severe. There are many areas in this section that seem satisfactory for American shad spawning and numerous sites close to most spawning areas that would be adequate for young American shad to grow: plankton (Table 16) and bottom fauna (Table 17) populations seemed adequate to support young American shad—and young and adults of most species of "game" fishes. Because fish would tend to concentrate in the deeper areas, especially from Simsbury to Tariffville, there could be significant competition between American shad and the resident fishes and predation of the young American shad by the resident fishes. A decision regarding American shad or a resident "game" fish population might have to be reached. Young American shad should have little trouble moving through Tariffville gorge in the fall and there are areas in the gorge that would be adequate for spawning adults. There are numerous nursery areas for the young fish between the gorge and the Rainbow Reservoir Dam. Other estimates of the ability of American shad to withstand various environmental changes in the Susquehanna (Carlson *et al.*, 1968) and Delaware (Barker, 1965; Chittendon, unpublished reports) Rivers were similar to ours and we believe American shad would be able to tolerate the environmental conditions found in the lower Farmington River.

Our evaluation of the existing effluent sources concurs with Bock *et al.* (1965) considering the present river and effluent discharges, i.e., fish populations should not be measurably affected by them. Fish swimming into either the most toxic industrial (Charles W. House & Sons, Inc.) or domestic (Tariffville Municipal Sewage Treatment Plant) effluent should seldom die because, after losing equilibrium, they would be carried downstream by the water mass to areas unaffected by the effluents and recover. The general influx of effluents around Farmington, i.e., the effects of the gravel pit, Pequabuck River and Farmington Municipal Sewage Treatment Plant, as indicated by measurements and observations of total alkalinity, specific conductance, community metabolism, temperature, and fishes, coupled with the change from a steeper gradient, rocky bottom to a lower gradient shifting sands, bottom suggests a potential detriment to the fish fauna.

Although there was not as much data available as desired we feel that the growth and population densities of desirable fishes is very low and feel reclamation is the best answer.

RECOMMENDATIONS

(1) Further studies concerning the fisheries of the lower Farmington River are not economically justified until the fish-passage facilities at Rainbow Reservoir are within approximately four years of completion. A general limnological survey should then be conducted for one year, followed by a complete or partial reclamation of the lower river from the grist-mill dam in Farmington to the dam at Rainbow Reservoir. Eggs and adults of American shad and eggs, smolts, or adults of some anadromous salmonid should be introduced the following spring or fall. This general survey should be conducted for at least three years following initial stocking of these anadromous fishes. Selection of the anadromous salmonid should consider the results of the sea-run brown trout and coho salmon projects currently underway in Connecticut and be consistent with the reintroduction of Atlantic salmon in the Connecticut River.

(2) A reclamation project from the grist-mill dam in Farmington to the dam at Rainbow Reservoir should be undertaken immediately if anadromous salmonids are not to be introduced in the foreseeable future. The area should be restocked with largemouth bass from the grist-mill dam in Farmington to Pickerel Cove in Tariffville; northern pike in Pickerel Cove; and northern pike, or largemouth bass, or both, and landlocked alewife (possibly golden shiner) in Rainbow Reservoir. These fish could be destroyed if plans are changed regarding the anadromous fishes.

(3) The acquisition of more land adjoining the river should be continued. Development of boat access areas should be delayed until the anadromous fisheries are established and good fishing areas determined. Since there are a reasonable number of boat access points within most areas that could be used if a warm-water fishery was developed in the interim period we feel the fishermen could use the fishery.

(4) Although the existing effluent sources studied do not appear to have any serious effects on the biota of the river, especially fishes, certain effluents, individuals, and riparian owners are seriously effecting the aesthetic values of the lower Farmington River. Cleaning up the basin and shores of the Farmington River would be a most worthy venture of the Farmington River Watershed Association to supervise. There are probably many adult and scout groups in the area that would be willing to help.

(5) Another useful project would be to produce a guide to the river for recreationists. Appendix A contains some of the information we have on the lower Farmington River. We would be glad to assist anyone in this venture.

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APPENDIX A

RECREATIONAL OPPORTUNITIES ON THE FARMINGTON RIVER

A wide range of activities are available to anyone wishing to observe the wondrous sights and challenges of nature on the Farmington River—from canoeing the rapids at Unionville and Tariffville Gorge to leisurely boating on the placid waters from Farmington to Tariffville.

The section of the river from Collinsville to the gravel pit in Farmington has a rapid discharge with alternating pools and riffles. The bedrock, large boulder, and rock bottom type in the riffles are generally passable for small boats and canoes. Public access to this section for canoeists and boat fishermen is restricted to the Fish and Game access area and the site of the old Collinsville Ax Company. The spring, early summer, and fall seasons generally offer the greatest canoeing challenge because of the increased flows that usually occur at these times. Travel time between Collinsville and the gravel pit averages about two hours. Angling from shore or boat is excellent for trout, smallmouth bass, rockbass, and panfish. Large schools of minnows, song and shore birds can be seen by a keen eye in this section.

Although the active dredging operations of the Connecticut Sand and Gravel Company increase the turbidity of the water downstream, the reservoir excavated by the gravel pit provides an excellent canoeing, boating and fishing area (panfish, pickerel, and largemouth bass).

The gradient from the gravel pit downstream to the power lines in Farmington is reduced with fewer riffles and shallower pools than the upstream areas with the exception of one long deep pool beginning at the mouth of the Pequabuck River and ending downstream at the grist-mill dam. Canoeing and boating in this section is hampered by low river discharges exposing the shallow riffles in the summer and during periods of decreased precipitation. Accessible boat and canoe launching points are numerous; travel can begin at the gravel pit, at the Pequabuck River Meadow Road Bridge or between these points by traveling the farm road connecting to Meadow Road. The Farmington River is a very short distance from the Meadow Road Bridge, making the Pequabuck River an excellent entrance or exit for fishermen, boating enthusiasts and canoeists. The few deep pools immediately downstream from the gravel pit contain some trout, but generally warm-water species (largemouth bass, black crappie, pickerel, sunfish, and rockbass) occur in this section and downstream. The reduced gradient and small shallow backwater areas appear to be excellent brooding sites for migratory waterfowl. Both juvenile and adult black and mallard ducks were commonly observed in late spring and early summer. The shallow riffles also provide excellent white sucker spawning areas in the spring. Although the grist-mill dam prevents continuous travel, small boats and canoes may be easily portaged. Traveling from the gravel pit to the power lines takes less than three hours.

The river widens and decreases further in gradient from the power lines downstream to the boat access area in Simsbury. There are a few shallow areas, but small boats and canoes are able to pass freely except at times of exceptionally low river discharges. The steep river banks in this section make public access difficult. The small tertiary road which parallels the power lines linking with Girard Avenue in Farmington is an excellent entry point to the river. The sand bottom is generally unproductive of game fish except in the large weed beds, where largemouth bass and panfish are frequently caught. Shore and song birds, large schools of minnows, and waterfowl can be seen in this section. Canoeists and boating enthusiasts who desire a long relaxed trip may enjoy taking the half a day required to paddle this section.

The river meanders from the boat access area in Simsbury downstream to the mouth of Salmon Brook, the depth increasing downstream. This section of the river is passable throughout the year for even large fishing boats. Angling for eels, carp, pickerel, panfish, and largemouth bass may be productive. Rafts of black ducks and mallards and the numerous shore birds merit a visit to this section of the Farmington River in the autumn.

Through Tariffville Gorge the river has fewer deep pools, but more riffles and many large boulders. Downstream from the old dam site, the river deepens for a short distance then widens to many shallow riffles and eventually forms the Rainbow Reservoir. Because of the steep gradient and hence very fast current, the gorge offers a challenge for the most experienced canoeist. The spring and early summer seasons afford the greatest challenge in contrast to the dry seasons which expose the shallow riffles. The upstream section of the reservoir has impassable areas most seasons of the year.

Canoeing the gorge takes less than an hour, although an additional two hours are needed to travel to the Fish and Game access area in Rainbow Reservoir. Public access points to the upstream portion of this section are limited to the entrance from Salmon Brook or via a tertiary road which connects to Main Street in Tariffville. The Fish and Game access area for people using Rainbow Reservoir provides an excellent launching or docking area. Fishing in the upper reaches of this section is restricted to the shore because of the rapid current, whereas trolling and still fishing are possible in Rainbow Reservoir. Panfish, pickerel, carp, and largemouth bass are the species most commonly caught in this section of the river. Boating and water skiing are also possible in this large reservoir.

Whether your interests are in fishing, boating, canoeing, or observing the wonders of nature in either a single section or the entire 30.3 miles from Collinsville to Rainbow, a trip on the Farmington River will be an exciting, interesting, and educational experience.