NEW JERSEY
1980
STATE WATER QUALITY INVENTORY

REPORT TO CONGRESS
THROUGH THE
U.S. ENVIRONMENTAL PROTECTION AGENCY
(PURSUANT TO SECTION 305 (B) PL 95–217)

Prepared By
NEW JERSEY
DEPARTMENT OF
ENVIRONMENTAL PROTECTION
DIVISION OF WATER RESOURCES

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CHAPTER V

ANALYSIS OF THE OCCURRENCE AND DISTRIBUTION OF TOXIC SUBSTANCES IN NEW JERSEY'S SURFACE AND GROUND WATERS

The New Jersey Department of Environmental Protection developed a program in 1977 to sample and evaluate the presence of toxic substances in the state's ground and surface waters. The Program on Environmental Cancer and Toxic Substances (PECTS) with the assistance of various other offices in the Department has been conducting this program throughout the state. The sampling sites for both ground and surface waters have been selected with the help of the Division of Water Resource's Office of Areawide Planning in 1977 and 1978. The results of these first two years of sampling are discussed in this chapter. All laboratory work was performed by the Department of Environmental Sciences of Rutgers University.

Surface waters sampled in 1977-1978 were from only two areas of the state - the Northeast and Monmouth County Water Quality Planning Areas. Groundwaters were sampled in both the Northeast and Monmouth County areas, as well as in the Upper and Lower Delaware and the Upper Raritan Water Quality Planning areas.

All results presented in this chapter are taken directly from the Water Quality Management Plans for each respective area. These plans were completed in 1979 and certified by the Governor in March 1980. Results are discussed in two sections - "Surface Water Analysis" and "Ground Water Analysis".

The PECTS office is currently preparing summaries on both the surface and ground waters data collected in the state through this program for the last three years. These summaries will evaluate areas and data not covered in this report.

Partly as a result of the information gathered through the surface and groundwater toxics sampling program, various actions have been taken by the State regarding the further evaluation and the control of toxic substances in the environment. The specific activities which are underway to address the problem of toxics include:

- Expansion of the toxic substance monitoring program in the ground and surface waters.

- Revision of surface and ground water standards to include numerical limits for toxics and hazardous substances.

- Development of a permit and enforcement program for facilities which accept hazardous wastes.

- Registration program for haulers of hazardous substances.

- Development of the Interagency Hazardous Waste Strike Force.

- Participation in the development of an Interstate Manifest System.

- Establishment of procedures to set limits for toxic and hazardous substances from wastewater discharges to ground and surface waters.

- Development of a State permit program for wastewater discharges to ground and surface waters.

- Development of an industrial pretreatment program.

- Implementation of a spill prevention and spill clean-up program for active solid waste operations.

- Development of a hazardous substance control program for abandoned storage or disposal sites.

- Implementation of a hazardous substance manifest system.

Surface Water Analysis

exerpted from the following:

Northeast Water Quality Management Plan
New Jersey Department of Environmental Protection
Division of Water Resources
April 1, 1979

Monmouth County Water Quality Management Plan
New Jersey Department of Environmental Protection
Division of Water Resources
April, 1979

Toxic and Carcinogenic Substance Monitoring Program

A study to identify toxic and carcinogenic substances within the surface waters of the Northeast WQM planning area was implemented by the Water Quality Management Planning Program. The purpose of this sampling program, the first of its kind for this area of New Jersey, was to take one time grab samples throughout the study area to provide a foundation for future toxic sampling programs. With the knowledge and questions raised by this effort, more comprehensive and intensive studies can be developed. A list of parameters evaluated can be found in Table V-1, with location of toxic sampling sites illustrated in Figure V-A.

The analytical instrumentation employed, e.g. gas chromatography with electron capture detector, has the capability of measuring contamination as low as ten parts per trillion (10 nanograms per liter), however, as the sensitivity of the analytical techniques increases, so does the probability of error. When analyses are being conducted in the parts-per-trillion range, there is increased possibility of sample contamination, as well as instrument and observer variability. The testing procedures, as they require analysis of many complex compounds, are still in the early stages of development and should be treated as such. Since a one time grab sample was employed; this single sample value may not represent the true ambient quality.

(A) Volatile Organic Compounds

Organic compounds were found throughout the study area in various concentrations (mostly in parts per trillion levels). The parameters observed most frequently included: chloroform, bromodichloromethane, bromoform, and dibromochloromethane. EPA research has concluded that these and other similar organics are formed through the process of chlorination. Since wastewater facilities are present throughout the 208 area, they are probably a prime source of these toxics.

Organic compounds which are associated with the commercial and industrial sectors were generally found throughout the study area in parts per trillion quantities. These parameters and some of their applications for commercial and industrial use are methylene chloride (paint stripper, soluent, cleaner); 1,1,1 trichloroethylene, 1,1,2,2 tetrachlorethane (metal degreaser, dry cleaner); carbon tetrochloride (refrigerant, propellant, dry cleaner); 1,1,1 trichloroethane (cold cleaning solvent for machinery, batch cleaning); 1,1,2,2 tetrachloroethylene (dry cleaner).

Table V-2 summarizes the sampling results for volatile organic compounds, polynuclear aromatic hydrocarbons, PCB's and insecticides, and metals. Since one time sampling was employed, results for the tributaries and sections of the rivers main stems were aggregated for analysis.

The table lists the percentage of samples in which each parameter was found, and the total number of samples taken, for each segment. The percentages listed are for any detectable (machine measurable) concentration, therefore they indicate compounds present, but are not quantitative measures. There are no federal or state standards for volatile organic compounds, with the exception of the trihalomethanes (denoted by an asterisk on Table V-2). The trihalomethanes which has an EPA recommended limit of 100 parts per billion of the sample. The results of this sampling program indicate that there were no violations of these procedures for the recommended limits.

(B) Aromatic Hydrocarbon

These compounds (o,m,p diclorobenzene and trichlorobenzene) were found only in the urban portions of the study area (tidal waters). The Arthur Kill, Newark Bay and the Hudson River all showed evidence of these compounds. No Federal or State standards exist for these parameters. These materials are used as metal cleaners, solvents, dielectric fluids, lubrication and other industrial and commercial purposes.

(C) PCB (Polychlorinated biphenyls) and Pesticides

PCB's were found throughout the study area, with concentrations in the parts per trillion range. Although the concentrations found for PCB's are in violation of EPA recommended levels for aquatic organics (one part per trillion), they conform to the requirements for finished potable water (one part per billion). Further study is suggested to identify the probable sources of PCB's. Additional verification, through intensive survey, would be required to confirm quantitative values. PCB's are used in the manufacturing process as a medium in electric transformers and as a solvent for plastics paints, licquers, lubricants and waxes.

Pesticides were found sporadically in the urban industrial areas (Kill Van Kull, Hudson River, Hackensack River, Newark Bay, and Arthur Kill). Pesticides were found in the Pompton River and Upper Passaic less frequently. As mentioned with the PCB's, the levels recommended by the EPA are exceeded

Table V-1

Parameter Evaluated in the Northeast Study Area

LAS	Dibromochloromethane	Lindane
Fluorides	Trifluoromethane	Aldrin
Cyanides	Carbon tetrachloride	Dieldrin
Dissolved Solids	1,2, dibromoethane	Heptachlor
Beryllium	1,2, Dichloroethane	Heptachlor Epoxide
Sodium	1,1,1, Trichloroethane	Toxaphene
Methylene Chloride	Vinyl Chloride	O,P'-DDE
Methyl Chloride	1,1,2,2, Tetrachloroethylene	P,P'-DDT
Methyl Bromide	O,M,P - Dichloro Benzene	P,P'-DDT
Bromoform	Diiodomethane	Methyoxchlor
Bromodicloromethane + 1,1,2 - Trichloroethylene	Polychlorinated Biphenyl	Mirex
1,1,2,2 - Tetrachloroethane	BHC - (alpha)	Endrin
1,1,2-Trichloroethane	BHC-B C-(beta)	Chlordane

Table V-2

Frequency (Percent) of Toxic Substances Detected

Example: (# of Cases Sampled) % Detected

Parameters / Segment	Upper Passaic	Whippany	Rockaway	Mid Passaic	Pequannock	Wanaque	Ramapo	Pompton	Lower Passaic	Peckman	Saddle River	Ho-Ho-Kus Brook	Rahway	Arthur Kill	Newark Bay	Kill Van Kull	Upper New York Bay	Hudson	Hackensack
Silver	(10) 0	(6) 0	(10) 0	(5) 0	(8) 0	(5) 0	(4) 0	(4) 0	(18) 0	(5) 0	(7) 0	(3) 0	(7) 14	(3) 0	(4) 0	(2) 0	(2) 0	(3) 0	(12) 8
Arsenic	(10) 60	(6) 50	(10) 20	(5) 40	(8) 13	(5) 0	(4) 0	(4) 0	(18) 94	(5) 40	(7) 57	(3) 100	(7) 100	(3) 100	(4) 100	(2) 100	(2) 100	(3) 100	(12) 92
Beryllium	(10) 0	(6) 0	(10) 0	(5) 0	(8) 0	(5) 0	(4) 0	(4) 0	(18) 0	(5) 0	(7) 0	(3) 0	(7) 0	(3) 33	(4) 0	(2) 0	(2) 50	(3) 0	(12) 0
Cadmium	(10) 0	(6) 0	(10) 10	(5) 0	(8) 0	(5) 0	(4) 0	(4) 0	(18) 0	(5) 0	(7) 0	(3) 0	(7) 0	(3) 0	(4) 50	(2) 50	(2) 100	(3) 0	(12) 0
Copper	(10) 70	(6) 100	(10) 80	(5) 100	(8) 75	(5) 40	(4) 75	(4) 100	(18) 94	(5) 100	(7) 85	(3) 100	(7) 0	(3) 100	(4) 100	(2) 100	(2) 100	(3) 100	(12) 100
Chromium	(10) 70	(6) 33	(10) 50	(5) 100	(8) 0	(5) 0	(4) 50	(4) 0	(18) 89	(5) 60	(7) 71	(3) 100	(7) 86	(3) 100	(4) 100	(2) 100	(2) 100	(3) 100	(12) 83
Iron	(10) 100	(6) 100	(10) 100	(5) 100	(8) 100	(5) 100	(4) 100	(4) 100	(18) 100	(5) 100	(7) 100	(3) 100	(7) 100	(3) 100	(4) 100	(2) 100	(2) 100	(3) 100	(12) 100
Mercury	(10) 20	(6) 17	(10) 10	(5) 20	(8) 0	(5) 0	(4) 0	(4) 0	(18) 56	(5) 2	(7) 14	(3) 0	(7) 0	(3) 66	(4) 50	(2) 50	(2) 100	(3) 67	(12) 83
Manganese	(10) 100	(6) 100	(10) 90	(5) 100	(8) 100	(5) 100	(4) 100	(4) 100	(18) 56	(5) 100	(7) 100	(3) 100	(7) 0	(3) 100	(4) 100	(2) 100	(2) 100	(3) 100	(12) 100
Sodium	(10) 100	(6) 100	(10) 100	(5) 100	(8) 100	(5) 100	(4) 100	(4) 100	(18) 100	(5) 100	(7) 100	(3) 100	(7) 100	(3) 100	(4) 100	(2) 100	(2) 100	(3) 100	(12) 100
Nickle	(10) 20	(6) 100	(10) 20	(5) 80	(8) 0	(5) 60	(4) 75	(4) 25	(18) 22	(5) 60	(7) 28	(3) 67	(7) 100	(3) 100	(4) 75	(2) 100	(2) 100	(3) 100	(12) 75
Lead	(10) 90	(6) 100	(10) 80	(5) 100	(8) 50	(5) 80	(4) 100	(4) 100	(18) 89	(5) 100	(7) 100	(3) 100	(7) 100	(3) 100	(4) 100	(2) 100	(2) 100	(3) 100	(12) 92
Selenium	(10) 50	(6) 0	(10) 0	(5) 0	(8) 13	(5) 20	(4) 0	(4) 0	(18) 0	(5) 0	(7) 0	(3) 0	(7) 100	(3) 67	(4) 75	(2) 100	(2) 100	(3) 100	(12) 17
Zinc	(10) 70	(6) 83	(10) 50	(5) 80	(8) 50	(5) 0	(4) 25	(4) 0	(18) 94	(5) 80	(7) 28	(3) 67	(7) 100	(3) 100	(4) 100	(2) 100	(2) 100	(3) 100	(12) 83

Table V-2 cont.

Frequency (Percent) of Toxic Substances Detected

Example: (# of Cases Sampled) % Detected

Parameters \ Segment	Upper Passaic	Whippany	Rockaway	Mid Passaic	Pequannock	Wanaque	Ramapo	Pompton	Lower Passaic	Peckman	Saddle River	Ho-Ho-Kus Brook	Rahway	Arthur Kill	Newark Bay	Kill Van Kull	Upper New York Bay	Hudson	Hackensack
Diiodomethane	(13) 0	(8) 0	(10) 0	(5) 0	(8) 0	(5) 0	(4) 0	(4) 0	(17) 0	(5) 0	(7) 0	(3) 0	(7) 0	(3) 67	(4) 50	(2) 50	(2) 50	(3) 33	(11) 0
Polychlorinated Biphenyl (PCBS)	(13) 54	(8) 88	(10) 90	(4) 75	(8) 88	(5) 100	(4) 75	(3) 67	(16) 88	(5) 80	(7) 100	(3) 100	(7) 100	(3) 33	(4) 25	(2) 0	(2) 50	(3) 33	(10) 80
BHC ∝	(13) 0	(8) 13	(10) 0	(4) 0	(8) 0	(5) 0	(4) 0	(3) 0	(16) 13	(5) 0	(7) 0	(3) 0	(7) 0	(3) 33	(4) 25	(2) 0	(2) 0	(3) 0	(11) 0
BHC B	(13) 54	(8) 25	(10) 10	(4) 75	(8) 0	(5) 0	(4) 25	(3) 33	(16) 25	(5) 0	(7) 0	(3) 0	(7) 14	(3) 67	(4) 25	(2) 100	(2) 0	(3) 33	(11) 36
Lindane	(13) 8	(8) 0	(10) 0	(4) 50	(8) 0	(5) 0	(4) 0	(3) 33	(16) 0	(5) 0	(7) 0	(3) 0	(7) 0	(3) 0	(4) 0	(2) 0	(2) 0	(3) 0	(11) 9
Aldrin	(13) 0	(8) 13	(10) 0	(4) 0	(8) 0	(5) 0	(4) 0	(3) 0	(16) 0	(5) 0	(7) 0	(3) 0	(7) 0	(3) 0	(4) 0	(2) 0	(2) 50	(3) 33	(11) 9
Dieldrin	(13) 15	(8) 25	(10) 10	(4) 0	(8) 0	(5) 0	(4) 0	(3) 33	(16) 0	(5) 0	(7) 0	(3) 0	(7) 0	(3) 0	(4) 0	(2) 0	(2) 0	(3) 0	(11) 9
Heptachlor	(13) 0	(8) 13	(10) 0	(4) 0	(8) 13	(5) 0	(4) 0	(3) 67	(16) 0	(5) 20	(7) 0	(3) 0	(7) 14	(3) 67	(4) 50	(2) 100	(2) 0	(3) 67	(11) 9
Toxaphene	(13) 0	(8) 0	(10) 0	(4) 0	(8) 0	(5) 0	(4) 0	(0) 0	(16) 0	(5) 0	(7) 0	(3) 0	(7) 0	(3) 0	(4) 0	(2) 0	(2) 0	(3) 0	(11) 0
O,P'-DDE	(13) 15	(8) 13	(10) 0	(4) 0	(8) 0	(5) 0	(4) 0	(3) 67	(16) 0	(5) 0	(7) 0	(3) 0	(7) 0	(3) 0	(4) 25	(2) 0	(2) 0	(3) 0	(11) 18
O,P'-DDT	(13) 8	(8) 13	(10) 0	(4) 0	(8) 0	(5) 0	(4) 0	(3) 0	(16) 0	(5) 0	(7) 0	(3) 0	(7) 0	(3) 0	(4) 0	(2) 50	(2) 0	(3) 33	(11) 9
P,P'-DDD	(13) 8	(8) 0	(10) 0	(4) 0	(8) 0	(5) 0	(4) 0	(3) 0	(16) 0	(5) 0	(7) 0	(3) 0	(7) 0	(3) 0	(4) 0	(2) 50	(2) 0	(3) 67	(11) 9
P,P'-DDT	(13) 8	(8) 0	(10) 0	(4) 0	(8) 0	(5) 0	(4) 0	(3) 0	(16) 0	(5) 0	(7) 0	(3) 0	(7) 0	(3) 0	(4) 0	(2) 50	(2) 0	(3) 33	(11) 9
Methyoxychlor	(13) C	(8) 0	(10) 0	(4) 0	(8) 0	(5) 0	(4) 0	(3) 0	(16) 0	(5) 0	(7) 0	(3) 0	(7) 0	(3) 0	(4) 0	(2) 0	(2) 0	(3) 0	(11) 0
Mirex	(13) 0	(8) 0	(10) 0	(4) 0	(8) 0	(5) 0	(4) 0	(3) 0	(16) 0	(5) 0	(7) 0	(3) 0	(7) 0	(3) 0	(4) 0	(2) 50	(2) 0	(3) 33	(11) 0
Endrin	(13) 8	(8) 0	(10) 0	(4) 0	(8) 0	(5) 0	(4) 0	(3) 33	(16) 0	(5) 0	(7) 0	(3) 0	(7) 0	(3) 0	(4) 25	(2) 50	(2) 0	(3) 0	(11) 9
γ Chloradane	(13) 31	(8) 13	(10) 0	(4) 25	(8) 0	(5) 0	(4) 0	(3) 67	(16) 6	(5) 0	(7) 0	(3) 0	(7) 0	(3) 0	(4) 25	(2) 50	(2) 0	(3) 0	(11) 9
Heptachlor Epoxide	(13) 8	(8) 25	(10) 20	(4) 75	(8) 0	(5) 0	(4) 25	(3) 33	(16) 6	(5) 0	(7) 0	(3) 0	(7) 14	(3) 33	(4) 25	(2) 0	(2) 0	(3) 0	(11) 9

Table V-2 cont.

Frequency (Percent) of Toxic Substances Detected

Example: (# of Cases Sampled) % Detected

Parameters \ Segment	Upper Passaic	Whippany	Rockaway	Mid Passaic	Pequannock	Wanaque	Ramapo	Pompton	Lower Passaic	Peckman	Saddle River	Ho-Ho-Kus Brook	Rahway	Arthur Kill	Newark Bay	Kill Van Kull	Upper New York Bay	Hudson	Hackensack
Methylene Chloride	(13) 0	(8) 0	(10) 0	(5) 0	(8) 0	(5) 0	(4) 0	(4) 0	(19) 0	(5) 0	(7) 0	(3) 0	(7) 0	(3) 0	(4) 25	(2) 0	(2) 50	(3) 67	(11) 0
Methyl Chloride	(13) 0	(8) 0	(10) 0	(5) 0	(8) 0	(5) 0	(4) 0	(4) 0	(19) 0	(5) 0	(7) 0	(3) 0	(7) 0	(3) 0	(4) 0	(2) 0	(2) 0	(3) 0	(11) 0
Methyl Bromide	(13) 0	(8) 0	(10) 0	(5) 0	(8) 0	(5) 0	(4) 0	(4) 0	(19) 0	(5) 0	(7) 0	(3) 0	(7) 0	(3) 0	(4) 0	(2) 0	(2) 0	(3) 0	(11) 0
Chloroform*	(13) 39	(8) 88	(10) 60	(5) 100	(8) 63	(5) 0	(4) 50	(4) 0	(19) 90	(5) 100	(7) 100	(3) 100	(7) 100	(3) 100	(4) 100	(2) 100	(2) 100	(3) 100	(11) 91
Bromoform*	(13) 8	(8) 0	(10) 0	(5) 0	(8) 25	(5) 20	(4) 25	(4) 25	(19) 11	(4) 50	(7) 86	(3) 0	(7) 14	(3) 67	(4) 100	(2) 100	(2) 100	(3) 100	(11) 27
Bromodichloromethane*+ 1,1,2-Trichlorethylene	(13) 85	(8) 100	(10) 60	(5) 100	(8) 63	(5) 100	(4) 100	(4) 100	(19) 84	(5) 80	(7) 86	(3) 100	(7) 71	(3) 100	(4) 100	(2) 100	(2) 100	(3) 67	(11) 91
1,1,2,2 Tetrachloroethane	(13) 15	(8) 13	(10) 0	(5) 10	(8) 25	(5) 60	(4) 25	(4) 75	(19) 37	(5) 0	(7) 0	(3) 0	(7) 0	(3) 0	(4) 0	(2) 0	(2) 0	(3) 0	(11) 0
1,1,2 Trichloroethane	(13) 15	(8) 0	(6) 17	(5) 60	(8) 13	(5) 0	(4) 25	(4) 25	(19) 32	(5) 20	(7) 0	(3) 33	(7) 14	(3) 0	(4) 0	(2) 0	(2) 50	(3) 33	(11) 0
Dibromochloromethane*	(13) 46	(8) 13	(10) 20	(5) 100	(8) 13	(5) 20	(4) 100	(4) 75	(19) 68	(5) 60	(7) 42	(3) 0	(7) 14	(3) 100	(4) 75	(2) 100	(2) 100	(3) 67	(11) 55
Trifluromethane*	(13) 0	(8) 0	(10) 0	(5) 0	(8) 0	(5) 0	(4) 0	(4) 0	(19) 0	(5) 20	(7) 0	(3) 0	(7) 0	(3) 0	(4) 75	(2) 100	(2) 50	(3) 67	(11) 0
Carbon Tetrachloride*	(13) 77	(8) 88	(10) 80	(5) 80	(8) 75	(5) 100	(4) 100	(4) 100	(19) 100	(5) 80	(7) 86	(3) 67	(7) 86	(3) 100	(4) 100	(2) 100	(2) 100	(3) 67	(11) 100
1,2 dibromoethane	(13) 0	(8) 13	(10) 0	(5) 0	(8) 0	(5) 20	(4) 25	(4) 0	(19) 16	(5) 0	(7) 0	(3) 0	(7) 100	(3) 67	(4) 0	(2) 0	(2) 0	(3) 0	(11) 0
1,2 dichloroethane	(13) 0	(8) 0	(10) 0	(5) 0	(8) 0	(5) 0	(4) 0	(4) 0	(19) 0	(5) 0	(7) 0	(3) 0	(7) 100	(3) 67	(4) 25	(2) 50	(2) 0	(3) 0	(11) 0
1,1,1 Trichloroethane	(13) 69	(8) 100	(10) 100	(5) 100	(8) 75	(5) 100	(4) 100	(4) 100	(19) 100	(5) 80	(7) 100	(3) 100	(7) 100	(3) 100	(4) 100	(2) 100	(2) 100	(3) 67	(11) 100
Vinyl chloride	(13) 0	(8) 0	(10) 0	(5) 100	(8) 0	(5) 0	(4) 0	(4) 0	(19) 0	(5) 0	(7) 0	(3) 0	(7) 0	(3) 0	(4) 0	(2) 0	(2) 0	(3) 0	(11) 0
1,1,2,2 Tetrachloroethylene	(13) 85	(8) 75	(10) 70	(5) 100	(8) 100	(5) 100	(4) 100	(4) 100	(19) 100	(5) 80	(7) 100	(3) 100	(7) 100	(3) 100	(4) 100	(2) 100	(2) 100	(3) 100	(11) 100
o,m,p dichlorobenzene	(13) 0	(8) 0	(10) 0	(5) 0	(8) 0	(5) 0	(4) 0	(4) 0	(19) 0	(5) 0	(7) 0	(3) 0	(7) 0	(3) 33	(4) 50	(2) 0	(2) 0	(3) 33	(11) 0
Trichloro Benzene	(13) 0	(8) 0	(10) 0	(5) 0	(8) 0	(5) 0	(4) 0	(4) 0	(19) 0	(5) 0	(7) 0	(3) 0	(7) 0	(3) 33	(4) 0	(2) 0	(2) 0	(3) 0	(11) 0

for aquatic organisms yet remain within potable water standards for compounds which limits have been established (Endrin, Lindane). The only pesticides which were not found in any area were toxaphene and methyoxychlor.

(D) Metals

The metals found with the greatest frequency are copper, iron, manganese, and sodium. These are commonly found and are generally considered to be naturally occurring throughout the area. Other parameters detected, such as arsenic, chromium, mercury, nickel, selenium, lead, and zinc were found in urban or developed areas. These compounds are considered to be components of urban runoff and industrial point sources. There were two violations of State standards for lead, one in the tidal Passaic River (tidal) and one in the tidal portion of the Hackensack River. Both areas where violations occurred are outside of the potable water areas. Chromium was also detected at one site on the tidal portion of the Hackensack River at levels above EPA recommended concentrations. There were no other violations recorded for the remaining parameters where state or federal criteria exist.

(E) Effluent Sampling

The Water Quality Management Program designed and implemented a 24 hour composite sampling (5 samples per facility) of 12 wastewater facilities. (All discharge to non-potable waters, since water purveyors have similar programs in progress or planned for potable waters). Those toxic and carcinogenic compounds previously analyzed in the surface water sampling program, were analyzed for the effluent samples. As was anticipated, the data confirmed that treatment plants with greater industrial flows have larger concentrations of organic compounds in their effluents. However, this was not true for all compounds. Some organic compounds (dichlorobenzene), BHC (beta), and heptachlor were also detected in high quantities in the effluent of facilities that treat a high proportion of domestic wastes. The presence of organics, and the possible presence of other substances not tested, reinforces the need for an accurate inventory of industrial wastes discharged to municipal treatment plant. (The Office of Sludge Management and Industrial Pretreatment is preparing such an inventory). Further research may be needed to determine components of commercial and domestic wastes (cleaners, both home and office; paints and thinners, etc.) so that their contribution to the total flow of organic compounds can be identified. The Riverview sewage treatment plant, which treats almost exclusively domestic wastes, contained organic compounds in its effluents which normally are not associated with residential usage.

After all the data is reviewed, it may be necessary to implement industrial pretreatment and/or domestic restrictions on the use of hazardous compounds. The organic compounds were detected in parts per billion values, which are much higher than those found in ambient water samples. The concentration of the effluent is greatly reduced by dilution in the rivers but may still present threats to aquatic organisms. Only further research and continued monitoring can resolve questions of their short term and long term effects.

Conclusion

The surface waters of the Northeast Study Area, both potable and tidal, show evidence of low levels of contamination with suspected toxics and carcinogens. The effects of the low concentrations upon the biota or human consumption are not fully understood. Specific sources of these chemicals have not been identified.

The detection of toxic and suspected carcinogenic in the surface waters is in its infancy, and the determination of acceptable levels of these substances is even more difficult to resolve. EPA is currently developing numerical criteria for some organic compounds. These standards require extensive research and testing which are very time consuming and will probably delay results until verification of testing is completed.

A combined effort by the State and Federal agenices, both giving high priority to potable waters, should help insure the safety of present and future water supplies. The following programs are currently being undertaken, to provide information, control and prevention of toxic and suspected carcinogens in surface and drinking waters:

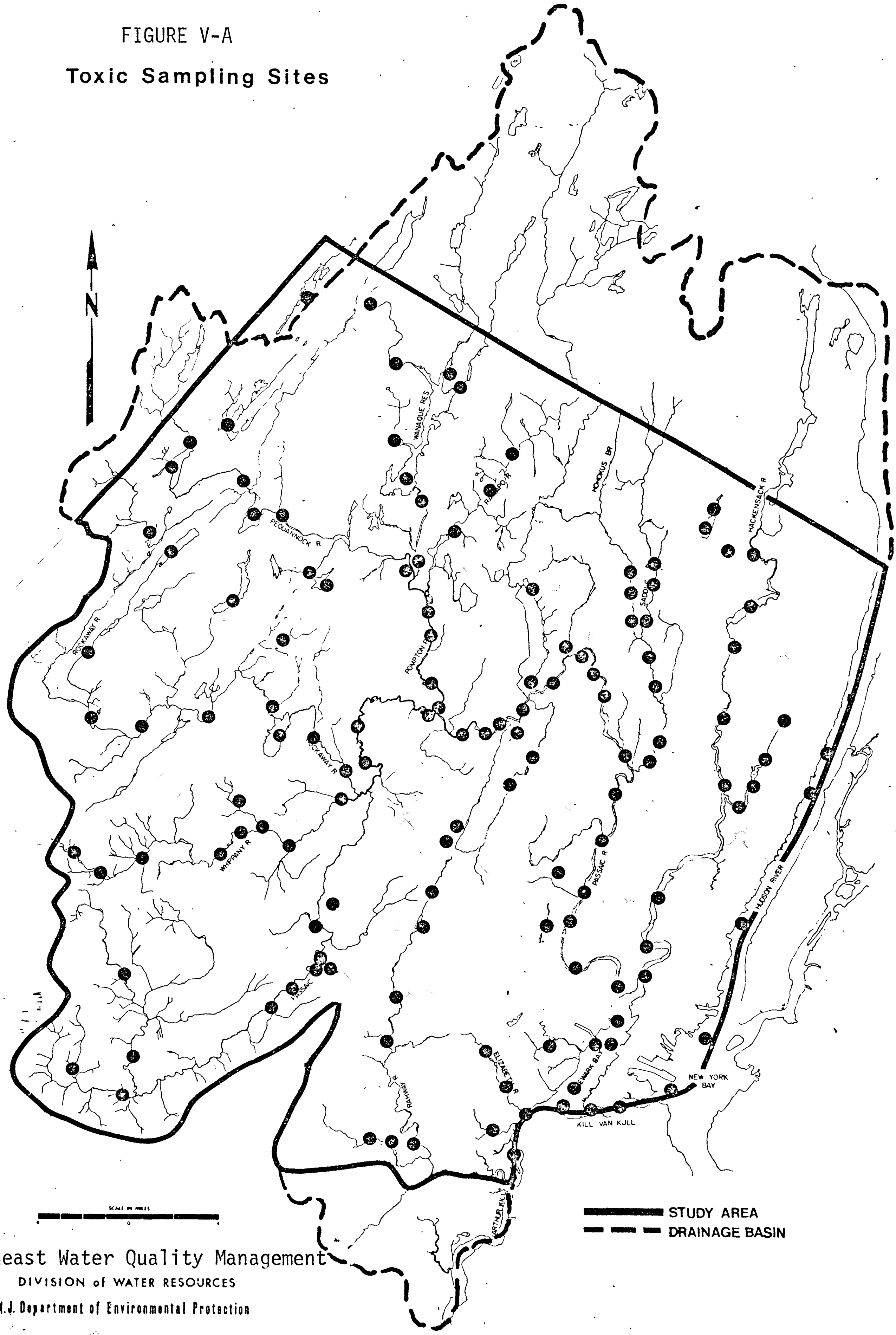
1. The DEP Program on Environmental Cancer and Toxic Substances plans to sample intensively for toxics and carcinogens, in the Northeast study area. This effort should help establish more statistically accurate results.

2. The DEP Office of Sludge Management and Industrial Pretreatment is preparing a survey to identify sources of toxic wastes within municipal wastewater systems. After a source has been located, pretreatment by the producer may be required.

3. The National Pollutant Discharge Elimination System (NPDES) requires dischargers of waste (point sources) to apply for a permit to discharge. The ultimate goal is to eliminate all discharges of pollution by 1985.

FIGURE V-A

Toxic Sampling Sites



Northeast Water Quality Management

DIVISION of WATER RESOURCES

N.J. Department of Environmental Protection

Toxic and Carcinogenic Substances Monitoring Program

The surface water Sampling Program for the Monmouth County WQM Plan concentrated on monitoring for toxic and carcinogenic substances.

The analytical instrumentation employed, e.g. gas chromatography with electron capture detector, have the capability of measuring contamination as low as ten parts per trillion (10 nanograms per liter). However, as the sensitivity of analytical techniques increases, so does the probability of error. When analyses are conducted in the parts-per-trillion range there is increased possibility of sample contamination, as well as instrument and observer variability. In order to statistically control for the variability of these ultra-sensitive values, a lower limit of 0.1 parts per billion (ppb) was established (with the exception of the metals analyses) as a cut off point for purposes of data analysis. Thus, any values detected below this limit were not considered and are represented by a dash in the summary tables. Cut-off limits for the metals are variable and given in the table notes. The summary tables were prepared using N.J. ambient stream standards, N.J. Potable Water Standards, and for the majority of the toxic parameters-EPA recommend criteria.

Analyses of the sampling results follow by watershed. It should be emphasized that these results were based on a one-event grab sample. Further sampling would be required to verify these findings.

Swimming River Reservoir System

(A) Volatile Organic Compounds

A total of nine different organic compounds were observed within this watershed, Table V-3. The most frequently observed of these compounds was 1,1,1-trichloroethane which was observed at eleven sampling sites out of a possible fifteen. This was followed by 1,1,2,2-tetrachloroethane (six sites) and 1,1,2-trichloroethane (four sites). The sub-watershed with the greatest number of organics (seven) was Big Brook. This is not totally unexpected as Big Brook has the largest drainage area of this system, and also has a point source discharge in its headwaters. However, the sampling station with the largest number of organics (eight) of all sampling sites within the Reservoir System, was the finished water at the Swimming River water treatment plant. In addition, the concentrations reported at the treatment plant were an order of magnitude higher than any found in the contributing streams. It should be noted, however, that the levels of trihalomethanes reported in the treated water were considerably below the EPA proposed interim standard of 100 ppb of total trihalomethanes in drinking water.

It appears obvious that the chlorination process at the treatment plant has produced these higher levels of trihalomethanes in the treated water.

(B) Pesticide and PCB Compounds

Three pesticides: lindane, heptachlor, and γ-chlordane, as well as PCBs were observed within this watershed, Table V-3. All three pesticides were observed in Willow Brook only. Lindane and γ-chlordane were observed at levels below recommended maximum criteria for domestic water supply but above EPA criteria for protection of freshwater aquatic life. Hepatchlor was reported at one station at a level above the recommended criterion for domestic water supply.

PCBs were reported at one station on Big Brook and at one station on Mine Brook, at levels below the recommended criterion for domestic water supply, but above the criterion for protection of freshwater aquatic life. It is not readily apparent what sources could be contributing the pesticides and PCBs. This condition should be investigated by further monitoring.

(C) Metals

Of the five metals reported above trace levels within this watershed, Table V-3, two (iron and manganese) were at levels above standard for domestic water supply. Both iron and manganese are naturally occuring and are removed in the water treatment process.

(D) Polynuclear Aromatic Hydrocarbons

None were observed to be present at concentrations in excess of 0.1 parts per billion.

Table V-3

Swimming River Reservoir System

Volatile Organic Compounds	Ramanessen Brook	Willow Brook	Big Brook	Yellow Brook	Mine Brook	Monmouth Consolidated raw	Monmouth Consolidated finished
No. of Sampling Stations	(2)	(3)	(4)	(2)	(2)	(1)	(1)
	No. of Sampling Stations Having a Result Greater Than 0.1 parts per billion						
chloroform	0	0	1	1	1	0	1
bromoform	0	0	0	0	0	0	1
(bromodichloromethane + 1,1,2-trichloroethylene)	0	0	1	0	0	1	1
1,1,2,2-tetrachloroethane	2	1	2	0	0	0	1
1,1,2-trichloroethane	0	0	1	1	1	0	1
dibromochloromethane	0	0	1	0	0	1	1
carbon tetrachloride	0	0	1	0	1	0	1
1,1,1-trichloroethane	1	2	2	2	2	1	1
1,1,2,2-tetrachloroethylene	0	0	0	1	1	0	0
Pesticide and PCB Compounds							
PCB	0	0	1	0	1	0	0
lindane	0	3	0	0	0	0	0
heptachlor	0	1	0	0	0	0	0
γ -chlordane	0	2	0	0	0	0	0

Polynuclear Aromatic Hydrocarbons - None were found to be present at levels in excess of 0.1 parts per billion (ppb).

Metals							
copper #1	-	-	-	-	-	1	1
chromium #1	-	-	1	-	-	-	-
iron ##1	2	3	4	2	2	-	-
mercury +1	-	-	-	-	1	-	-
manganese ##1	-	3	3	-	-	1	-

Notes

\# - Number in column indicates the number of sampling stations for which the concentration reported was greater than 0.002 parts per million (mg/l).

\## - Number in column indicates the number of sampling stations for which the concentration reported was greater than the state standard.

\+ - Number in column indicates the number of sampling stations for which the concentration reported was greater than 0.003 ppm (mg/l).

Shark River-Glendola Reservoir System

(A) Volatile Organic Compounds

A total of nine different organic compounds were observed within this watershed, Table V-4. The most frequently observed compound was 1,1,1-trichloroethane which was reported at five of the seven sampling stations. Next in frequency was 1,1,2,2-tetrachloroethylene, which was observed at three stations. Five of the nine compounds were observed at the raw water intake for the Monmouth Consolidated water treatment plant at Remsen Mill Road. However, the largest number of organics (eight) were found in the finished water from the Jumping Brook water treatment plant. The concentrations of organics reported in the treated water were in some instances two or three orders of magnitude higher than that observed in the stream water. However, these concentrations were still below the EPA proposed interim standard of 100 parts per billion of total trihalomethanes in drinking water. Again it is obvious that the chlorination process at the water treatment plant has contributed to the higher observed values of trihalomethanes in the treated water.

(B) Pesticide and PCB Compounds

None were observed to be present at concentrations in excess of 0.1 ppb. Only BHC- B and lindane were reported as present at very low levels below 0.1 ppb.

(C) Metals

Of the four metals reported above trace levels within this watershed (Table V-4), two, iron and sodium, were at levels above State standards for domestic water supply. Iron exceeded standard at every station except the finished water at the treatment plant where it is removed. The high iron is a natural condition of the area. Sodium was found to exceed the standard at a station on a small tributary, which is diluted to a low level by the time the waters reach the treatment plant.

(D) Polynuclear Aromatic Hydrocarbons

Only one of the four polynuclear aromatic hydrocarbons monitored (fluoranthene) was found to be present at a level above 0.1 ppb. This occurance was observed at only one station (Table V-4). There is no known criterion for this compound. However, the value observed was low compared to the range of the volatile organic compounds monitored.

Table V-4

Shark River-Glendola Reservoir System

(See accompanyng notes for specific cut-off limits indicating the presence or absence of a particular substance)

Volatile Organic Compounds	Shark R. @ Shark R. Rd.	Unnamed Trib. @ Wycoff Rd.	Unnamed Trib @ Rt. 33	Shark R. @ School-house Rd.	Monmouth Consolidated: Shark R. intake @ Remsen Mill Rd.	Monmouth Consolidated: Glendola Re-servoir intake	Treated water
chloroform	-	-	-	-	+	-	+
bromoform	-	-	-	-	-	+	+
(bromodichloromethane + 1,1,2-trichloroethylene)	-	-	-	-	-	-	+
1,1,2,2-tetrachloroethane	-	+	-	-	-	-	-
1,1,2-trichloroethane	-	-	-	-	+	-	+
dibromochloromethane	-	-	-	-	-	-	+
carbon tetrachloride	-	-	-	-	+	-	+
1,1,1-trichloroethane	-	+	+	-	+	+	+
1,1,2,2-tetrachloroethylene	-	-	+	-	+	-	+
Pesticide and PCB Compounds - None were found to be present at levels in excess of 0.1 parts per billion (ppb).							
Polynuclear Aromatic Hydrocarbons[1]							
fluoranthene	X	-	-	-	-	-	-
Metals							
iron[2]	X	X	X	X	X	X	-
mercury[3]	-	-	-	-	X	-	-
sodium[2]	-	-	X	-	-	-	-
lead[4]	-	X	-	-	-	-	-

Notes

1 - A (+) indicates that the reported concentration was greater than 0.1 parts per billion (ug/l); results less than 0.1 ppb are represented by a dash (-).
2 - An (X) indicates that the reported concentration of the particular metal exceeded the state standard at that sampling station; a result less than standard is indicated by a dash (-).
3 - An (X) indicates that the reported concentration of the metal was greater than 0.0003 parts per million (mg/l), a result ≤ 0.0003 ppm is indicated by a dash (-).
4 - An (X) indicates that the reported concentration of the metal was greater than 0.002 ppm (mg/l), a result ≤ 0.002 ppm is indicated by a dash (-).

The Manasquan River System

(A) Volatile Organic Compounds

Ten different organic compounds were observed within this watershed, (See Tables V-5, V-6, and V-7). The most frequently observed compound was 1,1,1-trichloroethane, which was reported at eight of the fourteen sampling stations. This compound was followed by a similar one, 1,1,2-trichloroethane (five stations), and by 1,1,2,2 tetrachloroethylene (five stations). The station with the most observations of organics (nine out of ten) above threshold level was at Center Street on the Debois Creek Tributary (Table V-6). This site is just downstream of the Freehold Borough Sewage Treatment Plant. The station on the main stem of the Manasquan River with the most observations (five) was Burke Road, downstream of the Lone Pine Landfill. Although Debois Creek is clearly the worst stream in this watershed for number of organics observed, most were dissipated or diluted below threshold level by the time the waters reached the most downstream station on this tributary. By comparison, only one compound was found at a significant level on all the other tributaries of the Manasquan which were monitored (Table V-7). The conclusion is that the point sources on Debois Creek are the contributors of these low levels of organics. The probable cause would be the chlorination of sewage effluent from these dischargers. Also, it appears from the data that Lone Pine Landfill is contributing low levels of some organics landfill leachate. This condition should be verified by further sampling.

(B) Pesticide and PCB Compounds

Three pesticides, BHC- B, lindane, and heptachlor epoxide, as well as PCBs were observed within this watershed (Tables V-5, V-6, and V-7). All three pesticides were observed at two Debois Creek stations only. Lindane and heptachlor epoxide were, respectively, observed at concentrations below and just meeting EPA recommended criteria for domestic water supply, but both were above criteria for protection of freshwater aquatic life. Although there is no recommended criterion for BHC- B at the present time, it was observed at a level an order of magnitude above the other pesticides.

PCBs were observed at two stations on Debois Creek and at two stations on the mainstem of the Manasquan River at concentrations below the recommended criterion for domestic water supply, but above the criterion for protection of freshwater aquatic life. It is unclear at this time which sources are contributing the pesticides and PCBs. Further investigation and monitoring may indicate the sources of this low level contamination.

(C) Polynuclear Aromatic Hydrocarbons

Only fluoranthene, of the four polynuclear aromatic hydrocarbons monitored, was found to be present at a level above 0.1 ppb. This observation was noted at only one station (Table V-5). Although there is no known criteria for this compound, the value observed was moderate compared to the range of volatile organic compounds monitored.

(D) Metals

Eight metals were observed above trace levels within this watershed (Tables V-5, V-6, and V-7), of which three, iron, manganese and sodium, were at levels above standard for domestic water supply. Both iron and manganese are naturally occuring in the area. The high sodium appears to be due to point source discharges and is diluted downstream.

Table V-5

Manasquan River-Main Stem

(See accompanying notes for specific cut-off limits indicating the presence or absence of a particular substance)

Volatile Organic Compounds[1]	Manasquan R. @ Burke Rd.	Manasquan R. @ Georgia School-house Rd.	Manasquan R. @ Route 9	Manasquan R. @ Lakewood-Farmingdale Rd.	Manasquan R. @ Hospital Rd.
chloroform	+	-	-	-	-
1,1,2,2-tetra-chloroethane	-	+	+	-	-
1,1,2-trichlorethane	+	-	-	-	+
1,2-dibromoethane	+	-	-	-	-
1,1,1-trichloroethane	+	-	+	+	+
1,1,2,2-tetrachloroe-thylene	+	-	-	-	-
Pesticide and PCB Compounds[1]					
PCB	-	-	+	+	-
Polynuclear Aromatic Hydrocarbons[1]					
fluoranthene	-	-	-	-	+
Metals					
arsenic[2]	X	-	-	-	-
chromium[2]	X	-	-	-	-
iron[3]	X	X	X	X	X
manganese[3]	X	-	-	-	-

Notes

[1] - A (+) indicates that the reported concentration was greater than o.1 parts per billion; (ppb) results less than 0.1 ppb are represented by a dash (-).

[2] - An (X) indicates that the reported concentration of the particular metal at that sampling station was greater than 0.002 ppm, a result $\leq$ 0.002 ppm is indicated by a dash (-).

[3] - An (X) indicates that the reported concentration of the particular metal exceeded the State standard at that sampling station, a result less than standard is indicated by a dash (-).

Table V-6

Debois Creek Tributary To The Manasquan River

(See accompanying notes for specific cut-off limits indicating the presence or absence of a particular substance)

Volatile Organic Compounds[1]	Debois Ck. @ Center St.	Debois Ck. @ Route 33	Debois Ck. @ Jones Siding Rd.	Debois Ck. @ Strickland Rd.
chloroform	+	+	+	-
bromoform		+	-	-
(bromodichloromethane + 1,1,2-trichloroethylene)	+	+	+	-
1,1,2,2-tetrachloroethane	+	-	+	-
1,1,2-trichloroethane	+	+	+	-
dibromochloromethane	+	-	-	-
carbon tetrachloride	+	+	+	-
1,2-dibromoethane	+	-	-	-
1,1,1-trichloroethane	+	-	+	-
1,1,2,2-tetrachloroethylene	+	+	+	+
Pesticides and PCB Compounds[1]				
PCB	+	+	-	-
BHC- B	+	-	+	-
lindane	+	-	+	-
heptachlor epoxide	+	-	-	-

Polynuclear Aromatic Hydrocarbons - None were found to be present at levels greater than 0.1 parts per billion (ppb).

Metals	Debois Ck. @ Center St.	Debois Ck. @ Route 33	Debois Ck. @ Jones Siding Rd.	Debois Ck. @ Strickland Rd.
copper[2]	X	X	-	X
iron[3]	X	X	X	X
mercury[4]	X	-	-	-
manganese[3]	X	X	X	X
sodium[3]	X	X	-	-
lead[2]	X	X	-	-

Notes

[1] - A (+) indicates that the reported concentration was greater than 0.1 parts per billion (ppb); results less than 0.1 ppb are represented by a dash (-).

[2] - An (X) indicates that the reported concentration of the particular metal was greater than 0.003 ppm (mg/l); a result $\leq$ 0.003 ppm is indicated by a dash (-).

[3] - An (X) indicates that the reported concentration of the particular metal exceeded the State standard at that sampling station; a result less than standard is indicated by a dash (-).

[4] - An (X) indicates that the reported concentration of the particular metal was greater than 0.0002 ppm; a result $\leq$ 0.0002 ppm is indicated by a dash (-).

Table V-7

Other Tributaries To The Manasquan River

Volatile Organic Compounds[1]	Mingamahone Bk. @ Cranberry Bog Rd.	Mingamahone Bk. @ Hurley Pond Rd.	Timber Swamp Bk. @ Manassa Rd.	Bear Swamp Br. @ Herbertsville Rd.	Marsh Bog Bk. @ Preventorium Rd.
1,1,1-trichloroethane	-	-	+	-	+

Pesticides and PCB Compounds - None were found to be present at reported concentrations greater than 0.1 parts per billion (ppb).

Polynuclear Aromatic Hydrocarbons - None were found to be present at levels greater than 0.1 parts per billion (ppb).

Metals[2]	Mingamahone Bk. @ Cranberry Bog Rd.	Mingamahone Bk. @ Hurley Pond Rd.	Timber Swamp Bk. @ Manassa Rd.	Bear Swamp Br. @ Herbertsville Rd.	Marsh Bog Bk. @ Preventorium Rd.
iron	X	X	X	X	X
manganese	-	-	-	X	-
sodium	-	-	-	-	X

Notes

[1] - A (+) indicates that the reported concentration of a particular compound at that sampling station was greater than 0.1 ppb; results less than 0.1 ppb are represented by a dash (-).

[2] - An (X) indicates that the reported concentration of the particular metal exceeded the State standard at that sampling station; a result less than the standard value is indicated by a dash (-).

Small (Non-Priority) Watersheds

(A) Volatile Organic Compounds

A total of six organic compounds were observed in four separate small watersheds (Table V-8). One sampling station was located on each of the four streams. 1,1,1-trichloroethane was observed in all four streams, followed by 1,1,2,2-tetrachloroethylene which was found in three of the streams. Mahoras Brook contained most of the organics (four of the six) at very low concentrations. This stream is located near an industrial area.

(B) Pesticides and PCB Compounds

No pesticides were observed to be present at concentrations exceeding 0.1 ppb. PCBs were reported (Table V-8) in McGeliards Brook and Mahoras Brook at levels exceeding the EPA recommended criterion. The sources of this compound are unknown. This finding is being verified by second round sampling.

(C) Metals

Three of five metals reported above trace levels (Table V-8. in these watersheds were at concentrations in excess of standards, namely iron, manganese and sodium. The iron and manganese were naturally occuring. The high sodium level occured on Mahoras Brook, which may be due to an industrial source.

Table V-8

Non-priority Streams Within the Monmouth County Study Area

(See accompanying notes for specific cut-off limits indicating the presence or absence of a particular substance)

Volatile Organic Compounds[1]	Doctors Cr. @ N. Egypt-Allentown Rd.	Manalapan Bk.@ Iron Ore Rd.	McGeliards Bk. @ Route 537	Mahoras Bk. @ Route 35
chloroform	-	-	+	-
(bromodichloromethane + 1,1,2-trichloroethylene)	-	-	-	+
dibromochloromethane	-	-	-	+
1,1,1-trichloroethane	+	+	+	+
1,1,2,2-tetrachloroethylene	+	-	+	+
diiodomethane	+	-	-	-
Pesticide and PCB Compounds[1]				
polychlorinated biphenyls (PCB)	-	-	+	+

Polynuclear Aromatic Hydrocarbons - None were found present at levels greater than 0.1 parts per billion (ppb).

Metals				
arsenic[2]	X	-	-	-
iron[3]	X	X	X	X
manganese[3]	X	-	-	X
sodium[3]	-	-	-	X
lead[2]	-	-	X	-

Notes

1 - A (+) indicates that the reported concentration was greater than 0.1 parts per billion (ppb); results less than 0.1 ppb are represented by a dash (-).

2 - An (X) indicates that the reported concentration of the particular metal at that sampling station was greater than 0.002 ppm; a result $\leq$ 0.002 is indicated by a dash (-).

e3 - An (X) indicates that the reported concentration of the particular metal exceeded the State standard at that sampling station; a result less than the standard value is indicated by a dash (-).

Summary Results of the surface water sampling program indicate the widespread presence of low levels of volatile organic compounds. The most frequently observed by far was 1,1,1-trichloroethane (found at twenty-eight of a possible 40 sampling sites), followed by 1,1,2, 2-tetrachloroethylene (13 sites), chloroform, 1,1,2,2-tetrachloroethane, and 1,1,2-trichloroethane (each at 11 sites).

The highest concentrations within the study area were found in the finished water at both of Monmouth Consolidated's water treatment plants. The formation of these organics is due to the chlorination process used to disinfect the potable water before distribution. There is no acute health hazard due to the presence of these organics, as the concentrations observed were below the proposed EPA interim standard of 100 ppb (ug/l) for total trihalomethane compounds. However, there is a research need to determine if there are any chronic effects.

Very few pesticides were observed in the surface waters; when found at low concentration, they were continued to small areas. Their presence may be due to local household use.

The presence of low concentrations of PCB's was noted at scattered locations in several watersheds. There appears to be no pattern to its distribution, and the sources are unknown at this time. The low levels present in some streams could affect the biota present. Further monitoring may yield more information as to the sources of both PCBs and the few pesticides that were found.

High metal concentrations were noted for iron, manganese and sodium. Iron and manganese occur naturally and are removed by water treatment processes. High sodium concentrations appear to be associated with point source discharges and are eventually diluted to lower levels by stream flow.

Trihalomethanes were also observed downstream of sewage treatment plants. Although the effects of low concentrations of these compounds on biota are not known at this time, the concern expressed for their presence in drinking water should make their presence in ambient waters suspect. Additionally, other products of chlorination, e.g. chloramines, as well as free available chlorine, have been shown to have adverse effects on biota. In the interest of keeping the formation of such substances to a minimum, at those sewage treatment plants where chlorination is the preferred method of disinfection, it is recommended that DEP restrict chlorine dosage to that level adequate to achieve effective disinfection (chlorine optimization) and that excessive chlorination be prohibited,

Monmouth County
Surface Toxic Sampling Results - Second Round

The second round of surface water quality sampling conducted during the summer of 1978, was designed to provide more information on the characteristics of particular sources of toxic pollutants. These sources included discharge from a municipal sewage treatment plant, treated industrial discharge, industrial cooling water discharge, urban runoff, and agricultural/suburban runoff.

About a third of the second round samples were taken to investigate point sources. The Freehold Boro plant, which treats both household and industrial wastes, was selected as a representative of municipal plants, the Worthington Biochemical/Charms discharge as a representative of industrial. For both of these plants, the discharge pipe, a site upstream of pipe, and a site downstream were each sampled every six hours for twenty-four hours. Industrial cooling water was sampled once at each of the four active discharge pipes of the 3M Company. All of these discharges are on Debois Creek, a tributary of the Manasquan River, which has major pollution sources and is a proposed site of a regional wastewater treatment system and a major potable water reservoir.

The most intensively sampled of the landfills was Lone Pine, on the headwaters of the Manasquan River. Four samples downstream of the landfill were taken four days apart, one sample was taken at the same site during rainfall, and one sample was taken at a site assumed to be upstream of the influence of the landfill. The effects on water quality by two other landfills were investigated by sampling upstream and downstream of the section where leachate may be expected to enter. These two were Neptune Township landfill, on Hollow Brook, and Howell Township landfill, on the Manasquan River.

To investigate the role of urban land as a source of toxics, samples were taken at Weamaconk Creek at a site where the watershed was entirely developed but which had no known point source discharges. One could, therefore, assume that any pollutants in the stream at the sampling site entered through urban runoff (or illegal storm sewer connections). This site was sampled four times four days apart, and once during rain.

Fifteen sites in the upper Navesink River were selected to examine toxic levels in a relatively undeveloped area. The selected sites generally coincide with Swimming River Reservoir sites of the first round. Although most of the sites had point source discharges upstream, these discharges were small enough to assume that the water quality generally depends upon runoff from the watershed. The results of the sampling support this assumption. The only exception was on Big Brook, at a site just downstream of discharge from

Marlboro State Hospital. Since the sampling was done so close to the discharge site, it had the characteristics of a municipal discharge and, thus, was treated as such in the analysis.

i. Volatile Organic Compounds

Analysis of the second round data reveals several associations of various organic chemicals with particular sources and sampling sites. Table V-9 shows the occurrences of light organics and pesticides at the point source discharges and at sampling sites where pollution would be due to non-point sources.

Four of the trihalomethanes (chloroform, bromoform, bromodichloromethane, dibromochloromethane) and carbon tetrachloride may be created as a byproduct of disinfection with chlorine. The data verifies chlorination as a major contributor of these substances. The Freehold Boro, Charms/Worthington, and Marlboro hospital discharges all had reportable levels of these substances. The highest concentration of trihalomethanes found was chloroform from the Marlboro State Hospital Treatment plant.

Trifluoromethane, a trihalomethane not associated with chlorination, data was anomalous and difficult to interpret because it was not found at all at any of the first round sampling stations. In the second round sampling, it was found in some (Freehold Boro STP and 3M cooling water) but not all point discharges and in several (Weamaconk Creek, Ramanessen Brook, Willow Brook, Yellow Brook and Hollow Brook) but not all watersheds containing few, if any, point sources. The highest concentration of trifluoromethane was found on a small tributary of Big Brook, downstream of an industrial park along Boundary Road.

The chloroethylenes (1,1,2-trichloroethylene, 1,1,2,2-tetrachloroethylene) were found only in sources expected to receive wastes from industrial processing. These sites were at the Freehold Boro, Charms/Worthington, 3M cooling water and Lone Pine landfill, except for occassional low levels on Weamaconk Creek and somewhat higher levels on Wemrock and Hollow Brook. The highest levels were found in the 3M cooling water.

Table V-9

- Selected Results of Second Round Surface Toxic Sampling

	Freehold Boro STP	Charms/ Worthington	3-M Cooling Water	Lone Pine Landfill	Weama-conk Creek	Marlboro State Hosp.	Ramanessen Brook	Willow Brook	Big Brook	Yellow Brook
trihalomethanes	*	*	✓	✓		**				
carbon tetrachloride	*	✓	*			*				
1,2-dichloroethane				?	**		**	**	***	
1,1,1-trichloroethane		*	**		*					
1,1,2-trichlorcethane			*	*						
1,1,2,2-tetrachloroethane										
1,1,2-trichloroethylene	*	*	***	*						
1,1,2,2-tetrachloroethylene	**	**	✓	*	✓					
methyl chloride				*						
methylene chloride	*				*					
vinyl chloride			*	**						
1,2-dibromoethane				*	✓					
trifluoromethane	*		*	?	*		*	*		
diiodomethane				*						
PCB's	**		✓	✓	✓	*				
BHC-B	***	**		***	*		*	*	*	*
lindane		✓						**		
aldrin		*			✓	**				
heptachlor		**		***	✓		*	**	✓	*
heptachlor epoxide	*	✓			✓			*	*	*
γ chlordane	✓	✓		*	*		✓	✓		

✓ - substance has been detected, but average concentration is below the minimum reportable concentration

* - substance has been detected at levels above the minimum reportable concentration

** - substance has been detected at levels above ten times the minimum reportable concentration

*** - substance has been detected at levels above hundred times the minimum reportable concentration

? - substance has been detected above and below Lone Pine Landfill (either the landfill is not the source, or else upstream site is not above influence of landfill).

Table V-9 cont.

	Mine Brook	Mahoras Brook	McGeliards Brook	Wemrock Brook	Manasquan River near Farmingdale	Hollow Brook	Minimum Reportable Concentration	Standards Potable	Standards Biota
trihalomethanes							.100-1.000		
carbon tetrachloride							.100		
1,2-dichloroethane		**			*		1.600		
1,1,1-trichloroethane					✓		2.000		
1,1,2-trichloroethane							1.000		
1,1,2,2-tetrachloroethane							.300		
1,1,2-trichloroethylene						*	.300		
1,1,2,2-tetrachloroethylene				**			.060		
methyl cloride							6.000		
methylene chloride					**		90.000		
vinyl chloride							.500		
1,2-dibromoethane							.100		
trifluoromethane						✓	.500		
diiodomethane							.300		
PCB's							.060	1.000	.001
BHC-B	*		**	**		*	.010		
lindane			✓				.010	4.000	.010
aldrin					*		.010	1.000	.003
heptachlor	*		**	**	✓		.010	.100	.001
heptachlor epoxide	*						.010	.100	
γ chlordane				*		✓	.010	3.000	.010

✓ - substance has been detected, but average concentration is below the minimum reportable concentration
* - substance has been detected at levels above the minimum reportable concentration
** - substance has been detected at levels above ten times the minimum reportable concentration
*** - substance has been detected at levels above hundred times the minimum reportable concentration
? - substance has been detected above and below Lone Pine Landfill (either the landfill is not the source, or else upstream site is not above influence of landfill).

The chloroethanes (1,1,1-trichloroethane, 1,1,2-trichloroethane) were found almost exclusively in industrial sources, particularly cooling water, and sources expected to receive industrial waste. These sites were Charms/ Worthington Biochemical Corp., 3M cooling water, and Lone Pine landfill. Additionally, low levels were observed on Weamaconk Creek and on the Manasquan River, downstream near Farmingdale. An exception was 1,2-dichloroethane, which was not found in point discharges, but rather in streams which contain few, if any, point sources: Weamaconk Creek, Ramanessen Brook, Willow Brook, Big Brook and Mahoras Brook,also this substance was present in samples taken in the vicinity of Lone Pine Landfill and further downstream in the Manasquan River near Farmingdale. The highest concentration of 1,2-dichloroethane was observed on the same small tributary of Big Brook, as previously noted in the case of trifluoromethane, downstream of an industrial park. Also like that of trifluoromethane, the presence of 1,2-Dichloroethane is difficult to interpret because it was not found at all in the first round and was not easily attributed to any particular source.

Lone Pine landfill and, to some extent, Weamaconk Creek samples have contained synthetic organics not usually found in the other sources, among them: methyl chloride, methylene chloride, vinyl choride and 1,2-dibromoethane.

ii. <u>Pesticides and PCB</u>

With the exception of the urban stream, Weamaconk Creek, and downstream of Lone Pine landfill, the sources of PCB were found to be the point discharges: Freehold Boro STP, 3M cooling water and Marlboro State Hospital. The highest concentration was observed in the discharge from the Freehold Boro STP.

The beta form of benzene hexachloride (BHC) and heptachlor were found in most of the point discharges and stream samples. The concentrations observed for heptachlor, for the most part, exceeded both the recommendations for domestic water supply and for protection of freshwater aquatic life. The highest concentrations of both compounds were observed downstream at Lone Pine landfill.

Lindane was almost exclusively and consistently found at several stations along Willow Brook, at concentrations below the domestic water supply recommendation, but exceeding the criterion for freshwater aquatic life.

Aldrin was found to be present in the point sources of Charms/Worthington Biochemical Corp. and Marlboro State Hospital and also in the following streams: Weamaconk Creek, Yellow Brook, the Manasquan River near Farmingdale. Concentrations of this compound in these streams were less than the domestic water supply recommendations but exceeded the criterion for freshwater aquatic life.

Heptachlor epoxide was observed at the point sources of Freehold Boro STP and Charms/Worthington Biochemical Corp. and in the following streams: Weamaconk Creek, Big Brook and Mine Brook. Concentrations in the latter two streams exceeded the recommendation for domestic water supply.

The gamma form of chlordane was observed at the point sources of Charms/Worthington Biochemical Corp. and Freehold Boro STP, downstream of Lone Pine landfill, and in the following streams: Weamaconk Creek, Ramanessen Brook, Willow Brook, Wemrock Brook and Hollow Brook. Concentrations of this compound in these streams were less than the domestic water supply recommendation but exceeded the criterion for freshwater aquatic life.

DDT and its derivatives were found occassionally at low levels, at the following sampling stations: Charms/Worthington Biochemical Corp., Weamaconk Creek, Ramanessen Brook, Willow Brook, Yellow Brook and Mine Brook. Concentrations of these compounds were below domestic water supply recommendations but exceeded the criteria for freshwater aquatic life.

iii. Metals

Elevated chromium concentrations were observed in the 3M Co. cooling water discharge.

Iron and manganese levels were almost universally high, as is characteristic of the area. Iron concentrations downstream of Lone Pine landfill were exceptionally high.

High sodium levels in the discharges from Freehold Boro STP and Charms/Worthington Biochemical Corp. have raised the sodium concentration of sections of Debois Creek above domestic water supply recommendations. Elevated sodium concentrations were also found downstream of Lone Pine landfill.

Lead concentrations exceeding domestic water supply recommendations were observed in the segments of the following streams: Debois Creek, above the 3M Co. discharge, the Manasquan River, in the vicinity of Lone Pine landfill, and Weamaconk Creek.

iv. Polycyclic Aromatic Hydrocarbons

The number of chemical compounds belonging to this group, which were analyzed during the second round of sampling, was more than double that monitored during the first round. The results were also considerably different. Whereas these compounds were hardly ever observed during the first round of sampling, the second round results indicated that some of these substances were found at practically every station in the low parts-per-billion (ug/l) range. The highest concentration, that of benzo(e)pyrene, was observed in Weamaconk Creek. Nothing can be concluded about the significance of the presence of these compounds as appropriate standards or recommended criteria are lacking.

v. Conventional Parameters

High ammonia levels were found in the discharges from the Freehold Boro STP and Charms/Worthington Biochemical Corp. Toxic levels (to biota) were also observed in Debois Creek downstream of each of these point sources. Potentially toxic levels were found to be associated with Lone Pine and Neptune landfill.

Low levels of cyanide were found in the majority of samples. Concentrations exceeded domestic water supply standards in the Manasquan River downstream of Lone Pine landfill and in Weamaconk Creek. Any detectable level of cyanide exceeded the recommended criterion for freshwater and marine aquatic life and wildlife.

Ground Water Analysis

excerpted from the following:

Northeast Water Quality Management Plan
New Jersey Department of Environmental Protection
Division of Water Resources
April, 1979

Monmouth County Water Quality Management Plan
New Jersey Department of Environmental Protection
Division of Water Resources
April, 1979

Lower Delaware Water Quality Management Plan
New Jersey Department of Environmental Protection
Division of Water Resources
May, 1979

Upper Delaware Water Quality Management Plan
New Jersey Department of Environmental Protection
Division of Water Resources
March, 1979

Upper Raritan Water Quality Management Plan
New Jersey Department of Environmental Protection
Division of Water Resources
May, 1979

Ground Water Quality

Approximately 25% of all potable water in the Northeast Study Area comes from ground water. Water is collected below the surface in an underground reservoir of gaps between rocks, termed an aquifer. Ground water is known for its purity because it is usually filtered by the ground enroute to the aquifer. However, any contamination of ground water is a very serious problem due to its long duration and uncertainty of human health risks. In recent years, the Northeast region of New Jersey has experienced several recorded incidents of ground water contamination. For example, in August 1978, approximately 7000 gallons of gasoline were lost by a refinery in Leonia; since then, gas has periodically appeared in storm and sanitary sewers in that area, indicating the likelihood of ground water contamination. In October 1977, 3000 to 6000 gallons of gasoline leaked from a gas station in Harding Township, contaminating four domestic wells. In 1977 South Orange closed eight wells after the odor of gasoline was detected at the town's ground water pumping station. 600 parts per million were recorded in one of the wells; a leak in an underground gas station tank was the suspected source. South Orange has had to find its water elsewhere; the cost so far has exceeded 500,000 dollars. Records of ground water contamination reveal many such accidents, occurring from a variety of sources. Sometimes the sources of pollution can be difficult to locate and control. By the time ground water pollution is discovered it usually is too late to reverse the damage.

The pollution sources that are expected to pose the greatest threat to ground water quality in the Northeast Study Area are stormwater runoff, landfills, chemical spills from industry, and waste disposal lagoons. Other ways ground water may be contaminated are faulty septic systems, highway deicers, and agricultural practices.

Areawide water quality management programs to implement abatement measures for all pollution sources, including ground water, are required for all areas of the state. The New Jersey Division of Water Resources is expected to initiate a program in the near future to assess the effects of industrial impoundments on ground water. In order to evaluate the region's ground water quality, the Northeast WQM Program undertook a short-term ground water sampling program to begin to fill data gaps and to help in assessing future regulations and controls.

Early in the planning process the WQM Program, in coordination with the DEP Program on Environmental Carcinogens and Toxic Substances (PECTS), entered into a contract with Rutgers University for ground water sampling at approximately 80 sites for a wide range of parameters. The purpose of the project was to obtain an assessment of the degree of contamination of ground water supplies by selected toxic and carcinogenic compounds. Fifteen standard parameters were also included in the study. All laboratory work was performed by the Department of Environmental Sciences of Rutgers University.

Tests were conducted to detect quantities of the substances listed in Table V-10, and locations of wells sampled are shown in figures V-B and V-C.

Table V-10

PARAMETERS SELECTED FOR GROUND WATER MONITORING PROGRAM

Standard Parameters

C° Temperature
pH
Ammonia-N
Organic-N
Nitrate-N
Nitrite-N
Phosphorous
Sulphate
Alkalinity
Chloride
Flouride
Cyanide
LAS
Dissolved Solids
Fecal Coliform

Light Organic Compounds

methylene chloride
methyl chloride
methyl bromide
chloroform
bromoform
bromodichloromethane
dibromodichloromethane
trifluoromethane
carbon tetrachloride
1,2 - dibromoethane
1,2 - dichloroethane
1,1 - trichloroethane
vinyl chloride
1,1 1,2 - dichloroethylene
1,1,2 - trichloroethylene
o,m,p - dichlorobenzene
trichlorobenzene
tetrachloroethylene

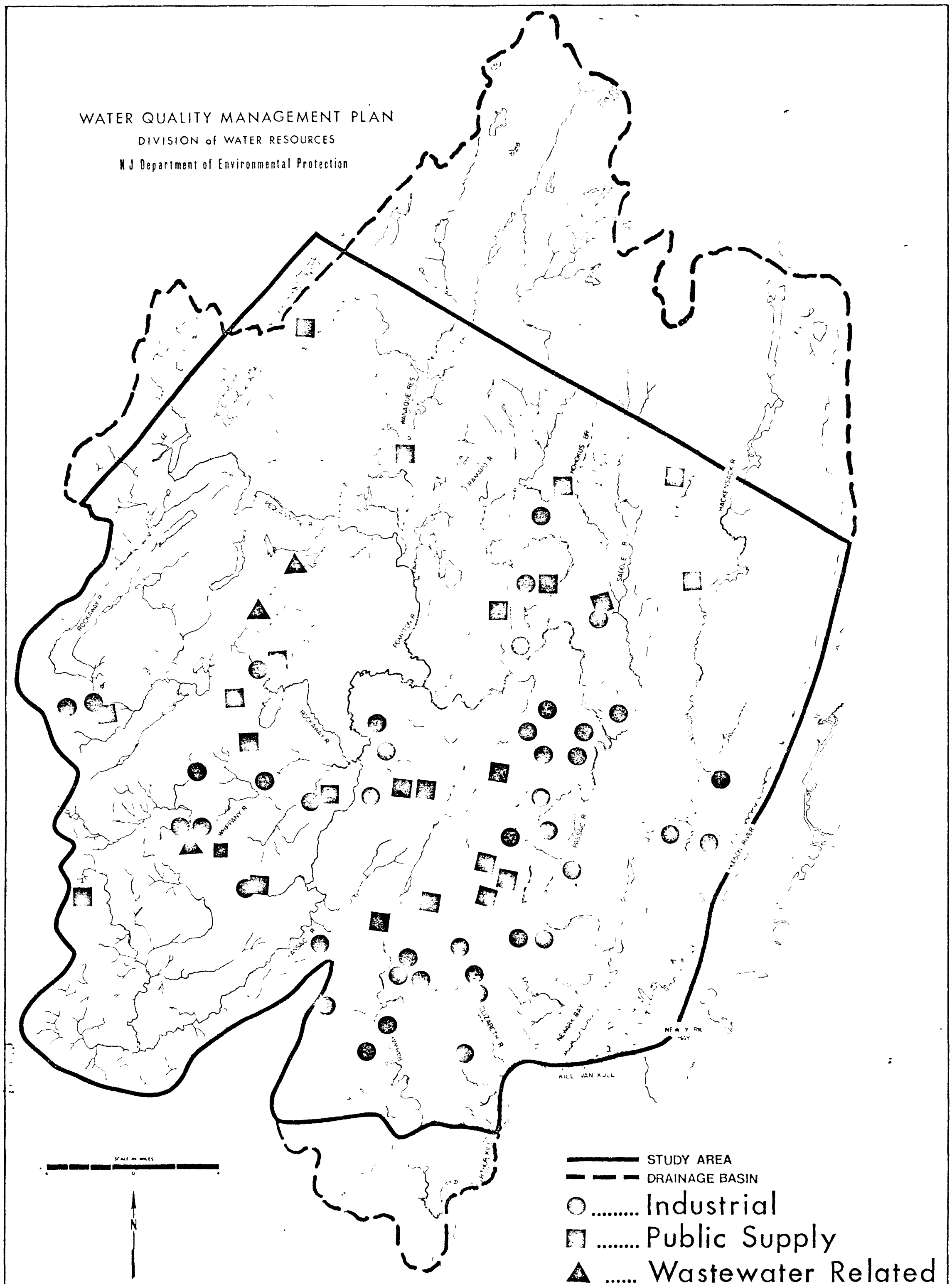
Heavy Metals

arsenic and compounds
beryllium and compounds
cadmium and compounds
chromium and compounds
copper and compounds
nickel and compounds
lead and compounds
zinc and compounds
selenium and compounds

Pesticides and PCB

Polychlorinated Biphenyls (PCB)
BHC
lindane
aldrin
dieldrin
endrin
heptachlor
heptachlor epoxide
toxaphene
DDT and associated compounds

FIGURE V-B



-Ground Water Sampling Sites.

FIGURE V-C

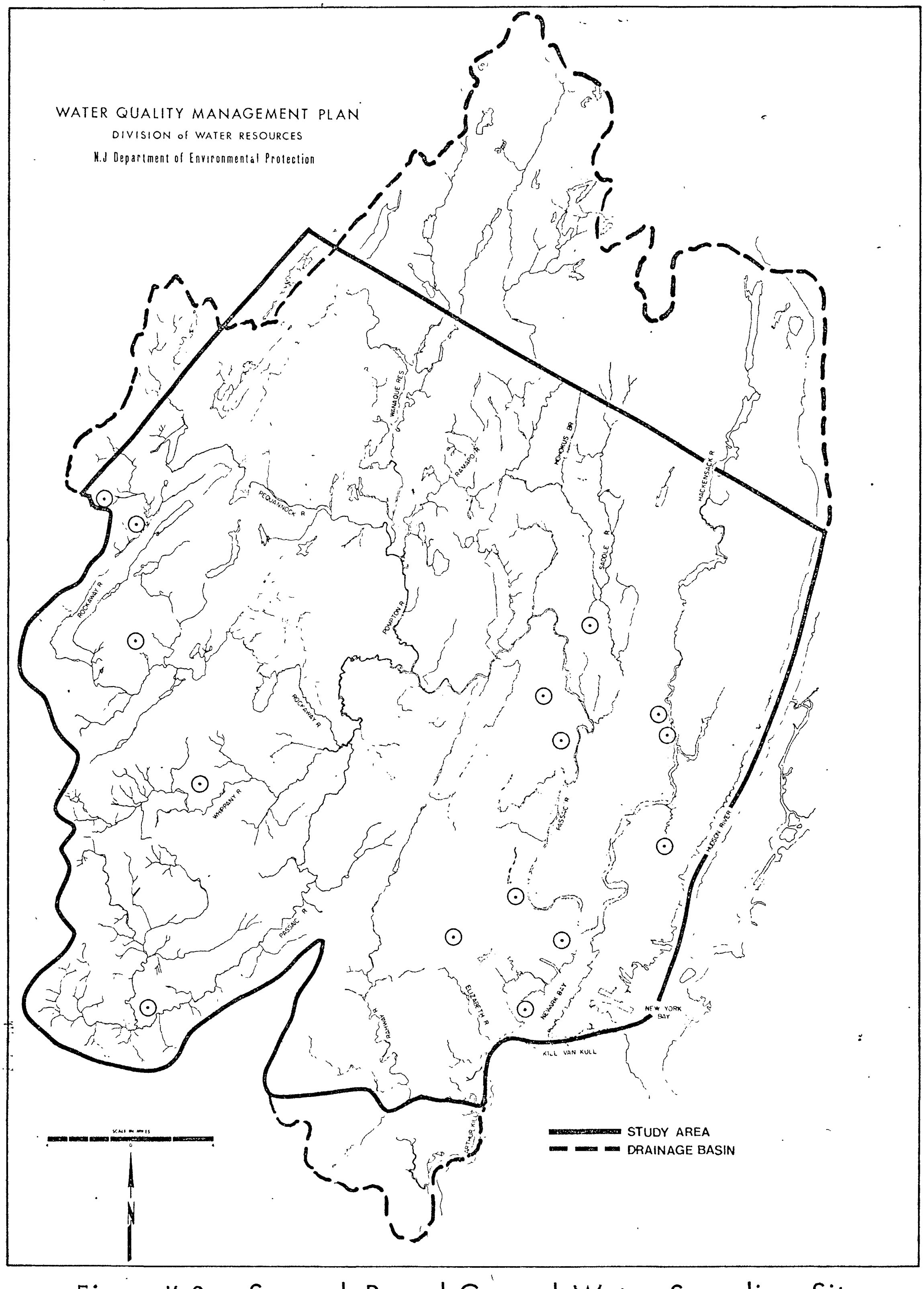


Figure V-C – Second Round Ground Water Sampling Sites.

Ground Water Quality (Toxic). Sampling for toxic and carcinogen chemicals in Monmouth County was part of the state-wide Program on Environmental Cancer and Toxic Substances of the DEP. The sites were selected by the WQM staff; the laboratory work was performed by the Department of Environmental Science of Rutgers University.

The Monmouth County sampling program was done in two rounds. The first round, in June 1977, sampled 40 sites distributed over the wells in the three major aquifers, wells in several minor ones, and landfill monitoring wells. The second round, in May 1978, sampled 19 wells in the Englishtown aquifer and one landfill monitoring well. The sampled wells are listed in Table V-14 and mapped in Figures V-D to V-H.

The sampling data is divided into four categories: organic chemicals, PCB's (polychlorinated biphenols) and pesticides, metals, and conventional water quality indicators.

None of the wells sampled had any organic chemical or PCB, and pesticide concentrations above or near current and suggested water quality standards. Standards have not been set, however, for a number of these substances because of insufficient research on their health effects. Table V-11 summarizes the data by listing for each chemical the limit of detectability, the recommended standard, the maximum concentration of all samples, and the number of wells in each aquifer the substance was detected. Chemicals that were not detected in any sample are not included.

Care must be taken in interpretting the sampling data because of questions regarding its consistency. As a check of laboratory consistency, four wells in the first round sampled were measured twice during the same visit. In a number of cases values measured from the same well varied substantially. Table V-12 lists the result of the duplicate samples. The cases in which the duplicate measurements were both above detectable levels are noted in Table V-11 likewise, the cases in which only one shows detectable levels are also noted.

Comparison of the results of the first and second round sampling of the Englishtown aquifer also raises questions of data consistency. Most striking are the results of sampling of 1,1, 2,2 - tetrachlrolthylene; although it was undetected in eight samples in the first round, it was detected in 18 of 21 second round samples. Similarly, BHC-B, which is undetected in the first round, is detected in 8 wells in the second.

As a further check of consistency, four of the wells sampled in the first round were resampled in the second. The results, summarized in Table V-13, show that no chemical was duplicated in the same well in both rounds. It is uncertain how much of data inconsistency reflects laboratory problems in measuring chemicals at such low levels and how much is due to actual field concentration variability. The results of the duplicate measurements, however, do suggest that at least part of this variability occurs in the laboratory.

Observation of Table V-11; shows that there is no readily discernable distribution pattern of these chemicals among the aquifers. No aquifer is noticeably better or worse than the others. Even the samples from landfill monitoring wells are not appreciably different from those of the other wells.

Although no apparent pattern of spatial distribution emerges from the Englishtown aquifer data, a pattern does appear from the Magothy-Raritan aquifer (see Fiqure V-14). The four northern-most wells, those along Raritan Bay, have detectable levels of pesticides which hardly appear in any of the other wells of that aquifer. Since the Magothy-Raritan aquifer has outcrops in a highly developed area of Middlesex County and the northwest corner of Monmouth County, these values may indicate contamination in aquifer recharge.

The metal and conventional sections of the sampling program verified the problems noted. These are local saltwater intrusion problems in the Keyport-Union Beach area and high countywide natural background levels of iron and manganese. Also, elevated levels of a number of metals were observed in some of the landfill monitoring wells.

Despite questions regarding the accuracy of the data, there is no apparent threat to public health from organic chemicals and pesticides in Monmouth County groundwater. Further research may, of course, suggest different standards or other chemicals with toxic and carcinogenic properties. Although standards have not been set for 1,1,2,2-tetrachlorethylene and 1,1,1-trichloroethane, these chemicals are so ubiquitous that if further research indicates a health hazard from these levels, appropriate action should be taken. Evidence of detectable concentrations of a number of pollutants in the northern Raritan-Magothy aquifer wells does indicate the need for protecting aquifers from degradation in heavily developed areas. Although no values exceeded current or recommended standards, several wells had values which were more than half of the recommended limit. These wells should receive high priority in any subsequent sampling.

Inconsistency and variability has caused difficulties in interpreting the sampling data. Future sampling should place a greater emphasis on quality control. There should be a greater number of duplicate, perhaps even triplicate, measurements until the results of such repetition are consistent. Awareness of background variability is also necessary for proper interpretation of the data. Several "typical" wells should be monitored intensively to examine how concentrations of organic chemicals, PCB's and pesticides vary within three hours, within 24 hours, within a month, and within a year. Knowing the natural variability would allow an investigator to determine how much importance to attribute to one sample. If the intensive sampling shows that concentrations vary, then a number of samples would be required to establish water qualities for a particular well. If the concentrations prove to be stable, then fewer samples may be sufficient.

Table V-11

Summary of Ground Water Toxic Sampling

	limit of detectability (µg/l)	maximum all samples (µg/l)	recommended standard (µg/l)	Raritan-Magothy	English-town (round 1)	English-town (round 2)	Mt. Laurel-Wenonah	Kirk-wood & Vincen-town	Red Bank Sand	Landfill Monitoring
# of samples				13	8	21	7	5	3	5
# of duplicates				2	0	0	1	1	0	0
ORGANIC CHEMICALS										
Methylene Chloride	90.0	1,900	none	0	0	1	0	0	0	0
Chloroform	.8	7.12	***	2(--)	1	0	0	0	0	0
Bromodichloromethane & 1,1,2 trichloroethylene	.02	.63	***	9(+-)	5		3(-)	3	0	4
1,1,2 Trichloroethylene	.3	.689	none			2				
Dibromochloromethane	.1	.11	***	1	0	0	0	0	0	0
Carbon Tetrachloride	.1	.85	none	2(--)	1	2	0	0	0	0
1,2-Dibromoethane	.1	.12	none	0	0	0	0	0	0	1
1,1,1-Trichloroethane	2.0	3.553	none	1	1	7	1(-)	0	1	2
1,1,2,2-Tetrachloroethane	.06	3.86	none	2(--)	1	18	2	0	0	4
P Dichlorobenzene	1.25	1.204	none	0	0	1	0	0	0	0
Diiodomethane	.3	.76	none	1	1	0	1(-)	0	0	1
PCB's & PESTICIDES										
PCB's	.06	.56	1.0*	1	0	2	2(+)	1	0	1
BHC	.01	.129	none	0	1	0	1	0	0	1
BHC B	.01	.137	none	0	0	8	0	0	0	0
Lindane	.01	.032	5*,4**	1(-)	1	0	3(+)	0	0	2
Aldrin	.01	.205	1.0*	3(-)	2	3	1	0	0	0
Dieldrin	.01	.154	1.0*	3(+)	2	1	1	0	0	0
Heptachlor	.01	.081	1.0*	1(-)	1	5	1	0	0	1
Heptachlor Epoxide	.01	.014	1.0*	0	0	1	0	0	0	0
O,P'-DDE	.01	.241	50.0*	4(-)	2	5	3(+)	0	1	0
O,P'-DDT	.04	.413	50.0*	3(-)	2	0	2(+)	0	1	0
P,P'-DDD	.02	.397	50.0*	4(+)	2	1	2(+)	0	1	0
P,P'-DDT	.04	.641	50.0*	5(-)	2	0	2(+)	1	1	0
Endrin	.01	.147	.5*,.2**	3(+)	2	0	2(+)	1	0	0
γ-Chlordane	.01	.107	3.0*	3(+)	2	5	2(+)	0	0	1

\+ Duplicate measurements are both above limit of detectability
\- Only one of two duplicate measurements is above limit of detectability
* Recommended standards from United States Environmental Protection Agency (1972)
** Standards from National Interim Primary Drinking Water Regulations (United States Environmental Protection Agency 1976)
*** Recommended standard for total trihalomethanes is 50 µg/l (United States Environmental Protection Agency, 1972)

Table V-13

Comparison of First and Second Round Toxic Sampling Results for Four Wells (μg/l)

	limit of detectability	Bell Lab		Belmar Boro W.D.		Lily-Tulip Cup Inc.		Worthington Biochemical Co.	
ROUND		1	2	1	2	1	2	1	2
Methylene chloride	90.0	-	1900.0	-	-	-		-	-
1,1,2-trichloroethylene	.3	-	-	-	.488	-	-	-	.689
Carbon tetrachloride	.1	-	.123	-	.318	-	-	-	-
1,1,1-trichloroethane	2.0	-	-	-	3.553	-	2.276	-	2.968
1,1,2,2-tetrachloroethylene	0.6	-	1.319	-	1.406	-	1.332	-	.964
Diiodomethane	.3	-	-	-	-	-	-	.76	-
BHC-A	.01	.046	-	-	-	-	-	-	-
BHC-B	.01	-	.041	-	-	-	.069	-	.039
Lindane	.01	.032	-	-	-	-	-	-	-
Aldrin	.01	.205	-	-	.036	-	-	-	-
Dieldrin	.01	.130	-	-	-	-	-	-	-
Heptachlor	.01	.081	-	-	-	-	-	-	-
O,P'-DDE	.01	.145	-	-	.012	-	-	-	-
O,P'-DDT	.04	.413	-	-	-	-	-	-	-
O,P-DDD	.02	.276	-	-	-	-	-	-	.013
P,P-DDT	.04	.328	-	-	-	.031	-	-	-
Endrin	.01	.147	-	-	-	-	-	-	-
γ-Chlordane	.01	.107	-	-	-	-	-	-	.022

- = Below limit of detectability
(only chemicals with concentrations above detectability limits are listed)

TABLE V-14

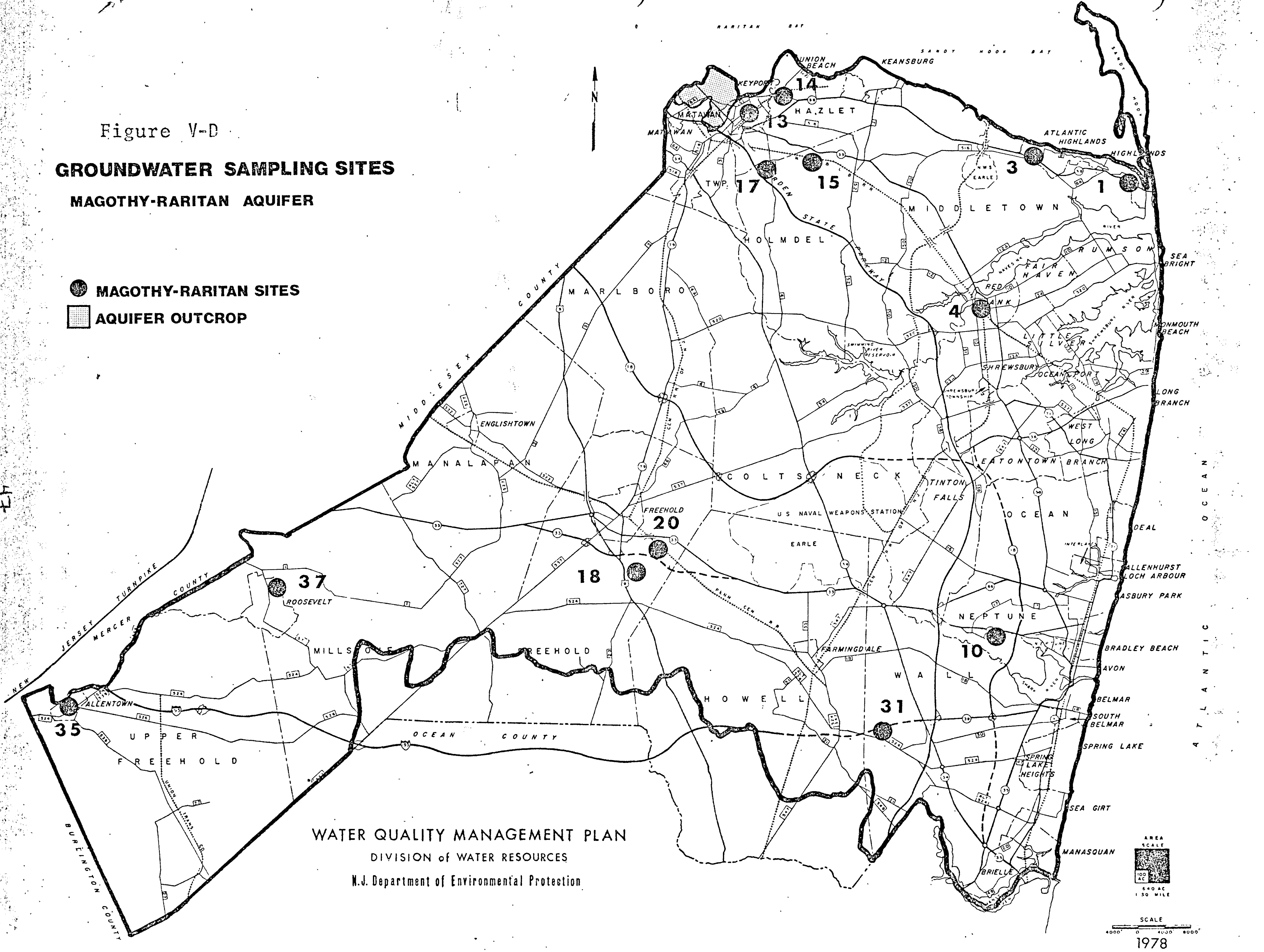
Groundwater Sampling Sites

Site Number	Well Owner and Number	Location	Date of Sampling
Magothy - Raritan Aquifer			
1	Highlands Water Dept. #2	Miller St., Highlands	6/77
3	Atlantic Highlands Water Dept. #2	Lincoln Ave. Atlantic Highlands	6/77
4	Red Bank Water Dept. #1B	Chestnut St. Red Bank	6/77
10	Monmouth Consolidated Water Co. #5	Old Corlies Rd. Neptune	6/77
13	Keyport Water Dept. #7	American Legion Dr. Keyport	6/77
14	Union Beach Water Dept. #1	Florence Dr. Union Beach	6/77
15	West Keansburg Water Co. #3	Hunters Lane Holmdel	6/77
17	Kenneth Hopper	Holmdel Rd. Holmdel	6/77
18	Freehold Twp. Water Dept. #4	Koening Ln. Freehold Twp.	6/77
20	3-M Co.	Willowbrook Rd. Freehold Twp.	6/77
31	Brisbane Child Treatment Center #3	Wall Twp.	6/77
35	Allentown Water Dept. #1	Church St. Allentown	6/77
37	Roosevelt Water Dept. #1956	Oscar Rd. Roosevelt	6/77

Figure V-D

GROUNDWATER SAMPLING SITES

MAGOTHY-RARITAN AQUIFER



WATER QUALITY MANAGEMENT PLAN

DIVISION of WATER RESOURCES

N.J. Department of Environmental Protection

TABLE V-14 continued

Groundwater Sampling Sites

Site Number	Well Owner and Number	Location	Date of Sampling
Englishtown Aquifer			
2	Atlantic Highlands Water Dept. #3	Lincoln Ave. Atlantic Highlands	6/77
5	Bell Laboratories #1	Holmdel	6/77 and 5/78
11	Belmar Boro Water Dept. #2 Electric	12th Ave. & Railroad Belmar	6/77 and 5/78
16	Lily-Tulip Cup Inc.	Rts. 35 & 52 Holmdel	6/77 and 5/78
19	Worthington Biochemical Co. #1	Halls Mill Rd. Freehold Twp.	6/77 and 5/78
29	Farmingdale Water Dept. #4	Main St. Farmingdale	6/77
36	Rutgers University	Upper Freehold Twp.	6/77
40	Old Brick Reformed Church	Rt. 520 Marlboro	7/77
41	Mandapan Twp. Water Dept.	Freehold-Englishtown Road Tenant	5/78
42	L.W. Bahrenburg	Beers St. Hazlet	5/78
43	R. Hicks Sr.	Rt. 79 Morganville	5/78
44	Upper Freehold Board of Education #1	Davies Station Rd. Imlaystown	5/78
45	L. Saunders	Spring Valley Rd. Morganville	5/78

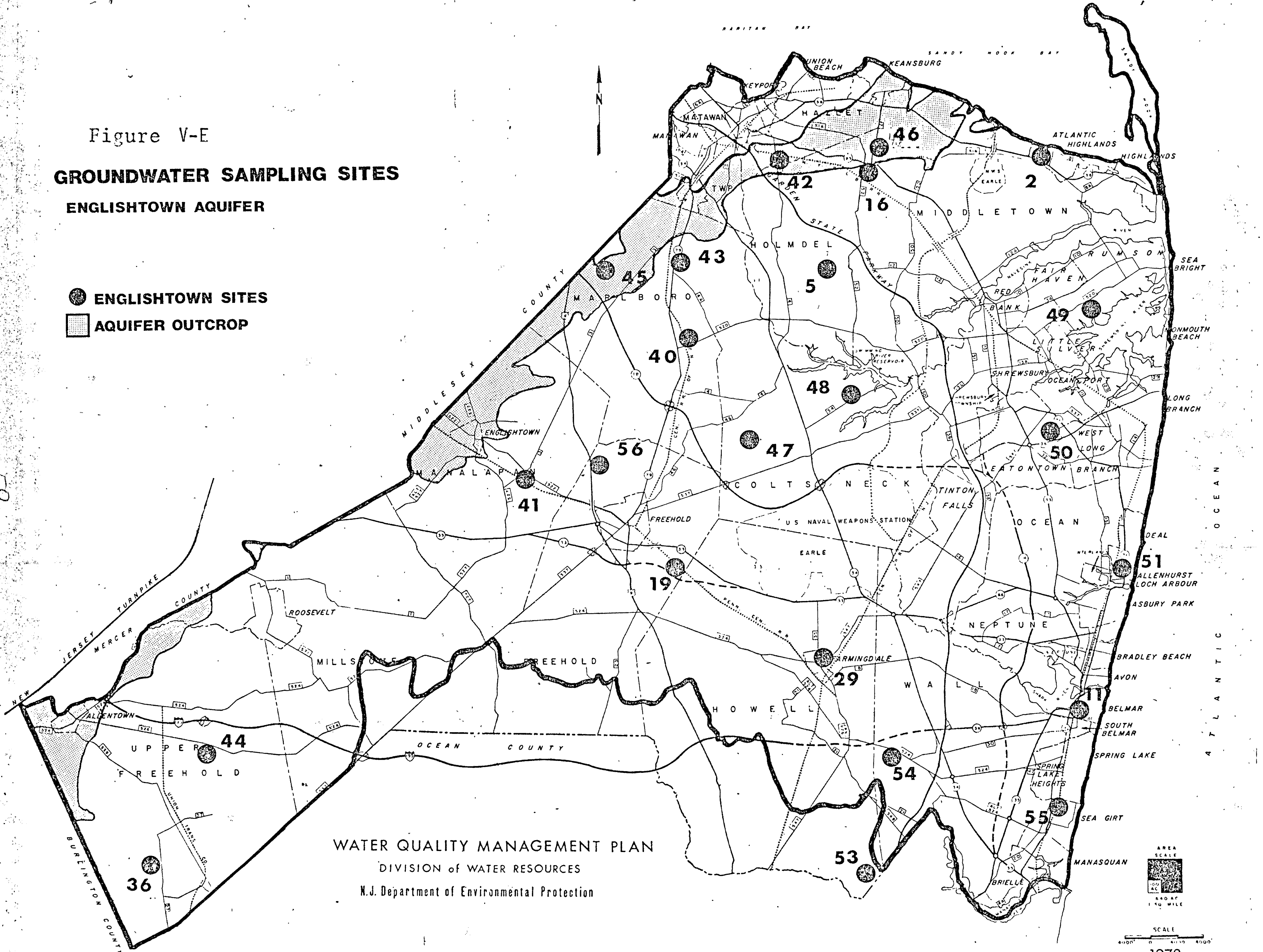
TABLE V-14 continued
Groundwater Sampling Sites

Site Number	Well Owner and Number	Location	Date of Sampling
46	Mrs. Kolb	Palmer Ave. Middletown	5/78
47	Cedar Drive School	Cedar Dr. Colts Neck	5/78
48	Lairds Distillers	Eatontown and Freehold Rd., Colts Neck	5/78
49	Rumson Country Club	Rumson Rd. Rumson	5/78
50	Old Orchard Country Club	Monmouth Rd. Eatontown	5/78
51	Allenhurst Water Dept. #4	Main and Hume Sts. Allenhurst	5/78
53	Parkway Water Co. #1	Western Dr. Howell	6/78
54	U.S.G.S. - Allaire #2	Allaire State Park Howell	5/78
55	Sea Girt Water Dept. #5	Baltimore Ave. Sea Girt	5/78
56	Freehold Twp. Water Dept. Pt. Ivy #3	Edwards Dr. Freehold Twp.	6/78

Figure V-E

GROUNDWATER SAMPLING SITES

ENGLISHTOWN AQUIFER



WATER QUALITY MANAGEMENT PLAN

DIVISION of WATER RESOURCES

N.J. Department of Environmental Protection

1978

TABLE V-14 continued

Groundwater Sampling Sites

Site Number	Well Owner and Number	Location	Date of Sampling
Mt. Laurel - Wenonah Aquifer			
6	PVC Container Corp.	Industrial Way Eatontown	6/77
7	C.J. Hampton	Old Tavern Rd. Howell	6/77
9	Avon Water Dept. #1	Main St. Avon	6/77
21	Allied Diesal Service	Rt. 33 Freehold Twp.	6/77
23	M. Bailey	Elton Rd. Freehold Twp.	6/77
28	Central Jersey Concrete	Yellowbrook Rd. Howell	6/77
33	P. Coleman	West Front St. Red Bank	6/77
38	A. Ogrodnick	Disbrow Mill Rd. Perrineville	6/77
Red Bank Sands Aquifer			
32	C. Brant	Megill Rd. Wall Twp.	6/77
34	Dr. T. Frucht	Hochokockson Rd. Colts Neck	6/77
39	U.S. Army	Fort Monmouth Tinton Falls	7/77

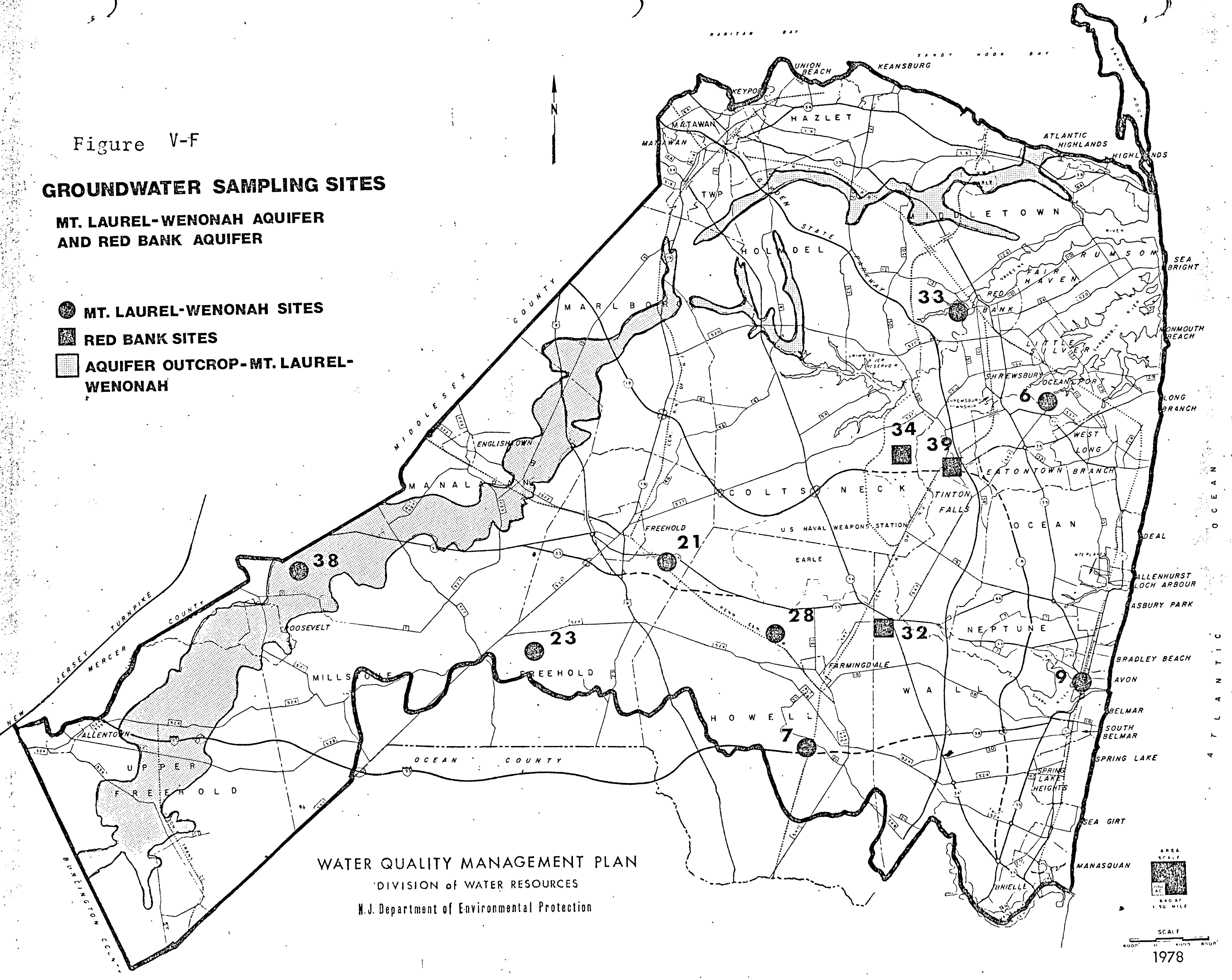


Figure V-F

GROUNDWATER SAMPLING SITES

MT. LAUREL-WENONAH AQUIFER AND RED BANK AQUIFER

TABLE V-14 continued

Groundwater Sampling Sites

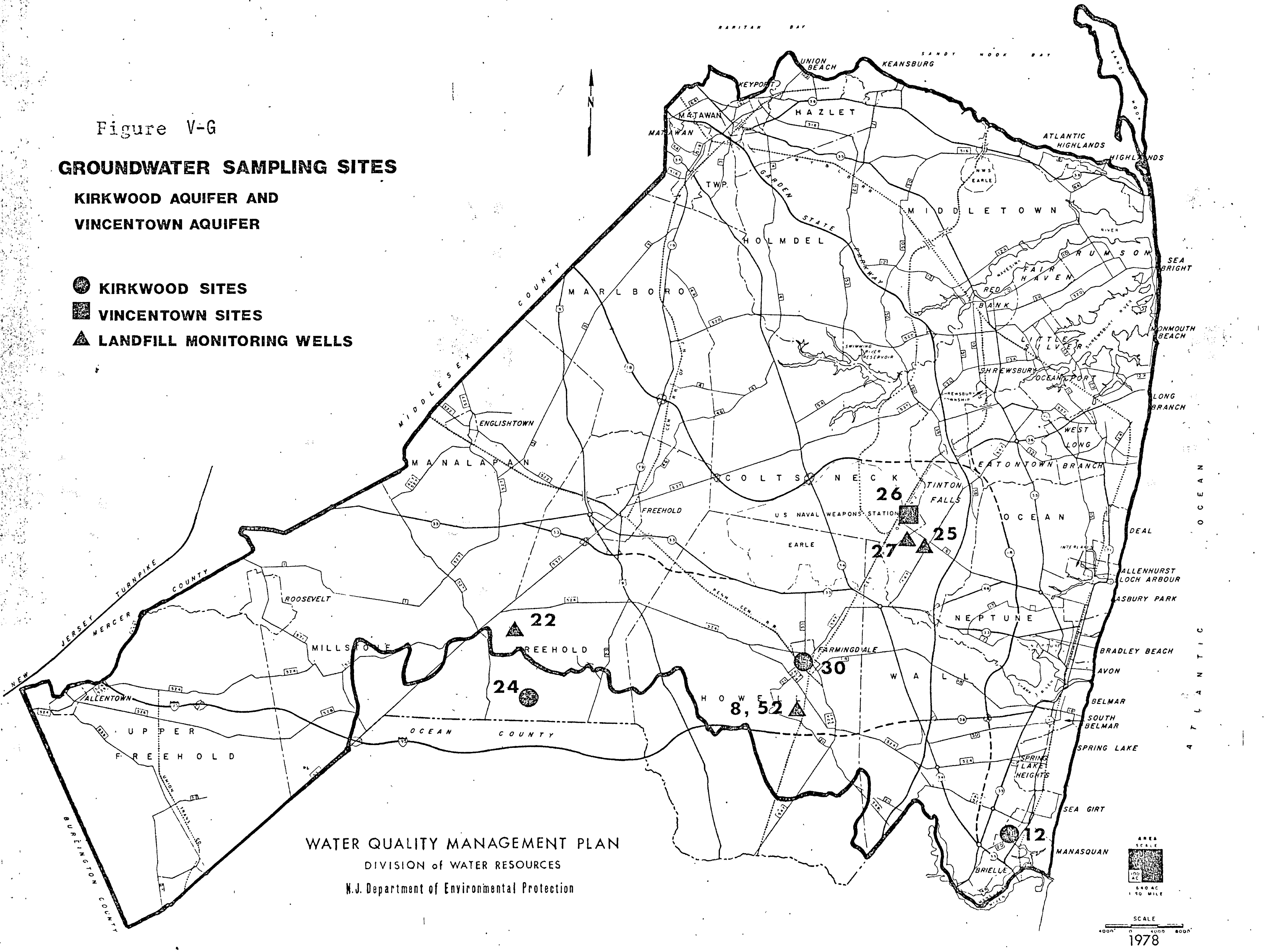
Site Number	Well Owner and Number	Location	Date of Sampling
Vincentown Aquifer			
26	Naval Ammunition Depot Army Area	off Asbury Ave. Colts Neck Twp.	6/77
Kirkwood Aquifer			
12	Manasquan Water Dept. #5	South St. Manasquan	6/77
24	Girl Scouts Camp Nomoco	Nomoco Rd.	6/77
30	Foster Canning	Farmingdale	6/77
Landfill Monitoring Wells			
8	Howell Twp. Municipal Landfill #1	Old Tavern Rd. Howell	6/77
22	Lone Pill Landfill #2	Elton Rd. Freehold Twp.	6/77
25	Monmouth County Reclamation Center #5	Asbury Ave. Tinton Falls	6/77
27	Shrewsbury Disposal #1	Asbury Ave. Tinton Falls	6/77
52	Howell Twp. Municipal Landfill #2	Old Tavern Rd. Howell	5/78

Figure V-G

GROUNDWATER SAMPLING SITES

KIRKWOOD AQUIFER AND VINCENTOWN AQUIFER

- KIRKWOOD SITES
- VINCENTOWN SITES
- LANDFILL MONITORING WELLS

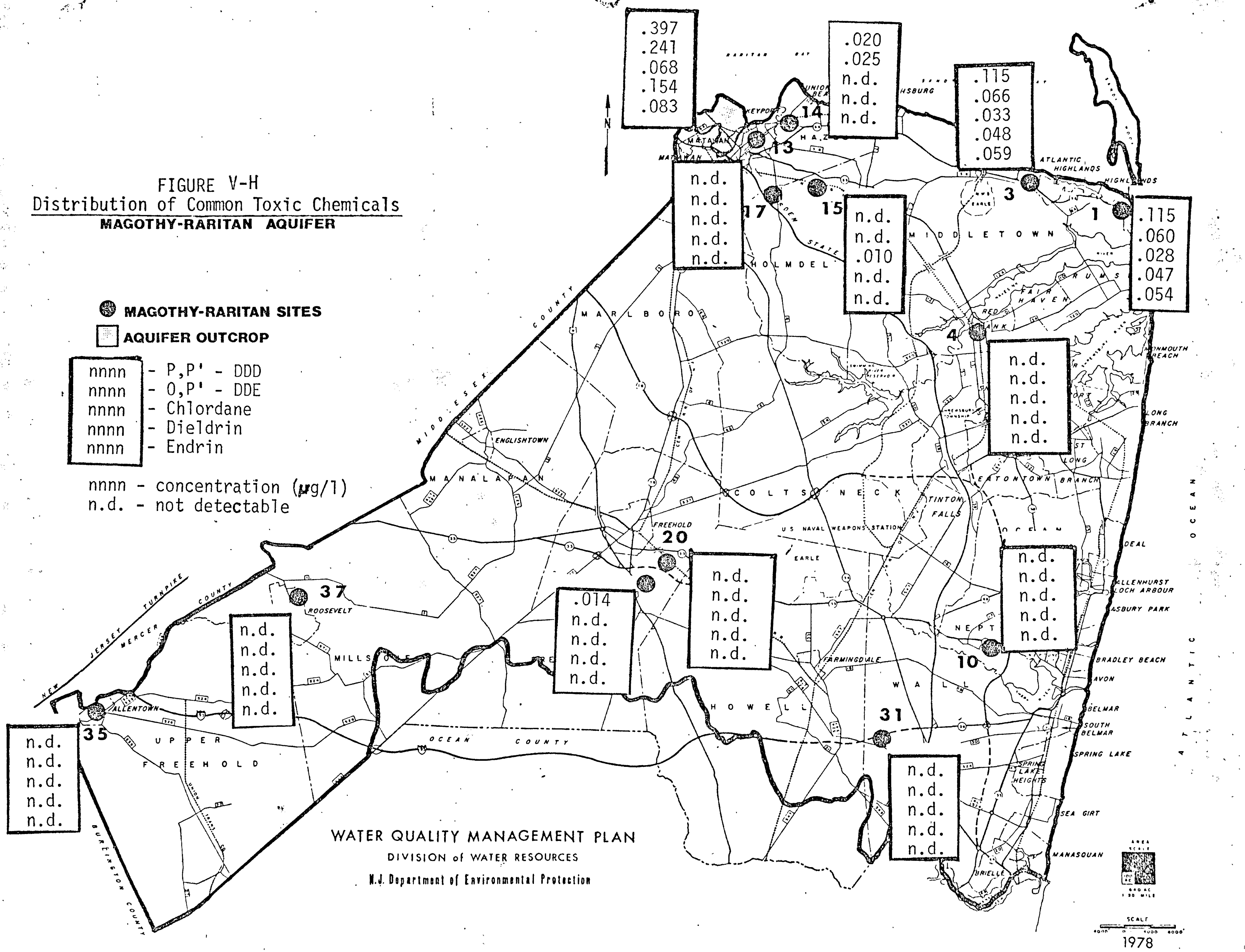


WATER QUALITY MANAGEMENT PLAN

DIVISION of WATER RESOURCES

N.J. Department of Environmental Protection

FIGURE V-H
Distribution of Common Toxic Chemicals
MAGOTHY-RARITAN AQUIFER



Lower Delaware Planning Area
Ground Water Quality

Ground Water

Ground water is an essential source of potable water in Salem and Cumberland Counties. In addition to the water purveyors which utilize ground water for most of their supply, many homes have private wells, and industries and businesses throughout the area use ground water to supply drinking water to their employees and for plant processes. The public has indicated that ground-water protection is of high priority in the Lower Delaware study area.

208 Ground-Water Sampling Study

The importance of ground water as a potable water supply for the residents of the study area makes it essential that this resource be protected. Providing of appropriate protective measures, however, cannot be instituted without first having an understanding of the area's ground water quality. Unfortunately, there is only a limited amount of ground water quality data available from previous sampling. The data which does exist for the area was examined; and based on this information, as well as input from several government agencies and the public, a sampling study was designed.

Sixty wells were sampled during the summer of 1977 in an initial round of sampling. An additional twenty-five samples were collected after the initial data was examined. If, however, the first round of sampling revealed that water potentially used as a source of public supply exceeded health-related potable water criteria, that well was immediately resampled for the parameter(s) in question by the New Jersey Bureau of Potable Water. The second round sampling sites included wells which exceeded criteria in the initial sampling; as well as new wells. Some of these new wells were selected because they were in the vicinity of wells exceeding criteria in round one.

In addition to public supply wells, industrial, landfill, and private wells were sampled. The wells sampled, listed in Table V-15, are each identified by a number and shown on the map in Figure V-I.

Table V-15

Wells Which Were Sampled as Part of The WQM Study

Well Owner	Location	Map # and Sample I.D.# **	Aquifer	Lat./Long.	Local Well#	Well Depth(ft.)
Bridgeton Water Dept.	Bridgeton City	Cu1	Cohansey-U. Kirkwood	-	2	97
Millville Water Dept.	Millville City	Cu2a	Kirkwood	-	13	295
Millville Water Dept.	Millville City	Cu2b	Cohansey-U. Kirkwood	-	15	110
Vineland Water Dept.	Vineland City	Cu3	Cohansey-U. Kirkwood	392941/745831	11	154
Berry Miller	Commercial Twp.	Cu4	Kirkwood	391502/750248		194
N.J. State Prison (medium sec.)	Leesburg	Cu5	Cohansey-U. Kirkwood	-	2	269
Seabrook Farms	U. Deerfield	Cu6	Cohansey-U. Kirkwood	-	3b	186
Owens-Illinois Inc.	Vineland City	Cu7	Cohansey-U. Kirkwood	-	3	116
Fortescue Realty	Downe Twp.	Cu8	Kirkwood	-		365
Wheaton Glass co.	Millville City	Cu9	Cohansey-U. Kirkwood	-	12	150
N.J. Silica Sand	Maurice River Twp.	Cu10	Cohansey-U. Kirkwood	392056/745742		85
Mr. Cicarelli	Vineland City	Cu11	Cohansey-U. Kirkwood			35
Maurice River Twp. Mun. Landfill	Maurice River Twp.	Cu12	Cape May		1 (at Rt.47)	17
Mrs. Vennel	Deerfield	Cu13	Cohansey-U. Kirkwood			65
Fairton Primary School	Fairton	Cu14	Cohansey-U. Kirkwood			150
Albert Stubee	Fairfield	Cu15	Kirkwood			110
Petersen Packing Co.	Port Norris	Cu16	Cohansey-U. Kirkwood		1	140
Sidney Scott	Hopewell	Cu17	Cohansey-U. Kirkwood			102
Landis Sewer. Auth.	Vineland	Cu18	Cohansey-U. Kirkwood		4102	34
Landis Sewer Auth.	Vineland	Cu19	Cohansey-U. Kirkwood		36	34
Landis Sewer Auth.	Vineland	Cu20	Cohansey-U. Kirkwood		35	45
Landis Sewer Auth.	Vineland	Cu21	Cohansey-U. Kirkwood		05	29
Dr. Lisowski	Hopewell	Cu22	Cohansey-U. Kirkwood			57
Penna. Glass Sand Co.		Cu23	Cohansey-U. Kirkwood		2	82
George Weist	Upper Deerfield	(Cu24)	Cohansey-U. Kirkwood			64
Jason Errett	Vineland	(Cu25)				68
Anthony Chipola	Millville	(Cu26)				100
Howard Hill	Deerfield	(Cu27)				81
S. Lamnin	Vineland	(Cu28)				97

Table V-15 (continued)

Well Owner	Location	Map # and Sample I.D.# **	Aquifer	Lat./Long.	Local Well#	Well Depth(ft.)
Salem City Water Dept.	Salem City	SA1	Mt. Laurel-Wenonah	-	2	145
Elmer Water Co.	Elmer Boro	SA2	Mt. Laurel-Wenonah	393534/751018	6	500
Oldmans Twp. Water Dept. (Auburn City)	Oldmans Twp.	SA3	Raritan-Magothy			205
Parvin State Park	Pittsgrove	SA4a	Mt. Laurel-Wenonah	393038/750800	(office well)	90
Parvin State Park	Pittsgrove	SA4b	Kirkwood	393015/750810	PW-B	154
Penns Grove Water Supply Co.	Penns Grove	SA5	Raritan-Magothy	-		54
Woodstown Water Dept.	Woodstown Boro	SA6	Raritan-Magothy	-	3	713
N.J. Tpk. Serv. Area 1N		SA7	Raritan-Magothy	-	1	390
Cowtown Auctioneers Inc.	Pilesgrove Twp.	SA8	Mt. Laurel-Wenonah	-		115
Mannington Mills Co.	Mannington Twp.	SA9	Mt. Laurel-Wenonah		4	119
B. F. Goodrich Co.	Oldmans Twp.	SA10	Raritan-Magothy	-	PW-2	129
Atlantic City Electric Co.	Pennsville	SA11	Raritan-Magothy	-	3A	235
Pennsville Twp. Water Dept.	Pennsville Twp.	SA12	Raritan-Magothy	-	4	137
E.I. DuPont Inc. (Chambers Works)		SA13a	Quaternary	-	R-5	122
E.I. DuPont Inc. (Chambers Works)		SA13b	Raritan-Magothy	-	DW-8	356
E.I. DuPont Inc. (Carney's Point)		SA13c	Raritan-Magothy	-	CP-1	195
E.I. DuPont Inc. (Carney's Point)		SA13d	Quaternary	-	CP-4	89
Nostrip Chemical	Oldmans Twp.	SA14	Raritan-Magothy	-		165
B.F. Goodrich	Oldmans Twp.	SA15a	Raritan-Magothy		Monit. well #5	18
B.F. Goodrich	Oldmans Twp.	SA15b	Raritan-Magothy	-	Monit. well #6	19
W.B. Reeves	Elmer	SA16	Cohansey-U. Kirkwood	393406/751728		68
Paul J. Sassi	Alloway	SA17	Mt. Laurel-Wenonah	393354/751917		308
E. Burrel	L. Alloway Creek	SA18	Vincentown	393016/752621		165
Paul Weininger (Colonial Farms)	Pittsgrove	SA19	Cohansey-U.Kirkwood	-		82
H. F. Smith	Quinton	SA20	Vincentown	393242/752445		90
National Lead	Pedricktown	SA21a	Raritan-Magothy	-	Monit. well #3	18
National Lead	Pedricktown	SA21b	Raritan-Magothy	-	Monit. well A	17
Q.T. Solid Waste Disposal Area	Quinton Twp.	SA22	Cohansey-U. Kirkwood	-	2	20
John Dawson	L. Alloway Creek	SA23	Mt. Laurel-Wenonah	-		285
Garden State Egg Co.	Woodstown	SA24	Mt. Laurel-Wenonah	-	(loading dock)	166

Table V-15 (continued)

Well Owner	Location	Map # and Sample I.D.#	Aquifer	Lat./Long.	Local Well#	Well Depth(ft.)
		SA25		-		
A.R. Hackett	Woodstown	SA26	Vincentown	-		60
Larry Pompper	Mannington	SA27	Vincentown	-		55
M.W. Dawson	Oldmans	SA28	Raritan-Magothy	-		124
Walter E. Hill	L. Alloways Creek	SA29	Kirkwood	-		65
Elmer Community Hosp.	Elmer	SA30	Cohansey-U. Kirkwood		(Reserve well)	58
Alex Linski	Pennsville Twp.	SA31	Raritan-Magothy	-		366
William H. Ferrel Jr.	Pedricktown	(SA32)	Raritan-Magothy			78
Roy Griffin	Pedricktown	(SA33)	Raritan-Magothy		1	58
Vineland Live and Dressed Poultry	Norma	(SA34)			4	178
Mayerfeld Farms	Norma	(SA35)				70

** Sites within parentheses are not shown on the map (Figure III-7)

Figure V-I

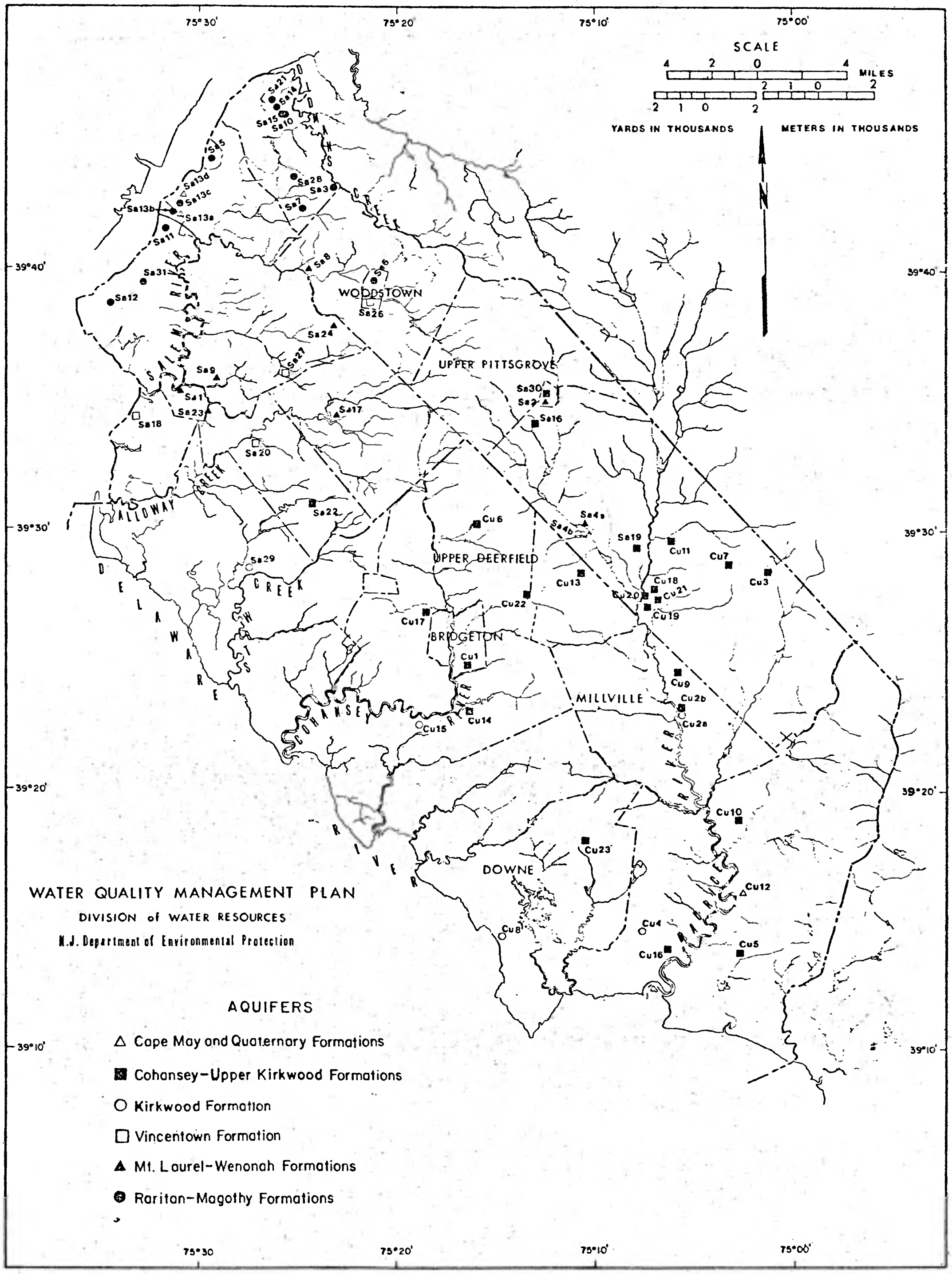


Figure V-I Ground-Water Sampling Sites

The ground-water sampling study is a cooperative effort between the WQM Program and a study being undertaken by the Program on Environmental Cancer and Toxic Substances (PECTS). The PECTS study is focusing its attention on the determination of whether carcinogenic chemicals are present in the ground water. The analysis of several other important parameters was funded by the WQM Program. The chemical parameters for which the ground water was analyzed are listed in Tables V-16 and V-17 Through this cooperative effort, both DEP units will benefit as the analytical results will be much more comprehensive than originally anticipated by either. The samples will therefore be of greater value in establishing a baseline of ground water quality for the area.

In the choosing of sampling sites, the public potable water suppliers were given priority due to the health related concerns of the program.

Analysis of ground water sampling data is particularly difficult because the movement of pollutants underground is often hard to predict. If a particular pollutant appears in one sample taken from a well but not in a subsequent sample, interpretation may be difficult. The contaminant may be travelling in the ground water in a slug that is flushed past the well before the next sampling. Alternatively, the original detection of the pollutant may have been an analytical error. In the case of complex compounds such as those monitored in this study, behavior is particularly hard to predict since little is known about what happens to these substances in the ground water.

Similarly, the presence of contaminants in one well may or may not have implications for other wells in a region. Intensive study of geology, ground water movement, and proximity of other wells, as well as additional sampling, will be needed to fully evaluate the implications of sampling data from this initial study.

Ground-Water Sampling Findings

Several of the samples exceeded potable water criteria. However, most of the samples having excessive concentrations were from wells not used for potable water supply. Those public supply wells which were partially resampled by the Bureau of Potable Water met criteria. A listing of all the samples which exceeded the criteria is given in Table V-18.

Table V-16 Analyses Funded by the WQM Program

a) Metals

silver
iron
sodium
manganese
mercury

b) Other Parameters

temperature
pH
alkalinity
ABAS
fluoride
chloride
sulfate
nitrate
nitrite
ammonia
organic nitrogen
phosphate, total
total dissolved solids
fecal coliform
cyanide (free)

Table V-17 Analyses Funded by Program on Environmental Cancer and Toxic Substances

Light Organic Compounds	Pesticides and PCB
methylene chloride	Polychlorinated Biphenyls (PCB
methyl chloride	BHC
methly bromide	lindane
chloroform	aldrin
bromoform	dieldrin
bromodichloromethane	endrin
dibromodichloromethane	heptachlor
trifluoromethane	heptachlor epoxide
carbon tetrachloride	toxaphene
1,2 - dibromoethane	DDT and associated compounds
1,2 - dichloroethane	
1,1 - trichloroethane	**Heavy Metals**
vinyl chloride	
1,1 1,2 - dichloroethylene	arsenic and compounds
1,1,2 - trichloroethylene	beryllium and compounds
o,m,p - dichlorobenzene	cadmium and compounds
trichlorobenzene	chromium and compounds
tetrachloroethylene	copper and compounds
	nickel and compounds
	lead and compounds
	zinc and compounds
	selenium and compounds

Table V-18 Samples Which Exceeded Potable Water Criteria

Sample I.D.#	Owner	Use of Water**	Criteria Exceeded First Round Sampling	 Second Round Sampling
Sa 1	Salem City Water Dept.	PS	iron	*
Sa 3	Oldmans Twp. Water Dept.	PS	heptachlor endrin	iron
Sa 5	Penns Grove Water Dept.	PS	heptachlor expoxide endrin manganese	manganese
Sa 6	Woodstown Water Dept.	PS	sodium	sodium fluoride dissolved solids
Sa 7	N.J. Turnpike Service Area 1N	PS	iron	*
Sa 12	Pennsville Twp. Water Dept.	PS	iron manganese	iron manganese
Cu 2a	Millville Water Dept.	PS	iron	*
Cu 2b	Millville Water Dept.	PS	iron	*
Cu 4	Berry Miller	PS	iron	*
Cu 6	Seabrook Farms	PS	lead	–
Sa 4b	Parvin State Park	PS	iron	*
Sa 8	Cowtown Auctioneers	P	iron manganese	*
Sa 17	Paul J. Sassi	P	manganese	*

Table V-18 (Continued)

Sample I.D.#	Owner	Use of Water**	Criteria Exceeded	
			First Round Sampling	Second Round Sampling
Sa 18	E. Burrel	P	iron	*
Sa 19	Paul Weininger	P	manganese	*
Sa 20	H.F. Smith	P	iron manganese	*
Sa 28	M.W. Dawson	P	PCB iron manganese	iron manganese
Sa 29	Walter Hill	P	PCB iron	iron manganese
Sa 30	Elmer Community Hospital (reserve well)	P	PCB iron	heptachlor
Sa 26	A.R. Hackett	P	iron	*
Sa 31	Alex Linski	P	chloride iron sodium dissolved solids	iron dissolved solids
Sa 32	William Ferrel Jr.	P	*	iron manganese
Sa 33	Roy Griffin	P	*	manganese sulfate
Sa 35	Henry Mayerfield	P	*	manganese
Sa 13b	DuPont	P	iron sodium	iron sodium
Cu 11	Mr. Cicarelli	P	arsenic iron manganese	*

Table V-18 (Continued)

Sample I.D.#	Owner	Use of Water**	Criteria Exceeded First Round Sampling	 Second Round Sampling
Cu 13	Mrs. Vennel	P	manganese	*
Cu 15	Albert Stubee	P	iron	*
Cu 24	George Weist	P	*	lead
Cu 25	Jason Errett	P	*	manganese
Cu 28	Mrs. Lamnin	P	*	chloride
Sa 9	Mannington Mills Co.	I/L	iron manganese	*
Sa 10	B.F. Goodrich Company	I/L	iron manganese	*
Sa 11	Atlantic City Electric Co.	I/L	iron	*
Sa 13a	DuPont	I/L	trihalomethanes iron manganese sodium chloride dissolved solids	trihalomethanes iron manganese chloride
Sa 13c	DuPont	I/L	iron sodium manganese chloride	*
Sa 13d	DuPont	I/L	iron manganese sodium dissolved solids	*

Table V-18 (Continued)

Sample I.D.#	Owner	Use of Water**	Criteria Exceeded First Round Sampling	 Second Round Sampling
Sa 14	Nostrip Chemical	I/L	iron	*
Sa 15a	B.F. Goodrich	I/L	iron manganese sodium cyanide	iron manganese
Sa 15b	B.F. Goodrich	I/L	sulfate iron manganese cyanide dissolved solids	*
Sa 21a	National Lead	I/L	cadmium lead iron manganese sodium chloride sulfate	cadmium iron manganese sodium lead sulfate chloride
Sa 21b	National Lead	I/L	cadmium lead iron manganese sodium chromium sulfate	*
Sa 22	Q.T. Solid Waste Disposal Area	I/L	iron mercury (at limit)	iron manganese
Sa 24	Garden State Egg Company	I/L	iron	*
Sa 34a	Vineland Live and Dressed Poultry	I/L	*	iron

Table V-18 (Continued)

Sample I.D.#	Owner	Use of Water**	Criteria Exceeded First Round Sampling	Criteria Exceeded Second Round Sampling
Cu 12	Maurice River Township Municipal Landfill	I/L	iron manganese	*
Cu 16	Peterson Packing Company	I/L	iron	*
Cu 19	Landis Sewer Authority	I/L	iron sodium manganese	*
Cu 20	Landis Sewer Authority	I/L	iron sodium MBAS	*
Cu 21	Landis Sewer Authority	I/L	arsenic iron sodium	iron manganese sodium
Cu 23	Pennsylvania Glass Sand Co.	I/L	PCB	-

\- Sampled, but criteria not exceed
* not sampled
** PS = Potable Water Supply
I/L = Industrial Use or Landfill Monitoring
P = Private Well

Of the other parameters which were tested for in the ground-water sampling study the following exceeded potable water criteria in some samples: heptachlor, endrin, heptachlor epoxide, lead, polychlorinated biphenyls, chloride, dissolved solids, arsenic, trihalomethanes, sulfate, cyanide, cadmium, methylene blue activated substances, and chromium. Several of these samples were from wells which are not used for drinking water supplies; nevertheless the results are of concern due to the possibility that other wells, some of which may be used for potable water supply, may be similarly affected. It should be noted that it had already been known that contamination exists in the vicinity of some of the sampled wells. For example, contamination had been known to exist in the area surrounding the DuPont plants in Salem County, and corrective measures have been underway for years.

Ground Water

Ground water is an essential source of potable water in the Upper Delaware region. Ground water is utilized by most water purveyors as their source of potable supplies. In addition, many homes have private wells, and industries and businesses throughout the area use ground water to supply drinking water to their employees and for plant processes. The public has indicated that ground water protection, especially as related to septic tank pollution, is of high priority in the Upper Delaware study area.

208 Ground-Water Sampling Study

The importance of ground water as a potable water supply for the residents of the study area makes it essential that this resource be protected. Appropriate protective measures, however, cannot be instituted without first having an understanding of the area's ground water quality. Unfortunately, there is only a limited amount of ground water quality data available from previous sampling. The data from the area which does exist was examined, and based on this information, as well as input from several government agencies and the public, a sampling study was designed.

Thirty-eight wells were sampled during the summer of 1977 in a first round of sampling. Provision was made for an additional twenty-two samples to be collected, in the summer of 1978, after examination of the initial data. In some cases, second round sites were first round wells from which samples exceeded potable water criteria. Other second round sites were wells which had not been sampled in the first round.

The samping sites for both rounds included public water suppliers, industries, and private wells. The wells sampled, listed in Table V-19, are each identified by a number and shown on the map in Figure V-J.

The ground-water sampling study is a cooperative effort between the WQM Program and a study being undertaken by the DEP Program on Environmental Cancer and Toxic Substances (PECTS). The PECTS study is focusing its attention on the

Table V-19

Wells Which Were Sampled as Part of the WQM Study

Well Owner	Location	Map # and Sample I.D.# **	Aquifer*	Lat/Long.	Local Well#	Well Depth(ft.)
Alpha Munic. Water Works	Alpha	W1	Kittatinny		2	263
Blair Academy	Blairstown	W2	Martinsburg		1	300
Brainards Mutual Water Assoc.	Harmony	W3	Kittatinny		1	180
Garden State Water Co.	Phillipsburg	W4	Glacial		A	85
Hackettstown MUA	Hackettstown	W5a	Kittatinny		Seber Well #5	143
Hackettstown MUA	Hackettstown	W5b	Glacial		Seber Well #4	45
N.J. Water Co.	Washington	W6	Kittatinny		3	345
Pequest Water Co.	Allamuchy	W7	Kittatinny		2	495
Stewartsville Water Co.	Stewartsville	W8	Kittatinny		1	250
Warren Resid. Group Center	White	W9	Precambrian		1	300
American Can Co.	Washington	W10	Dolomite		1	400
Ashland Chemical	Independence	W11	Kittatinny		1	395
J. T. Baker Co.	Phillipsburg	W12a	Kittatinny		3	100
J. T. Baker Co.	Phillipsburg	W12b	Kittatinny		1	90
Harmony Sand and Gravel	Roxbury	W13	Glacial		1	80
Hoffman La Roche	White	W14	Glacial		4	112
Ingersoll Rand	Phillipsburg	W15	Kittatinny		2	503
Mars M and M Co.	Hackettstown	W16	Kittatinny		4	100
Mobil Chem. Co.	Hackettstown	W17	(Shale-Limestone) fault zone		2	535
Oxford Textile Co.	Washington	W18	Hardyston		1	285
Oxwall Co.	Washington	W19	Hardyston		1	256
Westbrook Creamery	Frelinghuysen	W20	Kittatinny		1	110
Asbury Graphite	Asbury	W21	Kittatinny			132
Riegel Paper Co. (Warren Glen Mill)		W22	Kittatinny		1	300
Riegel Paper Co. (Riegelsville Mill)		W23	Kittatinny		4	200
Frelinghuysen School	Frelinghuysen	W24	Martinsburg			135
C. Stanowski	Knowlton	W25	Martinsburg			52
Blairstown Plumbing	Blairstown	W26	Glacial			172
Allen Bull	Blairstown	W27	Glacial			65
Mrs. Ryman	Knowlton	W28	Kittatinny			80
Diamond Hill Estates Water Co.	Hackettstown	(W29)			1	250
Hillcrest Homeowners Assoc.	Mansfield	(W30)			2	250
Samuel Sadlon	Oxford	(W31)				85

Table V-19 (continued)

Well Owner	Location	Map # and Sample I.D.# **	Aquifer*	Lat/Long.	Local Well#	Well Depth(ft.)
Bloomsbury Water Dept.	Bloomsbury	UDHT1	Kittatinny		1	250
Ridge Water Co.	Holland	UDHT2	(Limestone)		1	86
Milford Water Co.	Milford	UDHT3	Brúnswick		2	250
Magnesium Elektron	Kingwood	UDHT4	Brunswick		3	108
Stockton Water Co.	Stockton	UDHT5	Stockton		1	278
Riegel Paper Co. (Milford Plant)		UDHT6a	Glacial		1	339
Riegel Paper Co. (Hughsville Mill)		UDHT6b	Kittatinny		4	79
Rosemont Water Co.	Delaware	UDHT7	Stockton		1	400
Sam Faust	Changewater	(UDHT8)				20
Sam J. Smith	Glen Gardner	(UDHT9)				30

* For most of the wells, the probable aquifer tapped was determined from an examination of the Geologic Overlays of the State Atlas Sheets. For detailed study of particular well sites, it is advisable to confirm the aquifer involved through a field examination.

** Sites within parentheses are not shown on the map (Figure III-6)

Figure V-J

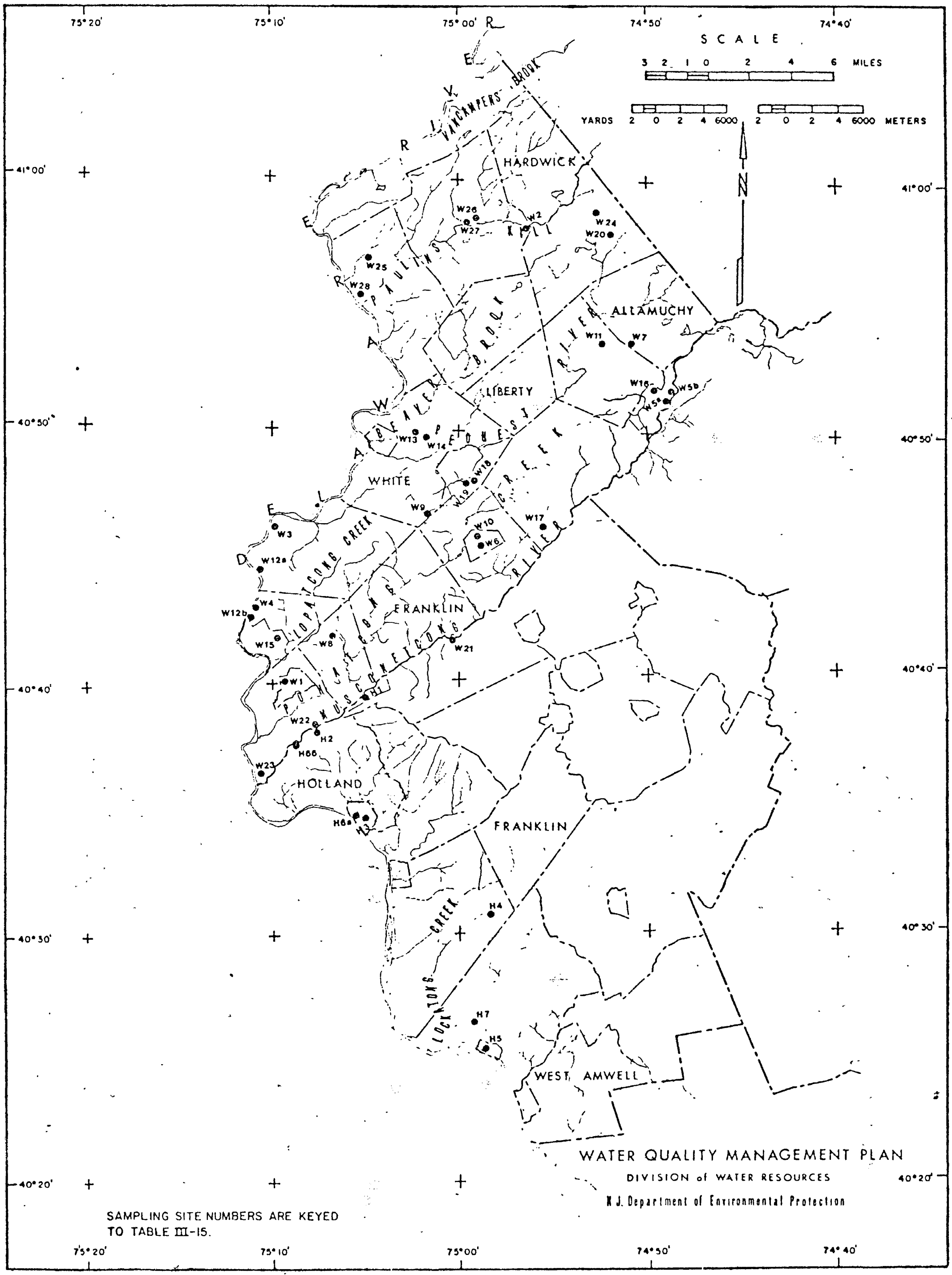


Figure V-J Ground-Water Sampling Sites

determination of whether carcinogenic chemicals are present in the ground water. The analysis of several other important parameters was funded by the WQM Program. The chemical parameters for which the ground water was analyzed are listed in Tables V-20 and V-21 Through this cooperative effort, both DEP units will benefit as the analytical results will be more comprehensive than originally anticipated by either. The samples will therefore be of greater value in establishing a baseline of ground water quality for the area.

In the selection of sampling sites, public potable water suppliers were given priority due to the health related concerns of the program. Wells at industrial sites were sampled in order to determine whether their activities are affecting ground water quality. Additionally, some wells in areas where septic tanks are used were chosen in order to determine their effects on the area's ground water quality.

Analysis of ground water sampling data is particularly difficult because the movement of pollutants underground is often hard to predict. If a particular pollutant appears in one sample taken from a well but not in a subsequent sample, interpretation may be difficult. The contaminant may be travelling in the ground water in a slug that is flushed past the well before the next sampling. Alternatively, the original detection of the pollutant may have been an analytical error. In the case of complex compounds such as those monitored in this study, behavior is particularly hard to predict since little is known about what happens to these substances in the ground water.

Similarly, the presence of contaminants in one well may or may not have implications for other wells in a region. Intensive study of geology, ground water movement, and proximity of other wells, as well as additional sampling, will be needed to fully evaluate the implications of sampling data from this initial study.

Ground-Water Sampling Findings

The data from the sampling program show the ground water to be of generally good quality. There are, however, some instances in which potable water criteria were exceeded. The parameters whose concentrations, in some samples, exceeded recommended limits for potable water use were: chloride, cyanide, dissolved solids, mercury, manganese, sulfate, iron, sodium and fecal coliforms. Most of the samples containing excessive concentrations are from wells not being used for potable water purposes; only violations of iron, manganese and sodium criteria were confirmed in resampling of the wells. Iron and manganese were confirmed in follow up samples to violate potable water criteria in two industrial use wells. A manganese violation was also confirmed in one potable supply. Excessive iron or manganese can cause unpleasant taste in drinking water, can stain fabrics or utensils, and may be objectionable for industrial processes. One sodium violation was confirmed, in a potable supply (Frelinghuysen School). Sodium compounds are commonly

Table V-20 Analyses Funded by the WQM Program

a) Metals

silver

iron

sodium

manganese

mercury

b) Other Parameters

temperature

pH

alkalinity

ABAS

fluoride

chloride

sulfate

nitrate

nitrite

ammonia

organic nitrogen

phosphate as phosphorus, total

total dissolved solids

fecal coliform

cyanide (free)

Table V-21 Analyses Funded by Program on Environmental Cancer and Toxic Substances

<u>Light Organic Compounds</u>

methylene chloride
methyl chloride
methyl bromide
chloroform
bromoform
bromodichloromethane
dibromodichloromethane
trifluoromethane
carbon tetrachloride
1,2 - dibromoethane
1,2 - dichloroethane
1,1 - trichloroethane
vinyl chloride
1,1 1,2 - dichloroethylene
1,1,2 - trichloroethylene
o,m,p - dichlorobenzene
trichlorobenzene
tetrachloroethylene

<u>Pesticides and PCB</u>

polychlorinated biphenyls (PCB)
BHC
lindane
aldrin
dieldrin
endrin
heptachlor
heptachlor epoxide
toxaphene
DDT and associated compounds

<u>Heavy Metals</u>

arsenic and compounds
beryllium and compounds
cadmium and compounds
chromium and compounds
copper and compounds
nickel and compounds
lead and compounds
zinc and compounds
selenium and compounds

present in water, but may be increased by use of fertilizer or deicing salts. The sodium content of drinking water is only significant for persons placed on a low-sodium diet. The samples collected from public potable water supply wells were generally of satisfactory quality; however, two samples collected during the first round of sampling contained concentrations of mercury slightly above the potable water standard. However, subsequent samples collected at these sites were of satisfactory quality. Fecal coliforms were absent in all but one of the samples collected from the public suppliers. When this well (Stewartsville Water Company) was resampled, coliforms were not found.

UPPER RARITAN PLANNING AREA

In an attempt to identify possible ground water pollution problems, the 208 program, along with the DEP Program on Environmental Carcinogens and Toxic Substances (PECTS) contracted Rutgers University to initiate a ground water sampling program. This program included studies of selected toxic and carcinogenic compounds as well as fifteen standard parameters.

The program has currently sampled a total of 46 different wells which are shown in Figure V - K. A complete listing of all the parameters can be found in Table V-22.

Table V-22

PARAMETERS SELECTED FOR GROUND WATER MONITORING PROGRAM

Standard Parameters

Temperature
pH
Ammonia-N
Organic-N
Nitrate-N
Nitrite-N
Phosphorous
Sulphate
Alkalinity
Chloride
Flouride
Cyanide
LAS
Dissolved Solids
Fecal Coliform

Light Organic Compounds

methylene chloride
methyl chloride
methyl bromide
chloroform
bromoform
bromodichloromethane
dibromodichloromethane
trifluoromethane
carbon tetrachloride
1,2-dibromoethane
1,2-dichloroethane
vinyl chloride
1,1,1,2-dichloroethylene
1,1,2-trichloroethylene
o,m,p-dichloro benzene
trichloro benzene
tetrachloroethylene

Heavy Metals

arsenic and compounds
beryllium and compounds
cadmium and compounds
chromium and compounds
copper and compounds
nickel and compounds
lead and compounds
zinc and compounds
selenium and compounds

Pesticides and PCB

polychlorinated biphenyls (PCB)
BHC
lindane
aldrin
dieldrin
endrin
heptachlor
heptachlor epoxide
toxaphene
DDT and associated compounds

FIGURE V-K

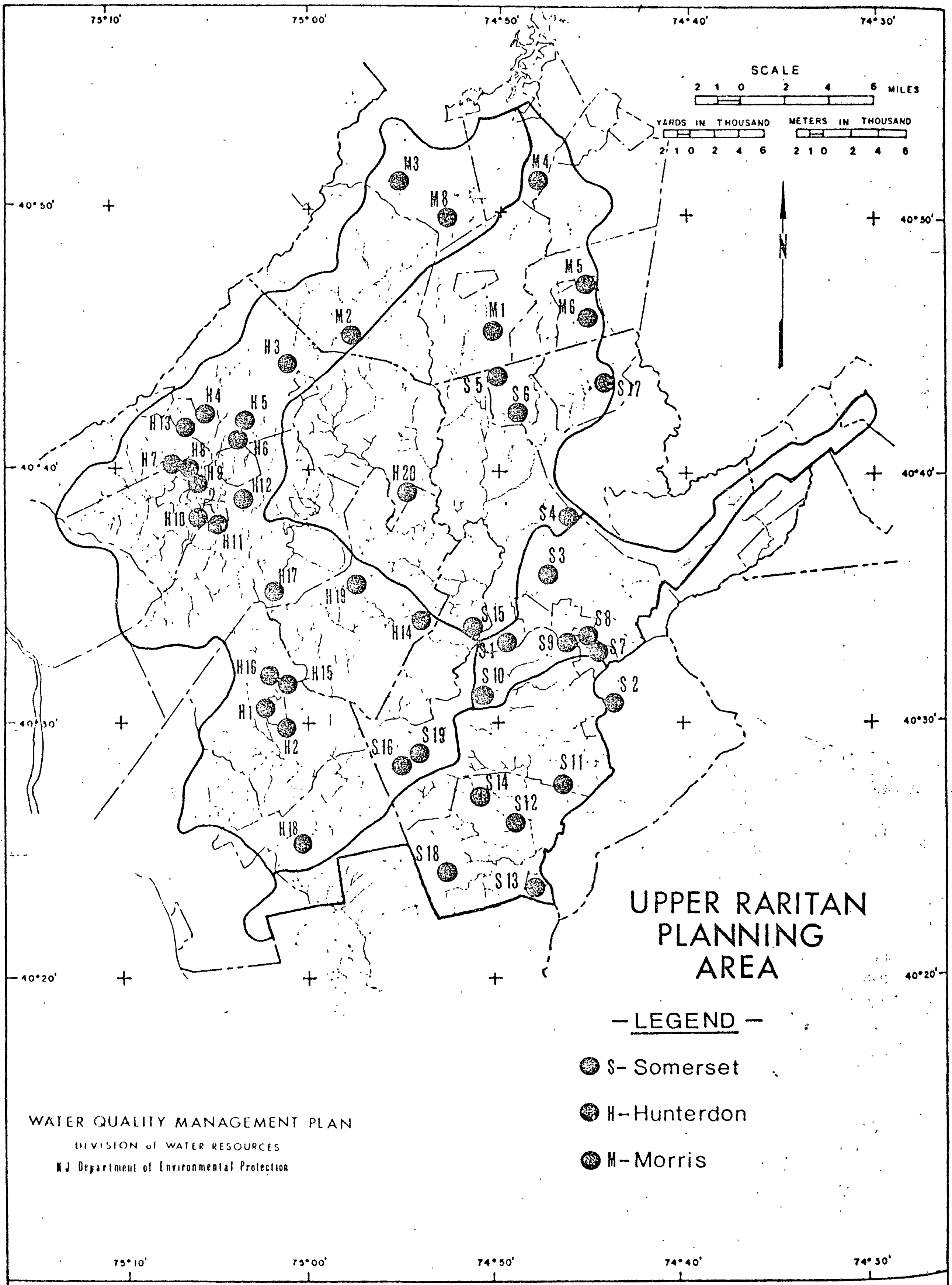


FIGURE V-K GROUND WATER SAMPLING SITES

Non-Metal Toxics (Organics, Pesticides, and PCB's)

A recent concern in the Upper Raritan area is the contamination of potable water supplies by trace quantities of organic compounds and the resulting potential risks to human health. Developments such as the discovery of high incidences of a rare liver cancer among vinyl chloride workers and a statistical study linking elevated cancer rates to toxic contamination of the Mississippi River have spurred academic and government scientists to investigate the far-reaching effects of organics in the environment. Tests were conducted for a total of twenty different organic compounds.

No standards currently exist for organic compounds because not enough is known about the hazards of long term exposure to these substances. However, the Environmental Protection Agency has proposed an interim standard of 100 parts per billion for Total Trihalomethanes (Chloroform, Bromoform, Dibromochloromethane, and Bromodichloromethane).

Criteria for PCB's and most pesticides have been established by both the EPA and National Academy of Science (NAS). Pesticide levels are especially significant in the Upper Raritan planning area where much of the land use is rural and agricultural. Table V-23 summarizes the detectable toxics in the planning area.

Morris County

There were no violations to report for any of the parameters in Morris County. Most had concentrations which were nondetectable at all sites sampled. The majority of the Trihalomethane values that were detectable were less than 1/10 the proposed interim standards of 100 ppb. Pesticides and PCB's generally remained well below the recommended EPA and NAS criteria. Among those compounds showing up in trace or slight amounts were:

Chloroform at sites M-2 and M-4
Bromodichloromethane and 1,1,2-Trichloroethane at M-4
1,1,2,2-Tetrachloroethane at M-2
1,1,1-Trichloroethane at M-4
1,1,2,2-Tetrachloroethylene at M-4
PCB's at sites M-4 and M-6
Heptachlor at M-6
Heptachlor Epoxide at sites M-5,6
P,P'-DDT at M-5
Endrin at sites M-5 and M-6

Table V-23
SUMMARY OF NON-METAL TOXICS

Parameter	Recommended Criteria (ng/l-ppt)	Sites in Violation of Criteria	Minimum Reportable Concentrations(5) (ng/l-ppt)	Parameter Detectable at Sites
Methylene Chloride	None	---	900	M - None S - None H - None
Methyl Chloride	None	---	6,000	M - None S - None H - None
Methyl Bromide	None	---	1,000	M - None S - None H - None
Chloroform	100,000 for TTHM's(4)	None	800	M - 2,4 S - 1,2,4,6,7,9,10,12,13,14,15,16, 18,19 H - 1 through 8,10,11,13,15,18,20
Bromoform	100,000 for TTHM's(4)	None	1,000	M - 2,5,6 S - 4,10,12 H - 11,13,15
Bromodichloromethane and 1,1,2-Trichloroethylene	100,000(4) None (A)	---	300	M - 1,3,4,5,6 S - 1,3,4,6 through 16,18,19 H - 1,2,4,6,7,8,10,11,13,14,15,16,17
1,1,2,2-Tetrachloroethane	None	---	60	M - 1,2,3,5,6 S - 3,7 through 13 H - 10,11,13,15,16
1,1,2-Trichloroethane	None	---	1,000	M - None S - 10,13,14,15 H - 4
Dibromochloromethane	100,000 for TTHM's(4)	None	100	M - 2,3,5,6 S - 4,7 through 11,13 H - 2,4,6,13,15
Trifluoromethane	None	---	---	M - None S - None H - 9

(A) Sampled as single parameter in first round, however, TTHM's standard not applicable.

Table V-23 (Continued)
SUMMARY OF NON-METAL TOXICS

Parameter	Recommended Criteria (ng/l-ppt)	Sites in Violation of Criteria	Minimum Reportable Concentrations (5) (ng/l-ppt)	Parameter Detectable at Sites
Carbon Tetrachloride	None	---	100	M - 2,4,5 S - 1,2,4,6,7,9,10,12,13,16 H - 1,2,3,5,7,8,10,13
1,2-Dibromoethane	None	---	100	M - 2 S - 2 H - 2,6
1,2-Dichloroethane	None	---	600	M - None S - None H - 14 through 17
1,1,1-Trichloroethane	None	---	2,000	M - 2 through 6,8 S - 1 through 4,6 through 19 H - 1,2,8,10,11,13,16,18,19,20
Vinyl Chloride	None	---	500	M - None S - None H - None
1,1,2,2-Tetrachloroethylene	None	---	60	M - 2,4,5,6 S - 1,3,4,6 through 14,16,18,19 H - 2 through 6,8,10,11,13,15,16
o,m,p-Dichloro Benzene	None	---	o - 2,200 m - 1,250 p - 1,250	M - None S - None H - None
Trichloro Benzene	None	---	2,000	M - None S - None H - None
Diiodomethane	None	---	300	M - None S - 1,2,10 H - 3,15
Polychlorinated Biphenyls	1,000(6)	None	60	M - 4,6 S - 6,10,14,16,17,18 H - 5,7,8

Table V-23 (Continued)

SUMMARY OF NON-METAL TOXICS

Parameter	Recommended Criteria (ng/l-ppt)	Sites in Violation of Criteria	Minimum Reportable Concentrations (5) (ng/l-ppt)	Parameter Detectable at Sites
BHC-	None	---	10	M - 1 S - 2,5,7,10,13 H - 11,14,17
BHC-B	None	---	10	M - 1,3,5,6 S - 1 through 8,10,11,19 H - 3,6 through 20
Lindane	4,000(3)	None	10	M - 1,3,5,6 S - 2 through 6,8,10,11,13 H - 6 through 9, 14 through 17
Aldrin	1,000(6)	None	10	M - 1,2,3,5,6 S - 7,8,10,11,13 H - 6,7,8,11,12,16,17
Dieldrin	1,000(6)	None	10	M - 1,2,3,5,6 S - 10,11,13 H - 6,16
Heptachlor	100(6)	H-18, Private potable well concentration sampled = 320 ppt	10	M - 1,2,5,6 S - 3,5,8,10,11,13 H - 7,10 through 13,15 through 18
Heptachlor Epoxide	100(6)	H-20, Private potable well concentration sampled = 137 ppt	10	M - 2,3,5,6 S - 8,10,11,13,19 H - 12,15,16,17,20
Toxaphene	5,000(3)	None	600	M - None S - None H - None
o,p'-DDE	50,000(6)	None	10	M - 1,2,5,6 S - 3,5,10,11,13 H - 10,14,15,16,17,20
o,p'-DDT	50,000(6)	None	40	M - 2,5,6 S - None H - 13,16,20

Table V-23 (Continued)

SUMMARY OF NON-METAL TOXICS

Parameter	Recommended Criteria (ng/l-ppt)	Sites in Violation of Criteria	Minimum Reportable Concentrations(5) (ng/l-ppt)	Parameter Detectable at Sites
p,p'-DDD	50,000(6)	None	20	M - 2,5,6 S - None H - 13,16,20
p,p'-DDT	50,000(6)	None	40	M - 2,5,6 S - None H - 16
Methoxychlor	100,000(3)	None	80	M - None S - None H - None
Mirex	None	---	20	M - 2,5,6 S - None H - 12,13,16
Endrin	200(3)	None	10	M - 2,5,6 S - 10,13 H - 12,13,16,20
Chlordane	3,000(3)	None	10	M - 3,5,6 S - 10,11,13 H - 4,16,17,20

(3) "National Interim Primary Drinking Water Regulations," USEPA, September 1976.
(4) "Proposed Interim Primary Drinking Water Regulations" for total trihalomethanes (TTHM's), USEPA, February 1978.
(5) Department of Environmental Science, Cook College - Rutgers University, 1978.
(6) Recommended Criteria, NAS/EPA.

Somerset County

For the most part, toxic values in Somerset County are slightly higher than the other counties within the planning area. However, no concentrations came close to violating the recommended EPA and NAS criteria. There were also very many samples which had concentrations too low to detect. Among the more significant of these detected were:

- Chloroform at sites S-1, 10, 14, and 15
- Bromoform at S-10
- Bromodichloromethane and 1,1,2-Trichloroethylene at sites S-1 and s-13
- Carbon Tetrachloride at S-1 and S-10
- 1,1,2-Trichloroethane at S-10
- Dibromochloromethane at S-10
- 1,1,1-Trichloroethane at sites S-1, 2, 3, 7, 8, 9, 10, 11, 12, 13, 14 and 15
- 1,1,2,2-Tetrachloroethylene at S-10, 11, and 13
- Dilodomethane at S-10
- PCB's at S-6, 10, 16, 17, and 18
- Dieldrin at site S-10
- Heptachlor Epoxide at S-6 and S-10

Although concentrations were all relatively low, site, S-10 exhibited signs of pollution, as it had slight amounts of each and every parameter that was detectable.

Hunterdon County

Several detectable amounts of organic compounds were present during sampling, but once again values were relatively low. Overall, the county had the best pesticide and PCB levels throughout the planning area, with most parameters nondetectable at nearly all of the sites. However, two samples violated the recommended criteria by the EPA and National Academy of Science. The violations occurred at H-18, where Heptachlor concentrations were more than three times the allowable standards, and at H-20 where Heptachlor Epoxide exceeded the criteria. Heptachlor is an insecticide widely used for termite control. Heptachlor is applied through pressure injection into the soil around the foundation of a house. It is a very persistent pesticide which is designed to stick to the soil particles in a bond that can last up to twenty years. Heptachlor Epoxide is merely an oxidation end product of this pesticide. The long lasting effects of this type of pollution make it an important consideration, especially in areas such as these with a seasonally high water table. Among the most significant of the other detectable organic compounds are:

Chloroform at sites H-1, 4, 10 and 11
1,1,2-Trichloroethane at H-4
1,1,1-Trichloroethane at H-1, 2, 3, 4, 7, 8, 10, 11, and 13
BHC-B at site H-20
P,P'-DDD at site H-20
Chlordane at site H-20

Conclusions

Analysis of ground water sampling data is particularly difficult because the movement of pollutants underground is often hard to predict. If a particular pollutant appears in one sample taken from a well but not in a subsequent sample, interpretation may be difficult. The contaminant may be traveling in the ground water in a slug that is flushed past the well before the next sampling. Alternatively, the original detection of the pollutant may have been an analytical error, or merely a seasonal occurrence due to the fluctuation of rainfall. In the case of complex compounds such as those monitored in this study, behavior is particularly hard to predict since little is known about what happens to these substances in the ground water system.

Similarly, the presence of contaminants in one well may or may not have implications for other wells in a region. Intensive study of geology, ground water movement, and proximity of other wells, as well as additional sampling, will be needed to fully evaluate the implications of sampling data from this initial study.

Many of the samples, by nature of their violations, have given an indication of possible groundwater contamination. The sites pointed out from the first two rounds of sampling are:

M-6
S-2, 3, 4, 8, 9, 10, and 12
H-6, 13, 19, and 20

These possible problem sites help define areas where remedial strategies can be put into effect, once the sources of pollution have been determined.

CHAPTER VII

SHELLFISH HARVEST

The shellfish industry in New Jersey is a significant national industry. New Jersey shellfish account for a major portion of the national market of clams, oysters and mussels. From 1967 through 1975 the areas open to shellfish harvesting decreased about 11%. This trend continued in 1976 as an additional 7007 acres were reclassified either from approved to condemned or approved to seasonally approved; 5150 of these acres were in the Atlantic Ocean and were reclassified as a result of the ocean monitoring system developed and required at that time by the Federal government. In 1977, 1641 acres were reclassified but unlike previous years most of this area was upgraded from condemned to approved (only 42 acres were downgraded from approved to condemned). For the first time in six years the areas approved for shellfish harvesting experienced a net gain. In 1978 there was a reclassification of approximately 5912 acres of which 3734 acres were upgraded; the remaining 2178 acres were downgraded to restricted or condemned classifications. Reclassifications in 1979 resulted in a net loss with approximately 12,858 acres downgraded, of a total 21,133 acres reclassified. The proposed reclassifications for 1980 show a large increase of harvestable shellfish growing areas. Total changes proposed are 14,507 acres, with all but 175 acres being upgraded.

The Bureau of Shellfish Control of the New Jersey Department of Environmental Protection has classified the waters into four categories of shellfish harvesting areas. These read as follows:

1) Approved - Waters meeting the sanitary standards for approved shellfish harvesting as recommended by the National Shellfish Sanitation Program. Waters not classified as condemned, special restricted, or seasonal shall be considered approved for the harvest of shellfish.

2) Special Restircted Area - Waters condemned for the harvest of oysters, clams and mussels. However, harvesting for futher processing may be done under special permit from the State Department of Environmental Protection.

3) Seasonal - Waters which are condemned and opened for the harvest of oysters, clams and mussels each year automatically by operation of regulation according to the schedule of 7:12-1.3(b) seasonal areas approved November 1 through April 30, condemned May 1 through October 31 and 1.3(c) seasonal areas approved January 1 through April 30, condemned May 1 through December 31 yearly.

4) Condemned - Waters not meeting the established sanitary standards as recommended by the National Shellfish Sanitation Program of the Federal Food and Drug Administration. Applications for removal of shellfish to be used for human consumption from areas classified as

and water temperature are controlled to maintain maximum pumping rates in the shellfish. The water in the depuration tanks is also disinfected to maintain high quality. Following the depuration process laboratory analyses are performed to verify that the shellfish meet market standards. The depurated shellfish are then released for marketing.

New Jersey's two depuration plants are located in Highlands, Monmouth County, the center of the soft clam resource. Primary harvest sites are the Navesink and Shrewsbury Rivers. Specially designated non-power boats are used for harvesting under the direction of the New Jersey Marine Police. At the end of the daily harvest activities, shellfish are loaded aboard a "mother craft" for transportation to the depuration plant. All aspects of harvesting and transportation of these shellfish are closely monitored by the New Jersey Marine Police to insure complete compliance with program procedures.

In New Jersey there are four major basins subject to shellfish regulations. These are: 1) Raritan River Basin; 2) New Jersey North Coastal Basin; 3) New Jersey South Coastal Basin; 4) Delaware Basin Zone 5 and 6.

RARITAN RIVER BASIN

Only a small portion of the Raritan River Basin need be examined, as most of this Basin consists of freshwater habitats. Considered here are Raritan Bay, Lower New York Bay, Sandy Hook Bay, Navesink River, Shrewsbury River, and their tributaries. There are no waters in this Basin classified fully open to shellfish harvesting. Out of the total acreage available for shellfish, 35% are fully closed while the rest are classified Special Restricted. Revisions to the 1977 classifications include:

Raritan Bay (Union Beach Area) - approximately 524 acres downgraded from Special Restricted to condemned (June 1978).

NEW JERSEY NORTH COASTAL BASIN

This Basin consists of a large portion of the Atlantic Ocean coastal environment in New Jersey. Much of the acreage classified in this Basin is in the Barnegat Bay area. The Barnegat Bay area comprises 65% of the total acreage available for shellfish harvesting in this Basin (46,158 acres). The rest of the Basin is made up of a number of smaller bays, rivers, creeks and their tributaries. These include Shark River, Manasquan River, Little Egg Harbor, Cedar Run, Westcunk Creek, Tuckerton Creek, Big Thorofare and Big Creek.

Fully open shellfish harvesting acreage constitutes 81% (1977) of the total available acreage in this Basin. These areas are located in Barnegat Bay and Little Egg Harbor. This leaves 18% (1977) of the total available acreage fully closed, and 1% (1977) classified as seasonal. Under the Shellfish Relay Program, clams are removed from condemned waters in the Manasquan and Shark Rivers and deposited for harvest in Barnegat Bay and Great Bay. Reclassifications in 1979 resulted in the downgrading of large portions of Barnegat Bay. Reclassifications in the North Coastal Basin since 1977 include:

June, 1978:

Big Thorofare - approximately three acres are upgraded from condemned to approved.

Judies Creek, Roundabout Creek, Ballanger Creek and Winter Creek - approximately 65 acres are upgraded from condemned to seasonal.

Cedar Creek area - approximately 666 acres upgraded from condemned to seasonal.

Forked River - approximately 127 acres upgraded from condemned to seasonal.

May, 1979:

Upper Barnegat Bay (Mantoloking Area) - approximately 321 acres downgraded from approved to seasonal.

Kettle Creek - Silver Bay - approximately 553 acres downgraded from approved to seasonal.

Barnegat Bay (Lavallette Area) - approximately 859 acres downgraded from approved to seasonal.

Barnegat Bay (Seaside Park Area) - approximately 2122 acres downgraded from approved to seasonal.

1980 Proposed:

Long Beach Island - approximately 361 acres upgraded from condemned to seasonal, 38 acres upgraded from condemned to approved and 175 acres downgraded from approved to seasonal.

The New Jersey North Coastal Basin is comprised of two counties, Monmouth County and Ocean County (although the northern tip of Monmouth County is in the Raritan River Basin). According to the annual summaries of the New Jersey Landings reports (1972 through 1977), these two counties have had decreasing shellfish catches.

NEW JERSEY SOUTH COASTAL BASIN

The New Jersey South Coastal Basin, combined with the New Jersey North Coastal Basin, make up more than 90% of the Atlantic Ocean coastal zone in New Jersey. In comparison with the three other basins (Raritan River, New Jersey North Coastal and Delaware Zones 5 and 6) that support shellfish harvesting, this is the most productive one. According to statistics reported in the annual summaries of New Jersey Landings reports, this Basin has an annual shellfish harvest of at least double the combined totals of the other three basins. However, much of this production is due to the Relay Program which includes shellfish transplanted from condemned waters in the North Coastal Basin.

The Bureau of Shellfish Control of the Division of Water Resources, NJDEP, assigns shellfish classifications to over 160 rivers, bays, creeks, thorofares and channels in this basin. The largest systems are Great Bay, Mullica River, Absecon Bay, Great Egg Harbor Bay, Great Egg Harbor River, Ludlam Bay and Great Sound. Of the total area classified, 46% of the acreage is designated as approved, 41% is fully closed, 6% is classified as special restricted and 7% is seasonal (based on 1977 data).

Reclassifications which have taken place in this basin since 1977 include:

June, 1978:

Mullica River - approximately 465 acres are upgraded from condemned to seasonal.

Great Egg Harbor Bay - approximately 43 acres upgraded from seasonal to approved.

Ludlam Bay - approximately 228 acres upgraded from condemned to approved.

May, 1979:

Great Egg Harbor River - approximately 217 acres downgraded from seasonal to condemned.

1980 Proposed:

Reed Bay - Absecon Bay Area - approximately 3,395 acres upgraded from condemned to seasonal.

Lakes Bay - approximately 996 acres upgraded from condemned to seasonal.

Scull Bay - approximately 586 acres upgraded from condemned to seasonal.

Steelman Bay - small undetermined area downgraded from approved to condemned.

Somers Cove - small undetermined area upgraded from condemned to approved.

Strathmere - small undetermined area downgraded from seasonal to condemned.

Townsends Inlet - small undetermined area downgraded from approved to condemned.

In the New Jersey South Coastal Basin the acreage available for shellfish harvesting is located in Atlantic and Cape May Counties. The shellfish harvest in Atlantic County has experienced large increases since the early 1970's, while Cape May County harvests have remained fairly constant.

DELAWARE BASIN

This Basin has six areas which are subject to shellfish classifications. The Delaware Bay contains 97% of the total classified acreage in the basin and is the only area in the basin that contains waters acceptable to fully approved shellfish harvesting. The other five areas, which are classified either fully closed or seasonal, include the Maurice River and Cove area, the Cohansey River area, the Back Creek area, the Cedar Creek area and the Nantuxent Creek area.

Of the total acreage available for shellfish harvesting, 88% is classified approved, 10% fully closed and 2% seasonally approved (1977 data). The reclassifications for this region since 1977 are as follows:

June, 1978:

Delaware Bay (Maurice River Cove) - approximately 538 acres downgraded from approved to seasonal.

May, 1979:

Mouth of Dennis Creek - approximately 296 acres upgraded from condemned to approved.

East Point Area - approximately 622 acres downgraded from approved to seasonal.

Cohansey River - approximately 449 acres downgraded from approved to Condemned.

1980 Proposed:

Fishing Creek - approximately 100 acres upgraded from condemned to seasonal.

The large percentage of important shellfish harvesting areas in this basin are in Cumberland County. Shellfish catches in Cumberland County have flucuated in the 1970's but remained fairly constant overall.

ATLANTIC OCEAN

None of the four basins previously discussed included figures on the Atlantic Ocean. There are 280,708 acres of marine waters which are regulated by the Bureau of Shellfish Control. Of this total area, 66% (184,274 acres) of the waters were classified as approved while the remainder were classified as fully closed (1977 data). Major reclassifications have been proposed in 1980 for the Atlantic Ocean harvesting area. Proposals include upgrading 8,856 acres in the Monmouth County Coastal Region from condemned to seasonal. The reclassifications of the Atlantic Ocean since 1977 are as follows:

June, 1978:

Atlantic Ocean (Ship Bottom Area) - approximately 1676 acres downgraded from approved to condemned, and 520 acres upgraded from condemned to approved.

Atlantic Ocean (Shark River Inlet) - approximately 1110 acres downgraded from approved to condemned.

Atlantic Ocean (Cape May Area) - approximately 2,410 acres upgraded from condemned to approved.

May, 1979:

Atlantic Ocean (Northern Ocean County) - approximately 718 acres downgraded from approved to condemned and approximately 867 acres upgraded from condemned to approved.

Atlantic Ocean (Long Beach Area) - approximately 7,112 acres upgraded from condemned to approved.

Atlantic Ocean (Atlantic County Area) - approximately 6,997 acres downgraded from approved to condemned.

1980 Proposed:

Atlantic Ocean (Monmouth County Area) - approximately 8,856 acres upgraded from condemned to approved.

SUMMARY

It is important to be cautious when examining shellfish harvesting data for the past ten years as seen in the following "Total N.J. Shellfish Catch". These figures represent the total amount of shellfish (clams, oysters and mussels) produced in New Jersey and not the total amount taken from New Jersey harvest areas. Three major factors affecting this data must be considered: 1) catches from non-state harvest areas are included in these figures; 2) out of state fishermen use New Jersey' harvest areas and take their catches to other states for processing; 3) and shellfish harvested by sports fisherman. When these three factors are combined with the fact that no other data is available, one can readily see the difficulty involved when attempting to discuss past and future harvest trends.

Table VII.1

YEAR	TOTAL NJ SHELLFISH CATCH (in pounds)
1967	45,597,800
1968	36,096,057
1969	39,383,458
1970	42,955,839
1971	32,067,077
1972	25,303,811
1973	24,896,494
1974	25,501,852
1975	38,325,940
1976	31,519,713
1977	39,302,494
1978	34,925,000
1979	45,281,000

Table VII.2

COMPOSITION OF SHELLFISH YEARLY CATCHES AND MONETARY VALUES, 1978-1979.

	1978		1979	
Specie	Catch (pounds)	Values (dollars)	Catch	Value
Hard clam	804,000	1.3 million	898,000	1.57 million
Soft clam	121,000	147,000	19190,000	208,000
Oyster	1,500,000	2.0 million	1,675,000	2.36 million
Surf Clam	15,200,000	7.6 million	12,325,000	6.3 million
Quahog	17,300,000	5.2 million	24,968,000	7.5 million
Scallops	4,763,000	11.6 million	5,225,000	16.85 million
Totals	34,925,000	27.85 million	45,281,000	34.79 million

However, it should be noted that the total acreage approved for shellfish harvesting in New Jersey experienced a net gain in 1977 which is the reverse of a five year downward trend. This positive trend of 1977 is continued in 1978, but reversed in 1979. Positive gains will occur in 1980 also.

The following table indicates the net change in shellfish growing area acreage and the total shellfish growing area acreage by designated classifications.

Table VII.3

BAY AND ESTUARINE SHELLFISH GROWING AREA ACREAGES RECLASSIFIED

YEAR ADOPTED	TOTAL ACRES DOWNGRADED	TOTAL ACRES UPGRADED	NET CHANGE
1980 (Proposed)	175	14,332	+14,157
1979	12,858	8,275	- 4,583
1978	583	1,129	+ 546*
1977	42	1,599	+ 1,557
1976	2,353	2,135	- 218
1975	5,018	885*	- 4,133
1974	5,462	146	- 5,316
1973	2,490	0	- 2,490
1972	2,951	5,511*	+ 2,560

*represents acreage reclassified from condemned to special restricted

CHAPTER IX
LAKES MANAGEMENT

The N.J.D.E.P. Lakes Management Program was created in order to fulfill its obligation under Section 314 of Public Law 92-500, the Water Pollution Control Act Amendments of 1972. In order of priority, the three primary functions of the program are:

1. Lake Restoration - federal Clean Lakes Program
2. Intensive Lake Surveys
3. Lake Eutrophication Classification

This chapter will include a summary report of the first thirteen intensive surveys conducted as a part of this program. The thirteen lake surveys were completed in 1977-1978. A glossary and discussion of methods employed is also included.

In 1979 25 additional lakes were included in the intensive lakes survey program. The analysis of the data collected on these 25 lakes has not been completed and therefore is not included within this report. Table IX-1 below presents the lakes surveyed in 1979.

Table IX-1
1979 Public Lakes Survey

Lake	County
Hammonton	Atlantic
Overpeck	Bergen
Strawbridge	Burlington
New Brooklyn	Camden
Kirkwood	Camden
Lily	Cape May
Mary Elmer	Cumberland
Sunset	Cumberland
Weequahic	Essex
Vernona Park	Essex
Woodbury	Gloucester
Bethel	Gloucester
Linclon Park	Hudson
North Hudson Park	Hudson
Etra	Mercer
Spring	Mercer
Davidson's Mill	Middlesex
Devoe	Middlesex
Manalapan	Middlesex
Imlaystown	Monmouth
Topenemus	Monmouth
Manahawkin	Ocean
Memorial	Salem
Clove	Sussex
Echo	Union

Table IX-2
Results of Intensive Surveys, 1977-1978

Lake/Location	Lake Classification (nutrient level)	Source(s) of Pollution	Lake Management Recommendations	Eligibility for Restoration Funding
Allamuchy Lake, Warren County	Eutrophic	Nonpoint-farm and residential run-off	Dredging, non-point control and dam rehabilitiation.	no
Allentown Lake,	Eutrophic	Agricultural land run-off consisting of nutrients and sediments.	Reduction in nutrient and sediment loadings and actions to make lakes less favorable to macrophyte growth.	yes - Grant approved for restoration
Boonton Reservoir, Morris County	Mesotrophic	Both point and non-point sources contribute although the major limiting factor-phosphorous was contributed predominately by nonpoint sources.	Reduction of nutrient inputs and inlake corrective actions.	no
Branchbrook Park Lake, Essex County	Eutrophic	Nonpoint source surface runoff with occasional contributions from malfunctioning sewer line.	Reconstruction of storm and sanitary sewers, dredging and erosion control. Reduction of nutrient input with inactivation of nutrients presently inlake, and removal of organic matter in lake.	yes - restoration started.

Table IX-2 con't

Lake/Location	Lake Classification (nutrient level)	Source(s) of Pollution	Lake Management Recommendations	Eligibility for Restoration Funding
Clarks Pond, Cumberland County	Oligo-mesotrophic	Nonpoint sources-agricultural and residential run-off.	Deepening of lake with in-lake nutrient removal.	no
Deal Lake, Monmouth County	Meso-eutrophic	Both point source and nonpoint sources contribute, with non-point sources predominating.	Model ordinances controlling residential non-point sources, and sedimentation basin.	yes - restoration proposal being written.
Dennisville Lake Cape May County	Eutrophic	Point source - sewage treatment plant.	Phosphorous removal at sewage treatment plant and removal or inactivation of nutrients in lake.	no
Ludlam's Pond, Cape May County	Oligo-mesotrophic	Nonpoint source run-off from woodland residences.	Ongoing natural processes.	no
Rainbow Lake, Salem County	Meso-eutrophic	Non-point sources from residential, agricultural and wooded areas.	Best management practices controlling agricultural pollutants and enforcement of septage disposal regulations.	no
Round Valley Reservoir, Hunterdon County	Oligotrophic to mesotrophic	Non-point sources (woodland) directly, although water is pumped to it from Raritan River.	Allow reservoir to maintain its' current condition.	yes
Saxton Lake, Morris and Warren Counties	Eutrohpic	Both point and non-point sources contribute.	Nutrient removal, especially at Musconetcong STP.	yes

Table IX-2 con't

Lake/Location	Lake Classification (nutrient level)	Source(s) of Pollution	Lake Management Recommendations	Eligibility for Restoration Funding
Waterloo Lake, Morris and Sussex Counties	Eutrophic	Both point and nonpoint sources contribute.	Nutrient removal, especially at Musconetcong Sewerage Treatment Plant	yes
Speedwell and Pocahontas Lakes, Morris County	Eutrophic	Predominately point sources (sewage treatment plants) with some non-point sources adding, (residential and woodland runoff).	Advanced treatment of discharges to lake tributaries.	yes
Sunset Lake, Somerset County	Mesotrophic	Non-point sources including residential and woodland runoff with construction activities; and an overflowing sewerline.	Improved construction practices and prevention of residential runoff contamination.	no

1977-1978 Intensive Survey Lakes
N.J. Lakes Management Program
Division of Water Resources, NJDEP

Monmouth County Area:

Deal Lake
Allentown Lake

Upper Raritan Area:

Sunset Lake
Round Valley Reservoir

Northeast Study Area:

Speedwell/Pocahontas Lakes
Boonton Reservoir
Branchbrook Park

Upper Delaware Area:

Saxton/Waterloo Lakes
Allamuchy Pond

Lower Delaware Area:

Rainbow Lake
Clark's Pond

Cape May Area:

Dennisville Lake
Ludlam's Pond

General Methods

Samples were taken monthly at all lake inlets and outlets (or as close as possible to the inlet or outlet). Additional samples were taken at any known point-source discharges within the watershed. Measurements of certain physical and chemical parameters were made in the field, along with qualitative observations. Algal analysis was carried out at the New Jersey Department of Environmental Protection Scotch Road Laboratories, while chemical and bacteriological analyses were performed by the New Jersey Department of Health Laboratories in Trenton.

Three times during the year (summer, fall, and spring) in-lake samples were taken by boat, and some additional measurements were made (Secchi disk readings, depth, dissolved oxygen profile, temperature, and chemical parameters at vertical intervals). This data was incorporated into the overall analysis where appropriate.

Additional special samples were taken if necessary, usually involving qualitative analysis of various parameters. This data was generally used to supplement the monthly sample results.

Additional data was obtained by contacting appropriate agencies or individuals, such as Municipal Offices, United States Geological Survey, or other state offices.

Comprehensive

Glossary

Abiotic - pertaining to any non-biological factor or influence, such as geological or meteorological characteristics.

Adsorption - external attachment to, the process by which a molecule becomes attached to the surface of a particle.

Aphotic Zone - dark zone, below the depth to which light penetrates. Generally equated with the zone in which most photosynthetic algae can not survive, due to the light deficiency.

Assimilative Capacity - ability to incorporate inputs into the system. With lakes, the ability to absorb nutrients without showing extremely adverse effects.

Background Value - value for a parameter that represents the conditions in a system prior to a given influence in space or time.

Best Management Practices - (BMP's) State-of-the-art techniques and procedures used in an operation such as farming or waste disposal in order to minimize pollution or waste.

Biota - Plant and animal life.

Biotic - pertaining to biological factors or influences, concerning biological activity.

Bloom - excessively large standing crop of algae, usually visible to the naked eye.

CFS - cubic feet per second, a measure of flow.

Chlorophyll - photosynthetic pigment found in most plants, generally proportional in quantity to the plant biomass present.

Chlorophyte - green algae, algae of the division Chlorophyta.

Chrysophyte - golden or yellow-green algae, algae of the division Chrysophyta.

Confluence - meeting point of two rivers or streams.

Cosmetic - acting upon symptoms or given conditions without correcting the actual cause of the symptoms or conditions.

Cryptophyte - algae of variable pigment concentration, with various other unusual features. Algae of the division Cryptophyta, which is often placed under other taxonomic divisions.

Cyanophyte - bluegreen algae, algae of the division Cyanophyta.

Deoxygenation - depletion of oxygen in an area, used often to describe possible hypolimnetic conditions.

Detention Basin - artificially or naturally dug out area acting as a holding pond, delaying the movement of water into a system or downstream in that system. Used in lake and river management to give physical, chemical and biological processes a chance to purify water before it enters a system or given part of a system.

Diatom - specific type of chrysophyte, having a siliceous frustule (shell) and often elaborate ornamentation, commonly found in great variety in fresh or saltwaters. Often placed in its own division, the Bacillariophyta.

Dinoflagellate - unicellular algae, usually motile, having pigments similar to diatoms and certain unique features. More commonly found in saltwater. Algae of the division Pyrrhophyta.

Domestic Wastewater - water and dissolved or particulate substances after use in any of a variety of household tasks or systems such as sanitary systems or washing operations.

Dystrophic - trophic state of a lake in which large quantities of nutrients may be present, but are generally unavailable (due to organic binding or other causes) for primary production. Often associated with acid bogs.

Epilimnion - upper layer of a stratified lake. Layer that is mixed by wind and has a higher average temperature than the hypolimnion. Roughly approximates the euphotic zone.

Euglenoid - algae similar to green algae in pigment composition, but with certain unique features related to food storage and cell wall structure. Algae of the division Euglenophyta.

Eutrophic - high nutrient, high productivity trophic state generally associated with unbalanced ecological conditions and poor water quality.

Eutrophication - process by which a body of water ages, most often passing from a low nutrient concentration, low productivity stage to a high nutrient concentration, high productivity stage. Eutrophication is a long-term natural process, but it can be greatly accelerated by man's activities. Eutrophication as a result of man's activities is termed cultural eutrophication.

French Drain - water outlet which allows fairly rapid removal of water from surface, but then allows subsurface percolation. Generally consists of sand and gravel layers under grating or similar structure, at lowest point of a sloped area. Water runs quickly through the coarse layers, then percolates through soil, usually without the use of pipes. The intent is the purification of most percolating waters.

Groundwater - water in the soil or underlying strata, subsurface water.

Hydraulic detention time - lake water retention time, amount of time that an average random water molecule spends in a water body; time that it takes for water to pass from an inlet to an outlet of a water body.

Hypolimnion - lower layer of a stratified lake. Layer that is mainly without light, generally equated with the aphotic zone, and has a lower average temperature than the epilimnion.

Intermittant - non-continuous, generally referring to the occasional flow through a set drainage path. Flow of a discontinuous nature.

Leachate - water and dissolved or particulate substances moving out of a specified area, usually a landfill, by a completely or partially subsurface route.

Leaching - process whereby nutrients and other substances are removed from matter (usually soil or vegetation) by water. Most often this is a chemical replacement action, prompted by the qualities's of the water.

Lentic - standing, having low motion. Refers to lakes and impoundments.

Limiting Nutrient - that nutrient of which there is the least quantity, in relation to its importance to plants. The limiting nutrient will be the first essential compound to disappear from a productive system, and will cause cessation of that productivity at that time. The chemical form in which the nutrient occurs and the nutritional requirements of the plants involved are important here.

Limnology - the comprehensive study of lakes, encompassing physical, chemical and biological lake conditions.

Loading - inputs into a receiving water that exert a detrimental effect on some subsequent use of that water.

Lotic - flowing, moving. Refers to streams or rivers.

Macrophyte - higher plant, macroscopic plant, plant of higher taxonomic position than algae, usually a vascular plant. Aquatic macrophytes are those macrophytes that live completely or partially in water.

Mesotrophic - an intermediate trophic state, with variable but moderate nutrient concentrations and productivity.

MGD - million gallons per day, a measure of flow.

Nitrogen-fixation - the process by which certain bacteria and bluegreen algae make organic nitrogen compounds (initially NH_4^+) from elemental nitrogen (N_2) taken from the atmosphere or dissolved in the water.

Non-point Source - a diffuse source of loading, possibly localized but not distinctly defineable in terms of location. Includes runoff from all land types.

Oligotrophic - low nutrient concentration, low productivity trophic state, often associated with very good water quality, but not necessarily the most desireable stage, since often only minimal aquatic life can be supported.

Periphyton - attached forms of plants and animals, growing on a substrate. Often dominant algae form in flowing waters.

Photic Zone - illuminated zone, surface to depth beyond which light no longer penetrates. Generally equated with the zone in which photosynthetic algae can survive and grow, due to adequate light supply.

Photosynthesis - process by which primary producers make organic molecules (generally glucose) from inorganic ingredients, using light as an energy source. Oxygen is evolved by the process as a byproduct.

Phytoplankton - algae suspended, floating or moving only slightly under their own power in the water column. Often the dominant algae form in standing waters.

Point Source - a specific source of loading, accurately defineable in terms of location. Includes effluents or channeled discharges that enter natural waters at a specific point.

Potable - usable for drinking purposes, fit for human consumption.

Primary Productivity (Production) - conversion of inorganic matter to organic matter by photosynthesizing organisms. The creation of biomass by plants.

Riffle Zone - stretch of a stream or river along which morphological and flow conditions are such that rough motion of the water surface results. Usually a shallow rocky area with rapid flow and little sediment accumulation.

Runoff - water and its various dissolved substances or particulates that flows at or near the surface of land in an unchanneled path toward channeled and usually recognized waterways (such as a stream or river).

Secondary Productivity - the growth and reproduction (creation of biomass) by herbivorous (plant-eating) organisms. The second level of the trophic system.

Sedimentation - the deposition of solids of varying nature on the bottom of a lake or stream bed.

Stagnant - motionless, having minimal circulation or flow.

Standing Crop - current quantity of organisms, biomass on hand. The amount of live organic matter in a given area at any point in time.

Stratification - process whereby a lake becomes separated into two relatively distinct layers as the result of temperature and density differences. Further differentation of the layers usually occurs as the result of chemical and biological processes. In most lakes, seasonal changes in temperature will reverse this process after some time, resulting in the mixing of the two layers.

Succession - the natural process by which land and vegetation patterns change, proceeding in a direction determined by the forces acting on the system.

Tertiary Productivity - the growth and reproduction (creation of biomass) by organisms that eat herbivorous (plant-eating) organisms. The third level of the trophic system.

Thermocline - boundary level between the epilimnion and hypolimnion of a stratified lake, variable in thickness, and generally approximating the maximum depth of light penetration and mixing by wind.

Trophic State - the stage or condition of an aquatic system, characterized by biological, chemical and physical parameters.

Taxon (Taxa) - any hierarchical division of a recognized classification system, such as a genus or species.

Watershed - drainage basin, the area from which an aquatic system receives water.

PART II: General Lake Information and Individual Report Summaries

Allamuchy Pond
Allentown Lake
Boonton Reservoir
Branchbrook Park Lake
Clark's Pond
Deal Lake
Dennisville Lake/Ludlam's Pond
Rainbow Lake
Round Valley Reservoir
Saxton Lake/Waterloo Lake
Speedwell Lake/Pocahontas Lake
Sunset Lake

GENERAL INFORMATION

LAKE NAME: Allamuchy Pond

LAKE LOCATION:

USGS Quadrangle: Tranquility Lat: 40°54'40" Long: 74°49'00"

County: Warren County

Municipality: Allamuchy Township

LAKE STATUS: (Public or Private): Mostly public (FW-2), but a small portion (about 4 acres near the outlet) owned by Villa Madonna Convent, and part of the State owned acreage is included in the land area leased to a farmer.

LAKE SIZE:

Average Depth Approximately 10 ft. (3.05 M)

Range of Depth to 25 ft. (7.62 M)

Area 49.2 acres (19.9 hectares)

Volume 160.4 million gal. (607,000 M^3)

WATERSHED INFORMATION:

Size about 800 acres (1.25 sq. mi.) or 324 hectares (3.24 sq. km.)

Land use Farmland and pasture land comprise about 0.25 sq. mi., residential and business areas make up about 0.1 sq. mi., and the rest of the watershed is woodl

WATER AND NUTRIENT SOURCES:

Tributaries 1 actual inlet tributary, with 3 branches upstream (1 from Weirtown, called inlet # 2, and 2 from Woodland, called inlet #1 after their confluence).

Springs Springs in lake bottom

Effluents None known

Runoff May be considerable from farm and pasture land during rainy periods, flowing into the tributary just upstream of the lake. Also has runoff input from Weirtown.

Precipitation Long-term avg. = 48.8 in/yr (124 cm/yr)
1977 = 48.1 in (122 cm)

Other

LAKE USE:

Present Fishing, but usually only ice fishing in the winter, due to heavy summer weed growths.

Past Commercial ice operation, fishing, boating, swimming.

Potential Fishing, boating.

STUDY PERIOD: 5/77 - 6/78

CONCLUSIONS

Allamuchy Pond is suffering from accelerated eutrophication, and experiences high nutrient concentrations, dissolved oxygen deficiencies and nuisance growths of macrophytes and algae. As many as five tributaries supply water to the pond, along with some springs in the bottom of the pond, but the inputs from some sources are not believed to be very significant. Two tributaries merge and then flow between pasture and cropland south of the pond, with a small stream from Weirtown entering at the north end of the farm. Runoff from the pasture and cropland of the farm, and from aninal pens and residential/business areas in Weirtown contribute significant inputs to these tributaries, which then enter the lake as a single stream. This is by far the largest and most enriched tributary, and provides the most significant inputs to the pond. The other tributaries are intermittant, and act mainly as drainage paths for woodland areas. None of the direct inputs are believed to be very signficant.

The tributary that passes by the farm was not adequately sampled, but those values that were obtained indicated poor water quality with a slightly elevated pH and alkalinity, and high phosphorus and nitrogen levels (total phosphate averaging 0.34 mg/l and total nitrogen averaging 3.6 mg/l.)

The tributary from Weirtown was more adequately sampled, and also had poor water quality. However, most average nutrient values were not quite as high as for the main tributary, with total phosphate at 0.18 mg/l and total nitrogen at 3.1 mg/l. The pH and alkalinity were somewhat higher though, at averages of 8.1 and 157 mg/l, respectively.

The morphology of Allamuchy Pond is like that of a bowl with an irregular, wide rim. The average rim depth is about six feet, and the entire outlet cove is included. The bowl occupies the center of the lake, and has an average depth of twenty to twenty five feet. The rim area had lesser concentrations of phosphorus in the water column, and was choked by dense growths of macrophytes and filamentous green algae during the warmer months. The average total phosphate concentration was 0.23 mg/l, while the average total nitrogen level was about 3.2 mg/l. The pH averaged 8.0, with an average alkalinity of 96 mg/l. Dissolved oxygen levels were sometimes very low, but the average level was an acceptable 7.5 mg/l.

Conditions in the bowl were similar with respect to pH, alkalinity and most nutrient values, although phosphorus concentrations (both forms) were a bit higher than at the outlet (total phosphate averaged 0.34 mg/l). The State Surface Water Quality Standard for phosphorus was contravened at both the outlet and in-lake stations, and in both studied tributaries. Phosphorus is more likely to limit productivity in the system than nitrogen, but due to the rather large concentrations, nutrients are probably not the major limiting factor. Temperature and dissolved oxygen profiles showed weak stratification below 10 to 12 feet of depth, with severe summer dissolved oxygen deficiencies in the hypolimnion. The role of internal nutrient recycling in the eutrophication of Allamuchy Pond is uncertain, but it is likely that such recycling is very important at the present time. Macrophytes have access to some bottom deposits, and probably release some nutrients into the water column. Deoxygenation of the hypolimnion also facilitates phosphorus recycling.

Bacteriologically, animal wastes and some residential runoff give the studied tributaries some large bacterial populations, and the State Surface Water Quality Standard for fecal coliform was contravened in the tributary from Weirtown. Total coliform geometric means were greater than 1000 MPN/100 ml, generally indicating poor water quality. In the pond itself, a few higher values were obtained for the measured bacteriological parameters, but geometric means were all fairly low, indicating no health hazards or major effects by the bacterial inputs on the pond itself.

The macrophyte populations of the rim area were very dense at times, and were dominated by Potamogeton crispus (Curly-leaf Pondweed) and Myriophyllum spicatum (Eurasian Watermilfoil). Associated algae included filamentous green algae (in dense mats), chlorococcalean green algae and various bluegreen algae. While the microscopic algae were seldom dominant at the outlet, cell concentrations were often high, and the chlorophyll *a* concentration (from microscopic algae) averaged 48.15 mg/m^3, a very high value.

In the open waters of the pond macrophytes were rarely seen, and bluegreen algae dominated the phytoplankton during part of the year. Light and temperature limited winter growth, and the spring sampling produced a small assemblage of pollution - tolerant forms from many algal divisions. Cell concentrations were variable, but averaged out to a high 86000 cells/ml, with only a moderate average chlorophyll *a* level (13.81 mg/m^3). Diversity was depressed throughout the lake, and dominance was often great. Poor water quality conditions were indicated.

The water quality indices employed supported the conclusions drawn here, and eutrophic conditions were indicated overall. Phosphorus may limit productivity at times (especially in the rim area), but other factors such as light or competitive inhibition are probably more important factors during much of the year. Most species present are pollution tolerant, and nutrient enrichment is high, but little indication of organic pollution was given by the indices.

On the basis of the accumulated data and analyses made, it can be concluded that Allamuchy Pond is in a eutrophic state. Great productivity (resulting in nuisance conditions) and dissolved oxygen deficiencies can be expected for years to come, until the pond becomes a marsh or meadow, unless restorative action is taken.

Conclusions

The indications of the data are that Allentown Lake is experiencing accelerated eutrophication as a result of nutrient loading from runoff from the agricultural lands surrounding its tributaries. Increased sediment loads and biological production are causing the lake to be filled in rapidly. Increasing productivity in the lake is manifested primarily as aquatic macrophytes, but algal blooms would be expected in the absence of the macrophytes. As it is, this lake would be classified as eutrophic.

Phosphorus appears to be the limiting nutrient, although light may become a factor when growth is dense. The retention time for water in the lake is rather low, which is normally a retardent to eutrophication, but in this case the nutrient and sediment loadings, due to runoff, are great enough to overshadow the effect of rapid flushing rate.

With the macrophyte situation as it is, flow could be expected to continue to decrease in all peripheral areas of the lake, and filling will continue until only a stream within a marshy meadow remains. Any restorative action will have to include both reduction of nutrient inputs and elimination of nutrient reserves along with some action to make the environment less favorable for macrophyte growth.

LAKE NAME: Allentown Lake (Conines Millpond)

LAKE LOCATION:

USGS Quadrangle: Allentown Lat. 40°10'40" Long. 74°35'00"

County: Monmouth

Municipality: Allentown Borough and Upper Freehold Township

LAKE STATUS: (Public or Private) Public FW-2

LAKE SIZE:

Average Depth: 2.9 ft (0.88 M)

Range of Depth: To 10 ft (3.05 M)

Area: 31.8 acres (12.9 Hectares)
12.2 acres in Allentown
19.6 acres in Upper Freehold

Volume: 30 million gal. (113,500 M^3)

WATERSHED INFORMATION:

Size: Approx. 5000 acres (2023 Hectares) sending water into Allentown Lake before other lakes. 10,930 acres (4423 Hectares) including area sending water into Imlaystown Lake before Allentown Lake.

Land use: 75% agricultural 20% forested 5% developed (mostly residential)

WATER AND NUTRIENT SOURCES:

Tributaries: Doctors Creek
Negro Run

Springs: None known

Effluents: (Point Sources): None known

Runoff: Some from vicinity of lake, much into tributaries from farmland.

Precipitation: 40.17 in. (long term avg.) (102 cm.) 51.18 in. (1977) (130 cm.)

Other: Possibly some septic input from residences around Lake, but not indicated as a major influence.

LAKE USE:

Present: Some fishing

Past: Boating, fishing, swimming

Potential: Boating, fishing, swimming

STUDY PERIOD: 5/77 through 5/78

GENERAL INFORMATION

LAKE NAME:	Boonton Reservoir
LAKE LOCATION:	
USGS Quadrangle	Boonton Lat. 40°53'00" Long. 74°24'30"
County	Morris
Municipality	Boonton and Parsippany - Troy Hills
LAKE STATUS: (Public or Private)	Private - Jersey City Bureau of Water
LAKE SIZE:	
Average Depth	25 ft (7.62 M)
Range of Depth	To 94 ft (28.65 M)
Area	780 acres (315.7 hectares)
Volume	7620 Million Gal. (28.8 Million M^3) at spillway level. Often as much as 7 ft. below spillway during heavy usage.
WATERSHED INFORMATION:	
Size	119 sq. mi. (308 sq. km.)
Land use	Heavily Industrial/residential along Rockaway River and Industrial/residential/forested along tributaries.
WATER AND NUTRIENT SOURCES:	
Tributaries	One Inlet, Rockaway River, fed by several tributaries upstream; Beaver Brook, Mill Brook and Green Pond Brook.
Springs	Unknown
Effluents	See Point Source Data (On Flow Data Sheet)
Runoff	residential and some woodland runoff. Large drainage area.
Precipitation	Long-term avg. = 44.93 in/yr (114.1 cm/yr) 1977 = 54.99 in (139.7 cm)
Other	
LAKE USE:	
Present	Potable Water Supply - Jersey City, Fishing by permit
Past	Potable water supply, Fishing
Potential	Potable water supply, Fishing
STUDY PERIOD:	6/77 to 6/78

CONCLUSIONS

Boonton Reservoir is experiencing accelerated eutrophication as the result of various point and non-point source inputs. Non-point input sources include precipitation, residential and woodland runoff, and possibly some septic systems. Point sources include effluents from eleven plants involved in a variety of production processes, with sewage included in some effluents. Two sewage treatment plants also discharge in the study area.

Effluent quality was generally moderate to poor in relation to stream conditions at most plants, but flows were relatively low, making total inputs of given nutrients rather small. Phosphorus was shown to be more important than nitrogen in this system, and phosphorus loads from various sources were calculated from the accumulated data. No annual individual point-source phosphorus input exceeded 300 lbs/yr, while the total input to the reservoir was 27100 to 28600 lbs/yr. All together, point-source phosphorus inputs totalled 1145 to 1545 lbs/yr, or about 4.0 to 5.7% of the total load. This is not considered to be particularly significant. Non-point sources accounted for at least 94% of the total phosphorus load to the reservoir. The major phosphorus source appeared to be residential runoff from the highly developed areas along the Rockaway River, especially within eight miles of the Boonton Reservoir inlet.

Of the 27100 to 28600 lbs of phosphorus entering the reservoir annually, 17100 to 18600 lbs remain there (60 to 69%). This amounts to a retained load of 2.46 to 2.67 g $P/m^2/yr$. Vollenweider's Model indicates that reservoir phosphorus loading should not exceed 0.75 $g/m^2/yr$ in order for the reservoir to maintain an oligotrophic status. To keep the reservoir from becoming eutrophic, the load must be kept below 1.48 $g/m^2/yr$. As can be seen, the present load exceeds both of these critical values. Also, at the inlet of Boonton Reservoir, the Surface Water Quality Standard for phosphorus (0.05 mg/l) is contravened, with the average phosphorus concentration at 0.063 mg/l. This concentration has been substantially reduced by the time the water reaches the reservoir outlet.

Going back to the point-source inputs, the pH values for the effluents were generally somewhat elevated, alkalinity levels were extremely variable, and average dissolved oxygen concentrations were adequate. However, low dissolved oxygen values were recorded at some time for most effluents. Average values for the various forms of nitrogen were generally moderate. In all of these cases, even the most excessive inputs did not seem significant in terms of the overall loading picture. Likewise, while the temperatures of many effluents were elevated, the relatively small flows negated the possibility of any major thermal pollution.

Other measured parameters, such as oil and grease and heavy metals, were found to have occasionally high values, but average values were usually well within suggested limits, and total loads were very small. Yet localized adverse impacts could be expected as a result of all the various point-source inputs, and there is some question regarding the significance of these inputs in the long-term loading and degradation of Boonton Reservoir.

In light of the high degree of variability of the quality of each effluent over time, high variability of treatment plant efficiency or industrial process wastes is suggested. Reduction of this variability, by consistent (and highest possible) efficiency, would reduce inputs. And all inputs have some effect on the system, however small.

The morphology of the Rockaway River is such that inputs are reduced at least somewhat before the water reaches the reservoir, and the reservoir itself acts as a huge sink for various inputs. Inputs may enter the reservoir in large pulses, as indicated by general river data and the frequency of floods in the watershed. Some of these inputs may reach the outlet, due to the proximity of the inlet, but much of the nutrient load remains in the reservoir. The physical arrangement of the inlet and outlet lead to decreased circulation and increased hydraulic detention time in most of the reservoir. These conditions can both aid and hinder nutrient recycling and primary productivity in a water body.

Samples taken right at the outlet, at the surface, show relatively good to moderate water quality. The pH is somewhat elevated at an average of 8.0, but no other water quality problems are indicated. Samples taken twenty-five feet below the outlet surface show a decreased pH (down to an average of 7.1), but also show a decreased average dissolved oxygen concentration (down to 7.7 from 10.4 mg/l), with several very low individual values (as low as 2.6 mg/l). The reservoir does stratify (at between 25 and 40 feet), and the differences between surface and deep samples indicate that the raised surface pH results mainly from photosynthetic activity (by algae) and that the higher surface dissolved oxygen level is primarily the result of aeration by the wind and algal photosynthesis. The decreased oxygen levels at 25 feet and below are probably the result of oxygen use in decomposition and inadequate replenishment.

In-lake boat samples show relatively similar water quality to that of the outlet (both above and below the thermocline). However, inadequate data prevents the drawing of definite conclusions. It appears that phosphorus limits growth during the warmer months, and that overall surface water quality is moderate. More information on nutrient recycling and deoxygenation in this reservoir is needed, but it is suggested that the hypolimnion of Boonton Reservoir is deoxygenated during the summer and possibly nutrient-rich.

Total coliform counts were low to moderate at all river and reservoir stations, and in the effluents of most point sources. Average fecal coliform levels were excessive in the Hewlett-Packard Outfall #1 effluent (at a geometric average of 468 MPN/100ml), but this value was reduced by dilution upon entrance of the effluent to Hibernia Brook. Most effluent fecal coliform geometric averages were less than 50 MPN/100 ml. Green Pond Brook, which receives effluents from Picatinny Arsenal operations, had occasionally high fecal coliform counts. This indicated possibly large inputs by those effluents, but the geometric average was quite acceptable at 50 MPN/100ml. Fecal Streptococci levels were lower than the fecal coliform levels in the effluents.

At the inlet to the reservoir, total coliform counts were moderate, at an average of 850 MPN/100ml, and the fecal coliform geometric average exceeded the Surface Water Quality Standard (200 MPN/100ml), at 318 MPN/100ml. Fecal Streptococci concentrations had a geometric average of 114 MPN/100ml, and fecal coliform to fecal Streptococci ratios yielded variable source information. Residential runoff, especially from the nearest residential areas, is suspected as the major source of bacteria at the inlet.

At the outlet of the reservoir and at all in-lake stations the measured bacterial populations were relatively small, and no bacterial standards were contravened. Good to fair water quality was indicated.

Little data on primary productivity and community structure in the Rockaway River or its tributaries was collected, but no nuisance conditions were observed. In Boonton Reservoir, macrophytes are not a significant portion of the plant biomass, mainly due to limitations imposed by the depth of the reservoir.

Algae biomass in the reservoir is generally moderate, with chlorophyll a values averaging between 8 and 17 mg/m^3 for the in-lake surface stations. Cell counts were often high, mainly due to the presence of small-celled bluegreen algae. There were some moderate blooms, and the species composition of the algae community was indicative of eutrophic conditions. Dominance was moderate to high, and diversity was generally moderate, although rather variable. Bluegreen algae, chlorococcalean green algae, and pollution tolerent diatoms were the most abundant algae.

Nutrient concentrations were suitable for the support of moderate algae biomass, which is consistent with the observed chlorophyll a data. Yet the algae community structure and species composition are indicative of a highly productive system. The data implies that this reservoir is in transition from mesotrophic to eutrophic conditions, a supposition supported by the phosphorus loading analysis.

At the outlet, algae populations are somewhat smaller and slightly more balanced. While unrepresentative of the reservoir as a whole, they do indicate that the water at the outlet (especially that portion taken for drinking purposes) is not obviously hazardous with regard to algae contaminants at this time. However, large scale bluegreen blooms could eventually render the reservoir water unfit for drinking or bathing. Present treatment of the water drawn from the reservoir for potable use is adequate to eliminate any possible present algal impurities observed during this study.

The water quality indices employed indicated variable conditions, ranging from the lower mesotrophic range to the moderately eutrophic region of the trophic scale. The possibility of organic pollution was demonstrated by Palmer's Index, and Nygaard's Index indicated a transition from mesotrophic to eutrophic conditions. Evenness values indicated moderately balanced to unbalanced ecological conditions, and Carlson's Indices gave extremely varied trophic level indications, with an average solidly in the mesotrophic range.

On the basis of the accumulated data and analysis performed, Boonton Reservoir can be said to be in a mesotrophic state, moving rapidly toward eutrophic conditions. A reduction of nutrient inputs will be needed to halt this progression, and even then it may be some time before a new equilibrium is reached in the reservoir, unless in-lake corrective measures are taken.

GENERAL INFORMATION

LAKE NAME: Branchbrook Park Lake (a series of ponds)

LAKE LOCATION:

USGS Quadrangle	Orange
County	Essex
Municipality	Newark

LAKE STATUS: (Public or Private)
Public (FW-3)

LAKE SIZE:

Average Depth	Upper Pond = 2 ft. (.61 M)	Middle Pond = 6.7 ft. (2.04 M)	Lower Pond = 4 ft. (1.22 M)
Range of Depth	To 4 ft. (1.22 M)	9 ft. (2.74 M)	6 ft. (1.83 M)
Area	37.5 acres collectively (15.2 hectares)		
Volume	61.2 million gallons (232,000 M^3)		

WATERSHED INFORMATION:

Size	about 2 square miles (5.18 sq. km.)
Land use	100% residential

WATER AND NUTRIENT SOURCES:

Tributaries	No standard inlets, several springs feed a pipe that runs into the Upper Pond.
Springs	Several feed the inlet pipe at the Upper Pond.
Effluents	None, but a malfunctioning sewer line has occasional inputs.
Runoff	Significant quantities from adjacent fields, roads, and area storm sewers.
Precipitation	Long-term average = 53.90 inches/year (136.9 cm./yr.)
Other	1977 = 53.80 inches (136.6 cm.)

LAKE USE:

Present	Some fishing, Some Boating, aesthetics, Ice Skating
Past	Fishing, boating, aesthetics, Ice Skating
Potential	Fishing, Boating, aesthetics, Ice Skating

STUDY PERIOD. 5/77 to 7/78

CONCLUSIONS

Branchbrook Park is experiencing accelerated eutrophication as the result of elevated nutrient inputs from a variety of sources. Spring and well water used to feed the Upper Pond is of moderate to poor quality, residential runoff is channelled to the Lower Pond, and a malfunctioning sewer line occasionally allows direct inputs of domestic wastewater. The park area around the ponds provides some runoff inputs, but much of the water crossing the surface of this area percolates through the soil and is diverted from the ponds by a drainage pipe system.

The Surface Water Quality Standard for phosphorus (0.05 mg P/l) is exceeded at all stations, including the inlet pipe at the Upper Pond, with average values ranging from 0.06 to 0.13 mg P/l. Biologically available phosphorus levels are considerably lower during algal blooms, indicating possible phosphorus limitation of growth at times. Nitrogen levels in the system are rather high, and appear more than adequate to support observed primary productivity (See TKN and NO_3-N values). NH_3-N and NO_2-N concentrations are moderate to low, and no associated hazards are indicated. Grease and oil concentrations were often high in some areas.

The pH is slightly elevated, as a result of the combined influence of elevated primary production and relatively high alkalinity. The average pH values in the system ranged from 7.4 to 8.0, and average alkalinity ranged from 92 to 179. Average dissolved oxygen levels are adequate at most stations, although the average value for the Lower Pond inlet area is 5.4 mg/l, contravening the Surface Water Quality Standard of 6.0 mg/l. This is mainly attributed to the subsurface inlet source. Yet all the ponds experienced occasional low dissolved oxygen levels, with some values lower than 3.0 mg/l. In such an apparently well-aerated system this indicates a high rate of decomposition and/or respiration, which is commensurate with the large quantities of organic matter produced and retained in the system.

Various physical characteristics of Branchbrook Park Lake facilitate its eutrophication. The hydraulic detention time is at least two weeks, and probably averages out to more than a month. There is no flow from the outlet of the Lower Pond during certain critical summer dry periods. The system is also shallow, which allows for greater recycling of nutrients. Sedimentation is primarily the result of internal production and deposition, but various construction activities in the park area (most recently in the vicinity of the Senior Citizens Center) have contributed considerable sediment loads over the years.

Bacterial populations in the ponds are fairly large, and poor water quality is indicated. Fecal coliform counts are occasionally high in all areas, and the geometric mean exceeds the Surface Water Quality Standard at the outlet of the Middle Pond. Residential and park land runoff and the occasional overflowing domestic sewer pipe outlet are all possibly significant outside sources of bacteria in the ponds.

The watershed is sparsely vegetated, outside of the actual park area, which contains largely ornamental vegetation. The ponds themselves experience dense growths of several nuisance macrophytes, mainly <u>Potamogeton crispus</u> and <u>Myriophyllum spicatum</u>. There are also heavy algal blooms in this system, with bluegreen algae and species of the green algae orders Chlorococcales and Volvocales dominating. Almost all algal species present are pollution-tolerant, preferring nutrient-enriched waters. Average chlorophyll <u>a</u> and cell concentrations were quite high. Diversity was moderate, but higher than expected. Dominance was fairly high, but was lower than might be expected as the result of multiple species blooms.

The water quality indices employed indicated upper mesotrophic to eutrophic conditions for the ponds, with great potential for primary productivity. Phosphorus was again indicated as a possible growth-limiting factor, although light and temperature are also critical at times. Turbidity in the system is great, as the result of both algal cell concentrations and suspended non-living matter. Some organic pollution of this system is expected, but is not strongly implied by the indices. Diversity and dominance are highly variable in this system, with average values in the moderate range.

The lake can presently be characterized as eutrophic, but does not have to remain this way. To improve the water quality of this system, both reduction of detrimental external inputs and inactivation of internal nutrient reserves will be necessary. Removal of the large deposits of organic matter may also be essential to reducing excessive macrophyte growths.

GENERAL INFORMATION

LAKE NAME: CLARKS POND (UPPER, MAIN and LOWER)

LAKE LOCATION:

USGS Quadrangle: BRIDGETON Lat. 39°23'25"/Long. 75°12'20" (MAIN POND)

County: CUMBERLAND

Municipality: FAIRFIELD TOWNSHIP

LAKE STATUS (Public or Private): UPPER - Private; MAIN and LOWER - Public (ALL FW-2)

LAKE SIZE:

Average Depth: UPPER - 4 ft. (1.2M); MAIN - 6 ft. 3 in. (1.9M), and LOWER - 3 ft. (0.9M)

Range of Depth: UPPER - 10 ft. (3.0M); MAIN - 15 ft. (4.6M), and LOWER - 7.0 ft. (2.1M)

Area: UPPER POND - 11 acres (4.5 Hectares); MAIN POND - 37 acres (15.0 Hectares), and LOWER POND - 38 acres (15.4 Hectares)

Volume: UPPER - 14.3 million gal. (.05 million M^3); MAIN - 76.6 million gal. (.05 million M^3), and LOWER - 37.0 million gal. (.14 million M^3)

WATERSHED INFORMATION:

Size: Approximately 10 square miles

Land Use: UPPER - residential; MAIN - residential and wooded, and LOWER - protected Fish and Game land, wooded.

WATER AND NUTRIENT SOURCES:

Tributaries: MILL CREEK

Springs: Headwaters fed by springs in wooded areas

Effluents: None known

Runoff: From residential developments on both sides of upper and main lake

Precipitation: Long-term avg. = 40.26 in./yr. (102.3 cm/yr), 1977 = 41.98 in. (106.6 cm)

Other: Possibly some septic input from residences

LAND USE:

Present: Some swimming, fishing, boating (with difficulty)
Past: Swimming, fishing, boating
Potential: Swimming, fishing, boating

STUDY PERIOD: 8/77 - 8/78

CONCLUSIONS

Nutrient inputs to the Clark's Pond system (includes three ponds) include agricultural, residential and woodland runoff, and possibly some septic system inputs. However, total inputs do not appear to be great, and internal recycling is probably the major source of nutrients in the system. The shallowness of parts of the system and the presence of rooted aquatic macrophytes make the nutrient reserves on the bottoms of the ponds more significant.

Clark's Pond is an acid system (pH of about 5.0 to 5.8), with relatively low major nutrient concentrations in the water column (total phosphate of about 0.03 to 0.06 mg/l, total nitrogen of 2.1 to 2.3 mg/l). Phosphorus is the most likely limiting nutrient in this system. Alkalinity is also very low in the system (averaging 5 to 13 mg/l). Dissolved oxygen levels are variable in the system. Station averages were generally acceptable, but occasional low values resulted from the slow decomposition of large organic deposits (especially in the Upper Pond) and inadequate replenishment of the oxygen supply. The heavy growths of macrophytes observed in certain areas were largely responsible for this condition.

Bacteriologically, the system is in good condition. Station averages for all measured bacteriological parameters were generally low. Occasional high values were recorded, but the cause of such elevated values was not determined. Septic inputs are a possible cause, but this is not certain and the overall effect is not very significant.

Sedimentation of the Upper Pond was extensive, but external inputs were apparently not the major source of sediment. Large organic deposits have resulted from internal macrophyte production (up to 75% surface cover). Macrophyte populations were smaller in the deeper Main Pond, and sedimentation was not as great. Macrophyte populations were again large in the Lower Pond, and large organic deposits were observed.

The species composition of the macrophyte populations of the Upper and Main Ponds were quite similar, with Nuphar advena (Yellow Water Lilly) and Utricularia sp. (Bladderwort) as the dominant plants. In the Lower Pond, Myriophyllum spicatum (Eurasian Watermilfoil) dominated. The distribution of the rooted aquatic plants is closely tied to the placement of organic deposits and shallowness of the system, while Utricularia appears to be a superior competitor for water column nutrients in shallower waters.

Algal populations in the ponds were small (cell concentrations averaged 360 to 800 cells/ml, with chlorophyll *a* averages of 1.25 to 9.76 mg/lm^3), and the species composition was typical of acid water/low available nutrient systems. Some pollution tolerant algae were present, mainly those associated with organic enrichment.

The presence of these species was undoubtedly linked to the observed organic deposits. Measured diversity was not very high, but the low cell concentrations and insensitivity of the methods of analysis may have caused some species to go unnoticed. No specific dominance was observed, and good overall water quality was indicated by the algal community.

The various water quality indices employed yielded values indicative of moderate to good water quality, with overall conditions in the lower mesotrophic range. No significant nutrient enrichment was indicated by the species composition based indices, and good water quality was implied by the chemical/physical parameter based indices.

Considering the data and associated analyses, Clark's Pond can be considered a lower mesotrophic system. The shallowness of the system and the large nutrient reserves are leading to an unfortunate macrophyte problem, especially in the Upper and Lower Ponds, but the water quality in the system is generally good.

GENERAL INFORMATION

LAKE NAME: DEAL LAKE

LAKE LOCATION:

USGS Quadrangle - # 24, Asbury Park, Lat. 40°13'45"; Long. 74°0'30"

County - Monmouth

Municipality - Asbury Park City, Interlaken Boro, Allenhurst Boro, Loch Arbour, Deal Boro, Ocean Twp., Neptune Twp.

LAKE STATUS: (Public or Private)

PUBLIC FW-2

LAKE SIZE:

Average Depth - 5.3 feet (1.6 M)

Range of Depth - Up to 10 feet (3 M)

Area - 144 Acres (58 Hectares)

Volume - 245.2 million gallons (928,000 M^3)

WATERSHED INFORMATION:

Size - 4,400 acres (1,780 Hectares)

Land use - Mainly residential/business, with some light industry, waste disposal, and forested areas.

WATER AND NUTRIENT SOURCES:

Tributaries - Hollow Brook, Hog Swamp Brook, and 5 other unnamed tributaries.

Springs - Some at headwaters of streams, but seemingly not the major water source.

Effluents - (Point Sources): Lapin Products, 1501 Allen St. Asbury Park.

Runoff - Considerable, especially from residential area storm sewers. Some overland flow directly to lake.

Precipitation - 44.56 in./yr. (long-term avg.); 50.90 in./yr. (1977)
(113.2 cm) (129.3 cm)

Other - Neptune Twp. Landfill and Delisa Landfill, localized non-point sources, contribute some leachate and runoff.

LAKE USE:

Present - Some fishing and boating

Past - Swimming, fishing, boating

Potential - Swimming, fishing, boating.

STUDY PERIOD: 5/77 -- 8/78

Conclusions:

Biological data indicates that Deal Lake falls into the lower range of the eutrophic category, while chemical data indicates a condition in the upper mesotrophic category. There are many fine gradations in trophic state classification, and the fluctuations of Deal Lake under the multiple influence of its tributaries makes absolute assignment difficult. But the data obviously shows accelerating eutrophication, and a classification of meso-eutrophic (lower range of the eutrophic state) is justified. From this study and past information, it is apparent that the condition of the lake is deteriorating, and will continue to do so unless corrective action is taken.

Nitrogen : Phosphorus ratios, algal data, and various trophic state index relationships indicate that phosphorus limits primary productivity in Deal Lake. The nitrogen and phosphorus supplies are adequate to support elevated primary productivity, and when other conditions are favorable, blooms occur. Very high NH_3-N concentrations were also noted in tributary #1, indicating great nitrogen input, and possible toxicity.

The major sources of nutrients include non-point sources such as runoff and seepage from residential areas, golf courses, and the two landfills (especially Neptune Township Landfill),and one point source, effluent from Lapin Products Inc. (which exceeds the phosphorus effluent standard). While nutrient concentrations in all tributaries have a definite impact on the lake water, the flow in tributary #1, Hollow Brook, is by far the greatest, and would appear to have the greatest effect on the lake. Inlet tributaries #2 and 7 have the next greatest flows, but the greatest nutrient concentrations occur in the tributaries with least flow. This makes assignment of impact priorities difficult, but does indicate that none of the tributaries can be completely ignored.

Sediment loading to the lake is greatest from tributaries #1 and 7, mainly due to construction. The lake is gradually becoming shallower, and seems to be well oxygenated. Some localized oxygen deficiencies are to be expected, though, in quiet areas containing larger quantities of macrophyte or algal remains.

A fair portion of the nitrogen and phosphorus entering the lake is being incorporated into the sediments by one means or another, and may be made available for further production later, depending on conditions. Inlets of the tributaries and quieter portions of the lake (such as lagoons or large areas outside the main channel) are particularly likely to harbor large nutrient reserves and organic matter deposits.

Bacteriological parameters indicate fair to poor lake water quality, but no standards are contravened. However, several of the tributaries exceed the limit for fecal coliform, and overall water quality is not good. Residential runoff and Neptune Township Landfill leachate are suspected as the primary sources of bacteria.

Primary productivity shows great fluctuations in the lake, and bluegreen algae blooms and heavy macrophyte growths do occur. Species composition indicates poor water quality, and temperature seems to be the primary control over productivity. Various trophic state indices indicate fair to poor water quality.

Accelerated eutrophication and deterioration of water quality and general lake condition is occurring in Deal Lake. The lake has been subjected to the studied influences for some time, and is unable to cope with the nutrient loadings and other abuses it has been experiencing.

GENERAL INFORMATION

LAKE NAME:	Dennisville Lake (Johnson Pond)
LAKE LOCATION:	
USGS Quadrangle	Woodbine Lat. 74°49'30" Long. 39°11'30"
County	Cape May
Municipality	Dennis Township
LAKE STATUS: (Public or Private)	Private FW-2
LAKE SIZE:	
Average Depth	2.5 feet (.75M)
Range of Depth	Up to 6 feet (1.82 M) at dam, but most of the lake is below 4 feet (1.22 M) in depth
Area	100 Acres (40.5 hectares)
Volume	81.3 million gallons (308,000 M^3)
WATERSHED INFORMATION:	
Size	3264 acres (1321 hectares)
Land use	Nearly all wooded, with about 25 residences, a small campground, a few small fields, and the Woodbine State Colony.
WATER AND NUTRIENT SOURCES:	
Tributaries	One unnamed tributary with two branches
Springs	Several (about 7) between the stream origin and the lake.
Effluents	STP at Woodbine's State Colony at .18 MGD
Runoff	Mostly from woodland, but some from residences, and a campground, and farmland (minimal).
Precipitation	Long-term average = 40.30 inches (102.4 cm) 1977 avg. = 37.23 inc (94.6 cm
Other	Possibly some septic inputs from homes and campground by lake
LAKE USE:	
Present	Swimming, boating, fishing (all when possible)
Past	Swimming, boating, fishing (on regular basis)
Potential	Swimming, boating, fishing (on regular basis)
STUDY PERIOD:	8/77 through 7/78

GENERAL INFORMATION

LAKE NAME:	Ludlam's Pond (Holly Lake)
LAKE LOCATION:	
USGS Quadrangle	Woodbine Lat. 74°50'30" Long. 39°11'30"
County	Cape May
Municipality	Dennis Township
LAKE STATUS: (Public or Private)	Private FW-2
LAKE SIZE:	
Average Depth	1.5 feet (.46 M)
Range of Depth	Up to 6 feet (1.82 M) at dam. but most of lake is below 3 feet (.91 M) in depth
Area	55 Acres (22.3 Hectares)
Volume	27.1 million gallons (103,000 M^3)
WATERSHED INFORMATION:	
Size	1690 Acres (684 hectares)
Land use	Almost entirely wooded, with about 15 residences.
WATER AND NUTRIENT SOURCES:	
Tributaries	One unnamed tributary with two branches
Springs	Several along stream before the lake.
Effluents	None
Runoff	Almost entirely from woodland, although two roads are crossed by tributary branches, making some unnatural inputs possible.
Precipitation	Long-term avg. = 40.30 inches (102.4 cm) 1977 avg. = 37.23 inches (94.6 cm)
Other	None Known
LAKE USE:	
Present	Swimming, Boating, Fishing
Past	Swimming, Boating, Fishing
Potential	Swimming, Boating, Fishing
STUDY PERIOD:	8/77 through 7/78

CONCLUSIONS

The data indicates that Dennisville Lake is experiencing accelerated eutrophication as the result of the direct discharge of effluent from the Woodbine State Colony sewage treatment plant into the main branch of the lake's only tributary. Other possible negative influences on the system have been ruled out or shown to be of minimal significance in relation to the effluent impact. Variable values for the measured parameters reflect the influence of biological and physical processes along the stream above the lake, along with variable flow. Nevertheless, the acquired data is sufficient to assign Dennisville Lake to the eutrophic stage in the classification scheme.

The Ludlam's Pond system, a very similar system (with regard to background conditions) that lacks the influence of any treatment plant discharge, has conditions that fit mainly into the lower mesotrophic category. This leads to an interesting comparison, since Dennisville Lake would be expected to be much more chemically and biologically similar to Ludlam's Pond, if the treatment plant discharge had never entered the Dennisville Lake system. Some differences would undoubtedly persist, but the major factor in the differentiation of these systems is the treatment plant effluent.

Specifically, Dennisville Lake is experiencing high phosphorus concentrations, elevated pH and greatly increased primary productivity, compared to Ludlam's Pond. Nitrogen concentrations are also increased, but not as significantly as for the previously named parameters. Alkalinity, dissolved oxygen and bacterial populations show no significant differences. Further comparison, between the west branch and the east or main branch of the Dennisville Lake tributary, would seem to further indicate the similarity between the background water of the Dennisville Lake and Ludlam's Pond systems, while underscoring the influence of the sewage treatment plant effluent.

Phosphorus appears to be the major limiting factor for primary production in both systems, but other factors such as acidity in both systems and nitrogen and light in the Dennisville Lake system may be important during the highly productive months. A fair portion of the phosphorus entering Dennisville Lake is remaining there, either as live organic matter or in the sediments. A portion of this supply is likely to be recycled, allowing for further production. There does not appear to be any significant phosphorus accumulation in Ludlam's Pond waters or sediment.

Aquatic macrophytes do not appear to be a significant problem in either lake, although proper management of Ludlam's Pond may be preventing any nuisance development there. Algal productivity is not a problem during most of the year in Ludlam's Pond, but is causing nuisance conditions much of the time in Dennisville Lake. The species composition, dominance and biomass characteristics of the two systems differ considerably, with the Dennisville data indicating very poor water quality. Various water quality indices were employed with varying results, but in general the conclusions drawn here were supported.

Cosmetic treatment of the Dennisville Lake situation is possible, but any long term solution to the problem will have to involve removal or advanced treatment of the sewage treatment plant effluent and removal or inactivation of the nutrient reserves presently in the lake.

GENERAL INFORMATION

LAKE NAME: Rainbow Lake

LAKE LOCATION:

USGS Quadrangle	Millville - Lat. 39°29'55" Long. 75°06'50"
County	Salem
Municipality	Pittsgrove Township

LAKE STATUS: (Public or Private) Private (FW-2)

LAKE SIZE:

Average Depth	3 ft. (.91 M)
Range of Depth	to 6 ft. (1.83 M)
Area	77.5 acres (31.4 Hectares)
Volume	75.5 Million gal. (286,000 M3)

WATERSHED INFORMATION:

Size	Below Parvin and Thundergust Lakes, about 7.8 sq. km. (3 sq. mi)
Land use	Mostly residential on the east side of the lake, agricultural with a few residences and some Woodland on the west side. The tributaries are bordered by swamp in most areas.

WATER AND NUTRIENT SOURCES:

Tributaries	Muddy Run - From Parvin Lake, the main tributary. Lummis Marsh Brook - minor tributary on east side of la
Springs	Some in the swampy areas bordering each tributary.
Effluents	None known
Runoff	Some from agricultural areas in the watershed, possibly a little from residences near lake or Muddy Ru
Precipitation	Long-term avg. = 40.26 in/yr (102.3 cm/yr) 1977 = 41.98 in (106.6 cm)
Other	Reports of illegal sewage discharges into the Muddy Ru or onto adjacent land by septic tank cleaning service truck

LAKE USE:

Present	Some swimming, fishing, boating
Past	Swimming, fishing, boating
Potential	Swimming, fishing, boating

STUDY PERIOD: 6/77 to 7/78

Conclusions

Rainbow Lake receives water from two tributaries with varying water qualities. Muddy Run, the larger of the two tributaries, receives agricultural and some residential runoff, and may also be receiving some septic wastes. The septic wastes may enter the stream by the flow of contaminated groundwater, or possibly by illegal disposal by a septic tank cleaning service. However, no definite proof of either was uncovered.

The water quality in Muddy Run is generally poor. Turbidity was generally high, and total phosphate levels marginally exceeded the State Surface Water Quality Standard on the average, at 0.16 mg/l. Nitrogen levels were moderate to high (all forms), with total nitrogen levels averaging 2.8 mg/l. The pH was quite variable, but averaged a near-neutral 6.9, and alkalinity was fairly low (average of 17 mg/l). Dissolved oxygen levels were always acceptable.

Lummis Marsh Brook, the smaller of the tributaries, receives inputs from largely unknown non-point sources. Some septic wastes may also enter this stream, but agricultural runoff and natural decomposition in adjacent swampy areas are the most likely major input sources. Water quality is generally better than in Muddy Run, with much lower turbidity and an average total phosphate level of 0.08 mg/l. Most forms of nitrogen had average values very similar to those in Muddy Run, but nitrate-nitrogen concentrations were very high, averaging 3.1 mg/l. The pH was acidic, at an average of 5.8, and the alkalinity to pH4 was very low, averaging 8 mg/l. Dissolved oxygen levels were generally acceptable in this stream, too.

At the lake outlet the water chemistry is very similar to that at the Muddy Run station, with nearly identical average pH, alkalinity and nitrogen (all forms) values. The total phosphate values were slightly lower at the lake outlet, and the average concentration (0.13 mg/l) was slightly less than the State Water Quality Standard. At the in-lake station, the average total phosphate concentration was 0.21 mg/l, exceeding the State Standard.

The average values for other chemical parameters were quite similar to those at the lake outlet and in Muddy Run. Dissolved oxygen levels in the lake were fairly uniform when tested, and bordered on the lower limit of acceptability in some cases. No stratification was observed, and wind aeration kept decomposition from depleting the oxygen supply. Plant activity can be assumed to add oxygen during the day and to remove it at night. Due to the large standing crop of algae in Rainbow Lake, fluctuations in dissolved oxygen levels may be considerable.

Bacteriologically, the system does appear to be in relatively good condition. Total coliform, fecal coliform and fecal Streptococci levels were variable (sometimes very high), but all geometric means were low to moderate values, resulting in compliance with the State Surface Water Quality Standard for fecal coliform. Fecal coliform to fecal Streptococci ratios did not yield any particularly useful information regarding bacterial input sources.

Macrophytes did not form a very significant portion of the aquatic plant biomass in this system. Some Elodea was observed in Muddy Run, while some Myriophyllum was found in Rainbow Lake. The algae were more abundant, with cell concentrations for the lake averaging 31000 to 48000 cells/ml (outlet and in-lake station averages). Chlorophyll a averages for the two lake stations were 21.4 and 27.2 mg/m^3. The cell concentrations and chlorophyll a levels at the Muddy Run station were similar to those of the lake, while the values for Lummis Marsh Brook were much smaller.

Several bluegreen algae blooms were recorded for the lake and Muddy Run, and the algal flora for these stations were considered pollution tolerant. Chlorococcalean greens, bluegreens, and pollution tolerant diatoms were the most abundant algae. The fact that the blooms (not normal in the stream environment) were also found upstream in Muddy Run means that such populations were washed out of upstream lakes. This suggests that the observed eutrophication problem extends beyond the Rainbow Lake study area. Dominance was either very low or very high, averaging out to a moderate value. Diversity followed a similar pattern.

The water quality indices employed gave fairly consistent indications of upper mesotrophy to lower eutrophy (using average values). The biotic community goes through periods of extreme imbalance, and the species compositon is indicative of a eutrophic environment. Phosphorus appears to be the limiting factor in this system at least part of the time, but light and temperature are undoubtedly important factors at times.

On the basis of the accumulated data and various analyses, Rainbow Lake can be categorized as a lower eutrophic lake. It is not certain that the lake is rapidly getting worse, but conditions are certainly not improving. More work is needed to discern the relative importance of the tributary inputs and internal recycling to the present state of the lake. It appears that the Muddy Run inputs are most significant, and reductions of these inputs might improve the lake's condition greatly. However, as the result of past potential accumulation of nutrients in the shallow lake, internal recycling might keep the system in a highly productive phase for quite some time after any major input reductions. The shallowness of the system encourages such a situation, while the low hydraulic detention time deters it. More detailed investigation is needed here.

GENERAL INFORMATION

LAKE NAME: ROUND VALLEY RESERVOIR

LAKE LOCATION:

USGS Quadrangle Flemington, Lat. 40°37', Long. 74°50'

County Hunterdon

Municipality Clinton

LAKE STATUS: (Public or Private) Public (FW-2)

LAKE SIZE:

Average Depth 71 ft. (21.6M)

Range of Depth 160 ft. (48.8M)

Area 2,350 acres (951 hectares)

Volume 54,267 million gal. (205.4 million M^3)

WATERSHED INFORMATION:

Size: Surrounding drainage area is only about 3 square miles, but this artificial reservoir was filled by pumping in water from the Raritan River

Land use: Wooded, recreational use; includes boat launch area, swimming facility, picnic and camping areas.

WATER AND NUTRIENT SOURCES:

Tributaries: No real inlets. Water pumped in from Raritan River

Springs: Some in bottom of reservoir

Effluents: None, although water can be and has been pumped into the reservoir

Runoff: Some woodland runoff from small surrounding watershed

Precipitation: Long-term Avg. = 43.39 in/yr (110.2 cm/yr)
1977 = 50.01 in (127 cm)

Other

LAKE USE:

Present: Swimming, boating, fishing

Past: Swimming, boating, fishing

Potential: Potable water, swimming, boating, fishing

STUDY PERIOD: 6/77 - 7/78

CONCLUSIONS

Round Valley Reservoir, after being formed from a horseshoe-shaped ridge (Cushetunk Mountain) and filled with Raritan River water, had rather poor initial water quality. Since it has a very long hydraulic detention time and minimal nutrient inputs, natural biological, chemical and physical processes have been able to act on the system over the past decade to purify the water.

The result has been a great improvement in water quality, and the reservoir has become a popular recreational facility. It has an excellent fish population and an algal community that is large enough to support the observed secondary and tertiary production, yet not nearly large enough to cause nuisance conditions. In the shallower areas, dense macrophyte growths often occur, and recreational areas have been treated for the reduction of these growths. Yet in areas not used for recreational purposes, these growths are beneficial, functioning collectively as an important part of the fish habitat and as a nutrient sponge. Overall, the system appears to have very well balanced ecological conditions, and is one of the highest quality aquatic environments in New Jersey.

As regards water chemistry, nutrient concentrations are generally low, with total phosphorus averaging about 0.01 mg/l, and total nitrogen at about 2.1 mg/l.

The pH is slightly basic, averaging 7.5, and the alkalinity to pH 4 averages about 46 mg/l, a relatively low but acceptable value.

The reservoir stratifies in late spring and becomes destratified in the fall, with the summer thermocline at 25 to 40 feet of depth. The dissolved oxygen concentrations in both the epilimnion and hypolimnion are fairly high, with no deoxygenation of the hypolimnion and a lowest observed level of 6.0 mg/l.

The quality of the water in the boat launch area is not as good as in the open waters of the reservoir, probably as a combined result of shallowness and man's influence. Similar water quality is expected for the swimming area. Nevertheless, these areas have at least moderate water quality, and do not have any observable effect on the main body of the reservoir.

Bacteriologically, the system is in good condition as regards coliform and fecal Streptococci levels. Slightly higher levels were found in the boat launch area and would be predicted for the swimming area, but good water quality was still indicated.

The water quality indices employed all gave indications of good water quality, in the oligotrophic or lower mesotrophic range of conditions. The indices utilizing algal quantities or species composition gave no indication of any significant pollution or enrichment. The indices using chlorophyll a or phosphorus concentrations indicated a low to moderate potential for primary productivity.

On the basis of the accumulated data, Round Valley Reservoir can be considered on the borderline between oligotrophy and mesotrophy. It has moved toward this condition from more mesotrophic or almost eutrophic conditions. This water quality improvement is the result of the purifying action of natural processes, aided by minimal nutrient inputs and long hydraulic detention time. The reservoir is presently at its optimal condition with respect to its value to man. Greater nutrient concentrations or productivity could lead to ecological imbalances, while continued decreases in nutrient concentrations or primary production could severely restrict the quantity of aquatic life that the reservoir could support.

This system should be guarded and watched over carefully, since it is such a valuable resource. Hopefully, it has reached an aquatic and ecological equilibrium, at least as regards present influences on the system. If and when large-scale pumping of reservoir water for domestic use begins, further changes could be expected. But if consideration is given and care taken, such potential use of the reservoir does not necessarily have to reduce or impair its present value or uses.

GENERAL INFORMATION

LAKE NAME: Saxton Lake

LAKE LOCATION:

USGS Quadrangle: Tranquility (Longitude 74°47'30" - Latitude 40°53'45")

County: Morris and Warren

Municipality: Mount Olive Township and Allamuchy Township

LAKE STATUS: (Public or Private): Public (and some Privately Owned Sections)
FW-2

LAKE SIZE:

Average Depth: 5 feet (1.52 M)

Range of Depth: To 10 feet (3.05 M)

Area: 60 acres (24.3 hectares)

Volume: 97.9 million gallons (370,400 M^3)

WATERSHED INFORMATION:

Size: Total of 70.0 square miles (181.3 sq. km.), but only 9.5 square miles (24.6 sq. km.) downstream of Waterloo Lake.
Land use: about 90% forested and 10% residential, excluding area upstream of Waterloo Lake.

WATER AND NUTRIENT SOURCES:

Tributaries: Musconetcong River, which receives water from two (2) unnamed tributaries near the Saxton Lake Inlet.
Springs: None known, but probably some at the tributary headwater lakes (includes Deer Park Lake).
Effluents: None after Waterloo Lake.

Runoff: Woodland (and possibly some residential) runoff.

Precipitation: Long term avg. = 48.8 in./yr. (124 cm./yr.)
1977 = 48.1 in./yr. (122 cm./yr.)
Other: Possibly some septic inputs from lakeside residences (about 60 homes).

LAKE USE:

Present: Boating, fishing.

Past: Swimming, boating, fishing.

Potential: Swimming, boating, fishing.

STUDY PERIOD: 5/77 to 6/78

GENERAL INFORMATION

LAKE NAME: Waterloo Lake

LAKE LOCATION:

USGS Quadrangle: Stanhope (Longitude 74°45'00" - Latitude 40°55'00")

County: Morris and Sussex

Municipality: Mount Olive Township and Byram Township

LAKE STATUS: (Public or Private): Public FW-2

LAKE SIZE:

Average Depth: 4 feet (1.22 M)

Range of Depth: To 9 feet (2.74 M)

Area: 48 acres (19.4 hectares)

Volume: 62.3 million gallons (235,900 M^3)

WATERSHED INFORMATION:

Size: Total of 60.5 square miles (156.7 sq. km.), but only 30.8 square miles (79.8 sq. km.) downstream of Lake Musconetcong.

Land use: about 50% forested, with about 30% residential/industrial, and 20% open area (farmland, gravel pits, etc.).

WATER AND NUTRIENT SOURCES:

Tributaries: Musconetcong River, which in turn receives water from Wills and Lubbers Run between Waterloo Lake and Lake Musconetcong.

Springs: None known, but probably some at tributary headwaters.

Effluents: Musconetcong STP, Consolidated School STP, US Mineral Products discharges.

Runoff: Woodland and residential runoff, plus some landfill leachate.

Precipitation: Long-term avg. = 48.8 in./yr. (124 cm./yr.)
1977 = 48.1 in./yr. (122 cm./yr.)

Other: Possibly some septic inputs from Waterloo Village.

LAKE USE:

Present: Fishing, aesthetics

Past: Fishing, aesthetics

Potential: Fishing, aesthetics, possibly boating and swimming if made more accessible.

STUDY PERIOD: 5/77 to 6/78

CONCLUSIONS

The stretch of the Musconetcong River between Lake Musconetcong and Waterloo Lake is experiencing large inputs of nutrients, mainly from the developed areas at Stanhope and Lockwood and the Musconetcong sewage treatment plant in Mount Olive Township. Other inputs exist, such as those from the U.S. Mineral Products discharges, the Byram Twp. Consolidated School sewage treatment plant, and runoff or leachate from area landfills, but these are relatively insignificant (compared to the major inputs). A substantial load of nutrients is also contributed by the waters leaving Lake Musconetcong. A great decrease in nutrient load, especially phosphorus, occurs in the river just before the Waterloo Lake inlet.

Inputs below Waterloo Lake are greatly decreased, and the nutrient load remains relatively constant until it passes out of the section of the river under study. Almost no phosphorus build-up occurs in Waterloo Lake, and while a quantitatively large build-up was detected in Saxton Lake, that build-up is proportionately small in relation to the total load passing through the lake. The passage of most of the phosphorus load through both lakes is the result of relatively large flows and low hydraulic detention times for the lakes.

Phosphorus is the most likely limiting nutrient for this system, but water velocity and light probably limit productivity at certain times and places. Nutrient concentrations are generally large throughout the system, and water in both lakes exceeds the Surface Water Quality Standard of 0.05 mg P/l on the average. Nitrogen quantities (and apparently micronutrient levels) were adequate to support great productivity when other conditions were favorable, and nuisance conditions occurred in both lakes and along slow flowing stretches of the river during the warmer months. It is important to note that despite the large phosphorus load, increased phosphorus inputs might lead to even worse nuisance conditions at times.

Non-rooted floating macrophytes and attached submerged macrophytes were the abundant forms in nuisance growths, along with mats of the green alga Hydrodictyon. Trailing growths of the periphytic green alga Cladophora were also occasionally large. Other pollution tolerant species were present, but were overshadowed by the above growths during the summer. Total productivity and biomass for the year were great as a result of the extensive summer growths of a few macrophyte and algae species. Still, the overall number of species present was much larger than expected for such a system.

The large summer populations of algae and macrophytes exert a strong influence on dissolved oxygen in the system. Between community respiration, decomposition, and reduced aeration by wind (due to surface growths), dissolved oxygen supplies are almost totally depleted in Saxton Lake at times, and are somewhat depressed in Waterloo Lake on occasion. Elevation of pH is also caused by these growths, although the chemical inputs to the system are also responsible for the observed pH levels.

Bacterial levels in the water leaving Lake Musconetcong were not particularly high, but inputs from developed areas along the river, Lubbers Run and Wills Brook greatly increased total coliform, fecal coliform and fecal Streptococci concentrations. The Surface Water Quality Standard for fecal coliform bacteria (geometric mean of 200 MPN/100 ml) was exceeded along most of Wills Brook, in the effluents of the sewage treatment plants, and on the surface of Waterloo and Saxton Lakes. A potential health hazard therefore exists. Fecal coliform:fecal Streptococci ratios were not overly useful in identifying the nature of the major source of bacteria, but the raw data shows that inputs from the Musconetcong STP are very substantial, and indicates that present chlorination is inadequate to control bacterial outputs from the plant. While bacterial outputs from the Consolidated School STP were not nearly as great as those from the Musconetcong STP, chlorination at that plant is apparently also inadequate.

The various water quality indices employed in this study produced varying and conflicting results. As a result of the exclusion of algal mats and macrophyte growths from the quantitative analyses, many index values suggested less polluted conditions than actually existed. Other less affected indices produced values indicative of a moderately eutrophic environment.

Considering the data analyses and observations made, both Waterloo and Saxton Lakes can be classified as moderately eutrophic. However, their state is the result of continued nutrient inputs, and is not dependent on any long-term nutrient build-up and recycling process. Consequently, nutrient input reductions, especially as regards phosphorus, should yield corresponding increases in water quality. Cessation of eutrophication, and probably a reversal of present trends could then be expected, since the flushing rate for the two lakes is high. Corresponding improvement in the condition of the Musconetcong River should alleviate some of the problems and nuisances presently encountered there, and would certainly increase the chances of fish survival in this trout maintenance area. Treatment of the symptoms of eutrophication would be fruitless in this case.

GENERAL INFORMATION

LAKE NAME:	Speedwell Lake
LAKE LOCATION:	
USGS Quadrangle	Morristown Long. 74°29'00" Lat. 40° 48' 45"
County	Morris
Municipality	Morristown & Morris Township
LAKE STATUS: (Public or Private)	Public FW-2
LAKE SIZE:	
Average Depth	4.5 ft. (1.37 M)
Range of Depth	to about 8 ft. (2.44 M)
Area	27 acres (10.9 hectares)
Volume	39.4 Million Gal. (149,300 M^3)
WATERSHED INFORMATION:	
Size	approx. 25 sq. mi. (64.8 sq. km.)
Land use	residential, industrial, wooded
WATER AND NUTRIENT SOURCES:	
Tributaries	Whippany River and its tributaries.
Springs	None Known
Effluents	3 STP's discharge into the river or its tributaries within 4 miles of the lake.
Runoff	Some residential, some woodland runoff.
Precipitation	Long-term avg. = 47.6 in/yr (120.9 cm/yr) 1977 = 50.3 in. (127.8 cm.)
Other	Possibly some septic inputs, but not significant (only a few homes by lake).
LAKE USE:	
Present	Fishing, aesthetics, some boating
Past	Fishing, boating, swimming
Potential	Fishing, boating, swimming
STUDY PERIOD:	5/77 through 5/78

GENERAL INFORMATION

LAKE NAME:	Pocahontas Lake
LAKE LOCATION:	
USGS Quadrangle	Morristown
County	Morris
Municipality	Morristown
LAKE STATUS: (Public or Private)	Public FW-2
LAKE SIZE:	5 ft. (1.52 M)
Average Depth	5 ft. (1.52 M)
Range of Depth	To about 8 ft. (2.44 M)
Area	14.5 acres (5.9 hectares)
Volume	23.7 Million Gal. (89,700 M^3)
WATERSHED INFORMATION:	
Size	approx. 26 sq. mi. (67.3 sq. km)
Land use	residential, industrial, wooded
WATER AND NUTRIENT SOURCES:	
Tributaries	Whippany River from Speedwell Lake, with a small Tributary in between.
Springs	None Known
Effluents	Same as for Speedwell Lake
Runoff	Residential, plus some woodland and railroad runoff.
Precipitation	Long term avg. = 47.6 in/yr (120.9 cm/yr) 1977= 50.3 in. (127.8 cm)
Other	
LAKE USE:	
Present	Fishing, aesthetics
Past	Fishing, boating
Potential	Fishing, boating
STUDY PERIOD:	5/77 through 5/78

CONCLUSIONS

Speedwell and Pocahontas Lakes are receiving excessive quantities of nutrients and sediment, but do not consistently exhibit all the features of a eutrophic environment. Low hydraulic detention time, along with some turbidity, appears to be minimizing the effects of the eutrophication that is taking place. Nutrient concentrations are high, alkalinity, pH and dissolved oxygen values are moderate, and chlorophyll a and cell concentrations are relatively low. Diversity was fairly high, and no extreme dominance was observed. Severe nuisance conditions did not occur during this study, but would be predicted for low flow conditions. A sizeable portion of the present species composition of the lakes is dislodged periphyton, and quantitative indications point toward eutrophic conditions. Under lower water velocity, or possibly even with the present velocity but on a longer time scale, a shift in community structure to a more conventional eutrophic lake biota could be expected.

Inputs to the Whippany River are large, even upstream of the area studied. Concentrations of phosphorus in the river or its tributaries exceed the 0.05 mg/l Surface Water Quality Standard upstream of the sewage treatment plants in the study area, and the concentrations of phosphorus and other nutrients in the effluents of the plants are very high. However, the small flow of the Delbarton School STP makes its inputs relatively insignificant in the overall picture. The inputs from the Greystone Park State Hospital STP amount to about ten percent of the maximum load, measured at the inlet of Speedwell Lake, while the major contributor is the Butterworth STP, which accounts for about seventy-six percent of the maximum load. The remainder of the inputs, about twelve percent, come from residential and some woodland runoff. There is also significant residential runoff entering the lakes directly (especially Pocahontas Lake), which was not accurately quantified in this study.

Phosphorus will limit productivity in these lakes before nitrogen does, but nutrients do not appear to be the limiting factor in the study area at this time. However, present productivity could be reduced and the risk of future productivity problems minimized if significant reductions in phosphorus loading were made. Placing effluent limitations on the sewage treatment plants would yield great reductions, but would still not provide the 90% overall reduction necessary to keep the phosphorus concentration at the inlet to Speedwell Lake below 0.05 mg/l. Phosphorus is accumulating in both lakes at rates greatly exceeding those considered permissible by Vollenweider, even with the low hydraulic detention times of these lakes.

Quantities of nitrogen in the system are adequate to support excessive primary productivity, and ammonia levels are occassionally high enough to create toxic conditions for some distance downstream of each sewage treatment plant discharge. However, dissolved oxygen concentrations are usually sufficient to convert most ammonia to nitrate before it reaches the lakes.

Bacteriologically, the system is in acceptable condition, with total coliform, fecal coliform and fecal Streptococci levels indicating no health hazards or unusual conditions. Geometric means for fecal coliform were well within the Surface Water Quality Standard of 200 MPN/100 ml. Chlorine levels were occasionally high in the effluent of the Butterworth STP, but the plant is effectively eliminating a potentially large bacterial input. Bacterial populations, while not excessive at any point in the system, do increase in the lakes. The bacterial inputs of direct residential runoff into the lakes are apparently quite significant for this system.

The water quality indices employed in the analysis of compiled data yielded explainable but often non-supportive results. The indices suggest great potential for productivity, but little realization of this potential. Diversity and evenness are high, suggesting relatively balanced ecological conditions. Species composition-based indices give variable and conflicting results, with few strong indications of advanced eutrophication. Chemistry-based indices suggest decidedly eutrophic conditions. Various physical factors interfere with the validity of the indices, but the general indication is one of advanced eutrophication without all the symptoms of a eutrophic environment. Whether or not these symptoms will be acquired will depend on continued activities within the drainage basin and certain external factors, such as natural changes in the flow through the system.

GENERAL INFORMATION

LAKE NAME:	Sunset Lake
LAKE LOCATION:	
USGS Quadrangle	Gladstone (and Bernardsville) Lat. 40°38'25" Long. 74°37'40"
County	Somerset
Municipality	Bridgewater Township
LAKE STATUS: (Public or Private)	Private (FW-2)
LAKE SIZE:	
Average Depth	2.3 ft. (.70 M)
Range of Depth	to 9 ft. (2.74 M)
Area	15.0 Acres (6.1 Hectares)
Volume	1.85 Million Gallions (7000 M^3)
WATERSHED INFORMATION:	
Size	Approx. 1 sq. mile (2.6 sq. km.)
Land use	Mostly residential, some forested land.
WATER AND NUTRIENT SOURCES:	
Tributaries	2 small tributaries merge into Chambers Brook
Springs	None Known, although possibly some in lake.
Effluents	No typical effluents, but a nearby domestic sewer manhole occasionally overflows.
Runoff	Excess from residences on land all around lake.
Precipitation	Long-term avg. = 44.93 in/yr (114.1 cm/yr) 1977 = 56.13 in. (142.6 cm.)
Other	Possibly some septic input from residences not yet sewered. Also, considerable sediment input from construction in area.
LAKE USE:	
Present	Swimming, fishing and boating
Past	Some Swimming, fishing and boating
Potential	Swimming, fishing and boating
STUDY PERIOD:	6/77 through 7/78

CONCLUSIONS

Sunset Lake is acting as a detention basin for the products of watershed development, and the quality of water passing through the lake is improved slightly by such passage. Residential and woodland runoff in this area carry a relatively large sediment load and a moderate nutrient load, especially where construction activities are involved. There is also a poorly designed sewerline that overflows through a manhole near the lake's inlet.

At the inlet, the Surface Water Quality Standard for phosphorus is contravened, and the sediment load is often very large. Direct inputs of sediment to the lake are also significant. The water is often turbid after storms, and the progression of sediment from construction sites to the lake is visually obvious. Much of the sediment and phosphorus loads remains in the lake, and the phosphorus standard was not contravened at the outlet. Quantities of nitrogen, while adequate to support much primary production, were not really excessive. The concentration of available phosphorus may indeed limit production in the lake, since the orthophosphate concentration is much smaller than the total phosphate concentration in the incoming waters.

The pH of the lake water is slightly elevated, but the alkalinity is not, and primary production does not seem to account for the rise in all cases. Dissolved oxygen values are generally high, and very few values below 6 mg/l were detected during the study. The shallowness of the system allows for good aeration, and decomposition and respiration in the lake apparently cause no significant deficiencies.

Bacterial inputs at the inlet are high, and the Surface Water Quality Standard for fecal coliform is greatly exceeded by the geometric average for this station. A combination of human and animal wastes are responsible, coming from the malfunctioning sewerline, runoff, and possibly some septic tank leaching. By the time the water reaches the outlet, bacterial populations are moderate and no state standards are contravened.

The low hydraulic detention time, turbidity and possibly low available phosphorus concentrations result in moderate primary productivity in the lake. Algal cell counts were generally low, and no blooms were recorded. Chlorophyll a values were occasionally elevated, but averaged out to a moderate level at all stations. The algae present included some pollution-tolerant forms, but few strong indications of eutrophy were given. Algal quantity, quality, and community structure were generally indicative of a system in transition from mesotrophic to eutrophic conditions. Macrophytes (Myriophyllum) were somtimes abundant, but no long-term, extensive population was observed. Turbidity may be responsible for the lack of continual heavy macrophyte growth in this otherwise apparently optimal macrophyte environment, possibly along with some substrate deficiencies (much loose sand). However, the eventual establishment of dense macrophyte populations could be expected in this shallow system, probably within the next 5 years.

Water quality indices employed gave varying values, due to the fluctuating characteristics of incoming waters and relatively low hydraulic detention time. Average values were indicative of a system in the upper mesotrophic range of conditions. Primary production is slightly less than might be expected on the basis of phosphorus concentrations, but a variety of factors may be responsible for this, including turbidity, flow, and phosphorus availability.

Considering the data, Sunset Lake appears to be in an upper mesotrophic state, and is moving toward eutrophic conditions. Poor construction practices in the watershed and inputs typical of residential areas are impacting the lake, and can be expected to continue to do so until corrective action is taken.

PART III: Discussion

Spectrum of Lake Types and Conditions

Common Problems Facing New Jersey Lakes

Measuring Water Quality - Utility of Various Parameters and Indices

Evaluation of Other Limnological Information and Procedures used in making Trophic State Determinations

Suggestions for Future Studies

General Lakes Management and Restoration work needed in New Jersey

DISCUSSION

Spectrum of Lake Types and Conditions:

A total of fifteen lakes were studied, but there were two sets of two lakes which were situated in series on a given waterway, leaving thirteen independent systems studied. Of the thirteen aquatic systems, eight were found to be eutrophic. Two others were categorized as in an upper mesotrophic state, and still two more were assigned to the lower mesotrophic state. One system was considered to be on the borderline between oligotrophy and mesotrophy.

While thirteen systems is a rather small sampling of New Jersey's 1000 + lakes, it is a fairly representative grouping. Lakes of various depths, geographic areas and watershed sizes were selected, and a very wide variety of nutrient sources had inputs to the studied lakes. These nutrient input sources included wastewater treatment facilities, farmland (cattle and crops) runoff, urban runoff, industrial operations, woodland runoff, and groundwater flow. Average depths ranged from 1.5 ft (0.46M) to 71 ft. (21.6M), while watershed areas were between 1.0 and 120 square miles (2.6 to 308 square kilometers).

By totaling the quantified or estimated inputs by each contributing general source of nutrients for all of the studied systems and dividing each source's total by the total inputs to all of the systems studied, the following table is generated:

General Nutrient Source	Average Contribution (as % of total inputs)
Urban (Residential) Inputs	36.0
Farm-related Inputs	26.9
Sewage-related Inputs	20.0
Woodland (Natural) Inputs	16.5
Industrial Inputs	0.6

As can be seen, the normally non-point source inputs from urban areas are the greatest, with farm inputs (also usually non-point source inputs) second and sewage inputs (most often point-source inputs) third in average magnitude. Inputs from natural sources (usually woodland runoff or subsurface flow) are fourth and inputs from industrial sources are last in terms of average quantities contributed. It must be remembered that these are generalizations based on the thirteen systems studied, and may apply only to those systems as a group. However, they do seem fairly representative of New Jersey lakes on the whole.

Yet in fact, a single general source contributed over half of the total inputs to each system, with that major source varying from system to system. Of the thirteen systems studied, five were considered to be most affected by urban inputs, three were believed to be most affected by farm-related inputs, three were determined to be most affected by sewage inputs, and two systems appeared to be primarily affected by woodland inputs. Only industrial inputs were not found to be the major nutrient source in any case. Yet no nutrient source contributed 100% of the total nutrient load, so multiple sources were responsible for the system's condition in each case.

Geographic location appears to be significant in determining the major source of nutrients for a given New Jersey lake. Urban inputs tended to be much more significant in the northern New Jersey systems than in the southern New Jersey systems, while farm inputs (mainly agricultural) and woodland inputs were more significant in the southern systems than in the northern areas. The significance of sewage inputs showed no geographical pattern. These statements are quite logical when one considers the patterns of population distribution and land use in this state.

The 1977-78 Intensive Lake Surveys, if assumed to be representative of New Jersey lakes as a group, indicate a preponderance of eutrophic lakes. Mestrophic lakes are not uncommon, but oligotrophic lakes appear to be rare in this state. One type of lake to be noted is the dystrophic lake, a category into which at least two of the studied lakes might be placed. However, productivity in the studied lakes was higher than expected for typical dystrophic lakes due to man's influence, and it seemed more appropriate to place these lakes in the mesotrophic category. However, there are truly dystrophic lakes in New Jersey.

Natural causes (especially shallowness) and man's influence appear to be the main reasons why there are very few (if any) truly oligotrophic lakes in New Jersey. Most New Jersey lakes are man-made to begin with, and these lakes tend to be very shallow (less than 6 ft. average depth). Shallowness generally precludes oligotrophy, and human-caused inputs to most New Jersey lakes speed up the aging process of lakes (accelerated eutrophication).

Consequently, mesotrophic and eutrophic lakes are abundant in New Jersey, and restoration is often necessitated before effective lake management programs can be instituted.

Common Problems Facing New Jersey Lakes:

As the result of various past investigations into water quality in New Jersey, and especially from the 1977-78 Intensive Lake Surveys, the following influences can be listed as the major factors in the degradation of New Jersey's lakes;

1. The general development of watersheds into urban/business/ industrial communities results in increased nutrient, sediment and bacterial inputs into aquatic systems. This is in part unavoidable, but inadequate or inconsiderate design, construction and operation can accentuate the problem. Large scale paving and the construction of storm sewer systems that empty directly into a waterway result in very variable flows and allow for increased inputs of all types. People, by their very nature and their concentration in this state, frequently form an obstacle to maintaining clean lakes.

2. Poor or inefficient land use practices result in increased inputs to aquatic systems, especially nutrients and sediments. This problem is related to the first major influence discussed, but is completely avoidable. Improper application or complete disuse of best management practices in farm operations and development (actual construction work) results in the entrance of huge quantities of sediment to New Jersey's aquatic systems. Lakes, having much greater hydraulic detention times than most stretches of river or stream, become the eventual resting place for much of this sediment. The sediment itself bears nutrients that can result in nuisance growths, but additional nutrients enter aquatic systems via runoff from farms (crops and cattle) and construction sites, due to inadequate ground cover and overfertilizing. The implementation of good soil conservation techniques is clearly lacking in many areas of this state. Recent and current legislation regarding soil conservation should improve this situation.

3. Lack of advanced wastewater treatment and inadequate consideration of water quality in wastewater treatment facility design and operation result in large nutrient inputs to New Jersey's waterways. Bacterial inputs are sometimes considerable also. While the influence of sewage-related inputs on water quality ranked third in overall importance, according to the 1977-78 Intensive Lake Surveys, sewage inputs are almost always the major factor in determining water quality when such inputs are present. Problems related to sewage inputs to aquatic systems (including septic wastes) are to some extent unavoidable, since humans make waste and it must be disposed of; however, the extent to which these inputs affect New Jersey's waters is much too great.

Preventable septic system and treatment plant malfunctions occur, and this State's waterways are often forced to suffer as the result of inadequate treatment facility or septic system design or the economic infeasibility of advanced wastewater treatment.

4. The high frequency of naturally shallow or shallow man-made lakes in New Jersey increases the impact of nutrient and sediment inputs to aquatic systems in this State. The majority of New Jersey lakes have an average depth of less than six feet, facilitating macrophyte growth and internal recycling of nutrients. Some of these shallow lakes are in good condition, but none have yet been found that could be called oligotrophic. While not the ultimate panacea, depth alone goes a long way toward maintaining acceptable water quality in a lake in the face of increased inputs. Nuisance conditions are less frequent in New Jersey's deeper lakes, and it is generally believed that the water quality of these lakes can be greatly improved by input reductions alone without any major in-lake restoration work. Lack of depth makes lake restoration and management more difficult.

Measuring Water Quality - Utility of Various Parameters and Indices:

A variety of parameters and indices were used to measure water quality in the lakes studies, and the cumulative indication of all these factors was used to assign a trophic state designation to each lake. The reliability of the individual indications of the parameters and indices was variable, but the cumulative indication of all the factors seemed very sound. The results illustrate the importance of basing conclusions on the indications of multiple factors, rather than just one or two measured parameters. Some parameters or indices were more useful than others, and the usefullness of some was limited by the methods of measurement or natural background interferences in the aquatic systems studied. The following is an evaluation of the parameters or indices used as indicators of water quality and trophic state in these studies;

1. Algal Cells Per Milliliter: The yearly average cell concentration is a good indicator in most cases. However, interference can arise in the form of extensive growths of macrophytes, which tend to competitively reduce phytoplankton populations, even in heavily nutrient-enriched waters. Also, a large cell concentration of bluegreen algae may contain no more biomass than an average green algae concentration, making certain comparisons difficult.

2. Algal Quality: In the hands of a competent investigator, qualitative algal analysis can yield valuable information about an aquatic system. However, some quantitative data (cell counts, chlorophyll or dry weight) is essential to support qualitative analyses.

3. Community Structure: Analysis of the structure of the biotic community is a very effective tool in measuring water quality. It combines qualitative and quantitative measurements, and facilitates comparisons with other systems. Only the algal portion of the aquatic community was analyzed in depth in these studies, but very significant indications were still obtained. Even more significance could be attached to community structure analysis if the other components (such as macrophytes, zooplankton and fish) were adequately measured. Community structure analysis, which involves measuring the quantity, quality, distribution and interactions of the organisms in an aquatic system, is probably the best indicator of aquatic conditions. However, it is not really a single indicator, since it takes many individually measured parameters (such as diversity, cell concentration, and qualitative indications) into consideration.

4. Percentage of Algae in Given Groups: Essentially, this is part of the community structure analysis, but has some use by itself. By knowing the typical patterns of dominance and succession for given lake types, the distribution of algal biomass among the major algal groups can yield significant information. It is generally not a strong indicator but is useful in conjunction with quantitative data.

5. Diversity (numbers of taxa present): This indicator is also incorporated into the community structure analysis, but may yield some useful indications by itself. In general, by the methods used in these studies, low diversities indicated very low or very high nutrient concentrations, while high diversities indicated moderate nutrient concentrations. More sensitive methods of analysis or coupling with qualitative data would strengthen the indications obtained.

6. Chlorophyll a Concentration: Quantitatively, this was a very useful indicator. The yearly average concentration gave a reasonable indication of trophic state, but winter values were depressed in all cases by light and temperature limitations. Therefore, spring, summer and fall values were more representative of actual water quality, with summer values alone giving very strong indications.

7. Algal Biomass: Accurate quantitative biomass measurements were not made in these studies, although chlorophyll measurements ane cell concentrations gave a reasonable estimate of algal quantities. Algal growth was visually appraised as high, medium or low, but dry weight or ash-free weights would have been more useful. Such measurements would compliment algal cell concentration and chlorophyll data. Such biomass measurements of the macrophyte community would be useful, too.

8. Secchi Disk Readings: Secchi disk visibility measurements give a rather undefinable measure of water quality, which is based on an inverse relationship between phytoplankton concentration and light penetration of water. However, great interference can result from non-algal sources of turbidity, severely limiting the overall usefullness of this parameter. Nevertheless, this parameter has some value in estimating light conditions in an aquatic system and is quickly and easily measured.

9. Temperature: This is an easily measured parameter and is very useful in ecological studies but has little value as a water quality indicator.

10. pH: As with temperature, pH is very useful in ecological studies, but has limited value as a water quality indicator. At very high or very low values it indicates unusual and possibly hazardous conditions, but other parameters are needed to adequately characterize a system.

11. Alkalinity to pH 4: This parameter has roughly the same value as pH in characterizing water quality. It gives more of an indication of a system's ability to assimilate acid inputs than the system's actual condition.

12. Dissolved Oxygen: This is a very useful parameter in defining water quality, and enables one to predict many of the other qualities of a system. Nearly all aquatic life depends on an adequate supply of oxygen, and a variety of factors contribute to its concentration value at any given time. In conjunction with some basic knowledge of a system's oxygen sources and demands, dissolved oxygen measurements can be an extremely useful tool in classifying the system. Measurements from all times of day are most useful, but only daytime readings were made in these studies.

13. Total Phosphate and Orthophosphate: These parameters are very useful by themselves, and form the basis for many indices. There is much controversy over what portion of the phosphorus in a system is biologically available, but orthophosphate measurements can be used to approximate the minimum quantity available, while total phosphate values can be used to approximate the maximum available quantity. Any measurement of phosphorus in an aquatic system is usually useful, since phosphorus is the most common limiting nutrient. Phosphorus measurements are more useful when obtained in conjunction with the measurement of other chemical parameters.

14. Forms of Nitrogen (TKN, $NO3^{-N}$, NO_2-N, NH_3-N): These parameters are almost as useful as phosphorus, since nitrogen is an essential plant nutrient and the interactions of the various forms of nitrogen are important in most aquatic systems. These parameters alone do not tell the whole story, but are invaluable to an accurate characterization of a system.

15. Bacterial Parameters (Total and Fecal Coliform, Fecal Streptococci, Ratios): In these studies, bacterial parameters seemed very useful in determining water quality, but there is some controversy regarding the validity of the indications of bacterial parameters and ratios. It may be true that too little is known about natural background populations to rely heavily on bacterial parameter indications, and the limited survival time of most fecal bacteria in open surface waters often makes the

absolute bacterial population numbers questionable. The ratios of fecal coliform to fecal Streptococci bacteria obtained in these studies were mostly inapplicable to the determination of the type of bacteria source, but were useful in a few cases. More complete bacterial data would be helpful, but present methods of bacterial analysis are not always reliable or practical.

16. Shannon-Weaver Diversity Index and Evenness: The Shannon-Weaver Diversity Index yields a number of limited utility, since it is dependent upon statistical factors that may be unique to a given system, therefore reducing the comparative value of this index. However, the potentially interfering factors can be eliminated by dividing the actual diversity index value obtained by the maximum possible value obtainable under the conditions of the system under study. This value is called the Evenness, and is essentially a decimal rating (a number between 0.0 and 1.0) of community structure, based on the theory that the higher the diversity, the more stable and balanced the community. In these studies, summer evenness values were very useful, but winter values tended to make the yearly average less distinctive. It is a useful parameter in conjunction with qualitative data on the portion of the community measured by the index.

17. Palmer's Indices: These indices are intended to give a measure of pollution, especially by organic compounds, by the use of weighted indicator species of algae. The appearance of significant numbers of these species in water does give a strong indication of organic pollution, but their absence does not necessarily preclude such pollution. Also, these studies revealed other species that appeared to be more significant indicators for New Jersey lakes. This is a common problem of such indices, and limits their usefulness. Palmer's Indices gave only moderately accurate results in these studies overall.

18. Nygard's Indices: These indices are intended to give a measure of the trophic condition of a lake by the use of indicator groups of algae. Ratios of the quantities of certain groups to others are used. Often in these studies there were none of the algae present that are used in the denominators of these equations, making their valid use difficult. However, if a modification was made such that the denominator was always at least one, the indices would be more useful. As it was, the compound index used in these studies produced fairly accurate indications. Improvements could be made, however, and the index was not sufficient alone to predict water quality.

19. Carlson's Indices: These indices are intended to give a numerical measure of the trophic state of a lake by using values for several parameters in several equations. Phosphorus concentrations, chlorophyll a quantities and Secchi disk readings are the parameter values used, and there are a variety of assumptions made in using them. Phosphorus is assumed to be the limiting nutrient, phytoplankton is assumed to be the major producer of chlorophyll a in the system, and algae concentrations are assumed to be the major factor in controlling light penetration of the water (and therefore the Secchi disk reading). When the above assumptions are true, the indices agree closely and give reliable indications of the trophic state. However, New Jersey lakes harbor a variety of possible interferences, and one or more of the indices was frequently invalid in these studies. Consequently, these indices yielded only moderately accurate indications overall. Also, to properly interpret the index values and judge the validity of the indices in every instance, one must have a degree of basic limnological training that would enable the investigator to make trophic state predictions based on the raw parameter values. Therefore, the value of the indices is primarily communicative, enabling one to mathematically express knowledge that may be acquired by other means. This is true of many of the indicator systems used.

Evaluation of Other Limnological Information and Procedures Used in Making Trophic State Determinations:

1) Flow Measurements: Quantitative measures of flow are essential to nutrient loading analyses, and should be made as accurately and frequently as possible. In these studies the primary source of flow data was U.S.G.S., which had monitoring stations at or near some of the study stations. Some flow data was also obtained from meters at individual point sources, and a few measurements were made in the field by N.J.D.E.P. personnel. However, flow data for some stations was inadequate and severely limited some loading analyses. U.S.G.S. and point-source data should be supplemented with field measurements made with a portable flowmeter at each station whenever samples are taken.

2) Site Selection: Selection of sampling sites is generally based on three factors;

a) the need for information from a given area or point,

b) the representative nature of a given area or point, and

c) the accessability of the site.

An effort was made to select sampling stations for each system such that valid information was acquired for;

a) the inlets of a lake

b) the outlets of a lake

c) the lake itself

d) all point sources upstream of the lake

e) a point upstream of any sampled point source

f) important confluences or suspect stretches of stream

The sites selected proved to be essential and representative, but not always accessible in a practical sense. Selecting sites as near to a road as possible is generally a good practice, but practicality must be sacrificed if making the site convenient significantly decreases it representativeness or the validity of the information obtained from it. The importance of various stations should be ascertained by several samplings, and special attention given to the major stations. This was not always done in these studies.

Since these studies were primarily lake surveys, emphasis should be placed on the lake stations. This was not always done, hindering accurate characterization of some lakes. The lake data obtained was very useful, and showed the extreme improtance of in - lake sampling. Chemical data from inlets and outlets was also very useful, but biological data from these sites was not as useful or representative of lake conditions as that obtained from the in - lake stations.

It is also often useful to take samples from special sites of interest, such as storm drains during storms or farm land during periods of peak runoff. Such supplementary information can be very valuable in testing suppositions made on the basis of data obtained from the regular sampling sites. This was rarely done, and made some conclusions more speculative than desired. Thoroughness is the key to success in limnological studies.

3) Sampling Frequency: Logically, it is best to sample as frequently as possible. However, as matter of practicality, the scientific research community generally finds a sampling interval of about two weeks to be acceptable for lake surveys. The two week period stems mainly from the time necessary for a complete algae turnover. Sampling at a frequency of twice a month will greatly decrease the probability that a major event will be missed, but may not be necessary. While such a sampling frequency is very desirable, longer intervals may be applicable, depending upon the system under study. Sampling every two weeks was found to be impractical for surveys conducted by the state, since finite manpower and resources had to be applied on a priority basis. One month intervals were used in these studies, which seemed a fair compromise between desired accuracy and practicality. While a two week sampling frequency is still recommended whenever possible, the observed one month intervals do not seem to have adversely affected the results of these surveys. Biological and chemical characterization of the lakes seemed entirely adequate, except where factors other than sampling frequency interfered. Also, when New Jersey lakes experience water quality problems or biological nuisances, they tend to experience these difficulties for periods of time much longer than one month. Therefore, for the purposes of these studies (trophic state determination and general characterization of water quality problems), sampling intervals of longer than two weeks seem applicable and acceptable. While sampling more frequently would tend to clarify the situation and increase the accuracy and validity of characterizations and conclusions, it is not believed that it would have changed any of the findings or conclusions of these studies.

4) Land Use and Drainage Basin Size Considerations: Recent literature indicates that nutrient loss from soil is very variable, depending on soil type and land use, but that generalized values can be applied. Forested land can be expected to lose the least amount of nutrients per year, with agricultural lands losing more nutrients. Urban inputs often contain the greatest nutrient quantities. So it is possible to make quantitative estimates of yearly inputs to a system from non-point sources, or at least to give an idea of what might be expected according to land use. Quantitative estimates were not given in this fashion in these studies (subtraction of point source inputs from total inputs was used to estimate non-point source inputs), but general expectations for water quality were expressed in terms of land use in the watershed. More theoretical loading could be used to supplement the data base acquired through such studies as these.

As regards drainage basin size, this areal value was used in conjunction with the value for lake area to form a ratio which could be used to obtain a general feel for potential water quality problems , especially when land use data is considered. The larger the drainage basin area to lake area ratio, the greater the expected nutrient imputs and the greater the probability of water quality problems. Charts exist that show anticipated conditions according to the ratio of watershed to lake area and general land use considerations. This was used but not emphasized in these studies, and proved to be a useful tool in predicting water quality or explaining observed conditions.

5) Limiting Nutrient Analysis: Several approaches to limiting nutrient determinations are commonly used today, including analysis of algal cell contents, analysis of overall system nutrient concentrations, and analysis of the potential response of a system to nutrient additions under controlled conditions (algal assay). The last approach is generally considered to be most accurate, but was somewhat impractical in these studies. Since chemical measurements were being made all over the system to determine input sources and quantities, it was convenient to use the second approach. This involves observation of a system's actual response to changing nutrient concentrations over the course of the study and application of conclusions from limnological literature to the observed ratios of nutrient concentrations (mainly phosphorus and nitrogen). This method was generally effective, but incorporates considerable uncertainty at times. Support from algal assays is desirable. Also, it must be remembered that nutrients are not always the limiting factor in a system, and provisions must be made for determining the influence of such potential limiting factors as light, temperature and current. A combination of in situ measurements and observations and laboratory algal assays would be an excellent approach to limiting factor analysis.

6) Vollenweider's Model and Other Loading Analyses: Predictions of lake conditions according to the indications of loading analyses based on the quantities and partitioning of nutrients (especially phosphorus) in a system are useful in trophic state determination and lake management. Controversy over the validity or usefulness of various models presently exists, and the individual investigator must recognize the appropriate applications and limitations of the various models.

In these studies, Vollenweider's Model was used in most cases, although the indications of this model were weakened whenever the studied system had a very short hydraulic detention time. Overall, the indications given by the model correlated well with observed conditions, and the model had some use in determining how far above or below acceptable phosphorus loading limits the system was. However, more credibility could be given to such analysis if multiple modeling systems were applied, with conclusions based on the overall indications obtained. Where additional analysis is impossible or impractical, Vollenweider's Model appears to give suitable results alone, as long as phosphorus is the system's limiting nutrient. Modifications of the model are also possible if the investigator has a good knowledge of the variables in the studied system and the limitations of the model, and such modification may be desirable.

Suggestions for Future Studies:

The 1977-78 Intensive Lake Surveys were successful, but improvement is certainly possible and future studies should benefit from analysis of the shortcomings of these studies. As a result of such analysis, the following changes in general approach and parameters emphasized can be recommended;

1) A good pre-study investigation of the system to be studied should be carried out, enabling investigators to make better judgements on site selection and related considerations.

2) To increase efficiency and allow the institution of necessary modifications, a mid-study evaluation of approach and progress should be made.

3) More comprehensive and accurate site selection is needed. Representativeness is essential, and efforts should be made to make all stations as accessible as possible. Also, no potential nutrient source should be deleted from the sampling program until it has been sampled several times and deemed insignificant.

4) More in-lake sampling should be performed, and great emphasis given to the results of this sampling. Lake perimeter, inlet and outlet samples are useful, but trophic state designations should be made primarily on the basis of in-lake sample data. Sediment (bottom muck) samples should also be taken in the lakes for the purpose of determining quantities and availability of nutrients and toxic compounds therein.

5) Sporadic sources of nutrients should be sampled wherever and whenever possible. Such sources as stormsewers and farm runoff may be very important.

6) Since inputs to a system may vary considerably with weather conditions, efforts should be made to sample during a variety of weather conditions.

7) Samples should be taken as frequently as possible, but sampling thoroughly should be stressed. For New Jersey lakes it appears that sampling frequency can be sacrified for thoroughness when practicality intervenes. Two week intervals would be optimal, but one month intervals appeared adequate for the 1977-78 studies.

8) Dissolved oxygen readings should be taken at various times under various conditions. Night time dissolved oxygen readings may be very useful, especially if plant biomass is very great. A series of readings from dusk until about noon of the next day might show an interesting and informative progression.

9) More flow measurements are needed. A portable flowmeter should be used to take a flow measurement at each station when it is sampled, unless there is extensive flow data available for the site or a permanent flow meter is in operation there (such as with many effluent discharges).

10) Limiting nutrient analysis should be carried out by algal assay, and the general growth potential of the water assessed. This would be a useful supplement to the present analyses, and has great potential in eutrophication studies. Additional equipment, lab space and personnel would be required, however.

11) More modeling should be incorporated into the studies. The use of several models could yield much insight into the system under study, and the potential comparisons of theoretical and actual values would be useful not only in the study but in the broad field of limnology. Predictions of responses to various actions would also be more reliable if checked and supported by the use of models.

12) The following parameters should be emphasized (used as the primary basis for trophic state determination) in future studies; a) Community structure - a "superparameter" that includes biomass, quality indications of organisms present, and evenness at each trophic level (although special attention may frequently be given to producers). Specific single parameters of use here include evenness as derived from the Shannon-Weaver Diversity Index, chlorophyll a concentration, dry weight or ash-free weight, and various judgemental or mathematical quality indices.

b) Dissolved oxygen concentrations

c) Phosphorus concentrations (all forms)

d) Nitrogen concentrations (all forms)

General Lakes Management and Restoration Work Needed in New Jersey:

Considering the results of the 1977-78 Intensive Lake Surveys and other studies of aquatic systems in New Jersey, the following management and restoration needs can be singled out as essential to the preservation or improvement of water quality in New Jerseys lakes;

1) The need for extensive control of non-point source inputs, especially of nutrients and sediment.

2) The need for planned development that addresses environmental considerations, or the prevention of development in certain areas.

3) The need for advanced wastewater treatment (with phosphorus and possibly nitrogen removal schemes) in many of the treatment facilities in New Jersey.

4) The need for an examination and evaluation of septic systems in many watersheds, coupled with necessary corrective action.

5) The need for the institution of best management practices in many operations, especially construction activities and farm operations (both crop and cattle).

6) The need for a large scale dredging project, aimed at restoring heavily silted-in lakes to their pre-degradation depths and deepening potentially troublesome lakes.

7) The need for the development and use of innovative management and restoration techniques in New Jersey, where population density and geological considerations often interact to cause water quality problems and the accelerated eutrophication of lakes.

APPENDIX A

APPENDIX A

DELAWARE RIVER BASIN COMMISSION

WATER QUALITY

of the

DELAWARE RIVER

1979

A STATUS REPORT

305(b) REPORT

March 12, 1980

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of the
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1979

305(b) Report

Introduction

Purpose and Scope

The purpose of this report is to assess the 1979 water quality of the Delaware River and its relationship to past water quality and future water quality goals. The report is prepared for the Delaware River Basin States for use in their water quality reports required by Section 305(b) of the Federal Clean Water Act of 1977. The major purpose of 305(b) reports is to analyze the effectiveness of the Clean Water Act. The reports, originally required annually, are now required every other year.

This report is the sixth in a series of such reports prepared by the Delaware River Basin Commission (DRBC). Previous reports presented water quality observations and trend information for 1974,[1] 1975,[2] 1976,[3] 1977,[4] and 1978.[5]

Selected parameters of interest are used to describe the 1979 water quality observed in the non-tidal Delaware River from Montague, New Jersey, (River Mile 246) to Trenton, New Jersey, (River Mile 134); the Delaware River Estuary from Trenton, New Jersey, to Liston Point, Delaware, (River Mile 48) and the upper Delaware Bay from Liston Point to the Mahon River mouth (River Mile 31). Figure 1, (page 15) shows the Delaware River zones and representative monitoring locations.

The description of current water quality conditions is followed by an examination of the relationship of current conditions to water quality conditions reported the previous four years. (See above referenced DRBC reports.) Trends in improvement or deterioration, current pollution abatement programs and the attainment of national water quality goals are discussed.

Data Presentation

Data summarized in this report were collected by the New Jersey Department of Environmental Protection (NJDEP) for the non-tidal Delaware River (Zone 1) and by the Delaware Department of Natural Resources and Environmental Control (DNREC) for the Delaware Estuary (Zones 2 through 5) and Delaware Bay (Zone 6). The Trenton, New Jersey (Zone 1) station, sampled by NJDEP, and all Estuary and Bay stations, sampled by DNREC, were done under contract to the DRBC. The remaining NJDEP Zone 1 stations, (upstream of Trenton) were sampled in cooperation with the U.S. Geological Survey.

Annual (1979) mean, maximum and minimum values for each selected parameter are plotted in a downstream (left to right) direction from Montague, New Jersey, to the Delaware Bay sampling location opposite the mouth of the Mahon River, Delaware. Applicable water quality standards are also shown. In addition, for dissolved oxygen the mean summer (June 16 to September 15) value and the minimum summer concentration observed is presented for each Estuary and Bay monitoring locations.

1979 Water Quality

The non-tidal Delaware River extends from Hancock, New York, (River Mile 330.7) to the head of tide at Trenton, New Jersey, (River Mile 133.4). This portion of the Delaware River has been designated as Zone 1 for water quality management purposes. Zone 1 is considered "effluent limited," that is, effluent requirements including secondary treatment for municipal wastes are sufficient to achieve and maintain water quality standards. In general the quality of Zone 1 is good.

The Delaware Estuary extends from the head of tide at Trenton, New Jersey, (River Mile 133.4) to Liston Point, Delaware, (River Mile 48.2). The large urban-industrial area (Trenton, Philadelphia, Camden, and Wilmington) transected by the Estuary severely affects water quality.

For water quality management purposes, the Delaware Estuary has been divided into four zones (Zones 2 through 5). All Estuary zones have been determined by DRBC to be "water quality limited" and thus, dischargers to the Estuary are subject to a wasteload allocation program established by DRBC.

The Delaware Bay extends from Liston Point, Delaware,(River Mile 48.2) to the confluence with Atlantic Ocean, (River Mile 0) between Cape May, New Jersey, and Cape Henlopen, Delaware. The Delaware Bay has been designated as Zone 6 and has been determined by DRBC to be "effluent limited." The water quality of Zone 6 is considered to be good, although some problem areas have been noted in the past.

Dissolved Oxygen

Figure 2, page 16, presents a profile of the mean annual dissolved oxygen concentrations and the highest and lowest observed values at each Delaware River monitoring location. Dissolved oxygen standards are also shown.

In 1979 all observed values in the non-tidal River from Montague, New Jersey to Trenton, New Jersey, were well above the established standards. Mean values ranged generally between 9 mg/1 and 10 mg/1 while minimum values were 6 mg/1 or greater.

The Delaware Estuary from Fieldsboro, New Jersey, to opposite the mouth of Appoquinimink Creek, Delaware had widespread areas where the minimum observed dissolved oxygen concentrations violate standards. The discharge of inadequately treated municipal wastewater is the primary cause.

A more detailed picture of Estuary dissolved oxygen conditions is presented in Figure 3, page 17, which shows the mean and minimum values observed in 1979 during the critical summer season (June 16-September 15). A classic dissolved oxygen sag curve is evident. The analysis indicates continued substandard dissolved oxygen concentrations in the Estuary with minimum values at the bottom of the dissolved oxygen sag below 1 mg/1.

In 1979 the summer dissolved oxygen sag bottom as shown by the mean summer curve was longer than in 1978 meaning that the downstream recovery occurred slower. This is a reversal of past trends which have seen a reduction in the dissolved oxygen curve width. This phenomenon may be attributable to higher fresh water flows which may move the oxygen-demanding substances downstream and/or introduce additional oxygen demanding substances contained in storm water runoff. Total summer flows at Trenton were seven percent higher in 1979 than in 1978.

The upper Delaware Bay is represented by the right hand three sampling locations of Figures 2 and 3 below River Mile 48.2. Both figures indicate that minimum dissolved oxygen standards were violated in 1979. The minimum dissolved oxygen concentration of 1.5 mg/1 was observed opposite the mouth of the Smyrna River on August 8. Similar low values were not observed on the same date at either station above or below the Smyrna River mouth location, nor in the Smyrna River itself. The low value, therefore, represents a localized random event.

Based upon the mean annual and mean summer profiles it appears that the 24-hour average dissolved oxygen concentration standard is generally being met in the Delaware Bay.

Water Temperature

Figure 4, page 18, presents a profile of the 1979 mean annual temperature of the non-tidal Delaware River, Estuary and Bay. The indicated maximum and minimum observed values and the profile show that the non-tidal River is slightly cooler than the Estuary. The profile is not significantly different from that observed in 1978. No violations of the applicable maximum temperature standards occurred at any station at any time. Maximum observed temperature was 30°C (several locations).

pH

The minimum, maximum and mean annual pH values are shown on Figure 5, page 18. Both the mean annual profile and the maximum observed values of the non-tidal river were lower in 1979 than in 1978. The only violations of the pH-upper limit standards of 8.5 were values of 8.6 and 9.0 observed at Trenton.

In the Estuary and Bay, the pH profile is not significantly different from the 1978 profile. All observations meet standards and generally range from 7 to 8 pH units.

Total Nitrogen

The mean, maximum and minimum annual total nitrogen concentrations are presented in Figure 6, page 19. In the non-tidal River from Montague, New Jersey, to Trenton, New Jersey, the 1979 profile is significantly higher than that observed previously in 1978. Since 1979 rainfall was much higher than 1978 rainfall (55.40 inches above Trenton versus 43.29

inches), the higher nitrogen concentrations may be attributable to runoff of agricultural chemicals.

The maximum total nitrogen value (5.1 mg/l) observed on the main stem was observed at Riegelsville, New Jersey, on May 16, 1979. All 1979 values were above 1 mg/l.

Total Phosphate

Figure 7, page 20, summarizes the 1979 phosphate concentrations. A profile of mean annual concentrations is presented along with the minimum and maximum values observed at each location.

The non-tidal river had higher phosphate values (approximately 0.01 mg/l to 1.0 mg/l higher) in 1979 than was observed in 1978. This may be related to rainfall as discussed above for nitrogen, the problem discussed below under fecal coliform, or both. The pattern observed in previous years of generally increasing concentrations from upstream locations to Trenton was again indicated. As in 1978 the mean annual phosphate concentrations peak at Frenchtown, New Jersey, (0.38 mg/l in 1979) and decline slightly thereafter.

The mean annual phosphate values for the Estuary and Bay locations were not different from 1978 observations. A slight decline is observed after the Navy Yard station, but generally all values were around 0.3 mg Phosphate/l.

Fecal Coliform Bacteria

Figure 8, page 21, presents the minimum, maximum and annual mean (geometric average) values for fecal coliform bacteria. Violations of the DRBC coliform standard are evident below Easton, Pennsylvania. The violations are attributable to the Easton sewage treatment plant which failed to operate its plant during its recent construction activities.

This plant has now been brought back in compliance with its permit.

Fecal coliform data for the Estuary are presented in Figure 9, page 22. The effects of the Philadelphia-Camden area's inadequately treated sewage treatment plant discharges are evident in the reach at and below River Mile 100. The values for 1979 are very similar to 1978 values except for the lower stations which are slightly less.

Other Parameters

The available 1979 data for iron, copper, manganese, chromium, zinc, lead, nickel, cadmium, mercury and silver in the Estuary were reviewed. Most values are below the applicable test sensitivities while others indicate no significant concentrations.

Water Pollution Control Program

Point Sources

The Delaware River Basin point source polluton abatement program is a cooperative process consisting of permitting or enforcement activities of the four Basin States, the U. S. Environmental Protection Agency and the Delaware River Basin Commission.

In the Basin all wastes must receive a minimum of secondary treatment prior to discharge to Basin waters. Where these levels of treatment are not sufficient to achieve and maintain State or Commission water quality standards, higher requirements are imposed. Currently, secondary treatment levels are sufficient to meet water quality standards in the non-tidal Delaware River above Trenton and in the Delaware Bay. In the Delaware Estuary, higher treatment levels are required.

The major implementation vehicle for abatement is the National Pollution Discharge Elimination System (NPDES) permit program. NPDES permits specify effluent requirements for individual dischargers and are enforceable. Originally a Federal responsibility, the NPDES permit program has now been delegated to each Basin State. DRBC effluent requirements are integrated into each NPDES permit.

In the Delaware Estuary, (Zones 2, 3, 4 and 5) DRBC allocates permissible oxygen demanding waste discharges (carbonaceous biochemical oxygen demand or CBOD) in order to achieve water quality standards. Based on mathematical modeling studies the assimilative capacity in terms of pounds CBOD/day was determined for each zone. After setting aside a small reserve in each zone, allocations to individual dischargers were made based on the concept of equal waste reduction by all discharges in a zone. In 1968, allocations were issued to approximately 90 waste dischargers to the Delaware Estuary. Since 1968, 25 additional allocations have been issued and 31 have been withdrawn.

At the conclusion of 1979 there were 84 dischargers with assigned allocations discharging to the Delaware Estuary. Based on NPDES Discharge Monitoring Reports, 58 of these dischargers are in compliance with their assigned allocations. They represent a combined total of 33 percent of the total pounds allocated. With the addition of the Philadelphia Southwest Sewage Treatment Plant, which was brought into compliance as of January 1, 1980, the combined total of the pounds allocated now in compliance is approximately 45 percent. The completion of upgrading of the remaining Philadelphia sewage treatment plants and plants for Trenton and Camden, New Jersey, in the early 1980's will result in a compliance of approximately 97 percent of the total allocated poundage.

Non-Point Sources and Other Programs

Because of the diffuse nature of non-point sources and the sometimes subtle corrective measures which are employed, it is difficult to assess the extent of the problem and the effectiveness of various abatement strategies. Section 208 water quality management planning programs have addressed this issue with mixed success.

Most types of non-point source pollution problems have been identified in the Basin. Agricultural runoff, urban-suburban runoff, malfunctioning septic systems and landfills are the most commonly cited problems by Section 208 and other studies. The following highlights several programs which are addressing non-point sources.

In New York State the method of operating the three Upper Basin New York City Reservoirs was modified in 1977. The modified releases are for the purpose of reducing the highly fluctuating flow volumes in the West Branch, Delaware River, while augmenting the low flows previously experienced in the East Branch, Delaware River, and Neversink River. In addition, during times of thermal stress additional flow volumes are released in order to alleviate high water temperatures. The temporary program has had a beneficial effect on water quality and it is now proposed that the program be made permanent.

Also in New York State there is the West Branch Delaware River Model Implementation Program which is assisting in the installation of agricultural runoff control measures in the area tributary to Cannonsville Reservoir. It is believed that the cooperative program will reduce the eutrophication of the reservoir. A smaller scale agricultural runoff program has been nearly completed for the Dragon Run watershed in New Castle County, Delaware. This cooperative program was conducted under the auspices of the New Castle County 208 program.

Urban and suburban runoff is both a quality and a quantity problem. Examples of programs seeking solutions to runoff problems include Mercer County, New Jersey, (stream corridors), Montgomery County, Pennsylvania, (institutional aspects of detention-retention basins), the City of Philadelphia effort to correlate pollutant loadings with land use, and the storm water manual being developed under the auspices of the State of New Jersey and Tri-County 208 studies.

The cost of relieving malfunctioning septic tanks in New Castle County, Delaware, has been examined extensively. The approach was developed by the New Castle 208 Program because of the difficulties in quantifying associated pollution problems. In Bucks County, Pennsylvania, Section 208 funding was utilized to gather data for a predictive model of potential on-site disposal problem areas. A brochure telling a homeowner how to operate an on-site system was published.

Hazardous waste disposal is a significant problem in the Basin. The Delaware River Basin Commission is developing site screening criteria, a method for applying the criteria, an assessment of needed disposal capacity and institutional alternatives. Previous phases of the study inventoried industrially-generated hazardous materials. Other ongoing studies of toxic and hazardous materials include the U. S. Geological Survey's Schuylkill River Assessment Study which is examining in-stream transport mechanisms and the various efforts of the states, EPA and others.

All the above programs will, to varying degrees, ultimately benefit the water quality of the Delaware River. The need for additional abatement efforts in the Estuary, be it point sources, non-point sources or both, is currently being examined by DRBC with a new Estuary water quality model developed by the U. S. Environmental Protection Agency.

Overall Status Assessment

Table 1, page 14, summarizes the overall trends and stream standard violations that were observed in the 1975-1979 period for the Delaware River, Estuary and Bay. The basis for Table 1 is the data contained in this report and in the four past reports in the series (2,3,4,5).

The data demonstrate that water quality has improved to some degree during the last half of the 70's decade. Both local areas with occasional problems and widespread problem areas exist and will likely continue to exist into the 1980's.

Attainment of the 1983 National Water Quality Goal

The 1972 and 1977 Federal Clean Water Acts promulgate the 1983 National water quality goal, commonly referred to as the fishable and swimmable goal. This goal calls for water quality that provides for the protection and propagation of fish life and allows for recreation in and on the water.

In general, the non-tidal Delaware River (197 miles) has water quality which provides for the protection and propagation of fish life and which allows for primary recreation. Occasional high summer fecal coliform concentrations make primary contact recreation questionable in the stretch of River between Easton, Pennsylvania and Trenton, New Jersey (50 miles).

The water quality of most sections of the Estuary (85 miles) does not now meet either the fishable and swimmable national goal because of low dissolved oxygen concentrations, high fecal coliform or the potential threat of toxic materials. The completion of upgrading programs, currently under way, could result in the attainment of the National Goal by the early 1980's in the upper Estuary (25 miles) and lower Estuary (22 miles). The heavily impacted middle Estuary (38 miles) is not likely to provide for fish propagation or primary contact recreation in the foreseeable future.

Except for occasional localized problems, water quality of the Bay (48 miles) meets the 1983 National goal at this time.

References

1. "Water Quality Inventory, Delaware Main Stem, 305(b) Report," Delaware River Basin Commission, Trenton, N.J., (April 2, 1975).
2. "Water Quality of the Delaware River, 1975, a Status Report, 305(b) Report," Delaware River Basin Commission, Trenton, N.J., (March 31, 1976).
3. "Water Quality of the Delaware River, 1976, A Status Report, 305(b) Report," Delaware River Basin Commission, Trenton, N.J., (March 29, 1977).
4. "Water Quality Inventory, Delaware River Main Stem., 1977 A Status Report 305(b) Report," Delaware River Basin Commission, Trenton, N.J., (March 31, 1978).
5. "Water Quality of the Delaware River, 1978, a Status Report," Delaware River Basin Commission, Trenton, N.J., (October 1979).

Table 1. Overall Status Assessment

Parameter	1975	1976	1977	1978	1979
Nontidal River:					
dissolved oxygen	no standards violations or trends evident	no standards violations or trends evident	standards violations no trends evident	no standards violations or trends evident	no standards violations or trends evident
phosphate	previous years not compared	no change from 1975	higher than 1976	less than 1977, similar to 1976	higher than 1978, similar to 1977
nitrogen	previous years not compared	no change	no change	no change	higher than previous years
fecal coliform	standards violations probable	no change from 1975	no change from 1976	decrease from previous year	standards violations
Estuary:					
Summer dissolved oxygen	improvement noted, widespread violations of standards	similar to 1973 conditions, improved width of sag curve maintained, widespread violations	improved over 1973 and 1974 conditions widespread violations	no change from 1977	bottom of sag curve longer than 1978 widespread violations
phosphate	decrease observed from previous years	trend of decreasing concentrations	similar concentrations as 1976	less than previous years	similar to 1978
nitrogen	decrease from previous year evident - NH_3, no trend-nitrate	decrease from 1975 - NH_3 no trend - NO_3	decrease from 1976 - NH_3 no trend - NO_3	no trend evident - total nitrogen	no trend evident - total nitrogen
fecal coliform	widespread violations of standards no trend evident	widespread violations, no trend evident	widespread violations, no trend evident	widespread violations, no trend evident	widespread violations, no trend evident
Bay:					
summer dissolved oxygen	occasional violations of standards evident, no trend	no standards violations or trends	no standards violations or trends	occasional violations evident, no trends	occasional violations evident, no trends
phosphate	decrease observed from previous years	decrease from previous year	similar to 1976 conditions	less than previous year	similar to 1978 conditions
nitrogen	decrease from previous years - NH_3, NO_3	decrease from 1975 - NH_3, NO_3	no change from 1976	no change from 1977	no change from 1978

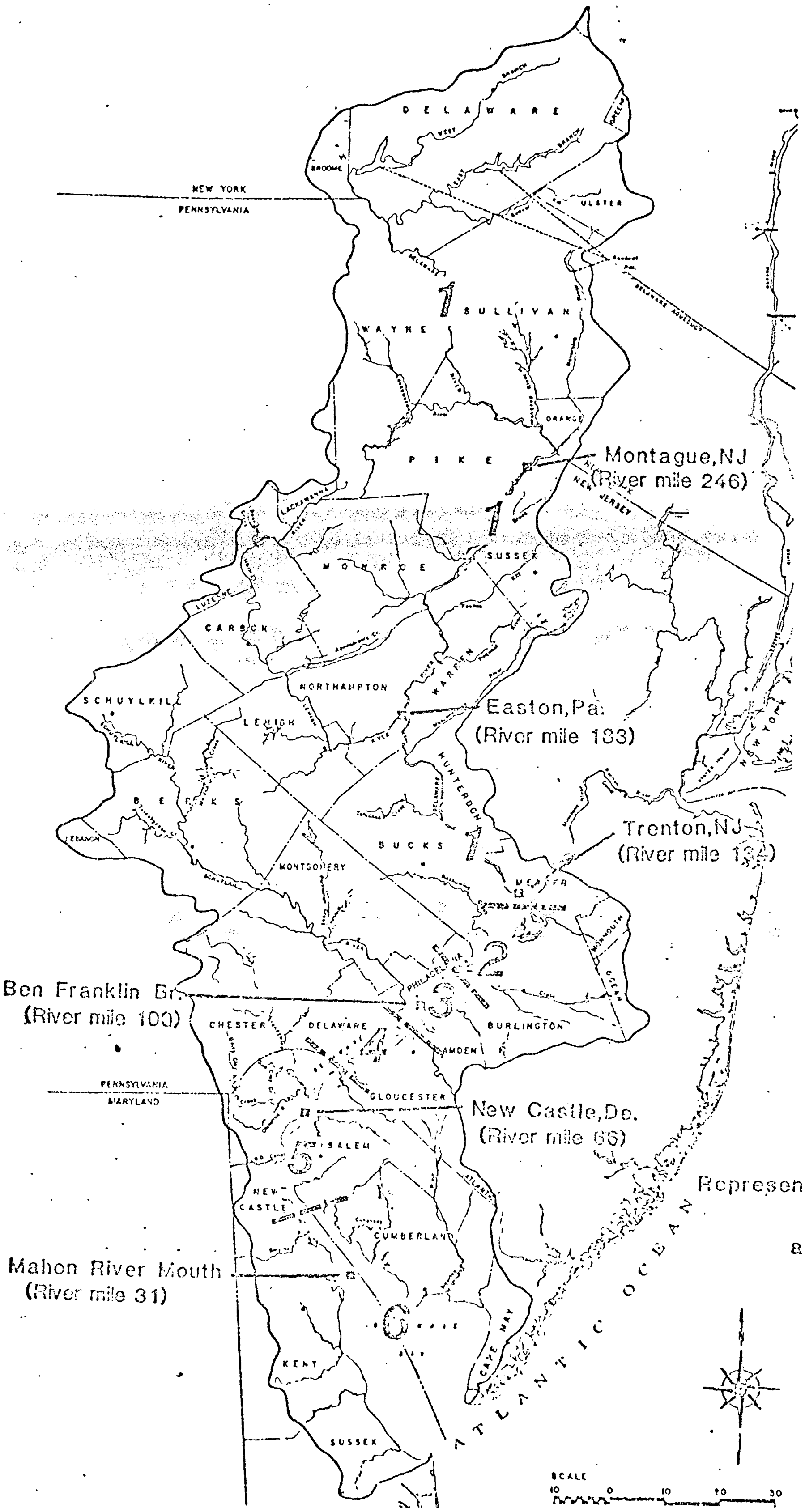


Figure 1

Representative Monitoring Locations
Delaware River
and Interstate Zones

Figure 2. Summary of 1979 Dissolved Oxygen Concentrations

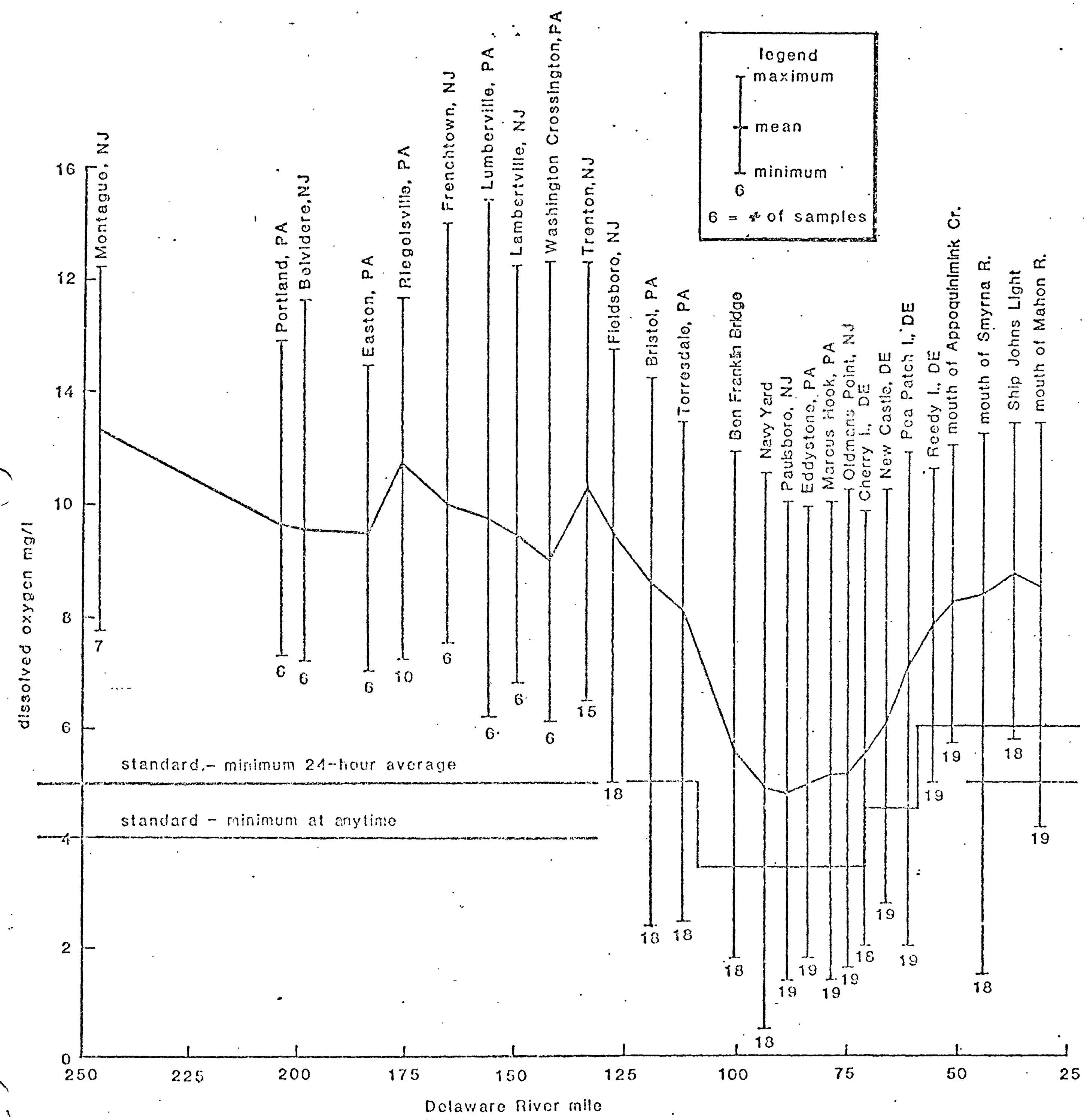


Figure 3. Minimum and Mean Delaware River Estuary and Bay Summer Dissolved Oxygen Concentrations

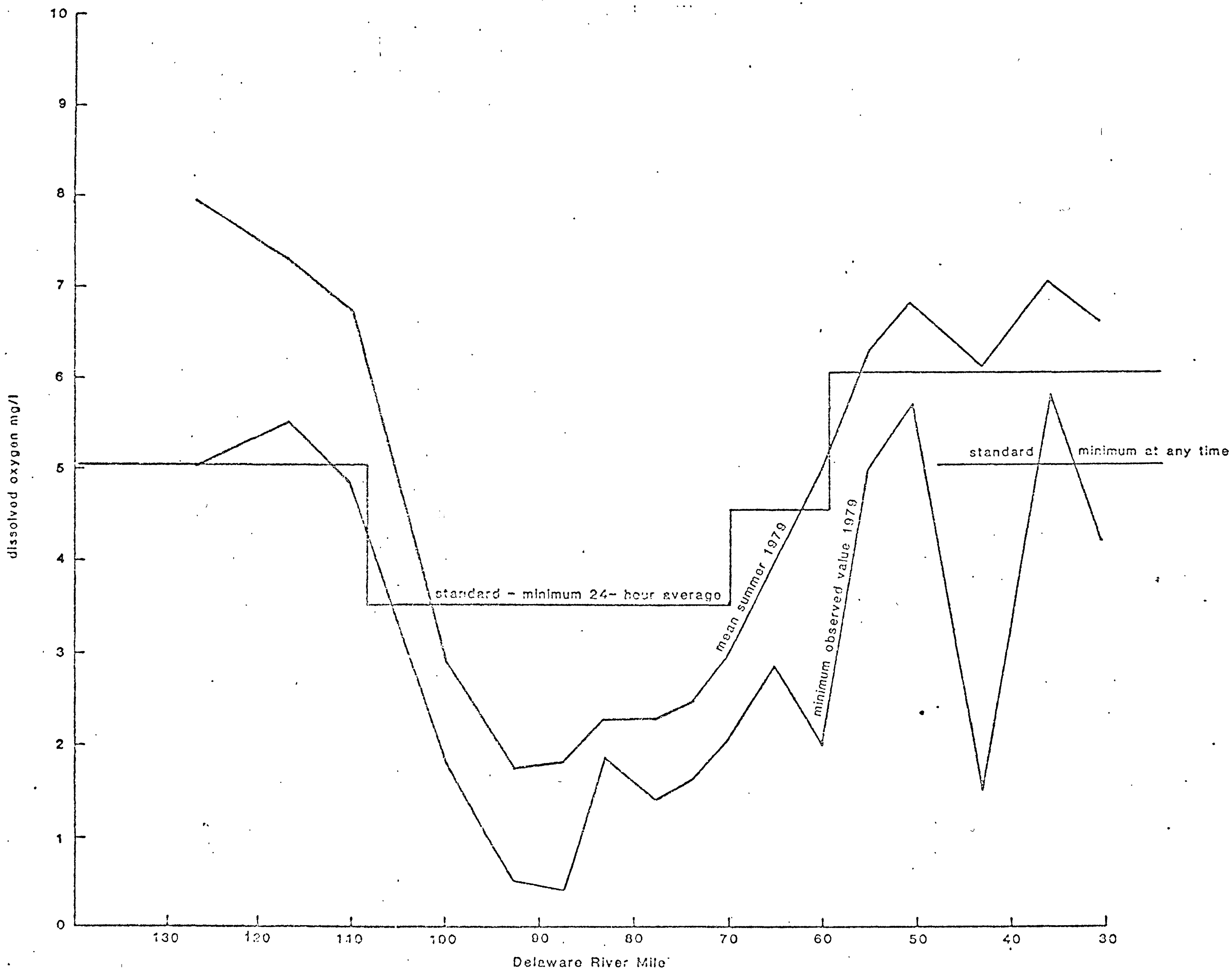


Figure 4. Summary of 1979 Water Temperature

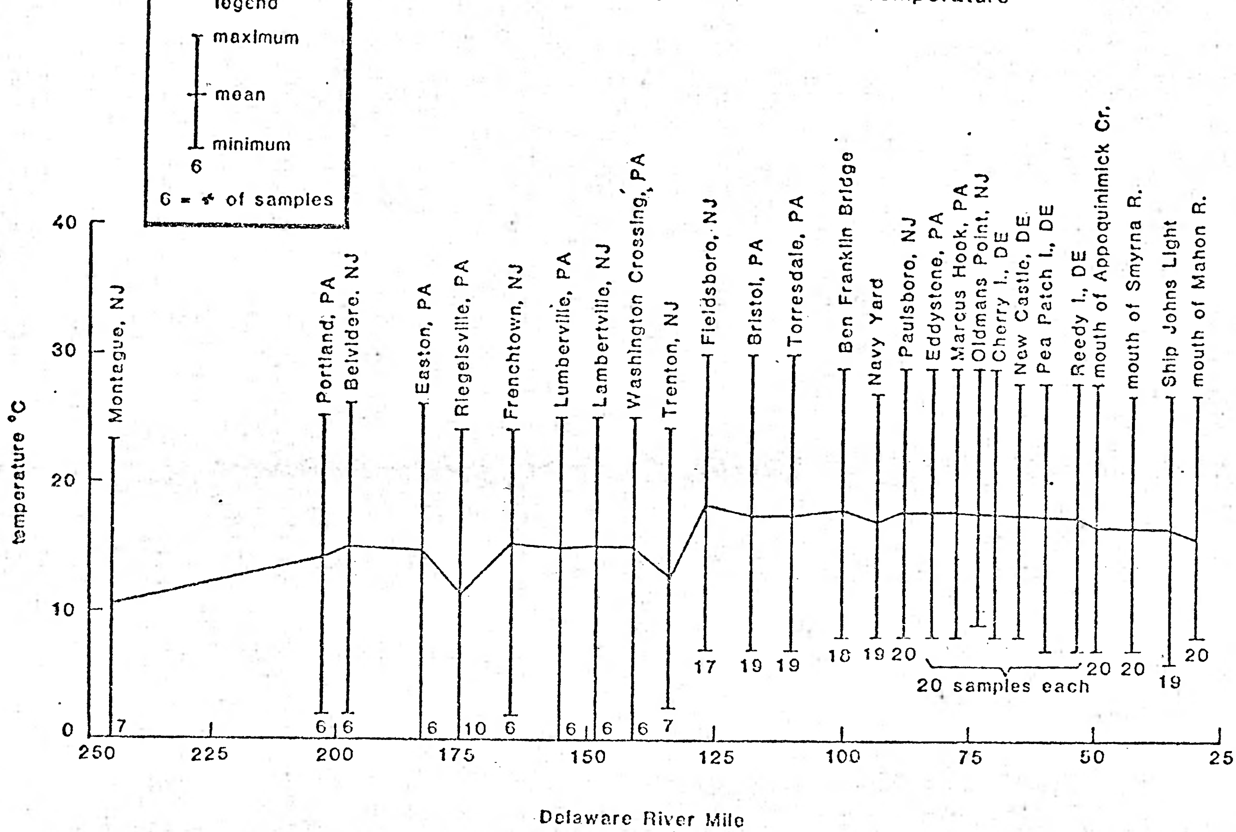


Figure 5. Summary of 1979 pH Values

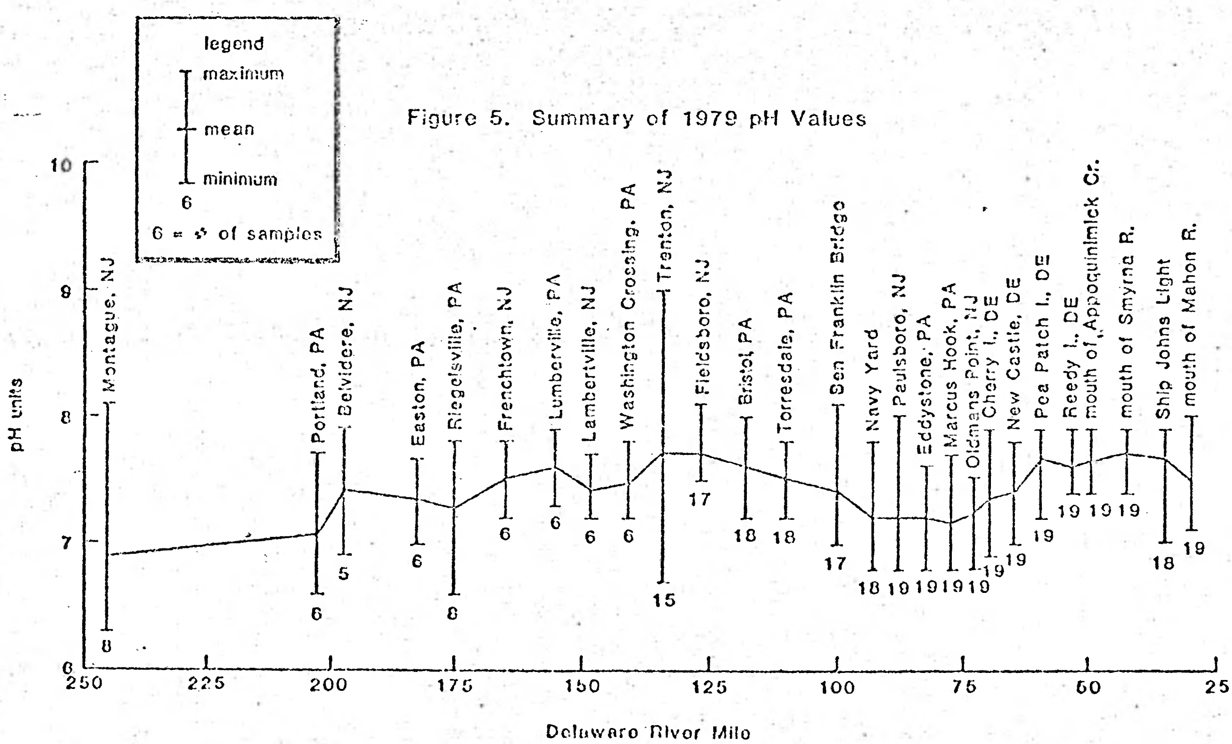


Figure 6. Summary of 1979 Nitrogen Concentrations

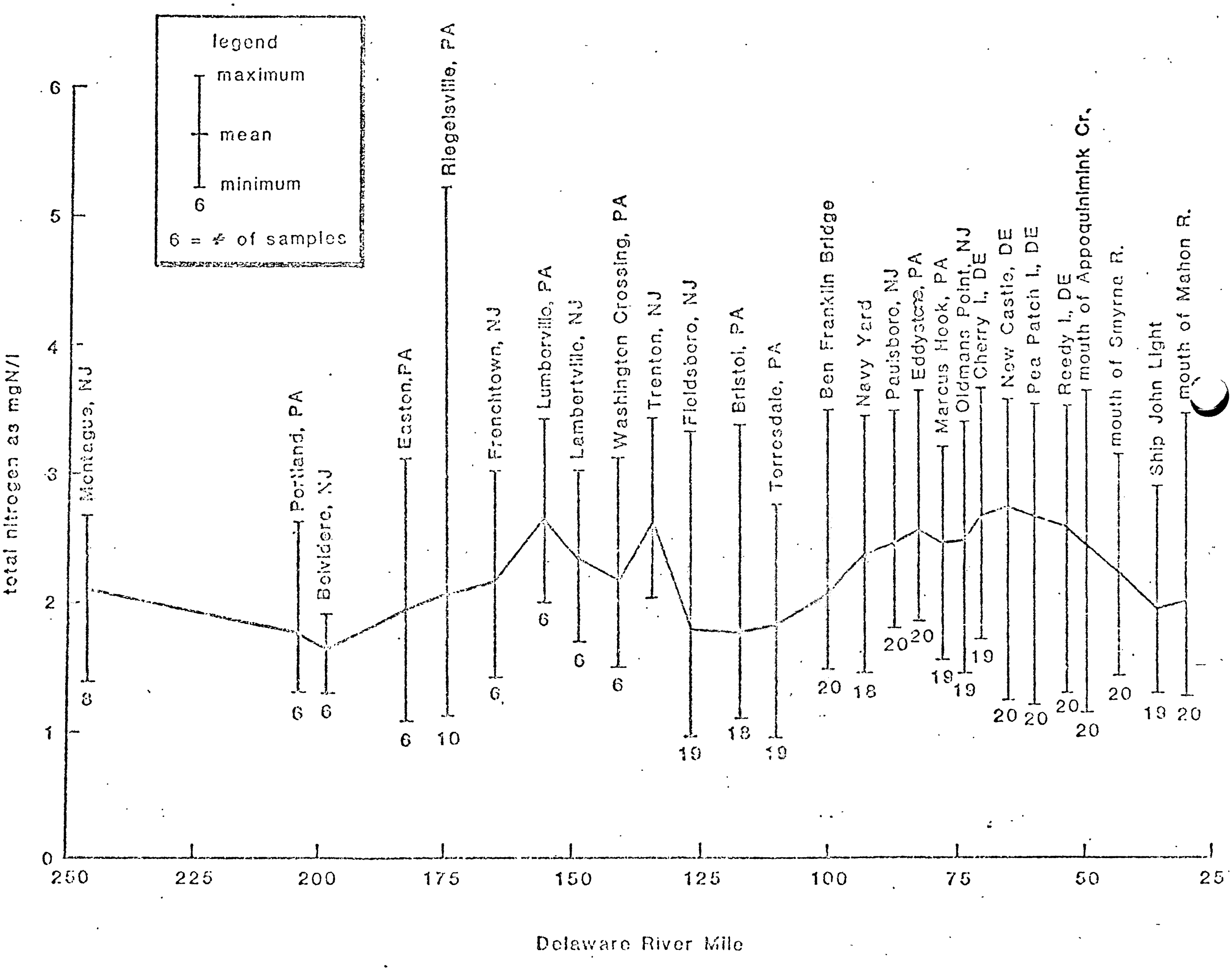


Figure 7. Summary of 1979 Phosphate Concentrations

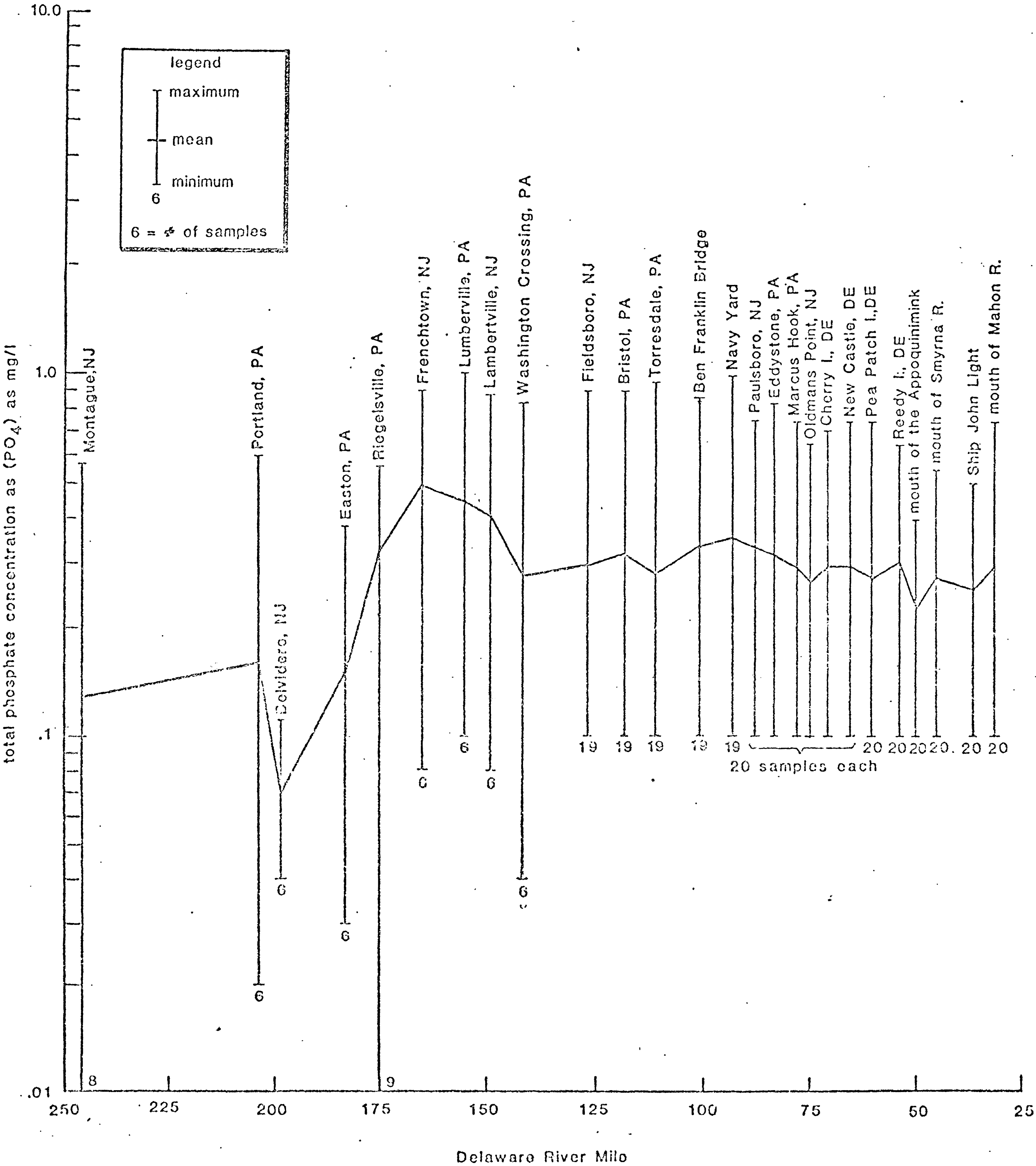


Figure 8. Summary of 1979 Fecal Coliform – Nontidal River

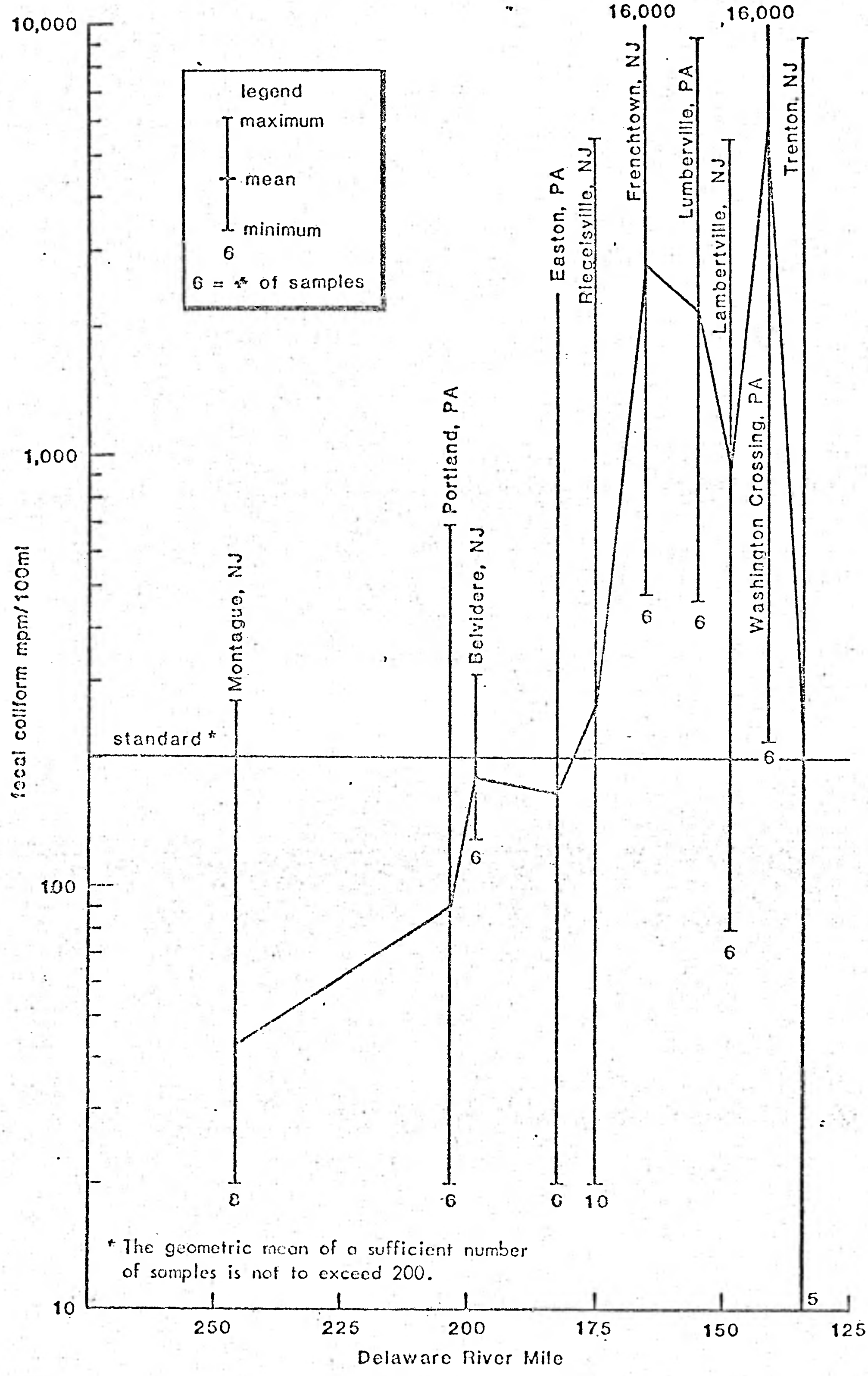
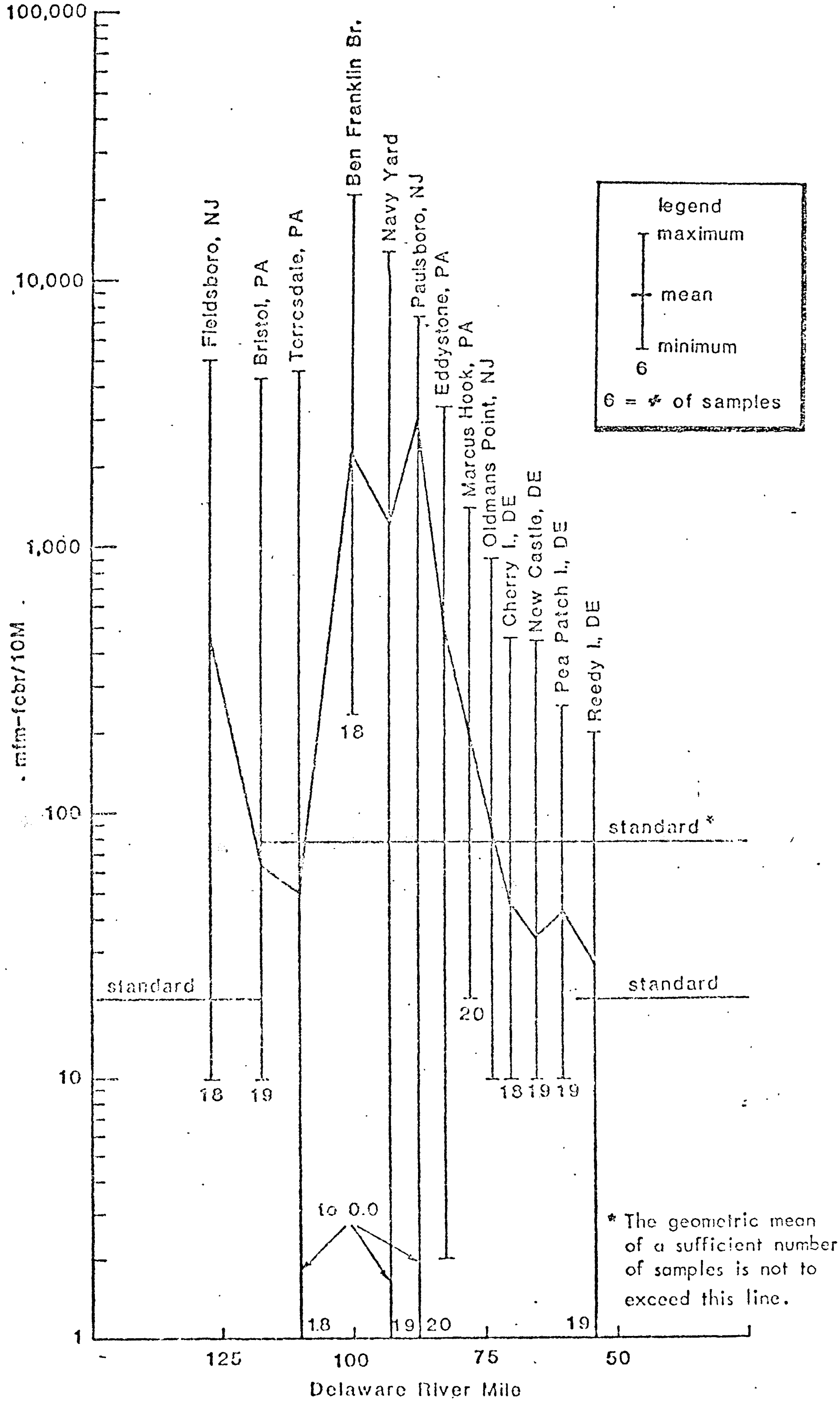


Figure 9. Summary of 1979 Fecal Coliform - Estuary



APPENDIX B

STATUS REPORT ON THE
INTERSTATE SANITATION DISTRICT WATERS

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FEBRUARY 1980

SUMMARY

Interstate Sanitation District waters exhibited some improvement during the past year. District waters meet dissolved oxygen requirements during the winter; however, in some locations, dissolved oxygen values in the summer drop below 1 mg/l for extended periods. The waters are also high in heavy metals, oil and grease, and bacterial contamination.

INTRODUCTION

New Jersey surface waters located within the New Jersey-New York Metropolitan Area form part of the jurisdiction of the Interstate Sanitation Commission.

The Commission's programs for the improvement of these waters in cooperation with the states include the following:

(1) to establish and attain of minimum dissolved oxygen requirements for all surface waters;

(2) to establish necessary pollutant removals for discharges into District waters;

(3) to monitor surface waters by analysis of samples obtained from continuous automatic sampling stations and from regularly scheduled boat surveys;

(4) to do routine sampling and analysis of municipal and industrial dischargers to determine whether Compact requirements are being met;

(5) to assist the states and the U.S. EPA with NPDES/SPDES compliance monitoring; and

(6) to assist the 208 agencies within the Interstate Sanitation District.

The waters described in this report and their tributary treatment plants are shown in Figure 1. These waters are:

ISC Class A Waters - NJ TW 1 Waters:	Sandy Hook Bay Raritan River Raritan Bay
ISC Class B-1 Waters - NJ TW 2 Waters:	Hudson River Upper New York Bay Arthur Kill South of the Outerbridge Crossing

ISC Class B-2 Waters - NJ TW 3 Waters: Kill Van Kull
Newark Bay
Arthur Kill North of the Outerbridge Crossing

The water classes and uses described below were promulgated by the Interstate Sanitation Commission and are compatible with New Jersey's classifications and uses, namely:

Class A Waters - Suitable for primary contact recreation and in designated areas for shellfish harvesting

Class B-1 Waters - Suitable for fishing and secondary contact recreation

Class B-2 Waters - Suitable for passage of anadramous fish and for maintenance of fishlife

These water classifications are defined in the Interstate Sanitation Commission Water Quality Regulations effective October 15, 1977. The Commission's water quality and effluent regulations were revised to help achieve higher quality waters throughout the District.

EXTENT OF WATER POLLUTION

Although the condition of the waters in this area has shown some improvement since the last 305(b) inventory was compiled, they still range from good to poor.

The primary municipal treatment plants in the District do not provide adequate pollutant removal and many of the biological treatment plants require upgrading. Figure 1 shows the location and degree of treatment at the sewage treatment plants within the Interstate Sanitation District. The quality of the District's waters is continuously degraded by: (1) untreated municipal and industrial discharges entering the Harbor waters daily, (2) combined sewers releasing raw sewage into the waterways during heavy rainfalls, and (3) large concentrations of both heavy metals and oil entering the waters from inadequately treated municipal and industrial wastes.

Evaluation of the water quality has been determined from the following:

(1) graphs of the seasonal variation of dissolved oxygen, temperature, pH, and conductivity derived from ISC remote automatic water quality monitors located within New Jersey and interstate (NJ-NY) waters;

(2) a statistical analysis of the dissolved oxygen data obtained

from the remote water quality monitoring stations; and

(3) pollutant parameters such as dissolved oxygen, heavy metals, nutrients, temperature, etc., derived from the analysis of samples obtained from ISC boat runs "A", "B", and "E".

The remote automatic water quality monitor locations are shown in Figure 2, station descriptions in Table 1, graphs of the monthly values in Figures 3-10, and dissolved oxygen data in Table 2. Figures 3-10 show, for the past five years, the monthly maximum, minimum and average values for each parameter at each station. The monthly maximum and minimum represent the single highest value and the single lowest value for the month, respectively. The monthly average is the average of the daily average values for the month. Dotted lines indicate a month for which less than ten days of data were available.

Figure 11 is a map of the six boat survey routes. Listings of the sampling stations are found in Tables 3-5 and 1978-1979 data are given in Tables 6-17. 1978 and 1979 pesticides and PCB's data collected on Commission boat surveys are summarized in Table 18. Tables 6-17 show the low value, the high value, the average value and the number of values for each parameter in each waterway. The average value for each parameter in each waterway was computed from data collected at all sampling stations within that waterway. The range of values for any particular parameter varies greatly from station to station within any particular waterway; therefore, the average values should be used with extreme care. The average value at a sampling station within a waterway will vary greatly from the average value shown for the entire waterway.

The boat surveys were run approximately once per month in the winter and twice per month in the summer.

CURRENT WATER CONDITIONS

General

Analysis of the data indicates that the effect of a constant influx of pollutants to the Metropolitan New York Area waters is especially pronounced during the summer months. As in the past, the waters are plagued by bacterial contamination and low levels of dissolved oxygen. Thermal pollution is also a problem in some areas. Table 19 shows the current status of wastewater treatment plants in New Jersey that are within the Interstate Sanitation District. A comparison of each treatment plant's status since the last 305(b) inventory is also shown.

Dissolved Oxygen

Although Figure 2 and Tables 3-10 show a general overall improvement since the last 305(b) inventory was compiled, District waters are still plagued by low dissolved oxygen values during the summer months. From Table 2 it can be seen that the Commission's dissolved oxygen requirements are being met only about one third of the time during the summer in the Arthur Kill; this is still unacceptable. The overall general improvement, however, is promising and is due in part to wastewater treatment projects being completed and less continuous bypassing of untreated sewage into District waters.

Additional dissolved oxygen data were analyzed from a review of boat survey samples. These data, especially in the Arthur Kill and the Kill Van Kull show generally higher values than those compiled from the remote monitor data. These values for dissolved oxygen are artificially high since provisions for tidal and other effects are not reflected in the boat survey data. Therefore, the boat survey data is misleading unless considered with the data from the continuous water monitors.

Other Parameters

A review of the boat survey data (Tables 6-18) shows that District waters are degraded by high concentrations of oil and grease, heavy metals, and coliform bacteria. These data are generally consistent with those of the previous 305(b) report submitted. Table 18 shows the presence of pesticides and PCB's throughout ISC District waters in both the water column and on the bottom of the waterways.

Chlorophyll data indicated a major occurrence of increased algal activity during September when a chlorophyll "a" value of 0.112 mg/l was obtained at station RB-14 in Raritan Bay. A sample of this water contained a light brown colored precipitate. This precipitate consisted of large numbers of *Skeletonema costatum* and oval shaped cells approximately 55 u x 30 u which appeared to be *Prorocentrum spp.*

FUTURE USES OF THE WATERS

In the future, use of the waters will more nearly approach their classifications compared to today. Although secondary treatment of municipal sewage will be the norm when present construction is completed, its effectiveness may be significantly diminished because (1) combined sewers will continue to discharge untreated sewage into the waters during heavy rains; (2) lack of pretreatment requirements will permit large amounts of oils and heavy metals from industries to enter the District waters; and

(3) heavy concentrations of both population and industry along certain narrow, confined waterways such as the Arthur Kill and the Kill Van Kull will contribute large quantities of waste so that even when secondary treatment is completed, dissolved oxygen values of about 3 mg/l will be the maximum attainable level.

The universal application of secondary treatment and adequate pretreatment should render such stretches of water as the Lower N.Y. Bay and Raritan Bay better for fishing and swimming. Another means of opening miles of beaches would be to build short dikes out from Fort Wadsworth, Staten Island, and Nortons Point, Brooklyn, to divert the flow from New York and New Jersey treatment plants through The Narrows, away from beaches, toward open sea. However, no practical amount of treatment technology will improve the Arthur Kill and the Kill Van Kull to the point at which the dissolved oxygen will be appreciably greater than 3 mg/l.

CONTROL ACTIONS AND COSTS

Although many of the waters of this District will never be able to be used for swimming, it is essential to prevent further deterioration. As the population and industrial capacity of this region continue to grow, the surrounding waters will have increased demands placed upon them. The ability of many of the waters to assimilate waste material and thermal discharges has already been exceeded for a considerable portion of the year.

However, the planning and construction of secondary treatment plants throughout the region and the universal application of Best Practical Treatment Technology to industrial discharges constitute a program capable of rendering the District waterways aesthetically appealing and viable for both public and commercial users. It must be kept in mind, however, that much of the effectiveness of both secondary treatment and BPT Technology will be negated unless a conscientious effort is directed toward abating the following problems: (1) combined sewers, (2) heavy metals, (3) sludge, and (4) oily wastes.

(1) Combined Sewers - Very little advantage will be gained by having secondary treatment plants exist alongside uncontrolled combined sewers. Although the treatment plant will provide a high degree of pollutant removal and discharge effluent with minimal bacterial contamination, heavy rains will cause regulators to bypass raw sewage and industrial wastes directly into the waterways. Heavy flows that occur during rainfall release vast quantities of solids, heavy metals, and oils that have settled out in the combined sewers during dry weather. Since these wastes receive no treatment whatsoever, their bacterial count is high and renders the chlorine usage by the waste treatment plants

ineffective. Secondary treatment represents a major step forward in pollution abatement, but the existence of combined sewers prevents it from being as effective as it should be. Elimination of combined sewers could cost billions of dollars, however, adequate pretreatment would be a viable option in preventing pollutants from entering the waterways.

(2) Heavy Metals - Heavy metals represent a particularly toxic group of elements that are discharged in large concentrations by many industries. During dry weather, much of the metal content of an industrial waste never reaches a treatment plant because the metals simply settle out of solution and concentrate in the sewers. During heavy rains, they are scoured out of the sewers and swept directly into a watercourse. Those metals that reach the treatment plant are only minimally removed and their presence lowers biological treatment efficiency.

(3) Sludge - As treatment plant efficiency increases and secondary treatment plants come on-stream, there will be greater quantities of solids. It is estimated that by the year 2000, sludge volume will increase three-fold from the current levels of 700 tons per day. Approximately 70 percent of the sludge currently produced by treatment plants in the New York-New Jersey Metropolitan Area is disposed of at sea. The U.S. EPA still requires an end to ocean disposal of sludge by the end of 1981.

The composting of sludge and spreading on land of the compost which has been opted for by many municipalities as an interim solution poses the direct threat of groundwater contamination from organic and inorganic toxic components found in the sludges.

(4) Oily Wastes - The northeast region of the United States has an enormous need for petroleum products, especially heating oils and gasoline. As a result, the area has many oil refineries, oil terminals, and an extensive product transportation system. Because such a vast amount of both crude and refined products are handled, spillage is significant, and a substantial amount of petroleum products enter receiving waterways of the District. To restore the quality of the waterways, all oil-laden wastes must be adequately treated. For this reason, the Interstate Sanitation Commission has an effluent requirement of "no noticeable oil" which is being implemented through the permit system through permit requirements and construction schedules.

Figure 1

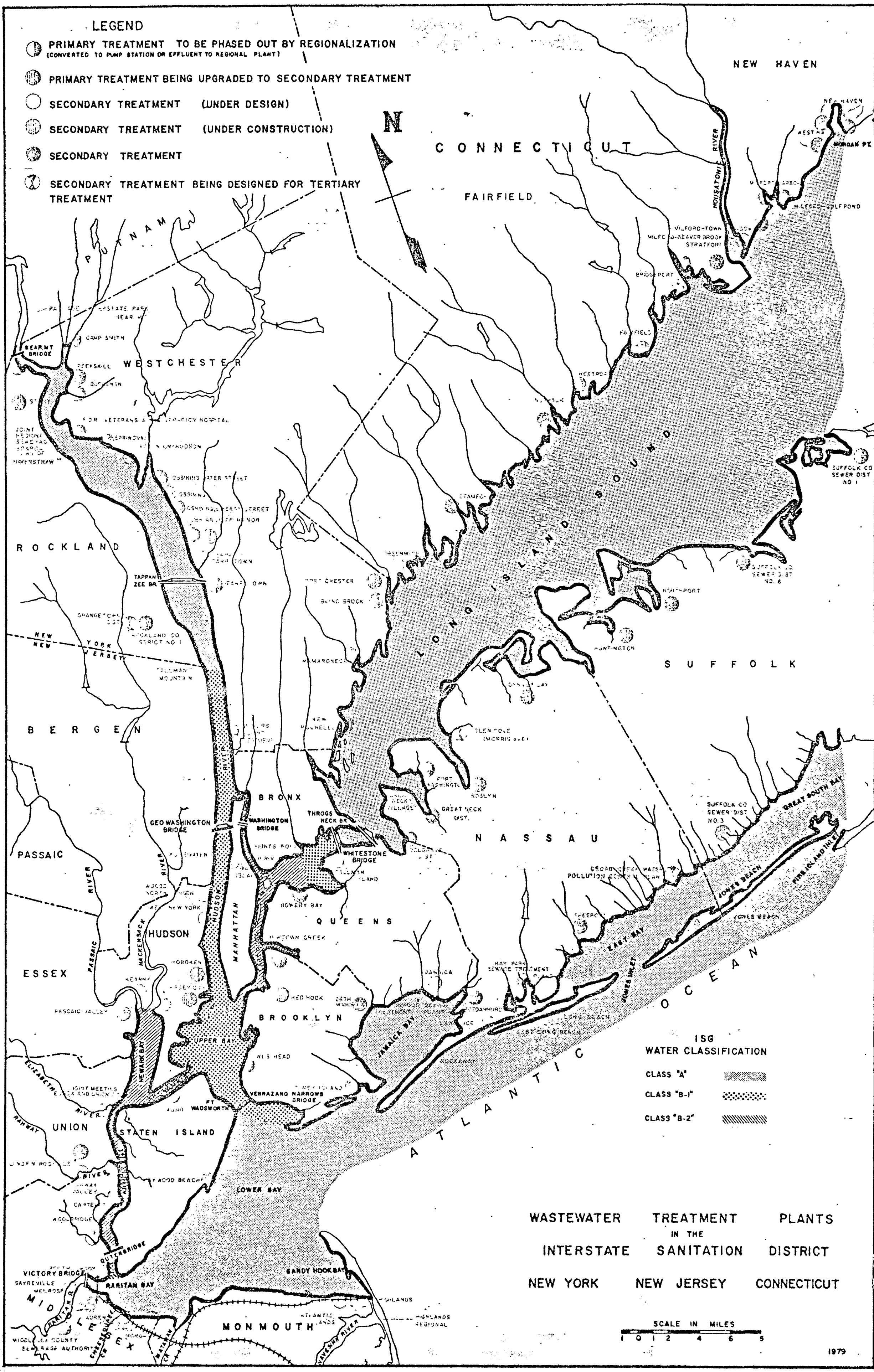
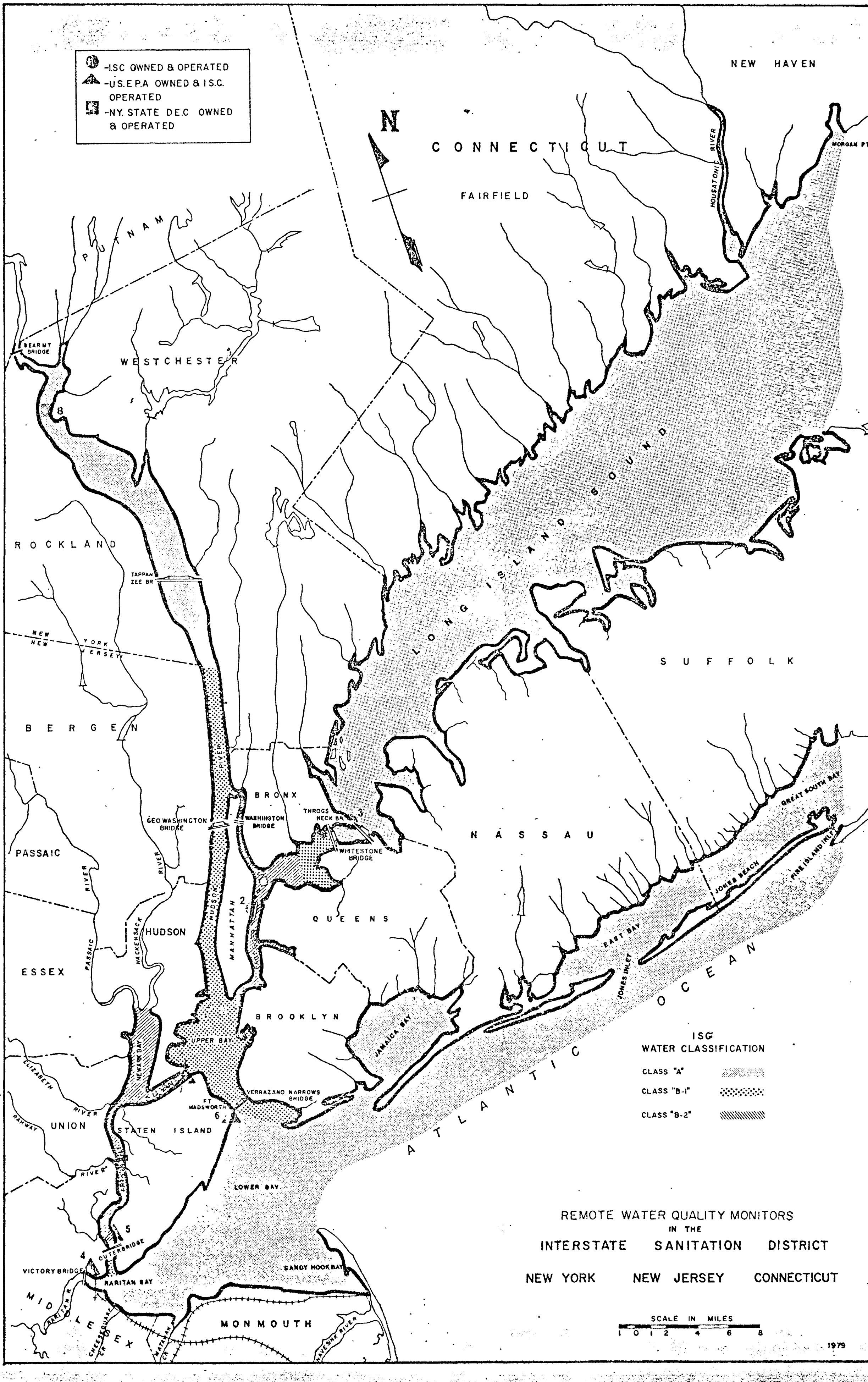

LEGEND
PRIMARY TREATMENT TO BE PHASED OUT BY REGIONALIZATION
(CONVERTED TO PUMP STATION OR EFFLUENT TO REGIONAL PLANT)
PRIMARY TREATMENT BEING UPGRADED TO SECONDARY TREATMENT
SECONDARY TREATMENT (UNDER DESIGN)
SECONDARY TREATMENT (UNDER CONSTRUCTION)
SECONDARY TREATMENT
SECONDARY TREATMENT BEING DESIGNED FOR TERTIARY TREATMENT
N
CONNECTICUT
FAIRFIELD
NEW HAVEN
PUTNAM
WESTCHESTER
ROCKLAND
BERGEN
PASSAIC
HUDSON
ESSEX
UNION
STATEN ISLAND
BRONX
MANHATTAN
QUEENS
BROOKLYN
NASSAU
SUFFOLK
MONMOUTH
MIDDLESEX
LONG ISLAND SOUND
ATLANTIC OCEAN
HUDSON RIVER
UPPER BAY
LOWER BAY
RARITAN BAY
SANDY HOOK BAY
JAMAICA BAY
EAST BAY
GREAT SOUTH BAY
JONES BEACH
JONES INLET
FIRE ISLAND INLET
HOUSATONIC RIVER
TAPPAN ZEE BR.
GEO WASHINGTON BRIDGE
WASHINGTON BRIDGE
THROGS NECK BR
WHITESTONE BRIDGE
VERRAZANO NARROWS BRIDGE
OUTERBRIDGE
VICTORY BRIDGE
NEW YORK
NEW JERSEY
ISC
WATER CLASSIFICATION
CLASS "A"
CLASS "B-1"
CLASS "B-2"
WASTEWATER TREATMENT PLANTS
IN THE
INTERSTATE SANITATION DISTRICT
NEW YORK NEW JERSEY CONNECTICUT
SCALE IN MILES
0 1 2 4 6 8
1979

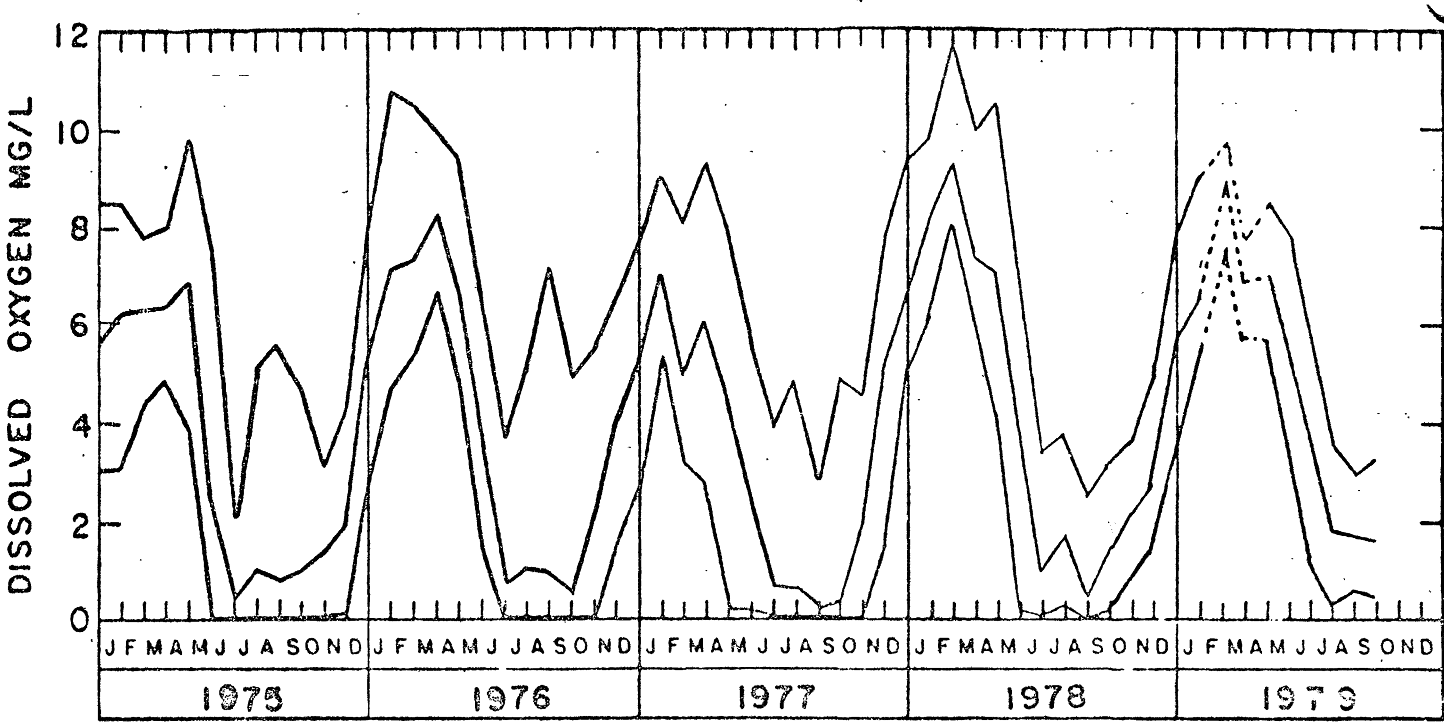
Figure 2

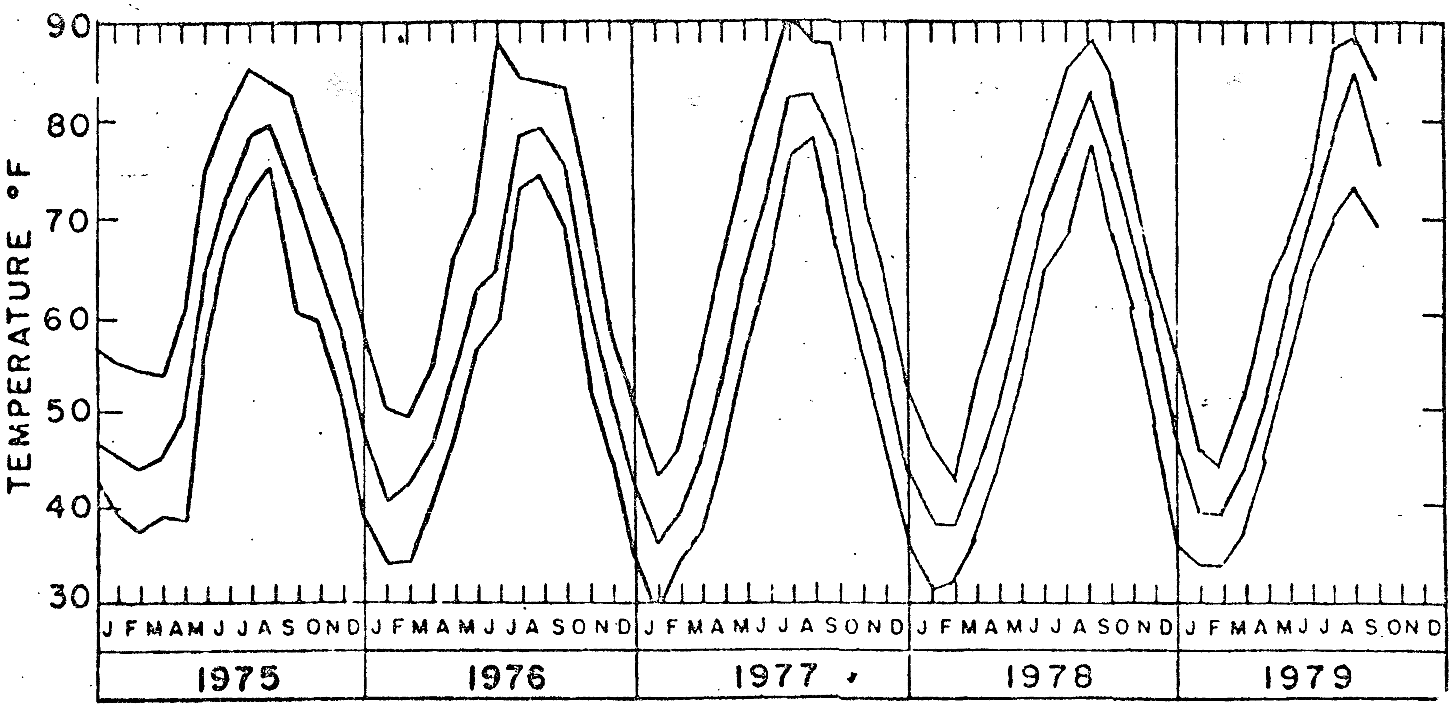


-ISC OWNED & OPERATED
-U.S. E.P.A OWNED & I.S.C. OPERATED
-NY. STATE D.E.C OWNED & OPERATED
N
CONNECTICUT
FAIRFIELD
NEW HAVEN
PUTNAM
WESTCHESTER
ROCKLAND
BERGEN
PASSAIC
HUDSON
ESSEX
UNION
MIDDLESEX
MONMOUTH
BRONX
MANHATTAN
QUEENS
BROOKLYN
STATEN ISLAND
NASSAU
SUFFOLK
LONG ISLAND SOUND
ATLANTIC OCEAN
BEAR MT BRIDGE
TAPPAN ZEE BR
GEO WASHINGTON BRIDGE
WASHINGTON BRIDGE
THROGS NECK BR
WHITESTONE BRIDGE
VERRAZANO NARROWS BRIDGE
FT WADSWORTH
OUTERBRIDGE
VICTORY BRIDGE
UPPER BAY
LOWER BAY
RARITAN BAY
SANDY HOOK BAY
JAMAICA BAY
EAST BAY
JONES INLET
JONES BEACH
GREAT SOUTH BAY
FIRE ISLAND INLET
MORGAN PT.
HOUSATONIC RIVER
HUDSON RIVER
HACKENSACK RIVER
PASSAIC RIVER
NEWARK BAY
ELIZABETH RIVER
RAHWAY RIVER
RARITAN R.
CHEESEQUAKE CR.
MATAWAN CR.
SHREWSBURY RIVER
NEW YORK
NEW JERSEY
ISC WATER CLASSIFICATION
CLASS "A"
CLASS "B-1"
CLASS "B-2"
REMOTE WATER QUALITY MONITORS IN THE INTERSTATE SANITATION DISTRICT
NEW YORK NEW JERSEY CONNECTICUT
SCALE IN MILES
0 1 2 4 6 8
1979

Figure 3

ARTHUR KILL — CON ED. (station no. 1)





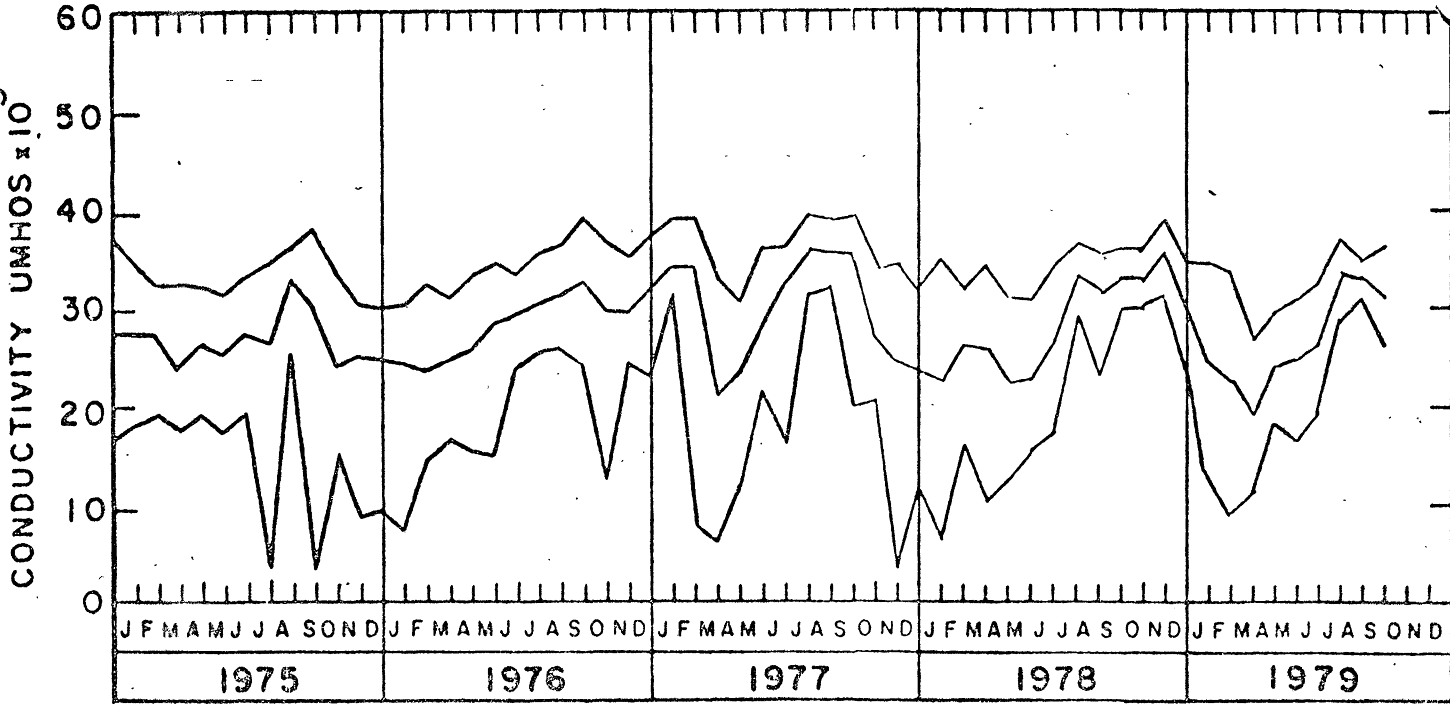
TOP LINE — maximum monthly value

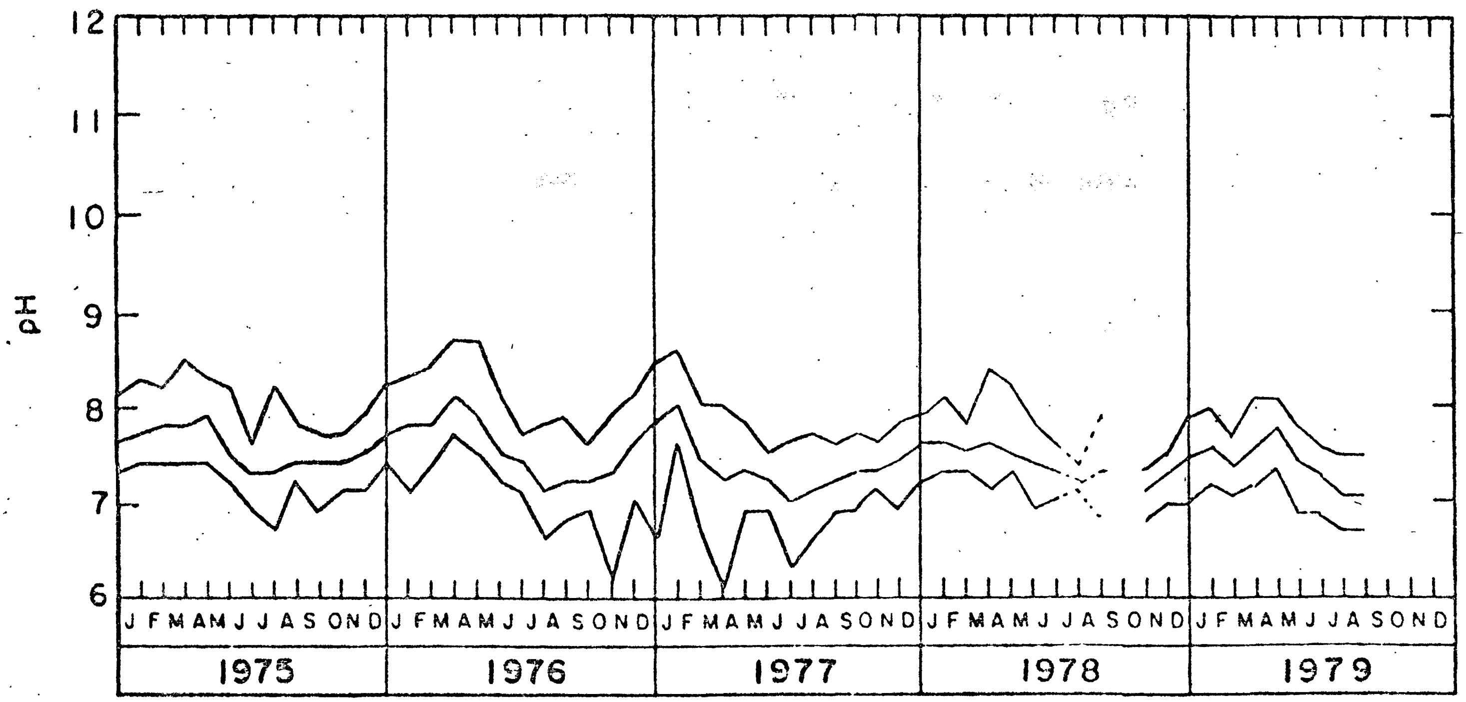
CENTER LINE — average of the daily average values

BOTTOM LINE — minimum monthly value

Figure 4

ARTHUR KILL — CON ED. (station no. 1)

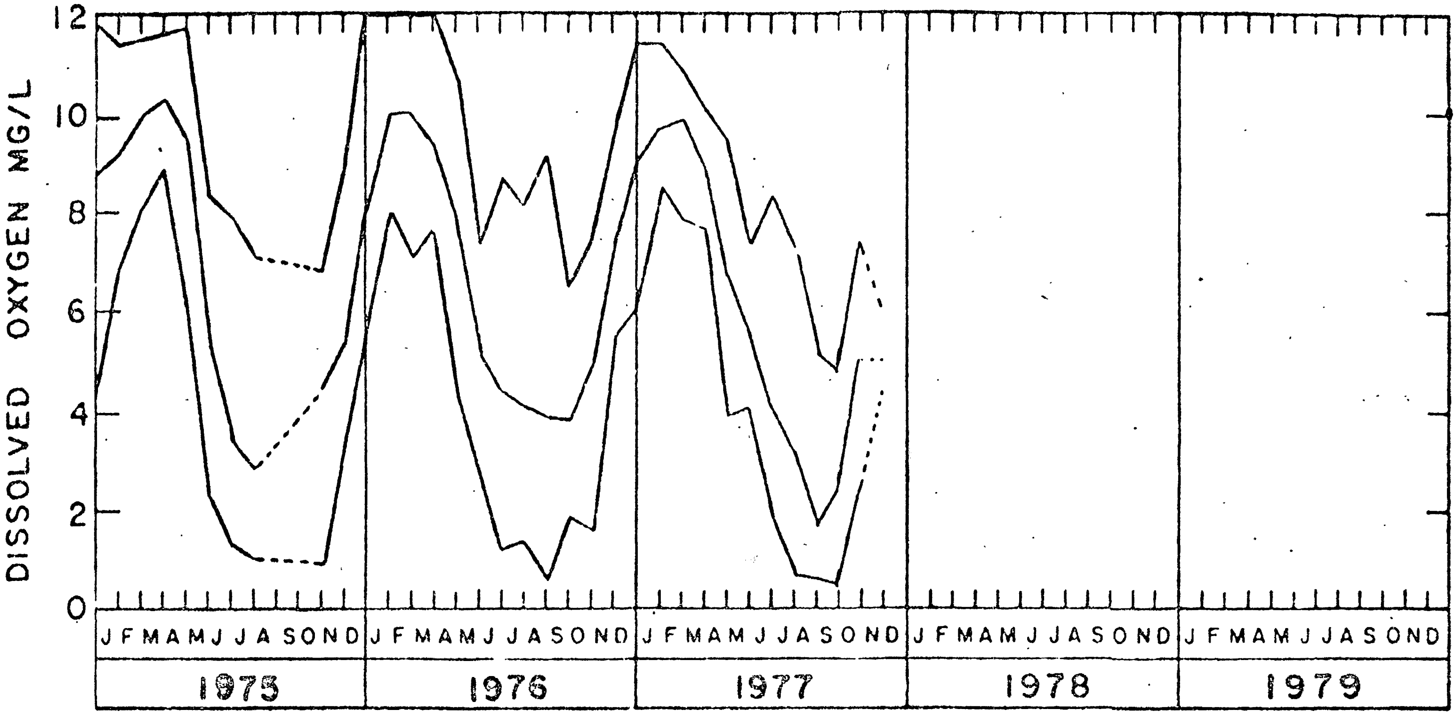


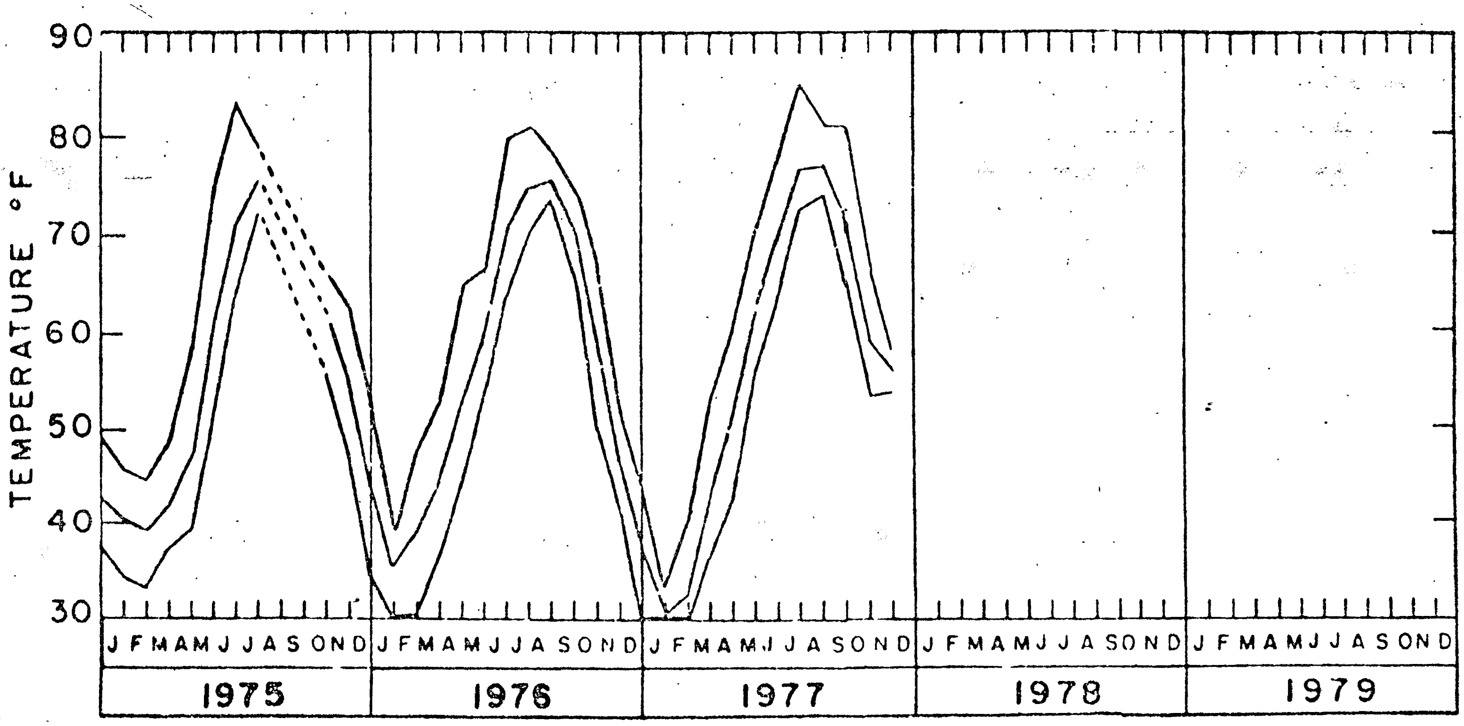


TOP LINE — maximum monthly value
CENTER LINE — average of the daily average values
BOTTOM LINE — minimum monthly value

Figure 5

RARITAN RIVER—VICTORY BRIDGE (station no. 4)





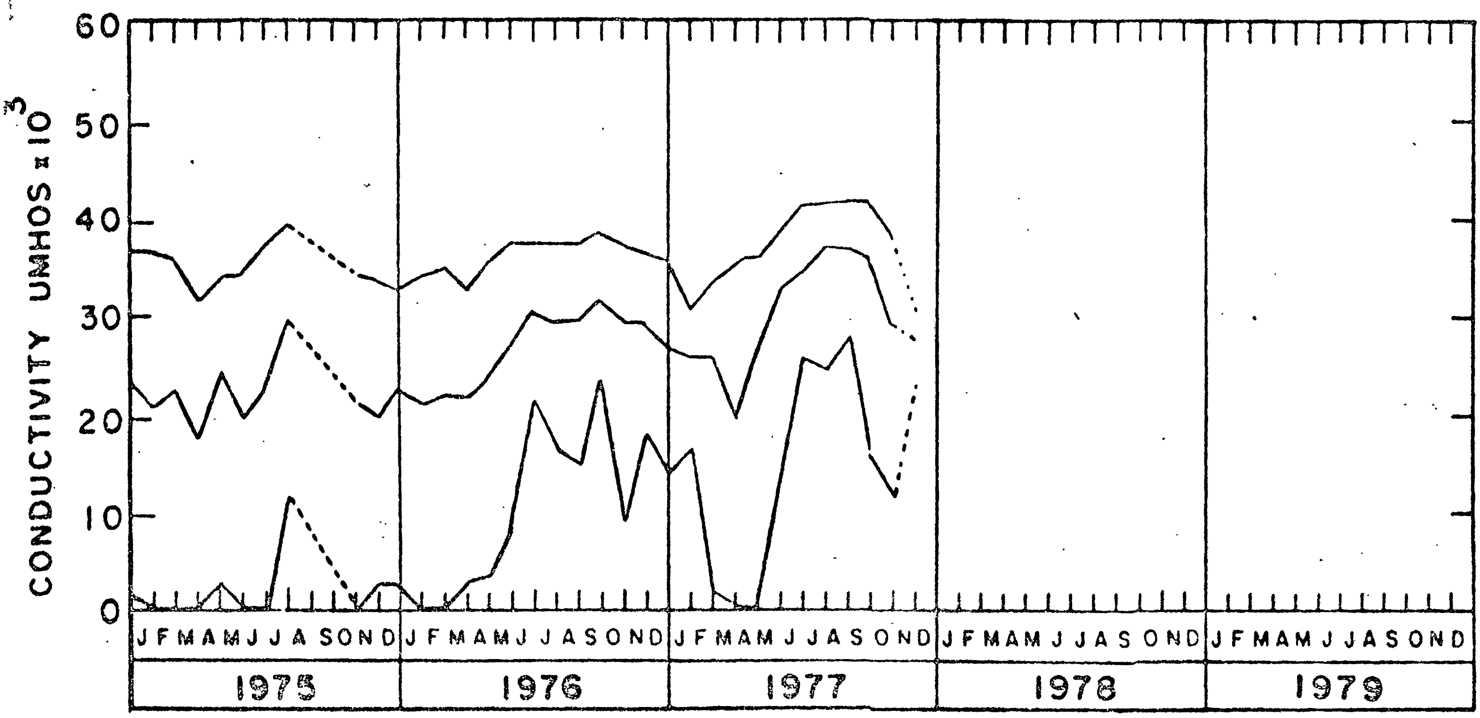
TOP LINE — maximum monthly value

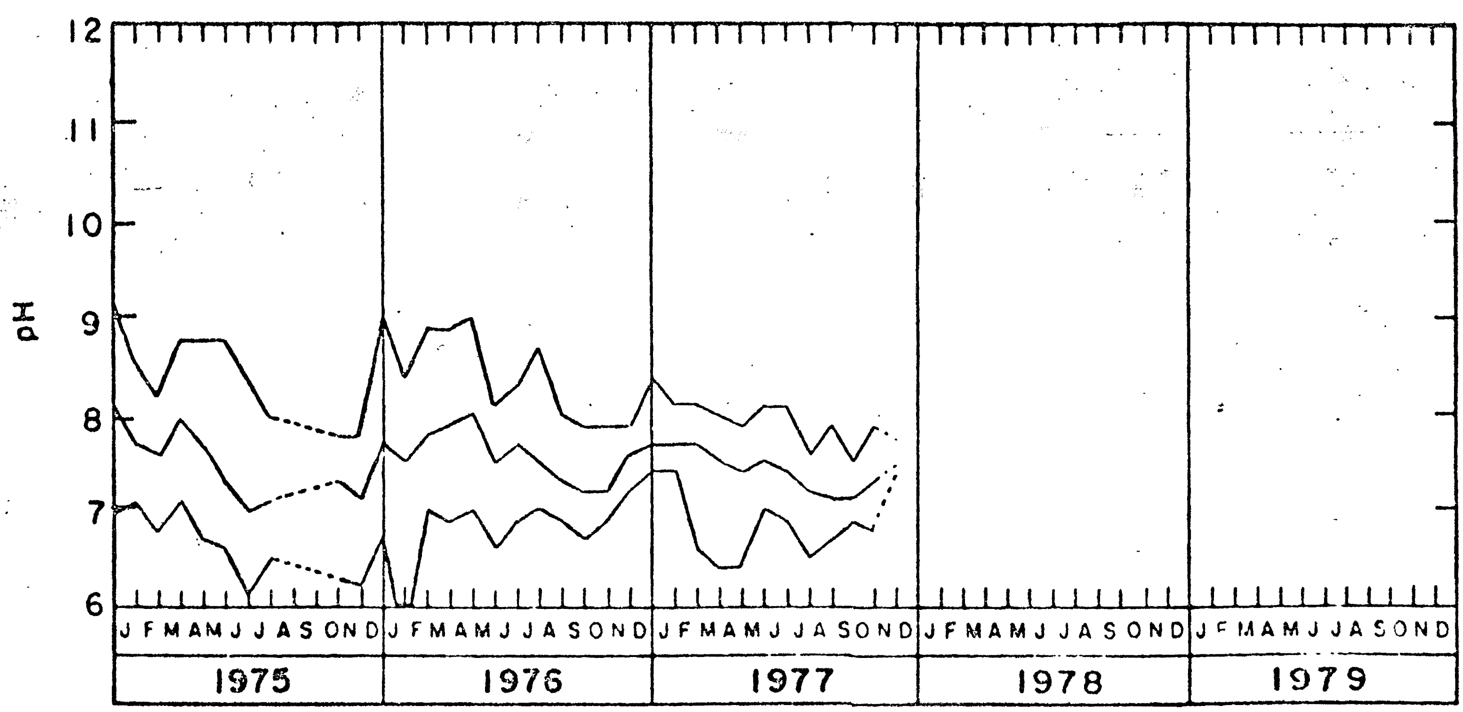
CENTER LINE — average of the daily average values

BOTTOM LINE — minimum monthly value

Figure 6

RARITAN RIVER—VICTORY BRIDGE (station no.4)

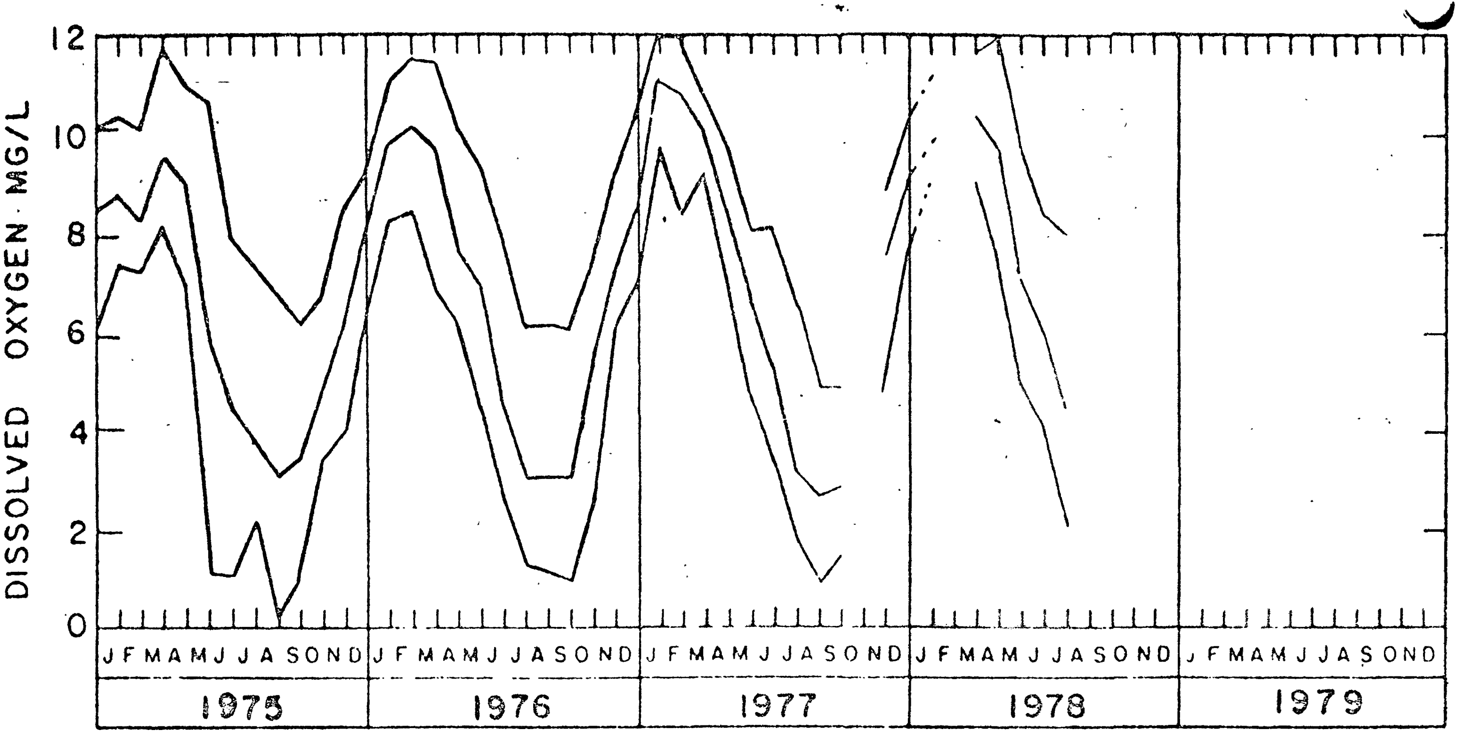


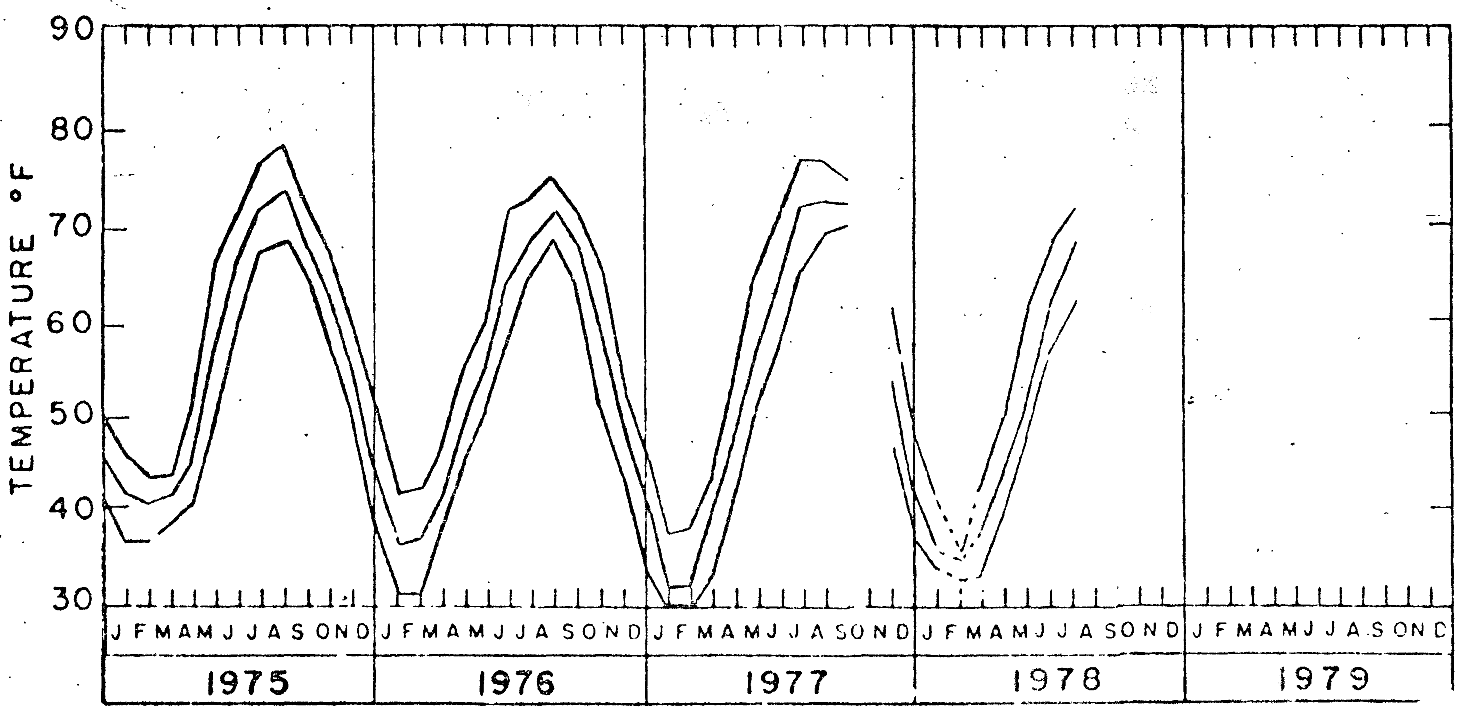


TOP LINE — maximum monthly value
CENTER LINE — average of the daily average values
BOTTOM LINE — minimum monthly value

Figure 7

THE NARROWS — FT. WADSWORTH (station no. 6)

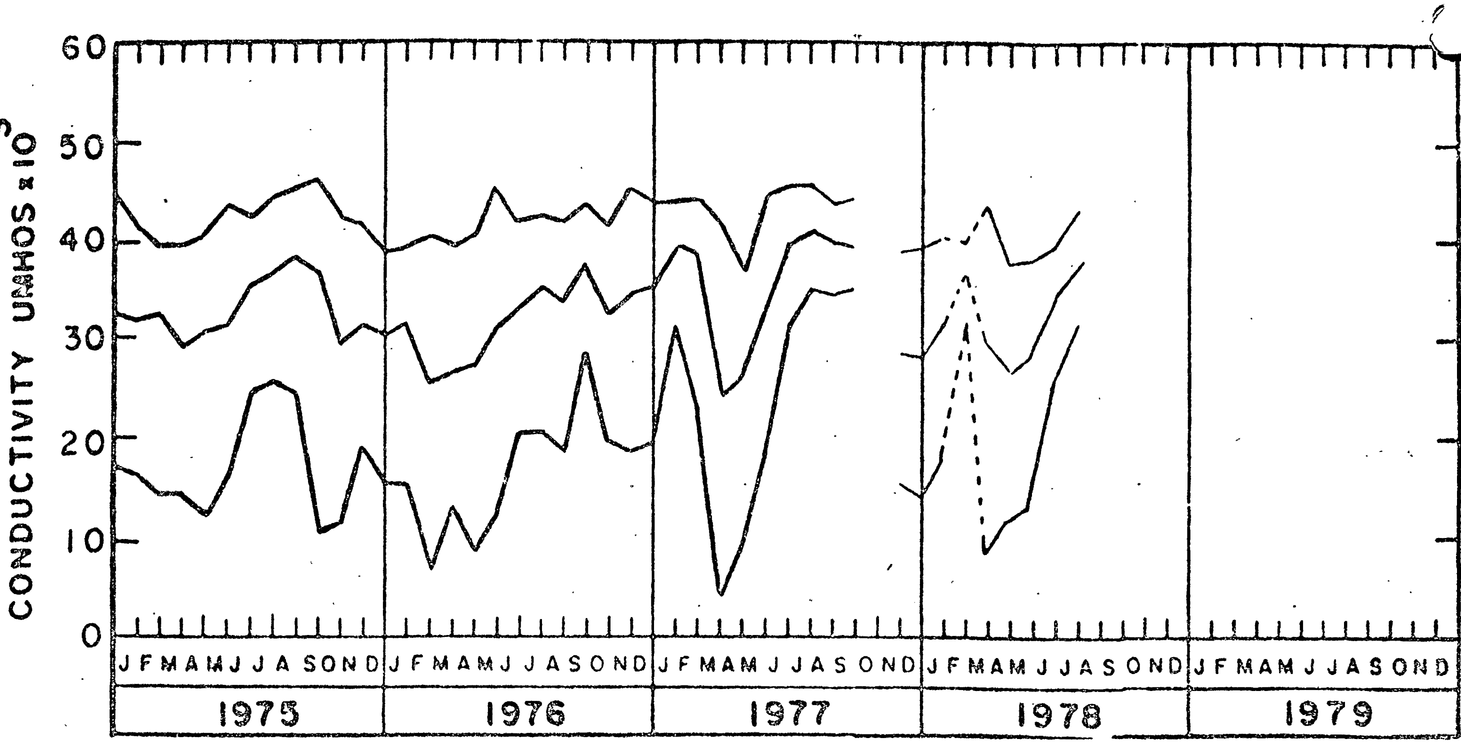


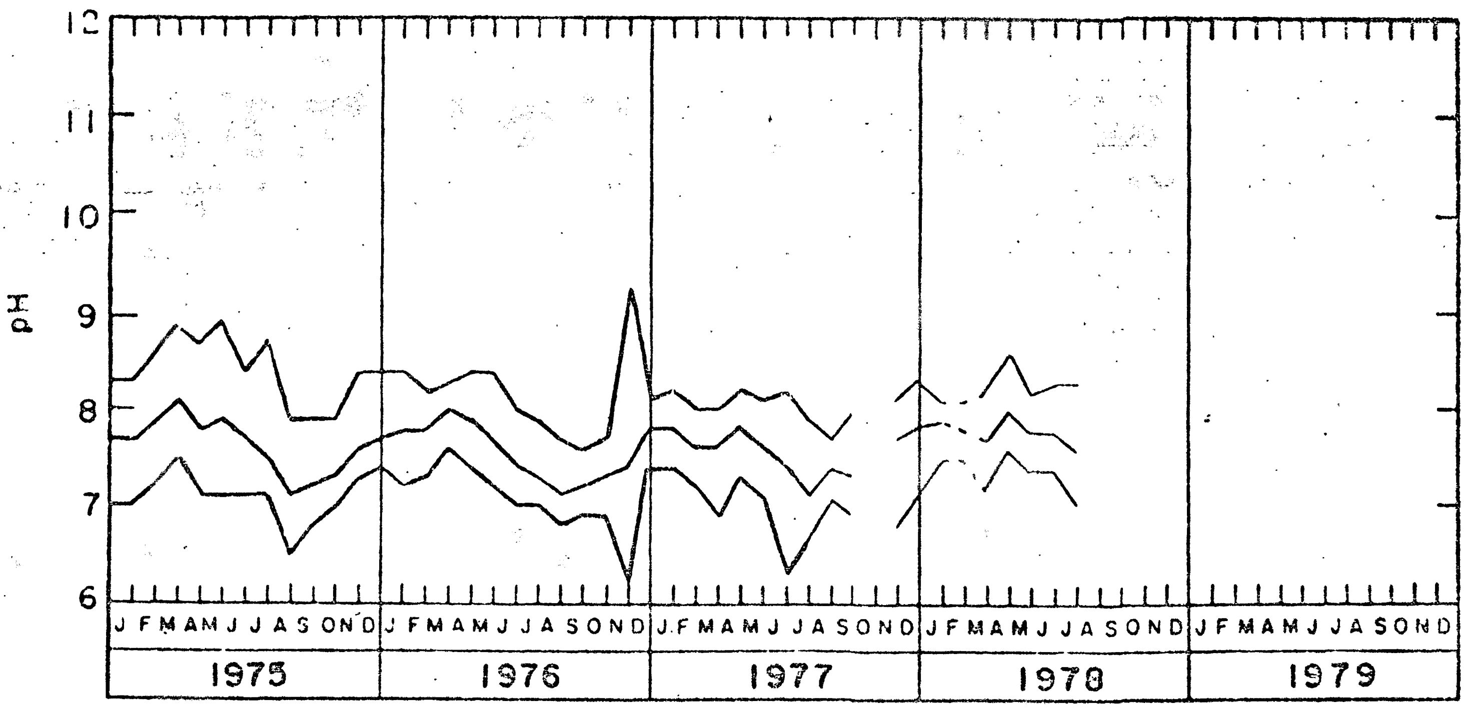


TOP LINE — maximum monthly value
CENTER LINE — average of the daily average values
BOTTOM LINE — minimum monthly value

Figure 8

THE NARROWS — FT. WADSWORTH (station no. 6)

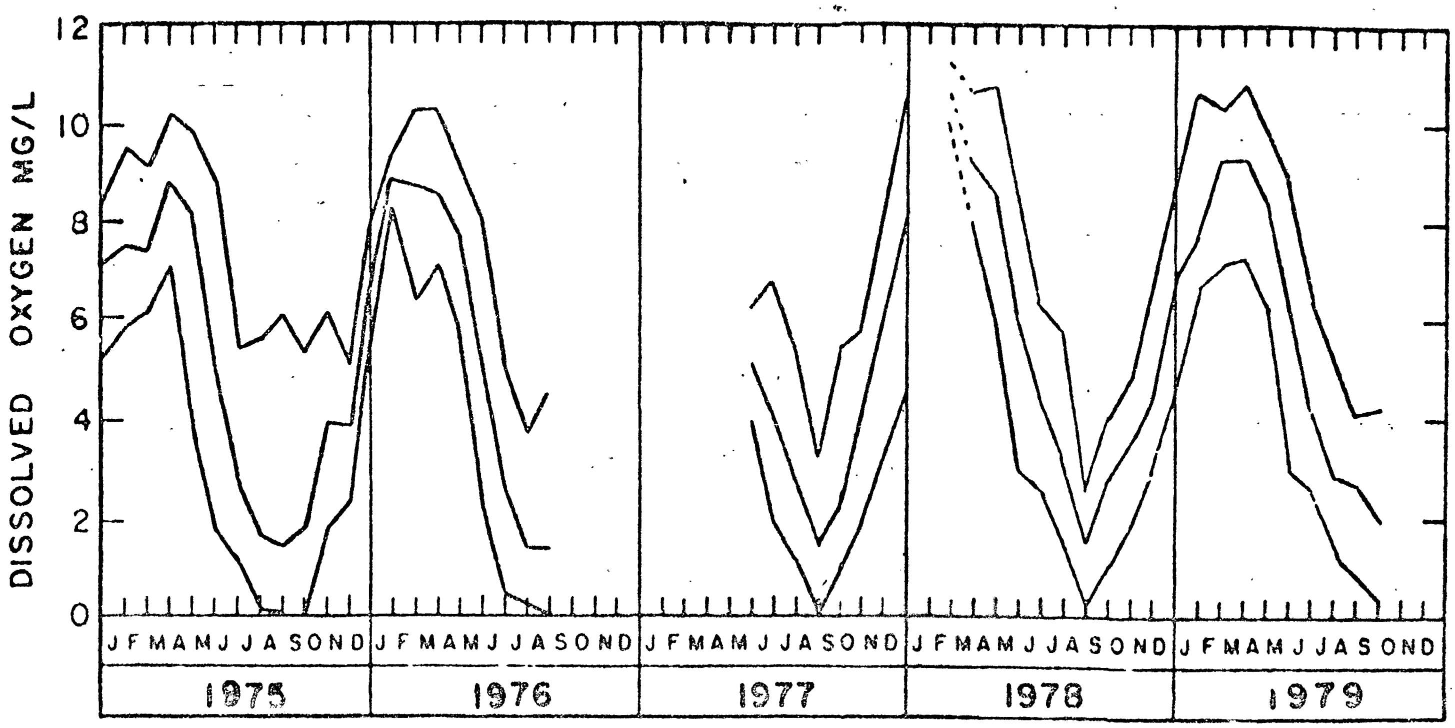


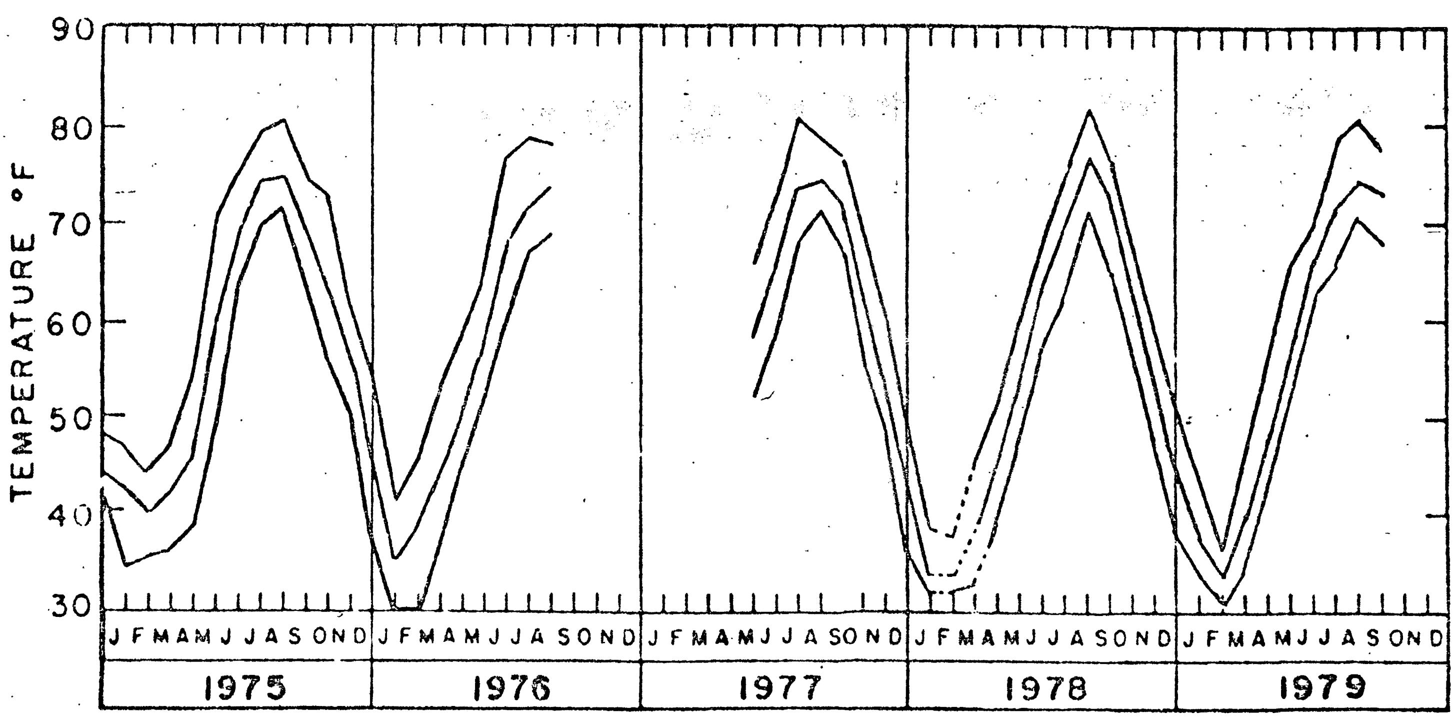


TOP LINE — maximum monthly value
CENTER LINE — average of the daily average values
BOTTOM LINE — minimum monthly value

Figure 9

KILL VAN KULL — U.S. GYPSUM (station no. 7)





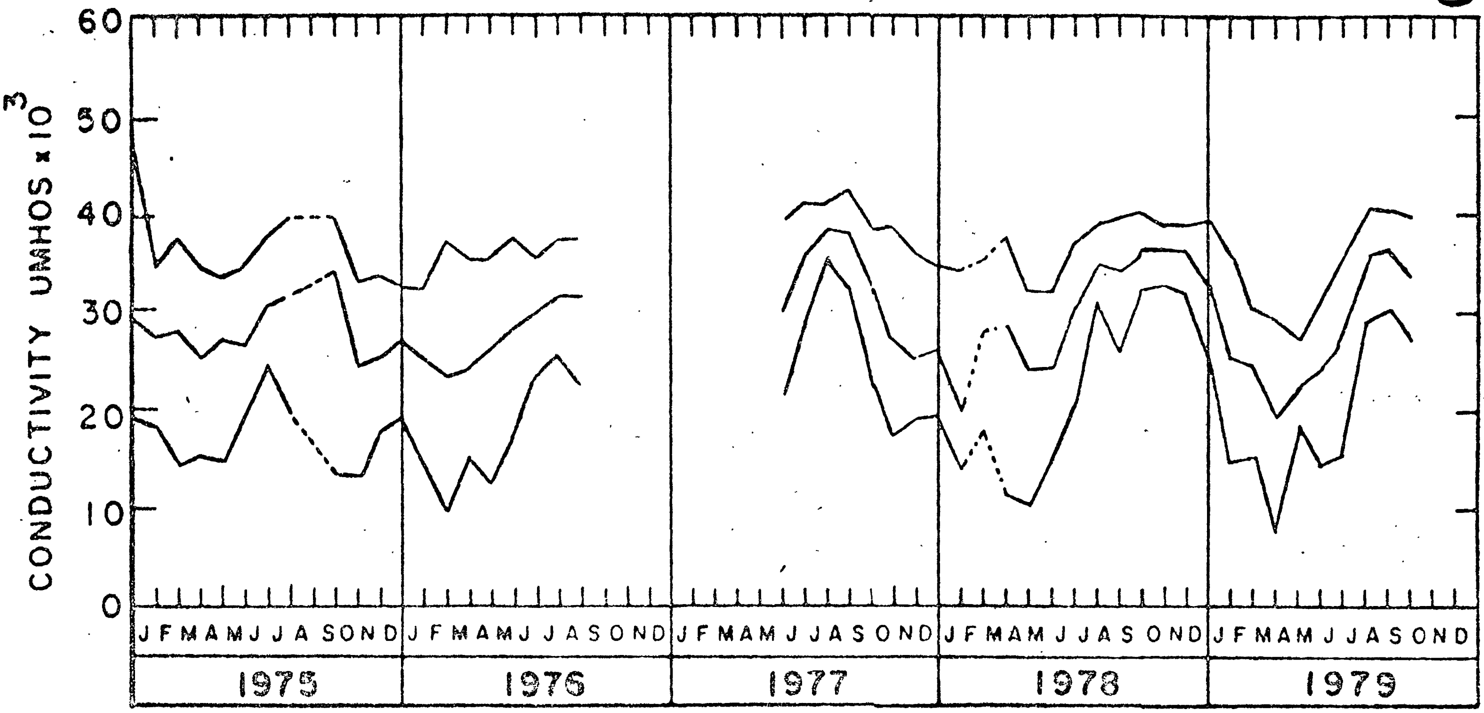
TOP LINE — maximum monthly value

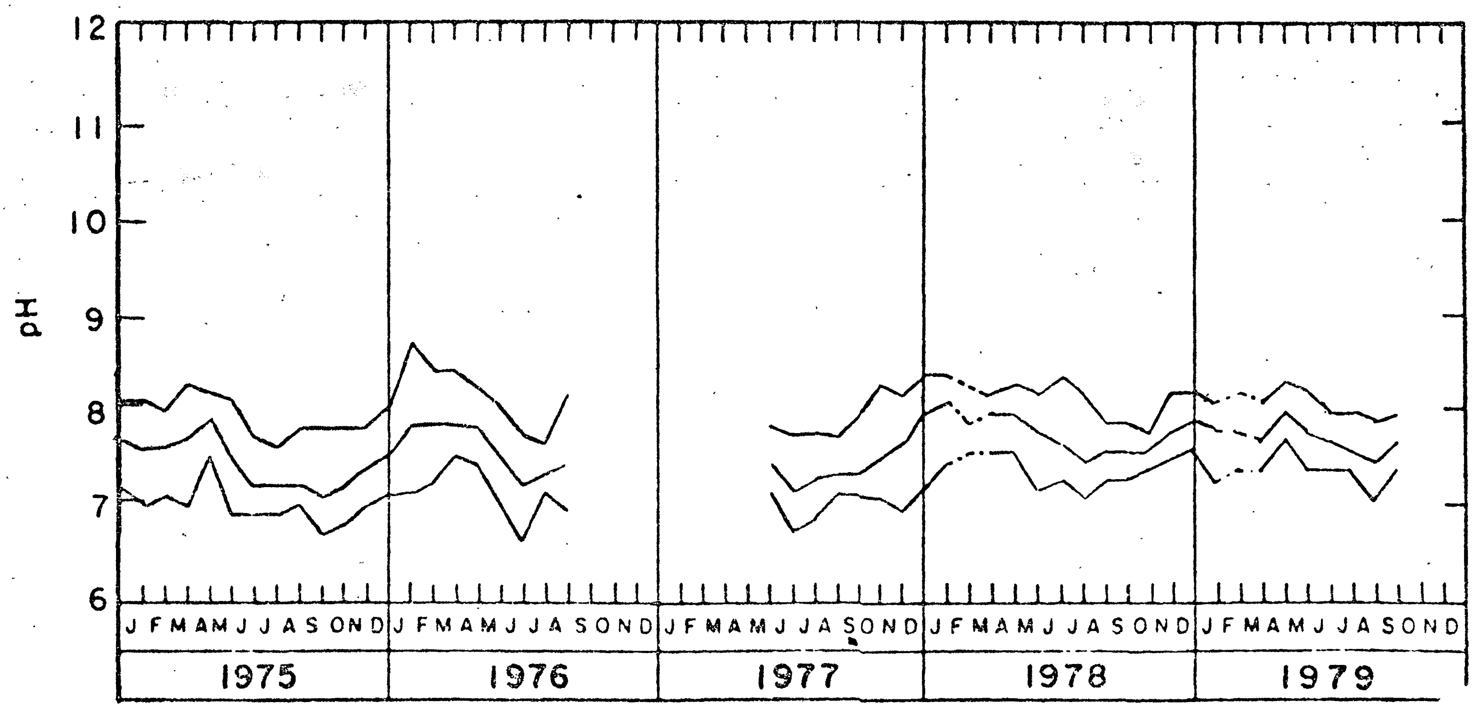
CENTER LINE — average of the daily average values

BOTTOM LINE — minimum monthly value

Figure 10

KILL VAN KULL — U.S. GYPSUM (station no. 7)





TOP LINE — maximum monthly value

CENTER LINE — average of the daily average values

BOTTOM LINE — minimum monthly value

Figure 11

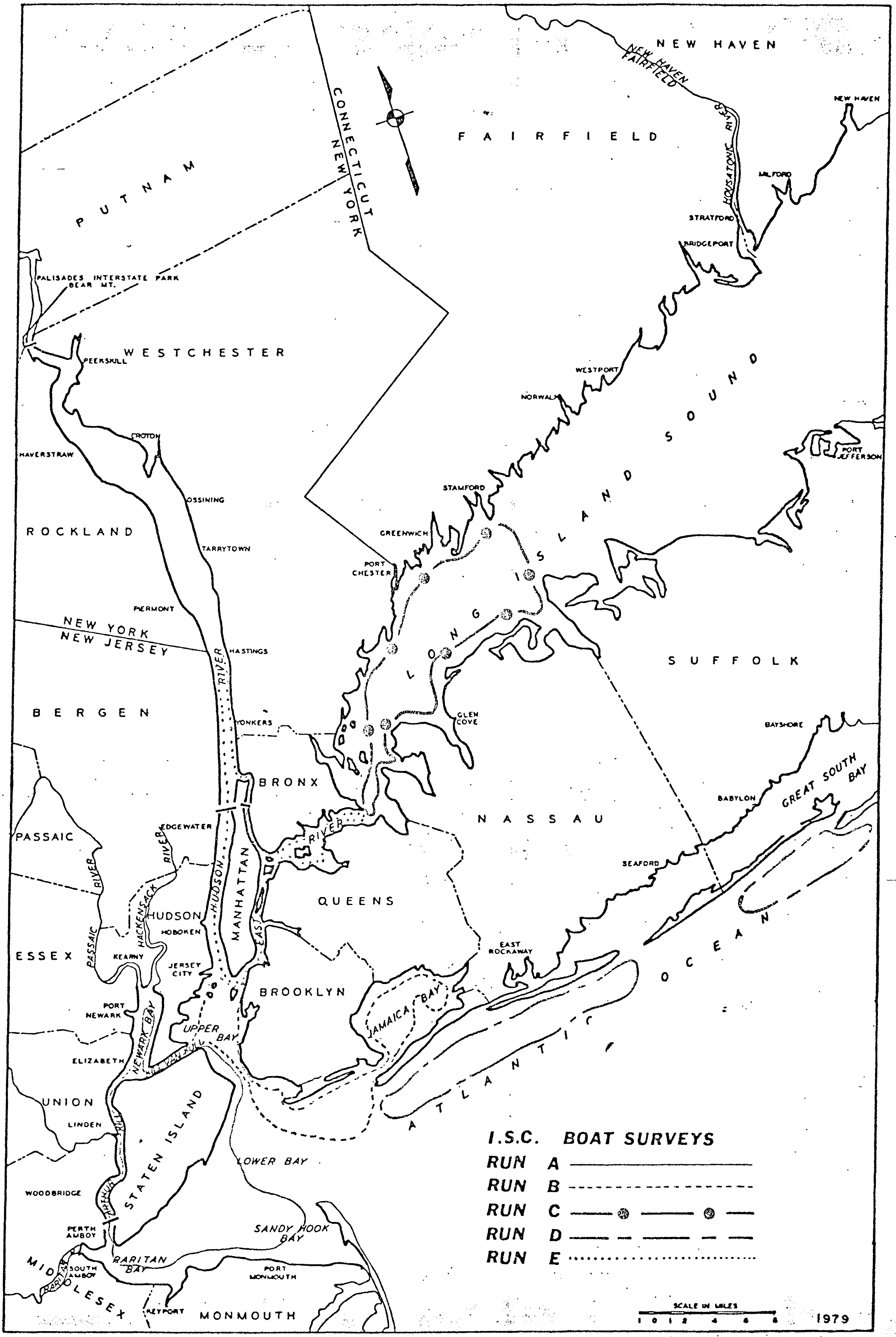

NEW HAVEN
NEW HAVEN
FAIRFIELD
FAIRFIELD
CONNECTICUT
NEW YORK
PUTNAM
HOUSATONIC RIVER
MILFORD
STRATFORD
BRIDGEPORT
PALISADES INTERSTATE PARK
BEAR MT.
WESTCHESTER
PEEKSKILL
WESTPORT
NORWALK
LONG ISLAND SOUND
PORT JEFFERSON
CROTON
HAVERSTRAW
OSSINING
STAMFORD
ROCKLAND
TARRYTOWN
GREENWICH
PORT CHESTER
PIERMONT
NEW YORK
NEW JERSEY
HASTINGS
SUFFOLK
BERGEN
HUDSON RIVER
YONKERS
GLEN COVE
BAYSHORE
BRONX
NASSAU
BABYLON
GREAT SOUTH BAY
PASSAIC
EDGEWATER
RIVER
HUDSON
MANHATTAN
EAST RIVER
QUEENS
SEAFORD
PASSAIC RIVER
HACKENSACK RIVER
HUDSON
HOBOKEN
ESSEX
KEARNY
JERSEY CITY
EAST ROCKAWAY
ATLANTIC OCEAN
BROOKLYN
PORT NEWARK
UPPER BAY
JAMAICA BAY
NEWARK BAY
KILL VAN KULL
ELIZABETH
UNION
LINDEN
STATEN ISLAND
ARTHUR KILL
LOWER BAY
WOODBRIDGE
PERTH AMBOY
SANDY HOOK BAY
RARITAN BAY
MIDDLESEX
RARITAN
SOUTH AMBOY
PORT MONMOUTH
KEYPORT
MONMOUTH
I.S.C. BOAT SURVEYS
RUN A
RUN B
RUN C
RUN D
RUN E
SCALE IN MILES
1 0 1 2 4 6 8
1979

TABLE 1

REMOTE AUTOMATIC WATER QUALITY MONITORING STATIONS IN THE INTERSTATE SANITATION DISTRICT

INTERSTATE SANITATION COMMISSION OWNED AND OPERATED

1. Arthur Kill - Consolidated Edison Arthur Kill Generating Station, Staten Island, New York

2. East River - Consolidated Edison Ravenswood Generating Station, Long Island City, New York

3. East River - Throgs Neck Bridge, Fort Schuyler, Bronx, New York

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY OWNED AND INTERSTATE SANITATION COMMISSION OPERATED

4. Raritan River - Victory Bridge, Perth Amboy, New Jersey (1)

5. Arthur Kill - Outerbridge Crossing, Staten Island, New York (2)

6. The Narrows - Fort Wadsworth, Staten Island, New York (3)

7. Kill Van Kull - U.S. Gypsum Company, Staten Island, New York (4)

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION OWNED AND OPERATED

8. Hudson River - Verplanck, New York

Notes:

(1) Out of service due to boat accident at Victory Bridge pier.
(2) Not presently in service.
(3) Out of service due to fire at Fort Wadsworth pier.
(4) Approximately 150 feet east of U.S. Gypsum Plant.

TABLE 2

INTERSTATE SANITATION COMMISSION

REMOTE AUTOMATIC WATER QUALITY MONITORING DATA

PERCENT OF TIME I.S.C. DISSOLVED OXYGEN REQUIREMENTS WERE MET

FOR THE PERIOD OF OCTOBER 1, 1978 THROUGH SEPTEMBER 30, 1979

MONTH	STATION 1 AK/CE	STATION 7 KVK/USG
October 1978	62.8	99.8
November 1978	91.1	100.0
December 1978	100.0	100.0
January 1979	100.0	100.0
February 1979	100.0	100.0
March 1979	100.0	100.0
April 1979	100.0	100.0
May 1978	100.0	100.0
June 1979	97.0	100.0
July 1979	40.4	71.0
August 1979	34.3	81.5
September 1979	31.5	95.3

TABLE 3

INTERSTATE SANITATION COMMISSION
SAMPLING STATIONS - BOAT RUN "A"

STATION	LATITUDE NORTH D M S	LONGITUDE WEST D M S	DESCRIPTION
AK-03	40-38-18	74-11-45	At the center of & on the northside of the B&O R.R. Bridge
AK-07	40-35-35	74-12-22	Middle of mouth of Rahway River & in line with shoreline along Tremley Reach
AK-13	40-33-02	74-15-00	Mid-channel between Flashing Red Buoy #12 & Flashing Green, Black Buoy #1
AK-18	40-30-24	74-15-34	Mid-channel of Ward Point Bend (west) and opposite Perth Amboy Ferry Slip
LB-01	40-30-44	74-06-03	500 feet from Old Orchard Light in line with the beacon at Old Orchard Shore
LB-02	40-33-45	74-04-20	B.W. Bell off Midland Beach
NB-03	40-39-20	74-08-45	Northside of C.R.N.J. Bridge over the Newark Bay South Reach Channel (mid-channel)
NB-05	40-38-47	74-09-10	Midway between Flashing Red Buoy #14 and Buoy N "2A"
NB-12	40-41-57	74-07-10	Newark Bay North Reach at mid-channel northside of LVRR Bridge
RB-07	40-27-39	74-02-47	Flashing Red Buoy R "4" off the tip of Leonardo (U.S.N.) Pier
RB-08	40-27-08	74-06-22	E-W: Line of Nun Buoy N "2" at channel entrance to Compton Creek & standpipe on Point Comfort. N-S: Approximately 200 yards west of Pews Creek.
RB-10	40-29-04	74-15-38	Qk Fl G "3" Buoy
RB-14	40-28-01	74-11-18	Buoy C "3" off Conaskonk Point at channel entrance to Keyport Harbor
RB-15	40-27-23	74-08-56	Private Fl G Buoy "1" on Belvedere Beach Point Comfort
UH-11	40-39-05	74-05-10	Located in the Kill Van Kull, in mid-channel & directly opposite Fl G & Black Buoy #3
UH-13	40-36-26	74-02-45	Middle of channel in Narrows under Verrazano Bridge

TABLE 4

INTERSTATE SANITATION COMMISSION
SAMPLING STATIONS - BOAT RUN "B"

STATION	LATITUDE NORTH D M S	LONGITUDE WEST D M S	DESCRIPTION
AC-01	40-31-47	73-56-37	Flashing Red R "2" Gong (4 sec.)
HR-01	40-42-20	74-01-36	Mid-channel of Hudson River N-S: Line of black buoys E-W: Fire Boat Pier (NY) and railroad pier (NJ)
JB-02	40-36-27	73-53-09	Mill Basin at east end of channel
JB-03	40-37-37	73-53-00	In channel 400 feet south of the end of Canarsie Pier
JB-05	40-35-45	73-48-40	At center pier of bridge over Beach Channel - Hammels
JB-07	40-38-52	73-49-20	At mouth of Bergen Basin, southeast of the sludge storage tank
JB-08	40-36-20	73-48-56	Under center of R.R. trestle
LB-03	40-34-03	73-59-00	200 feet south of Steeplechase Pier at Coney Island - N "2S"
LB-04	40-35-00	74-00-51	1/4 mile northeast of Norton Point, near the White Nun Buoy
RI-01	40-34-00	73-55-51	As near the outfall structure of the Coney Island plant as safety permits
RI-02	40-34-24	73-53-08	Under center of bridge from Barran Island to Rockaway
UH-03	40-39-14	74-03-35	Passaic Valley Outfalls E-W: Robbins Reef Light and forward water tower on Naval Dock N-S: Statue of Liberty and Black Bell Buoy #1-G
UH-13	40-36-26	74-02-45	Middle of channel in Narrows under Verrazano Bridge
UH-21	40-40-23	74-02-28	Main ship channel 10 yards to the west of Fl R Bell Buoy #30
UH-22	40-38-25	74-02-50	In mid-channel of Bay Ridge Channel E-W: Flashing Red Beacon on 69th St Ferry Dock (Brooklyn) N-S: Fl G Bell Buoy #3 and Fl R Gong Buoy #22
UH-29	40-42-17	75-59-54	Mid-channel of East River in line with Pier #11 (Manhattan) and Pier #1 (Brooklyn)

TABLE 5

INTERSTATE SANITATION COMMISSION
SAMPLING STATIONS - BOAT RUN "E"

STATION	LATITUDE NORTH D M S	LONGITUDE WEST D M S	DESCRIPTION
ER-01	40-42-24	73-59-27	Under Manhattan Bridge - mid-channel
ER-02	40-42-48	73-58-20	Under Williamsburg Bridge - mid-channel
ER-03	40-44-05	73-58-05	Mid-channel of East River E-W: Pier #73 (School Slip) Manhattan with open pier, foot of Greene Street, Brooklyn N-S: Poorhouse Flats Range
ER-04	40-45-22	73-57-11	Under Queensboro Bridge in the East Channel
ER-09	40-47-26	73-54-53	Mid-channel of East River E-W: Fl R Bell Beacon on Wards Island with tall stack on Con Edison's Astoria Plant
ER-11	40-47-50	73-52-02	Mid-channel of East River E-W: Fl R Beacon (College Point) with stack on Rikers Island N-S: Line from center of Sanitation Pier (Hunts Point) with Fl R #4 Buoy (Station approximately 250 yards SE of #4 Buoy)
HA-01	40-48-40	73-56-02	Third bridge after Triboro Bridge
HA-02	40-50-44	73-55-45	Hamilton Bridge (middle bridge of 3)
HR-01	40-42-20	74-01-36	Mid-channel of Hudson River N-S: Line of black buoys E-W: Fire Boat Pier (NY) and railroad pier (NJ)
HR-02	40-45-17	74-00-58	Mid-channel of Hudson River E-W: Heliport (NY) and Seatrain pier (NJ)
HR-03	40-47-41	73-59-09	Mid-channel of Hudson River E-W: Soldiers & Sailors Monument (NY) and circular apartment buildings (NJ)
HR-04	40-51-04	73-57-04	Mid-channel of Hudson River under George Washington Bridge
HR-05	40-52-40	73-55-02	Mid-channel of Spuyten Duyvil Creek under Henry Hudson Bridge
HR-07	40-56-51	73-54-27	Mid-channel of Hudson River E-W: Opposite Phelps Dodge (Yonkers)

Table 6

INTERSTATE SANITATION COMMISSION

1978 - 1979 BOAT SURVEY DATA

PARAMETER	HUDSON RIVER	UPPER NEW YORK BAY	LOWER NEW YORK BAY	KILL VAN KULL
Temperature (C) (Summer)				
Low	18.0	19.0	18.0	18.5
High	24.5	25.0	24.0	27.0
Average	21.0	22.6	21.6	22.6
No. of Values	12	21	18	5
Temperature (C) (Winter)				
Low	2.0	1.0	2.0	1.5
High	2.0	2.0	2.0	1.5
Average	2.0	1.5	2.0	1.5
No. of Values	1	5	4	1
Dissolved Oxygen (Summer)				
Low	2.4	2.4	3.2	2.6
High	8.8	6.6	8.8	6.0
Average	4.9	3.8	5.9	4.5
No. of Values	11	20	16	4
Dissolved Oxygen (Winter)				
Low	15.2	9.6	9.8	8.4
High	15.2	13.8	10.2	8.4
Average	15.2	10.6	10.1	8.4
No. of Values	1	5	4	1
BOD (5 day) (Summer)				
Low	1.3	1.2	0.6	1.6
High	2.9	3.0	5.7	2.4
Average	2.1	1.9	1.9	2.1
No. of Values	9	9	9	3
BOD (5 day) (Winter)				
Low	7.6	2.4	1.8	-
High	7.6	2.6	2.5	-
Average	7.6	2.5	2.2	-
No. of Values	1	2	2	-

NOTES: (1) All units are milligrams per liter unless otherwise shown.

(2) All averages are arithmetic means.

(3) Data are for October 1978 through September 1979. Summer data are for July, August and September; winter data are for December, January and February.

Table 7

INTERSTATE SANITATION COMMISSION

1978 - 1979 BOAT SURVEY DATA

PARAMETER	HUDSON RIVER	UPPER NEW YORK BAY	LOWER NEW YORK BAY	KILL VAN KULL
Fecal Coli (/100 ml) (Summer)				
Low	1000	540	<10	2200
High	25000	24000	4800	4100
Average	3500	5600	<190	3000
No. of Values	7	9	7	2
Fecal Coli (/100 ml) (Winter)				
Low	5100	3900	1500	-
High	5100	12000	8200	-
Average	5100	6800	3500	-
No. of Values	1	2	2	-
Total Coli (/100 ml) (Summer)				
Low	1700	<100	<100	6100
High	30000	>100000	5600	6100
Average	6900	>4600	<420	6100
No. of Values	4	5	6	1
Total Coli (/100 ml) (Winter)				
Low	20000	15000	2500	-
High	20000	27000	16000	-
Average	20000	20000	6300	-
No. of Values	1	2	2	-
pH (Standard Units)				
Low	7.1	7.0	7.0	6.9
High	8.0	8.0	8.5	7.6
Average	7.4	7.4	7.5	7.2
No. of Values	31	56	45	12
Conductivity (umhos/cm)				
Low	7300	16000	28000	18000
High	38000	47000	50000	43500
Average	22500	34500	38900	31100
No. of Values	29	50	41	11

NOTES: (1) Units are as shown.

(2) All averages are arithmetic means except coliforms which are geometric means and pH which is calculated from the arithmetic mean of the hydrogen ion concentration.

(3) Data are for October 1978 through September 1979. Summer data are for July, August and September; winter data are for December, January and February.

Table 8

INTERSTATE SANITATION COMMISSION

1978 - 1979 BOAT SURVEY DATA

PARAMETER	HUDSON RIVER	UPPER NEW YORK BAY	LOWER NEW YORK BAY	KILL VAN KULL
Turbidity (NTU)				
Low	2	1	1	2
High	23	7	18	11
Average	6	3	3	4
No. of Values	30	56	46	12
Chlorophyll a				
Low	0.000	0.000	0.000	0.000
High	0.017	0.079	0.037	0.005
Average	0.004	0.007	0.009	0.002
No. of Values	18	29	23	6
Chlorophyll b				
Low	0.000	0.000	0.000	0.000
High	0.003	0.005	0.002	0.003
Average	0.001	0.001	0.001	0.001
No. of Values	18	29	23	6
Chlorophyll c				
Low	0.000	0.000	0.000	0.000
High	0.011	0.038	0.021	0.006
Average	0.002	0.004	0.006	0.003
No. of Values	18	29	23	6
Total Carbon				
Low	21	22	23	27
High	38	38	40	37
Average	28	30	30	31
No. of Values	21	50	40	10
Total Org. Carbon				
Low	5	1	1	1
High	15	16	16	13
Average	9	9	8	9
No. of Values	21	50	40	10

NOTES: (1) All units are milligrams per liter unless otherwise shown.

(2) All averages are arithmetic means.

(3) Data are for October 1978 through September 1979.

Table 9

INTERSTATE SANITATION COMMISSION

1978 - 1979 BOAT SURVEY DATA

PARAMETER	HUDSON RIVER	UPPER NEW YORK BAY	LOWER NEW YORK BAY	KILL VAN KULL
Oil & Grease				
Low	0.1	0.1	0.1	0.1
High	0.3	1.1	0.5	0.4
Average	0.2	0.4	0.2	0.3
No. of Values	6	10	8	2
Ortho Phosphate Phosphorus				
Low	0.02	0.01	0.01	0.05
High	0.13	0.12	0.11	0.12
Average	0.09	0.06	0.05	0.08
No. of Values	12	20	13	4
Total Phosphate Phosphorus				
Low	0.07	0.07	0.05	0.12
High	0.25	0.22	0.15	0.20
Average	0.15	0.13	0.11	0.16
No. of Values	12	20	13	4
Ammonia Nitrogen				
Low	0.06	0.17	0.02	0.39
High	0.65	0.99	0.48	0.64
Average	0.40	0.42	0.24	0.55
No. of Values	12	20	13	4
Nitrite + Nitrate Nitrogen				
Low	0.19	0.12	0.05	0.25
High	0.50	0.53	0.43	0.54
Average	0.36	0.29	0.20	0.37
No. of Values	12	20	13	4
Total Kjeldahl Nitrogen				
Low	0.64	0.61	0.64	1.94
High	1.10	2.35	0.83	1.94
Average	0.81	1.30	0.71	1.94
No. of Values	3	10	3	1

NOTES: (1) All units are milligrams per liter.

(2) All averages are arithmetic means.

(3) Data are for October 1978 through September 1979.

Table 10

INTERSTATE SANITATION COMMISSION

1978 - 1979 BOAT SURVEY DATA

PARAMETER	HUDSON RIVER	UPPER NEW YORK BAY	LOWER NEW YORK BAY	KILL VAN KULL
Copper				
Low	0.004	0.003	0.004	0.011
High	0.042	0.214	0.091	0.100
Average	0.016	0.048	0.038	0.043
No. of Values	13	20	16	4
Zinc				
Low	<0.001	0.024	0.024	0.036
High	0.053	0.095	0.190	0.096
Average	<0.032	0.052	0.076	0.055
No. of Values	13	16	15	4
Chromium				
Low	<0.0010	<0.0010	<0.0010	<0.0010
High	0.0090	0.0080	0.0087	0.0058
Average	<0.0034	<0.0021	<0.0019	<0.0027
No. of Values	11	20	16	4
Lead				
Low	<0.005	<0.005	<0.005	0.010
High	0.015	0.015	0.040	0.010
Average	<0.007	<0.008	<0.013	0.010
No. of Values	13	20	16	4
Aluminum				
Low	0.120	0.010	0.010	0.200
High	0.300	0.360	0.140	0.200
Average	0.201	0.154	0.076	0.200
No. of Values	8	9	8	1
Iron				
Low	0.160	0.140	0.075	0.450
High	0.730	0.421	0.835	0.530
Average	0.449	0.262	0.263	0.490
No. of Values	9	9	8	2
Nickel				
Low	<0.005	<0.005	<0.005	<0.005
High	0.035	0.045	0.045	0.015
Average	<0.011	<0.017	<0.016	<0.010
No. of Values	13	19	16	4

NOTES: (1) All units are milligrams per liter.

(2) All averages are arithmetic means.

(3) Data are for October 1978 through September 1979.

(4) All values for heavy metals are for "total metals".

Table 11

INTERSTATE SANITATION COMMISSION

1978 - 1979 BOAT SURVEY DATA

PARAMETER	HUDSON RIVER	UPPER NEW YORK BAY	LOWER NEW YORK BAY	KILL VAN KULL
Cadmium				
Low	<0.0005	<0.0005	<0.0005	<0.0005
High	0.0020	0.0050	0.0112	0.0010
Average	<0.0010	<0.0012	<0.0014	<0.0006
No. of Values	13	20	16	4
Mercury				
Low	0.0001	<0.0001	<0.0001	0.0001
High	0.0003	0.0003	0.0004	0.0003
Average	0.0002	<0.0002	<0.0003	0.0002
No. of Values	4	7	6	2
Silver				
Low	<0.001	<0.001	<0.001	<0.001
High	0.001	0.001	0.006	0.001
Average	<0.001	<0.001	<0.002	<0.001
No. of Values	9	10	8	2
Cobalt				
Low	<0.001	<0.001	<0.001	<0.001
High	0.010	0.005	0.007	<0.001
Average	<0.002	<0.002	<0.002	<0.001
No. of Values	9	9	8	1
Tin				
Low	<0.050	<0.050	<0.050	<0.050
High	0.050	0.050	0.100	<0.050
Average	<0.050	<0.050	<0.063	<0.050
No. of Values	9	10	8	2
Arsenic				
Low	<0.002	<0.002	<0.002	<0.002
High	0.003	0.011	0.000	<0.002
Average	<0.002	<0.003	<0.002	<0.002
No. of Values	9	8	6	1
Phenols				
Low	0.003	<0.001	0.001	0.001
High	0.003	0.013	0.007	0.001
Average	0.003	<0.006	0.004	0.001
No. of Values	1	5	4	1

NOTES:
(1) All units are milligrams per liter.
(2) All averages are arithmetic means.
(3) Data are for October 1978 through September 1979.
(4) All values for heavy metals are for "total metals".

Table 12

INTERSTATE SANITATION COMMISSION

1978 - 1979 BOAT SURVEY DATA

PARAMETER	NEWARK BAY	ARTHUR KILL	RARITAN BAY	SANDY HOOK BAY
Temperature (C) (Summer)				
Low	20.0	19.5	19.0	18.0
High	27.0	31.5	26.0	25.0
Average	23.3	23.3	22.3	21.8
No. of Values	15	20	15	10
Temperature (C) (Winter)				
Low	1.5	1.8	1.0	1.5
High	1.8	1.8	1.8	1.5
Average	1.7	1.8	1.3	1.5
No. of Values	3	2	3	2
Dissolved Oxygen (Summer)				
Low	4.2	3.0	3.2	5.4
High	6.4	9.6	10.4	11.2
Average	5.4	4.9	6.2	7.7
No. of Values	12	16	12	8
Dissolved Oxygen (Winter)				
Low	8.6	7.8	9.2	9.6
High	8.8	8.4	9.6	10.0
Average	8.7	8.2	9.3	9.8
No. of Values	3	4	3	2
BOD (5 day) (Summer)				
Low	2.0	1.0	0.4	0.2
High	>4.8	5.4	4.4	4.4
Average	>2.8	>3.5	2.0	2.6
No. of Values	9	11	9	6
BOD (5 day) (Winter)				
Low	5.5	4.7	4.0	2.7
High	6.5	5.3	4.0	2.7
Average	6.0	5.0	4.0	2.7
No. of Values	2	2	1	1

NOTES: (1) All units are milligrams per liter unless otherwise shown.

(2) All averages are arithmetic means.

(3) Data are for October 1978 through September 1979. Summer data are for July, August and September; winter data are for December, January and February.

Table 13

INTERSTATE SANITATION COMMISSION

1978 - 1979 BOAT SURVEY DATA

PARAMETER	NEWARK BAY	ARTHUR KILL	RARITAN BAY	SANDY HOOK BAY
Fecal Coli (/100 ml) (Summer)				
Low	390	270	10	<10
High	700	41000	400	20
Average	530	3500	120	<13
No. of Values	3	10	4	3
Fecal Coli (/100 ml) (Winter)				
Low	-	3600	500	390
High	-	4600	1900	390
Average	-	4100	1100	390
No. of Values	-	2	3	1
Total Coli (/100 ml) (Summer)				
Low	1200	810	<100	<100
High	1700	>100000	5700	270
Average	1500	>15000	<660	<190
No. of Values	3	8	6	3
Total Coli (/100 ml) (Winter)				
Low	-	32000	20000	37000
High	-	62000	59000	37000
Average	-	45000	30000	37000
No. of Values	-	2	3	1
pH (Standard Units)				
Low	6.9	6.7	6.7	7.0
High	7.4	7.6	7.6	8.1
Average	7.2	7.2	7.2	7.4
No. of Values	36	46	36	24
Conductivity (umhos/cm)				
Low	11000	18000	23000	23000
High	39500	41000	42000	42500
Average	26200	30500	34000	35800
No. of Values	33	43	33	22

NOTES:

(1) Units are as shown.

(2) All averages are arithmetic means except coliforms which are geometric means and pH which is calculated from the arithmetic mean of the hydrogen ion concentration.

(3) Data are for October 1978 through September 1979. Summer data are for July, August and September; winter data are for December, January and February.

Table 14

INTERSTATE SANITATION COMMISSION

1978 - 1979 BOAT SURVEY DATA

PARAMETER	NEWARK BAY	ARTHUR KILL	RARITAN BAY	SANDY HOOK BAY
Turbidity (NTU)				
Low	2	3	2	2
High	12	27	15	11
Average	4	5	7	4
No. of Values	36	47	36	24
Chlorophyll a				
Low	0.000	0.000	0.000	0.000
High	0.030	0.040	0.112	0.033
Average	0.008	0.015	0.018	0.012
No. of Values	16	22	17	11
Chlorophyll b				
Low	0.000	0.000	0.000	0.000
High	0.006	0.004	0.003	0.001
Average	0.001	0.001	0.001	0.000
No. of Values	16	22	17	11
Chlorophyll c				
Low	0.000	0.000	0.000	0.000
High	0.020	0.015	0.046	0.024
Average	0.004	0.006	0.010	0.008
No. of Values	16	22	17	11
Total Carbon				
Low	27	25	23	24
High	40	45	37	35
Average	33	34	31	30
No. of Values	30	39	30	20
Total Org. Carbon				
Low	7	3	2	2
High	17	20	15	14
Average	12	11	10	9
No. of Values	30	39	30	20

NOTES: (1) All units are milligrams per liter unless otherwise shown.

(2) All averages are arithmetic means.

(3) Data are for October 1978 through September 1979.

Table 15

INTERSTATE SANITATION COMMISSION

1978 - 1979 BOAT SURVEY DATA

PARAMETER	NEWARK BAY	ARTHUR KILL	RARITAN BAY	SANDY HOOK BAY
Oil & Grease				
Low	0.1	0.2	0.1	0.1
High	1.2	1.0	0.4	0.3
Average	0.4	0.5	0.3	0.2
No. of Values	6	8	6	4
Ortho Phosphate Phosphorus				
Low	0.08	0.05	0.01	0.01
High	0.33	0.26	0.10	0.11
Average	0.21	0.15	0.05	0.05
No. of Values	10	20	11	7
Total Phosphate Phosphorus				
Low	0.20	0.08	0.07	0.05
High	0.43	0.44	0.17	0.16
Average	0.30	0.26	0.13	0.12
No. of Values	10	20	11	7
Ammonia Nitrogen				
Low	0.65	0.31	0.16	0.05
High	1.55	2.15	1.35	1.27
Average	0.93	1.08	0.66	0.55
No. of Values	10	20	11	7
Nitrite + Nitrate Nitrogen				
Low	0.24	0.20	0.18	0.15
High	0.57	1.04	0.55	0.80
Average	0.39	0.39	0.32	0.39
No. of Values	10	20	11	7
Total Kjeldahl Nitrogen				
Low	1.33	0.90	0.68	0.28
High	2.03	3.60	2.00	0.88
Average	1.61	1.88	1.27	0.58
No. of Values	3	13	3	2

NOTES: (1) All units are milligrams per liter.

(2) All averages are arithmetic means.

(3) Data are for October 1978 through September 1979.

Table 16

INTERSTATE SANITATION COMMISSION

1978 - 1979 BOAT SURVEY DATA

PARAMETER	NEWARK BAY	ARTHUR KILL	RARITAN BAY	SANDY HOOK BAY
Copper				
Low	0.005	0.012	0.006	0.003
High	0.060	0.155	0.082	0.072
Average	0.023	0.049	0.037	0.028
No. of Values	12	17	11	8
Zinc				
Low	0.032	0.063	0.032	0.033
High	0.095	0.173	0.186	0.107
Average	0.070	0.108	0.083	0.067
No. of Values	10	17	9	6
Chromium				
Low	<0.0010	<0.0010	<0.0010	<0.0010
High	0.0150	0.0080	0.0050	0.0051
Average	<0.0054	<0.0036	<0.0022	<0.0023
No. of Values	12	17	12	8
Lead				
Low	<0.005	<0.005	<0.005	<0.0050
High	0.075	0.030	0.035	0.0150
Average	<0.020	<0.014	<0.014	<0.0088
No. of Values	12	17	11	8
Aluminum				
Low	0.060	0.050	0.020	0.030
High	0.160	0.250	0.290	0.150
Average	0.096	0.103	0.158	0.095
No. of Values	5	7	5	4
Iron				
Low	0.295	0.290	0.230	0.130
High	0.485	0.665	1.630	0.467
Average	0.389	0.484	0.709	0.302
No. of Values	6	8	5	4
Nickel				
Low	0.010	<0.005	<0.005	<0.005
High	0.045	0.055	0.040	0.040
Average	0.026	<0.028	<0.018	<0.016
No. of Values	12	17	11	8

NOTES: (1) All units are milligrams per liter.

(2) All averages are arithmetic means.

(3) Data are for October 1978 through September 1979.

(4) All values for heavy metals are for "total metals".

Table 17

INTERSTATE SANITATION COMMISSION

1978 - 1979 BOAT SURVEY DATA

PARAMETER	NEWARK BAY	ARTHUR KILL	RARITAN BAY	SANDY HOOK BAY
Cadmium				
Low	<0.0005	<0.0005	<0.0005	<0.0005
High	0.0055	0.0050	0.0030	0.0010
Average	<0.0012	<0.0014	<0.0011	<0.0007
No. of Values	12	17	10	7
Mercury				
Low	<0.0001	<0.0001	<0.0001	0.0001
High	0.0005	0.0005	0.0003	0.0003
Average	<0.0004	<0.0003	<0.0002	0.0002
No. of Values	4	6	5	3
Silver				
Low	<0.001	<0.001	<0.001	<0.001
High	0.001	0.002	0.004	0.001
Average	<0.001	<0.001	<0.002	<0.001
No. of Values	6	8	5	4
Cobalt				
Low	<0.001	<0.001	<0.001	<0.001
High	0.006	0.005	0.008	0.004
Average	<0.003	<0.002	<0.003	<0.002
No. of Values	6	7	5	4
Tin				
Low	<0.050	<0.050	<0.050	<0.050
High	0.100	0.100	0.400	0.100
Average	<0.065	<0.056	<0.108	<0.063
No. of Values	5	8	6	4
Arsenic				
Low	<0.002	<0.002	<0.002	<0.002
High	0.003	0.004	0.001	0.002
Average	<0.002	<0.003	<0.002	<0.002
No. of Values	5	6	4	3
Phenols				
Low	<0.001	<0.001	<0.001	<0.001
High	0.005	0.005	0.004	0.008
Average	<0.003	<0.003	<0.002	<0.005
No. of Values	3	4	3	2

NOTES: (1) All units are milligrams per liter.

(2) All averages are arithmetic means.

(3) Data are for October 1978 through September 1979.

(4) All values for heavy metals are for "total metals".

TABLE 18

INTERSTATE SANITATION COMMISSION
1978 - 1979 PESTICIDES AND PCBs DATA
FROM
ISC BOAT RUNS A, B & E (1)(2)

WATERWAY	STATION	LATITUDE NORTH D M S	LONGITUDE WEST D M S	PESTICIDES OR PCBs NAME	FOUND VALUE (ppb)
ARTHUR KILL	AK-13	40-33-02	74-15-00	2-BHC	0.005
ARTHUR KILL	AK-18	40-30-24	74-15-34	2-BHC	0.004
HUDSON RIVER	HR-01	40-42-20	74-01-36	AROCLOR 1016	0.15
HUDSON RIVER (3)	HR-01	40-42-20	74-01-36	AROCLOR 1260	0.250
				DIELDRIN	0.0013
LOWER N.Y. BAY	LB-02	40-33-45	74-04-20	2-BHC	0.004

NOTES: (1) Samples were analyzed for pesticides and PCB's at all stations on Boat Runs A, B and E. Pesticides or PCB's were found only at the stations included in this table. The table lists only stations in New Jersey or interstate (NJ-NY) waters.

(2) Unless otherwise noted, all samples were taken 5 feet below the surface.

(3) Sediment sample taken on special Hudson River Survey. Units are milligrams per kilogram on a dry weight basis.

Table 19

CURRENT STATUS OF NEW JERSEY WASTEWATER TREATMENT PLANTS

WITHIN THE INTERSTATE SANITATION DISTRICT

WASTEWATER TREATMENT PLANT	DEGREE OF TREATMENT	DISCHARGE WATERWAY	AVERAGE DAILY FLOW (MGD) 1977	1979	COMPLIANCE WITH TREATMENT REQUIREMENTS 1977	1979	BASIS FOR NON-COMPLIANCE*
Carteret	primary	Arthur Kill	3.0	3.2	no	no	2
Joint Meeting of Essex and Union Counties	secondary activated sludge	Arthur Kill	62.9	64.8	no	yes	-
Linden-Roselle	primary	Arthur Kill	11.7	11.9	no	no	1
Rahway Valley Sewerage Authority	secondary activated sludge	Arthur Kill	29.0	32.8	yes	yes	-
Woodbridge	primary	Arthur Kill	4.2	3.4	no	no	2
Edgewater	primary	Hudson River	2.7	2.8	no	no	3
Hoboken	primary	Hudson River	14.2	15.5	no	no	3
Jersey City - East Side	primary	Hudson River	34.6	34.7	no	no	3
West New York	primary	Hudson River	8.7	9.0	no	no	3
Woodcliff - North Bergen	primary	Hudson River	1.6	2.6	no	no	3
Bayonne	primary	Kill Van Kull	12.7	13.2	no	no	3
Jersey City - West Side	primary	Newark Bay	23.9	21.2	no	no	3
Kearny	primary	Newark Bay	2.7	3.1	no	no	3
Passaic Valley Sewerage Commissioners	primary	Newark Bay **	250	250	no	no	1

Notes: * 1. Secondary treatment required - Construction underway.

2. Secondary treatment required - Plant is to be converted to a pump station with flows diverted to a regional sewage treatment plant.

3. Secondary treatment required - Planning underway.

** Temporarily discharging to Newark Bay during plant construction. Normal discharge is to Upper New York Bay.

Table 19
(continued)

CURRENT STATUS OF NEW JERSEY WASTEWATER TREATMENT PLANTS

WITHIN THE INTERSTATE SANITATION DISTRICT

WASTEWATER TREATMENT PLANT	DEGREE OF TREATMENT	DISCHARGE WATERWAY	AVERAGE DAILY FLOW (MGD) 1977	1979	COMPLIANCE WITH TREATMENT REQUIREMENTS 1977	1979	BASIS FOR NON-COMPLIANCE*
Middlesex County Sewerage Authority	secondary activated sludge - ozone type	Raritan Bay	81.5	91.9	yes	yes	-
Old Bridge Township S.A.	primary	Raritan Bay	0.9	0.8	no	no	2
Perth Amboy	primary	Raritan Bay	5.2	4.7	no	no	2
Sayreville - Melrose	primary	Raritan Bay	0.04	0.06	no	no	2
Sayreville - Morgan	primary	Raritan Bay	0.3	0.3	no	no	2
South Amboy	primary	Raritan Bay	0.8	0.6	no	no	2
Atlantic Highlands	primary	Sandy Hook Bay	0.5	0.5	no	no	2
Highlands	primary	Sandy Hook Bay	0.6	0.4	no	no	2
Atlantic Highlands/ Highlands Regional S.A.	secondary activated sludge	Sandy Hook Bay	plant is in planning stage				
Military Ocean Terminal	secondary activated sludge	Upper N.Y. Bay	0.13	0.13	yes	yes	-

Notes: * 1. Secondary treatment required - Construction underway.

2. Secondary treatment required - Plant is to be converted to a pump station with flows diverted to a regional sewage treatment plant.

3. Secondary treatment required - Planning underway.