ASSOCIATIONS BETWEEN WATER-QUALITY TRENDS IN NEW JERSEY STREAMS AND DRAINAGE-BASIN CHARACTERISTICS, 1975-86

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CONVERSION FACTORS

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter
mile (mi)	1.609	kilometer
	Area	
acre	4,047	square meter
square mile (mi^2)	2.590	square kilometer
	Flow	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
million gallons per day (Mgal/d)	0.04381	cubic meter per second
million gallons per day per square mile ($(Mgal/d)/mi^2$)	0.016911	cubic meter per second per square kilometer
	Mass	
ton, short	0.9072	megagram
ton per square mi (ton/mi^2)	0.35	megagram per square kilometer
	Mass Per Unit Time	
kilogram per day (kg/d)	2.205	pound per day
	Temperature	
degree Fahrenheit (°F)	°C = 5/9 x (°F-32)	degree Celsius (°C)

ASSOCIATIONS BETWEEN WATER-QUALITY TRENDS IN NEW JERSEY STREAMS AND DRAINAGE-BASIN CHARACTERISTICS, 1975-86

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ABSTRACT

Trends in the concentrations of 13 chemical constituents and 2 physical properties measured during 1975-86 at 60 stream-monitoring stations in New Jersey were analyzed for statistical association with drainage-basin characteristics. Basin characteristics assessed for the 60 drainage basins corresponding to the stream-monitoring stations included dominant land use, population, effluent discharge, road salting, fertilizer application, and estimates of soil erosion and irrigated land.

Trends in many constituents and properties were statistically associated ($p \leq 0.10$) with the dominant land use in the drainage basin, an indication that land use has a strong effect on water-quality trends in New Jersey. Urbanized basins were associated with increasing pH and increasing concentrations of dissolved sodium, magnesium, and chloride. Upward trends in concentrations of fecal streptococcus bacteria and total ammonia were most common in basins dominated by agricultural land use. Dominant land use nearest the monitoring station tended to be more strongly associated with the water-quality trends than was aggregate land use for the entire basin.

Effluent discharge from wastewater-treatment facilities also appears to have strongly affected water-quality trends in New Jersey drainage basins. Upward trends in pH and in concentrations of many dissolved ions were commonly found in basins having the greatest amounts of effluent discharged to streams. In addition, upward trends in concentrations of dissolved oxygen were detected in drainage basins where effluent was discharged primarily from nonmunicipal wastewater-treatment facilities rather than from municipal wastewater-treatment facilities. Trends in biochemical oxygen demand and nutrients showed little association with the amount of effluent discharged to streams.

Trends in concentrations of some dissolved ions, especially sodium and chloride, were strongly associated with the application rates of road-deicing salts. These associations explain the upward trends in concentrations of dissolved sodium and dissolved chloride commonly found in New Jersey streams. Dissolved-magnesium trends were associated with many drainage-basin characteristics; together these associations indicate storm runoff as a primary contributor of magnesium to streams.

Noteworthy is the absence of statistical associations between the trends in concentrations of nutrients and most measures describing drainage-basin activities. The nearly significant association detected between total phosphorus trends and cropland soil-erosion rates, together with the associations found between total ammonia trends and agricultural land use, seem to indicate that nonpoint sources may be more of an influence on these constituents than effluent discharge.

No spatial patterns were found in the trends for most water-quality constituents and properties; rather, the trends tended to occur uniformly across the State. An exception was the frequent occurrence of dissolved sodium trends in the northern one-half of New Jersey. In addition, the water-quality trends had little association with the seasons of the year or with changes in streamflow at the time of sampling.

Many of the associations identified in this report match those reported in national studies by previous investigators. However, information describing atmospheric deposition and various other nonpoint sources that have been associated with national water-quality trends were unavailable for the drainage basins discussed in this report.

INTRODUCTION

Federal and State programs designed to monitor and assess the quality of the Nation's waters increased in the 1970's and 1980's after the enactment of Federal and State clean-water laws. Many of these monitoring programs were intended to assess long-term trends in, and the effects of human activities on, water quality. In New Jersey, routine, statewide water-quality-monitoring programs have been in place since the mid-1970's.

Also in the 1970's and 1980's, many new Federal and state programs were developed to manage wastes entering surface and ground waters. The control and treatment of wastes to the Nation's rivers, lakes, estuaries, and oceans is estimated to have cost more than $406 billion from 1972 through 1986 (U.S. Environmental Protection Agency, 1990a). In New Jersey alone, an estimated $2.2 billion in Federal and State grants and loans was spent in this same period for new and upgraded public wastewater-treatment facilities (New Jersey Department of Environmental Protection, 1988). This latter cost for New Jersey does not include monies spent by commercial and industrial wastewater- treatment facilities, nor does it include funds spent by county and municipal governments.

In the 1980's, some studies were done to assess changes in surface-water quality resulting from water-pollution-control efforts. Smith and others (1987a, 1987b) examined two nationwide monitoring programs for time-series trends in water-quality data, and they attempted to explain the trends in relation to upstream basin characteristics and human activities. In an effort to determine if the regional trends in surface-water-quality data found by Smith and others (1987a, 1987b) could be detected in smaller areas, Hay and Campbell (1990) analyzed surface-water-quality trends in New Jersey among data collected in water years (WY) 1976-86[1] by the U.S. Geological Survey and the State of New Jersey. Hay and Campbell (1990) detected numerous water-quality trends, but did not evaluate factors that contribute to the occurrence of those trends.

[1]In this report, water year refers to the 12-month period October 1 through September 30. The water year is designated by the calendar year in which it ends; thus, the period October 1, 1975, through September 30, 1986, is referred to as "WY 1976-86." All water years are noted "WY"; years not preceded by this notation are calendar years.

The U.S. Geological Survey conducted an investigation during 1989-91 to identify associations between the water-quality trends reported by Hay and Campbell (1990) for New Jersey streams and characteristics of the upstream drainage basins. The purpose of the testing for associations between water- quality trends and basin characteristics is preliminary identification of basin characteristics that may have affected the detected water-quality trends. The results of these tests can then provide information on where more intensive analysis may be done in the future.

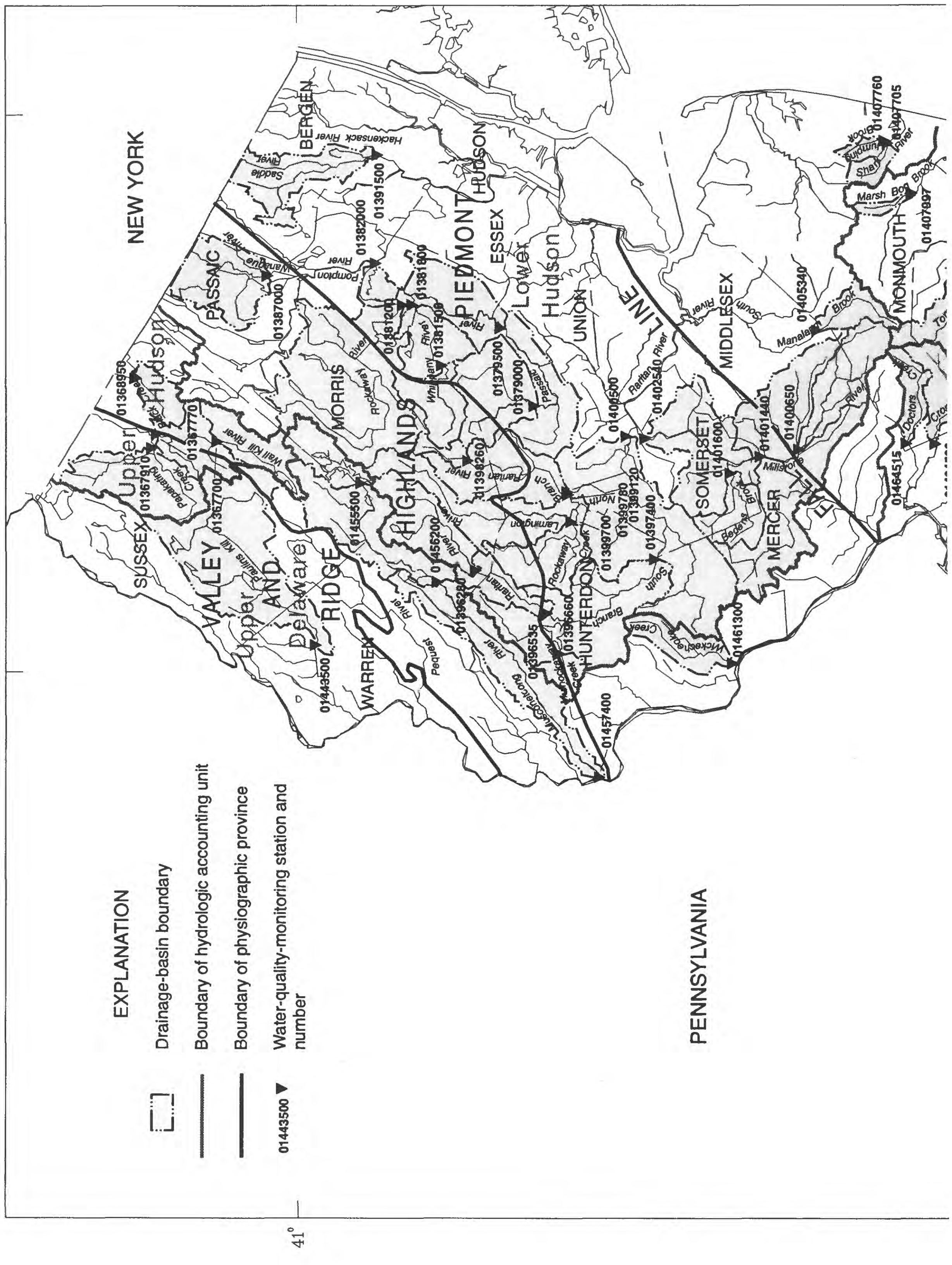
Thirteen water-quality constituents and two physical properties that Hay and Campbell (1990) most commonly found to have trends during WY 1976-86 were statistically analyzed to establish associations between trends and basin characteristics. These constituents and properties are pH, specific conductance, dissolved oxygen, biochemical oxygen demand, total ammonia, total nitrogen, total phosphorus, total organic carbon, dissolved calcium, dissolved magnesium, dissolved sodium, dissolved potassium, dissolved chloride, and fecal coliform and fecal streptococcus bacteria. A significant upward trend or downward trend was found for each of these constituents and properties at 10 percent or more of the stream-monitoring stations included in the previous analysis (Hay and Campbell, 1990). Trends in concentrations of two additional constituents, dissolved sulfate and total lead, also were common; however, these constituents were not included because certain laboratory and field- collection methods were found to have produced questionable results during WY 1976-86 (D.A. Rickert, U.S. Geological Survey, written commun., 1989; J.C. Schornick, U.S. Geological Survey, oral commun., 1991).

Purpose and Scope

This report describes the results of a study to identify statistical associations between the water-quality trends found in New Jersey streams from October 1, 1975, to September 30, 1986, (WY 1976-86) by Hay and Campbell (1990), and characteristics of the drainage basins above the stream-monitoring stations where data were collected. The report also describes the collection and preparation of various data used in the characterization of the drainage basins and the statistical methods employed to associate water-quality trends with the drainage-basin characteristics. Characteristics of basins include type and percentage of various land-use categories, amount and type of treated wastewaters released to streams, population density and change during WY 1976-86, amount of and change in agricultural fertilizer use, severity of soil erosion on cropland, amount of land irrigated for agricultural purposes, and amount of and changes in road-salt use.

Description of the Study Area

Sixty drainage basins compose the study area described in this report (fig. 1 and table 1). Seven of the 67 stream-monitoring stations analyzed for water-quality trends by Hay and Campbell (1990) were not included because most of their upstream drainage basin is outside New Jersey. The remaining 60 drainage basins range in size from 1.13 to 490 mi^2 and represent approximately 40 percent of the total land area of New Jersey. All but two of New Jersey's 21 counties are fully or partly drained by the 60 basins. The drainage basins in this report do not include any tidally influenced waters.


EXPLANATION
Drainage-basin boundary
Boundary of hydrologic accounting unit
Boundary of physiographic province
Water-quality-monitoring station and number
01443500
NEW YORK
PENNSYLVANIA
74°
75°
41°
SUSSEX
PASSAIC
BERGEN
MORRIS
ESSEX
HUDSON
UNION
WARREN
HUNTERDON
SOMERSET
MIDDLESEX
MERCER
MONMOUTH
VALLEY AND RIDGE
HIGHLANDS
PIEDMONT
Upper Hudson
Lower Hudson
Upper Delaware
Hackensack River
Saddle River
Pompton River
Wanaque River
Rockaway River
Passaic River
Wall Kill River
Paulins Kill
Pequest River
Raritan River
Lamington
Millstone
Manalapan Brook
South River
Marsh Bog Brook
Musconetcong River
Wickecheoke Creek

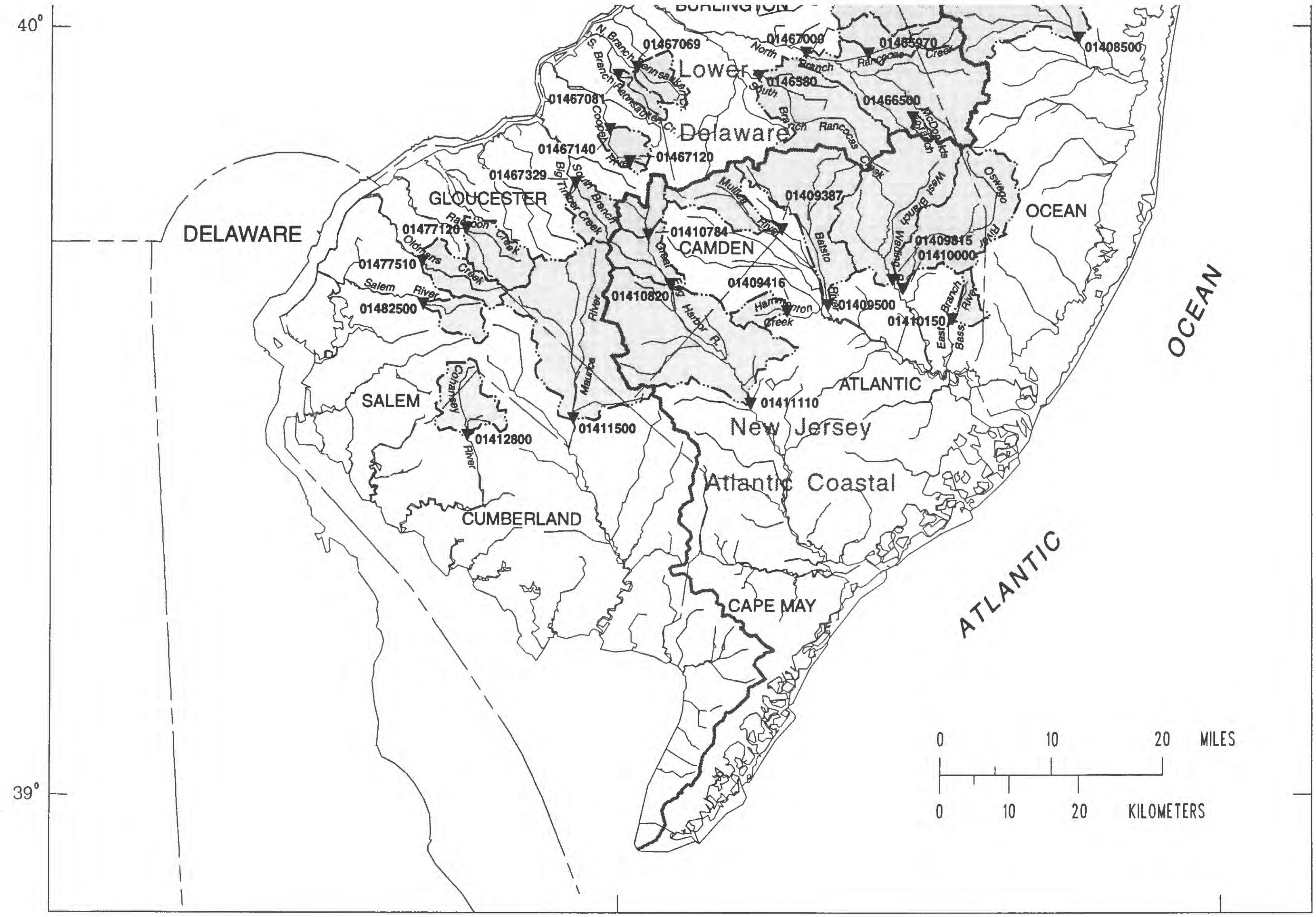


Figure 1. Location of stream water-quality-monitoring stations in New Jersey and corresponding drainage basins used in the study.

Table 1. New Jersey drainage basins used to associate trends in water-quality data with basin characteristics

[mi^2, square miles; hydrologic accounting unit from Seaber and others (1987); physiographic province from Ayers and Pustay (1988)]

Drainage basin	Monitoring-station number	Drainage area (mi^2)	Hydrologic accounting unit	Physiographic province
Wallkill River at Franklin	01367700	29.4	Upper Hudson	Valley and Ridge
Wallkill River near Sussex	01367770	60.8	Upper Hudson	Valley and Ridge
Papakating Creek at Sussex	01367910	59.4	Upper Hudson	Valley and Ridge
Black Creek near Vernon	01368950	17.3	Upper Hudson	Highlands
Passaic River near Millington	01379000	55.4	Lower Hudson	Piedmont
Passaic River near Chatham	01379500	100	Lower Hudson	Piedmont
Rockaway River at Pine Brook	01381200	136	Lower Hudson	Piedmont
Whippany River at Morristown	01381500	29.4	Lower Hudson	Piedmont
Whippany River near Pine Brook	01381800	68.5	Lower Hudson	Piedmont
Passaic River at Two Bridges	01382000	361	Lower Hudson	Piedmont
Wanaque River at Wanaque	01387000	90.4	Lower Hudson	Highlands
Saddle River at Lodi	01391500	54.6	Lower Hudson	Piedmont
SB Raritan River at Middle Valley	01396280	47.6	Lower Hudson	Highlands
SB Raritan River at Arch St at High Bridge	01396535	68.8	Lower Hudson	Piedmont
Mulhockaway Creek at Van Syckel	01396660	11.8	Lower Hudson	Piedmont
SB Raritan River at Three Bridges	01397400	181	Lower Hudson	Piedmont
NB Raritan River near Chester	01398260	7.57	Lower Hudson	Highlands
NB Raritan River at Burnt Mills	01399120	63.8	Lower Hudson	Piedmont
Rockaway Creek at Whitehouse	01399700	37.1	Lower Hudson	Piedmont
Lamington (Black) River at Burnt Mills	01399780	100	Lower Hudson	Piedmont
Raritan River at Manville	01400500	490	Lower Hudson	Piedmont
Millstone River at Grovers Mill	01400650	43.4	Lower Hudson	Piedmont
Millstone River at Kingston	01401440	172	Lower Hudson	Piedmont
Beden Brook near Rocky Hill	01401600	27.6	Lower Hudson	Piedmont
Millstone River at Weston	01402540	271	Lower Hudson	Piedmont
Manalapan Brook at Federal Rd near Manalapan	01405340	20.9	Lower Hudson	Coastal Plain
Shark River near Neptune City	01407705	9.96	Lower Hudson	Coastal Plain
Jumping Brook near Neptune City	01407760	6.46	Lower Hudson	Coastal Plain
Marsh Bog Brook at Squankum	01407997	4.91	N.J. Atlantic Coastal	Coastal Plain
Toms River near Toms River	01408500	123	N.J. Atlantic Coastal	Coastal Plain
Mullica River at outlet of Atsion Lake at Atsion	01409387	26.7	N.J. Atlantic Coastal	Coastal Plain
Hammonton Creek at Wescoatville	01409416	9.57	N.J. Atlantic Coastal	Coastal Plain
Batsto River at Batsto	01409500	67.8	N.J. Atlantic Coastal	Coastal Plain
WB Wading River at Maxwell	01409815	85.9	N.J. Atlantic Coastal	Coastal Plain
Oswego River at Harrisville	01410000	72.5	N.J. Atlantic Coastal	Coastal Plain
EB Bass River near New Gretna	01410150	8.11	N.J. Atlantic Coastal	Coastal Plain
Great Egg Harbor River near Sicklerville	01410784	15.1	N.J. Atlantic Coastal	Coastal Plain
Great Egg Harbor River near Blue Anchor	01410820	37.3	N.J. Atlantic Coastal	Coastal Plain
Great Egg Harbor River at Weymouth	01411110	154	N.J. Atlantic Coastal	Coastal Plain
Maurice River at Norma	01411500	112	Lower Delaware	Coastal Plain
Cohansey River at Seeley	01412800	28	Lower Delaware	Coastal Plain
Paulins Kill at Blairstown	01443500	126	Upper Delaware	Valley and Ridge
Musconetcong River at outlet of Lake Hopatcong	01455500	25.3	Upper Delaware	Highlands
Musconetcong River at Beatyestown	01456200	90.3	Upper Delaware	Highlands
Musconetcong River at Riegelsville	01457400	156	Upper Delaware	Highlands
Wickecheoke Creek at Stockton	01461300	26.6	Upper Delaware	Piedmont
Crosswicks Creek at Extonville	01464500	81.5	Lower Delaware	Coastal Plain
Doctors Creek at Allentown	01464515	17.4	Lower Delaware	Coastal Plain
SB Rancocas Creek at Vincentown	01465850	64.5	Lower Delaware	Coastal Plain
NB Rancocas Creek at Browns Mills	01465970	27.4	Lower Delaware	Coastal Plain
McDonalds Branch in Lebanon State Forest	01466500	2.35	Lower Delaware	Coastal Plain
NB Rancocas Creek at Pemberton	01467000	118	Lower Delaware	Coastal Plain
NB Pennsauken Creek near Moorestown	01467069	12.8	Lower Delaware	Coastal Plain
SB Pennsauken Creek at Cherry Hill	01467081	8.98	Lower Delaware	Coastal Plain
Cooper River at Norcross Rd at Lindenwold	01467120	1.13	Lower Delaware	Coastal Plain
Cooper River at Lawnside	01467140	12.7	Lower Delaware	Coastal Plain
SB Big Timber Creek at Blackwood Terrace	01467329	19.1	Lower Delaware	Coastal Plain
Raccoon Creek near Swedesboro	01477120	26.9	Lower Delaware	Coastal Plain
Oldmans Creek at Porches Mill	01477510	21	Lower Delaware	Coastal Plain
Salem River at Woodstown	01482500	14.6	Lower Delaware	Coastal Plain

Physiography, Geology, and Hydrology

New Jersey encompasses parts of four major physiographic provinces: Valley and Ridge, Highlands, Piedmont, and Coastal Plain (fig. 1) (Ayers and Pustay, 1988). The Coastal Plain and Piedmont provinces are separated by the Fall Line. The topographic, hydrologic, and geologic characteristics of the Coastal Plain are notably different from those of the northern three provinces. The State's surface drainage has been divided into five hydrologic-accounting areas by Seaber and others (1987): Upper Hudson, Lower Hudson, New Jersey Atlantic Coastal, Upper Delaware, and Lower Delaware (fig. 1).

The Coastal Plain is the largest physiographic province in New Jersey, comprising about 55 percent of the State's area. The geology of the Coastal Plain is typically unconsolidated sand, gravel, silt, and clay that thickens south and east of the Fall Line. The materials in the Coastal Plain are primarily marine sediments from the Cretaceous period, and they form extensive aquifers that are the primary source of water for public, commercial, and domestic purposes. Topographically, the Coastal Plain has low relief throughout. As much as 90 percent of the surface water in the Coastal Plain originates from ground-water sources. Ground water and surface water of the Coastal Plain tend to be acidic, have moderate to high noncarbonate hardness, and have low buffering capacity.

North of the Fall Line, the topography changes and land-surface elevation increases with latitude. The Piedmont Province is underlain by shale and sandstone; the Highlands Province by crystalline rocks such as gneiss, marble, and quartzite; and the Valley and Ridge Province by sedimentary units that include limestones. Where glaciation has occurred, glacial sand and gravel have filled the valleys. The quality of ground water and surface water north of the Fall Line is highly variable in quality because of the geologic variety of the three physiographic provinces.

The Upper Hudson drainage in New Jersey, as defined by Seaber and others (1987), includes the Wallkill River and its tributaries. These streams flow north into New York after draining 203 mi^2 of New Jersey (New Jersey Department of Environmental Protection, 1988). All these streams are in the Valley and Ridge Province. The Lower Hudson drainage includes much of northern and central New Jersey. This area contains the densely populated and industrialized sections of the State that are associated with the New York Metropolitan area. The Raritan River Basin is the largest basin (1,100 mi^2) that is entirely within the State (New Jersey Department of Environmental Protection, 1988). Major tributaries to the Raritan River are the North Branch Raritan River, the South Branch Raritan River, the Millstone River, and the South River. The Raritan River Basin drains parts of all four physiographic provinces in the State. The Passaic River Basin drains 919 mi^2 of northeastern New Jersey, including parts of the Piedmont and Highlands Provinces (New Jersey Department of Environmental Protection, 1988). Its major tributaries are the Pompton River, the Rockaway River, and the Saddle River. The Hackensack River Basin, originating in New York, drains 202 mi^2 of the Piedmont Province in the northeast corner of New Jersey (New Jersey Department of Environmental Protection, 1988).

The New Jersey Atlantic Coastal drainage includes the eastern half of southern New Jersey. The drainage area is fully within the Coastal Plain Province and consists of many streams that flow east to tidal bays and the Atlantic Ocean. A mixture of population centers, woodlands, and agricultural lands are found in the Atlantic Coastal drainage. Major streams and their drainage basins include the Toms (192 mi^2), Mullica (569 mi^2), and Great Egg Harbor (347 mi^2) Rivers (Velnich, 1984).

The western part of New Jersey drains to the Delaware River Basin. The Upper Delaware River drainage area includes all Delaware River drainage from Trenton north and transects all four physiographic provinces in the State. Major tributaries to the Delaware River in this drainage area are Paulins Kill (177 mi^2), the Pequest River (157 mi^2), and the Musconetcong River (156 mi^2) (Velnich, 1982). The Lower Delaware drainage area includes all Delaware River and Bay drainage south of Trenton. The Lower Delaware drainage is entirely within the Coastal Plain Province. Major streams in the Lower Delaware include Crosswicks Creek (144 mi^2), Rancocas Creek (340 mi^2), the Salem River (117 mi^2), and the Maurice River (382 mi^2) (Velnich, 1982). Much of the land use in the Delaware River Basin in New Jersey is farmland and woodland, but major population centers are found at Trenton and Camden.

Climate

Variation in the distribution of precipitation across the State reflects differences in terrain. Average annual precipitation in New Jersey statewide is 44 in.; annual precipitation ranges from 40 in. in the south to 52 in. in the northern mountains (Bauersfeld and others, 1991). Precipitation falls fairly uniformly throughout the year, although the interior of the State tends to receive the greatest amounts in the summer from thunderstorms. Annual snowfall is highly variable, ranging from 13 to 50 in. in the extreme southern and northern parts of the State, respectively.

January is typically the coldest month of the year in New Jersey. Average temperatures range from 33°F in the south to 25°F in the north (Ludlum, 1983). The warmest month usually is July. During July, average temperatures in New Jersey range from 70°F in the north to 76°F in the southwest.

During 1975-86, precipitation in New Jersey was highly variable in comparison to long-term averages. It was above normal during 1972-75 but well below normal during 1976-77. Lack of precipitation resulted in streamflows during 1976-77 that approached those during the drought of record in the mid-1960's. Precipitation and streamflows recovered in 1978 and 1979 to near and above normal; however, 1980 and 1981 were again years of reduced precipitation and streamflows across the State. A drought emergency was declared for the State from fall 1980 to fall 1981. During 1982-84, precipitation and streamflows were normal to above normal. Reduced precipitation, especially in the southern part of the State, occurred in the final 2 years of the period.

Previous Investigations

In the 1980's, there was much public and government interest in quantifying improvements in surface-water quality that resulted from national legislation in the 1970's aimed at reducing waste discharges to streams. The Association of State and Interstate Water Pollution Control Administrators (ASIWPCA)(1984) did a nationwide survey of state and interstate water- pollution-control agencies in order to qualitatively identify changes in water quality during 1972-82. Streamwater-quality data and professional opinion were the basis for the conclusions presented in the surveys. After compiling the surveys, ASWIPCA (1984) reported that 13 percent of the stream miles assessed nationwide had improved, whereas 3 percent had declined in quality. Using the same methodology for assessment of New Jersey surface waters, the New Jersey Department of Environmental Protection (NJDEP) (1984) noted a general improvement in water quality statewide as a result of improved wastewater treatment at municipal and industrial wastewater-treatment facilities.

Also in the early 1980's, new applications of statistical methods had been developed that allowed for improved analysis of time-series trends in water-quality data (Hirsch and others, 1982; Hirsch and Slack, 1984; Crawford and others, 1983; van Belle and Hughes, 1984). All these studies promoted the use of the Seasonal Kendall test for detecting trends in water-quality data. This test, a modification of the nonparametric Kendall's tau test, adjusts for the serial correlation of data that results from seasonal variations in water-quality data. Hirsch and others (1982) and Crawford and others (1983) also incorporated regression-analysis techniques for eliminating the detection of water-quality trends resulting from changes in streamflow; this process is termed flow adjustment.

Smith and others (1987a, 1987b) did trend analysis of water-quality data collected at more than 300 stream-monitoring stations nationwide using the Seasonal Kendall test and flow adjustment. They found widespread increases in concentrations of nitrate, chloride, arsenic, and cadmium; and decreases in concentrations of fecal coliform and fecal streptococcus bacteria and lead from October 1974 through October 1981. Trends in concentrations of suspended solids, phosphorus, and nitrate all exhibited distinct regional patterns.

Smith and others (1987a, 1987b) also identified statistical associations between the detected water-quality trends and various measures of upstream basin characteristics and human activities. They found that improvements in municipal wastewater treatment, declines in leaded-gasoline use, increased use of road-deicing materials, increased fertilizer-application rates, and increased combustion of fossil fuels all appear to be associated with the trends of selected constituents and properties. Possible causes of most localized or regional trends could not be determined because of the large scale of their study.

Lettenmaier and others (1991) analyzed water-quality trends at 403 stream-monitoring stations nationwide for 1978-87. The most frequently detected trends included increasing concentrations of dissolved ions and total nitrogen and decreasing concentrations of total phosphorus. Exploratory analysis of possible relations between the trends and drainage-basin characteristics resulted in few significant relations that could explain the observed trends.

In an effort to determine whether water-quality trends similar to those found by Smith and others (1987a, 1987b) could be detected in New Jersey, Hay and Campbell (1990) did trend analyses of water-quality data from New Jersey streams for WY 1976-86 and 1980-86. Hay and Campbell (1990) described the available water-quality data, the criteria developed to determine if trend analysis was possible, the statistical tests employed, and all trend results. They detected trends at 67 and 86 stream-monitoring stations for WY 1976-86 and 1980-86, respectively. All stations were sampled routinely 4 to 12 times per year for both study periods. The Seasonal Kendall test (flow adjusted, where possible) and the Censored Data Regression method (Cohn and Stedinger, 1987) were used to detect trends in the data for more than 50 constituents and properties.

Trends most frequently identified in New Jersey streams by Hay and Campbell (1990) for the WY 1976-86 and 1980-86 study periods included upward trends in specific conductance and concentrations of fecal streptococcus bacteria and dissolved oxygen, dissolved calcium, dissolved magnesium, dissolved sodium, and dissolved chloride; and upward trends and downward trends in pH and concentrations of total phosphorous, dissolved sulfate, and fecal coliform bacteria. Downward trends in concentrations of total lead and total organic carbon were noted for WY 1976-86 only. The trend results reported by Hay and Campbell (1990) for the 13 constituents and 2 properties examined in this report are summarized in table 2. Data from Hay and Campbell (1990) form the basis for associating trends in water quality data with basin characteristics, as discussed in this report.

Acknowledgments

Various agencies provided the U.S. Geological Survey with much of the information discussed in this report. The authors thank Michael Dillon and Isadore Cooperman of the New Jersey Department of Environmental Protection, Alfred Woodrow of the New Jersey Department of Transportation, Steven Rubin of the U.S. Environmental Protection Agency, and Tom Drewes of the U.S. Natural Resources Conservation Service (formerly the Soil Conservation Service) for their efforts in providing data on basin characteristics.

DRAINAGE-BASIN CHARACTERISTICS

The water-quality trends in New Jersey streams identified by Hay and Campbell (1990) are inherently related to characteristics of the drainage-basin above the monitoring station. An understanding of drainage-basin characteristics--such as streamflow, land uses, wastewater disposal, and human population--during the period of water-quality data collection used in the trend analysis can assist in determining which basin characteristics may have affected the observed water-quality changes. Other factors such as atmospheric deposition and climatic changes also can contribute to the trends detected in water quality.

Information on selected drainage-basin characteristics, also called ancillary data, that are considered to have important influences on water quality in New Jersey were assembled for the 60 drainage basins analyzed in this report (table 3). The ancillary data measure not only static conditions but also change during or preceding the WY 1976-86 study period. The investigators

Table 2. Results of trend analyses for 13 streamwater constituents and 2 physical properties at selected sites on New Jersey streams, water years 1976-86

[Based on data from Hay and Campbell (1990). µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; laboratory codes are those used by the U.S. Geological Survey for data storage and retrieval]

Constituent or physical property (unit)	Laboratory code	Number of monitoring stations analyzed for trends	Number (percent of total) with an upward trend	Number (percent of total) with a downward trend
Specific conductance (µs/cm)	00095	64	22 (34)	5 (8)
Dissolved oxygen (mg/L)	00300	62	17 (27)	2 (3)
Biochemical oxygen demand, 5 day (mg/L)	00310	49	4 (8)	7 (14)
pH (standard units)	00400	61	19 (31)	6 (10)
Total nitrogen, as N (mg/L)	00600	23	6 (26)	1 (4)
Total ammonia, as N (mg/L)	00610	21	9 (43)	0 (0)
Total phosphorus, as P (mg/L)	00665	46	5 (11)	4 (9)
Total organic carbon (mg/L)	00680	57	0 (0)	35 (61)
Dissolved calcium (mg/L)	00915	61	12 (21)	0 (0)
Dissolved magnesium (mg/L)	00925	61	16 (26)	3 (5)
Dissolved sodium (mg/L)	00930	62	39 (63)	3 (5)
Dissolved potassium (mg/L)	00935	62	2 (3)	17 (27)
Dissolved chloride (mg/L)	00940	63	49 (78)	2 (3)
Fecal coliform bacteria (MPN/100 mL)	31615	57	8 (14)	8 (14)
Fecal streptococcus bacteria (MPN/100 mL)	31677	53	17 (32)	0 (0)

Table 3. Drainage-basin characteristics tested in this study for associations with trends in water-quality data in New Jersey

[ft^3/s, cubic feet per second; mi^2, square mile; $Mgal/d/mi^2$, million gallons per day per square mile; $kg/d/mi^2$, kilograms per day per square mile; ton/mi^2, tons per square mile; ton/acre/yr, tons per acre per year]

Drainage-basin characteristic (unit)	Description
Stream discharge (ft^3/s)	Annual mean discharge for water years 1971-91 and 1976-86 at continuous gaging stations for 16 drainage basins; trends of either continuous or instantaneous stream discharge for all drainage basins.
Drainage basin size (mi^2)	Size of the drainage basin above the 60 water-quality monitoring stations.
Physiographic province	Physiographic province of the 60 monitoring stations, as listed in table 1.
Land-cover type (percent of basin)	The percentage of each drainage basin classified as agricultural, forested, or urban land; percentage of these land-cover types also determined for a 3.1- and 0.62-mile upstream area from each monitoring station (Mitchell and others, 1977).
Population	Estimated 1975 and 1986 population for each drainage basin, including change during the period and population density (N.J. Department of Labor, 1976, 1987).
Wastewater disposal ($Mgal/d/mi^2$, $kg/d/mi^2$)	Number of permitted-wastewater treatment facility discharges in each drainage basin for years 1975 and/or 1986; data from the Permit Compliance System data base (U.S. Environmental Protection Agency, 1990b) on the average yields of wastewater discharage and biochemical oxygen demand and total suspended solid loads discharged in 1986 per square mile in the basin and an area 3.1 miles upstream from each monitoring station; and the percentage of wastewater discharge originating from municipal and nonmunicipal facilities.
Road-salt application (ton/mi^2)	Estimated amount of calcium, sodium, and chloride applied to roads in each drainage basin during the winter seasons from 1975-76 through 1986-87 by the N.J. Department of Transportation (Alfred Woodrow, N.J. Department of Transportation, written commun., 1989); and trends in calcium, sodium, and chloride use during the same period.
Agricultural fertilizer (ton/mi^2)	Estimated amount of nitrogen and phosphorus fertilizer used in each basin during 1975-85 for agricultural purposes (Richard Alexander, U.S. Geological Survey, written commun., 1989), and trends in their use during the period.
Cropland soil erosion rates/irrigated acreage (ton/acre/yr) (percentage of basin area irrigated)	Average cropland erosion rates and percentage of area irrigated for 39 of the drainage basins (U.S. Department of Agriculture, 1986).

emphasized collection of ancillary data that were already in digital form for use in a geographic information system (GIS). The GIS was then used to assign all ancillary data to the 60 drainage basins.

Some of the ancillary data are direct measures of contaminant release to streams, such as amounts of effluent (treated wastewater) discharge from wastewater-treatment facilities, whereas other ancillary data are estimators for data that are unavailable. (For example, population density was used as an indicator of the density of urban development.) Some of the ancillary data were available only at the county or the regional level. As a result, the spatial nature of the data can describe a basin characteristic in general terms only. Where the ancillary data were descriptive for an area other than the drainage basin, such as a county or municipality, the data had to be adjusted to represent conditions within the drainage basin.

Certain drainage-basin characteristics and factors thought to be important indicators of water quality in New Jersey were not used in the study because the data were either unavailable or not readily available. These data included information on atmospheric-deposition rates of dissolved materials, the type and intensity of agricultural activities, and the locations of sewered and unsewered areas. Finally, some of the ancillary data described below to characterize drainage basins were not available for WY 1976-86, but rather for years immediately before or after this period.

Streamflow

Concentrations of many water-quality constituents are strongly related to flows in streams. In addition to the use of flow-adjustment procedures in trends testing by Hay and Campbell (1990) for many constituents, an understanding of streamflow conditions during WY 1976-86 may be helpful in attempting to find causes for the detected water-quality trends.

Streamflow characteristics during WY 1976-86 are available for all 60 drainage basins. Continuous streamflow records were published by the U.S. Geological Survey for 15 of the 60 monitoring stations (table 4). Streamflow was estimated at the remaining 45 water-quality monitoring stations. This estimation of streamflow is based on the observed gage height of the water in the stream at the time of water-quality sample collection; this height is indexed to sites instrumented to record streamflow continuously.

Streamflow characteristics for the 15 continuous-record stations for WY 1976-86 and WY 1972-91, as well as the relative degree to which streamflow in the drainage basin is regulated by upstream diversions and storage, are listed in table 4. Mean annual streamflow at 14 of the 15 gaging stations for WY 1976-86 was less than the mean annual streamflow during the 21-year period of WY 1972-91. Precipitation during 1975-86 was slightly above normal in the northern part of New Jersey (114 percent of normal at Newark) and below normal in the southern part of the State (87 percent of normal at Atlantic City). In addition, the State experienced droughts in 1980-81 and 1985; these droughts are a likely factor in the lower mean annual stream discharges reported for WY 1976-86.

Table 4. Statistical summary of stream-discharge characteristics and trends, water years 1971-91, for New Jersey stream-monitoring stations where continuous discharge measurements and water-quality trend results are available

[ft^3/s, cubic feet per second; n, sample size for trends testing and is the number of years of available annual mean streamflows; tau, Kendall's tau computed test statistic; p-value, the probability that the annual mean streamflows during water years 1971-91 resulted from chance rather than an actual change in annual mean flow. Amount of stream discharge regulation in drainage basin from Robert Schopp, U.S. Geological Survey, oral commun., 1993]

Monitoring-station name	Monitoring-station number	Mean annual streamflow (ft^3/s), for given range of water years		Amount of stream discharge regulation in drainage basin	Trends in annual mean flow, water years 1971-91		
		1971-91	1976-86		n	tau	p-value
Passaic River near Millington	01379000	109	102	Minor	21	-0.195	0.227
Passaic River near Chatham	01379500	201	184	Minor	21	-.229	.156
Whippany River at Morristown	01381500	66.8	62.4	Minor	21	-.171	.291
Wanaque River at Wanaque	01387000	72.9	78.0	Major	21	-.224	.165
Saddle River at Lodi	01391500	113	108	Moderate	21	-.162	.319
Raritan River at Manville	01400500	922	853	Moderate	21	-.162	.319
Shark River near Neptune City	01407705	15.0	14.4	Moderate	21	.010	.976
Jumping Brook near Neptune City	01407760	10.7	10.2	Moderate	21	.086	.608
Toms River near Toms River	01408500	221	212.2	Minor	21	-.210	.194
Batsto River at Batsto	01409500	120	113	Minor	21	-.067	.695
Crosswicks Creek at Extonville	01464500	147	139	Minor	21	-.276	.085
McDonalds Branch in Lebanon State Forest	01466500	2.24	2.13	None	21	-.210	.194
NB Rancocas Creek at Pemberton	01467000	182	171	Minor	21	-.162	.319
SB Pennsauken Creek at Cherry Hill	01467081	19.2	18.2	Minor	21	.474	.795
Raccoon Creek near Swedesboro	01477120	41.8	38.4	None	21	-.219	.174

Trend analysis of the annual mean streamflow during WY 1972-91 at the 15 continuous-record stations found no trend at any site for the period ($\alpha = 0.05$). Use of Kendall's tau correlation analysis (Snedecor and Cochran, 1967) showed that at one site, Crosswicks Creek at Extonville (U.S. Geological Survey station number 01464500), a downward trend in annual mean streamflow during the period was significant when α was increased to 0.10. A number of floods at the beginning of the period may have caused the observed trend in streamflow at this location.

Trends in instantaneous streamflow at the time of water-quality sampling during WY 1976-86 for all 60 stations were determined by use of the Seasonal Kendall test. Significant trends ($\alpha \leq 0.10$) were found at 12 stations (table 5). Instantaneous discharge decreased at 11 stations; all but two of these sites are located in the southern half of the State (fig. 2). These downward trends could be an artifact of procedural changes in the frequency of water-quality sampling and stream-height measurement that were made during WY 1976-86 at most stations. Sampling frequency was reduced from monthly at the beginning of the period to six times yearly in WY 1981. When the change was made to six samples per year, sample collection was not equally spaced throughout the year but was biased toward low-flow periods.

Geographic Setting

The geographic setting of a drainage basin is defined as the physiographic province in which the drainage basin is located (fig. 1 and table 1). When a drainage basin spans more than one physiographic province, the province where the monitoring station is located was taken to be the province for the entire basin. One-half of the 60 drainage basins are located entirely or partly in the Coastal Plain Province, which comprises approximately one-half of New Jersey. Nineteen drainage basins (32 percent of the 60) are in the Piedmont Province, four (6 percent) are in the Valley and Ridge Province, and seven (12 percent) are in the Highlands Province. On the whole, the distribution of water-quality monitoring stations and drainage basins by physiographic province is roughly proportional to the areas of the physiographic provinces within the State (fig. 1).

Land Use

New Jersey is a major industrial and commercial center in the northeastern United States. In 1990, 33 percent of the State was classified as urban land (U.S. Department of Commerce, 1991); no other state in the nation had a higher percentage of urban land. Yet, 21 percent of the land in New Jersey in 1990 was still active farmland. Forests accounted for 25 percent of the land use in the State, and the remaining 21 percent of land consisted of a variety of other uses such as wetlands, transportation corridors, and mining (U.S. Department of Commerce, 1991).

Even though slightly more than one-fifth of New Jersey was farmland in 1990, the amount of farmland has declined steadily throughout the State since the late 1800's. Between 1950 and 1989, the amount of farmland decreased by more than 800,000 acres (New Jersey Department of Agriculture, 1989). Much of this lost farmland was converted to residential, commercial, and industrial uses.

Table 5. Statistical trend results for instantaneous streamflow data, water years 1976-86, at the 60 New Jersey stream-monitoring stations tested for water-quality-data trends

[n, sample size for trends testing and is the number of instantaneous streamflow values; tau, Kendell's tau computed test statistic; p-value, the probability that instantaneous streamflow values occur randomly rather than occur as a result in an actual change in streamflow]

Monitoring-station name	Monitoring-station number	n	tau	p-value
Wallkill River at Franklin	01367700	43	0.089	0.506
Wallkill River near Sussex	01367770	46	-.064	.631
Papakating Creek at Sussex	01367910	43	-.096	.480
Black Creek near Vernon	01368950	41	.066	.640
Passaic River near Millington	01379000	49	-.025	.862
Passaic River near Chatham	01379500	48	-.107	.393
Rockaway River at Pine Brook	01381200	52	-.067	.579
Whippany River at Morristown	01381500	49	-.056	.660
Whippany River near Pine Brook	01381800	49	-.005	1.000
Passaic River at Two Bridges	01382000	50	.073	.544
Wanaque River at Wanaque	01387000	47	-.210	.087*
Saddle River at Lodi	01391500	47	-.132	.295
SB Raritan River at Middle Valley	01396280	41	-.101	.486
SB Raritan River at Arch St at High Bridge	01396535	45	-.076	.575
Mulhockaway Creek at Van Syckel	01396660	51	-.044	.730
SB Raritan River at Three Bridges	01397400	42	.184	.170
NB Raritan River near Chester	01398260	46	-.036	.807
NB Raritan River at Burnt Mills	01399120	46	-.129	.306
Rockaway Creek at Whitehouse	01399700	48	-.053	.685
Lamington (Black) River at Burnt Mills	01399780	40	-.082	.560
Raritan River at Manville	01400500	51	.045	.726
Millstone River at Grovers Mill	01400650	47	.133	.289
Millstone River at Kingston	01401440	48	.033	.816
Beden Brook near Rocky Hill	01401600	52	-.245	.033*
Millstone River at Weston	01402540	49	.021	.894
Manalapan Brook at Federal Rd near Manalapan	01405340	37	-.009	1.000
Shark River near Neptune City	01407705	49	-.031	.825
Jumping Brook near Neptune City	01407760	48	-.208	.088*
Marsh Bog Brook at Squankum	01407997	44	-.072	.600
Toms River near Toms River	01408500	57	.033	.785
Mullica River at outlet of Atsion Lake at Atsion	01409387	43	-.045	.759
Hammonton Creek at Wescoatville	01409416	43	.000	1.000
Batsto River at Batsto	01409500	50	-.148	.216
WB Wading River at Maxwell	01409815	59	-.218	.037*
Oswego River at Harrisville	01410000	48	-.299	.014*
EB Bass River near New Gretna	01410150	49	-.215	.074*
Great Egg Harbor River near Sicklerville	01410784	48	-.144	.243
Great Egg Harbor River near Blue Anchor	01410820	53	-.056	.644
Great Egg Harbor River at Weymouth	01411110	46	-.114	.375
Maurice River at Norma	01411500	59	.023	.852
Cohansey River at Seeley	01412800	53	.063	.594
Paulins Kill at Blairstown	01443500	51	.200	.086*
Musconetcong River at outlet of Lake Hopatcong	01455500	51	.010	.964
Musconetcong River at Beatyestown	01456200	51	.036	.788
Musconetcong River at Riegelsville	01457400	44	-.006	1.000
Wickecheoke Creek at Stockton	01461300	46	.045	.747
Crosswicks Creek at Extonville	01464500	48	-.144	.242
Doctors Creek at Allentown	01464515	44	.042	.774
SB Rancocas Creek at Vincentown	01465850	47	-.342	.005*
NB Rancocas Creek at Browns Mills	01465970	47	-.220	.074*
McDonalds Branch in Lebanon State Forest	01466500	63	-0.213	0.032*
NB Rancocas Creek at Pemberton	01467000	46	-.317	.011*
NB Pennsauken Creek near Moorestown	01467069	49	-.227	.058*
SB Pennsauken Creek at Cherry Hill	01467081	53	-.068	.565
Cooper River at Norcross Rd at Lindenwold	01467120	49	-.130	.285
Cooper River at Lawnside	01467140	50	-.015	.929
SB Big Timber Creek at Blackwood Terrace	01467329	51	.059	.636
Raccoon Creek near Swedesboro	01477120	50	.050	.696
Oldmans Creek at Porches Mill	01477510	49	-.021	.894
Salem River at Woodstown	01482500	49	-.065	.610

* Trend considered significant at α 0.10

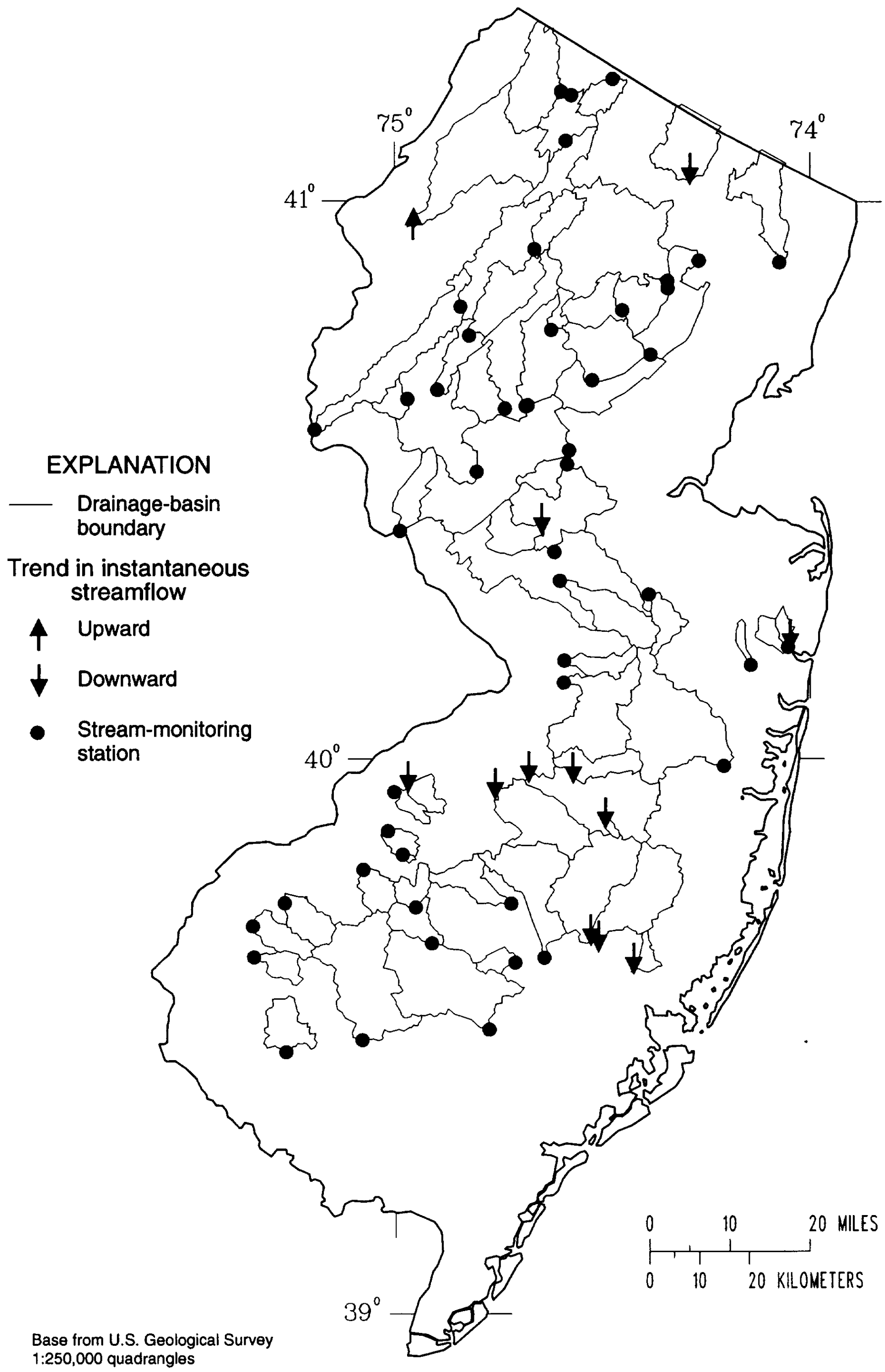


Figure 2. Locations of New Jersey stream-monitoring stations and detected trends in instantaneous streamflow, water years 1976-86.

Information on the presence and percentages of various land-use types in the 60 drainage basins can help identify the possible effects of land use on the observed water-quality changes. The only data that were readily available for describing land use in each of the 60 drainage basins are data from the National Cartographic Information Center at a scale of 1:250,000 (Mitchell and others, 1977). This national land-use data base, processed through the U.S. Geological Survey's Geographic Information Retrieval and Analysis System (GIRAS), is in digital form and is based on land-cover information from the late 1960's and early 1970's. Depending on the land use category, the GIRAS data base identifies individual land uses to a minimum resolution of approximately 10 acres. Because the GIRAS data have not been updated, no data were available to describe land use within the 60 drainage basins during WY 1976-86.

The GIRAS data differentiate land cover into 9 major classes and 37 subclasses (Anderson and others, 1976). The nine major classes are urban, agriculture, rangeland, forest, water, wetland, barren land, tundra, and perennial snow or ice.

The GIRAS data were assigned to each drainage basin with the assistance of a GIS to determine the type and percentage of each land use within the basin. Because urban, forest, and agriculture are the three most common land uses in the State according to the GIRAS data, the percentage of these land uses was the basis for characterizing each drainage basin (table 6). The percentage of the other six major land-cover types available in GIRAS were not determined because they are either not substantial or not present in the 60 drainage basins. The percentages of urban, agriculture, and forest land in areas 0.62 mi (1 kilometer) and 3.1 mi (5 kilometers) upstream from each monitoring station (table 6) also were identified with the GIRAS data to determine land use close to the monitoring stations.

Land-use characterization of each drainage basin indicated that forest was the dominant land use in 35 of the 60 drainage basins (58 percent); agricultural and urban land uses were dominant in 16 and 9 of the 60 drainage basins (27 and 15 percent), respectively (fig. 3). Closer to the monitoring stations, urban and agricultural land uses are more common. In the area 3.1 mi upstream from the monitoring station, forested land use was dominant in 29 of 60 areas (48 percent), agricultural land use was dominant in 19 of 60 areas (32 percent), and urban land use was dominant in 12 of 60 areas (20 percent). In the area 0.62 mi upstream from the monitoring station, urban and agriculture were each dominant in 22 of the 60 areas (37 percent), whereas forest was dominant in 16 of 60 areas (27 percent).

The GIRAS land-use data for the 60 drainage basins should be considered only as an indicator of the relative amount of urban, forest, and agricultural land in each basin during WY 1976-86. Because the GIRAS data are based on information that was collected 5 to 10 years before the beginning of WY 1976- 86, the GIRAS data may not accurately portray the amount of land in each land-use category in the drainage basins during the study period.

Table 6. Percentage of land use classified as forested, urban, and agricultural land in the New Jersey drainage basins studied
[Land use expressed as percentage of total area of basin; percentages may not add to 100 percent, owing to rounding and the presence of other land uses]

Drainage basin		Land use in the entire dainage basin			Land use in the area 3.1 miles upstream from monitoring station			Land use in the area 0.62 mile upstream from the monitoring station		
Monitoring-station name	Monitoring-station number	Forested	Urban	Agriculture	Forested	Urban	Agriculture	Forested	Urban	Agriculture
Wallkill River at Franklin	00367700	62.4	17.8	12.1	67.0	10.0	17.8	16.9	32.6	45.9
Wallkill River near Sussex	01367770	48.2	13.7	31.8	39.0	9.3	45.8	44.7	10.9	13.5
Papakating Creek at Sussex	01367910	82.0	13.0	2.6	11.7	6.5	80.8	0	47.8	50.7
Black Creek near Vernon	01368950	35.3	22.5	36.6	35.7	23.6	35.2	0	0	88.9
Passaic River near Millington	01379000	36.5	27.3	15.5	35.7	23.6	35.2	4.5	0	64.4
Passaic River near Chatham	01379500	31.0	40.6	15.0	15.2	55.4	6.6	0	100	0
Rockaway River at Pine Brook	01381200	58.1	31.3	2.9	24.4	54.3	10.0	13.9	69.6	0
Whippany River at Morristown	01381500	51.1	44.0	3.0	42.7	51.7	3.6	9.8	82.3	0
Whippany River near Pine Brook	01381800	28.8	55.3	2.2	11.0	57.1	1.4	0	34.5	0
Passaic River at Two Bridges	01382000	39.4	42.3	6.0	13.9	47.0	6.9	0	49.4	7.2
Wanaque River at Wanaque	01387000	74.4	15.6	0	64.9	19.7	0	9.4	26.3	0
Saddle River at Lodi	01391500	9.5	88.4	1.3	3.0	95.0	1.7	0	100	0
SB Raritan River at Middle Valley	01396280	56.4	16.5	24.7	57.1	10.4	32.5	58.8	8.3	33.0
SB Raritan River at Arch St at High Bridge	01396535	56.6	15.7	25.8	65.0	15.8	18.2	26.6	57.6	14.0
Mulhockaway Creek at Van Syckel	01396660	57.4	3.6	35.9	57.4	3.6	35.9	4.5	9.3	70.2
SB Raritan River at Three Bridges	01397400	40.8	11.3	43.8	15.8	20.1	64.1	0	16.0	84.0
NB Raritan River near Chester	01398260	63.0	26.2	10.8	60.7	27.3	12.0	28.8	45.6	25.6
NB Raritan River at Burnt Mills	01399120	50.6	14.0	35.0	25.8	8.2	65.9	0	9.5	90.5
Rockaway Creek at Whitehouse	01399700	44.8	10.3	44.3	43.0	14.3	41.7	38.5	10.9	50.6
Lamington (Black) River at Burnt Mills	01399780	46.9	10.7	39.3	36.6	12.5	50.1	27.4	3.8	68.8
Raritan River at Manville	01400500	34.8	14.0	48.8	18.5	60.4	19.9	0	69.0	31.0
Millstone River at Grovers Mill	01400650	25.2	11.2	63.1	5.0	13.9	81.1	0	7.7	92.3
Millstone River at Kingston	01401440	28.3	16.3	53.7	32.1	24.7	39.0	9.0	36.2	49.0
Beden Brook near Rocky Hill	01401600	42.2	9.3	48.4	31.9	10.4	57.7	0	17.7	82.3
Millstone River at Weston	01402540	34.7	18.3	45.1	16.3	13.9	69.4	19.3	23.6	57.1

Table 6. Percentage of land use classified as forested, urban, and agricultural land in the New Jersey drainage basins studied--Continued

Drainage basin		Land use in the entire dainage basin			Land use in the area 3.1 miles upstream from monitoring station			Land use in the area 0.62 mile upstream from the monitoring station		
Monitoring-station name	Monitoring-station number	Forested	Urban	Agriculture	Forested	Urban	Agriculture	Forested	Urban	Agriculture
Manalapan Brook at Federal Rd near Manalapan	01405340	28.7	3.4	66.8	28.8	5.2	65.6	70.4	0	29.6
Shark River near Neptune City	01407705	58.4	25.3	9.3	58.1	25.4	9.3	51.4	32.4	0
Jumping Brook near Neptune City	01407760	34.2	53.9	2.6	34.2	53.9	2.6	1.5	98.5	0
Marsh Bog Brook at Squankum	01407997	69.4	14.9	15.2	67.0	14.9	17.6	54.2	7.9	37.8
Toms River near Toms River	01408500	57.1	10.1	4.6	48.7	18.7	5.1	28.9	26.6	0
Mullica River at outlet of Atsion Lake at Atsion	01409387	53.4	9.4	6.9	78.3	1.3	1.8	6.3	19.9	12.0
Hammonton Creek at Wescoatville	01409416	17.4	22.5	50.1	17.4	22.5	50.1	22.4	0	53.5
Batsto River at Batsto	01409500	54.8	.9	14.9	83.4	.2	0	59.5	4.1	0
WB Wading River at Maxwell	01409815	68.4	.5	9.5	63.0	.3	12.0	78.2	0	2.5
Oswego River at Harrisville	01410000	80.6	3.6	2.6	69.6	0	6.1	66.9	0	0
EB Bass River near New Gretna	01410150	86.9	3.2	0	86.9	3.2	0	37.3	0	0
Great Egg Harbor River near Sicklerville	01410784	41.8	32.3	14.7	44.0	29.1	15.1	45.6	0	15.3
Great Egg Harbor River near Blue Anchor	01410820	41.1	24.8	18.5	41.6	17.7	17.9	27.1	12.2	5.0
Great Egg Harbor River at Weymouth	01411110	45.3	16.2	19.7	50.0	15.3	7.0	87.5	0	0
Maurice River at Norma	01411500	39.0	19.6	32.3	35.5	30.1	21.9	18.7	42.6	15.4
Cohansey River at Seeley	01412800	13.6	2.2	82.0	10.9	2.9	83.1	37.7	1.4	60.9
Paulins Kill at Blairstown	01443500	44.7	8.0	42.1	58.8	.6	39.6	65.1	2.4	32.5
Musconetcong River at outlet of Lake Hopatcong	01455500	55.7	24.5	0	38.2	33.9	0	10.0	58.7	0
Musconetcong River at Beatyestown	01456200	69.6	14.0	5.6	53.0	17.2	29.8	33.0	13.9	53.1
Musconetcong River at Riegelsville	01457400	55.7	10.9	27.4	54.9	2.4	42.7	40.0	6.7	53.4
Wickecheoke Creek at Stockton	01461300	23.3	1.1	75.7	26.1	1.0	72.9	51.6	0	48.4
Crosswicks Creek at Extonville	01464500	35.5	13.6	44.8	17.2	4.6	77.7	39.9	0	60.1
Doctors Creek at Allentown	01464515	17.9	7.9	73.0	2.1	10.9	85.8	0	60.8	30.9
SB Rancocas Creek at Vincentown	01465850	39.8	7.0	26.6	4.2	11.5	59.4	0	26.5	61.9

Table 6. Percentage of land use classified as forested, urban, and agricultural land in the New Jersey drainage basins studied--Continued

Drainage basin		Land use in the entire dainage basin			Land use in the area 3.1 miles upstream from monitoring station			Land use in the area 0.62 mile upstream from the monitoring station		
Monitoring-station name	Monitoring-station number	Forested	Urban	Agriculture	Forested	Urban	Agriculture	Forested	Urban	Agriculture
NB Rancocas Creek at Browns Mills	01465970	54.1	25.6	3.7	47.4	36.3	3.4	12.8	57.6	3.6
McDonalds Branch in Lebanon State Forest	01466500	96.0	0	0	96.6	0	0	91.3	0	0
NB Rancocas Creek at Pemberton	01467000	60.8	10.1	7.8	30.5	19.5	28.4	.1	49.4	33.3
NB Pennsauken Creek near Moorestown	01467069	18.4	41.8	39.1	18.8	43.0	37.5	11.8	64.9	23.3
SB Pennsauken Creek at Cherry Hill	01467081	8.4	66.0	24.9	8.8	68.0	22.5	0	94.7	5.3
Cooper River at Norcross Rd at Lindenwold	01467120	52.0	39.1	0	52.0	39.1	0	46.3	50.8	0
Cooper River at Lawnside	01467140	22.7	57.7	14.6	22.7	57.7	14.6	5.0	90.6	0
SB Big Timber Creek at Blackwood Terrace	01467329	24.7	42.5	27.4	25.9	46.8	21.2	.9	71.7	14.4
Raccoon Creek near Swedesboro	01477120	19.4	6.0	72.1	18.6	6.1	72.9	7.3	.1	73.0
Oldmans Creek at Porches Mill	01477510	18.9	2.8	73.4	8.3	2.4	82.7	0	4.4	73.1
Salem River at Woodstown	01482500	6.8	5.0	81.1	7.0	5.7	79.0	0	34.9	55.4

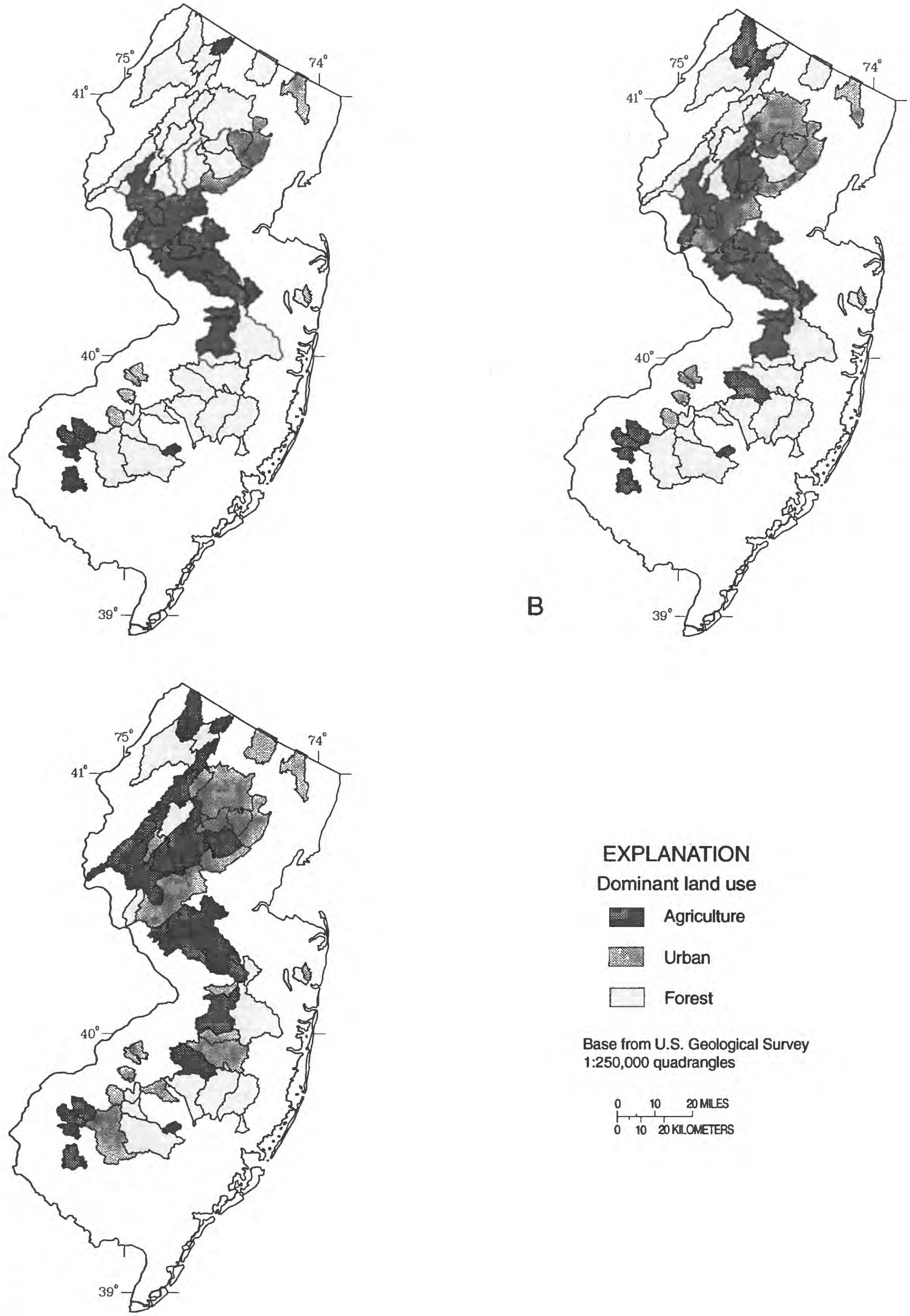


Figure 3. Dominant land use in the 60 New Jersey drainage basins studied: (A) entire drainage basin, (B) area 3.1 miles upstream from the monitoring station, and (C) area 0.62 mile upstream from the monitoring station. (Data from U.S. Geological Survey Geographic Information Retrieval and Analysis System.)

Population

New Jersey is the Nation's most densely populated state, having 1,041 persons per square mile in 1990 (Morgan and others, 1992). The State's total population was 7,730,000 in 1990, an increase of nearly 7 percent from the 1970 population of 7,248,000 and an increase of 5 percent from the 1980 population of 7,365,000. Since the 1940's, population has generally declined in older urban areas and increased in rural and agricultural areas.

The populations of the 60 drainage basins were estimated for 1975 and 1986 by use of information from the New Jersey Department of Labor (NJDOL) (1976, 1987) (table 7). The NJDOL population data for these years are municipal-level population estimates based on the previous decennial census. Population densities in 1975 and 1986, and change in density from 1975 to 1986, also were calculated for each drainage basin (table 7). The process of estimating drainage-basin population included the following steps, all done by use of a GIS: (1) conversion of the NJDOL data to population density, expressed as number of persons per square mile for each municipality in a drainage basin, (2) determination of the area of each municipality in a drainage basin, in square miles, (3) multiplication of the municipality's area within a drainage basin by its population density to create an estimated municipal population within the drainage basin, and finally (4) summation of the estimated municipal populations within the drainage basin, expressed as the number of persons.

The greatest number of persons during the study period (418,807 in 1975 and 424,547 in 1986) was in the basin above the Passaic River at Two Bridges. The second greatest population was in the basin above the Raritan River at Manville (165,855 in 1975 and 192,097 in 1986). The greatest population densities were identified in those basins closest to the New York City and Philadelphia metropolitan areas (fig. 4). The greatest population density was in the Cooper River Basin at Lindenwold (2,889 persons per square mile in 1986). The South Branch Big Timber Creek Basin at Blackwood Terrace had the greatest population density increase between 1975 and 1986, an estimated 500 additional persons per square mile over the 11-year period. Population decreases from 1975 to 1986 were identified for two drainage basins, and population in one drainage basin was virtually unchanged. Population increases were recorded in the remaining drainage basins.

Effluent Discharge

The New Jersey Department of Environmental Protection (1990) reported that the release of effluent from the approximately 1,100 permitted municipal and industrial facilities in the State continues to have an effect on the quality of surface waters, even though decades of extensive water-pollution-control efforts in New Jersey have focused on minimizing the effects of wastewater disposal on surface-water quality. Because of the investment in wastewater treatment and disposal, one would expect that the improvements in wastewater treatment would have a strong effect on the water-quality trends reported by Hay and Campbell (1990).

To determine associations between water-quality trends and effluent discharges, information was collected on the presence of wastewater-treatment facilities in the State and characteristics of the effluent (such as quality and quantity) for WY 1976-86. The primary

Table 7. Estimated population, population density, and density change from 1975 to 1986 in the New Jersey drainage basins studied

[Basin population in number of persons; population density in number of persons per square mile.]

Drainage basin		1975		1986		Change in population density, 1975-86
Monitoring-station name	Monitoring-station number	Basin population	Population density	Basin population	Population density	
Wallkill River at Franklin	01367700	10,999	374	11,841	403	+29
Wallkill River near Sussex	01367770	19,985	329	21,227	349	+20
Papakating Creek at Sussex	01367910	7,752	131	9,481	160	+29
Black Creek near Vernon	01368950	2,672	154	4,567	264	+110
Passaic River near Millington	01379000	34,943	631	36,692	662	+31
Passaic River near Chatham	01379500	83,740	837	85,071	851	+14
Rockaway River at Pine Brook	01381200	131,504	967	134,956	992	+25
Whippany River at Morristown	01381500	40,339	1,372	41,203	1,401	+29
Whippany River near Pine Brook	01381800	100,700	1,470	102,939	1,503	+33
Passaic River at Two Bridges	01382000	418,807	1,160	424,547	1,176	+16
Wanaque River at Wanaque	01387000	22,408	248	25,012	277	+29
Saddle River at Lodi	01391500	107,464	1,968	103,369	1,893	-75
SB Raritan River at Middle Valley	01396280	20,703	435	25,467	535	+100
SB Raritan River at Arch St at High Bridge	01396535	29,117	423	35,573	517	+94
Mulhockaway Creek at Van Syckel	01396660	1,513	128	2,132	181	+53
SB Raritan River at Three Bridges	01397400	53,858	298	66,560	368	+70
NB Raritan River near Chester	01398260	4,630	617	5,070	676	+59
NB Raritan River at Burnt Mills	01399120	21,061	330	23,236	364	+34
Rockaway Creek at Whitehouse	01399700	6,247	168	8,099	218	+50
Lamington (Black) River at Burnt Mills	01399780	23,199	232	28,739	287	+55
Raritan River at Manville	01400500	165,855	338	192,097	392	+54
Millstone River at Grovers Mill	01400650	24,028	554	26,645	614	+60
Millstone River at Kingston	01401440	90,501	526	106,333	618	+92
Beden Brook near Rocky Hill	01401600	8,463	307	9,490	344	+37
Millstone River at Weston	01402540	135,253	499	159,687	589	+90
Manalapan Brook at Federal Rd near Manalapan	01405340	8,650	414	12,594	603	+189
Shark River near Neptune City	01407705	6,631	670	7,410	748	+78
Jumping Brook near Neptune City	01407760	12,325	1,926	13,028	2,036	+110
Marsh Bog Brook at Squankum	01407997	2,796	571	3,050	622	+51
Toms River near Toms River	01408500	41,054	334	52,100	424	+90
Mullica River at outlet of Atsion Lake at Atsion	01409387	6,815	255	10,538	395	+140
Hammonton Creek at Wescoatville	01409416	2,337	246	2,452	258	+12
Batsto River at Batsto	01409500	3,381	50	6,872	101	+51
WB Wading River at Maxwell	01409815	1,999	23	2,661	31	+8
Oswego River at Harrisville	01410000	3,813	53	6,895	95	+42
EB Bass River near New Gretna	01410150	148	18	211	26	+8
Great Egg Harbor River near Sicklerville	01410784	14,001	927	16,997	1,126	+198
Great Egg Harbor River near Blue Anchor	01410820	21,643	580	27,311	732	+152
Great Egg Harbor River at Weymouth	01411110	49,812	323	62,009	403	+80
Maurice River at Norma	01411500	42,233	377	47,468	424	+47
Cohansey River at Seeley	01412800	4,662	167	4,973	178	+11
Paulins Kill at Blairstown	01443500	23,158	184	27,297	217	+33
Musconetcong River at outlet of Lake Hopatcong	01455500	15,552	615	17,313	684	+69
Musconetcong River at Beatyestown	01456200	53,285	590	59,366	657	+67
Musconetcong River at Riegelsville	01457400	69,836	448	78,063	500	+52
Wickecheoke Creek at Stockton	01461300	3,069	115	3,776	142	+27
Crosswicks Creek at Extonville	01464500	22,734	279	22,855	280	+1
Doctors Creek at Allentown	01464515	2,447	141	2,551	147	+6
SB Rancocas Creek at Vincentown	01465850	9,901	154	11,284	175	+21
NB Rancocas Creek at Browns Mills	01465970	10,547	385	11,641	425	+40
McDonalds Branch in Lebanon State Forest	01466500	54	23	48	21	-2
NB Rancocas Creek at Pemberton	01467000	32,072	272	42,236	358	+86
NB Pennsauken Creek near Moorestown	01467069	10,033	784	14,366	1,122	+338
SB Pennsauken Creek at Cherry Hill	01467081	17,878	2,009	19,002	2,135	+126
Cooper River at Norcross Rd at Lindenwold	01467120	3,114	2,831	3,178	2,889	+58
Cooper River at Lawnside	01467140	26,398	2,079	29,936	2,357	+279
SB Big Timber Creek at Blackwood Terrace	01467329	22,178	1,161	30,551	1,600	+439
Raccoon Creek near Swedesboro	01477120	4,960	184	5,984	222	+38
Oldmans Creek at Porches Mill	01477510	1,727	82	1,993	95	+13
Salem River at Woodstown	01482500	1,828	125	1,846	126	+1

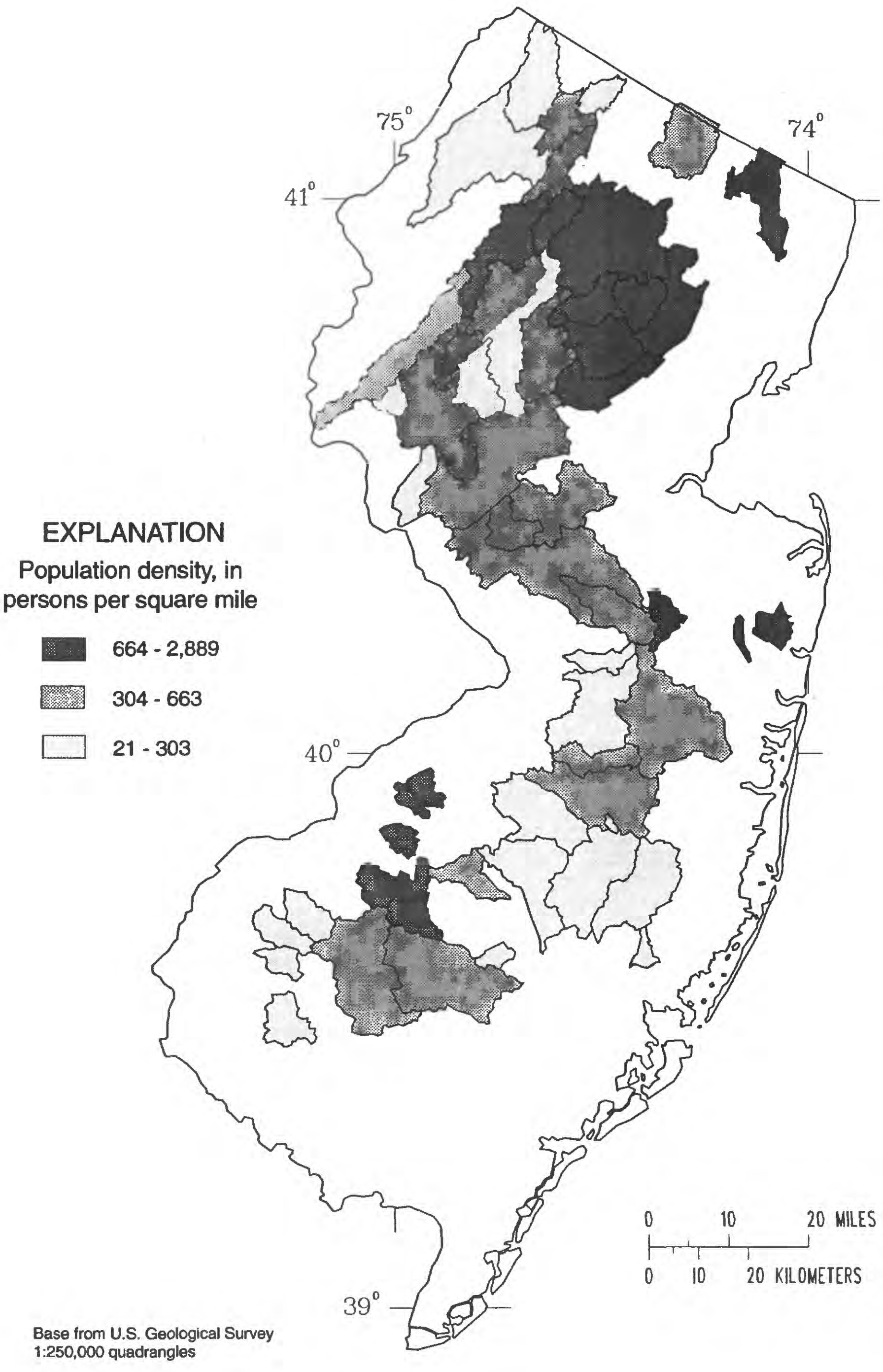


Figure 4. Estimated 1986 population density in the New Jersey drainage basins studied.

source of this information was the national Permit Compliance System (PCS) data base of the U.S. Environmental Protection Agency (1990b). The computerized PCS data base is maintained in conjunction with a national permitting program designed to control the treatment and release of wastewaters. These permits, known as National Pollutant Discharge Elimination System (NPDES) permits, are issued by the NJDEP (New Jersey Department of Environmental Protection) in New Jersey. As a result, the permits are called New Jersey Pollutant Discharge Elimination System (NJPDES) permits.

The PCS data base contains a variety of information that describes effluent discharges in New Jersey from the mid-1970's to the present. PCS data obtained for this study included data on the location of effluent discharges, the type of facility producing the effluent (either municipal or nonmunicipal), and the quantity and quality of the effluent. However, PCS data on effluent quality and quantity in New Jersey are generally not considered reliable or complete prior to the mid-1980's (Isadore Cooperman, New Jersey Department of Environmental Protection, oral commun., 1989). Because the PCS data base may not be reliable and complete for characterizing effluent released during much of the study period, a number of data-collection and -verification processes had to be used to build a data base on effluent discharges in the 60 drainage basins. These processes included (1) searching for and collecting data on effluent-discharge locations and on effluent quantity and quality from numerous sources, (2) verification of effluent-discharge locations by comparing location information from multiple sources, and (3) checking effluent-quantity and -quality data against published and other, more recent data. A thorough description of these data-collection and -verification processes can be found in Robinson and others (1995).

Digital data on the location, type, quantity, and quality of permitted effluent discharges in New Jersey for 1975 and 1986 were obtained from the PCS data base with the assistance of the NJDEP. Data for some wastewater facilities were incomplete for 1986; supplementary data for those facilities were obtained from the USEPA and by a review of paper files at the offices of the NJDEP in Trenton, N.J. PCS data from 1989 also were used to supplement missing PCS data from earlier years.

On the basis of the latitude and longitude data given in PCS, 1,380 and 1,226 permitted effluent discharges were identified in New Jersey for 1975 and 1986, respectively. To verify the location information, study personnel compared PCS latitude and longitude data with other locational information in PCS for the discharge facility (such as address, county, and known receiving water of the discharge). Where entries were found to be missing or incorrect, other information sources, such as The Environmental Information Inventory, Division of Water Resources (New Jersey Department of Environmental Protection, 1985) and paper files at the offices of the NJDEP in Trenton, N.J., were used to identify the correct locations.

Of the 1,380 permitted effluent discharges in New Jersey in 1975, 263 (19 percent) were in 49 of the 60 drainage basins studied (no permitted effluent discharges were on record for 11 drainage basins). In 1986, 46 drainage basins contained 296 (24 percent) of the total 1,226 permitted effluent discharges in the State. The number of wastewater discharges in each drainage basin for 1975 and 1986 are listed in table 8. A complete listing of the years 1975 and 1986 permitted effluent discharges is given by drainage basin in tables 9 and 10, respectively (at back of the report).

The greatest number of permitted effluent discharges, 85 in 1975 and 88 in 1986, were in the drainage basin above the Passaic River at Two Bridges. This drainage basin is in the heavily developed northeastern part of New Jersey that is adjacent to the New York City metropolitan area. The drainage basin above the Raritan River at Manville contained 59 permitted effluent discharges in 1986. (The Raritan River drains the industrialized central part of New Jersey.) The largest increase in the number of effluent discharges during 1975-86--an increase of 10--was in the Millstone River drainage basin above the Weston monitoring station. In contrast, decreases in the number of permitted effluent discharges were recorded for seven drainage basins during the 11-year period.

Data in PCS describing the quantity and quality of effluent discharged in 1975 and 1986 for each permitted facility in the drainage basins were provided by the NJDEP (Michael Dillon, New Jersey Department of Environmental Protection, written commun., 1990). The volume and rate of effluent discharged by a facility is most frequently stored in PCS in units of million gallons per day. Effluent quality is commonly reported as milligrams per liter of 5-day biochemical oxygen demand (BOD) and total suspended solids (TSS). Discharges of BOD and TSS were characterized for this study in units of kilograms per day. BOD and TSS loads were collected or calculated in kilograms per day because this was the unit of measurement most commonly used by PCS for these constituents.

The PCS data base contained data on the quantity and quality of effluent discharged in 1975 for only about 20 percent of the 263 permitted-wastewater discharges. Because PCS was the only available data base containing information on effluent discharged in 1975 for the entire State, no additional attempts were made to gather the missing 1975 data. As a result, neither the quantity and quality of effluent released in 1975 nor the changes in effluent quality and quantity during the trends-study period of WY 1976-86 could be evaluated.

Effluent quantity and quality data for 1986 were available in PCS for 46 percent (136) of the 296 permitted effluent discharges in the 60 drainage basins. To fill the gaps in 1986 data, study personnel used PCS data for 1989 because the 1989 data were more complete than previous years' data (Isadore Cooperman, New Jersey Department of Environmental Protection, oral commun., 1990). The 1989 PCS data were assumed to be representative of effluent quantity and quality for 1986. An additional 104 permitted discharges (35 percent of the total) were characterized by use of the 1989 PCS data (Steve Rubin, U.S. Environmental Protection Agency, written commun., 1991). Quantity and quality data for the remaining 19 percent (56 discharges) were gathered from paper files at the offices of the NJDEP in Trenton, N.J.

Median effluent flow in million gallons per day, and loads of BOD and TSS discharged in kilograms per day were generated for each discharge from the collected data. If loads of BOD and TSS were present in PCS, then they were used directly. If only BOD and TSS concentrations were reported, then BOD and TSS loads were calculated from reported

Table 8. Number of, and change in number of, permitted wastewater discharges in New Jersey drainage basins studied, 1975 and 1986

Drainage basin		Number of permitted discharges		Change in number, 1975 to 1986
Monitoring-station name	Monitoring-station number	1975	1986	
Wallkill River at Franklin	01367700	2	5	+3
Wallkill River near Sussex	01367770	9	11	+2
Papakating Creek at Sussex	01367910	1	3	+2
Black Creek near Vernon	01368950	3	4	+1
Passaic River near Millington	01379000	2	2	0
Passaic River near Chatham	01379500	16	15	-1
Rockaway River at Pine Brook	01381200	27	32	+5
Whippany River at Morristown	01381500	7	7	0
Whippany River near Pine Brook	01381800	20	23	+3
Passaic River at Two Bridges	01382000	85	88	+3
Wanaque River at Wanaque	01387000	2	4	+2
Saddle River at Lodi	01391500	8	9	+1
SB Raritan River at Middle Valley	01396280	6	7	+1
SB Raritan River at Arch St at High Bridge	01396535	6	7	+1
Mulhockaway Creek at Van Syckel	01396660	1	1	0
SB Raritan River at Three Bridges	01397400	16	21	+5
NB Raritan River near Chester	01398260	1	1	0
NB Raritan River at Burnt Mills	01399120	9	9	0
Rockaway Creek at Whitehouse	01399700	3	4	+1
Lamington (Black) River at Burnt Mills	01399780	10	9	-1
Raritan River at Manville	01400500	54	59	+5
Millstone River at Grovers Mill	01400650	4	6	+2
Millstone River at Kingston	01401440	21	30	+9
Beden Brook near Rocky Hill	01401600	2	3	+1
Millstone River at Weston	01402540	36	46	+10
Manalapan Brook at Federal Rd near Manalapan	01405340	0	1	+1
Shark River near Neptune City	01407705	1	2	+1
Jumping Brook near Neptune City	01407760	1	0	-1
Marsh Bog Brook at Squankum	01407997	2	0	-2
Toms River near Toms River	01408500	3	4	+1
Mullica River at outlet of Atsion Lake at Atsion	01409387	0	0	0
Hammonton Creek at Wescoatville	01409416	2	2	0
Batsto River at Batsto	01409500	0	0	0
WB Wading River at Maxwell	01409815	0	0	0
Oswego River at Harrisville	01410000	0	0	0
EB Bass River near New Gretna	01410150	0	0	0
Great Egg Harbor River near Sicklerville	01410784	1	1	0
Great Egg Harbor River near Blue Anchor	01410820	1	1	0
Great Egg Harbor River at Weymouth	01411110	4	2	-2
Maurice River at Norma	01411500	6	5	-1
Cohansey River at Seeley	01412800	1	1	0
Paulins Kill at Blairstown	01443500	7	12	+5
Musconetcong River at outlet of Lake Hopatcong	01455500	3	4	+1
Musconetcong River at Beatyestown	01456200	7	9	+2
Musconetcong River at Riegelsville	01457400	12	17	+5
Wickecheoke Creek at Stockton	01461300	2	2	0
Crosswicks Creek at Extonville	01464500	6	6	0
Doctors Creek at Allentown	01464515	1	1	0
SB Rancocas Creek at Vincentown	01465850	3	3	0
NB Rancocas Creek at Browns Mills	01465970	0	0	0
McDonalds Branch in Lebanon State Forest	01466500	0	0	0
NB Rancocas Creek at Pemberton	01467000	2	0	-2
NB Pennsauken Creek near Moorestown	01467069	1	1	0
SB Pennsauken Creek at Cherry Hill	01467081	2	3	+1
Cooper River at Norcross Rd at Lindenwold	01467120	0	0	0
Cooper River at Lawnside	01467140	7	8	+1
SB Big Timber Creek at Blackwood Terrace	01467329	1	1	0
Raccoon Creek near Swedesboro	01477120	1	1	0
Oldmans Creek at Porches Mill	01477510	0	0	0
Salem River at Woodstown	01482500	0	0	0

concentration data and effluent-discharge flow data. The median flow and the loads of BOD and TSS compiled for each permitted effluent discharge in 1986 are listed in table 10 (at back of the report).

The data on the quantity and quality of effluent for each wastewater facility were summarized into measures of effluent yields for each drainage basin. These yields were designed to provide a comparative assessment of the amount of effluent and BOD and TSS discharged in the 60 drainage basins. Yields were calculated by summing all effluent flows and loads of BOD and TSS in a drainage basin, and then dividing by the total drainage-basin area. Yields of effluent flows are in units of million gallons per day per square mile discharged, and for BOD and TSS as kilograms per day per square mile (table 11). In addition, effluent yields for the area 3.1 mi upstream from each monitoring station also were estimated (table 12) to determine whether effluent discharges and loads were greatest near the monitoring station or further upstream. Of the 60 drainage basins, 36 contained a permitted effluent discharge in the area 3.1 mi upstream from the monitoring station.

The greatest yields of effluent discharge and BOD released were in the drainage basin of the Cooper River at Lawnside; the Cooper River drains a heavily developed area to the Delaware River in southwestern New Jersey adjacent to Philadelphia. Overall, drainage basins in the central and northeastern parts of the State tended to have greater yields of effluent discharge and BOD and TSS than did other areas of the State (fig. 5). The median yields of effluent discharge and BOD and TSS released in the drainage basins were 0.03 $Mgal/d/mi^2$, 0.49 $kg/d/mi^2$, and 1.01 $kg/d/mi^2$, respectively.

In the 36 drainage basins having one or more permitted effluent discharges in the area 3.1 mi upstream from the monitoring station, computed yields of effluent discharge and BOD and TSS were generally less than computed yields for the entire drainage basin. The median yield of effluent discharge computed for the area 3.1 mi upstream from the monitoring station of the 36 drainage basins was less than 0.01 $Mgal/d/mi^2$, whereas median yields of BOD and TSS in the area 3.1 mi upstream were 0.16 and 0.49 $kg/d/mi^2$, respectively. This pattern indicates that most of the effluent discharges in the drainage basins were at a distance greater than 3.1 mi upstream from the monitoring stations.

The PCS data base also contains a Standard Industrial Classification (SIC) code (U.S. Office of Management and Budget, 1987) for each facility having an effluent discharge permit. The SIC code can be used to differentiate between municipal facilities (also known as publicly owned treatment works) and industrial facilities and to determine whether one type of facility was the primary source of effluent in a drainage basin. Municipal facilities are identified by the SIC code 4952; all other SIC codes were considered by the investigators to be nonmunicipal facilities. The percentages of effluent discharge and the BOD and TSS yields from municipal discharges are listed in tables 9 and 10 for the entire drainage basin and for the area 3.1 mi upstream from the monitoring station, respectively.

The SIC information indicates that municipal treatment facilities contributed 61 percent or more of the computed yields of effluent discharge in 28 of the 47 drainage basins having a permitted wastewater discharge (fig. 6). More than one-half of the yields of BOD and TSS were

Table 11. Yields of effluent, biochemical oxygen demand, and total suspended solids from permitted effluent discharges in New Jersey drainage basins studied, and percentage of yields in each drainage basin from municipal treatment facilities

[BOD, 5-day biochemical oxygen demand; TSS, total suspended solids; $Mgal/d/mi^2$, million gallons per day per square mile; $kg/d/mi^2$, kilograms per day per square mile; N.A., no information available; -, no wastewater discharges in drainage basin; <, less than. Source: Data from Michael Dillon, New Jersey Department of Environmental Protection, written commun., 1990, and Steve Rubin, U.S. Environmental Protection Agency, written commun., 1991]

Drainage basin		Yields			Percentage of yields in drainage basin from municipal treatment facilities		
Monitoring-station name	Monitoring-station number	Wastewater $Mgal/d/mi^2$	BOD $kg/d/mi^2$	TSS $kg/d/mi^2$	Waste-water	BOD	TSS
Wallkill River at Franklin	01367700	0.007	0.003	0.837	2.4	21.9	0
Wallkill River near Sussex	01367770	.008	.115	.417	.5	.2	0
Papakating Creek at Sussex	01367910	.002	.186	.258	92.5	98.1	98.0
Black Creek near Vernon	01368950	.007	.127	.397	0	0	0
Passaic River near Millington	01379000	.005	.238	.327	99.4	99.6	99.7
Passaic River near Chatham	01379500	.028	1.78	1.52	84.5	93.6	79.8
Rockaway River at Pine Brook	01381200	.047	.588	.917	.4	68.7	41.6
Whippany River at Morristown	01381500	.047	2.62	.645	85.3	91.3	41.7
Whippany River near Pine Brook	01381800	.062	4.61	2.89	75.8	97.8	82.1
Passaic River at Two Bridges	01382000	.062	4.71	3.55	62.2	53.0	50.7
Wanaque River at Wanaque	01387000	.001	.042	.103	90.7	98.7	99.2
Saddle River at Lodi	01391500	.068	4.21	3.89	97.6	99.9	99.4
SB Raritan River at Middle Valley	01396280	.007	.467	.597	47.7	19.7	19.7
SB Raritan River at Arch St at High Bridge	01396535	.005	.323	.413	47.7	19.7	19.7
Mulhockaway Creek at Van Syckel	01396660	.001	.001	.002	N.A.	0	0
SB Raritan River at Three Bridges	01397400	.009	.448	.962	64.7	51.9	28.2
NB Raritan River near Chester	01398260	.019	.944	.918	100	100	100
NB Raritan River at Burnt Mills	01399120	.009	.318	1.39	74.0	95.7	19.1
Rockaway Creek at Whitehouse	01399700	.004	.133	.389	79.0	40.7	24.1
Lamington (Black) River at Burnt Mills	01399780	.010	.051	.163	13.8	41.8	22.8
Raritan River at Manville	01400500	.010	.288	.808	34.9	45.2	17.7
Millstone River at Grovers Mill	01400650	.052	1.80	1.89	97.2	98.9	99.0
Millstone River at Kingston	01401440	.020	1.80	3.08	67.7	25.4	15.6
Beden Brook near Rocky Hill	01401600	.006	.306	.258	21.7	7.5	7.9
Millstone River at Weston	01402540	.029	2.13	2.95	82.8	58.5	42.0
Manalapan Brook at Federal Rd near Manalapan	01405340	.001	-	.030	0	-	0
Shark River near Neptune City	01407705	.001	.033	.033	0	0	0
Jumping Brook near Neptune City	01407760	-	-	-	-	-	-
Marsh Bog Brook at Squankum	01407997	-	-	-	-	-	-
Toms River near Toms River	01408500	<.001	.011	.007	66.7	15.3	32.0
Mullica River at outlet of Atsion Lake at Atsion	01409387	-	-	-	-	-	-
Hammonton Creek at Wescoatville	01409416	.040	2.89	2.84	85.3	100	99.4
Batsto River at Batsto	01409500	-	-	-	-	-	-
WB Wading River at Maxwell	01409815	-	-	-	-	-	-
Oswego River at Harrisville	01410000	-	-	-	-	-	-
EB Bass River near New Gretna	01410150	-	-	-	-	-	-
Great Egg Harbor River near Sicklerville	01410784	.016	1.98	4.19	100	100	100
Great Egg Harbor River near Blue Anchor	01410820	.006	.801	1.69	100	100	100
Great Egg Harbor River at Weymouth	01411110	.002	.194	.411	100	99.9	100
Maurice River at Norma	01411500	.002	-	.020	0	-	0
Cohansey River at Seeley	01412800	.011	-	.223	0	-	0
Paulins Kill at Blairstown	01443500	.022	.211	.499	15.3	84.5	61.4
Musconetcong River at outlet of Lake Hopatcong	01455500	.002	.027	.024	17.4	89.5	90.6
Musconetcong River at Beatyestown	01456200	.012	.615	.667	90.9	99.8	99.0
Musconetcong River at Riegelsville	01457400	.015	2.05	2.00	43.9	18.4	20.0
Wickecheoke Creek at Stockton	01461300	.003	.032	.060	16.1	100	80.4
Crosswicks Creek at Extonville	01464500	.019	1.51	1.62	3.5	1.4	2.2
Doctors Creek at Allentown	01464515	.004	.327	.394	100	100	100
SB Rancocas Creek at Vincentown	01465850	.002	.111	.069	66.9	49.7	42.6
NB Rancocas Creek at Browns Mills	01465970	-	-	-	-	-	-
McDonalds Branch in Lebanon State Forest	01466500	-	-	-	-	-	-
NB Rancocas Creek at Pemberton	01467000	-	-	-	-	-	-
NB Pennsauken Creek near Moorestown	01467069	.017	.688	.974	100	100	100
SB Pennsauken Creek at Cherry Hill	01467081	.038	1.72	.526	100	100	98.4
Cooper River at Norcross Rd at Lindenwold	01467120	-	-	-	-	-	-
Cooper River at Lawnside	01467140	.160	8.90	.803	99.6	100	99.8
SB Big Timber Creek at Blackwood Terrace	01467329	<.001	.000	<.001	100	100	100
Raccoon Creek near Swedesboro	01477120	.002	.026	.057	100	100	100
Oldmans Creek at Porches Mill	01477510	-	-	-	-	-	-
Salem River at Woodstown	01482500	-	-	-	-	-	-

Table 12. Yields of effluent, biochemical oxygen demand and total suspended solids from permitted effluent discharges in an area 3.1 miles upstream from the monitoring stations in New Jersey drainage basins studied, and percentage of yields in each drainage basin from municipal treatment facilities

[BOD, 5-day biochemical oxygen demand; TSS, total suspended solids; $Mgal/d/mi^2$, million gallons per day per square mile; $kg/d/mi^2$, kilograms per day per square mile; N.A., no information available; -, no wastewater discharges in drainage basin; <, less than. Source: Data from Michael Dillon, New Jersey Department of Environmental Protection, written commun., 1990; and Steve Rubin, U.S. Environmental Protection Agency, written commun., 1991]

Drainage basin		Yields			Percentage of yields in drainage basin from municipal treatment facilities		
Monitoring-station name	Monitoring-station number	Wastewater $Mgal/d/mi^2$	BOD $kg/d/mi^2$	TSS $kg/d/mi^2$	Wastewater	BOD	TSS
Wallkill River at Franklin	01367700	0.008	-	1.06	0	-	0
Wallkill River near Sussex	01367770	.009	0.002	.195	0	0	0
Papakating Creek at Sussex	01367910	.006	.481	.667	92.5	98.1	98.0
Black Creek near Vernon	01368950	.003	.077	.639	0	0	0
Passaic River near Millington	01379000	-	-	-	-	-	-
Passaic River near Chatham	01379500	.017	.794	1.18	91.2	97.7	70.2
Rockaway River at Pine Brook	01381200	<.001	.001	<.001	0	0	0
Whippany River at Morristown	01381500	.120	6.78	1.66	85.7	91.4	41.9
Whippany River near Pine Brook	01381800	.033	1.52	1.50	93.3	100	97.6
Passaic River at Two Bridges	01382000	-	-	-	-	-	-
Wanaque River at Wanaque	01387000	.003	.110	.268	92.2	98.7	99.2
Saddle River at Lodi	01391500	.003	-	.004	0	-	0
SB Raritan River at Middle Valley	01396280	.010	.413	.628	0	0	0
SB Raritan River at Arch St at High Bridge	01396535	-	-	-	-	-	-
Mulhockaway Creek at Van Syckel	01396660	-	.003	.005	-	0	0
SB Raritan River at Three Bridges	01397400	.012	.205	.298	67.1	100	73.3
NB Raritan River near Chester	01398260	.050	2.44	2.38	100	100	100
NB Raritan River at Burnt Mills	01399120	.002	.026	.021	0	0	0
Rockaway Creek at Whitehouse	01399700	.011	.344	1.01	79.0	40.7	24.1
Lamington (Black) River at Burnt Mills	01399780	<.001	.002	.003	89.3	53.0	78.2
Raritan River at Manville	01400500	.007	.150	.490	0	0	0
Millstone River at Grovers Mill	01400650	.121	4.16	4.21	100	100	100
Millstone River at Kingston	01401440	.004	.023	.058	0	0	0
Beden Brook near Rocky Hill	01401600	.012	.731	.614	0	0	0
Millstone River at Weston	01402540	-	-	-	-	-	-
Manalapan Brook at Federal Rd near Manalapan	01405340	-	-	-	-	-	-
Shark River near Neptune City	01407705	.001	.086	.081	0	0	0
Jumping Brook near Neptune City	01407760	-	-	-	-	-	-
Marsh Bog Brook at Squankum	01407997	-	-	-	-	-	-
Toms River near Toms River	01408500	-	-	-	-	-	-
Mullica River at outlet of Atsion Lake at Atsion	01409387	-	-	-	-	-	-
Hammonton Creek at Wescoatville	01409416	.089	7.47	7.32	100	100	100
Batsto River at Batsto	01409500	-	-	-	-	-	-
WB Wading River at Maxwell	01409815	-	-	-	-	-	-
Oswego River at Harrisville	01410000	-	-	-	-	-	-
EB Bass River near New Gretna	01410150	-	-	-	-	-	-
Great Egg Harbor River near Sicklerville	01410784	-	-	-	-	-	-
Great Egg Harbor River near Blue Anchor	01410820	-	-	-	-	-	-
Great Egg Harbor River at Weymouth	01411110	-	-	-	-	-	-
Maurice River at Norma	01411500	-	-	-	-	-	-
Cohansey River at Seeley	01412800	.029	-	.576	0	-	0
Paulins Kill at Blairstown	01443500	-	-	-	-	-	-
Musconetcong River at outlet of Lake Hopatcong	01455500	.001	.064	.058	95.2	99.4	98.2
Musconetcong River at Beatyestown	01456200	.018	.729	.639	94.1	100	99.9
Musconetcong River at Riegelsville	01457400	.002	.079	.050	0	0	0
Wickecheoke Creek at Stockton	01461300	.001	.083	.124	100	100	100
Crosswicks Creek at Extonville	01464500	-	-	-	-	-	-
Doctors Creek at Allentown	01464515	.011	.848	1.02	100	100	100
SB Rancocas Creek at Vincentown	01465850	.004	.164	.094	93.3	87.1	80.5
NB Rancocas Creek at Browns Mills	01465970	-	-	-	-	-	-
McDonalds Branch in Lebanon State Forest	01466500	-	-	-	-	-	-
NB Rancocas Creek at Pemberton	01467000	-	-	-	-	-	-
NB Pennsauken Creek near Moorestown	01467069	.044	1.78	2.52	100	100	100
SB Pennsauken Creek at Cherry Hill	01467081	N.A.	-	.021	N.A.	-	0
Cooper River at Norcross Rd at Lindenwold	01467120	-	-	-	-	-	-
Cooper River at Lawnside	01467140	.216	37.5	23.8	99.2	100	99.8
SB Big Timber Creek at Blackwood Terrace	01467329	<.001	.001	.001	100	100	100
Raccoon Creek near Swedesboro	01477120	.005	.067	.149	100	100	100
Oldmans Creek at Porches Mill	01477510	-	-	-	-	-	-
Salem River at Woodstown	01482500	-	-	-	-	-	-

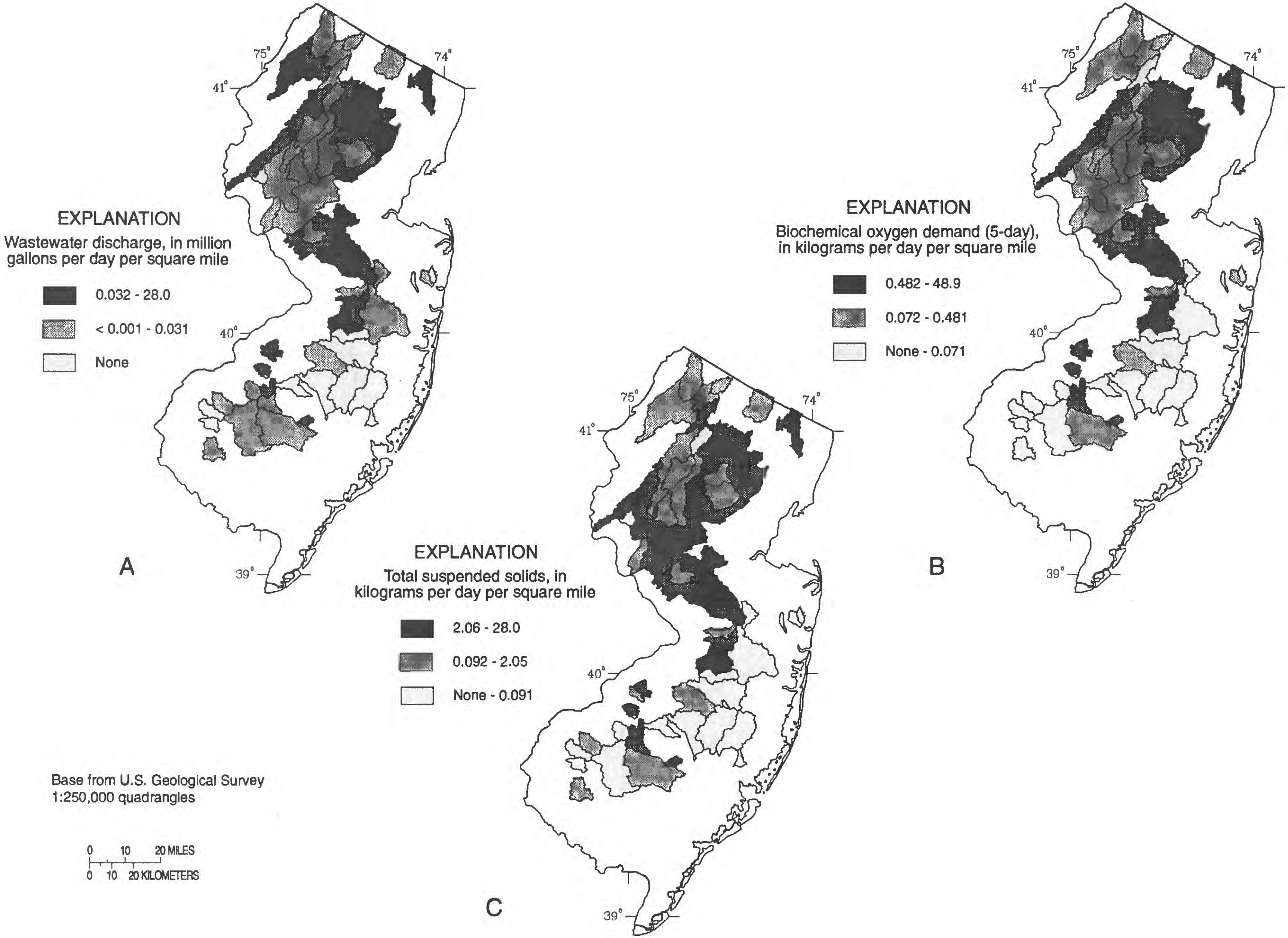


Figure 5. Yields of (A) discharge, (B) biochemical oxygen demand (5-day), and (C) total suspended solids for effluent released by wastewater-treatment facilities in the New Jersey drainage basins studied.

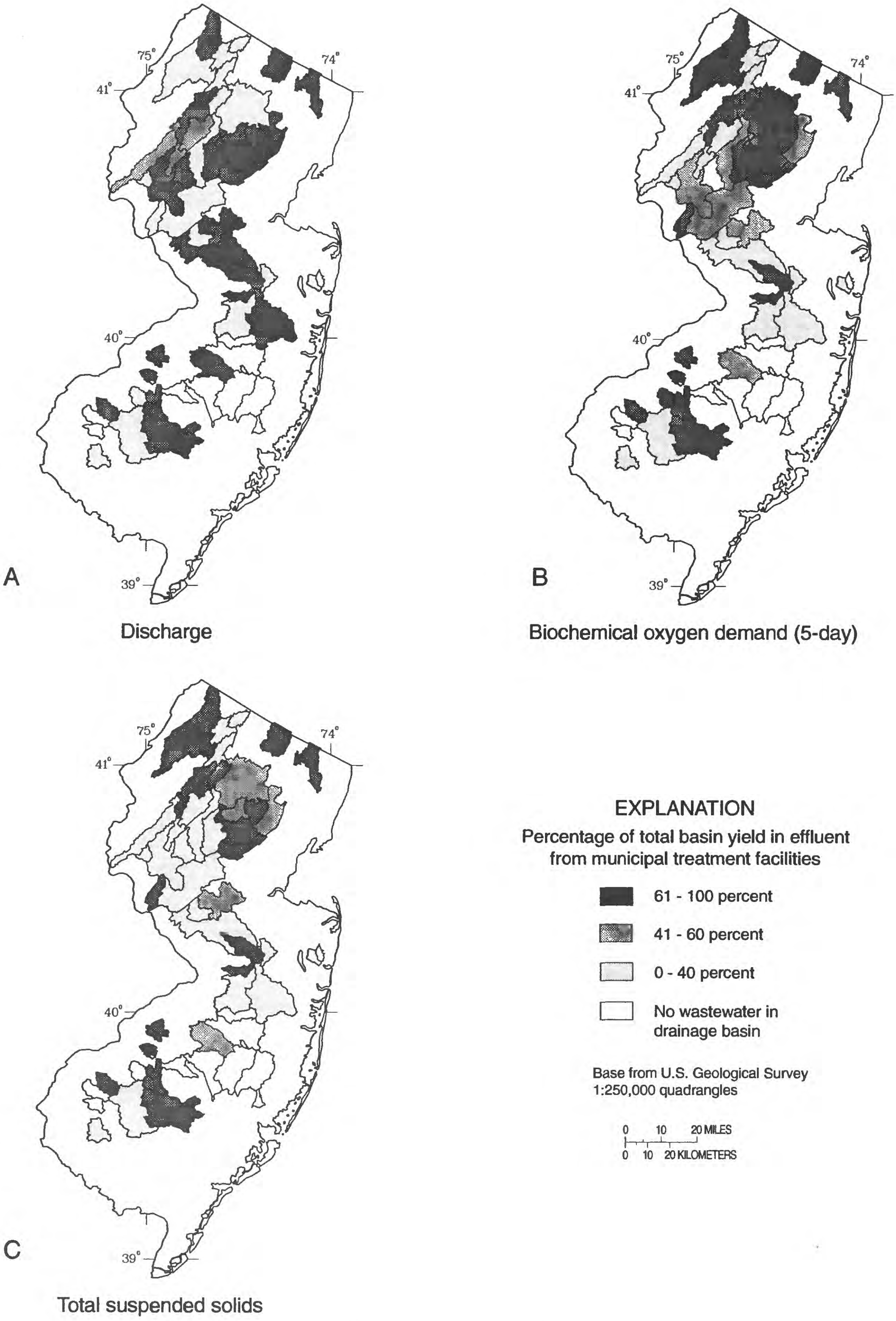


Figure 6. Percentage of yields of (A) discharge, (B) biochemical oxygen demand (5-day), and (C) total suspended solids for effluent released from municipal wastewater-treatment facilities in the New Jersey drainage basins studied.

from municipal facilities in 26 and 22, respectively, of the 47 drainage basins. Similar ratios of municipal to nonmunicipal sources of effluent were found when determining the sources of effluent in the areas 3.1 mi upstream from the monitoring stations.

Road-Salt Application

Application of deicing salts to roadways in the winter has the potential for adding large amounts of sodium, calcium, and chloride to surface waters by way of runoff and to ground through infiltration. Road salts have an effect on the concentrations of dissolved constituents in surface waters (Athayde and others, 1983; Harrison and Wilson, 1985; Scott, 1980). Smith and others (1987a, 1987b) reported that increasing chloride concentrations nationwide were strongly associated with rates of road-salt application. Application of road salts in New Jersey may be linked to the common upward trends in dissolved calcium, sodium, and chloride concentrations in New Jersey (Hay and Campbell, 1990).

Data on the amount of road salt applied to interstate and state highways for 1975-86 were obtained from the New Jersey Department of Transportation (NJDOT) (Alfred Woodrow, New Jersey Department of Transportation, written commun., 1989); (table 13 at back of report). These data account only for NJDOT application of road salts; municipalities, counties, and state-highway authorities do not report their application rates to NJDOT. Road-salt application data from the NJDOT are compiled according to the following four regions of the state:

Region	Counties
1	Hunterdon, Morris, Somerset, Sussex, Warren
2	Bergen, Essex, Hudson, Passaic, Union
3	Mercer, Middlesex, Monmouth, Ocean
4	Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Salem

Road-salt application data from NJDOT were provided by winter season and region as tons of sodium chloride (rocksalt); gallons of calcium chloride in a water solution 32 percent by weight; tons of dry calcium chloride; and tons of a premix of five parts sodium chloride to one part calcium chloride. These data were used to calculate tons of calcium, sodium, and chloride applied per square mile for each drainage basin during each winter season from 1975-76 through 1986-87, based on the percentage of a drainage basin in each NJDOT region. This method requires the assumption of a uniform application rate across each region. The results of these calculations are listed in table 14 (at back of report).

Road-salt application rates for winter 1980-81 were used as a static measure of road-salt applications in the 60 drainage basins. Estimated sodium, chloride, and calcium applications were greatest in the northern part of New Jersey (fig. 7). This part of the State receives more snowfall and has colder temperatures than the southern part of the State. Estimated chloride applications in the 60 drainage basins for winter 1980-81 ranged from 0.83 to 7.64 ton/mi^2; estimated sodium applications for winter 1980-81 ranged from 0.47 to 4.1 ton/mi^2; and estimated calcium applications ranged from 0.1 to 1.0 ton/mi^2.

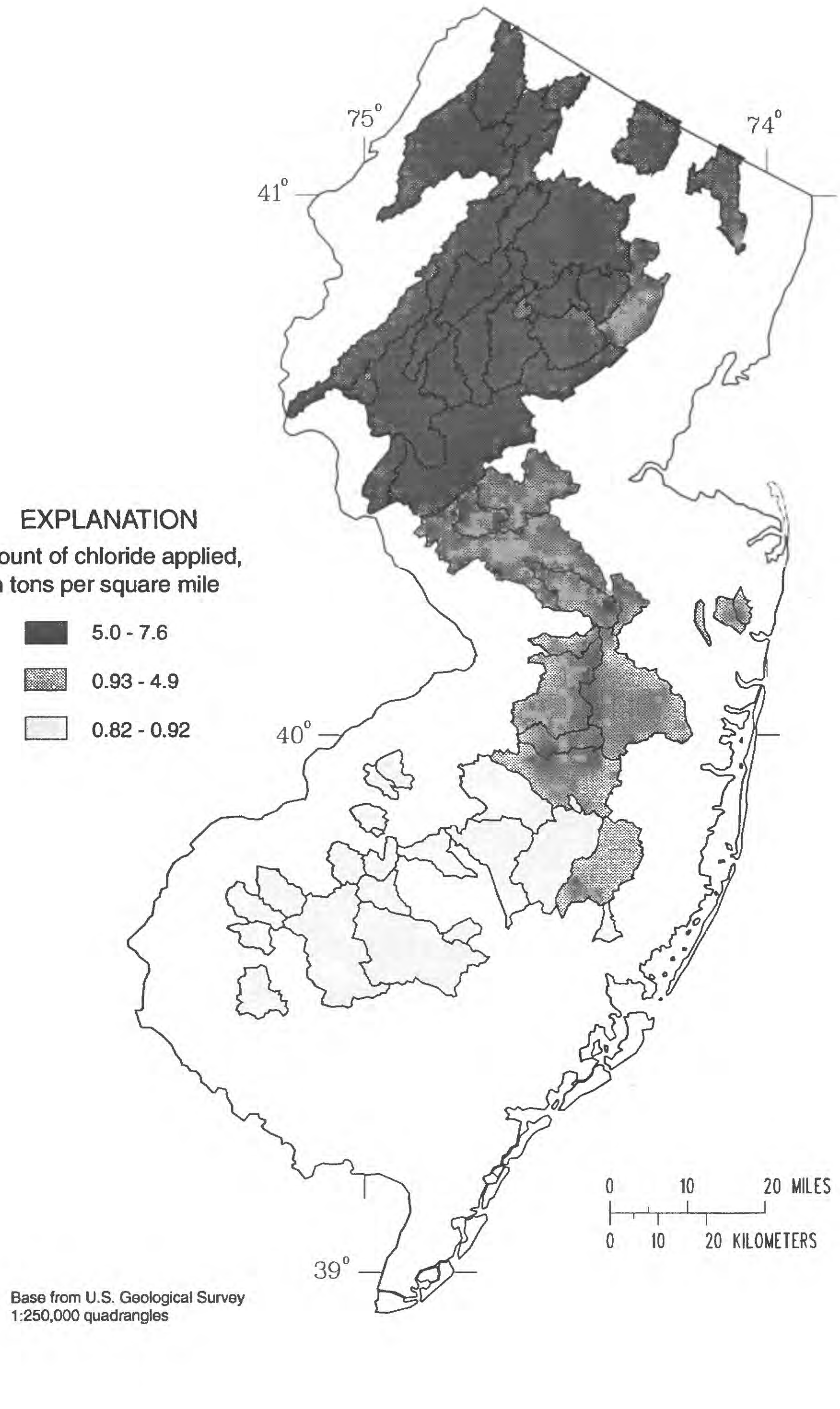


Figure 7. Estimated amounts of chloride applied to roadways by the New Jersey Department of Transportation in the New Jersey drainage basins studied, winter 1980-81.

Trends in the estimated use of road salts in the 60 drainage basins during 1975-87 were calculated to determine whether application rates changed significantly over the period. The trends in the application of calcium, sodium, and chloride for each drainage basin during 1975-87 were determined by use of the Kendall's tau test for trend (Snedecor and Cochran, 1967). A trend in applications of calcium, sodium and chloride over time was considered to be significant at $\alpha \leq 0.10$.

Results of the trend analyses indicate that calcium application declined significantly in all drainage basins during 1975-87, whereas the estimated application of sodium and chloride increased significantly in 50 of the 60 drainage basins (table 15 and fig. 8). In all drainage basins where an upward trend in sodium application was found, an upward trend in chloride application also was found.

Agricultural Activities

Despite being the most densely populated state in the Nation, New Jersey still supports a productive and economically important agricultural industry. Gross farm income in the State grew from $413.5 million in 1975 to $607.5 million in 1986 (Ferdos Ali, New Jersey Department of Agriculture, written commun., 1992), while farm acreage decreased from approximately 1 million acres to less than 900,000 acres. Cash crops, such as nursery plants, vegetables, fruit, and grain crops, are the most important agricultural products grown in New Jersey. Other agricultural activities that are important locally include horse, dairy, and poultry farming and egg production.

The effects of agricultural activities on water quality in New Jersey are not thought to be as widespread as the effects of other potential sources of water contamination, such as permitted effluent discharges and urban runoff (New Jersey Department of Environmental Protection, 1990). Information describing agricultural activities and their potential environmental effects in the 60 drainage basins were gathered for drainage-basin characterization. This information included agricultural-fertilizer use by county for 1975-85, cropland soil-erosion rates, and the area of land irrigated.

Agricultural-fertilizer use has been cited as contributing to water-quality problems in many areas of the country (U.S. Environmental Protection Agency, 1984, 1990a). Data on agricultural-fertilizer use by county in New Jersey during 1975-85 (obtained from Richard B. Alexander, U.S. Geological Survey, written commun., 1989) are estimates of tons of nitrogen and phosphorus applied. These estimates were obtained by use of the methodology described by Alexander and Smith (1990).

Drainage-basin estimates of agricultural-fertilizer use were calculated from the county data for each year during 1975-85; these estimates are in table 16 (at back of report). The estimates of fertilizer use by drainage basin were based on the assumption that the nitrogen- and phosphorus-fertilizer applications were uniform across each county. All fertilizer-use estimates of phosphorus and nitrogen were calculated in tons per square mile.

Table 15. Results of statistical testing for trends in the application of chloride, sodium, and calcium to roadways in the New Jersey drainage basins studied, 1975-87

[n, sample size for trends testing, equal to the number of yearly values; tau, Kendell's tau computed test statistic; p-value, the probability that the road-salt application values occur randomly rather than occur as result of actual change in application]

Drainage basin			Chloride		Sodium		Calcium	
Monitoring-station name	Monitoring-station number	n	tau	p-value	tau	p-value	tau	p-value
Wallkill River at Franklin	01367700	12	0.545	0.016	0.606	0.007	-0.727	0.001
Wallkill River near Sussex	01367770	12	.545	.016	.606	.007	-.727	.001
Papakating Creek at Sussex	01367910	12	.545	.016	.606	.007	-.727	.001
Black Creek near Vernon	01368950	12	.545	.016	.606	.007	-.727	.001
Passaic River near Millington	01379000	12	.545	.016	.606	.007	-.727	.001
Passaic River near Chatham	01379500	12	.545	.016	.606	.007	-.727	.001
Rockaway River at Pine Brook	01381200	12	.545	.016	.606	.007	-.727	.001
Whippany River at Morristown	01381500	12	.545	.016	.606	.007	-.727	.001
Whippany River near Pine Brook	01381800	12	.545	.016	.606	.007	-.727	.001
Passaic River at Two Bridges	01382000	12	.545	.016	.606	.007	-.727	.001
Wanaque River at Wanaque	01387000	12	.576	.011	.606	.007	-.727	.001
Saddle River at Lodi	01391500	12	.576	.011	.606	.007	-.727	.001
SB Raritan River at Middle Valley	01396280	12	.545	.016	.606	.007	-.727	.001
SB Raritan River at Arch St at High Bridge	01396535	12	.545	.016	.606	.007	-.727	.001
Mulhockaway Creek at Van Syckel	01396660	12	.545	.016	.606	.007	-.727	.001
SB Raritan River at Three Bridges	01397400	12	.545	.016	.606	.007	-.727	.001
NB Raritan River near Chester	01398260	12	.545	.016	.606	.007	-.727	.001
NB Raritan River at Burnt Mills	01399120	12	.545	.016	.606	.007	-.727	.001
Rockaway Creek at Whitehouse	01399700	12	.545	.016	.606	.007	-.727	.001
Lamington (Black) River at Burnt Mills	01399780	12	.545	.016	.606	.007	-.727	.001
Raritan River at Manville	01400500	12	.545	.016	.606	.007	-.727	.001
Millstone River at Grovers Mill	01400650	12	.242	.304	.273	.244	-.515	.024
Millstone River at Kingston	01401440	12	.242	.304	.273	.244	-.515	.024
Beden Brook near Rocky Hill	01401600	12	.545	.016	.606	.007	-.727	.001
Millstone River at Weston	01402540	12	.242	.304	.273	.244	-.515	.024
Manalapan Brook at Federal Rd near Manalapan	01405340	12	.242	.304	.273	.244	-.515	.024
Shark River near Neptune City	01407705	12	.242	.304	.273	.244	-.515	.024
Jumping Brook near Neptune City	01407760	12	.242	.304	.273	.244	-.515	.024
Marsh Bog Brook at Squankum	01407997	12	.242	.304	.273	.244	-.515	.024
Toms River near Toms River	01408500	12	.242	.304	.273	.244	-.515	.024
Mullica River at outlet of Atsion Lake at Atsion	01409387	12	.545	.016	.545	.016	-.545	.016
Hammonton Creek at Wescoatville	01409416	12	.545	.016	.545	.016	-.545	.016
Batsto River at Batsto	01409500	12	.545	.016	.545	.016	-.545	.016
WB Wading River at Maxwell	01409815	12	.545	.016	.545	.016	-.545	.016
Oswego River at Harrisville	01410000	12	.545	.016	.545	.016	-.545	.016
EB Bass River near New Gretna	01410150	12	.545	.016	.545	.016	-.545	.016
Great Egg Harbor River near Sicklerville	01410784	12	.545	.016	.545	.016	-.545	.016
Great Egg Harbor River near Blue Anchor	01410820	12	.545	.016	.545	.016	-.545	.016
Great Egg Harbor River at Weymouth	01411110	12	.545	.016	.545	.016	-.545	.016
Maurice River at Norma	01411500	12	.545	.016	.545	.016	-.545	.016
Cohansey River at Seeley	01412800	12	.545	.016	.545	.016	-.545	.016
Paulins Kill at Blairstown	01443500	12	.545	.016	.606	.007	-.727	.001
Musconetcong River at outlet of Lake Hopatcong	01455500	12	.545	.016	.606	.007	-.727	.001
Musconetcong River at Beatyestown	01456200	12	.545	.016	.606	.007	-.727	.001
Musconetcong River at Riegelsville	01457400	12	.545	.016	.606	.007	-.727	.001
Wickecheoke Creek at Stockton	01461300	12	.545	.016	.606	.007	-.727	.001
Crosswicks Creek at Extonville	01464500	12	.242	.304	.273	.244	-.515	.024
Doctors Creek at Allentown	01464515	12	.242	.304	.273	.244	-.515	.024
SB Rancocas Creek at Vincentown	01465850	12	.545	.016	.545	.016	-.545	.016
NB Rancocas Creek at Browns Mills	01465970	12	.545	.016	.545	.016	-.545	.016
McDonalds Branch in Lebanon State Forest	01466500	12	.545	.016	.545	.016	-.545	.016
NB Rancocas Creek at Pemberton	01467000	12	.545	.016	.545	.016	-.545	.016
NB Pennsauken Creek near Moorestown	01467069	12	.545	.016	.545	.016	-.545	.016
SB Pennsauken Creek at Cherry Hill	01467081	12	.545	.016	.545	.016	-.545	.016
Cooper River at Norcross Rd at Lindenwold	01467120	12	.545	.016	.545	.016	-.545	.016
Cooper River at Lawnside	01467140	12	.545	.016	.545	.016	-.545	.016
SB Big Timber Creek at Blackwood Terrace	01467329	12	.545	.016	.545	.016	-.545	.016
Raccoon Creek near Swedesboro	01477120	12	.545	.016	.545	.016	-.545	.016
Oldmans Creek at Porches Mill	01477510	12	.545	.016	.545	.016	-.545	.016
Salem River at Woodstown	01482500	12	.545	.016	.545	.016	-.545	.016

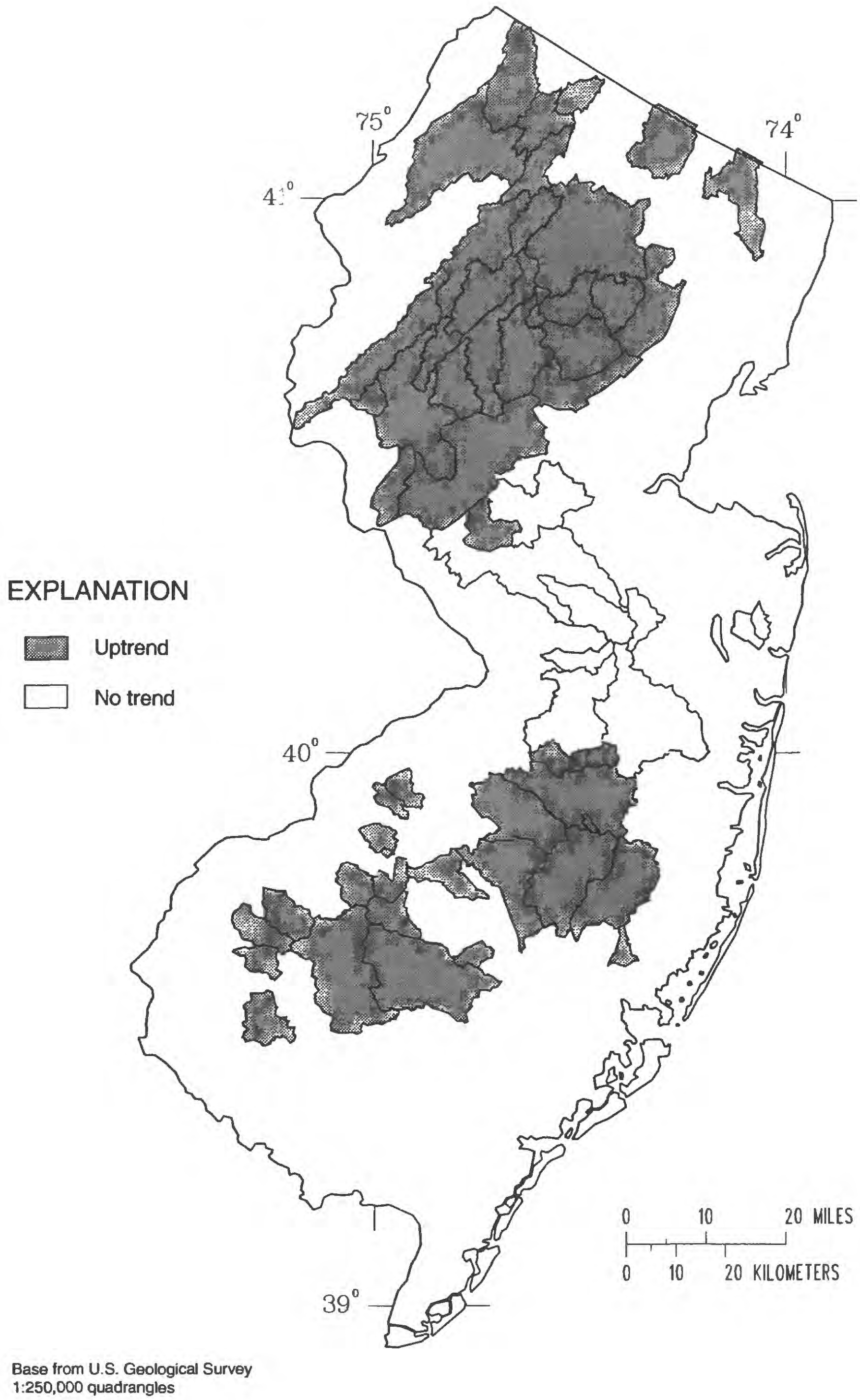


Figure 8. Trends in the estimated amounts of sodium and chloride applied to roadways by the New Jersey Department of Transportation in the New Jersey drainage basins studied, winters 1975-76 through 1986-87.

In 1980 (chosen as a representative year during WY 1976-86), the greatest amount of phosphorus applied per square mile was in drainage basins in the central and southwestern parts of the State (fig. 9). The drainage basins where phosphorus application rates were the greatest also tended to be the basins where agriculture was the dominant land use (fig. 3). Estimated phosphorus use in 1980 ranged from 0.03 to 7.04 ton/mi^2. In the same year, estimated nitrogen-fertilizer use in the 60 drainage basins ranged from 0.03 to 9.48 ton/mi^2. Drainage basins where areal applications of phosphorus fertilizer were greatest tended to be basins where areal applications of nitrogen fertilizer also were greatest.

Drainage-basin estimates of nitrogen- and phosphorus-fertilizer applications for 1975-85 were tested for time-series trends to determine whether the amount applied increased or decreased significantly during the period. Trends were identified with the Kendall's tau test for trend; a significant trend was identified at $\alpha < 0.1$. Results of the trend testing (table 17) show that estimated nitrogen fertilizer applications significantly increased in all 60 drainage basins, whereas estimated phosphorus applications declined in 52 of the 60 drainage basins. The eight drainage basins where no trend in phosphorus- fertilizer application was found also had the smallest application rates and were generally urbanized. Possible causes for the increases in nitrogen-fertilizer use and decreases in phosphorus-fertilizer use during the period include the following: the drop in cost of nitrogen fertilizer coupled with the rise in cost of phosphorus fertilizer over time; the fact that nitrogen fertilizers are generally favored by farmers because crop response is stronger than for phosphorus fertilizers; and the amount of phosphorus naturally in New Jersey soils tends to be adequate for most crops (David Smart, Natural Resources Conservation Service, oral commun., 1993).

Estimates of cropland soil-erosion rates and of the amount of land under agricultural irrigation in predominantly agricultural or forested areas of New Jersey were made in the early 1980's as part of the U.S. Department of Agriculture's (USDA) Soil Erosion, Sediment, and Animal Waste (SEASAW) Study (U.S. Department of Agriculture, 1986). The soil-erosion and irrigated-acreage estimates in the SEASAW study are based on data collected by the USDA at random locations in 20 large drainage basins of the State for the purpose of providing statistically valid estimates at the drainage-basin level (U.S.Department of Agriculture, 1986). Of the 60 drainage basins tested for water-quality trends, 39 are among the drainage basins in the SEASAW study. The soil-erosion and irrigated-acreage estimates from the SEASAW study for these 39 drainage basins are listed in table 18.

Of the basins investigated, the South Branch of the Raritan River Basin had the greatest cropland soil-erosion rate at 10 ton/acre/yr, followed by the Musconetcong River Basin at 9.8 ton/acre/yr (fig. 10). In most drainage basins, cropland soil-erosion rates were greater than 5 ton/acre/yr; soil-erosion rates greater than 5 ton/acre/yr generally result in a net loss of soil (Thomas Drewes, U.S. Soil Conservation Service, oral commun., 1989).

Irrigated acreage generally was a small percentage of the area of the drainage basins analyzed. Basins draining to the Delaware River in southwestern New Jersey had the greatest percentage of irrigated land: approximately 14 percent of each of the basins (table 13). The percentage of the drainage basin irrigated in all remaining basins was less than 10 percent.

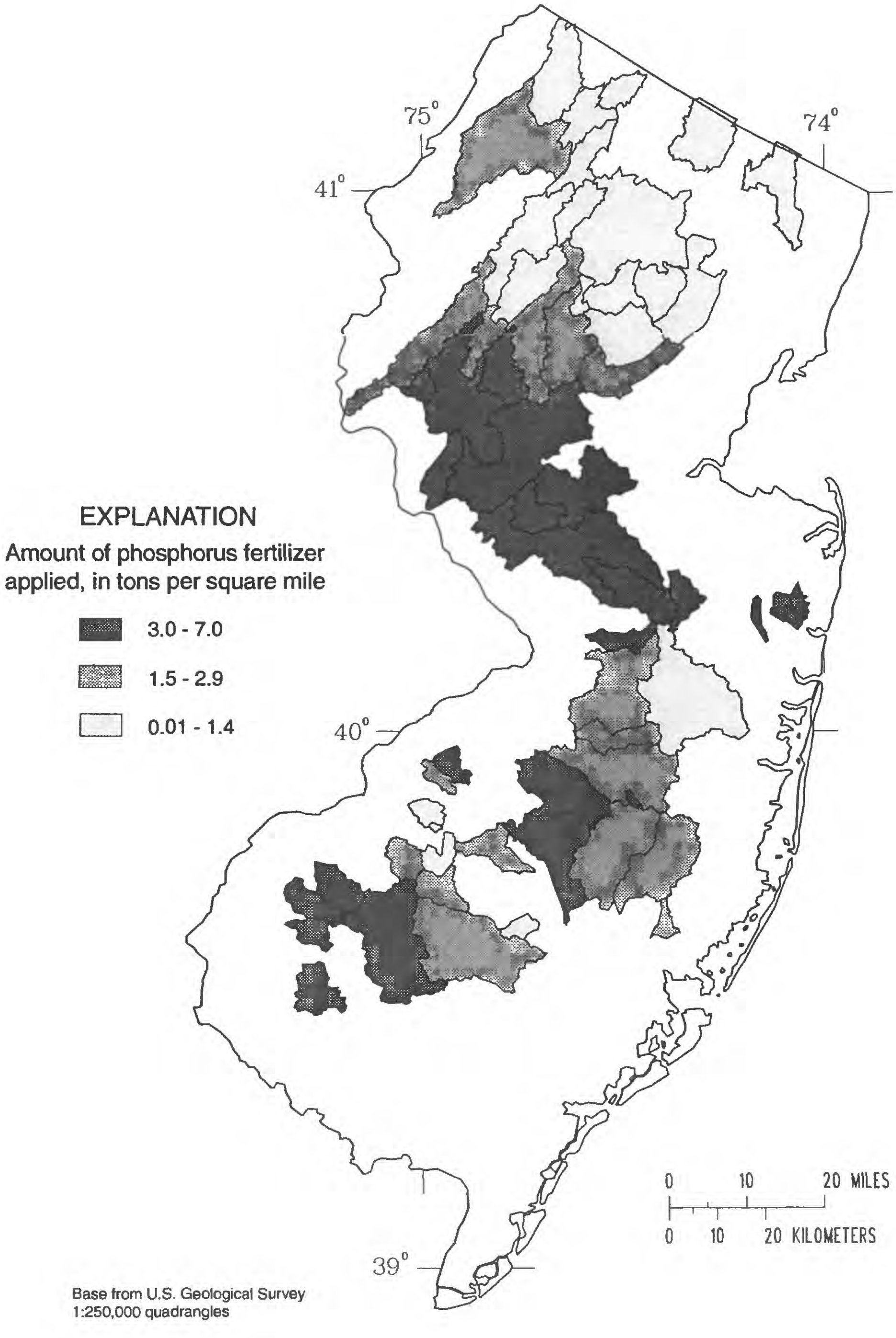


Figure 9. Estimated amounts of phosphorus fertilizer applied in the New Jersey drainage basins studied, 1980.

Table 17. Results of statistical testing for trends in the use of phosphorus and nitrogen fertilizers in the New Jersey drainage basins studied, 1975-85

[n, sample size for trends testing, equal to the number of yearly values; tau, Kendell's tau computed test statistic; p-value, the probability that fertilizer application values occur randomly rather than occur as a result of actual changes in application]

Drainage basin			Phosphorus fertilizer		Nitrogen fertilizer	
Monitoring-station name	Monitoring-station number	n	tau	p-value	tau	p-value
Wallkill River at Franklin	01367700	11	-0.418	0.087	0.418	0.087
Wallkill River near Sussex	01367770	11	-.418	.087	.418	.087
Papakating Creek at Sussex	01367910	11	-.418	.087	.418	.087
Black Creek near Vernon	01368950	11	-.418	.087	.418	.087
Passaic River near Millington	01379000	11	-.418	.087	.418	.087
Passaic River near Chatham	01379500	11	-.418	.087	.418	.087
Rockaway River at Pine Brook	01381200	11	-.400	.101	.418	.087
Whippany River at Morristown	01381500	11	-.400	.101	.418	.087
Whippany River near Pine Brook	01381800	11	-.400	.101	.418	.087
Passaic River at Two Bridges	01382000	11	-.418	.087	.418	.087
Wanaque River at Wanaque	01387000	11	-.418	.080	.436	.071
Saddle River at Lodi	01391500	11	-.418	.080	.436	.071
SB Raritan River at Middle Valley	01396280	11	-.400	.101	.418	.087
SB Raritan River at Arch St at High Bridge	01396535	11	-.418	.087	.418	.087
Mulhockaway Creek at Van Syckel	01396660	11	-.418	.087	.418	.087
SB Raritan River at Three Bridges	01397400	11	-.418	.087	.418	.087
NB Raritan River near Chester	01398260	11	-.400	.101	.418	.087
NB Raritan River at Burnt Mills	01399120	11	-.418	.087	.418	.087
Rockaway Creek at Whitehouse	01399700	11	-.418	.087	.418	.087
Lamington (Black) River at Burnt Mills	01399780	11	-.418	.087	.418	.087
Raritan River at Manville	01400500	11	-.418	.087	.418	.087
Millstone River at Grovers Mill	01400650	11	-.418	.087	.418	.087
Millstone River at Kingston	01401440	11	-.418	.087	.418	.087
Beden Brook near Rocky Hill	01401600	11	-.418	.087	.418	.087
Millstone River at Weston	01402540	11	-.418	.087	.418	.087
Manalapan Brook at Federal Rd near Manalapan	01405340	11	-.418	.087	.418	.087
Shark River near Neptune City	01407705	11	-.418	.087	.418	.087
Jumping Brook near Neptune City	01407760	11	-.418	.087	.418	.087
Marsh Bog Brook at Squankum	01407997	11	-.418	.087	.418	.087
Toms River near Toms River	01408500	11	-.418	.087	.418	.087
Mullica River at outlet of Atsion Lake at Atsion	01409387	11	-.418	.087	.418	.087
Hammonton Creek at Wescoatville	01409416	11	-.418	.087	.418	.087
Batsto River at Batsto	01409500	11	-.418	.087	.418	.087
WB Wading River at Maxwell	01409815	11	-.418	.087	.418	.087
Oswego River at Harrisville	01410000	11	-.418	.087	.418	.087
EB Bass River near New Gretna	01410150	11	-.418	.087	.418	.087
Great Egg Harbor River near Sicklerville	01410784	11	-.400	.101	.418	.087
Great Egg Harbor River near Blue Anchor	01410820	11	-.418	.087	.418	.087
Great Egg Harbor River at Weymouth	01411110	11	-.418	.087	.418	.087
Maurice River at Norma	01411500	11	-.418	.087	.418	.087
Cohansey River at Seeley	01412800	11	-.418	.087	.418	.087
Paulins Kill at Blairstown	01443500	11	-.418	.087	.418	.087
Musconetcong River at outlet of Lake Hopatcong	01455500	11	-.418	.087	.418	.087
Musconetcong River at Beatyestown	01456200	11	-.418	.087	.418	.087
Musconetcong River at Riegelsville	01457400	11	-.418	.087	.418	.087
Wickecheoke Creek at Stockton	01461300	11	-.418	.087	.418	.087
Crosswicks Creek at Extonville	01464500	11	-.418	.087	.418	.087
Doctors Creek at Allentown	01464515	11	-.418	.087	.418	.087
SB Rancocas Creek at Vincentown	01465850	11	-.418	.087	.418	.087
NB Rancocas Creek at Browns Mills	01465970	11	-.418	.087	.418	.087
McDonalds Branch in Lebanon State Forest	01466500	11	-.418	.087	.418	.087
NB Rancocas Creek at Pemberton	01467000	11	-.418	.087	.418	.087
NB Pennsauken Creek near Moorestown	01467069	11	-.418	.087	.418	.087
SB Pennsauken Creek at Cherry Hill	01467081	11	-.418	.087	.418	.087
Cooper River at Norcross Rd at Lindenwold	01467120	11	-.400	.101	.418	.087
Cooper River at Lawnside	01467140	11	-.400	.101	.418	.087
SB Big Timber Creek at Blackwood Terrace	01467329	11	-.418	.087	.418	.087
Raccoon Creek near Swedesboro	01477510	11	-.418	.087	.418	.087
Oldmans Creek at Porches Mill	01477120	11	-.418	.087	.418	.087
Salem River at Woodstown	01482500	11	-.418	.087	.418	.087

Table 18. Cropland soil-erosion rates and estimated acreage irrigated in 39 of the New Jersey drainage basins studied, 1986

[Data from U.S. Department of Agriculture (1986); ton/acre/yr, tons per acre per year; <, less than]

Drainage basin: Monitoring-station name	Drainage basin: Monitoring-station number	Rate of cropland erosion (ton/acre/yr)	Estimated irrigated acreage: Number of acres	Estimated irrigated acreage: Percentage of drainage-basin area
Wallkill River at Franklin	01367700	3.6	0	0
Wallkill River near Sussex	01367770	3.6	0	0
Papakating Creek at Sussex	01367910	3.6	0	0
Black Creek near Vernon	01368950	3.6	0	0
SB Raritan River at Middle Valley	01396280	10.0	172	<1
SB Raritan River at Arch St at High Bridge	01396535	10.0	251	<1
Mulhockaway Creek at Van Syckel	01396660	10.0	43	<1
SB Raritan River at Three Bridges	01397400	10.0	661	<1
NB Raritan River near Chester	01398260	8.1	0	0
NB Raritan River at Burnt Mills	01399120	8.1	0	0
Rockaway Creek at Whitehouse	01399700	8.1	0	0
Lamington (Black) River at Burnt Mills	01399780	8.1	0	0
Millstone River at Grovers Mill	01400650	7.2	1,762	6
Millstone River at Kingston	01401440	7.2	6,983	6
Beden Brook near Rocky Hill	01401600	7.2	1,121	6
Millstone River at Weston	01402540	7.2	10,927	6
Manalapan Brook at Federal Rd near Manalapan	01405340	7.2	174	<1
Marsh Bog Brook at Squankum	01407997	4.8	0	0
Maurice River at Norma	01411500	7.2	5,735	8
Cohansey River at Seeley	01412800	7.1	2,477	8
Paulins Kill at Blairstown	01443500	3.6	0	0
Musconetcong River at outlet of Lake Hopatcong	01455500	9.8	51	<1
Musconetcong River at Beatyestown	01456200	9.8	184	<1
Musconetcong River at Riegelsville	01457400	9.8	240	<1
Wickecheoke Creek at Stockton	01461300	9.8	0	0
Crosswicks Creek at Extonville	01464500	5.8	2,379	5
Doctors Creek at Allentown	01464515	5.8	508	5
SB Rancocas Creek at Vincentown	01465850	4.0	1,029	2
NB Rancocas Creek at Browns Mills	01465970	4.0	437	2
McDonalds Branch in Lebanon State Forest	01466500	4.0	38	2
NB Rancocas Creek at Pemberton	01467000	4.0	1,882	2
NB Pennsauken Creek near Moorestown	01467069	5.1	1,173	14
SB Pennsauken Creek at Cherry Hill	01467081	5.1	823	14
Cooper River at Norcross Rd at Lindenwold	01467120	5.1	102	14
Cooper River at Lawnside	01467140	5.1	1,162	14
SB Big Timber Creek at Blackwood Terrace	01467329	5.1	1,749	14
Raccoon Creek near Swedesboro	01477120	5.1	2,463	14
Oldmans Creek at Porches Mill	01477510	5.1	809	6
Salem River at Woodstown	01482500	8.5	562	6

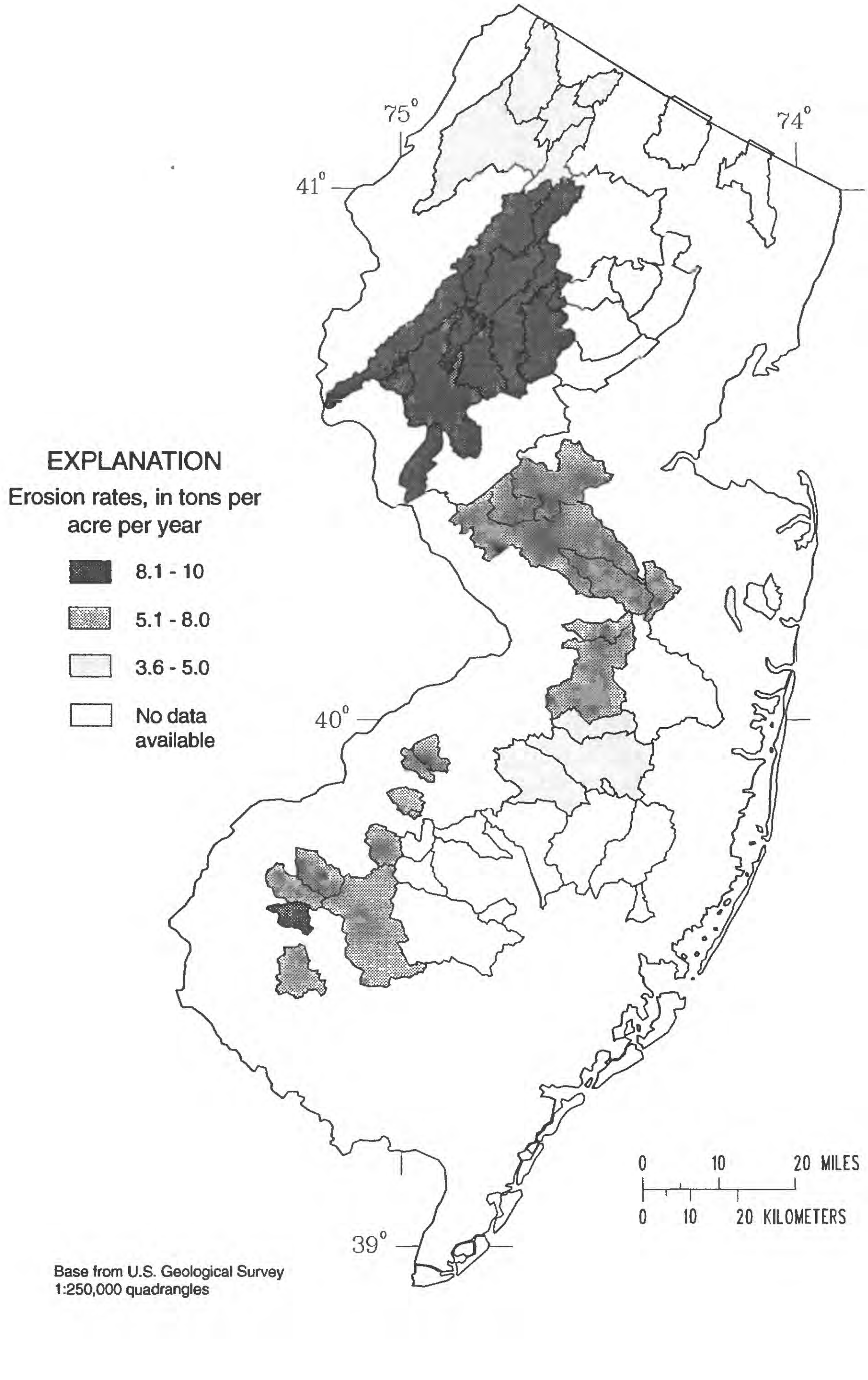


Figure 10. Estimated cropland soil-erosion rates in 39 of the New Jersey drainage basins studied, early 1980's.

METHODS OF STUDY

Statistical Methods for Associating Water-Quality Trends and Drainage-Basin Characteristics

Associations between water-quality trends and drainage-basin characteristics were determined by means of contingency-table analyses. A contingency-table analysis (Snedecor and Cochran, 1967) is designed to test the association of one variable (for example, trends for a streamwater constituent or property) with a second variable (for example, a basin characteristic). A contingency-table analysis is not intended to imply a statistical cause-and- effect relation, as might be implied by results from regression or correlation analysis. Smith and others (1987a, 1987b) and Lettenmaier and others (1991) used contingency-table analyses in their interpretations of nationwide water-quality trends. In this study also, contingency-table analyses were used to identify associations among the trends of the 15 constituents and properties with each other and to determine whether each trend had a seasonal component.

Contingency tables associating water-quality trends to basin characteristics were usually constructed in 3x3 arrays: the trend results for a constituent or property (upward trend, downward trend, or no trend) against three categorical definitions of a drainage-basin characteristic. The null hypothesis, H_0, of the contingency-table analysis is that the row classification (water-quality trend) is independent of the column classification (basin characteristic).

Contingency tables are used to compare the expected count for each cell in the array with the observed count. The expected count for a cell is the count one would expect to find, given the assumption of independence, if only the row and column counts are known. If the differences between expected and observed counts are small, then the null hypothesis is accepted. If the difference between the observed and expected counts is sufficiently large (larger than the test statistic at a given α level), then the null hypothesis is rejected. In this case, a significant statistical association between the row and column classifications is considered to exist. Significance of association between two variables in a contingency table is tested by use of a chi-square statistic or by the exact significance through enumeration of all possible table configurations.

Associations were considered to be statistically significant at $\alpha \leq 0.10$; this is the probability that an apparent association between the two variables could have resulted solely by chance arrangement of the data rather than through probable association between the two variables.

If more than one cell in a contingency table had an expected frequency of less than 1, or if more than 20 percent of the cells had an expected frequency of less than 5, then the observed data were not considered to be distributed sufficiently to represent a chi-square distribution (Cochran, 1952). Either arrangement can result in inaccurate probabilities from chi-square testing. When this insufficient distribution of expected values in the contingency table occurred, the exact significance was determined through enumeration of all possible table configurations (Cochran, 1952).

All drainage-basin characteristics analyzed for association with the water-quality trends were classified into three categories for use in contingency tables. If the basin characteristic was described in terms of a continuous value, such as the amount of road salt applied in a basin, then the category assigned to a basin was based on the 33rd and 67th percentiles of the ranked values for all basins. If the basin characteristic was a categorical term (such as physiographic province), then the terms were grouped into three classes on the basis of similar characteristics. A description of the categories of drainage-basin characteristics used in contingency-table analyses is given in table 19.

One set of contingency-table variables, seasonal trends for selected constituents and properties, was divided into six categories. Each category was a water-quality trend result for data from a 2-month period (or season) during WY 1976-86. This category resulted in a 36 array; WY 1976-86 trend result reported by Hay and Campbell (1990) against the trend result for each 2-month period. All contingency-table results are listed in table 20 (at back of report).

As mentioned previously, a contingency-table analysis test for the presence or absence of statistical association between water-quality trends and a drainage-basin characteristic does not determine cause-and-effect relations between the variables. In addition, streamwater quality can be affected by many factors, some of which could not be quantified and tested for association. As a result, the associations identified in this report by the contingency-table analyses are designed to indicate which drainage-basin characteristics and activities may have affected the trends in water quality in New Jersey streams. These associations can serve as the basis for future cause-and-effect investigations of water quality.

Methods for Selecting Drainage Basins

In using chi-square contingency-table analysis, one assumes that the variable data are independent and random. In 10 of the 60 drainage basins analyzed, 2 or more monitoring stations tested for trends in water-quality data are on the same stream. This can mean that the water-quality data, and therefore, trends in those data, may not be independent. Water-quality trends that are related to other water-quality trends on the same stream had to be eliminated before contingency-table analysis could be done. Correlation analyses of data for each constituent and property measured at the monitoring stations on the same stream were done to identify which water-quality trends were not independent.

The water-quality data used in the correlation analysis were the same data used in the trend analysis by Hay and Campbell (1990). Where significant correlation was found in the data for a particular constituent at two monitoring stations, one monitoring station was dropped from the data base. As a result, a unique list of monitoring stations (or drainage basins) was generated for each constituent and property for use in the contingency-table analysis.

A nonparametric statistical test for data correlation, Spearman's Rank- Correlation Coefficient (Conover, 1980), was used to identify the presence of correlation in the water-quality data. This statistical method identifies relation between variables on the basis of ranks of the data for each variable; no assumptions on the distribution of the data are required. To ensure

Table 19. Categorical definitions of drainage-basin characteristics as used in contingency-table analysis of data for the New Jersey drainage basins studied

[The category definitions for continuous variables were calculated by use of the 33rd and 67th percentiles of the distribution of the data; mi^2, square miles; $Mgal/d/mi^2$, million gallons per day per square mile; $kg/d/mi^2$, kilograms per day per square mile; ton/mi^2, tons per square mile]

Basin characteristic	Category 1	Category 2	Category 3
Drainage-basin size (mi^2)	1.13-25.3	26.0-68.8	69.0-490
Physiographic province	Coastal Plain	Piedmont	New England; Valley and Ridge
Dominant land-use type	Urban	Forest	Agriculture
Population			
a. 1986 population (persons)	48-9,482	9,483-29,780	29,781-424,547
b. 1986 population density (persons per square mile)	21-303	304-663	664-2,889
c. Change in population density, 1975-86 (persons per square mile)	-75-+29	+30-+70	+71-+438
Permitted wastewater discharge			
a. Change in number of treatment facilities, 1975-86	Decrease	No change	Increase
b. Wastewater yields in drainage basin			
1. Wastewater discharge ($Mgal/d/mi^2$)	0.000	<0.001-0.031	0.032-28.0
2. Biochemical oxygen demand, 5-day ($kg/d/mi^2$)	0.000-0.071	0.072-0.481	0.482-48.9
3. Total suspended solids ($kg/d/mi^2$)	0.000-0.091	0.092-2.05	2.06-28.0
c. Percentage of wastewater flow, biological oxygen demand, and total suspended soilds originating from municipal facilities	0-40	41-60	61-100
d. Wastewater yields in area 3.1 miles upstream from the monitoring station			
1. Wastewater discharge ($Mgal/d/mi^2$)	0.000-0.005	0.006-0.012	0.013-0.216
2. Biochemical oxygen demand, 5-day ($kg/d/mi^2$)	0.000-0.067	0.068-0.671	0.672-37.5
3. Total suspended solids ($kg/d/mi^2$)	0.000-0.093	0.094-0.710	0.711-23.8
Road-salt application in winter, 1980-81			
a. Calcium (ton/mi^2)	0.09-0.10	0.11-0.63	0.64-1.1
b. Sodium (ton/mi^2)	0.46-0.52	0.53-2.7	2.8-4.1
c. Chloride (ton/mi^2)	0.82-0.92	0.93-4.9	5.0-7.6
Agricultural activities			
a. 1980 fertilizer application (ton/mi^2)			
1. Phosphorus	0.01-1.4	1.5-2.9	3.0-7.0
2. Nitrogen	0.02-1.9	2.0-3.9	4.0-9.5
b. Cropland soil erosion rate (tons per acre per year)	3.6-5.0	5.1-8.0	8.1-10
c. Irrigated land in basin (percent of drainage basin)	0.00-1.00	1.01-5.00	5.01-14.0

that the water-quality data were collected under similar hydrologic conditions, the data from the two monitoring stations used in the correlation analysis had to be collected on the same day. Significant correlation was identified at $\alpha = 0.05$.

Before the correlation analysis was done, all remark codes in the water-quality data were eliminated. Data with "less than" remark codes were assigned half the detection limit, and data with "greater than" remark codes were assigned the highest detection value plus 1.

When the data for a constituent or property were significantly correlated at two or more monitoring stations, the following criteria were applied to select the monitoring station for use in the contingency-table analysis:

- If either no trend or a trend in the same direction was found for a constituent or property at two monitoring stations on the same stream, then the downstream station was selected.

- If an upward trend or a downward trend was found for a constituent or property at one station but no trend was found at the second station, then the station where the trend was found was selected regardless of its location on the stream.

- If a constituent or property was tested for trends at only one of two stations, then the station analyzed for trends was selected.

- If three stations were on the same stream, then each pair was tested as above. If data at the most upstream and most downstream stations were both correlated with the data at the middle station but not with each other, and if trends were found at all three stations, then the middle station was excluded.

Results of the correlation analysis are listed in table 21 (at back of report). Correlation analyses resulted in the elimination of one to eight monitoring stations depending on the constituent or property (table 22). Specific conductance, pH, and concentrations of dissolved oxygen and total organic carbon, were most frequently correlated on the same stream. The number of drainage basins remaining in the data set after the correlation analyses ranged from 17 for concentrations of total ammonia to 52 for concentrations of dissolved sodium (table 22). The water-quality trends for these drainage basins (Hay and Campbell, 1990) are listed in table 23 (at back of report) and shown in figures 11-13.

ASSOCIATIONS BETWEEN WATER-QUALITY TRENDS AND DRAINAGE-BASIN CHARACTERISTICS

Contingency-table analyses reveal that trends of many of the streamwater constituents and properties found in New Jersey streams during WY 1976-86 appear to be affected by the drainage-basin characteristics described in this report. Test results show that all of the drainage-basin characteristics were statistically associated with the trends of one or more of the 13 constituents or 2 physical properties (table 24). A detailed discussion of the results of

Table 22. Summary of correlation-test results on water-quality data collected at New Jersey stream-monitoring stations whose trends were used in contingency-table analysis

[μS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliter]

Constituent or property (units)	Number of monitoring stations tested for correlation	Number of monitoring stations eliminated because of data correlation	Number of monitoring stations whose trends were tested for association with basin characteristics
Specifc conductance (μS/cm)	23	7	50
Dissolved oxygen (mg/L)	23	8	47
Biochemical oxygen demand, 5-day (mg/L)	23	5	39
pH (standard units)	23	6	48
Total nitrogen, as N (mg/L)	23	1	20
Total ammonia, as N (mg/L)	23	2	17
Total phosphorus, as P (mg/L)	23	3	39
Total organic carbon (mg/L)	23	7	43
Dissolved calcium (mg/L)	23	4	50
Dissolved magnesium (mg/L)	23	4	50
Dissolved sodium (mg/L)	23	4	52
Dissolved potassium (mg/L)	23	4	51
Dissolved chloride (mg/L)	23	5	51
Fecal coliform (MPN/100 mL)	23	3	48
Fecal streptococcus (MPN/100 mL)	23	2	45

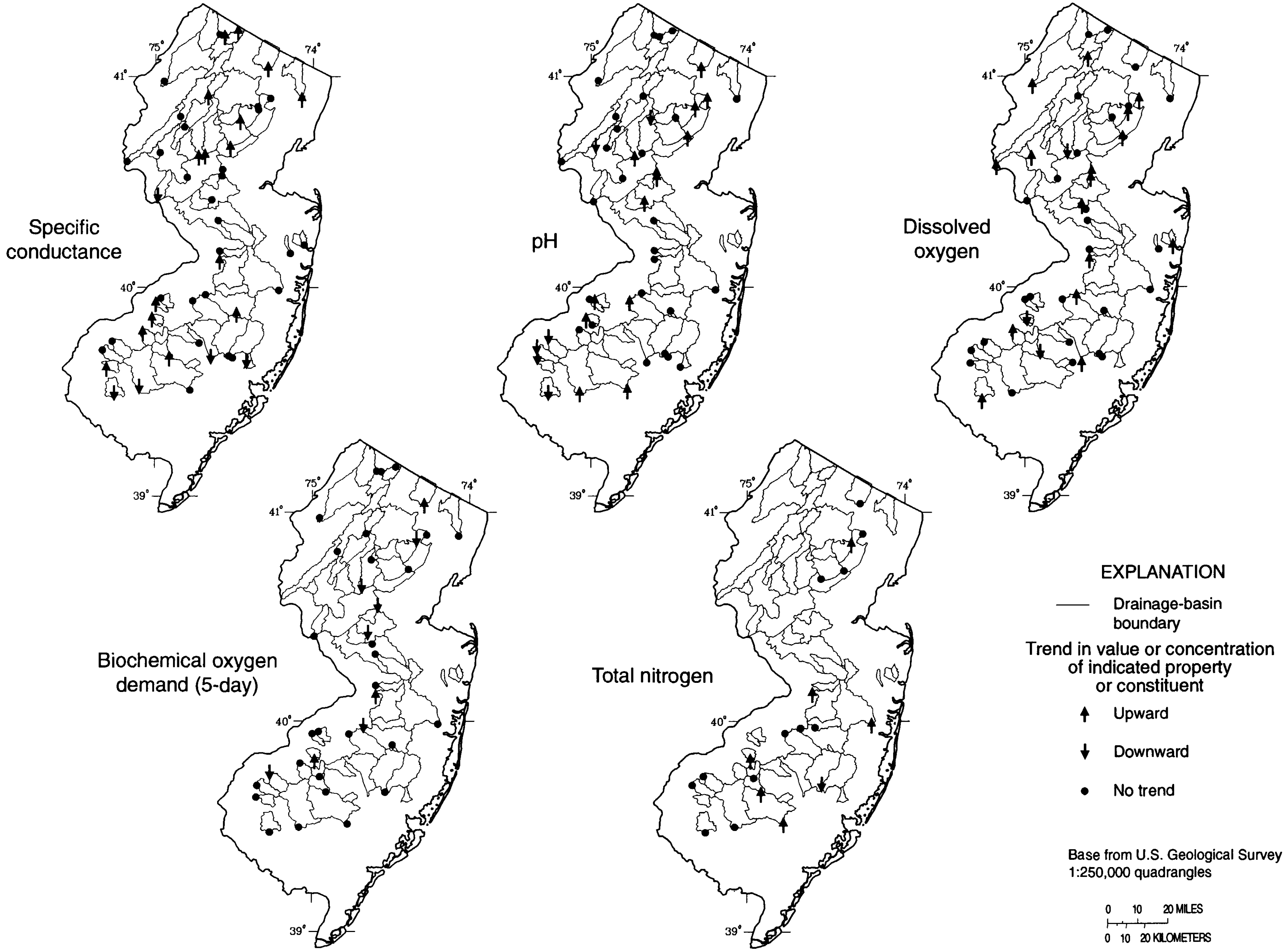


Figure 11. Locations of New Jersey stream-monitoring stations and trends in specific conductance, pH, and concentrations of dissolved oxygen, biochemical oxygen demand (5-day), and total nitrogen used in contingency-table analysis.

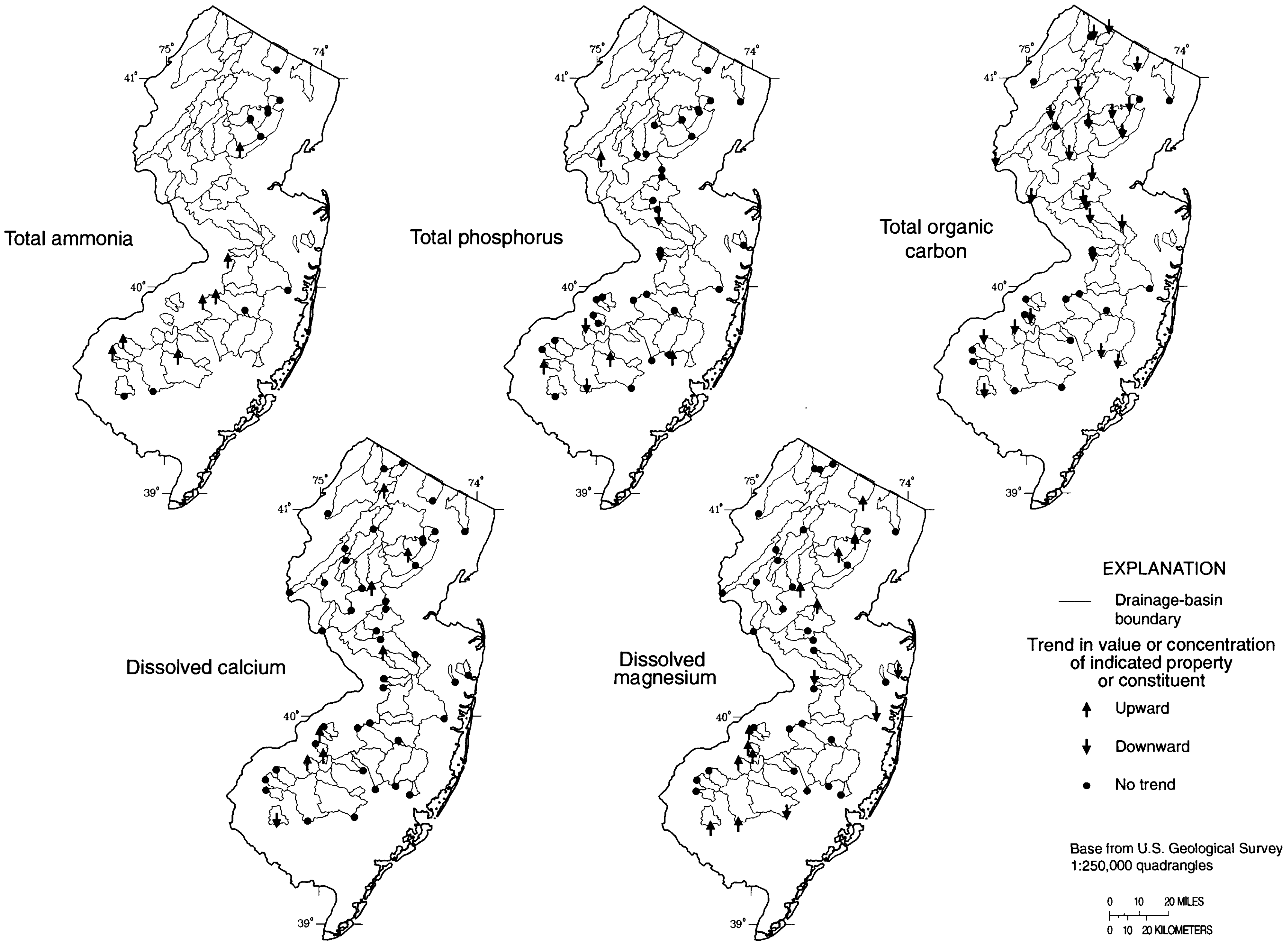


Figure 12. Locations of New Jersey stream-monitoring stations and trends in concentrations of total ammonia, total phosphorus, total organic carbon, dissolved calcium, and dissolved magnesium used in contingency-table analysis.

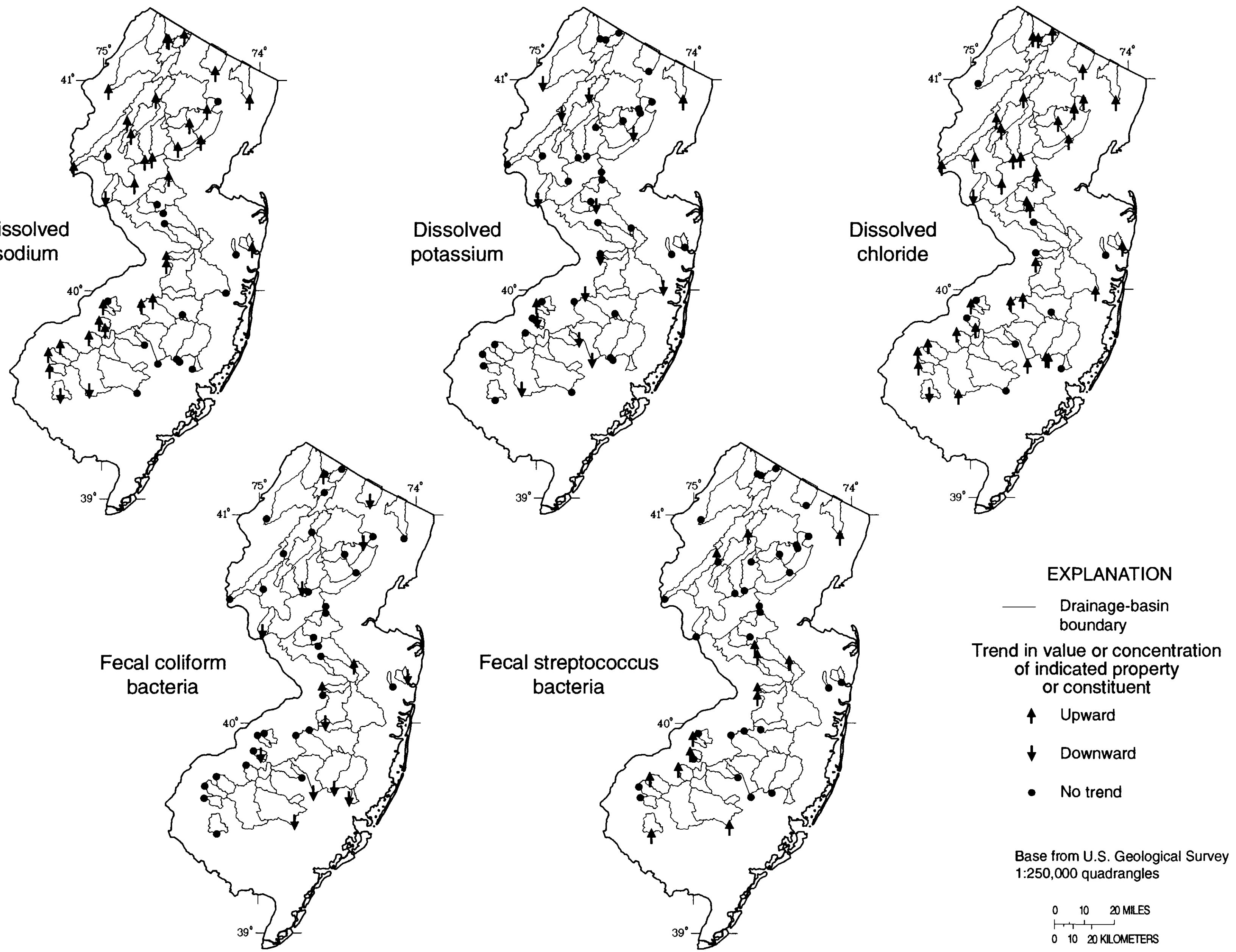


Figure 13. Locations of New Jersey stream-monitoring stations and trends in concentrations of dissolved sodium, dissolved potassium, dissolved chloride, fecal coliform bacteria, and fecal streptococcus bacteria used in contingency-table analysis.

Table 24. Streamwater constituents and properties whose trends were significantly associated with drainage-basin characteristics in New Jersey

Drainage-basin characteristic	Associated trends in constituent concentrations or physical property
1. Drainage-basin size	Specific conductance, dissolved chloride
2. Physiographic region of drainage basin	Total organic carbon, dissolved sodium
3. Presence of agricultural, urban, or forest land as the dominant land use	
a. Entire drainage basin	pH, dissolved potassium, fecal streptococcus bacteria
b. Area 3.1 miles upstream from monitoring station	pH, total ammonia, dissolved magnesium, dissolved potassium, fecal coliform bacteria
c. Area 0.62 mile upstream from monitoring station	pH, total ammonia, dissolved magnesium, dissolved sodium, dissolved chloride
4. Population	
a. 1986 drainage-basin population	pH
b. 1986 drainage-basin population density	Specific conductance, pH
c. Change in population density, 1975-86	Biochemical oxygen demand
5. Wastewater disposal	
a. Change in number of wastewater discharges, 1975-86	Specific conductance, total ammonia
b. Wastewater yields in entire drainage basin	
1. Wastewater discharge bacteria	pH, dissolved sodium, fecal streptococcus
2. Biochemical oxygen demand, 5-day	pH, dissolved sodium
3. Total suspended solids	pH, dissolved sodium
c. Wastewater yields in area 3.1 miles upstream from monitoring station	
1. Wastewater discharge	Total ammonia, as N
2. Biochemical oxygen demand, 5-day	Dissolved calcium, dissolved sodium, dissolved chloride, fecal coliform bacteria
3. Total suspended solids	Dissolved calcium, dissolved chloride
d. Percentage of yields in entire basin originating from municipal facilities	
1. Wastewater discharge	Dissolved oxygen
2. Biochemical oxygen demand, 5-day	Specific conductance
3. Total suspended solids	Dissolved chloride, fecal streptococcus bacteria
e. Percentage of yields in area 3.1 miles upstream from monitoring station originating from municipal facilities	
1. Wastewater discharge	Dissolved oxygen, fecal coliform bacteria
2. Biochemical oxygen demand, 5-day	Dissolved oxygen
3. Total suspended solids	Dissolved oxygen
6. Road-salt application	
a. Trends in sodium use, 1975-86	Dissolved magnesium
b. Trends in chloride use, 1975-86	Dissolved magnesium
c. Road-salt application (winter 1980)	
1. Chloride	Specific conductance, dissolved magnesium, dissolved sodium, dissolved chloride
2. Sodium	Specific conductance, pH
3. Calcium	Specific conductance, pH
7. Agricultural Activities	
a. Trends in phosphorous fertilizer application, 1975-85	Dissolved magnesium
b. 1980 applications of phosphorous and nitrogen fertilizers	Specific conductance, pH
c. Soil erosion rates	Fecal streptococcus bacteria
d. Percentage of drainage basin area irrigated	pH, dissolved magnesium

contingency-table analyses by drainage-basin characteristic is given in the paragraphs that follow. Probabilities of statistically strong associations ($p \leq 0.01$) are noted in the text, as are the probabilities for tests that were nearly statistically significant ($p > 0.10$ and $p < 0.15$).

Contingency-table testing for associations among the water-quality trends revealed a number of expected associations (table 25). Increases in the concentration of dissolved ions were frequently associated with one another, as were increases in specific conductance and increases in dissolved ions. Because specific conductance is a measure of electrical conductivity in water, concentrations of dissolved ions are closely related to specific conductance (Hem, 1985). Another expected relation among the trends was an increase in dissolved-oxygen concentration with decreasing biochemical oxygen demand (BOD). Although in-stream dissolved-oxygen concentrations are typically affected by many factors, the amount of oxygen-demanding waste (measured as BOD), can be a dominant factor. Certain expected associations between trends, such as between concentrations of dissolved oxygen and nutrients and between fecal coliform and fecal streptococcus bacteria, were not found.

Trends in the concentrations of only one constituent, dissolved sodium, were associated with seasons. Upward trends in dissolved sodium were more frequent during October through January than at other times of the year. Increasing chloride concentrations were nearly associated with seasons ($p = 0.146$) because increases in chloride concentration tended to occur during October through January. These results indicate that basin activities during the fall and winter appear to have a stronger affect on the upward trends in dissolved sodium and chloride concentrations than do activities at other times of the year. Increasing dissolved-oxygen concentrations also were nearly associated with seasons ($p = 0.109$); increasing dissolved oxygen concentrations were present more frequently during August through November than in other months of the year.

Streamflow

Tests of association between water-quality trends and trends in instantaneous streamflow were done to identify possible effects of changes in streamflow on the observed water-quality changes. These tests also served to measure the effectiveness of the flow-adjustment procedure used by Hay and Campbell (1990).

A statistically significant association between the trends in total nitrogen concentrations and instantaneous-streamflow trends was the only significant association found for all 15 streamwater constituents and properties. Upward trends in this constituent generally occurred where no trends in streamflow were found.

Fecal streptococcus bacteria trends were nearly associated with instantaneous-streamflow trends ($p = 0.107$). Like the total nitrogen trends, upward trends in fecal streptococcus bacteria were detected primarily at stations where no streamflow trends were found.

Table 25. Significant associations among water-quality trends in the New Jersey drainage basins studied

Streamwater property or constituent with trend	Associated streamwater property or constituent trends
Specific conductance	Biochemical oxygen demand, dissolved sodium, dissolved chloride, dissolved potassium
Dissolved oxygen	Biochemical oxygen demand
Biochemical oxygen demand	Specific conductance, dissolved oxygen
pH	Dissolved calcium
Total nitrogen	- -[1]
Total ammonia	Dissolved sodium, dissolved magnesium
Total phosphorus	Fecal streptococcus bacteria
Total organic carbon	Dissolved chloride
Dissolved calcium	pH, dissolved magnesium
Dissolved magnesium	Dissolved calcium, total ammonia
Dissolved sodium	Dissolved chloride, total ammonia, specific conductance
Dissolved potassium	Specific conductance
Dissolved chloride	Specific conductance, dissolved sodium, total organic carbon
Fecal coliform bacteria	- -[1]
Fecal streptococcus bacteria	Total phosphorus

[1]No other streamwater-property or -constituent trends associated with trends in this property or constituent.

The trends determined by Hay and Campbell (1990) for total nitrogen and fecal streptococcus bacteria were, for the most part, not based on flow-adjusted values. As such, associations between trends and streamflow would be expected for these constituents. Overall, the absence of associations between water-quality trends and instantaneous-streamflow trends indicates that the flow-adjustment procedure used by Hay and Campbell (1990) was effective in removing the effects of streamflow variation on the water-quality data.

Geographic Setting

Most identified trends were uniform throughout the State and were independent of physiographic factors, as evidenced by the absence of associations between the water-quality trends and the physiographic province of the drainage basin. Trends in only two water-quality constituents, downward trends in total organic carbon concentrations and upward trends in dissolved sodium concentrations, were significantly associated with physiographic province. Downward trends in total organic carbon were more common than expected north of the Fall Line. The reasons for this are not known. In contrast, upward trends in dissolved sodium tended to occur at more stations north of the Fall Line (70 percent of the drainage basins) than south of the Fall Line (52 percent of the drainage basins). The upward trends in dissolved sodium could be due to the more frequent use of road salts in the northern part of the State.

In a second set of tests to determine the distribution of the water-quality trends, associations between the trends and drainage-basin size were evaluated. Overall, the water-quality trends showed little association with drainage-basin size. Only trends in specific conductance and concentrations of dissolved chloride were significantly associated with drainage-basin size. For specific conductance, nearly one-half of the upward trends were found in the smallest drainage basins (smaller than 25.5 mi^2). Increases in dissolved-chloride concentrations were more common at stations in the largest drainage basins (larger than 68.7 mi^2), whereas the smallest drainage basins had a higher number of stations where no trends were found. The conservative chemical behavior of chloride in surface water may explain the frequent increases in the larger drainage basins. This conservative chemical behavior causes chloride concentrations to increase in a downstream direction.

Land Use

Trends in pH and several chemical constituents were associated with the dominant land use in the drainage basin. These associations were found at more monitoring stations and were statistically stronger where the dominant land use nearest the monitoring station, as opposed to that of the entire basin, was associated with the trends. In addition to pH, constituents whose trends were associated with land use were concentrations of fecal coliform and streptococcus bacteria, dissolved magnesium, dissolved potassium, dissolved chloride, dissolved sodium, and total ammonia.

Trends in pH were consistently associated with the dominant land use above the monitoring station, regardless of whether the entire drainage basin or only the areas 3.1 mi and 0.62 mi upstream from the monitoring station were considered. Downward trends in pH were found at more stations than expected in agricultural basins, whereas upward trends in pH were found at more stations than expected in urban drainage basins. The associations for pH trends were strongest for the dominant land use in the area 0.62 mi upstream from the monitoring station. These results match information in the literature describing land-use effects on the quality of runoff. Increases in the pH of runoff from urban drainages have been documented by Halverson and others (1984) and Harrison and Wilson (1985). Dornbush and others (1974) report pH reductions in runoff from agricultural fields due to the leaching of cations.

Upward trends in the concentrations of dissolved magnesium and potassium were found at more stations than expected in drainage basins dominated by urban land. The association between dissolved-magnesium trends and the dominant land use in the area 0.62 mi upstream from the monitoring station was highly significant ($p = 0.002$). Downward trends in dissolved-potassium concentrations tended to occur at monitoring stations in forested basins. Trends in the concentrations of two additional dissolved ions, sodium and chloride, were statistically associated with the land use in the area 0.62 mi upstream from the monitoring station and not with the dominant land use in the entire drainage basin. Upward trends in sodium and chloride concentrations during WY 1976-86 were found at monitoring stations where the nearby upstream land use was primarily urban or agriculture. Lettenmaier and others (1991) also reported statistical associations between upward trends in concentrations of dissolved ions and the presence of urban lands.

Trends in the concentrations of fecal streptococcus bacteria were associated with land use in the entire drainage basin, but showed no association with nearby land uses; upward trends were common in agricultural drainage basins. In contrast, fecal coliform bacteria trends were associated with land use only in the area 3.1 mi upstream from the monitoring station. Downward trends in fecal coliform bacteria concentrations were most frequent where the area 3.1 mi upstream was dominated by forest. The ratio of fecal coliform bacteria to fecal streptococcus bacteria is often used to distinguish whether the source of the bacteria is either humans or other warm-blooded animals. In order to determine if the trends in the concentrations of fecal coliform and fecal streptococus bacteria had any association to the fecal coliform/fecal streptococcus ratio, contingency table tests were done with those two variables. No significant associations were detected in the tests; hence, trends in concentrations of these bacteria appear to be independent of each other.

Trends in concentrations of only one of three nutrients were found to be statistically associated with land use. Trends in concentrations of total ammonia were associated with the dominant land use in the areas 0.62 and 3.1 mi upstream from the monitoring station. In these associations, upward trends in concentrations of total ammonia were found at more monitoring stations than expected in agricultural basins; these upward trends were mostly in the southern half of the State. Various forms of ammonia are used in fertilizers to promote plant growth. In a comparison of the quality of streams draining agricultural, urban, and forested lands, Crawford and Lenat (1989) found higher concentrations of dissolved ammonia in the agricultural streams than in streams draining the other land uses.

Population

Contingency-table tests that associated water-quality trends with estimates of drainage-basin population and change in population density from 1975 to 1986 identified few statistically significant associations. Only trends in pH, specific conductance, and BOD concentrations were associated with drainage-basin population.

Trends in pH were strongly associated with estimates of 1986 drainage-basin population ($p = 0.007$) and to population-density estimates. Drainage basins having the lowest estimated population (less than 9,482 persons) and estimated density (less than 303 persons per square mile) had a higher proportion of the pH downward trends (fig. 14). In contrast, upward trends in pH occurred more frequently than expected in drainage basins having the greatest estimated population (over 29,781 persons) and density (more than 663 persons per square mile). These associations between pH trends and population tend to follow the same pattern as the associations found between land use and pH trends (for example, pH upward trends in urbanized basins and pH downward trends in agricultural basins).

Specific conductance trends were associated with drainage-basin population. As with pH trends, specific conductance downward trends were more common than expected in drainage basins with the lowest population density, whereas upward trends were found where population densities were the greatest.

Estimated change in population density from 1975 to 1986 in the 60 drainage basins was associated with the trends in only one constituent, BOD. Drainage basins with comparatively moderate population growth of 34-70 persons per square mile had the majority of trends in BOD during the 11-year period. A possible cause for the BOD trends in these basins may be the varying ability of existing infrastructure to accommodate the population changes and ultimately treat oxygen-consuming wastes.

Effluent Discharge

The upgrading of municipal wastewater-treatment systems throughout New Jersey has been considered a major success in water-pollution control in the State (New Jersey Department of Environmental Protection, 1984, 1986). An unanswered question is, "Have these efforts in wastewater management resulted in improved water quality in many of the State's streams?" In a partial attempt to answer this question, the water-quality trends observed by Hay and Campbell (1990) were associated with measures of permitted effluent discharge such as change in the number of permitted effluent discharges during 1975-86, the quality and quantity of reported effluent discharged to streams during 1986-89, and the relative proportion of effluent discharged to streams from municipal facilities and nonmunicipal facilities.

Trends in pH and in concentrations of dissolved calcium, dissolved sodium, dissolved chloride, and fecal coliform bacteria were most frequently associated with estimates of the quality and quantity of effluent discharged in a drainage basin. Dissolved-oxygen trends were associated with data describing the source of the effluent as either municipal or nonmunicipal. Trends in other streamwater constituents whose presence is frequently related to wastewater-

EXPLANATION

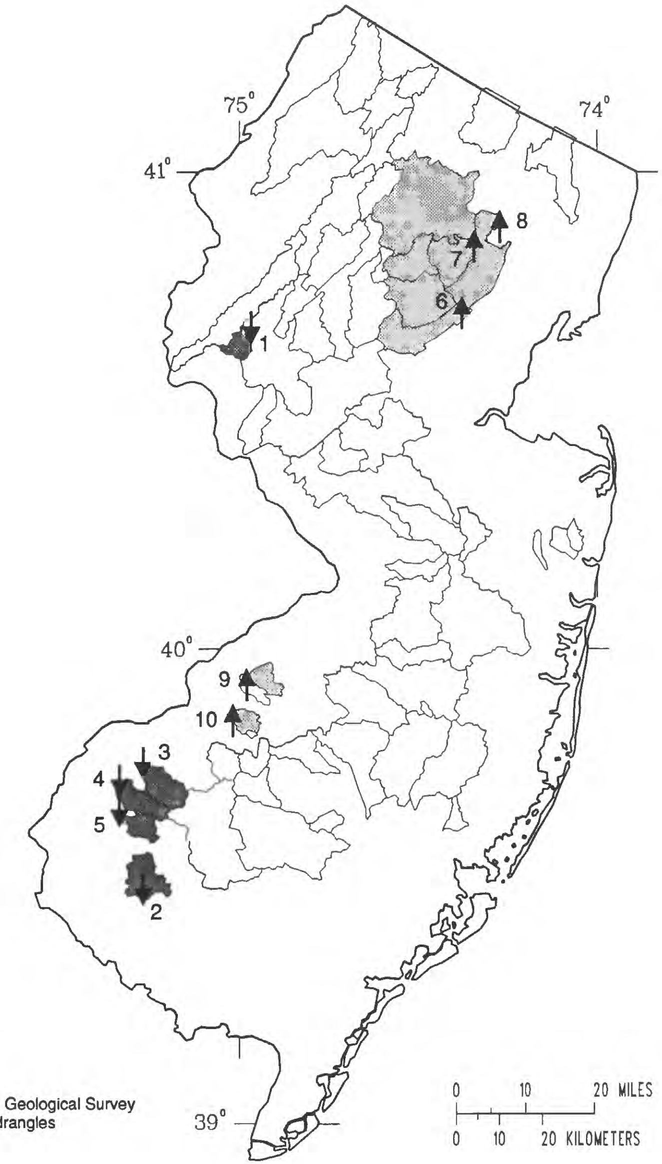
POPULATION DENSITY, IN PERSONS PER SQUARE MILE--Ranges represent greatest and least densities in study area

21 - 303

664 - 2,889

↑ 8 ↓ 1 **STREAM-MONITORING STATION WHERE UPTRENDS (↑) AND DOWNTRENDS (↓) IN pH WERE FOUND, WITH THE GREATEST AND LEAST POPULATION DENSITIES, RESPECTIVELY**--Site number corresponds to the monitoring-station numbers and names below

Site number	Station number	Station name
1	1396660	Mulhockaway Creek at Van Syckel
2	1412800	Cohansey River at Seeley
3	1477120	Raccoon Creek near Swedesboro
4	1477510	Oldmans Creek at Porches Mill
5	1482500	Salem River at Woodstown
6	1379500	Passaic River near Chatham
7	1381200	Rockaway River at Pine Brook
8	1382000	Passaic River at Two Bridges
9	1467069	North Branch Pennsauken Creek near Moorestown
10	1467140	Cooper River at Lawnside



Base from U.S. Geological Survey
1:250,000 quadrangles

Figure 14. New Jersey drainage basins having uptrends in pH and the greatest population density in 1986 of the drainage basins studied, and drainage basins having downtrends in pH and the least population density in 1986.

disposal practices (for example, concentrations of BOD, total nitrogen, total organic carbon, and total phosphorus) were found to be minimally related to the measures of effluent discharge used in the analyses. This absence of trends may be indicative of too great a distance between the monitoring station and the zone of assimilation that typically develops below effluent-discharge sites.

Streams in New Jersey where reduced dissolved-oxygen concentrations are most frequent appear to be significantly affected by effluent discharges (New Jersey Department of Environmental Protection, 1990). However, the dissolved-oxygen trends identified by Hay and Campbell (1990) had no statistical association with the yields of effluent or with yields of BOD and TSS discharged upstream from the monitoring station (table 17). Statistical associations were found between the trends in dissolved-oxygen concentrations and information describing the source of effluent in a drainage basin. Upward trends in dissolved-oxygen concentrations were more common than expected in drainage basins where greater than 60 percent of the total effluent was discharged from nonmunicipal treatment facilities (fig. 15). Similar associations were found when the source of the effluent discharge and BOD and TSS loads near the monitoring station (within 3.1 mi) were compared to the trends in dissolved-oxygen concentrations. These results indicate that nonmunicipal effluent disposal may have had the greater effect on dissolved-oxygen upward trends in the streams. These results are similar to those reported by Smith and others (1987a, 1987b) in their analysis of national water-quality trends, although they tested for trends in dissolved-oxygen deficit rather than dissolved-oxygen concentration. In several water-quality modeling studies for New Jersey streams, the investigators have concluded that instream dissolved-oxygen concentrations will not change significantly for a number of years after improved wastewater treatment at municipal facilities because of the persisting sediment oxygen demand downstream from the facilities (New Jersey Department of Environmental Protection, 1987a, 1987b). This may explain the lack of associations between the trends in dissolved-oxygen concentrations and measures of municipal effluent disposal.

Interpretation of trends in dissolved-oxygen concentrations should also take into account instream temperature change because dissolved-oxygen concentrations vary inversely with temperature. Smith and others (1987a, 1987b) attempted to reduce the effect of temperature on dissolved-oxygen concentration data by testing for trends in dissolved-oxygen deficit (DOD). The DOD is equal to the dissolved-oxygen-saturation concentration at the time of sample collection minus the observed dissolved-oxygen concentration. Another method for factoring out temperature effects on dissolved oxygen would be to compare trends in dissolved-oxygen concentrations to trends in temperature. Hay and Campbell (1990) detected significant temperature trends at 4 of the 60 monitoring stations. At two of these four monitoring stations, Passaic River at Two Bridges and Raritan River at Manville, concurrent upward trends in temperature and dissolved-oxygen concentrations indicate that the dissolved-oxygen trends may be independent of temperature changes. These two monitoring stations were also below stream reaches where high yields of effluent, BOD, and TSS were discharged.

Trends in pH were associated with the yield of effluent, BOD, and TSS discharged in the drainage basin; the associations with BOD yields were highly significant ($p = 0.006$). Monitoring stations where pH upward trends were found tended to be in drainage basins having

EXPLANATION

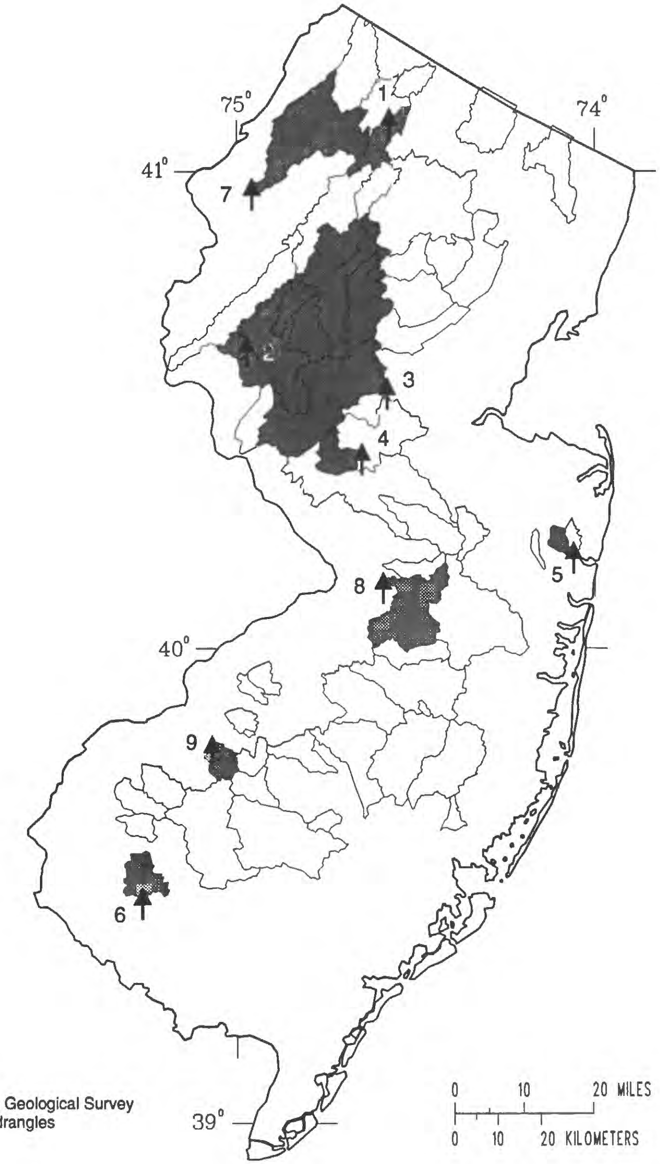
Percentage of effluent discharge in basin originating from nonmunicipal facilities

Greater than 60 percent

60 percent or less

↑ 8 **STREAM-MONITORING STATION WHERE UPTRENDS IN DISSOLVED-OXYGEN CONCENTRATIONS WERE FOUND AND GREATER THAN 60 PERCENT OF THE EFFLUENT DISCHARGE IN BASIN ORIGINATING FROM NONMUNICIPAL FACILITIES**--Site number corresponds to the monitoring-station numbers and names below

Site number	Station number	Station name
1	1367700	Wallkill River at Franklin
2	1396660	Mulhockaway Creek at Van Syckel
3	1400500	Raritan River at Manville
4	1401600	Beden Brook near Rocky Hill
5	1407705	Shark River near Neptune City
6	1412800	Cohansey River at Seeley
7	1443500	Paulins Kill at Blairstown
8	1464500	Crosswicks Creek at Extonville
9	1467329	South Branch Big Timber Creek at Blackwood Terrace



Base from U.S. Geological Survey
1:250,000 quadrangles

Figure 15. New Jersey drainage basins where uptrends in dissolved-oxygen concentrations were found and where greater than 60 percent of effluent discharge originated from nonmunicipal wastewater-treatment facilities.

the greatest yields of these measures of discharged effluent. However, the pH upward trends were not associated with the primary type of facility (municipal or nonmunicipal) present upstream. Because many of the drainage basins having the greatest yields of effluent also tended to be predominantly urban, a clear pattern is present between pH increases in the State's waters and urban land use. The investigators hypothesize that the pH increases are related to stream eutrophication, which in turn leads to increased aquatic-plant growth in the streams. Respiration (photosynthesis) of aquatic plants during daylight hours can cause pH to rise.

Trends in concentrations of fecal coliform and fecal streptococcus bacteria had statistical associations with various measures of effluent discharge upstream from the monitoring stations. Smith and others (1987a, 1987b) also reported associations between trends in fecal coliform and streptococcus bacteria and measures of municipal effluent. All downward trends in fecal coliform bacteria concentrations were associated with effluent primarily from municipal sources within the area 3.1 mi upstream from the monitoring stations. Other studies have documented downward trends in fecal bacteria concentrations in streams that received effluent from improved municipal treatment facilities (U.S. General Accounting Office, 1986). Increasing concentrations of fecal streptococcus bacteria had somewhat conflicting associations with measures of effluent discharged. Upward trends in the concentrations of these bacteria were more frequent than expected where effluent was discharged in the drainage basin, as well as where BOD loads in the area 3.1 mi upstream from the monitoring station were smallest (less than 0.08 kg/d/mi2). These results indicate that sources other than effluent disposal are the principal influence on fecal streptoccus bacteria concentrations in New Jersey streams. Such possible sources may include waterflow wastes, pet wastes, and urban and agricultural runoff.

Effluent discharged to streams, especially effluent of municipal origin, can contain large quantities of dissolved ions. Upward trends in dissolved calcium, sodium, and chloride in New Jersey streams were frequently associated with measures of effluent discharge. Increases in these dissolved ions were found in drainage basins where yields of effluent discharge were moderate to high. Upward trends in dissolved-chloride concentrations exhibited a statistically strong association with greater amounts of BOD discharged within the area 3.1 mi upstream from the monitoring station ($p = 0.006$). This association may be due to the presence of chloride in sewage and (or) to the chlorination process for disinfecting sewage. Although municipal effluent discharges have been identified as contributing much of the BOD loads in New Jersey during the study period (New Jersey Department of Environmental Protection, 1984), the upward trends in dissolved-chloride concentrations were more prevalent in drainage basins where effluent-related BOD and TSS yields originated from nonmunicipal facilities. Taken together, these associations indicate that permitted effluent discharges and urban land-use activities are likely significant sources of dissolved ions in New Jersey streams. Smith and others (1987a, 1987b) noted that they expected but did not find statistical associations between trends in dissolved chloride and measures of effluent quantity and quality.

Specific-conductance trends were associated with change in the number of effluent discharges in a drainage basin from 1975 to 1986 and yields of BOD. Upward trends in specific conductance tended to occur at monitoring stations where the number of permitted effluent discharges increased and in drainage basins where effluent BOD yields were primarily from municipal facilities. The specific-conductance upward trends may be due to dissolved and suspended ions in the discharged effluent and (or) to the chlorination of wastewaters.

Total ammonia concentration was the only measure of nutrients whose trends had statistical association with measures of effluent discharge. All upward trends in concentrations of total ammonia were in drainage basins having moderate amounts of effluent discharge (0.003 - 0.013 Mgal/day/square mile). Trends in total phosphorus were not statistically associated with the effluent yield or the source of the effluent, but three of the four upward trends in total phosphorus detected by Hay and Campbell (1990) were in drainage basins where either no effluent or the least amount of effluent was discharged. The overall absence of associations between measures of effluent discharge and nutrient-concentration trends indicate that nonpoint sources may be equal to point sources or of greater importance as a source of nutrients in New Jersey streams. Smith and others (1987a, 1987b) reported strong associations between downward trends in total-phosphorus concentrations and large point-source loads to streams.

Road-Salt Application

The use of road salt in the 1980-81 winter season was strongly associated with the increased concentrations of dissolved chloride, magnesium, and sodium detected at many monitoring stations on New Jersey streams. Trends in specific conductance also were statistically associated with road-salt applications. However, only trends in dissolved-magnesium concentrations were statistically associated with trends in the use of chloride or sodium as a road salt during 1975-86. Noteworthy are the absence of associations between instream dissolved-calcium trends and data on calcium use as a deicing material. The dissolved-calcium trends are, thus, apparently independent of the use of calcium in deicing materials. Most of the loads of calcium in New Jersey's streams probably originate from other sources; road salts may be contributing minor amounts of the total calcium loads.

Trends in concentrations of dissolved chloride and sodium were significantly associated with the estimated 1980-81 winter application of chloride for road deicing. Upward trends in dissolved-chloride and -sodium concentrations were found more frequently than expected in drainage basins having the highest application rates of chloride (fig. 16). Smith and others (1987a, 1987b) also found that increasing dissolved-chloride concentrations were positively correlated with road-salt-application rates. No significant associations were found, however, when dissolved-chloride and -sodium concentration trends were compared to estimated amounts of sodium used for road deicing in 1980 or to trends in chloride and sodium use during 1975-86. As with calcium, other sources or sinks of sodium may mask the detected trends.

A statistically strong association was found between upward trends in dissolved-magnesium concentrations and drainage basins with the greatest chloride application rates in 1980 ($p = 0.009$). In addition, upward trends in dissolved-magnesium concentration were strongly associated with trends in chloride and sodium use as road-deicing agents during 1975-86 ($p = 0.002$). Because magnesium was not identified as being a component in the road salts used by the NJDOT, the increases in dissolved magnesium are probably originating from other sources. The associations with road-salt use are probably coincidental. Dissolved magnesium in

EXPLANATION

Drainage basin where chloride application rate is 5.0 to 7.6 tons per square mile

8 **STREAM-MONITORING STATION WHERE UPTRENDS IN DISSOLVED-CHLORIDE CONCENTRATIONS WERE FOUND AND CHLORIDE APPLICATION RATES WERE THE GREATEST OF THE DRAINAGE BASINS STUDIED**--Site number corresponds to the monitoring-station numbers and names below

Site number	Station number	Station name
1	1367770	Wallkill River near Sussex
2	1367910	Papakating Creek at Sussex
3	1368950	Black Creek near Vernon
4	1379500	Passaic River near Chatham
5	1381200	Rockaway River at Pine Brook
6	1381500	Whippany River at Morristown
7	1381800	Whippany River near Pine Brook
8	1387000	Wanaque River at Wanaque
9	1391500	Saddle River at Lodi
10	1396280	South Branch Raritan River at Middle Valley
11	1396660	Mulhockaway Creek at Van Syckel
12	1397400	South Branch Raritan River at Three Bridges
13	1399120	North Branch River at Burnt Mills
14	1399700	Rockaway Creek at Whitehouse
15	1399780	Lamington (Black) River at Burnt Mills
16	1400500	Raritan River at Manville
17	1455500	Musconetcong River at outlet of Lake Hopatcong
18	1456200	Musconetcong River at Beatyestown
19	1457400	Musconetcong River at Riegelsville

Base from U.S. Geological Survey
1:250,000 quadrangles

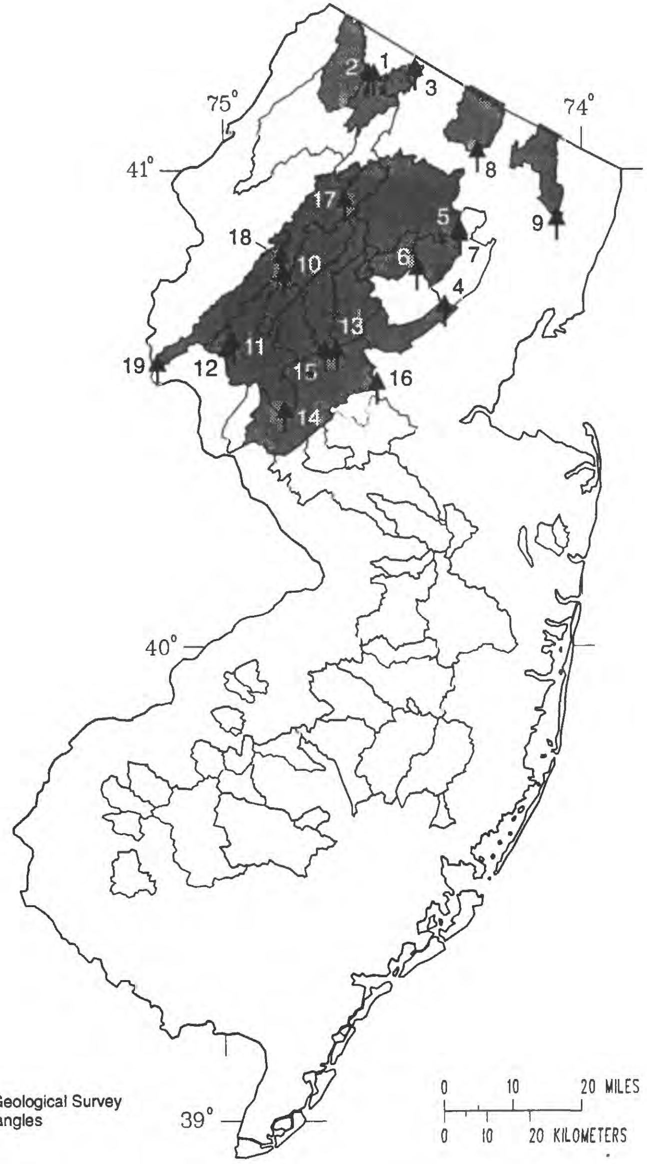


Figure 16. New Jersey drainage basins where uptrends in concentrations of dissolved chloride were found and where the chloride application rate due to road salting were the greatest during winter 1980-81 of the basins studied.

streams has frequently been identified in association with runoff from urban areas, soils, and roadways (Harrison and Wilson, 1985, and Athayde and others, 1983). Tedrow (1986) mentions that magnesium is a common macronutrient in many New Jersey soils and that some soils contain excessive amounts of magnesium. These soils, by way of surface runoff, may be contributing to the increasing dissolved-magnesium concentrations observed. Together, this information points to storm runoff and nonpoint sources as a strong factor in the upward trends in dissolved magnesium.

Statistical associations were found between specific-conductance upward trends and sodium and chloride use in winter 1980-81. Increases in specific conductance were positively associated with drainage basins in which the greatest amounts of sodium and chloride were applied to roadways. Upward trends in specific conductance were nearly associated with drainage basins identified as areas of increasing chloride and sodium use during 1975-86 ($p = 0.110$).

Agricultural Activities

Four indicators of agriculturally related activities in the 60 drainage basins were compared to the water-quality trends. These indicators were trends in agricultural-fertilizer use during 1975-85 (measured as tons of phosphorus per square mile), amount of agricultural fertilizer applied in 1980 (tons of phosphorus and nitrogen per square mile), soil-erosion rates (tons per acre per year), and percentage of a drainage basin being irrigated (expressed as a percentage of the total acres in the drainage basin). All four of these indicators had few statistically significant associations with the water-quality trends.

Trends in dissolved-magnesium concentrations were associated with the percentage of the area in a drainage basin irrigated and nearly associated with soil-erosion rates. Increases in dissolved-magnesium concentrations were also strongly associated with drainage basins where phosphorus-fertilizer use did not change ($p = 0.007$). Upward trends in dissolved-magnesium concentrations also tended to occur in drainage basins having the greatest percentage of irrigated land. Upward trends in dissolved-magnesium concentrations also were nearly associated with drainage basins where soil-erosion rates were moderate (5-8 ton/acre/yr) ($p = 0.102$). The overall strength of associations between dissolved-magnesium upward trends and measures of agricultural activity indicates that either agricultural runoff or soil erosion or both may be contributing factors in the magnesium trends.

Trends in pH were strongly associated with fertilizer use in the drainage basin ($p = 0.009$) and with the percentage of areas in the basin being irrigated. Upward trends in pH were found frequently in drainage basins where the greatest amounts of phosphorus and nitrogen fertilizer were applied. Some of this fertilizer is perhaps being transported to area streams through runoff and may be causing eutrophication in those streams. As discussed earlier, increased photosynthesis in streams as a result of eutrophication can contribute to upward trends in pH. Upward trends and downward trends in pH tended to occur in basins where the highest percentage of land was being irrigated. These pH trends may be due not only to the release of soil cations during irrigation, which causes pH to decrease, but also to the flushing of soil nutrients to stream, which results in increased pH through entrophication.

Specific-conductance trends were inversely associated with agricultural fertilizer use in 1980. More than one-half of monitoring stations where specific-conductance upward trends were found were in drainage basins where fertilizer-use rates were lowest. Most specific-conductance downward trends were found in drainage basins with the highest application rates. These results seem to signify considerable independence between the specific-conductance trends and agricultural activities.

Trends in only one constituent, concentrations of fecal streptococcus bacteria, were found to be significantly associated with soil-erosion estimates, but this association was strong ($p = 0.004$). Drainage basins where cropland soil-erosion rates were moderate (5-8 ton/acre/yr) were associated with upward trends in fecal-streptococcus-bacteria concentrations; these associations were found across the southern part of the State (fig. 17). The increases in concentrations of fecal streptococcus bacteria in basins having moderate soil-erosion rates indicate that agricultural activities are influencing the concentration of this constituent in streamwater.

Upward trends in total phosphorus concentrations were nearly associated with soil-erosion rates ($p = 0.126$). These upward trends tended to be more frequent than expected in drainage basins where soil-erosion estimates were greater than 8 ton/acre/yr, an indication that agricultural activities are a source of the increases in total phosphorus concentrations. Smith and others (1987a, 1987b) reported associations between upward trends in total-phosphorus concentrations throughout the nation and measures of agricultural activities in drainage basins.

SUMMARY AND CONCLUSIONS

Trends in the concentrations of 13 streamwater constituents and the values of 2 physical properties measured at selected monitoring stations on New Jersey streams during water years 1976-86 (as reported by Hay and Campbell, 1990) were analyzed for statistical associations with various drainage-basin characteristics, including human activities within the basins. These analyses were designed to identify possible causal factors for the water-quality trends. The constituents and properties used in the analyses were pH, specific conductance, and concentrations of dissolved oxygen, biochemical oxygen demand (BOD), total nitrogen, total ammonia, total phosphorus, total organic carbon, dissolved calcium, dissolved magnesium, dissolved sodium, dissolved potassium, dissolved chloride, fecal coliform bacteria, and fecal streptococcus bacteria.

Basin-characteristic data were collected for the drainage basins that were analyzed for trends and whose drainages are entirely or predominantly within New Jersey. Data for some constituents and properties from some monitoring stations on the same streams were excluded from the analysis because correlation among the data violated fundamental analytical assumptions. The number of monitoring stations varied by constituent or property, from 17 for total ammonia to 52 for dissolved sodium.

Information collected on drainage-basin characteristics included measures of physiographic province, area, location, dominant land use, population, effluent discharge, application of road salt, agricultural-fertilizer use, cropland soil-erosion rates, and the amount of

EXPLANATION

Drainage basin where soil-erosion rate is 5.1 to 8.0 tons per acre per year

8 **STREAM-MONITORING STATION WHERE UPTRENDS IN FECAL STREPTOCOCCUS BACTERIA CONCENTRATIONS WERE FOUND AND WHERE CROPLAND SOIL-EROSION RATES RANGED FROM 5.1 TO 8.0 TONS PER ACRE PER YEAR** --Site number corresponds to the monitoring-station numbers and names below

Site number	Station number	Station name
1	1400650	Millstone River at Grovers Mill
2	1401440	Millstone River at Kingston
3	1405340	Manalapan Brook near Manalapan
4	1412800	Cohansey River at Seeley
5	1464500	Crosswicks Creek at Extonville
6	1464515	Doctors Creek at Allentown
7	1467081	South Branch Pennsauken Creek at Cherry Hill
8	1467140	Cooper River at Lawnside
9	1467329	South Branch Big Timber Creek at Blackwood Terrace
10	1477120	Raccoon Creek at Swedesboro

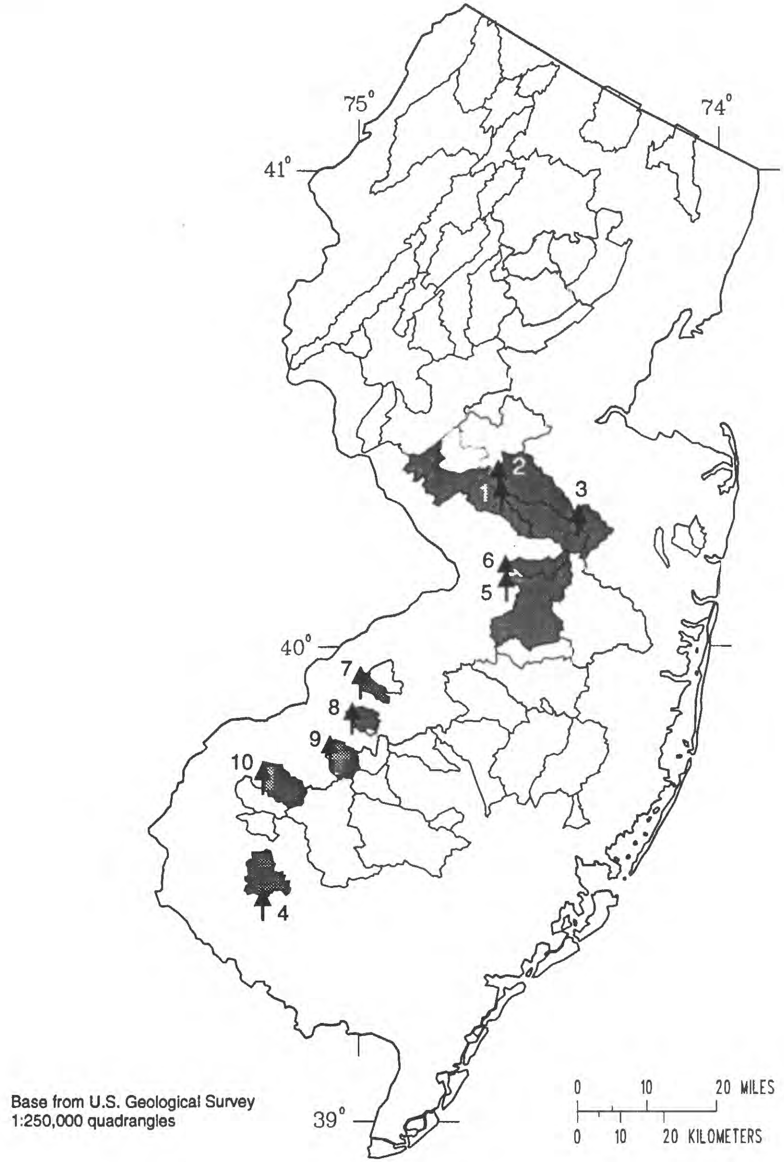


Figure 17. New Jersey drainage basins where uptrends in concentrations of fecal streptococcus bacteria were found and where cropland soil-erosion rates ranged from 5.1 to 8.0 tons per acre per year.

land irrigated for agricultural purposes. Data describing trends during 1975-86 in a particular drainage-basin characteristic were gathered if available, but data were unavailable for most of the characteristics for the full range of years. Otherwise, the characteristic was described for a shorter period within that range. Detailed information on nonpoint sources and atmospheric deposition, two sources suspected as major contributors of dissolved constituents in streamwater, was unavailable for the 60 drainage basins in New Jersey.

Statistical associations between the water-quality trends and drainage-basin characteristics were determined by the use of contingency-table analyses. The contingency-table analyses were also used to identify associations among the water-quality trends and the seasonal occurrence of trends. A significant association was identified at $\alpha = 0.10$.

Trends in the concentrations of dissolved constituents were commonly associated with one another, as were the trends in specific conductance with trends in concentrations of dissolved constituents. Another notable association among trend results was upward trends in dissolved-oxygen concentrations with downward trends in BOD concentrations. Most trends in constituent concentrations were associated with trends in the concentration of one or more other constituents.

Most trends in water-quality data were found to be independent of seasons; however, trends in concentrations of dissolved sodium and dissolved oxygen did show seasonal effects. Increases in dissolved-oxygen concentrations were nearly significantly associated with increases in concentrations during late summer and early fall, whereas increases in dissolved-sodium concentrations were associated with increases in dissolved sodium in late fall and early winter. The trends in water-quality data also showed few associations with trends in instantaneous streamflow, an indication that the flow-adjustment procedures used by Hay and Campbell (1990) prior to their trends testing was effective in removing the effects of streamflow on the water-quality data.

The trends in water quality also appear to be generally independent of the area and location of the upstream drainage basins. Of the few associations found, the most notable was the occurrence of upward trends in dissolved-chloride concentrations in the largest drainage basins. This occurrence tends to match the conservative behavior of this ion in streams that results in larger concentrations in a downstream direction.

Tests for association between the dominant land use in the drainage basins and trends in water-quality data revealed various associations, indicating that land use is a strong influence on many of the observed trends. These associations were strongest for the dominant land use closest to the monitoring stations; thus, for certain constituents, local land uses rather than land use in the entire drainage basin have the greater effects on changes in the data. Upward trends in pH and concentrations of dissolved potassium, calcium, sodium and chloride were strongly associated to land use in many drainage basins, most commonly at stations in urbanized areas. In agricultural basins, upward trends in concentrations of fecal streptococcus bacteria and total ammonia and downward trends in pH were common. These associations are consistent with results of other studies relating land use to water-quality conditions and trends.

Measures of drainage-basin population had few associations with trends in water-quality data. Upward trends in specific conductance were common in basins having the highest population densities in the State, whereas downward trends in pH occurred in basins having the lowest population densities. These associations are similar to those found between the trends in water-quality data and land use (for example, upward trends in specific conductance in urban drainage basins and downward trends in pH in agricultural drainage basins).

The number of permitted effluent discharges and their releases of BOD and TSS seems to have had a strong affect on water-quality trends in New Jersey based on the number of significant associations between the two variables, even though most discharge points are more than 3 mi upstream from monitoring stations. Upward trends in pH and concentrations of dissolved sodium and chloride were associated with basins having the greatest yields of effluent, BOD, and TSS. Trends in fecal coliform and streptococcus bacteria concentrations were associated with various measures of effluent discharge. Downward trends in fecal coliform bacteria were found more commonly at monitoring stations near municipal sources of effluent than at stations not near municipal wastewater-treatment facilities. More dissolved-oxygen-concentration upward trends were found at stations where effluents were of nonmunicipal origin than where effluents were of municipal origin. However, trends in dissolved-oxygen concentrations did not show any association with the yields of effluent discharges in a drainage basin. Few associations were found between trends in instream BOD and nutrient concentrations when compared with measures of effluent discharges. This indicates that nonpoint sources could be equal to point sources or of greater importance as contributors of oxygen-demanding substances and nutrients to surface waters of New Jersey or that the monitoring stations are too far downstream from the effluent discharges for BOD and nutrient concentrations to be affected by the discharges.

The prevalence of upward trends in dissolved sodium and chloride concentrations at similar monitoring stations in the State indicates a possible common source of these constituents. One such source is the use of road salt, which increased during the WY 1976-86 period of trend analysis. Positive and commonly strong associations were found between upward trends in concentrations of these dissolved ions at monitoring stations and the amount of sodium and chloride used for road salting upstream; thus, road salting appears to be a significant source of these dissolved ions.

Upward trends in dissolved-magnesium concentrations also were strongly associated with road-salt use. In addition, upward trends in dissolved-magnesium concentrations were strongly associated with urban land and agricultural-fertilizer use. Because magnesium is not a major component of road salts, the cause of the increases in this dissolved ion could be impervious-surface runoff, soil-disturbing activities, and (or) atmospheric deposition.

Upward trends in specific conductance and pH were found in drainage basins having the greatest amounts of agricultural phosphorus- and nitrogen-fertilizer use in the State. Upward trends in fecal streptococcus bacteria concentration were found in drainage basins where cropland soil-erosion rates were moderate, whereas upward trends in total phosphorus concentrations were nearly associated with the greatest soil-erosion rates in the State. Upward trends in pH and dissolved-magnesium concentrations were found where the amount of land being irrigated was largest. These associations indicate that nonpoint sources could be important factors in the detected trends in the water-quality data.

The downward trends in concentrations of total organic carbon found at monitoring stations throughout New Jersey had very few associations with basin characteristics. This absence of associations indicates that possible causes of the downward trends were not addressed in this report and that further analysis of the trends would be necessary to identify possible causes.

Some of the associations identified between water-quality trends and drainage-basin characteristics in this study are consistent with those reported in earlier studies; these include upward trends in dissolved chloride and sodium in drainage basins having the greatest road-salt applications and upward trends in dissolved-oxygen concentrations where nonmunicipal effluent discharges predominate. Other associations described by those investigators were not found in New Jersey, such as decreases in total phosphorus in drainage basins receiving the greatest amounts of effluent. In addition, many of the associations presented in this report are supported by the results of other studies that more intensely assessed the effects of land use and drainage-basin characteristics on water quality. The absence of associations in New Jersey between trends in nutrients and measures of stream oxygen with basin characteristics indicates that more intensive analysis would be required to identify possible causes for these trends.

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Table 9. Permitted effluent discharges in the New Jersey drainage basins studied, 1975

[NJPDES, New Jersey Pollutant Discharge Elimination System; --, no name of permitted discharge found. Source: Data from Michael Dillon, New Jersey Department of Environmental Protection, written commun., 1989]

Drainage basin		NJPDES permit number	Permitted effluent discharger
Monitoring-station name	Monitoring-station number		
Wallkill River at Franklin	01367700	4596	THE NEW JERSEY ZINC COMPANY
		33472	TRI-COUN'TY WATER CONDITIONING CO.
Wallkill River near Sussex	01367770	141	AMES RUBBER CORPORATION
		2275	ACCURATE FORMING CORPORATION
		4596	THE NEW JERSEY ZINC COMPANY
		6661	PLASTOID CORPORATION
		20885	PLASTOID CORPORATION
		22055	FRANKLIN, BD. OF PUBLIC WORKS, BOROUGH
		27367	WALLKILL SEWER COMPANY
		31038	FRANKLIN BD. OF PUBLIC WORKS
		33472	TRI-COUN'TY WATER CONDITIONING CO.
Papakating Creek at Sussex	01367910	29041	REGENCY APARTMENTS
Black Creek near Vernon	01368950	21814	VERNON VALLEY RECREATION ASSN
		23841	VERNON TWP. SCHOOL BOARD
		23949	GREAT GORGE'S MOUNTAIN VIEW
Passaic River near Millington	01379000	2925	MILLINGTON QUARRY
		29912	NEW JERSEY DEPT. OF TRANSPORTATION
Passaic River near Chatham	01379500	442	AT&T BELL LABORATORIES
		2551	REHEIS CHEMICAL CO.
		2607	PLASMA GRAPHICS CORPORATION
		2925	--
		3042	MILLMASTER CHEMICAL COMPANY\
		3140	AZOPLATE CORPORATION
		20281	PARK CENTRAL SEWAGE TREATMENT
		21083	VETERANS ADMINISTRATION
		21636	NEW PROVIDENCE BOROUGH OF WTP
		22489	WARREN TWP. SEWAGE AUTHORITY
		22497	STAGE IV SEWAGE TREATMENT PLT
		22845	HARRISON BROOK
		24465	PASSAIC, TOWNSHIP OF
		27961	WATER POLLUTION CONTROL
		29912	NEW JERSEY DEPT. OF TRANSPORTATION
		29963	GLASFLEX CORPORATION
Rockaway River at Pine Brook	01381200	1261	KEUFFEL & ESSER CO
		1635	HOWMET TURBINE COMPONENTS CORP.
		2496	MC WILLIAMS FORGE CO INC
		2500	PICATINNY ARSENAL
		2593	GHA LOCK JOINT

Table 9. Permitted effluent discharges in the New Jersey drainage basins studied, 1975--Continued

Drainage basin		NJPDES permit number	Permitted effluent discharger
Monitoring-station name	Monitoring-station number		
Rockaway River at Pine Brook--Continued	01381200-Cont.	3409	MT HOPE ROCKS PRODUCTS
		3441	PYAH INDUSTRIES INC
		3506	ADRON
		3611	CARPENTER LE & COMPANY INC
		21181	CEDAR HILL SCHOOL STP
		22349	ROCKAWAY VALLEY REG S.A.
		22802	WHITE MEADOW LAKE PROP.OWNERS
		24457	OUR LADY OF THE MAGNIFICAT
		25712	VIBRATION MOUNTING & CONTROLS
		26115	HARDEN FUEL / V & H TRUCKING
		26603	RANDOLPH HIGH SCHOOL STP
		26867	JEFFERSON TWP.-ROCK
		27847	SERVOMETER CORPORATION
		29394	BERKSHIRE SAND & STONE CO INC
		30287	MONTVILLE TOWNSHIP MUA
		30317	MONTVILLE TOWNSHIP MUA
		30911	SCERBO BROTHERS INC
		32166	ASCO ELECTRIC
		32221	LESLIE CO
		32808	ROCKAWAY TOWNSQUARE MALL
		35050	W P REALTY CO
		52396	PNEU HYDRO PRODUCTS INC
Whippany River at Morristown	01381500	2542	PARKE-DAVIS DIV WARNER LAMBERT
		24929	WOODLAND STP
		25674	ACTION TECHNOLOGY COMPANY
		26689	ENGR. DEPT.-GREYSTONE PARK
		26751	ST MARY'S ABBEY
		29734	FABRICATED PLASTICS
		33684	CHAMPION INTL DAIRYPAK DIV
Whippany River near Pine Brook	01381800	1155	SANDOZ PHARMACEUTICALS CORPORATION.
		1708	SANDOZ PHARMACEUTICALS CORPORATION.
		1881	PRECISION ROLLED PRODUCTS INC.
		2542	PARKE-DAVIS DIV WARNER LAMBERT
		3450	LEEMING PACQUIN COMPANY
		3476	EXXON RESEARCH & ENGRG CO
		3697	COLLOID CHEMICAL INC
		24902	HANOVER SEWERAGE AUTHORITY
		24911	BUTTERWORTH STP
		24929	WOODLAND STP

Table 9. Permitted effluent discharges in the New Jersey drainage basins studied, 1975--Continued

Drainage basin		NJPDES permit number	Permitted effluent discharger
Monitoring-station name	Monitoring-station number		
Whippany River near Pine Brook--Continued	01381800-Cont.	25496	MORRISTOWN TOWN OF
		25674	ACTION TECHNOLOGY COMPANY
		25739	LITTON INDUSTRIES INC AIRTRON
		26689	ENGR. DEPT.-GREYSTONE PARK
		26751	ST MARY'S ABBEY
		28339	CAMPBELL-PRATT OIL CO
		29734	FABRICATED PLASTICS
		33685	CHAMPION INTL DAIRYPAK DIV
		35777	EXXON CENTRAL SERVICES
		36081	EAST HANOVER TWP WELL NO2 FLTR
Passaic River at Two Bridges	01382000	442	AT&T BELL LABORATORIES
		540	CIBA-GEIGY CORPORATION
		1155	SANDOZ PHARMACEUTICALS CORP.
		1261	KEUFFEL & ESSER CO
		1490	ORANGE PRODUCTS INC
		1635	HOWMET TURBINE COMPONENTS CORP.
		1651	FRITZSCHE DODGE & OLCOTT
		1708	ROWE INTERNATIONAL OF CANADA
		1881	PRECISION ROLLED PRODUCTS INC.
		2003	AUTOMATIC SWITCH COMPANY
		2496	MC WILLIAMS FORGE CO INC
		2500	PICATINNY ARSENAL
		2542	PARKE-DAVIS DIV WARNER LAMBERT
		2551	REHEIS CHEMICAL CO.
		2593	GHA LOCK JOINT
		2607	--
		2828	WHIPPANY PAPERBOARD CO.
		2925	--
		3042	--
		3140	--
		3409	MT HOPE ROCKS PRODUCTS
		3441	--
		3450	LEEMING PACQUIN COMPANY
		3476	EXXON RESEARCH & ENGRG CO
		3506	ADRON
		3611	CARPENTER LE & COMPANY INC
		3620	W F & JOHN BARNES
		3697	COLLOID CHEMICAL INC
		3743	M.POLNAR INC.
		20281	PARK CENTRAL SEWAGE TREATMENT

Table 9. Permitted effluent discharges in the New Jersey drainage basins studied, 1975--Continued

Drainage basin		NJPDES	
Monitoring-station name	Monitoring-station number	permit number	Permitted effluent discharger
Passaic River at Two Bridges--Continued	01382000-Cont.	20427	CALDWELL, BOROUGH OF
		21083	VETERANS ADMINISTRATION
		21181	CEDAR HILL SCHOOL STP
		21636	NEW PROVIDENCE BOROUGH OF WTP
		21938	US ARMY NIKE 79/80 E HANOVER
		22349	ROCKAWAY VALLEY REG S.A.
		22489	WARREN TWP. SEWAGE AUTHORITY
		22497	STAGE IV SEWAGE TREATMENT PLT
		22802	WHITE MEADOW LAKE PROP.OWNERS
		22845	HARRISON BROOK
		24431	MONTVILLE TOWNSHIP MUA
		24457	OUR LADY OF THE MAGNIFICAT
		24465	PASSAIC TOWNSHIP OF
		24511	LIVINGSTON TOWNSHIP OF
		24902	HANOVER SEWERAGE AUTHORITY
		24911	BUTTERWORTH STP
		24929	WOODLAND STP
		24937	MADISON-CHATHAM JOINT MEETING
		24970	PARSIPPANY, TOWNSHIP OF
		25496	MORRISTOWN TOWN OF
		25518	FLORHAM PARK STP
		25674	ACTION TECHNOLOGY COMPANY
		25712	VIBRATION MOUNTING & CONTROLS
		25721	BUTLER WATER DEPARTMENT
		25739	LITTON INDUSTRIES INC AIRTRON
		26115	--
		26603	RANDOLPH HIGH SCHOOL STP
		26654	SISTERS OF CHARITY-ST. ELIZABE
		26689	ENGR. DEPT.-GREYSTONE PARK
		26751	ST MARY'S ABBEY
		26867	JEFFERSON TWP.-ROCK
		27847	--
		27961	WATER POLLUTION CONTROL
		28096	PCI INC.
		28339	CAMPBELL-PRATT OIL CO
		29394	--
		29734	FABRICATED PLASTICS
		29912	NEW JERSEY DEPT. OF TRANSPORTATION
		29955	RESISTOFLEX CORPORATION
		29963	GLASFLEX CORPORATION

Table 9. Permitted effluent discharges in the New Jersey drainage basins studied, 1975--Continued

Drainage basin: Monitoring-station name	Drainage basin: Monitoring-station number	NJPDES permit number	Permitted effluent discharger
Passaic River at Two Bridges--Continued	01382000-Cont.	30287	MONTVILLE TOWNSHIP MUA
		30317	MONTVILLE TOWNSHIP MUA
		30911	SCERBO BROTHERS INC
		32166	--
		32221	LESLIE CO
		32573	NATIONAL MANUFACTURING CO
		32808	ROCKAWAY TOWNSQUARE MALL
		33685	CHAMPION INTL DAIRYPAK DIV
		34053	CARSAU CORPORATION
		34134	GREEN HAMMER METAL PRODUCTS CO
		35050	W P REALTY CO
		35424	BROE WN BOVERT-RECOMA INC
		35777	EXXON CENTRAL SERVICES
		36081	--
		52396	PNEU HYDRO PRODUCTS INC
Wanaque River at Wanaque	01387000	30261	WANAQUE BOROUGH SEWERAGE AUTHO
		32395	RINGWOOD PLAZA S T P
Saddle River at Lodi	01391500	1244	DART INDUSTRIES INC
		3221	ALL PURPOSE ROLL LEAF
		23931	HEARTHSTONE AT MAHWAH
		24791	RIDGEWOOD VILLAGE COMPOST-FRAN
		24813	NORTHWEST BERGEN COUNTY S.A.
		27910	HOME FUEL OIL COMPANY
		29726	C M & SON TRUCKING INC
		33987	IBM CORPORATION
SB Raritan River at Middle Valley	01396280	1236	WELSH FARMS INC
		21954	MT OLIVE TOWNSHIP
		22683	SKYVIEW STP
		23493	WASHINGTON TWP M.U.A.
		28304	QUALITY INN
		34975	ADVANCED ENVIRON TECH CORPORATION
SB Raritan River at High Bridge	01396535	1236	WELSH FARMS INC
		21954	MT OLIVE TOWNSHIP
		22683	SKYVIEW STP
		23493	WASHINGTON TWP M.U.A.
		28304	QUALITY INN
		34975	ADVANCED ENVIRON TECH CORPORATION
Mulhockaway Creek at Van Syckel	01396660	24091	UNION TOWNSHIP BD OF ED

Table 9. Permitted effluent discharges in the New Jersey drainage basins studied, 1975--Continued

Drainage basin		NJPDES permit number	Permitted effluent discharger
Monitoring-station name	Monitoring-station number		
SB Raritan River at Three Bridges	01397400	1236	WELSH FARMS INC
		20389	CLINTON SEWERAGE AUTHORITY
		21954	MT OLIVE TOWNSHIP
		22047	RARITAN TOWNSHIP STP
		22144	GLEN GARDNER CTR. FOR GERIATRI
		22683	SKYVIEW STP
		23175	CLINTON TOWNSHIP BD OF ED
		23493	WASHINGTON TWP M.U.A.
		24091	UNION TOWNSHIP BD OF ED
		24571	BORO OF CARTERET STP
		26450	LENTINE AGGREGATES
		28304	QUALITY INN
		28436	FLEMINGTON BOROUGH COUNCIL
		28487	YOUTH CORRECTIONAL INSTITUTION
		28754	MEENAN OIL CO INC
		34975	ADVANCED ENVIRON TECH CORPORATION
NB Raritan River near Chester	01398260	21334	MENDHAM BOROUGH STP
NB Raritan River at Burnt Mills	01399120	21334	MENDHAM BOROUGH STP
		21881	PEAPACK & GLADSTONE, BOROUGH
		26387	BERNARDSVILLE, BOROUGH OF
		26824	CHESTER SHOPPING CENTER
		27227	JOHN Z. DELOREAN
		28495	BEDMINISTER STP
		29637	BERNARDSVILLE QUARRY, INC.
		29807	NJ DEPT. OF TRANS.-MAINTENANCE FAC
		33995	ENVIRONMENTAL DISPOSAL CORPORATION
Rockaway Creek at Whitehouse	01399700	2917	OLDWICK MATERIALS INC
		28452	BEST A. M. CO INC
		98922	READINGTON-LEBANON SEWERAGE AU
Lamington River at Burnt Mills	01399780	876	HERCULES CORPORATION
		2861	COUNTY CONCRETE CORPORATION
		2917	OLDWICK MATERIALS INC
		20338	BRANCHBURG, TOWNSHIP OF
		21865	LAMINGTON RIVER FARMS
		22675	ROXBURY-AJAX TER.STP, TOWNSHIP
		22781	VALLEY ROAD SEWERAGE CO
		28452	BEST A. M. CO INC
		31755	JIM SALERNO PONTIAC INC
		98922	READINGTON-LEBANON SEWERAGE AU

Table 9. Permitted effluent discharges in the New Jersey drainage basins studied, 1975--Continued

Drainage basin		NJPDES permit number	Permitted effluent discharger
Monitoring-station name	Monitoring-station number		
Raritan River at Manville	01400500	876	--
		892	EXXON CO USA
		1139	ETHICON INC
		1236	WELSH FARMS INC
		1333	NATIONAL STARCH & CHEMICAL CO
		1961	DEVRO INC
		2569	RCA CORPORATION SOLID STATE PLANT
		2861	COUNTY CONCRETE CORPORATION
		2917	OLDWICK MATERIALS INC
		3051	WILSON-FIBERFIL/DART & KRAFT
		3158	PRINTING PRODUCTS DIVISION
		3298	ETHYL CORPORATION
		3638	TAYLOR FORGE STAINLESS
		3905	3 BRIDGES FARM
		20338	BRANCHBURG, TOWNSHIP OF
		20354	BRANCHBURG NESHANIC STP
		20362	BRANCHBURG, TOWNSHIP OF
		20389	CLINTON SEWERAGE AUTHORITY
		20991	SAINT BERNARDS CHURCH
		21334	MENDHAM BOROUGH STP
		21865	LAMINGTON RIVER FARMS
		21881	PEAPACK & GLADSTONE BOROUGH
		21954	MT OLIVE TOWNSHIP
		22047	RARITAN TOWNSHIP STP
		22144	GLEN GARDNER CTR. FOR GERIATRI
		22675	--
		22683	SKYVIEW STP
		22781	VALLEY ROAD SEWERAGE CO
		23175	CLINTON TOWNSHIP BD OF ED
		23493	WASHINGTON TWP M.U.A.
		23914	NJ TRANSIT RAIL OPERATIONS INC
		24091	UNION TOWNSHIP BD OF ED
		24571	--
		26387	BERNARDSVILLE BOROUGH OF
		26450	LENTINE AGGREGATES
		26697	READINGTON TOWNSHIP BD OF ED
		26824	CHESTER SHOPPING CENTER
		27227	JOHN Z. DELOREAN
		28304	QUALITY INN
		28436	FLEMINGTON BOROUGH COUNCIL

Table 9. Permitted effluent discharges in the New Jersey drainage basins studied, 1975--Continued

Drainage basin: Monitoring-station name	Drainage basin: Monitoring-station number	NJPDES permit number	Permitted effluent discharger
Raritan River at Manville--Continued	01400500-Cont.	28452	BEST A. M. CO INC
		28487	YOUTH CORRECTIONAL INSTITUTION
		28495	BEDMINISTER STP
		28754	MEENAN OIL CO INC
		29271	TAYLOR OIL CO.
		29637	BERNARDSVILLE QUARRY INC.
		29807	NJ DEPT. OF TRANS.-MAINTENANCE FAC
		29921	CRESTLINE DIV OF N A PRODUCTS
		31755	JIM SALERNO PONTIAC INC
		32328	VIANINI PIPE INC
		32662	DARTCO MANUFACTURING
		33995	ENVIRONMENTAL DISPOSAL CORPORATION
		34975	ADVANCED ENVIRON TECH CORPORATION
		98922	READINGTON-LEBANON SEWERAGE AU
Millstone River at Grovers Mill	01400650	2666	CARTER-WALLACE INC
		22918	ROOSEVELT, BOROUGH OF
		23787	EAST WINDSOR WATER POLLUTION
		29475	HIGHTSTOWN STP
Millstone River at Kingston	01401440	191	COLUMBIAN CHEMICALS COMPANY
		272	DAVID SARNOFF RESEARCH CENTER
		426	IBM CORPORATION-CARD MFG PLANT
		795	MOBIL TECHNICAL CENTER
		981	STONY BROOK PLT
		2666	CARTER-WALLACE INC
		4561	COCA-COLA FOODS
		20729	NEW JERSEY TURNPIKE AUTHORITY
		20770	PRINCETON SEWER OPER. COMM.
		22110	EDUCATIONAL TESTING SERVICE
		22560	PRINCETON FARMS WTP
		22918	--
		23205	PRINCETON THEOLOGICAL SEMINARY
		23787	EAST WINDSOR WATER POLLUTION
		24104	THE LINPRO COMPANY
		27731	FMC CORPORATION
		29475	HIGHTSTOWN STP
		31445	FIRMENICH INCORPORATED
		31950	HUB SERVALL RECORD MFG CORPORATION
		32611	NATIONAL METALIZING
		35319	PENNINGTON FARMS WTP

Table 9. Permitted effluent discharges in the New Jersey drainage basins studied, 1975--Continued

Drainage basin		NJPDES permit number	Permitted effluent discharger
Monitoring-station name	Monitoring-station number		
Beden Brook near Rocky Hill	01401600	22390	NORTH PRINCETON DEV SLF
		32417	BEDENS BROOK CLUB
Millstone River at Weston	01402540	191	COLUMBIAN CHEMICALS COMPANY
		272	DAVID SARNOFF RESEARCH CENTER
		426	IBM CORPORATION-CARD MFG PLANT
		795	MOBIL TECHNICAL CENTER
		981	STONY BROOK PLT
		2666	CARTER-WALLACE INC
		3255	3M COMPANY
		4561	COCA-COLA FOODS
		20656	GENERAL SERVICE ADMINISTRATION
		20729	--
		20770	PRINCETON SEWER OPER. COMM.
		20796	PRINCETON SEWER OPER. COMM.
		22110	EDUCATIONAL TESTING SERVICE
		22390	NORTH PRINCETON DEV SLF
		22560	PRINCETON FARMS WTP
		22918	--
		23124	MONTGOMERY TOWNSHIP OF
		23205	PRINCETON THEOLOGICAL SEMINARY
		23523	OKONITE CO., THE
		23663	CARRIER CLINIC
		23787	EAST WINDSOR WATER POLLUTION
		24104	THE LINPRO COMPANY
		26140	JOHNSON & JOHNSON BABY PRODS.
		26891	MONTGOMERY STP 1
		26905	MONTGOMERY STP#2 TOWNSHIP OF
		26913	SLEEPY HOLLOW STP
		27731	FMC CORPORATION
		29475	HIGHTSTOWN STP
		31119	STONY BROOK REGIONAL S.A.
		31445	FIRMENICH INCORPORATIONORATED
		31950	HUB SERVALL RECORD MFG CORPORATION
		32417	BEDENS BROOK CLUB
		32565	INGERSOLL-RAND RESEARCH INC
		32611	NATIONAL METALIZING
		35190	NORTH BRUNSWICK, TOWNSHIP OF
		35319	PENNINGTON FARMS WTP
Shark River near Neptune City	01407705	21148	MONMOUTH SERVICE AREA STP

Table 9. Permitted effluent discharges in the New Jersey drainage basins studied, 1975--Continued

Drainage basin		NJPDES permit number	Permitted effluent discharger
Monitoring-station name	Monitoring-station number		
Jumping Brook near Neptune City	01407760	3573	FINETEX INC
Marsh Bog Brook at Squankum	01407997	26638	FARMINGDALE GARDEN APTS.
		28622	FREQUENCY ENGINEERING LABS
Toms River near Toms River	01408500	4120	CIBA-GEIGY CORPORATION
		35041	MAPLE GLEN PARK
		35653	FOUNTAINHEAD PARK INC
Hammonton Creek at Westcoatville	01409416	24210	WHITEHALL LABORATORIES
		25160	HAMMONTON WASTEWATER TREATMENT
Great Egg Harbor near Sicklerville	01410784	26972	BERLIN BOROUGH WPC PLANT
Great Egg Harbor near Blue Anchor	01410820	26972	BERLIN BOROUGH WPC PLANT
Great Egg Harbor at Weymouth	01411110	4588	AKZO CHEMICALS INC.
		26409	LINDENWOLD BOROUGH MUA
		26522	CENTRAL MAINT MP 275
		26972	BERLIN BOROUGH WPC PLANT
Maurice River at Norma	01411500	4103	SHIELDALLOY CORPORATION
		5312	O I GLASS CONTAINER STS INC
		20125	MILES PETROLEUM INC
		25658	PIONEER METAL FINISHERS INC
		32361	RON-SON MUSHROOM PROD INC
		36129	MARSHALL SERVICE INC
Cohansey River at Seeley	01412800	24147	CUMBERLAND COUNTY UTILITIES
Paulins Kill at Blairstown	01443500	4791	LIMECREST PLANT SPARTA
		20184	NEWTON, TOWN OF
		22063	SUSSEX COUNTY BRD FREEHOLDERS
		24163	'BIG N' SHOPPING CENTER STP
		26701	SUSSEX COUNTY BRD FREEHOLDERS
		27057	SPARTA TWP PLAZA SEWAGE PLANT
		28819	HART & ILIFF FUEL OIL COMPANY
Musconetcong River at Outlet of Lake Hopatcong	01455500	21105	ARTHUR STANLICK SCHOOL
		21156	CONSOLIDATED SCHOOL
		26212	MT ARLINGTON SANITATION CORPORATION
Musconetcong River at Beatyestown	01456200	4600	US MINERAL PRODUCTS
		5568	COOKE COLOR & CHEMICAL CO.
		21105	ARTHUR STANLICK SCHOOL
		21156	CONSOLIDATED SCHOOL
		21369	HACKETTSTOWN MUA

Table 9. Permitted effluent discharges in the New Jersey drainage basins studied, 1975--Continued

Drainage basin		NJPDES permit number	Permitted effluent discharger
Monitoring-station name	Monitoring-station number		
Musconetcong River at Beatyestown--Continued	01456200-Cont.	22632	BYRAM TOWNSHIP BD OF ED
		26212	MT ARLINGTON SANITATION CORPORATION
Musconetcong River at Riegelsville	01457400	4421	RIEGEL PRODUCTS CORPORATION
		4448	WARREN GLEN MILL
		4600	US MINERAL PRODUCTS
		5568	--
		21105	ARTHUR STANLICK SCHOOL
		21156	CONSOLIDATED SCHOOL
		21369	HACKETTSTOWN MUA
		22632	BYRAM TOWNSHIP BD OF ED
		25569	BLOOMSBURY WATER COMPANY
		26212	MT ARLINGTON SANITATION CORPORATION
		28592	DIAMOND HILL ESTATES SEWAGE CO
		31208	ASBURY GRAPHITE MILLS INC
Wickechcoke Creek at Stockton	01461300	27537	MAGNESIUM ELEKTRON INC
		27561	DELAWARE TOWNSHIP MUA
Crosswicks Creek at Extonville	01464500	4855	U.S. ARMY FT. DIX & TRNG. CNTR
		21091	JEFFERSON MIDDLE & HIGH SCHOOL
		21407	PLUMSTEAD TWP SCHOOL DIST.
		22985	WRIGHTSTOWN MUA
		27464	HANOVER MOBILE VILLAGE
		27511	CALIFORNIA VILLA MOBILE
Doctors Creek at Allentown	01464515	20206	ALLENTOWN WTP
SB Rancocas Creek at Vincentown	01465850	21768	NEW LISBON STATE SCHOOL
		23736	SOUTHAMPTON SEWERAGE CO
		33367	STOKES OF VINCENTOWN INC
NB Rancocas Creek at Brownsmills	01467000	21733	PEMBERTON
		28665	MOBILE ESTATES OF SOUTHAMPTON
NB Pennsauken Creek near Moorestown	01467069	23981	MOUNT LAUREL MUA
SB Pennsauken Creek at Cherry Hill	01467081	24040	WOODSTREAM STP
		31879	MAPLE SHADE TOWNSHIP OF
Cooper River at Lawnside	01467140	3999	HUSSMANN REFRIGERATOR CO
		20621	LAWNSIDE BOROUGH OF
		21652	SOMERDALE, BOROUGH OF
		22403	VOORHEES TOWNSHIP
		25101	CHERRY HILL TOWNSHIP

Table 9. Permitted effluent discharges in the New Jersey drainage basins studied, 1975--Continued

Drainage basin		NJPDES	
Monitoring-station name	Monitoring-station number	permit number	Permitted effluent discharger
Cooper River at Lawnside--Continued	01467140-Cont.	25119	CHERRY HILL TOWNSHIP
		26361	GIBBSBORO SEWAGE CORPORATION
SB Big Timber Creek at Blackwood Terrace	01467329	29840	CAMDEN C'NTY SEWAGE TRETMT PLT
Raccoon Creek near Swedesboro	01477120	20532	HARRISON TWP-MULLICA HILL STP

Table 10. Permitted effluent discharges and effluent quantity and quality in the New Jersey drainage basins studied, 1986

[--, no name of permitted discharger found; NJPDES, New Jersey Pollutant Discharge Elimination system; SIC, standard industrial code; Mgal/d, million gallons per day; BOD, 5-day biochemical oxygen demand; kg/d, kilograms per day; TSS, total suspended solids; *, wastewater discharge is within the area 3.1 miles upstream from the monitoring station; -, no data available. Source: Data from Michael Dillon, New Jersey Department of Environmental Protection, written commun., 1990]

Drainage basin		NJPDES		Within	Effluent quantity and quality			
Monitoring-station name	Monitoring-station number	permit number	Name of permitted wastewater discharge	area 3.1 miles upstream	SIC number	Discharge (Mgal/d)	BOD (kg/d)	TSS (kg/d)
Wallkill River at Franklin	01367700	4596	THE NEW JERSEY ZINC COMPANY	*	1000	0.240	-	31.201
		27049	POPE JOHN XXIII HIGH SCHOOL		4952	0.006	0.030	0.010
		33472	TRI-CN'TY WATER CONDITION CO.		7389	0.0010	-	0.500
		27081	SPARTA HIGH SCHOOL		8211	-	0.075	0.110
		27073	SPARTA BD OF ED HIGH SCHOOL #		8211	0.002	0.032	0.014
Wallkill River near Sussex	01367770	4596	THE NEW JERSEY ZINC COMPANY		1000	0.240	-	31.201
		141	AMES RUBBER CORPORATION	*	3069	0.256	-	5.491
		6661	PLASTOID CORP	*	3357	0.001	-	0.020
		20885	PLASTOID CORPORATION		3357	0.217	-	11.482
		2275	ACCURATE FORMING CORPORATION	*	3471	0.013	0.046	0.420
		31038	FRANKLIN BOARD OF PUBLIC WORKS		4941	0.028	-	1.625
		27049	POPE JOHN XXIII HIGH SCHOOL		4952	0.006	0.030	0.010
		53350	--		4953	0.491	17.915	14.810
		33472	TRI-CN'TY WATER CONDITION CO.		7389	0.001	-	0.500
		27081	SPARTA HIGH SCHOOL		8211	-	0.075	0.110
		27073	SPARTA BD OF ED HIGH SCHOOL #		8211	0.002	0.032	0.014
Papakating Creek at Sussex	01367910	21857	--	*	4952	0.310	28.000	38.950
		29041	REGENCY APARTMENT	*	6513	0.015	0.400	0.200
		31585	HIGH POINT REGIONAL HS	*	8211	0.010	0.149	0.577
Black Creek near Vernon	01368950	32841	STONEHILL STP	*	1400	0.040	1.080	10.981
		23949	GREAT GORGE'S MOUNTAIN VIEW		7011	0.262	4.300	6.600
		21814	VERNON VALLEY RECREATION ASSN		7032	0.009	0.059	0.108
		23841	VERNON TWP SCHOOL BOARD	*	8211	0.007	0.260	0.080
Passaic River near Millington	01379000	29912	NEW JERSEY DOT		4784	0.004	0.120	0.120
		20290	CHATHAM TOWNSHIP MAIN SEWAGE		4952	0.684	34.000	46.800
Passaic River near Chatham	01379500	29963	GLASFLEX CORPORTION		2821	0.019	-	0.241
		2551	REHEIS CHEMICAL CO.		2833	0.521	-	9.350
		29912	NEW JERSEY DOT		4784	0.004	0.120	0.120
		20290	CHATHAM TOWNSHIP MAIN SEWAGE	*	4952	0.684	34.000	46.800
		21636	NEW PROVIDENCE BOROUGH OF WTP	*	4952	0.885	43.660	36.120

Table 10. Permitted effluent discharges and effluent quantity and quality in the New Jersey drainage basins studied, 1986--Continued

Drainage basin: Monitoring-station name	Drainage basin: Monitoring-station number	NJPDES permit number	Name of permitted wastewater discharge	Within area 3.1 miles upstream	Effluent quantity and quality: SIC number	Discharge (Mgal/d)	BOD (kg/d)	TSS (kg/d)
Passaic River near Chatham--Continued	01379500--Cont.	50369	--		4952	0.080	1.890	2.000
		22497	STAGE IV SEWAGE TREATMENT PLT		4952	0.311	8.600	14.150
		22489	WARREN TWP. SEWAGE AUTHORITY		4952	0.318	6.500	3.500
		24465	PASSAIC TOWNSHIP OF		4952	0.827	51.000	40.000
		22845	HARRISON BROOK		4952	1.237	14.325	25.665
		27961	WATER POLLUTION CONTROL		4952	1.866	272.000	145.300
		20281	PARK CENTRAL SEWAGE TREATMENT	*	6513	0.030	1.790	2.050
		442	AT&T BELL LABORATORIES	*	7391	0.121	-	33.221
		21083	VETERANS ADMINISTRATION		9711	0.390	27.562	30.716
		34801	GIBSON TUBE INC		-	0.053	-	3.428
Rockaway River at Pine Brook	01381200	3409	MT HOPE ROCKS PRODUCTS		1011	0.025	-	0.191
		1261	KEUFFEL & ESSER CO		2641	0.037	-	0.075
		2500	PICATINNY ARSENAL		2800	5.620	26.295	30.934
		523	AIR PRODUCTS & CHEMICALS INC		2813	0.020	-	2.778
		34720	VEX CORP		2821	-	-	0.003
		3611	CARPENTER LE & COMPANY INC		2851	0.280	28.290	39.512
		3506	ADRON		2869	-	-	0.009
		25712	VIBRATION MOUNTING & CONTROLS		3069	9.000	-	6.810
		25674	ACTION TECHNOLOGY COMPANY		3079	0.001	-	0.011
		34681	THATCHER GLASS CORPORATION		3221	0.051	-	1.930
		2593	GHA LOCK JOINT		3312	.0.004	-	0.004
		34134	GREEN HAMMER METAL PRODUCTS CO		3354	0.042	-	1.560
		1635	HOWMET TURBINE COMPONENTS CORP		3369	0.114	-	1.350
		2496	MC WILLIAMS FORGE CO INC		3462	0.520	-	16.423
		52396	PNEU HYDRO PRODUCTS INC		3494	-	-	0.001
		3077	--		3625	0.129	0.085	33.292
		25721	BUTLER WATER DEPARTMENT		4941	0.340	9.526	50.671
		22349	ROCKAWAY VALLEY REG S.A.		4952	-	141.900	134.070
		30287	MONTVILLE TOWNSHIP MUA		4952	0.002	0.115	0.100
		30317	MONTVILLE TOWNSHIP MUA		4952	0.003	0.240	0.210
		26867	JEFFERSON TWP.-ROCK		4952	0.066	-	-
		32808	ROCKAWAY TOWNSQUARE MALL		6512	0.323	0.400	1.900
		22802	WHITE MEADOW LAKE PROP.OWNERS		6513	0.001	0.030	0.030
		35050	W P REALTY CO		7011	-	-	-
		21181	CEDAR HILL SCHOOL STP	*	8211	0.004	0.113	0.032

Table 10. Permitted effluent discharges and effluent quantity and quality in the New Jersey drainage basins studied, 1986--Continued

Drainage basin		NJPDES permit number	Name of permitted wastewater discharge	Within area 3.1 miles upstream	Effluent quantity and quality			
Monitoring-station name	Monitoring-station number				SIC number	Discharge (Mgal/d)	BOD (kg/d)	TSS (kg/d)
Rockaway River at Pine Brook--Continued	01381200--Cont.	26603	RANDOLPH HIGH SCHOOL STP		8211	0.009	0.049	0.170
		21091	JEFFERSON MIDDLE & HIGH SCHOOL		8211	0.013	0.147	0.220
		24457	OUR LADY OF THE MAGNIFICAT		8661	0.002	0.015	0.013
		32221	LESLIE CO		-	-	-	-
		30911	SCERBO BROTHERS INC		-	-	0.002	0.013
		34649	--		-	0.014	-	0.170
		32026	--		-	0.021	-	0.694
Whippany River at Morristown	01381500	33685	CHAMPION INTL DAIRYPAK DIV	*	2631*	0.013	-	0.348
		2542	PARKE-DAVIS DIV WARNER LAMBERT	*	2834	0.040	-	0.347
		35238	--	*	2844	0.125	-	14.050
		24929	WOODLAND STP	*	4952	1.291	71.135	5.690
		24911	BUTTERWORTH STP	*	4952	1.735	111.120	14.790
		26689	ENGR. DEPT.-GREYSTONE PARK	*	8063	0.328	17.100	13.650
		26751	ST MARY'S ABBEY		8661	0.015	0.235	0.270
Whipany River near Pine Brook	01381800	3514	--		2087	0.021	-	0.737
		33685	CHAMPION INTL DAIRYPAK DIV		2631	0.013	-	0.348
		3450	LEEMING PACQUIN COMPANY		2834	-	-	2.400
		2542	PARKE-DAVIS DIV WARNER LAMBERT		2834	0.040	-	0.347
		1155	SANDOZ PHARMACEUTICALS CORP.		2834	0.621	-	48.767
		35238	--		2844	0.125	-	14.050
		3697	COLLOID CHEMICAL INC		2869	0.010	-	0.055
		29734	FABRICATED PLASTICS		3052	-	-	-
		1881	PRECISION ROLLED PRODUCTS INC.		3369	0.008	0.008	0.171
		1708	ROWE INTERNATIONAL OF CANADA	*	3581	0.152	-	2.510
		25739	LITTON INDUSTRIES INC AIRTRON		3679	0.002	-	0.294
		54127	--		3728	0.419	-	4.843
		24902	HANOVER SEWERAGE AUTHORITY	*	4952	2.100	104.350	100.250
		24929	WOODLAND STP		4952	1.291	71.135	5.690
		24911	BUTTERWORTH STP		4952	1.735	111.120	14.790
		25496	MORRISTOWN TOWN OF		4952	3.250	513.400	300.780
		28339	CAMPBELL-PRATT OIL CO		5171	-	-	-
		35777	EXXON CENTRAL SERVICES		6512	0.006	-	0.141
		3476	EXXON RESEARCH & ENGRG CO		7391	0.215	0.567	0.420
		31305	--		7391	0.700	-	2.649

Table 10. Permitted effluent discharges and effluent quantity and quality in the New Jersey drainage basins studied, 1986--Continued

Drainage basin: Monitoring-station name	Drainage basin: Monitoring-station number	NJPDES permit number	Name of permitted wastewater discharge	Within area 3.1 miles upstream	Effluent quantity and quality: SIC number	Discharge (Mgal/d)	BOD (kg/d)	TSS (kg/d)
Whipany River near Pine Brook--Continued	01381800--Cont	26689	ENGR. DEPT.-GREYSTONE PARK		8063	0.328	17.100	13.650
		26654	SISTERS OF CHARITY-ST. ELIZABE		8661	-	-	-
		26751	ST MARY'S ABBEY		8661	0.015	0.235	0.270
Passaic River at Two Bridges	01382000	3409	MT HOPE ROCKS PRODUCTS		1011	0.025	-	0.191
		3743	M.POLNAR INC.		2033	0.111	-	9.760
		3514	--		2087	0.021	-	0.737
		1651	FRITZSCHE DODGE & OLCOTT		2087	0.746	12.555	3.175
		33685	CHAMPION INTL DAIRYPAK DIV		2631	0.013	-	0.348
		1261	KEUFFEL & ESSER CO		2641	0.037	-	0.075
		2500	PICATINNY ARSENAL		2800	5.620	26.295	30.934
		523	AIR PRODUCTS & CHEMICALS INC		2813	0.020	-	2.778
		34720	VEX CORP		2821	-	-	0.003
		29963	GLASFLEX CORPORTION		2821	0.019	-	0.241
		540	CIBA-GEIGY CORP		2833	0.460	37.723	17.652
		2551	REHEIS CHEMICAL CO.		2833	0.521	-	9.350
		3450	LEEMING PACQUIN COMPANY		2834	-	-	2.400
		2542	PARKE-DAVIS DIV WARNER LAMBERT		2834	0.040	-	0.347
		1155	SANDOZ PHARMACEUTICALS CORP.		2834	0.621	-	48.767
		35238			2844	0.125	-	14.050
		3611	CARPENTER LE & COMPANY INC		2851	0.280	28.290	39.512
		3506	ADRON		2869	-	-	0.009
		3697	COLLOID CHEMICAL INC		2869	0.010	-	0.055
		29734	FABRICATED PLASTICS		3052	-	-	-
		25712	VIBRATION MOUNTING & CONTROLS		3069	9.000	-	6.810
		1490	ORANGE PRODUCTS INC		3079	0	0.118	0.130
		25674	ACTION TECHNOLOGY COMPANY		3079	0.001	-	0.011
		29955	RESISTOFLEX CORPORATION		3079	0.070	1906.753	1246.244
		34681	THATCHER GLASS CORPORATION		3221	0.051	-	1.930
		2593	GHA LOCK JOINT		3312	0.004	-	0.004
		34134	GREEN HAMMER METAL PRODUCTS CO		3354	0.042	-	1.560
		1881	PRECISION ROLLED PRODUCTS INC.		3369	0.008	0.008	0.171
		1635	HOWMET TURBINE COMPONENTS CORP		3369	0.114	-	1.350
		2496	MC WILLIAMS FORGE CO INC		3462	0.520	-	16.423

Table 10. Permitted effluent discharges and effluent quantity and quality in the New Jersey drainage basins studied, 1986--Continued

Drainage basin		NJPDES		Within	Effluent quantity and quality			
Monitoring-station name	Monitoring-station number	permit number	Name of permitted wastewater discharge	area 3.1 miles upstream	SIC number	Discharge (Mgal/d)	BOD (kg/d)	TSS (kg/d)
Passaic River at Two Bridges--Continued	01382000--Cont.	32573	NATIONAL MANUFACTURING CO		3469	0.022	-	0.142
		2003	AUTOMATIC SWITCH COMPANY		3471	0.003	-	-
		52396	PNEU HYDRO PRODUCTS INC		3494	-	-	0.001
		1708	ROWE INTERNATIONAL OF CANADA		3581	0.152	-	2.510
		3077	--		3625	0.129	0.085	33.292
		61875	--		3652	0.001	-	0.006
		25739	LITTON INDUSTRIES INC AIRTRON		3679	0.002	-	0.294
		54127	--		3728	0.419	-	4.843
		29912	NEW JERSEY DOT		4784	0.004	0.120	0.120
		25721	BUTLER WATER DEPARTMENT		4941	0.340	9.526	50.671
		22349	ROCKAWAY VALLEY REG S.A.		4952	-	141.900	134.070
		30287	MONTVILLE TOWNSHIP MUA		4952	0.002	0.115	0.100
		30317	MONTVILLE TOWNSHIP MUA		4952	0.003	0.240	0.210
		24431	MONTVILLE TOWNSHIP MUA		4952	0.035	2.405	2.125
		26867	JEFFERSON TWP.-ROCK		4952	0.066	-	-
		50369	--		4952	0.080	1.890	2.000
		22497	STAGE IV SEWAGE TREATMENT PLT		4952	0.311	8.600	14.150
		22489	WARREN TWP. SEWAGE AUTHORITY		4952	0.318	6.500	3.500
		20290	CHATHAM TOWNSHIP MAIN SEWAGE		4952	0.684	34.000	46.800
		24465	PASSAIC TOWNSHIP OF		4952	0.827	51.000	40.000
		21636	NEW PROVIDENCE BOROUGH OF WTP		4952	0.885	43.660	36.120
		25518	FLORHAM PARK STP		4952	0.887	83.000	118.000
		22845	HARRISON BROOK		4952	1.237	14.325	25.665
		24929	WOODLAND STP		4952	1.291	71.135	5.690
		24911	BUTTERWORTH STP		4952	1.735	111.120	14.790
		27961	WATER POLLUTION CONTROL		4952	1.866	272.000	145.300
		24902	HANOVER SEWERAGE AUTHORITY		4952	2.100	104.350	100.250
		24937	MADISON-CHATHAM JOINT MEETING		4952	2.806	159.850	94.550
		25496	MORRISTOWN TOWN OF		4952	3.250	513.400	300.780
		20427	CALDWELL BOROUGH OF		4952	3.700	526.500	362.000
		24511	LIVINGSTON TOWNSHIP OF		4952	3.717	107.000	143.500
		24970	PARSIPPANY TOWNSHIP OF		4952	10.025	83.600	96.900
		28339	CAMPBELL-PRATT OIL CO		5171	-	-	0
		35777	EXXON CENTRAL SERVICES		6512	0.006	-	0.141
		32808	ROCKAWAY TOWNSQUARE MALL		6512	0.323	0.400	1.900

Table 10. Permitted effluent discharges and effluent quantity and quality in the New Jersey drainage basins studied, 1986--Continued

Drainage basin					Effluent quantity and quality			
Monitoring-station name	Monitoring-station number	NJPDES permit number	Name of permitted wastewater discharge	Within area 3.1 miles upstream	SIC number	Discharge (Mgal/d)	BOD (kg/d)	TSS (kg/d)
Passaic River at Two Bridges--Continued	01382000--Cont.	22802	WHITE MEADOW LAKE PROP.OWNERS		6513	0.001	0.030	0.030
		20281	PARK CENTRAL SEWAGE TREATMENT		6513	0.030	1.790	2.050
		35050	W P REALTY CO		7011	-	-	-
		442	AT&T BELL LABORATORIES		7391	0.121	-	33.221
		3476	EXXON RESEARCH & ENGRG CO		7391	0.215	0.567	0.420
		31305	--		7391	0.700	-	2.649
		30961	--		7991	0.008	0.053	0.182
		26689	ENGR. DEPT.-GREYSTONE PARK		8063	0.328	17.100	13.650
		21181	CEDAR HILL SCHOOL STP		8211	0.004	0.113	0.032
		26603	RANDOLPH HIGH SCHOOL STP		8211	0.009	0.049	0.170
		21091	JEFFERSON MIDDLE & HIGH SCHOOL		8211	0.013	0.147	0.220
		26654	SISTERS OF CHARITY-ST. ELIZABE		8661	-	-	-
		24457	OUR LADY OF THE MAGNIFICAT		8661	0.002	0.015	0.013
		26751	ST MARY'S ABBEY		8661	0.015	0.235	0.270
		21938	US ARMY NIKE 79/80 E HANOVER		9711	0.008	0.381	0.490
		21083	VETERANS ADMINISTRATION		9711	0.390	27.562	30.716
		35424	BROE WN BOVERT-RECOMA INC	*	-	-	-	-
		32221	LESLIE CO		-	-	-	-
		63886	--		-	-	-	-
		30911	SCERBO BROTHERS INC		-	-	0.002	0.013
		34649	--		-	0.014	-	0.170
		32026	--		-	0.021	-	0.694
		34801	GIBSON TUBE INC		-	0.053	-	3.428
Wanaque River at Wanaque	01387000	30261	WANAQUE BOROUGH SEWERAGE AUTHO	*	4952	0.235	9.800	24.000
		32395	RINGWOOD PLAZA S T P	*	6512	0.011	0.110	0.165
		34169	PETER COOPER SCHOOL	*	8211	0.009	0.024	0.023
		29432	OBERT ERSKINE SCHOOL		8211	0.004	-	-
Saddle River at Lodi	01391500	29726	C M & SON TRUCKING INC		3531	-	-	0.165
		20109	IBM CORPORATION		3674	0.018	0.475	0.935
		3221	ALL PURPOSE ROLL LEAF	*	3861	0.120	-	0.200
		23931	HEARTHSTONE AT MAHWAH		4952	0.007	1.000	1.000
		24791	RIDGEWOOD VILLAGE COMPOST-FRAN		4952	3.036	203.900	171.800
		24813	NORTHWEST BERGEN COUNTY S.A.		4952	6.342	390.000	374.500
		33987	IBM CORPORATION		5065	0.016	-	1.642
		28827	APPLE RIDGE COUNTRY CLUB		7997	0.008	0.133	0.120
		98469	--		-	0.069	-	-

Table 10. Permitted effluent discharges and effluent quantity and quality in the New Jersey drainage basins studied, 1986--Continued

Drainage basin					Effluent quantity and quality			
Monitoring-station name	Monitoring-station number	NJPDES permit number	Name of permitted wastewater discharge	Within area 3.1 miles upstream	SIC number	Discharge (Mgal/d)	BOD (kg/d)	TSS (kg/d)
SB Raritan River at Middle Valley	01396280	1236	WELSH FARMS INC	*	2026	0.458	19.645	29.871
		34975	ADVANCED ENVIRON TECH CORP		4225	0.004	-	3.330
		22683	SKYVIEW STP		4952	0.078	5.940	7.290
		21954	MT OLIVE TOWNSHIP		4952	0.358	5.400	7.200
		35220	QUITY SHOPPING PLAZA		6512	0.001	0.159	-
		28304	QUALITY INN		7011	0.016	0.250	-
		23493	WASHINGTON TWP M.U.A.		9631	-	26.200	25.900
SB Raritan River at High Bridge	01396535	1236	WELSH FARMS INC		2026	0.458	19.645	29.871
		34975	ADVANCED ENVIRON TECH CORP		4225	0.004	-	3.330
		22683	SKYVIEW STP		4952	0.078	5.940	7.290
		21954	MT OLIVE TOWNSHIP		4952	0.358	5.400	7.200
		35220	QUITY SHOPPING PLAZA		6512	0.001	0.159	-
		28304	QUALITY INN		7011	0.016	0.250	-
		23493	WASHINGTON TWP M.U.A.		9631	-	26.200	25.900
Mulhockaway Creek at Van Syckel	01396660	24091	UNION TOWNSHIP BD OF ED	*	8211	-	0.030	0.060
SB Raritan River at Three Bridges	01397400	26450	LENTINE AGGREGATES		1423	0.050	-	7.000
		1236	WELSH FARMS INC		2026	0.458	19.645	29.871
		1660	--	*	2821	0.620	-	10.804
		3298	ETHYL CORP	*	3079	0.113	-	2.150
		3336	US BRONZE POWDERS CORP	*	3399	-	-	1.470
		34975	ADVANCED ENVIRON TECH CORP		4225	0.004	-	3.330
		28436	FLEMINGTON BOROUGH COUNCIL	*	4952	0.230	6.870	15.030
		22047	RARITAN TOWNSHIP STP	*	4952	1.265	30.150	24.550
		22683	SKYVIEW STP		4952	0.078	5.940	7.290
		21954	MT OLIVE TOWNSHIP		4952	0.358	5.400	7.200
		20389	CLINTON SEWERAGE AUTHORITY		4952	0.854	60.650	73.050
		28754	MEENAN OIL CO INC		5171	-	-	168.000
		35220	QUITY SHOPPING PLAZA		6512	0.001	0.159	-
		28304	QUALITY INN		7011	0.016	0.250	-
		35084	EXXON RESEARCH & ENG CO		7391	0.019	0.073	0.210
		24091	UNION TOWNSHIP BD OF ED		8211	-	0.030	0.060
		22144	GLEN GARDNER CTR. FOR GERIATRI		8211	-	2.700	2.210
		23175	CLINTON TOWNSHIP BD OF ED		8211	0.002	0.020	0.060
		28363	NORTH HUNTERDON HIGH SCHOOL		8211	0.017	0.300	1.160
		28487	YOUTH CORRECTIONAL INSTITUTION		9223	0.219	51.700	71.600

Table 10. Permitted effluent discharges and effluent quantity and quality in the New Jersey drainage basins studied, 1986--Continued

Drainage basin		NJPDES		Within	Effluent quantity and quality			
Monitoring-station name	Monitoring-station number	permit number	Name of permitted wastewater discharge	area 3.1 miles upstream	SIC number	Discharge (Mgal/d)	BOD (kg/d)	TSS (kg/d)
SB Raritan River at Three Bridges--Continued	01397400--Cont.	23493	WASHINGTON TWP M.U.A.		9631	-	26.200	25.900
NB Raritan River near Chester	01398260	21334	MENDHAM BOROUGH STP	*	4952	0.377	18.500	18.000
NB Raritan River at Burnt Mills	01399120	29637	BERNARDSVILLE QUARRYINC.		1429	0.260	-	185.043
		33995	ENVIRONMENTAL DISPOSAL CORP	*	3079	0.099	1.600	1.300
		29807	NEW JERSEY DOT-MAINTENANCE FAC	*	4784	-	0.040	0.007
		21881	PEAPACK & GLADSTONE BOROUGH		4952	0.131	4.500	2.260
NB Raritan River at Burnt Mills	01399120	28495	BEDMINISTER STP		4952	0.175	3.540	4.490
		26387	BERNARDSVILLE BOROUGH OF		4952	0.372	23.830	19.420
		21334	MENDHAM BOROUGH STP		4952	0.377	18.500	18.000
		26824	CHESTER SHOPPING CENTER		6512	0.012	0.575	0.480
		27227	JOHN Z. DELOREAN	*	8811	-	0.039	0.019
Rockaway Creek at Whitehouse	01399700	2917	OLDWICK MATERIALS INC	*	1423	0.058	-	14.530
		31488	DURLING FARMS INC	*	2026	0.023	7.539	13.868
		98922	READINGTON-LEBANON SEWERAGE AU	*	4952	0.316	5.200	9.000
		28452	BEST A. M. CO INC	*	6512	0.003	0.030	0.020
Lamington River at Burnt Mills	01399780	2917	OLDWICK MATERIALS INC		1423	0.058	-	14.530
		2861	COUNTY CONCRETE CORP		1442	2.150	-	-
		31488	DURLING FARMS INC		2026	0.023	7.539	13.868
		20338	BRANCHBURG, TOWNSHIP OF	*	4952	0.025	0.125	0.230
		22781	VALLEY ROAD SEWERAGE CO		4952	0.019	0.180	0.400
		98922	READINGTON-LEBANON SEWERAGE AU		4952	0.316	5.200	9.000
		31755	JIM SALERNO PONTIAC INC		5511	0.019	-	4.059
		28452	BEST A. M. CO INC		6512	0.003	0.030	0.020
		21865	LAMINGTON RIVER FARMS	*	7997	0.003	0.111	0.064
Raritan River at Manville	01400500	26450	LENTINE AGGREGATES		1423	0.050	-	7.000
		2917	OLDWICK MATERIALS INC		1423	0.058	-	14.530
		29637	BERNARDSVILLE QUARRYINC.		1429	0.260	-	185.043
		2861	COUNTY CONCRETE CORP		1442	2.150	-	-
		1961	DEVRO INC	*	2013	0.012	-	0.030
		31488	DURLING FARMS INC		2026	0.023	7.539	13.868
		1236	WELSH FARMS INC		2026	0.458	19.645	29.871
		2313	AMERICAN CYANAMID COMPANY	*	2810	3.515	71.500	
		3051	WILSON-FIBERFIL/DART & KRAFT		2815	0.040	0.670	1.411
		1660	--		2821	0.620	-	10.804

Table 10. Permitted effluent discharges and effluent quantity and quality in the New Jersey drainage basins studied, 1986--Continued

Drainage basin		NJPDES permit number	Name of permitted wastewater discharge	Within area 3.1 miles upstream	Effluent quantity and quality			
Monitoring-station name	Monitoring-station number				SIC number	Discharge (Mgal/d)	BOD (kg/d)	TSS (kg/d)
Raritan River at Manville--Continued	01400500--Cont.	3905	3 BRIDGES FARM		2834	0.003	0.033	0.094
		32662	DARTCO MANUFACTURING		2865	0.003	-	0.057
		33995	ENVIRONMENTAL DISPOSAL CORP		3079	0.099	1.600	1.300
		3298	ETHYL CORP		3079	0.113	-	2.150
		32328	VIANINI PIPE INC		3272	0.008	-	0.016
		3336	US BRONZE POWDERS CORP		3399	-	-	1.470
		29921	CRESTLINE DIV OF N A PRODUCTS		3493	0.003	1.574	1.830
		3638	TAYLOR FORGE STAINLESS		3498	0.010	0.968	1.127
		3158	PRINTING PRODUCTS DIVISION		3555	-	-	-
		2569	RCA CORP SOLID STATE PLANT		3674	0.017	-	0.515
		1139	ETHICON INC		3841	-	-	3.715
		23914	NJ TRANSIT RAIL OPERATIONS INC		4011	0.004	-	0.426
		34975	ADVANCED ENVIRON TECH CORP		4225	0.004	-	3.330
		29807	NEW JERSEY DOT-MAINTENANCE FAC		4784	-	0.040	0.007
		20362	BRANCHBURG TOWNSHIP OF		4952	0.001	0.025	0.007
		22781	VALLEY ROAD SEWERAGE CO		4952	0.019	0.180	0.400
		20338	BRANCHBURG, TOWNSHIP OF		4952	0.025	0.125	0.230
		20354	BRANCHBURG NESHANIC STP		4952	0.026	0.460	0.245
		22683	SKYVIEW STP		4952	0.078	5.940	7.290
		21881	PEAPACK & GLADSTONE BOROUGH		4952	0.131	4.500	2.260
		28495	BEDMINISTER STP		4952	0.175	3.540	4.490
		28436	FLEMINGTON BOROUGH COUNCIL		4952	0.230	6.870	15.030
		98922	READINGTON-LEBANON SEWERAGE AU		4952	0.316	5.200	9.000
		21954	MT OLIVE TOWNSHIP		4952	0.358	5.400	7.200
		26387	BERNARDSVILLE BOROUGH OF		4952	0.372	23.830	19.420
		21334	MENDHAM BOROUGH STP		4952	0.377	18.500	18.000
		20389	CLINTON SEWERAGE AUTHORITY		4952	0.854	60.650	73.050
		22047	RARITAN TOWNSHIP STP		4952	1.265	30.150	24.550
		29271	TAYLOR OIL CO.	*	5171	0.050	-	17.032
		28754	MEENAN OIL CO INC		5171	-	-	168.000
		31755	JIM SALERNO PONTIAC INC		5511	0.019	-	4.059
		27324	SOMERSET COUNTY SHOPPING CTR.	*	6512	0.050	1.764	1.654
		35220	QUITY SHOPPING PLAZA		6512	0.001	0.159	-
		28452	BEST A. M. CO INC		6512	0.003	0.030	0.020
		26824	CHESTER SHOPPING CENTER		6512	0.012	0.575	0.480

Table 10. Permitted effluent discharges and effluent quantity and quality in the New Jersey drainage basins studied, 1986--Continued

Drainage basin					Effluent quantity and quality			
Monitoring-station name	Monitoring-station number	NJPDES permit number	Name of permitted wastewater discharge	Within area 3.1 miles upstream	SIC number	Discharge (Mgal/d)	BOD (kg/d)	TSS (kg/d)
Raritan River at Manville--Continued	01400500--Cont.	28304	QUALITY INN		7011	0.016	0.250	-
		35084	EXXON RESEARCH & ENG CO		7391	0.019	0.073	0.210
		21865	LAMINGTON RIVER FARMS		7997	0.003	0.111	0.064
		24091	UNION TOWNSHIP BD OF ED		8211	-	0.030	0.060
		22144	GLEN GARDNER CTR. FOR GERIATRI		8211	-	2.700	2.210
		23175	CLINTON TOWNSHIP BD OF ED		8211	0.002	0.020	0.060
		26697	READINGTON TOWNSHIP BD OF ED		8211	0.003	0.023	0.026
		28363	NORTH HUNTERDON HIGH SCHOOL		8211	0.017	0.300	1.160
		20991	SAINT BERNARDS CHURCH		8661	0.002	13.000	52.000
		27227	JOHN Z. DELOREAN		8811	0	0.039	0.019
		28487	YOUTH CORRECTIONAL INSTITUTION		9223	0.219	51.700	71.600
		23493	WASHINGTON TWP M.U.A.		9631	-	26.200	25.900
		32581	OLIVETTI CORP. OF AMERICA		-	-	-	-
		33111	COLORGUARD CORPORATION		-	0.010	-	0.076
Millstone River at Grovers Mill	01400650	60992	--		2655	-	-	0.001
		4243	L CHEMICALS USA INC		2850	0.020	2.241	1.235
		2534	GENERAL ELECTRIC COMPANY		3662	0.094	-	0.711
		3832	HIGHTSTOWN BOROUGH OF WTP		4941	0.051	-	0.280
		23787	EAST WINDSOR WATER POLLUTION	*	4952	5.249	180.700	182.650
		29475	HIGHTSTOWN STP		4952	0.412	19.000	28.000
Millstone River at Kingston	01401440	426	IBM CORP-CARD MFG PLANT		2645	0.040	442.411	921.690
		60992	--		2655	-	-	0.001
		191	COLUMBIAN CHEMICALS COMPANY		2816	0.045	-	0.280
		2666	CARTER-WALLACE INC		2830	0.450	66.922	59.336
		31445	FIRMENICH INCORPORATED	*	2844	-	0.001	-
		4243	L CHEMICALS USA INC		2850	0.020	2.241	1.235
		4561	COCA-COLA FOODS		3411	0.040	10.981	0.067
		32611	NATIONAL METALIZING		3479	0.019	-	0.007
		3794	MC LEAN ENGR LABS INC		3621	0.004	-	0.151
		31950	HUB SERVALL RECORD MFG CORP		3652	0.001	-	0.015
		2534	GENERAL ELECTRIC COMPANY		3662	0.094	-	0.711
		57339	--		3679	0.039	-	1.275
		3832	HIGHTSTOWN BOROUGH OF WTP		4941	0.051	-	0.280
		981	STONY BROOK PLT		4941	0.260	10.467	55.676
		20770	PRINCETON SEWER OPER. COMM.		4952	0.017	0.660	0.600

Table 10. Permitted effluent discharges and effluent quantity and quality in the New Jersey drainage basins studied, 1986--Continued

Drainage basin		NJPDES permit number	Name of permitted wastewater discharge	Within area 3.1 miles upstream	Effluent quantity and quality			
Monitoring-station name	Monitoring-station number				SIC number	Discharge (Mgal/d)	BOD (kg/d)	TSS (kg/d)
Millstone River at Kingston--Continued	01401440--Cont.	22560	PRINCETON FARMS WTP		4952	0.038	0.442	0.535
		35319	PENNINGTON FARMS WTP		4952	0.214	3.487	2.823
		29475	HIGHTSTOWN STP		4952	0.412	19.000	28.000
		23787	EAST WINDSOR WATER POLLUTION		4952	5.249	180.700	182.650
		99147	FI SOUTH BRUNSWICK SANITARY	*	4953	0.001	-	0.034
		24104	THE LINPRO COMPANY		6513	0.665	13.300	30.150
		272	DAVID SARNOFF RESEARCH CENTER	*	7391	0.155	3.872	2.347
		27731	FMC CORPORATION	*	7391	0.355	-	3.096
		795	MOBIL TECHNICAL CENTER		7391	0.310	36.140	66.459
		22110	EDUCATIONAL TESTING SERVICE		8299	0.028	0.470	0.439
		23221	SAINT JOSEPH'S PREP SEM.	*	8661	0.007	0.050	0.050
		23205	PRINCETON THEOLOGICAL SEMINARY		8661	0.070	9.239	6.438
		809	--		8731	0.004	2.500	5.500
		23922	--	*	8922	0.165	-	4.403
		59838	INPRO COMPANY		-	0.001	-	0.090
Beden Brook near Rocky Hill	01401600	35301	--		4952	0.097	1.639	1.464
		32417	BEDENS BROOK CLUB		7992	0.004	0.039	0.039
		22390	NORTH PRINCETON DEV SLF	*	8069	0.345	20.170	16.955
Millstone River at Weston	01402540	426	IBM CORP-CARD MFG PLANT		2645	0.040	442.411	921.690
		26140	JOHNSON & JOHNSON BABY PRODS.		2647	0.049	0.392	0.231
		60992	--		2655	0	-	0.001
		191	COLUMBIAN CHEMICALS COMPANY		2816	0.045	-	0.280
		2666	CARTER-WALLACE INC		2830	0.450	66.922	59.336
		31445	FIRMENICH INCORPORATED		2844	-	0.001	-
		4243	L CHEMICALS USA INC		2850	0.020	2.241	1.235
		3255	3M COMPANY		3281	0.261	-	18.950
		23523	OKONITE CO. THE		3315	-	-	4.790
		4561	COCA-COLA FOODS		3411	0.040	10.981	0.067
		32611	NATIONAL METALIZING		3479	0.019	-	0.007
		3794	MC LEAN ENGR LABS INC		3621	0.004	-	0.151
		31950	HUB SERVALL RECORD MFG CORP		3652	0.001	-	0.015
		2534	GENERAL ELECTRIC COMPANY		3662	0.094	-	0.711
		57339	--		3679	0.039	-	1.275

Table 10. Permitted effluent discharges and effluent quantity and quality in the New Jersey drainage basins studied, 1986--Continued

Drainage basin		NJPDES permit number	Name of permitted wastewater discharge	Within area 3.1 miles upstream	Effluent quantity and quality			
Monitoring-station name	Monitoring-station number				SIC number	Discharge (Mgal/d)	BOD (kg/d)	TSS (kg/d)
Millstone River at Weston--Continued	01402540--Cont.	3832	HIGHTSTOWN BOROUGH OF WTP		4941	0.051	-	0.280
		981	STONY BROOK PLT		4941	0.260	10.467	55.676
		26891	MONTGOMERY STP 1		4952	-	0.130	0.080
		20770	PRINCETON SEWER OPER. COMM.		4952	0.017	0.660	0.600
		22560	PRINCETON FARMS WTP		4952	0.038	0.442	0.535
		26913	SLEEPY HOLLOW STP		4952	0.040	1.230	1.810
		35301	--		4952	0.097	1.639	1.464
		22764	VALLEY ROAD SEWERAGE CO		4952	0.109	3.760	1.650
		35319	PENNINGTON FARMS WTP		4952	0.214	3.487	2.823
		26905	MONTGOMERY STP#2 TOWNSHIP OF		4952	0.225	3.830	1.635
		29475	HIGHTSTOWN STP		4952	0.412	19.000	28.000
		20796	PRINCETON SEWER OPER. COMM.		4952	4.180	598.326	587.169
		23787	EAST WINDSOR WATER POLLUTION		4952	5.249	180.700	182.650
		31119	STONY BROOK REGIONAL S.A.		4952	6.447	63.755	61.675
		99147	FI SOUTH BRUNSWICK SANITARY		4953	0.001	-	0.034
		24104	THE LINPRO COMPANY		6513	0.665	13.300	30.150
		32565	INGERSOLL-RAND RESEARCH INC		7391	0.001	0.005	0.022
		272	DAVID SARNOFF RESEARCH CENTER		7391	0.155	3.872	2.347
		795	MOBIL TECHNICAL CENTER		7391	0.310	36.140	66.459
		27731	FMC CORPORATION		7391	0.355	-	3.096
		32417	BEDENS BROOK CLUB		7992	0.004	0.039	0.039
		23663	CARRIER CLINIC		8063	0.033	0.878	1.465
		22390	NORTH PRINCETON DEV SLF		8069	0.345	20.170	16.955
		23124	MONTGOMERY TOWNSHIP OF		8211	-	0.300	0.070
		22110	EDUCATIONAL TESTING SERVICE		8299	0.028	0.470	0.439
		23221	SAINT JOSEPH'S PREP SEM.		8661	0.007	0.050	0.050
		23205	PRINCETON THEOLOGICAL SEMINARY		8661	0.070	9.239	6.438
		809	--		8731	0.004	2.500	5.500
		23922	--		8922	0.165	-	4.403
		20656	GENERAL SERVICE ADMINISTRATION		9711	0.021	0.545	0.260
		59838	INPRO COMPANY		-	0.001	-	0.090
Manalapan Brook at Federal Road near Manalapan	01405340	4910	PEERLESS TUBE COMPANY		3079	0.070	-	1.600
Shark River near Neptune City	01407705	34258	MOLECU WIRE CORP		3496	0.005	-	0.038
		21148	MONMOUTH SERVICE AREA STP	*	5812	0.012	0.855	0.805

Table 10. Permitted effluent discharges and effluent quantity and quality in the New Jersey drainage basins studied, 1986--Continued

Drainage basin		NJPDES permit number	Name of permitted wastewater discharge	Within area 3.1 miles upstream	Effluent quantity and quality			
Monitoring-station name	Monitoring-station number				SIC number	Discharge (Mgal/d)	BOD (kg/d)	TSS (kg/d)
Toms River near Toms River	01408500	35041	MAPLE GLEN PARK		4941	0.004	-	0.027
		35653	FOUNTAINHEAD PARK INC		4952	0.008	0.545	0.757
		31267	--		6515	-	2.260	0.730
		29513	JACKSON TOWNSHIP BD. OF ED.		8211	-	0.750	0.850
Hammonton Creek at Westcoatville	01409416	24210	WHITEHALL LABORATORIES		2834	0.147	-	0.425
		25160	HAMMONTON WASTEWATER TREATMENT	*	4952	0.855	71.500	70.000
Great Egg Harbor near Sicklerville	01410784	26972	BERLIN BOROUGH WPC PLANT		4952	0.610	77.390	163.700
Great Egg Harbor near Blue Anchor	01410820	26972	BERLIN BOROUGH WPC PLANT		4952	0.610	77.390	163.700
Great Egg Harbor at Weymouth	01411110	26972	BERLIN BOROUGH WPC PLANT		4952	0.610	77.390	163.700
		26522	CENTRAL MAINT MP 275		5812	-	0.080	0.080
Maurice River at Norma	01411500	32361	RON-SON MUSHROOM PROD INC		2033	0.030	-	0.596
		4103	SHIELDALLOY CORPORATION		2819	0.300	-	2.300
		5312	O I GLASS CONTAINER STS INC		3466	0.273	-	2.130
		25658	PIONEER METAL FINISHERS INC		3471	0.006	-	0.020
		36129	ARSHALL SERVICE INC		-	0.010	-	0.783
Cohansey River at Seeley	01412800	62731	EABROOK PLANT	*	2033	0.800	-	16.140
Paulins Kill at Blairstown	01443500	4791	LIMECREST PLANT SPARTA		1422	5.850	-	44.940
		5711	SCHERING CORPORATION		2834	0.044	0.203	2.146
		52272	--		3365	-	-	-
		27057	SPARTA TWP PLAZA SEWAGE PLANT		4952	0.041	3.185	5.475
		20184	NEWTON TOWN OF		4952	1.042	54.900	94.550
		28819	HART & ILIFF FUEL OIL COMPANY		5171	-	-	0.076
		24163	'BIG N' SHOPPING CENTER STP		6513	0.003	0.040	0.040
		50580			6513	0.026	0.155	0.200
		22063	SUSSEX COUNTY BRD FREEHOLDERS		8011	0.009	0.230	0.200
		28894	KITTATINNY REGIONAL BD OF ED		8211	0.006	0.050	0.020
		27065	SPARTA BD OF ED ALPINE SCHOOL		8211	0.007	0.028	0.075
		26701	SUSSEX COUNTY BRD FREEHOLDERS		9711	0.040	9.989	15.170
Musconetcong River at outlet of Lake Hopatcong	01455500	26212	MT ARLINGTON SANITATION CORP	*	4952	0.020	1.610	1.433
		21105	ARTHUR STANLICK SCHOOL		8211	0.004	0.069	0.035
		21156	CONSOLIDATED SCHOOL		8211	0.090	0.110	0.088
		26239	OUR LADY OF LAKE REG SCHOOL	*	8661	0.001	0.009	0.026

Table 10. Permitted effluent discharges and effluent quantity and quality in the New Jersey drainage basins studied, 1986--Continued

Drainage basin		NJPDES permit number	Name of permitted wastewater discharge	Within area 3.1 miles upstream	Effluent quantity and quality			
Monitoring-station name	Monitoring-station number				SIC number	Discharge (Mgal/d)	BOD (kg/d)	TSS (kg/d)
Musconetcong River at Beatyestown	01456200	4812	AMERACE-ESNA CORP.	*	3069	0.096	-	0.036
		4600	US MINERAL PRODUCTS		3296	0.062	-	1.248
		21369	HACKETTSTOWN MUA	*	4952	1.535	65.870	57.710
		26212	MT ARLINGTON SANITATION CORP		4952	0.020	1.610	1.433
		27821			4952	0.987	76.000	95.200
		22632	BYRAM TOWNSHIP BD OF ED		8211	-	0.150	0.190
		21105	ARTHUR STANLICK SCHOOL		8211	0.004	0.069	0.035
		21156	CONSOLIDATED SCHOOL		8211	0.090	0.110	0.088
		26239	OUR LADY OF LAKE REG SCHOOL		8661	0.001	0.009	0.026
Musconetcong River at Riegelsville	01457400	4928	&M/MARS - DIV OF MARS INC		2065	0.040	24.382	14.262
		4421	RIEGEL PRODUCTS CORPORATION	*	2621	0.295	12.282	7.816
		4448	WARREN GLEN MILL		2621	2.140	634.315	607.536
		32247	--		2819	0.007	-	0.660
		4812	AMERACE-ESNA CORP.		3069	0.096	-	0.036
		28657	P PERFORMANCE POLYMERS INC		3079	0.549	-	7.095
		31208	ASBURY GRAPHITE MILLS INC		3295	0.050	4.885	6.304
		4600	US MINERAL PRODUCTS		3296	0.062	-	1.248
		26212	MT ARLINGTON SANITATION CORP		4952	0.020	1.610	1.433
		28592	DIAMOND HILL ESTATES SEWAGE CO		4952	0.100	8.700	7.850
		27821	--		4952	0.987	76.000	95.200
		21369	HACKETTSTOWN MUA		4952	1.535	65.870	57.710
		23094	GARDEN STATE TRUCK PLAZA		5541	0.044	0.610	1.990
		22632	BYRAM TOWNSHIP BD OF ED		8211	-	0.150	0.190
		21105	ARTHUR STANLICK SCHOOL		8211	0.004	0.069	0.035
		21156	CONSOLIDATED SCHOOL		8211	0.090	0.110	0.088
		26239	OUR LADY OF LAKE REG SCHOOL		8661	0.001	0.009	0.026
Wickechcoke Creek at Stockton	01461300	27537	MAGNESIUM ELEKTRON INC		2819	0.188	-	0.802
		27561	DELAWARE TOWNSHIP MUA	*	4952	0.036	2.200	3.300
Crosswicks Creek at Extonville	01464500	22985	WRIGHTSTOWN MUA		4952	0.143	4.600	7.600
		27464	HANOVER MOBILE VILLAGE		6515	0.008	0.780	0.950
		27511	CALIFORNIA VILLA MOBILE		6515	0.015	0.100	0.100
		21407	PLUMSTEAD TWP SCHOOL DIST.		8211	0.002	0.180	0.275
		22578	CGUIRE AFB WRIGHTSTOWN		9711	1.240	99.715	82.800
		4855	U.S. ARMY FT. DIX & TRNG. CNTR		9711	2.693	212.570	250.460

Table 10. Permitted effluent discharges and effluent quantity and quality in the New Jersey drainage basins studied, 1986--Continued

Drainage basin: Monitoring-station name	Drainage basin: Monitoring-station number	NJPDES permit number	Name of permitted wastewater discharge	Within area 3.1 miles upstream	Effluent quantity and quality: SIC number	Effluent quantity and quality: Discharge (Mgal/d)	Effluent quantity and quality: BOD (kg/d)	Effluent quantity and quality: TSS (kg/d)
Doctors Creek at Allentown	01464515	20206	ALLENTOWN WTP	*	4952	0.184	14.750	17.750
SB Rancocus Creek at Vincentown	01465850	33367	STOKES OF VINCENTOWN INC	*	2033	0.018	1.360	1.190
		23736	SOUTHAMPTON SEWERAGE CO	*	4952	0.251	9.190	4.900
		21768	NEW LISBON STATE SCHOOL		8211	0.106	7.950	5.400
NB Pennsauken Creek near Moorestown	01467069	23981	MOUNT LAUREL MUA	*	4952	0.565	22.800	32.300
SB Pennsauken Creek at Cherry Hill	01467081	31879	MAPLE SHADE TOWNSHIP OF	*	4941	-	-	0.187
		24040	WOODSTREAM STP		4952	0.888	40.100	12.050
		63975	--		5541	-	-	0.006
Cooper River at Lawnside	01467140	3999	HUSSMANN REFRIGERATOR CO	*	2542	0.021	-	0.695
		20621	LAWNSIDE BOROUGH OF	*	4952	0.273	42.000	38.000
		25119	CHERRY HILL TOWNSHIP	*	4952	0.372	27.000	17.000
		21652	SOMERDALE BOROUGH OF	*	4952	0.511	32.200	50.470
		25101	CHERRY HILL TOWNSHIP	*	4952	0.674	71.500	38.500
		22403	VOORHEES TOWNSHIP	*	4952	0.890	304.136	157.834
		26361	GIBBSBORO SEWAGE CORP		4952	0.134	11.000	9.250
		26409	LINDENWOLD BOROUGH MUA		4952	2.400	133.710	43.580
SB Big Timber Creek at Blackwood Terrace	01467329	29840	CAMDEN C'NTY SEWAGE TRETMT PLT	*	4952	0.003	0.010	0.020
Raccoon Creek near Swedesboro	01477120	20532	HARRISON TWP-MULLICA HILL STP	*	4952	0.125	1.800	4.000

Table 13. Road-salt application in Regions I-IV in New Jersey by winter season, 1975-76 through 1986-87

[All data are tons applied. Source: A.T. Woodrow, New Jersey Department of Transportation, written commun., 1989]

Region[1] and winter season	Sodium chloride	Calcium chloride in solution	Calcium chloride bulk (dry)	Sodium chloride/ calcium chloride premix
Region 1				
1975-76	14,367	0	2,682	0
1976-77	4,722	0	1,026	9,106
1977-78	10,738	0	1,678	12,150
1978-79	8,129	0	1,123	12,199
1979-80	1,686	0	187	9,318
1980-81	5,008	0	555	11,416
1981-82	29,015	154,994	613	3,181
1982-83	18,365	115,193	62	0
1983-84	34,983	239,278	642	0
1984-85	29,161	188,226	188	0
1985-86	34,819	242,995	82	0
1986-87	38,753	237,680	2	0
Region 2				
1975-76	8,278	0	1,570	0
1976-77	4,310	0	682	0
1977-78	7,149	5,553	1,170	5,553
1978-79	6,071	4,898	882	4,898
1979-80	1,889	4,370	345	4,370
1980-81	1,483	7,650	104	7,650
1981-82	11,705	61,990	234	3,655
1982-83	11,146	58,357	9	77
1983-84	18,983	131,506	0	0
1984-85	17,784	115,684	0	0
1985-86	19,807	114,050	0	0
1986-87	21,615	98,231	0	0

Table 13. Road-salt application in Regions I-IV in New Jersey by winter season, 1975-76 through 1986-87--Continued

[All data are tons applied. Source: A.T. Woodrow, New Jersey Department of Transportation, written commun., 1989]

Region[1] and winter season	Sodium chloride	Calcium chloride in solution	Calcium chloride bulk (dry)	Sodium chloride/ calcium chloride premix
Region 3				
1975-76	11,589	0	820	0
1976-77	4,175	0	94	6,676
1977-78	4,118	0	200	9,144
1978-79	1,500	0	0	9,871
1979-80	1,302	0	0	5,220
1980-81	1,952	0	5	6,656
1981-82	9,968	34,837	77	4,796
1982-83	7,056	43,028	8	452
1983-84	14,327	99,797	0	0
1984-85	10,992	81,849	288	0
1985-86	13,153	90,243	0	0
1986-87	21,164	126,830	0	0
Region 4				
1975-76	4,518	0	326	0
1976-77	1,811	0	93	4,102
1977-78	1,145	0	129	5,872
1978-79	839	0	81	6,600
1979-80	909	0	38	4,106
1980-81	1,286	0	3	2,971
1981-82	4,289	22,747	53	45
1982-83	3,800	26,472	514	0
1983-84	7,409	79,923	192	0
1984-85	9,147	82,417	0	0
1985-86	12,769	103,245	60	0
1986-87	15,867	128,040	0	0

[1] Regions described on page 34.

Table 14. Estimated road-salt application in the New Jersey drainage basins studied, in terms of chloride, sodium, and calcium by basin and winter season, 1975-76 through 1986-87

[Source: A.T. Woodrow, New Jersey Department of Transportation, written commun., 1989]

Drainage basin			Application rate, in tons per square mile		
Monitoring-station name	Monitoring-station number	Winter season	Chloride	Sodium	Calcium
Wallkill River at Franklin	01367700	1975-76	4.93	2.64	0.68
		1976-77	4.29	2.26	0.65
		1977-78	7.10	3.84	0.94
		1978-79	6.20	3.36	0.80
		1979-80	3.23	1.74	0.44
		1980-81	4.91	2.67	0.62
		1981-82	9.53	5.82	0.36
		1982-83	5.36	3.38	0.07
		1983-84	10.38	6.43	0.27
		1984-85	8.54	5.36	0.13
		1985-86	10.16	6.40	0.13
		1986-87	11.27	7.13	0.11
Wallkill River near Sussex	01367770	1975-76	4.93	2.64	0.68
		1976-77	4.29	2.26	0.65
		1977-78	7.10	3.84	0.94
		1978-79	6.20	3.36	0.80
		1979-80	3.23	1.74	0.44
		1980-81	4.91	2.67	0.62
		1981-82	9.53	5.82	0.36
		1982-83	5.36	3.38	0.07
		1983-84	10.38	6.43	0.27
		1984-85	8.54	5.36	0.13
		1985-86	10.16	6.40	0.13
		1986-87	11.27	7.13	0.11
Papakating Creek at Sussex	01367910	1975-76	4.93	2.64	0.68
		1976-77	4.29	2.26	0.65
		1977-78	7.10	3.84	0.94
		1978-79	6.20	3.36	0.80
		1979-80	3.23	1.74	0.44
		1980-81	4.91	2.67	0.62
		1981-82	9.53	5.82	0.36
		1982-83	5.36	3.38	0.07
		1983-84	10.38	6.43	0.27
		1984-85	8.54	5.36	0.13
		1985-86	10.16	6.40	0.13
		1986-87	11.27	7.13	0.11
Black Creek near Vernon	01368950	1975-76	4.93	2.64	0.68
		1976-77	4.29	2.26	0.65
		1977-78	7.10	3.84	0.94
		1978-79	6.20	3.36	0.80
		1979-80	3.23	1.74	0.44
		1980-81	4.91	2.67	0.62
		1981-82	9.53	5.82	0.36
		1982-83	5.36	3.38	0.07
		1983-84	10.38	6.43	0.27
		1984-85	8.54	5.36	0.13
		1985-86	10.16	6.40	0.13
		1986-87	11.27	7.13	0.11

Table 14. Estimated road-salt application in the New Jersey drainage basins studied, in terms of chloride, sodium, and calcium by basin and winter season, 1975-76 through 1986-87--Continued

[Source: A.T. Woodrow, New Jersey Department of Transportation, written commun., 1989]

Drainage basin			Application rate, in tons per square mile		
Monitoring-station name	Monitoring-station number	Winter season	Chloride	Sodium	Calcium
Passaic River near Millington	01379000	1975-76	4.93	2.64	0.68
		1976-77	4.29	2.26	0.65
		1977-78	7.10	3.84	0.94
		1978-79	6.20	3.36	0.80
		1979-80	3.23	1.74	0.44
		1980-81	4.91	2.67	0.62
		1981-82	9.53	5.82	0.36
		1982-83	5.36	3.38	0.07
		1983-84	10.38	6.43	0.27
		1984-85	8.54	5.36	0.13
		1985-86	10.16	6.40	0.13
		1986-87	11.27	7.13	0.11
Passaic River near Chatham	01379500	1975-76	5.24	2.81	0.73
		1976-77	4.63	2.45	0.68
		1977-78	7.52	4.07	1.00
		1978-79	6.55	3.56	0.84
		1979-80	3.45	1.85	0.48
		1980-81	5.17	2.81	0.66
		1981-82	9.86	6.01	0.39
		1982-83	5.74	3.62	0.07
		1983-84	10.90	6.78	0.26
		1984-85	9.15	5.75	0.13
		1985-86	10.78	6.79	0.13
		1986-87	11.92	7.54	0.11
Rockaway River at Pine Brook	01381200	1975-76	4.93	2.64	0.68
		1976-77	4.29	2.26	0.65
		1977-78	7.10	3.84	0.94
		1978-79	6.20	3.36	0.80
		1979-80	3.23	1.74	0.44
		1980-81	4.91	2.67	0.62
		1981-82	9.53	5.82	0.36
		1982-83	5.36	3.38	0.07
		1983-84	10.38	6.43	0.27
		1984-85	8.54	5.36	0.13
		1985-86	10.16	6.40	0.13
		1986-87	11.27	7.13	0.11
Whippany River at Morristown	01381500	1975-76	4.93	2.64	0.68
		1976-77	4.29	2.26	0.65
		1977-78	7.10	3.84	0.94
		1978-79	6.20	3.36	0.80
		1979-80	3.23	1.74	0.44
		1980-81	4.91	2.67	0.62
		1981-82	9.53	5.82	0.36
		1982-83	5.36	3.38	0.07
		1983-84	10.38	6.43	0.27
		1984-85	8.54	5.36	0.13
		1985-86	10.16	6.40	0.13
		1986-87	11.27	7.13	0.11

Table 14. Estimated road-salt application in the New Jersey drainage basins studied, in terms of chloride, sodium, and calcium by basin and winter season, 1975-76 through 1986-87--Continued

[Source: A.T. Woodrow, New Jersey Department of Transportation, written commun., 1989]

Drainage basin		Winter season	Application rate, in tons per square mile		
Monitoring-station name	Monitoring-station number		Chloride	Sodium	Calcium
Whippany River near Pine Brook	01381800	1975-76	4.93	2.64	0.68
		1976-77	4.29	2.26	0.65
		1977-78	7.10	3.84	0.94
		1978-79	6.20	3.36	0.80
		1979-80	3.23	1.74	0.44
		1980-81	4.91	2.67	0.62
		1981-82	9.53	5.82	0.36
		1982-83	5.36	3.38	0.07
		1983-84	10.38	6.43	0.27
		1984-85	8.54	5.36	0.13
		1985-86	10.16	6.40	0.13
		1986-87	11.27	7.13	0.11
Passaic River at Two Bridges	01382000	1975-76	5.58	2.99	0.78
		1976-77	4.99	2.65	0.73
		1977-78	7.99	4.32	1.06
		1978-79	6.93	3.77	0.89
		1979-80	3.69	1.98	0.51
		1980-81	5.46	2.97	0.70
		1981-82	10.23	6.22	0.43
		1982-83	6.17	3.89	0.07
		1983-84	11.49	7.16	0.25
		1984-85	9.82	6.18	0.13
		1985-86	11.45	7.22	0.13
		1986-87	12.63	7.99	0.11
Wanaque River at Wanaque	01387000	1975-76	8.16	4.36	1.14
		1976-77	7.72	4.17	1.02
		1977-78	11.49	6.21	1.53
		1978-79	9.81	5.35	1.24
		1979-80	5.47	2.91	0.78
		1980-81	7.65	4.14	1.00
		1981-82	12.97	7.77	0.69
		1982-83	9.34	5.91	0.09
		1983-84	15.84	10.00	0.17
		1984-85	14.83	9.37	0.15
		1985-86	16.49	10.44	0.15
		1986-87	17.96	11.39	0.12
Saddle River at Lodi	01391500	1975-76	8.16	4.36	1.14
		1976-77	7.72	4.17	1.02
		1977-78	11.49	6.21	1.53
		1978-79	9.81	5.35	1.24
		1979-80	5.47	2.91	0.78
		1980-81	7.65	4.14	1.00
		1981-82	12.97	7.77	0.69
		1982-83	9.34	5.91	0.09
		1983-84	15.84	10.00	0.17
		1984-85	14.83	9.37	0.15
		1985-86	16.49	10.44	0.15
		1986-87	17.96	11.39	0.12

Table 14. Estimated road-salt application in the New Jersey drainage basins studied, in terms of chloride, sodium, and calcium by basin and winter season, 1975-76 through 1986-87--Continued

[Source: A.T. Woodrow, New Jersey Department of Transportation, written commun., 1989]

Drainage basin			Application rate, in tons per square mile		
Monitoring-station name	Monitoring-station number	Winter season	Chloride	Sodium	Calcium
SB Raritan River at Middle Valley	01396280	1975-76	4.93	2.64	0.68
		1976-77	4.29	2.26	0.65
		1977-78	7.10	3.84	0.94
		1978-79	6.20	3.36	0.80
		1979-80	3.23	1.74	0.44
		1980-81	4.91	2.67	0.62
		1981-82	9.53	5.82	0.36
		1982-83	5.36	3.38	0.07
		1983-84	10.38	6.43	0.27
		1984-85	8.54	5.36	0.13
		1985-86	10.16	6.40	0.13
		1986-87	11.27	7.13	0.11
SB Raritan River at High Bridge	01396535	1975-76	4.93	2.64	0.68
		1976-77	4.29	2.26	0.65
		1977-78	7.10	3.84	0.94
		1978-79	6.20	3.36	0.80
		1979-80	3.23	1.74	0.44
		1980-81	4.91	2.67	0.62
		1981-82	9.53	5.82	0.36
		1982-83	5.36	3.38	0.07
		1983-84	10.38	6.43	0.27
		1984-85	8.54	5.36	0.13
		1985-86	10.16	6.40	0.13
		1986-87	11.27	7.13	0.11
Mulhockaway Creek at Van Syckel	01396660	1975-76	4.93	2.64	0.68
		1976-77	4.29	2.26	0.65
		1977-78	7.10	3.84	0.94
		1978-79	6.20	3.36	0.80
		1979-80	3.23	1.74	0.44
		1980-81	4.91	2.67	0.62
		1981-82	9.53	5.82	0.36
		1982-83	5.36	3.38	0.07
		1983-84	10.38	6.43	0.27
		1984-85	8.54	5.36	0.13
		1985-86	10.16	6.40	0.13
		1986-87	11.27	7.13	0.11
SB Raritan River at Three Bridges	01397400	1975-76	4.93	2.64	0.68
		1976-77	4.29	2.26	0.65
		1977-78	7.10	3.84	0.94
		1978-79	6.20	3.36	0.80
		1979-80	3.23	1.74	0.44
		1980-81	4.91	2.67	0.62
		1981-82	9.53	5.82	0.36
		1982-83	5.36	3.38	0.07
		1983-84	10.38	6.43	0.27
		1984-85	8.54	5.36	0.13
		1985-86	10.16	6.40	0.13
		1986-87	11.27	7.13	0.11

Table 14. Estimated road-salt application in the New Jersey drainage basins studied, in terms of chloride, sodium, and calcium by basin and winter season, 1975-76 through 1986-87--Continued

[Source: A.T. Woodrow, New Jersey Department of Transportation, written commun., 1989]

Drainage basin			Application rate, in tons per square mile		
Monitoring-station name	Monitoring-station number	Winter season	Chloride	Sodium	Calcium
NB Raritan River near Chester	01398260	1975-76	4.93	2.64	0.68
		1976-77	4.29	2.26	0.65
		1977-78	7.10	3.84	0.94
		1978-79	6.20	3.36	0.80
		1979-80	3.23	1.74	0.44
		1980-81	4.91	2.67	0.62
		1981-82	9.53	5.82	0.36
		1982-83	5.36	3.38	0.07
		1983-84	10.38	6.43	0.27
		1984-85	8.54	5.36	0.13
		1985-86	10.16	6.40	0.13
		1986-87	11.27	7.13	0.11
NB Raritan River at Burnt Mills	01399120	1975-76	4.93	2.64	0.68
		1976-77	4.29	2.26	0.65
		1977-78	7.10	3.84	0.94
		1978-79	6.20	3.36	0.80
		1979-80	3.23	1.74	0.44
		1980-81	4.91	2.67	0.62
		1981-82	9.53	5.82	0.36
		1982-83	5.36	3.38	0.07
		1983-84	10.38	6.43	0.27
		1984-85	8.54	5.36	0.13
		1985-86	10.16	6.40	0.13
		1986-87	11.27	7.13	0.11
Rockaway Creek at Whitehouse	01399700	1975-76	4.93	2.64	0.68
		1976-77	4.29	2.26	0.65
		1977-78	7.10	3.84	0.94
		1978-79	6.20	3.36	0.80
		1979-80	3.23	1.74	0.44
		1980-81	4.91	2.67	0.62
		1981-82	9.53	5.82	0.36
		1982-83	5.36	3.38	0.07
		1983-84	10.38	6.43	0.27
		1984-85	8.54	5.36	0.13
		1985-86	10.16	6.40	0.13
		1986-87	11.27	7.13	0.11
Lamington River at Burnt Mills	01399780	1975-76	4.93	2.64	0.68
		1976-77	4.29	2.26	0.65
		1977-78	7.10	3.84	0.94
		1978-79	6.20	3.36	0.80
		1979-80	3.23	1.74	0.44
		1980-81	4.91	2.67	0.62
		1981-82	9.53	5.82	0.36
		1982-83	5.36	3.38	0.07
		1983-84	10.38	6.43	0.27
		1984-85	8.54	5.36	0.13
		1985-86	10.16	6.40	0.13
		1986-87	11.27	7.13	0.11

Table 14. Estimated road-salt application in the New Jersey drainage basins studied, in terms of chloride, sodium, and calcium by basin and winter season, 1975-76 through 1986-87--Continued

[Source: A.T. Woodrow, New Jersey Department of Transportation, written commun., 1989]

Drainage basin			Application rate, in tons per square mile		
Monitoring-station name	Monitoring-station number	Winter season	Chloride	Sodium	Calcium
Raritan River at Manville	01400500	1975-76	4.93	2.64	0.68
		1976-77	4.29	2.26	0.65
		1977-78	7.10	3.84	0.94
		1978-79	6.20	3.36	0.80
		1979-80	3.23	1.74	0.44
		1980-81	4.91	2.67	0.62
		1981-82	9.53	5.82	0.36
		1982-83	5.36	3.38	0.07
		1983-84	10.38	6.43	0.27
		1984-85	8.54	5.36	0.13
		1985-86	10.16	6.40	0.13
		1986-87	11.27	7.13	0.11
Millstone River at Grovers Mill	01400650	1975-76	4.23	2.52	0.25
		1976-77	3.73	2.12	0.36
		1977-78	4.60	2.55	0.52
		1978-79	3.88	2.11	0.49
		1979-80	2.23	1.23	0.26
		1980-81	2.94	1.63	0.33
		1981-82	5.04	3.01	0.28
		1982-83	2.58	1.62	0.05
		1983-84	4.93	3.12	0.05
		1984-85	3.89	2.39	0.13
		1985-86	4.53	2.86	0.05
		1986-87	7.43	4.70	0.07
Millstone River at Kingston	01401440	1975-76	4.26	2.53	0.27
		1976-77	3.76	2.12	0.38
		1977-78	4.71	2.61	0.54
		1978-79	3.99	2.17	0.51
		1979-80	2.27	1.25	0.27
		1980-81	3.03	1.68	0.35
		1981-82	5.25	3.14	0.28
		1982-83	2.71	1.70	0.05
		1983-84	5.18	3.27	0.06
		1984-85	4.10	2.53	0.13
		1985-86	4.79	3.02	0.05
		1986-87	7.60	4.81	0.07
Beden Brook near Rocky Hill	01401600	1975-76	4.70	2.60	0.54
		1976-77	4.11	2.21	0.55
		1977-78	6.27	3.41	0.80
		1978-79	5.43	2.95	0.70
		1979-80	2.90	1.57	0.38
		1980-81	4.26	2.33	0.53
		1981-82	8.05	4.90	0.33
		1982-83	4.44	2.80	0.06
		1983-84	8.58	5.34	0.20
		1984-85	7.01	4.38	0.13
		1985-86	8.31	5.23	0.10
		1986-87	10.00	6.32	0.09

Table 14. Estimated road-salt application in the New Jersey drainage basins studied, in terms of chloride, sodium, and calcium by basin and winter season, 1975-76 through 1986-87--Continued

[Source: A.T. Woodrow, New Jersey Department of Transportation, written commun., 1989]

Drainage basin			Application rate, in tons per square mile		
Monitoring-station name	Monitoring-station number	Winter season	Chloride	Sodium	Calcium
Millstone River at Weston	01402540	1975-76	4.43	2.56	0.37
		1976-77	3.90	2.16	0.45
		1977-78	5.33	2.93	0.64
		1978-79	4.56	2.48	0.59
		1979-80	2.52	1.38	0.31
		1980-81	3.51	1.93	0.42
		1981-82	6.35	3.83	0.31
		1982-83	3.39	2.13	0.05
		1983-84	6.52	4.08	0.12
		1984-85	5.24	3.26	0.13
		1985-86	6.17	3.89	0.07
		1986-87	8.55	5.41	0.08
Manalapan Brook at Federal Rd near Manalapan	01405340	1975-76	4.23	2.52	0.25
		1976-77	3.73	2.12	0.36
		1977-78	4.60	2.55	0.52
		1978-79	3.88	2.11	0.49
		1979-80	2.23	1.23	0.26
		1980-81	2.94	1.63	0.33
		1981-82	5.04	3.01	0.28
		1982-83	2.58	1.62	0.05
		1983-84	4.93	3.12	0.05
		1984-85	3.89	2.39	0.13
		1985-86	4.53	2.86	0.05
		1986-87	7.43	4.70	0.07
Shark River near Neptune City	01407705	1975-76	4.23	2.52	0.25
		1976-77	3.73	2.12	0.36
		1977-78	4.60	2.55	0.52
		1978-79	3.88	2.11	0.49
		1979-80	2.23	1.23	0.26
		1980-81	2.94	1.63	0.33
		1981-82	5.04	3.01	0.28
		1982-83	2.58	1.62	0.05
		1983-84	4.93	3.12	0.05
		1984-85	3.89	2.39	0.13
		1985-86	4.53	2.86	0.05
		1986-87	7.43	4.70	0.07
Jumping Brook near Neptune City	01407760	1975-76	4.23	2.52	0.25
		1976-77	3.73	2.12	0.36
		1977-78	4.60	2.55	0.52
		1978-79	3.88	2.11	0.49
		1979-80	2.23	1.23	0.26
		1980-81	2.94	1.63	0.33
		1981-82	5.04	3.01	0.28
		1982-83	2.58	1.62	0.05
		1983-84	4.93	3.12	0.05
		1984-85	3.89	2.39	0.13
		1985-86	4.53	2.86	0.05
		1986-87	7.43	4.70	0.07

Table 14. Estimated road-salt application in the New Jersey drainage basins studied, in terms of chloride, sodium, and calcium by basin and winter season, 1975-76 through 1986-87--Continued

[Source: A.T. Woodrow, New Jersey Department of Transportation, written commun., 1989]

Drainage basin			Application rate, in tons per square mile		
Monitoring-station name	Monitoring-station number	Winter season	Chloride	Sodium	Calcium
Marsh Bog Brook at Squankum	01407997	1975-76	4.23	2.52	0.25
		1976-77	3.73	2.12	0.36
		1977-78	4.60	2.55	0.52
		1978-79	3.88	2.11	0.49
		1979-80	2.23	1.23	0.26
		1980-81	2.94	1.63	0.33
		1981-82	5.04	3.01	0.28
		1982-83	2.58	1.62	0.05
		1983-84	4.93	3.12	0.05
		1984-85	3.89	2.39	0.13
		1985-86	4.53	2.86	0.05
		1986-87	7.43	4.70	0.07
Toms River near Toms River	01408500	1975-76	4.23	2.52	0.25
		1976-77	3.73	2.12	0.36
		1977-78	4.60	2.55	0.52
		1978-79	3.88	2.11	0.49
		1979-80	2.23	1.23	0.26
		1980-81	2.94	1.63	0.33
		1981-82	5.04	3.01	0.28
		1982-83	2.58	1.62	0.05
		1983-84	4.93	3.12	0.05
		1984-85	3.89	2.39	0.13
		1985-86	4.53	2.86	0.05
		1986-87	7.43	4.70	0.07
Mullica River at outlet of Atsion Lake at Atsion	01409387	1975-76	0.95	0.56	0.06
		1976-77	1.18	0.65	0.13
		1977-78	1.40	0.75	0.19
		1978-79	1.47	0.79	0.20
		1979-80	0.99	0.54	0.12
		1980-81	0.82	0.46	0.09
		1981-82	1.44	0.84	0.10
		1982-83	0.86	0.48	0.10
		1983-84	1.51	0.92	0.06
		1984-85	1.81	1.14	0.03
		1985-86	2.54	1.59	0.04
		1986-87	3.14	1.98	0.04
Hammonton Creek at Westcoatville	01409416	1975-76	0.95	0.56	0.06
		1976-77	1.18	0.65	0.13
		1977-78	1.40	0.75	0.19
		1978-79	1.47	0.79	0.20
		1979-80	0.99	0.54	0.12
		1980-81	0.82	0.46	0.09
		1981-82	1.44	0.84	0.10
		1982-83	0.86	0.48	0.10
		1983-84	1.51	0.92	0.06
		1984-85	1.81	1.14	0.03
		1985-86	2.54	1.59	0.04
		1986-87	3.14	1.98	0.04

Table 14. Estimated road-salt application in the New Jersey drainage basins studied, in terms of chloride, sodium, and calcium by basin and winter season, 1975-76 through 1986-87--Continued

[Source: A.T. Woodrow, New Jersey Department of Transportation, written commun., 1989]

Drainage basin			Application rate, in tons per square mile		
Monitoring-station name	Monitoring-station number	Winter season	Chloride	Sodium	Calcium
Batsto River at Batsto	01409500	1975-76	0.95	0.56	0.06
		1976-77	1.18	0.65	0.13
		1977-78	1.40	0.75	0.19
		1978-79	1.47	0.79	0.20
		1979-80	0.99	0.54	0.12
		1980-81	0.82	0.46	0.09
		1981-82	1.44	0.84	0.10
		1982-83	0.86	0.48	0.10
		1983-84	1.51	0.92	0.06
		1984-85	1.81	1.14	0.03
		1985-86	2.54	1.59	0.04
		1986-87	3.14	1.98	0.04
West Branch Wading River at Maxwell	01409815	1975-76	0.96	0.57	0.06
		1976-77	1.19	0.66	0.13
		1977-78	1.41	0.76	0.19
		1978-79	1.48	0.80	0.20
		1979-80	0.99	0.54	0.12
		1980-81	0.83	0.47	0.09
		1981-82	1.45	0.85	0.10
		1982-83	0.87	0.48	0.10
		1983-84	1.53	0.93	0.06
		1984-85	1.82	1.14	0.03
		1985-86	2.55	1.60	0.04
		1986-87	3.16	1.99	0.04
Oswego River at Harrisville	01410000	1975-76	2.21	1.32	0.13
		1976-77	2.17	1.22	0.22
		1977-78	2.64	1.45	0.32
		1978-79	2.41	1.30	0.32
		1979-80	1.47	0.81	0.18
		1980-81	1.64	0.91	0.18
		1981-82	2.83	1.68	0.17
		1982-83	1.53	0.92	0.08
		1983-84	2.83	1.77	0.05
		1984-85	2.62	1.62	0.06
		1985-86	3.31	2.08	0.04
		1986-87	4.80	3.03	0.05
East Branch Bass River near New Gretna	01410150	1975-76	1.14	0.68	0.07
		1976-77	1.33	0.74	0.15
		1977-78	1.59	0.86	0.21
		1978-79	1.61	0.87	0.22
		1979-80	1.06	0.58	0.13
		1980-81	0.95	0.53	0.10
		1981-82	1.65	0.97	0.11
		1982-83	0.96	0.54	0.10
		1983-84	1.71	1.05	0.06
		1984-85	1.93	1.21	0.03
		1985-86	2.65	1.67	0.04
		1986-87	3.39	2.14	0.04

Table 14. Estimated road-salt application in the New Jersey drainage basins studied, in terms of chloride, sodium, and calcium by basin and winter season, 1975-76 through 1986-87--Continued

[Source: A.T. Woodrow, New Jersey Department of Transportation, written commun., 1989]

Drainage basin			Application rate, in tons per square mile		
Monitoring-station name	Monitoring-station number	Winter season	Chloride	Sodium	Calcium
Great Egg Harbor near Sicklerville	01410784	1975-76	0.95	0.56	0.06
		1976-77	1.18	0.65	0.13
		1977-78	1.40	0.75	0.19
		1978-79	1.47	0.79	0.20
		1979-80	0.99	0.54	0.12
		1980-81	0.82	0.46	0.09
		1981-82	1.44	0.84	0.10
		1982-83	0.86	0.48	0.10
		1983-84	1.51	0.92	0.06
		1984-85	1.81	1.14	0.03
		1985-86	2.54	1.59	0.04
		1986-87	3.14	1.98	0.04
Great Egg Harbor near Blue Anchor	01410820	1975-76	0.95	0.56	0.06
		1976-77	1.18	0.65	0.13
		1977-78	1.40	0.75	0.19
		1978-79	1.47	0.79	0.20
		1979-80	0.99	0.54	0.12
		1980-81	0.82	0.46	0.09
		1981-82	1.44	0.84	0.10
		1982-83	0.86	0.48	0.10
		1983-84	1.51	0.92	0.06
		1984-85	1.81	1.14	0.03
		1985-86	2.54	1.59	0.04
		1986-87	3.14	1.98	0.04
Great Egg Harbor at Weymouth	01411110	1975-76	0.95	0.56	0.06
		1976-77	1.18	0.65	0.13
		1977-78	1.40	0.75	0.19
		1978-79	1.47	0.79	0.20
		1979-80	0.99	0.54	0.12
		1980-81	0.82	0.46	0.09
		1981-82	1.44	0.84	0.10
		1982-83	0.86	0.48	0.10
		1983-84	1.51	0.92	0.06
		1984-85	1.81	1.14	0.03
		1985-86	2.54	1.59	0.04
		1986-87	3.14	1.98	0.04
Maurice River at Norma	01411500	1975-76	0.95	0.56	0.06
		1976-77	1.18	0.65	0.13
		1977-78	1.40	0.75	0.19
		1978-79	1.47	0.79	0.20
		1979-80	0.99	0.54	0.12
		1980-81	0.82	0.46	0.09
		1981-82	1.44	0.84	0.10
		1982-83	0.86	0.48	0.10
		1983-84	1.51	0.92	0.06
		1984-85	1.81	1.14	0.03
		1985-86	2.54	1.59	0.04
		1986-87	3.14	1.98	0.04

Table 14. Estimated road-salt application in the New Jersey drainage basins studied, in terms of chloride, sodium, and calcium by basin and winter season, 1975-76 through 1986-87--Continued

[Source: A.T. Woodrow, New Jersey Department of Transportation, written commun., 1989]

Drainage basin			Application rate, in tons per square mile		
Monitoring-station name	Monitoring-station number	Winter season	Chloride	Sodium	Calcium
Cohansey River at Seeley	01412800	1975-76	0.95	0.56	0.06
		1976-77	1.18	0.65	0.13
		1977-78	1.40	0.75	0.19
		1978-79	1.47	0.79	0.20
		1979-80	0.99	0.54	0.12
		1980-81	0.82	0.46	0.09
		1981-82	1.44	0.84	0.10
		1982-83	0.86	0.48	0.10
		1983-84	1.51	0.92	0.06
		1984-85	1.81	1.14	0.03
		1985-86	2.54	1.59	0.04
		1986-87	3.14	1.98	0.04
Paulins Kill at Blairstown	01443500	1975-76	4.93	2.64	0.68
		1976-77	4.29	2.26	0.65
		1977-78	7.10	3.84	0.94
		1978-79	6.20	3.36	0.80
		1979-80	3.23	1.74	0.44
		1980-81	4.91	2.67	0.62
		1981-82	9.53	5.82	0.36
		1982-83	5.36	3.38	0.07
		1983-84	10.38	6.43	0.27
		1984-85	8.54	5.36	0.13
		1985-86	10.16	6.40	0.13
		1986-87	11.27	7.13	0.11
Musconetcong River Outlet of Lake Hopatcong	01455500	1975-76	4.93	2.64	0.68
		1976-77	4.29	2.26	0.65
		1977-78	7.10	3.84	0.94
		1978-79	6.20	3.36	0.80
		1979-80	3.23	1.74	0.44
		1980-81	4.91	2.67	0.62
		1981-82	9.53	5.82	0.36
		1982-83	5.36	3.38	0.07
		1983-84	10.38	6.43	0.27
		1984-85	8.54	5.36	0.13
		1985-86	10.16	6.40	0.13
		1986-87	11.27	7.13	0.11
Musconetcong River at Beattystown	01456200	1975-76	4.93	2.64	0.68
		1976-77	4.29	2.26	0.65
		1977-78	7.10	3.84	0.94
		1978-79	6.20	3.36	0.80
		1979-80	3.23	1.74	0.44
		1980-81	4.91	2.67	0.62
		1981-82	9.53	5.82	0.36
		1982-83	5.36	3.38	0.07
		1983-84	10.38	6.43	0.27
		1984-85	8.54	5.36	0.13
		1985-86	10.16	6.40	0.13
		1986-87	11.27	7.13	0.11

Table 14. Estimated road-salt application in the New Jersey drainage basins studied, in terms of chloride, sodium, and calcium by basin and winter season, 1975-76 through 1986-87--Continued

[Source: A.T. Woodrow, New Jersey Department of Transportation, written commun., 1989]

Drainage basin			Application rate, in tons per square mile		
Monitoring-station name	Monitoring-station number	Winter season	Chloride	Sodium	Calcium
Musconetcong River at Riegelsville	01457400	1975-76	4.93	2.64	0.68
		1976-77	4.29	2.26	0.65
		1977-78	7.10	3.84	0.94
		1978-79	6.20	3.36	0.80
		1979-80	3.23	1.74	0.44
		1980-81	4.91	2.67	0.62
		1981-82	9.53	5.82	0.36
		1982-83	5.36	3.38	0.07
		1983-84	10.38	6.43	0.27
		1984-85	8.54	5.36	0.13
		1985-86	10.16	6.40	0.13
		1986-87	11.27	7.13	0.11
Wickechcoke Creek at Stockton	01461300	1975-76	4.93	2.64	0.68
		1976-77	4.29	2.26	0.65
		1977-78	7.10	3.84	0.94
		1978-79	6.20	3.36	0.80
		1979-80	3.23	1.74	0.44
		1980-81	4.91	2.67	0.62
		1981-82	9.53	5.82	0.36
		1982-83	5.36	3.38	0.07
		1983-84	10.38	6.43	0.27
		1984-85	8.54	5.36	0.13
		1985-86	10.16	6.40	0.13
		1986-87	11.27	7.13	0.11
Crosswicks Creek at Extonville	01464500	1975-76	3.20	1.91	0.19
		1976-77	2.94	1.66	0.29
		1977-78	3.60	1.99	0.42
		1978-79	3.13	1.70	0.40
		1979-80	1.84	1.02	0.22
		1980-81	2.28	1.27	0.26
		1981-82	3.92	2.34	0.23
		1982-83	2.05	1.26	0.06
		1983-84	3.87	2.43	0.05
		1984-85	3.24	2.00	0.10
		1985-86	3.91	2.47	0.05
		1986-87	6.09	3.85	0.06
Doctors Creek at Allentown	01464515	1975-76	4.23	2.52	0.25
		1976-77	3.73	2.12	0.36
		1977-78	4.60	2.55	0.52
		1978-79	3.88	2.11	0.49
		1979-80	2.23	1.23	0.26
		1980-81	2.94	1.63	0.33
		1981-82	5.04	3.01	0.28
		1982-83	2.58	1.62	0.05
		1983-84	4.93	3.12	0.05
		1984-85	3.89	2.39	0.13
		1985-86	4.53	2.86	0.05
		1986-87	7.43	4.70	0.07

Table 14. Estimated road-salt application in the New Jersey drainage basins studied, in terms of chloride, sodium, and calcium by basin and winter season, 1975-76 through 1986-87--Continued

[Source: A.T. Woodrow, New Jersey Department of Transportation, written commun., 1989]

Drainage basin			Application rate, in tons per square mile		
Monitoring-station name	Monitoring-station number	Winter season	Chloride	Sodium	Calcium
SB Rancocas Creek at Vincentown	01465850	1975-76	0.95	0.56	0.06
		1976-77	1.18	0.65	0.13
		1977-78	1.40	0.75	0.19
		1978-79	1.47	0.79	0.20
		1979-80	0.99	0.54	0.12
		1980-81	0.82	0.46	0.09
		1981-82	1.44	0.84	0.10
		1982-83	0.86	0.48	0.10
		1983-84	1.51	0.92	0.06
		1984-85	1.81	1.14	0.03
		1985-86	2.54	1.59	0.04
		1986-87	3.14	1.98	0.04
NB Rancocas Creek at Browns Mills	01465970	1975-76	2.25	1.34	0.13
		1976-77	2.19	1.23	0.23
		1977-78	2.67	1.47	0.32
		1978-79	2.43	1.32	0.32
		1979-80	1.48	0.81	0.18
		1980-81	1.67	0.93	0.18
		1981-82	2.87	1.71	0.17
		1982-83	1.55	0.93	0.08
		1983-84	2.87	1.79	0.05
		1984-85	2.64	1.64	0.07
		1985-86	3.33	2.10	0.04
		1986-87	4.84	3.06	0.05
McDonalds Branch in Lebanon State Forest	01466500	1975-76	0.95	0.56	0.06
		1976-77	1.18	0.65	0.13
		1977-78	1.40	0.75	0.19
		1978-79	1.47	0.79	0.20
		1979-80	0.99	0.54	0.12
		1980-81	0.82	0.46	0.09
		1981-82	1.44	0.84	0.10
		1982-83	0.86	0.48	0.10
		1983-84	1.51	0.92	0.06
		1984-85	1.81	1.14	0.03
		1985-86	2.54	1.59	0.04
		1986-87	3.14	1.98	0.04
NB Rancocas Creek at Browns Mills	01467000	1975-76	2.14	1.28	0.13
		1976-77	2.11	1.19	0.22
		1977-78	2.56	1.41	0.31
		1978-79	2.35	1.27	0.31
		1979-80	1.44	0.79	0.17
		1980-81	1.60	0.89	0.18
		1981-82	2.75	1.63	0.17
		1982-83	1.49	0.89	0.08
		1983-84	2.76	1.72	0.05
		1984-85	2.57	1.60	0.06
		1985-86	3.26	2.05	0.04
		1986-87	4.70	2.97	0.05

Table 14. Estimated road-salt application in the New Jersey drainage basins studied, in terms of chloride, sodium, and calcium by basin and winter season, 1975-76 through 1986-87--Continued

[Source: A.T. Woodrow, New Jersey Department of Transportation, written commun., 1989]

Drainage basin			Application rate, in tons per square mile		
Monitoring-station name	Monitoring-station number	Winter season	Chloride	Sodium	Calcium
NB Pennsauken Creek near Moorestown	01467069	1975-76	0.95	0.56	0.06
		1976-77	1.18	0.65	0.13
		1977-78	1.40	0.75	0.19
		1978-79	1.47	0.79	0.20
		1979-80	0.99	0.54	0.12
		1980-81	0.82	0.46	0.09
		1981-82	1.44	0.84	0.10
		1982-83	0.86	0.48	0.10
		1983-84	1.51	0.92	0.06
		1984-85	1.81	1.14	0.03
		1985-86	2.54	1.59	0.04
		1986-87	3.14	1.98	0.04
SB Pennsauken Creek at Cherry Hill	01467081	1975-76	0.95	0.56	0.06
		1976-77	1.18	0.65	0.13
		1977-78	1.40	0.75	0.19
		1978-79	1.47	0.79	0.20
		1979-80	0.99	0.54	0.12
		1980-81	0.82	0.46	0.09
		1981-82	1.44	0.84	0.10
		1982-83	0.86	0.48	0.10
		1983-84	1.51	0.92	0.06
		1984-85	1.81	1.14	0.03
		1985-86	2.54	1.59	0.04
		1986-87	3.14	1.98	0.04
Cooper River at Norcross Rd at Lindenwold	01467120	1975-76	0.95	0.56	0.06
		1976-77	1.18	0.65	0.13
		1977-78	1.40	0.75	0.19
		1978-79	1.47	0.79	0.20
		1979-80	0.99	0.54	0.12
		1980-81	0.82	0.46	0.09
		1981-82	1.44	0.84	0.10
		1982-83	0.86	0.48	0.10
		1983-84	1.51	0.92	0.06
		1984-85	1.81	1.14	0.03
		1985-86	2.54	1.59	0.04
		1986-87	3.14	1.98	0.04
Cooper River at Lawnside	01467140	1975-76	0.95	0.56	0.06
		1976-77	1.18	0.65	0.13
		1977-78	1.40	0.75	0.19
		1978-79	1.47	0.79	0.20
		1979-80	0.99	0.54	0.12
		1980-81	0.82	0.46	0.09
		1981-82	1.44	0.84	0.10
		1982-83	0.86	0.48	0.10
		1983-84	1.51	0.92	0.06
		1984-85	1.81	1.14	0.03
		1985-86	2.54	1.59	0.04
		1986-87	3.14	1.98	0.04

Table 14. Estimated road-salt application in the New Jersey drainage basins studied, in terms of chloride, sodium, and calcium by basin and winter season, 1975-76 through 1986-87--Continued

[Source: A.T. Woodrow, New Jersey Department of Transportation, written commun., 1989]

Drainage basin			Application rate, in tons per square mile		
Monitoring-station name	Monitoring-station number	Winter season	Chloride	Sodium	Calcium
SB Big Timber Creek at Blackwood Terrace	01467329	1975-76	0.95	0.56	0.06
		1976-77	1.18	0.65	0.13
		1977-78	1.40	0.75	0.19
		1978-79	1.47	0.79	0.20
		1979-80	0.99	0.54	0.12
		1980-81	0.82	0.46	0.09
		1981-82	1.44	0.84	0.10
		1982-83	0.86	0.48	0.10
		1983-84	1.51	0.92	0.06
		1984-85	1.81	1.14	0.03
		1985-86	2.54	1.59	0.04
		1986-87	3.14	1.98	0.04
Raccoon Creek near Swedesboro	01477120	1975-76	0.95	0.56	0.06
		1976-77	1.18	0.65	0.13
		1977-78	1.40	0.75	0.19
		1978-79	1.47	0.79	0.20
		1979-80	0.99	0.54	0.12
		1980-81	0.82	0.46	0.09
		1981-82	1.44	0.84	0.10
		1982-83	0.86	0.48	0.10
		1983-84	1.51	0.92	0.06
		1984-85	1.81	1.14	0.03
		1985-86	2.54	1.59	0.04
		1986-87	3.14	1.98	0.04
Oldmans Creek at Porches Mill	01477510	1975-76	0.95	0.56	0.06
		1976-77	1.18	0.65	0.13
		1977-78	1.40	0.75	0.19
		1978-79	1.47	0.79	0.20
		1979-80	0.99	0.54	0.12
		1980-81	0.82	0.46	0.09
		1981-82	1.44	0.84	0.10
		1982-83	0.86	0.48	0.10
		1983-84	1.51	0.92	0.06
		1984-85	1.81	1.14	0.03
		1985-86	2.54	1.59	0.04
		1986-87	3.14	1.98	0.04
Salem River at Woodstown	01482500	1975-76	0.95	0.56	0.06
		1976-77	1.18	0.65	0.13
		1977-78	1.40	0.75	0.19
		1978-79	1.47	0.79	0.20
		1979-80	0.99	0.54	0.12
		1980-81	0.82	0.46	0.09
		1981-82	1.44	0.84	0.10
		1982-83	0.86	0.48	0.10
		1983-84	1.51	0.92	0.06
		1984-85	1.81	1.14	0.03
		1985-86	2.54	1.59	0.04
		1986-87	3.14	1.98	0.04

Table 16. Estimated application of phosphorus and nitrogen fertilizer in the New Jersey drainage basins studied, 1975-85

[Based on data supplied by R.B. Alexander, U.S. Geological Survey, written commun., 1989]

Drainage basin			Fertilizer application rate, in tons per square mile	
Monitoring-station name	Monitoring-station number	Year	Phosphorus	Nitrogen
Wallkill River at Franklin	01367700	1975	1.42	1.75
		1976	1.40	1.80
		1977	1.53	1.75
		1978	1.25	1.65
		1979	1.34	1.78
		1980	1.32	1.78
		1981	1.27	1.90
		1982	1.29	1.91
		1983	1.07	1.49
		1984	1.34	1.95
		1985	1.29	2.08
Wallkill River near Sussex	01367770	1975	1.41	1.73
		1976	1.38	1.78
		1977	1.52	1.73
		1978	1.23	1.64
		1979	1.33	1.76
		1980	1.31	1.76
		1981	1.26	1.88
		1982	1.27	1.89
		1983	1.06	1.48
		1984	1.33	1.93
		1985	1.28	2.06
Papakating Creek at Sussex	01367910	1975	1.40	1.73
		1976	1.38	1.78
		1977	1.51	1.73
		1978	1.23	1.63
		1979	1.32	1.76
		1980	1.30	1.75
		1981	1.25	1.87
		1982	1.27	1.88
		1983	1.05	1.47
		1984	1.32	1.93
		1985	1.27	2.05
Black Creek near Vernon	01368950	1975	1.40	1.73
		1976	1.38	1.78
		1977	1.51	1.73
		1978	1.23	1.63
		1979	1.32	1.76
		1980	1.30	1.75
		1981	1.25	1.87
		1982	1.27	1.88
		1983	1.05	1.47
		1984	1.32	1.93
		1985	1.27	2.05

Table 16. Estimated application of phosphorus and nitrogen fertilizer in the New Jersey drainage basins studied, 1975-85--Continued

[Based on data supplied by R.B. Alexander, U.S. Geological Survey, written commun.,1989]

Drainage basin			Fertilizer application rate, in tons per square mile	
Monitoring-station name	Monitoring-station number	Year	Phosphorus	Nitrogen
Passaic River near Millington	01379000	1975	1.13	1.40
		1976	1.12	1.44
		1977	1.22	1.40
		1978	0.99	1.32
		1979	1.07	1.42
		1980	1.05	1.42
		1981	1.01	1.51
		1982	1.02	1.52
		1983	0.85	1.19
		1984	1.07	1.56
		1985	1.03	1.66
Passaic River near Chatham	01379500	1975	1.59	1.96
		1976	1.56	2.01
		1977	1.71	1.96
		1978	1.39	1.85
		1979	1.50	1.99
		1980	1.48	1.99
		1981	1.42	2.12
		1982	1.44	2.13
		1983	1.19	1.67
		1984	1.50	2.18
		1985	1.44	2.32
Rockaway River at Pine Brook	01381200	1975	0.75	0.93
		1976	0.74	0.96
		1977	0.81	0.93
		1978	0.66	0.88
		1979	0.71	0.95
		1980	0.70	0.94
		1981	0.67	1.01
		1982	0.68	1.01
		1983	0.57	0.79
		1984	0.71	1.04
		1985	0.69	1.10
Whippany River at Morristown	01381500	1975	0.72	0.89
		1976	0.71	0.91
		1977	0.77	0.88
		1978	0.63	0.84
		1979	0.68	0.90
		1980	0.67	0.90
		1981	0.64	0.96
		1982	0.65	0.96
		1983	0.54	0.75
		1984	0.68	0.99
		1985	0.65	1.05

Table 16. Estimated application of phosphorus and nitrogen fertilizer in the New Jersey drainage basins studied, 1975-85--Continued

[Based on data supplied by R.B. Alexander, U.S. Geological Survey, written commun.,1989]

Drainage basin			Fertilizer application rate, in tons per square mile	
Monitoring-station name	Monitoring-station number	Year	Phosphorus	Nitrogen
Whippany River near Pine Brook	01381800	1975	0.72	0.89
		1976	0.71	0.91
		1977	0.77	0.88
		1978	0.63	0.84
		1979	0.68	0.90
		1980	0.67	0.90
		1981	0.64	0.96
		1982	0.65	0.96
		1983	0.54	0.75
		1984	0.68	0.99
		1985	0.65	1.05
Passaic River at Two Bridges	01382000	1975	0.90	1.12
		1976	0.89	1.14
		1977	0.97	1.11
		1978	0.79	1.05
		1979	0.85	1.13
		1980	0.84	1.13
		1981	0.81	1.21
		1982	0.82	1.21
		1983	0.68	0.95
		1984	0.85	1.24
		1985	0.82	1.32
Wanaque River at Wanaque	01387000	1975	0.01	0.02
		1976	0.01	0.02
		1977	0.01	0.02
		1978	0.01	0.02
		1979	0.01	0.02
		1980	0.01	0.02
		1981	0.01	0.02
		1982	0.01	0.02
		1983	0.01	0.01
		1984	0.01	0.02
		1985	0.01	0.02
Saddle River at Lodi	01391500	1975	0.14	0.17
		1976	0.14	0.18
		1977	0.15	0.17
		1978	0.13	0.17
		1979	0.13	0.18
		1980	0.13	0.18
		1981	0.13	0.19
		1982	0.13	0.19
		1983	0.11	0.15
		1984	0.13	0.19
		1985	0.13	0.21

Table 16. Estimated application of phosphorus and nitrogen fertilizer in the New Jersey drainage basins studied, 1975-85--Continued

[Based on data supplied by R.B. Alexander, U.S. Geological Survey, written commun.,1989]

Drainage basin			Fertilizer application rate, in tons per square mile	
Monitoring-station name	Monitoring-station number	Year	Phosphorus	Nitrogen
SB Raritan River at Middle Valley	01396280	1975	0.72	0.89
		1976	0.71	0.91
		1977	0.77	0.88
		1978	0.63	0.84
		1979	0.68	0.90
		1980	0.67	0.90
		1981	0.64	0.96
		1982	0.65	0.96
		1983	0.54	0.75
		1984	0.68	0.99
		1985	0.65	1.05
SB Raritan Raritan River at High Bridge	01396535	1975	1.63	2.01
		1976	1.61	2.07
		1977	1.76	2.01
		1978	1.43	1.90
		1979	1.54	2.05
		1980	1.52	2.04
		1981	1.46	2.18
		1982	1.47	2.19
		1983	1.23	1.71
		1984	1.54	2.24
		1985.	1.48	2.39
Mulhockaway Creek at Van Syckel	01396660	1975	4.85	5.98
		1976	4.77	6.14
		1977	5.23	5.97
		1978	4.25	5.64
		1979	4.58	6.08
		1980	4.51	6.07
		1981	4.34	6.47
		1982	4.38	6.50
		1983	3.64	5.09
		1984	4.57	6.67
		1985	4.40	7.09
SB Raritan River at Three Bridges	01397400	1975	3.64	4.48
		1976	3.58	4.61
		1977	3.92	4.48
		1978	3.19	4.23
		1979	3.43	4.56
		1980	3.38	4.55
		1981	3.25	4.86
		1982	3.29	4.88
		1983	2.73	3.82
		1984	3.43	5.00
		1985	3.30	5.32

Table 16. Estimated application of phosphorus and nitrogen fertilizer in the New Jersey drainage basins studied, 1975-85--Continued

[Based on data supplied by R.B. Alexander, U.S. Geological Survey, written commun., 1989]

Drainage basin			Fertilizer application rate, in tons per square mile	
Monitoring-station name	Monitoring-station number	Year	Phosphorus	Nitrogen
NB Raritan River near Chester	01398260	1975	0.72	0.89
		1976	0.71	0.91
		1977	0.77	0.88
		1978	0.63	0.84
		1979	0.68	0.90
		1980	0.67	0.90
		1981	0.64	0.96
		1982	0.65	0.96
		1983	0.54	0.75
		1984	0.68	0.99
		1985	0.65	1.05
NB Raritan River at Burnt Mills	01399120	1975	2.08	2.57
		1976	2.05	2.64
		1977	2.24	2.56
		1978	1.83	2.42
		1979	1.97	2.61
		1980	1.94	2.61
		1981	1.86	2.78
		1982	1.88	2.79
		1983	1.56	2.19
		1984	1.96	2.86
		1985	1.89	3.05
Rockaway Creek at Whitehouse	01399700	1975	4.62	5.70
		1976	4.54	5.85
		1977	4.98	5.69
		1978	4.05	5.37
		1979	4.36	5.79
		1980	4.30	5.78
		1981	4.13	6.17
		1982	4.18	6.20
		1983	3.47	4.85
		1984	4.36	6.35
		1985	4.19	6.76
Lamington River at Burnt Mills	01399780	1975	3.07	3.78
		1976	3.02	3.88
		1977	3.31	3.78
		1978	2.69	3.57
		1979	2.89	3.84
		1980	2.85	3.84
		1981	2.74	4.09
		1982	2.77	4.11
		1983	2.30	3.22
		1984	2.89	4.22
		1985	2.78	4.48

Table 16. Estimated application of phosphorus and nitrogen fertilizer in the New Jersey drainage basins studied, 1975-85--Continued

[Based on data supplied by R.B. Alexander, U.S. Geological Survey, written commun.,1989]

Drainage basin			Fertilizer application rate, in tons per square mile	
Monitoring-station name	Monitoring-station number	Year	Phosphorus	Nitrogen
Raritan River at Manville	01400500	1975	3.46	4.27
		1976	3.41	4.39
		1977	3.73	4.27
		1978	3.04	4.03
		1979	3.27	4.34
		1980	3.22	4.34
		1981	3.10	4.63
		1982	3.13	4.65
		1983	2.60	3.64
		1984	3.27	4.76
		1985	3.14	5.07
Millstone River at Grovers Mill	01400650	1975	3.80	4.69
		1976	3.74	4.82
		1977	4.10	4.69
		1978	3.34	4.43
		1979	3.59	4.77
		1980	3.54	4.76
		1981	3.40	5.08
		1982	3.44	5.10
		1983	2.86	4.00
		1984	3.59	5.23
		1985	3.45	5.56
Millstone River at Kingston	01401440	1975	4.15	5.12
		1976	4.09	5.27
		1977	4.48	5.12
		1978	3.65	4.84
		1979	3.92	5.21
		1980	3.87	5.20
		1981	3.72	5.55
		1982	3.76	5.58
		1983	3.12	4.37
		1984	3.92	5.72
		1985	3.77	6.08
Beden Brook near Rocky Hill	01401600	1975	3.97	4.89
		1976	3.90	5.03
		1977	4.28	4.89
		1978	3.48	4.62
		1979	3.75	4.97
		1980	3.69	4.97
		1981	3.55	5.30
		1982	3.59	5.32
		1983	2.98	4.17
		1984	3.74	5.45
		1985	3.60	5.80

Table 16. Estimated application of phosphorus and nitrogen fertilizer in the New Jersey drainage basins studied, 1975-85--Continued

[Based on data supplied by R.B. Alexander, U.S. Geological Survey, written commun.,1989]

Drainage basin			Fertilizer application rate, in tons per square mile	
Monitoring-station name	Monitoring-station number	Year	Phosphorus	Nitrogen
Millstone River at Weston	01402540	1975	3.88	4.78
		1976	3.82	4.91
		1977	4.18	4.78
		1978	3.40	4.51
		1979	3.66	4.86
		1980	3.61	4.85
		1981	3.47	5.18
		1982	3.51	5.20
		1983	2.91	4.07
		1984	3.66	5.33
		1985	3.52	5.67
Manalapan Brook at Federal Rd near Manalapan	01405340	1975	3.22	3.97
		1976	3.17	4.08
		1977	3.47	3.97
		1978	2.83	3.75
		1979	3.04	4.04
		1980	3.00	4.03
		1981	2.88	4.30
		1982	2.91	4.32
		1983	2.42	3.39
		1984	3.04	4.43
		1985	2.92	4.71
Shark River near Neptune City	01407705	1975	3.62	4.47
		1976	3.56	4.59
		1977	3.91	4.46
		1978	3.18	4.22
		1979	3.42	4.54
		1980	3.37	4.54
		1981	3.24	4.84
		1982	3.28	4.86
		1983	2.72	3.81
		1984	3.42	4.98
		1985	3.29	5.30
Jumping Brook near Neptune City	01407760	1975	3.62	4.47
		1976	3.56	4.59
		1977	3.91	4.46
		1978	3.18	4.22
		1979	3.42	4.54
		1980	3.37	4.54
		1981	3.24	4.84
		1982	3.28	4.86
		1983	2.72	3.81
		1984	3.42	4.98
		1985	3.29	5.30

Table 16. Estimated application of phosphorus and nitrogen fertilizer in the New Jersey drainage basins studied, 1975-85--Continued

[Based on data supplied by R.B. Alexander, U.S. Geological Survey, written commun.,1989]

Drainage basin			Fertilizer application rate, in tons per square mile	
Monitoring-station name	Monitoring-station number	Year	Phosphorus	Nitrogen
Marsh Bog Brook at Squankum	01407997	1975	3.62	4.47
		1976	3.56	4.59
		1977	3.91	4.46
		1978	3.18	4.22
		1979	3.42	4.54
		1980	3.37	4.54
		1981	3.24	4.84
		1982	3.28	4.86
		1983	2.72	3.81
		1984	3.42	4.98
		1985	3.29	5.30
Toms River near Toms River	01408500	1975	0.28	0.35
		1976	0.28	0.36
		1977	0.31	0.35
		1978	0.25	0.33
		1979	0.27	0.36
		1980	0.26	0.36
		1981	0.26	0.38
		1982	0.26	0.38
		1983	0.21	0.30
		1984	0.27	0.39
		1985	0.26	0.42
Mullica River at outlet of Atsion Lake at Atsion	01409387	1975	2.36	2.92
		1976	2.33	3.00
		1977	2.55	2.91
		1978	2.07	2.75
		1979	2.23	2.97
		1980	2.20	2.96
		1981	2.12	3.16
		1982	2.14	3.17
		1983	1.78	2.49
		1984	2.23	3.25
		1985	2.15	3.46
Hammonton Creek at Westcoatville	01409416	1975	0.89	1.10
		1976	0.88	1.13
		1977	0.96	1.10
		1978	0.78	1.04
		1979	0.84	1.12
		1980	0.83	1.12
		1981	0.80	1.19
		1982	0.81	1.20
		1983	0.67	0.94
		1984	0.84	1.23
		1985	0.81	1.31

Table 16. Estimated application of phosphorus and nitrogen fertilizer in the New Jersey drainage basins studied, 1975-85--Continued

[Based on data supplied by R.B. Alexander, U.S. Geological Survey, written commun., 1989]

Drainage basin			Fertilizer application rate, in tons per square mile	
Monitoring-station name	Monitoring-station number	Year	Phosphorus	Nitrogen
Batsto River at Batsto	01409500	1975	3.09	3.81
		1976	3.04	3.92
		1977	3.34	3.81
		1978	2.71	3.60
		1979	2.92	3.88
Batsto River at Batsto--Continued	01409500-Cont.	1980	2.88	3.87
		1981	2.77	4.13
		1982	2.80	4.15
		1983	2.32	3.25
		1984	2.92	4.25
		1985	2.81	4.52
West Branch Wading River at Maxwell	01409815	1975	3.08	3.80
		1976	3.03	3.90
		1977	3.32	3.80
		1978	2.70	3.59
		1979	2.91	3.86
		1980	2.87	3.86
		1981	2.76	4.11
		1982	2.79	4.13
		1983	2.32	3.24
		1984	2.90	4.24
		1985	2.80	4.51
Oswego River at Harrisville	01410000	1975	1.96	2.42
		1976	1.93	2.49
		1977	2.12	2.42
		1978	1.72	2.28
		1979	1.85	2.46
		1980	1.83	2.46
		1981	1.76	2.62
		1982	1.77	2.63
		1983	1.48	2.06
		1984	1.85	2.70
		1985	1.78	2.87
East Branch Bass River near New Gretna	01410150	1975	2.97	3.66
		1976	2.92	3.76
		1977	3.20	3.66
		1978	2.60	3.46
		1979	2.80	3.72
		1980	2.76	3.72
		1981	2.66	3.96
		1982	2.69	3.98
		1983	2.23	3.12
		1984	2.80	4.08
		1985	2.69	4.34

Table 16. Estimated application of phosphorus and nitrogen fertilizer in the New Jersey drainage basins studied, 1975-85--Continued

[Based on data supplied by R.B. Alexander, U.S. Geological Survey, written commun.,1989]

Drainage basin			Fertilizer application rate, in tons per square mile	
Monitoring-station name	Monitoring-station number	Year	Phosphorus	Nitrogen
Great Egg Harbor near Sicklerville	01410784	1975	1.51	1.87
		1976	1.49	1.92
		1977	1.63	1.87
		1978	1.33	1.76
		1979	1.43	1.90
		1980	1.41	1.90
		1981	1.35	2.02
		1982	1.37	2.03
		1983	1.14	1.59
		1984	1.43	2.08
		1985	1.38	2.22
Great Harbor near Blue Anchor	01410820	1975	2.16	2.67
		1976	2.13	2.74
		1977	2.33	2.66
		1978	1.90	2.52
		1979	2.04	2.71
		1980	2.01	2.70
		1981	1.93	2.89
		1982	1.95	2.90
		1983	1.62	2.27
		1984	2.04	2.97
		1985	1.96	3.16
Great Egg Harbor at Weymouth	01411110	1975	2.55	3.15
		1976	2.51	3.24
		1977	2.75	3.15
		1978	2.24	2.97
		1979	2.41	3.20
		1980	2.37	3.20
		1981	2.29	3.41
		1982	2.31	3.43
		1983	1.92	2.68
		1984	2.41	3.51
		1985	2.32	3.74
Maurice River at Norma	01411500	1975	5.08	6.26
		1976	4.99	6.43
		1977	5.48	6.26
		1978	4.45	5.91
		1979	4.80	6.37
		1980	4.72	6.36
		1981	4.54	6.78
		1982	4.59	6.81
		1983	3.82	5.34
		1984	4.79	6.98
		1985	4.61	7.43

Table 16. Estimated application of phosphorus and nitrogen fertilizer in the New Jersey drainage basins studied, 1975-85--Continued

[Based on data supplied by R.B. Alexander, U.S. Geological Survey, written commun., 1989]

Drainage basin			Fertilizer application rate, in tons per square mile	
Monitoring-station name	Monitoring-station number	Year	Phosphorus	Nitrogen
Cohansey River at Seeley	01412800	1975	6.34	7.81
		1976	6.23	8.03
		1977	6.83	7.81
		1978	5.56	7.37
		1979	5.99	7.95
		1980	5.89	7.93
		1981	5.67	8.46
		1982	5.73	8.50
		1983	4.76	6.66
		1984	5.97	8.71
		1985	5.75	9.27
Paulins Kill at Blairstown	01443500	1975	1.75	2.16
		1976	1.72	2.22
		1977	1.89	2.16
		1978	1.54	2.04
		1979	1.65	2.20
		1980	1.63	2.19
		1981	1.57	2.34
		1982	1.58	2.35
		1983	1.32	1.84
		1984	1.65	2.41
		1985	1.59	2.56
Musconetcong River Outlet of Lake Hopatcong	01455500	1975	0.94	1.15
		1976	0.92	1.19
		1977	1.01	1.15
		1978	0.82	1.09
		1979	0.88	1.17
		1980	0.87	1.17
		1981	0.84	1.25
		1982	0.85	1.26
		1983	0.70	0.98
		1984	0.88	1.29
		1985	0.85	1.37
Musconetcong River at Beattystown	01456200	1975	1.40	1.73
		1976	1.38	1.78
		1977	1.51	1.73
		1978	1.23	1.64
		1979	1.33	1.76
		1980	1.31	1.76
		1981	1.26	1.88
		1982	1.27	1.89
		1983	1.06	1.48
		1984	1.32	1.93
		1985	1.28	2.06

Table 16. Estimated application of phosphorus and nitrogen fertilizer in the New Jersey drainage basins studied, 1975-85--Continued

[Based on data supplied by R.B. Alexander, U.S. Geological Survey, written commun.,1989]

Drainage basin			Fertilizer application rate, in tons per square mile	
Monitoring-station name	Monitoring-station number	Year	Phosphorus	Nitrogen
Musconetcong River at Riegelsville	01457400	1975	2.93	3.62
		1976	2.89	3.72
		1977	3.16	3.62
		1978	2.57	3.41
		1979	2.77	3.68
		1980	2.73	3.67
		1981	2.63	3.92
		1982	2.65	3.94
		1983	2.21	3.08
		1984	2.77	4.04
		1985	2.66	4.29
Wickechcoke Creek at Stockton	01461300	1975	4.85	5.98
		1976	4.77	6.14
		1977	5.23	5.97
		1978	4.25	5.64
		1979	4.58	6.08
		1980	4.51	6.07
		1981	4.34	6.47
		1982	4.38	6.50
		1983	3.64	5.09
		1984	4.57	6.67
		1985	4.40	7.09
Crosswicks Creek at Extonville	01464500	1975	2.05	2.52
		1976	2.01	2.59
		1977	2.21	2.52
		1978	1.79	2.38
		1979	1.93	2.57
		1980	1.90	2.56
		1981	1.83	2.73
		1982	1.85	2.75
		1983	1.54	2.15
		1984	1.93	2.81
		1985	1.86	2.99
Doctors Creek at Allentown	01464515	1975	3.63	4.48
		1976	3.58	4.61
		1977	3.92	4.48
		1978	3.19	4.23
		1979	3.43	4.56
		1980	3.38	4.55
		1981	3.25	4.85
		1982	3.29	4.88
		1983	2.73	3.82
		1984	3.43	5.00
		1985	3.30	5.32

Table 16. Estimated application of phosphorus and nitrogen fertilizer in the New Jersey drainage basins studied, 1975-85--Continued

[Based on data supplied by R.B. Alexander, U.S. Geological Survey, written commun., 1989]

Drainage basin			Fertilizer application rate, in tons per square mile	
Monitoring-station name	Monitoring-station number	Year	Phosphorus	Nitrogen
SB Rancocas Creek at Vincentown	01465850	1975	3.09	3.81
		1976	3.04	3.92
		1977	3.34	3.81
		1978	2.71	3.60
		1979	2.92	3.88
		1980	2.88	3.87
		1981	2.77	4.13
		1982	2.80	4.15
		1983	2.32	3.25
		1984	2.92	4.25
		1985	2.81	4.52
NB Rancocas Creek at Brown Mills	01465970	1975	1.93	2.38
		1976	1.90	2.44
		1977	2.08	2.38
		1978	1.69	2.24
		1979	1.82	2.42
		1980	1.79	2.41
		1981	1.73	2.58
		1982	1.74	2.59
		1983	1.45	2.03
		1984	1.82	2.65
		1985	1.75	2.82
McDonalds Branch in Lebanon State Forest	01466500	1975	3.09	3.81
		1976	3.04	3.92
		1977	3.34	3.81
		1978	2.71	3.60
		1979	2.92	3.88
		1980	2.88	3.87
		1981	2.77	4.13
		1982	2.80	4.15
		1983	2.32	3.25
		1984	2.92	4.25
		1985	2.81	4.52
NB Rancocas Creek at Browns Mills	01467000	1975	2.02	2.49
		1976	1.99	2.56
		1977	2.18	2.49
		1978	1.77	2.35
		1979	1.91	2.53
		1980	1.88	2.53
		1981	1.81	2.70
		1982	1.83	2.71
		1983	1.52	2.12
		1984	1.91	2.78
		1985	1.83	2.96

Table 16. Estimated application of phosphorus and nitrogen fertilizer in the New Jersey drainage basins studied, 1975-85--Continued

[Based on data supplied by R.B. Alexander, U.S. Geological Survey, written commun.,1989]

Drainage basin			Fertilizer application rate, in tons per square mile	
Monitoring-station name	Monitoring-station number	Year	Phosphorus	Nitrogen
NB Pennsauken Creek near Moorestown	01467069	1975	3.09	3.81
		1976	3.04	3.92
		1977	3.34	3.81
		1978	2.71	3.60
		1979	2.92	3.88
		1980	2.88	3.87
		1981	2.77	4.13
		1982	2.80	4.15
		1983	2.32	3.25
		1984	2.92	4.25
		1985	2.81	4.52
SB Pennsauken Creek at Cherry Hill	01467081	1975	2.01	2.48
		1976	1.97	2.54
		1977	2.16	2.47
		1978	1.76	2.34
		1979	1.90	2.52
		1980	1.87	2.51
		1981	1.80	2.68
		1982	1.81	2.69
		1983	1.51	2.11
		1984	1.89	2.76
		1985	1.82	2.94
Cooper River at Norcross Rd at Lindenwold	01467120	1975	1.51	1.87
		1976	1.49	1.92
		1977	1.63	1.87
		1978	1.33	1.76
		1979	1.43	1.90
		1980	1.41	1.90
		1981	1.35	2.02
		1982	1.37	2.03
		1983	1.14	1.59
		1984	1.43	2.08
		1985	1.38	2.22
Cooper River at Lawnside	01467140	1975	1.51	1.87
		1976	1.49	1.92
		1977	1.63	1.87
		1978	1.33	1.76
		1979	1.43	1.90
		1980	1.41	1.90
		1981	1.35	2.02
		1982	1.37	2.03
		1983	1.14	1.59
		1984	1.43	2.08
		1985	1.38	2.22

Table 16. Estimated application of phosphorus and nitrogen fertilizer in the New Jersey drainage basins studied, 1975-85--Continued

[Based on data supplied by R.B. Alexander, U.S. Geological Survey, written commun., 1989]

Drainage basin			Fertilizer application rate, in tons per square mile	
Monitoring-station name	Monitoring-station number	Year	Phosphorus	Nitrogen
SB Big Timber Creek at Blackwood Terrace	01467329	1975	2.88	3.56
		1976	2.84	3.65
		1977	3.11	3.55
		1978	2.53	3.36
		1979	2.72	3.62
		1980	2.68	3.61
		1981	2.58	3.85
		1982	2.61	3.87
		1983	2.17	3.03
		1984	2.72	3.97
		1985	2.62	4.22
Raccoon Creek near Swedesboro	01477120	1975	4.90	6.04
		1976	4.82	6.21
		1977	5.28	6.04
		1978	4.30	5.70
		1979	4.63	6.14
		1980	4.56	6.13
		1981	4.38	6.54
		1982	4.43	6.57
		1983	3.68	5.15
		1984	4.62	6.74
		1985	4.45	7.17
Oldmans Creek at Porches Mill	01477510	1975	6.13	7.56
		1976	6.03	7.77
		1977	6.61	7.55
		1978	5.38	7.13
		1979	5.79	7.68
		1980	5.70	7.67
		1981	5.48	8.18
		1982	5.54	8.22
		1983	4.61	6.44
		1984	5.78	8.43
		1985	5.56	8.97
Salem River at Woodstown	01482500	1975	7.56	9.33
		1976	7.44	9.59
		1977	8.16	9.32
		1978	6.64	8.80
		1979	7.15	9.49
		1980	7.04	9.47
		1981	6.77	10.10
		1982	6.84	10.15
		1983	5.69	7.95
		1984	7.13	10.40
		1985	6.87	11.07

Table 20. Probabilities derived from contingency-table analyses of water-quality data and drainage-basin characteristics in the New Jersey drainage basins studied

[All values are determined from exact probability or chi-square distribution; probability analysis based on chi-square are noted by parenthetical numbers that indicate the degrees of freedom; -, denotes that the analysis was not performed]

Test	Specific conductance	Dissolved oxygen	Biochemical oxygen demand	pH	Total nitrogen	Total ammonia	Total phosphorus	Total organic carbon
1. Trends in one constituent versus trends in another constituent								
A. Specific conductance	-	0.313	0.066	0.814	0.860	0.621	0.309	0.415
B. Dissolved oxygen	0.313	-	.097	.774	.240	.554	.628	.476
C. Biochemical oxygen demand	.066	.097	-	1.000	.531	.597	.676	.167
D. pH	.814	.774	.774	-	.331	.336	.141	.893
E. Total nitrogen	.860	.240	.531	.331	-	1.000	.559	1.000
F. Total ammonia	.621	.554	.597	.336	1.000	-	.464	.608
G Total phosphorus	.309	.628	.676	.141	.559	.464	-	.798
H Total organic carbon	.415	.476	.167	.893	1.000	.608	.798	-
I. Dissolved calcium	.136	.219	.552	.083	.357	1.000	.203	.355
J. Dissolved magnesium	.213	.621	.554	.726	.210	.026	.728	.339
K. Dissolved sodium	.000	.931	.666	.546	.471	.066	.418	1.000
L. Dissolved potassium	.025	.370	.502	.287	.580	1.000	.543	.304
M. Dissolved chloride	.028	.576	.695	.448	.625	1.000	1.000	.061
N. Fecal coliform bacteria	.116	.173	.150	.711	.580	.470	1.000	.318
O. Fecal streptococcus bacteria	.148	.786	.710	.362	.520	.523	.033	.792(1)
2. Season trends versus period-of-study 1975-86 trends								
A. Stations with positive and negative trends	.597	.109	.660	.778	.338	-	.590	.958
B. Stations with positive trends only	.883	.147	1.000	.526	.338	-	1.000	-
C. Stations with negative trends only	.263	.273	1.000	.974	-	-	1.000	.991
3. Trends in instantaneous streamflow versus water-quality trends	.862	.610	.420	.600	.077	1.000	.801	.673
4. Drainage-basin area versus water-quality trends	.098	.528	.285	.156	.709	.521	.967	.859
5. Physiographic region of drainage basin versus water-quality trends	.770	.673	.249	.270	.816	.134	1.000	.076(2)

Table 20. Probabilities derived from contingency-table analyses of water-quality data and drainage-basin characteristics in the New Jersey drainage basins studied--Continued

[All values are determined from exact probability or chi-square distribution; probability analysis based on chi-square are noted by parenthetical numbers that indicate the degrees of freedom; -, denotes that the analysis was not performed]

Test	Specific conductance	Dissolved oxygen	Biochemical oxygen demand	pH	Total nitrogen	Total ammonia	Total phosphorus	Total organic carbon
6. Water quality trends versus dominant land use								
A. Entire drainage basin	.740	.615	.929	.072	.763	.258	.727	.449
B. Area 3.1 miles upstream from monitoring station	.707	.317	.573	.073	.905	.042	.505	.681
C. Area 0.62 mile upstream from monitoring station	.554	.850	.323	.013	.107	.018	.171	.335
7. Water-quality trends versus drainage-basin population								
A. 1986 population	.225	.347	.717	.007	.805	.292	.154	.816(2)
B. 1986 population density	.100	.259	.772	.037	.930	.457	.468	.463(2)
C. Population density change 1975-1986	.225	.583	.029	.723	.480	.650	.697	.127(2)
8. Water-quality trends versus effluent disposal								
A. Change in number of treatment facilities in drainage basin 1975-1986	.016	.426	.832	.135	1.000	.012	.198	.331
B. Wastewater yields in basin								
1. Wastewater discharge	.426	.716	.893	.048	.805	.377	.181	.368
2. Biochemical oxygen demand, 5-day	.654	.914	.968	.006	1.000	.510	.460	.172(2)
3. Total suspended solids	.589	.523	1.000	.076	.829	1.000	.320	.490(2)
C. Wastewater yields in area 3.1 mi upstream from monitoring station								
1. Wastewater discharge	.394	.782	1.000	.704	.571	.071	.892	.179
2. Biochemical oxygen demand, 5-day	.463	1.000	.530	.250	1.000	.429	.874	.539
3. Total suspended solids	.560	1.000	1.000	.418	.143	.571	.892	1.000
D. Percent municipal loads in basin								
1. Wastewater discharge	.163	.064	1.000	.516	.560	1.000	.191	.536
2. Biochemical oxygen demand, 5-day	.094	.123	.416	.265	.776	1.000	.642	.327
3. Total suspended solids	.858	.308	.766	.270	.776	.640	.848	.889

Table 20. Probabilities derived from contingency-table analyses of water-quality data and drainage-basin characteristics in the New Jersey drainage basins studied--Continued

[All values are determined from exact probability or chi-square distribution; probability analysis based on chi-square are noted by parenthetical numbers that indicate the degrees of freedom; -, denotes that the analysis was not performed]

Test	Specific conductance	Dissolved oxygen	Biochemical oxygen demand	pH	Total nitrogen	Total ammonia	Total phosphorus	Total organic carbon
E. Percent municipal loads in area 3.1 miles upstream from monitoring station								
1. Wastewater discharge	1.000	.060	.769	.760	.375	.500	.325	.432
2. Biochemical oxygen demand	1.000	.057	.291	.919	.375	.500	.548	.448
3. Total suspended solids	.680	.057	.769	.804	.375	.583	.543	.793
9. Water-quality trends versus trends in road-salt application in drainage basin								
A. Trends in road-salt applications, 1975-1987								
1. Trends in sodium application	.110	.813	.214	.687	.646	.537	.344	1.000
2. Trends in chloride application	.250	1.000	.556	.203	.646	.537	.282	1.000
B. Drainage-basin application rates, 1980-81								
1. Chloride	.031	.216	.460	.220	1.000	.467	.856	.106(2)
2. Sodium and calcium	.026	.193	.324	.057	1.000	.521	1.000	.103
10. Water-quality trends versus trends in drainage-basin phosphorus-fertilizer usage	1.000	.179	.324	1.000	.646	.228	1.000	.680
11. Water-quality trends versus drainage-basin fertilizer application rates, 1980								
A. Nitrogen	.076	.453	.567	.009	.199	.151	.291	.929
B. Phosphorus	.076	.453	.567	.009	.199	.151	.291	.929
12. Water-quality trends versus soil erosion rates	.930	.948	.946	.258	.500	1.000	.126	.147
13. Water-quality trends versus percent total acreage irrigated in drainage basin	.969	1.000	.709	.023	1.000	1.000	.797	.156

Table 20. Probabilities derived from contingency-table analyses of water-quality data and drainage-basin characteristics in the New Jersey drainage basins studied--Continued

[All values are determined from exact probability or chi-square distribution; probability analysis based on chi-square are noted by parenthetical numbers that indicate the degrees of freedom; -, denotes that the analysis was not performed]

Test	Dissolved calcium	Dissolved magnesium	Dissolved sodium	Dissolved potassium	Dissolved chloride	Fecal coliform bacteria	Fecal streptococcus bacteria
1. Constituent versus constituent							
A. Specific conductance	.136	.213	.000	.025	.028	.116	.148
B. Dissolved oxygen	.219	.621	.931	.370	.576	.173	.786
C. Biochemical oxygen demand	.552	.554	.666	.502	.695	.150	.710
D. pH	.083	.726	.546	.287	.448	.711	.362
E. Total nitrogen	.357	.210	.471	.580	.625	.580	.520
F. Total ammonia	1.000	.026	.066	1.000	1.000	.470	.523
G Total phosphorus	.203	.728	.418	.543	1.000	1.000	.033
H Total organic carbon	.355	.339	1.000	.304	.061	.318	.792(1)
I. Dissolved calcium	-	.001	.562	.314	1.000	1.000	.361
J. Dissolved magnesium	.001	-	.122	.589	.420	.128	.596
K. Dissolved sodium	.562	.122	-	.432	.000	.342	.745
L. Dissolved potassium	.314	.589	.432	-	.817	.694	.156
M. Dissolved chloride	1.000	.420	.000	.817	-	.321	.224
N. Fecal coliform bacteria	1.000	.128	.342	.694	.321	-	.223
O. Fecal streptoccus bacteria	.361	.596	.745	.156	.224	.223	-
2. Season trends versus period-of-study, 1975-86 trends							
A. Stations with positive and negative trends	.667	.445	.259	.620	.298	-	-
B. Stations with positive trends only	.825	.798	.039(5)	1.00	.146(5)	-	-
C. Stations with negative trends only	-	.273	1.000	.888	1.000	-	-
3. Trends in instantaneous streamflow versus water-quality trend	.431	.578	.254	.297	.238	.797	.107
4. Drainage-basin size versus water-quality trends	.208	.828	.821	.174	.073	.326	.564
5. Physiographic regions versus water-quality trends	.596	.375	.091	.918	.206	.744	.346

Table 20. Probabilities derived from contingency-table analyses of water-quality data and drainage-basin characteristics in the New Jersey drainage basins studied--Continued

[All values are determined from exact probability or chi-square distribution; probability analysis based on chi-square are noted by parenthetical numbers that indicate the degrees of freedom; -, denotes that the analysis was not performed]

Test	Dissolved calcium	Dissolved magnesium	Dissolved sodium	Dissolved potassium	Dissolved chloride	Fecal coliform bacteria	Fecal streptococcus bacteria
6. Water quality trends versus dominant land use							
A. Entire basin	.584	.568	.740	.089	.356	.479	.023
B. Area 3.1 miles upstream from monitoring station	.372	.064	.416	.030	.346	.050	.214
C. Area 0.62 mile upstream from monitoring station	.209	.002	.076	.347	.061	.139	.643
7. Water-quality trends versus population							
A. 1986 population	.137	.227	.677	.597	.344	.364	.611
B. 1986 population density	.310	.167	.251	.569	.570	.804	.440
C. Population density change 1975-1986	.528	.293	.637	.705	.506	.148	.220
8. Water-quality trends versus effluent disposal							
A. Change in number of treatment facilities in drainage basin 1975-1986	.615	.949	.172	.683	.314	1.000	1.000
B. Wastewater yields in basin							
1. Wastewater discharge	.788	.130	.017	.316	.319	.129	.076(2)
2. Biochemical oxygen demand, 5-day	.705	.711	.017	.357	.895	.272	.446
3. Total suspended solids	.797	.758	.045	.465	.649	.360	.781
C. Wastewater yields in area 3.1 miles upstream from monitoring station							
1. Wastewater discharge	.680	.358	.210	.780	.145	.399	1.000
2. Biochemical oxygen demand, 5-day	.063	.743	.057	.847	.006	.065	.014
3. Total suspended solids	.088	.430	.312	.544	.012	.267	.408
D. Percent municipal loads in basin							
1. Wastewater discharge	1.000	.901	.122	.543	.259	.688	.453
2. Biochemical oxygen demand, 5-day	.639	.516	.503	.479	.109	.459	.151
3. Total suspended solids	1.000	.844	.886	.383	.020	.541	.086
E. Percent municipal loads in area 3.1 miles upstream from monitoring station							
1. Wastewater discharge	1.000	1.000	.680	.233	.298	.018	.708
2. Biochemical oxygen demand, 5-day	.292	.774	1.000	.370	.244	.171	.811
3. Total suspended solids	.284	.828	1.000	.361	.216	.305	.656

Table 20. Probabilities derived from contingency-table analyses of water-quality data and drainage-basin characteristics in the New Jersey drainage basins studied--Continued

[All values are determined from exact probability or chi-square distribution; probability analysis based on chi-square are noted by parenthetical numbers that indicate the degrees of freedom; -, denotes that the analysis was not performed]

Test	Dissolved calcium	Dissolved magnesium	Dissolved sodium	Dissolved potassium	Dissolved chloride	Fecal coliform bacteria	Fecal streptococcus bacteria
9. Water-quality trends versus trends in road-salt application in drainage basin							
A. Trends in road-salt applications, 1975-1987							
1. Trends in sodium application	.874(1)	.002	.325	.672	.627	.175	.309(1)
2. Trends in chloride application	1.000(1)	.002	.700	.634	.578	.135	.189(1)
B. Drainage-basin application rates, 1980-81							
1. Chloride rates	.698	.009	.004	1.000	.080	.594	.190
2. Sodium and calcium	1.000	.450	.383	.118	.276	.615	.291
10. Water-quality trends versus trends in drainage-basin phosphorus-fertilizer usage	.539(1)	.007	.760	1.000	1.000	.469	.407
11. Water-quality trends versus drainage-basin fertilizer application rates, 1980							
A. Nitrogen	.121	.310	.138	.288	.278	.930	.924
B. Phosphorus	.121	.310	.138	.288	.278	.930	.924
12. Water-quality trends versus soil erosion rates	.870	.102	.531	1.000	.163	.831	.004
13. Water-quality trends versus percent total acreage irrigated in drainage basin	.462	.046	.495	.752	.799	.463	.259

Table 21. Results of Spearman-rho correlation analyses of water-quality data from paired monitoring stations on the same New Jersey stream, water year 1976-86

[-, correlation analysis not performed because of lack of data]

Constituent or property		Paired monitoring stations		Number of paired values for test	Correlation coefficient	Probability
Code	Name					
00095	Specific conductance	01367700	01367770	37	0.955	0.000
00095	Specific conductance	01379000	01379500	56	0.563	0.000
00095	Specific conductance	01379500	01382000	0	-	-
00095	Specific conductance	01381500	01381800	7	0.516	0.236
00095	Specific conductance	01396280	01396535	41	0.965	0.000
00095	Specific conductance	01396535	01397400	13	0.666	0.013
00095	Specific conductance	01397400	01396280	10	0.437	0.207
00095	Specific conductance	01398260	01399120	17	0.848	0.000
00095	Specific conductance	01401440	01402540	6	0.918	0.010
00095	Specific conductance	01410784	01410820	62	0.658	0.000
00095	Specific conductance	01410820	01411110	11	0.494	0.122
00095	Specific conductance	01411110	01410784	10	0.071	0.845
00095	Specific conductance	01456200	01457400	6	0.045	0.933
00095	Specific conductance	01465970	01467000	39	0.719	0.000
00095	Specific conductance	01467120	01467140	26	-0.530	0.005
00300	Dissolved oxygen	01367700	01367770	38	0.848	0.000
00300	Dissolved oxygen	01379000	01379500	56	0.883	0.000
00300	Dissolved oxygen	01379500	01382000	0	-	-
00300	Dissolved oxygen	01381500	01381800	7	0.176	0.706
00300	Dissolved oxygen	01396280	01396535	40	0.912	0.000
00300	Dissolved oxygen	01396535	01397400	13	0.862	0.000
00300	Dissolved oxygen	01397400	01396280	10	0.758	0.011
00300	Dissolved oxygen	01398260	01399120	16	0.696	0.003
00300	Dissolved oxygen	01401440	01402540	6	0.034	0.950
00300	Dissolved oxygen	01410784	01410820	63	0.784	0.000
00300	Dissolved oxygen	01410820	01411110	11	0.919	0.000
00300	Dissolved oxygen	01411110	01410784	11	0.764	0.006
00300	Dissolved oxygen	01456200	01457400	5	0.981	0.003
00300	Dissolved oxygen	01465970	01467000	39	0.954	0.000
00300	Dissolved oxygen	01467120	01467140	25	0.840	0.000
00310	Biochemical oxygen demand	01367700	01367770	37	0.587	0.000
00310	Biochemical oxygen demand	01379000	01379500	54	0.292	0.032
00310	Biochemical oxygen demand	01379500	01382000	0	-	-
00310	Biochemical oxygen demand	01381500	01381800	7	0.800	0.031
00310	Biochemical oxygen demand	01396280	01396535	37	0.501	0.002
00310	Biochemical oxygen demand	01396535	01397400	12	0.394	0.205
00310	Biochemical oxygen demand	01397400	01396280	10	0.605	0.064
00310	Biochemical oxygen demand	01398260	01399120	14	0.051	0.863
00310	Biochemical oxygen demand	01401440	01402540	6	0.778	0.068
00310	Biochemical oxygen demand	01410784	01410820	59	0.164	0.214

Table 21. Results of Spearman-rho correlation analyses of water-quality data from paired monitoring stations on the same New Jersey stream, water year 1976-86--Continued

Constituent or property		Paired monitoring stations		Number of paired values for test	Correlation coefficient	Probability
Code	Name					
00310	Biochemical oxygen demand	01410820	01411110	11	0.270	0.422
00310	Biochemical oxygen demand	01411110	01410784	11	0.305	0.362
00310	Biochemical oxygen demand	01456200	01457400	4	-	-
00310	Biochemical oxygen demand	01465970	01467000	38	0.608	0.000
00310	Biochemical oxygen demand	01467120	01467140	24	-0.495	0.014
00400	pH	01367700	01367770	37	0.697	0.000
00400	pH	01379000	01379500	56	0.541	0.000
00400	pH	01379500	01382000	0	-	-
00400	pH	01381500	01381800	7	0.555	0.196
00400	pH	01396280	01396535	42	0.851	0.000
00400	pH	01396535	01397400	14	-0.410	0.145
00400	pH	01397400	01396280	11	-0.504	0.114
00400	pH	01398260	01399120	16	0.390	0.135
00400	pH	01401440	01402540	6	0.949	0.004
00400	pH	01410784	01410820	59	0.836	0.000
00400	pH	01410820	01411110	11	0.952	0.000
00400	pH	01411110	01410784	11	0.743	0.009
00400	pH	01456200	01457400	6	-0.210	0.690
00400	pH	01465970	01467000	38	0.798	0.000
00400	pH	01467120	01467140	26	0.073	0.725
00600	Total nitrogen	01367700	01367770	33	0.438	0.011
00600	Total nitrogen	01379000	01379500	35	0.277	0.108
00600	Total nitrogen	01379500	01382000	0	-	-
00600	Total nitrogen	01381500	01381800	5	-0.967	0.007
00600	Total nitrogen	01396280	01396535	36	0.523	0.001
00600	Total nitrogen	01396535	01397400	12	-0.263	0.408
00600	Total nitrogen	01397400	01396280	8	-0.451	0.262
00600	Total nitrogen	01398260	01399120	12	0.456	0.136
00600	Total nitrogen	01401440	01402540	4	-	-
00600	Total nitrogen	01410784	01410820	53	0.730	0.000
00600	Total nitrogen	01410820	01411110	9	0.666	0.050
00600	Total nitrogen	01411110	01410784	10	0.265	0.459
00600	Total nitrogen	01456200	01457400	5	0.425	0.476
00600	Total nitrogen	01465970	01467000	18	0.372	0.129
00600	Total nitrogen	01467120	01467140	11	0.383	0.245
00610	Total ammonia	01367700	01367770	36	0.301	0.074
00610	Total ammonia	01379000	01379500	47	0.218	0.141
00610	Total ammonia	01379500	01382000	0	-	-
00610	Total ammonia	01381500	01381800	6	-0.205	0.696
00610	Total ammonia	01396280	01396535	37	0.132	0.437

Table 21. Results of Spearman-rho correlation analyses of water-quality data from paired monitoring stations on the same New Jersey stream, water year 1976-86--Continued

Constituent or property		Paired monitoring stations		Number of paired values for test	Correlation coefficient	Probability
Code	Name					
00610	Total ammonia	01396535	01397400	12	-0.091	0.779
00610	Total ammonia	01397400	01396280	9	-0.122	0.754
00610	Total ammonia	01398260	01399120	16	-0.121	0.656
00610	Total ammonia	01401440	01402540	4	-	-
00610	Total ammonia	01410784	01410820	60	0.561	0.000
00610	Total ammonia	01410820	01411110	10	0.715	0.020
00610	Total ammonia	01411110	01410784	11	0.345	0.299
00610	Total ammonia	01456200	01457400	5	0.924	0.025
00610	Total ammonia	01465970	01467000	30	0.899	0.000
00610	Total ammonia	01467120	01467140	19	0.168	0.492
00665	Total phosphorus	01367700	01367770	36	0.384	0.021
00665	Total phosphorus	01379000	01379500	51	0.576	0.000
00665	Total phosphorus	01379500	01382000	0	-	-
00665	Total phosphorus	01381500	01381800	5	0.730	0.161
00665	Total phosphorus	01396280	01396535	41	0.603	0.000
00665	Total phosphorus	01396535	01397400	13	0.102	0.739
00665	Total phosphorus	01397400	01396280	10	0.204	0.572
00665	Total phosphorus	01398260	01399120	16	0.649	0.006
00665	Total phosphorus	01401440	01402540	5	-0.636	0.249
00665	Total phosphorus	01410784	01410820	59	0.668	0.000
00665	Total phosphorus	01410820	01411110	10	0.529	0.116
00665	Total phosphorus	01411110	01410784	11	0.544	0.084
00665	Total phosphorus	01456200	01457400	6	-0.095	0.859
00665	Total phosphorus	01465970	01467000	39	0.477	0.002
00665	Total phosphorus	01467120	01467140	25	0.340	0.096
00680	Total organic carbon	01367700	01367770	35	0.610	0.000
00680	Total organic carbon	01379000	01379500	53	0.448	0.001
00680	Total organic carbon	01379500	01382000	0	-	-
00680	Total organic carbon	01381500	01381800	7	-0.645	0.118
00680	Total organic carbon	01396280	01396535	40	0.602	0.000
00680	Total organic carbon	01396535	01397400	12	0.373	0.233
00680	Total organic carbon	01397400	01396280	9	0.034	0.931
00680	Total organic carbon	01398260	01399120	16	0.850	0.000
00680	Total organic carbon	01401440	01402540	4	-	-
00680	Total organic carbon	01410784	01410820	61	0.804	0.000
00680	Total organic carbon	01410820	01411110	11	0.834	0.001
00680	Total organic carbon	01411110	01410784	11	0.834	0.001
00680	Total organic carbon	01456200	01457400	5	-0.361	0.550
00680	Total organic carbon	01465970	01467000	36	0.703	0.000
00680	Total organic carbon	01467120	01467140	25	0.006	0.976

Table 21. Results of Spearman-rho correlation analyses of water-quality data from paired monitoring stations on the same New Jersey stream, water year 1976-86--Continued

Constituent or property						
Code	Name	Paired monitoring stations		Number of paired values for test	Correlation coefficient	Probability
00915	Dissolved calcium	01367700	01367770	37	0.951	0.000
00915	Dissolved calcium	01379000	01379500	56	0.774	0.000
00915	Dissolved calcium	01379500	01382000	0	-	-
00915	Dissolved calcium	01381500	01381800	7	0.275	0.551
00915	Dissolved calcium	01396280	01396535	40	0.494	0.001
00915	Dissolved calcium	01396535	01397400	13	0.501	0.081
00915	Dissolved calcium	01397400	01396280	10	-0.275	0.442
00915	Dissolved calcium	01398260	01399120	17	0.816	0.000
00915	Dissolved calcium	01401440	01402540	6	0.386	0.449
00915	Dissolved calcium	01410784	01410820	51	0.526	0.000
00915	Dissolved calcium	01410820	01411110	10	0.969	0.000
00915	Dissolved calcium	01411110	01410784	11	-0.574	0.065
00915	Dissolved calcium	01456200	01457400	6	0.628	0.182
00915	Dissolved calcium	01465970	01467000	38	0.706	0.000
00915	Dissolved calcium	01467120	01467140	26	0.152	0.459
00925	Dissolved magnesium	01367700	01367770	37	0.966	0.000
00925	Dissolved magnesium	01379000	01379500	56	0.818	0.000
00925	Dissolved magnesium	01379500	01382000	0	-	-
00925	Dissolved magnesium	01381500	01381800	7	0.606	0.149
00925	Dissolved magnesium	01396280	01396535	40	0.260	0.105
00925	Dissolved magnesium	01396535	01397400	13	0.059	0.848
00925	Dissolved magnesium	01397400	01396280	10	0.084	0.817
00925	Dissolved magnesium	01398260	01399120	17	0.894	0.000
00925	Dissolved magnesium	01401440	01402540	6	0.480	0.336
00925	Dissolved magnesium	01410784	01410820	51	0.771	0.000
00925	Dissolved magnesium	01410820	01411110	10	0.722	0.018
00925	Dissolved magnesium	01411110	01410784	11	0.069	0.841
00925	Dissolved magnesium	01456200	01457400	6	-0.083	0.875
00925	Dissolved magnesium	01465970	01467000	38	0.769	0.000
00925	Dissolved magnesium	01467120	01467140	26	0.213	0.297
00930	Dissolved sodium	01367700	01367770	37	0.871	0.000
00930	Dissolved sodium	01379000	01379500	56	0.253	0.060
00930	Dissolved sodium	01379500	01382000	0	-	-
00930	Dissolved sodium	01381500	01381800	7	0.576	0.175
00930	Dissolved sodium	01396280	01396535	40	0.519	0.001
00930	Dissolved sodium	01396535	01397400	13	0.292	0.333
00930	Dissolved sodium	01397400	01396280	10	-0.289	0.417
00930	Dissolved sodium	01398260	01399120	17	0.817	0.000
00930	Dissolved sodium	01401440	01402540	6	0.522	0.288
00930	Dissolved sodium	01410784	01410820	52	0.758	0.000

Table 21. Results of Spearman-rho correlation analyses of water-quality data from paired monitoring stations on the same New Jersey stream, water year 1976-86--Continued

Constituent or property		Paired monitoring stations		Number of paired values for test	Correlation coefficient	Probability
Code	Name					
00930	Dissolved sodium	01410820	01411110	10	0.685	0.029
00930	Dissolved sodium	01411110	01410784	11	0.244	0.469
00930	Dissolved sodium	01456200	01457400	6	-0.062	0.907
00930	Dissolved sodium	01465970	01467000	38	0.777	0.000
00930	Dissolved sodium	01467120	01467140	26	0.074	0.719
00935	Dissolved potassium	01367700	01367770	37	0.887	0.000
00935	Dissolved potassium	01379000	01379500	56	0.316	0.018
00935	Dissolved potassium	01379500	01382000	0	-	-
00935	Dissolved potassium	01381500	01381800	7	0.330	0.470
00935	Dissolved potassium	01396280	01396535	40	0.472	0.002
00935	Dissolved potassium	01396535	01397400	13	0.643	0.018
00935	Dissolved potassium	01397400	01396280	10	-0.110	0.762
00935	Dissolved potassium	01398260	01399120	17	0.812	0.000
00935	Dissolved potassium	01401440	01402540	6	0.120	0.821
00935	Dissolved potassium	01410784	01410820	52	0.602	0.000
00935	Dissolved potassium	01410820	01411110	10	0.698	0.025
00935	Dissolved potassium	01411110	01410784	11	0.245	0.467
00935	Dissolved potassium	01456200	01457400	6	0.783	0.066
00935	Dissolved potassium	01465970	01467000	38	0.809	0.000
00935	Dissolved potassium	01467120	01467140	26	-0.146	0.477
00940	Dissolved chloride	01367700	01367770	37	0.905	0.000
00940	Dissolved chloride	01379000	01379500	56	0.293	0.029
00940	Dissolved chloride	01379500	01382000	0	-	-
00940	Dissolved chloride	01381500	01381800	7	0.640	0.121
00940	Dissolved chloride	01396280	01396535	39	0.970	0.000
00940	Dissolved chloride	01396535	01397400	13	0.770	0.002
00940	Dissolved chloride	01397400	01396280	9	0.581	0.101
00940	Dissolved chloride	01398260	01399120	17	0.864	0.000
00940	Dissolved chloride	01401440	01402540	6	0.440	0.383
00940	Dissolved chloride	01410784	01410820	52	0.767	0.000
00940	Dissolved chloride	01410820	01411110	10	0.966	0.000
00940	Dissolved chloride	01411110	01410784	11	-0.081	0.812
00940	Dissolved chloride	01456200	01457400	6	-0.073	0.890
00940	Dissolved chloride	01465970	01467000	38	0.750	0.000
00940	Dissolved chloride	01467120	01467140	26	0.026	0.898
31615	Fecal coliform bacteria	01367700	01367770	37	0.202	0.230
31615	Fecal coliform bacteria	01379000	01379500	55	0.848	0.000
31615	Fecal coliform bacteria	01379500	01382000	0	-	-
31615	Fecal coliform bacteria	01381500	01381800	7	-0.214	0.645
31615	Fecal coliform bacteria	01396280	01396535	38	0.704	0.000

Table 21. Results of Spearman-rho correlation analyses of water-quality data from paired monitoring stations on the same New Jersey stream, water year 1976-86--Continued

Constituent or property						
Code	Name	Paired monitoring stations		Number of paired values for test	Correlation coefficient	Probability
31615	Fecal coliform bacteria	01396535	01397400	11	-0.015	0.965
31615	Fecal coliform bacteria	01397400	01396280	8	0.068	0.872
31615	Fecal coliform bacteria	01398260	01399120	16	0.923	0.000
31615	Fecal coliform bacteria	01401440	01402540	6	0.909	0.012
31615	Fecal coliform bacteria	01410784	01410820	48	0.387	0.007
31615	Fecal coliform bacteria	01410820	01411110	10	0.112	0.759
31615	Fecal coliform bacteria	01411110	01410784	10	-0.193	0.593
31615	Fecal coliform bacteria	01456200	01457400	5	0.730	0.161
31615	Fecal coliform bacteria	01465970	01467000	37	0.320	0.053
31615	Fecal coliform bacteria	01467120	01467140	26	0.243	0.233
31677	Fecal streptococcus bacteria	01367700	01367770	37	0.398	0.015
31677	Fecal streptococcus bacteria	01379000	01379500	49	0.765	0.000
31677	Fecal streptococcus bacteria	01379500	01382000	0	-	-
31677	Fecal streptococcus bacteria	01381500	01381800	7	0.032	0.945
31677	Fecal streptococcus bacteria	01396280	01396535	38	0.717	0.000
31677	Fecal streptococcus bacteria	01396535	01397400	12	0.419	0.175
31677	Fecal streptococcus bacteria	01397400	01396280	9	0.330	0.387
31677	Fecal streptococcus bacteria	01398260	01399120	16	0.487	0.055
31677	Fecal streptococcus bacteria	01401440	01402540	5	-0.050	0.937
31677	Fecal streptococcus bacteria	01410784	01410820	48	0.065	0.662
31677	Fecal streptococcus bacteria	01410820	01411110	10	0.538	0.109
31677	Fecal streptococcus bacteria	01411110	01410784	10	0.340	0.336
31677	Fecal streptococcus bacteria	01456200	01457400	5	0.576	0.309
31677	Fecal streptococcus bacteria	01465970	01467000	35	0.178	0.307
31677	Fecal streptococcus bacteria	01467120	01467140	21	0.300	0.187

Table 23. Water-quality trend results for New Jersey stream monitoring stations and streamwater constituents and properties used in contingency-table analysis

[Data from Hay and Campbell (1990). -, no analysis for trend or trend eliminated because of data correlation; U, upward trend; O, no trend found; D, downward trend]

Drainage basin		Constituent or property							
Monitoring station name	Monitoring station number	Specific conductance	Dissolved oxygen	Biochemical oxygen demand, 5-day	pH	Total nitrogen	Total ammonia, as N	Total phosphorus, as P	Total organic carbon
Wallkill River at Franklin	1367700	-	U	-	-	-	-	-	-
Wallkill River near Sussex	1367770	U	-	O	O	-	-	-	D
Papakating Creek at Sussex	1367910	O	O	O	O	-	-	-	O
Black Creek near Vernon	1368950	U	O	O	O	-	-	-	D
Passaic River near Millington	1379000	U	-	-	-	O	U	-	-
Passaic River near Chatham	1379500	-	U	O	U	O	O	O	D
Rockaway River at Pine Brook	1381200	O	O	O	U	U	O	O	D
Whippany River at Morristown	1381500	U	O	-	O	-	O	O	D
Whippany River near Pine Brook	1381800	O	U	D	O	O	O	O	D
Passaic River at Two Bridges	1382000	O	U	O	U	O	O	O	O
Wanaque River at Wanaque	1387000	U	O	U	U	O	O	O	D
Saddle River at Lodi	1391500	U	O	O	O	-	-	O	O
SB Raritan River at Middle Valley	1396280	O	-	-	O	-	-	-	O
SB Raritan River at Arch St at High Bridge	1396535	-	-	-	O	-	-	-	-
Mulhockaway Creek at Van Syckel	1396660	O	U	-	D	-	-	U	-
SB Raritan River at Three Bridges	1397400	O	O	-	O	-	-	-	-
NB Raritan River near Chester	1398260	-	-	O	D	-	-	O	D
NB Raritan River at Burnt Mills	1399120	U	O	-	O	-	-	-	-
Rockaway Creek at Whitehouse	1399700	U	D	-	U	-	-	O	D
Lamington (Black) River at Burnt Mills	1399780	O	O	D	O	-	-	O	-
Raritan River at Manville	1400500	O	U	O	U	-	-	O	O
Millstone River at Grovers Mill	1400650	O	O	O	O	-	-	D	D
Millstone River at Kingston	1401440	-	O	O	-	-	-	O	D
Beden Brook near Rocky Hill	1401600	O	U	D	U	-	-	O	D
Millstone River at Weston	1402540	O	U	D	U	-	-	O	D
Manalapan Brook at Federal Rd near Manalapan	1405340	-	-	-	-	-	-	-	D
Shark River near Neptune City	1407705	O	U	-	-	-	-	O	-
Jumping Brook near Neptune City	1407760	O	-	-	-	-	-	O	-
Marsh Bog Brook at Squankum	1407997	O	O	-	-	-	-	-	-
Toms River near Toms River	1408500	O	O	O	O	U	O	O	O

Table 23. Water-quality trend results for New Jersey stream monitoring stations and streamwater constituents and properties used in contingency-table analysis--Continued

Drainage basin		Constituent or property							
Monitoring station name	Monitoring station number	Specific conductance	Dissolved oxygen	Biochemical oxygen demand, 5-day	pH	Total nitrogen	Total ammonia, as N	Total phosphorus, as P	Total organic carbon
Mullica River at outlet of Atsion Lake at Atsion	1409387	O	O	-	-	-	-	-	O
Hammonton Creek at Wescoatville	1409416	-	O	-	-	-	-	-	-
Batsto River at Batsto	1409500	D	U	-	O	-	-	O	-
WB Wading River at Maxwell	1409815	O	O	O	O	D	-	O	-
Oswego River at Harrisville	1410000	O	O	-	O	-	-	U	D
EB Bass River near New Gretna	1410150	D	-	-	O	-	-	-	D
Great Egg Harbor River near Sicklerville	1410784	-	-	O	-	O	-	-	-
Great Egg Harbor River near Blue Anchor	1410820	U	D	O	-	U	U	U	-
Great Egg Harbor River at Weymouth	1411110	O	-	O	U	U	-	O	O
Maurice River at Norma	1411500	D	O	O	U	O	O	D	O
Cohansey River at Seeley	1412800	D	U	O	D	O	O	O	D
Paulins Kill at Blairstown	1443500	O	U	O	O	-	-	-	O
Musconetcong River at outlet of Lake Hopatcong	1455500	U	O	O	O	-	-	-	D
Musconetcong River at Beatyestown	1456200	O	-	O	O	-	-	-	D
Musconetcong River at Riegelsville	1457400	O	U	-	O	-	-	-	D
Wickecheoke Creek at Stockton	1461300	D	O	O	O	-	-	-	D
Crosswicks Creek at Extonville	1464500	U	U	U	O	U	U	D	D
Doctors Creek at Allentown	1464515	O	O	O	O	-	-	O	O
SB Rancocas Creek at Vincentown	1465850	O	O	O	U	O	U	O	O
NB Rancocas Creek at Browns Mills	1465970	-	-	-	-	O	-	-	-
McDonalds Branch in Lebanon State Forest	1466500	U	O	O	O	-	O	O	O
NB Rancocas Creek at Pemberton	1467000	O	U	D	O	O	U	O	O
NB Pennsauken Creek near Moorestown	1467069	O	O	O	U	-	-	O	-
SB Pennsauken Creek at Cherry Hill	1467081	U	O	O	O	-	-	O	O
Cooper River at Norcross Rd at Lindenwold	1467120	-	D	U	O	U	-	O	D
Cooper River at Lawnside	1467140	U	-	-	U	-	-	O	O
SB Big Timber Creek at Blackwood Terrace	1467329	U	U	O	O	-	-	D	D
Raccoon Creek near Swedesboro	1477120	O	O	D	D	O	U	O	D
Oldmans Creek at Porches Mill	1477510	O	O	O	D	O	U	O	O
Salem River at Woodstown	1482500	U	O	O	D	-	-	U	O

Table 23. Water-quality trend results for New Jersey stream monitoring stations and streamwater constituents and properties used in contingency-table analysis--Continued

Drainage basin		Constituent						
Monitoring-station name	Monitoring-station number	Dissolved calcium	Disolved magnesium	Dissolved sodium	Disolved potassium	Disolved chloride	Fecal coliform bacteria	Fecal streptococcus bacteria
Wallkill River at Franklin	1367700	U	-	-	-	-	O	-
Wallkill River near Sussex	1367770	-	O	U	O	U	O	O
Papakating Creek at Sussex	1367910	O	O	U	O	U	U	O
Black Creek near Vernon	1368950	O	O	U	O	U	O	O
Passaic River near Millington	1379000	-	-	U	-	-	-	-
Passaic River near Chatham	1379500	O	O	U	D	U	O	O
Rockaway River at Pine Brook	1381200	O	U	U	O	U	O	O
Whippany River at Morristown	1381500	U	U	U	O	U	O	O
Whippany River near Pine Brook	1381800	O	U	O	O	U	D	O
Passaic River at Two Bridges	1382000	O	O	O	O	U	O	O
Wanaque River at Wanaque	1387000	O	U	U	O	U	D	O
Saddle River at Lodi	1391500	O	O	U	U	U	O	U
SB Raritan River at Middle Valley	1396280	O	O	U	-	U	-	O
SB Raritan River at Arch St at High Bridge	1396535	-	-	-	-	-	-	-
Mulhockaway Creek at Van Syckel	1396660	O	O	O	O	U	O	-
SB Raritan River at Three Bridges	1397400	O	O	U	O	U	-	-
NB Raritan River near Chester	1398260	-	-	-	O	-	-	O
NB Raritan River at Burnt Mills	1399120	U	U	U	O	U	O	-
Rockaway Creek at Whitehouse	1399700	O	O	U	O	U	D	O
Lamington (Black) River at Burnt Mills	1399780	U	U	U	O	U	O	O
Raritan River at Manville	1400500	O	U	U	O	U	O	O
Millstone River at Grovers Mill	1400650	U	O	O	O	O	O	U
Millstone River at Kingston	1401440	O	O	O	D	U	O	U
Beden Brook near Rocky Hill	1401600	O	O	O	O	U	O	O
Millstone River at Weston	1402540	O	O	O	O	U	O	O
Manalapan Brook at Federal Rd near Manalapan	1405340	O	-	-	O	-	U	U
Shark River near Neptune City	1407705	O	D	U	O	U	O	O
Jumping Brook near Neptune City	1407760	-	O	U	O	U	D	-
Marsh Bog Brook at Squankum	1407997	O	O	O	O	O	O	O
Toms River near Toms River	1408500	O	D	O	D	U	-	-
Mullica River at outlet of Atsion Lake at Atsion	1409387	O	O	O	D	O	O	O
Hammonton Creek at Wescoatville	1409416	-	-	-	-	-	-	-
Batsto River at Batsto	1409500	O	O	O	D	U	D	O
WB Wading River at Maxwell	1409815	-	-	O	O	U	-	-
Oswego River at Harrisville	1410000	O	O	O	O	U	D	O

Table 23. Water-quality trend results for New Jersey stream monitoring stations and streamwater constituents and properties used in contingency-table analysis--Continued

Drainage basin		Constituent						
Monitoring-station name	Monitoring-station number	Dissolved calcium	Disolved magnesium	Dissolved sodium	Disolved potassium	Disolved chloride	Fecal coliform bacteria	Fecal streptococcus bacteria
EB Bass River near New Gretna	1410150	O	O	O	-	O	D	-
Great Egg Harbor River near Sicklerville	1410784	-	-	-	-	-	-	-
Great Egg Harbor River near Blue Anchor	1410820	-	-	-	-	-	-	-
Great Egg Harbor River at Weymouth	1411110	O	D	O	O	O	D	U
Maurice River at Norma	1411500	O	U	D	D	U	-	-
Cohansey River at Seeley	1412800	D	U	D	O	D	O	U
Paulins Kill at Blairstown	1443500	O	O	U	D	O	O	O
Musconetcong River at outlet of Lake Hopatcong	1455500	O	O	U	D	U	O	U
Musconetcong River at Beatyestown	1456200	O	O	U	D	U	O	U
Musconetcong River at Riegelsville	1457400	O	O	U	O	U	O	O
Wickecheoke Creek at Stockton	1461300	O	O	D	D	D	D	O
Crosswicks Creek at Extonville	1464500	O	O	U	D	U	O	U
Doctors Creek at Allentown	1464515	O	D	U	O	O	U	U
SB Rancocas Creek at Vincentown	1465850	O	O	U	O	U	O	O
NB Rancocas Creek at Browns Mills	1465970	-	-	-	-	-	D	O
McDonalds Branch in Lebanon State Forest	1466500	O	O	O	O	O	-	-
NB Rancocas Creek at Pemberton	1467000	O	O	U	D	U	O	O
NB Pennsauken Creek near Moorestown	1467069	O	O	O	O	O	O	O
SB Pennsauken Creek at Cherry Hill	1467081	U	U	U	U	U	O	U
Cooper River at Norcross Rd at Lindenwold	1467120	U	U	U	D	U	D	O
Cooper River at Lawnside	1467140	O	U	U	O	O	O	U
SB Big Timber Creek at Blackwood Terrace	1467329	U	U	U	O	U	O	U
Raccoon Creek near Swedesboro	1477120	O	O	U	O	U	O	U
Oldmans Creek at Porches Mill	1477510	O	O	U	O	U	O	O
Salem River at Woodstown	1482500	O	O	U	O	U	O	O