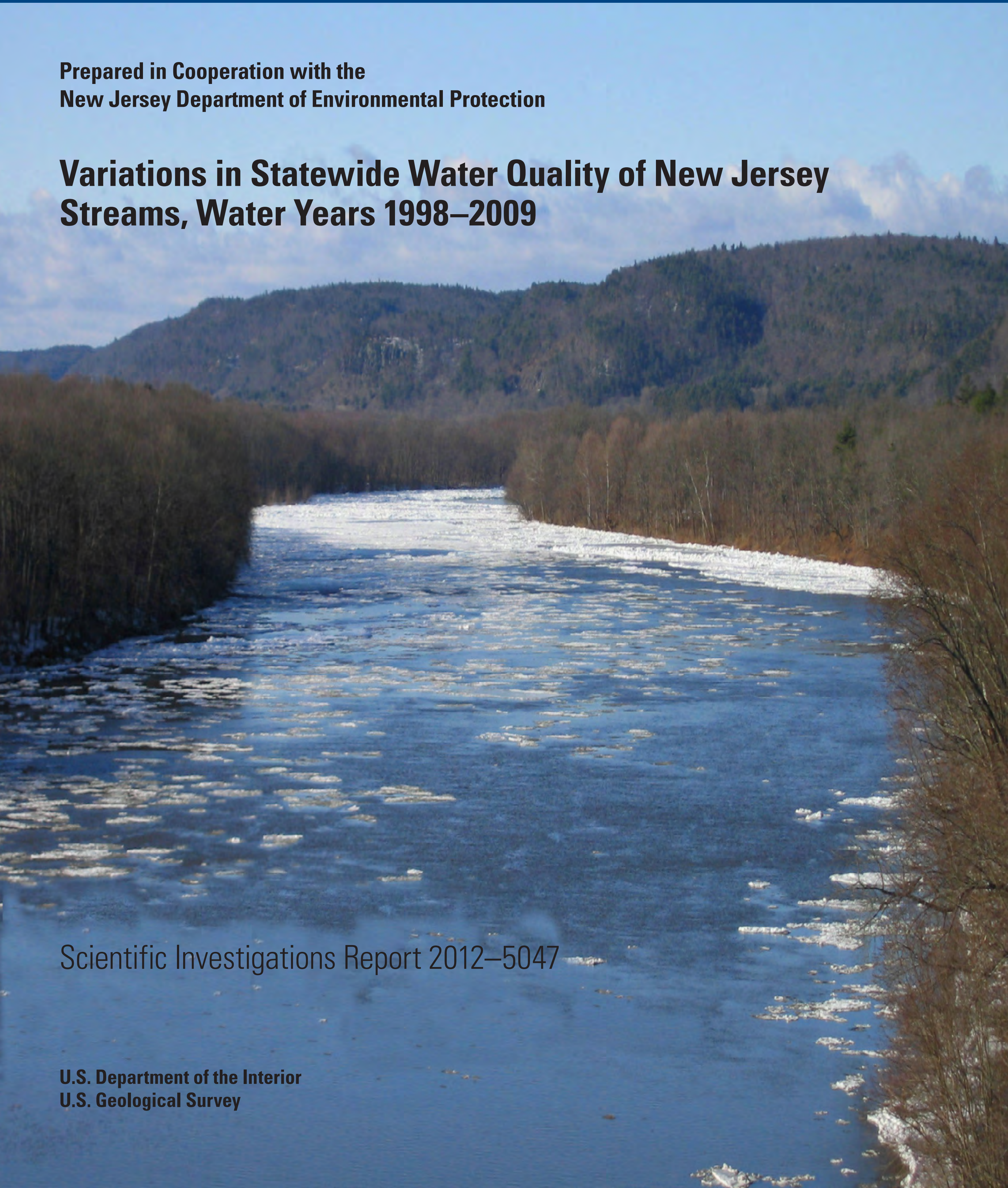
Prepared in Cooperation with the New Jersey Department of Environmental Protection

Variations in Statewide Water Quality of New Jersey Streams, Water Years 1998–2009



Scientific Investigations Report 2012–5047

U.S. Department of the Interior
U.S. Geological Survey

Front cover: Looking downstream from U.S. Geological Survey station 01438500, Delaware River at Montague, New Jersey (Statewide Status station during water year 2009).

Back cover: Top: U.S. Geological Survey station 01440000, Flat Brook near Flatbrookville, New Jersey (Index streamgaging station).

Bottom: U.S. Geological Survey station 01378780, Primrose Brook at Morristown National Historical Park (Background station during water years 2001–09) (File photographs).

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By Heather A. Heckathorn and Anna C. Deetz

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U.S. Department of the Interior
KEN SALAZAR, Secretary

U.S. Geological Survey
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U.S. Geological Survey, Reston, Virginia: 2012

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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.305	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square foot (ft^2)	929	square centimeter (cm^2)
square foot (ft^2)	0.093	square meter (m^2)
square inch (in^2)	6.452	square centimeter (cm^2)
square mile (mi^2)	259	hectare (ha)
square mile (mi^2)	2.59	square kilometer (km^2)
	Volume	
cubic inch (in^3)	16.39	cubic centimeter (cm^3)
cubic inch (in^3)	0.016	cubic decimeter (dm^3)
cubic inch (in^3)	0.01639	liter (L)
cubic foot (ft^3)	28.32	cubic decimeter (dm^3)
cubic foot (ft^3)	0.02832	cubic meter (m^3)
cubic yard (yd^3)	0.7646	cubic meter (m^3)
	Flow rate	
foot per second (ft/s)	0.3048	meter per second (m/s)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

°F=(1.8×°C)+32

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

°C=(°F-32)/1.8

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

Variations in Statewide Water Quality of New Jersey Streams, Water Years 1998–2009

By Heather A. Heckathorn and Anna C. Deetz

Abstract

Statistical analyses were conducted for six water-quality constituents measured at 371 surface-water-quality stations during water years 1998–2009 to determine changes in concentrations over time. This study examined year-round concentrations of total dissolved solids, dissolved nitrite plus nitrate, dissolved phosphorus, total phosphorus, and total nitrogen; concentrations of dissolved chloride were measured only from January to March. All the water-quality data analyzed were collected by the New Jersey Department of Environmental Protection and the U.S. Geological Survey as part of the cooperative Ambient Surface-Water-Quality Monitoring Network.

Stations were divided into groups according to the 1-year or 2-year period that the stations were part of the Ambient Surface-Water-Quality Monitoring Network. Data were obtained from the eight groups of Statewide Status stations for water years 1998, 1999, 2000, 2001–02, 2003–04, 2005–06, 2007–08, and 2009. The data from each group were compared to the data from each of the other groups and to baseline data obtained from Background stations unaffected by human activity that were sampled during the same time periods.

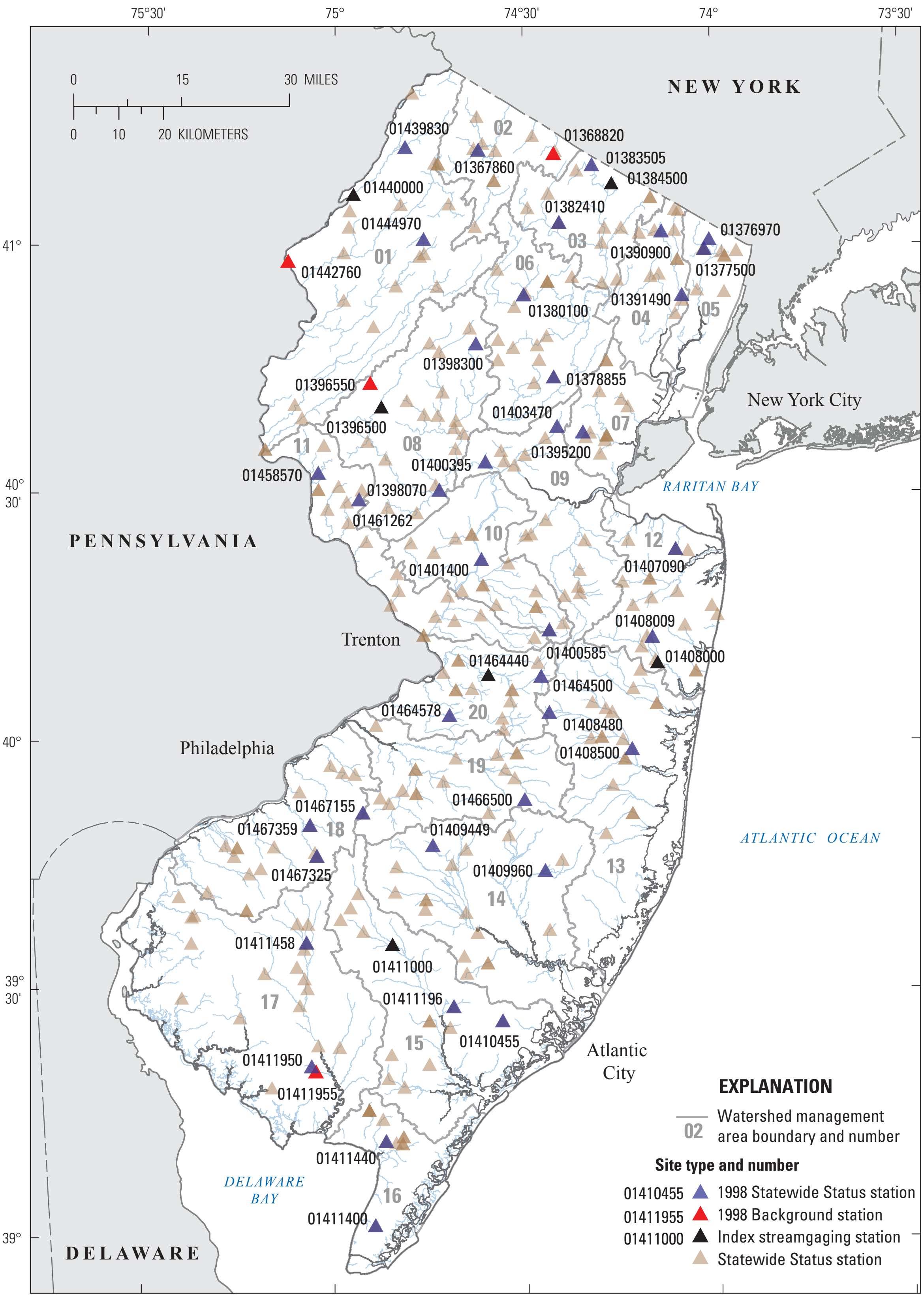
The Kruskal-Wallis test was used to determine whether median concentrations of a selected water-quality constituent measured in a particular 1-year or 2-year group were different from those measured in other 1-year or 2-year groups. If the median concentrations were found to differ among years or groups of years, then Tukey's multiple comparison test on ranks was used to identify those years with different or equal concentrations of water-quality constituents. A significance level of 0.05 was selected to indicate significant changes in median concentrations of water-quality constituents.

More variations in the median concentrations of water-quality constituents were observed at Statewide Status stations (randomly chosen stations scattered throughout the State of New Jersey) than at Background stations (control stations that are located on reaches of streams relatively unaffected by human activity) during water years 1998–2009. Results of tests on concentrations of total dissolved solids, dissolved chloride, dissolved nitrite plus nitrate, total phosphorus, and total nitrogen indicate a significant difference in water quality at Statewide Status stations but not at Background stations during the study period. Excluding water year 2009, all significant changes that were observed in the median concentrations were ultimately increases, except for total phosphorus, which varied significantly but in an inconsistent pattern during water years 1998–2009.

Streamflow data aided in the interpretation of the results for this study. Extreme values of water-quality constituents generally followed inverse patterns of streamflow. Low streamflow conditions helped explain elevated concentrations of several constituents during water years 2001–02. During extreme drought conditions in 2002, maximum concentrations occurred for four of the six water-quality constituents examined in this study at Statewide Status stations (maximum concentration of 4,190 milligrams per liter of total dissolved solids) and three of six constituents at Background stations (maximum concentration of 179 milligrams per liter of total dissolved solids). The changes in water quality observed in this study parallel many of the findings from previous studies of trends in New Jersey.

Introduction

The U.S. Geological Survey (USGS), in cooperation with the New Jersey Department of Environmental Protection (NJDEP), implemented the Ambient Surface-Water-Quality Monitoring Network (Network) in 1985 and redesigned it in 1997 (New Jersey Department of Environmental Protection, 1997). This Network of 115 stations was designed to define background water quality in each of the four physiographic provinces of New Jersey; measure surface-water quality near the downstream end of each NJDEP Watershed Management Area (WMA); determine the statewide status of, and trends in, surface-water quality; measure nonpoint-source contributions from major land-use areas and atmospheric deposition; and coordinate biological monitoring locations with water-monitoring locations (DeLuca and others, 2005). Stations within the Network are located throughout the 20 WMAs in the State of New Jersey; each water-quality sampling station was categorized into one of five groups—Delaware River main stem, Watershed Integrator, Land Use Indicator, Background, and Statewide Status (hereafter referred to as Status stations) (figs. 1–9).



Base from U.S. Geological Survey digital line graph files 1:24,000, Universal Transverse Mercator projection, Zone 18, NAD83

Figure 1. Locations of selected water-quality monitoring stations in New Jersey streams, water year 1998.

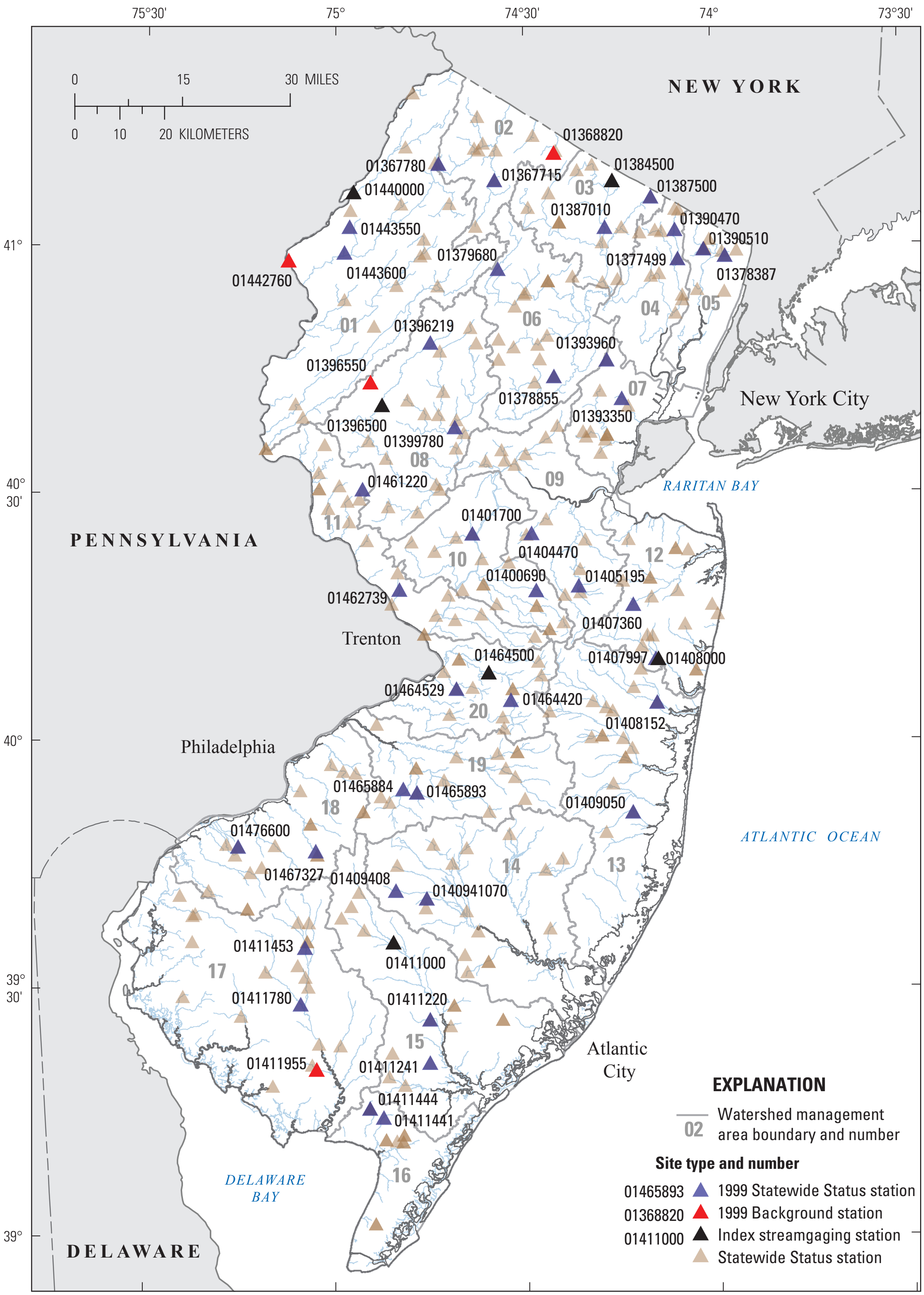


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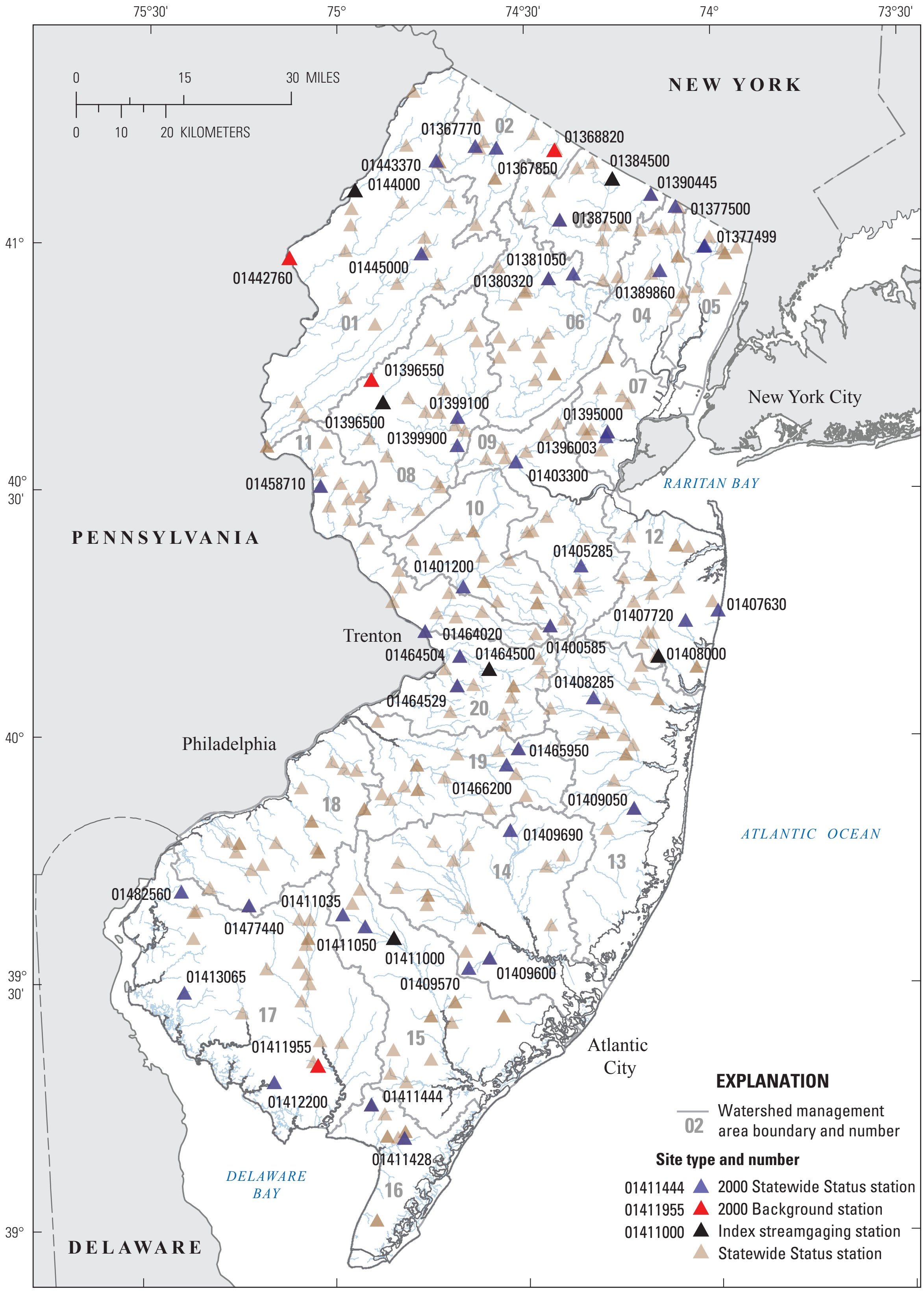
Figure 2. Locations of selected water-quality monitoring stations in New Jersey streams, water year 1999.



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Universal Transverse Mercator projection, Zone 18, NAD83

Figure 3. Locations of selected water-quality monitoring stations in New Jersey streams, water year 2000.

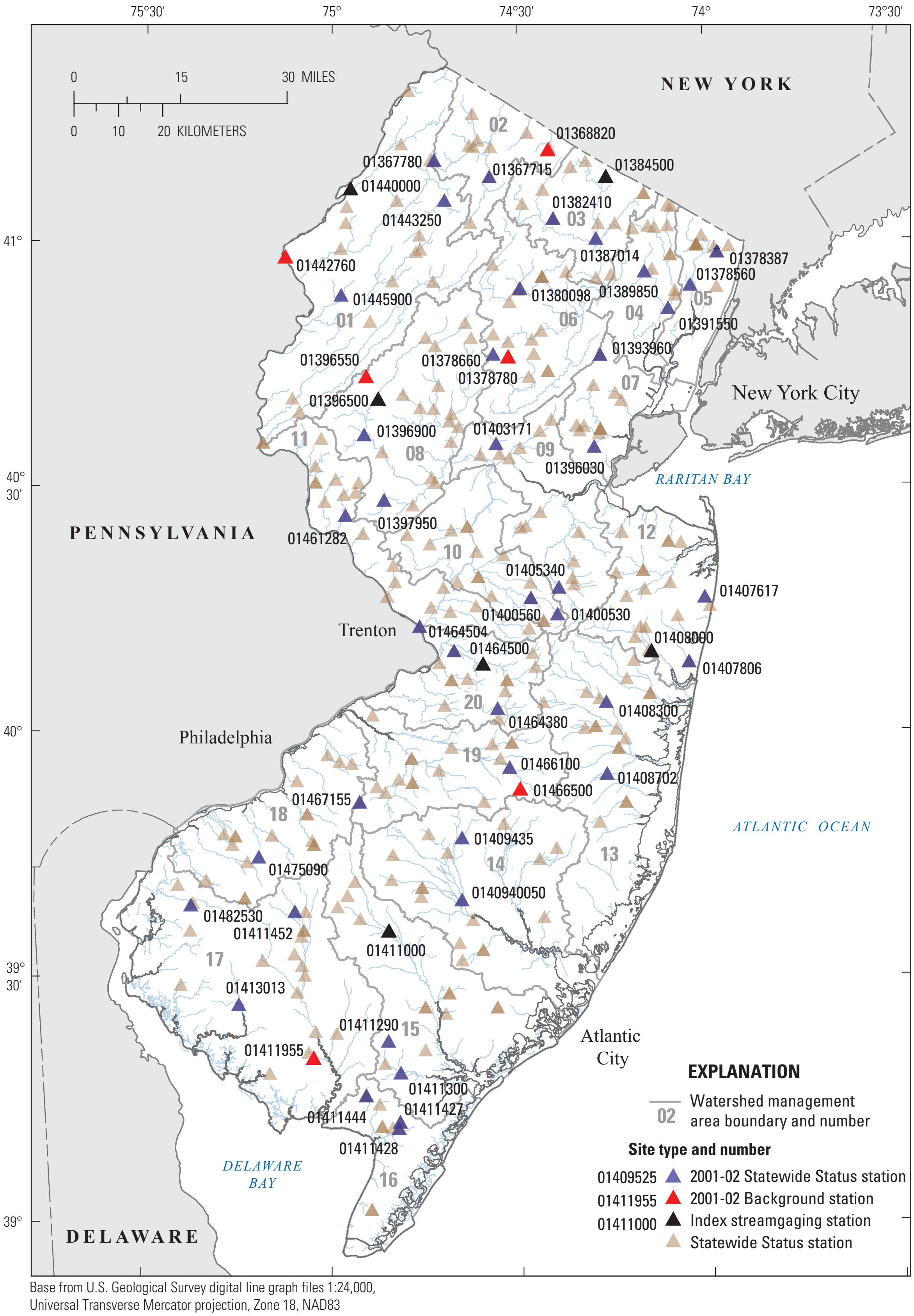

Figure 4. Locations of selected water-quality monitoring stations in New Jersey streams, water years 2001–02.

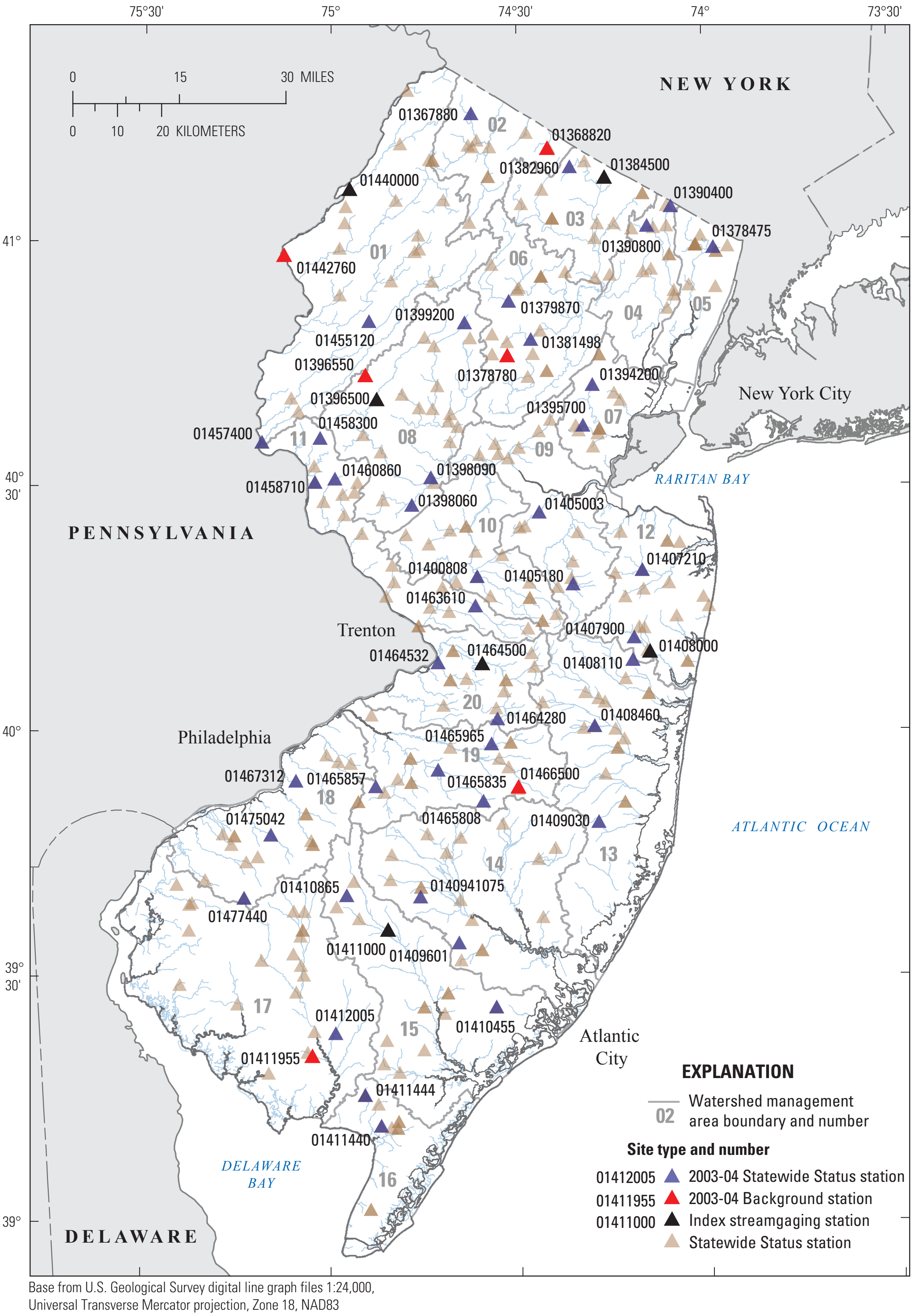

Figure 5. Locations of selected water-quality monitoring stations in New Jersey streams, water years 2003–04.

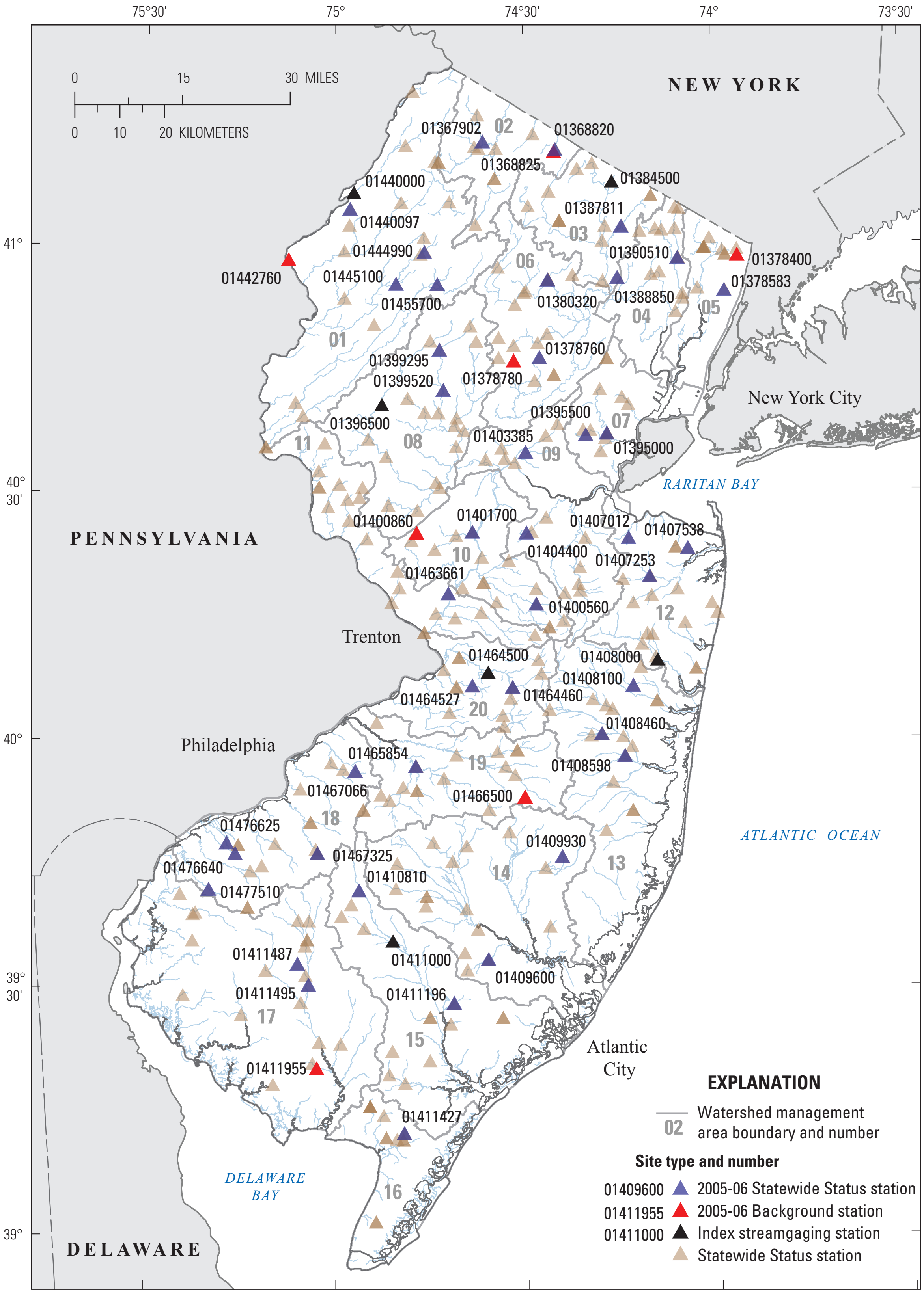

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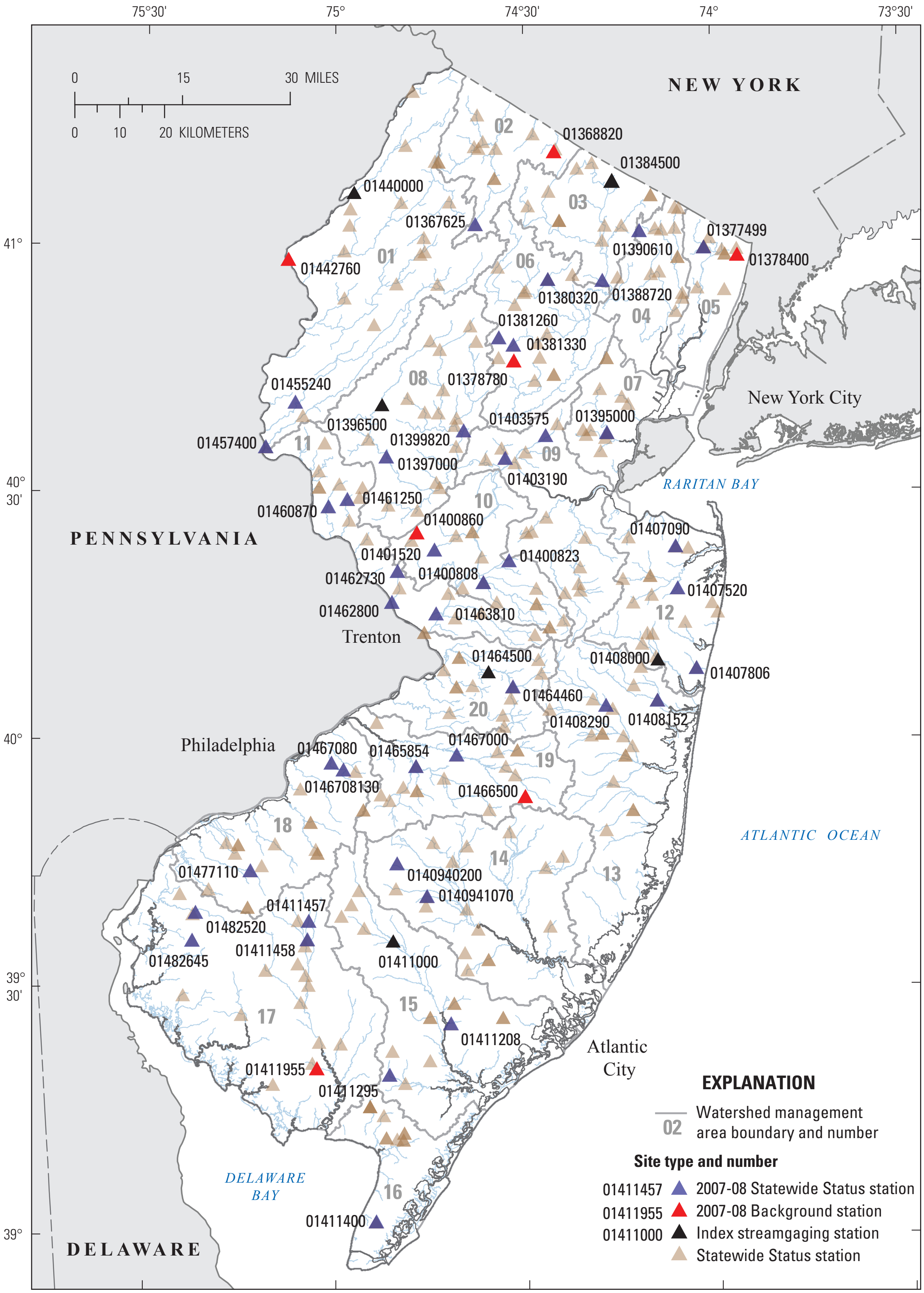
Figure 6. Locations of selected water-quality monitoring stations in New Jersey streams, water years 2005–06.



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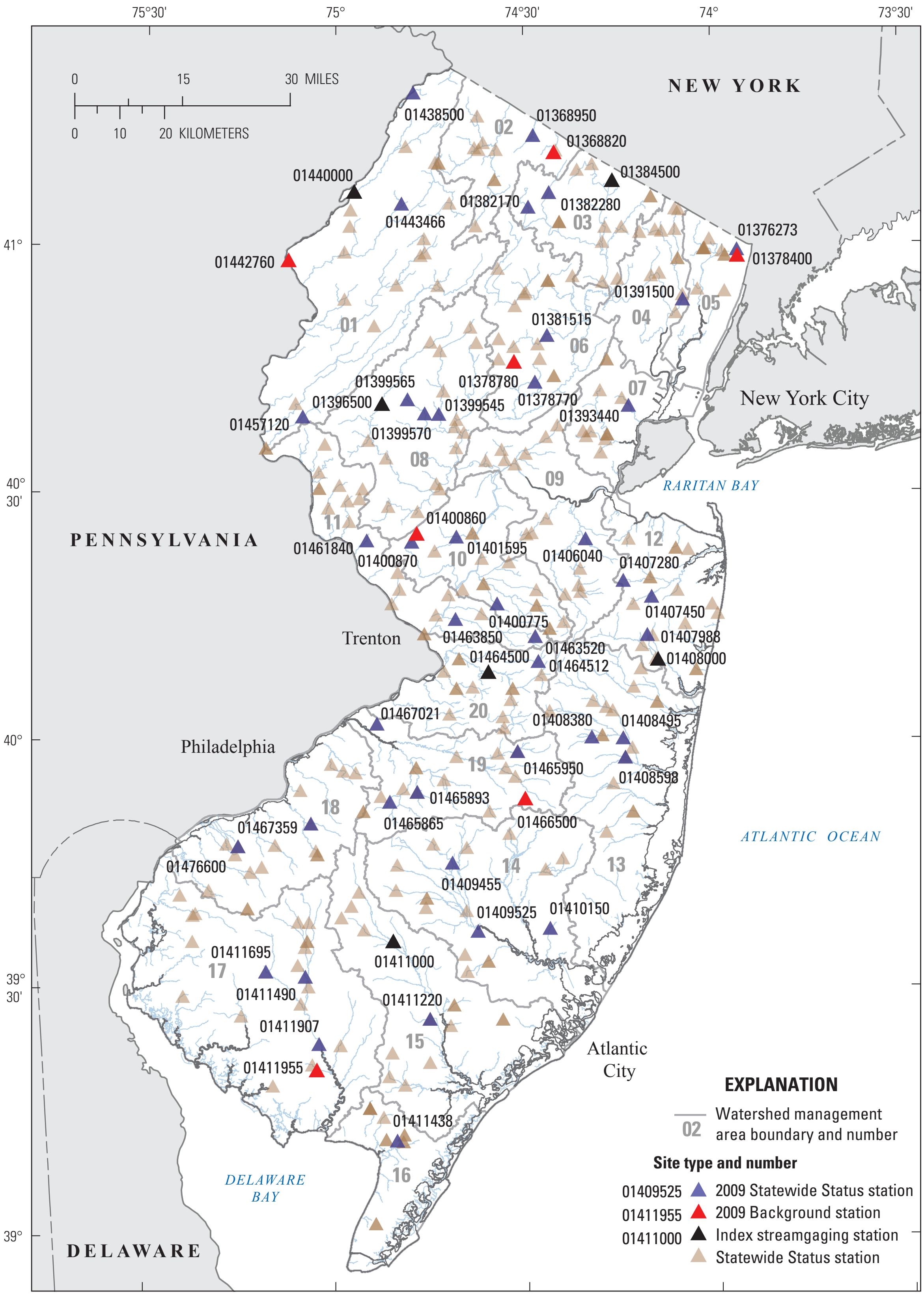
Universal Transverse Mercator projection, Zone 18, NAD83

Figure 7. Locations of selected water-quality monitoring stations in New Jersey streams, water years 2007–08.



Base from U.S. Geological Survey digital line graph files 1:24,000,
Universal Transverse Mercator projection, Zone 18, NAD83

Figure 8. Locations of selected water-quality monitoring stations in New Jersey streams, water year 2009.

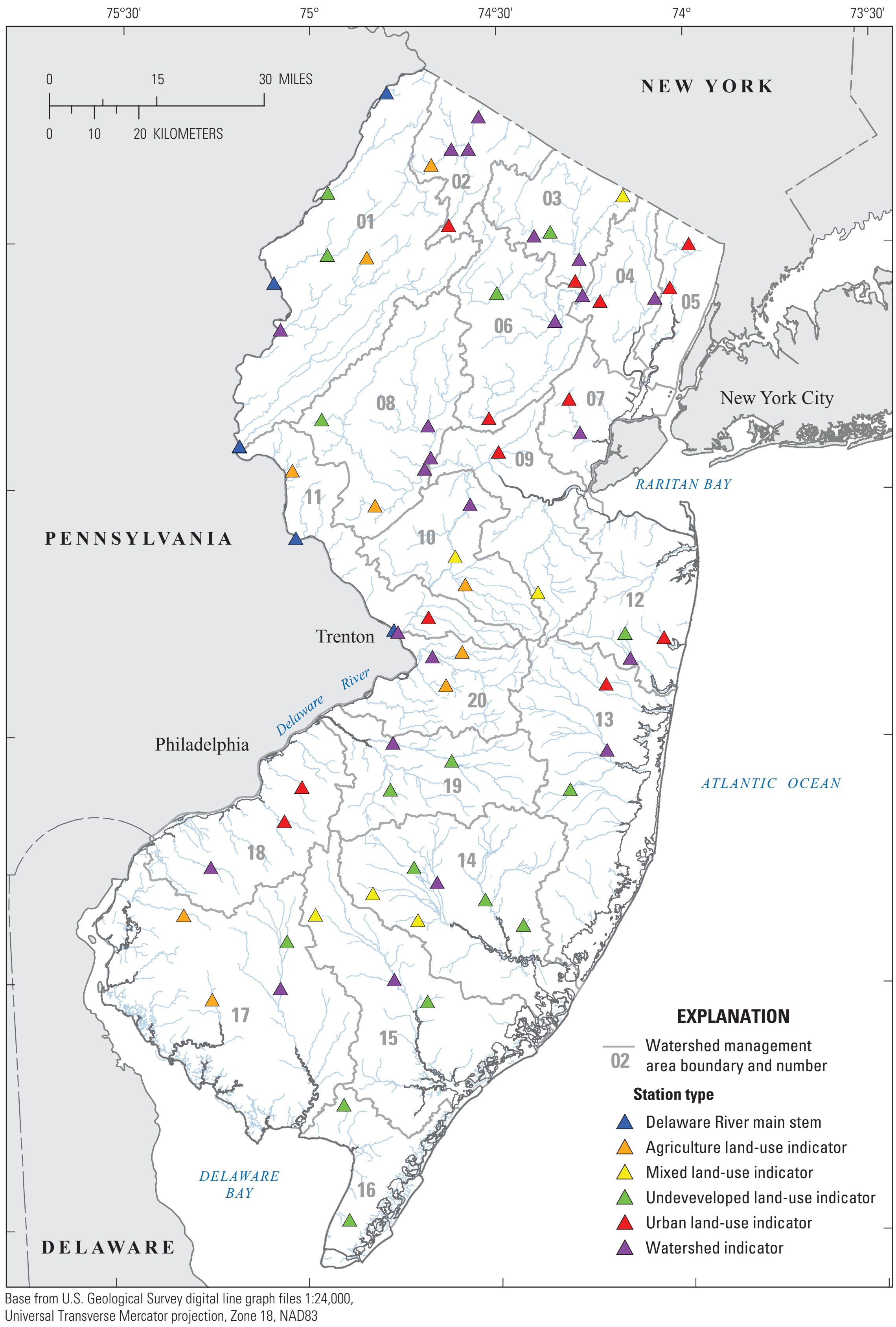


Figure 9. Locations of Delaware River main stem, Land Use indicator and Watershed Integrator stations within the Ambient Surface-Water-Quality Monitoring Network in New Jersey, water years 1998–2009.

Delaware River main stem stations are located on the main stem of the Delaware River, the physical boundary separating New Jersey and Pennsylvania (fig. 9). Stations designated as Watershed Integrator are located in 17 of the 20 WMAs, near the farthest downstream point that is unaffected by tides. These stations are used to monitor the integrated effects of different types of land use and point and nonpoint sources within each WMA on the quality of the surface water (fig. 9). Data obtained from Land Use Indicator stations are used in contaminant-load studies to assess the effects of the dominant type of land use (urban, agriculture, forest, barren, wetland, and water) on constituent loads to streams. The purpose of the Status stations within the Network was to establish a surface-water-quality dataset from which statistical analyses could be conducted and trends could be determined and compared statewide (DeLuca and others, 2005). Background stations that represent each physiographic province throughout the State are located on reaches of streams unaffected by human activity and have been used to establish a baseline of water quality representative of the physiographic province in which they are located.

Of particular interest to the NJDEP is the existence or nonexistence of significant variations in concentrations of water-quality constituents among sets of stations designated as Status stations within the study period, water years[1] 1998–2009. The USGS, in cooperation with the NJDEP, conducted a study to examine changes in concentrations of water-quality constituents between sets of Status stations during water years 1998–2009. Datasets obtained from each of the eight sets of Status stations—one set for each of water years 1998, 1999, 2000, 2001–02, 2003–04, 2005–06, 2007–08, and 2009—were compared. The water-quality constituents total dissolved solids (TDS), dissolved chloride, dissolved nitrite plus nitrate, dissolved phosphorus, total phosphorus, and total nitrogen were chosen for statistical analysis in cooperation with the NJDEP. These constituents are of particular interest because of the existence of an in-stream standard (New Jersey Department of Environmental Protection, 2010) or because of the constituent's relevance to the eutrophication of flowing freshwaters. Year-round measurements of five water-quality constituents and measurements of chloride made only during winter months (January to March) were evaluated. Datasets obtained from Background stations were used as baselines for comparison of changes in water quality during the study period. This comparison of Status and Background data is informative because Background stations are located in basins that are relatively unaffected by human activity and, therefore, show little change in water quality over time.

The data for this study came from samples collected quarterly during November–December, February–March, May–June, and August–September. In addition to the measurement of physical characteristics at each station, samples were collected and analyzed for concentrations of various water-quality constituents including, but not limited to, total and dissolved nutrients, dissolved major ions, and dissolved organic carbon. These data are stored in the USGS National Water Information System (NWIS) computer database (described in Mathey, 1998) and are available to the public at the USGS NWIS website (*http://waterdata.usgs.gov/nj/nwis/qw/*).

The approach utilized to evaluate variations in statewide water quality was to use two statistical tests, the Kruskal-Wallis and Tukey's multiple comparison tests. The Kruskal-Wallis method was used to test the equality of the medians of a particular constituent among subsets of stations (sets of Status stations for each 1- or 2-year period). Tukey's multiple comparison test (Tukey's test) was used to determine whether the differences, if any, between the population medians were statistically significant.

Purpose and Scope

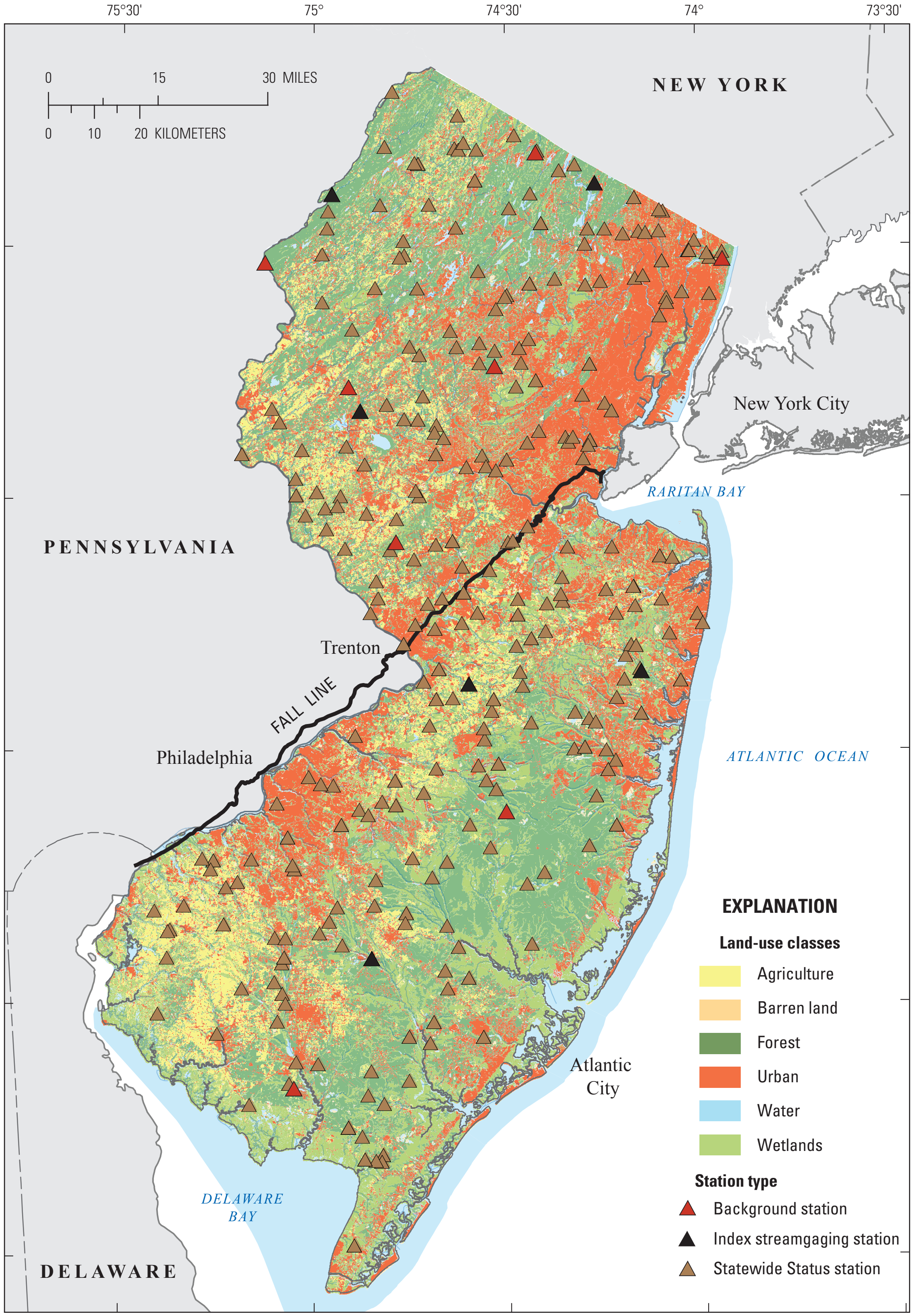
This report presents the results of statistical analyses used to identify significant variations in surface-water quality in the State of New Jersey among eight time periods ranging from water year 1998 to water year 2009. Water-quality data from randomly selected stations representative of streams throughout New Jersey were used in the analyses. Consistent increases or decreases in concentrations of selected water-quality constituents are identified and compared with results from previous investigations. Summary statistics for each water-quality constituent for each of the eight time periods, as well as results of statistical analyses of variations in statewide water quality, are discussed and presented in figures and tables.

Year-round measurements of TDS, dissolved nitrite plus nitrate, dissolved phosphorus, total phosphorus, and total nitrogen were statistically analyzed. Concentrations of dissolved chloride measured only from January to March, when road salt application is likely to occur, were also statistically analyzed. Differences between water quality measured at Status stations and water quality measured at Background stations during the selected time frame are identified. Some changes in water quality are compared to variations in annual streamflow at representative streamgaging stations. Results of statistical analyses of variations in statewide water quality are discussed and presented in tables and figures.

Study Area

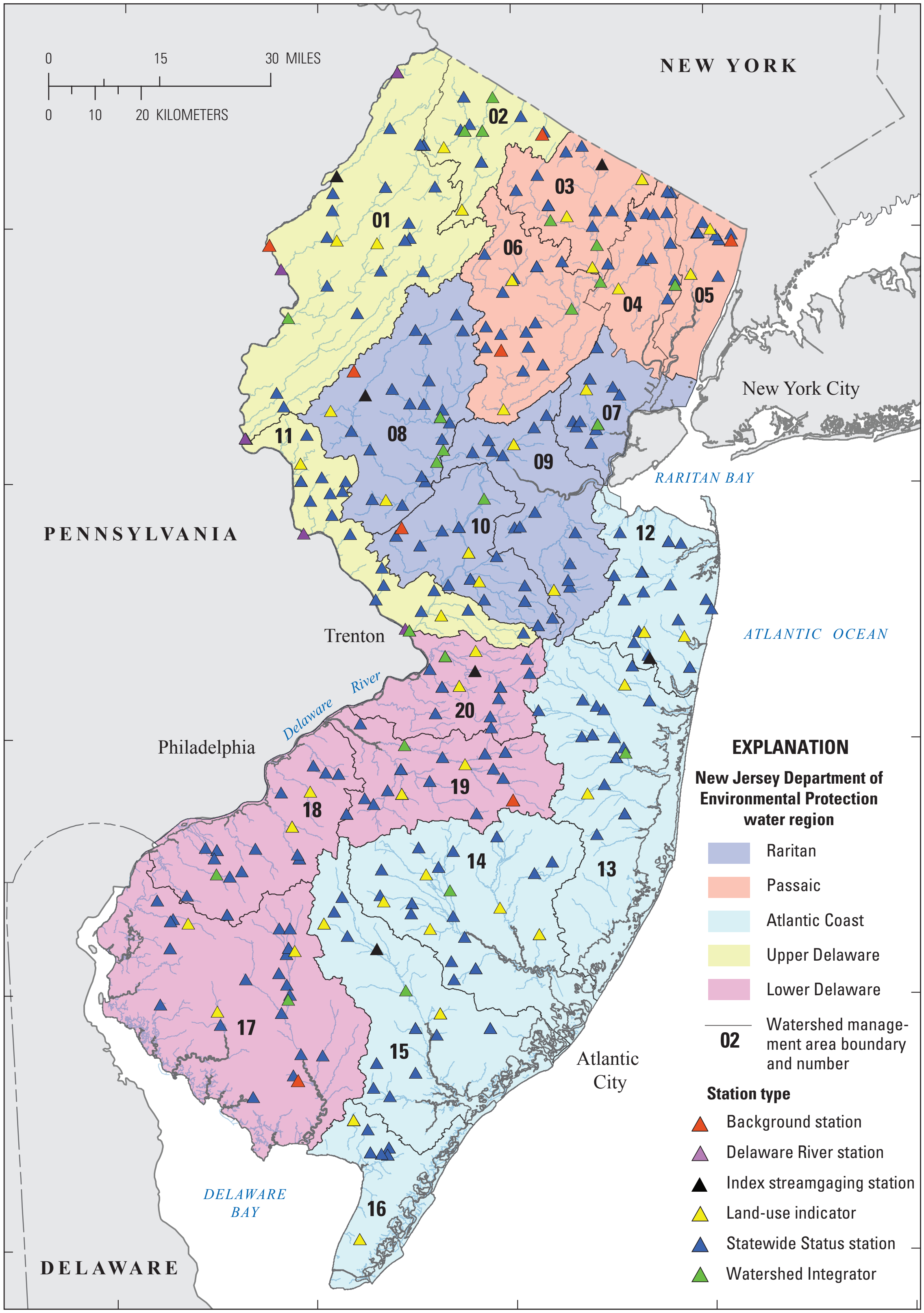
The Fall Line, which divides New Jersey into the northern and southern regions, marks the geologic boundary of sedimentary and crystalline bedrock to the north and gravel, sand, silt, and clay to the south (fig. 10). The elevation is greater, and the topographic relief is more variable, in the northern region than in the southern region. New Jersey has been divided into five water regions—Passaic, Raritan, Upper Delaware, Lower Delaware, and Atlantic Coastal (fig. 11). These regions were further divided into Water Management Areas (WMAs), established by the NJDEP to protect New

[1] A water year is the 12-month period beginning October 1 and ending September 30. It is designated by the year in which it ends.



Base from U.S. Geological Survey digital line graph files 1:24,000,
Universal Transverse Mercator projection, Zone 18, NAD83

Figure 10. Location of the Fall Line, land use, and station types in New Jersey.



Base from U.S. Geological Survey digital line graph files 1:24,000, Universal Transverse Mercator projection, Zone 18, NAD83

Figure 11. Location of New Jersey Department of Environmental Protection water regions and Watershed Management Areas with locations of water-quality stations in New Jersey.

Jersey's freshwater resources, then subdivided into over 100 individual watersheds. Land use varies considerably throughout the State of New Jersey. Urban land is concentrated in the northeastern part of the State near New York City and along the Atlantic coast. Agricultural land tends to be in the western half of the State, and forests are dense in the northwestern and southeastern part of the State (fig. 10).

Previous Investigations

Three previous studies reported on trends in the water quality at Network stations throughout New Jersey. Hickman and Gray (2010) report trends in water-quality constituents at fixed stations (Watershed Integrator and Land Use Indicator) within the Network during water years 1998 to 2007. Hickman and Gray conducted trend tests on six water-quality constituents for 70 water-quality stations—69 fixed stations and 1 station on the main stem of the Delaware River—during the period of study. Monotonic trends were identified using procedures in the ESTREND computer program (Schertz and others, 1991). Flow-adjusted values of dissolved oxygen, pH, TDS, total phosphorus, total organic nitrogen plus ammonia, and dissolved nitrite plus nitrate were analyzed for trends. Values of water quality were adjusted for flow to reduce some of the effects of streamflow on the variations in water quality.

Hickman and Barringer (1999) analyzed data from 83 fixed stations and identified changes in 24 water-quality constituents that were unadjusted and streamflow-adjusted for water years 1986 to 1995. Hay and Campbell (1990) identify changes in 48 water-quality constituents during two periods—water years 1976 to 1986 and water years 1980 to 1986.

Study Methods and Design

Water-quality data at Status stations and Background stations, and streamflow at selected Index stations discussed in this report, were retrieved from the USGS National Water Information System (NWIS) computer database (described in Mathey, 1998) and are available[2] to the public at *http://www.waterdata.usgs.gov/nj/nwis*

The streamwater quality in New Jersey is monitored by the USGS New Jersey Water Science Center in cooperation with several other State and local agencies. These data, accumulated over many water years, have contributed to a better understanding of the water quality in the State.

Selection of Water-Quality Stations

A total of 371 stations sampled for water quality were included in the study. Of the five station types in the Network, this report focuses on two—Status and Background (appendixes 1–8).

A different set of Status stations was chosen annually for water years 1998 to 2002; beginning with water year 2003 and continuing through 2009, a different set was chosen biennially. With the exception of water year 1998, when 38 Status stations were chosen for inclusion in the Network, 42 Status stations were selected for each 1-year or 2-year period electronically by a random-number generator from the more than 800 stations in the NJDEP Ambient Monitoring Network (AMNET), which is an existing universe of stations throughout the State that are intended to represent all non-tidal New Jersey stream reaches.

During water years 1998–2000, there were four Background stations in the Network. Two additional stations were added in 2001. In 2005, one Background station was relocated, and one was added to the Network for a total of seven Background stations.

The drainage basins of most of the Status stations included in this study range from 0.25 to 804 square miles and lie entirely within New Jersey or within New Jersey and adjacent parts of southern New York. One station is on the main stem Delaware River and has a drainage area of 3,480 square miles, including large parts of Pennsylvania and New York. Drainage basins of Background stations are generally much smaller than those of Status stations and, in this study, range from 0.35 to 6.46 square miles and lie entirely within New Jersey or within New Jersey and adjacent parts of eastern Pennsylvania.

Field and Laboratory Measurements and Sample Collection

Field measurements and sample collection at each station were conducted by personnel of either the USGS or the NJDEP. Field methods for the collection of water-quality data are described in the USGS National Field Manual (U.S. Geological Survey, variously dated). Samples of surface water were collected from multiple points across a cross section and composited in a churn splitter (U.S. Geological Survey, variously dated). In compliance with standard USGS protocols, the sample-collection vessel varied depending on stream velocity. For samples collected from wadeable streams or with a weighted-bottle sampler from a bridge at unwadeable reaches, an open-mouth bottle was used at stations with velocities less than 1.5 feet per second. A DH-81 or DH-95 sampler was used for isokinetic sample collection from wadeable streams or sample collection from a bridge, respectively, when velocities equaled or exceeded 1.5 feet per second (U.S. Geological Survey, variously dated). Depth-and-width-integrated samples from multiple points across the cross section were composited in a churn splitter; the composite was then split into subsamples for laboratory analysis for individual constituents (U.S. Geological Survey, variously dated). Additionally, the composite sample was filtered and split into subsamples to be analyzed for dissolved constituents.

[2] The data are published annually in data reports for individual water years. Data reports were printed through water year 2005 and are available at *http://wdr.water.usgs.gov/*. Beginning with water year 2006, only electronic versions of data reports were published.

Concentrations of TDS, total phosphorus, dissolved phosphorus, dissolved chloride, and dissolved nitrite plus nitrate were measured analytically at the National Water Quality Laboratory in Denver, Colorado; total and dissolved phosphorus were analyzed by the USGS laboratory in Ocala, Florida, for a brief period of time during water year 2004. Laboratory methods used to determine concentrations of total phosphorus, dissolved phosphorus, and dissolved nitrite plus nitrate changed throughout the study period. Methods of laboratory analysis are listed in table 1. Concentrations of total nitrogen were calculated using methods described later in this report.

Streamflow

The USGS, in cooperation with Federal, State, and local agencies, collects a large amount of streamflow data in New Jersey each water year. These data constitute a valuable database for developing an improved understanding of the water resources of the State.

In an effort to provide an areal depiction of annual streamflow in the State, six continuous-recording gaging stations, maintained and operated by the USGS New Jersey Water Science Center, with relatively long periods of record were chosen as Index streamgaging stations for this study (figs. 1–8 and 10–12; appendix 9). The periods of record for the six Index stations range from 69 years at Crosswicks Creek at Extonville, NJ, (01464500) to 90 years at South Branch Raritan River near High Bridge, NJ (01396500). These six gages were selected because the variation in annual streamflow measured by them is believed to accurately represent the variation in unregulated annual streamflow in the different water regions throughout the State. One Index streamgaging station was chosen from each of the following four water

Table 1. References for methods of laboratory analyses of selected water-quality constituents in New Jersey, water years 1998–2009.

Water-quality constituent	Comment	Reference for method of laboratory determination
Total dissolved solids	For period of study	Fishman and Friedman (1989)
Dissolved chloride	For period of study	Fishman and Friedman (1989)
Dissolved nitrite plus nitrate	From the beginning of the period of study through September 30, 2003	Fishman (1993)
	October 1, 2003, to July 31, 2004	Fishman and Friedman (1989)
	August 1, 2004, to the end of the period of study	Fishman (1993)
Dissolved phosphorus	From the beginning of the period of study through September 30, 2003	Fishman (1993)
	October 1, 2003, to July 31, 2004	Fishman and Friedman (1989)
	August 1, 2004, to the end of the period of study	Fishman (1993)
Total phosphorus	From the beginning of the period of study through December 31, 2002	Patton and Truitt (1992)
	January 1, 2003, to September 30, 2003	Patton and Kryskalla (2003)
	October 1, 2003, to July 31, 2004	Fishman and Friedman (1989)
	August 1, 2004, to the end of the period of study	Patton and Kryskalla (2003)
Total nitrogen	For period of study	Calculated[1] from laboratory-reported concentrations of dissolved organic nitrogen plus ammonia (Fishman, 1993), dissolved nitrite plus nitrate, and total particulate nitrogen (U.S. Environmental Protection Agency, 1997)

[1]Method of calculation is described in the text.

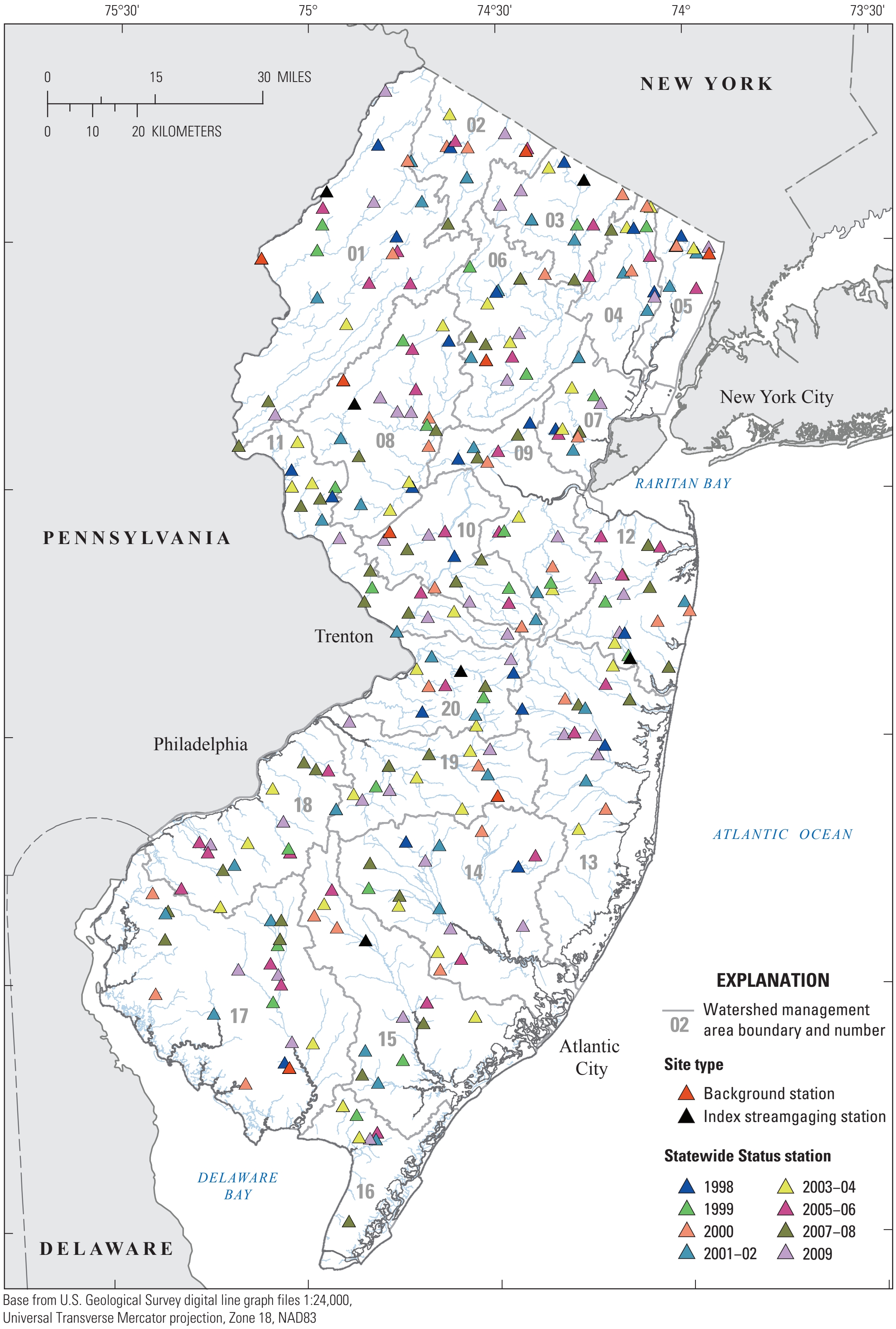


Figure 12. Locations of Statewide Status stations, by 1-year and 2-year groups, Background stations and Index streamgaging stations in New Jersey.

regions of the State —Passaic, Raritan, Upper Delaware, and Lower Delaware; two stations were chosen from the Atlantic Coastal water regions—one in each of the upper and lower Atlantic Coastal water regions.

In order to compare annual streamflows among Index streamgages to one another, annual mean streamflows during 1998–2009 were converted to nonexceedance values. For each Index streamgage, each annual mean streamflow was compared to the range of annual mean streamflows measured during the period of record; the nonexceedance value is the percentage of all annual mean streamflows not exceeded by the annual mean streamflow in that year (fig. 13). As an example, a nonexceedance value lower than 50 percent indicates that the annual mean streamflow for that particular year is less than the annual mean streamflow measured in most years of the period of record. Likewise, a nonexceedance value of 20 percent indicates that the annual mean streamflow for that particular year was exceeded 80 percent of the time that the streamgage has been in operation.

The flow-duration curve is a cumulative frequency curve that shows the percentage of time specified discharges were equaled or exceeded during a given period (Searcy, 1959). The flow-duration curve combines the streamflow characteristics of a stream throughout the range of discharge in one curve (Searcy, 1959).

Daily mean discharge data, the mean of instantaneous discharge values for a day (Buchanan and Somers, 1976) from each of the six Index streamgaging stations were used to calculate flow durations. Daily mean streamflows for the streamgaging stations are available on the World Wide Web (*http://waterdata.usgs.gov/nj/nwis/*).

Preparation for Statistical Analysis

The water-quality constituents investigated in this study were selected in cooperation with NJDEP. As previously discussed, the constituents were chosen on the basis of the availability of the data and applicability to New Jersey stream-water standards, as well as the likelihood that the constituents would exhibit changes over time that reflect the fluctuations in New Jersey land use and management practices (New Jersey Department of Environmental Protection, 2010).

Laboratory Reporting Conventions

Three types of water-quality values are discussed in this report—estimated values, less-than censored values (nondetects), and uncensored values. The reporting convention that the USGS National Water Quality Laboratory (NWQL) uses for these constituents is the laboratory reporting level (LRL). The LRL is generally equal to twice the yearly determined long-term method detection level (LT-MDL), a detection level derived by determining the standard deviation of a minimum

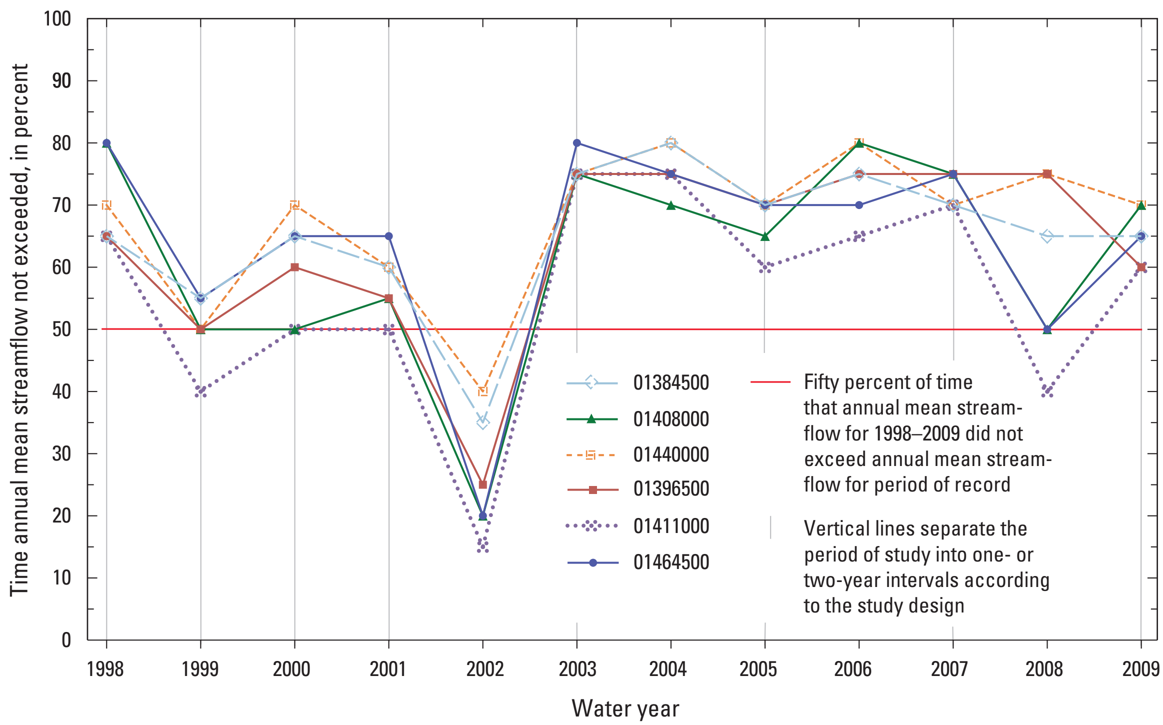


Figure 13. Percentage of time that annual mean streamflow did not exceed annual mean streamflow for the period of record at six Index streamgaging stations in New Jersey, water years 1998–2009.

of 24 method detection limit spiked-sample measurements over an extended period of time. A spiked sample is a quality-control sample used to evaluate the effects of sample matrix on the performance of an analytical method (U.S. Geological Survey, variously dated). The LT-MDL controls false positive error. The probability of falsely reporting a concentration at or greater than the LT-MDL for a sample that did not contain an analyte is predicted to be less than or equal to 1 percent. The LRL controls false negative error. The probability of falsely reporting a non-detection for a sample that contained an analyte at a concentration equal to or greater than the LRL is predicted to be less than or equal to 1 percent. Analytes detected at concentrations between the LT-MDL and the LRL and that pass identification criteria are “estimated” (noted with a remark code of E) by the laboratory.

Less-than censored values, or nondetects, are measurements whose values are known only to be less than a threshold. Nondetects indicate that the reported concentration was less than the reporting level. For samples in which the analyte is not detected, the value of the LRL is reported with a “less than” (<) remark code. Uncensored values, or detects, indicate that the concentration was reliably determined to be greater than or equal to the laboratory reporting level.

As a result of changes in methods or reporting protocols, the reporting level for a given constituent sometimes changed during the period of study. Water-quality data used for this study were modified in an effort to provide a more accurate determination of changes in water-quality constituents than those that would have been calculated from unmodified data retrieved directly from the NWIS database. These modifications are described below.

Recensoring of Nondetect Data

For some nondetect results, the USGS NWQL set laboratory reporting levels to twice the concentration of the long-term method detection limit to reduce the possibility of reporting false positives (Oblinger-Childress and others, 1999). This practice complicates statistical interpretation. Typically, results of statistical analyses calculated with nondetects reported with laboratory reporting levels are biased (Hickman and Gray, 2010). To avoid such bias, laboratory reporting levels for nondetect values were set back to the long-term method detection limit (half of the laboratory reporting level), as recommended by Helsel (2005). There were multiple LRLs associated with each analyte during the period of study as a result of changing laboratory methods of analysis and precision of analytical instruments. In these cases, censored values were corrected to the highest LT-MDL.

Calculation of Total Nitrogen

As noted in table 1, values of total nitrogen (TN) were not determined by laboratory methods but were determined by a calculation summing laboratory results for concentrations of dissolved organic nitrogen plus ammonia (Kjeldahl) (DKN), dissolved nitrite plus nitrate (NO_2+NO_3), and total particulate nitrogen (TPN). Because any of the contributing constituents can potentially be a non-detect, total nitrogen values are often censored. If the value for total nitrogen was censored below the reporting level, then the following set of rules was applied to the recalculation of total nitrogen:

If *DKN* or NO_2+NO_3 or *TPN* was not detected (*ND*)

and if

$$\sum (ND) < 0.1\ (TN),$$

then *TN* was determined using

$$TN = \sum (DKN + (NO_2+NO_3) + TPN) - \sum (ND); \quad (1)$$

If *DKN* or NO_2+NO_3 or *TPN* was not detected (*ND*)

and if

$$\sum (ND) \geq 0.1\ (TN),$$

then *TN* was determined using

$$TN = \sum (DKN + (NO_2+NO_3) + TPN); \quad (2)$$

If *DKN* and NO_2+NO_3 and *TPN* were not censored < LRL,

then

$$TN = \sum (DKN + (NO_2+NO_3) + TPN), \quad (3)$$

where

TN	=	concentration of total nitrogen, in mg/L (milligrams per liter);
DKN	=	concentration of dissolved ammonia plus organic nitrogen, in mg/L as N;
NO_2+NO_3	=	concentration of dissolved nitrite plus nitrate, in mg/L as N;
TPN	=	concentration of total particulate nitrogen, in mg/L as N; and
ND	=	concentration of the water-quality constituent(s) that was not detected.

The sum of the contributing constituent LRLs, equal to 0.18 mg/L, was used to impose an overall LRL for total nitrogen. A rule was imposed so that 10 percent of the total nitrogen concentration would be greater than the sum of contributing constituent LRLs (0.18 mg/L) (Jacob Gibs, U.S. Geological Survey, oral commun., 2010). Of the concentrations of total nitrogen in the dataset, the nearest existing concentration to 1.80 mg/L was 1.76 mg/L, which was used as the LRL for total nitrogen (Jacob Gibs, U.S. Geological Survey, oral commun., 2010). Using the same recensoring techniques as the other water-quality constituents included in this study, concentrations of total nitrogen at or below the LRL were recensored to half of the LRL, or in this case 0.88 mg/L.

Calculation of Summary Statistics

Summary statistics include the number of measurements, the number of censored results, the maximum reporting level for censored results, the minimum and maximum values, and the 25th percentile (Q1), median (Q2), and 75th percentile (Q3) values. The quartile components of the summary statistics for this study were produced by use of Minitab statistical software (Minitab, Inc.), whereas the minimum and maximum values reported are the concentrations reported from the laboratory. One of four methods was used to determine the quartiles. Selection of the method was based on the percentage of measurements made up of nondetects. Summary statistics for datasets without nondetects were calculated by Minitab statistical software's descriptive statistics function. The three remaining methods used by Minitab are briefly described below.

Kaplan-Meier Method

As recommended by Helsel (2005), the Kaplan-Meier method was used for estimating summary statistics if one or more measurements of a water-quality constituent were nondetects and if fewer than 50 percent of the measurements were nondetects. The Kaplan-Meier method, as discussed by Helsel, is used to estimate summary statistics on "survival" data, which comprise uncensored data and right-censored data. For this study and in the case of datasets with left-censored data, the survival data need to be mathematically flipped before computing statistics, then re-transformed. Within Minitab, calculations were done with a macro obtained from the "Practical Statistics for the Sciences" website at *http://www.practicalstats.com/* (Helsel, 2011).

Regression on Order Statistics Method

If nondetect measurements accounted for 50 to 80 percent of the data for an individual water-quality constituent, the Regression on Order Statistics (ROS) method was used to determine the 25th percentile, median, and 75th percentile values of that dataset (described in Helsel, 2005). The ROS approach is based on developing a linear regression for data or logarithms of data versus their normal quantiles (Helsel, 2005). Because the datasets in this study were not normally distributed, the robust approach to the ROS method was used. Using this approach requires less assumption of normality than the fully parametric method (Helsel, 2005). Calculations were done with a macro obtained from the "Practical Statistics for the Sciences" website at *http://www.practicalstats.com/*.

Highly Censored Datasets

If greater than 80 percent of the results for a particular water-quality constituent during the entire period of study were censored, then only a high-sample percentile (95th percentile) was reported, as recommended by Helsel (2005). The remaining statistics in the suite of summary statistics were not reported.

Identification of Variations in Statewide Water-Quality

Procedures used to identify trends in the selected water-quality constituents were performed using Minitab statistical software (Minitab, Inc). The Anderson-Darling test for normality established that all constituents for both Status and Background stations deviated widely from a normal distribution. Nonparametric statistics were used to evaluate the data using three statistical tests—Kruskal-Wallis, Tukey's test on ranks, and Mann-Whitney. For each water-quality constituent, Kruskal-Wallis was used first to determine whether the median water-quality values were or were not the same. If the medians differed, then Tukey's test on ranks was performed to determine the median water-quality values that were different. Both statistical tests were performed using water-quality data that had been re-censored, if applicable (previously discussed), back to the long-term method detection limit. Lastly, the Mann-Whitney test determined whether a statistical difference existed between the results for Status and Background stations.

For the purpose of this study, the level of significance, or alpha value, was specified at 0.05. The level of significance indicates how likely it is that the results of trend analyses were due to a random factor rather than a pattern of change in water-quality constituent or trend. The smaller the significance level, the less likely it is that the results of trend analyses were due to random change in water quality. At a significance level of 0.05, there is only a 1 in 20 chance that the test result was due to a random change in water quality rather than a trend.

Kruskal-Wallis Test

The Kruskal-Wallis method tests the equality of median concentrations among groups of data. This nonparametric test typically is performed to determine whether all populations have the same median or whether at least one median is different (Helsel and Hirsch, 1992). In this study, Kruskal-Wallis was applied to the ranks of concentrations of each water-quality constituent to determine whether median concentrations varied among sets of stations. The null hypothesis (H_0) states that median rank concentrations are equal at each set of stations. The alternate hypothesis states that the median rank concentrations from at least one set of stations differ from the others. The test results in a level of significance, indicating the probability that a difference among median ranks exists. If the level of significance produced was less than 0.05, then the null hypothesis was accepted, indicating the median rank concentration from one set of stations was statistically different from that in at least one other set of stations.

Tukey's Multiple Comparison Test

If the null hypothesis of the Kruskal-Wallis method was rejected, then Tukey's test was performed on ranks to identify which median rank concentrations were significantly different at the 0.05 level. Tukey's groups are represented by the letters, or a combination of the letters, A through C. Sets of stations in group A have the highest mean rank concentration, and those in groups B through C have successively lower median rank concentrations. Groups of data with at least one letter in common do not differ significantly from one another.

Mann-Whitney Test

The Mann-Whitney test is a rank-sum test that determines whether or not there is a statistical difference between two independent sample groups. The null hypothesis of the Mann-Whitney test states that the median values of the two groups are the same. Differences were considered to exist at the 0.05 level of significance, indicating that the median concentrations are different (Ott, 1988). In this study, this nonparametric test was used to verify that concentration data for Background stations differed from concentration data for Status stations.

Graphical Representation of Data

Distributions of constituent data that were re-censored using methods previously discussed are graphically displayed in boxplots. If the dataset was composed solely of detected concentrations, then those unadjusted concentrations were plotted. Because the boxplots contain results from re-censored data, values may differ slightly between the boxplots and tables containing summary statistics obtained from uncensored data using the Kaplan-Meier method or ROS. The plots show the median [midpoint of the data (50th percentile) — the center line of the box], the variation [interquartile range (25th to 75th percentiles) — the box height], the spread (upper and lower adjacent values — vertical lines or whiskers), and the presence or absence of extreme values or outliers (individual points).

Variations in Statewide Water Quality of Streams in New Jersey

Summary statistics for the data analyzed are presented in tables 2 and 3. Summary statistics for five of the six constituents were calculated from year-round data; summary statistics for dissolved chloride were calculated only from the data obtained from January to March when road salt application was likely to occur.

Statistical analyses determined whether the median concentrations of selected water-quality constituents were significantly different for each set of Status and Background stations during water years 1998–2009. For each water-quality constituent, the levels of significance that were achieved by performing Kruskal-Wallis for Status stations and for Background stations as well as results of Tukey's test, if applicable, appear in tables 4 and 5, respectively. Additionally, the distribution of median ranked concentrations for each group of stations is shown in the boxplots in figures 14–25 with Tukey's test results presented as letters A through C where the lowest median concentrations are in group A and the highest are in group C.

Only a small change in level of significance indicated whether changes in median concentrations of selected constituents were significant. For example, a 0.051 level of significance indicates no significant variation in median concentrations, but a 0.050 level of significance indicates that the variation in median concentrations is statistically significant. For their own purposes and with caution, readers may consider identifying variations in concentrations using different guidelines.

Identification of Variations in Statewide Water Quality

Statistical analyses of the six selected water-quality constituents in samples collected during water years 1998–2009 are discussed below. The Kruskal-Wallis method tests median concentrations for levels of significance, whereas Tukey's test groups data with respect to mean concentrations. Results of both tests of Status and Background stations are presented in tables 4 and 5, respectively. Additionally, Tukey's groups are shown in figures 14, 16, 18, 22, and 24.

Total Dissolved Solids

The median concentrations of TDS measured during 1998–2009 for Status stations were determined to vary significantly within the study period with the lowest median concentration occurring in water year 1998 (105 mg/L) and the highest concentration in water year 2007 (142 mg/L) (fig 14). In contrast, a statistical difference among median concentrations of TDS for Background stations during water years 1998–2009 was not established (fig. 15).

Table 2. Summary statistics for selected water-quality constituents at selected Statewide Status stations in New Jersey, water years 1998–2009.

[<, less than; E, estimated]

			Nondetect measurements			Statistic, in milligrams per liter				
Water year(s)	Number of stations	Number of measurements	Number of non-detects	Percentage of all measurements	Reporting level, maximum during period of study, in milligrams per liter	Minimum	25th percentile	Median	75th percentile	Maximum
Total dissolved solids										
1998	38	150	0	0	10	15	60	105	176	714
1999	40	157	1	0.6		19	68	109	202	1,172
2000	40	159	0	0		15	53	117	195	904
2001–02	40	319	2	0.6		10	76	129	239	4,190
2003–04	42	336	0	0		31	79	128	204	656
2005–06	42	336	0	0		22	88	141	243	1,127
2007–08	42	336	0	0		22	96	142	244	1,082
2009	42	168	0	0		17	58	114	187	1,171
Dissolved chloride										
1998	38	38	0	0	0.33	2.9	7.2	14.7	39.9	290.5
1999	40	40	0	0		4.9	13.4	22.5	50.8	583.7
2000	40	40	0	0		3.1	8.8	36.4	81.3	466.5
2001–02	40	80	0	0		3.0	14.8	27.3	67.8	2,231.8
2003–04	42	84	0	0		2.8	15.4	38.6	103.0	272.5
2005–06	42	84	0	0		1.2	22.6	35.1	77.8	571.5
2007–08	42	84	0	0		4.7	22.7	42.2	110.9	578.1
2009	42	42	0	0		3.3	13.3	23.2	78.0	634.0
Dissolved nitrite + nitrate										
1998	38	150	24	16	0.06	<0.05	0.10	0.40	0.85	5.32
1999	40	159	13	8		<0.037	0.18	0.68	1.30	7.62
2000	40	159	18	11		E0.021	0.08	0.50	1.24	6.12
2001–02	40	318	28	9		E0.02	0.12	0.54	1.27	9.77
2003–04	42	336	28	8		<0.02	0.29	0.88	1.66	5.46
2005–06	42	336	20	6		E0.033	0.32	0.70	1.27	13.31
2007–08	42	336	6	2		E0.021	0.32	0.70	1.34	12.83
2009	42	168	17	10		E0.02	0.12	0.38	1.22	6.00
Dissolved phosphorus										
1998	38	150	85	57	0.05	<0.01	0.002	0.006	0.021	1.126
1999	40	159	119	75		0.015	0.026	0.040	0.058	1.209
2000	40	159	20	13		E0.003	0.006	0.012	0.042	0.800
2001–02	40	319	18	6		E0.0018	0.005	0.012	0.034	1.776
2003–04	42	336	42	13		E0.0018	0.005	0.013	0.028	0.451
2005–06	42	336	14	4		E0.002	0.006	0.010	0.026	1.110
2007–08	42	336	10	3		E0.004	0.009	0.016	0.031	0.646
2009	42	168	17	10		E0.0041	0.008	0.014	0.030	0.834

Table 2. Summary statistics for selected water-quality constituents at selected Statewide Status stations in New Jersey, water years 1998–2009.—Continued

[<, less than; E, estimated]

			Nondetect measurements			Statistic, in milligrams per liter				
Water year(s)	Number of stations	Number of measurements	Number of nondetects	Percentage of all measurements	Reporting level, maximum during period of study, in milligrams per liter	Minimum	25th percentile	Median	75th percentile	Maximum
Total phosphorus										
1998	38	150	46	31	0.05	<0.01	0.008	0.023	0.056	1.355
1999	40	159	72	45		0.016	0.035	0.043	0.061	1.251
2000	40	159	5	3		E0.004	0.016	0.035	0.090	0.859
2001–02	40	319	5	2		E0.002	0.015	0.036	0.077	1.762
2003–04	42	336	19	6		E0.0019	0.013	0.037	0.071	0.515
2005–06	42	336	4	1		E0.0037	0.018	0.039	0.084	3.023
2007–08	42	336	1	0		E0.004	0.020	0.035	0.067	0.885
2009	42	168	7	4		E0.0044	0.015	0.030	0.070	0.845
Total nitrogren										
1998	38	150	31	21	1.76	<0.15	0.42	0.77	1.26	7.14
1999	40	159	15	9		<0.114	0.55	1.07	1.69	8.22
2000	40	159	18	11		E0.13	0.49	1.01	1.70	7.65
2001–02	40	316	34	11		E0.11	0.48	0.85	1.75	10.50
2003–04	42	335	86	26		E0.17	0.58	1.21	1.94	5.94
2005–06	42	334	50	15		E0.147	0.74	1.14	1.80	14.11
2007–08	42	336	39	12		E0.247	0.70	1.12	1.89	13.90
2009	42	168	28	17		<0.212	0.47	0.85	1.67	6.90

Because significant variations in median concentrations of TDS were not identified at Background stations, Tukey's test was performed on Status data only. Results of Tukey's test show that mean concentrations of TDS in waters years 1998, 1999, 2000, and 2009 are unlike mean concentrations in water years 2005–06 and 2007–08 (table 2). The results also indicate that mean concentrations are lowest in water years 1998, 1999, 2000 and 2009, whereas mean concentrations are highest in water years 2005 through 2008. With the exception of water year 2009, results of Tukey's test indicate a consistent increase in mean concentrations of TDS during water years 1998–2009 (fig 14).

Dissolved Chloride

Concentrations of dissolved chloride are often highest during the winter as a result of runoff of road de-icing agents entering waterways. To eliminate seasonal bias, only measurements from January to March were used in the determination of the statistical significance of changes in median concentrations of dissolved chloride for Status and Background stations. For Status stations, the median concentrations differed significantly among water years 1998 to 2009 with the lowest median concentration in water year 1998 (14.7 mg/L) and highest in water year 2007 (42.2 mg/L) (fig. 16). Median concentrations of dissolved chloride for Background stations did not show a significant difference during water years 1998–2009 (fig. 17).

Because significant differences in median concentrations of dissolved chloride were not identified at Background stations, Tukey's test was not performed on data collected at Background stations. Results from Tukey's test revealed that the mean concentrations of dissolved chloride for Status stations for water year 1998 were statistically different from those for water years 2003–04, 2005–06, and 2007–08 (table 2). The lowest mean concentrations of dissolved chloride occurred in water year 1998, whereas the highest mean concentrations occurred during water years 2003 to 2008 and were not significantly different from one another. With the exception of 2009, results of Tukey's test indicate a

Table 3. Summary statistics for selected water-quality constituents at selected Background stations in New Jersey, water years 1998–2009.

[<, less than; E, estimated; -, no data due to highly censored dataset]

			Nondetect measurements			Statistic, in milligrams per liter				
Water year(s)	Number of stations	Number of measurements	Number of non-detects	Percentage of all measurements	Reporting level, maximum during period of study, in milligrams per liter	Minimum	25th percentile	Median	75th percentile	Maximum
Total dissolved solids										
1998	4	16	0	0	10	19	24	51	113	135
1999	4	16	0	0		18	24	60	117	164
2000	4	16	0	0		20	24	52	112	133
2001–02	6	47	0	0		11	24	42	98	179
2003–04	6	48	0	0		18	28	66	99	167
2005–06	7	56	0	0		18	27	83	109	172
2007–08	7	56	0	0		18	24	83	108	169
2009	7	28	0	0		18	27	89	113	171
Dissolved chloride										
1998	4	4	0	0	0.33	1.0	1.7	7.6	28.3	34.0
1999	4	4	0	0		1.2	2.0	8.3	28.5	33.9
2000	4	4	0	0		0.9	1.7	7.7	27.7	33.0
2001–02	6	12	0	0		1.2	3.1	4.8	15.9	38.8
2003–04	6	12	0	0		1.1	3.6	5.0	15.5	47.3
2005–06	7	14	0	0		1.0	3.4	5.0	18.2	47.7
2007–08	7	14	0	0		1.0	3.7	5.3	15.6	40.9
2009	7	7	0	0		1.2	3.4	5.4	22.3	38.8
Dissolved nitrite + nitrate										
1998	4	16	6	38	0.06	<0.05	0.05	0.11	0.30	0.53
1999	4	16	3	19		<0.05	0.07	0.10	0.28	0.74
2000	4	16	1	6		E0.02	0.03	0.10	0.29	0.85
2001–02	6	47	13	28		E0.02	0.02	0.12	0.29	1.59
2003–04	6	48	14	29		<0.02	0.02	0.10	0.37	1.19
2005–06	7	56	22	39		E0.04	0.05	0.06	0.16	0.56
2007–08	7	56	15	27		E0.03	0.03	0.08	0.18	0.41
2009	7	28	8	29		E0.02	0.03	0.07	0.16	0.33
Dissolved phosphorus										
1998	4	16	11	69	0.05	<0.001	0.003	0.006	0.012	0.024
1999	4	16	14	88		<0.05	-	-	0.05*	0.054
2000	4	16	6	38		E0.003	0.004	0.007	0.009	0.010
2001–02	6	47	14	30		E0.002	0.004	0.004	0.006	0.021
2003–04	6	48	15	31		E0.002	0.003	0.004	0.008	<0.02
2005–06	7	56	14	25		E0.002	0.004	0.004	0.006	0.020
2007–08	7	56	21	38		E0.004	0.006	0.008	0.010	0.016
2009	7	28	14	50		E0.004	0.008	0.008	0.010	0.019

Table 3. Summary statistics for selected water-quality constituents at selected Background stations in New Jersey, water years 1998–2009.—Continued

[<, less than; E, estimated; -, no data due to highly censored dataset]

			Nondetect measurements			Statistic, in milligrams per liter				
Water year(s)	Number of stations	Number of measurements	Number of non-detects	Percentage of all measurements	Reporting level, maximum during period of study, in milligrams per liter	Minimum	25th percentile	Median	75th percentile	Maximum
Total phosphorus										
1998	4	16	8	50		<0.001	0.007	0.010	0.020	0.031
1999	4	16	14	88		E0.036	-	-	0.04*	0.050
2000	4	16	4	25		E0.004	0.004	0.010	0.012	0.024
2001–02	6	47	8	17	0.05	E0.002	0.003	0.007	0.013	0.044
2003–04	6	48	10	21		<0.002	0.003	0.007	0.015	0.032
2005–06	7	56	6	11		E0.002	0.003	0.007	0.014	0.106
2007–08	7	56	15	27		E0.004	0.005	0.008	0.018	0.044
2009	7	28	10	36		E0.004	0.007	0.007	0.017	0.025
Total nitrogren										
1998	4	16	7	44		<0.15	0.21	0.21	0.56	0.75
1999	4	16	4	25		<0.12	0.23	0.37	0.54	0.91
2000	4	16	3	19		<0.12	0.23	0.37	0.54	0.91
2001–02	6	47	19	40	1.76	E0.09	0.09	0.25	0.44	1.70
2003–04	6	48	35	73		<0.12	0.13	0.18	0.32	1.40
2005–06	7	56	38	68		<0.14	0.16	0.20	0.32	0.86
2007–08	7	56	43	77		<0.14	0.12	0.14	0.22	1.90
2009	7	28	15	54		<0.11	0.19	0.23	0.35	0.50

*95th Percentile Value

consistent increase in mean concentrations of dissolved chloride during the water years 1998–2009 (fig. 16).

Dissolved Nitrite Plus Nitrate

Median concentrations of nitrite plus nitrate for Status stations during water years 1998–2009 were determined to vary significantly with the lowest (0.38 mg/L) and highest (0.88 mg/L) median concentrations occurring in water years 2009 and 2003–04, respectively (fig. 18). In contrast, nitrite plus nitrate concentrations for Background stations show no statistical difference among median concentrations during water years 1998 to 2009 (fig. 19).

Tukey's test was not performed on concentrations of nitrite plus nitrate for Background stations because median concentrations did not vary significantly. For Status stations, results of Tukey's test show that water years 1998 and 2009 had the lowest mean concentrations, and mean concentrations are statistically similar to each other, yet different than the mean concentrations for the remaining sets of stations for the water years 1998–2009 (table 2). Mean concentrations were relatively low in water years 1999, 2000, and 2001–02 but not as low as those in water years 1998 and 2009. Finally, the highest mean concentrations occurred in water years 2003–04, 2005–06, and 2007–08, signifying that the sets of Status stations in those years have statistically similar mean concentrations of dissolved nitrite plus nitrate. With the exception of 2009, results of Tukey's test indicate a general increase in mean concentrations of dissolved nitrite plus nitrate during the study period (fig. 18).

Table 4. Results of statistical tests to determine whether constituent concentrations differ among years at selected Statewide Status stations in New Jersey, water years 1998–2009.

[A, B, C, differing letters indicate significant differences in mean values, according to the Tukey multiple-comparison test]

Kruskal-Wallis			Tukey's Test		
Water year(s)	**Significance level achieved**	**[1]Ho**	**A**	**B**	**C**
Total dissolved solids					
1998				B	
1999				B	
2000				B	
2001–02	0.000	Reject	A	B	
2003–04			A	B	
2005–06			A	B	
2007–08			A	B	
2009				B	
Dissolved chloride					
1998				B	
1999			A	B	
2000			A	B	
2001–02	0.000	Reject	A	B	
2003–04			A	B	
2005–06			A	B	
2007–08			A	B	
2009			A	B	
Dissolved nitrite + nitrate					
1998					C
1999			A	B	C
2000				B	C
2001–02	0.000	Reject		B	C
2003–04			A		
2005–06			A	B	
2007–08			A		
2009					C

Kruskal-Wallis			Tukey's Test		
Water year(s)	**Significance level achieved**	**[1]Ho**	**A**	**B**	**C**
Dissolved phosphorus					
1998					
1999					
2000					
2001–02	0.059	Accept			
2003–04					
2005–06					
2007–08					
2009					
Total phosphorus					
1998				B	
1999			A	B	
2000			A	B	
2001–02	0.023	Reject	A		
2003–04			A	B	
2005–06			A		
2007–08			A	B	
2009			A	B	
Total nitrogen					
1998				B	
1999			A	B	
2000			A	B	
2001–02	0.000	Reject	A	B	
2003–04			A		
2005–06			A		
2007–08			A		
2009			A	B	

[1]Ho, Null hypothesis: no difference in median concentrations among years.

Dissolved Phosphorus

Median concentrations of dissolved phosphorus for Status stations show no statistically significant changes in concentration among water years 1998 to 2009 at an achieved statistical significance level of 0.059, just outside the standard of 0.050 chosen for this study. Because there were no significant differences among median concentrations at Status stations (fig. 20), Tukey's test was not performed on data obtained from Status stations. For Background stations, all median concentrations were less than the highest LT-MDL, and therefore, the data were not considered to be significantly different (fig. 21).

Total Phosphorus

Median concentrations of total phosphorus at Status stations show a statistical difference among water years 1998 to 2009 with the lowest median concentration (0.023 mg/L) in 1998 and the highest (0.043 mg/L) in 1999 (fig. 22).

Table 5. Results of statistical tests to determine whether constituent concentrations differ among years at selected Background stations in New Jersey, water years 1998–2009.

[A, B, C, differing letters indicate significant differences in mean values, according to the Tukey multiple-comparison test]

	Kruskal-Wallis		Tukey's Test				Kruskal-Wallis		Tukey's Test		
Water year(s)	Significance level achieved	[1]Ho	A	B	C	Water year(s)	Significance level achieved	[1]Ho	A	B	C
Total dissolved solids						Dissolved phosphorus					
1998						1998					
1999						1999					
2000						2000					
2001–02	0.791	Accept				2001–02	1.000	Accept			
2003–04						2003–04					
2005–06						2005–06					
2007–08						2007–08					
2009						2009					
Dissolved chloride						Total phosphorus					
1998						1998					
1999						1999					
2000						2000					
2001–02	0.998	Accept				2001–02	0.369	Accept			
2003–04						2003–04					
2005–06						2005–06					
2007–08						2007–08					
2009						2009					
Dissolved nitrite + nitrate						Total nitrogen					
1998						1998					
1999						1999					
2000						2000					
2001–02	0.148	Accept				2001–02	0.586	Accept			
2003–04						2003–04					
2005–06						2005–06					
2007–08						2007–08					
2009						2009					

[1]Ho, Null hypothesis: no difference in median concentrations among years.

Concentrations of total phosphorus for Background stations do not show a statistical change during water years 1998–2009 (fig. 23). For Background stations, because greater than 80 percent of the data for total phosphorus at Background stations were nondetects, a median concentration was not computed for water year 1999.

Because a significant difference in mean concentrations of total phosphorus was not found at Background stations for the study period, Tukey's test was not performed on data obtained from Background stations. Tukey's test was performed on data from Status stations to determine which years were statistically different from others. Results of Tukey's test confirmed that water year 1998 had the lowest mean concentration, which is unlike mean concentrations for the remainder of the study period (table 2). Keeping in mind that the Kruskal-Wallis method tests median concentrations, whereas Tukey's test groups data with respect to mean concentrations, results of Tukey's test indicate that the highest mean concentrations occurred in water years 2001–02 and 2005–06.

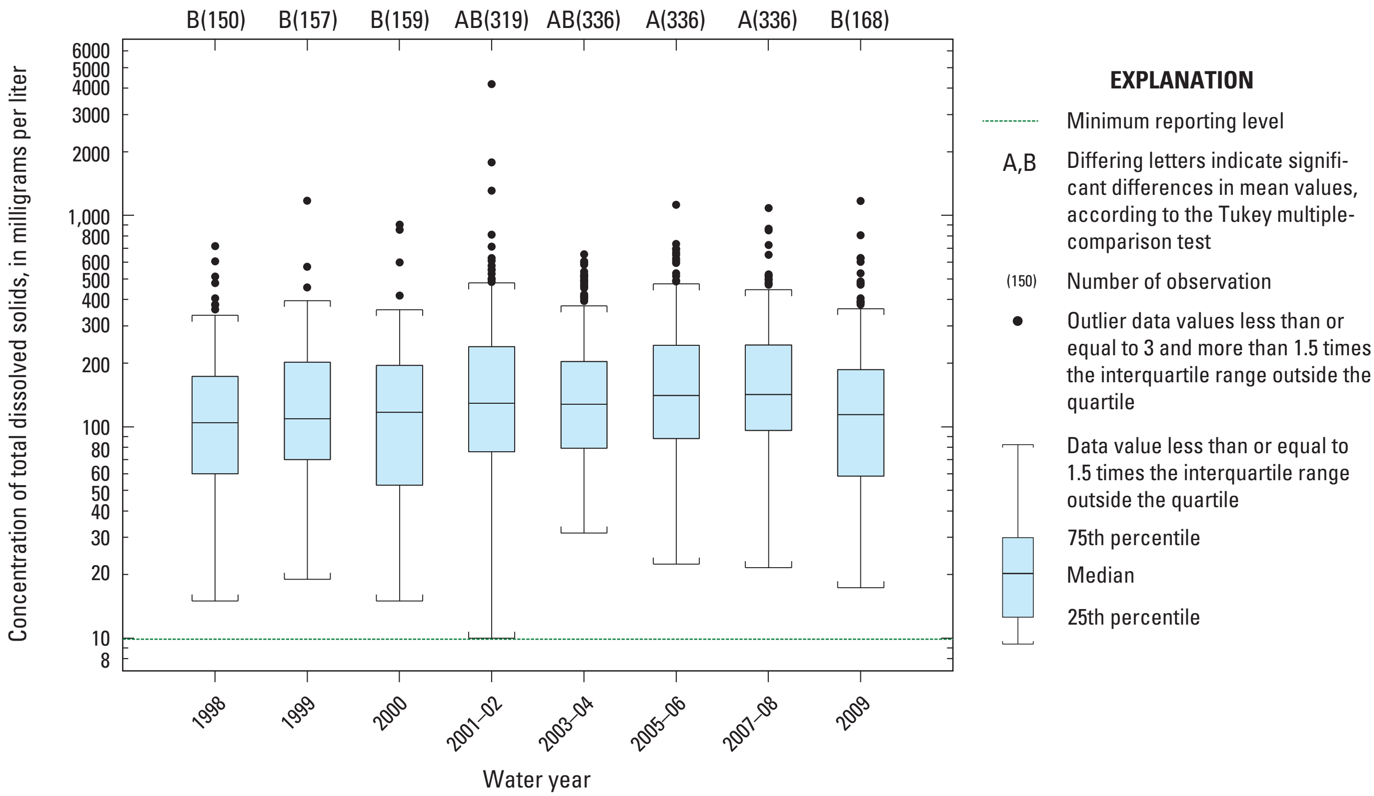


Figure 14. Distribution of total dissolved solids for selected Statewide Status stations in New Jersey during water years 1998–2009.

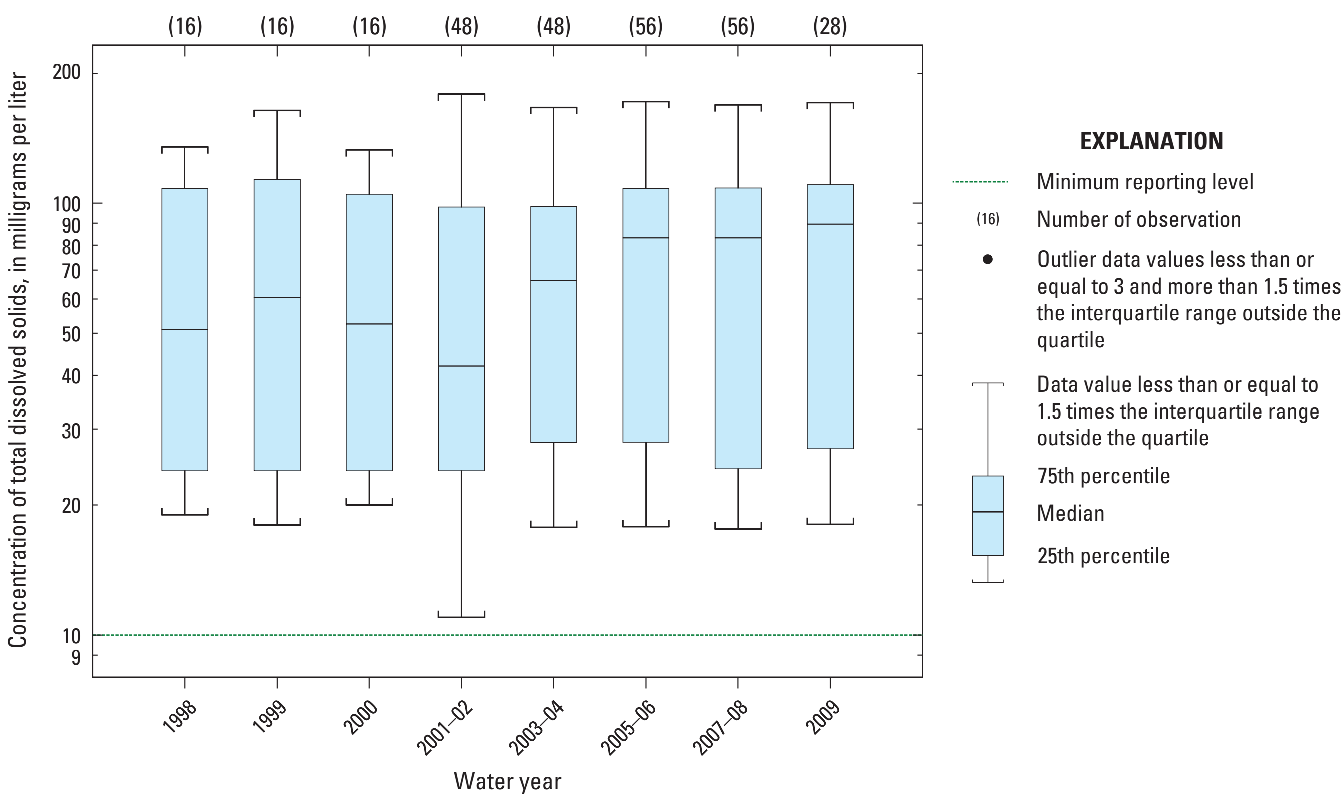


Figure 15. Distribution of total dissolved solids for selected Background stations in New Jersey during water years 1998–2009.

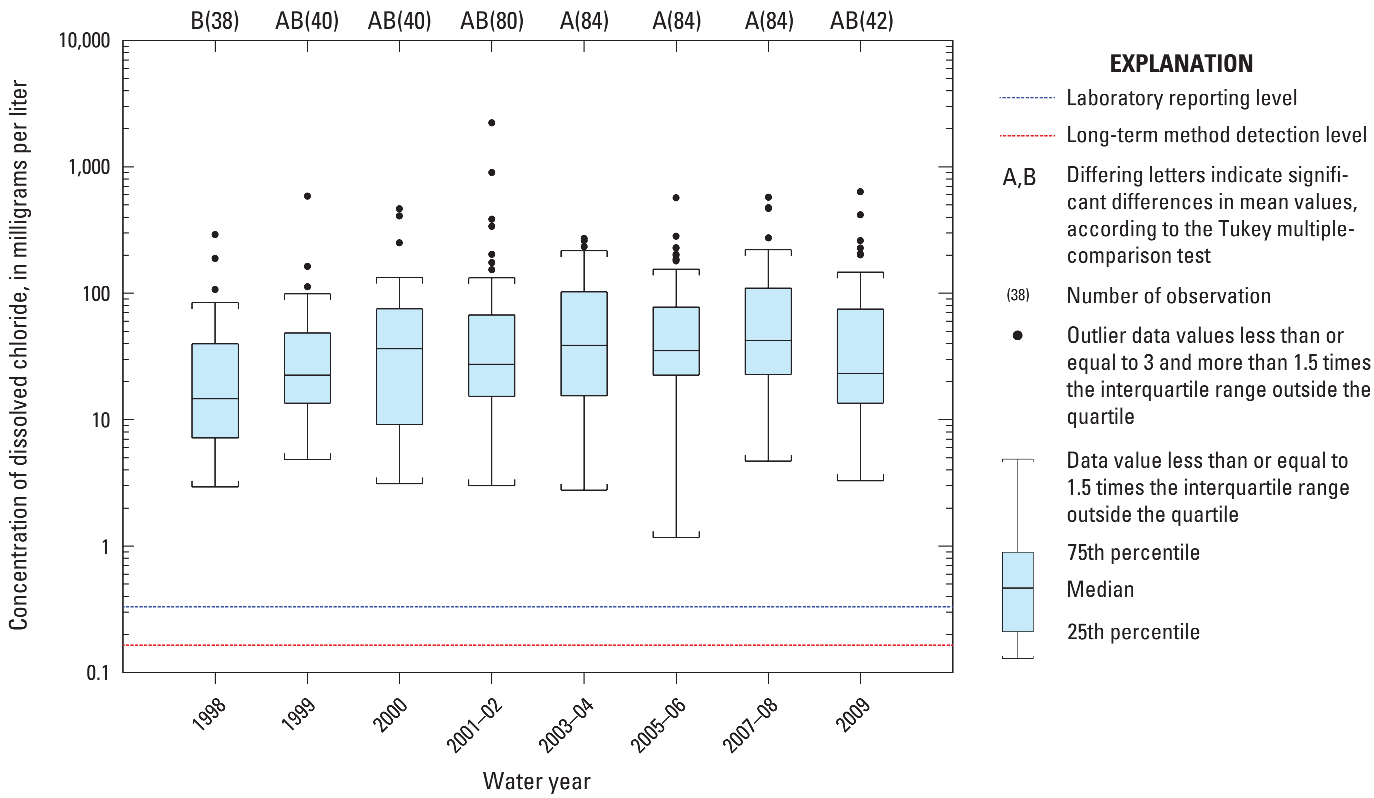


Figure 16. Distribution of dissolved chloride for selected Statewide Status stations in New Jersey during water years 1998–2009.

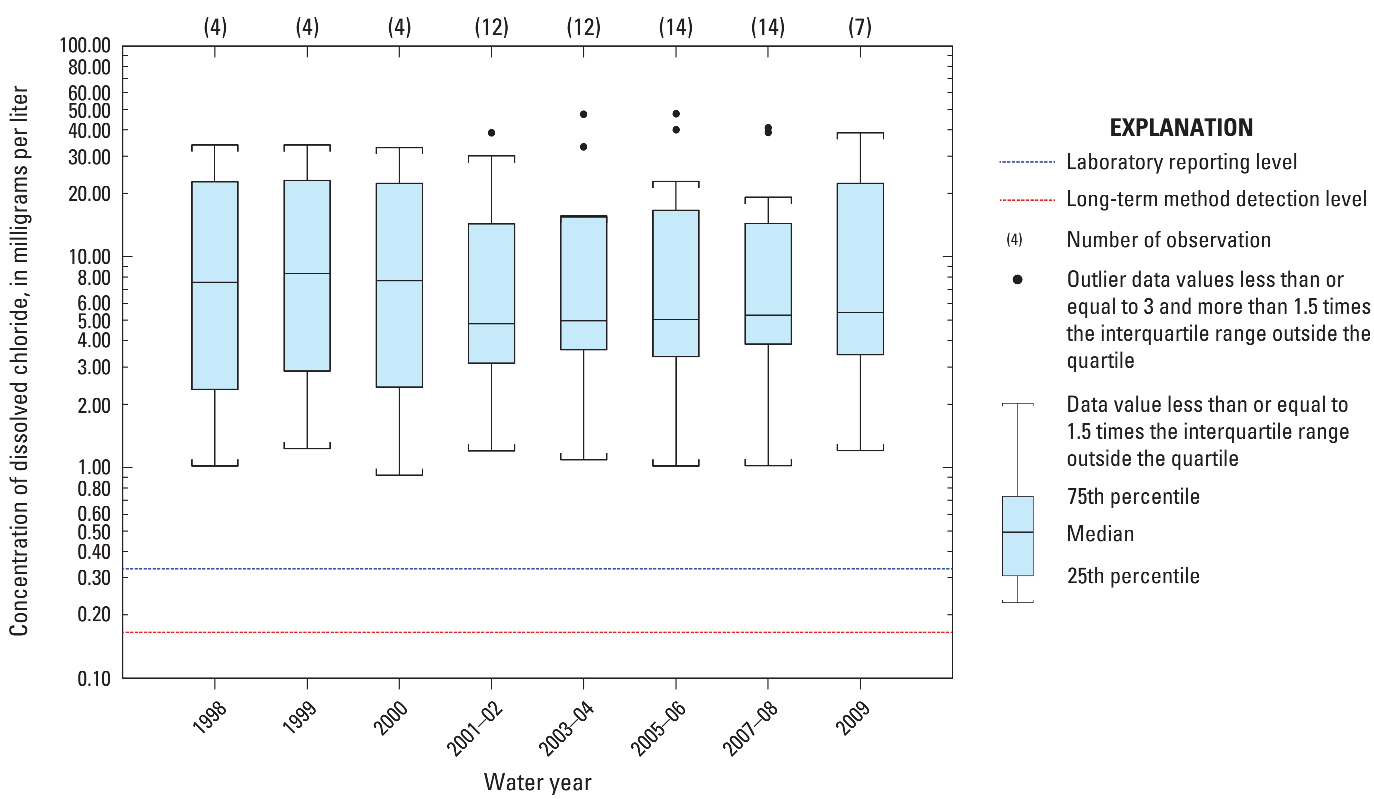


Figure 17. Distribution of dissolved chloride for selected Background stations in New Jersey during water years 1998–2009.

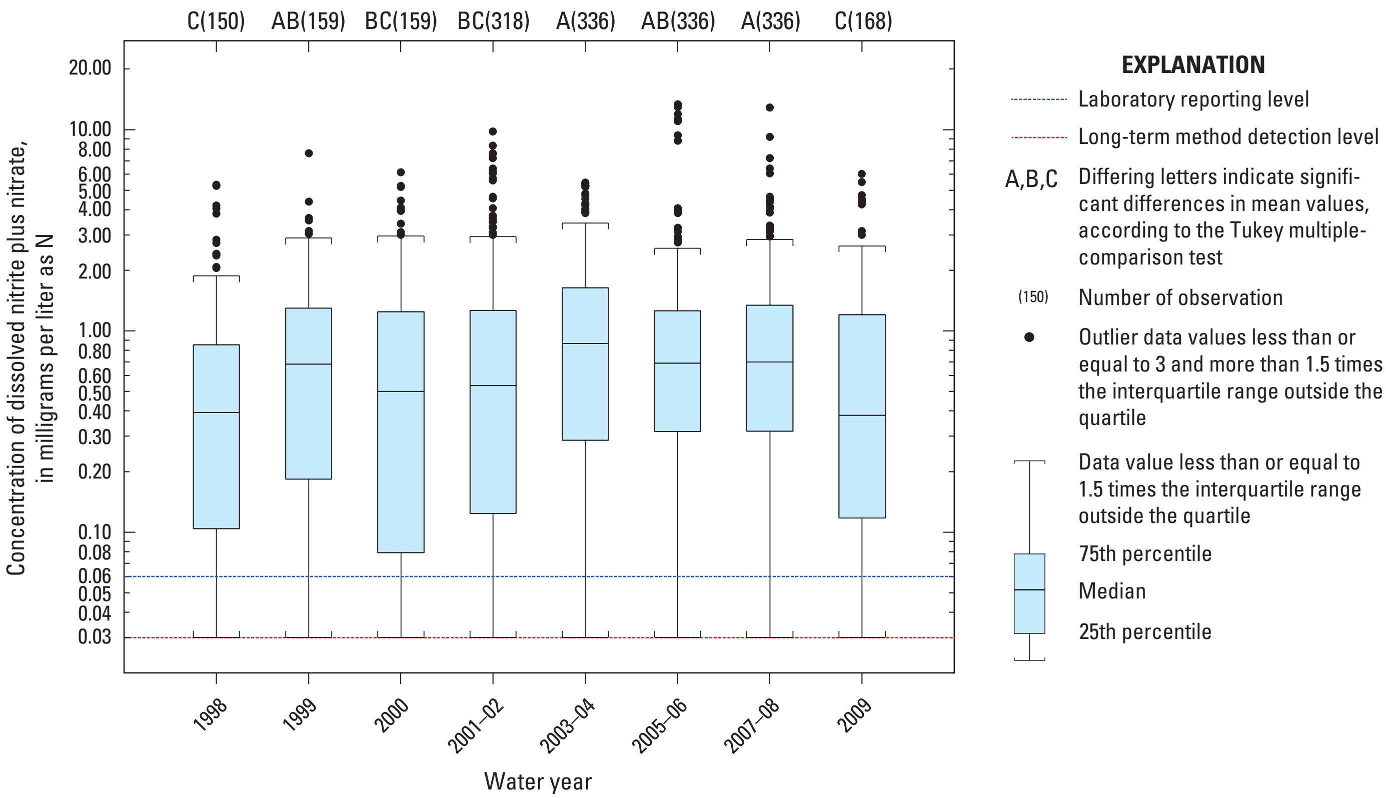


Figure 18. Distribution of dissolved nitrite plus nitrate for selected Statewide Status stations in New Jersey during water years 1998–2009.

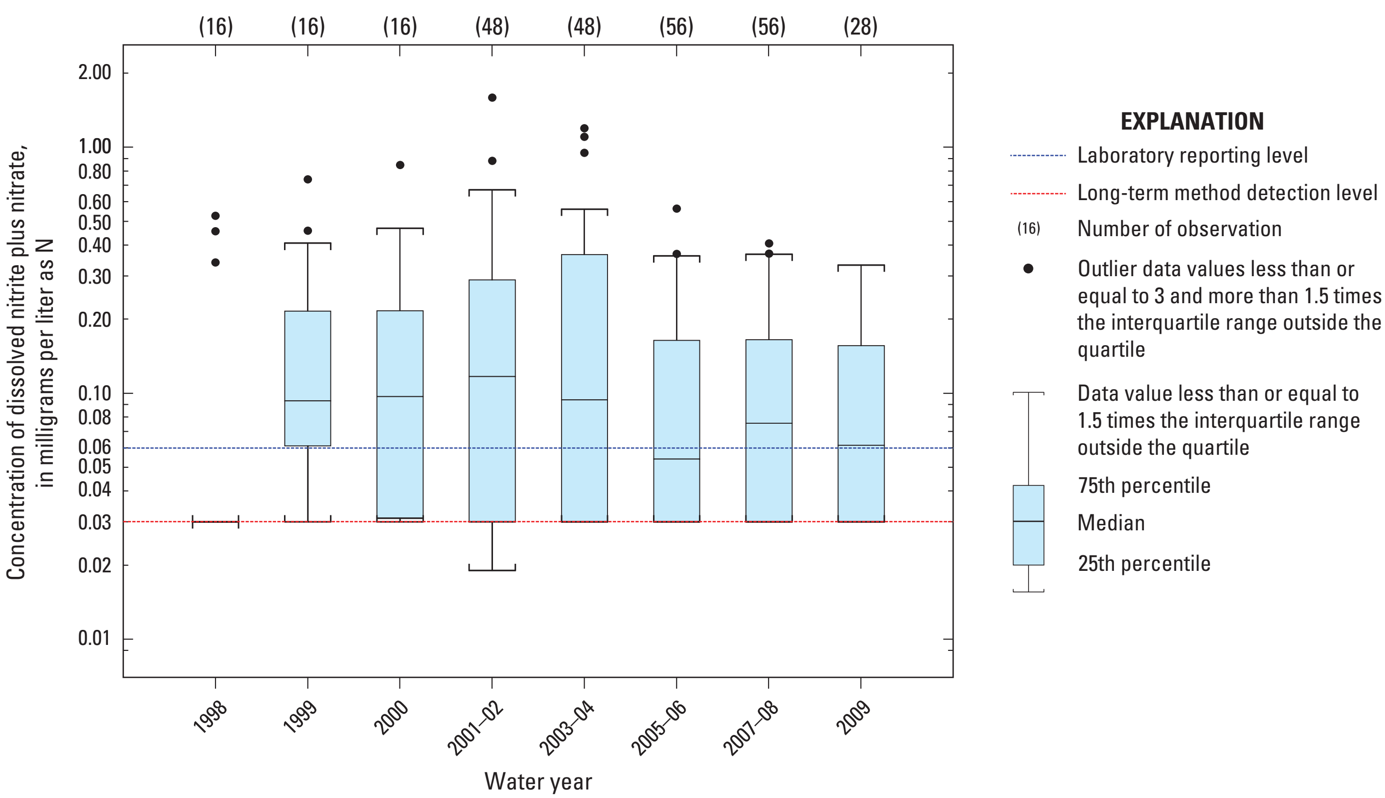


Figure 19. Distribution of dissolved nitrite plus nitrate for selected Background stations in New Jersey during water years 1998–2009.

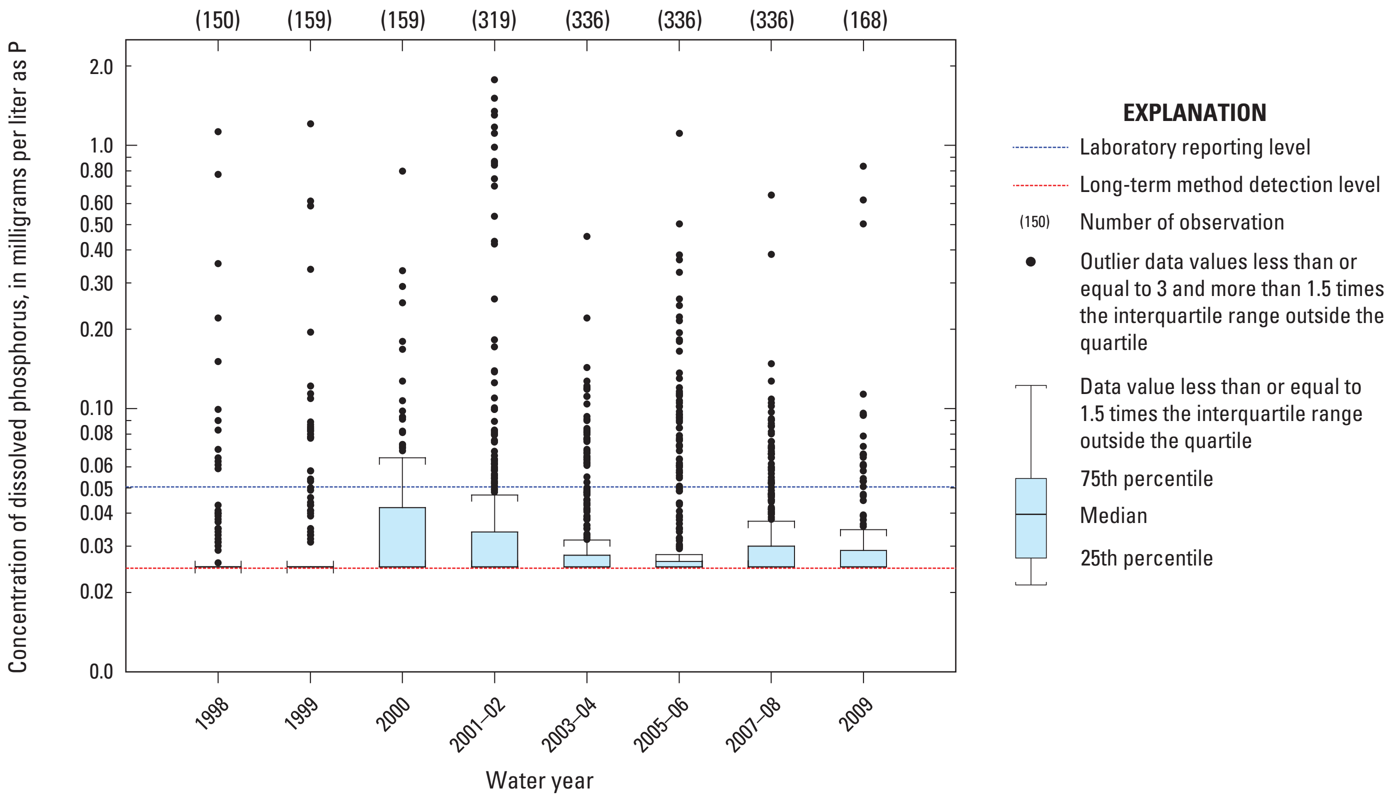


Figure 20. Distribution of dissolved phosphorus for selected Statewide Status stations in New Jersey during water years 1998–2009.

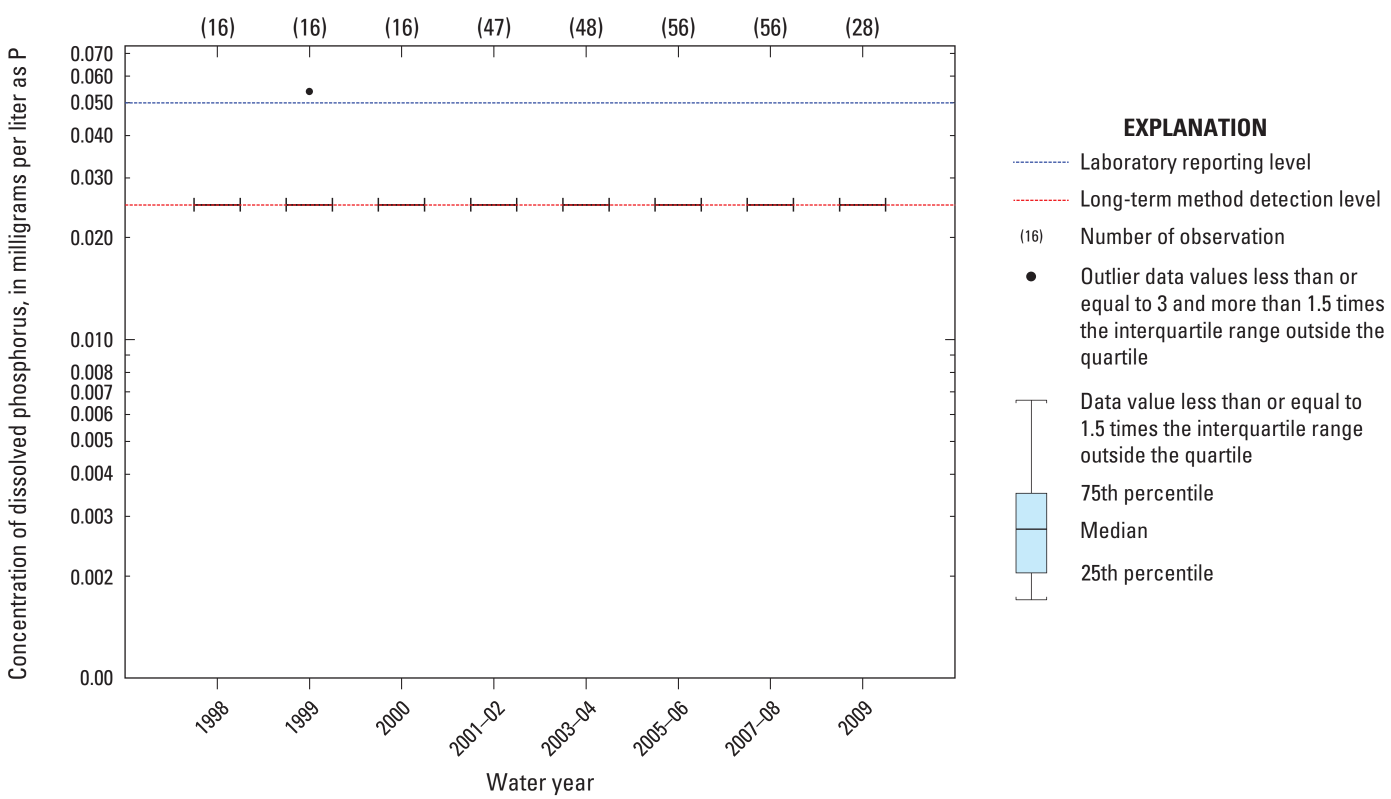


Figure 21. Distribution of dissolved phosphorus for selected Background stations in New Jersey during water years 1998–2009.

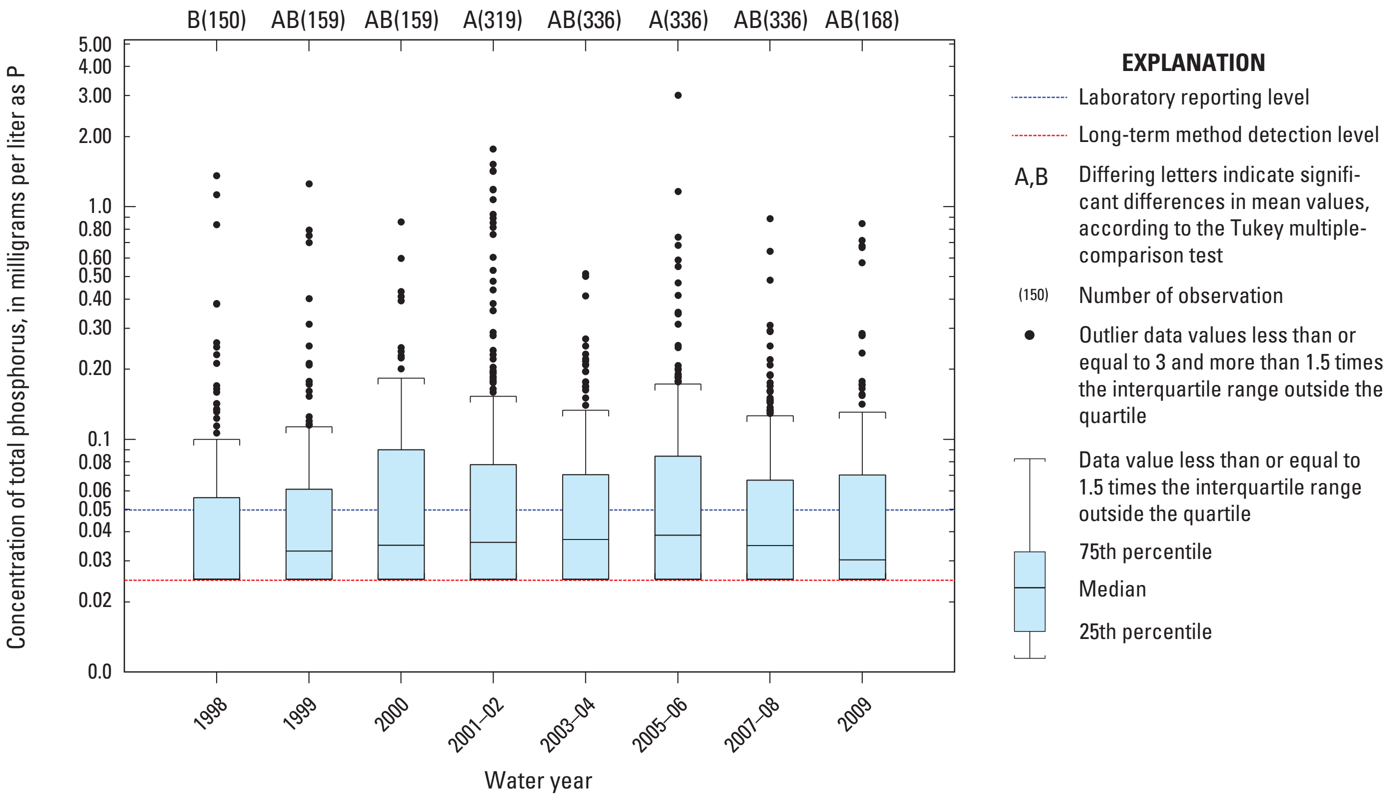


Figure 22. Distribution of total phosphorus for selected Statewide Status stations in New Jersey during water years 1998–2009.

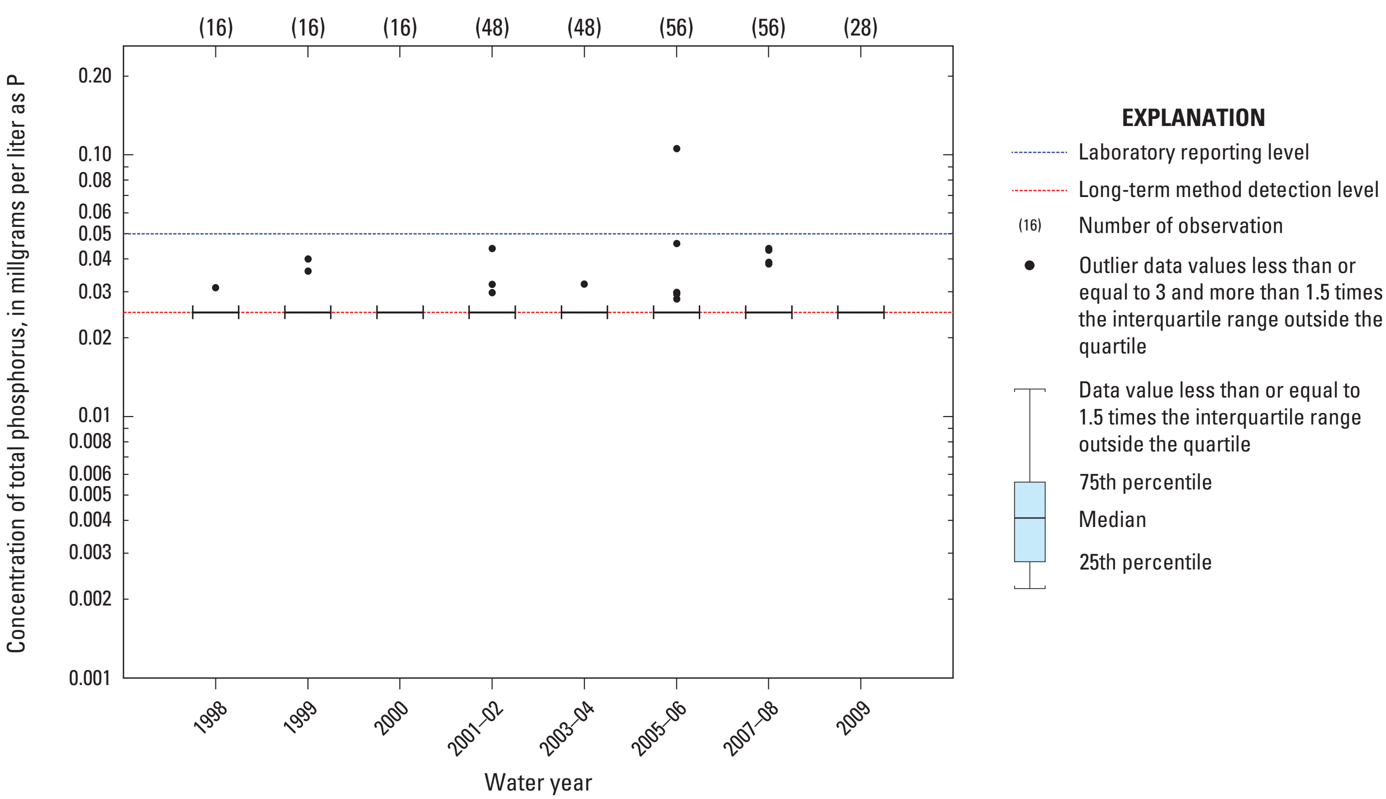


Figure 23. Distribution of total phosphorus for selected Background stations in New Jersey during water years 1998–2009.

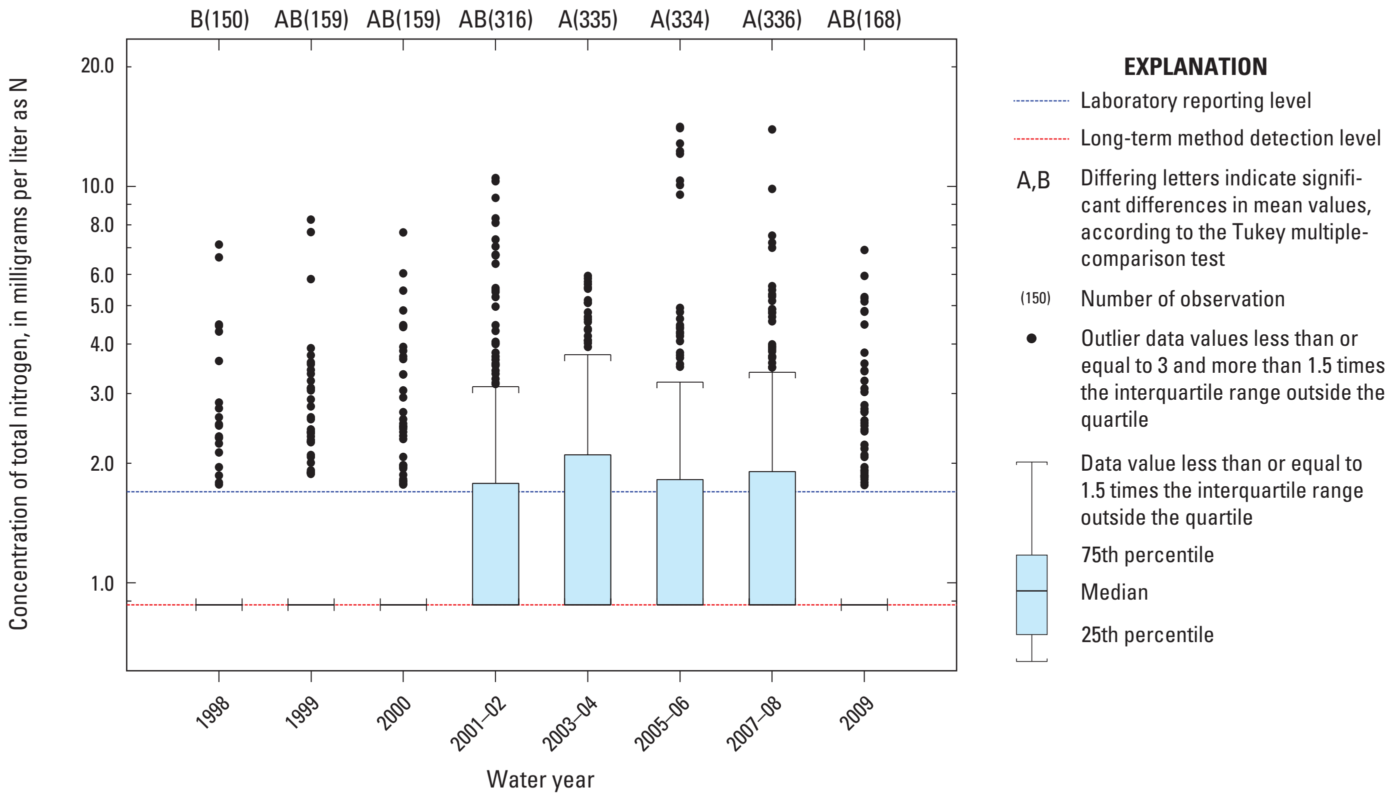


Figure 24. Distribution of total nitrogen for selected Statewide Status stations in New Jersey during water years 1998–2009.

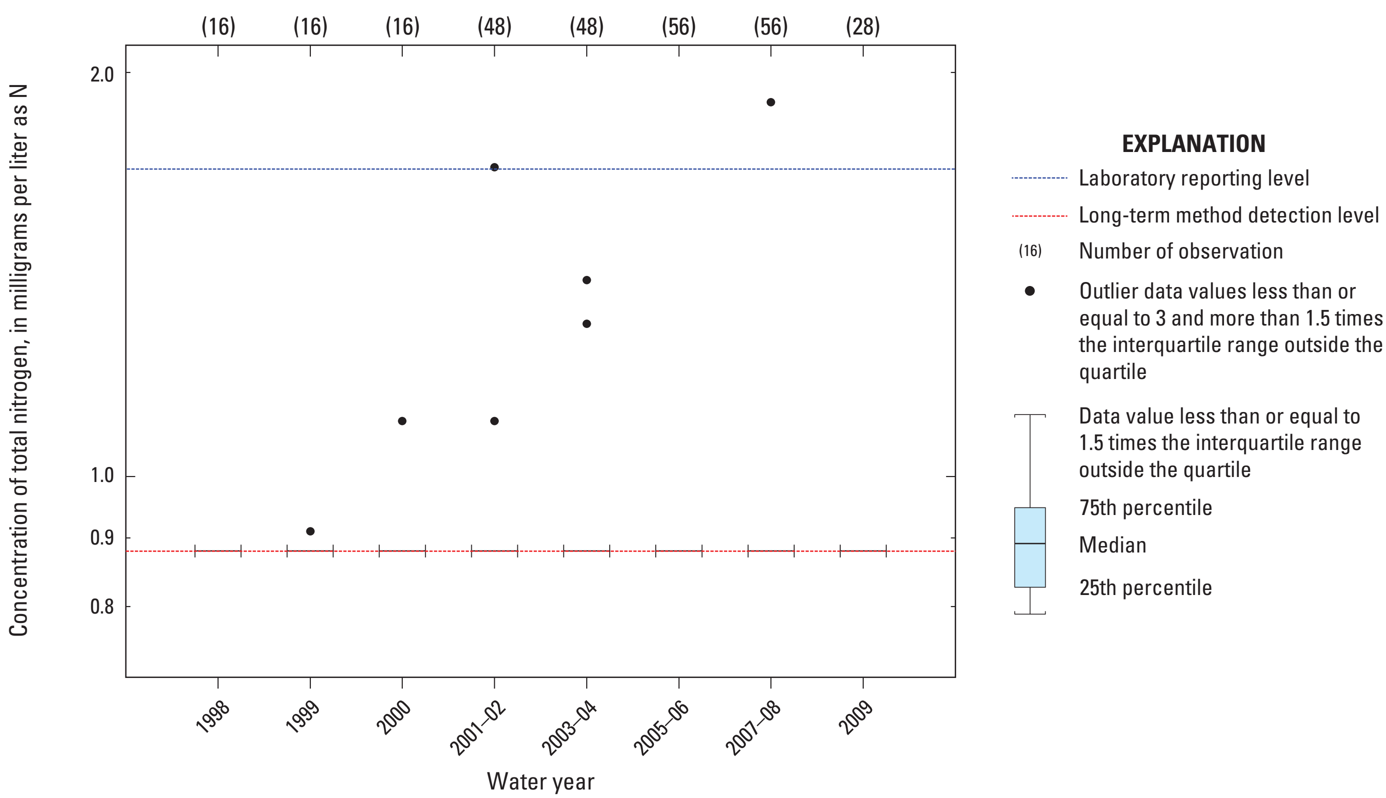


Figure 25. Distribution of total nitrogen for selected Background stations in New Jersey during water years 1998–2009.

Total Nitrogen

Results of statistical analyses show a significant difference among median concentrations of total nitrogen for Status stations but not for Background stations during water years 1998–2009 (figs. 24–25). The lowest median concentration of total nitrogen for Status stations, 0.77 mg/L, occurred in water year 1998, whereas the highest median concentration, 1.21 mg/L, occurred during water years 2003–04 (fig. 24).

Results of Tukey's test on data from Status stations confirm that the lowest mean concentration of total nitrogen occurred in water year 1998 and is significantly less than the mean concentrations from the remainder of the study period (table 2). The mean concentrations of total nitrogen in water years 2003–04, 2005–06, and 2007–08 are statistically similar, and these mean concentrations are the highest for the study period. With the exception of 2009, results of Tukey's test indicate a general increase in mean concentrations of total nitrogen during the study period (fig. 24).

Identification of Consistent Increases or Decreases in Statewide Water Quality

Except for water year 2009, median concentrations of TDS, dissolved chloride, dissolved nitrite plus nitrate, and total nitrogen increased significantly for Status stations during water years 1998–2009 (fig. 14–25). No significant variations of median concentrations of any of the selected water-quality constituents were observed for Background stations during the study period. Furthermore, no significant decreases in median concentrations of any water-quality constituent were observed during the study period.

Comparison of Water Quality between Statewide Status Stations and Background Stations

A final test was performed to determine whether median concentrations of constituents measured for Status stations were different from the median concentrations measured for Background stations. Samples collected at Background stations are believed to represent basins that are unaffected by human activity. Therefore, the water quality at these stations was expected to differ from the water quality at Status stations, which are located in basins with various land uses. The Mann-Whitney test, a rank sum test, confirmed that median concentrations of all constituents differed among samples collected at Background and at Status stations.

Comparison of Variations in Water Quality to Streamflow

Streamflow information aids in the interpretation of water-quality data. Although streamflow was not measured at the Status stations, generalizations about regional streamflow patterns could be made by comparing the percentage of time that streamflow was not exceeded during water years 1998–2009 at each Index station (fig. 13). Non-exceedances of annual mean streamflow for the period of the study could provide insight when observing annual changes in water-quality constituents.

In general, an increase in streamflow results in decreased concentrations of many dissolved constituents in the water column as a result of dilution. In contrast, when drought conditions are present, dissolved constituents generally become concentrated in the water column. This phenomenon may work in reverse for certain water-quality characteristics, such as turbidity, which tend to increase during periods of rain as runoff enters waterways.

Median concentrations of dissolved chloride, dissolved nitrite plus nitrate, dissolved phosphorus, total phosphorus, and total nitrogen at Status stations increased significantly from water year 1998 to water year 1999, whereas the percentage non-exceedances of annual mean streamflow at the Index streamgaging stations decreased during the same time period (figs. 13, 16, 18, 20, 22, 24). Just the opposite was observed from water year 2008 to 2009 for concentrations of TDS, dissolved chloride, nitrite plus nitrate, and total nitrogen at Status stations (figs. 13–14, 16, 18, 24). Although the percentage of time that mean annual streamflow was not exceeded at four of the six Index stations increased from 2008 to 2009, the concentrations of these constituents decreased significantly. Comparisons were not made for the years not mentioned because both annual mean streamflow and concentrations of constituents showed no clear upward or downward change during those times.

Extreme drought conditions were observed throughout the State in water year 2002 (New Jersey Department of Environmental Protection, 2002). The percentage of time that annual mean streamflow in water year 2002 was not exceeded clearly deviated from the percentage of time that annual mean streamflow for water years 1998–2009 was not exceeded (fig. 13). The maximum concentrations of TDS, dissolved chloride, dissolved phosphorus, and total phosphorus at the Status stations during the study period occurred during water years 2001–02; similarly, the maximum concentrations of TDS, dissolved nitrite plus nitrate, dissolved phosphorus, total phosphorus, and total nitrogen for Background stations occurred during water years 2001–02 (figs. 14–16, 19–23, 25). The extremely low streamflow conditions in water years 2001 and 2002 resulted in elevated concentrations of many dissolved constituents in waterways. These conditions help to explain why the maximum concentrations of several constituents occurred during 2001–02.

Comparison of Variations in Annual Water Quality to Results of Previous Trend Tests

Previous investigations examined potential trends in the water quality of streams at Network stations that were not categorized as Status or Background; this group of stations (including Delaware River main stem, Watershed Integrator, and Land Use Indicator stations) is referred to as fixed. Results from two previous studies of trends conducted during water years 1986–95, Hickman and Barringer (1999), and water years 1998–2007, Hickman and Gray (2010), were compared to results of this study on variations of water quality at Status stations. Both previous trend analyses used streamflow-adjusted concentrations of water quality for selected water-quality constituents, whereas this study did not correct for instantaneous discharge because the data values were unavailable. One other investigation of trends in New Jersey water quality by Hay and Campbell (1990) specified a higher significance level (0.10) to identify trends; therefore, results from Hay and Campbell were not used for comparison. Only trends identified at the 0.05 level of significance were considered for comparison because this was the significance level chosen for this particular study.

Previous analyses by Hickman and Barringer (1999) and Hickman and Gray 2010) indicate trends of increasing or decreasing concentrations of selected water-quality constituents during the periods of study 1986–95 and 1998–2007, respectively. Because the list of stations designated as Status changed every 1 to 2 years during water years 1998–2009, specific trends could not be established during the study period. Instead, only significant variations in water quality could be identified by this study rather than trends. Therefore, comparisons between previous studies and this one are made on the basis of general changes in concentrations of water-quality constituents during the study period.

Previous trend analyses by Hickman and Barringer (1999) and Hickman and Gray (2010) identify a trend of increasing concentrations of TDS at fixed stations. Hickman and Barringer (1999) identified trends at 26 fixed sites—24 fixed stations with increasing concentrations and 2 with decreasing concentrations. Similarly, Hickman and Gray identified trends at 24 fixed sites, all with increasing concentrations. Although specific trends were not identified in this investigation of Status data, there are some similarities to results of previous studies of trends. An increase in median concentrations of TDS is seen from water years 1998 to 2008, which generally agrees with the upward trends identified in Hickman and Barringer (1999), as well as Hickman and Gray (2010).

The study by Hickman and Barringer (1999) identified an upward trend in dissolved chloride concentrations at most of the fixed stations from 1986 to 1995. Trends were identified at 32 stations, 29 with increasing concentrations and 3 with decreasing concentrations. Likewise, results of statistical analyses of concentrations of dissolved chloride at Status stations show significant variations during water years 1998–2009. Median concentrations increased significantly from 1998 to 2008, which is comparable to the results of Hickman and Barringer (1999).

Trends in dissolved nitrite plus nitrate were compared with results from Hickman and Barringer (1999) and Hickman and Gray (2010); both studies identified more stations with increasing concentrations than decreasing concentrations. Hickman and Barringer identified increasing and decreasing trends of nitrite plus nitrate at 19 and 8 stations, respectively. Similarly, 19 of the 23 stations that exhibited trends in the study by Hickman and Gray had increasing concentrations. Median concentrations of dissolved nitrite plus nitrate at Status stations also showed a significant change in concentrations during water years 1998–2009. In general, concentrations of dissolved nitrite plus nitrate increased significantly during the study period.

Trends in concentrations of total phosphorus were determined in the two previous trend studies. Results from Hickman and Barringer (1999) indicated that all 24 stations that exhibited a trend had decreasing concentrations. Trends in total phosphorus concentrations over the period of study analyzed by Hickman and Gray (2010) were identified at 17 stations with decreasing concentrations identified for 12 stations and increasing concentrations identified for 5 stations. Although median concentrations of total phosphorus varied significantly during the study period of this investigation, the variations were not consistently increasing or decreasing concentrations.

Hickman and Barringer (1999) found trends in concentrations of total nitrogen at 42 of the 83 stations studied. Of the 42 stations where trends were identified, 41 had decreasing trends. In contrast, median concentrations of total nitrogen at Status stations during water years 1998–2009 generally increased significantly.

Summary and Conclusions

Variations in concentrations of selected water-quality constituents measured year-round during water years 1998–2009 were determined for 371 stations on New Jersey streams. Water-quality constituents included in the statistical analyses are TDS, dissolved chloride, dissolved nitrate plus nitrite, dissolved phosphorus, total phosphorus, and total nitrogen. Statistical analyses of dissolved chloride were conducted on measurements made only during January to March; the other constituents were measured throughout the year. Samples for the analyses of all water-quality constituents were collected by the NJDEP or the USGS as part of the cooperative Ambient Surface-Water-Quality Monitoring Network.

Stations were divided according to the 1-year or 2-year period that the stations were part of the Ambient Surface-Water-Quality Monitoring Network with respect to each station type. Data were obtained from the eight groups of Statewide Status stations for water years 1998, 1999, 2000, 2001–02, 2003–04, 2005–06, 2007–08, and 2009. The data obtained from each of the eight groups of Status stations were statistically compared to each of the other groups and then to baseline data obtained from Background stations during the same time period.

Variations in concentrations of water-quality constituents were determined using two statistical tests, the Kruskal-Wallis and Tukey's multiple comparison tests. Both were conducted at a 0.05 level of significance to indicate a significant change in constituent concentrations during the selected time frame. The Kruskal-Wallis test determined whether median concentrations of a selected water-quality constituent were significantly different from those measured in other 1-year or 2-year periods during water years 1998–2009. If median concentrations were found to differ significantly among years or groups of years, then Tukey's multiple comparison test on ranks identified which periods had equal or different median concentrations of selected water-quality constituents. A third test, the Mann-Whitney rank-sum test, was used to determine whether water quality at Status stations differed from that at Background stations.

Results of statistical analyses showed significant variations in median concentrations of some water-quality constituents during water years 1998–2009. On the basis of statistical analyses, median concentrations of dissolved chloride measured from January to March and TDS, dissolved nitrite plus nitrate, total phosphorus, and total nitrogen measured throughout the year varied significantly among water years 1998 to 2009 for Status stations but did not differ significantly for Background stations. Furthermore, median concentrations of dissolved chloride, TDS, dissolved nitrite plus nitrate, and total nitrogen significantly increased from the beginning to the end of the study period at Status stations.

Results of analyses of median concentrations of dissolved phosphorus showed no significant change for either Status stations or Background stations. Additionally, results of statistical analyses of water quality at Status stations and at Background stations confirmed the statistical difference between the two different types of stations.

Excluding water year 2009, median concentrations of TDS, dissolved chloride, dissolved nitrite plus nitrate, and total nitrogen increased significantly for Status stations during water years 1998–2009, whereas no significant variations of median concentrations of any of the selected water-quality constituents were observed for Background stations during the study period. No significant decreases in median concentrations of any water-quality constituent were observed during the study period.

Streamflow data offered some insight into the interpretation of changes in water-quality constituents. For example, the maximum concentrations of TDS, dissolved chloride, dissolved phosphorus, and total phosphorus for water years 1998 to 2009 at Status stations occurred during an extreme drought in 2002 when dissolved constituents generally were concentrated in the water column as a result of low streamflow conditions.

Ultimately, the significant variations in median concentrations of water-quality constituents that were observed in this study occurred only at Status stations during the 11-year period of this study. Because Background stations are representative of baseline water quality in New Jersey, it was expected that no significant changes occurred at those stations.

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Appendixes

Appendix 1. Description of selected Background and Statewide Status water-quality stations included in the study of variations in statewide water quality of New Jersey streams, water year 1998.

[All stations were sampled as part of the cooperative Ambient Surface Water-Quality Monitoring Network. Latitude in degrees minutes seconds; longitude in degrees minutes seconds; NAD83, North American Datum of 1983. Drainage area is in square miles]

Station number	Station name	Latitude	Longitude	Datum for latitude/ longitude	Hydrologic unit code	Drainage area
	Background stations					
01368820	Double Kill at Wawayanda NJ	411113	742512	NAD83	02020007	6.46
01396550	Spruce Run at Newport NJ	404329	745433	NAD83	02030105	5.67
01411955	Gravelly Run at Laurel Lake NJ	392014	750303	NAD83	02040206	3.19
01442760	Dunnfield Creek at Dunnfield NJ	405815	750736	NAD83	02040104	3.56
	Statewide Status stations					
01367860	Papakating Creek near Sussex NJ	411139	743716	NAD83	02020007	36.70
01376970	Hackensack River at Old Tappan NJ	410044	740028	NAD83	02030103	51.60
01377500	Pascack Brook at Westwood NJ	405934	740116	NAD83	02030103	29.60
01378855	Black Brook at Madison NJ	404413	742521	NAD83	02030103	0.42
01380100	Beaver Brook at Rockaway NJ	405408	743005	NAD83	02030103	22.20
01382410	Macopin River at Echo Lake NJ	410252	742424	NAD83	02030103	4.42
01383505	Wanaque River near Awosting NJ	410949	741905	NAD83	02030103	27.80
01390900	Ramsey Brook at Allendale NJ	410144	740806	NAD83	02030103	2.55
01391490	Saddle River at Rochelle Park NJ	405401	740452	NAD83	02030103	55.50
01395200	Robinsons Branch trib at Scotch Plains NJ	403732	742048	NAD83	02030104	2.89
01398070	South Branch Raritan River at Elm St at Neshanic Station NJ	403034	744336	NAD83	02030105	248.00
01398300	Dawsons Brook near Ironia NJ	404815	743741	NAD83	02030105	1.04
01400395	Peters Brook at Rt 28 at Somerville NJ	403358	743617	NAD83	02030105	9.55
01400585	Rocky Brook at Perrineville NJ	401338	742621	NAD83	02030105	2.83
01401400	Heathcote Brook at Kingston NJ	402210	743658	NAD83	02030105	9.00
01403470	Green Brook at North Plainfield NJ	403815	742454	NAD83	02030105	8.01
01407090	Town Brook at Middletown NJ	402320	740617	NAD83	02030104	0.92
01408009	Mingamahone Brook near Earle NJ	401245	741006	NAD83	02040301	3.32
01408480	Shannoc Brook trib at Colliers Mills NJ	400339	742625	NAD83	02040301	3.15
01408500	Toms River near Toms River NJ	395911	741324	NAD83	02040301	123.00
01409449	Indian Mills Brook at Indian Mills NJ	394735	744447	NAD83	02040301	4.33
01409960	Papoose Branch near Sim Place NJ	394432	742710	NAD83	02040301	4.40
01410455	South Branch Absecon Creek near Pomona NJ	392623	743358	NAD83	02040302	5.73
01411196	Babcock Creek near Mays Landing NJ	392808	744133	NAD83	02040302	16.30
01411400	Fishing Creek at Rio Grande NJ	390139	745347	NAD83	02040206	2.29
01411440	Old Robins Branch near North Dennis NJ	391150	745209	NAD83	02040206	2.96
01411458	Little Ease Run at Porchtown NJ	393549	750432	NAD83	02040206	14.30
01411950	Buckshutem Creek near Laurel Lake NJ	392051	750346	NAD83	02040206	12.90
01439830	Big Flat Brook at Tuttles Corner NJ	411200	744855	NAD83	02040104	28.30
01444970	Pequest River at Rt 206 below Springdale NJ	410052	744601	NAD83	02040105	10.10

Appendix 1. Description of selected Background and Statewide Status water-quality stations included in the study of variations in statewide water quality of New Jersey streams, water year 1998.—Continued

[All stations were sampled as part of the cooperative Ambient Surface Water-Quality Monitoring Network. Latitude in degrees minutes seconds; longitude in degrees minutes seconds; NAD83, North American Datum of 1983. Drainage area is in square miles]

Station number	Station name	Latitude	Longitude	Datum for latitude/ longitude	Hydrologic unit code	Drainage area
	Statewide Status stations—Continued					
01458570	Nishisakawick Creek near Frenchtown NJ	403239	750247	NAD83	02040105	10.10
01461262	Plum Brook near Locktown NJ	402925	745620	NAD83	02040105	1.87
01464440	Lahaway Creek at Route 537 at Prospertown NJ	400802	742741	NAD83	02040201	3.54
01464578	Annaricken Brook near Jobstown NJ	400319	744207	NAD83	02040201	2.82
01466500	McDonalds Branch in Byrne State Forest NJ	395306	743019	NAD83	02040202	2.35
01467155	North Branch Cooper River at Kresson NJ	395133	745544	NAD83	02040202	1.04
01467325	South Branch Big Timber Creek at Turnersville NJ	394619	750257	NAD83	02040202	7.70
01467359	North Branch Big Timber Creek at Glendora NJ	395004	750401	NAD83	02040202	18.80

Appendix 2. Description of selected Background and Statewide Status water-quality stations included in the study of variations in statewide water quality of New Jersey streams, water year 1999.

[All stations were sampled as part of the cooperative Ambient Surface Water-Quality Monitoring Network. Latitude in degrees minutes seconds; longitude in degrees minutes seconds; NAD83, North American Datum of 1983. Drainage area is in square miles]

Station number	Station name	Latitude	Longitude	Datum for latitude/ longitude	Hydrologic unit code	Drainage area
	Background stations					
01368820	Double Kill at Wawayanda NJ	411113	742512	NAD83	02020007	6.46
01396550	Spruce Run at Newport NJ	404329	745433	NAD83	02030105	5.67
01411955	Gravelly Run at Laurel Lake NJ	392014	750303	NAD83	02040206	3.19
01442760	Dunnfield Creek at Dunnfield NJ	405815	750736	NAD83	02040104	3.56
	Statewide Status stations					
01367715	Wallkill River at Scott Road at Franklin NJ	410800	743443	NAD83	02020007	40.60
01367780	Papakating Creek near Wykertown NJ	411000	744337	NAD83	02020007	1.99
01377499	Musquapsink Brook at River Vale NJ	405932	740123	NAD83	02030103	7.07
01378387	Tenakill Brook at Old Closter Dock Rd at Closter NJ	405843	735800	NAD83	02030103	8.69
01378855	Black Brook at Madison NJ	404413	742521	NAD83	02030103	0.42
01379680	Rockaway River at Longwood Valley NJ	405714	743416	NAD83	02030103	22.10
01387010	Wanaque River at Highland Ave at Wanaque NJ	410214	741708	NAD83	02030103	96.40
01387500	Ramapo River near Mahwah NJ	410553	740946	NAD83	02030103	120.00
01390470	Saddle River at Saddle River NJ	410155	740559	NAD83	02030103	15.40
01390510	Saddle River at Ridgewood Ave at Ridgewood NJ	405821	740532	NAD83	02030103	22.30
01393350	West Branch Elizabeth River near Union NJ	404132	741437	NAD83	02030104	2.53
01393960	West Branch Rahway River at Northfield Ave at West Orange NJ	404611	741659	NAD83	02030104	3.92
01396219	Stony Brook at Fairview Ave at Naughright NJ	404819	744502	NAD83	02030105	3.32
01399780	Lamington River at Burnt Mills NJ	403805	744112	NAD83	02030105	100.00
01400690	Cranbury Brook near Prospect Plains NJ	401819	742823	NAD83	02030105	7.64
01401700	Pike Run near Rocky Hill NJ	402512	743827	NAD83	02030105	22.20
01404470	Ireland Brook at Patricks Corner NJ	402513	742904	NAD83	02030105	6.52
01405195	Matchaponix Brook at Englishtown NJ	401852	742141	NAD83	02030105	23.60
01407360	Yellow Brook near Marlboro NJ	401634	741306	NAD83	02030104	3.76
01407997	Marsh Bog Brook at Squankum NJ	401001	740932	NAD83	02040301	4.91
01408152	South Branch Metedeconk River near Laurelton NJ	400442	740924	NAD83	02040301	30.80
01409050	North Branch Forked River near Forked River NJ	395127	741320	NAD83	02040301	13.40
01409408	Pump Branch near Waterford Works NJ	394159	745039	NAD83	02040301	9.78
0140941070	Great Swamp Branch below US Rt 206 near Hammonton NJ	394104	744547	NAD83	02040301	8.07
01411220	South River near Belcoville NJ	392625	744520	NAD83	02040302	20.40
01411241	Gibson Creek at Route 50 near Corbin City NJ	392111	744521	NAD83	02040302	3.95
01411441	Savages Run in Belleplain State Forest NJ	391432	745233	NAD83	02040206	5.55
01411444	West Creek near Leesburg NJ	391536	745441	NAD83	02040206	6.64
01411453	Still Run near Malaga NJ	393507	750454	NAD83	02040206	26.90
01411780	Muddy Run near Norma NJ	392813	750535	NAD83	02040206	56.50

Appendix 2. Description of selected Background and Statewide Status water-quality stations included in the study of variations in statewide water quality of New Jersey streams, water year 1999.—Continued

[All stations were sampled as part of the cooperative Ambient Surface Water-Quality Monitoring Network. Latitude in degrees minutes seconds; longitude in degrees minutes seconds; NAD83, North American Datum of 1983. Drainage area is in square miles]

Station number	Station name	Latitude	Longitude	Datum for latitude/longitude	Hydrologic unit code	Drainage area
	Statewide Status stations—Continued					
01443550	Jacksonburg Creek near Millbrook NJ	410221	745753	NAD83	02040105	2.43
01443600	Jacksonburg Creek near Blairstown NJ	405915	745842	NAD83	02040105	8.34
01461220	Wickecheoke Creek at Croton NJ	403035	745549	NAD83	02040105	3.81
01462739	Jacobs Creek at Bear Tavern NJ	401826	745001	NAD83	02040105	5.16
01464420	Crosswicks Creek near New Egypt NJ	400503	743227	NAD83	02040201	45.80
01464529	Bacons Run near Mansfield Square NJ	400627	744105	NAD83	02040201	4.41
01465884	Sharps Run at Route 541 at Medford NJ	395418	744929	NAD83	02040202	4.41
01465893	Little Creek at Chairville NJ	395353	744718	NAD83	02040202	6.32
01467327	South Branch Big Timber Creek trib at Grenloch NJ	394646	750314	NAD83	02040202	4.27
01476600	Still Run near Mickleton NJ	394719	751526	NAD83	02040202	3.98

Appendix 3. Description of selected Background and Statewide Status water-quality stations included in the study of variations in statewide water quality of New Jersey streams, water year 2000.

[All stations were sampled as part of the cooperative Ambient Surface Water-Quality Monitoring Network. Latitude in degrees minutes seconds; longitude in degrees minutes seconds; NAD83, North American Datum of 1983. Drainage area is in square miles]

Station number	Station name	Latitude	Longitude	Datum for latitude/ longitude	Hydrologic unit code	Drainage area
	Background stations					
01368820	Double Kill at Wawayanda NJ	411113	742512	NAD83	02020007	6.46
01396550	Spruce Run at Newport NJ	404329	745433	NAD83	02030105	5.67
01411955	Gravelly Run at Laurel Lake NJ	392014	750303	NAD83	02040206	3.19
01442760	Dunnfield Creek at Dunnfield NJ	405815	750736	NAD83	02040104	3.56
	Statewide Status stations					
01367770	Wallkill River near Sussex NJ	411138	743431	NAD83	02020007	60.80
01367850	West Branch Papakating Creek at Mccoys Corner NJ	411149	743754	NAD83	02020007	11.00
01377499	Musquapsink Brook at River Vale NJ	405932	740123	NAD83	02030103	7.07
01377500	Pascack Brook at Westwood NJ	405934	740116	NAD83	02030103	29.60
01380320	Stony Brook at Boonton NJ	405544	742615	NAD83	02030103	12.10
01381050	Crooked Brook near Towaco NJ	405618	742219	NAD83	02030103	1.68
01382410	Macopin River at Echo Lake NJ	410252	742424	NAD83	02030103	4.42
01387500	Ramapo River near Mahwah NJ	410553	740946	NAD83	02030103	120.00
01389860	Diamond Brook at Fair Lawn NJ	405637	740830	NAD83	02030103	3.19
01390445	West Branch Saddle River at Upper Saddle River NJ	410424	740554	NAD83	02030103	3.12
01395000	Rahway River at Rahway NJ	403708	741700	NAD83	02030104	40.90
01396003	Robinsons Branch at Central Ave at Rahway NJ	403634	741717	NAD83	02030104	21.70
01399100	Middle Brook at Burnt Mills NJ	403858	744054	NAD83	02030105	6.67
01399900	Chambers Brook at North Branch Depot NJ	403532	744059	NAD83	02030105	10.20
01400585	Rocky Brook at Perrineville NJ	401338	742621	NAD83	02030105	2.83
01401200	Duck Pond Run at Clarksville NJ	401824	744005	NAD83	02030105	3.74
01403300	Raritan River at Queens Bridge at Bound Brook NJ	403334	743140	NAD83	02030105	804.00
01405285	Barclay Brook near Englishtown NJ	402053	742126	NAD83	02030105	4.94
01407630	Poplar Brook at Deal NJ	401523	735946	NAD83	02030104	3.36
01407720	Jumping Brook at Green Grove NJ	401410	740455	NAD83	02030104	2.58
01408285	Maple Root Branch at Bowman Rd near Holmansville NJ	400452	741936	NAD83	02040301	5.63
01409050	North Branch Forked River near Forked River NJ	395127	741320	NAD83	02040301	13.40
01409570	Landing Creek at US Rt 30 at Egg Harbor City NJ	393208	743927	NAD83	02040301	3.57
01409600	Landing Creek near Egg Harbor City NJ	393324	743610	NAD83	02040301	14.70
01409690	West Branch Wading River at Chatsworth NJ	394851	743249	NAD83	02040301	9.24
01411035	Hospitality Branch at Blue Bell Road near Cecil NJ	393840	745909	NAD83	02040302	4.51
01411050	Hospitality Branch near Cecil NJ	393714	745538	NAD83	02040302	14.20
01411428	Dennis Creek trib 2 at Dennisville NJ	391134	744932	NAD83	02040206	4.00
01411444	West Creek near Leesburg NJ	391536	745441	NAD83	02040206	6.64
01412200	Pages Run at Newport NJ	391818	750951	NAD83	02040206	3.86
01413065	Canton Drain at Maskell Mill NJ	392909	752358	NAD83	02040206	6.53

Appendix 3. Description of selected Background and Statewide Status water-quality stations included in the study of variations in statewide water quality of New Jersey streams, water year 2000.—Continued

[All stations were sampled as part of the cooperative Ambient Surface Water-Quality Monitoring Network. Latitude in degrees minutes seconds; longitude in degrees minutes seconds; NAD83, North American Datum of 1983. Drainage area is in square miles]

Station number	Station name	Latitude	Longitude	Datum for latitude/ longitude	Hydrologic unit code	Drainage area
	Statewide Status stations—Continued					
01443370	Dry Brook at County Route 519 near Branchville NJ	411006	744411	NAD83	02030105	2.69
01445000	Pequest River at Huntsville NJ	405851	744635	NAD83	02040105	31.00
01458710	Copper Creek near Frenchtown NJ	403039	750242	NAD83	02040105	2.52
01464020	Assunpink Creek at Peace St at Trenton NJ	401302	744607	NAD83	02040105	91.40
01464504	Crosswicks Creek at Groveville Rd at Groveville NJ	401002	744039	NAD83	02040201	98.00
01464529	Bacons Run near Mansfield Square NJ	400627	744105	NAD83	02040201	4.41
01465950	North Branch Rancocas Creek at Hanover Furnace NJ	395846	743129	NAD83	02040202	13.50
01466200	Pole Bridge Branch near Browns Mills NJ	395648	743321	NAD83	02040202	24.90
01477440	Oldmans Creek at Jessups Mill NJ	393944	751352	NAD83	02040202	4.15
01482560	Two Penny Run near Danceys Corner NJ	394122	752430	NAD83	02040206	3.44

Appendix 4. Description of selected Background and Statewide Status water-quality stations included in the study of variations in statewide water quality of New Jersey streams, water years 2001–02.

[All stations were sampled as part of the cooperative Ambient Surface Water-Quality Monitoring Network. Latitude in degrees minutes seconds; longitude in degrees minutes seconds; NAD83, North American Datum of 1983. Drainage area is in square miles]

Station number	Station name	Latitude	Longitude	Datum for latitude/ longitude	Hydrologic unit code	Drainage area
	Background stations					
01368820	Double Kill at Wawayanda NJ	411113	742512	NAD83	02020007	6.46
01378780	Primrose Brook at Morristown National Hist Park NJ	404554	743147	NAD83	02030103	1.07
01396550	Spruce Run at Newport NJ	404329	745433	NAD83	02030105	5.67
01411955	Gravelly Run at Laurel Lake NJ	392014	750303	NAD83	02040206	3.19
01442760	Dunnfield Creek at Dunnfield NJ	405815	750736	NAD83	02040104	3.56
01466500	McDonalds Branch in Byrne State Forest NJ	395306	743019	NAD83	02040202	2.35
	Statewide Status stations					
01367715	Wallkill River at Scott Road at Franklin NJ	410800	743443	NAD83	02020007	40.60
01367780	Papakating Creek near Wykertown NJ	411000	744337	NAD83	02020007	1.99
01378387	Tenakill Brook at Old Closter Dock Rd at Closter NJ	405843	735800	NAD83	02030103	8.69
01378560	Coles Brook at Hackensack NJ	405440	740225	NAD83	02030103	7.00
01378660	Passaic River at Tempe Wick Rd near Mendham NJ	404617	743411	NAD83	02030103	1.80
01380098	Beaver Brook at Morris Ave at Denville NJ	405421	742949	NAD83	02030103	22.10
01382410	Macopin River at Echo Lake NJ	410252	742424	NAD83	02030103	4.42
01387014	Wanaque River at Wanaque Ave at Pompton Lakes NJ	410025	741733	NAD83	02030103	98.00
01389850	Goffle Brook at Hawthorne NJ	405620	740947	NAD83	02030103	8.77
01391550	Saddle River at Garfield NJ	405150	740559	NAD83	02030103	60.40
01393960	West Branch Rahway River at Northfield Ave at West Orange NJ	404611	741659	NAD83	02030104	3.92
01396030	South Branch Rahway River at Colonia NJ	403457	741803	NAD83	02030104	9.31
01396900	Capoolong Creek at Lansdowne NJ	403628	745457	NAD83	02030105	14.10
01397950	Third Neshanic River at Copper Hill NJ	402829	745147	NAD83	02030105	10.30
01400530	Millstone River at Bairds Rd near Perrineville NJ	401428	742406	NAD83	02030105	4.58
01400560	Millstone River at Applegarth NJ	401628	742821	NAD83	02030105	15.00
01403171	West Branch Middle Brook at Chimney Rock Rd at Martinsville NJ	403521	743348	NAD83	02030105	6.29
01405340	Manalapan Brook at Federal Road near Manalapan NJ	401746	742352	NAD83	02030105	20.90
01407617	Whale Pond Brook at Larchwood Ave at Oakhurst NJ	401631	740035	NAD83	02030104	5.25
01407806	Hannabrand Brook at Old Mill Rd near Spring Lk Hghts NJ	400836	740312	NAD83	02030104	3.13
01408300	Toms River at Whitesville NJ	400342	741628	NAD83	02040301	45.20
01408702	Jakes Branch at Dover Rd near Double Trouble NJ	395455	741625	NAD83	02040301	0.25
0140940050	Mullica River at Constable Bridge near Batsto NJ	393933	743932	NAD83	02040301	47.00
01409435	Skit Branch near Hampton Gate NJ	394709	743930	NAD83	02040301	4.91
01411290	Tuckahoe River near Estell Manor NJ	392219	745113	NAD83	02040302	8.78
01411300	Tuckahoe River at Head of River NJ	391825	744914	NAD83	02040302	30.80
01411427	Dennis Creek trib 2 above Johnson Pond at Dennisville NJ	391223	744921	NAD83	02040206	2.77
01411428	Dennis Creek trib 2 at Dennisville NJ	391134	744932	NAD83	02040206	4.00

Appendix 4. Description of selected Background and Statewide Status water-quality stations included in the study of variations in statewide water quality of New Jersey streams, water years 2001–02.—Continued

[All stations were sampled as part of the cooperative Ambient Surface Water-Quality Monitoring Network. Latitude in degrees minutes seconds; longitude in degrees minutes seconds; NAD83, North American Datum of 1983. Drainage area is in square miles]

Station number	Station name	Latitude	Longitude	Datum for latitude/ longitude	Hydrologic unit code	Drainage area
	Statewide Status stations—Continued					
01411444	West Creek near Leesburg NJ	391536	745441	NAD83	02040206	6.64
01411452	Still Run at Little Mill Road near Clayton NJ	393808	750558	NAD83	02040206	10.60
01413013	Barrett Run at Bridgeton NJ	392646	751451	NAD83	02040206	7.58
01443250	Paulins Kill at Warbasse Jct Rd near Lafayette NJ	410508	744157	NAD83	02040105	11.40
01445900	Honey Run near Hope NJ	405333	745841	NAD83	02040105	10.20
01461282	Wickecheoke Creek at Sergeantsville NJ	402638	745758	NAD83	02040105	22.80
01464020	Assunpink Creek at Peace St at Trenton NJ	401302	744607	NAD83	02040105	91.40
01464380	North Run at Cookstown NJ	400258	743346	NAD83	02040201	7.28
01464504	Crosswicks Creek at Groveville Rd at Groveville NJ	401002	744039	NAD83	02040201	98.00
01466100	Mount Misery Brook at Upton NJ	395544	743152	NAD83	02040202	28.40
01467155	North Branch Cooper River at Kresson NJ	395133	745544	NAD83	02040202	1.04
01475090	Edwards Run at Jefferson NJ	394448	751142	NAD83	02040202	2.92
01482530	Major Run at Sharptown NJ	393856	752228	NAD83	02040206	3.04

Appendix 5. Description of selected Background and Statewide Status water-quality stations included in the study of variations in statewide water quality of New Jersey streams, water years 2003–04.

[All stations were sampled as part of the cooperative Ambient Surface Water-Quality Monitoring Network. Latitude in degrees minutes seconds; longitude in degrees minutes seconds; NAD83, North American Datum of 1983. Drainage area is in square miles]

Station number	Station name	Latitude	Longitude	Datum for latitude/ longitude	Hydrologic unit code	Drainage area
	Background stations					
01368820	Double Kill at Wawayanda NJ	411113	742512	NAD83	02020007	6.46
01378780	Primrose Brook at Morristown National Hist Park NJ	404554	743147	NAD83	02030103	1.07
01396550	Spruce Run at Newport NJ	404329	745433	NAD83	02030105	5.67
01411955	Gravelly Run at Laurel Lake NJ	392014	750303	NAD83	02040206	3.19
01442760	Dunnfield Creek at Dunnfield NJ	405815	750736	NAD83	02040104	3.56
01466500	McDonalds Branch in Byrne State Forest NJ	395306	743019	NAD83	02040202	2.35
	Statewide Status stations					
01367880	Clove Brook trib at Rose Morrow Road near Colesville NJ	411541	743726	NAD83	02020007	4.46
01378475	Dorotockeys Run at Harrington Park NJ	405914	735829	NAD83	02030103	4.10
01379870	Mill Brook at Randolph NJ	405243	743131	NAD83	02030103	4.83
01381498	Whippany River at Ridgedale Ave at Morristown NJ	404804	742757	NAD83	02030103	27.70
01382960	Green Brook near West Milford NJ	410909	742133	NAD83	02030103	1.85
01390400	Saddle River at Old Stone Ch Rd at Upper Saddle River NJ	410416	740518	NAD83	02030103	6.32
01390800	Valentine Brook at Allendale NJ	410153	740909	NAD83	02030103	2.48
01394200	Rahway River at Morris Ave at Springfield NJ	404229	741807	NAD83	02030104	18.10
01395700	Robinsons Branch trib 2 at Westfield NJ	403730	741940	NAD83	02030104	1.93
01398060	Furmans Brook at Furmans Corner NJ	402750	744709	NAD83	02030105	5.00
01398090	Pleasant Run at Neshanic Station NJ	403111	744407	NAD83	02030105	10.80
01399200	Lamington (Black) River near Ironia NJ	405007	743839	NAD83	02030105	10.90
01400808	Bear Brook at Cranbury Rd at Princeton Junction NJ	401905	743644	NAD83	02030105	12.00
01405003	Lawrence Brook at Riva Ave at Milltown NJ	402655	742646	NAD83	02030105	36.10
01405180	McGellairds Brook at Englishtown NJ	401806	742125	NAD83	02030105	14.90
01407210	Hop Brook at Willow Brook Road near Holmdel NJ	401947	741020	NAD83	02030104	6.37
01407900	Manasquan River at West Farms NJ	401134	741143	NAD83	02040301	33.50
01408110	Haystack Brook near Southard NJ	400847	741158	NAD83	02040301	1.77
01408460	Manapaqua Branch at Lakehurst NJ	400044	741809	NAD83	02040301	6.32
01409030	Long Branch near Wells Mills NJ	394902	741735	NAD83	02040301	1.69
0140941075	Cedar Brook at Columbia Road at Hammonton, NJ	393953	744556	NAD83	02040301	3.57
01409601	Indian Cabin Creek at Fifth Avenue near Elwood NJ	393415	743951	NAD83	02040301	1.89
01410455	South Branch Absecon Creek near Pomona NJ	392623	743358	NAD83	02040302	5.73
01410865	Squankum Branch at Malaga Rd near Williamstown NJ	394004	745738	NAD83	02040302	3.02
01411440	Old Robins Branch near North Dennis NJ	391150	745209	NAD83	02040206	2.96
01411444	West Creek near Leesburg NJ	391536	745441	NAD83	02040206	6.64
01412005	Menantico Creek at Route 49 at Millville NJ	392311	745921	NAD83	02040206	26.30
01455120	Pohatcong Creek at Janes Chapel Rd at Mount Bethel NJ	405019	745400	NAD83	02040105	1.80
01457400	Musconetcong River at Riegelsville NJ	403533	751110	NAD83	02040105	156.00

Appendix 5. Description of selected Background and Statewide Status water-quality stations included in the study of variations in statewide water quality of New Jersey streams, water years 2003–04.—Continued

[All stations were sampled as part of the cooperative Ambient Surface Water-Quality Monitoring Network. Latitude in degrees minutes seconds; longitude in degrees minutes seconds; NAD83, North American Datum of 1983. Drainage area is in square miles]

Station number	Station name	Latitude	Longitude	Datum for latitude/ longitude	Hydrologic unit code	Drainage area
	Statewide Status stations—Continued					
01458300	Harihokake Creek at Harpence Rd near Mount Pleasant NJ	403601	750151	NAD83	02040105	0.98
01458710	Copper Creek near Frenchtown NJ	403039	750242	NAD83	02040105	2.52
01460860	Lockatong Creek at Route 12 at Baptistown NJ	403101	745930	NAD83	02040105	8.46
01463610	Assunpink Creek at Edinburg NJ	401528	743704	NAD83	02040105	25.00
01464280	South Run near Cookstown NJ	400138	743336	NAD83	02040201	6.06
01464532	Blacks Creek at Fieldsboro NJ	400831	744301	NAD83	02040201	23.05
01465808	South Branch Burrs Mill Brook near Hedger House NJ	395134	743555	NAD83	02040202	7.09
01465835	South Branch Rancocas Creek at Retreat NJ	395523	744304	NAD83	02040202	44.10
01465857	Southwest Branch Rancocas Creek at Elmwood Rd at Pine Grove NJ	395323	745300	NAD83	02040202	2.67
01465965	Ong Run at Browns Mills NJ	395835	743436	NAD83	02040202	1.87
01467312	Newton Creek at West Collingswood NJ	395405	750541	NAD83	02040202	4.51
01475042	Mantua Creek at Mantua Ave at Wenonah NJ	394727	750937	NAD83	02040202	29.20
01477440	Oldmans Creek at Jessups Mill NJ	393944	751352	NAD83	02040202	4.15

Appendix 6. Description of selected Background and Statewide Status water-quality stations included in the study of variations in statewide water quality of New Jersey streams, water years 2005–06.

[All stations were sampled as part of the cooperative Ambient Surface Water-Quality Monitoring Network. Latitude in degrees minutes seconds; longitude in degrees minutes seconds; NAD83, North American Datum of 1983. Drainage area is in square miles]

Station number	Station name	Latitude	Longitude	Datum for latitude/ longitude	Hydrologic unit code	Drainage area
	Background stations					
01368820	Double Kill at Wawayanda NJ	411113	742512	NAD83	02020007	6.46
01378400	Dwars Kill at Anderson Ave at Alpine NJ	405836	735603	NAD83	02030103	0.35
01378780	Primrose Brook at Morristown National Hist Park NJ	404554	743147	NAD83	02030103	1.07
01400860	Stony Brook trib 3 at Rileyville NJ	402506	744714	NAD83	02030105	1.28
01411955	Gravelly Run at Laurel Lake NJ	392014	750303	NAD83	02040206	3.19
01442760	Dunnfield Creek at Dunnfield NJ	405815	750736	NAD83	02040104	3.56
01466500	McDonalds Branch in Byrne State Forest NJ	395306	743019	NAD83	02040202	2.35
	Statewide Status stations					
01367902	Clove Brook at Loomis Avenue at Sussex NJ	411228	743633	NAD83	02020007	19.80
01368825	Double Kill at Wawayanda Road at Wawayanda NJ	411131	742458	NAD83	02020007	9.70
01378583	Overpeck Creek at Englewood NJ	405424	735808	NAD83	02030103	2.09
01378760	Loantaka Brook near Morristown NJ	404618	742738	NAD83	02030103	1.33
01380320	Stony Brook at Boonton NJ	405544	742615	NAD83	02030103	12.10
01387811	Ramapo River at Lenape Lane at Oakland NJ	410212	741429	NAD83	02030103	135.00
01388850	Packanack Brook at Packanack Lake NJ	405558	741510	NAD83	02030103	1.90
01390510	Saddle River at Ridgewood Ave at Ridgewood NJ	405821	740532	NAD83	02030103	22.30
01395000	Rahway River at Rahway NJ	403708	741700	NAD83	02030104	40.90
01395500	Robinsons Branch at Goodmans Crossing NJ	403655	742020	NAD83	02030104	12.70
01399295	Tanners Brook near Milltown NJ	404717	744332	NAD83	02030105	2.78
01399520	Herzog Brook near Pottersville NJ	404224	744300	NAD83	02030105	4.91
01400560	Millstone River at Applegarth NJ	401628	742821	NAD83	02030105	15.00
01401700	Pike Run near Rocky Hill NJ	402512	743827	NAD83	02030105	22.20
01403385	Bound Brook at Route 28 at Middlesex NJ	403451	742957	NAD83	02030105	23.90
01404400	Oakeys Brook near Patricks Corner NJ	402506	742952	NAD83	02030105	4.75
01407012	Gravelly Brook at Church Street at Matawan NJ	402427	741343	NAD83	02030104	2.36
01407253	Willow Brook near Holmdel NJ	401947	741025	NAD83	02030104	7.56
01407538	McClees Creek near Fairview NJ	402309	740420	NAD83	02030104	2.50
01408100	North Branch Metedeconk River at Lakewood NJ	400635	741309	NAD83	02040301	19.40
01408460	Manapaqua Branch at Lakehurst NJ	400044	741809	NAD83	02040301	6.32
01408598	Sunken Branch near Toms River NJ	395803	741432	NAD83	02040301	4.58
01409600	Landing Creek near Egg Harbor City NJ	393324	743610	NAD83	02040301	14.70
01409930	Plains Branch near Warren Grove NJ	394551	742428	NAD83	02040302	5.04
01410810	Fourmile Branch at New Brooklyn NJ	394147	745624	NAD83	02040302	7.74
01411196	Babcock Creek near Mays Landing NJ	392808	744133	NAD83	02040302	16.30
01411427	Dennis Creek trib 2 above Johnson Pond at Dennisville NJ	391223	744921	NAD83	02040206	2.77
01411487	Green Branch near Six Points NJ	393253	750603	NAD83	02040206	3.05

Appendix 6. Description of selected Background and Statewide Status water-quality stations included in the study of variations in statewide water quality of New Jersey streams, water years 2005–06.—Continued

[All stations were sampled as part of the cooperative Ambient Surface Water-Quality Monitoring Network. Latitude in degrees minutes seconds; longitude in degrees minutes seconds; NAD83, North American Datum of 1983. Drainage area is in square miles]

Station number	Station name	Latitude	Longitude	Datum for latitude/ longitude	Hydrologic unit code	Drainage area
	Statewide Status stations—Continued					
01411495	Blackwater Branch at Norma NJ	393020	750421	NAD83	02040206	12.50
01440097	Vancampens Brook at Millbrook NJ	410422	745745	NAD83	02040104	5.16
01444990	Kymers Brook at Brighton NJ	405907	744553	NAD83	02040105	16.90
01445100	Pequest River at Long Bridge NJ	405516	745025	NAD83	02040105	48.40
01455700	Musconetcong River above Lubbers Run at Lockwood NJ	405512	744351	NAD83	02040105	36.20
01463661	Shipetaukin Creek near Lawrenceville NJ	401746	744217	NAD83	02040105	5.93
01464460	Lahaway Creek near Hornerstown NJ	400625	743211	NAD83	02040201	21.40
01464527	Blacks Creek at Chesterfield NJ	400634	743830	NAD83	02040201	8.91
01465854	South Branch Rancocas Creek at Eayrestown NJ	395649	744727	NAD83	02040202	66.40
01467066	North Branch Pennsauken Creek at Gaither Drive at Fellowship NJ	395615	745658	NAD83	02040202	6.61
01467325	South Branch Big Timber Creek at Turnersville NJ	394619	750257	NAD83	02040202	7.70
01476625	Rattling Run at Tomlin NJ	394617	751551	NAD83	02040202	2.51
01476640	Pargey Creek at Swedesboro Ave at Repaupo NJ	394734	751712	NAD83	02040202	4.44
01477510	Oldmans Creek at Porches Mill NJ	394157	752000	NAD83	02040202	21.00

Appendix 7. Description of selected Background and Statewide Status water-quality stations included in the study of variations in statewide water quality of New Jersey streams, water years 2007–08.

[All stations were sampled as part of the cooperative Ambient Surface Water-Quality Monitoring Network. Latitude in degrees minutes seconds; longitude in degrees minutes seconds; NAD83, North American Datum of 1983. Drainage area is in square miles]

Station number	Station name	Latitude	Longitude	Datum for latitude/ longitude	Hydro-logic unit code	Drainage area
	Background stations					
01368820	Double Kill at Wawayanda NJ	411113	742512	NAD83	02020007	6.46
01378400	Dwars Kill at Anderson Ave at Alpine NJ	405836	735603	NAD83	02030103	0.35
01378780	Primrose Brook at Morristown National Hist Park NJ	404554	743147	NAD83	02030103	1.07
01400860	Stony Brook trib 3 at Rileyville NJ	402506	744714	NAD83	02030105	1.28
01411955	Gravelly Run at Laurel Lake NJ	392014	750303	NAD83	02040206	3.19
01442760	Dunnfield Creek at Dunnfield NJ	405815	750736	NAD83	02040104	3.56
01466500	McDonalds Branch in Byrne State Forest NJ	395306	743019	NAD83	02040202	2.35
	Statewide Status stations					
01367625	Wallkill River at Sparta NJ	410225	743747	NAD83	02020007	5.88
01377499	Musquapsink Brook at River Vale NJ	405932	740123	NAD83	02030103	7.07
01380320	Stony Brook at Boonton NJ	405544	742615	NAD83	02030103	12.10
01381260	Dismal Brook at Mt Pleasant Rd at Mount Freedom NJ	404843	743409	NAD83	02030103	0.99
01381330	Whippany River at Whitehead Rd at Washington Val NJ	404748	743148	NAD83	02030103	8.91
01388720	Beaver Dam Brook at Ryerson Rd at Lincoln Park NJ	405535	741734	NAD83	02030103	13.10
01390610	Hohokus Brook at De Yoe Pond outlet at Campgaw NJ	410134	741137	NAD83	02030103	1.16
01395000	Rahway River at Rahway NJ	403708	741700	NAD83	02030104	40.90
01397000	South Branch Raritan River at Stanton NJ	403420	745205	NAD83	02030105	147.00
01399820	Chambers Brook near North Branch NJ	403726	743947	NAD83	02030105	4.71
01400808	Bear Brook at Cranbury Rd at Princeton Junction NJ	401905	743644	NAD83	02030105	12.00
01400823	Devils Brook at New Road near Monmouth Junction NJ	402143	743242	NAD83	02030105	3.81
01401520	Beden Brook near Hopewell NJ	402302	744427	NAD83	02030105	6.67
01403190	Middle Brook at Route 28 at Bound Brook NJ	403405	743313	NAD83	02030105	16.90
01403575	Stony Brook at West End Ave at North Plainfield NJ	403651	742646	NAD83	02030105	7.92
01407090	Town Brook at Middletown NJ	402320	740617	NAD83	02030104	0.92
01407520	Pine Brook at Tinton Falls NJ	401815	740604	NAD83	02030104	12.10
01407806	Hannabrand Brook at Old Mill Rd near Spring Lk Hghts NJ	400836	740312	NAD83	02030104	3.13
01408152	South Branch Metedeconk River near Laurelton NJ	400442	740924	NAD83	02040301	30.80
01408290	Dove Mill Branch at Whitesville NJ	400408	741730	NAD83	02040301	7.87
0140940200	Hays Mill Creek near Chesilhurst NJ	394502	745027	NAD83	02040301	7.13
0140941070	Great Swamp Branch below US Rt 206 near Hammonton NJ	394104	744547	NAD83	02040301	8.07
01411208	Gravelly Run at Route 559 at Gravelly Run NJ	392538	744206	NAD83	02040302	8.63
01411295	Tuckahoe River at Route 49 at Hunters Mill NJ	391926	745140	NAD83	02040302	17.80
01411400	Fishing Creek at Rio Grande NJ	390139	745347	NAD83	02040206	2.29
01411457	Little Ease Run at Grant Ave near Franklinville NJ	393806	750419	NAD83	02040206	12.40
01411458	Little Ease Run at Porchtown NJ	393549	750432	NAD83	02040206	14.30
01455240	Merrill Creek near Stewartsville NJ	404056	750629	NAD83	02040105	6.14

Appendix 7. Description of selected Background and Statewide Status water-quality stations included in the study of variations in statewide water quality of New Jersey streams, water years 2007–08.—Continued

[All stations were sampled as part of the cooperative Ambient Surface Water-Quality Monitoring Network. Latitude in degrees minutes seconds; longitude in degrees minutes seconds; NAD83, North American Datum of 1983. Drainage area is in square miles]

Station number	Station name	Latitude	Longitude	Datum for latitude/ longitude	Hydro- logic unit code	Drainage area
	Statewide Status stations—Continued					
01457400	Musconetcong River at Riegelsville NJ	403533	751110	NAD83	02040105	156.00
01460870	Lockatong Creek at Kingwood NJ	402816	750116	NAD83	02040105	15.00
01461250	Wickecheoke Creek at Locktown NJ	402909	745814	NAD83	02040105	9.24
01462730	Jacobs Creek at Woosamonsa Rd near Harbourton NJ	402027	745018	NAD83	02040105	1.84
01462800	Jacobs Creek at Somerset NJ	401642	745113	NAD83	02040105	13.30
01463810	Shabakunk Creek near Lawrenceville NJ	401519	744416	NAD83	02040105	11.70
01464460	Lahaway Creek near Hornerstown NJ	400625	743211	NAD83	02040201	21.40
01465854	South Branch Rancocas Creek at Eayrestown NJ	395649	744727	NAD83	02040202	66.40
01467000	North Branch Rancocas Creek at Pemberton NJ	395812	744104	NAD83	02040202	118.00
01467080	South Branch Pennsauken Creek at Maple Shade NJ	395625	745854	NAD83	02040202	8.10
0146708130	South Branch Pennsauken Creek at Main St at Maple Shade NJ	395715	750048	NAD83	02040202	12.40
01477110	Raccoon Creek at Mullica Hill NJ	394410	751329	NAD83	02040202	15.60
01482520	Salem River at Sharptown NJ	393909	752204	NAD83	02040206	27.30
01482645	Swedes Run at Swedes Bridge near Portertown NJ	393546	752233	NAD83	02040206	3.55

Appendix 8. Description of selected Background and Statewide Status water-quality stations included in the study of variations in statewide water quality of New Jersey streams, water year 2009.

[All stations were sampled as part of the cooperative Ambient Surface Water-Quality Monitoring Network. Latitude in degrees minutes seconds; longitude in degrees minutes seconds; NAD83, North American Datum of 1983. Drainage area is in square miles]

Station number	Station name	Latitude	Longitude	Datum for latitude/ longitude	Hydrologic unit code	Drainage area
	Background stations					
01368820	Double Kill at Wawayanda NJ	411113	742512	NAD83	02020007	6.46
01378400	Dwars Kill at Anderson Ave at Alpine NJ	405836	735603	NAD83	02030103	0.35
01378780	Primrose Brook at Morristown National Hist Park NJ	404554	743147	NAD83	02030103	1.07
01400860	Stony Brook trib 3 at Rileyville NJ	402506	744714	NAD83	02030105	1.28
01411955	Gravelly Run at Laurel Lake NJ	392014	750303	NAD83	02040206	3.19
01442760	Dunnfield Creek at Dunnfield NJ	405815	750736	NAD83	02040104	3.56
01466500	McDonalds Branch in Byrne State Forest NJ	395306	743019	NAD83	02040202	2.35
	Statewide Status stations					
01368950	Black Creek near Vernon NJ	411321	742832	NAD83	02020007	17.30
01376273	Sparkill Brook at Piermont Road at Northvale NJ	405923	735607	NAD83	02030101	0.50
01378770	Great Brook at Woodland Road at Green Village NJ	404330	742827	NAD83	02030103	14.10
01381515	Whippany River at Malapardis NJ	404908	742627	NAD83	02030103	31.60
01382170	Pequannock River at NJ Route 23 near Oak Ridge NJ	410440	742923	NAD83	02030103	19.30
01382280	Mossmans Brook near Uttertown NJ	410625	742604	NAD83	02030103	3.41
01391500	Saddle River at Lodi NJ	405325	740450	NAD83	02030103	54.60
01393440	Elizabeth River above Ursino Lake at Elizabeth NJ	404037	741335	NAD83	02030104	16.80
01399545	Lamington River at Lamington NJ	403938	744345	NAD83	02030105	53.60
01399565	Rockaway Creek at Rockaway Rd at Mountainville NJ	404124	744840	NAD83	02030105	9.07
01399570	Rockaway Creek at McCrea Mills NJ	403942	744557	NAD83	02030105	17.00
01400775	Bear Brook at Route 535 near Locust Corner NJ	401641	743438	NAD83	02030105	6.69
01400870	Stony Brook trib 3 near Hopewell NJ	402412	744806	NAD83	02030105	2.60
01401595	Rock Brook near Blawenburg NJ	402447	744102	NAD83	02030105	9.03
01406040	Deep Run at Route 516 near Old Bridge NJ	402429	742035	NAD83	02030105	15.60
01407280	Big Brook at Route 79 at Marlboro NJ	401926	741440	NAD83	02030104	2.58
01407450	Mine Brook at Colts Neck NJ	401729	741010	NAD83	02030104	5.48
01407988	Marsh Bog Brook near Shacks Corner NJ	401252	741054	NAD83	02040301	2.05
01408380	Blacks Branch at Lakehurst NJ	400031	741948	NAD83	02040301	7.61
01408495	Union Branch at Pine Lake Park NJ	400023	741450	NAD83	02040301	62.50
01408598	Sunken Branch near Toms River NJ	395803	741432	NAD83	02040301	4.58
01409455	Springers Brook near Hampton Furnace NJ	394519	744146	NAD83	02040301	18.30
01409525	Lucas Branch at Sweetwater NJ	393704	743747	NAD83	02040301	3.94
01410150	East Branch Bass River near New Gretna NJ	393723	742629	NAD83	02040301	8.11
01411220	South River near Belcoville NJ	392625	744520	NAD83	02040302	20.40
01411438	Dennis Creek trib 1 near North Dennis NJ	391141	745029	NAD83	02040206	2.74
01411490	Green Branch at Brotmanville NJ	393132	750450	NAD83	02040206	7.63
01411695	Indian Run at Husted Station Road at Palatine NJ	393208	751103	NAD83	02040206	7.49

Appendix 8. Description of selected Background and Statewide Status water-quality stations included in the study of variations in statewide water quality of New Jersey streams, water year 2009.—Continued

[All stations were sampled as part of the cooperative Ambient Surface Water-Quality Monitoring Network. Latitude in degrees minutes seconds; longitude in degrees minutes seconds; NAD83, North American Datum of 1983. Drainage area is in square miles]

Station number	Station name	Latitude	Longitude	Datum for latitude/ longitude	Hydrologic unit code	Drainage area
	Statewide Status stations—Continued					
01411907	White Marsh Run at Millville NJ	392323	750240	NAD83	02040206	8.77
01438500	Delaware River at Montague NJ	411833	744743	NAD83	02040104	3480.00
01443466	Neldons Brook at Swartswood Road at Swartswood NJ	410505	744937	NAD27	02040105	9.68
01457120	Musconetcong River at Route 579 at Bloomsbury NJ	403920	750520	NAD83	02040105	145.00
01461840	Alexauken Creek tributary at Mount Airy NJ	402422	745511	NAD83	02040105	3.48
01463520	Assunpink Creek at Roosevelt NJ	401243	742837	NAD83	02040105	1.50
01463850	Miry Run at Route 533 at Mercerville NJ	401449	744112	NAD83	02040105	10.70
01464512	Doctors Creek at Red Valley NJ	400941	742807	NAD83	02040201	3.83
01465865	Barton Run at Tuckerton Road near Medford NJ	395243	745137	NAD83	02040202	12.00
01465893	Little Creek at Chairville NJ	395353	744718	NAD83	02040202	6.32
01465950	North Branch Rancocas Creek at Hanover Furnace NJ	395846	743129	NAD83	02040202	13.50
01467021	Mill Creek at Levitt Parkway at Willingboro NJ	400209	745337	NAD83	02040202	9.12
01467359	North Branch Big Timber Creek at Glendora NJ	395004	750401	NAD83	02040202	18.80
01476600	Still Run near Mickleton NJ	394719	751526	NAD83	02040202	3.98

Appendix 9. Description of selected Index streamgaging stations included in the study of variations in statewide water quality of New Jersey streams, water years 1998–2009.

[All stations are maintained and operated by the U.S. Geological Survey, New Jersey Water Science Center. Latitude in degrees minutes seconds; longitude in degrees minutes seconds; NAD83, North American Datum of 1983. Drainage area is in square miles. Annual mean streamflow is in cubic feet per second]

Station number	Station name	Latitude	Longitude	Datum for latitude/ longitude	Hydrologic unit code	Drainage area	Period of record	Annual mean streamflow for period of record[1]
01384500	Ringwood Creek near Wanaque NJ	410738	741557	NAD83	02030103	17.9	1935-present	33.6
01396500	South Branch Raritan River near High Bridge NJ	404040	745245	NAD83	02030105	65.3	1919-present	123
01408000	Manasquan River at Squankum NJ	400941	740917	NAD83	02040301	44.0	1932-present	73.5
01411000	Great Egg Harbor River at Folsom NJ	393541	745106	NAD83	02040302	57.1	1925-present	85.2
01440000	Flat Brook near Flatbrookville NJ	410622	745709	NAD83	02040104	64.0	1924-present	112
01464500	Crosswicks Creek at Extonville NJ	400814	743600	NAD83	02040201	81.5	1940-present	133

[1]Annual mean streamflow for beginning of period of record through September 30, 2009.

For additional information, write to:

Director
U.S. Geological Survey
New Jersey Water Science Center
Mountain View Office Park
810 Bear Tavern Rd., Suite 206
West Trenton, NJ 08628

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