EVALUATION OF WATER QUALITY STATUS IN THE RARITAN RIVER BASIN, WATER YEARS 1991-97

A Technical Report for the Raritan Basin Watershed Management Project

New Jersey Water Supply Authority

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Data provided by the US Geological Survey

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Acknowledgements

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INTRODUCTION

The Clean Water Act (CWA) of 1972 was enacted to address the issue of water quality in our nation's waterways. One of its goals is to improve water quality in streams to a fishable and swimmable status. Initial efforts for improving in stream water quality focused on implementing Best-Available-Technology for treating effluent from municipal wastewater treatment plants. Efforts focused on improving the quality of these point source discharges by requiring secondary and advanced treatment. This technology reduced the amount of nutrients, total suspended solids biochemical oxygen demand, heavy metals and other pollutants discharged to streams,

The effort to clean up point source discharges has lead to substantial improvements in water quality of many streams during the first 20 years of the CWA. On many streams improving the quality of point source effluent without addressing non point sources of pollution was not enough to attain fishable and swimmable status. During the first 20 years of the CWA nonpoint sources of pollution were rarely evaluated (Jarrell, 1999). Law suits, beginning in the late 1980's, pushed the U.S. Environmental Protection Agency (USEPA) and state agencies to consider both point and nonpoint sources of pollution on a watershed basis (Jarrell, 1999).

The New Jersey Department of Environmental Protection (NJDEP) has implemented a watershed management approach for characterizing water quality in New Jersey. Three watershed management areas (Upper Raritan, WMA 8; Lower Raritan, WMA 9; Millstone, WMA 10) comprise the Raritan River Basin. Both point and nonpoint source contributions to pollution need to be characterized in these areas. The watershed approach considers the concerns of many stakeholders including municipal and industrial dischargers, water purveyors, municipal officials, environmental groups, agriculture, and development interests in working toward best management practices for cleaner water in the Raritan River Basin.

NJDEP, as required by section 303d of the CWA, has identified a number of stream reaches in the Raritan Basin that exhibit current or historical exceedances of surface water quality standards (NJDEP, 1998). The water quality parameters with exceedances of standards include: pH, temperature, fecal coliform, dissolved oxygen, ammonia, and total phosphorus. Biological impairment based on results from macroinvertebrate studies, occurs along many stream reaches in the basin (NJDEP, 1997). The most frequently occurring exceedances of standards were for biological impairment followed by fecal coliform and total phosphorus. Exceedances occurred on Beden Brook, Etra Lake, Lamington River, Millstone River, Manalapan Brook, Matchaponix Brook, Mulhockaway Creek, Neshanic River, North Branch Raritan River, Raritan River (mainstem), Rockaway Creek, S.B. Raritan River, Spruce Run, and Stony Brook (NJDEP, 1997).

This report is one part of a series of technical reports written for the Raritan Basin watershed management project implemented by the NJDEP and coordinated by the New Jersey Water Supply Authority (NJWSA). This report provides technical analysis of water quality in the basin. Information from this report will contribute to a more detailed characterization and assessment study and be incorporated into a large report integrating other reports on basin setting, basin water budget, water supply, biology, pollutant loads, and studies of riparian areas.

PURPOSE AND SCOPE

This report documents the results of the analysis of 17 water quality constituents that are among the most important for characterizing the water quality and health of streams in the watershed. The results of analyses of 801 samples collected at 21 sites in the Raritan River Basin collected during the water years 1991 through 1997 are presented. This evaluation of water quality includes descriptive statistics of concentrations, analysis of data in relation to water quality standards, comparisons between sites, analysis of changes in concentrations by season and flow condition, and a summary of trends over time.

In addition to the analysis of the 17 constituents, results from studies on other constituents is summarized in this report. This includes a summary of recent studies on pesticides, volatile organic compounds, in the water column and trace elements and organic compounds in stream bed sediments is also presented. Previous studies on trends and relations of water quality to streamflow are also summarized to give a more comprehensive evaluation of water quality conditions in the Raritan River Basin.

These results will be used by the stakeholders for planning purposes. Knowing which streams have elevated levels of constituents, and when these levels occur is needed for prioritizing the streams that could benefit most from implementation of best management practices.

DESCRIPTION OF STUDY AREA

The Raritan River Basin comprises an area of 1,105 square miles in central and northern New Jersey. It is the largest drainage Basin entirely within the state of New Jersey. The major subbasins are the South and North Branch Raritan Rivers, Millstone River, South River, Bound Brook and Lawrence Brook. The major impoundments in the basin include Spruce Run Reservoir, Round Valley Reservoir and Budd Lake. The basin drains all or portions of 100 municipalities in Hunterdon, Mercer, Middlesex, Monmouth, Morris, Somerset and Union counties.

The Raritan River basin drains an area encompassing three physiographic provinces. Northern portions of the North and South Branch Raritan Rivers are located in the Highlands province. This area is underlain by predominately granite, gneiss, and small amounts of marble of Precambrian age. These rocks are resistant to erosion and create a hilly upland dissected by deep steep-sided valleys of major streams. The entire Bound Brook subbasin and a large portion of the North and South Branch Raritan River subbasins are located in the Piedmont physiographic province. The Piedmont province is a broad lowland containing ridges underlain by interbedded sandstone, shale, conglomerate, basalt, and diabase. The South River, Lawrence Brook and much of the Millstone River subbasins are within the Coastal Plain physiographic province. The Coastal Plain is mainly flat and underlain by unconsolidated layers of sand, silt and clay (NJDEP, 1992).

Twenty-one water-quality stations sampled by the NJDEP/USGS cooperative network from 1991-97 are located throughout the basin (**fig**. 1). Twelve sites drain basins located entirely in one province; five in the Highlands, four in the Coastal Plain, and three in the Piedmont province. Eight sites drain basins located in two provinces. The Raritan River at Bound Brook subbasin includes stream flows originating in all three provinces (**fig. 1**).

Mixed land uses are predominant in most of the basins draining to these sites (**table 1**). Only Neshanic River at Reaville and Spruce Run at Glen Gardner have a single land use type representing more than 50 percent of the basin. Neshanic River is 51.9 percent agricultural and Spruce Run is 51.4 percent forested. The most intense urban land use is located along the mainstem of the Raritan River, the Bound Brook subbasin, and the lower portions of the Lawrence Brook and South River subbasins. The highest percentages of forested land use are found in the upper portions of the North and South Branch Raritan Rivers. The highest percentages of agricultural land uses are found in the South Branch Raritan River and Millstone River subbasins.

Municipal and industrial point source discharges exist in all the major subbasins (**table 1**). The Neshanic River, Manalapan Brook, and Millstone River near Manalapan are the only sites without any point sources discharged to the stream upstream from the site. Raritan River at Queens Bridge at Bound Brook integrates the S.B. Raritan, N.B. Raritan and Millstone River subbasins and has 76 industrial and municipal point sources upstream.

PREVIOUS STUDIES

Relations of water quality to streamflow were determined for 18 water quality constituents at 21 surface-water stations within the Raritan River basin for the years 1976-93 (Buxton and others, 1999). Storm water runoff was found to be the most likely contributor of instream loads for total organic carbon, suspended sediment, chloride, total ammonia plus organic nitrogen, and total ammonia. Trends were evaluated for both high and low flow periods for both concentrations and loads. Median concentrations for 1989-93 were compared to the median values from 1976-93.

Trend tests on values of 24 water-quality characteristics at 83 surface-water quality stations in New Jersey, including 21 stations in the Raritan River Basin, were conducted on data from 1986-95 (Hickman and Barringer, 1999). The presence of trends in the concentrations of constituents at stream sites were analyzed for statistical association with drainage basin characteristics (Robinson and others, 1996).

Two recent studies on volatile organic compounds focused on the presence and distribution of volatile organic compounds in streams in New Jersey. The presence and variability of 86 volatile organic compounds in streams in New Jersey and Long Island New York, including 12 stations in the Raritan River Basin, was evaluated from data collected during January 27-30, 1997, from stations chosen to represent an urban land-use gradient (O'Brien and others, 1998). The occurrence and seasonal variability of VOCs at seven stations, including 4 stations in the Raritan River Basin, sampled routinely from April 1996 through April 1997, was evaluated in a second study (Reiser and O'Brien, 1998).

The presence and variability of 85 pesticides in seven New Jersey streams, including four in the Raritan River Basin, was determined from the evaluation of data collected routinely from April 1996 through June 1998 (Reiser, 1999). Variability in concentrations over the study period were evaluated by season, streamflow and land use. A second recent study focused on the presence and distribution of pesticides at 50 stream sites, including 9 stations in the Raritan River Basin, from data collected June 9-18, 1997 (Reiser and O'Brien, 1999). Stations were chosen to represent the gradient of land uses found in the study area and analyses focused on the relation of concentrations to land use.

The presence and distribution of trace elements in bed sediment data from 1976-93 in New Jersey streams, including over 40 sites in the Raritan River Basin, was recently evaluated (O'Brien, 1997). The relation of concentrations to basin characteristics was evaluated. The presence and distribution of chlorinated organic compounds in bed sediment data from 1976-93 in New Jersey streams, including 41 sites in the Raritan River Basin, was recently evaluated (Stackelberg, 1997).

An AMNET biological impairment status was assigned to 457 stream sites in New Jersey by the Bureau of Water Monitoring of the NJDEP, in 1993 (NJDEP, 1995). The AMNET rating is based on the benthic-macroinvertebrate population at the stream site. Species of the instream macroinvertebrate community occupy distinct niches based on their tolerance to environmental conditions. An integrated assessment of the benthic community results in an impairment status for each site. The three possible ratings are non-impaired--the benthic community is comparable to communities found in other undisturbed streams within the region and is characterized by a maximum taxa richness, balanced taxa groups, and good representation of intolerant species; moderately impaired --the macroinvertebrate richness and community balance are reduced and intolerant taxa are absent; or severely impaired-- the benthic community has dramatically changed and macroinvertebrates are dominated by a few tolerant taxa (Buxton and others, 1999). Chemical and physical data along with biological impairment status are good indicators of stream quality and possible sources of impairment.

METHODS OF STUDY

Selection of Constituents

Seventeen constituents considered to be important indicators of the water quality in the Raritan River Basin were chosen for analysis in this preliminary evaluation. There is a sufficient amount of data for the chosen constituents during the period 1991-97 necessary to complete a statistical analysis. The constituents chosen for analysis include alkalinity as calcium carbonate (CaCO3), ammonia plus organic nitrogen (TKN), biochemical oxygen demand (BOD), chloride, dissolved oxygen, fecal coliform, hardness, nitrate plus nitrite, pH, sodium, sulfate, total organic carbon, total phosphorus, total dissolved solids (TDS), and total suspended solids, un-ionized ammonia and water temperature. Nine of these constituents were chosen for analysis because of existing quality criteria. The other eight constituents, TKN, BOD, chloride, nitrate plus nitrite, total organic carbon, total phosphorus, total dissolved solids, and total suspended solids were chosen for this study and for analysis of loads in the second phase of this project. Thirteen of the 17 constituents have established surface water-quality and/or drinking water standards. . Alkalinity, BOD, TKN and total organic carbon do not have water quality standards.

Ammonia plus organic nitrogen (TKN) represents the reduced portion of total nitrogen in a stream. High ammonia concentration is a concern of water purveyors because of increased treatment costs. Organic nitrogen and ammonia are both oxygen consumers and an indicator of ecosystem health. No water quality standards exist for TKN.

Un-ionized ammonia concentrations were analyzed for the assessment of water quality conditions in the basin. Un-ionized ammonia has a surface water quality standard of 0.05 milligrams per liter (mg/L) in nontrout streams and 0.02 mg/L in trout streams (NJDEP, 1998). Samples collected from the USGS/NJDEP network are not analyzed for un-ionized ammonia. However, total ammonia concentrations, pH and water temperature were used to compute un-ionized ammonia for this project. Un-ionized ammonia has the lowest detection frequency of the 17 constituents at sampling sites in the basin (**table 2**). Un-ionized ammonia has been found to exceed water quality standards in 4 stream reaches in the basin (NJDEP, 1997).

The biochemical oxygen demand (BOD, 5-day) was chosen because it is a measure of potential oxygen consumption and a good measure of stress to the stream ecosystem. Biochemical oxygen demand is a measure of residual dissolved oxygen after a 5-day period of incubation at 20^{o} C. Oxygenated water is added to the sample enhancing the ability of microorganisms to decompose organic matter in the water and consume oxygen in the process. BOD can be used to evaluate the organic load in a quantitative way (Hem, 1985). No water quality standard exists for BOD.

Dissolved oxygen (DO) is a direct measurement of the water quality of the river. The concentration of dissolved oxygen in streams depends on physical, chemical and biological characteristics of the water body. Warm temperatures, the presence of organic compounds and biological activity reduce the amount of dissolved oxygen in water. The presence of organic compounds can cause biological and chemical oxygen demand in water. Turbulence, photosynthesis and decreases in temperature increase the amount of dissolved oxygen in water. DO concentrations have been found to be below the water quality standards on the Millstone and North Branch Raritan Rivers (NJDEP, 1998). Three different surface water standards exist for dissolved oxygen in New Jersey surface waters. The criteria are > 4 mg/L in nontrout waters, >5 mg/L in waters classified as trout maintenance and >7 mg/L in waters classified as trout production (NJDEP, 1998).

Fecal coliform levels are a measure of the sanitary quality of water. Fecal coliform bacteria can indicate the presence of untreated wastewater and animal feces. High numbers can cause streams to be unsuitable for swimming. Previous studies have found fecal coliform levels exceeding the established criteria at all sites evaluated in the basin (NJDEP, 1997). Fecal coliform levels have two surface water standards. Levels should not exceed a geometric mean of 200 colonies per 100 milliliters (ml) or 400 colonies/100 ml in more than 10 percent of total samples collected in a 30-day period (NJDEP, 1998).

The drinking water standard for hardness is > 50 mg/L and < 250 mg/L (USEPA, 1996). Hardness is said to represent the soap-consuming capacity of water. Water with hardness concentrations not meeting these standards is undesirable to consumers. Hardness, therefore, is a concern of water purveyors. Concentrations of calcium and magnesium and all other divalent cations contribute to hardness concentrations (Buxton, 1999)

Nitrate plus nitrite represents the oxidized form of nitrogen in the stream. Nitrate plus nitrite has a combined drinking water standard of 11 mg/L (USEPA, 1996). Nitrite is found in very small concentrations in surface waters because it is rapidly oxidized to nitrate. Nitrite enters surface water from wastewater treatment plants. It is a primary nutrient of rooted aquatic plants and algae. Nitrate is found in surface water in much higher levels than nitrite. Nitrate is considerably less toxic to aquatic organisms than are ammonia and nitrite; however in excess amounts (>10 mg/L), nitrate contributes to methemoglobinemia in small children and fish (Buxton and others, 1999).

Total organic carbon is a direct measure of organic compounds in a stream. Increased levels may indicate a potential for forming disinfection by-products in drinking water. Data on concentrations of specific forms of organic carbon such as chloroform and other disinfection by-products and other VOCs are not routinely collected throughout the basin and generally are found in very low concentrations. No drinking water or surface water standard exists in New Jersey for total organic carbon.

The New Jersey surface water standard for pH is > 6.5 and <8.5 (NJDEP, 1998). The pH of water is a measure of the negative logarithm of the hydrogen ion concentration. Values less than 7 are considered acidic and values greater than 7 are considered basic. The aquatic life found in a stream is influenced by the pH. Typically the pH of stream water in the Coastal Plain portion of the Raritan River Basin is lower than the pH of water from streams in the Piedmont and Highlands physiographic provinces.

Total phosphorus concentrations are important to stream health. It is a primary nutrient for algae and aquatic plants and can stimulate excessive growth. Exceedances of the 0.1 mg/L surface water standard are common throughout the Raritan River Basin. This standard shall not be exceeded in any stream, unless it can be demonstrated that total phosphorus is not a limiting nutrient and will not render the waters unsuitable for the designated uses (NJDEP, 1998). For the purposes of this study, 0.1 mg/L is used as a reference point in all streams studied. A second surface- water standard of 0.05 mg/L exists for lakes and reservoirs and for streams at the point of entry to these water bodies (NJDEP, 1998). Phosphates are found in solution and attached to particulates. Phosphorus is a common element in igneous rock and is fairly abundant in sediments (Buxton and others, 1999). Orthophosphorus applied to agricultural land, lawns, and gardens can be washed into streams in runoff. Phosphorus also enters streams from wastewater treatment plants.

Total dissolved solids (TDS) is an important constituent for purveyors and water users. A high concentration of TDS can have impacts on the taste of water and could impact hospitals, industrial facilities and the stream ecosystems. TDS concentrations are increasing over time at some locations in the basin. The drinking water standard is 500 mg/L (USEPA, 1996).

Total suspended solids (TSS) are regulated and may be one of the more important indicators of non-point source pollution. The health of stream ecosystems is affected by concentrations of TSS. The primary sources of TSS in streams are from storm runoff, instream erosion, and resuspension. The surface water standard is 40 mg/L in nontrout waters and 25 mg/L in trout waters (NJDEP, 1998).

Dissolved chloride has a drinking water and surface water standard of 250 mg/L in New Jersey (NJDEP, 1998). Most of the highest concentrations in surface waters are caused by runoff from deicing salts applied to roads. Dissolved chloride is a good conservative element for quality assurance in a mass balance model. Conservative elements such as chloride are not removed or added to the stream by biological or chemical processes. The chloride load will stay the same or increase as water moves downstream. Changes in load are caused by discharges or withdrawals from the stream.

Sodium concentrations were analyzed to evaluate exceedances of the 50 mg/L drinking water standard (USEPA, 1996). Sodium tends to remain in solution when dissolved from weathering rocks and not form precipitates that can maintain low sodium concentrations (Buxton and others, 1999). Cation exchange processes in freshwater systems tend to extract divalent ions from solution and replace them with monovalent ions, especially sodium (Hem, 1985). Sodium salts used for deicing roads can be transported to streams in runoff.

Sulfate concentrations were analyzed to evaluate exceedances of the 250 mg/L surface water and drinking water standards (NJDEP, 1998). Sulfur is widely distributed in reduced form in both igneous and sedimentary rocks as metallic sulfides. When sulfide minerals undergo weathering in contact with aerated water, the sulfur is oxidized to yield sulfate ions (Hem, 1985). Combustion of fuels can also be a major source of sulfates in streams.

Water temperature influences the chemical and biological processes in a stream. The amount of sunlight, rainfall, air temperature, the amount of groundwater discharging to a stream and thermal point sources all influence water temperature of a stream. New Jersey surface water criteria for stream temperatures vary according to stream classification. In trout production waters, treated wastewater effluent is not to deviate more than 0.6^{o} Celsius from the ambient temperature (NJDEP, 1998). In trout production waters, treated effluent is not to cause ambient temperature to increase more than 1.1^{o} C or to cause water temperature to exceed 20^{o} C. In nontrout waters, no heat may be added which would cause temperatures to exceed 27.8^{o} C for small mouth bass or yellow perch waters, or 30^{o} C for other nontrout waters (NJDEP, 1998). For the purpose of this study a reference point of 20^{o} C for trout production and trout maintenance waters and a reference point 27.8 ^{o} C for nontrout waters was used for to evaluate streams with elevated water temperature.

Data Review

All data was reviewed extensively for quality assurance purposes and moved to a SAS data base for data manipulation and statistical analysis. Data for 20 constituents was plotted versus streamflow, plotted to observe seasonal differences and compared with measured levels of other constituents. The review resulted in less than 0.1 percent of the values being changed or removed from the database. The majority of the corrections were to field readings or data entered into the database manually from paper copies.

Missing values of total nitrate plus nitrite were replaced with values of dissolved nitrate plus nitrite. Little difference is observed when both values are present for a sample. Nitrate plus nitrite is present in water almost exclusively as dissolved species (Hem, 1985). Total organic carbon was calculated by adding suspended organic carbon to dissolved organic carbon. Missing values of total suspended solids were substituted with values of total suspended sediment.

Instantaneous flow data associated with each sample was checked by plotting the flows versus gage height, plotting flows versus mean daily flow when available and by using regression procedures to identify data outliers. Large residuals from the regressions were evaluated for possible errors. Thirty-one out of 801 flows associated with the samples from 1991 through 1997 were revised.

Statistical Methods

Water samples were categorized by the season and the hydrologic condition in which they were collected. The growing season is April through October, and the nongrowing season is November through March. The dates for defining these seasons are based on the average times of the first and final frosts in New Jersey (Ruffner and Bair, 1977). All samples were grouped into one of two flow categories, low flow or high flow. Low flow samples are defined as those collected when the streamflow was less than the seven year (1991-97) median flow at the site. High flow samples are defined as those collected when the streamflow was greater than the seven year median flow.

Detection frequencies were computed for each constituent (**table 2**). Water quality data that contain concentrations of constituents reported as less than or in some cases greater than an analytical detection limit set by the laboratory are considered censored data or nondetections. Seven of the fifteen constituents contain censored data. Nonparametric methods of statistical analysis are used on these censored data sets.

Percentiles show the percent of samples with concentrations that are less than a particular value. These statistics are used to analyze the distribution of concentrations in a data set. Percentiles of censored data sets are computed using a probability plotting procedure developed by Helsel and Cohn (1988). With this method the censored values contain nearly as much information for estimating percentiles as would the same observations had the detection limit been below them (Helsel and Cohn, 1988). Percentiles were used to summarize the data and to make comparisons at each site and among sites by season, and flow.

One-way analysis of variance (ANOVA) was applied to the ranks of concentrations to determine whether median concentrations varied among sites by season and flow condition, and whether concentrations at a single site varied by seasons and flow conditions. The null hypothesis (H_O) states that mean rank concentrations are equal at each site. The alternate hypothesis states that the mean rank concentration from at least one site differs from the others. If the null hypothesis is rejected, Tukey's test was used to determine which pairs of mean rank concentration were significantly different at the 0.05 level. Tukey's groups are represented by letters A through K. Sites in group A have the highest mean rank concentration, and those in groups B through K have successively lower rank concentrations. Sites containing one or more of the same letters do not differ significantly (Helsel and Hirsch, 1992). Two-way ANOVA was applied to ranks of concentrations to simultaneously test the significance of season, flow, and season as a function of flow as factors contributing to concentrations in streams.

Regression techniques were used to evaluate concentration and load. Relations between instantaneous streamflow and concentration were analyzed at each of the sites. Constituents detected in more than 50 percent of the samples from a site were analyzed by using tobit regression (Cohn, 1988). The tobit method uses censored data to develop the relation. If censored data accounted for more than 50 percent of the values at a site, the results are not considered reliable and are not discussed in this report. The relation was considered to be significant if the slope of the regression line was different from zero at the 0.05 level of significance. A base-10 logarithm transformation of streamflow and concentration was used to normalize the data before using tobit regression. Median concentrations of the 17 compounds were evaluated with respect to land use at the 21 sites by using least squares linear regression (Ott, 1988).

Trend tests by Hickman and Barringer, 1999 were conducted by using the Seasonal Kendall test on uncensored data sets (Helsel and Hirsch, 1992) and tobit regression on censored data sets. Results from Hickman and Barringer, 1999 are presented in this report for all constituents except total suspended solids. The seasonal kendall test was performed on total suspended solids data for this analysis. All censored values were given a value of 0.50 mg/L or one half the censored value.

Presentation of Tables and Figures

The tables and figures presented in this report summarize much of the statistical analysis of the water quality data. **Figures 2-18** are maps showing the median value of each constituent, the significant seasonal change in values and significant changes in values between low and high flow samples at each site. The red, yellow and green circles each represent a group of between 6 to 8 sites. The groups are distinguished by the median value at the site. For instance, the red dot represents approximately a third of the sites with the highest median values and the green dots represent the third of the sites with the lowest median values. Phosphorus, however, is divided into groups of sites above and below the 0.10 mg/L and 0.05 mg/L surface water standards. Also alkalinity is not divided into thirds because of the large differences in values between the coastal plain and the rest of the study area.

The maps in **figures 2-18** allow for comparison of median concentrations along stream reaches and between drainage basins. A significant increase in concentration in the growing season is represented by a plus sign in the circle representing the site. A significant decrease in concentration in the growing season is represented by a minus sign in the circle representing the site. The arrow pointing upward indicates significantly higher concentrations at high flows. The arrow pointing downward indicates significantly lower concentrations at high flows, as is the case for alkalinity at all sites (f**ig. 2**). These figures summarize the results listed in **tables 9-26** and **tables 27-43**. The tables are referenced in the text, however, not all of the figures are referenced in the text.

Boxplots presented in **figures 19 - 35**, show the distribution of values at each site. The boxplots for each site are grouped according to the subbasin in which the site is located. The horizontal line through the middle of the rectangle represents the median value at the site. The horizontal line at the top of the box indicates the 75th percentile--75 percent of the data are less than this value--and the horizontal line at the bottom of the rectangle represents the 25th percentile. The horizontal lines above and below the rectangle represent the highest and lowest data value within 1.5 times the inner quartile range (75th-25th percentile) outside the rectangle. Outliers are represented by the asterisks and the circle. For example, in **figure 19**, the inner quartile range (IQR) at site 01400650 is 12 mg/L (27 minus 15). The top horizontal line in the boxplot represents a data value of less than or equal to 12 mg/L times 1.5 (42 in this example). The maximum observed value at this site is 49 mg/L. The maximum value, therefore, is labeled as an outlier because it is greater than 42 mg/L.

Significant differences in values between sites are designated by the letters above each boxplot. Boxplots represented by the same letter indicate no significant difference in values between those sites. Sites labeled with an “A” are those in the group with the highest values. For example, in **figure 19**, 6 of the 7 sites in the S.B. Raritan River subbasin, 3 of 5 sites in the North Branch Raritan River subbasin and one site on the mainstem of the Raritan River are labeled with an “A” and therefore values are not statistically different.

The cumulative probability curves presented in **figures 36 -52**, are another way to analyze the distribution of data at each site. Curves with steeper slopes indicate a wider range of values. The y axis is a range of values covering all the samples analyzed. The x axis is the percent of time samples are below a given value. For example, **figure 36** shows that 100 percent of samples are less than 40 mg/L at the 4 sites in the coastal plain--both sites in the south river subbasin and sites 01400540 and 01400650 in the Millstone River subbasin--and that no values at the Raritan River mainstem sites and at the North Branch Raritan River subbasin sites are less than 20 mg/L. Horizontal lines representing the values of water quality standards are included in the figures to show the percentage of values at each site below the standard.

Tables 4a-4d list the drinking water and New Jersey surface water standards that exist for 13 of the 17 constituents. Four constituents do not have any existing standards. **Tables 4a and 4b** list the percentage of samples not meeting the standards in streams designated as nontrout waters and **tables 4c and 4d** list sites with samples not meeting the standards for trout streams (NJDEP, 1998). **Tables 4a and 4c** include a summary of all samples not meeting standards by season and flow condition and a summary of all samples not meeting standards at each site. **Tables 4b and 4d** show the percentage of samples not meeting the standards during low flow and high flow at each site.

Tables 9-26 list the statistical summary of values for each of the 17 water-quality constituents and streamflow from all samples at each site. The tables include the number of samples with data for the constituent at each site, the minimum and maximum value observed at the site and the 10th, 25th, 50th, 75th and 90th percentile values. The percentile statistics represent the percentage of values that are less than the number indicated. For example, in **table 9**, the 10th percentile indicates that 10 percent of the values of alkalinity measured at site 01396280 are less than 38 mg/L.

Tables 27- 43 list a comparison of median values by season and flow condition at each site, significant differences in concentrations between seasons and between flow conditions, and the season and flow condition with the highest and lowest median values. Significantly higher values in a season are indicated by a “G” for growing season and a “NG” for nongrowing season. Significantly higher values for a flow condition are indicated by a “LO” for low flow and a “HI” for high flow.

The columns titled “flow and season comparison” list which flow condition in which season has the highest and lowest median value at each site. The column titled “significance for season as a function of flow” indicates whether values collected from a particular flow condition in a single season is significant or not. For example, in table 27, alkalinity values at site 01396280 are shown to be significantly higher at low flow than at high flow when season was not considered. Also concentrations were significantly higher in the growing season than in the nongrowing season when flow was not considered. When season as a function of flow was added to the model as a third variable, it was found to be not significant in predicting variability in concentration.

STREAMFLOW

Streamflow is measured at each of the water quality sites in the Raritan River Basin. Instantaneous streamflow is determined for the mean time of each sample from ratings that relate water level elevation recorded during the sample to streamflow. Seven of the 21 sites have a continuous 15 minute record of streamflow. The other 14 sites have instantaneous streamflow measurements that are correlated to mean daily streamflows at nearby continuous-record gauging stations to estimate flow at the time of the sample. Streamflow at the time of sampling is needed for computation of loads.

Streamflow data can be used to develop a flow-duration curve summarizing magnitude and frequency of flow at each site. Flow and water quality at a particular flow condition can be compared between sites. Flow duration curves showing the percentage of time that a particular flow is equaled or exceeded at a site were developed at each of the sampling sites (**table 3**). Flow durations at the sites with continuous streamflow records were computed from a statistical package associated with the USGS database. The seven-day ten-year low-flow statistic (MA7CD10) was also computed at each site with a continuous record of streamflow. The MA7CD10 flow was computed from the entire period of streamflow record at all sites except for the S.B. Raritan River sites at Stanton, and Three Bridges, and the Raritan River sites at Manville and Bound Brook. Streamflow records after streamflow regulation began in September 1963 at Spruce Run and Round Valley Reservoirs were used for computing MA7CD10 flow at these sites.

Correlation procedures were used to estimate flow duration and MA7CD10 flow at the 14 sites without a continuous record of streamflow from streamflow records at nearby gauging stations. A streamflow record extension technique, maintenance of variance extension (MOVE1), was used to develop a correlation between instantaneous flow at the sampling site and mean daily flow at a nearby continuous-record gauging station (Hirsch, 1982). The log of flow is used to normalize the data before the relation is developed. This technique is best for estimating low to median flow conditions. The accuracy of the MOVE1 method was tested at the 7 gauging stations at various flow durations. Estimates of flows at the 25th percentile were found to be within 10 percent of the values computed from the daily flow record. The prediction of flows higher than the 25 percentile were found to have a larger standard error. A test for baseflow conditions excludes high flow measurements from the correlation. The flow duration values for Raritan River at Bound Brook and for Millstone River at Grovers Mill were estimated using drainage area adjustments from nearby gaging stations.

Samples at all sites cover the range of approximately 10 to 90 percent flow duration with some sites having high-flow samples that exceed the 1 percent duration and others with samples at flows as low as approximately the 98 percent duration (**tables 3 and 23**). The majority of the samples collected at high flows are during a receding hydrograph. These samples are not representative of water quality conditions throughout the entire hydrograph. Samples are random and no sampling has been conducted throughout a storm hydrograph. No samples were collected at any site at flows as low as the MA7CD10 flow (**table 3 and 23**).

Streamflows vary as a function of season. Highest monthly mean flows occur in the spring and lowest monthly mean flows occur in the fall. Six of the seven gages have highest mean monthly flows in March and lowest monthly flows in October. Mulhockaway Creek, the site with the smallest drainage area, has the lowest monthly flow in August and the highest monthly flow in April.

Comparison to Long-term Records

The statistics of mean daily stream flow at the 7 sites with continuous streamflow records for 1991-97 (**table 3**) were compared to the long term flow statistics at those sites. The long term statistics for S.B. Raritan River at Stanton and for Raritan River at Manville were based on the period 1964 through 1998. Earlier records of flow at these sites do not reflect the Spruce Run reservoir releases beginning in September 1963.

In general, flows were slightly higher during 1991-97 than for the longer period of record. The median flow during the period 1991-97 was from 2 to 13 percent higher at S.B. Raritan River at Stanton, Neshanic River, Lamington River, and Millstone River gages. Median flow was the same at Stony Brook, 1 percent lower at Mulhockaway Creek, and 2 percent lower at Raritan River at Manville. The median flow at Raritan River at Bound Brook, as estimated from the Raritan River below Calco dam at Bound Brook gage, during 1991-97 was 5 percent lower than the median for the period 1964-98.

Runoff was higher during 1991-97 at the 5 sites with drainage areas less than 400 square miles and lower at the 2 gages draining over 400 square miles. The highest mean daily flows, those exceeded only one percent of the time, were higher at all sites in 1991-97 except at the two sites draining the largest areas; Raritan River at Manville and Raritan River at Bound Brook. The one percent flow duration was 9 percent lower at the Manville gage and 15 percent lower at the Raritan River at Bound Brook site. Neshanic River had the largest increase of 18 percent in the one percent flow duration from the 1922-98 period to the 1991-97 period.

Baseflow was higher during 1991-97 at the 5 sites with drainage areas over 30 square miles and lower at the two gages draining under 30 square miles. Lowest mean daily flows, those exceeded 99 percent of the time, were higher at all sites except the Mulhockaway and Neshanic River sites. The 99 percent flow duration increased 29 to 54 percent at S.B. Raritan River at Stanton, Raritan River at Manville, Stony Brook, Millstone River and Raritan River at Bound sites. The 99 percent flow duration dropped slightly from 2.4 to 2.2 cfs at Mulhockaway Creek and dropped from 0.27 to 0.01 cfs at Neshanic River. The Neshanic River gage recorded no flow past the gage site for 28 consecutive days in August and September 1995. In 1966 no flow passed the gage for 11 consecutive days, 33 days total. Also, in 1965 no flow passed the gage for 5 consecutive days. The occurrence of days with no flow in 1995 rivals the 1965-66 period, however, the extreme low end of the flow duration curve has shown a sharper drop in flow for the period 1991- 97 than during earlier periods. Extreme low flows during dry periods in the late summer have occurred with greater frequency in the 1990's. This may be an indication that water tables in the area are dropping.

Monthly precipitation records from the National Oceanic and Atmospheric Administration's National Climatic Data Center were used to compare precipitation from 1991-97 to long-term periods (NOAA, 2000). The average annual precipitation in northern New Jersey climate division 1, covering the Piedmont, New England and Valley & Ridge physiographic provinces during 1991-97 is equal to long term averages. Precipitation averaged 47.1 inches per year in New Jersey climate division 1 from 1991-97. The precipitation from 1960-99 averaged 47.4 inches and the average from 1895-1999 was 46.0 inches. The average annual precipitation in southern New Jersey climate division 2, covering most of the New Jersey coastal plain province averaged 45.9 inches from 1991-97. Averages for this climatic division for 1960-99 and 1895-1999 were 44.6 and 44.3 inches respectively.

WATER QUALITY DATA

Major Ions, Nutrients and Field Parameters

Water Quality Standards

Water quality standards establish the water quality goals and policies underlying the management of New Jersey's waters (NJDEP, 1997). The criteria are set by the NJDEP to protect public health and welfare and to enhance the quality of water. The Federal Clean Water Act requires wherever attainable that surface-water quality standards should provide for protection and propagation of fish, shellfish and wildlife and to provide for recreation in and on the water (NJDEP, 1997). Drinking water standards are set by USEPA and NJDEP. These standards, known as maximum contaminant levels (MCLs) are the maximum permissible levels allowed in public drinking water (USEPA, 1996). The standard is set for water being delivered to public water supply users, after it has been treated. Both standards are used as references to instream measurements.

Water quality standards exist for 13 of the 17 constituents analyzed. A drinking water standard exists for 7 parameters and New Jersey surface water standards exist for 9 parameters. TDS, nitrate plus nitrite and sodium have drinking water standards only. For the purpose of this study, drinking water standards are used as a reference point for categorizing sites. Alkalinity, BOD, total ammonia plus organic nitrogen, and total organic carbon do not have standards. Standards for dissolved oxygen, total suspended solids, un-ionized ammonia, and water temperature are stricter for trout waters than for streams designated as nontrout waters. In addition, dissolved oxygen has a stricter standard in trout production streams (>7 mg/L) than in trout maintenance streams (>5 mg/L). Each station had at least one sample with a value that did not meet a standard.

The percentage of samples that do not meet the established criteria are listed by site and for all samples in trout and nontrout streams by flow condition and season (**tables 4a and 4c).** The percentage of samples exceeding the standard at each site during both high flow and low flow conditions are also listed separately in **tables 4b and 4d** for trout and nontrout streams. The percentage of samples not meeting standards is also presented by site in cumulative probability plots (**figures 36-52**). The cumulative probability plots show the percentage of data at each site that is less than a given concentration, fecal coliform count, or temperature. Horizontal lines across the plots represent established water quality standards. The intersection of the cumulative probability line with the horizontal line representing the standard indicates the percentage of data meeting the standard. The exception is for dissolved oxygen. The intersection of the lines indicates the percentage not meeting the standard.

The most common violations were for total phosphorus above 0.1 mg/L in 32 percent of samples--42 percent of samples at nontrout sites and 10.6 percent of samples at trout sites; fecal coliform, above 400 counts/100ml in 29 percent of all samples; and hardness less than 50 mg/L in 20.7 percent of samples. No samples during the study period exceeded the standard for chloride, total dissolved solids, nitrate plus nitrite, or sulfate. The fecal coliform standards for streams are not to exceed a geometric mean of 200 counts/100mL (**table 5**) and are not to exceed 400 counts/100mL for less than 10 percent of samples collected during a 30 day period (**Table 4a-4d**).

Fecal Coliform

Neshanic River at Reaville was the only site with greater than 50 percent of samples above 400 colonies/100ml (**fig 42**). Matchaponix Brook and Manalapan Brook had the fewest samples above 400 counts/100ml; 8.6 and 11 percent respectively (**fig. 42**). Five sites had more than 50 percent of samples over 400 colonies/100 mL at low flow. At high flow conditions, only Neshanic River had greater than 50 percent of samples above 400 colonies/100 mL (**table 4a)**.

The geometric mean of fecal coliform counts exceeds the New Jersey surface water standard of 200 counts/100/mL at six sites (table 5). A geometric mean of 200 is exceeded at four sites during low flow samples and at seven sites during high flow samples. The highest geometric mean during high and low flow conditions exists at Neshanic River. The lowest mean at high flows is 31.6 counts/ 100mL at Matchaponix Brook and 36.9 counts/100mL at Manalapan Brook. The lowest mean at low flows is 54.7 counts/ 100mL at Lamington River at Pottersville and 63.3 counts/ 100mL at S.B. Raritan River at Stanton. The geometric mean for all growing season samples from all sites in the basin is 218 versus 82.7 for all nongrowing season samples. Lower geometric mean counts in the nongrowing season may be related to lower water temperatures. The geometric mean from all low flow samples from all sites is 171 versus 126 for all high flow samples.

Phosphorus

Total phosphorus exceeded 0.1 mg/L in 60 percent or more of the samples at the Millstone River sites at Grovers Mill (70 percent) and Blackwells Mills (97 percent), Raritan River at Bound Brook (86 percent) and S.B. Raritan River at Three Bridges (60 percent) (**fig 47**). All sites in the North and South Branch Raritan River subbasins excluding Rockaway Creek and S.B. Raritan River at Three Bridges and Matchaponix Brook have less than 20 percent of samples exceeding the 0.1 mg/L standard. Mulhockaway River at Van Syckel was the only site without any samples exceeding 0.1 mg/l. More than 50 percent of samples exceeded the limit of 0.10 mg/L at seven sites during low flow and four sites at high flow (**tables 4b and 4d**).

Total phosphorus exceeded the limit of 0.05 mg/L set for lakes, reservoirs and streams at the point of entry to these water bodies in more than 70 percent of samples at ten sites (**table 4a**). More than 50 percent of samples exceeded the 0.05 mg/L standard at 15 sites during low flow and 11 sites at high flow. The 0.05 mg/L standard for lakes and streams at the point of entry to lakes may be a concern at the Mulhockaway Creek, Spruce Run, Stony Brook and Millstone River at Grovers Mill sites. The Mulhockaway Creek and Spruce Run sites are a short distance upstream of Spruce Run Reservoir (**fig 1**). The Stony Brook and Millstone River at Grovers Mill sites are upstream of Carnegie Lake. The percentage of samples exceeding the 0.05 mg/L limit at Mulhockaway Creek, Spruce Run, Stony Brook, and Millstone River is 18, 32, 67, and 97 percent respectively (**tables 4a and 4c**). At Mulhockaway Creek 25 percent of samples exceeded the standard at high flow and 11 percent at low flow. At Spruce Run 42 percent of low flow samples and 27 percent of high flow samples exceed the limit. At Millstone River at Grovers Mill 100 percent of low flow samples and 93 percent of high flow samples exceed 0.05 mg/L. At Stony Brook 71 percent of high flow and 63 percent of low flow samples exceed 0.05 mg/L.

Hardness

Hardness concentrations were less than the 50 mg/L drinking water standard in all samples at Manalapan Brook and Millstone River at Manalapan. Millstone River at Grovers Mill and Stony Brook at Princeton also had more than 50 percent of samples below the standard (**fig. 43**). All concentrations less than 50 mg/L at 17 of the 21 sites were during high flow conditions. Those concentrations less than 50 mg/L at low flow conditions were at 3 Coastal Plain sites and at Raritan River at Bound Brook (**table 4b and 4d**). Neshanic River has 35 percent of samples with concentrations greater than 100 mg/L, the highest percentage of samples at any site (**fig 43**). No samples exceeded the upper limit of 250 mg/L.

Water Temperature

Water temperature at the 7 sites designated as trout waters exceeded the standard of 20 degrees Celsius (^oC) in 30 out of 249 samples or 12 percent of samples (**fig. 52**). At least one water temperature measurement at each of the 7 sites exceeded 20^o C. All temperatures greater than the standard were measured during the growing season. Seventy percent were measured at flows less than the median. Only one measurement at Lamington River near Pottersville and North Branch Raritan River near Chester were greater than 20^o C. Twenty-six percent of water temperature readings at S.B. Raritan River at Stanton exceeded 20^o C, the most at any of the sites designated as trout waters (**table 4a**). The standard of 27.8^o C for nontrout waters was not exceeded at any sites. More than half of the water temperature measurements exceeded 20^o C during low flow conditions at the Raritan River sites at Manville and Bound Brook and Millstone River at Blackwells Mills.

pH

Measurements of pH were less than 6.5 or greater than 8.5 in 17 percent of all samples (**table 4a and 4c**). Differences exist between sites in the Coastal Plain and those in the Piedmont and Highlands physiographic provinces (**fig. 1**). The majority of violations in the North and South Branches of the Raritan River exceeded 8.5, while the majority of those in the Millstone and South River subbasins were less than 6.5 (**fig. 46**). More than 50 percent of pH measurements during high flows at Manalapan Brook and Matchaponix Brook were less than 6.5. All pH measurements were greater than 7.0 at sites in the North and South Branch Raritan River, and Raritan River mainstem subbasins (**fig. 46**). All pH measurements at coastal plain sites were less than 8.0.

Total Suspended Solids

Total suspended solids exceeded 25 mg/L in 2 out of 115 samples or 1.7 percent of the samples at sites designated as trout waters. Four of the seven sites had at least one sample that exceeded the standard, all at high flows (**table 4d**). Mulhockaway Creek, Spruce Run and North Branch Raritan River near Chester did not exceed the standard (**fig. 50**)

Total suspended solids exceeded the standard of 40 mg/L in 7.6 percent of all samples at sites designated as nontrout waters (**table 4a**). Eight of the 14 sites exceeded the standard at least once. Both sites in the South River subbasin and Millstone River at Grovers Mill, all draining areas exclusively in the coastal plain, did not exceed 30 mg/L (**fig. 50**). Stony Brook, Beden Brook, and Millstone River at Blackwells Mills each exceeded the standard in at least one sample at low flow conditions. The highest percentages at nontrout sites were at Raritan River at Bound Brook, Stony Brook at Princeton, and Neshanic River at Reaville. At high flow conditions, 32 percent of samples at Stony Brook and 24 percent of samples at Raritan River at Bound Brook exceeded 25 mg/L. Millstone River at Blackwells Mills was the only site in which samples collected at low flow exceeded the standard. This may be caused by algal blooms since all the samples were collected in the summer months.

Dissolved Oxygen

Dissolved oxygen concentrations met the standard for trout maintenance waters and for trout production waters at all sites with these designations. Only one sample was less than the 4 mg/L standard for nontrout waters, a sample at Millstone River at Grovers Mill at low flow in the summer. Thirty-two of the 42 samples with concentrations less than 7 mg/L were measured during low flow conditions. The Millstone River subbasin has the highest percentage of samples with concentrations less than 7.0 mg/l (**fig. 40**).

Sodium

Sodium exceeded the standard of 50 mg/L in 5.2 percent of samples. Five of the 7 sites designated as trout streams had at least one sample exceeding 50 mg/L. All of these samples were collected at high flows in the nongrowing season (**table 4c**). Nine of the 14 nontrout sites exceeded the standard with 5 sites exceeding at low flows. Millstone River at Manalapan had by far the highest percentage of exceedances; 43 percent compared to less than 9 percent of samples at the other sites. Fifty-eight percent of samples collected at the site during low flows exceeded 50 mg/L (**table 4b**). All samples collected at sites in the North Branch Raritan River subbasin and the Raritan River mainstem had concentrations less than 40 mg/L (**fig. 48**).

Un-ionized Ammonia

Un-ionized ammonia did not exceed the standard of 0.05 mg/L for nontrout waters at any sites (**fig. 51**). Five samples exceeded the 0.02 mg/L trout water standard, however only one sample was at a trout water stream, S.B. Raritan River at Stanton, NJ (**table 4c**). Four of the five samples were collected at low flow conditions in the growing season. One sample exceeded 0.02 mg/ L during high flow conditions in the growing season at Raritan River at Bound Brook.

Other Constituents

No samples during the study period exceeded the standard for chloride (250 mg/L), total dissolved solids (500 mg/L), nitrate plus nitrite (11.0 mg/L), or sulfate (250 mg/L) (**figs 39, 41, 44, and 49**). The highest chloride concentration observed was 190 mg/L at Neshanic River at high flow in the winter. The highest total dissolved solids concentration observed was 448 mg/L at Neshanic River at low flow in June. The highest nitrate plus nitrite concentration observed was 10.1 mg/L at Matchaponix Brook at low flow in July. The highest concentration of sulfate observed was 96 mg/L at Neshanic River at low flow in September.

Comparison to Season and Flow

A seasonal comparison was made of all samples not meeting water quality standards. All violations of dissolved oxygen concentration, un-ionized ammonia concentration and water temperature were in the growing season (**tables 4a and 4c**). Fecal coliform counts were highest in the growing season. Forty-six percent of growing season samples exceeded 400 counts per 100ml, and only 13 percent on nongrowing season samples exceeded that limit. Exceedances of total phosphorus and total suspended solids concentrations were only slightly higher in the growing season. The percentage of hardness concentrations below the standard for drinking water was slightly higher in the nongrowing season. Exceedances of pH and sodium concentrations were the same in both seasons.

A comparison by flow condition was made of all samples not meeting water quality standards. Dissolved oxygen, fecal coliform, total phosphorus, un-ionized ammonia and water temperatures did not meet the standard in a higher percentage of samples at low flow than at high flow conditions (**tables 4a and 4c**). Total suspended solids and sodium concentrations above the standard and hardness concentrations below the standard were more commonly found during high flow conditions. Measurements of pH above the standard of 8.5 were more commonly found at low flow conditions and those below the standard of 6.5 were more commonly found at high flow conditions. Comparisons of the percentage of samples not meeting standards during high and low flow at each site are presented in **tables 4a and 4c.**

Trends in Water Quality Characteristics

Results from trends tests for 17 constituents at each of the 21 stations are summarized in **table 6**. The results for 16 of the 17 constituents for the period 1986 through 1995 are derived from Hickman and Barringer, 1999. A trends test on total suspended solids data at each site was performed for this study. Trends were found to exist for at least one parameter at each site. Every compound except total suspended solids showed a trend at one or more stations. Trends tests for total ammonia and total organic nitrogen were performed separately. No trends tests were performed on un-ionized ammonia.

The results of tests on nutrient values -- ammonia, organic nitrogen, and phosphorus-- are consistent with the expected decrease in concentrations in treated wastewater discharged from sewage treatment plants (STPs) as a result of upgrades to plants (Hickman and Barringer, 1999). Total ammonia has decreased at all 21 sites tested and total organic nitrogen has decreased at 17 sites. These decreases have occurred at sites with and without STPs however. At the same time 4 sites have shown increases in nitrate plus nitrite and none have shown decreases. This is also consistent with STP upgrades that tend to oxidize the nitrogen in the effluent, which decreases concentrations of ammonia and increases concentrations of nitrate plus nitrite. Total phosphorus has decreased at 11 sites. All decreases in total phosphorus occurred at stations with STPs, while concentrations at those sites without STPs did not change significantly.

The results of tests on dissolved constituents-- chloride, dissolved solids, hardness, and sodium-- show increases at a large number of stations across the basin. There were no significant decreases. Increases are occurring at sites with and without STPs. These increases could be caused by changes in basin land use or other basin characteristics. Sulfate was the only dissolved constituent to show significant decreases at 6 sites. One station increased and the others had no significant change.

Increasing trends in pH and total alkalinity occurred at slightly less than half the stations. Five sites showed significant increasing trends in both alkalinity and pH. No decreasing trends were observed for either constituent. Total organic carbon has decreased at 4 of the 7 sites located in the S.B. Raritan River subbasin, North Branch Raritan River at Chester, and at Millstone River at Grovers Mill. No significant increases occurred. Biochemical oxygen demand decreased at 2 sites and increased at one site. Fecal coliform count decreased at one site and showed no change at others. Water temperature showed a decrease at 3 sites and no change at the others. There was no significant change in total suspended solids concentrations at any site. Results of trend tests on instantaneous flow at the time the sample was collected found decreasing trends at Spruce Run, Mulhockaway Creek, Lamington River near Pottersville, Stony Brook and Beden Brook. No sites had significant increases in flow.

Results from another study of trends at high- and at low flows for 13 of the 17 constituents analyzed in this study are summarized in **table 7**. The results are summarized from Buxton and others, 1999. The tests were performed on datasets with long-term data from 1976 through 1993. High flow samples used for this study are those sampled at flows that are only exceeded 25 percent of the time. Low flow samples are those sampled at conditions that are less than or equal to the streamflow occurring 75 percent of the time. Data was not tested if there was data in less than four of the 6 years in each one-third of the period of study (18 years). Twelve was the minimum number of low- or high-flow measurements used in a test (Buxton and others, 1999). Positive trends during low flow conditions indicate increases in concentrations from ground water and (or) point sources. Positive trends during high flow conditions indicate increases in concentrations from storm runoff.

Chloride and sodium increased during high flows at the most sites; 6 and 4 respectively. Both constituents also increased at 4 sites during low flow conditions. TKN was the constituent that showed the most decreases at sites during both high and low flows; 3 and 4 respectively. Hardness increased at 2 sites during high flow and 2 during low flow. Ammonia and organic carbon showed decreases at 3 sites (**table 7**). Dissolved oxygen, nitrate plus nitrite and total phosphorus increased at one or two sites. Total suspended solids and fecal coliform had no significant trends at high or low flow conditions. Alkalinity was not tested at any sites because of insufficient data.

Trends in the concentrations of 13 chemical constituents and 2 physical parameters measured during 1975-86 at 60 sites including 13 in the Raritan Basin were analyzed for statistical association with drainage-basin characteristics (Robinson and others, 1996). Urbanized basins were associated with increasing concentrations of sodium, chloride, magnesium and pH. Trends in dissolved solids, especially sodium and chloride, were strongly associated with application rates of road deicing salts. Upward trends in dissolved oxygen were associated with effluent discharged by nonmunicipal wastewater-treatment facilities. Trends in BOD and nutrients showed little association with the amount of effluent discharged to streams. Trends in total ammonia and agricultural land use, seem to indicate that nonpoint sources may be more of an influence than effluent discharge.

Relation of Concentration to Season and to Flow at Each Site and Between Sites

Concentrations of 15 constituents, fecal coliform counts and water temperature were compared at each site by season, flow, and season as a function of flow to explain variability in the data. Significant differences in levels of constituents between seasons were found to occur for each constituent at one or more sites. Significant differences in levels of constituents between flow conditions were found for each constituent except BOD. A test was also performed to see if the significant differences were caused by flow being a function of season. In most instances differences were not caused by flow being a function of season. In most cases when significant differences occurred between flow conditions, it was not limited to a single season.

The results of the analysis are presented in tables showing summary statistics and significant differences by season and flow condition (**tables 10-43**). The same summary is also presented on maps of the basin (**figures 2-18**). A summary of the distributions of constituents at each site and a comparison between sites is presented by boxplots (**figures 19-35**) and in cumulative probability plots (**figures 36-52**).

Alkalinity

Alkalinity as concentration of $CaCO_3$ is significantly lower in the Coastal Plain portion of the study area than in the Piedmont and Highlands physiographic provinces (**figures 2 and 19**). Three of the four sites in the coastal plain; Millstone River at Manalapan, Matchaponix Brook and Manalapan Brook have significantly lower concentrations than other sites; median concentrations range from 7.1 to 8.6 mg/L. Millstone River at Grovers Mill is slightly higher at 18.5 mg/L. Medians at the other stations ranged from 33 to 60 mg/L. Highest concentrations were measured in the South Branch Raritan River subbasin during low flow conditions in the summer. The lowest concentration (<1.0 mg/L) was observed at Matchaponix Brook (**table 9**). Concentrations less than 3.0 mg/L were observed at Matchaponix Brook, Manalapan Brook and Millstone River at Manalapan.

Concentrations are significantly higher at low flow than at high flow at each site (**table 27**). This indicates that runoff is diluting the buffering capacity of the water. Concentrations are also significantly higher in the growing season at 16 of the 21 sites. The increases in the growing season could be caused by algal growth. Concentrations at 19 of the 21 sites were lowest during high flow conditions in the nongrowing season. Concentrations significantly decrease as flow increases at all sites (**table 8**). Matchaponix Brook shows the sharpest decrease in concentration as flow increases. Flow as a function of season is a significant factor in explaining variability at S.B. Raritan River at High Bridge. Concentrations are significantly higher at low flow in the growing season.

Ammonia Plus Organic Nitrogen, Total (TKN)

Median concentrations of ammonia plus organic nitrogen are highest at the two most downstream Millstone River sites and at Raritan River at Bound Brook (0.50 - 0.54 mg/L)(**fig. 37**, **table 28**). In general, concentrations were highest in the Millstone River basin (**fig. 3**). The highest individual concentrations (greater than 2 mg/L) were measured at Millstone River at Grovers Mill, Stony Brook and Matchaponix Brook during low flow in the winter months and at Neshanic River during high flow in July. Concentrations at Mulhockaway Creek are significantly lower than at all the other sites.

Concentrations are significantly higher during the growing season at seven sites (**table 28**). Concentrations are significantly higher during low flows at Beden Brook and Raritan River at Manville and higher at high flow at Stony Brook. In general 13 sites have highest concentrations during high flow in the growing season. However, only Raritan River at Bound Brook shows high flow in the growing season to be a significant factor in explaining variability. The other sites were highest during low flow in either the growing or nongrowing seasons. Concentrations were found to significantly change as flow increases at only 6 of the sites (**table 8**). Beden Brook was the only site at which concentrations significantly decrease as flow increases. Five other sites have significantly higher concentrations as flows increase (**table 8**).

Biochemical Oxygen Demand

Median concentrations of biochemical oxygen demand were highest at Millstone River at Blackwells Mills, Stony Brook and S.B. Raritan River at Three Bridges (1.7 - 1.8 mg/L) (**fig 21** and **table 11**). The lowest median concentrations were at 3 of the 4 coastal plain sites; Manalapan Brook, Matchaponix Brook and Millstone River at Manalapan. Matchaponix Brook was significantly lower than the three sites with the highest concentrations.

Concentrations at sites did not vary much between seasons and flow conditions. No sites had significantly different concentrations at different flow conditions (**table 29**). Rockaway River was the only site to vary seasonally. Concentrations were significantly higher in the growing season. Highest instantaneous concentrations were 7.2 mg/L at Millstone River at Grovers Mill at low flow in February and 6.0 mg/L at S.B. Raritan River at Stanton at low flow in August. Stony Brook was the only site to have a significant relation between instantaneous flow and concentration (**table 8**). Concentrations were found to increase as flow increased.

Chloride

Highest median concentrations of chloride are at North Branch Raritan River at Chester and Lamington River at Pottersville (38 and 36 mg/L respectively) (**fig 22, table 12**). Lowest median concentrations are at Millstone River at Manalapan, Mulhockaway Creek and Spruce Run (14, 15, and 17 mg/L). Highest instantaneous concentrations ranging from 110 to 190 mg/L occurred during high flow conditions in the winter months.

Median concentrations at 13 sites were highest at high flow in the nongrowing season. Concentrations are significantly higher in the nongrowing season at four sites (**table 30**). All sites had lowest median concentrations in the growing season; 15 sites during high flow in the growing season. Three sites have significantly higher concentrations at high flows and three sites are significantly higher at low flow (**fig. 5**). Season as a function of flow was a significant factor in explaining variability in concentrations at five sites. High flow in the nongrowing season was the significant factor in determining highest concentrations at three sites; N.B. Raritan River at Burnt Mills, Lamington River at Burnt Mills, and Millstone River at Blackwells Mills. Low flow in the growing season was the significant variable defining when the highest concentrations of chloride found at 2 sites; N.B. Raritan River at Chester and Beden Brook.

Chloride concentrations were found to be significantly related to instantaneous flow at 8 sites (**table 8**). Concentrations increase as flow increases at four sites. Concentrations at S.B. Raritan River at Middle Valley were found to increase the most as flows increase. Four sites including Stony Brook, Raritan River at Bound Brook, Matchaponix Brook and Manalapan Brook have decreasing concentrations of chloride as flows increase. At N.B. Raritan River at Burnt Mills, concentrations increase with flow in the nongrowing season and decrease with flow in the growing season.

Dissolved Oxygen

Median concentrations of dissolved oxygen were fairly uniform across the study area (8.9 - 12.1 mg/L) (**fig. 23, table 13**). Concentrations at S.B. Raritan River at Middle Valley, Neshanic River, and North Branch Raritan River at Burnt Mills were significantly higher than Lamington River at Burnt Mills, Millstone River sites at Grovers Mill and Blackwells Mills and Matchaponix Brook (**table 31**). Lowest median values were at the sites in the coastal plain, Millstone River at Blackwells Mills and Raritan River at Bound Brook (**fig. 6**). Lowest instantaneous readings were at the Millstone River sites at Grovers Mill, and Blackwells Mills and at Neshanic River at Reaville during low flows in the growing season (**table 13**). The lowest reading was 2.9 mg/L at Millstone River at Blackwells Mills at low flow in August. The highest readings were 18.2 and 17.5 mg/L at Stony Brook and Neshanic River during high flow in April.

Season and the subsequent change in stream temperature is the dominant factor causing the variability of dissolved oxygen concentrations in streams. All sites had significantly higher concentrations of dissolved oxygen in the nongrowing season. Median concentrations were highest at all sites at high flow, however only 10 sites were significantly higher than at low flow. Season as a function of flow was a significant factor in explaining variability in concentrations at two sites (**table 31**). Low flow in the non-growing season was a significant variable in defining when the highest concentrations of dissolved oxygen were found at three sites; S.B. Raritan River at Middle Valley, Mulhockaway Creek and Manalapan Brook. Dissolved oxygen concentrations were found to significantly increase as flow increases at 12 sites (**table 8**). No sites showed a decrease in concentration with increasing flow. Season and the subsequent change in stream temperature is the dominant factor causing the variability of dissolved oxygen concentrations in streams.

Dissolved Solids, Total

Concentrations of total dissolved solids were significantly higher during low flow conditions then during high flow conditions at 17 sites (**table 32**). Median concentrations at low flow were higher than at high flow at all sites. Some of the highest individual concentrations measured however occurred during high flows in the winter. The second highest concentration recorded was 334 mg/L at S.B. Raritan River at Middle Valley during high flow in January (**table 14**). Chloride and sodium were also high during this sample, and contributed to high TDS as a result of runoff containing de-icing salts. Although the highest concentrations measured occurred at high flow in the winter, the highest mean rank concentrations occur at each site at low flow.

Lowest concentrations were measured during high flow in the growing season. Samples at Stony Brook and Millstone River at Manalapan recorded 56 and 57 mg/L respectively during high flow in the summer. Total dissolved solids significantly decreased as flow increased at 20 of the 21 sites (**table 8**). Concentrations at Millstone River at Manalapan did not significantly change as flow increased.

Concentrations were compared between seasons at each site. Manalapan Brook was the only site with significant seasonal difference; higher in the nongrowing season. Low flow in the growing season was a significant variable in defining when the highest concentrations of total dissolved solids found at two sites; S.B. Raritan River at High Bridge, and N.B. Raritan River at Burnt Mills.

Concentrations of total dissolved solids were significantly lower at Millstone River at Manalapan and Manalapan Brook than at the other sites (**fig**. **24, table 32**). Medians were 69 and 79 mg/ L respectively. Median concentrations were highest at Matchaponix Brook and Neshanic River; 159 and 157 mg/L respectively.

Fecal Coliform

Median fecal coliform counts were highest at all sites during the growing season (**table 33, fig. 8**). Counts were significantly higher during the growing season than during the nongrowing season at 17 sites (**table 33**). Median counts were higher during low flows than during high flows at 16 sites. Concentrations were significantly higher during low flow conditions at three sites (**table 33**)**.** Counts significantly decreased as flow increased at Rockaway Creek and Beden Brook (**table 8**). No other sites have a significant relation to flow.

Median fecal coliform counts were highest at Neshanic River (790) and North Branch Raritan River at Burnt Mills (310) and lowest at the Matchaponix Brook and Manalapan Brook sites (20) (**table 15**). Eight sites, including all 5 sites in the Millstone River subbasin, the Lamington River sites at Pottersville and Burnt Mills, and Neshanic River have one sample with counts exceeding 24,000 colonies per 100 mL. Five of these samples were collected between July 22 -24 1997 during a runoff event. The samples from the Neshanic River and Millstone River at Grovers Mill were collected at relatively low flows during the beginning of runoff events. Neshanic River and Millstone River at Blackwells Mills are the only sites at which all samples equaled or exceeded 20 counts.

Season is the dominant factor causing the variability of fecal coliform counts in streams. When studying season and flow together as factors in fecal coliform variability, flow was only a significant factor at S.B. Raritan River at Stanton. Both high flow and high flow in the growing season were significant variables contributing to highest coliform counts.

Hardness

Hardness concentrations are significantly lower during high flow than during low flow at all sites (**table 34**). Median concentrations are higher at 19 of the 21 sites in the growing season, but only significantly higher in the growing season at 7 sites. Flow as a function of season is a significant variable in determining variability in concentrations at Stony Brook and S.B. Raritan River at High Bridge. Hardness concentrations significantly decreased as flow increased at all 21 sites (**table 8**). Median concentrations were lowest at the in coastal plain and in the Millstone River subbasin (**figure 9**).

The highest concentrations were observed at Neshanic River (**table 16, fig. 26**). Concentrations over 200 mg/L were observed during low flows in the summer. Concentrations varied more at this site than the others. Concentrations less than 60 mg/L were observed during high flows during winter and spring. The smallest concentrations were measured at Millstone River at Manalapan and Manalapan Brook, two sites without any point sources in the coastal plain. Both sites have the least amount of variance in concentration during the sampling period. Flow is the predominant factor defining variability in hardness concentrations in the basin.

Nitrate Plus Nitrite

Concentrations of nitrate plus nitrite are significantly higher at Matchaponix Brook, and the Millstone River sites at Grovers Mill and Blackwells Mills than at the other sites (**fig 27**). Concentrations over 5 mg/L were measured from samples collected at these sites and at Rockaway Creek (**table 17**). Concentrations over 5 mg/L measured at the Millstone River sites and Matchaponix Brook were at low flow conditions in the summer. At Rockaway Creek the high concentration occurred during high flow in the spring. Only Neshanic River and Stony Brook had concentrations measured below 0.10 mg/L, at low flows in the growing season. Median concentrations were lowest at Stony Brook and Lamington River at Pottersville and highest at the Millstone River sites and Matchaponix Brook.

Ten sites had significantly higher concentrations in the nongrowing season than in the growing season (**table 35**). No sites were significantly higher in the growing season. Eleven sites were significantly higher during low flow and three sites were highest during high flow. Concentrations were found to significantly change as flow increases at 11 sites (**table 8**). Neshanic River and Raritan River at Manville were the only sites at which concentrations significantly increase as flow increases. Nine other sites have significantly lower concentrations as flows increase. (**table 8**).

Flow and season equally define variability of nitrate plus nitrite concentrations when both factors are studied together. Low flow conditions and the nongrowing season were the two variables significantly related to the highest mean rank concentrations at 18 of the 19 sites in the basin (**table 35**). High flow was not a significant factor at any site and growing season was only a significant factor at Matchaponix Brook as a function of low flow.

Organic Carbon, Total

Median concentrations of total organic carbon are highest at Millstone River at Blackwells Mills, Raritan River at Bound Brook, and Stony Brook (**table 18**). In general, the highest median concentrations were in the Millstone River, Lamington River and Raritan River mainstem subbasins (**fig. 11**). The lowest median concentrations were found at Spruce Run and Mulhockaway Creek and were significantly lower than at the other sites (**fig**. **28**). Highest concentrations--over 10 mg/L--were measured at Stony Brook, North Branch Raritan River near Chester, and Lamington River at Burnt Mills. Only S.B. Raritan River at Stanton had a concentration under 1.0 mg/L at low flow in March.

Concentrations were significantly higher during the growing season at seven sites (**table 36**). No sites had significantly higher concentrations in the nongrowing season. Three sites were significantly higher during low flow and two sites were significantly higher during high flow. Concentrations were highest during high flow conditions in the growing season at 13 sites. Concentrations were lowest during low flow conditions in the nongrowing season at 14 sites. Four sites have significantly increasing concentrations as flows increase (**table 8**). The other 17 sites did not have significant changes in concentration as flows increase.

Season is the dominant factor causing the variability of total organic carbon concentrations in streams. When season and flow were studied together as factors in fecal coliform variability, season was a significant factor at 15 sites. Both season and flow were significant factors at 5 sites. Flow alone was a factor only at the Mulhockaway Creek. Mulhockaway Creek has significantly higher concentrations at high flow.

pH

Median measurements of pH were highest at low flow conditions at 20 sites and the same at Rockaway Creek regardless of flow condition (**table 37**). Measurements of pH were significantly higher during low flow than at high flow at 12 sites. The lowest readings at all sites occurred during high flow conditions. Measurements of pH were found to significantly decrease with increasing flow at 17 sites (**table 8**). No significant relation between flow and pH exists at the other 4 sites. Measurements were significantly higher during the growing season at three sites.

Measurements of pH were significantly lower at sites located on the coastal plain-- Matchaponix Brook, Manalapan Brook, and the Millstone River sites-- than at other sites in the basin (**fig. 12**). Median measurements of pH ranged from 6.6 to 7.0 for coastal plain sites and 7.7 to 8.1 for sites draining areas entirely outside of the coastal plain. Raritan River at Bound Brook and Millstone River at Blackwells Mills are located in the piedmont province however a portion of the streamflow originates in the coastal plain. The median pH at these sites is 7.6 and 7.3 respectively. Readings equaling or exceeding 9.0 were observed at Neshanic River, Rockaway Creek, Stony Brook, and Beden Brook in the growing season. Readings below 6.0 were observed at Matchaponix Brook and Manalapan Brook (**table 19**). All measurements less than 6.0 were recorded during high flow conditions.

Flow was found to be the dominant factor causing the variability of pH in streams. When season and flow were studied together as factors in pH variability, flow was a significant factor at 12 sites. Season as a function of flow was a significant factor only at N.B. Raritan River at Burnt Mills. Season alone was a factor only at the Millstone River at Blackwells Mills.

Phosphorus

Median phosphorus concentrations were highest at the Millstone River sites at Blackwells Mills, and Grovers Mill, S.B. Raritan River at Three Bridges and Raritan River at Bound Brook (**table 20**). Median concentrations exceeded 0.1 mg/L at these sites. The lowest median concentrations--less than 0.04 mg/L-- were found at Mulhockaway Creek, Spruce Run and S.B. Raritan River at Stanton.

The highest measured concentrations were 0.75 mg/L at Millstone River at Blackwells Mills during low flow in August and 0.73 mg/L at Millstone River at Grovers Mill during high flow in June. One sample at both Neshanic River and Raritan River at Bound Brook exceeded a concentration of 0.60 mg/L during high flow in the summer. Millstone River at Blackwells Mills and Raritan River at Bound Brook were the only 2 sites studied in which all samples exceeded 0.05 mg/L (**figs. 30, 47**)

Nineteen of the 21 sites have higher median concentrations in the growing season than in the nongrowing season (**table 38**). Ten sites are significantly higher in the growing season. Sixteen of the 21 sites have higher median concentrations during low flow than high flow. Five sites have significantly higher concentrations at low flow. Median concentrations at Mulhockaway Creek are consistently low --less than or equal to 0.02 mg/L--regardless of season or flow condition (**table 38**).

Phosphorus concentrations were found to be significantly related to flow at 8 sites (**table 8**). Concentrations increase as flow increases at three sites. Concentrations at Millstone River at Manalapan were found to increase the most as flows increase. Five sites have decreasing concentrations of phosphorus as flows increase.

Flow and season equally define variability of phosphorus concentrations when both factors are studied together. Low flow conditions and the growing season were the two variables significantly related to the highest mean rank concentrations at 11 of the 21 sites in the basin (**table 38**). Mean rank concentrations were not significantly higher at high flow or nongrowing season at any site.

Sodium

Median sodium concentrations were highest at Millstone River at Blackwells Mills and Matchaponix Brook (**table 21**). Median concentrations were 20 mg/L at these sites. The lowest median concentrations--less than 10 mg/L--were found at Millstone River at Manalapan (6.5), Manalapan Brook (8.6), and Mulhockaway Creek (9.2) (**fig. 31**).

The highest measured concentrations exceeded 50 mg/L at S.B. Raritan River at Middle Valley, Matchaponix Brook, Neshanic River, Millstone River at Blackwells Mills and Stony Brook (**table 21**). All concentrations over 50 mg/L were collected during high flows in the nongrowing season except for one sample at Neshanic River that was collected at low flow in June. The lowest recorded concentrations were 5.1 mg/L at Millstone River at Manalapan and 5.4 mg/L at Stony Brook at Princeton, both during high flows in the growing season.

Concentrations at Stony Brook, Raritan River at Bound Brook, and Matchaponix Brook were significantly higher at low flow than at high flow (**table 39**). Concentrations at Mulhockaway Creek and Millstone River at Manalapan were significantly higher at high flow than at low flow. Concentrations at S.B. Raritan River at High Bridge, Mulhockaway Creek, and Millstone River at Manalapan were significantly higher in the nongrowing season than in the growing season. Flow as a function of season is a significant variable in determining variability in concentrations at five sites (**table 39**).

Sodium concentrations were found to be significantly related to flow at 7 sites (**table 8**). Concentrations increase as flow increases at Mulhockaway Creek and S.B. Raritan River at Stanton. Five sites have decreasing concentrations of sodium as flows increase.

Flow and season were found to equally define the variability of sodium in streams. When season and flow were studied together as factors in sodium variability, flow was a significant factor at 10 sites. Season was a significant factor at 8 sites. Season alone was a factor at 2 sites and season as a function of flow was a significant factor in variability at 6 sites. Highest mean rank concentrations were significantly related to high flow in the nongrowing season at 5 sites and low flow in the growing season at 1 site.

Sulfate

The highest median sulfate concentration was 49 mg/L at Matchaponix Brook (**fig. 32**). The second highest median concentration was 29 mg/L at Neshanic River. The lowest median concentrations were at S.B. Raritan River at Middle Valley (11mg/L), Lamington River at Pottersville (11.5 mg/L), and S.B. Raritan River at High Bridge (12 mg/L).

The highest concentration measured was 96 mg/L at Neshanic River (**table 22**). All concentrations over 70 mg/L were measured at Neshanic River, Beden Brook and Matchaponix Brook during low flows in the growing season. The lowest concentrations measured were 7.6 mg/L at Lamington River at Pottersville, 8.7 mg/L at Millstone River at Manalapan, and 8.6 mg/L at Stony Brook. These samples were collected in the growing season during high flows at Lamington River and Stony Brook and at low flow at Millstone River.

Highest median concentrations were observed at low flow conditions in the nongrowing season at 19 of the 20 sites (**table 40**). Concentrations were significantly higher at low flow than at high flow at 13 sites. Millstone River at Manalapan was the only site with significantly higher concentrations at high flow than at low flow. Four sites were significantly higher in the nongrowing season. Beden brook is the only site significantly higher in the growing season than the nongrowing season.

Sulfate concentrations were found to be significantly related to flow at 18 sites (**table 8**). Concentrations decrease as flow increases at 17 sites. Millstone River at Manalapan is the only site found to have increasing concentrations of sulfate as flows increase.

Flow was found to be the dominant factor causing the variability of sulfate in streams. When season and flow were studied together as factors in sulfate variability, flow was a significant factor at 17 sites. Flow as a function of season was a significant factor at 3 sites. Season alone was a factor at 5 sites. Mean rank concentrations are significantly higher at low flow at 14 sites

Total Suspended Solids

Median total suspended solids concentrations were highest at the Millstone River sites at Grovers Mill and Blackwells Mills; 11.5 mg/L and 10 mg/L respectively (**fig. 33**). Lowest median concentrations (2.0 mg/L) were found at Mulhockaway Creek and North Branch Raritan River at Chester (**table 24**).

The highest concentrations measured were 510 mg/L at Stony Brook, 501 mg/L at Neshanic River, and 427 mg/L at Raritan River at Bound Brook (**table 24**). These high concentrations were measured during the highest flows sampled at these sites. The highest concentration measured at North Branch Raritan River at Chester was 9 mg/L.

Median concentrations were lowest during low flow conditions in the nongrowing season at 17 sites and highest during high flows in the growing season at 14 sites (**table 41**). Only Beden Brook and S.B. Raritan River at Three Bridges were highest during low flow in the growing season. The other 5 sites were highest during high flow in the nongrowing season. Ten sites were significantly highest at high flow and 5 sites were significantly higher during the growing season. Flow as a function of season is a significant variable in determining variability in concentrations at two sites (**table 41**). Total suspended solids concentrations were found to increase significantly as flow increases at 13 sites (**table 8**). Eight sites have no significant relation between concentrations and flow.

Flow was found to be the dominant factor causing the variability of total suspended solids in streams. When season and flow were studied together as factors in total suspended solids variability, flow was a significant factor at 11 sites. Flow as a function of season was a significant factor at 2 sites. Season alone was a factor at 7 sites. Mean rank concentrations are significantly higher at high flow at 10 sites (**table 41**).

Un-ionized Ammonia

Un-ionized ammonia was found in small concentrations at all sites. Median concentrations at 9 sites are less than 0.0001 mg/L. The highest median concentration is 0.0006 mg/L at North Branch Raritan River near Chester (**table 26**). Median concentrations of 0.0005 mg/L were found at S.B. Raritan River at Three Bridges, Rockaway Creek and Raritan River at Bound Brook. The highest concentrations measured were 0.04 mg/L at Neshanic River, 0.025 mg/L at S.B. Raritan River at Stanton, and 0.02 mg/L at North Branch Raritan River at Burnt Mills. All samples with concentrations greater than 0.02 mg/L, including three samples from Neshanic River, and one from the South branch and North Branch sites were collected at low flow in the growing season.

Concentrations were significantly lower at Matchaponix Brook, Manalapan Brook, and Millstone River near Manalapan than at the other sites (**fig. 34**). Concentrations at 12 sites were significantly higher in the growing season than in the nongrowing season. Concentrations at the other nine sites did not vary significantly by season.

Concentrations at 13 sites were significantly higher at low flows than at high flows. Concentrations at the other eight sites did not vary significantly by flow condition. Median concentrations were highest at low flow in the growing season at 18 sites. Median concentrations highest at high flow in the growing season at Stony Brook and Raritan River at Bound Brook. Matchaponix Brook had highest median concentrations at low flow in the nongrowing season. Flow as a function of season is a significant variable in determining variability in concentrations only at North Branch Raritan River at Burnt Mills (**table 42**). Un-ionized ammonia concentrations were found to decrease significantly as flow increases at 13 sites (**table 8**). Eight sites have no significant relation between concentrations and flow.

Flow and season were found to equally define the variability of un-ionized ammonia in streams. When season and flow were studied together as factors in un-ionized ammonia variability, flow was a significant factor at 10 sites. Season alone was a factor at 8 sites and season as a function of flow was also a significant factor in variability at 1 of those sites. Highest mean rank concentrations were significantly related to low flow in the growing season at 1 site (**table 42**).

Water Temperature

Water temperatures did not vary significantly between sites (**fig**. **35**). The highest median temperatures were at Raritan River at Bound Brook (14.4^{o} C) and S.B. Raritan River at Three Bridges (14.0^{o} C). The lowest median temperatures were 9.5^{o} C at Lamington River near Pottersville and Lamington River at Burnt Mills (**table 25**). Median temperatures were generally lowest in the North Branch Raritan River subbasin and upper reaches of the S.B. Raritan River subbasin (**fig. 17**). The highest temperature measured was 26.5^{o} C at Raritan River at Bound Brook and at the S.B. Raritan River sites at Stanton and Three Bridges. The lowest maximum temperature measured was 20.0^{o} C at North Branch Raritan River at Chester. The minimum temperature recorded is less than 0.5^{o} C at all sites except Raritan River at Bound Brook (1.5^{o} C) and Millstone River at Grovers Mill (1.0^{o} C).

Water temperatures are significantly higher in the growing season than the nongrowing season at all sites. Temperatures are significantly higher at low flow than at high flow at 12 sites. Median temperatures are highest at all sites at low flow in the growing season. Lowest median temperatures are in the nongrowing season during high flow at 12 sites and during low flow at 9 sites (**table 43**). Water temperatures were found to decrease significantly as flow increases at 14 sites (**table 8**). Seven sites have no significant relation between concentrations and flow.

Season was found to be the dominant factor causing the variability of water temperature in streams. When season and flow were studied together as factors in water temperature variability, season was a significant factor at all sites. Flow as a function of season was also a significant factor at 3 sites. Flow alone was also a factor at 6 sites (**table 43**).

Relation of Constituents to Total Suspended Solids

Total suspended solids significantly increase with flow at most sites (**table 8**). Most suspended solids in surface water are found in stormwater runoff caused by erosion. Suspended sediments can transport nutrients, organic carbons and trace elements associated with sediment. Concentrations of total ammonia plus organic nitrogen, total phosphorus, and total organic carbon are measures of concentrations associated with sediment and also dissolved in water. The magnitude of these constituents can be a measure of the amount of these concentrations associated with sediment. Concentrations of total ammonia plus organic nitrogen, total phosphorus, and total organic carbon were found to significantly increase as concentrations of total suspended solids increased at 10, 11 and 13 sites respectively. Concentrations of nitrate plus nitrite are inversely related to suspended sediment concentration at 5 sites and increased with sediment concentrations at one site. Most nitrate plus nitrite is dissolved in the water column and not associated with sediment.

Pesticides

A summary of results from USGS studies of pesticides in surface waters in the Raritan River basin is also presented. The Long Island/New Jersey National water Quality Assessment (LINJ NAWQA) project examined pesticides in surface water in the basin in two studies. 1) Two sites in the basin were routinely sampled for these compounds from April 1996 through June 1998 and two sites were sampled from April 1996 through September 1996 and in June 1997. 2) In a second study, one sample was collected between June 9-18, 1997 from nine sites representing a variety of land uses in the basin.

Relation to Season, Flow and Standards

The LINJ NAWQA study analyzed the pesticide data from samples collected routinely from seven sites in New Jersey (**fig. 53**) including four sites in the Raritan River Basin to investigate the relation of concentrations to season, streamflow, and land use (Reiser, 1999). The samples were analyzed for 85 pesticides, including 50 herbicides, 28 insecticides and 7 degradation products. The four sites sampled routinely in the Raritan River Basin include 3 sites from the USGS/ NJDEP cooperative network and Bound Brook at Middlesex. The three network sites are Neshanic River at Reaville, NJ, Stony Brook at Princeton, and Raritan River at Bound Brook. Stony Brook and Neshanic River were only sampled in the growing season.

Specific results in this summary are for sites in the Raritan River Basin. Pesticides were frequently detected in each stream, however concentrations were generally low. The pesticides most frequently detected from all samples in the study were atrazine, in 97 percent of the samples; prometon, in 96 percent; metolachlor, in 95 percent; desethyl-atrazine, in 91 percent; simazine, in 88 percent; diazinon, in 58 percent; alachlor, in 56 percent; and carbaryl, in 54 percent. More than 97 percent of the samples contained at least five pesticides. Twenty-nine pesticides were detected at the highly urbanized Bound Brook site throughout the sampling period, the most detected at any site in the study, and 17 pesticides were detected at the Neshanic River site, the fewest at any site in the basin.

The concentrations of 9 pesticides infrequently exceeded established water-quality criteria at the Raritan River Basin sites. All twenty-six detections that exceeded criteria, occurred during the growing season. Twenty two of these detections occurred during high flow conditions. Concentrations of atrazine, and alachlor exceeded the New Jersey drinking water standard and cyanazine exceeded the U.S. Environmental Protection Agency human health advisory level during runoff shortly after spring applications of these pesticides. The high concentrations were measured at Stony Brook, Neshanic River and Raritan River at Bound Brook. These concentrations represent a potential threat to municipal water supplies in the Raritan River Basin. Dieldrin was detected in one sample at Stony Brook at low flow in the growing season and DDE in one sample during runoff in August at Raritan River at Bound Brook; both at concentrations that exceeded the New Jersey Department of Environmental Protection (NJDEP) surface water standard. Dieldrin concentrations also exceeded the NJDEP AQCR. One concentration of chlorpyrifos exceeded the New Jersey surface water standard at Bound Brook at Middlesex. Chlorthalonil, diazinon, and ethyl-parathion exceeded various chronic life criteria for the protection of aquatic life (AQCR); Canadian criteria, Great Lakes standards, and EPA standards respectively. These criteria were exceeded at Bound Brook at Middlesex and Raritan River at Bound Brook during the growing season, mostly at high flow conditions. Diazinon exceeded 0.08 mg/L in 10 samples at Bound brook at Middlesex and 3 samples at Raritan River at Bound Brook.

Pesticides were detected more frequently during the growing season than during the nongrowing season. Thirty-seven pesticides were detected during the growing season and 19 pesticides during the nongrowing season in the basin. Twenty pesticides were detected only during the growing season. The highest individual concentrations and highest median concentrations of most of the pesticides detected occurred during runoff in the growing season, and the lowest typically occurred during runoff in the nongrowing season. The median concentrations of most pesticides at most sites were equally low during base flow and runoff in the nongrowing season. Typically, concentrations were least variable during base-flow conditions in the nongrowing season. All 24 pesticides with the highest concentrations during runoff were sampled in the growing season. The four pesticides with highest concentrations during the nongrowing season were sampled during base-flow conditions.

Pesticide concentrations were related to land use in the drainage basin upstream from the sampling site. The highest median concentration and the maximum concentration of a pesticide were typically found at a site where land use in the drainage basin upstream from the site is generally associated with applications of that pesticide. Herbicides associated with agricultural land use, such as atrazine, generally were detected in higher concentrations than other pesticides, showed the strongest correlation to land use, and had the largest variability in concentration with season and streamflow. In general, insecticides were detected more frequently and in greater concentrations at urban sites than at other sites. The highest individual and median concentrations of 10 of the 13 insecticides detected were present in samples from the two sites with the highest urban land use. Ten of the 13 insecticides were detected at the highest frequencies at the three most urbanized sites.

Concentrations of 13 pesticides were significantly correlated with streamflow at one or more sites. The strongest relations were concentrations of two herbicides used for lawn care at a suburban site and two herbicides used for agriculture at Stony Brook correlated positively with streamflow during the growing season. Stony Brook is a basin with 28 percent agricultural land use. Concentrations of the insecticide diazinon also showed a strong positive correlation with streamflow during both seasons at Raritan River at Bound Brook, a site that drains 804 square miles of the 1,105 square mile Raritan River Basin. In general, most of the pesticides that correlated positively with streamflow were detected at sites where the predominant land use is associated with the use of the detected pesticide. Most of the pesticides with a negative relation to streamflow were detected at sites where the land use in the basin would not indicate use of the detected pesticide. The number of pesticides detected was found to increase significantly as streamflow increased at the Raritan River site. Numbers of pesticides generally increased with increased streamflow at the other 3 sites in the basin.

Pesticides Related to Land Use

A second LINJ NAWQA study analyzed the presence of 47 pesticides in 50 samples from 50 sites in New Jersey and Long Island New York (**fig. 54**), including 9 sites in the Raritan River Basin (Reiser and O'Brien, 1999). Pesticide compounds were detected in all of the 50 stream samples analyzed during the June 9-18, 1997 pesticide synoptic study. The samples were collected during high baseflow conditions. The number of pesticides detected at each site ranged from 1 to 14 with a median of seven. The seven most frequently detected pesticides were atrazine (in 93 percent of samples); metolachlor, (86 percent); prometon, (84 percent); desethyl-atrazine, (78 percent); simazine, (78 percent); carbaryl, (44 percent); and diazinon, (44 percent).

Water-quality criteria for aquatic life, maximum contaminant levels (MCLs) or health advisory levels (HAL's) have been established for 18 of the 25 compounds detected. None of the pesticides detected exceeded an MCL or HAL established by the USEPA, or the criteria for aquatic life in the Raritan River Basin.

Detection frequencies of 14 of the 25 pesticides detected were highest at agricultural sites. Acetochlor, azinphos-methyl, carbofuran, and pebulate were detected only at agricultural sites. Seven compounds were detected most frequently at urban sites. Four of these compounds, trifluralin, dieldrin, napropamide, and benfluralin were detected only at urban sites. Four compounds were detected most frequently at mixed land use sites. No pesticides were detected most frequently at forested sites.

The median concentration of the sum of pesticides detected at a site was highest for the agricultural group of sites (0.2 mg/L) and lowest at forested sites (0.025mg/L). The variability in concentrations of total pesticide concentrations was highest for urban sites and lowest for mixed-land-use sites. Total concentrations and number of pesticides detected at a site showed an increasing trend with increasing agricultural land use and an inverse relation with the total undeveloped land use in a basin.

Pesticide application rates in New Jersey were compared to detection frequencies in streams. Pendimethalin and chlorpyrifos, two of the three most heavily applied pesticides in New Jersey, have low water solubilities and high soil adsorption coefficients and were found to have low detection frequencies. Also chlorpyrifos is used primarily for termite control and it is less likely to be applied in areas exposed to water transport to the same degree as other compounds. Prometon has high solubility in water and a low soil sorption coefficient and proportionately low application rates (in pounds of active ingredient) and high detection frequencies in streams.

Volatile Organic Compounds

A summary of results from USGS studies of volatile organic compounds (VOCs) in surface waters in the Raritan River Basin is also presented. The LINJ NAWQA project examined VOCs in surface water in the basin during three studies. 1) Three sites in the basin were routinely sampled for these compounds from April 1996 through January 1998, and one site was sampled from April 1996 through January 1997. 2) Another study collected one sample at 42 sites including 12 sites in the basin from January 27-30, 1997. During the same study a sample was collected at 9 sites in the Bound Brook Basin to study VOCs found along stream reaches draining areas containing different land uses. 3) A third study involved collecting five samples at each of three sites along the Green Brook portion of the Bound Brook Basin before, during, and after a storm in February 1998.

Volatile Organic Compounds Related to Land Use

Samples from 42 stream sites, including 12 sites in the Raritan River Basin (**fig 55**) were analyzed for 86 VOC's (O'Brien and others, 1997). The samples were collected during high baseflow conditions during January 27-30, 1997. The study describes the spatial variability of VOCs in streams draining different land use compositions.

A total of 50 VOCs were detected at the 42 sites. the most frequently detected VOCs were methyl tert-butyl ether (MTBE), acetone, naphalene, PCE, chloroform, and TCE. MTBE was detected in all samples. All concentrations measured were less than established MCLs and HALs. None of the maximum concentrations were measured in the Raritan River Basin except for 0.04 mg/L of chlorobenzene at Bound Brook. The concentrations and numbers of VOCs detected were highest in the most urbanized areas. Total concentrations of all VOCs detected in samples were lowest in basins with predominately forested land use.

VOC samples were collected along two stream reaches representing different land uses in the Bound Brook Basin during January 27-30, 1997. Four sites sampled along the less developed Green Brook reach detected 6 VOCs compared to 37 VOCs detected at 4 sites along the more heavily developed Bound Brook Basin. Fourteen VOCs were detected at a small site draining a high percentage of urban commercial/industrial land use. Eleven of the VOCs were not detected at another site further downstream.

Volatile Organic Compounds Related to Flow and Land Use

Three sites along a stream reach in the Bound Brook Basin were sampled before during and after a storm event in February 1998 (**fig 56**). The results of total numbers of VOCs, total VOC concentrations, and MTBE concentrations measured for all the samples at each site is summarized in **figure 57**. Green Brook at Seeley Mills (01403400), the most upstream site with a high percentage of forested land use, has 5 VOCs present during baseflow before and after the storm and only 4 VOCs detected during storm runoff. Green Brook at Dunellen (01403700) is the site in the middle of the reach, with a higher percentage of urban land use. Eleven VOCs were present before the storm, 17 compounds during the storm runoff and 5 compounds at flow conditions near baseflow after the storm. Bound Brook at Middlesex (01403900) is the site furthest downstream, draining an area of 73 percent urban land use, consisting of older residential, and commercial/ industrial land uses. This site also contains industrial point source discharges. Ten VOCs were detected before the storm, 23 during the storm runoff and 8 VOCs during low flow after the storm. Thirteen compounds, mostly benzene compounds, were detected only during the storm runoff.

Numbers of VOCs and total concentrations were lower at all sites after the storm than before the storm. This may be caused by dilution at the 2 most down stream sites. Flows at the Bound Brook and Green Brook at Dunellen sites are twice as high in the sample collected after the storm as in the sample collected before the storm. Flow at the Green Brook at Seeley Mills sites was lower during the sample after the storm than in the sample collected before the storm. Slightly less total concentrations at the Seeley Mills site are not caused by dilution. MTBE appears to be flushed out of the system at the 2 upstream sites (**figure 57**).

Volatile Organic Compounds Related to Season

Volatile organic compounds (VOCs) were detected in 104 of the 112 samples collected during April 1996-April 1997 from seven streams (**fig. 53**), including 4 in the Raritan River Basin (Reiser and O'Brien, 1998). A total of 47 of the 86 VOCs analyzed were detected. Forty-three additional samples were collected between April 1997 and January 1998. Nine out of the 155 samples collected from April 1996 through January 1998 did not detect any VOCs; all were in the summer months. The largest numbers of VOCs were found at 3 sites in the Raritan River Basin; 40 at Bound Brook at Middlesex, 29 at Raritan River at Bound Brook and 22 at Neshanic River at Reaville. The Bound Brook site had the highest concentrations measured for 28 of the 47 VOCs detected.

The five most frequently detected VOC's in all samples were methyl tert-butyl ether (MTBE), in 78 percent of the samples; chloroform, 63 percent; trichloroethene (TCE), 51 percent; 1,1,1-trichloroethane (TCA), 41 percent; and tetrachloroethene (PCE), 35 percent. MTBE, TCE and PCE concentrations were higher in the cooler months and chloroform and TCA were higher in the warmer months.

Contrasting seasonal patterns may indicate different potential sources of VOCs in streams. Higher concentrations in cooler months, when flows are higher, indicate that nonpoint sources may be important in determining the presence and concentration of certain VOCs. Higher concentrations in warmer months, when flows are lower, indicate that point sources or ground-water contributions may be more important than surface runoff in determining the presence and concentration of other VOCs in streams.

Detection frequencies and median concentrations of MTBE, TCE, and PCE were highest at Bound Brook, whose drainage basin has the highest percentage of urban-industrial land use. Detection frequencies and median concentrations of chloroform were highest at the Passaic and Raritan River sites, the sites most affected by discharges from wastewater-treatment plants.

Concentrations of chloroform, bromodichloromethane, TCA, PCE, and chlorobenzene were found to decrease significantly with flow at one or more sites, indicating that dilution is likely an important determinant of concentrations of these VOCs.

Trace Elements and Organics in Bed Sediment

Trace metals and chlorinated organic compounds tend to accumulate in bed sediments of streams. Chlorinated organic compounds in the water column tend to sorb to organic carbon in both suspended and bed sediments. The USGS/NJDEP cooperative network has collected bed sediment data at one-third of the network sites in New Jersey each year since 1976 (O'Brien, 1997). This includes approximately 40 sites in the Raritan River Basin from 1976 though 1993.

An analysis of the data on trace elements in bed sediments in New Jersey streams shows that the presence of most trace elements is more closely related to land use or population in close proximity to the sampling site than to point sources in the basin (O'Brien, 1997). Eight elements were studied; arsenic, chromium, copper, iron, manganese, nickel, lead and zinc. Point sources were only important in determining the presence zinc. Arsenic is related to agricultural land use and differences in chromium result from differences in geology. The presence of copper, lead, and zinc is related to basin population. Iron, manganese, nickel did not show a relation to land use, population, total flow of point sources, or physiographic province. Median concentrations of six of the eight elements in the Raritan River Basin were less than some basins and greater than others. Median arsenic concentrations were highest in the Raritan and Raccoon River Basins. Median manganese concentrations were highest in the Raritan and Pequest/Paulins Kill Basins.

An analysis of the data on 18 chlorinated organic compounds in bed sediment in New Jersey streams showed DDT, DDE, DDD, chlordane, dieldrin, and PCB's to be the most frequently detected (Stackelberg, 1997). Chlordane and PCBs had the highest concentrations in all drainage basins studied. DDT, DDE and DDD were the most widely distributed and frequently detected in all basins regardless of land use. Chlordane, dieldrin, and PCBs were significantly higher in the most densely populated urban areas. The lowest detection frequencies and concentrations were in the basins with the highest percentage forested and undeveloped land use. Median concentrations and detection frequencies of organic carbon and the six most frequently detected compounds in samples in the Raritan River Basin were not extremely high or low compared to other basins. Other chlorinated insecticides were infrequently detected at low concentrations.

SUMMARY AND CONCLUSIONS

Seventeen water quality constituents were studied at 21 surface water-quality sites in the Raritan River basin. The water quality status of these sites is summarized by comparing the values of constituents to standards and by comparing values between sites. The sites with the best and worst water quality have been summarized. The most desirable rating for each constituent is given to the three sites with the most samples meeting the standard or having the most desirable median values. The least desirable rating is given to the three sites with the most samples not meeting the standard or with the most undesirable median value. **Table 44** lists the ratings for each constituent. The sites with the most desirable rating for the most constituents are Mulhockaway Creek, Spruce Run, Millstone River at Manalapan, Manalapan Brook, and Lamington River at Pottersville. The sites with the least desirable rating for the most constituents are Millstone River at Black Wells

Mills, Matchaponix Brook, Raritan River at Bound Brook, Neshanic River, and Millstone River at Grovers Mill. .

Surface water and/or drinking water standards exist for 13 of the 17 constituents studied. Nine of the 13 constituents did not meet standards at one or more sites in the basin. Results from recent studies of volatile organic compounds, pesticides, and trace elements and organics in stream bed-sediments were also summarized. The concentrations of 9 pesticides infrequently exceeded established water-quality criteria at sites in the Raritan River Basin.

The most commonly occurring constituents measured above standards in all samples are phosphorus, > 0.1 mg/L in 32 percent; fecal coliform, > 400 counts/100ml in 29 percent; hardness, < 50 mg/L in 21 percent; pH, > 8.5 or <6.5 in 17 percent; and water temperature in designated trout waters, >20 ^{o} C in 12 percent of samples. Chloride, TDS, nitrate plus nitrite and sulfate did not exceed the standard in any samples. Phosphorus was above 0.1 mg/L in all samples except one at Millstone River at Blackwells Mills and in more than half the samples at Raritan River at Bound Brook, Millstone River at Grovers Mills and S.B. Raritan River at Three Bridges.

Fecal coliform was above 400 counts/100ml in more than 50 percent of samples at Neshanic River. Geometric means were greater than the standard of 200 counts/100ml at 6 sites. Geometric mean of low flow samples was higher than high flow samples at 14 of the 21 sites. The geometric mean of low flow samples exceeded the standard at 7 sites and exceeded the standard in high flow samples at 4 sites. Only S.B. Raritan River at Three Bridges and Lamington River at Burnt Mills had geometric means exceeding 200 counts/100ml at high flow only.

Concentrations of all constituents change significantly as streamflow changes at one or more sites. All significant relations between alkalinity, un-ionized ammonia, total dissolved solids, hardness, pH, and water temperature were decreasing with increasing streamflow. All significant relations between biochemical oxygen demand, dissolved oxygen, total organic carbon and total suspended solids were increasing with increasing streamflow. Total ammonia, ammonia plus organic nitrogen, chloride, nitrate plus nitrite, total phosphorus, sodium and sulfate were found to increase with flow at one or more sites and decrease with flow at one or more sites. Increases in total suspended solids concentrations were significantly related to increases in total phosphorus, ammonia plus organic nitrogen, and total organic carbon at approximately half of the sites studied. Chloride concentrations at some sites, increased significantly with flow in the nongrowing season and decreased with flow in the growing season.

All constituents except biochemical oxygen demand were found to change significantly between the group of samples collected at flows less than the median and those collected at flows greater than the median at one or more sites. The following constituents were significantly higher in low flow samples at one or more sites; alkalinity, total dissolved solids, fecal coliform count, hardness, pH, total phosphorus, un-ionized ammonia, and water temperature. Dissolved oxygen, and total suspended solids were significantly higher in high flow samples at one or more sites. Ammonia plus organic nitrogen, chloride, nitrate plus nitrite, total organic carbon, sodium, and sulfate were significantly higher at some sites at low flow and significantly higher at other sites at high flow.

All constituents were found to change significantly between seasons at one or more sites. The following constituents were significantly higher in the growing season at one or more sites; alkalinity, ammonia plus organic nitrogen, biochemical oxygen demand, fecal coliform count, hardness, total organic carbon, pH, total phosphorus, unionized ammonia, and water temperature. The following constituents were significantly higher in the nongrowing season at one or more sites; chloride, dissolved oxygen, total dissolved solids, nitrate plus nitrite, and sodium. Sulfate was significantly higher in the nongrowing season at 4 sites and in the growing season at one site. Total suspended solids was significantly higher in the growing season at 5 sites and in the nongrowing season at one site.

Trends in data over time exist for all constituents except total suspended solids at one or more sites in the basin. All trends for total ammonia, organic nitrogen, fecal coliform, total organic carbon, total phosphorus, sulfate, and water temperature were decreasing over time. All observed trends for alkalinity, chloride, total dissolved solids, hardness, nitrate plus nitrite, pH, and sodium were increasing over time. Biochemical oxygen demand decreased at 2 sites and increased at one site.

Trends in data collected at high flow conditions exist for 10 of the 13 constituents analyzed and at low flow conditions for 8 of 13 constituents at one or more sites. All trends observed for total ammonia, total ammonia plus organic nitrogen, and total organic carbon concentrations decrease at one or more sites during either high flow and/or low flow. All trends observed for chloride, dissolved oxygen, total dissolved solids, hardness, nitrate plus nitrite, total phosphorus, and sodium increase at one or more sites during either high flow or low flow.

Pesticides were frequently detected in the Raritan River Basin, however concentrations were generally low. Pesticide concentrations were highest in the growing season. Pesticides were found to be related to land use. Concentrations of atrazine, alachlor, and cyanazine exceeded maximum contaminant levels and health advisory levels at high flow conditions in the late spring at sites with agricultural land use. Concentrations of chlorpyrifos, chlorthalonil, diazinon, and ethyl-parathion exceeded chronic life criteria for the protection of aquatic life. Dieldrin was detected in one sample and DDE in one sample at concentrations that exceeded New Jersey Department of Environmental Protection (NJDEP) health advisory levels.

Volatile organic carbons (VOCs) were also frequently detected in the Raritan River Basin, however concentrations were generally low. No VOCs exceeded maximum contaminant levels or health advisory levels. VOC concentrations were generally higher in the nongrowing season. Concentrations of some VOCs decreased significantly with increasing streamflow. The numbers of VOCs and total concentrations of VOCs detected increased during storm runoff at urban sites. Numbers of VOCs and total concentrations decreased at a lesser developed site. The concentrations and numbers of VOCs detected were highest in the most urbanized areas. Total concentrations of all VOCs detected in samples were lowest in basins with predominately forested land use.

An analysis of the data on trace elements in bed sediments in New Jersey streams shows that the presence of most trace elements is more closely related to land use or population in close proximity to the sampling site than to point sources in the basin. Analysis of chlorinated organic compounds in bed sediments found chlordane, dieldrin, and PCBs were significantly higher in the most densely populated urban areas. The lowest detection frequencies and concentrations were in the basins with the highest percentage forested and undeveloped land use.

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Table 1. NJDEP/USGS network surface water quality sites in the Raritan River basin from 1991-97, drainage basin characteristics, and historical period of record

[Flow record, C = continuous record, P = partial record; 1986 landuse data from New Jersey Department of Environmental Protection; population density from 1990 census; Impairment Status, N= nonimpaired, M= moderate, S=severe]

USGS Site Number	Site name	Drain-age Area (mi^2)	Flow Record	Historical period of water-quality record	Number of point sources upstream from site	AMNET biological impairment status	Land Use (in percent)						
							Urban	Agricul-ture	Forest	Water	Wet-land	Barren	Popul-ation Density
01396280	South Branch Raritan River at Middle Valley, NJ	47.6	P	1964-65, 1967, 1976-97	8	N	27.1	12.9	42.2	1.8	15.2	0.8	623
01396535	South Branch Raritan River at Arch Street at High Bridge, NJ	68.8	P	1976-97	8	N	26.0	15.5	43.9	1.5	12.4	0.7	537
01396588	Spruce Run near Glen Gardner, NJ	15.5	P	1979-97	2	N	16.3	22.5	51.4	0.4	8.6	0.7	257
01396660	Mulhockaway Creek at Van Syckel, NJ	11.8	C	1976-98	1	N	18.2	25.0	43.7	0.3	10.8	2.1	174
01397000	South Branch Raritan River at Stanton, NJ	147	C	1960-81, 1991-97	16	N	22.4	24.5	40.2	2.4	9.5	1.0	405
01397400	South Branch Raritan River, Three Bridges, NJ	181	P	1976-97	19	N	23.2	25.3	37.7	3.8	9.0	1.1	407
01398000	Neshanic River at Reaville, NJ	25.7	C	1957,1962, 1979-98	0	M	17.7	51.9	20.8	0.2	7.7	1.8	305
01398260	North Branch Raritan River near Chester, NJ	7.57	P	1964-65, 1967, 1976-97	1	N	37.3	6.6	45.4	0.4	10.0	0.3	569
01399120	North Branch Raritan River at Burnt Mills, NJ	63.8	P	1964, 1976-97	6	N	26.3	46.7	0.7	4.9	0.3	63.9	364
01399500	Lamington River near Pottersville, NJ	32.8	C	1977-97	5	N	28.2	13.0	40.7	1.8	14.7	1.7	609
01399700	Rockaway Creek at Whitehouse, NJ	37.1	P	1977-97	3	N	23.3	26.5	43.8	1.6	3.8	1.0	226
01399780	Lamington (Black) River at Burnt Mills, NJ	100	P	1964, 1976-98	12	N	21.	25.9	42.9	0.9	7.5	0.9	322
01400500	Raritan River at Manville, NJ	490	C	1923-25, 1959, 1962-73, 1976-97	47	M	25.2	29.3	34.7	2.0	7.8	1.1	425
01400540	Millstone River near Manalapan, NJ	7.37	P	1960-64, 1981-97	0	N	10.8	46.4	24.1	0.7	16.3	1.8	251
01400650	Millstone River at Grovers Mill, NJ	43.4	P	1976-98	6	M	24.7	41.5	22.9	1.3	7.3	2.3	751
01401000	Stony Brook at Princeton, NJ	44.5	C	1956-75, 1978-98	4	M	22.6	28.5	34.7	0.9	12.7	0.7	315
01401600	Beden Brook near Rocky Hill, NJ	27.6	P	1959-63, 1976-97	4	M	17.9	31.8	37.6	0.3	11.6	0.8	274
01402000	Millstone River at Blackwells Mills, NJ	258	C	1962-69, 1973, 1976-80, 1991-98	28	M	24.1	33.9	22.3	1.1	16.6	2.0	568

USGS Site Number	Site name	Drain-age Area (mi^2)	Flow Record	Historical period of water-quality record	Number of point sources upstream from site	AMNET biological impairment status	Land Use (in percent)						
							Urban	Agricul - ture	Forest	Water	Wet-land	Barren	Popul-ation Density
01403300	Raritan River at Queens Bridge at Bound Brook, NJ	804	P	1964-69, 1971-73, 1978, 1981-98	76	M	25.7	30.2	29.6	1.7	11.2	1.6	517
01405302	Matchaponix Brook at Mundy Avenue at Spotswood, NJ	44.1	P	1976-97	5	M	37.6	15.8	18.0	0.4	25.2	3.0	1220
01405340	Manalapan Brook at Federal Road near Manalapan, NJ	20.9	P	1976-97	0	S	13.7	42.5	18.8	0.9	22.1	1.9	199
Summary of Sub-basins													
	Raritan River basin	1,104	--	--	180	--	32.8	24.8	33.5	1.8	5.3	1.7	939
	Millstone River sub-basin	281	--	--	41	--	25.3	33.7	21.3	1.1	16.4	2.2	648
	South Branch Raritan River sub-basin	278	--	--	24	--	22.2	34.1	31.5	2.7	8.4	1.1	363
	North Branch Raritan River sub-basin	189	--	--	23	--	26.2	23.5	41.8	0.9	6.6	1.0	381
	South River sub-basin	133	--	--	6	--	32.4	16.1	22.1	1.3	24.4	3.7	1,215

Table 2. List of 17 constituents and chemical properties analyzed at 21 sites in Raritan River basin and the percentage of samples in which the constituent was detected

Constituent	Detection Frequency (in percent)
Alkalinity, as CaCO3	99.9
Ammonia, total and un-ionized ammonia	58.4
Ammonia + organic nitrogen, total	98.7
Biochemical Oxygen Demand (5-day)	61.2
Chloride	100
Dissolved Oxygen	100
Dissolved solids, total	100
Fecal Coliform Bacteria	87.6
Hardness	100
Nitrate + nitrite	99.9
Organic carbon, total	100
pH	100
Phosphorus, total	92.0
Sodium	100
Sulfate	100
Suspended solids, total	95.7
Water temperature	100

Table 3. Flow duration values of mean daily flow, and seven-day ten-year low flows

[Flows are in cubic feet per second, MA7CD10 flows are based on gage records through 1993, flow durations and mean daily flows are based on gage records from 1991 through 1997; *, MA7CD10 flow computed from 1964 through 1993, period representing regulated flow condition]

Station number (# of samples)	7-day 10-year low flow (MA7-CD10)	Mean daily flow	Flow duration values of mean daily discharge,						
			1%	10%	25%	median	75%	90%	99%
01396280(35)	15	89	530	170	100	65	40	29	16
01396535(37)	18	142	1,070	290	170	98	57	40	20
01396588(37)	2.2	26	300	62	33	17	8.7	5.7	2.5
01396660(37)	2.2	19.8	155	38	21	12.8	7.0	4.1	2.2
01397000(35)	*46	275	1,510	520	300	180	133	105	74
01397400(35)	*46	300	1,760	580	330	190	140	110	76
01398000(56)	0.27	46	550	89	37	14.9	4.1	1.5	0.01
01398260(35)	0.80	10.2	120	24	13	6.5	3.3	2.1	0.9
01399120(35)	6.8	133	1,100	280	140	75	27	23	10
01399500(37)	5.3	58.6	260	120	74	45	27	16	5.1
01399700(35)	5.7	48.6	400	100	58	33	19	13	6.3
01399780(37)	12	201	1,500	400	210	117	62	39	18
01400500(35)	*95	821	5,700	1,730	870	460	280	220	176
01400540(35)	2.9	10.5	81	20	12	7.2	4.3	3.2	2.3
01400650(30)	4.0	75	710	200	92	49	27	18	10
01401000(59)	0.22	73.4	861	160	63	23	6.9	2.8	0.63
01401600(37)	0.13	62.7	850	140	54	19	5.1	2.0	0.40
01402000(31)	17	384	3,577	919	407	208	110	73	38
01403300(56)	*74	1,190	9,390	2,700	1,250	590	280	180	135
01405302(35)	4.5	61.6	390	130	74	42	27	18	7.0
01405340(35)	5.8	23.2	150	42	26	16	10	8.0	5.4

Table 4a. Water quality standards and frequency of samples not meeting standards at the 14 USGS sites designated nontrout waters from samples in the Raritan River basin from 1991-97

[Alkalinity, biochemical oxygen demand, total ammonia + organic nitrogen (TKN) and total organic carbon do not have a standard; concentrations are in milligrams per liter, coliform is in colonies /mLat 01403300 and most probable number at other sites, pH is in standard units, and temperature is in degrees celsius; <, less than the standard; >, greater than the standard; *, trout maintenance; ** trout production; L, criteria in lakes, and reservoirs and tributaries at point of entry to such water bodies; G, geometric average; Blue shaded cells = high flow; Bold text = greater than 50% not meeting standards]

Standards	Chloride	Dissolved Oxygen	Dissolved solids, total	Fecal coliform	Hardness	Nitrite plus Nitrate	pH	Phos-phorus, total	Sodium	Sulfate	Suspended solids, total	Un-ionized ammonia	Water temperature
Drinking water	250	--	500	--	>50 <250	11	--	--	50	250	--	--	--
New Jersey Surface Water	250	> 4	--	400	--	--	>6.5 <8.5	L0.05 0.1	--	250	40	0.05	27.8
	Percent of samples not meeting the standard from all sites in nontrout waters												
All samples from all sites	0	0.1	0	31	<25,>0	0	<8.9,>11	**L74** 42	1.5	0	7.6	0	0
By Season													
All growing season sam ples	0	0.3	0	46	<22,>0	0	<5.3, >13	**L80**, 50	0.9	0	9.0	0	0
All nongrow ing season samples	0	0	0	13	<30,>0	0	<14, >6.8	**L66**, 30	1.8	0	5.4	0	0
By flow condition													
All high flow samples,	0	0	0	27	<29,>0	0	<9.3,>6.3	**L61**, 30	1.4	0	7.5	0	0
All low flow samples,	0	0.3	0	32	<10,>0	0	<4, >15	**L69**, 36	1.2	0	0.9	0	0
Stream sam pling sites	Percent of samples not meeting the nontrout water standard by site												
01397400	0	0	0	23	< 3, >0	0	<3, >6	**L83, 60**	0	0	3	0	0
01398000	0	0	0	**69**	< 5, >0	0	<2, >29	**L51**, 13	5.6	0	8	0	0
01399120	0	0	0	46	0	0	<0, >14	L49, 11	0	0	0	0	0
01399700	0	0	0	46	< 3, >0	0	<3, >15	**L76**, 41	0	0	0	0	0

Standards	Chloride	Dissolved Oxygen	Dissolved solids, total	Fecal coliform	Hardness	Nitrite plus Nitrate	pH	Phos-phorus, total	Sodium	Sulfate	Suspended solids, total	Un-ionized ammonia	Water temperature
01399780	0	0	0	34	< 10,>0	0	<0, >21	**L72**, 19	0	0	3	0	0
01400500	0	0	0	17	< 3,>0	0	<3, >9	**L75**, 34	0	0	0	0	0
01400540	0	0	0	23	<**100,** >0	0	<26, >0	**L80**, 31	0	0	6	0	0
01400650	0	3	0	21	< **80**,>0	0	<10, >0	**L97, 70**	0	0	0	0	0
01401000	0	0	0	26	< **50,**>0	0	<3, >25	**L67**, 38	1.8	0	15	0	0
01401600	0	0	0	40	< 16,>0	0	<0, >8	**L89**, 47	0	0	3	0	0
01402000	0	0	0	29	< 13,>0	0	0	**L100, 97**	3.2	0	9	0	0
01403300	0	0	0	30	< 18,>0	0	<2,>4	**L100, 86**	0	0	15	0	0
01405302	0	0	0	8.6	< 9, >0	0	<49, >0	L40, 14	5.7	0	0	0	0
01405340	0	0	0	11	<**100,** >0	0	<37, >0	**L77**, 31	0	0	0	0	0

Table 4b. Water quality standards and frequency of samples not meeting nontrout water standards at the 14 USGS sites designated nontrout waters from samples in the Raritan River basin from 1991-97

[Alkalinity, biochemical oxygen demand, total ammonia + organic nitrogen (TKN) and total organic carbon do not have a standard; concentrations are in milligrams per liter, coliform is in colonies/mL at 01403300 and most probable number at other sites, pH is in standard units, and temperature is in degrees Celsius; <, less than the standard; >, greater than the standard; *, trout maintenance; ** trout production; L, criteria in lakes, and reservoirs and tributaries at point of entry to such water bodies; G, geometric average; Blue shaded cells = high flow; Bold text = greater than 50% not meeting standards]

Standards	Chloride	Dissolved Oxygen	Dissolved solids, total	Fecal coliform	Hardness	Nitrite plus Nitrate	pH	Phos-phorus, total	Sodium	Sulfate	Suspended solids, total	Un-ionized ammonia	Water temperature
Drinking water	250	--	500	--	>50 <250	11	--	--	50	250	--	--	--
New Jersey Surface Water	250	> 4	--	400	--	--	>6.5 <8.5	L0.05 0.1	--	250	40	0.05	27.8
	Percent of samples not meeting the standard from all sites in nontrout waters by flow condition												
All high flow samples,	0	0	0	27	<29,>0	0	<9.3,>6.3	**L61**, 30	6.8	0	7.5	0	0
All low flow samples,	0	0.3	0	32	<10,>0	0	<4, >15	**L69**, 36	3.3	0	0.9	0	0
Stream sampling sites	Percentage of samples not meeting standards for nontrout waters by site												
01397400	0	0	0	30	<4, >0	0	<4, >0	**L83, 52**	0	0	5	0	0
	0	0	0	8	0	0	<0, >8	**L83, 75**	0	0	0	0	0
01398000	0	0	0	**56**	<10,>0	0	<16,>0	L50, 20	13	0	14	0	0
	0	0	0	**79**	0	0	<46, >4	**L52**, 4	4	0	0	0	0
01399120	0	0	0	22	0	0	<0,>11	L39, 11	0	0	0	0	0
	0	0	0	**71**	0	0	<0, >18	**L59**, 12	0	0	0	0	0
01399700	0	0	0	42	<4.2, >0	0	<0, >17	**L71**, 29	0	0	0	0	0
	0	0	0	**54**	0	0	<9, >10	**L90, 70**	0	0	0	0	0
01399780	0	0	0	41	<17, 0	0	<0, >5	**L59**, 12	5.6	0	7	0	0
	0	0	0	28	<5, 0	0	<0, >8	**L84**, 26	5	0	0	0	0
01400500	0	0	0	24	<6, 0	0	<6, >6	**L56**, 19	0	0	0	0	0
	0	0	0	11	0	0	<0, >11	**L94, 50**	0	0	0	0	0
01400540	0	0	0	26	**<100**, >0	0	<30 ,>0	**L83**, 39	35	0	10	0	0

Standards	Chloride	Dissolved Oxygen	Dissolved solids, total	Fecal coliform	Hardness	Nitrite plus Nitrate	pH	Phos-phorus, total	Sodium	Sulfate	Suspended solids, total	Un-ionized ammonia	Water temperature
	0	0	0	17	**<100**, >0	0	0	**L75**, 17	58	0	0	0	0
01400650	0	0	0	13	**<93**, >0	0	<13, 0	**L93, 60**	0	0	0	0	0
	0	6	0	29	**<68**, >0	0	<0, >7	**L100, 80**	0	0	0	0	0
01401000	0	0	0	27	<41, >0	0	<3, >21	**L71**, 46	17	0	32	0	0
	0	0	0	26	0	0	<3, >28	**L63**, 30	0	0	0	0	0
01401600	0	0	0	33	<38, >0	0	<12, 0	**L80**, 20	6	0	0	0	0
	0	0	0	45	0	0	<0, >5	**L95, 67**	0	0	0	0	0
01402000	0	0	0	20	<27, 0	0	0	**L100, 93**	6.7	0	6.7	0	0
	0	0	0	38	0	0	0	**100**	0	0	12	0	0
01403300	0	0	0	14	<26, 0	0	<5.9, >3	**L100, 79**	8.6	0	24	0	0
	0	0	0	**67**	<4.8, 0	0	0	**100**	4.8	0	0	0	0
01405302	0	0	0	12	<19, 0	0	**<75**, >00	L50, 25	0	0	0	0	0
	0	0	0	5	0	0	<26, >0	L32, 5.3	10	0	0	0	0
01405340	0	0	0	5	<**100**, 0	0	**<57**,>0	**L71**, 33	5	0	0	0	0
	0	0	0	29	<**100**, 0	0	<7, >0	**L86**, 29	0	0	0	0	0

Table 4c: **Water quality standards and percent of samples not meeting standards at the 7 USGS sites located in designated trout waters sampled in the Raritan River basin from 1991-97**

[Alkalinity, biochemical oxygen demand, total ammonia + organic nitrogen (TKN) and total organic carbon do not have a standard; concentrations are in milligrams per liter, coliform is in colonies /mL at 01403300 and most probable number at other sites, pH is in standard units, and temperature is in degrees Celsius; <, less than the standard; >, greater than the standard; *, trout maintenance; ** trout production; L, criteria in lakes, and reservoirs and tributaries at point of entry to such water bodies; G, geometric mean; Blue shaded cells = high flow; Bold text = greater than 50% not meeting standards]

Standards	Chlor-ide	Dissolved Oxygen	Dissolved solids, total	Fecal coliform	Hardness	Nitrite plus Nitrate	pH	Phos-phorus, total	Sodium	Sulfate	Suspended solids, total	Un-ionized ammonia	Water temperature
Drinking water	250	--	500	--	>50 <250	11	--	--	50	250	--	--	--
New Jersey Surface Water	250	*> 5 **> 7	--	400	--	--	>6.5 <8.5	L0.05 0.1	--	250	*25	*0.02	*20
	Percent of samples not meeting the standards from all sites in trout waters												
All samples from all trout sites	0	0	0	27	10.8	0	11.6	L41.7 10.6	0.4	0	1.7	0.4	12.0
By Season													
All growing season samples	0	0	0	40.6	<4.3,>0	0	<0.7, >10.2	**L51**, 13	0	0	1.7	0.8	21.7
All nongrowing season samples	0	0	0	10.3	<19,>0	0	<4.5, >8.5	L31, 7.5	0.9	0	1.8	0	0
By flow condition													
All high flow samples,	0	0	0	26.5	<20,>0	0	<2.9,>2.2	L36, 6.9	0.7	0	4.2	0	6.5
All low flow samples,	0	0	0	28	<0,>0	0	<1.8, >18	L49, 15	0	0	0	1.0	19
Stream sampling sites	Percent of samples not meeting the trout water standard by site												
**01396280	0	0	0	37	0	0	<6, >21	L**64**, 18	2.9	0	3	0	11
*01396535	0	0	0	40	< 5, >0	0	<3, >14	L44, 2.9	0	0	6	0	19
**01396588	0	0	0	29	< 30,>0	0	0	L32, 12	0	0	0	0	8.1
*01396660	0	0	0	29	< 8, >0	0	<0,>3	L18, 0	0	0	0	0	16
*01397000	0	0	0	23	< 3, >0	0	<3, >27	L32, 13	0	0	3	3.4	26
**01398260	0	0	0	17	< 9, >0	0	<3, >3	**L58**, 18	0	0	0	0	3
**01399500	0	0	0	14	< 19,>0	0	<0, >3	L44, 11	0	0	3	0	3

Table 4d. Water quality standards and percent of samples not meeting standards at the 7 USGS sites located in designated trout waters sampled in the Raritan River basin from 1991-97

[Alkalinity, biochemical oxygen demand, total ammonia + organic nitrogen (TKN) and total organic carbon do not have a standard; concentrations are in milligrams per liter, coliform is in colonies /mLat 01403300 and most probable number at other sites, pH is in standard units, and temperature is in degrees celsius; <, less than the standard; >, greater than the standard; *, trout maintenance; ** trout production; L, criteria in lakes, and reservoirs and tributaries at point of entry to such water bodies; G, geometric mean; Blue shaded cells = high flow; Bold text = greater than 50% not meeting standards]

Standards	Chloride	Dissolved Oxygen	Dissolved solids, total	Fecal coliform	Hardness	Nitrite plus Nitrate	pH	Phos-phorus, total	Sodium	Sulfate	Suspended solids, total	Un-ionized ammonia	Water temperature
Drinking water	250	--	500	--	>50 <250	11	--	--	50	250	--	--	--
New Jersey Surface Water	250	> 4	--	400	--	--	>6.5 <8.5	L0.05 0.1	--	250	40	0.05	27.8
	Percent of samples not meeting the standard from all sites in nontrout waters												
All samples from all sites	0	0.1	0	31	<25,>0	0	<8.9,>11	**L74** 42	1.5	0	7.6	0	0
By Season													
All growing season samples	0	0.3	0	46	<22,>0	0	<5.3, >13	**L80**, 50	0.9	0	9.0	0	0
All nongrowing season samples	0	0	0	13	<30,>0	0	<14, >6.8	**L66**, 30	1.8	0	5.4	0	0
By flow condition													
All high flow samples,	0	0	0	27	<29,>0	0	<9.3,>6.3	**L61**, 30	1.4	0	7.5	0	0
All low flow samples,	0	0.3	0	32	<10,>0	0	<4, >15	**L69**, 36	1.2	0	0.9	0	0
Stream sampling sites	Percent of samples not meeting the nontrout water standard by site												
01397400	0	0	0	23	< 3, >0	0	<3, >6	**L83, 60**	0	0	3	0	0
01398000	0	0	0	**69**	< 5, >0	0	<2, >29	**L51**, 13	5.6	0	8	0	0
01399120	0	0	0	46	0	0	<0, >14	L49, 11	0	0	0	0	0
01399700	0	0	0	46	< 3, >0	0	<3, >15	**L76**, 41	0	0	0	0	0

Standards	Chloride	Dissolved Oxygen	Dissolved solids, total	Fecal coliform	Hardness	Nitrite plus Nitrate	pH	Phos-phorus, total	Sodium	Sulfate	Suspended solids, total	Un-ionized ammonia	Water temperature
01399780	0	0	0	34	< 10,>0	0	<0, >21	**L72**, 19	0	0	3	0	0
01400500	0	0	0	17	< 3,>0	0	<3, >9	**L75**, 34	0	0	0	0	0
01400540	0	0	0	23	<**100,** >0	0	<26, >0	**L80**, 31	0	0	6	0	0
01400650	0	3	0	21	< **80**,>0	0	<10, >0	**L97, 70**	0	0	0	0	0
01401000	0	0	0	26	< **50,**>0	0	<3, >25	**L67**, 38	1.8	0	15	0	0
01401600	0	0	0	40	< 16,>0	0	<0, >8	**L89**, 47	0	0	3	0	0
01402000	0	0	0	29	< 13,>0	0	0	**L100, 97**	3.2	0	9	0	0
01403300	0	0	0	30	< 18,>0	0	<2,>4	**L100, 86**	0	0	15	0	0
01405302	0	0	0	8.6	< 9, >0	0	<49, >0	L40, 14	5.7	0	0	0	0
01405340	0	0	0	11	<**100,** >0	0	<37, >0	**L77**, 31	0	0	0	0	0

Table 5. Geometric Mean of Fecal coliform counts per 100/mL

[Bold text = exceeds New Jersey surface water standard, geometric mean > 200 counts/ 100mL]

Station number	Number of samples			Geometric mean		
	Total	High Flow	Low Flow	All samples	High Flow	Low Flow
01396280	35	18	17	158.288	146.32	172.028
01396535	37	20	17	158.405	116.504	**227.377**
01396588	37	24	13	106.333	102.066	114.685
01396660	37	17	20	132.165	137.825	127.538
01397000	31	16	15	94.778	138.330	63.321
01397400	35	23	12	178.180	**207.249**	133.370
01398000	35	17	18	**668.344**	**261.8**	**1618.0**
01398260	35	24	11	89.688	90.521	87.896
01399120	35	18	17	**263.293**	153.356	**466.645**
01399500	37	19	18	52.391	50.293	54.701
01399700	35	24	11	**222.647**	190.060	**314.458**
01399780	38	18	20	145.020	**213.755**	102.280
01400500	35	17	18	149.058	182.582	123.068
01400540	35	23	12	76.279	80.790	68.325
01400650	30	15	15	93.721	75.891	115.740
01401000	35	16	18	120.850	97.7	144.2
01401600	37	16	21	**214.810**	97.374	**392.512**
01402000	31	15	16	**233.750**	149.926	**354.464**
01403300	30	16	14	**281.800**	**216.8**	**381.1**
01405302	35	16	19	48.339	31.620	69.108
01405340	35	21	14	48.561	36.892	73.337
Samples from all sites by season						
Season		Number of Samples		Geometric Mean		
Growing		425		**218.52**		
Nongrowing		305		82.70		
Samples from all sites by flow condition						
Flow Condition		Number of Samples		Geometric Mean		
High Flow		393		125.66		
Low Flow		337		171.40		

Table 6. Summary of trends for 17 constituents at 21 sites in the Raritan River basin, 1986-95

[+, positive regression slope indicates values increase with time; -, negative regression slope indicates concentration decreases with time; NSIG, no significant change; NT, not tested; trend test for total suspended solids was on data from 1991 through 1997; slopes indicate change in units per year]

Constituent	01396280	01396535	01396588	01396660	01397000	01397400	01398000	01398260	01399120	01399500	01399700	01399780	01400500	01400540	01400650	01401000	01401600	01402000	01403300	01405302	01405340
Alkalinity, CaCO3	NSIG	NSIG	+.83	+1.5	NT	NSIG	+1.4	+1.1	NSIG	NSIG	+1.2	+1.5	NSIG	NSIG	+2.0	+2.0	+1.5	NT	NSIG	NSIG	NSIG
Ammonia, total	-.01	-.007	-.007	-.007	-.008	-.014	-.005	-.064	-.005	-.009	-.005	-.005	-.007	-.005	-.12	-.003	-.006	-.024	NT	-.03	-.006
Ammonia, unionized	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Organic, nitrogen, total	-.027	-.030	-.034	-.058	-.035	NSIG	-.036	-.032	-.035	-.032	NSIG	-.037	-.023	-.027	-.029	NSIG	-.035	-.046	-.037	NSIG	-.022
BOD, 5-day	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	-.091	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	-.150	NSIG	NSIG	NSIG	NSIG	NSIG	+.039
Chloride	+.60	+.52	+.50	+.63	NT	+1.3	NSIG	+2.4	+1.3	+1.6	+.79	+1.1	+.69	+.33	NSIG	+1.2	+1.6	NT	NSIG	NSIG	+.67
Dissolved oxygen	NSIG	NSIG	NSIG	NSIG	-.18	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	+.25	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG
Dissolved solids, total	+2.5	+1.8	+1.8	+2.7	NT	NSIG	NSIG	+6.5	+2.8	+3.2	+3.5	+2.7	NSIG	+.98	+5.8	+4.1	+9.3	NT	NSIG	NSIG	+1.1
Fecal Coliform	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	-210	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG
Hardness	+1.5	NSIG	+.85	+1.5	NT	NSIG	NSIG	+2.9	+1.3	+1.8	+1.1	+1.3	NSIG	NSIG	NSIG	+1.8	+3.8	NT	NSIG	NSIG	NSIG
Nitrite + nitrate	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	+.25	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	+.20	NSIG	+.072	+.16	NSIG	NSIG	NSIG
Organic carbon, total	-.13	-.11	-.19	-.095	NT	NSIG	NSIG	-.17	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	-.22	NSIG	NSIG	NT	NT	NSIG	NSIG
pH	NSIG	NSIG	+.10	+.067	NSIG	NSIG	NSIG	+.083	+.10	+.046	NSIG	+.10	NSIG	NSIG	+.057	NSIG	NSIG	NSIG	NSIG	NSIG	+.079
Phosphorus, total	-.009	-.009	-.016	-.015	-.010	NSIG	NSIG	-.049	-.01	-.009	NSIG	NSIG	NSIG	NSIG	-.034	NSIG	-.008	NSIG	NSIG	-.012	NSIG
Sodium	NSIG	+.17	+.23	+.20	NT	NSIG	NSIG	+.64	+.43	NSIG	+.39	+.38	NSIG	+.099	+1.2	NSIG	+1.2	NT	NSIG	NSIG	+.32
Sulfate	-.15	-.24	NSIG	-.33	NT	NSIG	-3.0	NSIG	NSIG	-.26	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	+1.8	NT	NSIG	NSIG	-.29
Suspended solids, total	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG
Water temperature	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	-.25	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	-.41	NSIG	NSIG	NSIG	-.25

Table 7. Summary of trend slopes for 17 constituents at 21 sites in the Raritan River basin, 1986-95

[+, positive regression slope indicates values increase with time; -, negative regression slope indicates concentration decreases with time; NSIG, no significant change; NT, not tested; trend test for total suspended solids was on data from 1991 through 1997; slopes indicate change in units per year]

Constituent	01396280	01396535	01396588	01396660	01397000	01397400	01398000	01398260	01399120	01399500	01399700	01399780	01400500	01400540	01400650	01401000	01401600	01402000	01403300	01405302	01405340
Alkalinity, CaCO3	NSIG	NSIG	+	+	NT	NSIG	+	+	NSIG	NSIG	+	+	NSIG	NSIG	+	+	+	NT	NSIG	NSIG	NSIG
Ammonia, total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NT	-	-
Ammonia, unionized	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Organic, nitrogen, total	-	-	-	-	-	NSIG	-	-	-	-	NSIG	-	-		-	NSIG	-	-	-	NSIG	-
BOD, 5-day	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	-	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	-	NSIG	NSIG	NSIG	NSIG	NSIG	+
Chloride	+	+	+	+	NT	+	NSIG	+	+	+	+	+	+	+	NSIG	+	+	NT	NSIG	NSIG	+
Dissolved oxygen	NSIG	NSIG	NSIG	NSIG	-	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	+	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG
Dissolved solids, total	+	+	+	+	NT	NSIG	NSIG	+	+	+	+	+	NSIG	+	+	+	+	NT	NSIG	NSIG	+
Fecal Coliform	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	-	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG
Hardness	+	NSIG	+	+	NT	NSIG	NSIG	+	+	+	+	+	NSIG	NSIG	NSIG	+	+	NT	NSIG	NSIG	NSIG
Nitrite + nitrate	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	+	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	+	NSIG	+	+	NSIG	NSIG	NSIG
Organic carbon, total	-	-	-	-	NT	NSIG	NSIG	-	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	-	NSIG	NSIG	NT	NT	NSIG	NSIG
pH	NSIG	NSIG	+	+	NSIG	NSIG	NSIG	+	+	+	NSIG	+	NSIG	NSIG	+	NSIG	NSIG	NSIG	NSIG	NSIG	+
Phosphorus, total	-	-	-	-	-	NSIG	NSIG	-	-	-	NSIG	NSIG	NSIG	NSIG	-	NSIG	-	NSIG	NSIG	-	NSIG
Sodium	NSIG	+	+	+	NT	NSIG	NSIG	+	+	NSIG	+	+	NSIG	+	+	NSIG	+	NT	NSIG	NSIG	+
Sulfate	-	-	NSIG	-	NT	NSIG	-	NSIG	NSIG	-	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	+	NT	NSIG	NSIG	-
Suspended solids, total	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG
Water temperature	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	-	NSIG	NSIG	NSIG	NSIG	NSIG	NSIG	-	NSIG	NSIG	NSIG	-

Table 8. Tobit regression slopes of significant relations between constituent concentrations and streamflow and between physical measurements and streamflow for 18 constituents at 21 sites in the Raritan River basin

[+, positive regression slope indicates concentration increases with increasing flow; -, negative regression slope indicates concentration decreases with increasing flow; NSR, no significant relation at 0.05 level]

Constituent	01396280	01396535	01396588	01396660	01397000	01397400	01398000	01398260	01399120	01399500	01399700	01399780	01400500	01400540	01400650	01401000	01401600	01402000	01403300	01405302	01405340
Alkalinity, CaCO3	- 0.49	- 0.32	- 0.19	- 0.34	- 0.29	- 0.35	- 0.24	- 0.35	- 0.35	- 0.26	- 0.32	- 0.25	- 0.29	- 0.45	- 0.30	- 0.20	- 0.26	- 0.19	- 0.20	- 0.72	- 0.46
Ammonia, total	NSR	- 0.70	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	+ 0.56	NSR	NSR	- 0.28	NSR	NSR	NSR	NSR
Ammonia, unionized	NSR	- 1.44	- 0.82	- 0.81	- 1.09	- 1.03	- 0.71	NSR	NSR	NSR	- 0.87	- 0.86	- 0.86	NSR	NSR	NSR	NSR	- 0.51	- 0.60	- 1.03	- 0.77
Ammonia + organic, nitrogen	NSR	NSR	NSR	NSR	+ 0.27	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	+ 0.37	NSR	+ 0.18	- 0.19	NSR	+ 0.11	+ 0.40	NSR
BOD, 5-day	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	+ 0.10	NSR	NSR	NSR	NSR	NSR
Chloride	NSR	NSR	NSR	+ 0.24	+ 0.13	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	- 0.12	+ 0.07	NSR	- 0.18	- 0.31	- 0.16
Dissolved oxygen	NSR	NSR	+ 0.07	+ 0.08	NSR	NSR	+ 0.06	+ 0.14	+ 0.12	+ 0.14	+ 0.17	NSR	+ 0.16	NSR	+ 0.15	+ 0.06	+ 0.17	+ 0.14	NSR	NSR	NSR
Dissolved solids, total	- 0.21	- 0.11	- 0.07	- 0.09	- 0.07	- 0.15	- 0.12	- 0.16	- 0.10	-0.15	-0.14	-0.14	-0.09	NSR	-0.12	-0.13	-0.18	-0.07	-0.20	-0.32	-0.11
Fecal Coliform	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	- 0.94	NSR	NSR	NSR	NSR	NSR	- 0.62	NSR	NSR	NSR	NSR
Hardness	- 0.38	- 0.25	- 0.12	- 0.24	- 0.21	- 0.25	- 0.21	- 0.29	- 0.20	- 0.21	- 0.22	- 0.20	- 0.20	- 0.09	- 0.11	- 0.15	- 0.23	- 0.12	- 0.21	- 0.33	- 0.15
Nitrite + nitrate	- 0.33	- 0.11	NSR	NSR	NSR	- 0.19	+ 0.45	- 0.63	NSR	NSR	NSR	NSR	+ 0.25	NSR	- 0.34	NSR	- 0.14	- 0.12	- 0.24	- 0.65	NSR
Organic carbon, total	+ 0.27	NSR	NSR	+ 0.21	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	+ 0.16	NSR	NSR	+ 0.17	NSR	NSR
pH	- 0.05	- 0.03	- 0.01	- 0.02	- 0.05	NSR	- 0.02	- 0.02	- 0.04	- 0.02	- 0.02	- 0.03	- 0.04	- 0.05	- 0.01	- 0.02	NSR	NSR	NSR	- 0.09	- 0.06
Phosphorus, total	NSR	NSR	NSR	NSR	NSR	NSR	+ 0.23	NSR	NSR	- 0.42	NSR	NSR	- 0.27	+ 0.44	NSR	+ 0.20	- 0.30	- 0.22	- 0.21	NSR	NSR
Sodium	NSR	NSR	NSR	+ 0.20	+ 0.14	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	- 0.15	- 0.12	- 0.15	NSR	- 0.21	- 0.35	NSR
Sulfate	NSR	NSR	- 0.05	- 0.05	- 0.08	- 0.29	- 0.24	- 0.14	- 0.19	- 0.12	- 0.18	- 0.12	- 0.19	+ 0.22	- 0.06	- 0.15	- 0.27	- 0.15	- 0.31	- 0.23	NSR
Suspended solids, total	+ 0.73	NSR	NSR	NSR	+ 0.55	+ 0.65	+ 0.54	NSR	+ 0.49	NSR	NSR	+ 0.51	+ 0.45	+ 0.81	NSR	+ 0.64	NSR	+0.33	+ 0.90	+ 0.70	+ 0.54
Water temperature	NSR	- 0.48	- 0.42	- 0.41	NSR	NSR	- 0.34	- 0.62	- 0.84	- 0.67	- 0.69	- 0.48	- 0.78	NSR	- 0.37	- 0.20	- 0.44	- 0.28	NSR	NSR	NSR

Table 9. Statistical summary of alkalinity as concentration of CaCO3 measured in all samples collected between 1991 and 1997 at the 21 study sites in the Raritan River Basin

[concentrations are in milligrams per liter]

Station number	Number of samples	Minimum	10 percentile	25 percentile	Median	75 percentile	90 percentile	Maximum
01396280	35	33.0	38.0	47.0	56.0	75.0	92.0	100
01396535	36	35.0	42.0	53.0	60.5	81.5	93.0	101
01396588	36	20.0	23.0	28.0	33.0	39.5	42.0	45.0
01396660	36	24.0	33.0	44.5	50.0	63.0	73.0	84.0
01397000	31	29.0	37.0	48.0	55.0	61.0	67.0	80.0
01397400	35	18.0	39.0	53.0	60.0	67.0	76.0	87.0
01398000	53	22.0	34.0	43.0	55.0	67.0	87.0	98.0
01398260	35	24.0	27.0	33.0	45.0	50.0	52.0	58.0
01399120	35	22.0	35.0	42.0	53.0	62.0	70.0	73.0
01399500	35	23.0	26.0	33.0	45.0	51.0	57.0	63.0
01399700	34	26.0	39.0	46.0	60.0	68.0	78.0	84.0
01399780	35	28.0	33.0	44.0	59.0	66.0	71.0	82.0
01400500	35	27.0	38.0	48.0	54.0	64.0	67.0	73.0
01400540	34	2.70	4.50	5.30	8.65	11.0	13.0	15.0
01400650	30	7.00	9.70	15.0	18.5	27.0	35.5	49.0
01401000	56	14.0	26.0	39.0	47.0	57.0	66.0	78.0
01401600	36	17.0	25.0	34.5	45.5	55.5	66.0	78.0
01402000	31	15.0	23.0	30.0	35.0	41.0	49.0	52.0
01403300	53	20.0	30.0	36.0	45.0	51.0	58.0	63.0
01405302	33	<1.0	2.00	3.40	7.20	13.0	18.0	28.0
01405340	35	2.00	3.40	4.80	7.10	9.60	11.0	13.0

Table 10. Statistical summary of concentrations of total ammonia plus organic nitrogen (TKN) measured in all samples collected between 1991 and 1997 at the 21 study sites in the Raritan River Basin

[concentrations are in milligrams per liter; <, less than the laboratory detection limit]

Station number	Number of samples	Minimum	10 percentile	25 percentile	Median	75 percentile	90 percentile	Maximum
01396280	35	0.03	0.15	0.190	0.290	0.460	0.78	1.00
01396535	34	0.04	0.10	0.150	0.200	0.400	0.63	1.30
01396588	35	<0.03	<0.03	0.100	0.170	0.280	0.50	0.90
01396660	36	<0.03	0.05	0.090	0.145	0.225	0.48	0.92
01397000	31	0.12	0.20	0.200	0.300	0.330	0.61	1.80
01397400	35	0.11	0.24	0.300	0.390	0.710	0.90	1.10
01398000	55	<0.03	0.12	0.190	0.300	0.510	1.00	2.10
01398260	35	0.06	0.14	0.170	0.300	0.400	0.64	1.40
01399120	35	<0.03	0.11	0.180	0.270	0.350	0.56	0.67
01399500	36	0.14	0.20	0.265	0.300	0.435	0.55	0.77
01399700	35	0.05	0.15	0.200	0.300	0.340	0.51	1.00
01399780	35	0.11	0.19	0.250	0.300	0.330	0.48	1.10
01400500	35	0.07	0.20	0.240	0.380	0.500	0.64	0.76
01400540	35	0.15	0.18	0.200	0.300	0.400	0.65	0.73
01400650	28	0.20	0.27	0.400	0.530	1.100	1.40	3.10
01401000	58	0.08	0.20	0.300	0.400	0.600	1.10	3.00
01401600	36	<0.03	0.19	0.255	0.390	0.560	0.67	0.83
01402000	31	0.26	0.30	0.440	0.540	0.700	0.77	1.60
01403300	53	0.30	0.30	0.400	0.500	0.700	0.90	1.50
01405302	31	<0.03	0.18	0.260	0.400	0.600	0.86	2.10
01405340	35	<0.03	0.16	0.200	0.300	0.360	0.46	0.60

Table 11. Statistical summary of concentrations of 5-day biochemical oxygen demand measured in all samples collected between 1991 and 1997 at the 21 study sites in the Raritan River Basin

[concentrations are in milligrams per liter; <, less than the laboratory detection limit]

Station number	Number of samples	Minimum	10 percentile	25 percentile	Median	75 percentile	90 percentile	Maximum
01396280	35	<1.0	<1.0	<1.00	1.30	1.7	2.7	4.4
01396535	35	<1.0	<1.0	<1.00	1.40	1.7	2.2	3.2
01396588	35	<1.0	<1.0	<1.00	1.20	1.8	2.1	3.3
01396660	34	<1.0	<1.0	<1.00	1.00	1.7	2.1	2.6
01397000	31	<1.0	<1.0	<1.00	1.50	2.0	2.4	3.9
01397400	35	<1.0	<1.0	1.1	1.70	2.4	3.9	6.0
01398000	35	<1.0	<1.0	<1.00	1.60	2.3	4.1	5.3
01398260	34	<1.0	<1.0	<1.00	1.00	1.8	2.4	2.8
01399120	35	<1.0	<1.0	<1.00	1.50	1.8	2.2	5.5
01399500	34	<1.0	<1.0	<1.00	1.15	1.6	2.1	2.4
01399700	35	<1.0	<1.0	<1.00	1.30	1.8	2.4	4.9
01399780	35	<1.0	<1.0	<1.00	1.50	1.9	2.3	4.2
01400500	33	<1.0	<1.0	<1.00	1.40	1.7	2.2	3.6
01400540	35	<1.0	<1.0	<1.00	<1.00	1.5	1.9	3.2
01400650	29	<1.0	<1.0	<1.00	1.60	2.2	3.0	7.2
01401000	34	<1.0	<1.0	1.2	1.70	2.1	2.8	4.3
01401600	34	<1.0	<1.0	<1.00	1.35	2.0	2.4	2.8
01402000	31	<1.0	<1.0	<1.00	1.80	2.4	2.8	5.0
01403300	13	<1.0	<1.0	<1.00	1.20	1.8	2.8	2.9
01405302	33	<1.0	<1.0	<1.00	<1.00	1.4	1.6	1.9
01405340	34	<1.0	<1.0	<1.00	<1.00	1.4	2.1	2.8

Table 12. Statistical summary of concentrations of chloride measured in all samples collected between 1991 and 1997 at the 21 study sites in the Raritan River Basin

[concentrations are in milligrams per liter; <, less than the laboratory detection limit]

Station number	Number of samples	Minimum	10 percentile	25 percentile	Median	75 percentile	90 percentile	Maximum
01396280	35	16.0	22	25.0	27.0	29.0	37.0	150
01396535	36	13.0	18	21.0	22.5	24.0	37.0	55
01396588	36	12.0	14	16.5	17.5	19.0	21.0	24
01396660	36	9.0	12	14.0	15.0	19.0	36.0	68
01397000	31	13.0	17	19.0	22.0	24.0	29.0	38
01397400	35	15.0	20	25.0	29.0	34.0	43.0	58
01398000	54	12.0	15	18.0	22.0	34.0	81.0	190
01398260	35	25.0	29	33.0	38.0	44.0	51.0	74
01399120	35	16.0	23	26.0	31.0	37.0	48.0	62
01399500	36	21.0	31	32.5	36.0	40.5	45.0	50
01399700	35	12.0	13	16.0	18.0	21.0	31.0	34
01399780	35	15.0	20	24.0	27.0	30.0	34.0	50
01400500	35	17.0	19	22.0	24.0	29.0	35.0	71
01400540	35	11.0	12	13.0	14.0	16.0	17.0	31
01400650	30	11.0	19	22.0	24.0	27.0	32.5	78
01401000	56	7.5	16	19.5	24.0	30.0	41.0	110
01401600	36	14.0	16	20.0	24.0	32.5	38.0	76
01402000	31	15.0	17	24.0	27.0	33.0	41.0	110
01403300	53	8.6	16	20.0	28.0	35.0	39.0	58
01405302	34	11.0	24	26.0	31.5	38.0	42.0	130
01405340	35	11.0	14	16.0	18.0	21.0	25.0	36

Table 13. Statistical summary of concentrations of dissolved oxygen measured in all samples collected between 1991 and 1997 at the 21 study sites in the Raritan River Basin

[concentrations are in milligrams per liter; <, less than the laboratory detection limit]

Station number	Number of samples	Minimum	10 percentile	25 percentile	Median	75 percentile	90 percentile	Maximum
01396280	35	8.10	9.20	9.60	11.3	13.6	14.8	15.4
01396535	36	8.50	8.80	9.65	10.8	13.1	14.5	15.6
01396588	36	8.80	8.90	9.75	10.9	13.0	14.5	15.6
01396660	36	7.70	8.60	9.60	10.8	13.1	14.3	15.6
01397000	31	8.20	8.60	9.60	10.3	13.4	14.5	15.8
01397400	35	7.80	8.40	9.50	10.5	13.0	13.7	16.4
01398000	50	5.40	7.55	10.4	12.1	13.8	15.2	17.5
01398260	34	8.40	8.80	9.20	11.3	12.8	14.1	15.0
01399120	35	8.20	9.20	10.1	11.0	13.5	14.0	14.9
01399500	36	7.80	8.50	9.15	10.9	12.9	14.2	16.0
01399700	35	6.50	8.40	9.40	11.6	13.0	14.1	14.6
01399780	37	7.70	8.90	10.1	11.7	13.8	14.3	15.1
01400500	35	6.60	8.30	8.70	10.3	13.0	14.8	15.5
01400540	35	7.50	7.80	8.50	10.0	11.8	13.5	14.1
01400650	30	2.90	5.65	6.60	9.50	11.1	12.4	13.2
01401000	53	6.00	7.50	9.30	11.0	13.4	15.2	18.2
01401600	34	5.50	6.50	8.80	10.5	13.1	14.3	15.5
01402000	31	4.40	5.50	6.40	8.90	12.2	13.0	13.9
01403300	52	6.10	6.70	8.05	9.80	12.0	13.6	16.0
01405302	35	6.00	7.20	7.90	9.30	11.5	12.4	13.5
01405340	35	7.80	8.10	8.90	10.1	11.9	12.8	15.1

Table 14. Statistical summary of concentrations of total dissolved solids measured in all samples collected between 1991 and 1997 at the 21 study sites in the Raritan River Basin

[concentrations are in milligrams per liter; <, less than the laboratory detection limit]

Station number	Number of samples	Minimum	10 percentile	25 percentile	Median	75 percentile	90 percentile	Maximum
01396280	35	93	108.0	121.0	138.0	155.0	168.0	334
01396535	36	85	99.0	124.5	136.0	147.5	157.0	187
01396588	36	89	94.0	99.0	105.5	112.5	116.0	123
01396660	36	90	102.0	110.0	119.0	129.0	136.0	202
01397000	31	87	104.0	109.0	125.0	130.0	137.0	150
01397400	35	89	120.0	129.0	151.0	172.0	188.0	222
01398000	53	91	124.0	139.0	157.0	193.0	256.0	448
01398260	35	96	117.0	133.0	147.0	168.0	184.0	204
01399120	35	104	112.0	136.0	144.0	154.0	169.0	173
01399500	35	92	101.0	122.0	136.0	149.0	157.0	171
01399700	34	95	111.0	120.0	130.0	144.0	161.0	187
01399780	35	88	112.0	118.0	132.0	145.0	157.0	210
01400500	35	88	114.0	124.0	142.0	148.0	153.0	205
01400540	33	57	59.0	65.0	69.0	71.0	74.0	101
01400650	30	60	94.5	105.0	120.0	140.0	163.5	200
01401000	55	56	92.0	114.0	126.0	145.0	174.0	263
01401600	36	88	95.0	123.0	143.5	181.5	216.0	259
01402000	31	86	107.0	120.0	149.0	157.0	170.0	274
01403300	53	65	88.0	119.0	144.0	171.0	195.0	203
01405302	31	74	121.0	139.0	159.0	208.0	225.0	315
01405340	34	61	69.0	72.0	79.0	86.0	89.0	114

Table 15. Statistical summary of fecal coliform counts measured in all samples collected between 1991 and 1997 at the 21 study sites in the Raritan River Basin

[<, less than the laboratory detection limit of 20; measured as colonies per milliliter at 01403300 and as most probable number at the other sites]

Station number	Number of samples	Minimum	10 percentile	25 percentile	Median	75 percentile	90 percentile	Maximum
01396280	35	<20	<20	20.0	230	700	1700	3500
01396535	35	<20	20.0	50.0	220	790	1700	9200
01396588	35	<20	20.0	50.0	130	460	1100	3500
01396660	35	<20	<20	50.0	170	790	1700	5400
01397000	30	<20	10.0	40.0	100	340	790	2400
01397400	35	<20	20.0	70.0	170	330	1300	9200
01398000	35	20.0	50.0	220	790	2200	5400	>24000
01398260	35	<20	<20	20.0	80.0	330	490	5400
01399120	35	<20	50.0	130	310	790	1300	3500
01399500	35	<20	<20	20.0	40.0	140	490	>24000
01399700	35	<20	<20	50.0	220	1100	1700	9200
01399780	35	<20	20.0	80.0	170	700	2400	>24000
01400500	35	<20	20.0	80.0	170	270	790	9200
01400540	35	<20	<20	<20	50.0	330	1300	>24000
01400650	29	<20	<20	40.0	110	330	490	>24000
01401000	34	<20	<20	20.0	130	490	1700	>24000
01401600	35	<20	20.0	80.0	230	790	3500	>24000
01402000	31	20.0	20.0	70.0	230	790	1800	>24000
01403300	10	<20	13.5	78.0	280	1100	2250	>24000
01405302	35	<20	<20	<20	20.0	170	330	5400
01405340	35	<20	<20	<20	20.0	130	430	16000

Table 16. Statistical summary of concentrations of hardness measured in all samples collected between 1991 and 1997 at the 21 study sites in the Raritan River Basin

[concentrations are in milligrams per liter]

Station number	Number of samples	Minimum	10 percentile	25 percentile	Median	75 percentile	90 percentile	Maximum
01396280	35	51.0	58.0	69.0	85.0	100	110	120
01396535	36	48.0	56.0	72.5	84.0	100	110	130
01396588	36	40.0	47.0	50.0	54.0	61.5	65.0	68.0
01396660	36	39.0	53.0	64.0	71.0	84.0	93.0	100
01397000	31	48.0	55.0	67.0	76.0	82.0	89.0	100
01397400	35	46.0	58.0	75.0	85.0	92.0	100	120
01398000	54	45.0	65.0	76.0	90.0	120	170	240
01398260	35	44.0	56.0	61.0	73.0	86.0	95.0	110
01399120	35	55.0	64.0	71.0	79.0	88.0	100	100
01399500	36	43.0	48.0	57.0	70.0	78.0	84.0	91.0
01399700	35	50.0	63.0	68.0	77.0	91.0	100	110
01399780	36	43.0	56.0	65.0	80.5	85.0	98.0	110
01400500	35	42.0	64.0	75.0	81.0	88.0	93.0	100
01400540	34	23.0	27.0	29.0	30.0	31.0	33.0	39.0
01400650	30	26.0	38.0	44.0	48.0	49.0	52.0	55.0
01401000	56	28.0	44.0	59.0	68.5	79.0	92.0	110
01401600	36	41.0	46.0	63.5	78.5	95.0	120	140
01402000	31	36.0	47.0	58.0	66.0	79.0	84.0	94.0
01403300	53	33.0	47.0	63.0	75.0	87.0	97.0	110
01405302	35	31.0	52.0	58.0	63.0	84.0	90.0	100
01405340	34	25.0	28.0	32.0	34.0	35.0	38.0	40.0

Table 17. Statistical summary of concentrations of nitrite plus nitrate measured in all samples collected between 1991 and 1997 at the 21 study sites in the Raritan River Basin

[concentrations are in milligrams per liter; <, less than the laboratory detection limit]

Station number	Number of samples	Minimum	10 percentile	25 percentile	Median	75 percentile	90 percentile	Maximum
01396280	35	0.910	1.000	1.3200	1.660	1.960	2.06	2.10
01396535	36	0.760	1.100	1.2500	1.385	1.725	1.80	2.00
01396588	36	0.390	0.800	0.9550	1.085	1.415	1.70	2.00
01396660	36	0.540	0.660	0.8250	0.915	1.090	1.26	1.50
01397000	31	0.363	0.550	0.9000	1.200	1.400	1.49	1.73
01397400	35	0.753	0.990	1.2400	1.530	1.800	2.00	2.90
01398000	54	<0.020	0.430	0.8900	1.600	2.180	2.60	4.40
01398260	35	0.630	0.960	1.3000	1.900	2.560	3.82	4.90
01399120	35	0.490	0.720	0.7400	0.930	1.070	1.17	1.51
01399500	36	0.330	0.449	0.5325	0.735	0.990	1.80	3.90
01399700	35	0.727	0.880	1.0000	1.200	1.460	1.63	5.49
01399780	36	0.220	0.620	0.7350	0.885	1.085	1.15	1.70
01400500	35	0.340	0.710	0.9300	1.200	1.500	1.76	2.30
01400540	35	0.720	0.870	1.1100	1.300	1.650	1.90	2.27
01400650	30	0.840	2.260	2.7300	3.700	4.200	5.60	6.30
01401000	57	0.090	0.222	0.4100	0.610	0.950	1.30	1.57
01401600	36	0.840	1.060	1.1900	1.530	2.130	2.30	4.14
01402000	31	1.190	1.490	1.7900	2.270	2.880	3.67	6.40
01403300	53	0.880	1.110	1.4000	1.800	2.300	2.80	3.27
01405302	34	0.900	2.730	3.1100	3.830	6.450	8.60	10.10
01405340	34	0.430	0.580	0.6600	0.923	1.080	1.29	1.65

Table 18. Statistical summary of concentrations of total organic carbon measured in all samples collected between 1991 and 1997 at the 21 study sites in the Raritan River Basin

[concentrations are in milligrams per liter; <, less than the laboratory detection limit]

Station number	Number of samples	Minimum	10 percentile	25 percentile	Median	75 percentile	90 percentile	Maximum
01396280	33	1.5	2.00	2.3	2.90	3.40	5.60	8.8
01396535	35	1.5	1.80	2.0	2.80	3.40	5.40	8.9
01396588	33	1.3	1.40	1.6	1.90	2.60	3.40	5.3
01396660	36	1.2	1.40	1.5	1.90	2.80	3.60	4.2
01397000	29	0.8	2.20	2.4	2.90	3.70	4.90	8.6
01397400	33	2.2	2.50	2.9	3.40	4.10	4.80	7.9
01398000	54	1.5	1.80	2.3	3.15	4.30	6.10	8.2
01398260	35	1.6	2.00	2.4	2.80	3.00	5.80	13.4
01399120	33	1.7	2.00	2.4	3.00	3.50	5.20	6.6
01399500	33	2.6	3.00	3.5	4.10	5.20	7.80	9.7
01399700	31	1.6	1.90	2.2	2.70	3.80	4.30	5.4
01399780	33	2.0	2.60	2.9	3.40	4.00	5.30	10.5
01400500	33	1.6	2.50	2.9	3.30	3.70	4.80	7.2
01400540	33	1.3	1.50	2.1	2.70	3.50	5.40	7.5
01400650	27	2.5	2.60	3.1	4.00	4.40	5.60	7.9
01401000	52	1.7	3.00	3.4	4.30	5.55	8.70	16.8
01401600	34	1.5	2.30	2.6	3.70	4.40	5.40	7.5
01402000	27	2.4	2.90	3.9	4.90	6.20	6.60	7.3
01403300	30	2.2	2.65	3.3	4.30	5.80	7.65	8.4
01405302	34	2.2	2.30	2.6	2.95	3.30	4.80	6.3
01405340	34	1.4	1.80	2.4	3.00	4.10	4.90	6.7

Table 19. Statistical summary pH measured in all samples collected between 1991 and 1997 at the 21 study sites in the Raritan River Basin

[measurements are in standard units]

Station number	Number of samples	Minimum	10 percentile	25 percentile	Median	75 percentile	90 percentile	Maximum
01396280	33	7.30	7.60	7.80	8.10	8.40	8.60	8.70
01396535	36	7.30	7.80	7.95	8.20	8.30	8.50	8.70
01396588	37	7.10	7.20	7.50	7.70	7.90	8.00	8.10
01396660	37	7.10	7.40	7.70	7.90	8.00	8.20	8.50
01397000	30	7.30	7.55	7.70	8.00	8.50	8.55	8.90
01397400	34	7.10	7.50	7.70	7.90	8.10	8.30	8.60
01398000	55	7.00	7.50	7.60	8.00	8.50	8.90	9.40
01398260	34	7.30	7.60	7.70	7.80	7.90	8.00	8.50
01399120	35	7.10	7.40	7.80	8.10	8.40	8.50	8.90
01399500	36	7.30	7.50	7.60	7.85	8.05	8.20	8.70
01399700	34	7.30	7.50	7.70	8.10	8.30	8.50	9.10
01399780	38	7.00	7.30	7.70	8.00	8.30	8.80	8.90
01400500	34	7.20	7.40	7.60	7.80	8.10	8.40	8.70
01400540	33	6.00	6.40	6.60	6.80	7.00	7.60	8.10
01400650	29	6.50	6.80	6.80	7.00	7.10	7.30	7.40
01401000	57	6.70	7.20	7.50	7.80	8.40	8.90	9.50
01401600	37	7.20	7.40	7.50	7.70	8.00	8.40	9.00
01402000	31	6.80	7.00	7.10	7.30	7.50	7.60	8.00
01403300	55	7.10	7.20	7.40	7.60	7.70	7.90	8.90
01405302	35	4.90	5.70	6.00	6.60	7.00	7.40	7.80
01405340	35	5.80	6.20	6.40	6.90	7.10	7.30	7.90

Table 20. Statistical summary of concentrations total phosphorus measured in all samples collected between 1991 and 1997 at the 21 study sites in the Raritan River Basin

[concentrations are in milligrams per liter; <, less than the laboratory detection limit]

Station number	Number of samples	Minimum	10 percentile	25 percentile	Median	75 percentile	90 percentile	Maximum
01396280	33	0.03	0.039	0.040	0.050	0.090	0.1300	0.210
01396535	34	<0.01	0.010	0.030	0.040	0.060	0.0800	0.100
01396588	34	<0.01	<0.010	0.016	0.030	0.050	0.1100	0.250
01396660	34	<0.01	<0.010	0.000	0.011	0.030	0.0500	0.070
01397000	31	<0.01	<0.010	0.011	0.030	0.060	0.1100	0.300
01397400	35	0.02	0.040	0.070	0.135	0.210	0.3100	0.570
01398000	55	<0.01	0.010	0.030	0.050	0.070	0.1000	0.680
01398260	33	<0.01	<0.010	0.030	0.050	0.090	0.2100	0.280
01399120	35	<0.01	<0.010	0.020	0.040	0.070	0.1000	0.170
01399500	36	<0.01	<0.010	0.020	0.040	0.075	0.1200	0.240
01399700	34	<0.01	0.030	0.060	0.075	0.130	0.2800	0.310
01399780	36	<0.01	0.030	0.040	0.060	0.080	0.1400	0.392
01400500	32	0.02	0.030	0.045	0.070	0.100	0.1100	0.180
01400540	35	<0.01	0.040	0.050	0.070	0.110	0.2190	0.460
01400650	30	0.03	0.050	0.080	0.125	0.160	0.3100	0.730
01401000	58	<0.01	0.030	0.040	0.065	0.120	0.2370	0.600
01401600	36	<0.01	0.040	0.075	0.092	0.170	0.2500	0.321
01402000	30	0.08	0.135	0.180	0.228	0.370	0.4535	0.750
01403300	52	0.06	0.070	0.129	0.180	0.300	0.4490	0.640
01405302	35	<0.01	<0.010	0.010	0.040	0.070	0.1000	0.230
01405340	35	<0.01	0.030	0.050	0.070	0.100	0.1200	0.210

Table 21. Statistical summary of concentrations of sodium measured in all samples collected between 1991 and 1997 at the 21 study sites in the Raritan River Basin

[concentrations are in milligrams per liter; <, less than the laboratory detection limit]

Station number	Number of samples	Minimum	10 percentile	25 percentile	Median	75 percentile	90 percentile	Maximum
01396280	35	8.00	12.0	13.0	14.0	15.0	19.0	81.0
01396535	36	6.50	10.0	11.0	12.0	13.0	18.0	30.0
01396588	36	7.70	8.80	9.75	11.0	11.0	11.0	13.0
01396660	36	6.70	7.60	8.40	9.20	11.0	18.0	40.0
01397000	31	6.80	9.50	11.0	12.0	13.0	16.0	20.0
01397400	35	8.30	11.0	15.0	18.0	23.0	28.0	33.0
01398000	54	9.80	12.0	13.0	15.5	20.0	31.0	67.0
01398260	35	12.0	14.0	16.0	17.0	21.0	26.0	37.0
01399120	35	9.90	12.0	13.0	16.0	18.0	25.0	33.0
01399500	36	11.0	15.0	17.0	19.0	21.0	23.0	26.0
01399700	35	8.00	9.50	10.0	12.0	14.0	17.0	29.0
01399780	36	11.0	12.0	13.5	15.0	17.0	19.0	34.0
01400500	35	11.0	12.0	13.0	15.0	16.0	20.0	37.0
01400540	34	5.10	5.50	6.10	6.65	7.80	8.70	15.0
01400650	30	7.30	13.5	15.0	17.5	26.0	32.0	49.0
01401000	56	5.40	12.0	13.0	16.0	20.0	25.0	55.0
01401600	36	9.80	11.0	14.0	16.0	21.0	27.0	40.0
01402000	31	9.90	13.0	16.0	20.0	23.0	26.0	59.0
01403300	53	6.00	12.0	14.0	17.0	22.0	26.0	33.0
01405302	35	7.60	15.0	16.0	20.0	26.0	31.0	68.0
01405340	35	6.10	6.90	7.40	8.60	11.0	12.0	17.0

Table 22. Statistical summary of concentrations of sulfate measured in all samples collected between 1991 and 1997 at the 21 study sites in the Raritan River Basin

[concentrations are in milligrams per liter]

Station number	Number of samples	Minimum	10 percen-tile	25 percen-tile	Median	75 percen-tile	90 percen-tile	Maximum
01396280	35	9.50	10.0	11.0	11.0	12.0	13.0	15.0
01396535	36	9.30	11.0	12.0	12.0	13.0	14.0	16.0
01396588	36	13.0	14.0	16.0	17.0	18.5	21.0	22.0
01396660	36	12.0	13.0	14.0	15.0	17.0	18.0	20.0
01397000	31	11.0	12.0	13.0	13.0	15.0	16.0	18.0
01397400	35	12.0	15.0	18.0	20.0	24.0	33.0	45.0
01398000	54	16.0	19.0	24.0	29.0	44.0	61.0	96.0
01398260	35	11.0	11.0	12.0	14.0	15.0	16.0	20.0
01399120	35	12.0	14.0	15.0	16.0	19.0	22.0	24.0
01399500	36	7.60	9.50	11.0	11.5	13.0	17.0	27.0
01399700	35	13.0	15.0	16.0	18.0	20.0	26.0	35.0
01399780	35	11.0	13.0	14.0	15.0	18.0	20.0	30.0
01400500	35	12.0	15.0	18.0	20.0	22.0	25.0	30.0
01400540	35	8.70	11.0	12.0	15.0	17.0	19.0	22.0
01400650	30	14.0	19.0	20.0	23.0	25.0	28.0	29.0
01401000	56	8.60	14.0	17.5	21.0	24.0	28.0	34.0
01401600	36	15.0	20.0	23.0	27.0	37.5	47.0	88.0
01402000	31	13.0	19.0	22.0	26.0	32.0	36.0	39.0
01403300	53	9.80	14.0	20.0	24.0	33.0	39.0	48.0
01405302	35	25.0	36.0	43.0	49.0	53.0	58.0	70.0
01405340	35	14.0	15.0	17.0	19.0	22.0	25.0	29.0

Table 23. Statistical summary of stream flows during samples collected between 1991 and 1997 at the 21 study sites in the Raritan River Basin

[Flows are in cubic feet per second

Station number	Number of samples	Minimum	10 percentile	25 percentile	Median	75 percentile	90 percentile	Maximum
01396280	35	25	39	42	66	100	140	300
01396535	37	34	40	60	110	180	300	600
01396588	37	3	4.2	9	17	32	68	325
01396660	37	2.8	4.6	7.5	11	23	55	203
01397000	35	76	85	139	187	330	435	1430
01397400	35	93	115	160	240	295	920	1490
01398000	56	0.5	2.8	6.35	15.5	39.5	152	1500
01398260	35	2.1	4	5.9	9	15	22	30
01399120	35	10	32	40	75	110	140	220
01399500	37	8.9	13	27	47	84	163	280
01399700	35	11	16	20	42	67	110	280
01399780	37	23	34	50	112	195	610	2600
01400500	35	207	239	278	459	755	1030	3870
01400540	35	3.7	5.3	6.4	9.8	13	20	34
01400650	30	8	12.5	18	48.5	82	150	200
01401000	59	1.3	4.4	11	22	70	754	5810
01401600	37	1.2	4.2	6.4	15	48	90	391
01402000	31	46	76	110	204	318	465	2770
01403300	56	140	170	350	840	2140	4370	14300
01405302	35	17	20	30	40	66	89	600
01405340	35	6.5	8	10	17	25	40	66

Table 24. Statistical summary of concentrations of total suspended solids measured in all samples collected between 1991 and 1997 at the 21 study sites in the Raritan River Basin

[concentrations are in milligrams per liter; <, less than the laboratory detection limit]

Station number	Number of samples	Minimum	10 percen-tile	25 percen-tile	Median	75 percen-tile	90 percen-tile	Maximum
01396280	30	<1.0	1.0	2.0	3.0	8.0	12	85
01396535	32	<1.0	1.0	2.5	5.0	8.0	10	36
01396588	32	<1.0	<1.0	1.0	3.0	5.0	7	17
01396660	32	<1.0	<1.0	1.0	2.0	4.0	8	19
01397000	31	<1.0	2.0	3.0	5.0	8.0	10	43
01397400	31	1	2.0	3.0	5.0	9.0	13	74
01398000	50	<1.0	1.0	2.0	3.0	7.0	21	501
01398260	30	<1.0	<1.0	1.0	2.0	4.0	6	9
01399120	31	<1.0	1.0	1.0	3.0	6.0	9	16
01399500	32	<1.0	1.0	1.0	3.0	5.5	8	106
01399700	31	<1.0	2.0	2.0	5.0	8.0	9	34
01399780	32	<1.0	2.0	3.0	4.0	8.0	12	103
01400500	31	1	2.0	3.0	6.0	12.0	13	24
01400540	31	3	4.0	5.0	8.0	13.0	19	132
01400650	26	1	5.0	6.0	11.5	17.0	26	34
01401000	53	<1.0	1	2	4	13	98	510
01401600	32	<1.0	1	2	4	8	17	53
01402000	31	2	4	6	10	19	25	68
01403300	53	<1.0	2	4	9	30	114	427
01405302	31	<1.0	1	2	4	9	12	16
01405340	31	2	3	5	7	12	17	29

Table 25. Statistical summary of temperature measured in all samples collected between 1991 and 1997 at the 21 study sites in the Raritan River Basin

[temperature is in degrees Celsius]

Station number	Number of samples	Minimum	10 percen-tile	25 percen-tile	Median	75 percen-tile	90 percen-tile	Maximum
01396280	35	0.0	0.50	2.50	10.0	15.5	20.0	21.0
01396535	37	0.0	1.00	4.50	10.5	17.2	21.0	24.0
01396588	37	0.0	1.10	4.00	11.0	17.0	19.5	23.5
01396660	37	0.0	1.20	4.00	11.5	17.5	20.0	20.5
01397000	31	0.0	2.00	5.00	11.5	20.0	23.0	26.5
01397400	35	0.0	1.50	5.00	14.0	20.0	23.0	26.5
01398000	54	0.0	3.00	4.90	12.0	20.2	24.2	26.0
01398260	35	0.0	1.50	3.50	10.6	17.0	18.0	20.0
01399120	35	0.0	1.50	4.00	10.5	20.0	22.0	24.5
01399500	37	0.0	1.00	2.50	9.50	17.0	19.0	23.5
01399700	35	0.0	2.00	3.50	10.0	19.5	22.0	25.0
01399780	38	0.0	0.50	3.00	9.50	18.0	21.5	25.5
01400500	35	0.0	1.50	5.50	11.5	24.0	25.0	26.0
01400540	35	0.0	1.50	5.50	11.0	17.5	20.0	23.0
01400650	30	1.00	2.75	7.00	13.8	21.5	23.8	26.0
01401000	55	0.0	2.00	4.50	13.5	20.0	23.1	26.0
01401600	37	0.0	0.50	4.00	10.5	19.0	21.5	24.5
01402000	31	0.0	2.00	7.00	12.5	21.5	23.0	25.0
01403300	55	1.50	2.20	6.00	14.4	22.5	24.5	26.5
01405302	35	0.0	1.50	5.80	11.5	17.9	22.0	24.5
01405340	35	0.0	0.50	5.00	11.0	16.5	20.5	24.0

Table 26. Statistical summary of concentrations of un-ionized ammonia measured in all samples collected between 1991 and 1997 at the 21 study sites in the Raritan River basin

[concentrations are in milligrams per liter; <, less than values of <0.001 are substituted for un-ionized ammonia when total ammonia is censored at <0.03]

Station number	Number of samples	Minimum	10 percentile	25 percentile	Median	75 percentile	90 percentile	Maximum
01396280	34	<0.001	<0.001	<0.001	<0.001	.0002	.0019	.0070
01396535	34	<0.001	<0.001	<0.001	<0.001	.0022	.0051	.0077
01396588	35	<0.001	<0.001	<0.001	<0.001	.0002	.0009	.0013
01396660	35	<0.001	<0.001	<0.001	<0.001	.0007	.0024	.0067
01397000	29	<0.001	<0.001	<0.001	<0.001	.0002	.0039	.0253
01397400	34	<0.001	<0.001	<0.001	.0005	.0025	.0063	.0092
01398000	35	<0.001	<0.001	<0.001	.0002	.0019	.0161	.0421
01398260	34	<0.001	<0.001	<0.001	.0006	.0012	.0031	.0062
01399120	35	<0.001	<0.001	<0.001	.0001	.0014	.0036	.0237
01399500	34	<0.001	<0.001	<0.001	<0.001	.0005	.0017	.0019
01399700	34	<0.001	<0.001	<0.001	.0005	.0027	.0051	.0076
01399780	35	<0.001	<0.001	<0.001	<0.001	.0003	.0008	.0081
01400500	34	<0.001	<0.001	<0.001	.0003	.0021	.0029	.0053
01400540	34	<0.001	<0.001	<0.001	<0.001	.0001	.0004	.0008
01400650	29	<0.001	<0.001	<0.001	.0002	.0008	.0021	.0032
01401000	34	<0.001	<0.001	<0.001	.0002	.0012	.0038	.0135
01401600	35	<0.001	<0.001	<0.001	.0002	.0010	.0030	.0084
01402000	31	<0.001	<0.001	.0001	.0003	.0008	.0009	.0027
01403300	19	<0.001	<0.001	.0003	.0005	.0009	.0022	.0031
01405302	35	<0.001	<0.001	<0.001	.0001	.0003	.0005	.0047
01405340	35	<0.001	<0.001	<0.001	<0.001	.0002	.0004	.0006

Table 27. Results of one-way and 2-way analysis of variance to determine differences in alkalinity concentrations between seasons and flow conditions using all data from 1991 -1997 water years

[--, indicates the distribution of concentrations did not differ at the 0.05 significance level; G, significant differences occur between seasons and largest concentrations occur in the growing season (April- October); NG, significant differences occur between seasons and largest concentrations occur in the nongrowing season (November- March); LO, significant differences occur between flow conditions and largest concentrations occur at low flow (less than median flow); HI, significant differences occur between flow conditions and largest concentrations occur at high flow (greater than median flow); Season(flow), indicates flow as a function of season; 2-way ANOVA column lists variables from test when significantly higher concentrations occur]

Station Number	ALKALINITY, AS CaCO3								
	Seasonal Comparison			Flow Comparison			Flow and season comparison		
	Median Concentration		Significant Seasonal difference	Median Concentration		Significant difference with flow	Highest Median Concen-tration	Lowest Median Concen-tration	Significant differences from 2-way ANOVA
	Growing	Non-growing		Low flow	High Flow				
01396280	49	47	G	75	47	LO	G(LO)	NG(HI)	G, LO
01396535	53	53	G	82	53	LO	G(LO)	G(HI)	LO, G(LO)
01396588	33	23	G	41	29	LO	G(LO)	NG(HI)	G, LO
01396660	49	39	G	60	42	LO	G(LO)	NG(HI)	G, LO
01397000	49	46	--	61	50	LO	G(LO)	NG(HI)	LO
01397400	56	39	--	72	56	LO	G(LO)	NG(HI)	LO
01398000	52	31	G	70	43	LO	G(LO)	NG(HI)	G, LO
01398260	45	29	G	50	36	LO	G(LO)	NG(HI)	G, LO
01399120	53	38	G	62	43	LO	G(LO)	NG(HI)	LO
01399500	43	26	G	50	34	LO	G(LO)	NG(HI)	G, LO
01399700	57	40	G	72	52	LO	G(LO)	NG(HI)	G, LO
01399780	51	31	G	66	44	LO	G(LO)	NG(HI)	G, LO
01400500	53	46	G	62	48	LO	G(LO)	NG(HI)	LO
01400540	8.5	4.5	G	12	8.2	LO	G(LO)	NG(HI)	G, LO
01400650	15	12	--	26	16	LO	G(LO)	NG(HI)	LO
01401000	42	32	G	56	36	LO	G(LO)	NG(HI)	LO
01401600	41	25	G	53	32	LO	G(LO)	NG(HI)	LO
01402000	34	25	G	40	30	LO	G(LO)	NG(HI)	LO
01403300	37	34	--	52	41	LO	G(LO)	G(HI)	LO
01405302	5.3	2.1	--	12	3.2	LO	G(LO)	NG(HI)	LO
01405340	6.4	3.4	G	9.8	6.2	LO	G(LO)	NG(HI)	G, LO

Table 28. Results of one-way and 2-way analysis of variance to determine differences in total ammonia plus organic nitrogen concentrations between seasons and flow conditions using all data from 1991-1997 water years

[--, indicates the distribution of concentrations during the growing season and nongrowing season or during high flow and low flow conditions did not differ at the 0.05 significance level; G, significant differences occur between seasons and largest concentrations occur in the growing season (April- October); NG, significant differences occur between seasons and largest concentrations occur in the nongrowing season (November- March); LO, significant differences occur between flow conditions and largest concentrations occur at low flow (less than median flow); HI, significant differences occur between flow conditions and largest concentrations occur at high flow (greater than median flow); Season(flow), indicates flow as a function of season; 2-way ANOVA column lists variables from test when significantly higher concentrations occur]

Station Number	TOTAL AMMONIA PLUS ORGANIC NITROGEN								
	Seasonal Comparison			Flow Comparison			Flow and season comparison		
	Median Concentration		Significant Seasonal difference	Median Concentration		Significant difference with flow	Highest Median Concen-tration	Lowest Median Concen-tration	Significant differences from 2-way ANOVA
	Growing	Non-growing		Low flow	High Flow				
01396280	0.30	0.20	--	0.23	0.30	--	G(HI)	NG(LO)	--
01396535	0.26	0.18	G	0.20	0.20	--	G(HI)	NG(HI)	G
01396588	0.20	0.12	G	0.16	0.18	--	G(HI)	NG(HI)	--
01396660	0.17	0.14	--	0.13	0.15	--	G(LO)	NG(LO)	--
01397000	0.30	0.30	--	0.28	0.30	--	G(HI)	NG(LO)	--
01397400	0.38	0.42	--	0.44	0.37	--	NG(LO)	G(HI)	--
01398000	0.40	0.20	G	0.30	0.27	--	G(HI)	NG(HI)	G
01398260	0.32	0.25	--	0.30	0.26	--	G(HI)	NG(HI)	--
01399120	0.30	0.24	--	0.30	0.22	--	NG(LO)	NG(HI)	--
01399500	0.34	0.30	G	0.32	0.30	--	G(HI)	NG(HI)	G
01399700	0.30	0.30	--	0.32	0.30	--	G(LO)	G(HI)	--
01399780	0.30	0.28	--	0.30	0.30	--	G(HI)	NG(LO)	--
01400500	0.44	0.30	--	0.43	0.25	LO	NG(LO)	NG(LO)	--
01400540	0.39	0.20	G	0.24	0.30	--	G(HI)	NG(LO)	G
01400650	0.53	0.53	--	0.56	0.53	--	NG(LO)	NG(HI)	--
01401000	0.50	0.34	--	0.36	0.50	HI	G(HI)	NG(LO)	HI, G
01401600	0.51	0.30	G	0.46	0.30	LO	G(LO)	NG(HI)	G
01402000	0.68	0.50	G	0.56	0.50	--	G(LO)	NG(LO)	--
01403300	0.60	0.40	--	0.50	0.50	--	G(HI)	NG(HI)	G(HI)
01405302	0.40	0.40	--	0.40	0.41	--	G(HI)	NG(LO)	--
01405340	0.33	0.25	--	0.30	0.30	--	G(HI)	NG(LO)	--

Table 29: **Results of one-way and 2-way analysis of variance to determine differences in biochemical oxygen demand concentrations between seasons and flow conditions using all data from 1991 -1997 water years**

[--, indicates the distribution of concentrations during the growing season and nongrowing season or during high flow and low flow conditions did not differ at the 0.05 significance level; G, significant differences occur between seasons and largest concentrations occur in the growing season (April- October); NG, significant differences occur between seasons and largest concentrations occur in the nongrowing season (November- March); LO, significant differences occur between flow conditions and largest concentrations occur at low flow (less than median flow); HI, significant differences occur between flow conditions and largest concentrations occur at high flow (greater than median flow); Season(flow), indicates flow as a function of season; 2-way ANOVA column lists variables from test when significantly higher concentrations occur]

Station Number	TOTAL AMMONIA PLUS ORGANIC NITROGEN								
	Seasonal Comparison			Flow Comparison			Flow and season comparison		
	Median Concentration		Significant Seasonal difference	Median Concentration		Significant difference with flow	Highest Mean Rank Concen-tration	Lowest Mean Rank Concen-tration	Significant differences from 2-way ANOVA
	Growing	Non-growing		Low flow	High flow				
01396280	0.30	0.20	--	0.23	0.30	--	G(HI)	NG(LO)	--
01396535	0.26	0.18	G	0.20	0.20	--	G(HI)	NG(HI)	G
01396588	0.20	0.12	G	0.16	0.18	--	G(HI)	NG(HI)	--
01396660	0.17	0.14	--	0.13	0.15	--	G(LO)	NG(LO)	--
01397000	0.30	0.30	--	0.28	0.30	--	G(HI)	NG(LO)	--
01397400	0.38	0.42	--	0.44	0.37	--	NG(LO)	G(HI)	--
01398000	0.40	0.20	G	0.30	0.27	--	G(HI)	NG(HI)	G
01398260	0.32	0.25	--	0.30	0.26	--	G(HI)	NG(HI)	--
01399120	0.30	0.24	--	0.30	0.22	--	NG(LO)	NG(HI)	--
01399500	0.34	0.30	G	0.32	0.30	--	G(HI)	NG(HI)	G
01399700	0.30	0.30	--	0.32	0.30	--	G(LO)	G(HI)	--
01399780	0.30	0.28	--	0.30	0.30	--	G(HI)	NG(LO)	--
01400500	0.44	0.30	--	0.43	0.25	LO	NG(LO)	NG(LO)	--
01400540	0.39	0.20	G	0.24	0.30	--	G(HI)	NG(LO)	G
01400650	0.53	0.53	--	0.56	0.53	--	NG(LO)	NG(HI)	--
01401000	0.50	0.34	--	0.36	0.50	HI	G(HI)	NG(LO)	HI, G
01401600	0.51	0.30	G	0.46	0.30	LO	G(LO)	NG(HI)	G
01402000	0.68	0.50	G	0.56	0.50	--	G(LO)	NG(LO)	--
01403300	0.60	0.40	--	0.50	0.50	--	G(HI)	NG(HI)	G(HI)
01405302	0.40	0.40	--	0.40	0.41	--	G(HI)	NG(LO)	--
01405340	0.33	0.25	--	0.30	0.30	--	G(HI)	NG(LO)	--

Table 30: **Results of one-way and 2-way analysis of variance to determine differences in chloride concentrations between seasons and flow conditions using all data from 1991 -1997 water years**

[--, indicates the distribution of concentrations during the growing season and nongrowing season or during high flow and low flow conditions did not differ at the 0.05 significance level; G, significant differences occur between seasons and largest concentrations occur in the growing season (April- October); NG, significant differences occur between seasons and largest concentrations occur in the nongrowing season (November- March); LO, significant differences occur between flow conditions and largest concentrations occur at low flow (less than median flow); HI, significant differences occur between flow conditions and largest concentrations occur at high flow (greater than median flow); Season(flow), indicates flow as a function of season; 2-way ANOVA column lists variables from test when significantly higher concentrations occur]

Station Number	TOTAL AMMONIA PLUS ORGANIC NITROGEN								
	Seasonal Comparison			Flow Comparison			Flow and season comparison		
	Median Concentration		Significant Seasonal difference	Median Concentration		Significant difference with flow	Highest Mean Rank Concen-tration	Lowest Mean Rank Concen-tration	Significant differences from 2-way ANOVA
	Growing	Non-growing		Low flow	High flow				
01396280	0.30	0.20	--	0.23	0.30	--	G(HI)	NG(LO)	--
01396535	0.26	0.18	G	0.20	0.20	--	G(HI)	NG(HI)	G
01396588	0.20	0.12	G	0.16	0.18	--	G(HI)	NG(HI)	--
01396660	0.17	0.14	--	0.13	0.15	--	G(LO)	NG(LO)	--
01397000	0.30	0.30	--	0.28	0.30	--	G(HI)	NG(LO)	--
01397400	0.38	0.42	--	0.44	0.37	--	NG(LO)	G(HI)	--
01398000	0.40	0.20	G	0.30	0.27	--	G(HI)	NG(HI)	G
01398260	0.32	0.25	--	0.30	0.26	--	G(HI)	NG(HI)	--
01399120	0.30	0.24	--	0.30	0.22	--	NG(LO)	NG(HI)	--
01399500	0.34	0.30	G	0.32	0.30	--	G(HI)	NG(HI)	G
01399700	0.30	0.30	--	0.32	0.30	--	G(LO)	G(HI)	--
01399780	0.30	0.28	--	0.30	0.30	--	G(HI)	NG(LO)	--
01400500	0.44	0.30	--	0.43	0.25	LO	NG(LO)	NG(LO)	--
01400540	0.39	0.20	G	0.24	0.30	--	G(HI)	NG(LO)	G
01400650	0.53	0.53	--	0.56	0.53	--	NG(LO)	NG(HI)	--
01401000	0.50	0.34	--	0.36	0.50	HI	G(HI)	NG(LO)	HI, G
01401600	0.51	0.30	G	0.46	0.30	LO	G(LO)	NG(HI)	G
01402000	0.68	0.50	G	0.56	0.50	--	G(LO)	NG(LO)	--
01403300	0.60	0.40	--	0.50	0.50	--	G(HI)	NG(HI)	G(HI)
01405302	0.40	0.40	--	0.40	0.41	--	G(HI)	NG(LO)	--
01405340	0.33	0.25	--	0.30	0.30	--	G(HI)	NG(LO)	--

Table 31: **Results of one-way and 2-way analysis of variance to determine differences in dissolved oxygen concentrations between seasons and flow conditions using all data from 1991 -1997 water years**

[--, indicates the distribution of concentrations during the growing season and nongrowing season or during high flow and low flow conditions did not differ at the 0.05 significance level; G, significant differences occur between seasons and largest concentrations occur in the growing season (April- October); NG, significant differences occur between seasons and largest concentrations occur in the nongrowing season (November- March); LO, significant differences occur between flow conditions and largest concentrations occur at low flow (less than median flow); HI, significant differences occur between flow conditions and largest concentrations occur at high flow (greater than median flow); Season(flow), indicates flow as a function of season; 2-way ANOVA column lists variables from test when significantly higher concentrations occur]

Station Number	DISSOLVED OXYGEN								
	Seasonal Comparison			Flow Comparison			Flow and season comparison		
	Median Concentration		Significant Seasonal difference	Median Concentration		Significant difference with flow	Highest Median Concen-tration	Lowest Median Concen-tration	Significant differences from 2-way ANOVA
	Growing	Non-growing		Low flow	High flow				
01396280	9.8	14	NG	12	11	--	NG(LO)	G(LO)	NG, NG(LO)
01396535	9.7	13	NG	10	12	--	NG(LO)	G(LO)	NG
01396588	9.9	13	NG	9.8	12	HI	NG(LO)	G(LO)	NG
01396660	9.6	14	NG	10	11	--	NG(LO)	G(LO)	NG, NG(LO)
01397000	9.8	14	NG	10	12	--	NG(HI)	G(HI)	NG
01397400	9.6	13	NG	10	12	--	NG(HI)	G(LO)	NG
01398000	11	14	NG	11	13	--	NG(HI)	G(LO)	NG
01398260	9.3	13	NG	10	12	--	NG(HI)	G(LO)	NG
01399120	10	14	NG	10	13	HI	NG(HI)	G(LO)	NG
01399500	9.6	14	NG	10	12	HI	NG(HI)	G(LO)	NG
01399700	9.7	13	NG	9.4	12	HI	NG(HI)	G(LO)	NG
01399780	10	14	NG	11	13	--	NG(HI)	G(LO)	NG
01400500	8.8	13	NG	9.6	13	HI	NG(HI)	G(LO)	NG
01400540	8.7	12	NG	9.6	10	--	NG(LO)	G(LO)	NG
01400650	7.0	11	NG	7.9	10	--	NG(LO)	G(LO)	NG
01401000	9.5	13	NG	10	13	HI	NG(LO)	G(LO)	NG
01401600	9.0	13	NG	9.1	13	HI	NG(HI)	G(LO)	NG
01402000	6.5	12	NG	6.4	11	HI	NG(LO)	G(LO)	NG
01403300	8.4	12	NG	9.6	10	--	NG(LO)	G(HI)	NG
01405302	7.9	11	NG	8.4	10	HI	NG(LO)	G(LO)	NG
01405340	9.2	12	NG	8.8	11	HI	NG(LO)	G(LO)	NG, NG(LO)

Table 32. Results of one-way and 2-way analysis of variance to determine differences in total dissolved solids concentrations between seasons and flow conditions using all data from 1991 - 1997 water years

[--, indicates the distribution of concentrations during the growing season and nongrowing season or during high flow and low flow conditions did not differ at the 0.05 significance level; G, significant differences occur between seasons and largest concentrations occur in the growing season (April- October); NG, significant differences occur between seasons and largest concentrations occur in the nongrowing season (November- March); LO, significant differences occur between flow conditions and largest concentrations occur at low flow (less than median flow); HI, significant differences occur between flow conditions and largest concentrations occur at high flow (greater than median flow); Season(flow), indicates flow as a function of season; 2-way ANOVA column lists variables from test when significantly higher concentrations occur]

Station Number	TOTAL DISSOLVED SOLIDS								
	Seasonal Comparison			Flow Comparison			Flow and season comparison		
	Median Concentration		Significant Seasonal difference	Median Concentration		Significant difference with flow	Highest Mean Rank Concen-tration	Lowest Mean Rank Concen-tration	Significant differences from 2-way ANOVA
	Growing	Non-growing		Low flow	High flow				
01396280	139	135	--	154	124	LO	G(LO)	G(HI)	LO
01396535	141	136	--	147	125	LO	G(LO)	G(HI)	LO, G(LO)
01396588	109	102	--	113	101	LO	NG(LO)	G(HI)	LO
01396660	122	119	--	126	110	LO	NG(LO)	G(HI)	LO
01397000	117	128	--	130	119	LO	NG(LO)	G(HI)	LO
01397400	148	156	--	172	144	LO	NG(LO)	G(HI)	LO
01398000	161	151	--	184	139	LO	NG(LO)	G(HI)	LO
01398260	153	139	--	167	137	LO	G(LO)	NG(HI)	LO
01399120	141	144	--	146	140	--	G(LO)	G(HI)	G(LO)
01399500	138	134	--	149	122	LO	G(LO)	NG(HI)	LO
01399700	138	126	--	152	126	LO	G(LO)	NG(HI)	LO
01399780	137	129	--	145	119	LO	G(LO)	G(HI)	LO
01400500	141	143	--	146	139	--	NG(LO)	G(HI)	--
01400540	68	69	--	69	68	--	G(LO)	G(HI)	--
01400650	114	122	--	139	108	LO	NG(LO)	G(HI)	LO
01401000	127	126	--	136	111	LO	G(LO)	G(HI)	LO
01401600	149	137	--	159	119	LO	G(LO)	G(HI)	LO
01402000	142	150	--	155	135	LO	NG(LO)	G(HI)	LO
01403300	139	149	--	182	131	LO	G(LO)	G(HI)	LO, NG
01405302	160	159	--	200	138	LO	NG(LO)	G(HI)	LO
01405340	74	84	NG	82	79	--	NG(LO)	G(HI)	--

Table 33: **Results of one-way and 2-way analysis of variance to determine differences in fecal coliform counts between seasons and flow conditions using all data from 1991 -1997 water years**

[--, indicates the distribution of counts during the growing season and nongrowing season or during high flow and low flow conditions did not differ at the 0.05 significance level; G, significant differences occur between seasons and largest counts occur in the growing season (April- October); NG, significant differences occur between seasons and largest counts occur in the nongrowing season (November- March); LO, significant differences occur between flow conditions and largest counts occur at low flow (less than median flow); HI, significant differences occur between flow conditions and largest counts occur at high flow (greater than median flow); Season(flow), indicates flow as a function of season; 2-way ANOVA column lists variables from test when significantly higher concentrations occur]

Station Number	FECAL COLIFORM COUNT								
	Seasonal Comparison			Flow Comparison			Flow and season comparison		
	Median Concentration		Significant Seasonal difference	Median Concentration		Significant difference with flow	Highest Median Count	Lowest Median Count	Significant differences from 2-way ANOVA
	Growing	Non-growing		Low flow	High flow				
01396280	490	50	G	330	180	--	G(LO)	NG(LO)	G
01396535	600	70	G	750	130	--	G(LO)	NG(LO)	G
01396588	280	50	G	130	110	--	G(HI)	NG(LO)	G
01396660	330	50	G	170	150	--	G(LO)	NG(LO)	G
01397000	170	70	--	50	170	--	NG(HI)	NG(LO)	HI,G(HI)
01397400	330	60	--	330	170	--	G(HI)	NG(LO)	--
01398000	1100	120	G	1100	640	--	G(LO)	NG(HI)	G
01398260	220	40	G	80	85	--	G(LO)	NG(LO)	G
01399120	640	150	G	490	170	LO	G(LO)	NG(HI)	G
01399500	45	20	--	40	35	--	G(LO)	NG(LO)	--
01399700	700	60	G	490	220	--	G(HI)	NG(LO)	G
01399780	270	80	--	350	310	--	G(HI)	NG(LO)	--
01400500	230	90	G	155	170	--	G(HI)	NG(LO)	G
01400540	330	<20	G	90	20	--	G(LO)	NG(LO)	G
01400650	330	35	G	225	80	--	G(LO)	NG(LO)	G
01401000	330	50	G	170	70	--	G(HI)	NG(LO)	G
01401600	600	90	G	280	80	--	G(LO)	NG(HI)	G
01402000	330	80	G	280	140	--	G(LO)	NG(LO)	G
01403300	490	50	G	490	130	--	G(LO)	NG(HI)	G
01405302	170	<20	G	80	<20	LO	G(HI)	NG(HI)	G
01405340	130	<20	G	45	20	LO	G(HI)	NG(LO)	G

Table 34: **Results of one-way and 2-way analysis of variance to determine differences in hardness concentrations between seasons and flow conditions using all data from 1991 -1997 water years**

[--, indicates the distribution of concentrations during the growing season and nongrowing season or during high flow and low flow conditions did not differ at the 0.05 significance level; G, significant differences occur between seasons and largest concentrations occur in the growing season (April- October); NG, significant differences occur between seasons and largest concentrations occur in the nongrowing season (November- March); LO, significant differences occur between flow conditions and largest concentrations occur at low flow (less than median flow); HI, significant differences occur between flow conditions and largest concentrations occur at high flow (greater than median flow); Season(flow), indicates flow as a function of season; 2-way ANOVA column lists variables from test when significantly higher concentrations occur]

Station Number	HARDNESS								
	Seasonal Comparison			Flow Comparison			Flow and season comparison		
	Median Concentration		Significant Seasonal difference	Median Concentration		Significant difference with flow	Highest Median Concen-tration	Lowest Median Concen-tration	Significant differences from 2-way ANOVA
	Growing	Non-growing		Low flow	High flow				
01396280	88	75	--	100	69	LO	G(LO)	NG(HI)	LO
01396535	96	81	--	100	74	LO	G(LO)	G(HI)	LO, G(LO)
01396588	57	51	G	62	51	LO	G(LO)	NG(HI)	LO
01396660	72	71	--	84	64	LO	G(LO)	NG(HI)	LO, G
01397000	76	75	--	82	71	LO	NG(LO)	NG(HI)	LO
01397400	88	82	--	96	80	LO	NG(LO)	NG(HI)	LO
01398000	98	80	--	130	76	LO	NG(LO)	NG(HI)	LO
01398260	81	64	G	90	65	LO	G(LO)	NG(HI)	LO, G
01399120	84	73	G	88	72	LO	G(LO)	G(HI)	LO
01399500	75	58	G	78	57	LO	G(LO)	G(HI)	LO, G
01399700	85	68	G	96	72	LO	G(LO)	NG(HI)	LO, G
01399780	82	65	G	85	65	LO	G(LO)	NG(HI)	LO, G
01400500	87	78	--	88	77	LO	G(LO)	NG(HI)	LO
01400540	30	30	--	31	29	LO	G(LO)	G(HI)	LO
01400650	48	47	--	49	44	LO	G(LO)	G(HI)	LO
01401000	69	67	--	84	64	LO	G(LO)	G(HI)	LO, G(LO)
01401600	84	70	G	86	61	LO	G(LO)	G(HI)	LO
01402000	69	64	--	75	61	LO	NG(LO)	G(HI)	LO
01403300	73	78	--	90	68	LO	NG(LO)	G(HI)	LO
01405302	74	61	--	83	58	LO	G(LO)	G(HI)	LO
01405340	33	34	--	35	34	LO	NG(LO)	G(HI)	LO

Table 35: **Results of one-way and 2-way analysis of variance to determine differences in nitrate plus nitrite concentrations between seasons and flow conditions using all data from 1991 -1997 water years**

[--, indicates the distribution of concentrations during the growing season and nongrowing season or during high flow and low flow conditions did not differ at the 0.05 significance level; G, significant differences occur between seasons and largest concentrations occur in the growing season (April- October); NG, significant differences occur between seasons and largest concentrations occur in the nongrowing season (November- March); LO, significant differences occur between flow conditions and largest concentrations occur at low flow (less than median flow); HI, significant differences occur between flow conditions and largest concentrations occur at high flow (greater than median flow); Season(flow), indicates flow as a function of season; 2-way ANOVA column lists variables from test when significantly higher concentrations occur]

Station Number	TOTAL NITRATE PLUS NITRITE AS NITROGEN								
	Seasonal Comparison			Flow Comparison			Flow and season comparison		
	Median Concentration		Significant Seasonal difference	Median Concentration		Significant difference with flow	Highest Mean Rank Concen-tration	Lowest Mean Rank Concen-tration	Significant differences from 2-way ANOVA
	Growing	Non-growing		Low flow	High flow				
01396280	1.7	1.6	--	1.9	1.3	LO	NG(LO)	G(HI)	LO
01396535	1.3	1.4	--	1.6	1.3	LO	NG(LO)	G(HI)	LO, NG
01396588	1.0	1.1	NG	1.1	1.1	--	NG(HI)	G(HI)	--
01396660	0.9	0.9	--	1.0	0.8	LO	NG(LO)	G(HI)	LO
01397000	1.0	1.2	NG	1.3	1.0	LO	NG(LO)	G(HI)	NG, LO
01397400	1.4	1.6	--	1.6	1.3	LO	G(LO)	G(HI)	LO
01398000	1.0	2.1	NG	1.0	1.9	HI	NG(HI)	G(LO)	NG
01398260	2.5	1.6	--	3.3	1.5	LO	G(LO)	NG(HI)	LO
01399120	0.8	1.0	NG	0.8	0.9	--	NG(HI)	G(HI)	NG
01399500	0.6	0.9	NG	0.8	0.7	--	NG(LO)	G(HI)	NG
01399700	1.2	1.2	--	1.2	1.2	--	NG(LO)	G(LO)	--
01399780	0.8	0.9	NG	0.8	1.0	--	NG(HI)	G(LO)	NG
01400500	0.9	1.5	NG	1.0	1.3	HI	NG(HI)	G(LO)	NG
01400540	1.2	1.5	NG	1.2	1.3	--	NG(HI)	G(LO)	NG
01400650	3.8	3.6	--	4.1	2.7	LO	NG(LO)	G(LO)	LO
01401000	0.5	0.7	NG	0.5	0.7	--	NG(HI)	G(LO)	NG
01401600	1.6	1.5	--	1.8	1.2	LO	NG(LO)	G(HI)	LO
01402000	2.4	2.3	--	2.8	2.0	LO	G(LO)	G(HI)	LO
01403300	1.7	1.9	--	2.4	1.5	LO	G(LO)	G(HI)	LO
01405302	4.5	3.6	--	6.4	3.1	LO	G(LO)	G(HI)	LO, G(LO)
01405340	0.7	1.0	NG	0.7	1.0	HI	NG(HI)	G(LO)	--

Table 36: **Results of one-way and 2-way analysis of variance to determine differences in total organic carbon concentrations between seasons and flow conditions using all data from 1991 - 1997 water years**

[--, indicates the distribution of concentrations during the growing season and nongrowing season or during high flow and low flow conditions did not differ at the 0.05 significance level; G, significant differences occur between seasons and largest concentrations occur in the growing season (April- October); NG, significant differences occur between seasons and largest concentrations occur in the nongrowing season (November-March); LO, significant differences occur between flow conditions and largest concentrations occur at low flow (less than median flow); HI, significant differences occur between flow conditions and largest concentrations occur at high flow (greater than median flow); Season(flow), indicates flow as a function of season; 2-way ANOVA column lists variables from test when significantly higher concentrations occur]

Station Number	TOTAL ORGANIC CARBON								
	Seasonal Comparison			Flow Comparison			Flow and season comparison		
	Median Concentration		Significant Seasonal difference	Median Concentration		Significant difference with flow	Highest Mean Rank Concen-tration	Lowest Mean Rank Concen-tration	Significant differences from 2-way ANOVA
	Growing	Non-growing		Low flow	High flow				
01396280	3.0	2.4	--	2.9	2.8	--	G(HI)	NG(LO)	G
01396535	2.8	2.5	--	2.8	2.8	--	G(HI)	NG(LO)	G
01396588	1.9	1.8	--	2.0	1.8	--	G(HI)	NG(HI)	--
01396660	1.8	2.1	--	1.6	2.4	HI	G(HI)	NG(LO)	HI
01397000	3.2	2.5	--	2.7	3.2	--	G(HI)	NG(LO)	G
01397400	3.7	3.2	--	3.5	3.4	--	G(HI)	NG(HI)	--
01398000	3.6	2.3	G	3.5	2.6	LO	G(LO)	NG(HI)	G
01398260	2.8	2.8	--	2.9	2.6	--	NG(LO)	NG(HI)	NG(LO)
01399120	3.0	3.0	--	3.2	2.6	--	NG(LO)	NG(LO)	--
01399500	4.0	4.2	--	4.0	4.2	--	G(HI)	NG(LO)	G
01399700	2.2	2.4	--	2.7	2.7	--	G(LO)	NG(LO)	--
01399780	3.0	2.9	--	3.4	3.4	--	G(LO)	NG(LO)	--
01400500	3.3	2.6	--	3.6	3.2	--	G(LO)	NG(HI)	G
01400540	3.3	2.2	G	2.7	2.8	--	G(HI)	NG(LO)	G
01400650	4.2	3.5	G	3.8	4.2	--	G(HI)	NG(LO)	G, HI
01401000	4.3	4.0	--	4.0	5.4	HI	G(HI)	NG(LO)	G, HI
01401600	3.8	3.2	--	4.0	3.1	LO	G(LO)	NG(HI)	G, LO
01402000	5.4	4.2	G	5.0	4.8	--	G(HI)	NG(LO)	G
01403300	4.5	3.2	G	4.1	4.4	--	G(HI)	NG(LO)	G, HI
01405302	3.2	2.6	G	3.0	2.8	--	G(HI)	NG(LO)	G
01405340	4.1	2.7	G	3.8	2.7	LO	G(LO)	NG(HI)	G

Table 38: **Results of one-way and 2-way analysis of variance to determine differences in total phosphorus concentrations of phosphorus between seasons and flow conditions using all data from 1991 -1997 water years**

[--, indicates the distribution of concentrations during the growing season and nongrowing season or during high flow and low flow conditions did not differ at the 0.05 significance level; G, significant differences occur between seasons and largest concentrations occur in the growing season (April- October); NG, significant differences occur between seasons and largest concentrations occur in the nongrowing season (November - March); LO, significant differences occur between flow conditions and largest concentrations occur at low flow (less than median flow); HI, significant differences occur between flow conditions and largest concentrations occur at high flow (greater than median flow); Season(flow), indicates flow as a function of season; 2-way ANOVA column lists variables from test when significantly higher concentrations occur]

Station Number	PHOSPHORUS, TOTAL								
	Seasonal Comparison			Flow Comparison			Flow and season comparison		
	Median Concentration		Significant Seasonal difference	Median Concentration		Significant difference with flow	Highest Median Concen-tration	Lowest Median Concen-tration	Significant differences from 2-way ANOVA
	Growing	Non-growing		Low flow	High flow				
01396280	0.08	0.05	--	0.09	0.04	LO	G(LO)	NG(HI)	LO
01396535	0.06	0.03	G	0.04	0.04	--	G(LO)	NG(LO)	G
01396588	0.03	0.02	--	0.04	0.03	--	G(LO)	NG(HI)	--
01396660	0.02	0.01	--	0.01	0.02	--	G(LO)	NG(LO)	--
01397000	0.04	0.03	--	0.04	0.02	--	G(LO)	G(HI)	--
01397400	0.14	0.12	--	0.18	0.10	--	G(LO)	NG(HI)	G(LO)
01398000	0.05	0.04	--	0.05	0.04	--	G(HI)	G(LO)	--
01398260	0.08	0.04	G	0.08	0.04	--	G(LO)	NG(HI)	G
01399120	0.06	0.03	--	0.05	0.03	--	G(LO)	NG(HI)	--
01399500	0.06	0.03	G	0.05	0.03	--	G(LO)	NG(HI)	--
01399700	0.08	0.08	--	0.12	0.07	--	G(LO)	G(HI)	--
01399780	0.07	0.05	G	0.07	0.06	--	G(LO)	NG(LO)	G
01400500	0.10	0.05	G	0.10	0.07	LO	G(LO)	NG(LO)	G, G(LO)
01400540	0.10	0.07	G	0.06	0.07	--	G(HI)	NG(LO)	G
01400650	0.14	0.10	--	0.14	0.11	--	G(LO)	NG(HI)	--
01401000	0.08	0.05	--	0.06	0.07	--	G(HI)	NG(LO)	--
01401600	0.12	0.08	G	0.11	0.08	LO	G(LO)	NG(HI)	LO
01402000	0.31	0.19	G	0.37	0.19	LO	G(LO)	G(HI)	LO
01403300	0.21	0.15	G	0.34	0.14	LO	G(LO)	NG(HI)	LO
01405302	0.02	0.04	--	0.02	0.04	--	G(HI)	G(LO)	--
01405340	0.09	0.06	G	0.08	0.06	--	G(HI)	NG(LO)	G

Table 39: **Results of one-way and 2-way analysis of variance to determine differences in sodium concentrations between seasons and flow conditions using all data from 1991 -1997 water years**

[--, indicates the distribution of concentrations during the growing season and nongrowing season or during high flow and low flow conditions did not differ at the 0.05 significance level; G, significant differences occur between seasons and largest concentrations occur in the growing season (April- October); NG, significant differences occur between seasons and largest concentrations occur in the nongrowing season (November- March); LO, significant differences occur between flow conditions and largest concentrations occur at low flow (less than median flow); HI, significant differences occur between flow conditions and largest concentrations occur at high flow (greater than median flow); Season(flow), indicates flow as a function of season; 2-way ANOVA column lists variables from test when significantly higher concentrations occur]

Station Number	SODIUM								
	Seasonal Comparison			Flow Comparison			Flow and season comparison		
	Median Concentration		Significant Seasonal difference	Median Concentration		Significant difference with flow	Highest Mean Rank Concen-tration	Lowest Mean Rank Concen-tration	Significance for season as function of flow
	Growing	Non-growing		Low flow	High flow				
01396280	14	15	--	14	14	--	NG(HI)	G(HI)	--
01396535	12	17	NG	12	12	--	NG(HI)	G(HI)	NG
01396588	10	11	--	11	11	--	NG(HI)	G(HI)	--
01396660	9.2	12	NG	9	10	HI	NG(HI)	G(LO)	HI, NG, NG(HI)
01397000	11	13	--	12	12	--	NG(HI)	G(HI)	--
01397400	17	20	--	21	16	--	NG(LO)	G(HI)	NG
01398000	15	17	--	16	15	--	NG(LO)	G(HI)	LO
01398260	17	19	--	18	17	--	NG(HI)	G(HI)	NG(HI)
01399120	15	16	--	15	16	--	NG(HI)	G(HI)	NG(HI)
01399500	19	20	--	19	18	--	NG(HI)	G(HI)	--
01399700	11	12	--	13	11	--	G(LO)	G(HI)	--
01399780	14	16	--	15	14	--	NG(HI)	G(HI)	NG(HI)
01400500	15	15	--	15	16	--	G(HI)	G(LO)	--
01400540	6.4	7.2	NG	6.4	7.4	HI	NG(HI)	NG(LO)	HI, NG(HI)
01400650	16	19	--	24	16	--	NG(LO)	G(HI)	--
01401000	16	14	--	16	13	LO	G(LO)	G(HI)	LO
01401600	16	17	--	18	15	--	G(LO)	G(HI)	LO, G(LO)
01402000	19	20	--	20	18	--	NG(HI)	G(HI)	--
01403300	17	17	--	22	15	LO	G(LO)	G(HI)	LO
01405302	21	20	--	22	16	LO	NG(LO)	G(HI)	LO
01405340	8.6	8.6	--	8.6	8.6	--	NG(HI)	G(HI)	----

Table 40. Results of one-way and 2-way analysis of variance to determine differences in sulfate concentrations between seasons and flow conditions using all data from 1991 -1997 water years

[--, indicates the distribution of concentrations during the growing season and nongrowing season or during high flow and low flow conditions did not differ at the 0.05 significance level; G, significant differences occur between seasons and largest concentrations occur in the growing season (April- October); NG, significant differences occur between seasons and largest concentrations occur in the nongrowing season (November- March); LO, significant differences occur between flow conditions and largest concentrations occur at low flow (less than median flow); HI, significant differences occur between flow conditions and largest concentrations occur at high flow (greater than median flow); G(LO), growing season during low flow; yes, significant difference in concentrations in flow as a function of season] Season(flow), indicates flow as a function of season; 2-way ANOVA column lists variables from test when significantly higher concentrations occur]

Station Number	SULFATE								
	Seasonal Comparison			Flow Comparison			Flow and season comparison		
	Median Concentration		Significant Seasonal difference	Median Concentration		Significant difference with flow	Highest Mean Rank Concen-tration	Lowest Mean Rank Concen-tration	Significant differences from 2-way ANOVA
	Growing	Non-growing		Low flow	High flow				
01396280	11	12	NG	11	12	--	NG(LO)	G(LO)	NG
01396535	12	13	NG	12	12	--	NG(LO)	G(LO)	NG, LO, NG(LO)
01396588	17	18	--	17	16	--	NG(LO)	G(HI)	--
01396660	15	17	NG	15	15	--	NG(LO)	G(LO)	NG, NG(LO)
01397000	13	13	--	13	13	--	NG(LO)	NG(HI)	LO, NG(LO)
01397400	20	20	--	24	18	LO	NG(LO)	NG(HI)	LO
01398000	32	28	--	44	25	LO	NG(LO)	G(HI)	LO
01398260	14	13	--	15	13	LO	NG(LO)	NG(HI)	LO
01399120	17	16	--	18	15	LO	NG(LO)	G(HI)	LO
01399500	11	12	--	13	11	LO	NG(LO)	G(HI)	LO
01399700	19	18	--	20	17	LO	NG(LO)	NG(HI)	LO
01399780	15	14	--	18	14	LO	NG(LO)	G(HI)	LO
01400500	20	20	--	22	18	LO	NG(LO)	G(HI)	LO
01400540	13	20	--	12	16	HI	NG(HI)	G(LO)	HI
01400650	22	24	--	23	23	--	NG(LO)	G(HI)	NG
01401000	20	22	--	22	18	LO	NG(LO)	G(HI)	LO
01401600	27	25	G	35	25	LO	G(LO)	NG(HI)	LO
01402000	27	26	--	32	23	LO	NG(LO)	G(HI)	LO
01403300	24	24	--	36	21	LO	NG(LO)	G(HI)	LO
01405302	50	45	--	53	44	LO	NG(LO)	NG(HI)	LO
01405340	18	22	NG	18	20	--	NG(LO)	G(LO)	NG

Table 41: **Results of one-way and 2-way analysis of variance to determine differences in total suspended solids concentrations between seasons and flow conditions using all data from 1991 -1997 water years**

[--, indicates the distribution of concentrations during the growing season and nongrowing season or during high flow and low flow conditions did not differ at the 0.05 significance level; G, significant differences occur between seasons and largest concentrations occur in the growing season (April- October); NG, significant differences occur between seasons and largest concentrations occur in the nongrowing season (November-March); LO, significant differences occur between flow conditions and largest concentrations occur at low flow (less than median flow); HI, significant differences occur between flow conditions and largest concentrations occur at high flow (greater than median flow); Season(flow), indicates flow as a function of season; 2-way ANOVA column lists variables from test when significantly higher concentrations occur]

Station Number	TOTAL SUSPENDED SOLIDS								
	Seasonal Comparison			Flow Comparison			Flow and season comparison		
	Median Concentration		Significant Seasonal difference	Median Concentration		Significant difference with flow	Highest Median Concen-tration	Lowest Median Concen-tration	Significant differences from 2-way ANOVA
	Growing	Non-growing		Low flow	High flow				
01396280	5.0	3.0	--	3.0	7.0	HI	G(HI)	NG(LO)	--
01396535	6.0	3.5	G	5.0	5.0	--	G(HI)	NG(LO)	G
01396588	3.0	2.0	G	3.0	3.0	--	G(HI)	NG(HI)	G
01396660	2.0	2.0	--	2.0	3.5	--	NG(HI)	NG(LO)	NG(HI)
01397000	5.0	3.0	--	4.0	5.0	--	G(HI)	NG(LO)	--
01397400	5.5	5.0	--	3.0	6.0	HI	G(LO)	NG(LO)	HI
01398000	3.0	3.0	--	3.0	6.0	HI	G(HI)	NG(LO)	HI
01398260	3.0	1.0	--	2.0	4.0	HI	G(HI)	NG(LO)	G, HI
01399120	3.0	4.0	--	2.0	6.5	HI	G(HI)	NG(LO)	HI
01399500	4.0	2.5	--	3.5	3.0	--	NG(HI)	NG(LO)	--
01399700	5.0	4.0	--	4.5	6.0	--	G(HI)	NG(LO)	--
01399780	4.0	5.5	--	4.0	8.0	HI	NG(HI)	NG(LO)	HI
01400500	7.5	6.0	--	5.5	6.0	--	G(HI)	G(LO)	--
01400540	8.0	7.5	--	6.0	9.5	HI	NG(HI)	NG(LO)	HI
01400650	14	8.0	G	7.0	15	--	G(HI)	NG(LO)	G, HI
01401000	4.0	3.5	--	2.5	7.0	HI	G(HI)	NG(LO)	HI
01401600	5.0	3.0	--	4.0	4.5	--	G(LO)	NG(LO)	G
01402000	13	6.5	G	9.5	10	--	G(HI)	NG(LO)	G-
01403300	15	5.0	G	5.0	24	HI	G(HI)	NG(LO)	G, HI
01405302	2.0	6.5	NG	3.0	8.0	HI	G(HI)	G(LO)	G(HI), HI
01405340	5.0	8.0	--	7.0	7.5	--	NG(HI)	G(LO)	--

Table 42: **Results of one-way and 2-way analysis of variance to determine differences in un-ionized ammonia concentrations between seasons and flow conditions using all data from 1991 -1997 water years**

[--, indicates the distribution of concentrations during the growing season and nongrowing season or during high flow and low flow conditions did not differ at the 0.05 significance level; G, significant differences occur between seasons and largest concentrations occur in the growing season (April- October); NG, significant differences occur between seasons and largest concentrations occur in the nongrowing season (November-March); LO, significant differences occur between flow conditions and largest concentrations occur at low flow (less than median flow); HI, significant differences occur between flow conditions and largest concentrations occur at high flow (greater than median flow); Season(flow), indicates flow as a function of season; 2-way ANOVA column lists variables from test when significantly higher concentrations occur]

Station Number	UN-IONIZED AMMONIA								
	Seasonal Comparison			Flow Comparison			Flow and season comparison		
	Median Concentration		Significant Seasonal difference	Median Concentration		Significant difference with flow	Highest Median Concentration	Lowest Median Concentration	Significant differences from 2-way ANOVA
	Growing	Non-growing		Low flow	High flow				
01396280	0.00016	0.00014	G	0.0003	0.0002	LO	G(LO)	NG(HI)	G, LO
01396535	0.00016	0.00014	G	0.0003	0.0002	LO	G(LO)	NG(HI)	LO, G
01396588	0.00073	0.00016	G	0.0004	0.0001	LO	G(LO)	NG(HI)	G
01396660	0.00016	0.00008	G	0.0003	0.0001	--	G(LO)	NG(HI)	G
01397000	0.0002	0.00008	--	0.0008	0.0002	LO	G(LO)	NG(HI)	LO
01397400	0.0004	0.0007	--	0.0027	0.0005	LO	G(LO)	NG(HI)	LO
01398000	0.0008	0.0001	G	0.0004	0.0002	--	G(LO)	NG(LO)	G
01398260	0.0006	0.0006	--	0.0008	0.0006	--	G(LO)	NG(HI)	--
01399120	0.0002	0.0001	G	0.0003	0.0002	LO	G(LO)	NG(HI)	G, G(LO)
01399500	0.0002	0.0002	--	0.0007	0.0002	LO	G(LO)	NG(HI)	--
01399700	0.0006	0.0004	G	0.0012	0.0003	--	G(LO)	NG(HI)	--
01399780	0.0007	0.0004	G	0.0004	0.0001	LO	G(LO)	NG(HI)	LO, G
01400500	0.001	0.0002	G	0.0009	0.0002	LO	G(LO)	NG(HI)	G, LO
01400540	0.001	0.0002	--	0.00006	0.00006	--	G(LO)	NG(HI)	--
01400650	0.0003	0.0002	--	0.0005	0.0001	LO	G(LO)	G(HI)	LO
01401000	0.0007	0.0006	--	0.0003	0.0002	--	G(HI)	NG(LO)	--
01401600	0.0004	0.0001	G	0.0005	0.0001	--	G(LO)	NG(HI)	--
01402000	0.0004	0.0001	G	0.0007	0.0001	LO	G(LO)	NG(HI)	LO
01403300	0.0006	0.0003	--	0.0008	0.0003	--	G(HI)	NG(LO)	--
01405302	0.0001	0.0001	--	0.0004	0.00002	LO	NG(LO)	G(HI)	LO
01405340	0.0007	0.0002	G	0.00003	0.00002	LO	G(LO)	NG(HI)	--

Table 43: **Results of one-way and 2-way analysis of variance to determine differences in water temperatures between seasons and flow conditions using all data from 1991 -1997 water years**

[--, indicates the distribution of temperatures during the growing season and nongrowing season or during high flow and low flow conditions did not differ at the 0.05 significance level; G, significant differences occur between seasons and largest temperatures occur in the growing season (April- October); NG, significant differences occur between seasons and highest temperatures occur in the nongrowing season (November-March); LO, significant differences occur between flow conditions and largest temperatures occur at low flow (less than median flow); HI, significant differences occur between flow conditions and largest temperatures occur at high flow (greater than median flow); Season(flow), indicates flow as a function of season; 2-way ANOVA column lists variables from test when significantly higher concentrations occur]

Station Number	WATER TEMPERATURE								
	Seasonal Comparison			Flow Comparison			Flow and season comparison		
	Median Temperature		Significant Seasonal differ- ence	Median Temperature		Significant difference with flow	Highest Mean rank Temperature	Lowest Mean Rank Temperature	Significant differences from 2-way ANOVA
	Growing	Non-growing		Low flow	High flow				
01396280	15	2.5	G	12	9.0	--	G(LO)	NG(LO)	G, G(LO)
01396535	17	3.2	G	20	12	LO	G(LO)	NG(HI)	G, LO
01396588	17	3.2	G	17	9.2	LO	G(LO)	NG(HI)	G, LO
01396660	17	3.5	G	16	9.0	--	G(LO)	NG(LO)	G
01397000	19	3.5	G	16	10	--	G(LO)	NG(HI)	G
01397400	20	3.8	G	16	12	--	G(LO)	NG(HI)	G
01398000	19	4.5	G	19	6.0	LO	G(LO)	NG(HI)	G
01398260	17	3.5	G	17	8.0	--	G(LO)	NG(HI)	G
01399120	20	4.0	G	19	5.8	LO	G(LO)	NG(HI)	G
01399500	14	1.4	G	13	5.5	LO	G(LO)	NG(HI)	G
01399700	18	3.2	G	14	9.0	--	G(LO)	NG(LO)	G
01399780	17	2.0	G	14	6.0	LO	G(LO)	NG(HI)	G, LO
01400500	23	5.5	G	23	6.5	LO	G(LO)	NG(HI)	G, LO
01400540	16	5.2	G	12	11	--	G(LO)	NG(LO)	G
01400650	21	6.8	G	16	9.0	--	G(LO)	NG(LO)	G
01401000	18	3.2	G	19	7.0	LO	G(LO)	NG(HI)	G, LO
01401600	18	2.3	G	18	5.0	LO	G(LO)	NG(LO)	G, G(LO)
01402000	21	5.6	G	21	7.0	LO	G(LO)	NG(LO)	G
01403300	21	5.5	G	22	13	LO	G(LO)	NG(HI)	G, LO, G(LO)
01405302	18	5.6	G	14	9.2	--	G(LO)	NG(LO)	G
01405340	16	5.0	G	16	8.5	LO	G(LO)	NG(LO)	G

Table 44: **Summary of water quality conditions at 21 NJDEP/USGS sites sampled in the Raritan River basin from 1991-97**

[Green Cells = the 3 sites with most samples meeting the standard or 3 sites with lowest median values for each constituent (highest median DO and alkalinity values); Red Cells = the 3 sites with most samples not meeting standards or 3 sites with highest median values (lowest median DO and alkalinity values); Alkalinity, biochemical oxygen demand, total ammonia + organic nitrogen (TKN) and total organic carbon do not have a standard; Ratings for pH and hardness are based on percent of samples meeting or not meeting both a high and low standard; *, trout maintenance; ** trout production; # coastal plain waters have naturally low alkalinity]

Station Number	Nutrients					Inorganics						Other Constituents					
	Ammonia + Organic Nitrogen	Ammonia, Un-ionized	Nitrite plus Nitrate	Organic Carbon, Total	Phosphorus, total	Alkalinity	Chloride	Dissolved solids, total	Hardness	Sodium	Sulfate	Biochemical Oxygen Demand	Dissolved Oxygen	Fecal coliform	pH	Suspended solids, total	Water temperature
South Branch Raritan River Sub-basin																	
**01396280 – South Branch, Middle Valley																	
*01396535 – South Branch, High Bridge																	
**01396588 – Spruce Run																	
*01396660 – Mulhockaway Cr.																	
*01397000 – South Branch, Stanton																	
01397400 – South Branch, Three Bridges																	
01398000 – Neshanic River																	
North Branch Raritan River Sub-basin																	
**01398260 – North Branch, Chester																	
01399120 – North Branch, Burnt Mills																	
**01399500 – Lamington River, Pottersville																	
01399700 – Rockaway Creek																	
01399780 – Lamington River, Burnt Mills																	

Station Number	Nutrients					Inorganics						Other Constituents					
	Ammonia + Organic Nitrogen	Ammonia, Un-ionized	Nitrite plus Nitrate	Organic Carbon, Total	Phosphorus, total	Alkalinity	Chloride	Dissolved solids, total	Hardness	Sodium	Sulfate	Biochemical Oxygen Demand	Dissolved Oxygen	Fecal coliform	pH	Suspended solids, total	Water temperature
Millstone River Sub-basin																	
01400540 – Millstone River, Manalapan						#											
01400650 – Millstone River, Grovers Mill																	
01401000 – Stony Brook, Princeton																	
01401600 – Beden Brook																	
01402000 – Millstone River, Blackwells Mills																	
Raritan River Mainstem																	
01400500 – Raritan River, Manville																	
01403300 – Raritan River, Bound Brook																	
South River Sub-basin																	
01405302 – Matchaponix Br.						#											
01405340 – Manalapan Brook						#											