HYDROLOGIC CONDITIONS IN THE UPPER ROCKAWAY RIVER BASIN, NEW JERSEY, 1984-86

By F.L. Schaefer, P.T. Harte, J.A. Smith, and B.A. Kurtz

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MANUEL LUJAN, JR., Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information write to:

District Chief
U.S. Geological Survey
Mountain View Office Park
Suite 206
810 Bear Tavern Road
West Trenton, NJ 08628

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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
foot per mile (ft/mi)	0.1894	meter per kilometer
square foot (ft^2)	0.09294	square meter
square mile (mi^2)	2.590	square kilometer
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
cubic foot per second per square mile [$(ft^3/s)/mi^2$]	0.01093	cubic meter per second per square kilometer
gallon per minute (gal/min)	0.06309	liter per second
million gallons (Mgal)	3,785	cubic meters
million gallons per day (Mgal/d)	0.04381	cubic meter per second

Temperature Conversion

Temperature in degrees Celsius (°C) is converted to degrees Fahrenheit (°F) by the equation: $°F = (9/5)\ °C + 32$.

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

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By F.L. Schaefer[1], P.T. Harte[1], J.A. Smith[1], and B.A. Kurtz[2]

ABSTRACT

This report contains an evaluation of the water resources of the upper Rockaway River basin in north-central New Jersey done by the U.S. Geological Survey in cooperation with the New Jersey Department of Environmental Protection and Energy. From October 1984 through September 1986, water levels were measured in 61 wells, stream discharge was measured at 46 sites, and water-quality samples from 29 wells and 15 stream sites were collected and analyzed in the 116-square-mile study area. In addition, streambed material was sampled at seven sites and stream biology was assessed at eight sites.

The course of the Rockaway River generally follows preglacial bedrock channels that contain glacial valley-fill deposits. These deposits, which typically are 100 to 200 feet thick, contain highly productive aquifers that are tapped by many high-yield (up to 1,500 gallons per minute) public-supply wells. These wells are the major source of water within the basin. Much of the water withdrawn through these wells is induced recharge from streams to aquifers. The valley-fill deposits are underlain by bedrock composed primarily of Precambrian granite and gneiss.

Ground water in the valley-fill aquifer system is present under unconfined and confined conditions. The limited extent of the confining units causes the entire ground-water system to act as one interconnected system. In parts of the unconfined aquifer not affected by pumping, ground water generally flows from points of recharge along the valley walls to points of discharge in the valleys, such as the Rockaway River or tributary streams or lakes. Where pumping is not a factor, ground-water flow in the confined aquifer is generally downvalley. Where pumping is a factor, ground water flows toward the pumped wells, creating local cones of depression.

Streamflow at the two gaging stations in the basin--Berkshire Valley at the upstream end of the developed part of the study area, and above Reservoir at Boonton at the downstream end of the study area--varied by one-half to one order of magnitude during the period from May 1985 through September 1986. The lowest mean daily flow for this period was 9.6 ft^3/s (cubic feet per second) at Berkshire Valley and 27 ft^3/s at Boonton Reservoir. The highest mean daily flow for the same period was 331 ft^3/s at Berkshire Valley and 1,590 ft^3/s at Boonton Reservoir.

Four seepage runs were made on the Rockaway River, Green Pond Brook, Beaver Brook, and Stony Brook to identify gaining and losing stream reaches.

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[1] U.S. Geological Survey
[2] New Jersey Department of Environmental Protection and Energy

The loss of water from most reaches results from ground-water pumpage, but some can be attributed to a combination of both pumpage and natural factors such as changes in the altitude and slope of the water table and changes in surface-water storage.

The pH and major-ion chemistry of ground and surface waters are similar. pH ranges from 6.1 to 9.3 for ground water and from 6.4 to 8.5 for surface water. Both waters are characteristically a calcium magnesium, bicarbonate carbonate water type. Concentrations of most trace elements and nutrients were less than U.S. Environmental Protection Agency maximum contaminant levels. The predominant trace elements are iron and manganese.

Differences in water quality between aquifers and within each aquifer generally are small. Volatile organic compounds (VOC's) are persistent in some valley-fill-aquifer waters, however. VOC's in concentrations greater than 0.8 micrograms per liter were detected in 10 of the 19 valley-fill aquifer wells sampled; none was detected in the 7 bedrock wells. Eight of the 10 samples with detectable concentrations of VOC's were from high-yield production wells in the highly developed parts of the basin.

In general, Rockaway River water quality is acceptable for drinking and most other uses. Concentrations of most trace elements and nutrients are low. The quality of Rockaway River water varies slightly from the upstream, less developed reaches to the downstream, more developed reaches, but in general, these differences are not significant.

In contrast, concentrations of trace elements and organic compounds in streambed material increased significantly from upstream, primarily forested lands to downstream, commercial, industrial, and residential lands. The presence of most of the trace elements and all of the organic compounds detected at these downstream sites probably is the result of human activities.

Results of the stream-biology assessment indicate that (1) stream conditions throughout the study area are healthy, although enriched; and (2) differences in stream biota are a function of the physical characteristics of the Rockaway River rather than differences in water quality.

INTRODUCTION

Population growth and an increasing demand for potable water have raised concern about water supply and quality in parts of the Rockaway River basin. To address these concerns, this short-term study of the area's ground- and surface-water resources was conducted by the U.S. Geological Survey (USGS) in cooperation with the New Jersey Department of Environmental Protection and Energy (NJDEPE) (formerly called the New Jersey Department of Envionmental Protection) from October 1984 through September 1986. The study focused on the glacial valley-fill aquifer system because it is now the major source of water supply for the resident population. Another major focus was the streams of the basin that are hydraulically connected to the valley-fill aquifer system. Bedrock aquifers also were evaluated because they are potential alternative water supplies.

Purpose and Scope

This report describes the water resources of the upper Rockaway River basin above Boonton Reservoir, including the ground-water and surface-water systems and the quality of ground water and surface water in the study area. The report also discusses the chemical quality of streambed material and presents a biological assessment of the macroinvertebrate communities of the Rockaway River.

Water-level measurements in 61 wells, stream-discharge measurements at 46 sites, and results of analyses of water-quality samples from 29 wells and 15 stream sites are presented. Results of analyses of streambed material sampled at seven sites, and an assessment of stream biology at eight sites, also are included.

Previous Studies

The water resources of Morris County were described by Gill and Vecchioli (1965) in their study of the availability of ground water in the county. Geraghty and Miller (1968) investigated potential water supplies for the Borough of Wharton and, in 1969, completed a similar study evaluating ground-water conditions in the Town of Dover (Geraghty and Miller, 1969). Subsequently, an evaluation of ground-water resources of the Rockaway River basin within the communities of Denville Township, Boonton Township, Town of Boonton, Montville Township, and Mountain Lakes Borough was done by Geraghty and Miller (1978). That same year, the determination of available water supplies within the Rockaway Valley Regional Sewage Authority service area was conducted by Tetra Tech (Summers and others, 1979). A water-resource study of the lower Rockaway River valley was performed by Geonics (1979). Canace and others (1983) mapped the thickness and extent of the glacial valley-fill deposits in six areas of the Pequannock and Rockaway River basins to determine the feasibility of supplementing surface-water supplies with ground water. Canace and others (in press) used geologic maps, well records, and geophysics to determine the thickness, composition, and geographic extent of the valley-fill deposits from Wharton Borough to Montville Township. Additional details on the surficial geology of the Dover and Boonton quadrangles was provided by Stanford (1989a, 1989b).

The New Jersey Department of Environmental Protection and Energy, as part of its Lakes Management Program, collected and analyzed hydrologic, chemical, and physical data for Boonton Reservoir and areas upstream along the main stem of the Rockaway River and selected tributaries (Wagner, 1979).

Site-Numbering System

All surface-water stations, including those at which streamflow, water quality, streambed-material characteristics, and stream biology are measured, are given a formal station number. These station numbers are assigned on the basis of station position along a stream and consist of an 8-digit number, such as 01379700. These numbers increase in the downstream direction.

The well-numbering system used in this report was developed by the USGS, New Jersey District, in 1978. The number consists of a two-digit county code followed by a sequence number. The code for Morris County is 27, and a representative well number is 27-242, which indicates the 242nd well inventoried in Morris County.

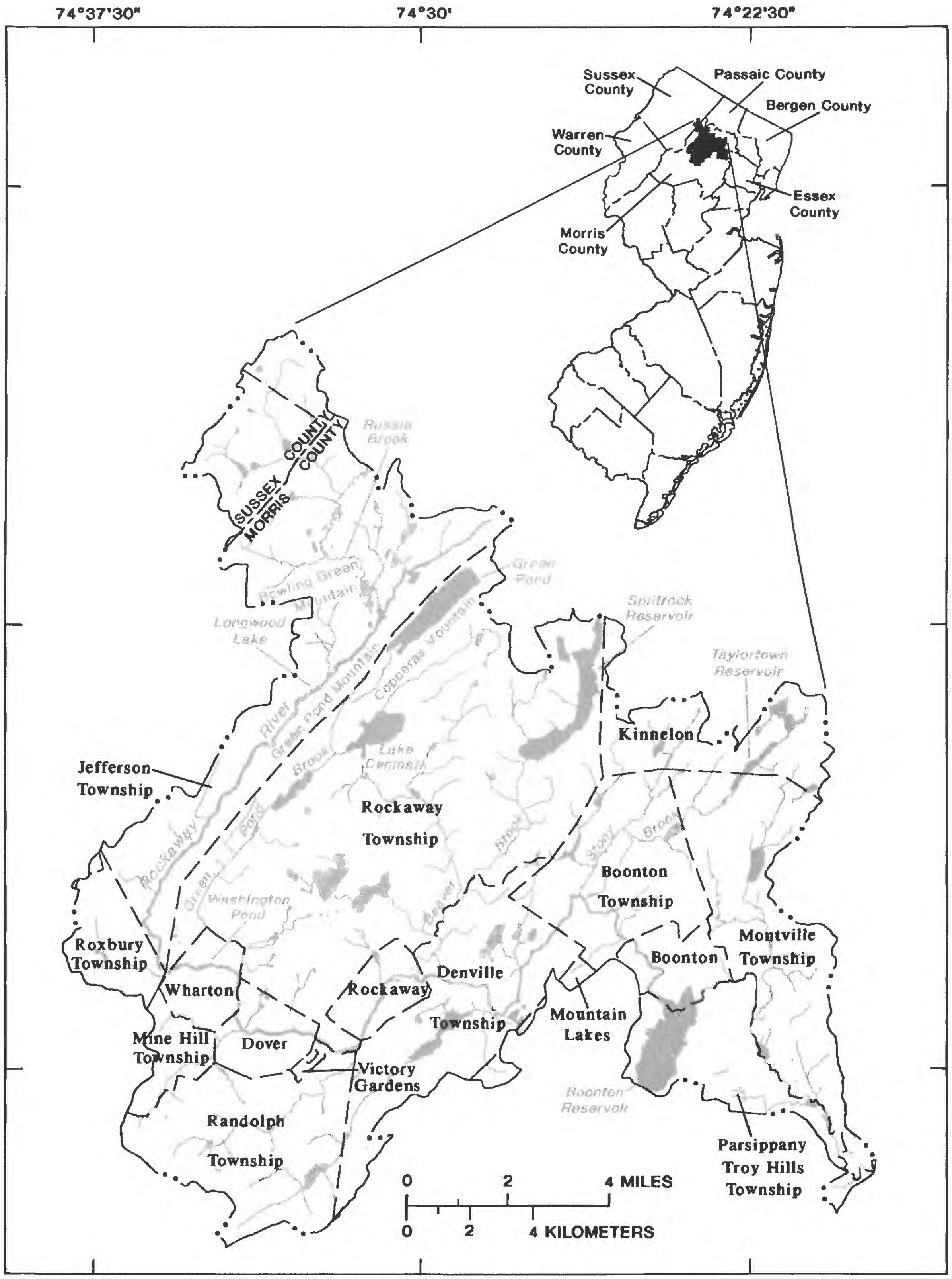
Acknowledgments

The authors thank Robert Canace and Scott Stanford of the NJDEPE for supplying geologic-framework and well data, and the late Harold Barker (NJDEPE) for surveying wells and surface-water measurement points. The authors also thank the individuals who served as water superintendents of the municipalities in the study area during the period of study: Stephen J. Koval, Town of Boonton; Joseph J. Lowell, Denville Township; Andrew V. Du-Jack, Town of Dover; James Cowley, Jefferson Township; Edward J. Rosenberger, Montville Township; Carl L. Danser, Mountain Lakes Borough; Clyde A. Canfield, Randolph Township; Gilbert Graner, Rockaway Borough; Donald Tironi, Rockaway Township, and William Husti, Wharton Borough.

DESCRIPTION OF STUDY AREA

The Rockaway River basin is located in north-central New Jersey (fig. 1), and is part of the larger Passaic River basin. The headwaters of the Rockaway River are in eastern Sussex and northwestern Morris Counties. The river flows generally southwestward until it reaches the Wharton Borough area and then flows eastward, transversing the dominant northeast trending ridges. The elevations of these ridges commonly are 1,000 to 1,300 ft above sea level, whereas the elevations in stream valleys are about 500 to 700 ft above sea level.

The upper Rockaway River basin occupies 116 mi^2 upstream from Boonton Reservoir. The major tributaries to the upper Rockaway River are Green Pond Brook, Beaver Brook, and Stony Brook. The length of the Rockaway River from its source to Boonton Reservoir is about 31 mi (fig. 1). The average streambed slope of this reach is about 25 ft/mi. The steepest slopes, about 50 to 75 ft/mi, are found upstream from Longwood Lake and in the area of the Town of Boonton. The smallest slopes, about 5 to 20 ft/mi, are found between the Town of Dover and Boonton Township. Selected views of the Rockaway River at five locations are shown in figure 2.



Base from U.S. Geological Survey, 1:24,000 quadrangles.
Boonton, 1943; Dover, 1943; Franklin, 1954; Mendham, 1954;
Morristown, 1954; Newfoundland, 1954

Figure 1.--Location of Rockaway River basin, New Jersey.

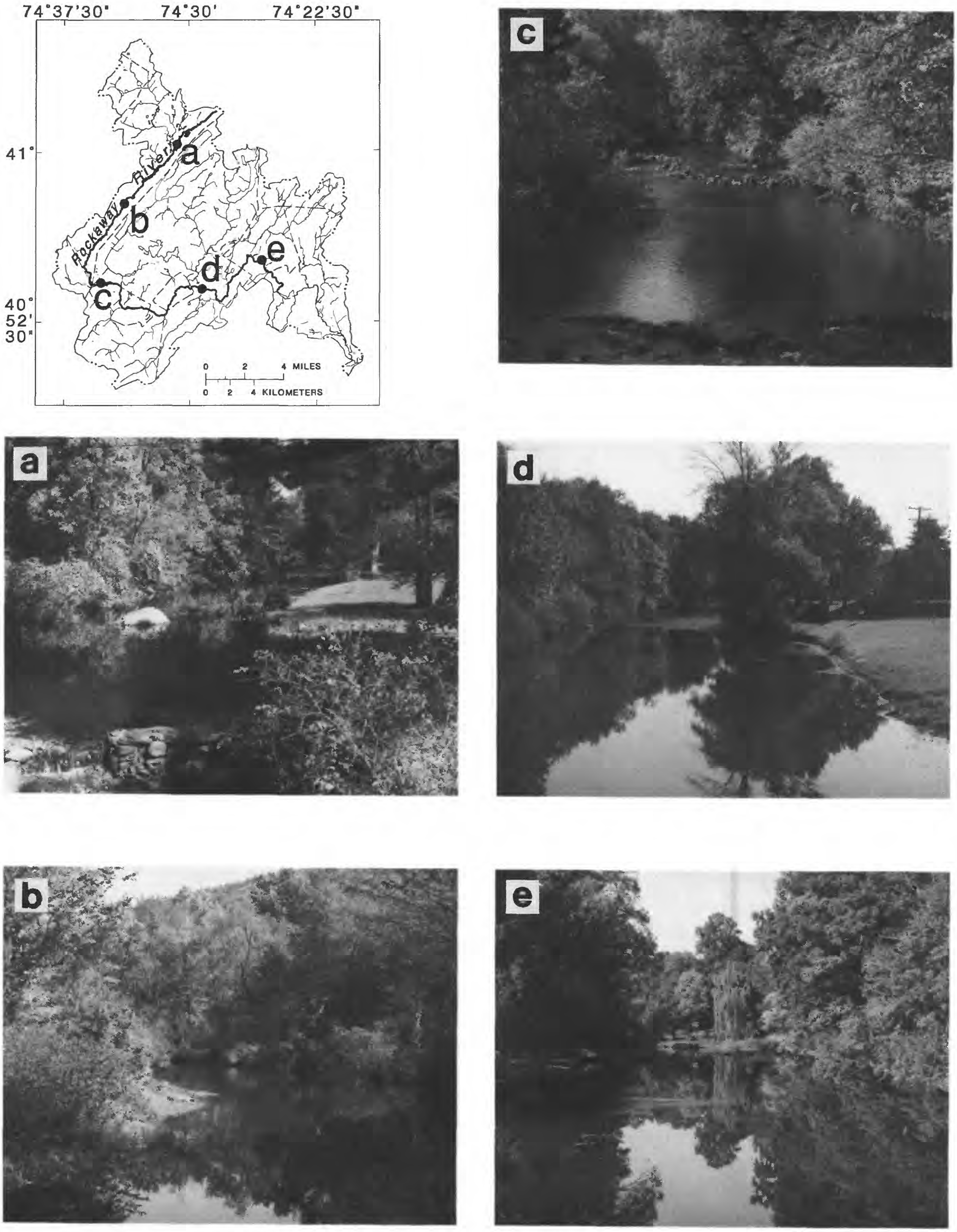


Figure 2.--Selected views of the Rockaway River: a, View upstream from Cozy Lake Road near Petersburg; b, View upstream from Taylor Road, Jefferson Township; c, View upstream from West Central Avenue near Wharton; d, View downstream from Savage Avenue at Denville; and e, View downstream from Powerville Road at Powerville.

The distribution of land-use types in the study area is related to the topography. The upland areas are mostly forested, whereas the lowlands are primarily residential, commercial, and industrial. The major urban centers include the Boroughs of Wharton and Rockaway; the Towns of Dover and Boonton; and Rockaway, Denville, and Boonton Townships.

Climate and Precipitation

The upper Rockaway River basin has a continental climate with moderately cold winters and warm or hot summers. The coldest months are December, January, and February, when average temperatures are near the freezing point. The warmest months are July and August, with average temperatures of about 71 to 73 °F. Average annual air temperature during 1951-80 was 50.3 °F at the Boonton 1SE weather station (fig. 3) (National Oceanic and Atmospheric Administration, 1982).

The study period, October 1984 through September 1986, comprises two water years[3], 1985 and 1986. At the Boonton 1SE weather station, average annual air temperature for the 1985 and 1986 water years was 51.5 °F and 50.6 °F, respectively--both near the 30-year normal. The largest departures from the monthly normals during the 2 years occurred in consecutive months, December 1984 and January 1985, with values of +6.2 °F and -2.8 °F, respectively.

Average annual precipitation in the study area during 1951-80 was 49.68 in. (National Oceanic and Atmospheric Administration, 1982). This average is based on precipitation measurements at three rain-gaging stations--Boonton 1SE, Morris Plains 1W, and Oak Ridge Reservoir. A fourth station in the study area, West Wharton, was activated in 1961 (fig. 3).

Average annual precipitation during water years 1985 and 1986 for the four stations shown in figure 3 was 42.70 and 48.26 in., respectively. Precipitation generally is evenly distributed throughout the year, but marked variations sometimes occur from month to month. During the study period, monthly precipitation varied from a low of 1.11 in. in April 1985 to a high of 7.67 in. in November 1985.

Geohydrologic Setting

The study area lies within the New England physiographic province, a belt of rugged topography approximately 15 to 20 mi wide that crosses north-central New Jersey in a northeast-southwest direction. The New England physiographic province is known locally as the New Jersey Highlands.

Bedrock Geology

The New Jersey Highlands are underlain primarily by erosion-resistant, highly metamorphosed Precambrian granite and gneiss and consists of ridges separated by narrow valleys. Several long ridges and valleys within the province are underlain by a belt of sedimentary rocks of Paleozoic age.

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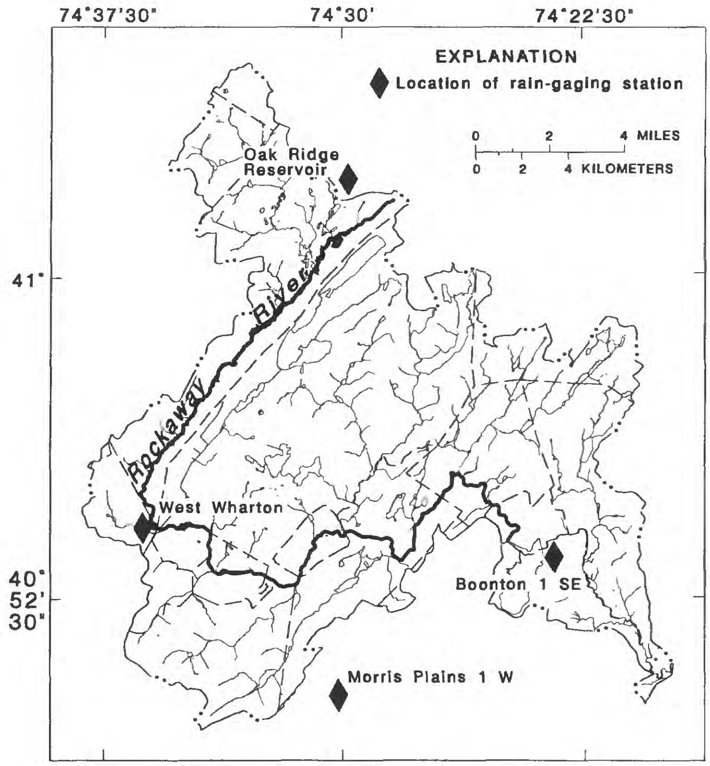
[3] A water year is the 12-month period from October 1 through September 30. It is designated by the calendar year in which it ends.



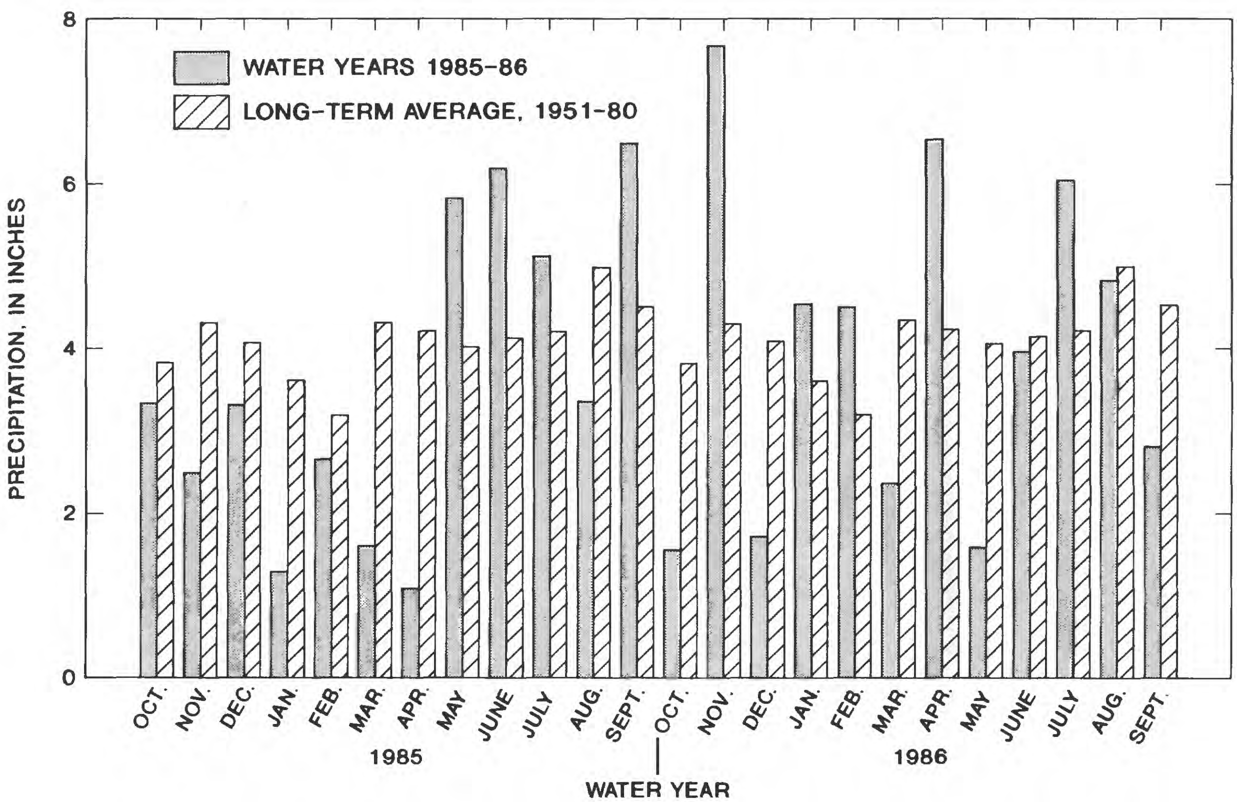


Figure 3.--Monthly average precipitation during the study period compared to 30-year average (1951-80) at Boonton, Morris Plains, Oak Ridge Reservoir, and West Wharton rain-gaging stations. (Data from National Weather Service. The 1951-80 long-term average does not include data from the West Wharton station, which was established in 1961.)

In the study area, the Paleozoic rocks lie within the Green Pond outlier, which is a 1- to 4-mi-wide, structurally complex belt of Paleozoic shales, carbonates, sandstones, and conglomerates. The shales, carbonates, and sandstones underlie Berkshire and Green Pond Valleys; conglomerate underlies Bowling Green, Copperas, and Green Pond Mountains.

The lower Rockaway River basin, which is outside the study area described by this report, is in the Piedmont physiographic province. Rocks in this province are primarily shale, sandstone, siltstone, argillite, mudstone, conglomerate, and interbedded basalt.

Table 1 lists the stratigraphic relations, lithologic properties, and geohydrologic characteristics of the geologic units within the Rockaway River basin, and figure 4 shows the generalized bedrock geology.

Glacial Deposits

Glacial deposits in the study area include till, stratified sand and gravel, silts, and clays deposited during the Wisconsin glaciation between 21,000 and 15,000 years ago. In the Rockaway Valley between Wharton and Denville (fig. 1), glacial deposits of Wisconsinan age overlie till and stratified sediment deposited during the Illinoian glaciation approximately 125,000 years ago. Till was deposited directly from moving glacial ice and consists of compact, heterogeneous mixtures of particles ranging in size from boulders to clay. The hydraulic conductivity of till generally is low, but where little silt or clay is present, till can yield sufficient water for domestic use (Canace and others, 1983, p. 13).

Stratified sands and gravels were deposited by glacial meltwater. Sediments deposited in the immediate vicinity of a glacier commonly are highly variable in size both vertically and horizontally, whereas those deposited farther from the glacier generally are more uniform in size and are finer-grained. The hydraulic conductivity of the sands and gravels also is highly variable. Well-sorted sands and gravels can yield several hundred gallons of water per minute to a well. Poorly sorted sands and gravels, in which fine particles fill the spaces between larger grains, may yield only small quantities of ground water. Fine-grained sand, silt, and clay that settled on the lake bottoms during melting of the glaciers range from thin stringers within sand and gravel deposits to continuous layers up to several tens of feet thick. The thicker, more continuous deposits restrict ground-water flow and may constitute confining layers separating more permeable water-bearing zones from other water-bearing zones or from surface water (Canace and others, 1983, p. 13).

Glacial deposits are thin or absent in upland parts of the study area. Where present, upland glacial deposits commonly are poorly sorted. Valley-fill sediments occupy preglacial and glacially deepened river valleys. The thickness of these deposits in the study area is greater in the centers of the valleys than at the edges. Thicknesses at the valley centers generally are 100 to 200 ft throughout the study area, but exceed 250 ft in Roxbury Township and 350 ft at Mountain Lakes (A.D. Gordon, U.S. Geological Survey, written commun., 1990). The approximate extent of the valley-fill deposits is shown in figure 6. Geologic sections through the valley-fill deposits are shown in Stanford (1989a, 1989b).

Table 1.--Stratigraphic, lithologic, and geohydrologic characteristics of geologic units in the Rockaway River basin

Geochronologic unit: Era	Period	Epoch	Rock-stratigraphic unit: Lithologic unit	Maximum thickness (feet)	Lithology	Geohydrologic characteristics
CENOZOIC	Quaternary	Holocene	Alluvium	10±	Generally dark brown to light gray, silt and fine sand. Minor clay and pebble to cobble gravel. Variable amounts of organic matter.	Too thin to be tapped by wells.
			Swamp and marsh deposits	30	Typically gray silt and clay basal layer, overlain by brown peat and capped by dark-brown to black muck and organic silt.	Permeability rapid along organic layers; as a whole, however, unsuitable for a water source.
			Talus	20±	Angular boulders of bedrock forming steep apron along base of cliffs.	Generally unsaturated deposits.
		Pleistocene	Stratified drift	300+	Generally moderately sorted sediment deposited by glacial meltwater in glacial lakes and outwash plains. Grain size ranges from clay to boulders. Clast lithology generally reflects local bedrock. Stratification common. Deposits commonly exhibit complex local variation both vertically and laterally.	Yields depend on degree of sorting and grain size. Well-sorted and coarse-grained deposits are good aquifers with yields up to 1,500 gallons per minute. Clay- and silt-rich deposits are generally unsuitable as aquifers.
			Unstratified drift	150+	Generally very poorly sorted, compact sediment deposited in thin veneer over bedrock. Grain size from clay to boulders but matrix is generally silty sand to sandy silt. Clast lithology generally reflects local bedrock. Thicker beds in terminal moraine.	Yields depend on degree of sorting and packing; however, till in terminal moraine sometimes acts as a confining unit.
					UNCONFORMITY	
MESOZOIC	Jurassic	Early	Brunswick Group, undivided sedimentary rocks	6,000-8,000	Red, brown, gray, and black siltstone, sandstone and conglomerate. Siltstone predominates with sandstone and conglomerate more abundant toward the west near the border fault. Minor evaporitic beds.	Moderate to large yields up to 400 gallons per minute from numerous fractures. Artesian conditions common, particularly in low-lying areas overlain by glacial clays.
			Brunswick Group, undivided basalt flows	300	Fine-grained basalt.	Generally low yields, less than 50 gallons per minute, from fractures.
					UNCONFORMITY	
PALEOZOIC	Devonian	Middle	Bellvale Sandstone	600	Interbedded black shale, black siltstone, and flaggy, medium-gray sandstone.	Generally low to moderate yields from fractures. Significant faulting or other structural features may increase yields to 425 gallons per minute.
			Marcellus Shale	2,000	Very dark gray, thickly bedded, slightly silty shale with prominent slaty cleavage.	Generally low yields, less than 16 gallons per minute, from fractures.
		Early	Kanouse Sandstone	215	Interbedded fine-grained, gray quartz-cemented conglomerate and sandstone. Some pelmatozoan ossicles comprise 10 to 20 percent of the rocks.	Generally low yields from fractures. No reported wells in the basin.
					UNCONFORMITY	

Table 1.--Stratigraphic, lithologic, and geohydrologic characteristics of geologic units in the Rockaway River basin--Continued

					UNCONFORMITY	
PALEOZOIC	Silurian	Late	Decker Formation	50	Predominantly a gray or greenish gray, fossiliferous, calcareous siltstone with abundant lenses, and beds of gray, fossiliferous dolomite. Bryozoans, brachiopods.	Generally low yields from fractures and solution cavities. No reported wells in the basin.
			High Falls Formation	350	Soft, purple-red, silty shale with some slaty cleavage. Thin red sandstone beds present in lower portion.	Generally very low yields from fractures. No reported wells in the basin.
		Middle & Early	Green Pond Conglomerate	1,500	Coarse conglomerate with predominantly white quartz pebbles in a purple-red matrix interbedded with and grading upward into quartzite and sandstone. Matrix may also be gray, green, or white. Massive bedding.	Generally low yields, less than 20 gallons per minute, from fractures.
					UNCONFORMITY	
	Ordovician	Late & Middle	Martinsburg Formation	3,000	Fine, dark-gray shale, slate, siltstone and sandstone. Prominent slaty cleavage. Siltstone weathers to orange-buff.	Generally low yields from interconnecting fractures. No reported wells in the basin.
					UNCONFORMITY	
	Cambrian	Middle & Early	Leithsville Formation	1,000+	Massive, slightly fossiliferous, light to medium gray, fine-to medium-grained dolomite and calcitic dolomite. Weathers to yellow-buff.	Generally moderate yields, up to 490 gallons per minute, from fractures and solution cavities.
		Early	Hardyston Quartzite	200	Blue-gray, quartz-pebble conglomerate, orthoquartzite and calcareous sandstone.	Low yields, less than 10 gallons per minute, from fractures.
					UNCONFORMITY	
PRECAMBRIAN			Amphibolite	Unknown	Brownish to dark-gray, medium-grained gneiss. Composed of about equal proportions of plagioclase feldspar, commonly andesine, and mafic minerals (hornblende, augite, and hypersthene). Generally uniform but locally layered. Found as inclusions in igneous rocks and as discrete layers associated with gneisses.	Some studies have shown that these lithologic units can have different water-bearing properties; however they generally are considered to have similar hydrologic characteristics. Yields generally are low, from fractures.
			Alaskite	do	White, tan, or buff, medium- to coarse-grained granite. Composed primarily of microperthite, quartz, and plagioclase with hornblende, augite, and biotite as variable minor constituents. Poor to excellent foliation.	
			Pyroxene gneiss	do	Typically green to grayish-green gneiss. Composed primarily of plagioclase or scapolite and diopside or augitic diopside. Sphene and quartz are common accessory minerals. Ranges from uniform to distinct compositional layering of alternating light and dark minerals. Forms layers and lenses intercalated with other metasedimentary rocks.	
			Quartz-oligoclase-biotite gneiss	do	Greenish-gray, medium-grained gneiss. Composed primarily of quartz, oligoclase and biotite with locally abundant magnetite. Moderate or large scale layering.	
			Hypersthene-quartz-andesine gneiss	do	Greenish-gray, dark-gray or brownish-gray gneiss. Composed primarily of andesine, quartz, and hypersthene. Clinopyroxene, hornblende, and biotite are usually present. Compositionally layered, producing dark and light bands.	
			Hornblende granite	do	Buff, locally pinkish to whitish, medium- to coarse-grained granite. Composed primarily of microperthite, oligoclase, quartz, and hornblende. Found in large, massive-appearing bodies.	
			Hornblende gneiss	do	Gray, buff, or greenish-gray gneiss with pronounced gneissic foliation. Composed primarily of quartz, microcline, albite, or oligoclase, and hornblende. Found generally in long planar features.	

Modified from Gill and Vecchioli, 1965, table 3; Lyttle and Epstein, 1987; Olsen, 1980; Sims, 1958, pl. 1; and Stanford, 1989a, 1989b. Estimated well yields from U.S. Geological Survey Ground Water Site Inventory data base.

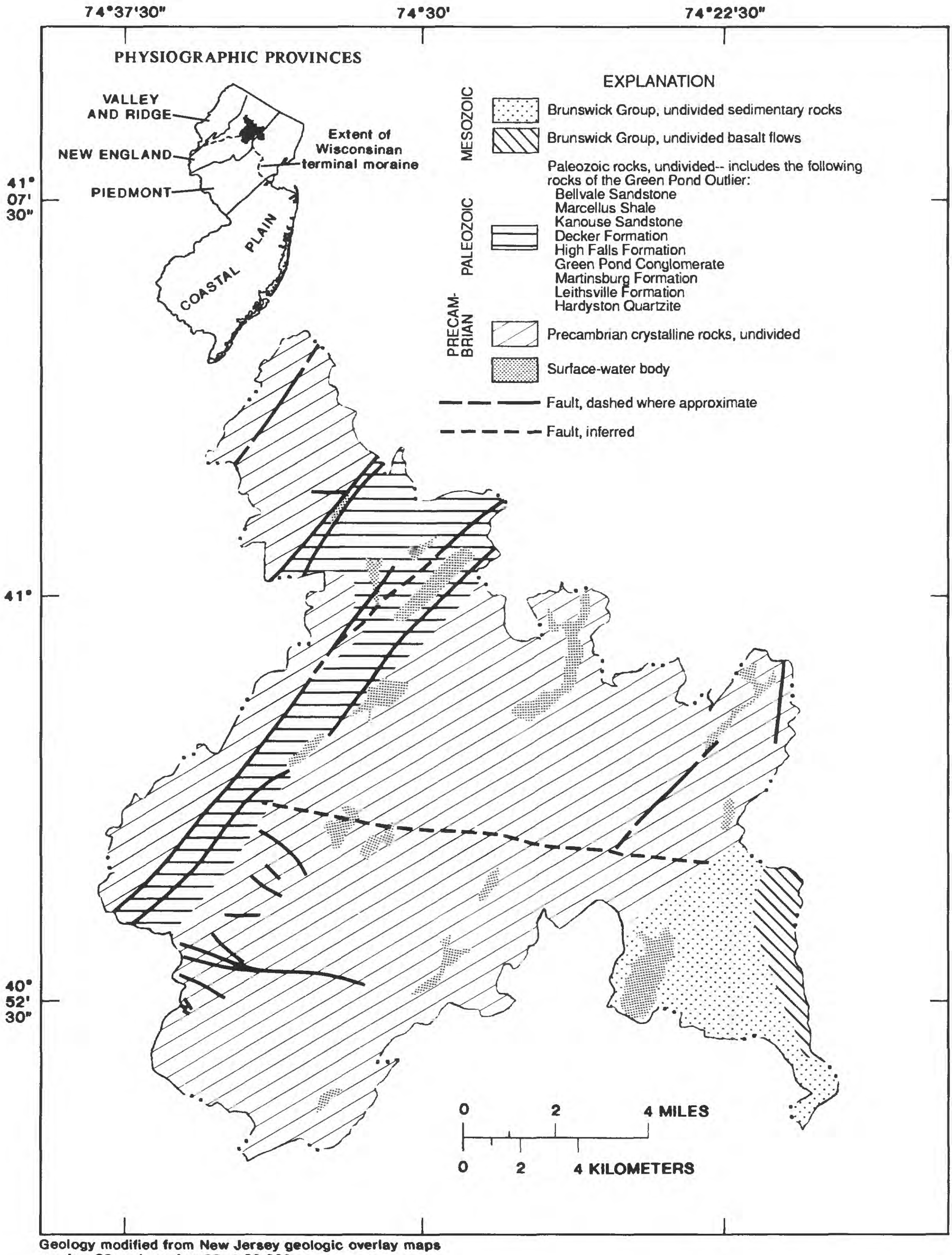


Figure 4.--Generalized bedrock geology of the upper Rockaway River basin and physiographic provinces of New Jersey.

Geohydrology

The following discussion of the geohydrology of the study area is from Gill and Vecchioli (1965, p. 16-18 and 26). Nearly all ground water in the study area originates from local precipitation. Much of the precipitation either flows overland directly to the streams or is retained in the soil, from which it is returned to the atmosphere by evapotranspiration. The remaining precipitation percolates through the soil to become ground water.

Ground water occurs under unconfined or water-table conditions throughout the study area; however, in much of the lowland areas, the consolidated rocks are covered by unconsolidated deposits that contain one or more relatively impermeable clay and silt beds. The impermeable layers confine the water in the underlying permeable zones, which consist of sand and gravel deposits and the consolidated rocks. Wherever such confinement exists, water beneath the confining layers is under hydrostatic pressure.

Ground water moves in response to hydraulic gradients. In the study area, the direction and magnitude of the natural gradients are controlled largely by the topography, so that the resulting water-table profile is a subdued representation of the surface topography. Water that enters the ground-water body in the upland recharge areas, where the water table is at relatively higher elevations, moves slowly toward the intervening stream channels lying at lower elevations. Ground water is discharged directly to the streams wherever they intersect the water table and supports streamflow during dry periods.

In addition to the natural discharge of ground water by seepage into streams and by evapotranspiration, ground water is discharged artificially by pumping from wells. In the undeveloped parts of the study area, the pumping has not been of sufficient magnitude or concentration to affect significantly the natural pattern of ground-water flow. In some places of continuous heavy withdrawals, however, the hydrostatic head has been lowered regionally. In some areas, wells near streams that are in hydraulic continuity with the aquifer reverse the natural gradients when they are being pumped and, thus, induce recharge from the streams.

In the area from Wharton Borough downstream to Boonton Township (fig. 1), municipal water supplies are obtained from the unconfined or confined valley-fill deposits along the Rockaway River. Under static, or nonpumping, conditions, the movement of ground water is toward the river. Under pumping conditions, the gradient is reversed and water moves from the Rockaway River toward the pumped wells.

Water Use

Surface- and ground-water supplies are used in the upper Rockaway River basin. The largest surface-water diversion is from Boonton Reservoir for the municipal supply of Jersey City, which is outside the basin. Much smaller volumes of water are diverted from Taylortown Reservoir for the Town of Boonton.

Ground water is the major source of supply within the basin. Most withdrawals are from the valley-fill aquifers (fig. 5). The municipalities that pump the most ground water (1985)--Town of Boonton, Denville Township, Town of Dover, Randolph Township, Rockaway Township, Rockaway Borough, Mountain Lakes Borough, and Wharton Borough--all obtain large amounts of water from these aquifers. The Town of Boonton owns and operates a well field in Boonton Township. Withdrawals for Randolph Township are for the entire Township, although only part of the Township is located within the basin. These withdrawals are important because almost all withdrawals in the Township are from the valley-fill aquifers. Because these aquifers are areally extensive and hydraulically connected, ground-water withdrawals outside the basin affect ground-water supplies within the basin.

Although withdrawals from the bedrock aquifers are much less than those from the valley-fill aquifers, both Jefferson and Montville Townships withdraw part of their water supply from bedrock aquifers. Most withdrawals from bedrock in the basin are from aquifers in the Jurassic rocks; smaller amounts are withdrawn from aquifers in the Precambrian and Devonian rocks.

Table 2 lists surface-water diversions and reported ground-water withdrawals by municipality for 1960, 1975, 1980, and 1985. All municipalities listed are in Morris County. No major ground-water withdrawals are known for the Sussex County part of the basin. Reported ground-water withdrawals include only the major public suppliers because water-use data currently (1990) are unavailable for domestic, industrial, agriculture, and commercial withdrawals.

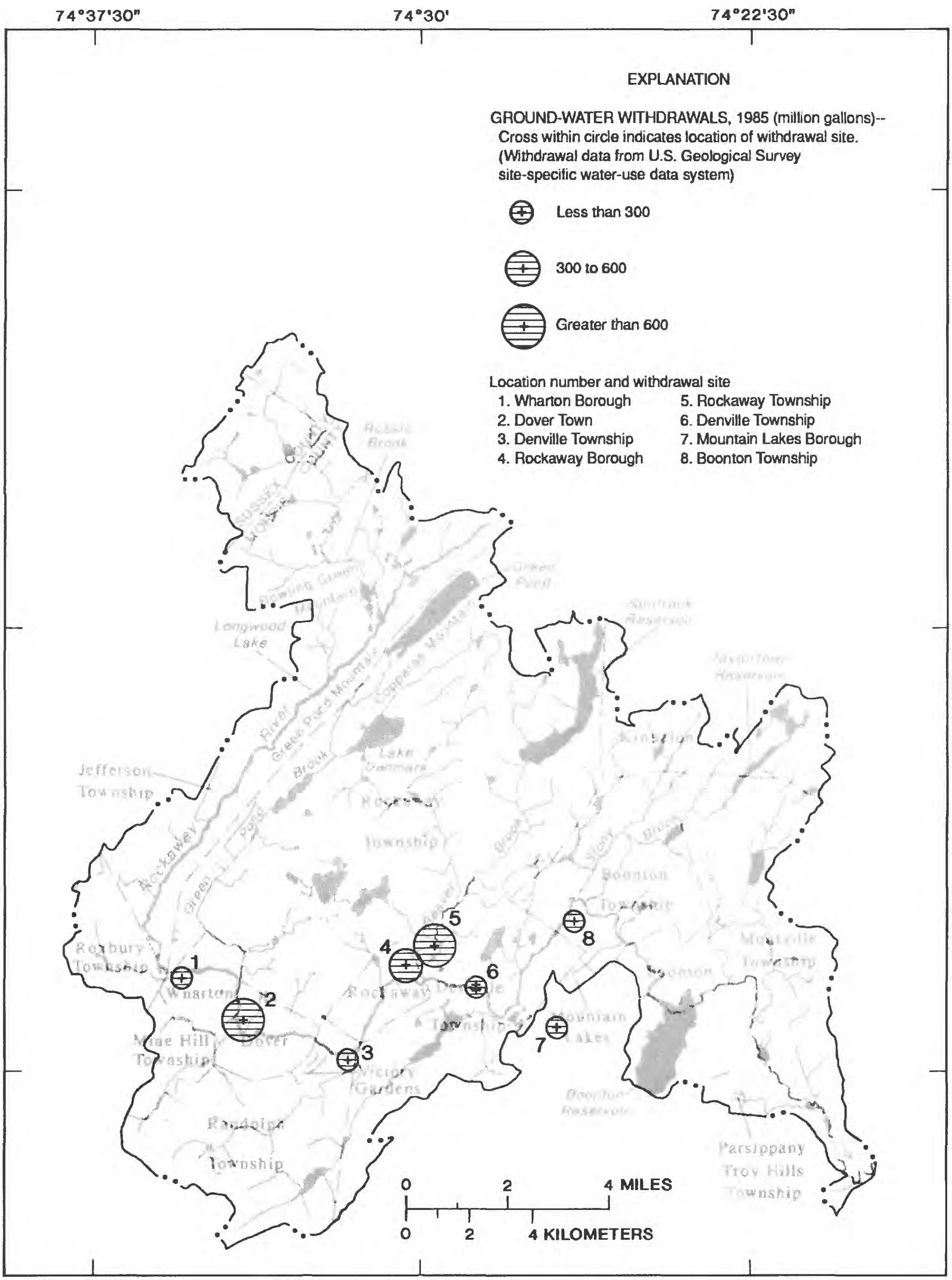
Total annual water use increased by 4,984 Mgal from 1960 to 1985. Diversions from Boonton and Taylortown Reservoirs during this period increased 3,167.2 Mgal. Reported ground-water withdrawals rose from 3,296.6 Mgal in 1960 to 5,113.4 Mgal in 1985, an increase of 1,816.8 Mgal. Ground-water withdrawals and surface-water diversions for 1980 and 1985 reflect imposed drought restrictions.

METHODS OF STUDY

From October 1984 through September 1986, water levels were measured in 61 wells, stream discharge was measured at 46 sites, and water-quality samples from 29 wells and 15 stream sites were collected and analyzed in the 116-square-mile study area. In addition, streambed material was sampled at seven sites and stream biology was assessed at eight sites.

Ground-Water Levels

Water levels were measured in 61 observation wells in the study area (fig. 6); 53 of these wells tap the valley-fill aquifers and 8 tap bedrock aquifers. Observation wells were selected on the basis of aquifer tapped, areal distribution, distance from pumped wells, and accessibility. A disproportionate number of wells in valley-fill aquifers were measured to facilitate the construction of water-table and potentiometric-surface maps for this aquifer system.



Base from U.S. Geological Survey, 1:24,000 quadrangles, Boonton, 1943; Dover, 1943; Franklin, 1954; Mendham, 1954; Morristown, 1954 and Newfoundland, 1954

Figure 5.--Locations of major ground-water withdrawals from valley-fill aquifers.

Table 2.--Diversions from reservoirs and withdrawals from aquifers for public water supplies in the upper Rockaway River basin

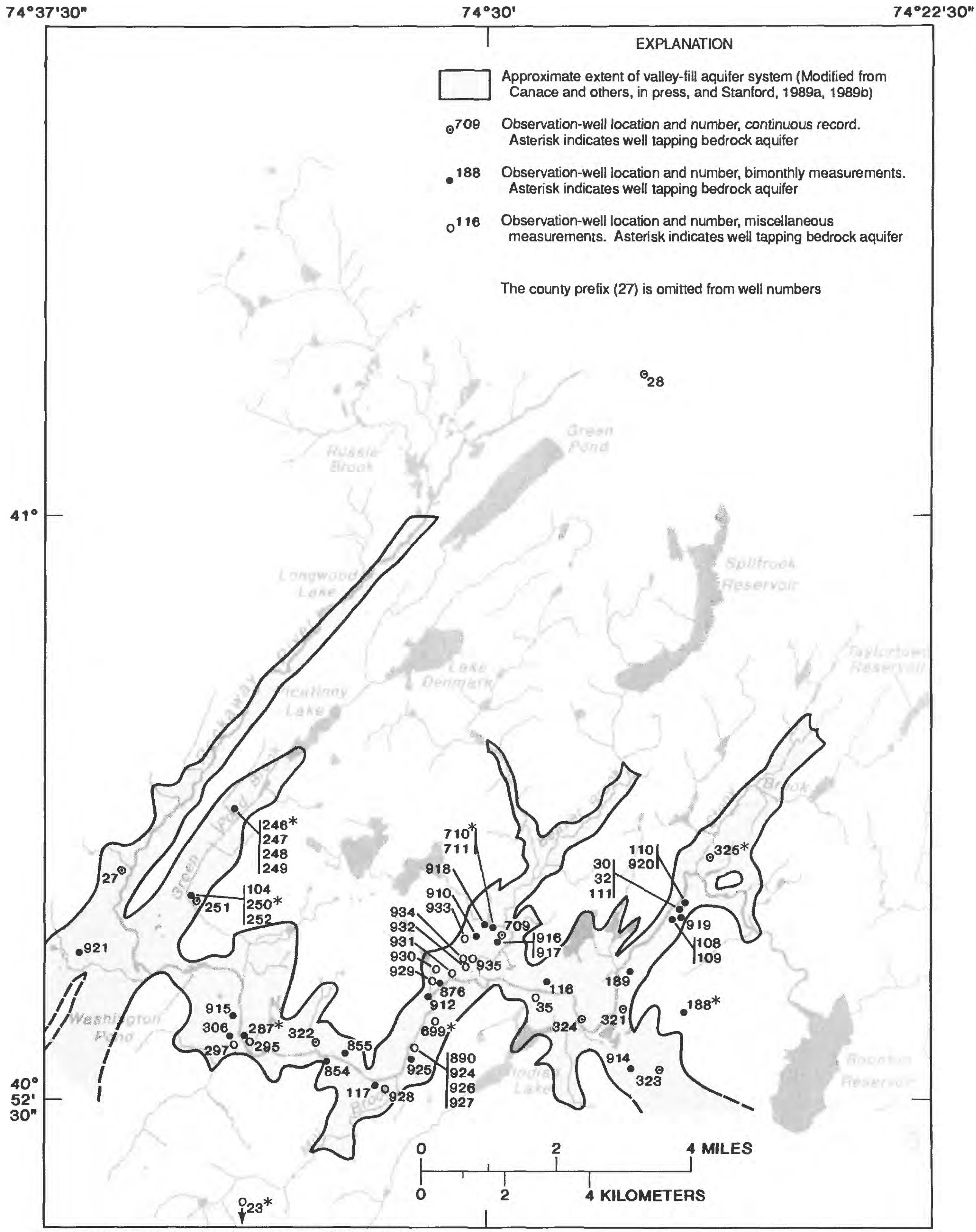
[Data in million gallons per year; ND, no data]

	1960	1975	1980	1985	Net change 1960-85
Surface-water diversions[1]					
Reservoir					
Boonton	20,985.3	23,837.0	21,497.2	23,981.6	
Taylortown	47.3	67.3	113.5 (1979)	218.2	
Total	21,032.6	23,904.3	21,610.7	24,199.8	+3,167.2
Ground-water withdrawals[2]					
Municipality					
Boonton Township[3]	501.5	330.1	301.1	297.0	
Denville Township	602.2	388.6	386.4	393.6	
Dover Town	920.5	967.2	1,150.3	1,118.2	
Jefferson Township	113.2	ND	ND	179.5	
Montville Township	173.0	75.1	343.5	372.9	
Mountain Lakes Borough	7.3	163.2	218.9	222.1	
Randolph Township	156.6	364.5	247.1	1,071.4	
Rockaway Borough	332.9	425.6	513.2	464.2	
Rockaway Township	296.0	454.5	455.7	733.0	
Wharton Borough	193.4	231.4	249.1	261.5	
Total	3,296.6	3,400.2	3,865.3	5,113.4	+1,816.8

1 Data from U.S. Geological Survey files.

2 Data for 1960 from Gill and Vecchioli (1965); data for 1975-85 from U.S. Geological Survey site-specific water-use data system.

3 Withdrawals from wells in Boonton Township are by the Town of Boonton.



Base from U.S. Geological Survey, 1:24,000 quadrangles.
Boonton, 1943; Dover, 1943; Franklin, 1954; Mendham, 1954;
Morristown, 1954 and Newfoundland, 1954

Figure 6.--Locations of ground-water-level measurement sites and approximate extent of the valley-fill aquifer system.

Most well information was obtained from well permits and records from the NJDEPE geologic study of the area (Canace and others, in press). All well-site and -construction data were then entered into the USGS Ground Water Site Inventory data base. These data are given in table 3 (at end of report).

Water-level data, collected during a 1-1/2-year period, include continuous water levels (measured with recorders) in 9 wells, manual bimonthly measurements in 35 wells, and 1 to 4 measurements each in 17 wells. Water-level recorders were serviced bimonthly, at which time the records containing the hourly data were removed. Each set of manual bimonthly measurements was made within a 5-day period. Field personnel used either steel tapes or electric tapes to measure the depth to water. In all cases, any nearby pumped wells were shut down for a minimum of 1 hour prior to the water-level measurement. Depth-to-water measurements were converted to altitudes above sea level by running levels from geodetic benchmarks to the water-level measurement points by using standard surveying techniques.

Surface-Water Measurements

Streamflow measurements were made at 46 sites in the study area (fig. 7). Discharge-measurement sites were selected to obtain maximum geographic coverage of the Rockaway River and all major tributaries. Stream discharge was measured continuously at 2 sites; at the remaining 44 sites, streamflow was measured three times during base-flow conditions and once during storm conditions.

The Rockaway River above Reservoir at Boonton gaging station (01380500) has been in operation since 1937. Another gaging station, Rockaway River at Berkshire Valley (01379700), was constructed for this study to measure flow entering the developed part of the basin. These two gaging stations were serviced at 5- to 6-week intervals, and discharge was measured to determine the stage-discharge relation. The new gaging station and the 44 discharge-measurement sites were located within the area of the valley-fill deposits. Discharge-measurement sites on the main stem were located at points upstream and downstream from tributaries and at or near major ground-water pumping centers. Most sites on tributaries were located near the valley walls to determine the streamflow entering the area of the valley-fill aquifer system.

Seepage runs were performed to identify gaining and losing reaches of streams and to determine variations in discharge during periods of base flow. Seepage runs consist of numerous discharge measurements made along a stream over a short period of time, generally 1 to 2 days, and are conducted during dry periods with no overland runoff. Gaining stream reaches contain progressively larger discharges downstream, whereas discharges in losing stream reaches decrease downstream. Gaining reaches are the result of ground-water flow into the stream. Gaining reaches are prevalent in the study area under natural conditions. Losing reaches are the result of induced flow from the stream into the ground-water system, commonly because of pumping from wells.

Stream-discharge measurements and computations were done in accordance with methods outlined in Rantz and others (1982).

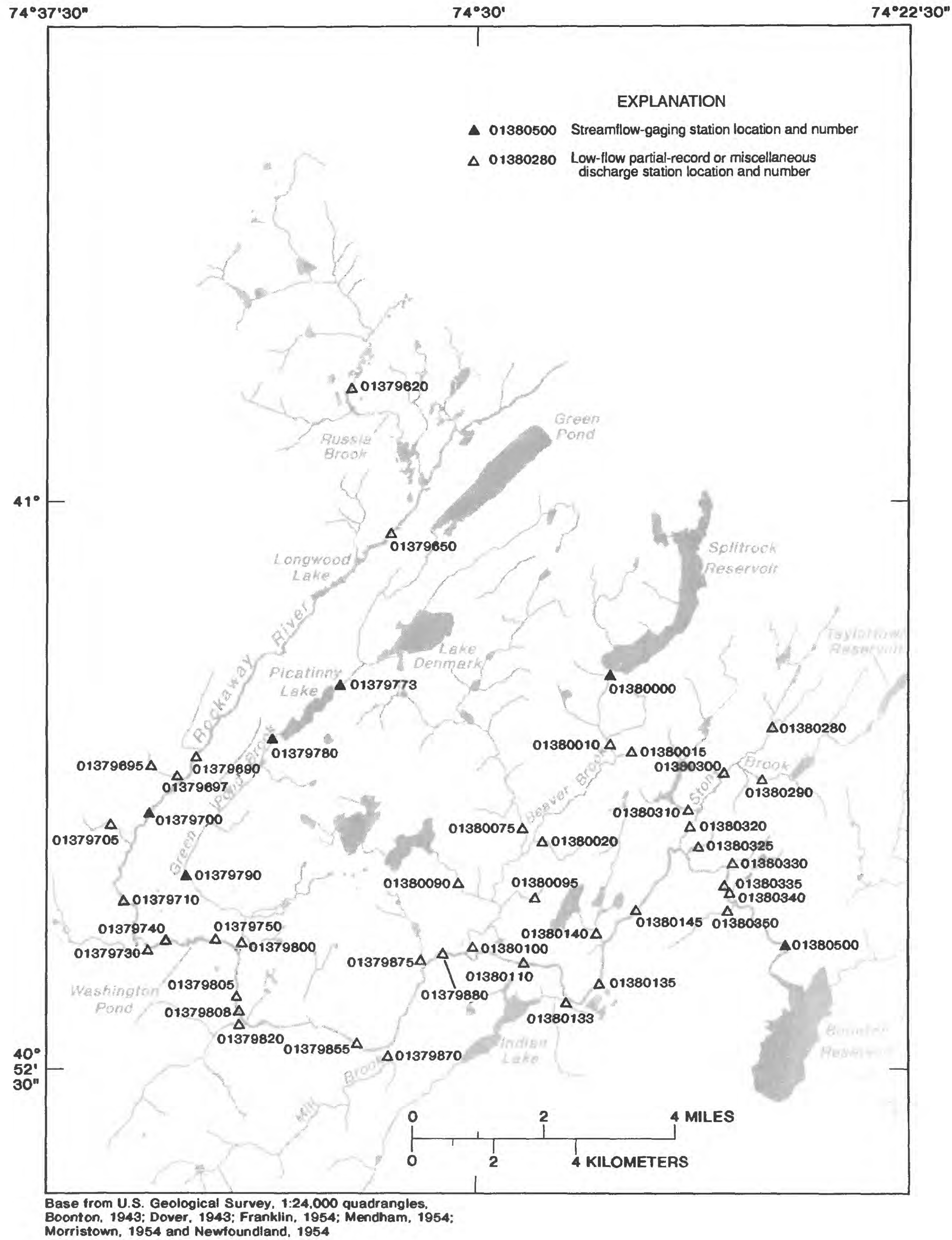


Figure 7.--Locations of surface-water measurement sites.

Water Quality

Ground- and surface-water samples collected for this investigation were analyzed for the following characteristics and constituents:

Physical and chemical characteristics	Dissolved major inorganic ions	Dissolved trace elements and compounds	Dissolved nutrients	Other organic compounds
Alkalinity (as $CaCO_3$)[1]	Calcium	Aluminum	Nitrogen, ammonia, as N	Dissolved organic carbon[2]
Bicarbonate/carbonate[1]	Chloride	Arsensic	Nitrogen, ammonia plus organic, as N	MBAS (detergents)[2]
Dissolved oxygen	Fluoride	Beryllium	Nitrogen, nitrite plus nitrate, as N	Phenols
Dissolved solids	Magnesium	Cadmium		Suspended organic carbon[2]
Hardness[1]	Potassium	Chromium		Volatile organic compounds[1]
pH	Silica	Copper	Nitrogen, nitrite, as N	
Specific conductance	Sodium	Cyanide	Orthophosphate	
Water temperature	Sulfate	Iron	Phosphorous	
		Lead		
		Manganese		
		Mercury		
		Nickel		
		Selenium		
		Zinc		

[1]Constituent or characteristic determined in ground-water samples only

[2]Constituent or characteristic determined in surface-water samples only

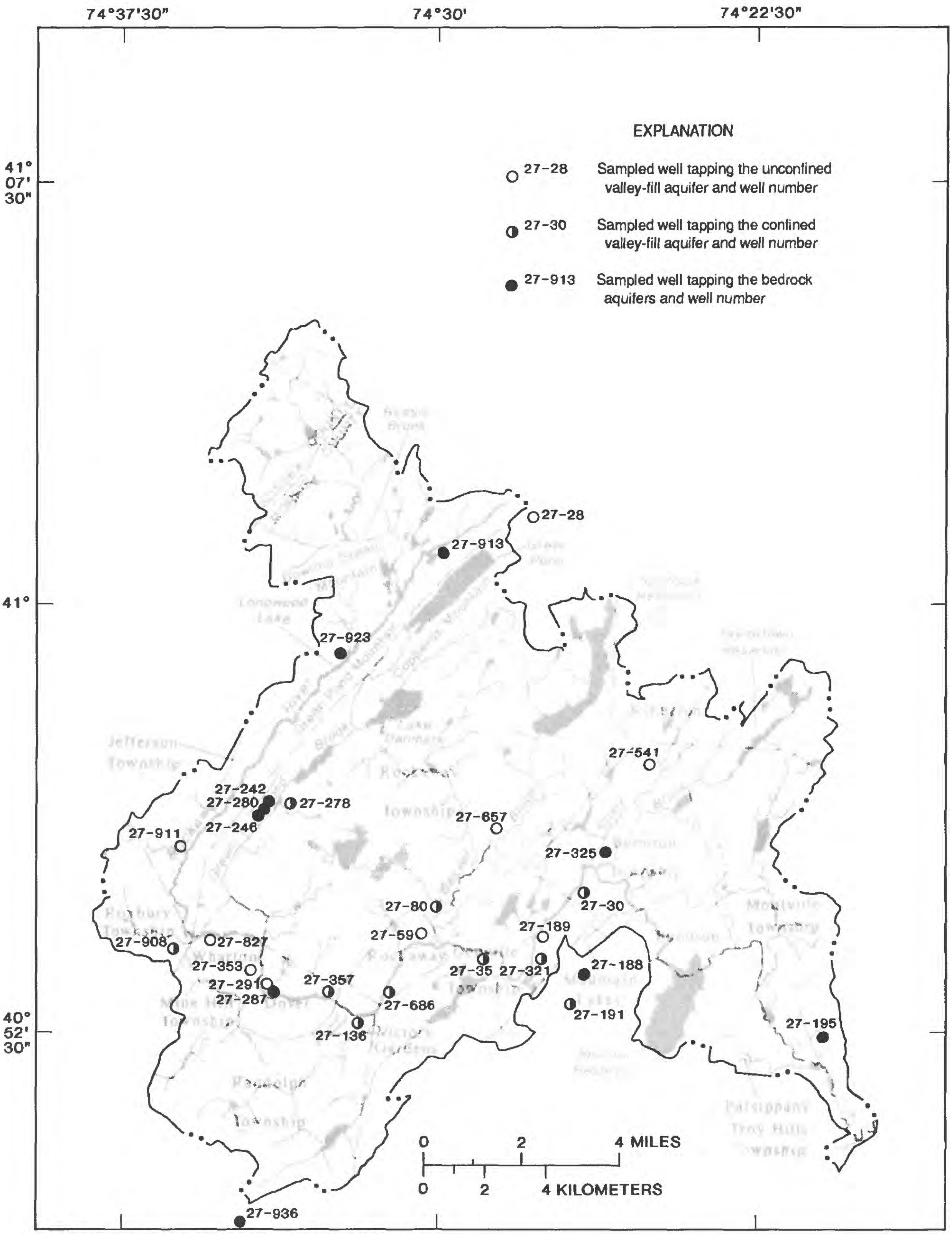
Ground Water

Water-quality samples were collected from 29 wells in the study area (fig. 8); well-site and -construction data are given in table 3 (at end of report). Wells for sampling were selected to maximize geographic coverage and to include at least one well that taps each major aquifer. In addition, sampling priority was given to high-yield production wells because these wells intercept large volumes of water and, therefore, are assumed to be representative of the average quality of water in the vicinity (Wood, 1976). Where no production wells were available for sampling, domestic or observation wells were sampled.

Ground-water samples were collected from November 1985 to February 1986. Most water samples were from wells tapping valley-fill aquifers. In order to ensure that water from a variety of lithologic types was represented, three wells sampled in August 1985 as part of other USGS studies in the Rockaway River basin were integrated into this study. The number of wells sampled in each geologic unit is shown below:

Geologic unit	Number of samples
Quaternary valley-fill deposits	19
Brunswick Group, undivided basalt flows	1
Bellvalle Sandstone	1
Marcellus Shale	1
Leithsville Formation	[1]2
Hardyston Quartzite	[1]1
Precambrian gneiss	4

[1] Wells sampled as part of other USGS studies in the Rockaway River basin



Base from U.S. Geological Survey, 1:24,000 quadrangles, Boonton, 1943; Dover, 1943; Franklin, 1954; Mendham, 1954; Morristown, 1954 and Newfoundland, 1954

Figure 8.--Locations of ground-water-quality sampling sites.

Prior to sampling, the wells were pumped and the characteristics of the well water were monitored until chemical stability was reached to ensure that the sample collected was representative aquifer water. The following water-quality characteristics were monitored: water temperature, pH, specific conductance, and dissolved oxygen concentration. Chemical stability was assumed when three successive measurements of each characteristic made at intervals of 5 minutes or more differed by less than the values specified in the USGS New Jersey District Quality Assurance Plan (M.A. Hardy, U.S. Geological Survey, written commun., 1986). A minimum of three casing volumes of water was pumped from each well. Production wells that were in regular use did not require much pumping to reach chemical stability; nevertheless, three casing volumes of water were withdrawn to ensure the collection of a representative sample. For many wells, the amount of pumping required to attain chemical stability exceeded that required to remove three casing volumes of water.

After chemical stability had been attained, samples were collected as close to the well head as possible and before any filters or pressure tanks. The techniques used are outlined in Wood (1976) and in the USGS New Jersey District Quality Assurance Plan (M.A. Hardy, U.S. Geological Survey, written commun., 1986). Production wells were sampled with the pumps that were in place. Water from observation wells was sampled for analysis for inorganic constituents by using a portable stainless-steel submersible pump with a polyvinyl-chloride (PVC) discharge line. Samples for analysis for organic constituents were collected from observation wells by using a Teflon[4] bailer that had ball valves at the top and bottom. The sampling device was positioned inside the well just above the well screen or just above the bottoms of the wells without screens.

Analysis of samples for certain constituents required some combination of filtering, preserving, and chilling in the field. Samples to be analyzed for dissolved trace elements and compounds were filtered through a 0.45-μm (micrometer) filter and acidified with nitric acid to a pH of 2.0 or lower. Treatment of samples to be analyzed for cyanide included the addition of sodium hydroxide to a pH of 12.0 and chilling to 4 °C (degrees Celsius). In order to determine the concentrations of nitrogen and phosphorus species, samples were filtered and preserved in opaque bottles with mercuric chloride and were chilled at 4 °C. Samples to be analyzed for dissolved organic carbon were filtered through a 0.45-μm silver filter into a glass bottle and chilled at 4 °C. Treatment of samples to be analyzed for phenols included acidification and the addition of copper sulfate. Samples to be analyzed for VOC's were collected in 40-mL (milliliter) glass septum bottles and chilled at 4 °C.

Most samples were then shipped to the USGS National Water-Quality Laboratory in Arvada, Colorado, for analysis. Concentrations of inorganic constituents were determined by using the methods of Fishman and Friedman (1989). Organic constituents (organic carbon, organic nitrogen, and phenols) were determined by using the methods of Wershaw and others (1987).

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[4] The use of brand, trade, or firm names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

In addition, samples were nonquantitatively screened for VOC's by means of gas chromatography with a photoionization detector and a Hall detector in series in the New Jersey District Laboratory (Kammer and Gibs, 1989).

Surface Water

Water-quality samples were collected at 15 stream sites on the Rockaway River and its major tributaries (fig. 9). Sampling sites were selected on the basis of geographic coverage, land use, locations of ground-water pumping centers, and the results of an initial water-quality reconnaissance conducted to identify areas of significant water-quality variations. The sites are described in table 7 (at end of report).

Representative samples were collected by using vertical and horizontal integrating techniques as described in Guy and Norman (1970). The water-quality constituents determined are listed on page 20.

Surface-water-quality samples were collected at the 15 sites during two periods of extreme discharge--base flow (October 16-17, 1984) and stormflow (November 4-5, 1985)--to bracket variations in constituent concentrations caused by changes in streamflow. The stormwater samples were collected during the initial increase in streamflow because the highest concentrations of constituents in streams frequently occur during this period. A prolonged dry period of about 30 days preceded the storm on November 4-5. In addition, monthly samples were collected from April 1985 through March 1986 at the two gaging stations on the Rockaway River, Berkshire Valley (01379700) and above Boonton Reservoir (01380500), to document seasonal variations in water quality.

Analysis of samples for certain constituents required some combination of filtering, preserving, and chilling in the field. Samples collected for analysis for dissolved trace elements and compounds were filtered through a 0.45-μm filter and acidified with nitric acid to a pH of 2.0 or lower. Treatment of samples to be analyzed for cyanide included the addition of sodium hydroxide to a pH of 12.0 and chilling to 4 °C. In order to determine concentrations of nitrogen and phosphorus species, samples were filtered and preserved in opaque bottles with mercuric chloride and chilled to 4 °C. Samples collected for analysis for dissolved organic carbon were filtered through a 0.45-μm silver filter into a glass bottle and chilled to 4 °C. Treatment of samples to be analyzed for phenols included acidification and the addition of copper sulfate.

All samples were then shipped to the USGS National Water-Quality Laboratory at Arvada, Colorado, for analysis. Concentrations of inorganic constituents were determined by the methods of Fishman and Friedman (1989); organic constituents were determined by using the methods of Wershaw and others (1987).

Streambed Material

Streambed samples were collected at seven sites on the main stem Rockaway River (fig. 10). Sampling sites were selected on the basis of locations of urban areas, waste-disposal areas, and known water-quality problems, and results of site examination for availability of sediments.

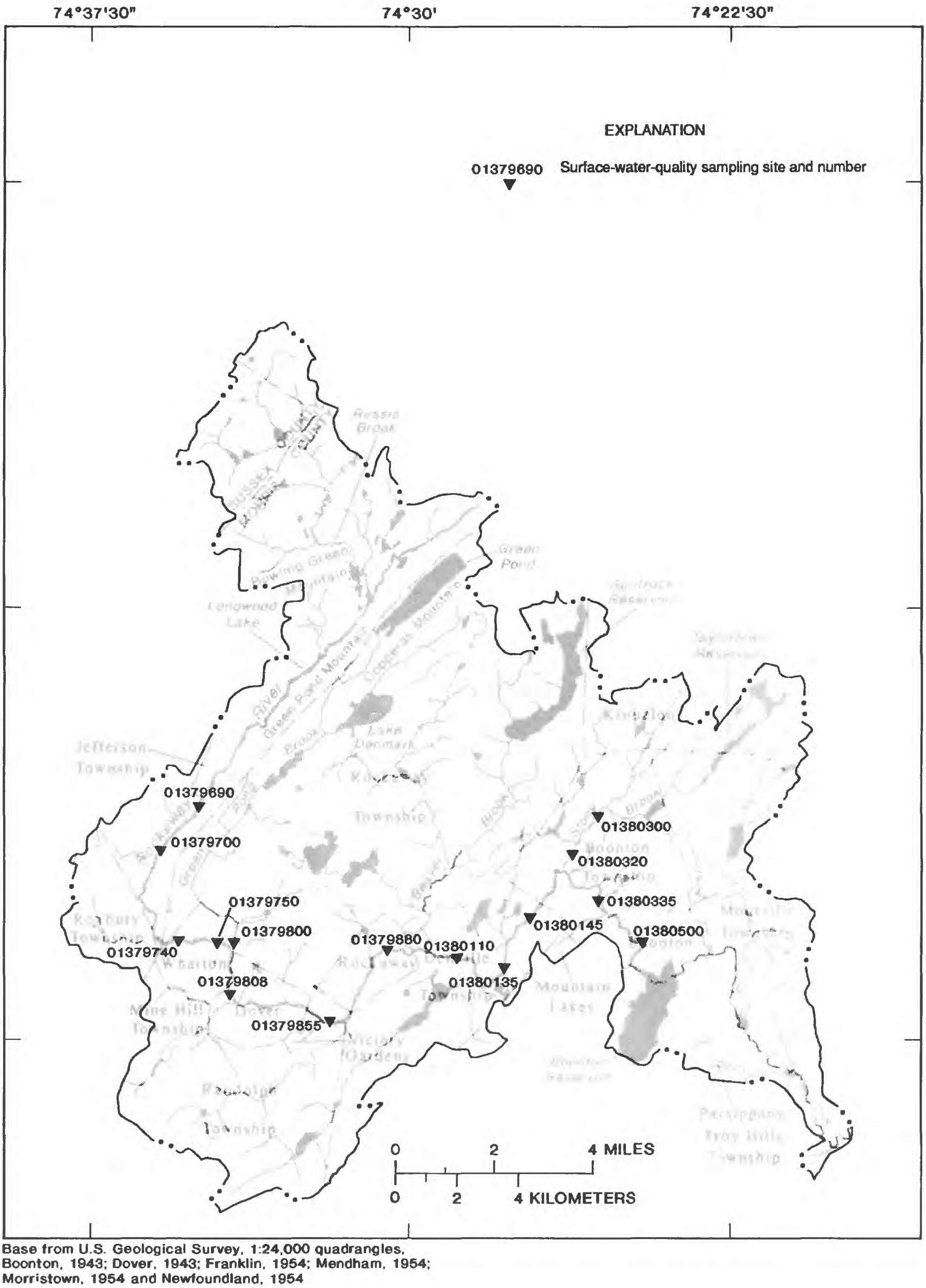


Figure 9.--Locations of surface-water-quality sampling sites.

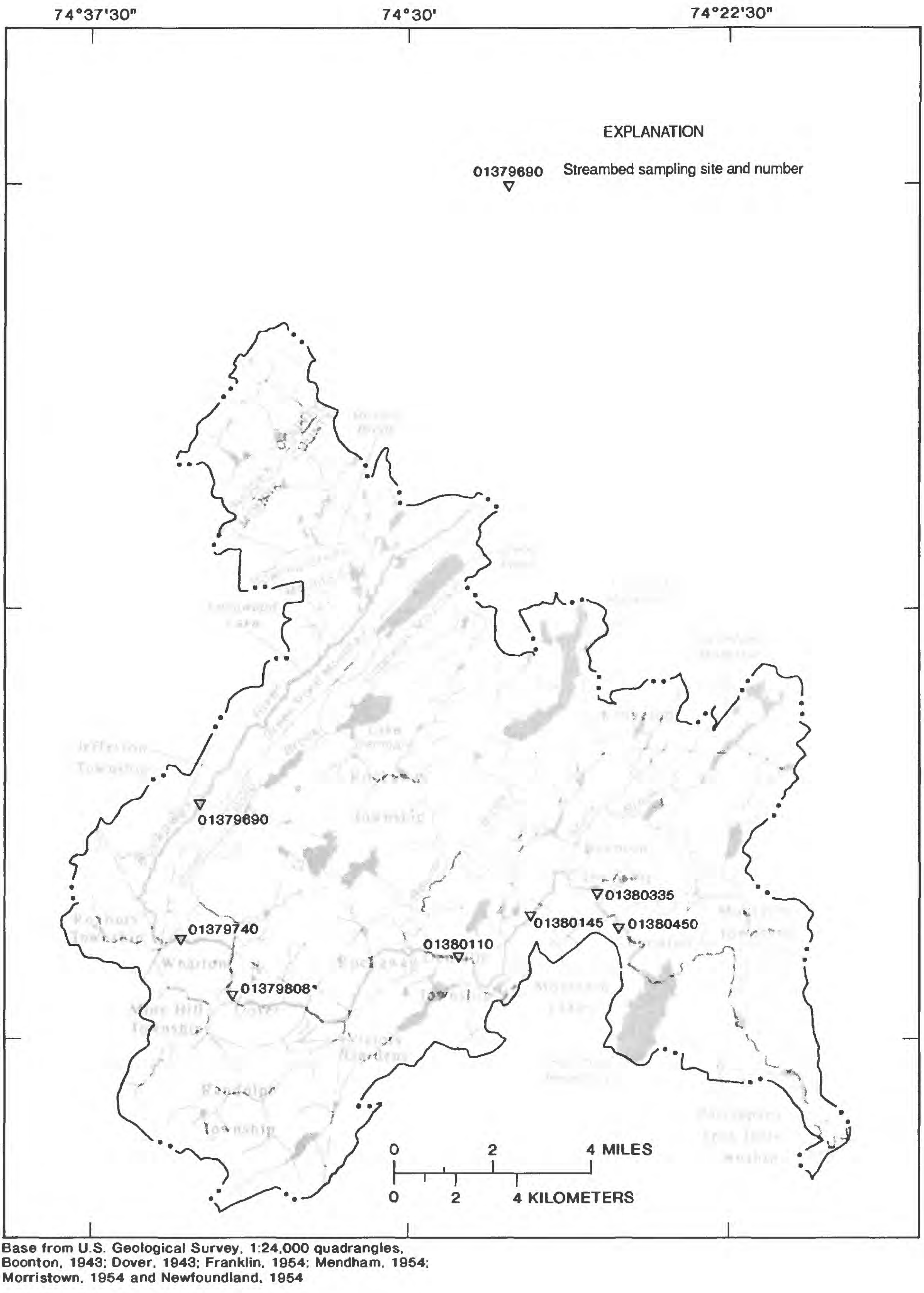


Figure 10.--Locations of streambed sampling sites.

Six of the seven sites also were surface-water-quality sites. The exception, site 01380450, was sampled instead of site 01380500 because insufficient sediments were available at the latter site. The streambed sampling sites are described in table 7 (at end of report).

Samples were collected from the upper 1 to 3 centimeters (about 0.4-1.2 in.) of streambed material in August 1985. Particles larger than 63 μm were excluded by wet sieving with native streamwater; the sediments analyzed were the silt-clay size fraction. Samples for trace-element analysis were collected and sieved with equipment made of polyethylene, PVC, and polyester. The samples analyzed for pesticides and methylene chloride-extractable organic compounds were collected with stainless-steel equipment.

Concentrations of trace elements on streambed materials were determined by using the methods of Fishman and Friedman (1989). Concentrations of organic constituents were determined by using the methods of Wershaw and others (1987).

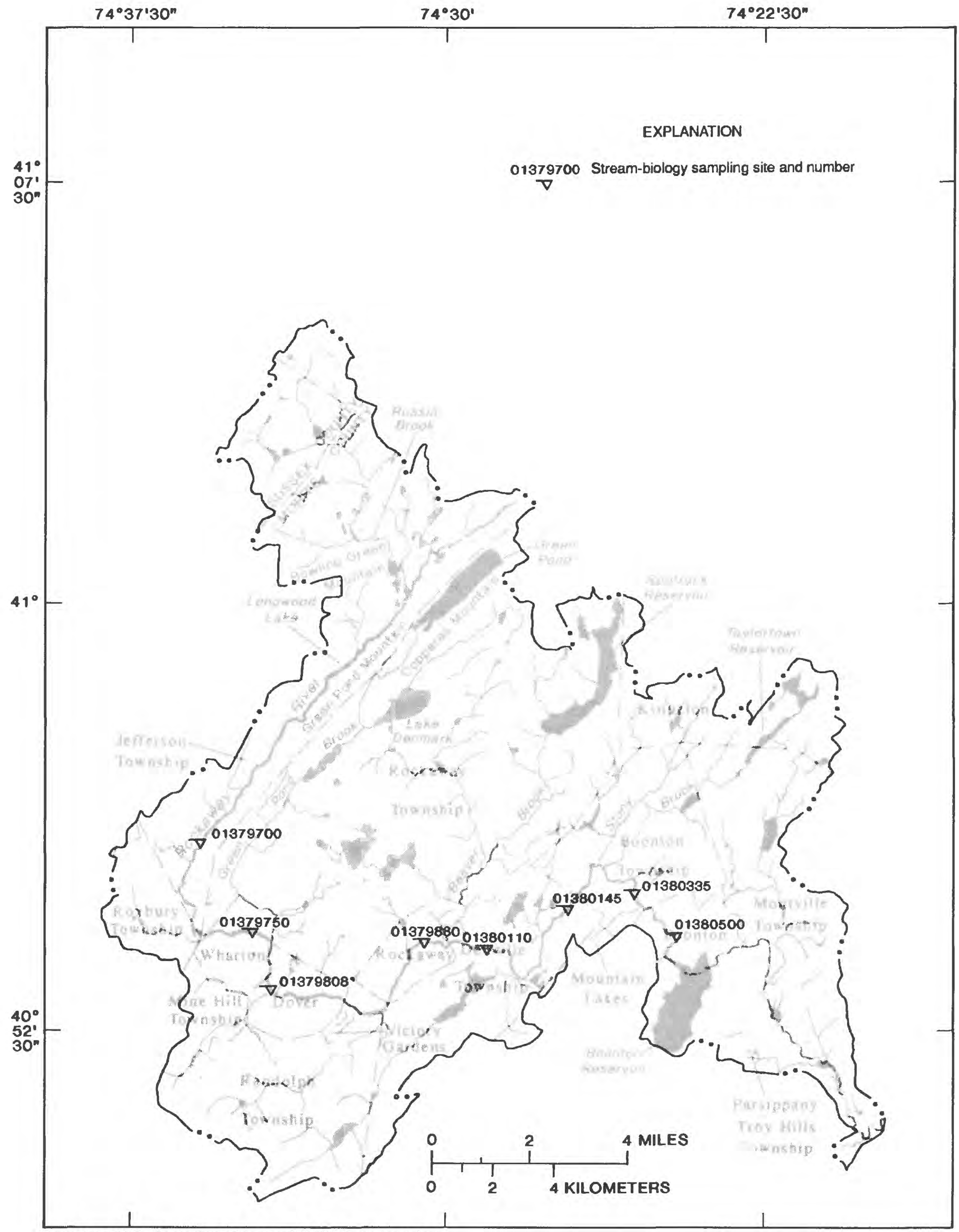
Stream Biology

Macroinvertebrate and periphyton communities in the Rockaway River were sampled in 1985 to identify organisms and to calculate various measures of biological stream health. All collection of stream-biology samples and analysis of biological data were performed by personnel from the NJDEPE.

The locations of the eight stream-biology sampling sites are shown in figure 11, and the sites are described in table 7 (at end of report). For the biology study, the Rockaway River was divided into three segments on the basis of stream topography and streamflow characteristics. The upper segment is composed of sites 01379700, 01379750, and 01379808; the middle segment is composed of sites 01379880, 01380110, and 01380145; and the lower segment is composed of sites 01380335 and 01380500. The sites on the upper and lower segments displayed rockier substrates and faster flow than the sites in the middle segment.

Macroinvertebrate collections were performed according to methods outlined in New Jersey Department of Environmental Protection (1983), with the following two exceptions. During retrieval, the Hester Dendy artificial substrates were enclosed in a Nitex bag to minimize the loss of organisms; also, a number 70 (210 μm) standard sieve was used instead of a number 30 (595 μm) sieve in processing the Hester Dendy samples. The number 70 sieve trapped many small organisms that would have been lost through the number 30 sieve.

Three replicate samplers were placed at each site and left in the stream for three 6-week colonization periods--one each during spring, summer, and fall 1985. Five of the substrates could not be recovered until they had undergone a 10-week colonization period. Although analysis of the substrates that underwent a lengthy colonization period supplied useful data, the statistics were not compared to those compiled from analysis of the substrates that underwent a 6-week colonization period. In addition to the Hester Dendy collections, three replicate macroinvertebrate samples were



Base from U.S. Geological Survey, 1:24,000 quadrangles,
Boonton, 1943; Dover, 1943; Franklin, 1954; Mendham, 1954;
Morristown, 1954 and Newfoundland, 1954

Figure 11.--Locations of stream-biology sampling sites.

collected during the spring from shallow-water areas at each site with a Surber 1-square-foot sampler. All samples subsequently were taken to the NJDEPE Biological Services Laboratory at Trenton, New Jersey, for species identification and enumeration.

Periphyton sampling was performed with diatometers according to the methods outlined in New Jersey Department of Environmental Protection (1983). The samples were processed at the Biological Services Laboratory following the methods outlined in New Jersey Department of Environmental Protection (1983). The diatometers consisted of modified slide boxes in which glass microscope slides served as artificial substrates. They were placed at each site and left in the stream for three 2-week colonization periods--one each during spring, summer, and fall 1985.

Information on ecological niches and pollutional classifications was taken from J.M. Kurtz (New Jersey Department of Environmental Protection, written commun., 1985). Species diversity and equitability indices were calculated according to the formulas presented in Weber (1973).

HYDROLOGIC CONDITIONS

Ground Water

In the upper Rockaway River basin, ground water occurs in the pore spaces of unconsolidated sediments and in the fractures of bedrock. The unconsolidated valley-fill aquifers in the study area are the most extensively used. Wells tapping these units can yield up to 1,500 gal/min, and the high yields are largely a result of induced recharge from streams to aquifers. Well yields for bedrock aquifers usually are at least an order of magnitude less.

In this study, water levels in 61 wells were measured to determine temporal fluctuations and to construct water-level contour maps. Water levels measured in wells represent the balance between recharge to and discharge from an aquifer. Precipitation provides the recharge, and natural seepage to surface waters and pumpage, where present, provide the discharge.

According to Heath (1983, p. 15), recharge occurs intermittently during and immediately following periods of precipitation, but discharge is continuous as long as ground-water levels are above the levels at which discharge occurs. Between periods of recharge, both ground-water levels and the rate of discharge decline. Most recharge of ground-water systems occurs during late fall, winter, and early spring, when plants are dormant and evaporation rates are low.

These aspects of recharge and discharge are apparent in the hydrographs of water levels in observation wells shown in figure 12. The data plotted are from continuous water-level recorders, and the locations of the observation wells are shown in figure 6. In general, recharge was lower during winter and spring 1985 than during the same period in 1986, as reflected by the lower water levels in most wells in 1985. Variations among the hydrographs are caused mainly by differences in geographic setting and hydraulic properties of the aquifer at the site, and the proximity to pumped

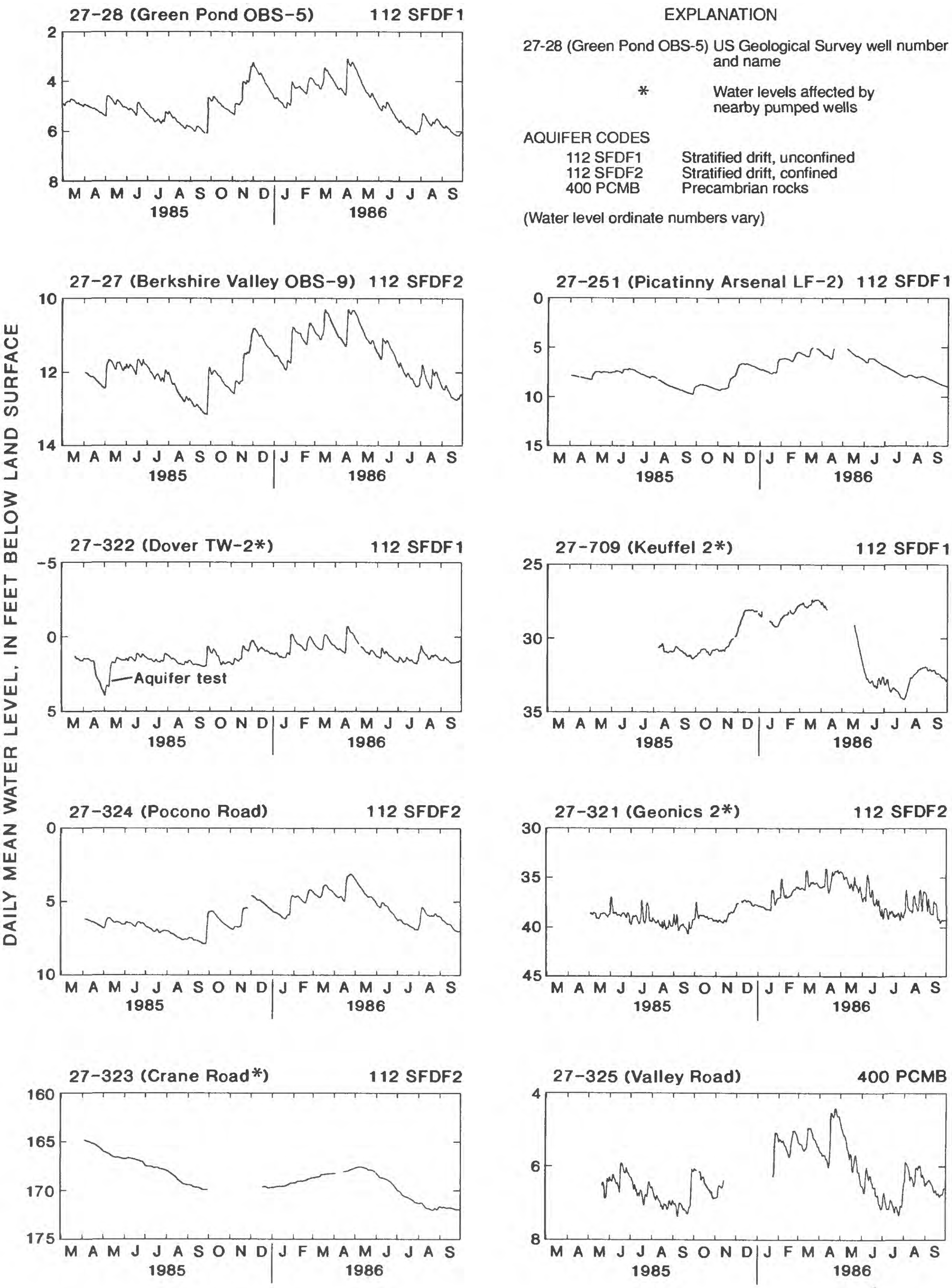


Figure 12.--Water levels in observation wells in the study area, March 1985-September 1986. (Well locations shown in figure 6.)

wells. Tables 4 and 5 (at end of report) contain water levels that were measured at 52 additional observation wells in the study area. All water levels were measured under static (nonpumping) conditions.

Ground water in the valley-fill aquifer system occurs under both unconfined and confined conditions. The limited extent of the confining units causes the entire ground-water system to act as one interconnected system. In areas of the unconfined aquifer not affected by pumping, ground water generally flows from points of recharge along the valley walls to points of discharge in the valleys, such as the Rockaway River or tributary streams (pl. 1a). Where pumping is a factor, ground water flows toward the pumped wells, creating local cones of depression.

The water-table map in plate 1a indicates cones of depression at the Rockaway Borough, Rockaway Township, and Boonton well fields. If the density of water-level data points had been higher, all of the major pumping centers (fig. 5) would indicate cones of depression. In plate 1a, some water-table contours are omitted for clarity. Contours are plotted at 10-ft intervals where the gradients are steepest and at smaller intervals where the gradients are more shallow. River-stage data (table 6, at end of report) also were used to construct the contours in plate 1a.

Ground water in the confined aquifer (pl. 1b) where pumping is not a factor generally flows downvalley. Near Mountain Lakes, flow in the confined aquifer exits the basin to the southeast through a buried river channel. A map of the bedrock surface from Wharton Borough to Montville Township is shown in Canace and others (in press).

Surface Water

Flow in the headwaters of the Rockaway River is controlled to a large extent by releases of storage from numerous lakes and ponds. Downstream, ground-water seepage, runoff from urban areas, and flow augmentation from Splitrock Reservoir play major roles in determining the quantity of surface water in the study area.

The difference in streamflow between the two gaging stations in the study area (fig. 7), Berkshire Valley (01379700) and above Reservoir at Boonton (01380500), generally ranged from one-half to one order of magnitude for the period May 1985 through September 1986 (fig. 13). The lowest mean daily flow for the period was 9.6 ft^3/s [0.39 $(ft^3/s)/mi^2$] at Berkshire Valley and 27 ft^3/s [0.23 $(ft^3/s)/mi^2$] at above Reservoir at Boonton. The highest mean daily flow for the same period was 331 ft^3/s [13.6 $(ft^3/s)/mi^2$] at Berkshire Valley and 1,590 ft^3/s [13.7 $(ft^3/s)/mi^2$] at above Reservoir at Boonton.

In order to provide a historical perspective, the annual mean discharges for the above Reservoir at Boonton gaging station (01380500) for water years 1938-86 are shown in figure 14. For the period of record, annual mean flow ranged from a low of 88.3 ft^3/s in 1965 to a high of 396 ft^3/s in 1952. The long-term mean flow is 226 ft^3/s (1938-86). The annual mean flows for water years 1985 and 1986 were 119 ft^3/s and 232 ft^3/s, respectively.

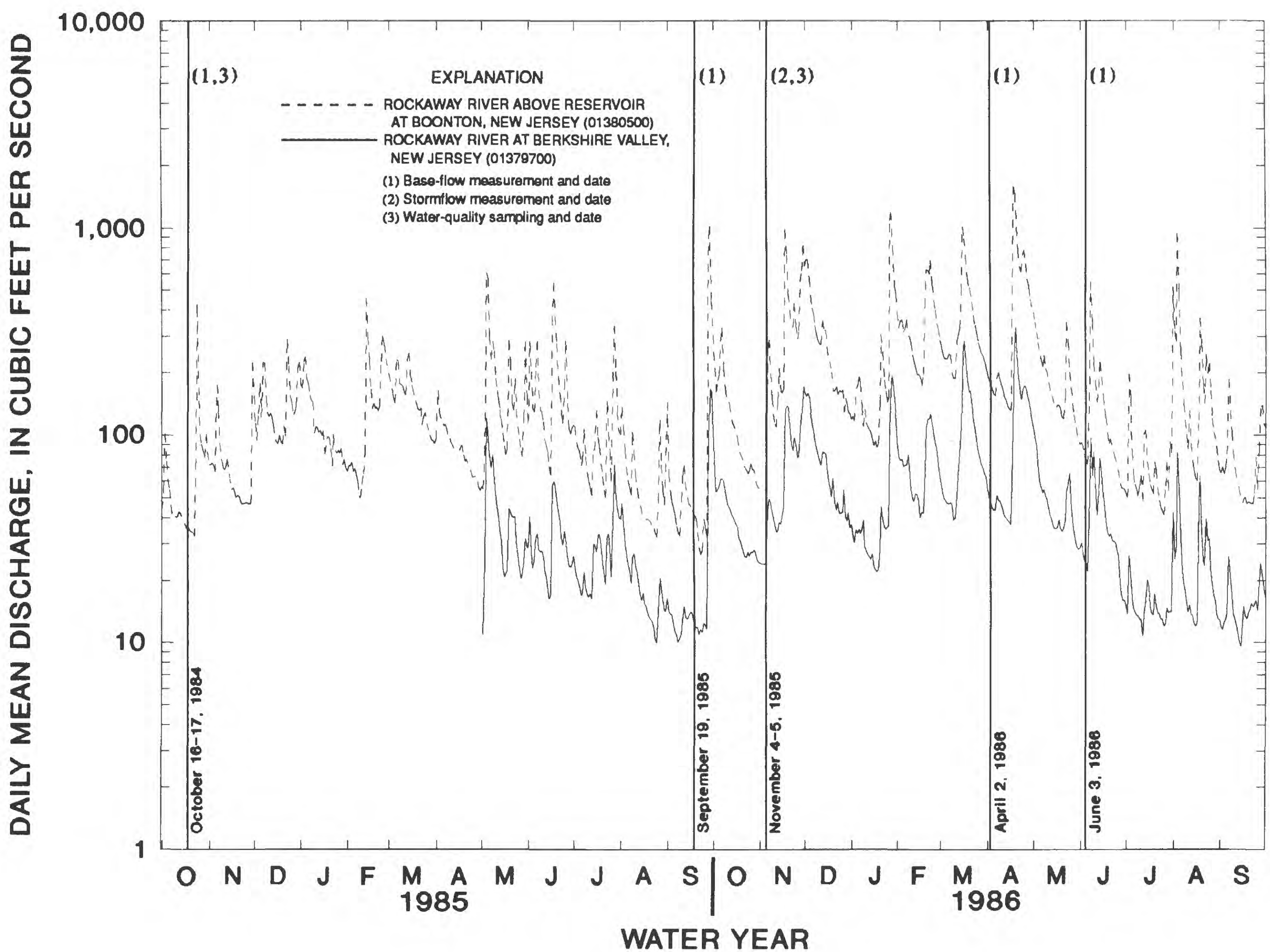


Figure 13.--Daily mean discharge of the Rockaway River at the Berkshire Valley and above Reservoir at Boonton gaging stations, water years 1985-86.

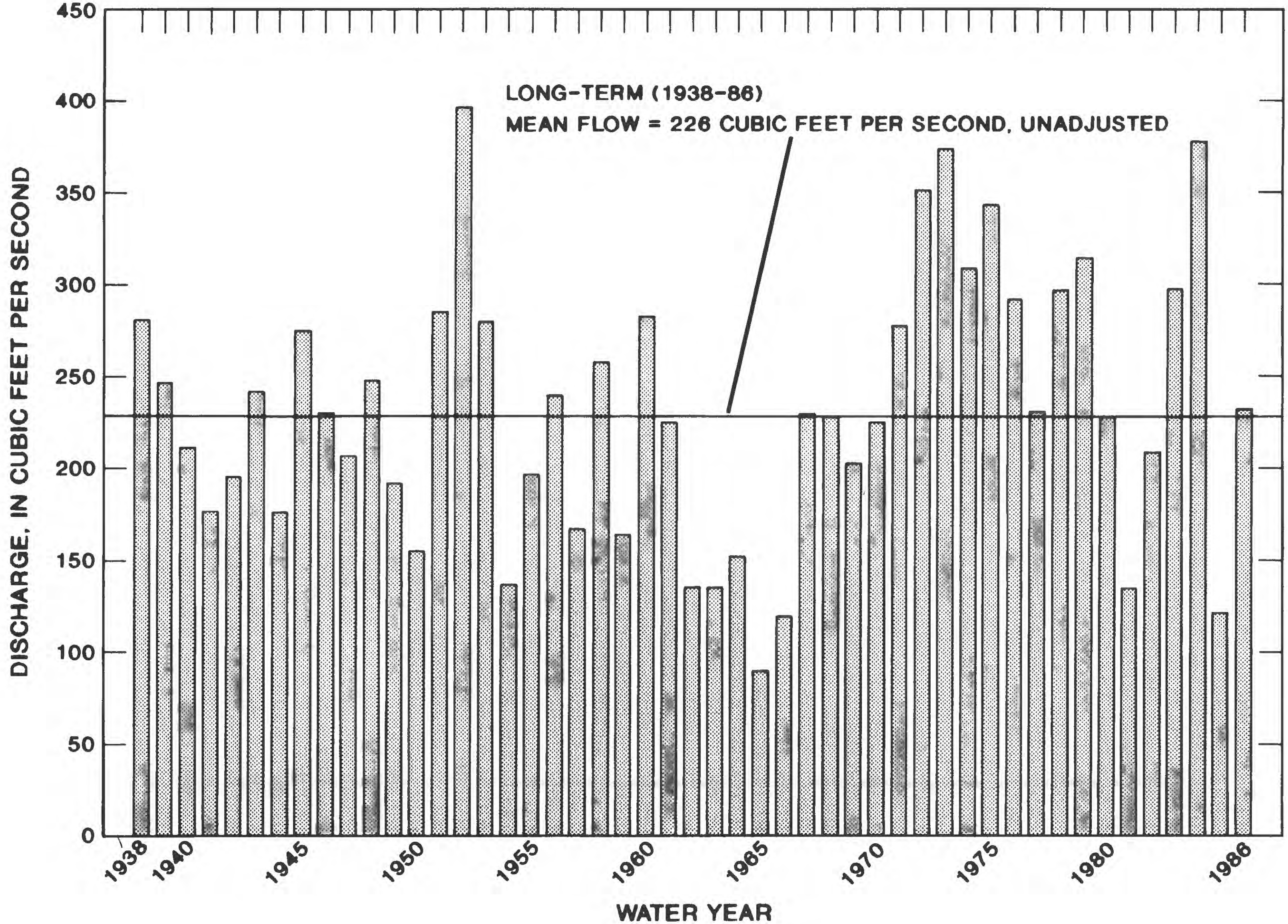


Figure 14.--Annual mean discharge of the Rockaway River at the above Reservoir at Boonton (01380500) streamflow-gaging station.

Duration curves of daily discharge at the Rockaway River above Reservoir at Boonton station (01380500) for 1938-83 and 1985-86 are shown in figure 15. The slope of the curves is indicative of streamflow variability. Steep curves indicate high streamflow variability, whereas moderate to low slopes indicate less variability. The moderate slopes below the 60-percent duration for both curves indicate a large ground-water contribution to streamflow. The more gentle slope of the 1985-86 curve shows a greater contribution from ground water during this 2-year period than the long-term average represented by the 1938-83 curve. In both cases, flow augmentation from Splitrock Reservoir modified the natural streamflow variability to some extent.

Seepage runs conducted during periods of base flow are used to identify losing reaches (water flows from the river to the aquifer) and gaining reaches (water flows from the aquifer to the river) along a stream, by determining whether stream discharge increases or decreases in the downstream direction. The results of four seepage runs conducted in the study area (table 7, at end of report) indicate that the main stem of the Rockaway River and its tributaries have gaining and losing reaches; however, a general gaining trend persists. Some reaches were found to gain water at some times and to lose water at other times. This phenomenon can be caused by (1) ground-water pumpage, which can induce recharge from the stream to the aquifer; (2) natural changes in water-table altitude and slope, which can change the ground-water gradient, affecting the input to the stream or even reversing the flow direction; and (3) changes in surface-water storage, particularly in swampy areas.

For most losing reaches in the upper Rockaway River basin (fig. 16), streamflow loss is the result of ground-water pumpage, but for others, streamflow loss can be attributed to a combination of pumpage and natural factors. In a study of the valley-fill aquifer system of the Ramapo River Valley, Hill and others (1992) showed a relation between streamflow loss and areas where there was a combination of high transmissivity and ground-water pumpage. At the Dover well field in the Rockaway River basin (fig. 5), the presence of thick, coarse-grained, high-transmissivity deposits enhances the possibility of streamflow loss, whether from human activities or natural causes. At the Rockaway Borough well field (fig. 5), stratigraphic data (Stanford, 1989b, section B-B') suggest the presence of a thick (greater than 100 ft) sequence of coarse-grained deposits indicative of high transmissivity, which would enhance the potential for streamflow loss there as well.

Losing reaches in which streamflow loss during base flow can be a function solely of natural causes are found along parts of Beaver Brook and Stony Brook, and along the Rockaway River between sites 01380335 and 01380500 (fig. 16). Streamflow loss in these reaches can be caused by (1) natural water-table gradients from the stream toward the aquifer; (2) streamflow loss to swamps; and (3) streamflow loss along the outcrop zone of a deep, confined aquifer system. Beaver Brook and Stony Brook may be examples of the third scenario. Geologic sections by Stanford (1989a) show that a confined aquifer crops out at the valley wall. Tributaries that drain the hillsides in these valleys are believed to recharge this confined aquifer.

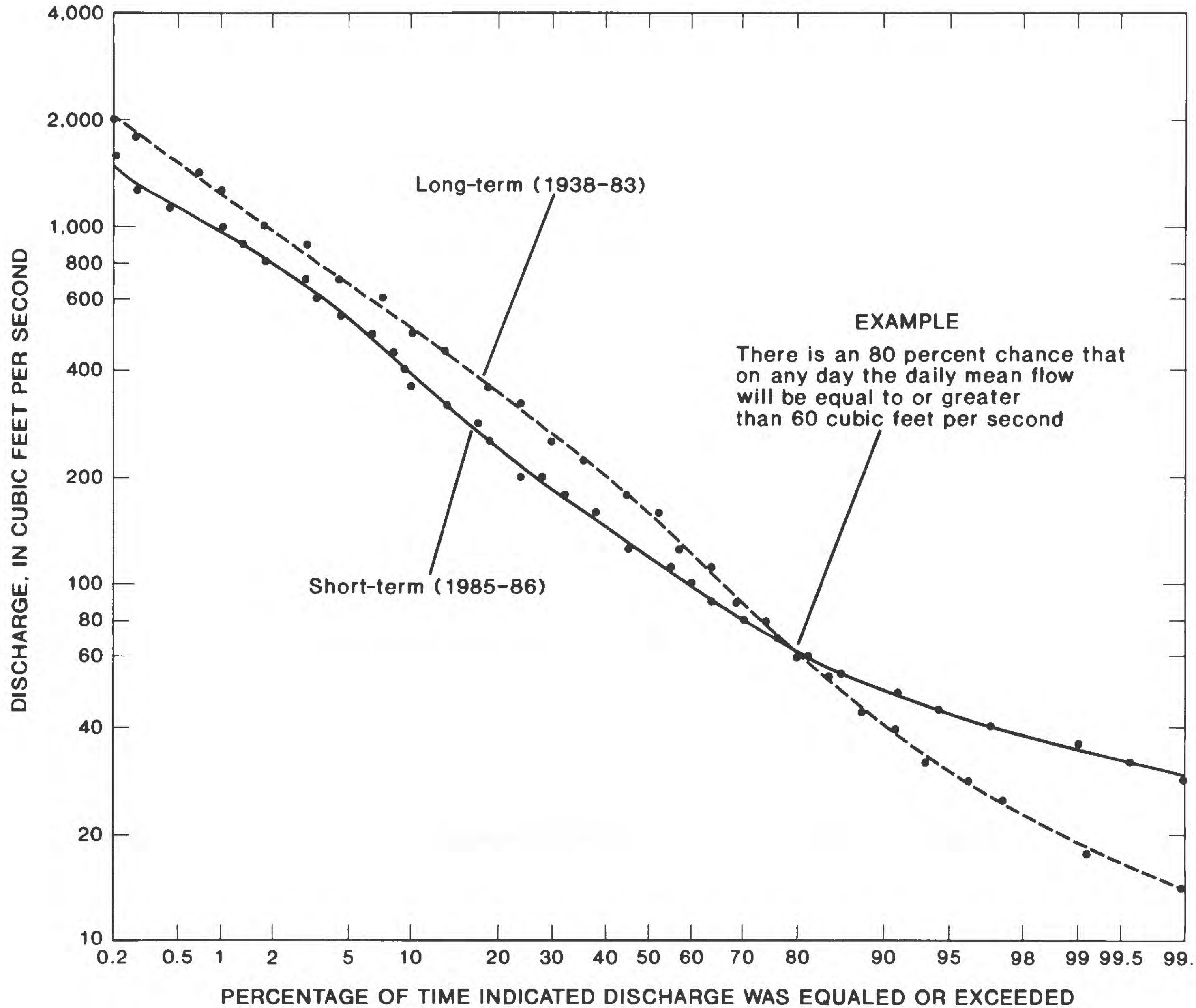
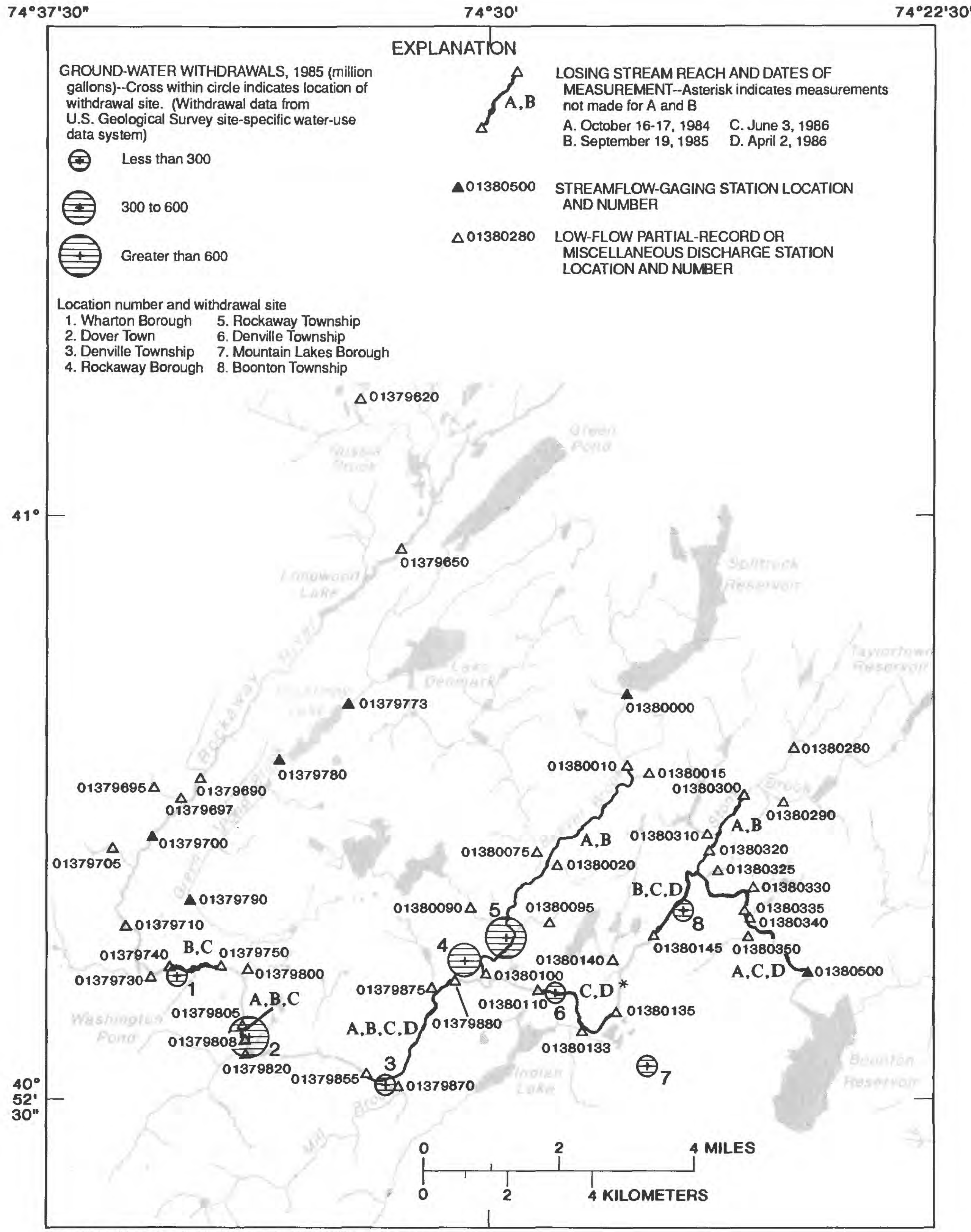


Figure 15.--Flow-duration curves of daily discharge of the Rockaway River at the above Reservoir at Boonton (01380500) streamflow-gaging station.



Base from U.S. Geological Survey, 1:24,000 quadrangles, Boonton, 1943; Dover, 1943; Franklin, 1954; Mendham, 1954; Morristown, 1954 and Newfoundland, 1954

Figure 16.--Losing stream reaches identified in the upper Rockaway River basin during four seepage runs. (Gaining reaches are those not highlighted.)

Water Quality

Water quality in the study area was determined from results of analyses of ground-water samples from 29 wells and surface-water samples from 15 stream sites.

Ground Water

The locations of the 29 wells sampled for water quality are shown in figure 8. In order to determine whether water quality varies among the hydrogeologic units because of natural factors or human activity, all ground-water chemical data were grouped into three categories: unconfined valley-fill aquifer, confined valley-fill aquifer, and bedrock aquifers. The bedrock aquifers include Precambrian gneiss, Hardyston Quartzite, dolomite of the Leithsville Formation, Jurassic shale and basalt, and Bellvalle Sandstone. The water-quality constituents determined are listed on page 20, and the analytical data are presented in tables 8 through 11 (at end of report).

The concentrations of major inorganic ions and the physical characteristics of water were similar among the aquifers (table 8). Highest pH (9.3) was measured in bedrock well 27-280, which taps a dolomitic limestone of the Leithsville Formation. The lowest pH (6.1) was measured in well 27-541, screened in the unconfined valley-fill aquifer. The highest specific-conductance values generally were measured in the two valley-fill aquifers, although considerable variation, from 159 to 674 μS/cm (microsiemens per centimeter at 25 degrees Celsius), was found among samples. Higher concentrations of sodium, calcium, magnesium, chloride, and sulfate also were found in valley-fill aquifers than in bedrock aquifers in most instances. Nevertheless, these concentrations are within U.S. Environmental Protection Agency (USEPA) and New Jersey Secondary Drinking-Water Regulations (U.S. Environmental Protection Agency, 1988b; New Jersey Register, 1989).

The percentages of the major ions in water can be shown on trilinear diagrams developed by Piper (1944). Trilinear diagrams of the ionic composition of ground-water samples from each of the three hydrogeologic units studied are shown in figures 17 through 19. In each figure, the apex of each of the two triangles represents 100 percent of one of the three ionic constituents. The large diamond-shaped field in the center represents the composition of the water with respect to both cations and anions. Overall, the three aquifers yielded water of similar major-ion chemistry. The majority of samples plotted in the calcium plus magnesium and carbonate plus bicarbonate portions of the trilinear diagrams. The exceptions are as follows: (1) samples from unconfined valley-fill wells 27-541, 27-657, and 27-911; (2) samples from confined valley-fill wells 27-278 and 27-908; and (3) samples from bedrock wells 27-195 and 27-936. In all seven of these samples, either calcium or sodium was the dominant cation and either chloride or sulfate was the dominant anion. The tight cluster of data points representing the ionic composition of water from the confined aquifer (fig. 18) indicates that this aquifer is less susceptible to anthropogenic contaminants from the surface, such as septic-system effluent and road salt, than is the unconfined aquifer; therefore, the quality of water in this aquifer is less variable than that of water from the unconfined aquifer.

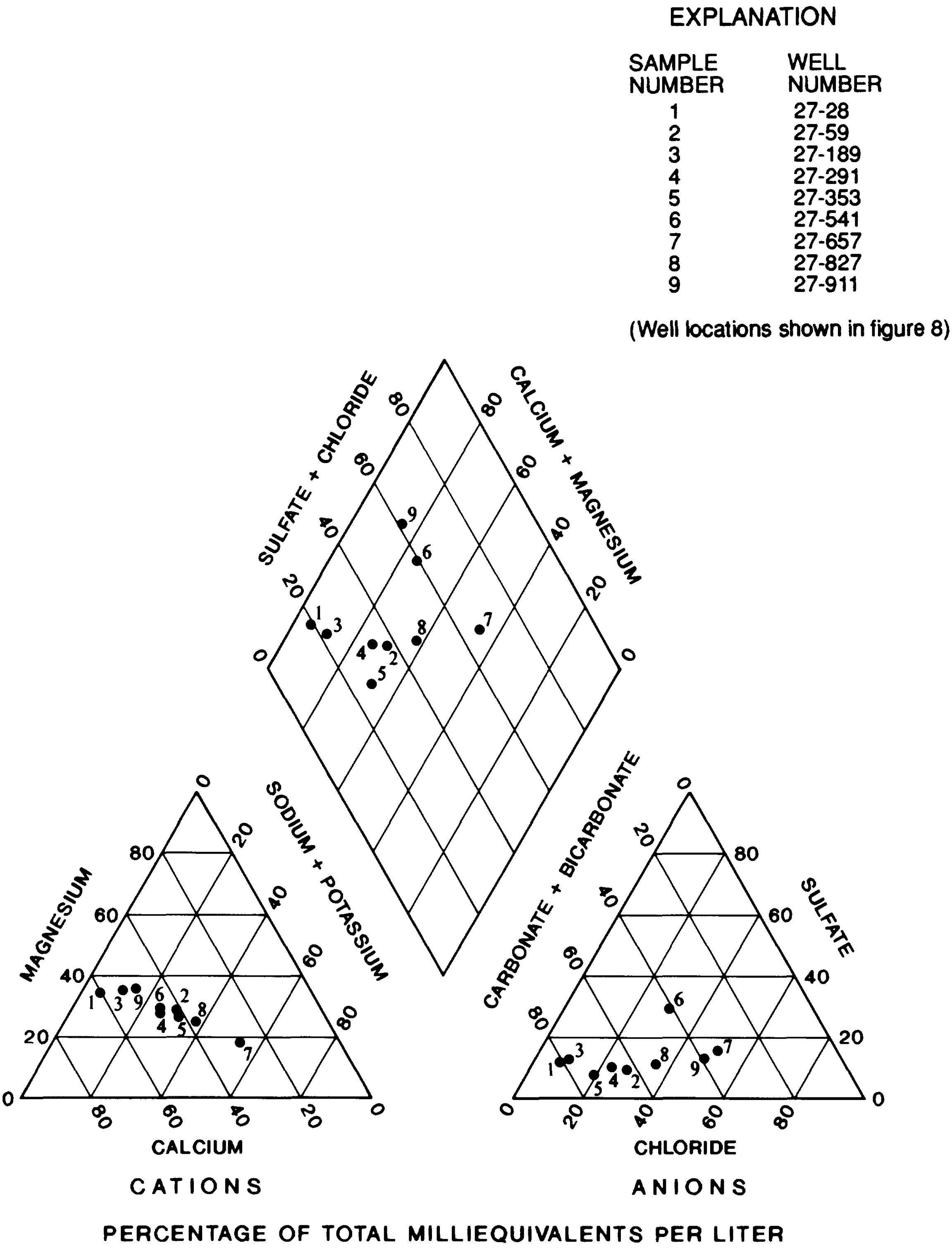


Figure 17.--Major-ion chemistry of water samples from the unconfined valley-fill aquifer.

EXPLANATION

SAMPLE NUMBER	WELL NUMBER
1	27-30
2	27-35
3	27-80
4	27-136
5	27-191
6	27-278
7	27-321
8	27-357
9	27-686
10	27-908

(Well locations shown in figure 8)

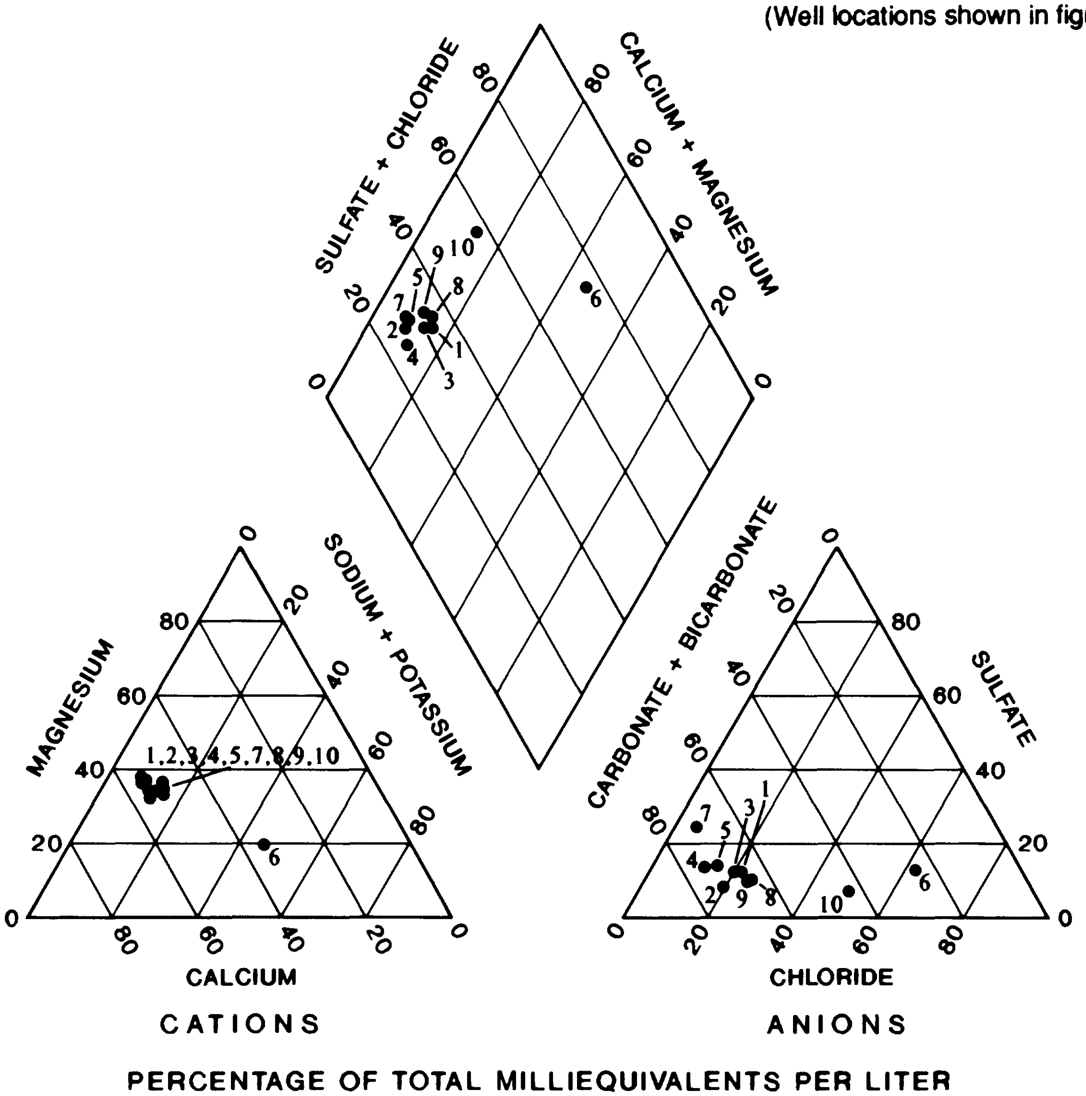


Figure 18.--Major-ion chemistry of water samples from the confined valley-fill aquifer.

EXPLANATION

SAMPLE NUMBER	WELL NUMBER
1	27-188
2	27-195
3	27-242
4	27-246
5	27-280
6	27-287
7	27-325
8	27-913
9	27-923
10	27-936

(Well locations shown in figure 8)

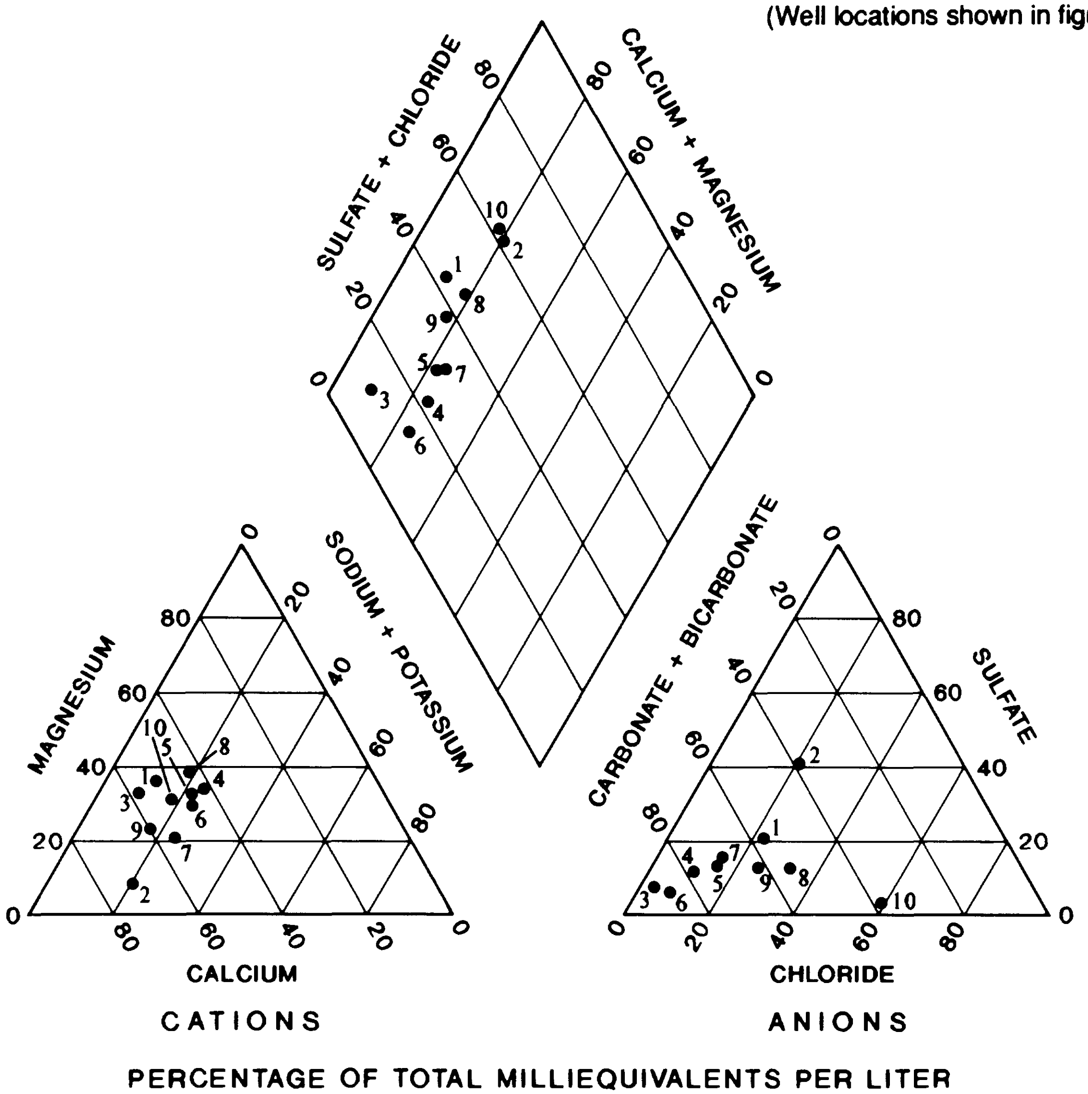


Figure 19.--Major-ion chemistry of water samples from the bedrock aquifers.

Most trace-element concentrations were at or below detection levels (table 9, at end of report). The exceptions were copper, iron, manganese, and zinc. Iron and manganese almost always are the trace elements found in the highest concentrations because of their wide distribution in nature (Hem, 1985). Concentrations of iron and manganese in ground water in the study area were higher in some bedrock wells than in wells in the other two aquifers. The USEPA and New Jersey Secondary Maximum Contaminant Levels (SMCL)[5] for iron and manganese are 300 μg/L and 50 μg/L, respectively; these standards are based on aesthetics rather than on any potential health risk (U.S. Environmental Protection Agency, 1988b; New Jersey Register, 1989).

Nutrient concentrations were low in all aquifers (table 10, at end of report). Concentrations of nitrate, the most prevalent species, were consistently below both the USEPA and New Jersey Maximum Contaminant Level (MCL)[6] of 10 mg/L (milligrams per liter) (U.S. Environmental Protection Agency, 1988a; New Jersey Register, 1989). Concentrations were highest in two unconfined valley-fill wells, 27-541 and 27-657, at 3.5 mg/L and 4.1 mg/L, respectively.

Only small differences in water quality were noted among the three hydrogeologic units. Most, if not all, of these differences can be attributed to natural factors, such as geology and ground-water flow paths. No significant geographic patterns were observed in ground water from an individual hydrogeologic unit.

Because VOC's can be very mobile in the ground-water system, water samples from 26 wells (those listed in table 8, excluding 27-242, 27-246, and 27-280) were screened nonquantitatively in the New Jersey District Laboratory for the following VOC's:

Chloromethane	Bromomethane
Vinyl chloride	Chloroethane
Methylene chloride	1,1-Dichloroethene
1,1-Dichloroethane	cis-1,2-Dichloroethene
Chloroform	trans-1,2-Dichloroethene

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[5] (USEPA) Secondary Maximum Contaminant Level: contaminants that affect the aesthetic quality of drinking water. At high concentrations or values, health implications as well as aesthetic degradation may also exist. SMCLs are not Federally enforceable but are intended as guidelines for the States (U.S. Environmental Protection Agency, 1988b).

[6] (USEPA) Maximum Contaminant Level: enforceable, health-based regulation that is to be set as close to the maximum contaminant level goal as is feasible. The definition of feasible means the use of best technology, treatment techniques, and other means that the Administrator of USEPA finds, after examination for efficacy under field conditions and not solely under laboratory conditions, are generally available (taking cost into consideration) (U.S. Environmental Protection Agency, 1988a).

1,1,1-Trichloroethane	1,2-Dichloroethane
Dichlorobromomethane	Carbon tetrachloride
trans-1,3-Dichloropropene	1,2-Dichloropropane
Chlorodibromomethane	Trichloroethene
cis-1,3-Dichloropropene	1,1,2-Trichloroethane
Bromoform	2-Chloroethylvinylether
Tetrachloroethene	1,1,2,2-Tetrachloroethane
1,2-Dichlorobenzene	Chlorobenzene
1,4-Dichlorobenzene	1,3-Dichlorobenzene
Toluene	Benzene
	Ethylbenzene

Only the VOC's listed in table 11 (at end of report) were detected, in 10 of the 26 samples. All 10 samples were from wells screened in the valley-fill aquifers, and 8 of the 10 were from high-yield production wells located in the main part of the Rockaway Valley downstream from Washington Pond. The most prevalent VOC's found in the samples were 1,1,1-trichloroethane, tetrachloroethene, and trichloroethene.

Surface Water

The locations of the 15 surface-water-quality stations are shown in figure 9. Twelve stations are located on the main stem of the Rockaway River, one is on Green Pond Brook, and two are on Stony Brook. The results of analyses of the samples collected at these stations indicate that the quality of surface water in the study area is generally good and suitable for most purposes with proper treatment; in most instances, the water quality meets USEPA and New Jersey MCL's and SMCL's (U.S. Environmental Protection Agency, 1988a, 1988b; New Jersey Register, 1989) and New Jersey Surface-Water-Quality (in-stream) Standards (New Jersey Department of Environmental Protection, 1989a).

Base flow and stormflow

Water-quality samples were collected at the 15 stations during two periods of extreme discharge--base flow (October 16-17, 1984) and stormflow (November 4-5, 1985). The constituents determined are listed on page 20; the analytical data are presented in tables 12 through 14 (at end of report).

A comparison between base-flow and storm-water quality indicates that specific conductance, alkalinity, and concentrations of major ions, such as calcium and chloride, generally were lower during the storm than during base-flow conditions. This relation is the result of dilution from runoff. Conversely, trace elements, such as aluminum, beryllium, copper, and lead, were found at higher concentrations during the storm than during base flow. These constituents usually are associated with urban runoff. The storm also resulted in higher concentrations of most nutrients, organic carbon, and detergents. At almost all stations during both sampling events, waters typically were a calcium bicarbonate type. During the storm, however, surface water at stations on Green Pond Brook and Stony Brook generally contained high concentrations of sodium, potassium, and chloride relative to those of the other major ions.

Concentrations of most trace elements in surface-water samples were at or below detection levels, with the exception of iron, manganese, copper, lead, and zinc. Concentrations of all trace elements but manganese were below USEPA and New Jersey MCL's and SMCL's, however (U.S. Environmental Protection Agency, 1988a, 1988b; New Jersey Register, 1989).

Selected constituents measured in the base-flow samples were used to construct constituent-concentration profiles for the Rockaway River (pl. 2a). These profiles show the concentration of the constituent as a function of river mile upstream from Boonton Dam. One station each on Green Pond Brook (01379800) and Stony Brook (01380320) are included on this plate. Storm-water quality data were not graphed because at some stations (especially 01380110 and 01380135) stormflow was sampled before discharge had increased to a flow rate commensurate with that at adjacent stations. The base-flow water-quality profiles generally indicate that concentrations are higher downstream than upstream. The water quality of Green Pond Brook and Stony Brook was substantially different, in many respects, from that of the Rockaway River; however, the flow of Stony Brook was nearly zero during the base-flow sampling. In Stony Brook, the pH, alkalinity, specific conductance, and concentrations of dissolved oxygen and most major ions were lower than that in the Rockaway River. Specific conductance and concentrations of sodium and chloride were higher in Green Pond Brook than in the Rockaway River.

Seasonal variations

Samples for water-quality analysis also were collected monthly at the two gaging stations (01379700, Berkshire Valley; and 01380500, above Boonton Reservoir) for a 12-month period, April 1985 through March 1986, to document seasonal variations. The constituents determined are listed on p. 20, and graphs of monthly variations in concentrations of selected constituents are shown in plate 2b. The constituents graphed in plate 2b are those that varied the most during the year. The instantaneous discharges at the time of sampling also are plotted. All of the analytical data are presented in tables 12 through 14 (at end of report).

In general, the pH, specific conductance, and concentrations of most major ions were lower at the upstream gaging station than at the downstream gaging station. Concentrations of iron, manganese, and zinc sometimes were higher at the upstream gaging station. At both stations, concentrations of many constituents varied significantly with the season and from month to month. Much of this variation in concentrations is caused by differences in streamflow; high flows reduce constituent concentrations by dilution, whereas concentrations usually increase during low flows.

Concentrations of dissolved oxygen were lowest during spring and summer, although they were 7.0 mg/L or greater at all times. Iron and manganese were the predominant trace elements at both gaging stations, and higher concentrations were noted during periods of low flow than during periods of high flow. Concentrations of dissolved nutrients were low at both sites throughout the year. Concentrations of organic constituents were similar at the two sites. The highest concentrations of dissolved organic carbon and phenols were found during spring and summer.

Chemical Quality of Streambed Material

The chemical quality of a river depends not only on the quality of the water and its aquatic life but also on the chemical composition of the streambed deposits and the interactions between these deposits and the water. Many constituents, especially trace elements and organic substances, are sorbed onto the suspended-sediment particles that are deposited onto the streambed later. Through time, these contaminants can accumulate in the bed material at concentrations many times greater than those originally present in the water (Hochreiter, 1982, p. 1).

Samples of streambed material were collected on August 14-16, 1985, at seven stations along the Rockaway River to determine the concentrations of trace elements and organic compounds that had been sorbed onto river sediments. The locations of the sampling stations are shown in figure 10. The section of the Rockaway River upstream from Washington Pond in Wharton, which includes stations 01379690 and 01379740, drains primarily forested areas; therefore, the effect of manmade inputs on streambed material at these locations is small. In contrast, the section of the Rockaway River between Wharton and Boonton Reservoir, which includes stations 01379808 through 01380450, drains an area consisting primarily of residential, commercial, and industrial land. Also included in this drainage area are seven USEPA National Priority List hazardous-waste sites (New Jersey Department of Environmental Protection, 1989b). As a result, the bed material at sites 01379808 through 01380450 might be affected by trace elements and organic compounds present in the environment as a result of human activities. This hypothesis is confirmed by the analytical data presented in tables 15 and 16 (at end of report), and by the constituent-concentration profiles shown in plate 2c, which show the concentrations of selected constituent as a function of river mile upstream from Boonton Dam. Eleven trace elements and nine organic compounds are shown in plate 2c.

Aluminum concentrations were fairly uniform throughout the study area. Arsenic and iron generally decreased downstream from station 01379690 (map 1 of pl. 2). Most of the other trace elements--cadmium, chromium, copper, lead, mercury, nickel, and zinc--generally increased downstream.

The results of the analyses of streambed material for organic compounds are given in table 16 (at end of report). The distribution of organic compounds closely parallels the distribution of trace elements. The graphs in plate 2c show measurable concentrations of chlordane, dieldrin, DDD, mirex, heptachlor epoxide, and PCB's at stations 01379808 (map 5 of pl. 2) through 01380450 (map 11a of pl. 2). These concentrations were normalized for the sediment samples' organic-carbon content to account for variations in the organic-matter content of the streambed samples. The normalized concentrations, which are given in parentheses in table 16 and are plotted in plate 2c, equal the measured concentrations of the constituent divided by the fractional mass of organic carbon in the respective streambed samples. The data describing trace-element and organochlorine sediment residues are analyzed further in Smith and others (1987).

Stream Biology

Macroinvertebrates are excellent indicators of stream health because of their sensitivity to environmental stress and their limited mobility. Water-quality conditions are reflected in their community structure. The measures used in this assessment included species diversity and equitability indices (species richness and distribution), pollutional classifications (indicator organisms and their percent abundance), and ecological niches (representation within trophic levels).

Periphyton communities also are good indicators of water quality because their species composition greatly depends on environmental conditions. Diatoms are the predominant component of periphytic assemblages associated with clean streams. As stream health deteriorates, community composition shifts from diatoms to green and blue-green algae and other organisms, such as protozoa, bacteria, and molds.

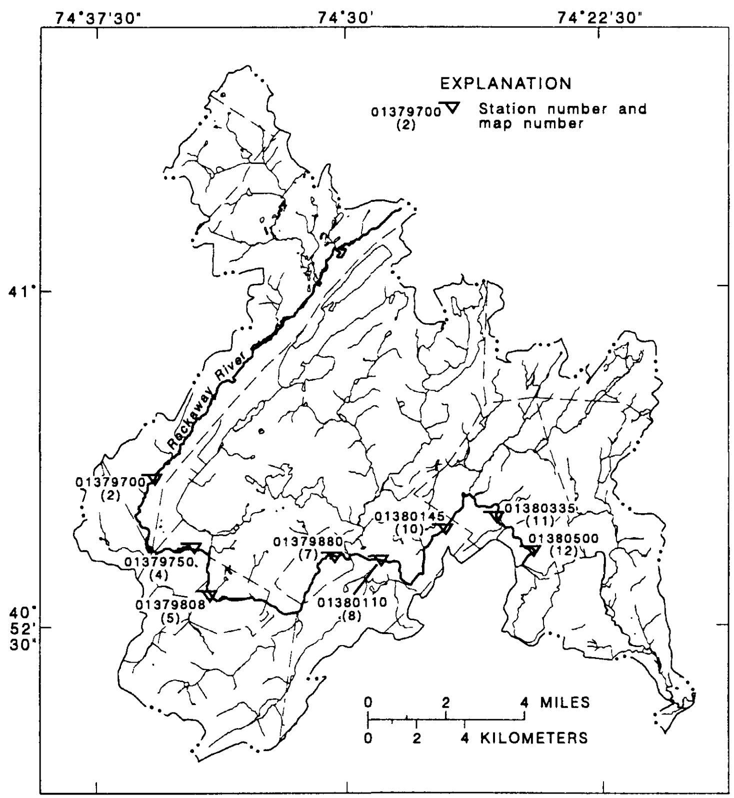
The macroinvertebrate data were emphasized in the assessment of the stream health of the Rockaway River. Although the diatometers provided useful information, excessive sampler losses resulted in an insufficient periphyton data base for definitive analysis. Of the 62 samplers placed in the stream, 16 were lost as a result of storm flows and vandalism, 35 were covered by floating vegetation and rendered useless, and 11 were retrieved intact and unobstructed. Only the data obtained from these 11 samplers are included in this report.

Quantitative macroinvertebrate and periphyton sampling was conducted three times (spring, summer, and fall) from May through November 1985 at eight stations on the Rockaway River (fig. 11). The biological data generated from this assessment indicated healthy, although enriched, stream conditions throughout the study area.

In order to make a biological assessment of the survey area, the river was divided into three segments on the basis of stream topography and streamflow characteristics. The sites on the upper (01379700, 01379750, 01379808) and lower (01380335, 01380500) segments had rockier stream bottoms and faster flows than those sites on the middle segment (01379880, 01380110, 01380145). Changes in the macroinvertebrate communities in the Rockaway River appeared to be attributable to the physical characteristics of the stream rather than to water quality.

Figure 20 shows bar graphs of macroinvertebrate population density, species-diversity index, and equitability index. Appendix A (at end of report) contains macroinvertebrate statistics for each sampling station, macroinvertebrate summary statistics for each stream segment, and a glossary of biological terms. These data are summarized below.

The indigenous macroinvertebrate populations of the Rockaway River were indicative of an absence of any significant variation in water quality throughout the entire survey area. The river supported healthy and generally well-balanced macroinvertebrate communities. Each stream segment had a mean species diversity of 4.1 based on the Shannon-Weaver function (Weber, 1973). The benthic fauna was composed predominantly of facultative



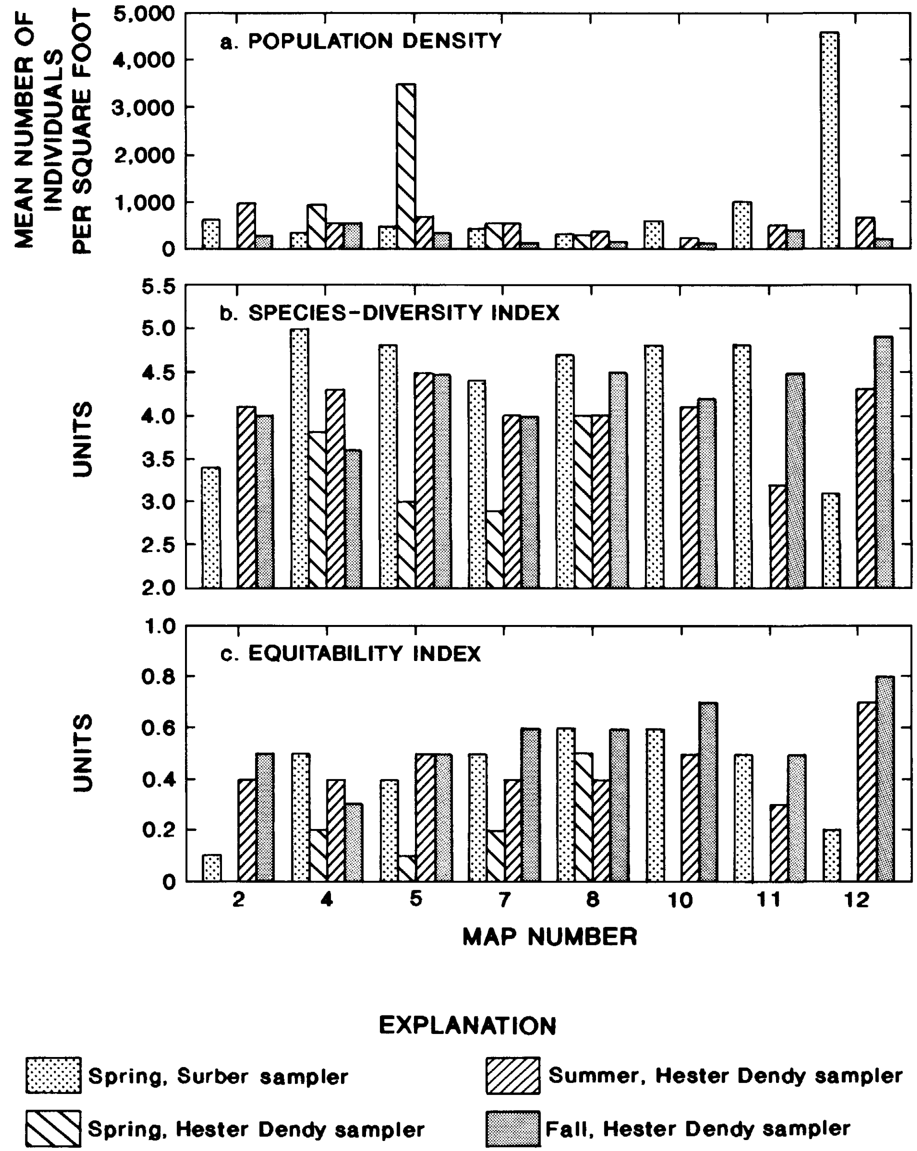


Figure 20.--a. Population density, b. species-diversity index, and c. equitability index for macroinvertebrates in the Rockaway River, May-November, 1985.

and pollution-sensitive organisms. Stoneflies (Plecoptera), mayflies (Ephemeroptera), caddisflies (Trichoptera), and beetles (Coleoptera) were among the clean-water organisms common to each sampling site.

Individuals classified as tolerant of organic contamination and (or) low concentrations of dissolved oxygen comprised a relatively small percentage of the population. Organic enrichment is indicated by the large proportion of scavengers, filter feeders, and periphyton feeders. The upper stream segment contained a high proportion of filter feeders (39 percent), scavengers (8 percent), and periphyton feeders (9 percent). With respect to the upper segment, the middle segment displayed a much lower, although still elevated, proportion of filter feeders (20 percent), but the proportions of scavengers (18 percent) and periphyton feeders (13 percent) were appreciably greater. The middle stream segment had a sandier stream bottom and lower velocity than the upper stream segment and provided a suitable environment for the propagation of aquatic macrophytes. The preponderance of submerged aquatic weed beds enabled the scavengers to proliferate. The lower stream velocity in the middle stream segment could also explain the decrease in filter feeders and the increase in periphyton feeders. Fine particulate organic matter tends to settle out of the water column in slow-moving waters, decreasing the food supply of filter-feeding organisms and concurrently permitting increased sunlight penetration, which is conducive to periphytic growth. Furthermore, scouring, which inhibits periphytic growth, is minimal in slow-moving waters. In the lower stream segment, filter feeders (39 percent) and scavengers (8 percent) were present in the same proportions as in the upper segment, whereas periphyton feeders (5 percent) were less abundant.

SUMMARY

The water resources of the upper Rockaway River basin, a 116-mi^2 area in north-central New Jersey, were evaluated from October 1984 through September 1986. For the evaluation, water levels were measured in 61 wells, stream discharge was measured at 46 sites, water-quality samples from 29 wells and 15 stream sites were collected and analyzed, streambed material was sampled at 7 sites, and stream biology was assessed at 8 sites.

The course of the Rockaway River generally follows preglacial bedrock channels that are filled with glacial valley-fill deposits. These deposits, which typically are 100 to 200 feet thick, contain highly productive aquifers that are tapped by many high-yield (as much as 1,500 gal/min) public-supply wells. These wells are the major source of potable water within the basin, and their high yields can largely be attributed to induced recharge from streams to aquifers. In the study area in 1985, more than 5,113 Mgal were withdrawn from the valley-fill aquifers. The valley-fill deposits are underlain by bedrock composed primarily of erosion-resistant, highly metamorphosed Precambrian granite and gneiss. In the Berkshire and Green Pond Valleys and on Green Pond, Bowling Green, and Copperas Mountains, bedrock is composed of Paleozoic shales, carbonates, sandstones, and conglomerates.

In the valley-fill aquifer system, ground water is present under unconfined (water-table) and confined conditions. The limited extent of the confining units causes the entire system to act as one interconnected system. Under natural conditions, water in the unconfined valley-fill aquifer flows from the valley walls downgradient to surface waters in the valleys. Ground-water flow is affected locally by pumpage. Ground water in the confined valley-fill aquifer under natural conditions flows downvalley.

Streamflow at the two gaging stations in the basin--Berkshire Valley (at the upstream end of the developed part of the study area) and above Reservoir at Boonton (at the downstream end of the study area)--varied by one-half to one order of magnitude for the period May 1985 through September 1986. The lowest daily flow for this period was 9.6 ft^3/s at Berkshire Valley and 27 ft^3/s at Boonton Reservoir. The highest daily flow for the same period was 331 ft^3/s at Berkshire Valley and 1,590 ft^3/s at Boonton Reservoir.

The Rockaway River and its tributaries include gaining and losing reaches; however, a general gaining trend persists. Along much of the main stem, ground-water pumpage probably contributes significantly to streamflow loss.

The pH and major-ion chemistry are similar for both ground and surface waters in the study area. pH ranges from 6.1 to 9.3 in ground water and from 6.4 to 8.5 in surface water. Both waters are characteristically a calcium magnesium, bicarbonate carbonate water type. Concentrations of most trace elements and nutrients are less than USEPA and New Jersey MCL's and SMCL's. The predominant trace elements are iron and manganese.

Differences in water quality between aquifers and within each aquifer generally are small. VOC's are found in some valley-fill aquifer waters, however. VOC's in concentrations greater than 0.8 $\mu g/L$ were detected in ground water from 10 of the 19 valley-fill aquifer wells sampled; none were detected in water from the 7 bedrock wells. Eight of the 10 samples with detectable concentrations of VOC's were from high-yield production wells in the highly developed parts of the basin.

Differences in water quality between upstream, less developed areas, and downstream, more developed areas, were identified on the basis of water samples collected during base-flow and stormflow conditions. Concentrations of most constituents increased downstream. Waters were a calcium bicarbonate type at most of the 15 stations. Specific conductance, alkalinity, and concentrations of major ions, such as calcium and chloride, generally were lower during the storm than during base-flow conditions as a result of dilution from runoff. Trace elements, such as aluminum, beryllium, copper, and lead were found at higher concentrations during the storm than during base flow. These trace elements usually are associated with urban runoff. With the exception of manganese, however, all trace-element concentrations were less than USEPA and New Jersey MCL's and SMCL's. The storm also resulted in higher concentrations of most nutrients, organic carbon, and detergents than those found during base-flow conditions.

Significant variations in constituent concentrations from month to month were found in stream samples collected at the two streamflow-gaging stations; however, much of the variation is caused by variations in streamflow. In general, the pH, specific conductance, and concentrations of most major ions were higher at the downstream gaging station than at the upstream station. The dissolved-oxygen concentrations were lowest during spring and summer at both stations, and concentrations were 7.0 mg/L or greater at all times. Iron and manganese were the predominant trace elements at both sites, and higher concentrations were noted during periods of low flow than during periods of high flow. Concentrations of dissolved nutrients were low at both sites throughout the year. Concentrations of organic constituents were similar at the two sites; the highest concentrations of dissolved organic carbon and phenols were measured during spring and summer.

These data indicate that the quality of surface waters in the study area is generally good and meets USEPA and New Jersey Primary and Secondary Drinking-Water Regulations and also New Jersey Surface-Water-Quality Standards.

Concentrations of trace elements and organic compounds in streambed material increased from upstream, primarily forested lands, to downstream, commercial, industrial, and residential lands. Specifically, the trace elements cadmium, chromium, copper, lead, mercury, nickel, and zinc were found at higher concentrations downstream from Washington Pond in Wharton than upstream. Measurable concentrations of the following organic compounds were found in the same area: chlordane, dieldrin, DDD, mirex, heptachlor epoxide, and PCB's. The presence of most of the trace elements and all of the organic compounds probably is the result of human activities.

Results of the stream-biology assessment indicate that (1) stream conditions are healthy, although enriched throughout the study area, and (2) the differences in stream biota are a function of the physical characteristics of the Rockaway River rather than differences in water quality.

REFERENCES CITED

Canace, Robert, Hutchinson, W.R., Saunders, W.R., and Andres, K.G., 1983, Results of the 1980-81 drought emergency ground-water investigation in Morris and Passaic Counties, New Jersey: New Jersey Geological Survey Open-File Report 83-3, 132 p.

Canace, Robert, Stanford, Scott, and Hall, David, in press, Hydrogeologic framework of the valley-fill deposits of the Rockaway River basin between Wharton and Montville, Morris County, New Jersey: New Jersey Geological Survey.

Fishman, M.J., and Friedman, L.C., eds., 1989, Methods for determination of inorganic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A1, 545 p.

Geonics, Ltd., 1979, Water resources study of the Rockaway Valley, Morris County, New Jersey: Clinton, N.J., Geonics, Ltd., 58 p.

Geraghty and Miller, Inc., 1968, Preliminary investigation of ground-water conditions in the Borough of Wharton, New Jersey: Port Washington, N.Y., Geraghty and Miller, Inc., 10 p.

_____ 1969, Appraisal of ground-water conditions in the Town of Dover, New Jersey: Port Washington, N.Y., Geraghty and Miller, Inc., 12 p.

_____ 1978, An evaluation of ground-water resources of the Rockaway River Valley within the communities of Denville, Boonton Township, Town of Boonton, Montville and Mountain Lakes, New Jersey: Port Washington, N.Y., Geraghty and Miller, Inc., 72 p.

Gill, H.E., and Vecchioli, John, 1965, Availability of ground water in Morris County, New Jersey: New Jersey Department of Conservation and Economic Development, Special Report 25, 56 p.

Guy, H.P., and Norman, V.W., 1970, Field methods for measurement of fluvial sediment: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. C2, 59 p.

Heath, R.C., 1983, Basic ground-water hydrology: U.S. Geological Survey Water-Supply Paper 2220, 84 p.

Hem, J.D., 1985, Study and interpretation of the chemical characteristics of natural water: U.S. Geological Survey Water-Supply Paper 2254, 263 p.

Hill, M.C., Lennon, G.P., Hebson, C.S., Brown, G.A., and Rheaume, S.J., 1992, Geohydrology of and simulation of ground-water flow in the valley-fill deposits in the Ramapo River Valley, New Jersey: U.S. Geological Survey Water-Resources Investigations Report 90-4151, 92 p.

Hochreiter, J.J., Jr., 1982, Chemical-quality reconnaissance of the water and surficial bed material in the Delaware River estuary and adjacent New Jersey tributaries, 1980-81: U.S. Geological Survey Water-Resources Investigations 82-36, 41 p.

Kammer, J.A., and Gibs, Jacob, 1989, An analytical technique for screening purgeable volatile organic compounds in water: U.S. Geological Survey Open-File Report 89-53, 13 p.

Kurtz, J.M., 1985, Ecological niches and pollution classifications of macroinvertebrates in New Jersey streams: Unpublished report on file at New Jersey Department of Environmental Protection, Division of Water Resources, Bureau of Monitoring and Data Management, Trenton, N.J., 30 p.

Lyttle, P.T., and Epstein, J.B., 1987, Geologic map of the Newark 1°x2° quadrangle, New Jersey, Pennsylvania, and New York: U.S. Geological Survey Miscellaneous Investigations Series Map I-1715, 2 sheets, scale 1:250,000.

National Oceanic and Atmospheric Administration, 1982, Monthly normals of temperature, precipitation, and heating and cooling degree days, 1951-80, New Jersey, in Climatography of the United States, No. 81: Asheville, N.C., National Oceanic and Atmospheric Administration, National Climatic Center, 9 p.

New Jersey Department of Environmental Protection, 1983, Field procedures manual for water data collection: Trenton, N.J., New Jersey Department of Environmental Protection, variable pagination.

_____ 1989a, Surface water quality standards, N.J.A.C. 7:9-4.1 et seq.: Trenton, N.J., New Jersey Department of Environmental Protection, August 1989, 118 p.

_____ 1989b, 1989 status report on the hazardous waste management program in New Jersey, site specific information: Trenton, N.J., New Jersey Department of Environmental Protection, October 1989, variable pagination.

_____ undated a, Geologic overlay sheet 22: Trenton, N.J., New Jersey Department of Environmental Protection, Bureau of Geology and Topography, scale 1:63,360.

_____ undated b, Geologic overlay sheet 25: Trenton, N.J., New Jersey Department of Environmental Protection, Bureau of Geology and Topography, scale 1:63,360.

New Jersey Register, 1989, v. 21, no. 54, January 3, 1989, unpaged.

Olsen, P.E., 1980, The latest Triassic and Early Jurassic formations of the Newark Basin (eastern North America, Newark Supergroup)--Stratigraphy, structure, and correlation: New Jersey Academy of Science Bulletin, v. 25, p. 25-51.

Piper, A.M., 1944, A graphic procedure in the geochemical interpretation of water analyses: EOS: Transactions of the American Geophysical Union, v. 25, p. 914-923.

Rantz, S.E., and others, 1982, Measurement and computation of streamflow--v. 1, Measurement of stage and discharge; v. 2, Computation of discharge: U.S. Geological Survey Water-Supply Paper 2175, 631 p.

Sims, P.K., 1958, Geology and magnetic deposits of Dover District, Morris County, New Jersey: U.S. Geological Survey Professional Paper 287, 162 p.

Smith, J.A., Harte, P.T., and Hardy, M.A., 1987, Trace-metal and organochlorine residues in sediments of the upper Rockaway River, New Jersey: Bulletin of Environmental Contamination and Toxicology, v. 39, p. 465-473.

Stanford, S.D., 1989a, Surficial geologic map of the Boonton quadrangle, Morris County, New Jersey: New Jersey Geological Survey Geologic Map Series 89-1, 1 sheet, scale 1:24,000.

_____ 1989b, Surficial geologic map of the Dover quadrangle, Morris and Sussex Counties, New Jersey: New Jersey Geological Survey Geologic Map Series 89-2, 1 sheet, scale 1:24,000.

Summers, Karen, and others, 1979, Determination of available water supply in the Rockaway Valley Regional Sewerage Authority service area, Morris County, New Jersey: Lafayette, California, Tetra Tech, Inc., 150 p.

U.S. Environmental Protection Agency, 1988a, Maximum contaminant levels (subpart B of 141, National interim primary drinking-water regulations): U.S. Code of Federal Regulations, Title 40, Parts 100 to 149, revised as of July 1, 1988, p. 530-533.

_____ 1988b, Secondary maximum contaminant levels (section 143.3 of part 143, National secondary drinking-water regulations): U.S. Code of Federal Regulations, Title 40, Parts 100 to 149, revised as of July 1, 1988, p. 608.

Wagner, L., 1979, Intensive lake survey of Boonton Reservoir (Rockaway River) Boonton and Parsippany-Troy Hills, New Jersey: Trenton, New Jersey, New Jersey Department of Environmental Protection, Division of Water Resources Lakes Management Program, 96 p.

Weber, C.I., 1973, Biological field and laboratory methods for measuring the quality of surface waters and effluents: Cincinnati, Ohio, U.S. Environmental Protection Agency EPA-670144-73-001, variable pagination.

Wershaw, R.L., Fishman, M.J., Grabbe, R.R., and Lowe, L.E., eds., 1987, Methods for the determination of organic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A3, 80 p.

Wood, W.W., 1976, Guidelines for collection and field analysis of ground-water samples for selected unstable constituents: U.S. Geological Survey Techniques of Water-Resources Investigations, book 1, chap. D2, 24 p.

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Table 3.--Well-site and -construction data for selected wells in the upper Rockaway River basin

[Twp, Township; DEP, Department of Environmental Protection; WD, Water Department; Dept, Department; Boro, Borough; MUA, Municipal Utilities Authority; CC, Country Club; TW, Test Well; Obs, Observation; CAF, Cafeteria; LF, Landfill; Inc, Incorporated; Rd, Road; MW, Monitoring Well; Rock-Super, Rockaway-Superfund; --, no data; USGS, U.S. Geological Survey]

USGS well number	New Jersey permit number	Owner	Local well name	Latitude (degrees)	Longitude (degrees)	Codes for types of data collected[1]
			BOONTON TOWNSHIP			
27- 30	25-07495	BOONTON TOWN WD	BTWD 5	405456	0742650	1,2
27- 32	25-17311	BOONTON TOWN WD	BTWD FIELD	405455	0742654	1
27-108	--	BOONTON TOWN WD	BTWD 1	405456	0742654	1
27-109	--	BOONTON TOWN WD	BTWD 2	405453	0742655	1
27-110	--	BOONTON TOWN WD	BTWD 3	405500	0742647	1
27-111	--	BOONTON TOWN WD	BTWD 4	405459	0742652	1
27-325	25-21174	BOONTON TOWN WD	VALLEY RD (GEONICS 3)	405542	0742617	1,2
27-541	22-04163	CUSACK, CHARLES	CUSACK 1	405712	0742457	2
27-919	--	BOONTON TOWN WD	BOONTON TW 2	405457	0742651	1
27-920	--	BOONTON TOWN WD	BOONTON TW 6	405502	0742643	1
			DENVILLE TOWNSHIP			
27- 35	25-09515	DENVILLE TWP WD	DTWD 5	405354	0742905	1,2
27-116	25-05142	DENVILLE TWP WD	DTWD 4	405407	0742859	1
27-189	--	MOUNTAIN LAKES WD	MLWD 4	405417	0742737	1,2
27-321	--	ROCKAWAY RIVER CC	GEONICS 2	405344	0742740	1,2
27-324	25-21172	ST CLARES HOSPITAL	POCONO RD	405334	0742828	1
27-916	25-24447	STATE OF NJ - DEP	DENVILLE TP-1	405438	0742950	1
27-917	25-24852	STATE OF NJ - DEP	DENVILLE TP-2	405432	0742946	1
			DOVER TOWN			
27-287	--	DOVER TOWN WD	DTWD OBS E	405318	0743407	1,2
27-291	25-16024	DOVER TOWN WD	DTWD 5	405317	0743404	2
27-295	25-24887	US GEOLOGICAL SURVEY	USGS S4	405318	0743407	1
27-297	25-24897	US GEOLOGICAL SURVEY	USGS S6	405316	0743412	1
27-306	25-25322	US GEOLOGICAL SURVEY	DOVER OBS D6	405316	0743412	1
27-322	25-09435	DOVER TOWN WD	DTWD TW-2	405314	0743250	1
27-357	25-10565	DOVER TOWN WD	DTWD 4 HOOEY	405309	0743229	2
27-854	25-09494	DOVER TOWN WD	DTWD TW 3	405304	0743243	1
27-855	25-10461	DOVER TOWN WD	DTWD TW 4	405309	0743229	1
			JEFFERSON TOWNSHIP			
27- 27	--	STATE OF NJ - DEP	BERKSHIRE VALLEY OBS-9	405531	0743619	1
27-911	25-25930	LOWERRE, F G	LOWERRE	405549	0743549	2
27-913	--	JEFFERSON TWP MUA	WHITE ROCK 2	410207	0743104	2
27-923	22-66039	RUSSINKO, GARY	RUSSINKO	405900	0743225	2
			MONTVILLE TOWNSHIP			
27-195	--	MONTVILLE TWP MUA	MTMUA 1	405229	0742111	2
			MOUNTAIN LAKES BOROUGH			
27-188	--	MOUNTAIN LAKES WD	TOWER HILL 4	405330	0742641	1,2
27-191	25-14698	MOUNTAIN LAKES WD	MLWD 5	405258	0742728	2
27-323	25-21173	MOUNTAIN LAKES WD	CRANE RD (GEONICS 1)	405253	0742708	1
27-914	25-13697	MOUNTAIN LAKES WD	MT LAKES P5 TEST	405258	0742735	1
			RANDOLPH TOWNSHIP			
27- 23	--	RANDOLPH TWP WD	MT FREEDOM 2 OBS	404921	0743356	1
27-117	25-19071	DENVILLE TWP WD	DTWD 6	405243	0743151	1
27-136	--	DENVILLE TWP WD	DTWD 3	405243	0743148	2
27-928	--	DENVILLE TWP WD	DENWD OBS	405242	0743147	1
27-936	25-10770	MORRIS COUNTY MUA	MCMUA MUSIKER	404921	0743349	2

Table 3.--Well-site and -construction data for selected wells in the upper Rockaway River basin--Continued

USGS well number	Primary use of site[2]	Date well constructed	Altitude of land surface (feet)[3]	Depth of well (feet)[4]	Top of open interval (feet)[4]	Bottom of open interval (feet)[4]	Diameter of interval (inches)	Aquifer code[5]
BOONTON TOWNSHIP								
27- 30	W	05/30/58	499.26	106	74.75	106	10	112SFDF2
27- 32	O	02/18/74	501.58	40	36	40	4	112SFDF1
27-108	W	10/20/30	504.86	43	20	40	26	112SFDF1
27-109	W	12/10/30	502.86	45	20	38	26	112SFDF1
27-110	W	08/28/46	497.91	25	20	25	26	112SFDF1
27-111	W	01/22/57	499.07	102.33	75.91	102.33	10	112SFDF2
27-325	O	09/24/79	501.71	147	140	147	6	400PCMB
27-541	W	06/15/59	510	44	--	--	6	112SFDF1
27-919	T	--	498.95	25	22	25	4	112SFDF1
27-920	T	--	495.48	59	57	59	1.6	112SFDF1
DENVILLE TOWNSHIP								
27- 35	W	09/28/61	509.21	201	178	198	16	112SFDF2
27-116	W	01/13/58	511.64	117	96	116	16	112SFDF2
27-189	C	08/25/47	503.89	64	32	64	17	112SFDF1
27-321	O	09/21/79	505	167	--	--	6	112SFDF2
27-324	O	09/27/79	500.48	200	185	200	6	112SFDF2
27-916	O	00/00/84	526.60	33	23	33	1.5	112SFDF1
27-917	O	00/00/84	519.20	47	37	47	2	112SFDF1
DOVER TOWN								
27-287	O	--	588.84	154	152	154	8	400PCMB
27-291	W	09/10/71	590.06	64	44	64	18	112SFDF1
27-295	O	05/10/84	588.64	28.6	18.6	28.6	2	112SFDF1
27-297	O	05/10/84	591.36	28.4	18.4	28.4	2	112SFDF1
27-306	O	08/14/84	591.46	60.5	50.5	59.5	4	112SFDF1
27-322	O	08/09/60	555	62	47	62	8	112SFDF1
27-357	W	07/19/62	555	138	118	138	18	112SFDF2
27-854	O	08/30/60	553.72	81	61	81	8	112SFDF2
27-855	O	04/05/62	553.85	150	126	150	8	112SFDF2
JEFFERSON TOWNSHIP								
27- 27	O	05/04/81	725.64	98	78	98	6	112SFDF2
27-911	W	02/22/85	700	102	100	102	6	112SFDF1
27-913	W	09/07/62	790	250	67.6	250	8	344BLVL
27-923	W	10/06/76	1060	263	50	263	5.4	344MRCL
MONTVILLE TOWNSHIP								
27-195	W	12/00/57	190	290	60	290	--	227BSLT
MOUNTAIN LAKES BOROUGH								
27-188	C	00/00/22	565.54	462	80	462	--	400PCMB
27-191	W	01/08/69	504.96	332	235	332	8	112SFDF2
27-323	O	09/11/79	502.76	250	237	250	6	112SFDF2
27-914	T	10/28/66	504.96	345	295	345	8	112SFDF2
RANDOLPH TOWNSHIP								
27- 23	O	--	800	218	11	218	8	400PCMB
27-117	U	09/06/77	545.58	139.58	124.58	139.58	16	112SFDF2
27-136	W	10/28/46	550	135	117	132	16	112SFDF2
27-928	O	00/00/86	544.34	13.4	--	--	--	112SFDF1
27-936	C	--	810	111	99.67	111	--	400PCMB

Table 3.--Well-site and -construction data for selected wells in the upper Rockaway River basin--Continued

USGS well number	New Jersey permit number	Owner	Local well name	Latitude (degrees)	Longitude (degrees)	Codes for types of data collected[1]
			ROCKAWAY BOROUGH			
27- 59	25-18231	ROCKAWAY BORO WD	RBWD 6	405413	0743026	2
27-686	25-14015	MCWILLIAMS FORGE INC	MCWILLIAMS 339	405308	0743116	2
27-699	25-05413	RADIO CORPORATION OF AMERICA	RCA 3	405322	0743053	1
27-876	25-05419	ROCKAWAY BORO WD	RBWD TW4	405358	0743046	1
27-890	25-23744	MCWILLIAMS FORGE INC	MCWILLIAMS 2	405303	0743120	1
27-912	--	ROCKAWAY BORO WD	RBWD 3 TEST	405342	0743057	1
27-924	25-23748	MCWILLIAMS FORGE INC	CONST DEWAT 1	405303	0743119	1
27-925	25-23986	MCWILLIAMS FORGE INC	MCWILLIAMS MW1	405305	0743115	1
27-926	25-24171	MCWILLIAMS FORGE INC	MCWILLIAMS 2A	405305	0743119	1
27-927	25-23987	MCWILLIAMS FORGE INC	MCWILLIAMS 3A	405308	0743116	1
27-929	25-27147	STATE OF NJ - DEP	ROCK-SUPER 1	405403	0743058	1
27-930	25-27148	STATE OF NJ - DEP	ROCK-SUPER 2	405408	0743048	1
27-931	25-27149	STATE OF NJ - DEP	ROCK-SUPER 3	405407	0743032	1
27-932	25-27150	STATE OF NJ - DEP	ROCK-SUPER 4	405414	0743024	1
27-933	25-27151	STATE OF NJ - DEP	ROCK-SUPER 5	405427	0743021	1
27-934	25-27152	STATE OF NJ - DEP	ROCK-SUPER 6	405420	0743034	1
27-935	25-27153	STATE OF NJ - DEP	ROCK-SUPER 7	405419	0743020	1
			ROCKAWAY TOWNSHIP			
27- 28	--	STATE OF NJ - DEP	GREEN POND OBS-5	410207	0742700	1,2
27- 80	25-15364	ROCKAWAY TWP WD	RTWD 7	405448	0743002	2
27-104	--	US ARMY - PICATINNY ARSENAL	PICATINNY MW16	405511	0743507	1
27-242	--	US ARMY - PICATINNY ARSENAL	PICATINNY CAF 1	405623	0743413	2
27-246	25-23213	US ARMY - PICATINNY ARSENAL	PICATINNY 65-1	405620	0743419	1,2
27-247	25-23214	US ARMY - PICATINNY ARSENAL	PICATINNY 65-2	405620	0743419	1
27-248	25-23215	US ARMY - PICATINNY ARSENAL	PICATINNY 65-3	405620	0743419	1
27-249	25-23216	US ARMY - PICATINNY ARSENAL	PICATINNY 65-4	405620	0743419	1
27-250	25-23208	US ARMY - PICATINNY ARSENAL	PICATINNY LF 1	405509	0743504	1
27-251	25-23209	US ARMY - PICATINNY ARSENAL	PICATINNY LF 2	405509	0743504	1
27-252	25-23210	US ARMY - PICATINNY ARSENAL	PICATINNY LF 3	405509	0743504	1
27-278	22-22814-4	US ARMY - PICATINNY ARSENAL	PICATINNY 176-SH	405635	0743339	2
27-280	22-22810-1	US ARMY - PICATINNY ARSENAL	PICATINNY H-2(D)	405619	0743415	2
27-657	25-23668	STIMENS, DAVID	TAYLOR 1	405558	0742839	2
27-709	25-21465	KEUFFEL & ESSER CO	KEUFFEL 2	405441	0742948	1
27-710	25-21466	KEUFFEL & ESSER CO	KEUFFEL 3	405440	0742950	1
27-711	25-21467	KEUFFEL & ESSER CO	KEUFFEL 4	405443	0742951	1
27-910	--	STATE OF NJ - DEP	SHELL 10	405439	0743005	1
27-918	--	ROCKAWAY TWP WD	ROCKAWAY TWP P7 TEST	405448	0743002	1
			ROXBURY TOWNSHIP			
27-908	25-22364	ZALASKY, MINNIE	ZALASKY	405341	0743642	2
27-921	--	STATE OF NJ - DEP	TW 10	405417	0743645	1
			WHARTON BOROUGH			
27-353	25-15799	WHARTON WD	WBWD 3	405339	0743408	2
27-827	25-08675	WHARTON WD	WBWD 2	405412	0743526	2
27-915	25-15572	WHARTON WD	WHARTON P3 TEST	405339	0743408	1

[1] Types of data collected: 1, water level; 2, water quality.

[2] Primary use of site: C, standby, emergency-supply; O, observation; W, withdrawal; T, test; U, unused.

[3] Referenced to sea level.

[4] Referenced to land surface.

[5] Aquifer codes:

112SFDF1- Stratified drift, unconfined
112SFDF2- Stratified drift, confined
227BSLT - Brunswick Group, undivided basalt flows
344BLVL - Bellvale Sandstone
344MRCL - Marcellus Shale
374LSVL - Leithsville Formation
377HRDS - Hardyston Quartzite
400PCMB - Precambrian rocks

Table 3.--Well-site and -construction data for selected wells in the upper Rockaway River basin--Continued

USGS well number	Primary use of site[2]	Date well constructed	Altitude of land surface (feet)[3]	Depth of well (feet)[4]	Top of open interval (feet)[4]	Bottom of open interval (feet)[4]	Diameter of interval (inches)	Aquifer code[5]
ROCKAWAY BOROUGH								
27- 59	W	03/01/76	520	83	58	83	12	112SFDF1
27-686	W	10/04/66	560	148	147	148	8	112SFDF2
27-699	W	06/14/56	582.72	543	63	543	--	400PCMB
27-876	O	04/30/56	530.67	72	61	71	--	112SFDF1
27-890	O	03/03/83	550	60	40	60	--	112SFDF1
27-912	T	--	531.17	128	125	128	2	112SFDF2
27-924	O	03/03/83	537.40	60	40	60	12	112SFDF1
27-925	O	07/21/83	536.90	30	10	30	2	112SFDF1
27-926	O	09/02/83	537.82	30	10	30	2	112SFDF1
27-927	O	08/31/83	537.94	30	10	30	2	112SFDF1
27-929	O	12/09/85	546.18	30.1	10.1	30.1	4	112SFDF1
27-930	O	01/20/86	555.64	92.02	72.02	92.02	4	112SFDF2
27-931	O	01/06/86	515.16	88.30	68.30	88.30	4	112SFDF2
27-932	O	01/16/86	510.99	37	17	37	4	112SFDF1
27-933	O	02/18/86	530.79	73.25	53.25	73.25	4	112SFDF1
27-934	O	02/10/86	532.11	61.02	41.02	61.02	4	112SFDF2
27-935	O	02/03/86	524.67	68.30	48.3	68.3	4	112SFDF2
ROCKAWAY TOWNSHIP								
27- 28	O	04/30/81	758.56	120	80	120	6	112SFDF1
27- 80	W	12/23/69	520	150	88	143	12	112SFDF2
27-104	O	01/15/81	692.63	20.4	10	20.4	4	112SFDF1
27-242	O	11/12/82	702.72	268	253	268	4	377HRDS
27-246	O	12/16/82	700.27	287	267	287	4	374LSVL
27-247	O	12/09/82	700	206	201	206	4	112SFDF2
27-248	O	12/15/82	700.32	140	135	140	4	112SFDF2
27-249	O	12/15/82	700.23	35	30	35	4	112SFDF1
27-250	O	12/02/82	692.85	345	325	345	4	374LSVL
27-251	O	12/07/82	693.29	65	60	65	4	112SFDF1
27-252	O	12/14/82	693.08	157	152	157	4	112SFDF2
27-278	O	02/24/84	689.31	60	50	60	4	112SFDF2
27-280	O	04/18/84	699.23	223	203	223	4	374LSVL
27-657	W	04/08/83	530	42	--	--	6	112SFDF1
27-709	O	07/14/80	524.10	50	--	--	6	112SFDF1
27-710	O	08/15/80	523.90	90	73	90	--	400PCMB
27-711	O	08/19/80	524.21	121	101	121	--	112SFDF2
27-910	O	03/24/81	543.81	68	28	68	4	112SFDF1
27-918	O	--	522.71	149	97	149	4	112SFDF2
ROXBURY TOWNSHIP								
27-908	W	12/30/81	710	135	131	135	6	112SFDF2
27-921	O	05/05/81	695.51	87.91	67.91	87.91	6	112SFDF2
WHARTON BOROUGH								
27-353	W	04/16/71	597.29	65	40	65	18	112SFDF1
27-827	W	12/21/60	650	32	27	32	16	112SFDF1
27-915	T	06/29/70	597.29	65	40	65	8	112SFDF1

Table 4.--Summary of ground-water levels in observation wells measured bimonthly in the upper Rockaway River Basin, May 1985-August 1986

USGS well number[1]	Local well name	Maximum water level[2] (feet)	Date	Minimum water level[2] (feet)	Date	Difference between maximum and minimum water levels (feet)	Aquifer code[3]	Water levels affected by pumpage?
27- 30	BOONTON 5	7.15	12/09/85	11.62	09/19/85	4.47	112SFDF2	YES
27- 32	BOONTON FIELD	8.85	08/06/86	10.92	06/11/86	2.07	112SFDF1	*[4]
27-104	PICATINNY ARSENAL MW 16	8.21	02/03/86	9.74	09/19/85	1.53	112SFDF1	NO
27-108	BOONTON 1	11.67	12/09/85	14.80	06/11/86	3.13	112SFDF1	*
27-109	BOONTON 2	9.87	10/07/85	11.58	06/11/86	1.71	112SFDF1	*
27-110	BOONTON 3	4.85	12/09/85	7.78	09/19/85	2.93	112SFDF1	*
27-111	BOONTON 4	7.29	12/09/85	11.56	09/19/85	4.27	112SFDF2	YES
27-116	DENVILLE 4	12.36	04/02/86	18.46	08/07/85	6.10	112SFDF2	YES
27-117	DENVILLE 6	5.67	04/02/86	9.70	08/07/85	4.03	112SFDF2	YES
27-188	MT. LAKES TOWER HILL 4	45.36	06/11/86	60.77	12/11/85	15.41	400PCMB	NO
27-189	MT. LAKES 4	9.08	08/05/86	11.39	09/19/85	2.31	112SFDF1	NO
27-246	PICATINNY ARSENAL 65-1	7.32	02/03/86	16.07	08/04/86	8.75	374LSVL	YES
27-247	PICATINNY ARSENAL 65-2	7.77	02/03/86	17.16	09/19/85	9.39	112SFDF2	YES
27-248	PICATINNY ARSENAL 65-3	6.41	02/03/86	14.03	09/19/85	7.62	112SFDF2	YES
27-249	PICATINNY ARSENAL 65-4	7.02	02/03/86	9.94	09/19/85	2.92	112SFDF1	YES
27-250	PICATINNY ARSENAL LF-1	16.01	04/02/86	20.89	09/19/85	4.88	374LSVL	NO
27-252	PICATINNY ARSENAL LF-3	12.22	04/02/86	17.85	09/19/85	5.63	112SFDF2	NO
27-287	DOVER OBS E	8.61	04/02/86	10.80	09/19/85	2.19	400PCMB	YES
27-306	DOVER OBS D6	12.16	12/10/85	14.84	09/19/85	2.68	112SFDF1	YES
27-710	KEUFFEL 3	26.39	04/02/86	31.74	08/07/86	5.35	400PCMB	YES
27-711	KEUFFEL 4	29.78	04/02/86	36.43	06/10/86	6.65	112SFDF1	YES
27-854	DOVER TW3	2.61	10/08/85	3.79	12/12/85	1.18	112SFDF2	NO
27-855	DOVER TW4	3.50	02/04/86	6.44	06/04/86	2.94	112SFDF2	NO
27-876	ROCKAWAY TW 4	9.84	06/10/86	12.16	09/19/85	2.32	112SFDF1	YES
27-910	SHELL 10	46.93	06/10/86	49.58	08/05/86	2.65	112SFDF1	*
27-912	ROCKAWAY 3 TEST	5.59	04/02/86	9.65	06/04/85	4.06	112SFDF2	NO
27-914	MT. LAKES P5 TEST	126.50	02/28/86	131.14	10/16/85	4.64	112SFDF2	YES
27-915	WHARTON P3 TEST	6.18	04/02/86	8.56	09/19/85	2.38	112SFDF1	NO
27-917	DENVILLE TP 2	14.53	04/02/86	18.82	09/19/85	4.29	112SFDF1	NO
27-918	ROCKAWAY P7 TEST	30.33	04/02/86	50.12	09/19/85	19.79	112SFDF2	YES
27-919	BOONTON TW 2	5.70	12/09/85	12.50	09/19/85	6.80	112SFDF1	*
27-920	BOONTON TW 6	2.39	12/09/85	5.43	09/19/85	3.04	112SFDF1	YES
27-921	TW 10	6.35	04/02/86	11.75	09/19/85	5.40	112SFDF2	NO

[1] Wells 27-916 and 27-925 excluded from table because of insufficient data.

[2] Referenced to land surface.

[3] Aquifer codes:

- 112SFDF1 Stratified drift, unconfined
- 112SFDF2 Stratified drift, confined
- 374LSVL Leithsville Formation
- 400PCMB Precambrian rocks

[4] *, not determined.

Table 5.--Ground-water levels in manually measured wells in the upper Rockaway River basin, 1985-86

[---, no data]

USGS well number	Local well name	Date of measurement	Water-level (feet below land surface)	Altitude of water level[1] (feet)	Aquifer code[2]
27-23	MT. FREEDOM 2 OBS	06/20/85	1.34	798.66	400PCMB
27-23	MT. FREEDOM 2 OBS	06/03/86	8.29	791.71	
27-30	BOONTON 5	06/07/85	9.64	489.62	112SFDF2
27-30	BOONTON 5	08/12/85	10.70	488.56	
27-30	BOONTON 5	09/19/85	11.62	487.64	
27-30	BOONTON 5	10/07/85	9.14	490.12	
27-30	BOONTON 5	12/09/85	7.15	492.11	
27-30	BOONTON 5	02/14/86	8.14	491.12	
27-30	BOONTON 5	04/02/86	8.12	491.14	
27-30	BOONTON 5	06/11/86	9.19	490.07	
27-30	BOONTON 5	08/06/86	8.87	490.39	
27-32	BOONTON FIELD	06/07/85	9.85	491.73	112SFDF1
27-32	BOONTON FIELD	08/12/85	9.58	492.00	
27-32	BOONTON FIELD	09/19/85	10.51	491.07	
27-32	BOONTON FIELD	10/07/85	9.19	492.39	
27-32	BOONTON FIELD	12/09/85	8.95	492.63	
27-32	BOONTON FIELD	02/14/86	9.58	492.00	
27-32	BOONTON FIELD	04/02/86	10.17	491.41	
27-32	BOONTON FIELD	06/11/86	10.92	490.66	
27-32	BOONTON FIELD	08/06/86	8.85	492.73	
27-35	DENVILLE 5	02/04/86	27.65	481.56	112SFDF2
27-35	DENVILLE 5	04/09/86	26.40	482.81	
27-35	DENVILLE 5	06/07/86	26.81	482.40	
27-104	PICATINNY MW16	06/05/85	9.09	683.54	112SFDF1
27-104	PICATINNY MW16	06/06/85	8.66	683.97	
27-104	PICATINNY MW16	08/05/85	9.19	683.44	
27-104	PICATINNY MW16	09/19/85	9.74	682.89	
27-104	PICATINNY MW16	10/07/85	8.76	683.87	
27-104	PICATINNY MW16	12/09/85	8.27	684.36	
27-104	PICATINNY MW16	02/03/86	8.21	684.42	
27-104	PICATINNY MW16	06/13/86	8.37	684.26	
27-104	PICATINNY MW16	08/04/86	8.95	683.68	
27-108	BOONTON 1	06/07/85	13.03	491.83	112SFDF1
27-108	BOONTON 1	08/12/85	13.16	491.70	
27-108	BOONTON 1	10/07/85	13.10	491.76	
27-108	BOONTON 1	12/09/85	11.67	493.19	
27-108	BOONTON 1	02/14/86	12.44	492.42	
27-108	BOONTON 1	04/02/86	13.87	490.99	
27-108	BOONTON 1	06/11/86	14.80	490.06	
27-108	BOONTON 1	08/06/86	12.06	492.80	
27-109	BOONTON 2	06/07/85	10.95	491.91	112SFDF1
27-109	BOONTON 2	08/12/85	10.52	492.34	
27-109	BOONTON 2	09/19/85	11.16	491.70	
27-109	BOONTON 2	10/07/85	9.87	492.99	
27-109	BOONTON 2	12/09/85	10.93	491.93	
27-109	BOONTON 2	02/14/86	11.35	491.51	
27-109	BOONTON 2	04/02/86	11.47	491.39	
27-109	BOONTON 2	06/11/86	11.58	491.28	
27-109	BOONTON 2	08/06/86	10.08	492.78	
27-110	BOONTON 3	06/07/85	5.82	492.09	112SFDF1
27-110	BOONTON 3	08/12/85	7.46	490.45	
27-110	BOONTON 3	09/19/85	7.78	490.13	
27-110	BOONTON 3	10/07/85	5.36	492.55	
27-110	BOONTON 3	12/09/85	4.85	493.06	
27-110	BOONTON 3	02/14/86	5.42	492.49	
27-110	BOONTON 3	04/02/86	5.54	492.37	
27-110	BOONTON 3	06/11/86	6.47	491.44	
27-110	BOONTON 3	08/06/86	5.21	492.70	
27-111	BOONTON 4	08/12/85	10.47	488.60	112SFDF2
27-111	BOONTON 4	09/19/85	11.56	487.51	
27-111	BOONTON 4	10/07/85	8.90	490.17	
27-111	BOONTON 4	12/09/85	7.29	491.78	
27-111	BOONTON 4	02/14/86	8.27	490.80	
27-111	BOONTON 4	04/02/86	8.42	490.65	
27-111	BOONTON 4	06/11/86	9.07	490.00	
27-111	BOONTON 4	08/06/86	8.66	490.41	

Table 5.--Ground-water levels in manually measured wells, in the upper Rockaway River basin, 1985-86--Continued

USGS well number	Local well name	Date of measure-ment	Water-level (feet below land surface)	Altitude of water level[1] (feet)	Aquifer code[2]
27-116	DENVILLE 4	06/04/85	18.20	493.44	112SFDF2
27-116	DENVILLE 4	08/07/85	18.46	493.18	
27-116	DENVILLE 4	10/09/85	18.33	493.31	
27-116	DENVILLE 4	12/11/85	15.91	495.73	
27-116	DENVILLE 4	02/14/86	14.83	496.81	
27-116	DENVILLE 4	04/02/86	12.36	499.28	
27-116	DENVILLE 4	06/10/86	17.49	494.15	
27-116	DENVILLE 4	08/05/86	18.18	493.46	
27-117	DENVILLE 6	08/07/85	9.70	535.88	112SFDF2
27-117	DENVILLE 6	10/09/85	7.61	537.97	
27-117	DENVILLE 6	12/11/85	6.96	538.62	
27-117	DENVILLE 6	02/14/86	6.10	539.48	
27-117	DENVILLE 6	04/02/86	5.67	539.91	
27-117	DENVILLE 6	06/10/86	8.98	536.60	
27-117	DENVILLE 6	08/05/86	8.96	536.62	
27-188	TOWER HILL 4	06/04/85	58.81	506.73	400PCMB
27-188	TOWER HILL 4	08/07/85	58.03	507.51	
27-188	TOWER HILL 4	10/09/85	60.38	505.16	
27-188	TOWER HILL 4	12/11/85	60.77	504.77	
27-188	TOWER HILL 4	02/14/86	58.76	506.78	
27-188	TOWER HILL 4	04/02/86	58.34	507.20	
27-188	TOWER HILL 4	06/11/86	45.36	520.18	
27-188	TOWER HILL 4	08/05/86	53.87	511.67	
27-189	MT LAKES 4	06/04/85	10.81	493.08	112SFDF1
27-189	MT LAKES 4	08/07/85	10.98	492.91	
27-189	MT LAKES 4	09/19/85	11.39	492.50	
27-189	MT LAKES 4	10/09/85	10.18	493.71	
27-189	MT LAKES 4	12/11/85	9.39	494.50	
27-189	MT LAKES 4	02/14/86	9.67	494.22	
27-189	MT LAKES 4	04/02/86	9.61	494.28	
27-189	MT LAKES 4	06/11/86	9.84	494.05	
27-189	MT LAKES 4	08/05/86	9.08	494.81	
27-246	PICATINNY 65-1	06/05/85	12.18	688.09	374LSVL
27-246	PICATINNY 65-1	08/05/85	14.92	685.35	
27-246	PICATINNY 65-1	09/19/85	15.11	685.16	
27-246	PICATINNY 65-1	10/07/85	12.01	688.26	
27-246	PICATINNY 65-1	12/09/85	8.79	691.48	
27-246	PICATINNY 65-1	02/03/86	7.32	692.95	
27-246	PICATINNY 65-1	04/02/86	7.60	692.67	
27-246	PICATINNY 65-1	06/13/86	13.87	686.40	
27-246	PICATINNY 65-1	08/04/86	16.07	684.20	
27-247	PICATINNY 65-2	06/05/85	12.04	687.96	112SFDF2
27-247	PICATINNY 65-2	08/05/85	14.08	685.92	
27-247	PICATINNY 65-2	09/19/85	17.16	682.84	
27-247	PICATINNY 65-2	10/07/85	11.88	688.12	
27-247	PICATINNY 65-2	12/09/85	9.01	690.99	
27-247	PICATINNY 65-2	02/03/86	7.77	692.23	
27-247	PICATINNY 65-2	04/02/86	8.21	691.79	
27-247	PICATINNY 65-2	06/13/86	12.05	687.95	
27-247	PICATINNY 65-2	08/04/86	9.56	690.44	
27-248	PICATINNY 65-3	06/05/85	11.56	688.76	112SFDF2
27-248	PICATINNY 65-3	08/05/85	12.91	687.41	
27-248	PICATINNY 65-3	09/19/85	14.03	686.29	
27-248	PICATINNY 65-3	10/07/85	10.70	689.62	
27-248	PICATINNY 65-3	12/09/85	7.32	693.00	
27-248	PICATINNY 65-3	02/03/86	6.41	693.91	
27-248	PICATINNY 65-3	04/02/86	8.03	693.30	
27-248	PICATINNY 65-3	06/13/86	11.00	689.32	
27-248	PICATINNY 65-3	08/04/86	8.93	691.39	
27-249	PICATINNY 65-4	06/05/85	8.67	691.56	112SFDF1
27-249	PICATINNY 65-4	08/05/85	8.91	691.32	
27-249	PICATINNY 65-4	09/19/85	9.94	690.29	
27-249	PICATINNY 65-4	10/07/85	9.02	691.21	
27-249	PICATINNY 65-4	12/09/85	7.11	693.12	
27-249	PICATINNY 65-4	02/03/86	7.02	693.21	
27-249	PICATINNY 65-4	04/02/86	7.06	693.17	
27-249	PICATINNY 65-4	06/13/86	7.69	692.54	
27-249	PICATINNY 65-4	08/04/86	8.49	691.74	

Table 5.--Ground-water levels in manually measured wells, in the upper Rockaway River basin, 1985-86--Continued

USGS well number	Local well name	Date of measurement	Water-level (feet below land surface)	Altitude of water level[1] (feet)	Aquifer code[2]
27-250	PICATINNY LF-1	06/05/85	19.76	673.09	374LSVL
27-250	PICATINNY LF-1	06/06/85	19.06	673.79	
27-250	PICATINNY LF-1	08/05/85	19.47	673.38	
27-250	PICATINNY LF-1	09/19/85	20.89	671.96	
27-250	PICATINNY LF-1	10/07/85	20.17	672.68	
27-250	PICATINNY LF-1	12/09/85	17.97	674.88	
27-250	PICATINNY LF-1	02/03/86	17.59	675.26	
27-250	PICATINNY LF-1	04/02/86	16.01	676.84	
27-250	PICATINNY LF-1	06/13/86	16.76	676.09	
27-250	PICATINNY LF-1	08/04/86	18.58	674.27	
27-252	PICATINNY LF-3	06/05/85	16.07	677.01	112SFDF2
27-252	PICATINNY LF-3	06/06/85	15.65	677.43	
27-252	PICATINNY LF-3	08/05/85	16.29	676.79	
27-252	PICATINNY LF-3	09/19/85	17.85	675.23	
27-252	PICATINNY LF-3	10/07/85	17.21	675.87	
27-252	PICATINNY LF-3	12/09/85	14.52	678.56	
27-252	PICATINNY LF-3	02/03/86	13.93	679.15	
27-252	PICATINNY LF-3	04/02/86	12.22	680.86	
27-252	PICATINNY LF-3	06/13/86	13.43	679.65	
27-252	PICATINNY LF-3	08/04/86	15.67	677.41	
27-287	DOVER OBS E	06/04/85	10.20	578.64	400PCMB
27-287	DOVER OBS E	08/07/85	10.13	578.71	
27-287	DOVER OBS E	09/19/85	10.80	578.04	
27-287	DOVER OBS E	10/08/85	9.70	579.14	
27-287	DOVER OBS E	12/10/85	8.75	580.09	
27-287	DOVER OBS E	02/04/86	8.74	580.10	
27-287	DOVER OBS E	04/02/86	8.61	580.23	
27-287	DOVER OBS E	06/11/86	8.98	579.86	
27-287	DOVER OBS E	08/04/86	9.21	579.63	
27-295	USGS S4	06/18/86	11.70	576.94	112SFDF1
27-297	USGS S6	06/18/86	12.97	578.39	112SFDF1
27-306	DOVER OBS D6	06/04/85	13.92	577.54	112SFDF1
27-306	DOVER OBS D6	08/07/85	14.07	577.39	
27-306	DOVER OBS D6	09/19/85	14.84	576.62	
27-306	DOVER OBS D6	10/08/85	13.22	578.24	
27-306	DOVER OBS D6	12/10/85	12.16	579.30	
27-306	DOVER OBS D6	02/04/86	12.18	579.28	
27-306	DOVER OBS D6	04/02/86	12.55	578.91	
27-306	DOVER OBS D6	06/11/86	12.42	579.04	
27-306	DOVER OBS D6	08/04/86	12.72	578.74	
27-699	RCA 3	02/03/86	---	550.38	400PCMB
27-699	RCA 3	04/08/86	---	551.33	
27-699	RCA 3	06/09/86	---	551.55	
27-699	RCA 3	08/15/86	---	549.35	
27-710	KEUFFEL 3	05/07/85	28.69	495.21	400PCMB
27-710	KEUFFEL 3	06/06/85	28.26	495.64	
27-710	KEUFFEL 3	08/06/85	29.34	494.56	
27-710	KEUFFEL 3	09/19/85	30.29	493.61	
27-710	KEUFFEL 3	10/08/85	29.75	494.15	
27-710	KEUFFEL 3	12/10/85	27.19	496.71	
27-710	KEUFFEL 3	02/12/86	27.22	496.68	
27-710	KEUFFEL 3	04/02/86	26.39	497.51	
27-710	KEUFFEL 3	06/10/86	31.62	492.28	
27-710	KEUFFEL 3	08/07/86	31.74	492.16	
27-711	KEUFFEL 4	05/07/85	32.56	491.65	112SFDF2
27-711	KEUFFEL 4	06/06/85	31.26	492.95	
27-711	KEUFFEL 4	08/06/85	32.68	491.53	
27-711	KEUFFEL 4	09/19/85	34.43	489.78	
27-711	KEUFFEL 4	10/08/85	32.54	491.67	
27-711	KEUFFEL 4	12/10/85	30.45	493.76	
27-711	KEUFFEL 4	02/12/86	30.71	493.50	
27-711	KEUFFEL 4	04/02/86	29.78	494.43	
27-711	KEUFFEL 4	06/10/86	36.43	487.78	
27-711	KEUFFEL 4	08/07/86	35.54	488.67	

Table 5.--Ground-water levels in manually measured wells, in the upper Rockaway River basin, 1985-86--Continued

USGS well number	Local well name	Date of measure-ment	Water-level (feet below land surface)	Altitude of water level[1] (feet)	Aquifer code[2]
27-854	DTWD TW3	06/04/85	3.38	550.34	112SFDF2
27-854	DTWD TW3	08/09/85	3.03	550.69	
27-854	DTWD TW3	09/19/85	3.65	550.07	
27-854	DTWD TW3	10/08/85	2.61	551.11	
27-854	DTWD TW3	12/12/85	3.79	549.93	
27-854	DTWD TW3	02/04/86	3.77	549.95	
27-854	DTWD TW3	04/02/86	3.75	549.97	
27-854	DTWD TW3	06/11/86	3.77	549.95	
27-854	DTWD TW3	08/04/86	3.77	549.95	
27-855	DTWD TW 4	06/04/85	6.44	547.41	112SFDF2
27-855	DTWD TW 4	08/07/85	4.29	549.56	
27-855	DTWD TW 4	08/09/85	4.15	549.70	
27-855	DTWD TW 4	09/19/85	5.32	548.53	
27-855	DTWD TW 4	10/08/85	4.20	549.65	
27-855	DTWD TW 4	12/10/85	3.55	550.30	
27-855	DTWD TW 4	02/04/86	3.50	550.35	
27-855	DTWD TW 4	04/02/86	3.63	550.22	
27-855	DTWD TW 4	06/11/86	4.72	549.13	
27-855	DTWD TW 4	08/04/86	4.19	549.66	
27-876	ROCKAWAY TW 4	06/04/85	11.42	519.25	112SFDF1
27-876	ROCKAWAY TW 4	08/06/85	11.51	519.16	
27-876	ROCKAWAY TW 4	09/19/85	12.16	518.51	
27-876	ROCKAWAY TW 4	10/08/85	11.21	519.46	
27-876	ROCKAWAY TW 4	12/10/85	10.48	520.19	
27-876	ROCKAWAY TW 4	02/04/86	10.15	520.52	
27-876	ROCKAWAY TW 4	04/02/86	10.04	520.63	
27-876	ROCKAWAY TW 4	06/10/86	9.84	520.83	
27-876	ROCKAWAY TW 4	08/06/86	9.90	520.77	
27-890	MCWILLIAMS 2	06/01/86	15.46	534.54	112SFDF1
27-910	SHELL 10	06/07/85	48.48	495.33	112SFDF1
27-910	SHELL 10	08/06/85	48.83	494.98	
27-910	SHELL 10	09/19/85	49.51	494.30	
27-910	SHELL 10	10/08/85	49.42	494.39	
27-910	SHELL 10	12/10/85	48.59	495.22	
27-910	SHELL 10	02/04/86	47.86	495.95	
27-910	SHELL 10	04/02/86	46.93	496.88	
27-910	SHELL 10	06/14/86	48.16	495.65	
27-910	SHELL 10	08/05/86	49.58	494.23	
27-912	ROCKAWAY 3 TEST	06/04/85	9.65	521.51	112SFDF2
27-912	ROCKAWAY 3 TEST	08/06/85	8.14	523.02	
27-912	ROCKAWAY 3 TEST	09/19/85	9.58	521.58	
27-912	ROCKAWAY 3 TEST	10/08/85	8.38	522.78	
27-912	ROCKAWAY 3 TEST	12/10/85	7.05	524.11	
27-912	ROCKAWAY 3 TEST	02/04/86	6.26	524.90	
27-912	ROCKAWAY 3 TEST	04/02/86	5.59	525.57	
27-912	ROCKAWAY 3 TEST	06/10/86	5.93	525.23	
27-912	ROCKAWAY 3 TEST	08/06/86	6.77	524.39	
27-914	MT LAKES P5 TEST	06/10/85	127.77	377.19	112SFDF2
27-914	MT LAKES P5 TEST	08/07/85	129.79	375.17	
27-914	MT LAKES P5 TEST	09/19/85	129.68	375.28	
27-914	MT LAKES P5 TEST	10/16/85	131.14	373.82	
27-914	MT LAKES P5 TEST	12/13/85	127.50	377.46	
27-914	MT LAKES P5 TEST	02/28/86	126.50	378.46	
27-914	MT LAKES P5 TEST	04/02/86	127.00	377.96	
27-914	MT LAKES P5 TEST	06/11/86	129.99	374.97	
27-914	MT LAKES P5 TEST	08/05/86	128.72	376.24	
27-915	WHARTON P3 TEST	06/14/85	8.01	589.28	112SFDF1
27-915	WHARTON P3 TEST	08/07/85	7.81	589.48	
27-915	WHARTON P3 TEST	09/19/85	8.56	588.73	
27-915	WHARTON P3 TEST	10/08/85	7.21	590.08	
27-915	WHARTON P3 TEST	12/10/85	6.24	591.05	
27-915	WHARTON P3 TEST	02/04/86	6.27	591.02	
27-915	WHARTON P3 TEST	04/02/86	6.18	591.11	
27-915	WHARTON P3 TEST	06/13/86	6.53	590.76	
27-915	WHARTON P3 TEST	08/04/86	6.54	590.75	

Table 5.--Ground-water levels in manually measured wells, in the upper Rockaway River basin, 1985-86--Continued

USGS well number	Local well name	Date of measure-ment	Water-level (feet below land surface)	Altitude of water level[1] (feet)	Aquifer code[2]
27-916	DENVILLE TP 1	05/07/85	WELL DRY		112SFDF1
27-916	DENVILLE TP 1	06/06/85	WELL DRY		
27-916	DENVILLE TP 1	08/06/85	WELL DRY		
27-916	DENVILLE TP 1	10/08/85	23.92	502.68	
27-916	DENVILLE TP 1	12/10/85	24.63	501.97	
27-916	DENVILLE TP 1	02/12/86	26.12	500.48	
27-916	DENVILLE TP 1	04/02/86	24.87	501.73	
27-916	DENVILLE TP 1	08/07/86	31.66	494.94	
27-917	DENVILLE TP 2	05/07/85	16.83	502.37	112SFDF1
27-917	DENVILLE TP 2	06/06/85	16.90	502.30	
27-917	DENVILLE TP 2	08/06/85	17.81	501.39	
27-917	DENVILLE TP 2	09/19/85	18.82	500.38	
27-917	DENVILLE TP 2	10/08/85	17.93	501.27	
27-917	DENVILLE TP 2	12/10/85	15.79	503.41	
27-917	DENVILLE TP 2	02/12/86	15.33	503.87	
27-917	DENVILLE TP 2	04/02/86	14.53	504.67	
27-917	DENVILLE TP 2	06/10/86	16.23	502.97	
27-917	DENVILLE TP 2	08/07/86	17.45	501.75	
27-918	ROCKAWAY P7 TEST	06/06/85	31.73	490.98	112SFDF2
27-918	ROCKAWAY P7 TEST	08/06/85	33.32	489.39	
27-918	ROCKAWAY P7 TEST	09/19/85	50.12	472.59	
27-918	ROCKAWAY P7 TEST	10/08/85	32.87	489.84	
27-918	ROCKAWAY P7 TEST	12/10/85	30.84	491.87	
27-918	ROCKAWAY P7 TEST	02/12/86	31.34	491.37	
27-918	ROCKAWAY P7 TEST	04/02/86	30.33	492.38	
27-918	ROCKAWAY P7 TEST	06/10/86	38.31	484.40	
27-918	ROCKAWAY P7 TEST	08/07/86	36.73	485.98	
27-919	BOONTON TW 2	06/07/85	6.94	492.01	112SFDF1
27-919	BOONTON TW 2	08/12/85	11.24	487.71	
27-919	BOONTON TW 2	09/19/85	12.50	486.45	
27-919	BOONTON TW 2	10/09/85	6.56	492.39	
27-919	BOONTON TW 2	12/09/85	5.70	493.25	
27-919	BOONTON TW 2	02/14/86	8.63	490.32	
27-919	BOONTON TW 2	04/02/86	8.37	490.58	
27-919	BOONTON TW 2	06/11/86	9.66	489.29	
27-919	BOONTON TW 2	08/06/86	9.49	489.46	
27-920	BOONTON TW 6	06/07/85	3.50	491.98	112SFDF1
27-920	BOONTON TW 6	08/12/85	5.04	490.44	
27-920	BOONTON TW 6	09/19/85	5.43	490.05	
27-920	BOONTON TW 6	10/07/85	3.07	492.41	
27-920	BOONTON TW 6	12/09/85	2.39	493.09	
27-920	BOONTON TW 6	02/14/86	3.01	492.47	
27-920	BOONTON TW 6	04/02/86	3.09	492.39	
27-920	BOONTON TW 6	06/11/86	3.96	491.52	
27-920	BOONTON TW 6	08/06/86	2.86	492.62	
27-921	TW 10	05/04/85	10.74	684.77	112SFDF2
27-921	TW 10	06/06/85	10.35	685.16	
27-921	TW 10	08/05/85	10.54	684.97	
27-921	TW 10	09/19/85	11.75	683.76	
27-921	TW 10	10/07/85	11.34	684.17	
27-921	TW 10	12/09/85	9.49	686.02	
27-921	TW 10	02/03/86	8.89	686.62	
27-921	TW 10	04/02/86	6.35	689.16	
27-921	TW 10	06/11/86	6.92	688.59	
27-921	TW 10	08/04/86	9.31	686.20	
27-924	CONST DEWAT 1	04/22/86	2.90	534.50	112SFDF1
27-924	CONST DEWAT 1	06/27/86	4.40	533.00	
27-925	MCWILLIAMS MW 1	09/01/85	2.76	534.14	112SFDF1
27-925	MCWILLIAMS MW 1	10/01/85	3.26	533.64	
27-925	MCWILLIAMS MW 1	11/01/85	2.46	534.44	
27-925	MCWILLIAMS MW 1	12/01/85	3.16	533.74	
27-925	MCWILLIAMS MW 1	01/01/86	2.31	534.59	
27-925	MCWILLIAMS MW 1	02/01/86	2.71	534.19	
27-925	MCWILLIAMS MW 1	03/01/86	2.71	534.19	
27-925	MCWILLIAMS MW 1	04/22/86	2.36	534.54	
27-925	MCWILLIAMS MW 1	05/01/86	2.36	534.54	
27-925	MCWILLIAMS MW 1	06/27/86	3.36	533.54	
27-926	MCWILLIAMS 2A	09/01/85	4.24	533.58	112SFDF1
27-926	MCWILLIAMS 2A	04/22/86	3.44	534.38	
27-926	MCWILLIAMS 2A	06/27/86	4.74	533.08	

Table 5.--Ground-water levels in manually measured wells, in the upper Rockaway River basin, 1985-86--Continued

USGS well number	Local well name	Date of measure-ment	Water-level (feet below land surface)	Altitude of water level[1] (feet)	Aquifer code[2]
27-927	MCWILLIAMS 3A	04/22/86	3.74	534.20	112SFDF1
27-927	MCWILLIAMS 3A	06/27/86	5.04	532.90	
27-928	DENWD OBS	06/19/86	4.77	539.57	112SFDF1
27-928	DENWD OBS	08/05/86	3.82	540.52	
27-929	ROCK-SUPER 1	06/09/86	14.92	531.26	112SFDF1
27-929	ROCK-SUPER 1	08/15/86	15.77	530.41	
27-930	ROCK-SUPER 2	06/09/86	38.29	517.35	112SFDF2
27-930	ROCK-SUPER 2	08/15/86	39.63	516.01	
27-931	ROCK-SUPER 3	06/09/86	4.71	510.45	112SFDF2
27-931	ROCK-SUPER 3	08/15/86	6.04	509.12	
27-932	ROCK-SUPER 4	06/09/86	9.23	501.76	112SFDF1
27-932	ROCK-SUPER 4	08/15/86	10.71	500.28	
27-933	ROCK-SUPER 5	06/09/86	26.41	504.38	112SFDF1
27-933	ROCK-SUPER 5	08/15/86	28.65	502.14	
27-934	ROCK-SUPER 6	06/09/86	18.25	513.86	112SFDF2
27-934	ROCK-SUPER 6	08/15/86	21.02	511.09	
27-935	ROCK-SUPER 7	06/09/86	22.15	502.52	112SFDF2

[1] Referenced to sea level.

[2] Aquifer codes:

112SFDF1	Stratified drift, unconfined
112SFDF2	Stratified drift, confined
374LSVL	Leithsville Formation
400PCMB	Precambrian rocks

Table 6.--Surface-water stage in the upper Rockaway River basin, 1984-86

Station number [1]	Date of measurement	Stage (feet below measurement point)	Altitude of stage [2] (feet)
01379700	04/02/86	-3.82	686.62
	06/03/86	-3.38	686.18
	08/04/86	-3.91	686.71
01379710	10/16/84	7.14	680.57
	09/19/85	7.05	680.66
	04/02/86	5.71	682.00
	06/03/86	6.57	681.14
	08/04/86	6.36	681.35
01379740	10/16/84	8.09	649.60
	09/19/85	8.14	649.55
	04/02/86	7.62	650.07
	06/03/86	7.74	649.95
	08/04/86	7.52	650.17
01379750	08/04/86	12.90	628.86
01379780	10/16/84	-2.14	692.14
	09/19/85	-1.89	691.89
	04/02/86	-2.48	692.48
	06/03/86	-2.38	692.38
	08/01/86	-2.36	692.36
01379790	10/16/84	-2.29	681.79
	09/19/85	-2.32	681.82
	04/03/86	-2.72	682.22
	06/03/86	-2.56	682.06
	08/01/86	-2.58	682.08
01379800	04/02/86	9.42	615.27
	06/03/86	9.60	615.09
	08/04/86	9.54	615.15
01379805	10/16/84	4.66	584.00
	09/19/85	4.67	583.99
	04/02/86	3.92	584.74
	06/03/86	4.27	584.39
	08/04/86	3.86	584.80
01379808	10/16/84	2.68	578.27
	04/02/86	2.07	578.88
	06/03/86	2.40	578.55
	08/04/86	2.07	578.88
01379855	08/05/86	39.21	542.22
01379880	09/19/85	2.41	504.92
	04/02/86	1.77	505.56
	06/03/86	2.10	505.23
	08/06/86	1.96	505.37
01380110	10/16/84	14.54	499.56
	09/19/85	14.46	499.64
	04/02/86	13.57	500.53
	06/03/86	14.10	500.00
[3]01380116	06/18/86	14.18	497.75
	08/05/86	13.77	498.16
01380133	04/02/86	11.64	495.57
	06/03/86	12.18	495.03
	08/05/86	11.32	495.89
01380135	10/17/84	13.49	493.65
	04/02/86	12.84	494.30
	06/03/86	13.26	493.88
	06/20/86	13.15	493.99
	08/05/86	12.28	494.86
01380145	10/17/84	15.71	491.98
	09/19/85	15.67	492.02
	04/02/86	15.08	492.61
	06/03/86	15.49	492.20
	06/20/86	15.33	492.36
	08/05/86	14.01	493.68
01380320	10/17/84	11.67	493.92
	04/02/86	12.18	493.41
	06/03/86	12.94	492.65
	08/05/86	11.86	493.73
01380335	10/17/84	17.72	482.07
	09/19/85	17.76	482.03
	04/02/86	17.11	482.68
	06/03/86	17.41	482.38
	06/20/86	17.29	482.50
	08/05/86	16.76	483.03
01380500	10/17/84	-1.93	366.40
	04/02/86	-2.55	367.02
	06/03/86	-2.19	366.66
	08/05/86	-2.76	367.23

[1] Station locations shown in plate 1a.
[2] Referenced to sea level.
[3] Station 01380116, Rockaway River at Diamond Spring Road at Denville, is located at latitude 40°53'40", longitude 74°28'29". This station is not in table 7 because discharge was not measured there.

Table 7.--Summary of instantaneous-discharge measurements in the upper Rockaway River basin

[Rt., Route; trib., tributary; Ave., Avenue; lat, latitude; long, longitude; *, estimate; **, mean for day(s); mi, mile; ft, foot; mi^2, square miles; ft^3/s, cubic feet per second; dashes indicate no data]

Station number [1]	Station name	Station type [2]	Codes for type(s) of water-quality data collected [3]	Location
01379620	Russia Brook at Russia Road at Milton	M	--	Lat 41°01'31", long 74°32'10", Morris County, Hydrologic Unit 02030103, at bridge on Russia Road, 0.1 mi south of Russia and 1.7 mi upstream of Lake Swannanoa.
01379650	Rockaway River at Oak Ridge Lake at Woodstock	M	--	Lat 40°59'38", long 74°31'24", Morris County, Hydrologic Unit 02030103, in Woodstock, 650 ft downstream of Oak Ridge Lake dam, 0.3 mi upstream of Longwood Lake and 2.0 mi south of Petersburg.
01379690	Rockaway River near Rt. 15 at Berkshire Valley	M	1,2	Lat 40°56'38", long 74°34'57", Morris County, Hydrologic Unit 02030103, 700 ft northwest of Berkshire Valley Road, 800 ft southeast of Taylor Road and 1.1 mi upstream of State Route 15.
01379695	Rockaway River trib. 9 near Rt. 15 at Berkshire Valley	M	--	Lat 40°56'36", long 74°35'42", Morris County, Hydrologic Unit 02030103, 200 ft east of State Route 15, 0.4 mi upstream of Taylor Road and 0.9 mi north of Berkshire Valley.
01379697	Rockaway River trib. 9 near mouth at Berkshire Valley	M	--	Lat 40°56'21", long 74°35'13", Morris County, Hydrologic Unit 02030103, 300 ft upstream of mouth, 950 ft downstream of Taylor Road and 0.6 mi north of Berkshire Valley.
01379700	Rockaway River at Berkshire Valley	G	1,3	Lat 40°55'51", long 74°35'42", Morris County, Hydrologic Unit 02030103, on left bank 60 ft downstream from bridge on Berkshire Valley Road in Berkshire Valley, 2.7 mi upstream from Stephens Brook, and 3.8 mi northwest of Dover.
01379705	Rockaway River trib. 1 near Berkshire Valley	M	--	Lat 40°55'43", long 74°36'22", Morris County, Hydrologic Unit 02030103, at bridge on Berkshire Valley Road, 0.5 mi above mouth and 0.8 mi west of Berkshire Valley.
01379710	Rockaway River near Wharton	M	--	Lat 40°54'44", long 74°36'08", Morris County, Hydrologic Unit 02030103, at former Wharton and Northern Railroad bridge, 1.0 mi upstream of Stephens Brook and 1.5 mi northwest of Wharton.
01379730	Stephens Brook at Wharton	M	--	Lat 40°54'09", long 74°36'07", Morris County, Hydrologic Unit 02030103, at bridge on Dewey Avenue, 0.5 mi from the mouth and 1.0 mi northwest of Wharton.
01379740	Rockaway River at West Central Ave. at Dover	M	1,2	Lat 40°54'13", long 74°35'25", Morris County, Hydrologic Unit 02030103, at bridge on West Central Avenue, 0.2 mi upstream of Washington Pond and 2.1 mi northwest of Dover.

Table 7.--Summary of instantaneous-discharge measurements in the upper Rockaway River basin--Continued

[Rt., Route; trib., tributary; Ave., Avenue; lat, latitude; long, longitude; *, estimate; **, mean for day(s); mi, mile; ft, foot; mi^2, square miles; ft^3/s, cubic feet per second; dashes indicate no data]

Station number	Drainage area (mi^2)	Discharge, ft^3/s					
		Base flow					Stormflow
		Low		Medium		High	
		10/16-17/84	9/19/85	6/3/86	6/20/86	4/2/86	11/4-5/85
01379620	8.55	--	--	--	--	15.3	--
01379650	17.5	--	--	--	--	29.9	--
01379690	23.1	6.48	9.87	25.9	--	44.3	22.6
01379695	.37	0	0	--	--	--	--
01379697	.86	0	0	*.1	--	--	--
01379700	24.4	6.68	11.8	23.8	**34.0	**48.0	**33.5
01379705	1.27	--	--	*.1	--	--	--
01379710	27.4	7.82	8.90	27.0	--	52.4	--
01379730	1.73	--	--	*1.0	--	--	--
01379740	30.3	10.8	11.8	36.1	--	56.4	38.1

Table 7.--Summary of instantaneous-discharge measurements in the upper Rockaway River basin--Continued

[Rt., Route; trib., tributary; Ave., Avenue; lat, latitude; long, longitude; *, estimate; **, mean for day(s); mi, mile; ft, foot; mi^2, square miles; ft^3/s, cubic feet per second; dashes indicate no data]

Station number [1]	Station name	Station type [2]	Codes for types of water-quality data collected [3]	Location
01379750	Rockaway River at Dover	L	1,3	Lat 40°54'12", long 74°34'36", Morris County, Hydrologic Unit 02030103, 500 ft downstream from Main Street, at Carpenter Plant, 0.5 mi upstream from Green Pond Brook, and 1.4 mi northwest of Dover.
01379773	Green Pond Brook at Picatinny Arsenal	G	--	Lat 40°57'34", long 74°32'24", Morris County, Hydrologic Unit 02030103, on left bank at Picatinny Arsenal, 500 ft upstream from Picatinny Lake, and 0.55 mi downstream from Burnt Meadow Brook.
01379780	Green Pond Brook below Picatinny Lake at Picatinny Arsenal	G	--	Lat 40°56'56", long 74°33'29", Morris County, Hydrologic Unit 02030103, on left bank 100 ft upstream from bridge on Whitmore Avenue at Picatinny Arsenal, and 200 ft downstream from dam on Picatinny Lake.
01379790	Green Pond Brook at Wharton	G	--	Lat 40°55'04", long 74°35'02", Morris County, Hydrologic Unit 02030103, on left bank 600 ft upstream from bridge on northbound lane of State Route 15, 0.2 mi northwest of Wharton, and 1.7 mi upstream from mouth.
01379800	Green Pond Brook at Dover	M	1	Lat 40°54'15", long 74°34'06", Morris County, Hydrologic Unit 02030103, at bridge on State Route 15, 50 ft west of Mount Pleasant Avenue at Dover and 0.2 mi from mouth.
01379805	Rockaway River above Dover well field at Dover	M	--	Lat 40°53'29", long 74°34'10", Morris County, Hydrologic Unit 02030103, 0.5 mi upstream from Jackson Brook, 0.7 mi downstream of Green Pond Brook, and 2.0 mi east of Roxbury.
01379808	Rockaway River below Dover well field at Dover	M	1,2,3	Lat 40°53'17", long 74°34'09", Morris County, Hydrologic Unit 02030103, 0.2 mi upstream from Jackson Brook, 1.0 mi downstream of Green Pond Brook, and 2.1 mi east of Roxbury.
01379820	Jackson Brook at mouth at Dover	M	--	Lat 40°53'09", long 74°34'07", Morris County, Hydrologic Unit 02030103, in Dover at mouth, 400 ft downstream of Spring Brook.
01379855	Rockaway River at Rockaway Road at Randolph	M	1	Lat 40°52'47", long 74°32'03", Morris County, Hydrologic Unit 02030103, at bridge on Dover-Rockaway Road, 800 ft north of Franklin Road, 0.8 mi downstream of bridge at East Blackwell Street and 1.3 mi southeast of Dover.
01379870	Mill Brook at Randolph	M	--	Lat 40°52'39", long 74°31'31", Morris County, Hydrologic Unit 02030103, at mouth, 600 ft downstream of bridge on Palmer Road, 0.4 mi downstream of bridge at Dover-Rockaway Road and 1.7 mi southeast of Dover.

Table 7.--Summary of instantaneous-discharge measurements in the upper Rockaway River basin--Continued

[Rt., Route; trib., tributary; Ave., Avenue; lat, latitude; long, longitude; *, estimate; **, mean for day(s); mi, mile; ft, foot; mi^2, square miles; ft^3/s, cubic feet per second; dashes indicate no data]

		Discharge, ft^3/s					
		Base flow					
Station number	Drainage area (mi^2)	Low 10/16-17/84	Low 9/19/85	Medium 6/3/86	Medium 6/20/86	High 4/2/86	Stormflow 11/4-5/85
01379750	30.8	11.0	11.6	32.2	--	58.5	53.2
01379773	7.65	**1.7	**2.7	**7.7	**8.4	**9.9	**5.1
01379780	9.16	**.46	**1.2	**5.6	**8.9	**11	**2.2
01379790	12.6	**3.3	**3.6	**9.3	**13.0	**19.0	**12.0
01379800	15.1	3.59	4.57	10.8	--	22.2	23.5
01379805	46.3	16.2	18.6	45.0	--	87.0	--
01379808	47.1	15.7	16.5	44.5	--	89.2	102
01379820	4.87	2.83	1.89	3.97	--	7.62	--
01379855	56.1	22.5	23.9	53.7	--	106	254
01379870	4.84	2.96	2.29	4.41	--	9.14	--

Table 7.--Summary of instantaneous-discharge measurements in the upper Rockaway River basin--Continued

[Rt., Route; trib., tributary; Ave., Avenue; lat, latitude; long, longitude; *, estimate; **, mean for day(s); mi, mile; ft, foot; mi^2, square miles; ft^3/s, cubic feet per second; dashes indicate no data]

Station number [1]	Station name	Station type [2]	Codes for type(s) of water-quality data collected [3]	Location
01379875	Foxs Pond outlet at Rockaway	M	--	Lat 40°53'53", long 74°30'58", Morris County, Hydrologic Unit 02030103, at Rockaway, 200 ft upstream of mouth, 600 ft east of State Route 513 and 0.5 mi downstream of Foxs Pond.
01379880	Rockaway River at Rockaway	M	1,3	Lat 40°54'04", long 74°30'32", Morris County, Hydrologic Unit 02030103, at Conrail railroad bridge at Rockaway, 0.2 mi upstream of bridge at Beach Street and 0.4 mi downstream of Foxs Pond outlet stream.
01380000	Beaver Brook at outlet of Splitrock Reservoir	G	--	Lat 40°57'38", long 74°27'43", Morris County, Hydrologic Unit 02030103, 50 ft below sluice gates at outlet of Splitrock Reservoir, 2 mi northeast of Hibernia, and 3.5 mi upstream of mouth of Hibernia Brook.
01380010	Beaver Brook at Meriden	M	--	Lat 40°56'49", long 74°27'38", Morris County, Hydrologic Unit 02030103, at bridge on Meriden-Lyonsville Road, 700 ft west of Meriden Road, 1.3 mi downstream of Splitrock Reservoir and 1.3 mi southwest of Lyonsville.
01380015	Beaver Brook trib. 3 at Meriden	M	--	Lat 40°56'41", long 74°27'21", Morris County, Hydrologic Unit 02030103, at bridge on Meriden Road, 0.2 mi south of Meriden-Lyonsville Road, at Meriden.
01380020	Beaver Brook trib. 2 at Ford Road at Beach Glen	M	--	Lat 40°55'32", long 74°28'47", Morris County, Hydrologic Unit 02030103, at bridge on Ford Road, 0.2 mi upstream of mouth and 0.5 mi southeast of Beach Glen.
01380075	Hibernia Brook at Beach Glen	M	--	Lat 40°55'50", long 74°29'14", Morris County, Hydrologic Unit 02030103, at bridge on Meriden-Lyonsville Road, at Beach Glen, 200 ft east of Green Pond Road and 0.5 mi upstream of mouth.
01380090	White Meadow Brook near Denville	M	--	Lat 40°55'01", long 74°30'13", Morris County, Hydrologic Unit 02030103, 100 ft west of Sanders Road, 0.7 mi downstream of White Meadow Lake and 0.8 mi north of Denville.
01380095	Beaver Brook trib. 1 near Denville	M	--	Lat 40°54'47", long 74°29'05", Morris County, Hydrologic Unit 02030103, at mouth, 100 ft upstream of Ford Road, 1.2 mi south of Beach Glen and 1.6 mi northwest of Denville.
01380100	Beaver Brook at Rockaway	M	--	Lat 40°54'08", long 74°30'06", Morris County, Hydrologic Unit 02030103, at bridge on Gill Avenue, at Rockaway, and 0.2 mi upstream of the mouth.

Table 7.--Summary of instantaneous-discharge measurements in the upper Rockaway River basin--Continued

[Rt., Route; trib., tributary; Ave., Avenue; lat, latitude; long, longitude; *, estimate; **, mean for day(s); mi, mile; ft, foot; mi^2, square miles; ft^3/s, cubic feet per second; dashes indicate no data]

Station number	Drainage area (mi^2)	Discharge, ft^3/s: Base flow: Low 10/16-17/84	Low 9/19/85	Medium 6/3/86	Medium 6/20/86	High 4/2/86	Stormflow 11/4-5/85
01379875	1.39	.10	.01	.37	--	1.61	--
01379880	64.3	25.4	23.5	56.4	--	110	252
01380000	5.50	**1.70	**1.80	**1.80	**2.40	**6.70	**5.10
01380010	6.80	2.00	1.88	1.90	--	11.1	--
01380015	.25	.04	.04	.09	--	.38	--
01380020	.41	.02	0	.06	--	.65	--
01380075	7.73	1.09	.83	2.64	--	15.9	--
01380090	3.35	.32	.34	.90	--	.77	--
01380095	.16	.11	.01	.03	--	.17	--
01380100	22.2	2.64	2.48	7.91	--	29.7	--

Table 7.--Summary of instantaneous-discharge measurements in the upper Rockaway River basin--Continued

[Rt., Route; trib., tributary; Ave., Avenue; lat, latitude; long, longitude; *, estimate; **, mean for day(s); mi, mile; ft, foot; mi^2, square miles; ft^3/s, cubic feet per second; dashes indicate no data]

Station number [1]	Station name	Station type [2]	Codes for type(s) of water-quality data collected [3]	Location
01380110	Rockaway River at Savage Ave. at Denville	M	1,2,3	Lat 40°53'57", long 74°29'11", Morris County, Hydrologic Unit 02030103, at bridge on Savage Avenue, 0.2 mi north of Route 46, 0.2 mi downstream of bridge on I-80 and 1.6 mi northwest of Denville.
01380133	Den Brook at Denville	M	--	Lat 40°53'25", long 74°28'18", Morris County, Hydrologic Unit 02030103, at bridge on Broadway Avenue, at Denville, 150 ft from mouth and 0.6 mi downstream from Indian Lake.
01380135	Rockaway River at Pocono Road at Denville	M	1	Lat 40°53'38", long 74°28'19", Morris County, Hydrologic Unit 02030103, at bridge on Pocono Road, 0.8 mi east of Denville and 1.0 mi downstream of bridge on Savage Avenue.
01380140	Rockaway River trib. 3 at Denville	M	--	Lat 40°54'13", long 74°27'50", Morris County, Hydrologic Unit 02030103, at bridge on Diamond Spring Road, 0.1 mi upstream of mouth, 0.6 mi downstream of Cedar Lake and 1.2 mi northeast of Denville.
01380145	Rockaway River at Bush Road at Denville	M	1,2,3	Lat 40°54'38", long 74°27'11", Morris County, Hydrologic Unit 02030103, at bridge on Bush Road, 0.2 mi east of Diamond Spring Road, 1.4 mi downstream of bridge at Pocono Road and 1.8 mi northeast of Denville.
01380280	Stony Brook trib. near Lake Juliet	M	--	Lat 40°57'04", long 74°24'48", Morris County, Hydrologic Unit 02030103, 0.1 mi northwest of Powerville Road, 0.8 mi downstream of Lake Juliet and 1.3 mi northwest of Taylortown.
01380290	Stony Brook near Taylortown	M	--	Lat 40°56'24", long 74°25'08", Morris County, Hydrologic Unit 02030103, at bridge on Powerville Road, 300 ft downstream of unnamed pond, 600 ft north of Rockaway Valley Road and 1.2 mi west of Taylortown.
01380300	Stony Brook near Rockaway Valley	L	1	Lat 40°56'25", long 74°25'39", Morris County, Hydrologic Unit 02030103, at bridge on Rockaway Valley Road, 0.2 mi downstream of unnamed tributary and 1.7 mi west of Taylortown.
01380310	Dixon Pond outlet stream at Boonton	M	--	Lat 40°55'57", long 74°26'17", Morris County, Hydrologic Unit 02030103, at bridge on Rockaway Valley Road, 800 ft upstream of mouth and 0.9 mi north of Powerville.
01380320	Stony Brook at Boonton	M	1	Lat 40°55'42", long 74°26'18", Morris County, Hydrologic Unit 02030103, at bridge on Valley Road, 0.4 mi from the mouth and 0.8 mi northwest of Powerville.

Table 7.--Summary of instantaneous-discharge measurements in the upper Rockaway River basin--Continued

[Rt., Route; trib., tributary; Ave., Avenue; lat, latitude; long, longitude; *, estimate; **, mean for day(s); mi, mile; ft, foot; mi^2, square miles; ft^3/s, cubic feet per second; dashes indicate no data]

Station number	Drainage area (mi^2)	Discharge, ft^3/s					
		Base flow					Stormflow
		Low		Medium		High	
		10/16-17/84	9/19/85	6/3/86	6/20/86	4/2/86	11/4-5/85
01380110	87.6	27.8	27.5	67.0	--	157	55.1
01380133	8.78	--	--	3.48	--	8.30	--
01380135	96.7	30.8	39.6	70.0	90.4	162	64.6
01380140	1.80	.11	.34	.23	--	1.84	--
01380145	99.5	30.8	41.7	86.5	94.4	165	360
01380280	2.49	.10	.15	.43	--	1.56	--
01380290	4.98	.14	*.06	*.50	--	5.13	--
01380300	8.43	0	.65	1.31	--	8.29	3.91
01380310	3.05	.08	.12	.37	--	4.54	--
01380320	12.7	0	0	2.65	--	13.5	5.65

Table 7.--Summary of instantaneous-discharge measurements in the upper Rockaway River basin--Continued

[Rt., Route; trib., tributary; Ave., Avenue; lat, latitude; long, longitude; *, estimate; **, mean for day(s); mi, mile; ft, foot; mi^2, square miles; ft^3/s, cubic feet per second; dashes indicate no data]

Station number [1]	Station name	Station type [2]	Codes for type(s) of water-quality data collected [3]	Location
01380325	Rockaway River trib. 7 at Powerville	M	--	Lat 40°55'23", long 74°26'17", Morris County, Hydrologic Unit 02030103, at west end of Rockaway Drive, 100 ft downstream of unnamed pond and 0.5 mi west of Powerville.
01380330	Griffith Pond outlet at Powerville	M	--	Lat 40°55'12", long 74°25'35", Morris County, Hydrologic Unit 02030103, at bridge on Rockaway Drive at Powerville, 300 ft upstream of the mouth and 1.2 mi northwest of Boonton.
01380335	Rockaway River at North Main Road at Powerville	M	1,2,3	Lat 40°54'53", long 74°25'40", Morris County, Hydrologic Unit 02030103, at bridge on North Main Street, 0.4 mi downstream of bridge on Powerville Road and 0.4 mi south of Powerville.
01380340	Hood Pond outlet at Powerville	M	--	Lat 40°54'47", long 74°25'31", Morris County, Hydrologic Unit 02030103, 100 ft upstream of mouth, 200 ft southwest of North Main Street and 0.6 mi south of Powerville.
01380350	Rockaway River trib. 1 at Powerville	M	--	Lat 40°53'39", long 74°25'33", Morris County, Hydrologic Unit 02030103, 700 ft from the mouth, 0.1 mi downstream of Powerville Road and 0.7 mi south of Powerville.
01380500	Rockaway River above Reservoir at Boonton	G	1,3	Lat 40°54'06", long 74°24'40", Morris County, Hydrologic Unit 02030103, on right bank under Conrail railroad bridge, just downstream of bridge on Morris Avenue in Boonton, 1.8 mi upstream from dam at Boonton Reservoir.

[1] Station locations shown in figure 7

[2] Station type: G - Gaging station
L - Low-flow partial-record station
M - Miscellaneous discharge station

[3] Water-quality data collected: 1 - Surface water
2 - Streambed material; data also collected at station 01380450, not listed above because discharge was not measured there
3 - Stream biology

Table 7.--Summary of instantaneous-discharge measurements in the upper Rockaway River basin--Continued

[Rt., Route; trib., tributary; Ave., Avenue; lat, latitude; long, longitude; *, estimate; **, mean for day(s); mi, mile; ft, foot; mi^2, square miles; ft^3/s, cubic feet per second; dashes indicate no data]

Station number	Drainage area (mi^2)	Discharge, ft^3/s					
		Base flow					
		Low		Medium		High	Stormflow
		10/16-17/84	9/19/85	6/3/86	6/20/86	4/2/86	11/4-5/85
01380325	.44	*.10	*.03	0	--	*.08	--
01380330	.82	.03	.02	.20	--	1.17	--
01380335	115	35.9	36.7	83.5	91.3	174	364
01380340	.18	.002	0	.05	--	.13	--
01380350	.79	.07	.06	.22	--	1.35	--
01380500	116	**36	39.6	74.6	**95.0	**175	**156

Table 8.--Results of analyses of ground-water samples from the upper Rockaway River basin for physical characteristics and dissolved major inorganic ions, 1985-86

[°C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; mg/L, milligrams per liter; ROE, residue on evaporation at 180 °C; lab, laboratory; ---, no data; <, less than the given value, which is the detection limit]

USGS well number	Local well name	Aquifer code[1]	Date sampled	Temperature (°C)	pH (units) field	pH (units) lab	Specific conductance (µS/cm) field	Specific conductance (µS/cm) lab	Dissolved solids (mg/L) sum	Dissolved solids (mg/L) ROE	Alkalinity as $CaCO_3$ (mg/L) field	Alkalinity as $CaCO_3$ (mg/L) lab
				Unconfined valley-fill aquifer								
27- 28	NJDEP Green Pond Obs-5	112SFDF1	12/30/85	10.0	8.4	8.3	276	285	156	150	---	113
27- 59	Rockaway Boro WD 6	112SFDF1	11/25/85	12.0	6.6	6.8	385	394	284	208	182	78
27-189	Mt. Lakes WD 4	112SFDF1	11/26/85	12.5	7.5	7.6	250	259	144	170	112	81
27-291	Dover Boro WD 5	112SFDF1	11/26/85	15.5	7.5	7.6	460	471	256	266	146	141
27-353	Wharton Boro WD 3	112SFDF1	11/26/85	12.0	7.8	7.7	536	546	311	300	210	182
27-541	Cusak, Charles	112SFDF1	11/27/85	11.5	6.1	6.8	159	169	112	102	30	31
27-657	Taylor, Robert	112SFDF1	11/27/85	14.0	6.2	6.4	209	214	135	126	35	20
27-827	Wharton Boro WD 2	112SFDF1	11/26/85	12.0	7.9	7.9	408	418	221	232	102	98
27-911	Lowerre, F.G.	112SFDF1	02/19/86	11.0	8.0	7.7	674	674	359	344	126	121
				Confined valley-fill aquifer								
27- 30	Boonton WD 5	112SFDF2	11/27/85	11.5	6.9	7.6	291	306	188	176	110	83
27- 35	Denville Twp. WD 5	112SFDF2	11/26/85	11.5	8.1	8.1	395	403	250	224	160	138
27- 80	Rockaway Twp. WD 7	112SFDF2	11/27/85	11.5	7.7	7.6	424	435	249	242	152	135
27-136	Denville Twp. WD 3	112SFDF2	11/26/85	12.0	8.1	8.0	388	397	222	222	146	128
27-191	Mt. Lakes WD 5	112SFDF2	11/26/85	11.5	8.3	8.2	331	341	223	204	142	117
27-278	Picatinny Ars. 176-SH	112SFDF2	02/19/86	12.0	6.5	6.4	425	426	221	223	49	45
27-321	Rockaway R. Country Club	112SFDF2	12/04/85	10.5	8.5	8.3	226	232	137	122	83	81
27-357	Dover WD 4	112SFDF2	11/26/85	12.0	8.2	8.0	330	339	195	180	113	107
27-686	McWilliams Forge 339	112SFDF2	01/14/86	15.0	8.0	8.4	394	401	219	210	130	135
27-908	Zalasky, Minnie	112SFDF2	01/27/86	10.5	8.2	8.1	606	566	304	319	121	117
				Bedrock aquifers								
27-188	Mt. Lakes WD Tow. Hill 4	400PCMB	01/07/86	11.0	6.7	7.0	342	330	196	186	86	89
27-195	Montville Twp. MUA 1	227BSLT	11/25/85	12.0	8.5	8.0	217	227	151	168	45	45
27-242	Picatinny Ars. CAF 1	377HRDS	08/14/85	12.5	7.2	8.4	226	214	126	110	98	91
27-246	Picatinny Ars. 65-1	374LSVL	08/21/85	12.5	8.2	8.4	281	270	146	150	104	97
27-280	Picatinny Ars. H-2	374LSVL	08/21/85	12.5	9.3	8.6	341	269	166	145	106	84
27-287	Dover WD Obs. E	400PCMB	12/17/85	12.0	8.2	8.1	135	140	96	81	70	61
27-325	Boonton WD-Valley Rd	400PCMB	01/17/86	11.0	8.1	8.5	195	201	120	104	68	67
27-913	Jeff. Twp. MUA-W.R. 2	344BLVL	11/27/85	11.0	6.1	6.8	247	252	144	140	62	60
27-923	Russinko, Gary	344MRCL	01/27/86	10.0	8.5	8.3	275	261	149	143	84	78
27-936	Morris Co. MUA-Musiker	400PCMB	01/07/86	10.5	6.4	6.8	247	235	134	134	38	46

[1] Aquifer codes:

112SFDF1 - Stratified drift, unconfined
112SFDF2 - Stratified drift, confined
227BSLT - Brunswick Group, undivided basalt flows
344BLVL - Bellvale Sandstone
344MRCL - Marcellus Shale
374LSVL - Leithsville Formation
377HRDS - Hardyston Quartzite
400PCMB - Precambrian rocks

Table 8.--Results of analyses of ground-water samples from the upper Rockaway River basin for physical characteristics and dissolved major inorganic ions, 1985-86--Continued

[°C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; mg/L, milligrams per liter; ROE, residue on evaporation at 180 °C; lab, laboratory; ---, no data; <, less than the given value, which is the detection limit]

USGS well number	Date sampled	Bicar-bonate (mg/L) field	Dis-solved oxygen (mg/L)	Hardness as $CaCO_3$ total (mg/L)	Hardness as $CaCO_3$ noncar-bonate (mg/L)	Sodium (mg/L)	Potas-sium (mg/L)	Cal-cium (mg/L)	Magne-sium (mg/L)	Silica (mg/L)	Chlo-ride (mg/L)	Sul-fate (mg/L)	Fluo-ride (mg/L)
					Unconfined valley-fill aquifer								
27- 28	12/30/85	135	0.4	150.0	33.0	3.3	0.5	37.0	13.0	12.0	6.7	16.0	<0.1
27- 59	11/25/85	221	1.9	130.0	50.0	24.0	1.4	30.0	13.0	20.0	53.0	27.0	.1
27-189	11/26/85	150	3.7	110.0	32.0	6.5	1.1	27.0	11.0	23.0	6.7	20.0	<.1
27-291	11/26/85	184	2.5	170.0	32.0	26.0	2.3	43.0	16.0	16.0	35.0	23.0	.1
27-353	11/26/85	257	.7	190.0	7.0	39.0	2.4	46.0	18.0	17.0	38.0	22.0	.2
27-541	11/27/85	38	5.7	58.0	27.0	8.3	.8	14.0	5.6	20.0	7.2	22.0	<.1
27-657	11/27/85	43	7.8	41.0	21.0	21.0	1.5	10.0	4.0	16.0	27.0	16.0	<.1
27-827	11/26/85	123	4.9	120.0	24.0	33.0	.7	29.0	12.0	16.0	45.0	21.0	<.1
27-911	02/19/86	152	---	280.0	160.0	21.0	1.6	65.0	29.0	15.0	110.0	42.0	<.1
					Confined valley-fill aquifer								
27- 30	11/27/85	138	1.4	130.0	44.0	9.8	1.3	31.0	12.0	18.0	24.0	20.0	.1
27- 35	11/26/85	201	3.1	190.0	53.0	8.0	1.2	45.0	19.0	25.0	26.0	18.0	.1
27- 80	11/27/85	184	2.5	190.0	51.0	12.0	1.9	43.0	19.0	22.0	26.0	26.0	.1
27-136	11/26/85	174	.9	180.0	52.0	10.0	1.3	44.0	17.0	21.0	15.0	25.0	.1
27-191	11/26/85	174	2.3	160.0	46.0	6.4	1.0	39.0	16.0	23.0	17.0	27.0	.1
27-278	02/19/86	57	---	100.0	56.0	38.0	1.9	26.0	8.8	12.0	80.0	23.0	.2
27-321	12/04/85	96	2.3	110.0	29.0	3.6	.8	26.0	11.0	18.0	2.9	26.0	.1
27-357	11/26/85	138	1.9	140.0	36.0	9.9	1.0	34.0	14.0	19.0	29.0	17.0	.2
27-686	01/14/86	157	2.3	180.0	47.0	10.0	1.1	45.0	17.0	17.0	33.0	18.0	.2
27-908	01/27/86	143	---	250.0	130.0	16.0	1.0	63.0	22.0	16.0	91.0	19.0	<.1
					Bedrock aquifers								
27-188	01/07/86	104	5.5	150.0	60.0	8.6	1.1	35.0	15.0	28.0	19.0	30.0	<.1
27-195	11/25/85	43	1.7	84.0	39.0	9.8	.4	30.0	2.2	38.0	13.0	36.0	<.1
27-242	08/14/85	---	.2	99.0	8.0	3.4	2.5	25.0	8.8	15.0	2.6	7.9	---
27-246	08/21/85	126	.0	100.0	3.0	14.0	1.5	22.0	11.0	9.7	10.0	15.0	---
27-280	08/21/85	---	.2	120.0	33.0	11.0	7.3	27.0	12.0	9.2	16.0	19.0	---
27-287	12/17/85	84	.2	53.0	0.0	7.0	1.3	13.0	5.0	20.0	2.3	4.6	<1.0
27-325	01/17/86	79	1.3	76.0	9.0	10.0	2.0	22.0	5.1	18.0	9.2	14.0	.5
27-913	11/27/85	82	.1	95.0	35.0	9.6	.8	20.0	11.0	16.0	28.0	15.0	.2
27-923	01/27/86	99	.2	100.0	27.0	9.8	.5	30.0	7.2	14.0	23.0	16.0	.1
27-936	01/07/86	45	6.6	89.0	43.0	8.2	1.4	22.0	8.3	26.0	38.0	3.1	<.1

Table 9.--Results of analyses of ground-water samples from the upper Rockaway River basin for dissolved trace elements and compounds, 1985-86

[Dissolved constituents, in micrograms per liter; <, less than the given value, which is the detection limit; ---, no data]

USGS well number	Local well name	Aquifer code[1]	Date sampled	Aluminum	Arsenic	Beryllium	Cadmium	Chromium	Copper
			Unconfined valley-fill aquifer						
27- 28	NJDEP Green Pond Obs-5	112SFDF1	12/30/85	<100	<1	<0.5	<1	<10	<1
27- 59	Rockaway Boro WD 6	112SFDF1	11/25/85	<100	<1	<.5	<1	<10	4
27-189	Mt. Lakes WD 4	112SFDF1	11/26/85	<100	<1	<.5	<1	<10	2
27-291	Dover WD 5	112SFDF1	11/26/85	<100	<1	<.5	<1	<10	3
27-353	Wharton WD 3	112SFDF1	11/26/85	<100	<1	<.5	<1	<10	2
27-541	Cusak, Charles	112SFDF1	11/27/85	<100	<1	<.5	<1	<10	41
27-657	Taylor, Robert	112SFDF1	11/27/85	<100	<1	<.5	<1	<10	70
27-827	Wharton WD 2	112SFDF1	11/26/85	<100	<1	<.5	<1	<10	1
27-911	Lowerre, F.G.	112SFDF1	02/19/86	<100	<1	<.5	<1	<10	2
			Confined valley-fill aquifer						
27- 30	Boonton WD 5	112SFDF2	11/27/85	<100	<1	<0.5	<1	<10	3
27- 35	Denville Twp. WD 5	112SFDF2	11/26/85	<100	<1	<.5	<1	<10	1
27- 80	Rockaway Twp. WD 7	112SFDF2	11/27/85	<100	<1	<.5	<1	<10	1
27-136	Denville Twp. WD 3	112SFDF2	11/26/85	<100	1	<.5	<1	<10	2
27-191	Mt. Lakes WD 5	112SFDF2	11/26/85	<100	<1	<.5	<1	<10	1
27-278	Picatinny Ars. 176-SH	112SFDF2	02/19/86	<100	<1	<.5	<1	<10	6
27-321	Rockaway R. Country Club	112SFDF2	12/04/85	<100	1	<.5	<1	<10	<1
27-357	Dover WD 4	112SFDF2	11/26/85	<100	<1	<.5	<1	<10	2
27-686	McWilliams Forge 339	112SFDF2	01/14/86	<100	1	<.5	<1	<10	<1
27-908	Zalasky, Minnie	112SFDF2	01/27/86	<100	<1	<.5	<1	<10	10
			Bedrock aquifers						
27-188	Mt. Lakes WD Tow. Hill 4	400PCMB	01/07/86	<100	<1	<0.5	<1	<10	1
27-195	Montville Twp. MUA 1	227BSLT	11/25/85	<100	<1	<.5	<1	<10	1
27-242	Picatinny Ars. CAF 1	377HRDS	08/14/85	20	1	<.5	<1	<1	<10
27-246	Picatinny Ars. 65-1	374LSVL	08/21/85	<10	<1	<.5	1	<1	<10
27-280	Picatinny Ars. H-2	374LSVL	08/21/85	20	<1	<.5	<1	<1	<10
27-287	Dover WD Obs. E	400PCMB	12/17/85	<100	<1	<.5	<1	<10	<1
27-325	Boonton WD-Valley Rd	400PCMB	01/17/86	<100	<1	<.5	<1	<10	<1
27-913	Jeff. Twp. MUA-W.R. 2	344BLVL	11/27/85	<100	3	<.5	<1	<10	<1
27-923	Russinko, Gary	344MRCL	01/27/86	<100	<1	<.5	<1	<10	<1
27-936	Morris Co. MUA-Musiker	400PCMB	01/07/86	<100	<1	<.5	<1	<10	4

[1] Aquifer codes:

112SFDF1 - Stratified drift, unconfined
112SFDF2 - Stratified drift, confined
227BSLT - Brunswick Group, undivided basalt flows
344BLVL - Bellvale Sandstone
344MRCL - Marcellus Shale
374LSVL - Leithsville Formation
377HRDS - Hardyston Quartzite
400PCMB - Precambrian rocks

Table 9.--Results of analyses of ground-water samples from the upper Rockaway River basin for dissolved trace elements and compounds, 1985-86--Continued

[Dissolved constituents, in micrograms per liter; <, less than the given value, which is the detection limit; ---, no data]

USGS well number	Date sampled	Cyanide	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Zinc
				Unconfined valley-fill aquifer					
27- 28	12/30/85	<0.01	190	<1	260	<0.1	<1	<1	40
27- 59	11/25/85	<.01	<3	<1	7	<.1	1	<1	8
27-189	11/26/85	<.01	3	<1	16	<.1	<1	<1	4
27-291	11/26/85	<.01	<3	1	<1	<.1	<1	<1	15
27-353	11/26/85	<.01	<3	<1	<1	<.1	<1	<1	13
27-541	11/27/85	<.01	7	1	<1	<.1	<1	<1	14
27-657	11/27/85	<.01	<3	1	<1	<.1	1	<1	17
27-827	11/26/85	<.01	<3	<1	<1	<.1	3	<1	15
27-911	02/19/86	<.01	<3	<1	230	<.1	<1	<1	12
				Confined valley-fill aquifer					
27- 30	11/27/85	<0.01	<3	<1	4	<0.1	<1	<1	16
27- 35	11/26/85	<.01	<3	<1	<1	<.1	1	<1	<3
27- 80	11/27/85	<.01	<3	<1	<1	<.1	<1	<1	8
27-136	11/26/85	<.01	<3	<1	9	<.1	<1	<1	17
27-191	11/26/85	<.01	<3	1	<1	<.1	<1	<1	<3
27-278	02/19/86	<.01	6	3	2	<.1	<1	<1	13
27-321	12/04/85	<.01	6	<1	17	<.1	1	<1	<3
27-357	11/26/85	<.01	14	<1	2	<.1	2	<1	9
27-686	01/14/86	<.01	14	<1	170	<.1	<1	<1	5
27-908	01/27/86	<.01	9	1	2	<.1	<1	<1	20
				Bedrock aquifers					
27-188	01/07/86	<0.01	15	<1	<1	<0.1	<1	<1	26
27-195	11/25/85	<.01	<3	<1	11	<.1	<1	<1	6
27-242	08/14/85	<.01	1,200	<10	370	---	---	<1	<3
27-246	08/21/85	<.01	13	<10	150	---	---	<1	12
27-280	08/21/85	<.01	11	<10	59	---	---	<1	8
27-287	12/17/85	<.01	250	1	19	<.1	<1	---	<3
27-325	01/17/86	<.01	19	<1	32	<.1	<1	<1	10
27-913	11/27/85	<.01	2,700	<1	340	<.1	<1	<1	26
27-923	01/27/86	<.01	<3	<1	14	<.1	<1	<1	10
27-936	01/07/86	<.01	4	1	<1	<.1	1	<1	13

Table 10.--Results of analyses of ground-water samples from the upper Rockaway River basin for dissolved nutrients and organic compounds, 1985-86

[Dissolved constituents, in milligrams per liter except for phenols; phenols are total, in micrograms per liter; <, less than the given value, which is the detection limit]

USGS well number	Local well name	Aquifer code[1]	Date sampled	Nitrogen, nitrite (as N)	Nitrogen, nitrite + nitrate (as N)	Nitrogen, ammonia + organic (as N)
			Unconfined valley-fill aquifer			
27- 28	NJDEP Green Pond Obs-5	112SFDF1	12/30/85	<0.01	<0.10	<0.2
27- 59	Rockaway Boro WD 6	112SFDF1	11/25/85	<.01	1.50	.3
27-189	Mt. Lakes WD 4	112SFDF1	11/26/85	<.01	1.50	.3
27-291	Dover WD 5	112SFDF1	11/26/85	<.01	.82	.4
27-353	Wharton WD 3	112SFDF1	11/26/85	<.01	.37	.2
27-541	Cusak, Charles	112SFDF1	11/27/85	<.01	3.50	.6
27-657	Taylor, Robert	112SFDF1	11/27/85	<.01	4.10	.4
27-827	Wharton WD 2	112SFDF1	11/26/85	<.01	.75	.2
27-911	Lowerre, F.G.	112SFDF1	02/19/86	<.01	<.01	.4
			Confined valley-fill aquifer			
27- 30	Boonton WD 5	112SFDF2	11/27/85	<0.01	0.83	0.3
27- 35	Denville Twp. WD 5	112SFDF2	11/26/85	<.01	1.90	.3
27- 80	Rockaway Twp. WD 7	112SFDF2	11/27/85	<.01	1.90	.5
27-136	Denville Twp. WD 3	112SFDF2	11/26/85	<.01	.52	.2
27-191	Mt. Lakes WD 5	112SFDF2	11/26/85	<.01	1.70	.4
27-278	Picatinny Ars. 176-SH	112SFDF2	02/19/86	<.01	.76	.3
27-321	Rockaway R. Country Club	112SFDF2	12/04/85	.01	.25	.2
27-357	Dover WD 4	112SFDF2	11/26/85	<.01	.74	.2
27-686	McWilliams Forge 339	112SFDF2	01/14/86	<.01	<.10	.3
27-908	Zalasky, Minnie	112SFDF2	01/27/86	<.01	1.30	.3
			Bedrock aquifers			
27-188	Mt. Lakes WD Tow. Hill 4	400PCMB	01/07/86	<0.01	1.90	0.3
27-195	Montville Twp. MUA 1	227BSLT	11/25/85	<.01	<.10	<.2
27-242	Picatinny Ars. CAF 1	377HRDS	08/14/85	<.01	<.10	<.2
27-246	Picatinny Ars. 65-1	374LSVL	08/21/85	<.01	<.10	<.2
27-280	Picatinny Ars. H-2	374LSVL	08/21/85	<.01	<.10	.4
27-287	Dover WD Obs. E	400PCMB	12/17/85	.01	.20	<.2
27-325	Boonton WD-Valley Rd	400PCMB	01/17/86	<.01	<.10	.2
27-913	Jeff. Twp. MUA-W.R. 2	344BLVL	11/27/85	<.01	<.10	.3
27-923	Russinko, Gary	344MRCL	01/27/86	<.01	<.10	.3
27-936	Morris Co. MUA-Musiker	400PCMB	01/07/86	<.01	1.10	.2

[1] Aquifer codes:

112SFDF1 - Stratified drift, unconfined
112SFDF2 - Stratified drift, confined
227BSLT - Brunswick Group, undivided basalt flows
344BLVL - Bellvale Sandstone
344MRCL - Marcellus Shale
374LSVL - Leithsville Formation
377HRDS - Hardyston Quartzite
400PCMB - Precambrian rocks

Table 10.--Results of analyses of ground-water samples from the upper Rockaway River basin for dissolved nutrients and organic compounds, 1985-86--Continued

[Dissolved constituents, in milligrams per liter except for phenols; phenols are total, in micrograms per liter; <, less than the given value, which is the detection limit]

USGS well number	Date sampled	Nitrogen, ammonia (as N)	Phosphorous	Phosphorous, ortho (as P)	Dissolved organic carbon	Phenols, total
			Unconfined valley-fill aquifer			
27- 28	12/30/85	0.05	0.13	0.07	0.8	2
27- 59	11/25/85	.02	.01	.02	1.4	7
27-189	11/26/85	.01	.07	.06	1.8	15
27-291	11/26/85	.02	.01	<.01	1.2	16
27-353	11/26/85	.02	.02	.02	1.2	29
27-541	11/27/85	.01	.01	.01	.9	<1
27-657	11/27/85	.01	<.01	<.01	1.6	11
27-827	11/26/85	.02	.03	.03	1.2	2
27-911	02/19/86	.26	.04	.04	1.9	<1
			Confined valley-fill aquifer			
27- 30	11/27/85	0.01	0.02	0.02	1.0	2
27- 35	11/26/85	<.01	.03	.03	.7	<1
27- 80	11/27/85	.01	.03	.03	1.9	1
27-136	11/26/85	<.01	.07	.08	1.4	<1
27-191	11/26/85	<.01	.05	.05	.8	1
27-278	02/19/86	.03	.01	.01	1.8	2
27-321	12/04/85	.06	.07	.04	1.2	4
27-357	11/26/85	.01	.06	.06	.9	3
27-686	01/14/86	.05	.10	.10	1.1	2
27-908	01/27/86	<.01	.10	.06	1.0	4
			Bedrock aquifers			
27-188	01/07/86	0.02	0.02	0.02	1.1	8
27-195	11/25/85	<.01	<.01	.01	1.4	<1
27-242	08/14/85	.04	.03	<.01	1.5	<1
27-246	08/21/85	.03	.03	.02	1.0	<1
27-280	08/21/85	.03	.04	.04	.6	<1
27-287	12/17/85	.01	.09	.09	.5	1
27-325	01/17/86	.02	.03	.04	1.7	16
27-913	11/27/85	.11	.06	.02	.9	2
27-923	01/27/86	.06	.03	.03	.8	3
27-936	01/07/86	.02	.02	.02	1.2	3

Table 11.--Presence of volatile organic compounds in ground-water samples from the upper Rockaway River basin, 1985-86

[X, compound was present at a concentration greater than 0.8 micrograms per liter]

USGS well number	Local well name	Sampling date	Volatile organic compounds						
			1,1-Dichloroethane	Chloroform	1,1,1-Trichloroethane	Tetrachloroethene	1,1-Dichloroethene	cis-1,2-Dichloroethene	Trichloroethene
27-35	Denville Twp WD 5	11/26/85			X				X
27-59	Rockaway Boro WD 6	11/25/85				X			X
27-80	Rockaway Twp WD 7	11/27/85	X	X	X		X	X	X
27-136	Denville Twp WD 3	11/26/85			X	X			
27-191	Mountain Lakes WD 5	11/26/85			X				
27-278	Picatinny Arsenal 176-SH	02/19/86		X		X			X
27-291	Dover WD 5	11/26/85			X	X			X
27-353	Wharton WD3	11/26/85							X
27-357	Dover WD 4	11/26/85			X	X			
27-541	Cusak, Charles	11/27/85			X				

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Table 12.--Results of analyses of surface-water samples from the upper Rockaway River basin for physical characteristics and dissolved major inorganic ions, 1984-86

[Sampling-event code: B, base-flow sample; S, stormflow sample; M, monthly sample; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; mg/L, milligrams per liter; ROE, residue on evaporation at 180 °C; lab, laboratory; ---, no data; <, less than the given value, which is the detection limit]

Station number[1]	Sampling-event code	Date sampled	Temperature (°C)	pH (units)		Specific conductance (µS/cm)		Dissolved solids (mg/L)		Alkalinity as $CaCO_3$ (mg/L)	Dissolved oxygen (mg/L)
				field	lab	field	lab	sum	ROE	lab	
01379690	B	10/16/84	11.0	7.6	7.6	230	230	130	143	58	7.9
	S	11/05/85	9.0	7.6	7.3	216	218	116	120	54	9.8
01379700	B	10/16/84	11.0	7.7	7.5	243	244	133	140	59	9.9
	M	04/23/85	17.0	7.7	7.3	---	210	112	118	44	9.6
	M	05/28/85	20.5	7.2	7.3	187	182	100	102	39	9.9
	M	06/27/85	17.5	6.8	7.2	200	189	104	121	42	10.4
	M	07/24/85	21.0	6.8	7.3	215	206	116	127	50	8.6
	M	08/29/85	20.5	6.9	7.1	248	239	125	143	58	8.2
	M	09/19/85	16.0	7.2	7.2	270	252	133	148	63	8.2
	M	10/23/85	10.0	7.1	7.2	126	191	102	115	41	9.8
	S	11/05/85	9.5	6.5	7.3	---	201	109	129	43	9.9
	M	11/20/85	9.5	7.0	7.5	138	133	75	74	20	10.8
	M	12/16/85	1.5	6.8	7.9	148	172	95	91	27	13.0
	M	01/31/86	.0	6.8	7.7	162	163	88	88	19	14.6
	M	02/26/86	.5	6.4	8.0	140	185	98	97	21	12.4
	M	03/24/86	5.5	6.8	7.4	153	162	84	88	23	12.2
01379740	B	10/16/84	12.5	7.9	7.8	272	271	157	162	82	10.0
	S	11/05/85	9.5	7.8	7.8	232	200	115	127	44	9.8
01379750	B	10/16/84	12.5	7.9	7.8	283	284	--	149	81	9.8
	S	11/05/85	10.0	8.0	7.2	224	214	119	135	53	10.5
01379800	B	10/16/84	13.0	7.8	7.7	422	422	227	252	82	11.2
	S	11/05/85	10.0	7.5	6.9	250	261	139	166	36	9.1
01379808	B	10/16/84	15.0	8.5	8.2	328	332	--	193	89	11.0
	S	11/05/85	9.5	7.7	7.1	228	221	120	149	45	9.3
01379855	B	10/16/84	11.0	7.9	7.8	370	369	206	223	90	13.9
	S	11/05/85	10.0	7.6	6.8	193	191	104	126	33	9.3
01379880	B	10/16/84	12.0	8.1	7.9	359	364	--	207	86	13.8
	S	11/05/85	10.0	7.9	6.6	177	166	87	97	33	10.0
01380110	B	10/16/84	14.0	8.2	7.9	332	338	184	204	81	14.7
	S	11/04/85	9.5	7.8	7.3	277	266	144	154	61	10.1
01380135	B	10/17/84	11.5	7.8	7.6	317	317	176	173	79	10.4
	S	11/04/85	9.5	7.6	7.1	268	254	136	153	57	9.5
01380145	B	10/17/84	12.0	7.8	7.6	319	320	--	201	77	9.9
	S	11/05/85	10.0	7.6	6.8	171	154	81	94	30	9.4
01380300	B	10/17/84	9.0	7.2	7.1	185	184	110	117	42	6.4
	S	11/04/85	10.0	7.3	7.0	138	143	82	97	24	8.5
01380320	B	10/17/84	10.0	7.0	6.9	163	162	--	103	36	4.0
	S	11/04/85	9.5	7.0	7.0	138	143	84	94	25	7.5
01380335	B	10/17/84	13.0	7.8	7.6	322	314	167	183	74	9.0
	S	11/05/85	10.0	7.9	7.1	240	230	--	130	51	10.0
01380500	B	10/17/84	13.0	8.2	7.9	330	311	166	177	74	10.8
	M	04/23/85	19.0	8.4	7.5	227	254	134	132	53	9.0
	M	05/28/85	22.5	7.1	7.3	240	229	129	135	48	7.0
	M	06/27/85	----	6.7	7.3	212	204	114	134	42	9.1
	M	07/24/85	23.0	7.2	7.5	245	234	130	149	50	8.7
	M	08/29/85	23.0	7.0	7.4	262	271	144	165	59	9.2
	M	09/19/85	17.0	7.8	7.8	290	277	151	171	63	9.2
	M	10/23/85	13.0	7.5	7.4	182	246	134	145	54	10.8
	S	11/05/85	9.5	8.0	7.6	227	254	138	162	53	10.6
	M	11/20/85	10.0	7.1	7.3	155	151	84	97	24	11.3
	M	12/16/85	1.0	7.8	7.9	195	195	103	104	32	13.5
	M	01/31/86	.0	6.8	7.9	188	185	100	104	22	15.8
	M	02/26/86	.0	6.9	8.4	162	218	110	121	25	12.8
	M	03/24/86	7.0	7.1	7.8	178	189	101	107	29	12.4

[1] Stations are described in table 7 and locations shown in figure 9.

Table 12.--Results of analyses of surface-water samples from the upper Rockaway River basin for physical characteristics and dissolved major inorganic ions, 1984-86--Continued

[Sampling-event code: B, base-flow sample; S, stormflow sample; M, monthly sample; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; mg/L, milligrams per liter; ROE, residue on evaporation at 180 °C; lab, laboratory; ---, no data; <, less than the given value, which is the detection limit]

Station number[1]	Date sampled	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Silica (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Fluoride (mg/L)
01379690	10/16/84	16.0	0.8	19.0	7.8	6.0	33.0	12.0	<0.1
	11/05/85	14.0	1.0	16.0	6.4	6.7	28.0	11.0	<.1
01379700	10/16/84	16.0	.9	19.0	8.1	6.7	33.0	13.0	<.1
	04/23/85	15.0	.7	16.0	6.5	4.4	29.0	13.0	<.1
	05/28/85	13.0	.5	15.0	5.7	5.6	25.0	11.0	.1
	06/27/85	13.0	.4	15.0	5.7	5.2	26.0	12.0	<.1
	07/24/85	14.0	.5	17.0	6.2	5.9	32.0	8.7	.1
	08/29/85	15.0	.8	19.0	7.6	8.0	30.0	9.3	<.1
	09/19/85	16.0	.9	20.0	8.4	6.3	34.0	9.6	<.1
	10/23/85	13.0	.8	14.0	5.6	7.7	25.0	11.0	<.1
	11/05/85	14.0	.9	16.0	6.3	6.7	28.0	11.0	<.1
	11/20/85	11.0	.9	8.9	3.3	7.5	19.0	11.0	<.1
	12/16/85	13.0	.7	12.0	4.5	9.8	26.0	13.0	<.1
	01/31/86	16.0	.8	9.2	3.5	7.8	26.0	12.0	<.1
	02/26/86	18.0	.7	10.0	3.9	8.4	30.0	13.0	<.1
	03/24/86	13.0	.7	10.0	3.8	6.8	24.0	11.0	<.1
01379740	10/16/84	15.0	.9	26.0	11.0	8.2	29.0	17.0	<.1
	11/05/85	14.0	1.1	18.0	7.3	7.4	27.0	13.0	<.1
01379750	10/16/84	15.0	1.0	25.0	10.0	8.3	30.0	17.0	<.1
	11/05/85	14.0	.9	18.0	7.3	7.5	27.0	12.0	<.1
01379800	10/16/84	34.0	2.1	31.0	11.0	7.7	63.0	28.0	.2
	11/05/85	26.0	2.0	16.0	5.4	5.2	45.0	17.0	<.1
01379808	10/16/84	21.0	1.4	28.0	11.0	8.2	40.0	20.0	.1
	11/05/85	17.0	1.5	16.0	6.2	6.0	32.0	14.0	<.1
01379855	10/16/84	25.0	1.6	31.0	12.0	9.6	52.0	20.0	.1
	11/05/85	14.0	1.9	14.0	5.3	7.8	29.0	12.0	<.1
01379880	10/16/84	24.0	1.7	30.0	12.0	10.0	50.0	19.0	.1
	11/05/85	10.0	2.2	12.0	4.7	6.1	22.0	10.0	<.1
01380110	10/16/84	21.0	1.7	28.0	11.0	9.7	45.0	19.0	.1
	11/04/85	17.0	1.5	21.0	8.4	8.2	35.0	16.0	.1
01380135	10/17/84	19.0	1.6	27.0	10.0	9.4	42.0	19.0	.1
	11/04/85	16.0	1.7	20.0	7.9	7.7	33.0	15.0	.1
01380145	10/17/84	20.0	1.6	26.0	10.0	9.2	42.0	19.0	.1
	11/05/85	9.5	2.0	11.0	4.3	6.0	20.0	10.0	<.1
01380300	10/17/84	10.0	1.1	15.0	6.1	16.0	20.0	16.0	<.1
	11/04/85	10.0	.8	10.0	4.1	10.0	19.0	13.0	<.1
01380320	10/17/84	10.0	1.1	13.0	5.0	11.0	18.0	15.0	.2
	11/04/85	9.0	1.3	11.0	4.3	10.0	19.0	14.0	.1
01380335	10/17/84	19.0	1.7	25.0	10.0	8.5	40.0	18.0	.1
	11/05/85	15.0	1.5	18.0	7.3	----	30.0	15.0	<.1
01380500	10/17/84	19.0	1.7	25.0	10.0	8.6	39.0	18.0	.1
	04/23/85	17.0	1.1	20.0	7.8	4.8	34.0	16.0	<.1
	05/28/85	16.0	1.0	18.0	7.0	7.9	30.0	18.0	.1
	06/27/85	14.0	.9	16.0	5.7	8.3	27.0	14.0	.1
	07/24/85	16.0	1.4	18.0	6.6	7.9	31.0	17.0	<.1
	08/29/85	19.0	1.4	21.0	8.2	9.2	35.0	13.0	.1
	09/19/85	19.0	1.5	21.0	8.6	7.5	38.0	16.0	.1
	10/23/85	16.0	1.3	19.0	7.4	9.5	32.0	15.0	.1
	11/05/85	18.0	1.6	20.0	7.6	8.5	35.0	15.0	<.1
	11/20/85	11.0	1.1	10.0	4.0	8.3	20.0	13.0	<.1
	12/16/85	14.0	1.2	14.0	5.1	11.0	24.0	14.0	.1
	01/31/86	17.0	1.0	11.0	4.0	8.8	28.0	15.0	<.1
	02/26/86	19.0	1.1	13.0	4.6	8.8	35.0	14.0	<.1
	03/24/86	15.0	1.0	13.0	4.6	7.9	26.0	14.0	<.1

Table 13.--Results of analyses of surface-water samples from the upper Rockaway River basin for dissolved trace elements and compounds, 1984-86

[All constituents dissolved, in micrograms per liter; sampling-event code: B, base-flow sample; S, stormflow sample; M, monthly sample; <, less than the given value, which is the detection limit; ---, no data]

Station number[1]	Sampling-event code	Date sampled	Aluminum	Arsenic	Beryllium	Cadmium	Chromium	Copper
01379690	B	10/16/84	100	<1.0	<0.5	<1.0	<10	<1.0
	S	11/05/85	100	<1.0	1.0	1.0	10	3
01379700	B	10/16/84	100	<1.0	<.5	<1.0	10	35
	M	04/23/85	200	<1.0	<.5	<1.0	<10	<1.0
	M	05/28/85	400	<1.0	<.5	<1.0	10	3
	M	06/27/85	100	<1.0	1.0	<1.0	10	1.0
	M	07/24/85	200	<1.0	.6	<1.0	<10	2
	M	08/29/85	<100	<1.0	.5	<1.0	<10	1.0
	M	09/19/85	<100	<1.0	<.5	<1.0	<10	5
	M	10/23/85	100	<1.0	<.5	<1.0	10	3
	S	11/05/85	100	<1.0	1.0	1.0	10	2
	M	11/20/85	100	<1.0	.8	<1.0	10	1.0
	M	12/16/85	<100	<1.0	<.5	<1.0	<10	<1.0
	M	01/31/86	<100	<1.0	<.5	<1.0	<10	4
	M	02/26/86	<100	<1.0	<.5	<1.0	<10	2
	M	03/24/86	<100	<1.0	<.5	<1.0	<10	3
01379740	B	10/16/84	<100	<1.0	<.5	<1.0	<10	<1.0
	S	11/05/85	100	<1.0	.5	2.0	<10	1.0
01379750	B	10/16/84	<100	<1.0	<.5	<1.0	<10	<1.0
	S	11/05/85	200	<1.0	<.5	1.0	<10	1.0
01379800	B	10/16/84	<100	<1.0	<.5	<1.0	<10	2
	S	11/05/85	100	<1.0	1.0	1.0	<10	2
01379808	B	10/16/84	<100	<1.0	<.5	<1.0	10	<1.0
	S	11/05/85	200	<1.0	<.5	<1.0	<10	4
01379855	B	10/16/84	<100	<1.0	<.5	<1.0	<10	1.0
	S	11/05/85	100	<1.0	1.0	1.0	<10	3
01379880	B	10/16/84	<100	<1.0	<.5	<1.0	<10	1.0
	S	11/05/85	100	<1.0	<.5	<1.0	<10	3
01380110	B	10/16/84	<100	<1.0	<.5	<1.0	<10	1.0
	S	11/04/85	200	<1.0	<.5	<1.0	<10	1.0
01380135	B	10/17/84	<100	<1.0	<.5	<1.0	10	1.0
	S	11/04/85	200	<1.0	<.5	1.0	<10	1.0
01380145	B	10/17/84	<100	<1.0	<.5	<1.0	<10	1.0
	S	11/05/85	200	<1.0	<.5	1.0	<10	2
01380300	B	10/17/84	100	<1.0	<.5	<1.0	10	1.0
	S	11/04/85	100	<1.0	1.0	1.0	<10	3
01380320	B	10/17/84	<100	<1.0	<.5	<1.0	10	1.0
	S	11/04/85	100	<1.0	1.0	1.0	10	3
01380335	B	10/17/84	<100	<1.0	<.5	<1.0	10	1.0
	S	11/05/85	---	---	---	---	---	---
01380500	B	10/17/84	<100	<1.0	<.5	<1.0	<10	1.0
	M	04/23/85	100	<1.0	<.5	<1.0	<10	<1.0
	M	05/28/85	400	<1.0	<.5	<1.0	<10	3
	M	06/27/85	200	<1.0	<.5	<1.0	<10	3
	M	07/24/85	100	<1.0	<.5	1.0	<10	5
	M	08/29/85	<100	<1.0	.9	<1.0	<10	3
	M	09/19/85	<100	1.0	<.5	---	<10	7
	M	10/23/85	<100	<1.0	<.5	<1.0	10	3
	S	11/05/85	100	<1.0	1.0	1.0	<10	3
	M	11/20/85	100	<1.0	<.5	<1.0	<10	3
	M	12/16/85	<100	<1.0	<.5	<1.0	<10	2
	M	01/31/86	<100	<1.0	<.5	<1.0	<10	1.0
	M	02/26/86	<100	<1.0	<.5	<1.0	<10	1.0
	M	03/24/86	<100	<1.0	<.5	<1.0	<10	2

[1] Stations are described in table 7 and locations shown in figure 9.

Table 13.--Results of analyses of surface-water samples from the upper Rockaway River basin for dissolved trace elements and compounds, 1984-86--Continued

[All constituents dissolved, in micrograms per liter; sampling-event code: B, base-flow sample; S, stormflow sample; M, monthly sample; <, less than the given value, which is the detection limit; ---, no data]

Station number[1]	Date sampled	Cyanide	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Zinc
01379690	10/16/84	<0.01	160	<1	22	<0.1	1.0	<1.0	4
	11/05/85	<.01	200	10	39	.1	<1.0	<1.0	81
01379700	10/16/84	<.01	200	1	52	<.1	30.0	<1.0	<3
	04/23/85	<.01	180	1	92	.1	11.0	<1.0	29
	05/28/85	<.01	480	2	42	<.1	3.0	<1.0	34
	06/27/85	<.01	440	5	35	<.1	3.0	<1.0	10
	07/24/85	<.01	360	3	38	<.1	3.0	<1.0	21
	08/29/85	<.01	210	3	67	.1	2.0	<1.0	15
	09/19/85	<.01	240	2	75	<.1	2.0	<1.0	33
	10/23/85	---	220	<1	37	<.1	<1.0	<1.0	28
	11/05/85	<.01	180	4	39	<.1	1.0	<1.0	16
	11/20/85	<.01	180	1	17	<.1	1.0	<1.0	22
	12/16/85	<.01	130	3	32	<.1	1.0	<1.0	15
	01/31/86	<.01	97	1	26	.2	1.0	<1.0	14
	02/26/86	<.01	120	3	33	<.1	1.0	<1.0	7
	03/24/86	<.01	95	1	25	<.1	<1.0	<1.0	9
01379740	10/16/84	<.01	94	<1	18	<.1	<1.0	<1.0	<3
	11/05/85	<.01	130	2	15	.1	5.0	<1.0	16
01379750	10/16/84	<.01	300	2	85	<.1	<1.0	<1.0	<3
	11/05/85	<.01	150	6	26	<.1	1.0	<1.0	8
01379800	10/16/84	<.01	41	2	160	.1	<1.0	<1.0	<3
	11/05/85	<.01	260	1	180	.1	3.0	<1.0	16
01379808	10/16/84	<.01	160	<1	18	<.1	<1.0	<1.0	26
	11/05/85	<.01	110	6	61	<.1	3.0	<1.0	8
01379855	10/16/84	<.01	150	1	39	.1	1.0	<1.0	8
	11/05/85	<.01	98	8	66	<.1	2.0	<1.0	11
01379880	10/16/84	<.01	160	1	38	<.1	1.0	<1.0	<3
	11/05/85	<.01	150	11	90	.2	3.0	<1.0	10
01380110	10/16/84	<.01	160	3	31	<.1	1.0	<1.0	23
	11/04/85	<.01	140	10	14	<.1	1.0	<1.0	7
01380135	10/17/84	<.01	140	2	31	<.1	2.0	<1.0	<3
	11/04/85	<.01	150	4	26	<.1	<1.0	<1.0	6
01380145	10/17/84	<.01	160	3	42	<.1	<1.0	<1.0	<3
	11/05/85	<.01	140	8	25	<.1	<1.0	<1.0	8
01380300	10/17/84	<.01	140	<1	82	<.1	<1.0	<1.0	3
	11/04/85	<.01	110	1	30	<.1	<1.0	<1.0	5
01380320	10/17/84	<.01	73	4	310	<.1	<1.0	<1.0	<3
	11/04/85	<.01	180	1	110	<.1	<1.0	<1.0	10
01380335	10/17/84	<.01	180	1	37	<.1	<1.0	<1.0	7
	11/05/85	---	---	---	---	---	---	---	---
01380500	10/17/84	<.01	160	2	18	<.1	2.0	<1.0	4
	04/23/85	<.01	190	1	50	<.1	<1.0	<1.0	14
	05/28/85	<.01	270	3	47	<.1	2.0	<1.0	7
	06/27/85	<.01	340	5	36	<.1	2.0	<1.0	10
	07/24/85	<.01	170	4	22	<.1	4.0	<1.0	11
	08/29/85	<.01	140	2	19	.3	2.0	<1.0	21
	09/19/85	<.01	110	<1	15	.4	3.0	<1.0	46
	10/23/85	<.01	230	<1	30	.1	<1.0	<1.0	23
	11/05/85	<.01	150	2	39	<.1	1.0	<1.0	16
	11/20/85	<.01	140	4	26	<.1	3.0	<1.0	12
	12/16/85	<.01	180	<1	42	<.1	1.0	<1.0	39
	01/31/86	<.01	97	1	37	<.1	<1.0	<1.0	9
	02/26/86	<.01	130	2	46	<.1	1.0	<1.0	12
	03/24/86	<.01	130	<1	38	<.1	1.0	<1.0	13

Table 14.--Results of analyses of surface-water samples from the upper Rockaway River basin for dissolved nutrients and organic compounds, 1984-86

[All constituents dissolved, in milligrams per liter, except for phenols; phenols are total, in micrograms per liter; sampling-event code: B, base-flow sample; S, stormflow sample; M, monthly sample; <, less than the given value, which is the detection limit; MBAS, methylene blue active substances; ---, no data]

Station number [1]	Sampling-event code	Date sampled	Nitrogen, nitrite (as N)	Nitrogen, nitrite + nitrate (as N)	Nitrogen, ammonia + organic (as N)	Nitrogen, ammonia (as N)	Phosphorous	Phosphorous, ortho (as P)
01379690	B	10/16/84	<0.01	<0.10	0.5	0.02	0.01	<0.01
	S	11/05/85	<.01	<.10	.2	.12	.03	.04
01379700	B	10/16/84	<.01	<.10	.3	<.01	<.01	<.01
	M	04/23/85	<.01	<.10	2.4	.03	.03	.06
	M	05/28/85	<.01	<.10	.3	.05	.05	<.01
	M	06/27/85	<.01	.13	.4	<.01	.02	<.01
	M	07/24/85	<.01	.10	.2	.02	.09	.02
	M	08/29/85	<.01	<.10	---	.01	.04	<.01
	M	09/19/85	<.01	<.10	---	<.01	.03	<.01
	M	10/23/85	.03	<.10	.5	<.01	.02	<.01
	S	11/05/85	<.01	.10	.5	.07	.03	.02
	M	11/20/85	<.01	.16	.6	.02	.02	.01
	M	12/16/85	<.01	.34	.3	.06	.01	.01
	M	01/31/86	<.01	.30	.3	.04	.01	.01
	M	02/26/86	<.01	.37	.3	.07	.01	.02
	M	03/24/86	<.01	.20	.4	.02	.01	.02
01379740	B	10/16/84	<.01	<.10	.7	<.01	.02	<.01
	S	11/05/85	<.01	<.10	.4	.04	.02	<.01
01379750	B	10/16/84	<.01	<.10	.4	.02	.03	.02
	S	11/05/85	<.01	<.10	.8	.01	.02	.02
01379800	B	10/16/84	<.01	.72	.5	.03	.01	.03
	S	11/05/85	<.01	.55	.5	.08	.04	.02
01379808	B	10/16/84	<.01	.12	.3	<.01	.04	.01
	S	11/05/85	<.01	.27	.5	.11	.03	.02
01379855	B	10/16/84	<.01	.51	.2	.04	<.01	.04
	S	11/05/85	<.01	.65	.5	.10	.04	.03
01379880	B	10/16/84	<.01	.48	.9	.06	.01	<.01
	S	11/05/85	<.01	.49	.4	.05	.05	.03
01380110	B	10/16/84	<.01	.38	.6	<.01	.02	.01
	S	11/04/85	<.01	.31	.4	.09	.02	.01
01380135	B	10/17/84	<.01	.33	.4	.05	.01	.01
	S	11/04/85	<.01	.34	.3	.17	.03	<.01
01380145	B	10/17/84	<.01	.38	.5	.07	<.01	<.01
	S	11/05/85	<.01	.53	.2	.14	.03	.02
01380300	B	10/17/84	<.01	.53	.2	.03	<.01	.01
	S	11/04/85	<.01	.25	.5	.06	.01	.01
01380320	B	10/17/84	<.01	.19	.4	.04	.01	.04
	S	11/04/85	.01	.26	.5	.06	.02	.01
01380335	B	10/17/84	.01	.37	.4	<.01	.02	.02
	S	11/05/85	<.01	.36	.6	.03	.05	.04
01380500	B	10/17/84	<.01	.43	.5	.02	<.01	.04
	M	04/23/85	<.01	.27	.6	.01	<.01	<.01
	M	05/28/85	<.01	.39	2.4	<.01	.43	<.01
	M	06/27/85	<.01	.40	.5	<.01	.04	<.01
	M	07/24/85	<.01	.33	.3	.06	.04	.02
	M	08/29/85	<.01	.32	---	.02	.07	<.01
	M	09/19/85	<.01	.21	---	<.01	.04	<.01
	M	10/23/85	.03	.29	.4	<.01	.02	<.01
	S	11/05/85	<.01	.43	.5	.07	.03	<.01
	M	11/20/85	.02	.34	---	.07	.03	.01
	M	12/16/85	<.01	.46	.5	.06	.01	.01
	M	01/31/86	<.01	.42	.3	.05	.01	.01
	M	02/26/86	<.01	.48	.4	.05	.01	<.01
	M	03/24/86	<.01	.43	.4	.02	.01	.02

[1] Stations are described in table 7 and locations shown in figure 9.

Table 14.--Results of analyses of surface-water samples from the upper Rockaway River basin for dissolved nutrients and organic compounds, 1984-86--Continued

[All constituents dissolved, in milligrams per liter, except for phenols; phenols are total, in micrograms per liter; sampling-event code: B, base-flow sample; S, stormflow sample; M, monthly sample; <, less than the given value, which is the detection limit; MBAS, methylene blue active substances; ---, no data]

Station number [1]	Date sampled	Dissolved organic carbon	Suspended organic carbon	Phenols	MBAS detergents
01379690	10/16/84	2.8	0.2	2	.01
	11/05/85	4.3	.2	4	.03
01379700	10/16/84	2.4	.2	10	.01
	04/23/85	3.6	<.1	4	.04
	05/28/85	4.4	.1	8	.03
	06/27/85	4.9	.1	4	.04
	07/24/85	5.4	<.1	6	.04
	08/29/85	3.7	.1	---	---
	09/19/85	3.7	.1	<1	.05
	10/23/85	4.1	<.1	5	---
	11/05/85	4.2	.2	5	.04
	11/20/85	5.0	<.1	<1	.03
	12/16/85	2.9	.2	1	---
	01/31/86	3.1	<.1	2	.06
	02/26/86	2.8	.2	<1	.05
	03/24/86	2.5	.3	<1	.05
01379740	10/16/84	2.2	.2	2	.02
	11/05/85	4.0	.1	5	.03
01379750	10/16/84	2.2	.3	5	.02
	11/05/85	3.5	.2	4	.03
01379800	10/16/84	3.6	.4	5	.04
	11/05/85	7.0	.7	4	.07
01379808	10/16/84	2.6	.2	<1	.02
	11/05/85	---	---	---	---
01379855	10/16/84	2.4	.4	2	.03
	11/05/85	7.7	1.3	3	.05
01379880	10/16/84	2.1	.2	4	.03
	11/05/85	6.2	1.7	2	.06
01380110	10/16/84	2.8	.3	1	.02
	11/04/85	4.2	<.1	12	.04
01380135	10/17/84	2.4	.2	5	.03
	11/04/85	4.4	.2	2	.04
01380145	10/17/84	2.6	.2	2	.02
	11/05/85	6.5	1.6	5	.05
01380300	10/17/84	2.9	.5	3	.03
	11/04/85	4.7	.8	2	.03
01380320	10/17/84	3.1	.5	5	.02
	11/04/85	5.6	.1	3	.03
01380335	10/17/84	2.6	.2	5	.03
	11/05/85	5.4	.8	1	.04
01380500	10/17/84	2.7	.1	1	.02
	04/23/85	3.5	<.1	4	.02
	05/28/85	4.4	.1	7	.04
	06/27/85	5.6	.5	8	.03
	07/24/85	8.1	.1	4	.05
	08/29/85	3.5	<.1	---	---
	09/19/85	3.3	<.1	<1	.05
	10/23/85	3.8	<.1	4	---
	11/05/85	4.3	.6	1	.04
	11/20/85	---	---	<1	.03
	12/16/85	3.6	.3	1	---
	01/31/86	2.8	<.1	2	.05
	02/26/86	3.3	.1	<1	.06
	03/24/86	3.0	.2	<1	.05

Table 15.--Concentrations of selected trace elements on sieved streambed material (less than 63-micrometer diameter) from the upper Rockaway River basin, August 14-16, 1985

[Concentrations in micrograms per gram; <, less than the given value, which is the detection limit]

Trace element	Station number						
	01379690	01379740	01379808	01380110	01380145	01380335	01380450
Aluminum	15,000	17,000	11,000	13,000	14,000	13,000	10,000
Arsenic	13	18	17	9	11	9	10
Beryllium	<3	<3	<3	<3	<3	<3	<3
Cadmium	1	<1	16	6	6	15	9
Chromium	160	300	550	400	420	500	420
Copper	41	32	110	110	110	170	120
Cyanide	<.5	<.5	<.5	<.5	<.5	<.5	<.5
Iron	30,000	33,000	39,000	22,000	28,000	21,000	22,000
Lead	50	50	270	280	330	420	360
Manganese	1,000	650	4,600	1,100	880	570	1,100
Mercury	.2	.2	.8	.6	.6	.9	.8
Nickel	30	20	40	50	40	50	40
Selenium	<1	1	1	<1	1	1	<1
Zinc	110	130	510	350	320	490	380

Table 16.--Concentrations of selected chlorinated organic compounds and organic carbon on sieved streambed material (less than 63-micrometer diameter) from the upper Rockaway River basin, August 14-16, 1985

[g/kg, grams per kilogram; µg/kg, micrograms per kilogram; <, less than the given value, which is the detection limit]

Compound	Station number						
	01379690	01379740	01379808	01380110	01380145	01380335	01380450
Total organic carbon (g/kg)	43	44	73	64	67	78	59
Chlordane (µg/kg)	16	<1.0	26	510	140	170	160
Normalized* (x 10^{-6})	(.37)	(.02)	(.36)	(8.0)	(2.1)	(2.2)	(2.7)
DDD (µg/kg)	1.9	2.0	26	74	55	61	50
Normalized* (x 10^{-6})	(.04)	(.05)	(.36)	(1.2)	(.82)	(.78)	(.85)
DDE (µg/kg)	1.4	1.4	10	12	7.6	9.2	24
Normalized* (x 10^{-6})	(.03)	(.03)	(.14)	(.19)	(.11)	(.12)	(.41)
DDT (µg/kg)	.1	<.1	7.1	14	5.4	<.1	7.7
Normalized* (x 10^{-6})	(.002)	(.002)	(.10)	(.20)	(.08)	(.001)	(.13)
Dieldrin (µg/kg)	.2	.1	.6	5.2	.9	.9	.6
Normalized* (x 10^{-6})	(.005)	(.002)	(.01)	(.08)	(.01)	(.01)	(.01)
Mirex (µg/kg)	<.1	<.1	80	32	23	29	8.2
Normalized* (x 10^{-6})	(.002)	(.002)	(1.1)	(.5)	(.3)	(.4)	(.14)
Heptachlor epoxide (µg/kg)	<.1	<.1	.7	10	<.1	3.3	3.8
Normalized* (x 10^{-6})	(.002)	(.002)	(.01)	(.16)	(.001)	(.04)	(.06)
Total PCB (µg/kg)	14	15	170	340	180	260	90
Normalized* (x 10^{-6})	(.33)	(.34)	(2.3)	(5.3)	(2.7)	(3.3)	(1.5)

* Normalized with total organic carbon

Example: Chlordane at station 01379690 =

$$\frac{16 \mu g/kg}{43 \times 10^{6} \ \mu g/kg} = 0.37 \times 10^{-6}$$

APPENDIX A

Appendix A.--Macroinvertebrate statistics for the upper Rockaway River basin, May-November 1985

1. Glossary of biological terms and abbreviations

Macroinvertebrate--An invertebrate (an animal that does not have a backbone) that is retained on a U.S. Standard No. 30 sieve (595 micrometers mesh opening). In this study a No. 70 sieve (210 micrometers mesh opening) was used. Common aquatic examples of macroinvertebrates include worms, insects, snails, and crayfish.

Periphyton--The community of microorganisms that are attached to or live on submerged surfaces. Examples include algae, bacteria, fungi, protozoans, and rotifers.

Pollutional Classifications[1]

Tolerant--Organisms frequently associated with gross organic contamination that generally are capable of thriving under anaerobic conditions.

Facultative--Organisms having a wide range of tolerance that frequently are associated with even moderate levels of organic contamination.

Intolerant--Organisms that are not found associated with even moderate levels of organic contaminants and that generally are intolerant of even moderate reductions in dissolved oxygen.

Pollutional Indices[1]

Species diversity--A measure of the quality of the environment based on richness and distribution of individuals among the species. The Shannon-Weaver function is used in this report.

3 - 4 = generally unpolluted, <1 = polluted

Equitability--A measure of the quality of the environment based on the species-distribution component of diversity. The Lloyd and Ghelardi formula is used in this report.

0.6 - 0.8 = unpolluted, <0.5 = slight degradation

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[1] Weber, C.I., 1973, Biological field and laboratory methods for measuring the quality of surface waters and effluents: Cincinnati, Ohio, U.S. Environmental Protection Agency, EPA-670144-73-001, variable pagination.

Ecological Niches[2]

Scavengers--Consumers of decomposing organic matter and (or) feces of other bugs. This group generally comprises less than 5 percent of the macroinvertebrate community. Stressful conditions may cause an increase in this percentage.

Filter feeders--Consumers of fine particulate organic matter, plankton, and small animals. Organic enrichment generally causes their relative abundance to exceed 15 percent of the population.

Periphyton feeders--Consumers of diatoms growing on rocks and plants, and filamentous algae. Organic enrichment often causes their proportion to exceed 5 percent of the population.

Abbreviations

Population density, MI/SF--Mean number of individuals per square foot.

(%A)--Percent abundance

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[2] Kurtz, J.M., 1985, Ecological niches and pollutional classifications of macroinvertebrates in New Jersey streams: Unpublished report on file at New Jersey Department of Environmental Protection and Energy, Trenton, New Jersey, 30 p.

2. Biological characteristics of macroinvertebrates, by season and sampling device

Station 01379700

Characteristic	Spring 1985 Surber sampling device	Spring 1985 Hester Dendy sampling device	Summer 1985 Hester Dendy sampling device	Fall 1985 Hester Dendy sampling device
Number of replicates	3	0*	3	3
Number of taxa	97		64	48
Population density, MI/SF	581.3		934.3	239.0
Species diversity index	3.4		4.1	4.0
Equitability index	.1		.4	.5
Dominant species (%A)	Parakief-feriella coronata(31) Gammarus fasciatus(10) Nais elinguis (7) Cricotopus bicinctus(6)		Microtendipes tarsalis(16) Rheotanytarsus distinctis-simus (16) Cricotopus bicinctus(12) Nanocladius rectinvervis(10)	Microtendipes tarsalis(27) Psectrocladius nigrus (8) Prostoma rubrum (8) Gammarus fasciatus (7)
Ecological niche (%A)				
Predator	3		4	14
Scavenger	11		6	13
Filter feeder	8		41	44
Detritivore	45		7	10
Herbivore	24		16	6
Omnivore	3		15	10
Periphyton feeder	5		10	1
Pollutional classification (%A)				
Tolerant	4		12	<1
Facultative	50		56	88
Intolerant	45		32	11
Observation	Filamentous green algae, Epistylis, and detritus			

* Hester Dendy sampling devices not recovered

2. Biological characteristics of macroinvertebrates, by season and sampling device--Continued

Station 01379750

Characteristic	Spring 1985 Surber sampling device	Spring 1985 Hester Dendy sampling device	Summer 1985 Hester Dendy sampling device	Fall 1985 Hester Dendy sampling device
Number of replicates	3	3	3*	3
Number of taxa	91	81	69	69
Population density, MI/SF	319.3	909.7	529.3	527.3
Species diversity index	5.0	3.8	4.3	3.6
Equitability index	.5	.2	.4	.3
Dominant species (%A)	Gammarus fasciatus(12) Nais bretscheri(11) Cricotopus bicinctus(7) Rheotanytarsus distinctissimus(7) Gillia altilis(6) Cricotopus sp.1(5) Nais simplex(4)	Rheotanytarsus exigua(42) Cricotopus bicinctus(7) Cheumatopsyche sp. (5)	Rheotanytarsus exigua(18) Cricotopus bicinctus(14) Isonychia bicolor(9) Stenonema smithae(7) Cheumatopsyche sp. (7)	Rheotanytarsus exigua(46) Nais simplex (10)
Ecological niche (%A)				
Predator	7	2	7	3
Scavenger	15	3	6	4
Filter feeder	17	53	28	59
Detritivore	24	6	16	14
Herbivore	18	15	27	11
Omnivore	1	4	2	17
Periphyton feeder	18	16	14	8
Pollutional classification (%A)				
Tolerant	6	1	2	10
Facultative	69	76	71	71
Intolerant	25	23	27	18
Observation	Elodea, Millfoil, filamentous green algae, and detritus			Large leaf detritus

* Replicate sample A, when retrieved, had been partially out of the water

2. Biological characteristics of macroinvertebrates, by season and sampling device--Continued

Station 01379808

Characteristic	Spring 1985 Surber sampling device	Spring 1985 Hester Dendy sampling device	Summer 1985 Hester Dendy sampling device	Fall 1985 Hester Dendy sampling device
Number of replicates	3	3	3	3
Number of taxa	92	93	68	67
Population density, MI/SF	452.0	3,476.3	664.7	305.7
Species diversity index	4.8	3.0	4.5	4.5
Equitability index	.4	.1	.5	.5
Dominant species (%A)	Rheotanytarsus distinctis-simus(18) Cheumatopsyche sp.(12) Gammarus fasciatus(9) Ephemerella rotunda(7) Symphitopsyche bifida(7)	Rheotanytarsus exigua(51)	Cricotopus bicinctus(18) Cheumatopsyche sp.(12) Rheotanytarsus exigua(9) Stenonema smithae(9) Prostoma rubrum(5)	Rheotanytarsus exigua(19) Gammarus fasciatus(9) Cricotopus slossonae(8) Cheumatopsyche sp.(7) Stenonema smithae(7)
Ecological niche (%A)				
Predator	5	1	8	11
Scavenger	10	2	7	11
Filter feeder	45	76	27	35
Detritivore	25	6	14	13
Herbivore	7	3	26	17
Omnivore	1	8	6	1
Periphyton feeder	7	3	11	10
Pollutional classification (%A)				
Tolerant	2	<1	4	1
Facultative	49	80	78	82
Intolerant	49	19	14	17
Observation	Filamentous green algae, Epistylis, and detritus	Epistylis	Blue-green algae mats	Epistylis

2. Biological characteristics of macroinvertebrates, by season and sampling device--Continued

Station 01379880

Characteristic	Spring 1985 Surber sampling device	Spring 1985 Hester Dendy sampling device	Summer 1985 Hester Dendy sampling device	Fall 1985 Hester Dendy sampling device
Number of replicates	3	2	3	3
Number of taxa	60	44	60	40
Population density, MI/SF	414.3	530.5	537.7	122.7
Species diversity index	4.4	2.9	4.0	4.0
Equitability index	.5	.2	.4	.6
Dominant species (%A)	Orthocladius paradorenus (15) Nais bretscheri(14) Cricotopus fugax(8) Symphitopsyche bifida(8) Ephemerella temporalis(6)	Gammarus fasciatus(51)	Cheumatopsyche sp.(20) Gammarus fasciatus(18) Symphitopsyche bifida(15)	Gammarus fasciatus(25) Symphitopsyche bifida(14) Prostoma rubrum(9) Orthocladius paradorenus(7)
Ecological niche (%A)				
Predator	7	1	2	11
Scavenger	3	53	22	27
Filter feeder	13	11	40	30
Detritivore	25	17	17	12
Herbivore	34	9	7	11
Omnivore	9	3	7	3
Periphyton feeder	8	6	6	7
Pollutional classification (%A)				
Tolerant	1	1	6	4
Facultative	52	89	68	72
Intolerant	47	10	26	24
Observation	Filamentous green algae, Epistylis, and detritus	Epistylis and detritus	Elodea, blue-green algae mats, Epistylis, and Vorticella	Epistylis

2. Biological characteristics of macroinvertebrates, by season and sampling device--Continued

Station 01380110

Characteristic	Spring 1985 Surber sampling device	Spring 1985 Hester Dendy sampling device	Summer 1985 Hester Dendy sampling device	Fall 1985 Hester Dendy sampling device
Number of replicates	3	2	2	3
Number of taxa	63	44	59	55
Population density, MI/SF	306.0	284.5	345.0	159.7
Species diversity index	4.7	4.0	4.0	4.5
Equitability index	.6	.5	.4	.6
Dominant species (%A)	Cricotopus fugax(20) Orthocladius paradorenus (11) Cricotopus slossonae(6) Glossosoma(6) Symphitopsyche bifida(4) Nais bretscheri(4)	Cricotopus bicinctus(32) Synorthocladius semivirens(10) Cricotopus slossonae(10)	Ferrissia rivularis(33) Aeolosoma leidyi(11) Gammarus fasciatus(10)	Prostoma rubrum(14) Gammarus fasciatus(11) Ferrissia rivularis(8) Pleurocera acuta acuta(8) Symphitopsyche bifida(8) Trimalacono-thrus(7)
Ecological niche (%A)				
Predator	8	2	3	17
Scavenger	3	3	17	17
Filter feeder	13	10	7	21
Detritivore	11	8	21	4
Herbivore	29	52	4	15
Omnivore	21	11	5	1
Periphyton feeder	14	13	41	24
Pollutional classification (%A)				
Tolerant	2	1	6	2
Facultative	60	85	53	77
Intolerant	38	14	41	20
Observation	Filamentous green algae and Epsitylis		Filamentous green algae	

2. Biological characteristics of macroinvertebrates, by season and sampling device--Continued

Station 01380145

Characteristic	Spring 1985 Surber sampling device	Spring 1985 Hester Dendy sampling device*	Summer 1985 Hester Dendy sampling device	Fall 1985 Hester Dendy sampling device
Number of replicates	3	3	3	2
Number of taxa	65	66	54	41
Population density, MI/SF	576.0	357.3	217.0	123.5
Species diversity index	4.8	4.8	4.1	4.2
Equitability index	.6	.6	.5	.7
Dominant species (%A)	Cheumatopsyche sp.(10) Gammarus fasciatus(9) Simulium vittatum(9) Symphitopsyche bifida(8) Hydropsyche betteni(7) Pseudocloeon cingulatum(5) Cricotopus fugax(4)	Laevapex fuscus(11) Gillia altilis(10) Stenacron inter-punctatum(8) Gammarus fasciatus(7) Ferrissia rivularis(6) Nanocladius Cras-sicornis (5) Dugesia tigrina(4) Cheumatopsyche sp.(4)	Gammarus fasciatus(20) Stenacron inter-punctatum(20) Cheumatopsyche sp.(11)	Stenacron inte punctatum(20) Psectrocladius sp.4(12) Polypedilum convictum(10) Gammarus fasciatus(9)
Ecological niche (%A)				
Predator	5	9	4	6
Scavenger	10	14	25	14
Filter feeder	37	11	19	22
Detritivore	16	5	13	6
Herbivore	20	20	24	34
Omnivore	5	7	4	13
Periphyton feeder	7	34	9	5
Pollutional classification (%A)				
Tolerant	3	2	5	2
Facultative	66	74	64	70
Intolerant	31	25	31	28
Observation	Filamentous green algae, blue-green algae, and Epistylis	Epistylis	Pieces of macrophytes	

* Hester Dendy sampling devices underwent a 10-week colonization period (5/10/85-7/31/85)

2. Biological characteristics of macroinvertebrates, by season and sampling device--Continued

Station 01380335

Characteristic	Spring 1985 Surber sampling device	Spring 1985 Hester Dendy sampling device	Summer 1985 Hester Dendy sampling device	Fall 1985 Hester Dendy sampling device
Number of replicates	3	0*	2	3
Number of taxa	87		51	70
Population density, MI/SF	979.3		498.0	387.0
Species diversity index	4.8		3.2	4.5
Equitability index	.5		.3	.5
Dominant species (%A)	Cheumatopsyche sp.(13) Eukiefferiella devonica(10) Symphitopsyche bifida(7) Gammarus fasciatus(6) Nais bretscheri(6) Cricotopus slossonae(5) Rheotanytarsus exigua(5)		Rheotanytarsus exigua(53)	Polypedilum convictum(15) Gammarus fasciatus(14) Cheumatopsyche sp.(11) Rheotanytarsus exigua(10)
Ecological niche (%A)				
Predator	5		4	6
Scavenger	8		5	19
Filter feeder	35		66	50
Detritivore	18		9	6
Herbivore	26		6	8
Omnivore	4		2	4
Periphyton feeder	3		7	7
Pollutional classification (%A)				
Tolerant	5		2	2
Facultative	67		85	81
Intolerant	28		12	17
Observation	Pieces of macrophytes, filamentous green algae, blue-green algae mats, and Epistylis		Pieces of macrophytes and blue-green algae mats	Pieces of macrophytes, filamentous green algae, and Epistylis

* Hester Dendy sampling devices not recovered

2. Biological characteristics of macroinvertebrates, by season and sampling device--Continued

Station 01380500

Characteristic	Spring 1985 Surber sampling device	Spring 1985 Hester Dendy sampling device*	Summer 1985 Hester Dendy sampling device	Fall 1985 Hester Dendy sampling device
Number of replicates	3	2	3	2
Number of taxa	66	46	44	52
Population density, MI/SF	4,586	471.5	639.0	158.7
Species diversity index	3.1	4.0	4.3	4.9
Equitability index	.2	.5	.7	.8
Dominant species (%A)	Cricotopus sp.1(37) Nais communis (17)	Ferrissia rivularis(17) Laevapex fuscus(14) Neocloeon sp.(13) Pseudocloeon cingulatum(10)	Rheotanytarsus exigua(17) Chimarra obscura(14) Neocloeon sp.(9) Cheumatopsyche sp.(6) Ferrissia rivularis(6)	Rheotanytarsus exigua(15) Gammarus fasciatus(8) Polypedilum convictum(6) Symphitopsyche sparna(5) Symphitopsyche bifida(4) Eukiefferiella discoloripes (4) Chaetogaster diaphanus(4)
Ecological niche (%A)				
Predator	1	1	3	7
Scavenger	5	8	5	9
Filter feeder	2	18	47	36
Detritivore	36	23	16	16
Herbivore	43	16	18	22
Omnivore	9	<1	1	1
Periphyton feeder	3	32	9	4
Pollutional classification (%A)				
Tolerant	4	5	3	3
Facultative	85	63	58	81
Intolerant	11	32	39	16
Observation	Filamentous green algae and Epistylis		Pieces of macrophytes and filamentous green algae	Pieces of macrophytes, filamentous green algae, and Epistylis

* Hester Dendy sampling devices underwent a 10-week colonization period (5/10/85-8/1/85)

3. Biological characteristics of macroinvertebrates by stream segment, May-November 1985

	Stream segment					
	Upper		Middle		Lower	
Characteristic	Range	Mean	Range	Mean	Range	Mean
Number of taxa	64 - 97	76	40 - 65	53	44 - 87	62
Species diversity index	3.0 - 5.0	4.1	2.9 - 4.8	4.1	3.1 - 4.9	4.1
Equitability index	0.1 - 0.5	0.3	0.2 - 0.7	0.5	0.2 - 0.8	0.5
Ecological niche (%A)						
Predator	1 - 14	6	1 - 17	6	1 - 7	4
Scavenger	2 - 15	8	3 - 53	18	5 - 19	8
Filter feeder	8 - 76	39	7 - 40	20	2 - 66	39
Detritivore	6 - 45	16	4 - 25	14	6 - 36	17
Herbivore	3 - 27	15	4 - 52	22	6 - 43	20
Omnivore	1 - 17	6	1 - 21	7	1 - 9	3
Periphyton feeder	1 - 18	9	5 - 41	13	3 - 9	5
Pollutional classification (%A)						
Tolerant	<1 - 12	4	1 - 6	3	2 - 5	3
Facultative	49 - 88	70	52 - 89	69	58 - 85	76
Intolerant	11 - 49	25	10 - 47	28	11 - 39	20

*U.S. GOVERNMENT PRINTING OFFICE:1993-711-175