WATER QUALITY IN THE POTOMAC-RARITAN-MAGOTHY AQUIFER SYSTEM IN THE REGION OF GREENWICH TOWNSHIP, GLOUCESTER COUNTY, NEW JERSEY

By Cynthia Barton and Jane Kozinski

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BRUCE BABBITT, *Secretary*

U.S. GEOLOGICAL SURVEY

Gordon P. Eaton, *Director*

For additional information write to:

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

Copies of this report can be obtained from:

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Multiply	By	To obtain
foot	0.3048	meter
mile	1.609	kilometer
foot per mile	0.1894	meter per kilometer
square mile	2.590	square kilometer

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.

ABBREVIATIONS

mg/L, milligrams per liter
μg/L, micrograms per liter
μS/L, microsiemens per liter
°C, degrees Celsius
pCi/L, picocuries per liter
meq/L, milliequivalents per liter

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ABSTRACT

Results of water-quality analyses of ground water from 185 wells were used to describe regional variations in water chemistry in the Potomac-Raritan-Magothy aquifer system, the sole-source aquifer in northern Gloucester County, New Jersey. The effects of industrial and other urban land uses on the quality of potable-water supplies were evaluated.

The chemistry of water in shallow parts of the upper and middle aquifers is affected by the quality of precipitation, recharge from overlying wetlands (some of which are filled with dredge spoils from the Delaware River) and from the Delaware River estuary, chemical reactions with aquifer materials, and contamination from industrial and landfill sites. Although local variations in ground-water chemistry are great, pH, specific conductance, and concentrations of dissolved solids generally are low in the ambient ground water. The predominant dissolved cation generally is calcium or sodium and the predominant anion is sulfate or bicarbonate. Dissolved sodium and bicarbonate predominate and pH, specific conductance, and concentrations of dissolved solids generally are higher in the confined part of the aquifer system downgradient from the recharge area than in the shallow part, near the recharge area. These characteristics reflect continued chemical reactions with aquifer materials (including mineral dissolution, oxidation-reduction reactions, cation exchange, and oxidation of lignite) and the quality of water leaking from overlying marine deposits. Concentrations of sodium and chloride are greater in the southern part of the region than in the northern part, most likely as a result of mixing with saline water from deep parts of the aquifer system in southern Gloucester County. Water in most of the confined lower aquifer is slightly saline, probably as a result of limited recharge through the overlying confining unit; however, water in the northeastern part of the region, near the area in which the hydrologic units crop out in Pennsylvania, is more dilute because it receives more recharge.

The presence of contaminated ground water at 34 industrial and landfill sites in the region was identified and investigated by the U.S. Environmental Protection Agency (USEPA) and the New Jersey Department of Environmental Protection. In general, ground water at or near all of these sites was potable but had a lower pH, a higher specific conductance, a lower concentration of dissolved oxygen, and higher concentrations of chloride, sulfate, calcium, magnesium, iron, manganese, nitrate, ammonium, and dissolved organic carbon than did ground water regionally. In addition, trace elements designated "priority pollutants" by the USEPA frequently were detected at concentrations greater than USEPA drinking-water regulations, and purgeable organic compounds were detected most frequently in ground-water samples from these sites or nearby areas. Ground-water chemistry at these sites is affected by addition of chemicals through leaks, spills, and disposal practices and by chemical reactions with aquifer materials. Recharge of slightly to moderately saline water from the estuary during drought can contribute to elevated concentrations of major ions in ground

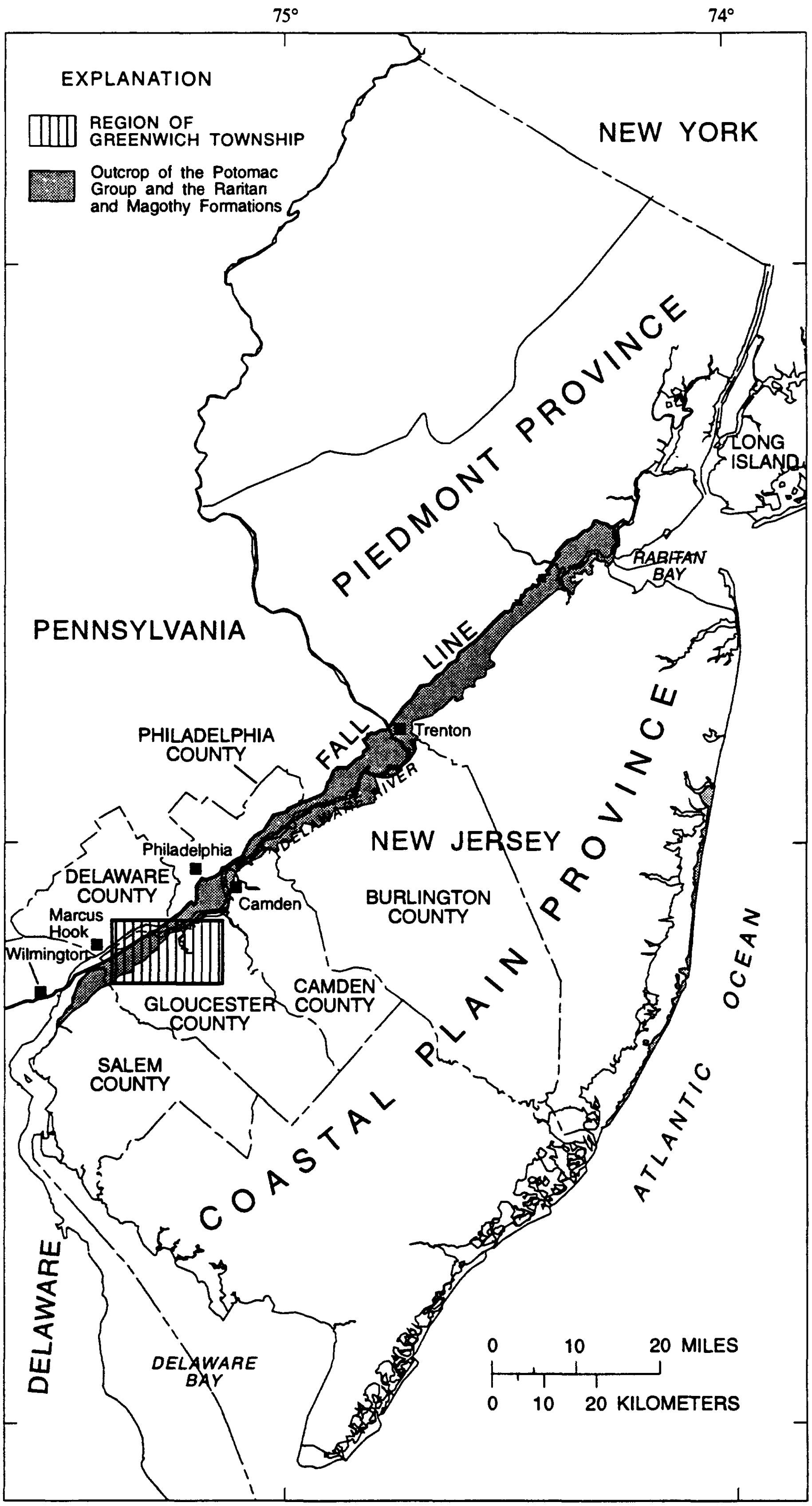
water at these sites. Detection of halogenated aliphatic compounds, decreases in pH, and increases in iron and sulfate concentrations in samples from public-supply wells in the region through time suggest that the water quality has degraded, possibly as a result of migration of contaminated ground water from industrial areas upgradient from the wells. Additional investigations are needed to identify specific sources of these constituents.

INTRODUCTION

In this report, the Greenwich Township region is defined as a rectangular, 115-square-mile area between latitudes 39°45'00" and 39°52'30" north and longitudes 75°07'30" and 75°22'30" west (fig. 1). The region includes Greenwich Township and immediately adjacent areas in northern Gloucester County, New Jersey, on the southeastern side of the Delaware River, and in Delaware and Philadelphia Counties, Pennsylvania, on the northwestern side. This area includes the outcrop and (or) shallow subcrop areas of the southeastward-dipping units that comprise the Potomac-Raritan-Magothy aquifer system, which underlies the Coastal Plain physiographic province of New Jersey (fig. 1). This aquifer system is the major source of water in southern New Jersey and is the principal source of potable-ground-water supplies in the Greenwich Township region. The local ground-water supply may be threatened by municipal and industrial sources of contamination (John Redmond, Greenwich Township, oral commun., 1985) and by recharge of saline water (Barksdale and others, 1958; Fusillo and others, 1984).

Contaminated ground water is present in the Greenwich Township region in an industrial complex in the recharge area of the aquifer system (table 1, at end of report). Petroleum and chemical industrial plants and storage facilities have existed along the Delaware River since the late 1800's. Current operations at these facilities include the use, production, storage, and disposal of organic and inorganic chemical compounds. At most sites, routine plant operations have resulted in spills or leaks of hazardous compounds, and elevated concentrations of organic and inorganic compounds have been detected in both deep and shallow parts of the aquifer system (table 1). Subsurface migration of ground water from these industrial facilities may threaten potable-water supplies. One of the six public-supply wells in Greenwich Township and Paulsboro Borough downgradient from the industrial complex is in danger of closure because of contamination by organic compounds (John Redmond, Greenwich Township, oral commun., 1985), and ground-water samples from four additional public-supply wells have been found to contain detectable concentrations of purgeable organic compounds (table 2, at end of report).

Most of the water in the Potomac-Raritan-Magothy aquifer system in the Greenwich Township region naturally consists of freshwater, water containing less than 1,000 mg/L dissolved solids (Heath, 1983, p. 64). Results of previous water-quality investigations have indicated, however, that slightly to moderately saline water (water containing dissolved solids in concentrations ranging from 1,000 to 3,000 mg/L) is found in parts of the aquifer system within this region (Barksdale and others, 1958, p. 124-128, fig. 24; Hardt and Hilton, 1969, p. 12-15, fig. 4; Kozinski and others, 1990). The saline water in the aquifer system may have entered the system



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

Figure 1. Location of the region of Greenwich Township, Gloucester County, New Jersey.

by means of induced recharge of slightly to moderately saline water from the Delaware River estuary and from deeper, confined parts of the aquifer system in southwestern Gloucester County (Barksdale and others, 1958, p. 125; Hardt and Hilton, 1969, p. 14 and 15). Hence, the encroachment of saltwater into the aquifer system is an additional threat to the potable-water supplies in the Greenwich Township region that may worsen as development and ground-water withdrawals increase.

In order to manage the potable-water supplies in the Greenwich Township region effectively, a detailed assessment of current ground-water contamination is needed. Therefore, the U.S. Geological Survey (USGS), in cooperation with Greenwich Township and the New Jersey Department of Environmental Protection (NJDEP), conducted an investigation of the ground-water resources in the Greenwich Township region during 1985-88. The objectives of the study were to (1) define the hydrogeologic framework, (2) assess the ground-water quality, (3) evaluate the threat of contamination to the potable-water supplies, (4) simulate the ground-water flow system, and (5) investigate alternatives for the future management of ground-water resources. This report addresses the second and third objectives.

Purpose and Scope

This report assesses the quality of ground water in the Potomac-Raritan-Magothy aquifer system in the Greenwich Township region by characterizing the chemistry and distribution of both potable and contaminated ground water. It presents water-quality data for 185 selected wells screened in the Potomac-Raritan-Magothy aquifer system, identifies water samples containing constituents in concentrations that exceeded applicable drinking-water regulations, and gives statistical summaries of the water-quality characteristics of the potable water in the aquifer system, as a whole and by aquifer. Regional trends in ground-water quality among and within the aquifers of the aquifer system are shown in Stiff diagrams and on distribution maps of selected chemical constituents in ground water from each aquifer. A map showing sites at which ground-water contamination has been identified by the USEPA and NJDEP and a table that summarizes the most frequently detected contaminants at these sites also are presented. Known and potential sources of contamination are listed and the affected aquifers at each site are identified. Ground-water-quality anomalies are identified and described. Changes in the quality of potable-ground-water supplies are estimated on graphs showing the change in concentrations of selected chemical constituents in samples of water from selected wells through time.

The water-quality data in this report are adequate to define, in general, the extent of ground-water contamination in the Greenwich Township region; however, they are inadequate to define the extent of contamination at specific sites. Defining the extent of contamination at individual sites was not an objective of this study.

Although the area studied during this investigation (fig. 1) includes small parts of Delaware and Philadelphia Counties, Pennsylvania, no water-quality samples were collected in the Pennsylvania part of the Greenwich

Township region during this study. All water-quality data presented herein were obtained from analyses of ground-water samples from northern Gloucester County, New Jersey.

Description of the Study Area

Physiography

In the extreme northwestern part of the Greenwich Township region in Pennsylvania, Precambrian and lower Paleozoic metamorphic and igneous rocks of the Piedmont physiographic province either crop out or are present as subcrops beneath a veneer of upper Cenozoic deposits (fig. 1). The Piedmont physiographic province is bounded on the southeast by the Fall Line (fig. 1). East of the Fall Line, the crystalline rocks of the Piedmont province are covered by deposits of the Coastal Plain physiographic province. The Coastal Plain, which extends across the rest of the region, is a southeastward-dipping, seaward-thickening wedge of unconsolidated to loosely consolidated sediments that range in age from Quaternary to Cretaceous. The maximum land-surface elevation in the New Jersey part of the region, 142 feet above sea level, is found in the southeastern part of the region. Most surface water drains northwestward into the Delaware River (pl. 1A) and, except for headwaters reaches, is affected by tides.

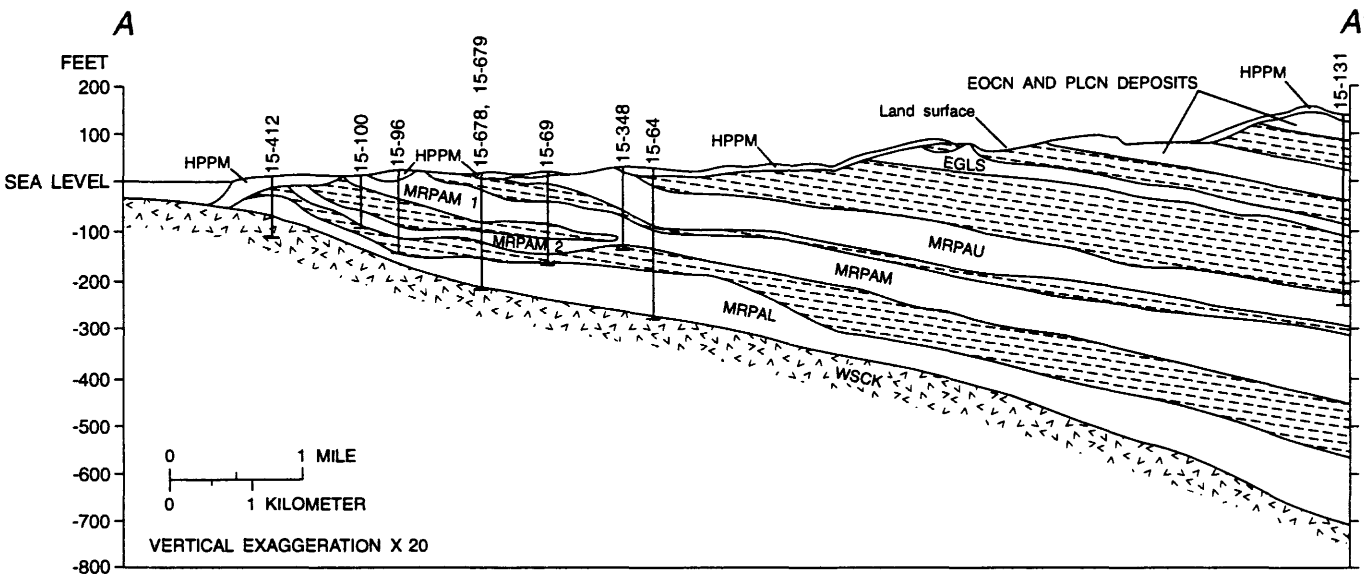
Geohydrology

A detailed discussion of the geohydrology of the Greenwich Township region is available in Barton and Kozinski (1991); this information is summarized here to define the aquifers and to identify the mineral sources of dissolved chemicals.

Upper Cenozoic alluvial deposits, consisting primarily of sand and gravel and averaging about 30 feet in thickness, mantle the surface throughout most of the region. Adjacent to the Delaware River, the underlying aquifers and confining units have been partly eroded and replaced by upper Cenozoic deposits as much as 100 feet thick. Upper Cenozoic sand and gravel deposits probably are connected hydraulically to the underlying aquifers.

A southeastward-dipping, seaward-thickening wedge of predominantly Cretaceous sediments underlies the upper Cenozoic deposits and constitutes the regional system of aquifers and confining units in the Greenwich Township region (fig. 2). The Englishtown aquifer system (fig. 2), a minor aquifer beneath the surface veneer of upper Cenozoic sediments in the southern part of the region, consists of a 0.5- to 2-mile-wide band of less than 50 feet of white-gray or yellow-brown fine- to coarse-grained quartzose sand containing local lenses of clay. Mica, glauconite, and lignite are found in sand beds within the unit, and calcareous fossils and fossiliferous siderite concentrations have been found in the massive, dark-colored beds. This deposit is marine or marginal marine in origin.

The Merchantville-Woodbury confining unit underlies the Englishtown aquifer system (fig. 2) or the surface veneer of upper Cenozoic sediments. The confining unit consists of brown, greenish-black, dark blue, or black interbedded silt, clay, and sand that reaches a thickness of more than



EXPLANATION

HYDROGEOLOGIC UNITS

HPPM	Undifferentiated upper Cenozoic deposits
EOCN AND PLCN DEPOSITS	Aquifers and confining unit in Eocene and Paleocene deposits
EGLS	Englishtown aquifer system
MRPAU	Upper aquifer of the Potomac-Raritan-Magothy aquifer system
MRPAM	Middle aquifer of the Potomac-Raritan-Magothy aquifer system. A "1" indicates the upper part of the middle aquifer; a "2" indicates the lower part
MRPAL	Lower aquifer of the Potomac-Raritan-Magothy aquifer system
WSCK	Paleozoic and Precambrian metamorphic and igneous rocks (bedrock of Wissahickon Formation)
	Confining unit
	Contacts between hydrogeologic units are approximate between well locations. Locations of sections and wells are shown on plate 1A
15-412	WELL LOCATION AND NUMBER
	BOTTOM OF GEOLOGIC OR GEOPHYSICAL LOG

Figure 2. Hydrogeologic section through the region of Greenwich Township, Gloucester County, New Jersey. (Location of hydrogeologic section is shown on pl. 1A) (From Barton and Kozinski, 1991, pl. 2b.)

190 feet in the southeastern part of the Greenwich Township region. The strata consist mostly of quartz, muscovite, and about 10 percent glauconite (Hardt and Hilton, 1969, p. 15), and contain marine-fossil fragments.

The oldest Cretaceous sediments, the Potomac Group and Raritan and Magothy Formations, underlie the Merchantville-Woodbury confining unit. Together, these geologic units form the Potomac-Raritan-Magothy aquifer system (fig. 2). These units crop out[1] in a 3- to 5-mile-wide band covering 44 square miles adjacent to and underlying the Delaware River. The deposits generally strike northeast-southwest and dip to the southeast at 40 to 60 feet per mile within the region (Barton and Kozinski, 1991). The aquifer system consists predominantly of nonmarine delta-plain deposits (Owens and Sohl, 1969, p. 239-242) that reach a total thickness of more than 850 feet in the southeastern part of the Greenwich Township region. The deposits are composed mainly of quartz, feldspars, micas, rock fragments, and lignite. Common opaque minerals in the deposits include magnetite, ilmenite, and pyrite; common accessory minerals include zircon, tourmaline, hornblende, rutile, staurolite, sillimanite, and other metamorphic minerals.

The aquifer system consists of three major aquifers and two confining units (Zapecza, 1989, p. 10; Barton and Kozinski, 1991)--the upper aquifer, the confining unit between the upper and middle aquifers, the middle aquifer, the confining unit between the middle and lower aquifers, and the lower aquifer (fig. 2). A third confining unit locally divides the middle aquifer into two parts. The upper and middle aquifers are connected hydraulically in some places because the confining unit between them is sandy and discontinuous. Upper Cenozoic deposits are thickest where parts of the Cretaceous aquifer system adjacent to the Delaware River have been eroded. Areas with significant thicknesses of upper Cenozoic deposits include an area adjacent to Raccoon Creek in Logan Township, where the upper Cenozoic clay and silt is as much as 60 feet thick, and an area in northern Paulsboro Borough and Greenwich and northwestern West Deptford Townships, where the sand and gravel is as much as 100 feet thick (pl. 1A).

The Potomac-Raritan-Magothy aquifer system is underlain by the relatively impermeable and predominantly metamorphic bedrock of the Wissahickon Formation (fig. 2). The Wissahickon Formation acts as the lower confining unit of the Potomac-Raritan-Magothy aquifer system.

The shallow ground-water flow system is regionally discontinuous and is most accurately defined on a local basis. In general, the water table is a subdued replica of the land surface, such that water flows from areas of high elevation to areas of low elevation. Throughout most of the region, the water table is above sea level. Some shallow ground water discharges to nearby surface water, which eventually drains into the Delaware River.

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[1] In this report, the terms "outcrop" and "subcrop" are used to describe areas in which the Cretaceous sediments are exposed at land surface or are overlain by Cenozoic sediments, respectively. The aquifers and confining units discussed herein have a one-to-one correspondence with the geologic formations in the study area, as described by Barton and Kozinski (1991, table 1, p. 8).

Adjacent to the river, horizontal hydraulic gradients between surface water and the shallow ground-water system are low and are affected by tides. In parts of Greenwich Township and Paulsboro Borough, the water table and stream stages are below sea level because the Delaware River is diked and floodgates are positioned at the mouths of major tributaries. In this area, the potential for river water to recharge the aquifer system is great. Recharge of the aquifer system occurs where streambeds and dike materials are sufficiently permeable so that water can move through or beneath the dike. Throughout most of the region, water potentially can move downward through leaky confining units to the deeper ground-water system. At some industrial sites, the water table is below ambient levels because of extensive pumping of shallow ground water. In the vicinity of these sites, vertical hydraulic gradients between the shallow and deep ground-water systems are reversed.

Ground-water levels in each aquifer of the Potomac-Raritan-Magothy aquifer system in 1986 ranged from near sea level in the subcrop area to more than 50 feet below sea level in eastern parts of the Greenwich Township region. Water levels decrease toward the east as a result of a large regional cone of depression that surrounds pumping centers in the Camden region (fig. 1). Similarity in the potentiometric surfaces of aquifers in the system probably is caused by the hydraulic connection among the aquifers that results from leaky confining units and a regionally similar distribution of ground-water withdrawals (Luzier, 1980; Eckel and Walker, 1986). Subsurface flow of ground water is primarily toward the southeast from the subcrop areas of each aquifer to areas downdip. Flow in the downdip parts of the upper and middle aquifers is eastward toward Camden County. Flow in the downdip parts of the lower aquifer is northeastward (fig. 1). Vertical hydraulic gradients among aquifers in the subcrop areas and shallow downdip parts of the aquifer system indicate a potential for water to move from the Delaware River into the aquifer system and downward through leaky confining units to deeper parts of the system. In the deep confined parts of the aquifer system in the southeastern part of the region, vertical hydraulic gradients among aquifers are reversed such that water potentially can move upward to the upper aquifer. Hydraulic heads in the overlying Englishtown aquifer system range from 60 feet above sea level in the subcrop area to less than 20 feet above sea level in eastern parts of the Greenwich Township region. Water probably leaks downward from the Englishtown aquifer system through the Merchantville-Woodbury confining unit to the upper aquifer.

Historical Land Use

The history of land use in the Greenwich Township region was discussed in detail by Evans and others (1974, p. 7-19) and is summarized here as a background for the subsequent discussion relating ground-water quality to land use.

Most of the Greenwich Township was settled by 1685. Upland parts of the region initially were favored for settlement because the land was better drained and comparatively free of mosquitoes, yet provided easy access to the river. Development of the region generally took the form of scattered farms rather than villages.

As early as 1749, dikes and floodgates were built on tributaries to the Delaware River to protect marshlands from tidal flooding so they could be farmed. These dikes and floodgates were precursors of the extensive flood-protection measures that exist today (1990) within Greenwich Township.

Industrial development in the region began in the late 1800's, when a second rail line was completed. A phosphate-fertilizer plant was built in Billingsport (northern Paulsboro Borough) and a dynamite plant was built in northeastern Greenwich Township about 1880. By the beginning of World War II, Paulsboro Borough had a sulfuric acid factory and an oil refinery. Greenwich Township, whose development was dominated by the sulfuric acid plant, still had some agriculture.

Since World War II, industrial growth has been responsible for most of the development in the region. Land devoted to industry, much of it "heavy" industry related to the manufacture, refining, storage, and transport of petroleum products or solvents, has replaced much of the farmland and some of the marshland. Most industrial development and population growth has been near the mouths of the tributaries to the Delaware River. Since the construction of U.S. Highway 130 and Interstate 295 (pl. 1A), however, development has increased throughout the region. Construction of bridges over the Delaware River in and near the Greenwich Township region in the 1950's was followed by residential development of much of the eastern and southeastern parts of the region because of the proximity of these areas to Philadelphia.

Well-Numbering System

Two systems are used by the USGS in New Jersey to identify wells. One uses a 15-digit station number or USGS National Water Data Storage and Retrieval System (WATSTORE) identifier. The first six digits represent degrees, minutes, and seconds of latitude, and the next seven digits represent degrees, minutes, and seconds of longitude at the well location at the time the well was inventoried. These numbers should not be used to provide well locations because they are not updated as new information becomes available. Current information about well locations is stored as latitude and longitude in the USGS National Water Information System (NWIS) data base. The remaining two digits of the station number indicate the sequence in which wells with the same latitude and longitude designation were inventoried.

The second numbering system employs a six-digit number developed by the New Jersey District of the USGS. The well number consists of a two-digit county code and a four-digit sequence number which indicates the order in which wells within the county were inventoried. The county code used in this report is 15, for Gloucester County.

Previous Investigations

Many regional investigations of the quality of water in the Potomac-Raritan-Magothy aquifer system adjacent to or including the Greenwich Township region have been published by the USGS, the NJDEP, and other State and county agencies. In an assessment of the water resources of the tri-State region in the lower Delaware River valley, Barksdale and others (1958) described the quality of water in the Potomac-Raritan-Magothy aquifer system and noted the presence of ground-water contamination from saltwater intrusion and hazardous-waste disposal in the northern Gloucester County area. Ground-water-quality data for the Potomac-Raritan-Magothy aquifer system were reported by Greenman and others (1961) for southeastern Pennsylvania, by Hardt and Hilton (1969) for Gloucester County, and by Rosenau and others (1969) for Salem County. Langmuir (1969a and 1969b) studied the geochemistry of iron in Coastal Plain aquifers in parts of Gloucester County and adjacent counties. Fusillo and Voronin (1981) and Fusillo and others (1984) compiled water-quality data for southwestern New Jersey, including the Greenwich Township region. Schaefer (1983) examined the distribution of chloride in Coastal Plain aquifers, including the Potomac-Raritan-Magothy aquifer system in the Greenwich Township region. Fusillo and others (1985) studied the distribution of purgeable organic compounds in the outcrop of the Potomac-Raritan-Magothy aquifer system. Kozinski and others (1990) investigated the chemistry of ground water at hazardous-waste sites in Logan Township. Ervin and others (1994) examined the inorganic and organic chemistry of ground water in the Potomac-Raritan-Magothy aquifer system in Camden County and surrounding areas. Balmer and Davis (in press) reported water-quality data for the Wissahickon Formation in Delaware County, Pennsylvania.

Acknowledgments

The cooperation of the municipalities, industries, and private-well owners in the Greenwich Township region in allowing USGS personnel to collect water samples and in providing water-chemistry analyses is greatly appreciated. The help of the NJDEP and the industries in the Greenwich Township region in providing information about sites at which ground-water contamination was identified by the USEPA and NJDEP also is appreciated.

METHODS OF INVESTIGATION

Sampling Network

The water-quality sampling network consists of 187 wells; 185 are screened in the Potomac-Raritan-Magothy aquifer system or undifferentiated upper Cenozoic deposits, one is screened in the Englishtown aquifer system, and one is screened in the Wenonah-Mt. Laurel aquifer (table 3, at end of report). Three additional wells listed in table 3 were used only for geologic information (wells 15-64, 15-96, and 15-412) and not for water-chemistry data. Of the 185 wells, 60 are screened in the upper aquifer (or undifferentiated upper Cenozoic deposits), 70 are screened in the middle aquifer, 46 are screened in the lower aquifer, and 9 are screened in a part of the Potomac-Raritan-Magothy aquifer system where individual aquifers could not be differentiated.

Sixty of the wells in the Potomac-Raritan-Magothy aquifer system, the well in the Englishtown aquifer system, and the well in the Wenonah-Mt. Laurel aquifer were sampled during this study (table 2). The 60 wells were chosen to obtain as uniform a distribution as possible throughout the Greenwich Township region, and to obtain samples from each of the aquifers of the Potomac-Raritan-Magothy aquifer system. Some wells were sampled specifically because they were known to contain elevated concentrations of certain organic or inorganic compounds. All public-supply wells in Greenwich Township and Paulsboro Borough were sampled to determine and monitor the quality of the potable-water supply. The median depth to the bottom of the screen in all sampled wells is 135 feet below land surface. The areal distribution of wells, especially those screened in the middle aquifer, is skewed toward wells screened in the shallow part of the aquifer system, biasing the assessment of regional variations in water quality.

Water-chemistry results for four of the 185 sampled wells in the Potomac-Raritan-Magothy aquifer system have not been reported in any previously published USGS reports, but are stored in the USGS WATSTORE system (tables 2 and 3). Analytical results used in this study are stored in the USGS NWIS data base. The locations of wells included in the network are shown on plate 1A. Location, well-construction, and hydrogeologic data for each well are listed in table 3.

Sampling Methods

Ground-water samples were collected during October 1986-September 1988. Sampling procedures varied with the type of well sampled. Wells equipped with vertical turbine pumps were sampled at discharge valves near the well head. Samples from domestic wells were collected at spigots located before holding tanks and water-treatment systems. Observation wells were sampled with a portable submersible pump; samples for analysis of purgeable organic compounds were collected with a Teflon[2] bailer. For all wells sampled, the temperature, pH, specific conductance, and dissolved-oxygen concentration of the discharged water were monitored as the well was pumped. Samples were collected after a minimum of three casing volumes of water were evacuated from the well and when the field measurements did not vary by more than 5 percent. After sample collection, alkalinity was determined by means of an incremental field titration. If organic contamination was suspected at a well site, sampling equipment was cleaned after sampling by flushing the pump and other equipment with a soap solution and then with deionized water to reduce the potential for cross-contamination of samples from different wells.

Field and Laboratory Analyses

Ground-water samples collected for this study were analyzed in the field for temperature, specific conductance, pH, alkalinity, and dissolved-oxygen concentration, and in the laboratory for nutrients, major and trace inorganic constituents, purgeable organic compounds, and pesticides (tables 2 and 4). Only samples from wells with a high probability of containing pesticides (for example, wells in or near agricultural areas) were analyzed for pesticides.

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[2] Use of trade or brand names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

Results of analyses of additional samples collected from wells in the network as part of a number of previous investigations are available in reports referenced in table 3. These samples generally were not analyzed for all of the same constituents as the samples collected during this study. Samples collected before 1980 were analyzed for most of the constituents listed in table 4 with the exception of organic compounds.

Analytical results generally are reported in units of micrograms per liter or milligrams per liter (tables 2 and 4). These units express the concentration of chemical constituents in solution as weight of solute per unit volume of solution. One thousand micrograms per liter is equivalent to one milligram per liter; one milligram per liter is generally equivalent to one part per million.

After collection, all samples were refrigerated and, with the exception of those analyzed for purgeable organic compounds, were mailed to the USGS National Water Quality Laboratory (NWQL) in Arvada, Colorado, within 72 hours. Analytical methods used by the NWQL for the determination of concentrations of dissolved solids, nutrients, and inorganic constituents are documented in Fishman and Friedman (1985). Concentrations of chloride and nutrients were determined by colorimetric methods. The concentration of sulfate was determined by turbidimetric methods. Concentrations of aluminum, arsenic, chromium, and potassium were determined by atomic absorption. Concentrations of the other inorganic constituents were measured by atomic emission with an inductively coupled argon radiofrequency plasma (ICP) excitation source.

Wershaw and others (1987) described the methods used by the NWQL to determine organic carbon, organic nitrogen, phenols, purgeable organic compounds, and pesticides in water. Organic carbon was measured by wet oxidation methods. Phenols were determined by colorimetric methods. Samples were analyzed for specific purgeable organic compounds (table 4) at the USGS New Jersey District laboratory (NJDL) with a purge-and-trap sample concentrator/gas chromatograph with a Hall detector in series with a photo-ionization detector (Kammer and Gibs, 1989). The detection limit (the concentration below which the presence of the purgeable organic compound being determined can be neither verified nor denied) is 0.80 μg/L. If any purgeable organic compound was detected, samples were shipped to the NWQL and analyzed for purgeable organic compounds by gas chromatography with a mass spectrometer. Detection limits for this method typically are either 0.20 or 3.0 μg/L, but can be several orders of magnitude higher if dilution of samples containing high concentrations of organic contaminants is required. Because the NJDL was uncertified for analysis of purgeable organic compounds at the time of the study, these analyses were done by the NWQL for quality-assurance/quality-control purposes. Carbamate pesticides were determined by high-performance liquid chromatography, and triazine pesticides were determined by gas chromatography.

Quality Assurance

The quality-control program followed by the NWQL is described by Friedman and Erdmann (1982), Peart and Thomas (1983), and Wershaw and others (1987). The program involves analyzing a large proportion of samples to evaluate accuracy and precision of laboratory measurements. The NWQL also

Table 4. Physical and chemical properties and chemical constituents measured in ground-water samples, and analytical detection limits

[μS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; μg/L, micrograms per liter; °C, degrees Celsius; pCi/L, picocuries per liter; *, the compound also was determined by using gas chromatography with a photoionization detector and an electrolytic conductivity detector in series at the U.S. Geological Survey, New Jersey District laboratory with a detection limit of 0.80 μg/L; +, the concentration of the compound was used in the calculation of the total concentration of purgeable organic compounds]

Field and laboratory measurements	**Detection limit**
alkalinity (as bicarbonate), field	0.1 mg/L
dissolved oxygen, field	.1 mg/L
dissolved solids (residue on evaporation, 180 °C)	1 mg/L
hardness (as calcium carbonate), lab	
pH, field	.1 unit
specific conductance, field	1 μS/cm
water temperature, field	.1 °C

Nutrients (dissolved)	**Detection limit (mg/L)**
nitrogen, ammonia, as N	0.010
nitrogen, ammonia + organic, as N	.10
nitrogen, nitrite, as N	.010
nitrogen, nitrite + nitrate, as N	.10
phosphorous, orthophosphate, as P	.010

Inorganic constituents	**Detection limit**
Major ions (dissolved)	**(mg/L)**
calcium	0.02
chloride	.1
magnesium	.01
potassium	.1
silica	.006
sodium	.2
sulfate	.2
Metals and trace elements (dissolved)	**(μg/L)**
aluminum	10
arsenic	1
barium	2
beryllium	.5
cadmium	1
chromium	10
cobalt	3
copper	10
fluoride (mg/L)	.1
iron	3
lead	10
lithium	4
manganese	1
mercury	.5
molybdenum	10
strontium	.5
vanadium	6
zinc	3
Radionuclides	**(pCi/L)**
Gross-alpha	0.1
Gross-beta	.1
Radium-226	.1
Radium-228	1.0

Organic constituents	**Detection limits**
organic carbon (dissolved)	0.10 mg/L
total recoverable phenols	1 μg/L
Purgeable organic compounds	.20-3.0 μg/L
* + benzene	
* + bromoform	
* + carbon tetrachloride	
* + chlorobenzene	
* + chlorodibromomethane	
* + chloroethane	
* + 2-chloroethyl vinyl ether	
* + chloroform	
1,2-dibromoethylene	
* 1,2-dichlorobenzene	
* 1,3-dichlorobenzene	
* 1,4-dichlorobenzene	
* + dichlorobromomethane	
dichlorodifluoromethane	
* + 1,1-dichloroethane	
* + 1,2-dichloroethane	
* + 1,1-dichloroethylene	
* + 1,2-cis/trans-dichloroethylene	
* + 1,2-dichloropropane	
1,3-dichloropropane	
* + cis-1,3-dichloropropene	
* trans-1,3-dichloropropene	
* + ethyl benzene	
* + methylbromide	
* methylchloride	
* + methylene chloride	
styrene	
* + 1,1,2,2-tetrachloroethane	
* + tetrachloroethylene	
* + toluene	
* + 1,1,1-trichloroethane	
* + 1,1,2-trichloroethane	
* + trichloroethylene	
trichlorofluoromethane	
* + vinyl chloride	
xylenes	

Pesticides	**Detection limit**
Carbamates (total)	2.0 μg/L
carbaryl	
methomyl	
prophan	
sevin	
Triazines (total)	0.10 μg/L
alachlor	
ametryne	
atrazine	
cyanazine	
metolachlor	
metribuzin	
prometone	
prometryne	
propazine	
simazine	
simetryn	
trifluralin	

is checked under the Quality Assurance Program of the USGS's Water Resources Division, in which standard samples are submitted for analysis and statistics on the results are tabulated.

A quality-assurance program was used during the current study to test the accuracy of the NWQL's determinations. Successive samples were collected from wells and were submitted "blind" to the laboratory. Two successive ground-water samples were collected from wells for which the probability of containing nutrients, selected inorganic constituents, or pesticides in concentrations greater than detection limits was high. Wells from which two successive samples were collected, and the type of analyses performed, are indicated in table 2 as two sets of analytical results--one for each sample from the same well collected on the same day.

Successive samples analyzed for nutrients were collected from wells 15-345, 15-357, 15-564, 15-620, 15-657, 15-668, 15-674, 15-676, 15-680, 15-713, 15-715, and 15-728 (table 2 and pl. 1A). Concentrations of ammonia plus organic nitrogen and phosphate as orthophosphate in successive samples were outside precision limits for comparison suggested by Feltz and others (1984) in 3 of the 12 successive sample sets that were analyzed. All other successive analyses were within suggested precision limits, were less than detection limits, or could not be compared to suggested precision limits because the concentrations were outside applicable concentration ranges.

Successive water samples that were analyzed for inorganic constituents were collected from wells 15-212, 15-296, 15-615, 15-668, 15-680, 15-712, and 15-728 (table 2 and pl. 1A). Concentrations of each of the constituents aluminum, cadmium, copper, iron, sulfate, and dissolved solids were outside suggested precision limits (Feltz and others, 1984) in one of the seven successive sample sets analyzed. For the other analyses, one of the following situations applied: results were within suggested precision limits, results were less than detection limits, results were outside applicable concentration ranges, or no precision limits were available.

Three successive samples were collected from each of the 62 wells sampled during this study for analysis for purgeable organic compounds. One of the samples from each set of three successive samples was analyzed for purgeable organic compounds at the NJDL within 72 hours of collection. The second sample from each set of successive samples was sent to the NWQL and analyzed within 3 weeks of collection for purgeable organic compounds to verify the NJDL analytical results. Successive samples from only 53 of the 62 sampled wells were chosen for analysis at the NWQL; 29 were wells in which purgeable organic compounds were detected by the NJDL and 24 were wells in which no purgeable organic compounds were detected. Results of analyses of successive samples done at the NWQL confirmed the results of those done at the NJDL both in the purgeable organic compound detected and in the order of magnitude of the concentration. In cases in which the results of analyses done by the two laboratories differed by an order of magnitude or more (without dilution of one of the samples), or in which detection limits were comparable but the analytical results from the two laboratories differed with regard to the presence or absence of a particular compound, a data check was performed and, if necessary, the analysis was rerun by both laboratories. Successive collection of samples and differences in holding times did not appear to affect variations in purgeable-organic-compound concentrations. The third sample from each set of three successive samples was refrigerated and held in reserve to be analyzed in the event that a sample was damaged or lost.

Statistical and Graphical Methods

The quality of potable water in the Potomac-Raritan-Magothy aquifer system in the Greenwich Township region is summarized in this report by means of descriptive statistics. Nontransformed and log-transformed concentration data were examined for normal distribution by using histograms to determine whether parametric statistics could be applied. Because most of the data are not normally or log-normally distributed, the 25th, 50th (median), and 75th percentiles are listed as measures of the central tendency and variability of the data. The concentration at a given percentile is the value at or below which the given percentage of the cases lie. The median, interquartile-range (25th and 75th percentiles), skewness, and extreme values for selected constituents in water in the Potomac-Raritan-Magothy aquifer system, as a whole and by aquifer, are illustrated graphically by means of boxplots. Boxplots display the major statistical features of a group of data and facilitate comparison of several groups (Helsel, 1987, p. 182; Ryan and others, 1985, p. 126-127). For these statistical analyses, the data set was limited to the period 1980-88.

The difference in water quality among the aquifers of the Potomac-Raritan-Magothy aquifer system was evaluated by use of the Kruskal-Wallis test--a nonparametric method for comparing the mean rank of the total sample to those of two or more independent groups on the basis of one factor (Conover, 1980). This method was used to test the null hypothesis that water-quality characteristics and chemical concentrations are similar in each aquifer. The alternative hypothesis is that the quality of water in at least one aquifer is different from that in the other aquifers. The significance level of the test is determined by using the H-value adjusted for ties in rank from the Kruskal-Wallis test, and a Chi-square distribution table. Differences among the mean ranks for all observations and the mean rank for each group were considered significant at or above the 0.05 significance level.

If the Kruskal-Wallis test indicated a significant difference in the data among aquifers, a multiple-comparisons test (Ryan and others, 1985, p. 98b) was used to determine whether the mean rank of a group was higher or lower than the mean rank for all observations. Groups with a mean rank greater than or less than two standard deviations from the mean rank of the pooled sample were considered significantly different. Results of the multiple-comparisons test are reported by indicating which aquifer was associated with a significantly higher or lower constituent concentration than that of the pooled sample.

The results of these statistical tests should be used with caution, as they may be biased by the uneven distribution of wells within the network. For example, few wells are screened in the deep confined part of the aquifer system in the south-southeastern part of the region, especially in the middle aquifer. Hence, some differences in water quality among aquifers may reflect a lack of data from this area.

Trilinear and Stiff diagrams were prepared to illustrate variations in major-ion concentrations among individual water samples (Hem, 1985, p. 173-180). Both illustrative techniques express ion concentrations in units of milliequivalents per liter, the molar-charge equivalent concentration of a chemical constituent relative to the hydrogen ion, which has unit mass and charge (Hem, 1985, p. 56). The major-ionic character of each water sample is characterized by plotting the relative proportions of the major dissolved ionic constituents, in percent milliequivalents per liter, on a trilinear diagram (presented in the section on potable-ground-water quality) (Piper, 1944; Back, 1966, p. A14, fig. 4; Freeze and Cherry, 1979, p. 149; Hem, 1985, p. 56, 173-180). The triangles at the lower left and lower right of the diagram graphically express the water composition in percent of cations and anions; each vertex represents 100 percent of a particular ion or group of ions. The relative composition of each water sample with respect to those ions is indicated by a point plotted within each triangle that indicates the percentage of the total cation or anion charge that results from the particular ions. The coordinates at each point total 100 percent.

The major ionic constituents of the water are illustrated in a slightly different way in the central, diamond-shaped part of the diagram. Points plotted on the diamond are located by intersection of lines extended from the two sample points plotted on the triangles to the central diamond, giving a point that represents the major-ion composition of each water sample on a percentage basis with respect to the total of all ions shown.

Regional trends in major-ion chemistry of water in the aquifers of the Potomac-Raritan-Magothy aquifer system are illustrated in a series of Stiff diagrams representing the chemistry of water samples along approximate flow paths (presented in the section on variations in major-ion chemistry). For a single water sample, the concentrations of major ions (in milliequivalents per liter) are plotted on line graphs that are stacked to form a distinctive graphical shape. Comparison of the graphical shapes provides a quick visual means for comparing the ionic composition of the water samples.

GROUND-WATER QUALITY

The quality of ground water is affected by the chemical composition of precipitation; the nature of the land cover, including slope, soil type, vegetation, and land use; the mineralogy of the aquifers; and ground-water flow patterns and residence times in the aquifer. In the Greenwich Township region, the quality of water in the Potomac-Raritan-Magothy aquifer system also is affected by induced ground-water recharge from the Delaware River estuary, anthropogenic contamination in the outcrop of the aquifer system, mixing with slightly to moderately saline water from downdip in the aquifer system in southern Gloucester County (Barksdale and others, 1958, fig. 16), and vertical leakage of variable-quality water from overlying aquifers.

Many field and laboratory measurements can be used to describe the quality of ground water. Those discussed in this report include pH (the negative logarithm to base 10 of the hydrogen-ion activity), alkalinity, specific conductance, and the concentrations of dissolved or total constituents such as major ions, trace elements, nutrients, and organic compounds. Properties of the minerals and water in the aquifer and biological factors affect the mobility of these constituents and their partitioning between water and aquifer materials. Properties of the aqueous system include temperature, pressure, pH, oxidation-reduction (redox) potential, and the concentrations of solutes and dissolved gases, such as oxygen and carbon dioxide.

Potable Water

The quality of potable water in the Potomac-Raritan-Magothy aquifer system in the Greenwich Township region is described statistically in table 5 and graphically by means of boxplots in figure 3. In this report, potable water is defined as water that conforms to primary drinking-water regulations (U.S. Environmental Protection Agency, 1988a; New Jersey Register, 1989). These regulations establish maximum contaminant levels (MCL's), enforceable health-based standards for contaminants in drinking water that, if present, may cause adverse human health effects (U.S. Environmental Protection Agency, 1988a). The number of wells from which water samples contained concentrations of constituents at or greater than MCL's, and the maximum concentrations measured, are listed in table 6.

For this study, ground-water samples that met primary but not secondary drinking-water regulations (U.S. Environmental Protection Agency, 1988a and 1988b; New Jersey Register, 1989) were classified as potable because no other supplies are available and, in some cases, the water can be treated so that it meets regulations. Secondary drinking-water regulations establish secondary maximum contaminant levels (SMCL's), which are standards for contaminants in drinking water that may adversely affect the taste, odor, or appearance of the water, or that may otherwise affect the public welfare (U.S. Environmental Protection Agency, 1988b; New Jersey Register, 1989). SCML's are not Federally enforceable but are intended as guidelines for the States (U.S. Environmental Protection Agency, 1988b). Table 6 lists the number of wells sampled and the number containing water that did not meet secondary drinking-water regulations during 1949-88; the maximum constituent concentrations measured also are listed in table 6. (The data set in table 6 was expanded to include data from a period of record longer than that used in the other statistical and graphical analyses in this report (1980-88) in order to obtain a correspondingly longer historical record of chloride and nitrate concentrations that exceeded primary drinking-water regulations.)

The differences in water quality among the aquifers of the Potomac-Raritan-Magothy aquifer system are summarized in table 5 by reporting the significance level of the results of the Kruskal-Wallis test. If the significance exceeds the 0.05 level, the aquifer that is associated with a significantly higher or lower constituent concentration than that of the total sample, as determined by means of a multiple-comparisons test, is noted.

The major-ionic character of potable water in the Greenwich Township region was characterized by plotting the percent concentration of major ions in each potable-water sample on a trilinear diagram (fig. 4). Only the most recent sample analysis for each well was evaluated for potability and was represented on the diagram. As shown by the scatter of points on each triangle of the diagram (cations or anions), potable water in this region is highly variable in terms of the major dissolved ionic constituents. This variability in water quality is similar to that determined for the aquifer

Table 5. **Summary of potable-water quality in the Potomac-Raritan-Magothy aquifer system, as a whole and by aquifer, in the region of Greenwich Township, Gloucester County, New Jersey, 1980-88**

[Concentrations are of dissolved constituents in mg/L (milligrams per liter) unless otherwise specified; µg/L, micrograms per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; *, sample number is small; --, no data; <, less than; >, greater than]

	Upper aquifer				Middle aquifer				Lower aquifer	
		Concentration				Concentration				Concentration
	Number of wells	25th percentile	Median	75th percentile	Number of wells	25th percentile	Median	75th percentile	Number of wells	25th percentile
Field and laboratory measurements										
alkalinity (as bicarbonate)	49	29	144	196	40	3	12	72	34	98
dissolved oxygen	27	<.10	.30	.40	29	<.10	.30	2.5	26	<.10
dissolved solids	52	160	223	269	42	106	152	223	34	204
hardness (as calcium carbonate)	52	29	44	71	42	32	49	84	35	28
pH (units)	46	5.95	7.30	8.00	33	4.98	5.56	6.50	33	6.69
specific conductance (µS/cm)	46	271	369	431	33	171	259	353	32	351
Nutrients										
nitrogen, ammonia (as N)	33	.6	.20	.32	30	.010	.06	.22	24	.20
nitrogen, ammonia + organic (as N)	33	.3	.5	.6	22	.20	.40	1.0	24	.30
nitrogen, nitrite (as N)	33	<.010	<.010	<.010	31	<.010	<.010	<.010	26	<.010
nitrogen, nitrate + nitrite (as N)	42	<.10	<.10	<.10	33	<.10	<.17	4.6	29	<.10
phosphorus, orthophosphate (as P)	42	<.010	.05	.17	32	<.010	<.010	.03	28	<.010
Major constituents										
calcium	52	7.4	12	20	42	6.9	11	16	34	7.9
chloride	54	14	24	43	45	16	25	46	35	28
magnesium	52	2.3	3.4	6.4	42	2.8	5.7	8.1	34	1.9
potassium	52	4.0	5.5	6.3	42	2.3	3.5	4.2	34	3.5
silica	52	7.7	9.2	10	44	7.5	8.8	14	34	8.6
sodium	37	11	49	83	29	7.8	24	54	27	36
sulfate	52	5.4	11	39	44	12	29	56	35	9
Trace elements (µg/L)										
aluminum	26	<10	<10	20	24	<10	15	80	26	<10
arsenic	32	<1	<1	<1	29	<1	<1	2	25	<1
barium	32	60	71	89	27	55	79	100	25	29
beryllium	32	<.5	<.5	<.5	27	<.5	<.5	.6	25	<.5
cadmium	41	<1	<1	<1	31	<1	<1	<1	26	<1
chromium	32	<10	<10	<10	29	<10	<10	<10	26	<10
cobalt	32	<3	<3	<3	27	<3	<3	9	26	<3
copper	32	<10	<10	<10	28	<10	<10	<10	26	<10
fluoride	16	<.1	.3	1.0	16	<.1	<.1	.3	13	.3
iron	42	25	195	1,525	34	51	1,435	10,000	30	210
lead	41	<10	<10	<10	31	<10	<10	<10	26	<10
lithium	32	<5	8	16	27	7	14	21	25	<5
manganese	42	6	18	123	34	53	99	308	30	16
mercury	3*	--	--	--	3*	--	--	--	1*	--
molybdenum	32	<10	<10	<10	27	<10	<10	<10	25	<10
strontium	32	245	385	463	29	98	160	395	27	370
vanadium	32	<6	<6	<6	27	<6	<6	<6	25	<6
zinc	42	4	11	42	33	16	41	79	26	4
Organic constituents										
organic carbon	34	.9	1.2	1.8	27	.8	1.0	1.2	27	.8
phenols, total (µg/L)	23	1	3	4	31	2	3	5	22	2

Table 5. Summary of potable-water quality in the Potomac-Raritan-Magothy aquifer system, as a whole and by aquifer, in the region of Greenwich Township, Gloucester County, NJ, 1980-88--Continued

Lower aquifer (cont) Concentration: Median	Lower aquifer (cont) Concentration: 75th percentile	Significance level[1]	Which aquifer is different[2]	Potomac-Raritan-Magothy aquifer system: Number of wells[3]	Concentration: 25th percentile	Concentration: Median	Concentration: 75th percentile	
								Field and laboratory measurements
131	171	>0.999	-M, +L	125	12	98	209	alkalinity (as bicarbonate)
.15	.30	.95	+M	83	<.10	.20	.40	dissolved oxygen
262	423	.990	-M, +L	131	145	218	279	dissolved solids
46	100	<.75		132	30	46	85	hardness (as calcium carbonate)
7.00	7.50	>.999	+U, -M	114	5.56	6.70	7.71	pH (units)
475	764	>.999	-M, +L	113	255	369	453	specific conductance (μS/cm)
								Nutrients
.28	.71	.975	+L	89	.05	.20	.34	nitrogen, ammonia (as N)
.80	1.2	<.75		88	.3	.5	.9	nitrogen, ammonia & organic (as N)
<.010	<.010	<.75		91	<.010	<.010	<.010	nitrogen, nitrite (as N)
<.10	<.10	.990	+M, -L	106	<.10	<.10	1.4	nitrogen, nitrate & nitrite (as N)
.02	.15	<.75		104	<.010	<.010	.15	phosphorus, orthophosphate (as P)
								Major constituents
13.5	31	.75		131	7.4	12	21	calcium
66	150	.990	-U, +L	138	16	29	73	chloride
3.2	9.6	<.75		131	2.2	4.2	7.7	magnesium
5.2	8.5	.995	-M	131	3.3	4.5	6.3	potassium
9.9	11	<.75		133	8.2	9.2	11	silica
53	97	.995	-M, +L	101	14	39	83	sodium
12	17	.95	+M	134	8	17	43	sulfate
								Trace elements (μg/L)
15	100	<.75		77	<10	<10	40	aluminum
<1	<1	<.75		86	<1	<1	2	arsenic
70	135	<.75		86	50	72	93	barium
<.5	1.0	<.75		86	<.5	<.5	1.0	beryllium
<1	4	<.75		100	<1	<1	2	cadmium
<10	<10	.75		88	<10	<10	<10	chromium
<3	<3	.90		87	<3	<3	<3	cobalt
<10	<10	<.75		88	<10	<10	<10	copper
.5	1.4	.950	-M, +L	52	<.1	.2	1.0	fluoride
1,800	5,075	.75		108	52	425	6,200	iron
<10	17	<.75		100	<10	<10	<10	lead
8	21	<.75		86	<5	9	17	lithium
66	113	.995	-U, +M	108	15	63	150	manganese
--	--	--		13	<.1	<.1	.2	mercury
<10	<10	<.75		86	<10	<10	<10	molybdenum
800	1,800	.90		90	205	380	670	strontium
<6	8	.975	+L	86	<6	<6	<6	vanadium
9	14	.90		103	5	12	42	zinc
								Organic constituents
1.3	1.6			89	.90	1.1	1.5	organic carbon
3	7			76	2	3	5	phenols, total (μg/L)

[1] Significance level is based on the Kruskal-Wallis test statistic adjusted for ties (Ryan and others, 1985).

[2] The aquifer that contains water with median constituent concentrations that are significantly higher than those of the total population at a 0.05 significance level or greater are identified as +U (upper), +M (middle), and +L (lower); the aquifer that contains water with median constituent concentrations that are significantly lower than those of the total population are identified as -U (upper), -M (middle), and -L (lower). A blank indicates no significant differences in water quality among the aquifers.

[3] Includes wells screened in the upper, middle, and lower aquifers, and in the Potomac-Raritan-Magothy aquifer system, undifferentiated.

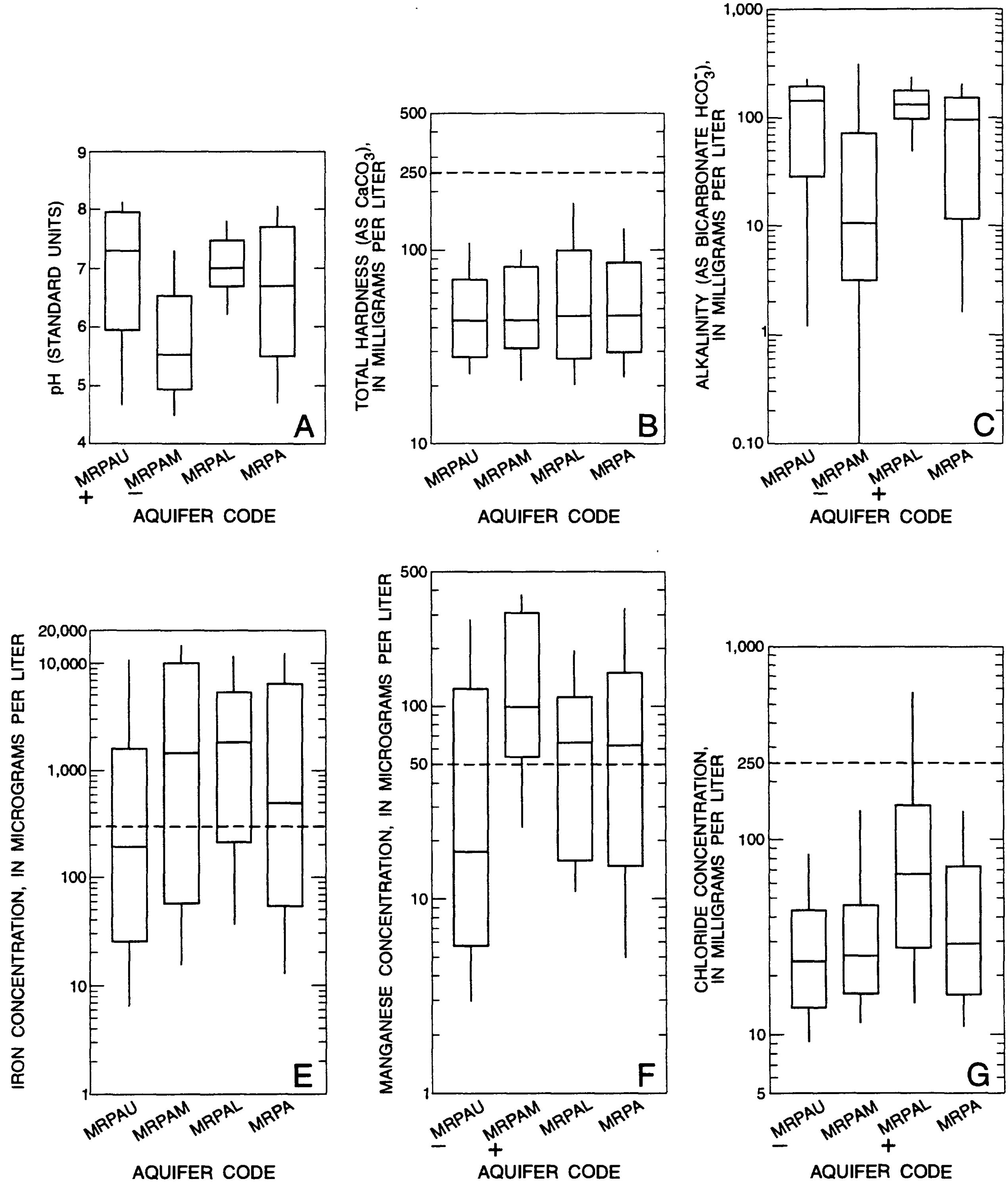
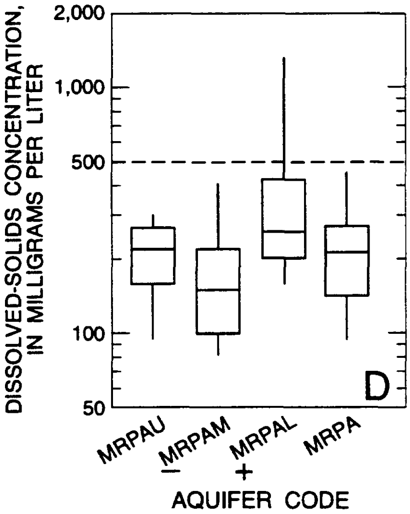
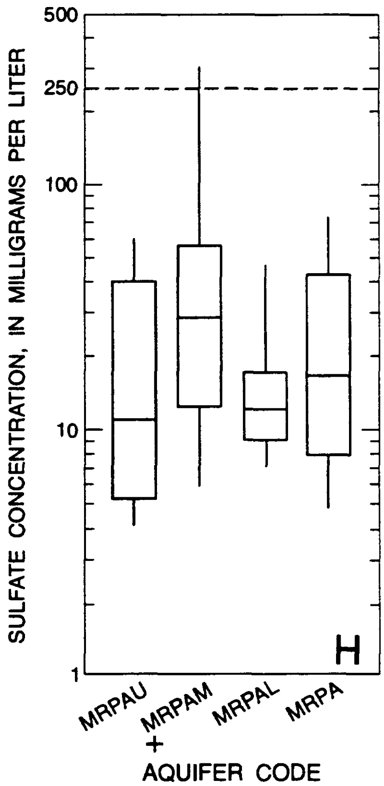


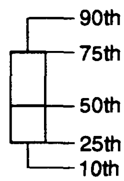
Figure 3. Boxplots of selected water-quality measurements and concentrations of constituents in potable water in the Potomac-Raritan-Magothy aquifer system in the region of Greenwich Township, Gloucester County, New Jersey, 1980-88.





EXPLANATION

Percentile - Percentage of analyses equal to or less than indicated value



---- Secondary maximum contaminant level

U.S. Environmental Protection Agency, 1988c

AQUIFER CODE

MRPA designates the Potomac-Raritan-Magothy aquifer system as a whole, MRPAU, MRPAM, MRPAL designate the upper, middle, and lower aquifers of the MRPA, respectively.

+ the mean rank or median concentration is statistically higher for the indicated aquifer than for the aquifer system as a whole (table 5).

− the mean rank or median concentration is statistically lower for the indicated aquifer than for the aquifer system as a whole (table 5).

Figure 3. Boxplots of selected water-quality measurements and concentrations of constituents in potable water in the Potomac-Raritan-Magothy aquifer system in the region of Greenwich Township, Gloucester County, New Jersey, 1980-88. --Continued

Table 6. Constituents frequently detected or measured at concentrations equal to or greater than drinking-water regulations in water from wells in the Potomac-Raritan-Magothy aquifer system in the region of Greenwich Township, Gloucester County, New Jersey, 1949-88

[mg/L, milligrams per liter; µg/L, micrograms per liter; --, no drinking-water regulation exists]

Constituent	Drinking-water regulation and reference	Number of wells sampled	Number of wells containing water in which constituent was detected (if no drinking-water regulation) or was measured at a concentration equal to or greater than the drinking-water regulation	Maximum concentration detected
		Anions and solids, dissolved (mg/L)		
Chloride	250 (2)	184	14	2,100
Nitrate (as N)	10 (1)	137	11	41
Sulfate	250 (2)	181	20	1,700
Residue on evaporation (dissolved solids)	500 (2)	177	33	6,060
		Trace elements, dissolved (µg/L)		
Arsenic	50 (1)	131	6	200
Cadmium	10 (1)	143	4	17
Chromium	50 (1)	132	4	2,000
Iron	300 (2)	180	118	300,000
Lead	50 (1)	143	7	2,600
Manganese	50 (2)	179	124	18,000
Mercury	2 (1)	48	8	370
		Organic constituents, total (µg/L)		
Benzene	1 (3)	138	35	43,000
Carbon tetrachloride	2 (3)	138	4	380
Chlorobenzene	4 (3)	114	17	7,400
Chloroform	--	138	19	2,700
1,2-Dichlorobenzene	--	73	8	170
1,3-Dichlorobenzene	--	73	3	50
1,4-Dichlorobenzene	--	73	5	54
1,1-Dichloroethane	--	138	16	200
1,2-Dichloroethane	2 (3)	138	19	24,000
1,1-Dichloroethylene	2 (3)	113	8	120
cis- plus trans-1,2-Dichloroethylene	10 (3)	138	20	4,700
1,2-Dichloropropane	--	114	6	28
Ethyl benzene	--	114	21	1,600
Methylene chloride	2 (3)	138	18	3,800
Tetrachloroethylene	1 (3)	138	21	820
Toluene	--	138	30	12,000
Purgeable organic compounds, total	50 (3)	138	30	43,123
Toxaphene	5 (1)	23	1	10
1,1,1-Trichloroethane	26 (3)	138	5	1,600
Trichloroethylene	1 (3)	138	30	5,040
Vinyl chloride	2 (1)	101	13	210
Xylenes, total	44 (3)	29	3	3,100

(1) U.S. Environmental Protection Agency, 1988a.

(2) U.S. Environmental Protection Agency, 1988b.

(3) New Jersey Register, 1989.

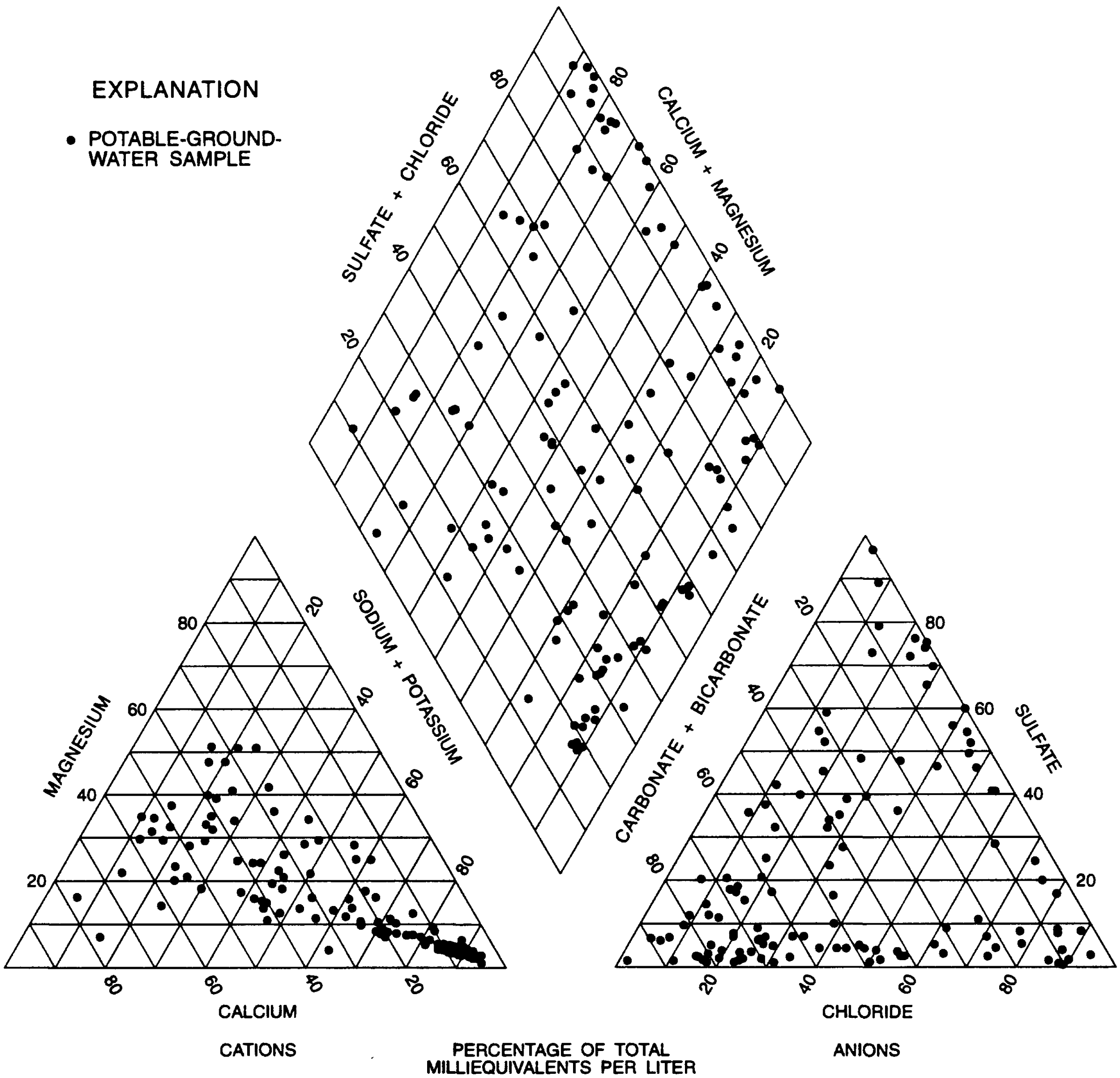


Figure 4. Percentage concentrations of major ions in potable water in the Potomac-Raritan-Magothy aquifer system in the region of Greenwich Township, Gloucester County, New Jersey, 1980-88.

system throughout New Jersey by other investigators (Back, 1966, p. A22, fig. 9; Ervin and others (1994) and, for the most part, reflects the changes in water quality that occur along flow paths in the aquifer system (discussed in detail in section on regional variations in ground-water quality). As shown by the grouping of points on each triangle, potable water in the Greenwich Township region generally is dominated by sodium (potassium constitutes a small percentage of the combined concentration of sodium plus potassium) and bicarbonate. Percentages of calcium in water samples are directly related to percentages of magnesium. The grouping of points on the diamond-shaped part of the diagram in figure 4 also illustrates the sodic and bicarbonate character of the potable water, but highlights the fact that many water samples are dominated by chloride or sulfate rather than bicarbonate.

Water from Sites at which Ground-Water Contamination has been Identified

An inventory of sites in the Greenwich Township region at which ground-water contamination has been identified and is being investigated by the USEPA and the NJDEP was compiled to determine the types of ground-water contaminants present and their areal distribution.

Information about the quality of water and potential contaminant sources was obtained from the New Jersey Ground-Water Pollution Index files (William Althoff, N.J. Department of Environmental Protection, written commun., 1986), the New Jersey Bureau of Environmental Evaluation and Risk Assessment files (Michael Velisio, N.J. Department of Environmental Protection, written commun., 1986), a report on chemical investigations of ground water at five industrial or waste-disposal sites in Logan Township (Kozinski and others, 1990), and written and oral communications with USEPA and NJDEP site investigators (referenced by site in table 1, at end of report).

Ground-water contamination was identified at 34 sites in the Greenwich Township region; these sites are shown on plate 1B. References containing results of assessments of specific sites are listed in table 1.

Of the 34 sites at which ground-water contamination was identified, 29 are industrial facilities and 5 are landfills. The types of contaminants found at each site were divided into four categories: purgeable organic compounds; oil and grease; other hydrocarbons, such as acid- and base/neutral-extractable organic compounds; and trace elements. The most frequently identified group of contaminants was purgeable organic compounds. Ground-water contamination was identified in all three aquifers of the Potomac-Raritan-Magothy aquifer system and in other, overlying aquifers. Ground-water contamination has been identified in the upper aquifer in Greenwich, Logan, and West Deptford Townships, and in Paulsboro and National Park Boroughs; in the middle aquifer in Greenwich and Logan Townships; and in the lower aquifer in Greenwich Township and Paulsboro Borough (pl. 1B).

Regional Variations

pH

The median pH of potable water in the Potomac-Raritan-Magothy aquifer system in the Greenwich Township region was 6.70 (table 5, fig. 3a); pH generally increased downdip from about 5 in the outcrop to greater than 8 in the southeastern part of the region. This trend is similar to that noted by Langmuir (1969a, p. 17, fig. 6) for water in the Potomac-Raritan-Magothy aquifer system in Camden and Burlington Counties. The pH in the unconfined part of the aquifer system is naturally low as a result of the presence of carbonic acid and, to a lesser extent, sulfuric acid in infiltrating waters (Langmuir, 1969a, p. 16-18). Carbonic acid forms through reaction of rainwater with carbon dioxide gas, which is produced when organic material oxidizes in the soil. Sulfuric acid is produced in the atmosphere by the reaction of rainwater with sulfur dioxide (largely from the burning of fossil fuels) and, to a greater extent, in the shallow part of the aquifer system by oxidation of ubiquitous sulfide minerals, such as pyrite and marcasite. Hydrogen ions also can be produced by bacterially mediated oxidation of iron and other reduced metal ions that forms metal-hydroxide compounds and further lowers the pH. These reactions become progressively less important downdip--that is, with distance from the recharge area--because dissolved oxygen is depleted as the water flows through the aquifer system. The pH increases downdip as hydrolysis of aquifer materials depletes hydrogen ions along the course of ground-water flow.

Water samples from the unconfined or shallow confined part of the aquifer system with a pH less than 5 or greater than 6 were collected predominantly from wells at or near industrial or other urban land. For example, samples from the middle aquifer with a pH less than 5 were collected from a well in northern Greenwich Township (15-683), from wells in Logan Township (15-388, 15-575, and 15-677), and from public-supply wells in Greenwich Township (15-69 and 15-348), Paulsboro Borough (15-212 and 15-213), and Bridgeport (15-166). Strong acids, such as sulfuric, nitric, nitrosylsulfuric, hydrofluoric, and hydrofluosilicic acids (table 1), are used, produced, or stored at the industrial sites in or near these areas and, if spilled or leaked, can lower the pH of the ground water below that of ambient water. The pH also can be lowered by the oxidation of reduced inorganic and organic contaminants.

The pH of water samples from the public-supply wells has varied through time, but generally decreased from 1978 to 1986 and increased from 1986 to 1988. Sequential samples from one public-supply well in Paulsboro Borough (15-212) showed an increase in pH from 4.7 in 1980 to 6.5 in 1982, and then a decrease to 4.5 in 1988. This variability in pH may be the result of a change in the chemistry of water pumped from the well or of a measurement or sampling error.

Ground-water samples from the shallow part of the middle aquifer with a pH greater than 6 were collected in northern Greenwich Township at wells 15-81, 15-652, 15-668, 15-681, and 15-682, and at the municipal landfill. (Water-quality data for observation-well-water samples from the landfill are unpublished and were obtained from John Redmond (Greenwich Township, written commun., 1988).) Basic compounds that can increase the pH of water include petroleum products (Robbins and Bristol, 1988) and lime used to neutralize waste acid and process water at industrial facilities.

Dissolved Solids and Specific Conductance

The median concentration of dissolved solids in samples of potable water from the Potomac-Raritan-Magothy aquifer system in the Greenwich Township region was 218 mg/L (fig. 3d); the median specific conductance was 369 μS/cm. In water from all aquifers, the concentration of dissolved solids was positively correlated with specific conductance. In water from the upper aquifer, the concentration of dissolved solids increased from less than 100 mg/L in the outcrop to greater than 300 mg/L in the southeastern part of the region. This progressive downgradient mineralization of water in the upper aquifer is caused by dissolution, redox, and ion-exchange reactions with aquifer materials. A similar trend in the concentration of dissolved solids may be present in the middle aquifer; however, few water-quality data are available for the deep confined parts of that aquifer.

The concentration of dissolved solids was significantly higher in samples from the lower aquifer than in samples from the aquifer system as a whole (table 5 and fig. 3d). In the lower aquifer, the concentration of dissolved solids increased from about 200 mg/L in the northeastern part of the region to more than 1,400 mg/L in the southwestern part. Ground-water samples from 33 of 185 wells (18 percent) contained dissolved solids in concentrations greater than the USEPA SMCL of 500 mg/L (table 6). The majority of these wells are screened in the lower aquifer (fig. 3d), indicating that this aquifer probably contains highly mineralized, and possibly stagnant, water.

Most of the ground-water samples from the industrial area of Paulsboro Borough and Greenwich and northwestern West Deptford Townships contained dissolved solids in concentrations greater than 500 mg/L (pl. 2a) and had specific conductances near or greater than 1,000 μS/cm. Additional water samples with concentrations of dissolved solids and specific conductances greater than background levels were found in the upper aquifer in Logan Township at wells 15-546, 15-582 through 15-584, 15-588 through 15-591, and 15-593 through 15-595; in the middle aquifer in Logan Township at wells 15-544, 15-549, and 15-554 through 15-556; and in the middle aquifer in West Deptford Township at well 15-279 (pl. 1A and table 2). Potential anthropogenic sources of elevated dissolved-solids concentrations and specific conductance are the chemicals used in nearby industrial activities and the increased dissolution of aquifer materials that would be caused by the input of these chemicals to the ground-water system. In Paulsboro Borough, northern Greenwich Township, and northern West Deptford Township (pl. 2A), recharge of slightly to moderately saline water from the Delaware River estuary during drought (Barton and Kozinski, 1991) also is a potential source of elevated dissolved-solids concentrations and specific conductance.

Specific conductance of water samples from the public-supply wells in Greenwich Township and Paulsboro Borough increased from 1980 through 1986 at an average rate of 8.5 μS/cm per year. Concentrations of dissolved solids probably increased concomitantly. These increases may be attributable to the migration of ground water with a high specific conductance from nearby industrial sites to the public-supply wells. Increasing dissolution of aquifer materials at each well site as a result of the chemistry of the ground water as it flows downgradient also can contribute to the increase in specific conductance through time.

Dissolved Oxygen

Concentrations of dissolved oxygen generally were less than 1.0 mg/L; the median concentration was 0.20 mg/L. Concentrations greater than 1.0 mg/L (maximum 10 mg/L) were found in water samples from wells screened in the unconfined or shallow confined parts of the upper and middle aquifers. The dissolved oxygen in the shallow subsurface is supplied predominantly through recharge and is present in concentrations similar to those in surface water in contact with the atmosphere (Hem, 1985, p. 155-156). As the water flows downward through the aquifer system, the concentration of dissolved oxygen decreases as oxygen reacts with oxidizable materials such as dead vegetation; fossilized organic material, such as lignite; and reduced minerals, such as pyrite.

Concentrations of dissolved oxygen greater than 1.0 mg/L also were found in samples from public-supply wells screened in the confined parts of the aquifer system (wells 15-165, 15-347, and 15-348). These elevated concentrations may be attributable, in part, to aeration of water by pumping equipment used by public suppliers and induced recharge of surface water as a result of continuous pumping.

Concentrations of dissolved oxygen in most samples from wells screened in the unconfined part of the aquifer system and at or near industrial sites were less than 1.0 mg/L, as in the upper aquifer in Logan Township at wells 15-546, 15-579, 15-585, 15-590, and 15-593 through 15-595, and in the upper Cenozoic deposits and the middle aquifer in Paulsboro Borough and in Greenwich Township at wells 15-81, 15-210, 15-212, 15-213, 15-652, 15-668, 15-673, 15-674, 15-679, and 15-681 (pl. 1A). The low concentrations of dissolved oxygen in samples from wells at these sites can be attributed to the consumption of oxygen as a result of decomposition of organic contaminants in the ground water (table 2).

Major Ions

Variations in major-ion chemistry throughout the Greenwich Township region by aquifer are illustrated in a series of Stiff diagrams (figs. 5, 6, and 7). Each diagram illustrates the relative amounts of each major ion in a well-water sample that was collected along a generalized flow path within an aquifer in the aquifer system. The regional variations measured are similar to those previously determined by Ervin and others (1994, pls. 2 and 3) in their study of the Potomac-Raritan-Magothy aquifer system in southeastern New Jersey.

As shown in figure 5, the quality of water samples from the shallow part of the upper aquifer (wells 15-626, 15-617, and 15-519) varied (pl. 1A). Water samples contained relatively high percentages of the cations calcium, magnesium (wells 15-626 and 15-519), or iron (well 15-617), and high percentages of the anions nitrate (well 15-626), sulfate (wells 15-617 and 15-626), or bicarbonate (wells 15-519 and 15-617). Sodium and

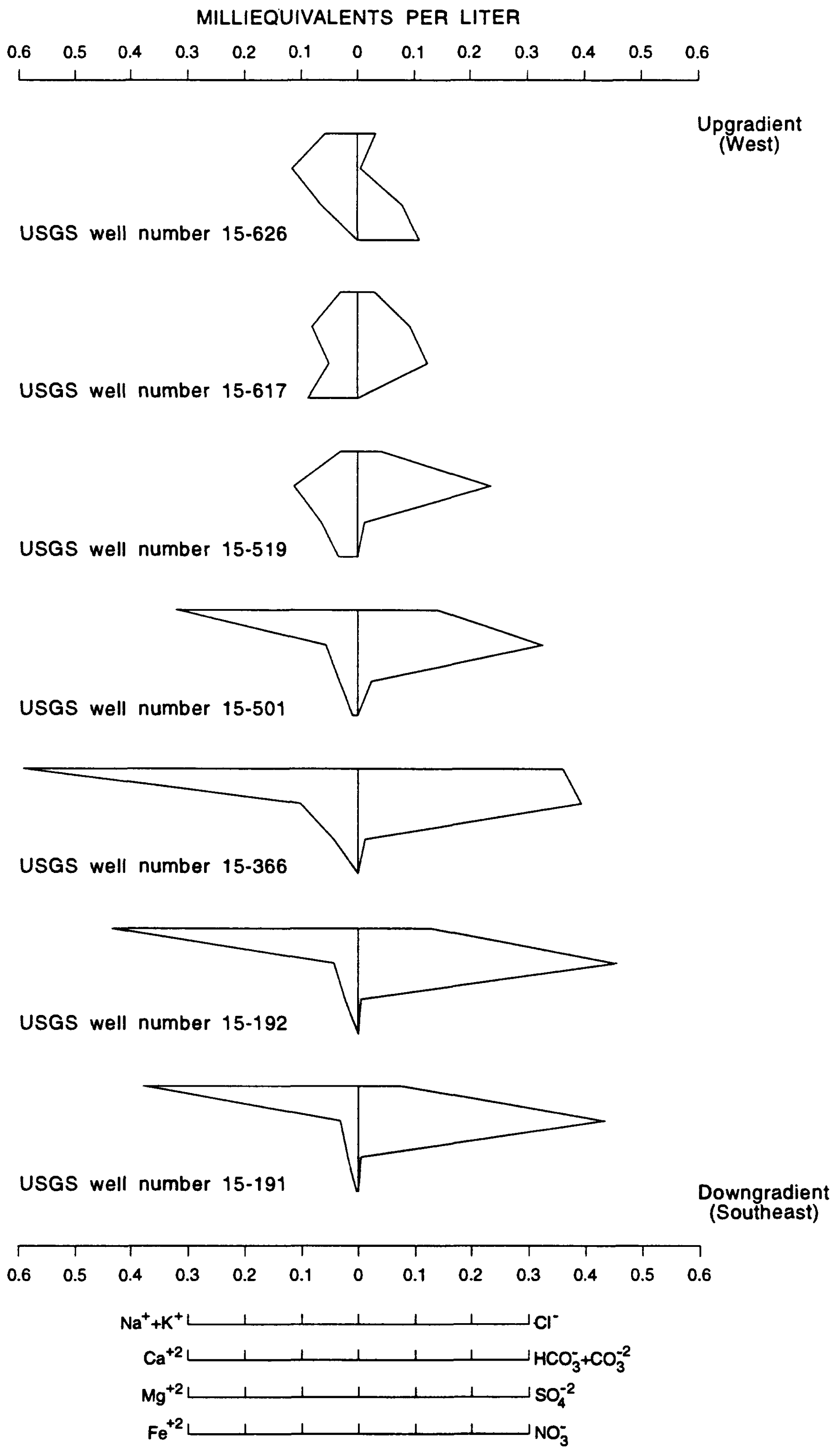


Figure 5. Regional variations in ionic composition of water in the upper aquifer of the Potomac-Raritan-Magothy aquifer system in the region of Greenwich Township, Gloucester County, New Jersey, 1980-88.

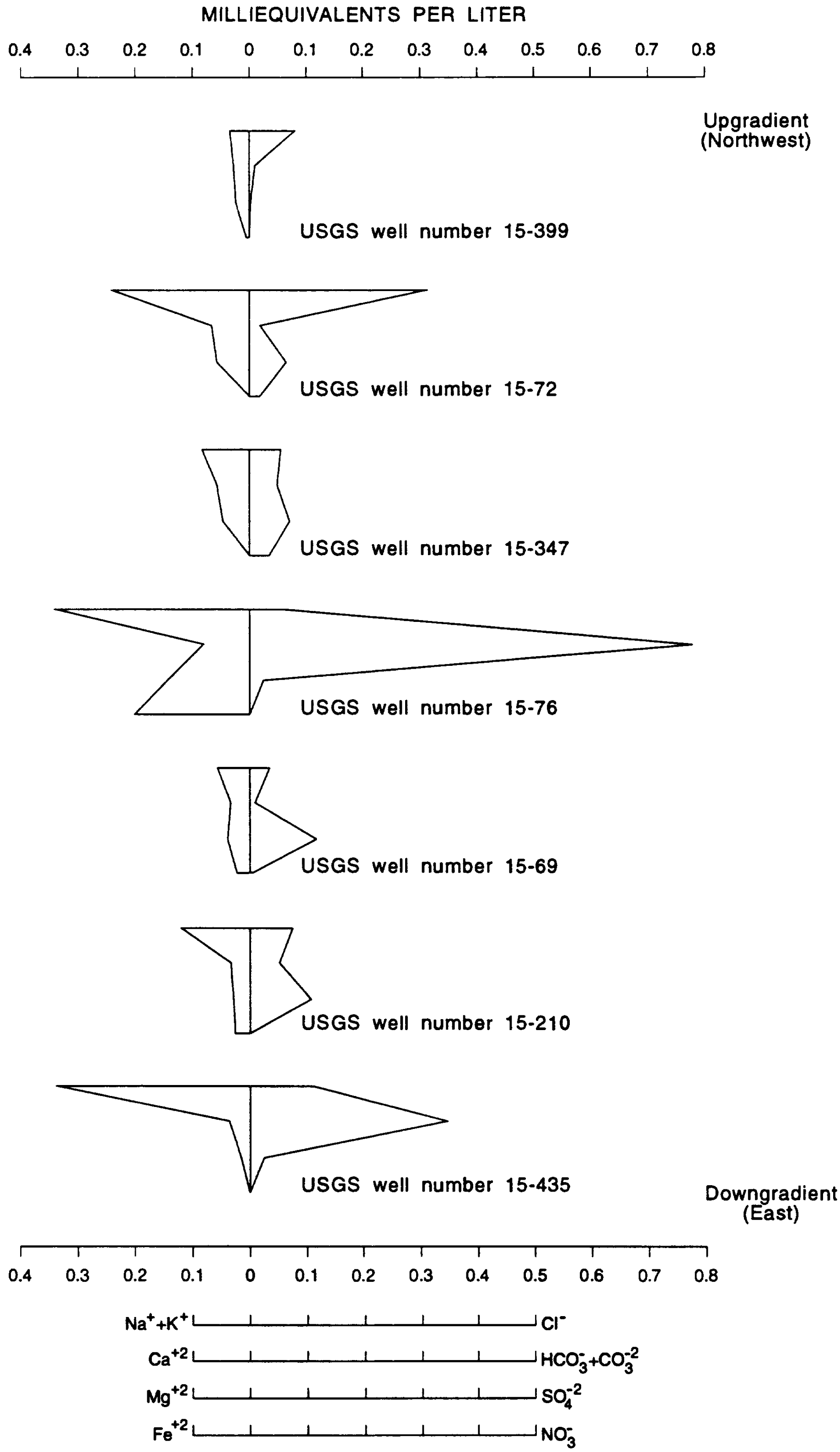


Figure 6. Regional variations in ionic composition of water in the middle aquifer of the Potomac-Raritan-Magothy aquifer system in the region of Greenwich Township, Gloucester County, New Jersey, 1980-88.

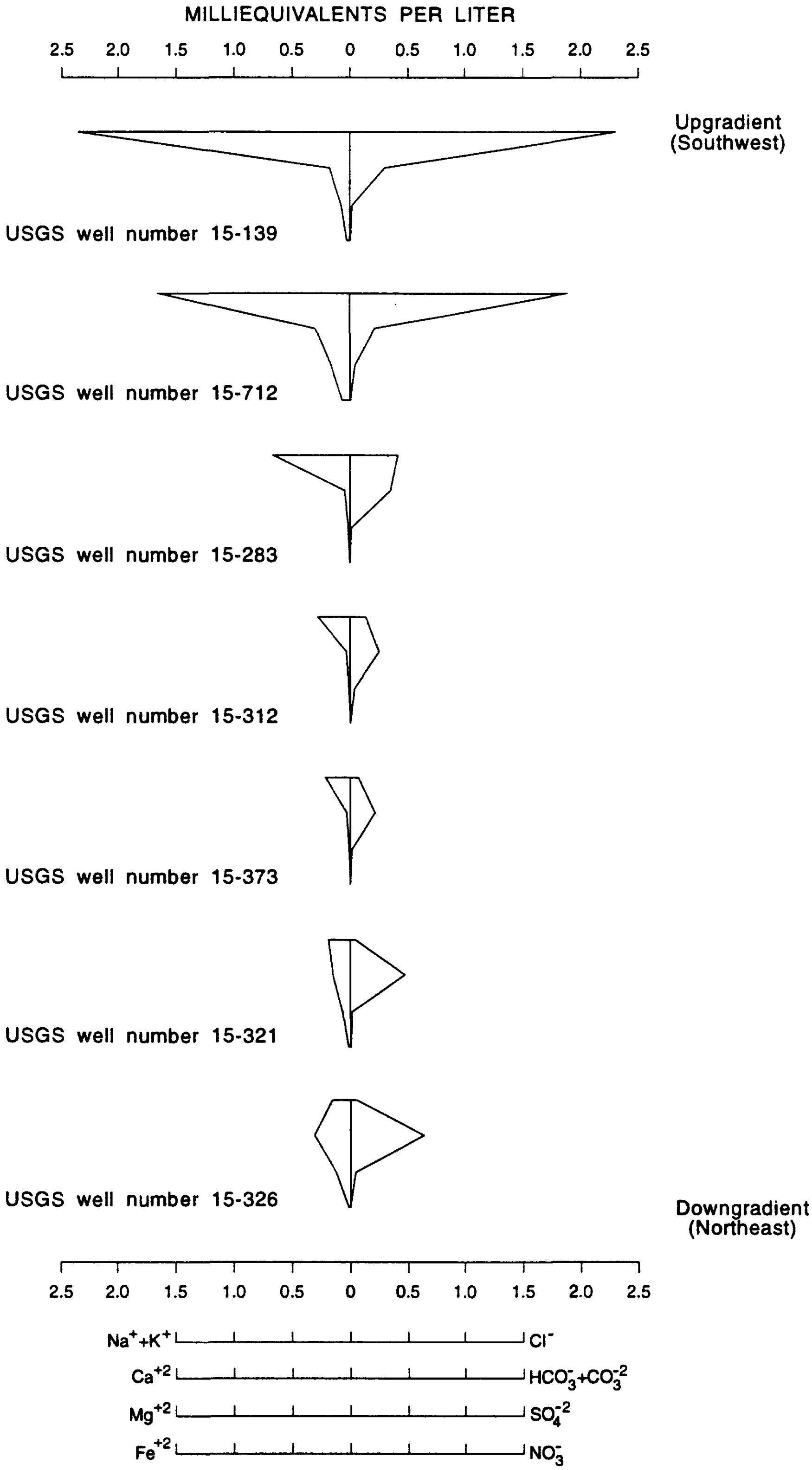


Figure 7. Regional variations in ionic composition of water in the lower aquifer of the Potomac-Raritan-Magothy aquifer system in the region of Greenwich Township, Gloucester County, New Jersey, 1980-88.

bicarbonate were the predominant ions in most water samples from deep parts of the aquifer (wells 15-191, 15-192, 15-366, and 15-501) (pl. 1A). In the southern part of the region, near the border between East Greenwich and Harrison Townships, water samples from the upper aquifer (wells 15-366 and 15-501) contained a higher percentage of chloride ions than did water samples from the rest of the aquifer.

As shown in figure 6, water quality in the shallow part of the middle aquifer (wells 15-69, 15-72, 15-76, 15-210, 15-347, and 15-399) also varied (pl. 1A). The predominant cation in all samples was sodium, but some water samples contained high percentages of calcium (wells 15-72, 15-76, and 15-347), iron (well 15-76), and magnesium (wells 15-72, 15-76, and 15-347). The predominant anion in three samples was sulfate (wells 15-69, 15-210, and 15-347); however, relatively higher percentages of chloride (wells 15-72 and 15-399) or bicarbonate (well 15-76) were found in some samples. Sodium and bicarbonate were the predominant ions in water samples from the deep part of the middle aquifer (well 15-435) (pl. 1A). No water-quality data are available for the middle aquifer in the south-central part of the region.

The variations in water quality in the shallow part of the aquifer system reflect the effects of numerous surface sources and near-surface processes. Higher percentages of calcium and sulfate than other ions in many samples from the shallow parts of the upper and middle aquifers reflect, in part, the quality of recharge to the aquifer system: precipitation that falls directly on the outcrop, water infiltrating from overlying wetlands, and water infiltrating from the Delaware River estuary. Because much of the outcrop area consists of either industrial or other urban land, however, anthropogenic contamination also affects the quality of water in these areas.

The predominance of sodium and bicarbonate in water samples from deep parts of the aquifer system is indicative of downflow mineralization of water as a result of progressive chemical reactions and ion exchange. The presence of additional sodium and chloride in the south-central part of the region may result from mixing with saline water, which is present in deep parts of the aquifer system beyond the boundaries of the study area.

Sodium and chloride were the predominant ions in three water samples from the lower aquifer in the western part of the region (fig. 7 and pl. 1A) (wells 15-139, 15-283, and 15-712), reflecting the presence of slightly saline water in these areas. To the northeast, near northern West Deptford Township (wells 15-312, 15-321, and 15-373) and Westville (well 15-326) (fig. 7 and pl. 1A), downgradient water in the lower aquifer probably mixes with and is diluted by freshwater recharge; hence, as the concentrations of sodium and chloride decrease, bicarbonate and calcium become predominant.

Variations in major-ion chemistry of ground water within and among the aquifers of the Potomac-Raritan-Magothy aquifer system in the Greenwich Township region are discussed in detail in the following sections by constituent or group of constituents.

Bicarbonate, calcium, and magnesium

Because the median pH of water samples from the aquifer system was 6.7, and the interquartile range was 5.56 to 7.71, bicarbonate probably is the predominant dissolved inorganic carbon species in the aquifer system (Hem, 1985, p. 107, fig. 19); however, carbonic acid probably is the predominant dissolved inorganic carbon species in water from the shallow part of the aquifer system, where the pH generally was less than 6.0 (Hem, 1985, p. 107, fig. 19). A computer program, WATEQF (Plummer and others, 1978), was used to compute bicarbonate concentrations from field measurements of alkalinity, pH, and temperature, after correction for speciation of the ions in solution. The median concentration of bicarbonate in 125 samples of potable ground water was 98 mg/L (table 5 and fig. 3c). The median alkalinity, expressed as an equivalent concentration of calcium carbonate, was 46 mg/L (table 5, fig. 3b)--that is, potable water from the aquifer system would be considered "soft" in accordance with the classification of Durfor and Becker (1964, p. 27).

In the upper Cenozoic deposits and the underlying unconfined or shallow confined parts of the upper and middle aquifers, concentrations of alkalinity (as bicarbonate) increased downgradient from less than the detection limit of 1.0 mg/L in the northwestern part of the region to greater than 200 mg/L in the east-southeastern part. Concentrations of alkalinity (as bicarbonate) greater than 50 mg/L also were measured in water samples from wells screened in the shallow parts of these aquifers in the industrial area in Paulsboro Borough and Greenwich and northwestern West Deptford Townships. Alkalinity concentrations (as bicarbonate) in the lower aquifer were significantly higher than those in the aquifer system as a whole (table 6, fig. 3c), and increased from slightly less than 100 mg/L in the northeastern part of the region to greater than 200 mg/L in the western part.

The median concentrations of calcium and magnesium in 131 samples of potable water from the Potomac-Raritan-Magothy aquifer system in the Greenwich Township region were 12 and 4.2 mg/L, respectively (table 5). Concentrations of these constituents were greater than the medians in the shallow parts of the upper and middle aquifers and were less than the medians in the deep confined parts of these aquifers. Calcium and magnesium concentrations in the lower aquifer increased from the northeastern part of the region to the southwestern part; concentrations of calcium exceeded 25 mg/L and those of magnesium exceeded 10 mg/L. Concentrations of calcium and magnesium also exceeded 25 and 10 mg/L, respectively, in water samples from most wells in the industrial area in Paulsboro Borough and Greenwich and northwestern West Deptford Townships, regardless of the aquifer in which the well was screened. Additional water samples containing calcium or magnesium in relatively high concentrations were collected from wells screened in the upper aquifer in Logan Township (wells 15-388, 15-546, 15-564, 15-576 through 15-578, 15-581, 15-587, and 15-589) and in West Deptford Township (well 15-297); in the middle aquifer in Logan Township at wells 15-166, 15-388, 15-395, and 15-417 (table 2; Fusillo and others, 1984, table 3), and at wells at industrial sites in Logan Township (table 2; Kozinski and others, 1990, app. 1-4) near Repaupo Station; and in the lower aquifer in West Deptford Township (wells 15-318, 15-320 through 15-322, and 15-410) (pl. 1A; Fusillo and others, 1984, table 3).

Variations in alkalinity and in the concentrations of calcium and magnesium are consistent with regional trends previously mapped by Ervin and others (1994, pls. 2B and 2C). The predominance of the bicarbonate ion in water downgradient from the recharge area probably results from abiotic decarboxylation and bacterially mediated oxidation of lignite (Chapelle and Knobel, 1985, p. 598-599; Chapelle and others, 1987), which is ubiquitous in the Potomac-Raritan-Magothy aquifer system in this region. This oxidation combined with sulfate reduction, described by the simplified reaction,

$$(2CH_2O + SO_4^{2-} \dashrightarrow 2HCO_3^- + H_2S),$$

contributes to bicarbonate production. Although uncommon in the Potomac-Raritan-Magothy aquifer system, dissolution of carbonate minerals can contribute to bicarbonate enrichment (Back, 1966, p. A15). Dissolution of calcium- and magnesium-bearing aquifer materials, such as plagioclases and amphiboles, increases the concentrations of calcium and magnesium dissolved in the ground water. The concentrations of these constituents decrease as sodium is released by ion-exchange reactions with montmorillonite (Knobel and Phillips, 1988, p. 54), a sodium-rich clay mineral that has a large cation-exchange capacity. Hence, the water downgradient from the recharge area is enriched in bicarbonate and sodium relative to the younger, more recently recharged water.

The high concentrations of bicarbonate and sodium in water from the confined parts of the aquifer system in the southeastern part of the region relative to those in water from other parts of the aquifer system also may reflect the quality of water infiltrating the aquifer system from overlying marine deposits such as the Englishtown aquifer system (fig. 2) (Chapelle, 1983; Chapelle and Knobel, 1983; Back, 1966, p. A15). Dissolution of the calcareous materials in the overlying units increases the concentrations of calcium, magnesium, and bicarbonate dissolved in the water in the aquifer system. The concentrations of calcium and magnesium subsequently decrease as a result of ion-exchange reactions with the sodium-rich mineral glauconite (Chapelle and Knobel, 1983) as the water moves through the Merchantville-Woodbury confining unit to the Potomac-Raritan-Magothy aquifer system.

Elevated concentrations of calcium and magnesium at some industrial and municipal sites may be attributable to disposal, use, and storage of compounds bearing these constituents; for example, gypsum (calcium sulfate) is stored in the industrial area in Paulsboro Borough. At most sites, however, the source of high concentrations (relative to background concentrations) is not readily apparent. Instead, elevated concentrations of bicarbonate, calcium, and magnesium may be attributable to reactions involving the oxidation of organic contaminants, production of carbon dioxide, and accelerated dissolution of aquifer materials by acid reactions.

Sodium and chloride

The median concentrations of sodium and chloride in samples of potable water from the Potomac-Raritan-Magothy aquifer system in the Greenwich Township region were 39 and 29 mg/L, respectively (table 4). In the upper aquifer, concentrations of sodium and chloride increased to the south to greater than 100 mg/L (well 150366, table 2), confirming regional trends mapped by Ervin and others (1994, pls. 5A and 6A) and Hardt and Hilton (1969, p. 16, fig. 4). Variations in the concentrations of sodium and chloride in the middle aquifer are similar to those in the upper aquifer; however, data for the southern part of the region are limited.

In the lower aquifer, concentrations of sodium and chloride increased to the southwest at a rate of about 250 mg/L per mile (pl. 2B). Concentrations greater than 250 mg/L--the USEPA SMCL for chloride (U.S. Environmental Protection Agency, 1988b)--were found in the southwestern part of the region in parts of East Greenwich, Greenwich, Harrison, Logan, and Woolwich Townships and in Swedesboro Borough. The 250-mg/L isoconcentration contour for the lower aquifer includes more of the Greenwich Township region than was previously mapped by Ervin and others (1994, pl. 6C) or Gill and Farlekas (1976, sheet 2). Fourteen of 184 wells sampled for chloride (8 percent) contained water with chloride concentrations greater than the 250-mg/L SMCL (table 2 and table 6); all samples containing chloride in concentrations greater than 250 mg/L were collected from wells screened in the lower aquifer (fig. 3g).

The presence of slightly saline water in some wells in the Greenwich Township region probably is the result of mixing with saline water from downdip parts of the aquifer system in southwestern Gloucester County (Ervin and others, 1994, pl. 6C; Gill and Farlekas, 1976, sheet 2). Extensive ground-water withdrawals in and to the east of the region relative to the downdip flow rate largely control the location of the front of saline water in the aquifer system. The front may be closer to the Delaware River within the Greenwich Township region than in other communities adjacent to the river because recharge from the Delaware River to all aquifers in the system is restricted in this area. Recharge may be restricted, particularly in the northwestern part of the region, where the aquifers (especially the lower aquifer) pinch out against bedrock in the river. The overlying upper Cenozoic alluvial deposits are thin (less than 30 feet) and less permeable than those found in other areas adjacent to the Delaware River where the saltwater front has been mapped (Barton and Kozinski, 1991).

Concentrations of sodium and chloride were significantly higher in water samples from the lower aquifer than in samples from the aquifer system as a whole (table 5, fig. 3g). The presence of saline water is more extensive in the lower aquifer than in the other aquifers of the aquifer system, probably because the lower aquifer receives much less recharge than the other aquifers within this region (Barksdale and others, 1958, p. 115). Recharge is limited because the lower aquifer is confined by a continuous unit of clay and silt throughout most of New Jersey (Zapecza, 1989, p. B10) and the Greenwich Township region (Barton and Kozinski, 1991).

Ground water in the lower aquifer is less saline in the northeastern part of the region than in the southwestern part of the region. In areas northeast of the region, the lower aquifer receives recharge from precipitation on the subcrop in Pennsylvania (Navoy and Carleton, 1995). Freshwater recharge may dilute the slightly saline water in the lower aquifer and impede northeastward and updip migration of the saline-water front from the southwestern part of the region into the northeastern part. Because ground-water withdrawals from the lower aquifer are extensive in the northeastern part of the region, updip migration of the front is possible; however, concentrations of chloride in water from wells 15-109 and 15-331, both screened in the lower aquifer, decreased slightly from 1966 through 1985 (from 110 to 90 mg/L and from 45 to 40 mg/L, respectively), indicating that the front of saline water probably is not migrating northeastward.

Recharge of slightly to moderately saline water (concentration of dissolved solids greater than 1,000 mg/L (Freeze and Cherry, 1979, p. 84)) from the Delaware River estuary may be responsible, in part, for elevated concentrations of sodium and chloride (up to 600 and 820 mg/L, respectively, see table 2) in water from the Potomac-Raritan-Magothy aquifer system in the Greenwich Township region. The river incises upper Cenozoic deposits, which may be hydraulically connected to the underlying aquifers. Hydraulic gradients determined during a previous study (Barton and Kozinski, 1991) indicate that the potential for recharge from the river is great in Greenwich Township and Paulsboro Borough, and that this recharge probably can be induced by extensive ground-water withdrawals. Induced recharge will occur, however, only if the upper Cenozoic deposits are permeable. Although the quality of river recharge is variable, slightly to moderately saline water is found in the Delaware River within the Greenwich Township region at Chester, Pennsylvania, on the average of at least once per year (Anderson and others, 1972, p. 381, fig. 7). When streamflow has been extremely low, as it was during the drought of the mid-1960's, measured chloride concentrations in the Delaware River at Chester have been as high as 2,000 mg/L (Hardt and Hilton, 1969, p. 13).

Concentrations of sodium and chloride in samples from wells screened in the upper Cenozoic deposits or the middle aquifer in the industrial area of Paulsboro Borough and Greenwich and northwestern West Deptford Townships generally were greater than 50 mg/L for each constituent (pl. 2C). Additional water samples from the upper and middle aquifers that contained elevated concentrations were from wells 15-387, 15-546, 15-549, 15-554, 15-555, 15-577, 15-579, 15-582 through 15-584, and 15-588 through 15-595 in Logan Township; from wells 15-192 and 15-194 in Mantua Township; and from wells 15-279 and 15-284 in West Deptford Township (pl. 1A). Three water samples contained concentrations of chloride greater than 1,000 mg/L. Elevated sodium or chloride concentrations at these sites may be caused by spills, leaks, or disposal of inorganic compounds containing sodium or chlorine, such as sodium nitrate, sodium hydroxide, sodium carbonate, and sodium bifluoride; chloride-enriched sewage from disposal systems and landfills; and sodium chloride used in wastewater-treatment systems or for road deicing. The slightly to moderately saline water in the Delaware River estuary during drought, however, may be the source of the elevated concentrations in those samples from wells adjacent to tidal surface water that contained high concentrations of both sodium and chloride.

A plot of the concentrations of sodium and chloride in ground-water samples from the middle aquifer in the Greenwich Township region (fig. 8) indicates that many of the samples contained sodium and chloride in ratios that are higher than would be expected if the concentrations were solely the result of dilution of slightly to moderately saline river water. With the assumption that the major-ion chemistry of river water can be expressed as a mixture of freshwater and seawater, sodium-to-chloride ratios for possible mixtures were calculated for comparison and are represented by the line on figure 8. River-water samples collected in 1980 (Hochreiter, 1982)

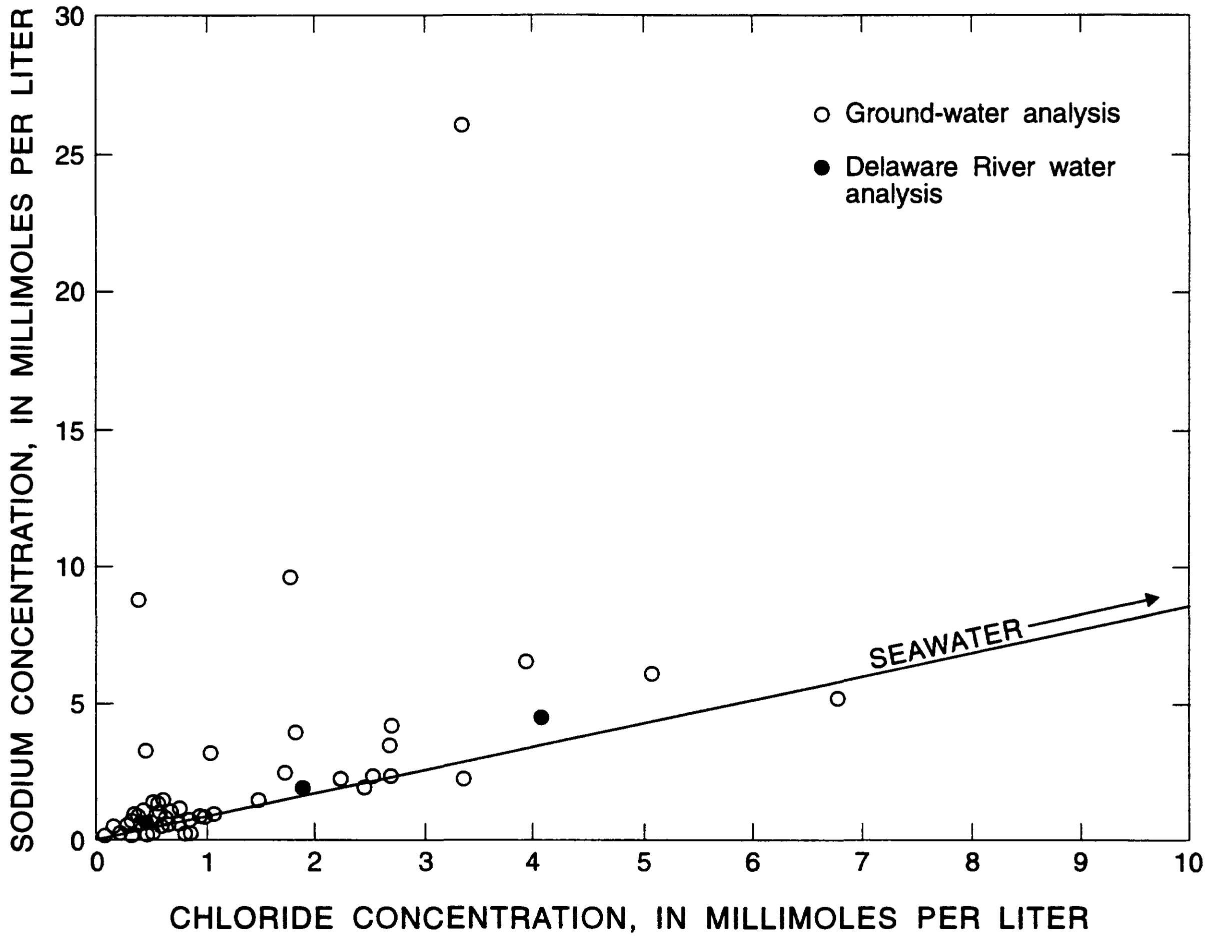


Figure 8. Concentrations of dissolved sodium and chloride in samples of water from the middle aquifer of the Potomac-Raritan-Magothy aquifer system and from the Delaware River in the region of Greenwich Township, Gloucester County, New Jersey, 1951-88. (Line is the ratio of sodium to chloride expected in water samples if concentrations were caused solely by mixing of seawater with freshwater. Concentrations of sodium and chloride for a representative sample of seawater (sodium concentration is 468 millimoles per liter and chloride concentration is 545 millimoles per liter) are beyond the extent of the graph (Drever, 1982, p. 234; Plummer and others, 1978). A density of 1.00 gram per cubic centimeter is assumed for all water samples because they were all dilute. Data for Delaware River water analyses from Hochreiter (1982, table 6, station number 01475200).)

contained sodium and chloride in ratios (fig. 8) that are close to those that would be expected if river water were predominantly diluted seawater. Most of the samples with higher-than-expected sodium-to-chloride ratios were from wells screened in the shallow part of the aquifer system in the industrial area in Paulsboro Borough and Greenwich and northwestern West Deptford Townships. High sodium-to-chloride ratios in samples from this area suggest that additional (possibly anthropogenic) sources of sodium may be present.

Chloride concentrations in water samples from the Greenwich Township and Paulsboro Borough public-supply wells, which are screened in the middle aquifer downgradient from the industrial area, varied irregularly from 1979 through 1986. Variable concentrations of this ion through time may reflect the conservative nature of chloride (that is, chloride does not react with aquifer materials) coupled with changes in the sources of chloride.

Sulfate

The form in which sulfur is present in the ground water depends on the composition of the source, chemical reactions along the flow path from the source, the amount of dissolved oxygen in the water, and the activities of sulfur-reducing and -oxidizing microbes. Sulfur is found in ground water primarily as sulfate (the most stable oxidized-sulfur species), as bisulfate, or as a sulfate-containing ion pair; however, sulfates (as well as sulfites, thiosulfates, and elemental sulfur) are easily reduced to sulfides by bacteria in anaerobic environments (Hem, 1985, p. 114-115). Oxidation of reduced sulfur compounds is an acidifying process that can occur through either chemical or bacterially mediated reactions over a wide range of pH conditions (Brady, 1974, p. 451).

One natural source of sulfur in the ground water is sulfur-containing gaseous and particulate compounds in the atmosphere from the combustion of fossil fuels, salt spray in marine environments, and volatilization of hydrogen sulfide in marsh environments. Atmospheric sulfur generally is added to the ground water in the form of sulfuric acid by precipitation. Organically bound sulfur, present in surface vegetation and in lignite, which is ubiquitous in the Potomac-Raritan-Magothy aquifer system, and sulfur-containing minerals such as sulfides, which are found in all deposits in the region, are important natural sources. Saline water incorporated with some aquifer materials during deposition or saline recharge from the Delaware River estuary also can contribute to sulfur concentrations in the aquifer system in the Greenwich Township region. Concentrations of sulfate in the river, measured at Marcus Hook, Pennsylvania (fig. 1), from 1949 through 1957 (Parker and others, 1964, p. 154, table 37), were as high as 409 mg/L during periods of drought.

Of the various sulfur compounds, ground-water samples from the Potomac-Raritan-Magothy aquifer system in the Greenwich Township region were analyzed only for sulfate. The median concentration of sulfate in potable-water samples from 134 wells screened in the Potomac-Raritan-Magothy aquifer system was 17 mg/L (table 5). In all three aquifers, background concentrations of sulfate generally were less than 50 mg/L (fig. 3h). Water from the middle aquifer contained significantly higher concentrations of sulfate than water from the aquifer system as a whole (fig. 3h). Concentrations of sulfate in the aquifer system appeared to decrease downgradient; however, regional trends were obscured by local variations.

Concentrations of sulfate greater than the USEPA SMCL of 250 mg/L (U.S. Environmental Protection Agency, 1988b) were measured in water samples from 20 of the 181 wells (11 percent) from which ground-water samples were analyzed for sulfate (table 6). Most of these wells are screened in the middle aquifer (fig. 3h) or in the overlying and hydraulically connected upper Cenozoic deposits, and are in the industrial area in Paulsboro Borough or Greenwich or northwestern West Deptford Townships (pl. 2D). Sulfate concentrations greater than 50 mg/L, but less than 250 mg/L, were found in the middle aquifer in Logan Township near Repaupo Station (well 15-395) and in West Deptford Township (wells 15-295 and 15-297); in the upper aquifer just south of the industrial area in Greenwich Township (Kenneth DiMuzio, Greenwich Township, written commun., 1988) and in Logan Township (wells 15-576, 15-579, 15-581, 15-587, 15-590, 15-595, and 15-714); and in the lower aquifer in Greenwich Township (wells 15-101 through 15-103, and 15-109), in Paulsboro Borough (wells 15-220, 15-221, and 15-439), and in West Deptford Township (well 15-410) (pl. 1A and table 2). The presence of sulfate-enriched ground water in the aquifer system has been reported at industrial facilities in other areas in southern New Jersey (Ervin and others, 1994, fig. 19; Farlekas and others, 1976, p. 48; Greenman and others, 1961, p. 76).

Because the aquifer system can receive induced recharge from the Delaware River estuary, recharge of slightly saline river water may, in part, be a source of sulfate to ground water in the industrial area in Paulsboro Borough and Greenwich and northwestern West Deptford Townships. Molar ratios of sulfate to chloride in ground-water samples from this area were greater than those that would be expected if sulfate concentrations were solely the result of dilution of saline recharge, suggesting additional (possibly anthropogenic) sources of sulfate.

Potential anthropogenic sources of sulfur in the Greenwich Township region include the manufacture and storage of sulfuric and nitrosylsulfuric acids; the use of elemental, molten sulfur; production of sulfuric acid at a plant that operated in the mid-1900's; storage of gypsum (calcium sulfate) and sulfuric acid; disposal and subsequent leaching of sulfur- and ammonium sulfate-containing wastes generated at a former coal-gasification plant; and the operation of a sulfur-processing plant at which sulfur is extracted from petroleum and then concentrated for later sale or use (table 1). In addition, petroleum, which contains reduced-sulfur-containing groups (Barker, 1979, p. 14, table 2.3), is stored, refined, and transferred at numerous sites within the region; petroleum wastes also are disposed of at sites within the region. At the industrial sites, sulfur can enter the ground water as sulfate (such as calcium sulfate) or in reduced form, such as reduced-sulfur-containing organic compounds, which can decompose to sulfide or oxidize to sulfate. Sulfur also can be added to the ground water in these areas through oxidation of pyrite or marcasite, which are ubiquitous in the aquifer system. Oxidation of sulfide minerals, a naturally occurring process, can be enhanced by introduction of chemical compounds that change the pH and redox conditions at these sites.

Oxidation of reduced-sulfur species to sulfate can occur through contact with aerated water in the unconfined part of the aquifer system. In the Greenwich Township region, aeration of water in the unconfined part of the aquifer system may be enhanced by tide-induced fluctuations in the water table (Barton and Kozinski, 1991).

Sulfate concentrations in samples from the public-supply wells in Greenwich Township and Paulsboro Borough, all of which are screened in the middle aquifer and are less than 1 mile downgradient from the area where sulfate concentrations are greater than 250 mg/L, generally increased at an average rate of 3 mg/L per year from 1968 through 1988 (fig. 9). The highest rates of increase were found in samples from wells 15-69 and 15-348 (fig. 9). Increasing sulfate concentrations through time, coupled with proximity to the area of elevated sulfate concentrations, indicate that sulfate-rich ground water may migrate from nearby industrial sites to the public-supply wells. Concentrations of sulfate in well 15-347 decreased slightly from 1980 to 1986 (fig. 9); this decrease may be attributable to pumping operations upgradient at nearby industrial sites to prevent the migration of contaminants to this well (D.A. Cox, Hercules, Incorporated, written commun., 1986; Homer Turner, E.I. Dupont, Inc., written commun., 1986).

Trace Elements

Radioactivity

The presence and distribution of radionuclides in ground water in the Greenwich Township region are poorly known. The NJDEP (R.H. Barg, New Jersey Department of Environmental Protection, written commun., 1982, p. 4) requires all public water suppliers to analyze composite water samples from their distribution systems for gross alpha-particle activity (the total radioactivity due to alpha-particle emissions) on a quarterly basis every 4 years; the NJDEP also can request additional analyses for gross beta-particle activities and concentrations of radium-226 and radium-228. When monitored from April 1985 through December 1987 (R.H. Barg, New Jersey Department of Environmental Protection, written commun., 1989), the quarterly gross alpha-particle activities in drinking-water samples from all distribution systems in the Greenwich Township region were below the USEPA MCL of 15 pCi/L (U.S. Environmental Protection Agency, 1988a). (One picocurie per liter is equal to 0.037 disintegrations of the radionuclide per second per liter of water.) Three water-supply systems in Gloucester County (Greenwich Township Water Department, Penns Grove Water Supply Company--Bridgeport Division, and Wenonah Water Department) withdraw water from the Potomac-Raritan-Magothy aquifer system; ground-water samples from all three water purveyors had levels of gross alpha-particle activity greater than 5 pCi/L, the level used to determine whether additional radiochemical analyses are necessary to show that composite drinking-water supplies are in compliance with established regulations for this characteristic. One quarterly composite sample from the Greenwich Township Water Department had an activity greater than 10 pCi/L. No water samples from the three water purveyors had concentrations of radium-226 greater than 3 pCi/L, the concentration used to determine whether analyses for radium-228 are necessary to show that composite drinking-water supplies are in compliance with established regulations for total radium.

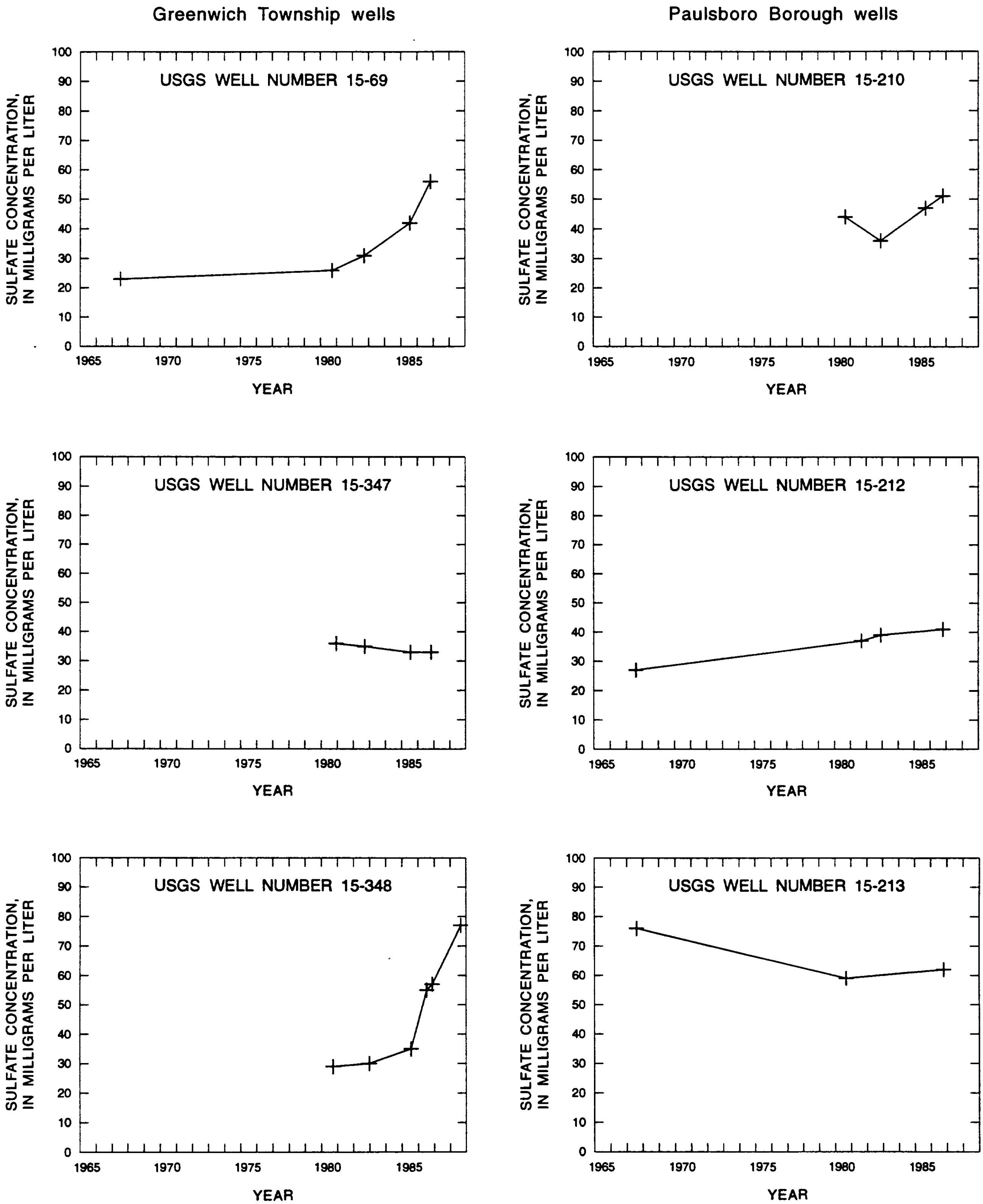


Figure 9. Variation in concentration of dissolved sulfate in water from public supply wells in Greenwich Township and Paulsboro Borough, Gloucester County, New Jersey, 1965-88. (Locations of wells shown on pl. 1A.)

For this study, gross alpha-particle activities were measured in untreated water samples collected in 1988 from the three public-supply wells in Greenwich Township and from the three public-supply wells in Paulsboro Borough. Gross alpha-particle activities in water samples from all six wells were less than the USEPA MCL, but were near or greater than 5 pCi/L in samples from wells 15-69, 15-348, 15-210, and 15-213 (pl. 1A and table 2). The radium-226 and radium-228 concentrations in an untreated water sample from well 15-348 were 3.3 pCi/L and 7.3 pCi/L, respectively. The combined concentrations of radium-226 and radium-228 exceeded 5 pCi/L, the USEPA MCL (U.S. Environmental Protection Agency, 1988a). Hence, radium concentrations in untreated water from well 15-348 may, at times, exceed established regulations. The results of these analyses imply that (1) ambient gross alpha-particle activities and radium concentrations in water in the Potomac-Raritan-Magothy aquifer system in the Greenwich Township region are elevated above background levels, but that (2) average radioactivity of samples from all drinking-water supplies in the region is below USEPA MCL's.

Elevated concentrations of radium-226 and radium-228 in ground water in the Greenwich Township region can be attributed to the local geology and geochemistry. Coastal Plain deposits in this region, derived from nearby granitic and metamorphic rocks of the Piedmont physiographic province to the north-northwest, commonly consist of minerals that contain the parent radionuclides uranium-238 and thorium-232 (Michel and Moore, 1980, p. 665). Radioactive-decay products of the parent radionuclides are radium-226 and radium-228, respectively, which generally are bound up in secondary iron oxyhydroxide minerals (Szabo and Zapecza, 1987). Solubility of the iron oxyhydroxides and movement of the daughter radionuclides are enhanced by low pH and reducing conditions (characterized by low concentrations of dissolved oxygen) (Zapecza and Szabo, 1988, p. 51). Such conditions are found naturally in the shallow confined part of the aquifer system, where the public-supply wells are screened, and probably accounts for the elevated gross alpha-particle activities in water samples from four of the six wells. Water from well 15-348, which had the highest gross alpha-particle activity and the highest concentrations of radium-226 and radium-228 of all the samples, had the lowest pH (4.08) of all water samples for which radiochemical analyses were done. (The dissolved-oxygen concentration in this sample was 1.0 mg/L.)

Priority pollutants

A priority pollutant is an element or compound that is one of 129 toxic chemicals on a list developed by the USEPA (Keith and Telliard, 1979). In this study, the most frequently detected priority pollutant was barium, which was detected in 99 percent of the 160 samples analyzed but always was present in concentrations less than the USEPA MCL of 1,000 $\mu g/L$ (U.S. Environmental Protection Agency, 1988a). The distribution of barium in each aquifer was similar to that of sodium in that concentrations increased downgradient. The presence of barium in ground water in the region can be attributed to progressive downgradient dissolution of aluminosilicate minerals such as feldspars and micas, which contain trace amounts of barium, or trace minerals such as barite. The presence of higher concentrations of barium in ground water in the confined parts of the aquifer system than in the unconfined parts also may reflect mixing with water infiltrating into the aquifer system from overlying marine deposits. Dissolution of barium-containing carbonate minerals, such as witherite and calcite, in the marine deposits can increase the concentrations of barium in the water that leaks to the Potomac-Raritan-Magothy aquifer system.

In most natural waters, concentrations of other priority pollutants, such as arsenic, chromium, and lead, typically are less than 10 μg/L, and cadmium concentrations are about 1 μg/L (Hem, 1985). Mercury concentrations in most natural waters are even lower, rarely exceeding a few tenths of a microgram per liter (Hem, 1985, p. 143). In ground-water samples from the Greenwich Township region, concentrations of arsenic, cadmium, chromium, lead, and mercury generally were below analytical detection limits (table 5). In samples from 31 wells (table 6), however, lead, arsenic, cadmium, and mercury were detected at concentrations at or greater than USEPA MCL's. None of the 31 wells is used for drinking-water supplies and none is screened in the lower aquifer.

Mercury was the most frequently detected of these priority pollutants, but only because all of the 48 water samples (from 48 wells) that were analyzed for mercury were collected from wells at sites in Logan Township with known ground-water contamination (table 6). The presence and concentration of mercury in ground water at these sites are discussed further by Kozinski and others (1990, p. 43-65 and p. 81-114).

Arsenic, cadmium, chromium, and lead were detected in 46, 41, 38, and 17 percent of the ground-water samples analyzed, respectively (table 5). The distributions of dissolved arsenic, cadmium, chromium, and lead in water from the upper, middle, and lower aquifers of the Potomac-Raritan-Magothy aquifer system in the Greenwich Township region are shown on plates 3A, 3B, and 4A, respectively. In these figures, a "cross" represents the most recent water sample from each well that was analyzed for at least two of these four priority pollutants. The length of each of the four axes of the cross is proportional to the concentration of the trace element.

The frequency of detection and concentrations of detected priority pollutants tended to be higher in water samples from all three aquifers in areas of industrial or other urban land uses in Paulsboro Borough and Greenwich, Logan, and West Deptford Townships. Priority pollutants were detected at concentrations greater than USEPA MCL's (U.S. Environmental Protection Agency, 1988a) in the upper and middle aquifers in Logan Township (wells 15-543, 15-544, 15-549, 15-554, 15-555, 15-556, 15-564, 15-569, 15-572, and 15-589) and in the middle aquifer in Greenwich Township (wells 15-501, 15-668, 15-679, and 15-683) (pl. 1A). Of the four priority pollutants, chromium was most frequently detected at concentrations greater than the MCL (50 μg/L) (U.S. Environmental Protection Agency, 1988a).

Detectable concentrations of chromium, lead, and cadmium were measured in the lower aquifer in northern West Deptford Township and in Westville--the same aquifer and area in which the concentrations of most major ions and other trace elements were elevated and have been increasing since 1971 (Ervin and others, 1994). The presence of trace elements and concentrations of major ions greater than background levels in water from the lower aquifer in this area have been attributed to the transport of contaminated water from sources upgradient in Pennsylvania (Ervin and others, 1994; Farlekas and others, 1976, p. 46-50); however, leakage of contaminated water from the unconfined aquifer through confining units or leaky annular spaces of wells is another possible source.

Natural sources of these trace elements in the ground water include the minerals galena and cerusite, which contain lead; carbonates, which contain trace amounts of cadmium; and pyrite, which contains trace amounts of arsenic. Possible anthropogenic sources of arsenic, chromium, and lead are discharges from coal and petroleum industries (see table 1). Dredge spoils from the Delaware River estuary that were deposited for many years in wetlands adjacent to the river also can be significant sources of trace elements (Evans and others, 1974, p. 42). Other potential sources of lead in ground water in the region include nonindustrial discharges of leaded gasoline (gasoline with a tetraethyl lead additive) and dissolution of lead water pipes in old buildings or lead-containing solder commonly used to join copper water pipes (Kish and others, 1987). Current or past application of pesticides containing trace elements, especially arsenic and lead, can contribute these elements to the ground water. Potential sources of cadmium in the region include the use and disposal of electroplated material, paint and dye pigments, batteries, fluorescent and video tubes, and plastic stabilizers (Moore and Ramamoorthy, 1984, p. 30).

Concentrations of these trace elements typically are low in natural waters because they have low solubilities and a strong tendency to be adsorbed onto sediment particles (Hem, 1985, p. 142-144). Trace elements in ground water can be mobilized by a change in redox conditions; a reduction in pH; an increase in organic and inorganic complexing agents, which form soluble trace-element complexes; an increase in salinity; and microbial activity (Horowitz, 1985, table 3.2-1, p. 39).

Iron

High concentrations of iron are a major problem in the development of the Potomac-Raritan-Magothy aquifer system for potable-water supplies because dissolved iron can oxidize and precipitate, forming rusty deposits that clog well screens and stain laundry and plumbing fixtures. Concentrations of iron greater than the USEPA SMCL of 300 $\mu g/L$ (U.S. Environmental Protection Agency, 1988b) have been measured in water samples from the aquifer system at numerous localities throughout New Jersey (Barksdale and others, 1958, p. 98; Langmuir, 1969a, 1969b; Fusillo and others, 1984, p. 13; Harriman and Sargent, 1985, p. 27). The median concentration of iron in samples of potable water from the Potomac-Raritan-Magothy aquifer system in the Greenwich Township region was 425 $\mu g/L$. Concentrations of iron in water from 118 of the 180 wells (66 percent) from which samples were analyzed for iron exceeded the SMCL (table 6 and fig. 3e).

As in other parts of New Jersey (Langmuir, 1969a, p. 20), concentrations of iron greater than 1,000 $\mu g/L$ (and in many cases greater than 10,000 $\mu g/L$) in the Greenwich Township region were found most frequently in the shallow confined part of the Potomac-Raritan-Magothy aquifer system within a few miles of the aquifers' outcrops or subcrops. In these areas, the reducing and acidic conditions that are necessary to keep iron in solution predominate: both dissolved-oxygen concentrations and pH were low (less than 1 mg/L and about 5.6, respectively). This spatial distribution of iron in ground water in the upper aquifer is illustrated on plate 4B. Elevated concentrations also were found locally in samples from the unconfined part of the aquifer system where similar reducing and acidic conditions prevail, perhaps because of wetland geochemical processes (Given, 1975, p. 58-59) or anthropogenic contamination. For example, concentrations of iron greater than 10,000 μg/L were frequently detected in water samples from the upper Cenozoic deposits and underlying middle aquifer in the industrial area of Paulsboro Borough and Greenwich and northwestern West Deptford Townships. Samples with high iron concentrations generally had pH values less than 5 and contained dissolved oxygen in concentrations less than 1 mg/L. High iron concentrations, low pH, and low dissolved-oxygen concentrations also were measured in water from the upper aquifer at wells 15-546, 15-549, 15-579, 15-584, and 15-590 through 15-595 in Logan Township (pl. 4B).

The presence of iron in high concentrations in the ground water can be attributed to dissolution of iron-containing minerals, such as pyrite, marcasite, siderite, magnetite, micas, amphiboles, and garnets. In many wells, corrosion of the iron casing adds iron to the ground water. Dissolution of iron-containing minerals can be enhanced by the presence of bacteria in an aquifer system (Hem, 1985, p. 82). In addition, complexing of iron with organic compounds can significantly enhance its solubility. High concentrations of dissolved iron persist if the water is acidic and reducing, and if concentrations of sulfur, particularly as sulfide, are low (Hem, 1985, p. 80-81, figs. 14 and 15). These conditions are found naturally in shallow confined parts of the aquifers and also can exist in the unconfined part of the aquifer system because of the oxidation of organic contaminants. Iron released by dissolution of aquifer minerals can precipitate in secondary minerals in other parts of the aquifer system as the chemistry, redox conditions, and pH of the ground water vary along the flow path.

Concentrations of iron in water samples from the public-supply wells in Greenwich Township (wells 15-69, 15-347, and 15-348) and in Paulsboro Borough (wells 15-210 and 15-212) varied from 1982 through 1986 but, except for those in samples from well 15-347, generally increased through time (pl. 1A and table 2). The maximum rate of increase, measured in well 15-69, was 500 μg/L per year. A concomitant decrease in pH in the same samples indicates that increasing iron concentrations may be attributable to the migration of increasingly acidic water.

Manganese

Dissolved manganese in water supplies can oxidize and precipitate on plumbing fixtures, causing black deposits or stains. The median concentration of manganese in the samples of potable water from the Potomac-Raritan-Magothy aquifer system in the Greenwich Township region was 63 μg/L, which exceeds the USEPA SMCL of 50 μg/L (U.S. Environmental Protection Agency, 1988b). Concentrations of manganese greater than this value were found in water samples from 124 of the 179 wells (69 percent) from which samples were analyzed for manganese (table 6 and fig. 3f). The concentration of manganese was significantly lower in the upper aquifer, and higher in the middle aquifer, than in the aquifer system as a whole (fig. 3f). In general, the concentration of manganese decreased downdip within each aquifer of the aquifer system, ranging from greater than 100 µg/L in the unconfined part of the aquifer system to less than 10 µg/L in the deep confined part.

Concentrations of manganese greater than 1,000 µg/L were detected in water samples from the upper Cenozoic deposits and middle aquifer in the industrial area in Paulsboro Borough and Greenwich and northwestern West Deptford Townships (wells 15-673, 15-679, and 15-683) (pl. 1A and table 2). Concentrations of manganese also exceeded 1,000 µg/L in water samples from the upper and middle aquifers in Logan Township (wells 15-544, 15-549, 15-554 through 15-556, 15-583, 15-584, 15-590, 15-592, and 15-595) (pl. 1A and table 2). In the lower aquifer, concentrations of manganese exceeded 100 µg/L in many wells in northern Greenwich, Logan, and West Deptford Townships and in National Park Borough (pl. 1A and table 2). The concentration of manganese in a sample from one well in the lower aquifer in northern Greenwich Township (well 15-357) was 10,000 µg/L (pl. 1A and table 2).

Elevated manganese concentrations can be attributed to dissolution of manganese-containing minerals, such as manganite, pyrolusite, tourmaline, amphiboles, and garnets, which are ubiquitous in the aquifer system. Manganese is similar to iron in that both metals participate in redox reactions (Hem, 1985, p. 85); however, in the aerated water in the unconfined part of the aquifer system, the predominant form of dissolved manganese (the 2+ oxidation state) is considerably more stable than dissolved iron (Hem, 1985, p. 86). Therefore, after iron has precipitated, manganese can remain in solution in relatively high concentrations in the aerated water in the unconfined part of the aquifer system. In addition, complexing of manganese with organic materials, which are likely to be present in the unconfined part of the aquifer system, can significantly enhance its solubility.

Concentrations of manganese in water samples from the public-supply wells in Greenwich Township (wells 15-69, 15-347, and 15-348) and in Paulsboro Borough (wells 15-210 and 15-212) varied from 1982 through 1986 (pl. 1A and table 2). Manganese concentrations in wells 15-69 and 15-348 increased during this period. These wells are near the industrial area, where manganese concentrations exceeded 1,000 µg/L, indicating that water containing elevated concentrations of manganese may be migrating downgradient to these wells. Manganese concentrations in samples from wells 15-210, 15-212, and 15-347 have decreased slightly through time (pl. 1A and table 2). The chemistry of water samples from well 15-347, the well closest to the industrial sites, probably has been affected by pumping at these sites designed to prevent the migration of contaminants to this well (D.A. Cox, Hercules, Incorporated, written commun., 1986; Homer Turner, E.I. Dupont, Inc., written commun., 1986).

<u>Other trace elements</u>

Beryllium, which substitutes in minor amounts for silicon in many silicate minerals, generally is present in natural waters at concentrations less than the detection limit of 0.5 µg/L (Hem, 1985, p. 135). In the Greenwich Township region, beryllium was detected in 26 percent of all ground-water samples analyzed (table 5). Strontium, which commonly substitutes in minor amounts for calcium or potassium in minerals, was detected in all ground-water samples analyzed. The median concentration of strontium in samples of potable water from the region was 380 μg/L. Concentrations of strontium decreased downgradient, as did those of calcium; therefore, its presence probably is controlled by the same reactions that control the concentration of calcium.

The median concentration of zinc in water samples from the Potomac-Raritan-Magothy aquifer system in the Greenwich Township region was 12 μg/L. In general, the concentration of zinc decreased downgradient as the pH increased. Zinc is found naturally in aquifer materials such as iron sulfide minerals (pyrite and marcasite) and calcite, and concentrations of zinc in natural ground waters typically are a few micrograms per liter (Hem, 1985, p. 139). Other potential sources of zinc in the Greenwich Township region are paints and metal-plating operations at the industrial sites. In addition, corrosion of some galvanized steel well casings may add zinc to the ground water.

Copper, cobalt, molybdenum, and vanadium were detected in few ground-water samples from the region; background concentrations of these elements were less than the detection limits. In the Greenwich Township region, aluminum was detected in samples from 80 percent of the 101 wells from which samples were analyzed for aluminum; the maximum concentration measured was 10,000 μg/L. Although substantial amounts of aluminum are present in many silicate minerals, this element is rarely found in neutral-pH water in concentrations greater than a few tens or hundreds of micrograms per liter.

Most ground-water samples that contained concentrations of zinc and cobalt greater than 10 μg/L or concentrations of aluminum greater than 250 μg/L, or that had detectable concentrations of copper, molybdenum, or vanadium, were collected from wells screened in the upper Cenozoic deposits or the middle aquifer at industrial sites in Paulsboro Borough and Greenwich and Logan Townships (pl. 1A and table 2). Concentrations of zinc, cobalt, and aluminum greater than 100 μg/L were measured in ground-water samples from the lower aquifer in Paulsboro Borough and Greenwich Township (wells 15-109, 15-118, 15-357, 15-439, and 15-672), and concentrations of copper exceeding the detection limit of 10 μg/L were found in water samples from wells screened in the upper Cenozoic deposits, upper aquifer, or middle aquifer in Paulsboro Borough and northern Greenwich Township (wells 15-69, 15-348, and 15-677), in Logan Township at Repaupo Station (wells 15-417 and 15-453), and in Mantua Township (wells 15-189 and 15-192) (pl. 1A and table 2). The presence of these trace elements in ground-water samples from wells at these sites probably is related to the dissolution of aquifer materials or industrial contaminants under reducing or acidic conditions.

Cobalt also was detected in water samples from all of the public-supply wells in Greenwich Township and from one well in Paulsboro Borough (well 15-213) in 1980 and 1986 and another well in Paulsboro Borough (well 15-212) in 1980 (Fusillo and others, 1984) (pl. 1A and table 2). Cobalt is not common in minerals; its presence in even trace amounts in manganese oxides can be related to anthropogenic sources. The cobalt concentrations may be an analytical artifact caused by the high iron concentrations also present in these samples.

Nutrients

Nitrogen is present in ground water as nitrate and nitrite anions, ammonium cations, and organic solutes (Hem, 1985, p. 124). The most stable and oxidized form of nitrogen in ground water is nitrate, which is highly mobile. The form of nitrogen that appears in the ground water, however, depends on the composition of the source of nitrogen, distance from the source, and the amount of dissolved oxygen in the water. Ammonium, the most reduced form, is strongly adsorbed onto mineral surfaces (Hem, 1985, p. 124). Under aerobic conditions ammonium, through a process called nitrification, can be oxidized by bacteria to nitrite and then to nitrate. Under anaerobic conditions, however, nitrate can be reduced by bacteria to nitrite, nitrous oxide, or nitrogen gas. This biochemical reduction is known as denitrification.

The primary sources of elevated concentrations of nitrogen in ground water are related to human activities and include leakage of sewage from septic systems or sewer lines, application of nitrogen-containing fertilizers, and disposal of nitrogen-containing organic or inorganic compounds. Nitrogen compounds also can enter the ground water through vegetative residues, farm manures, and atmospheric deposition of ammonium and nitrate salts. In addition, molecular nitrogen can be fixed (converted to nutrient forms) by microorganisms. During transport through the unsaturated zone, nitrogen can be lost through immobilization in organic nitrogen compounds, volatilization, uptake by plants and microorganisms, and adsorption by clay minerals (Brady, 1974, p. 424).

In the Greenwich Township region, background concentrations of nitrate plus nitrite (as N)[3] in the Potomac-Raritan-Magothy aquifer system typically are less than 0.10 mg/L (the detection limit). In all samples, concentrations of nitrite were at or near the detection limit; hence, concentrations of nitrate plus nitrite are discussed as concentrations of nitrate in this report. Water samples from 11 of the 137 wells sampled for nitrate analysis (8 percent) contained concentrations of nitrate greater than the USEPA MCL of 10 mg/L (table 6; U.S. Environmental Protection Agency, 1988a). All but one of these wells are screened in the Potomac-Raritan-Magothy aquifer system and all contained water with a pH less than about 5.6. Eight of these wells are at industrial sites. Concentrations of nitrate greater than the MCL were measured in water samples from the upper aquifer in Logan Township at wells 15-453, 15-564, and 15-575, and from the middle aquifer in Greenwich Township at well 15-96 (pl. 5A).

Samples from four wells in agricultural areas contained nitrate in concentrations greater than the USEPA MCL. One is screened in the upper aquifer in Logan Township (well 15-575), two are screened in the middle aquifer near Repaupo Station (wells 15-453 and 15-564) (pl. 5A), and one is screened in the Englishtown aquifer system in East Greenwich Township (well

[3] In this report, concentrations of all nitrogen species are reported as equivalent concentrations of nitrogen.

15-500) (pl. 1A). Elevated concentrations of nitrate in these wells can be attributed to application of nitrogen-containing fertilizers and (or) leakage of sewage from septic systems.

The concentration of nitrate (4.8 mg/L) in water from Greenwich Township public-supply well #5 (well 15-347), screened in the middle aquifer in northern Greenwich Township, was the highest concentration measured in water from the public-supply wells in Paulsboro Borough and Greenwich Township (pl. 1A). Since analytical results were first recorded in 1980, however, nitrate concentrations in all of the public-supply wells have been relatively constant and less than the MCL.

Maximum background concentrations of ammonia in water from the Potomac-Raritan-Magothy aquifer system were about 0.90 mg/L. The median concentration in ground water in this region (0.20 mg/L) is comparable to the median concentration of ammonia in the aquifer system in southeastern New Jersey (0.32 mg/L) reported by Fusillo and others (1984, p. 11, table 2). Elevated concentrations of ammonia (greater than 10 mg/L) or ammonia plus organic nitrogen (greater than 100 mg/L) were detected in water from the upper Cenozoic deposits and the middle aquifer in the industrial area of Paulsboro Borough and Greenwich and northwestern West Deptford Townships (pl. 5A). Concentrations of ammonia were very high in much of this area; the maximum concentration measured was 200 mg/L in a sample from well 15-668. Elevated ammonia concentrations (1-80 mg/L) also have been reported for water samples from the upper aquifer in Paulsboro Borough (well 15-674); from the middle aquifer in Greenwich Township (wells 15-652, 15-679, 15-681 through 15-683, and, on the basis of unpublished data, the wells at the Municipal Landfill (John Redmond, Greenwich Township, written commun., 1988)); and from the lower aquifer in Greenwich Township (wells 15-109, 15-357, and 15-672) and West Deptford Township (well 15-321) (pl. 1A).

A sample from well 15-398, a domestic well screened in the lower aquifer in a marshy area of Greenwich Township (pl. 1A), contained ammonia in a concentration of 15.0 mg/L. This elevated concentration may be the result of leakage from a nearby septic tank. The ammonia probably will persist in the ground water under the reducing and acidic conditions that are found naturally in a wetlands environment (Given, 1975).

Elevated nitrate or ammonia concentrations in ground water at industrial sites may be attributable to the use, storage, and disposal of nitrogen-containing inorganic and organic compounds. For example, numerous oxidized- and reduced-nitrogen-containing compounds, including ammonia, ammonium silicofluoride, and ammonium sulfate, are or were manufactured, generated, used, or stored at these sites (see table 1). In addition, petroleum, which commonly contains reduced-nitrogen-containing compounds such as amino and nitrilo groups (Barker, 1979, p. 14, table 2.3), is refined, stored, or transferred at a number of these sites (see table 1).

Ground-water samples from the Greenwich Township region that contained nitrate in elevated concentrations (greater than 10 mg/L) also had low concentrations of ammonia; those with high ammonia concentrations (greater than 10 mg/L) had low nitrate concentrations. Water samples from most industrial sites in Paulsboro Borough, Greenwich Township (pl. 5A), and Logan Township contained 5 to 300 times more ammonia (or ammonia plus organic nitrogen) than nitrate, indicating the proximity of sources of reduced nitrogen (predominantly nitrogen-containing organic compounds, ammonia, and ammonia-containing compounds). Because conditions are reducing and concentrations of organic compounds in ground water were high at these sites, reduction of nitrates also can contribute to the concentration of ammonia in the ground water. Nitrate concentrations increased relative to ammonia concentrations with distance from one site, indicating that (1) oxidizing conditions distant from the site may favor nitrification of the ammonia, or (2) the use of fertilizers may contribute additional nitrate to the ground water because this site is surrounded by agricultural land (Kozinski and others, 1990, p. 65).

Background concentrations of phosphorus (measured as orthophosphate) in the potable water in the Potomac-Raritan-Magothy aquifer system in the Greenwich Township region were less than 1 mg/L, and generally were less than 0.50 mg/L. These are typical background concentrations for natural ground water (Hem, 1985, p. 128). Higher concentrations of phosphorus were found in water samples from wells screened in the confined parts of the aquifer system than in samples from wells screened in the unconfined parts. The primary source of phosphorous in the ground water probably is dissolution of aquifer materials such as the phosphorous-containing mineral apatite. Dissolution of apatite is enhanced when the pH and calcium concentration of the ground water are low.

Organic Compounds

Dissolved organic carbon

The median concentration of dissolved organic carbon in samples of potable water from the Potomac-Raritan-Magothy aquifer system in the Greenwich Township region was 1.1 mg/L. This value is similar to the median (1.4 mg/L) reported for water from the aquifer system throughout southern New Jersey (Fusillo and others, 1984, p. 11, table 2), and to the median (0.70 mg/L) and range (0.20-15 mg/L) reported for natural ground waters (Thurman, 1985, p. 14). In natural ground waters, an inverse relation generally is observed between the concentration of dissolved organic carbon and well depth because, in many cases, the principal source of dissolved organic carbon in the aquifer system is surficial matter such as vegetation. In the Greenwich Township region, however, this inverse relation was not readily apparent, possibly because lignite and other fossilized organic matter, which are ubiquitous in the aquifer system, contribute to the concentration of dissolved organic carbon in the water downdip from the recharge area.

Concentrations of dissolved organic carbon greater than 5 mg/L (maximum 71 mg/L) were measured in samples from wells at industrial sites and in samples in which the ratio of the concentration of ammonia (or ammonia plus organic nitrogen) to the concentration of nitrate was greater than 5:1. Elevated concentrations were found in the upper aquifer in West Deptford Township (well 15-284); in the middle aquifer in Logan Township (wells 15-476 and 15-478); in the upper Cenozoic deposits or the middle aquifer in the industrial area in Paulsboro Borough and Greenwich and northwestern West Deptford Townships (many wells; see pl. 5B), and in Logan Township (wells 15-582 through 15-584, and 15-588 through 15-595); and in the lower aquifer in Greenwich Township (well 15-672). In addition, the total concentration of organic carbon (including organic compounds suspended in the ground water) in parts of the middle aquifer in Logan Township reached a maximum of 500 mg/L (well 15-584) (Kozinski and others, 1990, app. A, p. 104).

At many of these sites, breakdown of wetlands vegetation can contribute to elevated concentrations of dissolved organic carbon; however, concentrations of dissolved organic carbon at many of these sites were greater than 20 mg/L, the maximum concentration that might be expected from natural surface organic inputs alone (Hem, 1985, p. 152). These elevated concentrations are positively correlated with elevated concentrations (up to about 44,000 μg/L) of synthetically produced purgeable organic compounds.

<u>Purgeable organic compounds</u>

Water samples from 138 wells screened in the Potomac-Raritan-Magothy aquifer system in the Greenwich Township region were analyzed for synthetic organic chemical compounds (including purgeable organic compounds, acid- and base/neutral-extractable compounds, and pesticides). Most of the samples that were analyzed for acid- and base/neutral-extractable compounds were collected from industrial sites in Logan Township; the results of these analyses are discussed in detail by Kozinski and others (1990). Four samples were analyzed for pesticides during this study; of those analyzed, only one (from well 15-564) contained detectable concentrations of pesticides. The distribution of pesticides in ground water in the Potomac-Raritan-Magothy aquifer system is discussed by Louis and Vowinkel (1989). The following discussion deals only with the distribution of purgeable organic compounds in the Greenwich Township region.

Water samples collected from 76 wells in the Greenwich Township region during 1986-88 were analyzed for 36 purgeable organic compounds, which are listed in table 4. Before 1986, analytical methods used in the NWQL permitted the determination of only 27 of these compounds (table 2). Detectable concentrations of at least one purgeable organic compound were found in water from 56 of the 138 wells (41 percent) that were screened in the Potomac-Raritan-Magothy aquifer system in the Greenwich Township region and from which samples were analyzed for purgeable organic compounds. Purgeable organic compounds were detected in samples from all three aquifers, but were found most frequently in those from the middle aquifer (51 percent).

The NJDEP MCL's for selected purgeable organic compounds in ground-water samples (New Jersey Register, 1989) are listed in table 6. These regulations apply to the average concentration of the compound in four water samples collected from a supply system--not to a single untreated water sample collected from the well head (Barker Hamill, New Jersey Department of Environmental Protection, written commun., 1987, section 7:10-16.7). To estimate the severity of organic contamination of the ground water in the Greenwich Township region, the concentrations of organic compounds detected in the untreated water samples collected in the region were compared to these regulations. Twelve purgeable organic compounds were detected in concentrations equal to or greater than the drinking-water regulations (table 6). In order of decreasing frequency of detection, these compounds are benzene, trichloroethylene (TCE), cis- plus trans-1,2-dichloroethylene, tetrachloroethylene (PCE), chlorobenzene, 1,2-dichloroethane, vinyl chloride, methylene chloride, total xylenes, 1,1,1-trichloroethane, carbon tetrachloride, and 1,1-dichloroethylene.

Purgeable organic compounds for which no drinking-water regulations exist are not necessarily less toxic than those for which these levels have been established; however, their toxicity and other characteristics have not yet been promulgated into legislation. In order of decreasing frequency of detection, those purgeable organic compounds for which drinking-water regulations currently (1990) do not exist, but which were detected in more than one water sample from the Potomac-Raritan-Magothy aquifer system in the Greenwich Township region, include toluene, ethyl benzene, chloroform, 1,1-dichloroethane, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,2-dichloropropane, and 1,3-dichlorobenzene (table 6).

Thirty of the 138 well-water samples (22 percent) that were analyzed for purgeable organic compounds contained total purgeable organic compounds in concentrations equal to or greater than the NJDEP MCL of 50 μg/L (table 6; New Jersey Register, 1989). In order to facilitate the assessment of the distribution of purgeable organic compounds in ground water in the Greenwich Township region, the concentrations of 25 purgeable organic compounds (table 4) were summed for all water samples that were analyzed for these compounds. Some water samples were analyzed for more than 25 purgeable organic compounds and, in some samples, more than 25 were detected; other samples were analyzed for fewer than 25. The 25 purgeable organic compounds were selected to maximize the number of sites from which samples were analyzed for the same set of compounds, while minimizing the exclusion of compounds with significant concentrations from the total calculation.

The maximum total concentration of the 25 purgeable organic compounds was about 43,000 μg/L (well 15-76). Because only 25 compounds were included in this value, the total concentration of all purgeable organic compounds actually may be higher. Nevertheless, determination of the total concentration of purgeable organic compounds in this way allows for the comparison of concentrations among sites and permits an assessment of the distribution of these compounds among and within the aquifers.

The distributions of total purgeable-organic-compound concentrations within each of the three aquifers are represented on plates 6A through 6C. Each circle represents a well, and the diameter of the circle increases with the total concentration of purgeable organic compounds. Solid circles indicate that none of the 25 selected compounds was detected. These maps highlight the sites at which the ground water contains purgeable organic compounds.

High concentrations (greater than 100 μg/L) of the selected purgeable organic compounds were detected in water samples from the upper Cenozoic deposits or the upper aquifer in Logan Township (wells 15-546, 15-579, 15-590, 15-593 through 15-595, and 15-714), and in Paulsboro Borough (15-673) (pl. 6A). Unpublished data (D.A. Cox, Hercules, Incorporated, written commun., 1987; D.E. Choate, Mobil Oil Co., written commun., 1986), not shown on plate 6A, indicate that high concentrations of these purgeable organic compounds also were present in the upper aquifer in northern Greenwich

Township. In the industrial area of Logan Township near Bridgeport, samples from several wells contained no detectable concentrations of the selected purgeable organic compounds, whereas samples from other nearby wells screened in the same aquifer contained high concentrations. This distribution indicates that the presence of purgeable organic compounds in the ground water in this area is discontinuous spatially and, perhaps, temporally. Water samples from wells screened in the confined parts of the upper aquifer contained no detectable concentrations of the selected purgeable organic compounds.

Purgeable organic compounds (one or more of the 36 determined) were detected in water samples from 16 wells screened in the middle aquifer. Concentrations of purgeable organic compounds were highest (greater than 1,000 $\mu g/L$) in water from the middle aquifer in Logan Township (wells 15-475, 15-549, 15-555, and 15-582), and in Greenwich Township (15-76 and 15-682) (pl. 6B). As observed in the upper aquifer in the industrial area of Logan Township, purgeable organic compounds were discontinuously distributed in the middle aquifer in the industrialized part of Greenwich Township. In contrast to the confined upper aquifer, purgeable organic compounds were detected in many samples from wells screened in the confined parts of the middle aquifer.

Purgeable organic compounds were detected in water samples from eight wells screened in the lower aquifer (pl. 6C), including wells in Paulsboro Borough (wells 15-220, 15-221, and 15-439), Greenwich Township (15-109, 15-357, and 15-672), and Logan Township (wells 15-615 and 15-618). In one sample from Paulsboro Borough (well 15-221), the total concentration of the 25 purgeable organic compounds exceeded 10,000 $\mu g/L$.

The most likely sources of the purgeable organic compounds in most of the ground-water samples that contained detectable concentrations of these compounds are industrial activities at the surface. Downward transport of purgeable organic compounds from the upper aquifer (pl. 6A) to the middle aquifer (pl. 6B) and, in some cases, to the lower aquifer (pl. 6C) probably occurs through leaky confining units separating the aquifers and through leaky annular spaces of penetrating wells. Downward transport probably is enhanced by the pumping of water from underlying aquifers at each site in areas downdip. Vertical transport can be enhanced in parts of Paulsboro Borough and Greenwich Township where the upper and middle aquifers and the confining unit that separates them have been eroded and replaced by more than 100 feet of relatively permeable upper Cenozoic sand and gravel (Barton and Kozinski, 1991, p. 37, 54).

Surface sources of purgeable organic compounds detected in water samples from wells 15-210, 15-212, 15-213, 15-615, and 15-618, screened in the middle and lower aquifers (pls. 6B and 6C), are not readily apparent. In these cases, the purgeable organic compounds in the ground water probably are derived from upgradient locations in the same aquifer, although migration from overlying aquifers cannot be ruled out.

One class of purgeable organic compounds detected in ground water in the Greenwich Township region is the light monocyclic aromatic hydrocarbons, which include benzene, chlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, ethyl benzene, toluene, and xylenes.

These compounds are used as solvents, industrial intermediates, and fuel additives. Possible sources of aromatic hydrocarbons in ground water in the Greenwich Township region can be found at a number of industrial sites in Greenwich Township, Paulsboro Borough, and Logan Township, where these compounds are manufactured, used, or stored (table 1).

The most frequently detected aromatic hydrocarbons in ground-water samples from the Greenwich Township region, in order of decreasing frequency of detection, were benzene, ethyl benzene, and toluene. These compounds were detected in samples from each of the three aquifers. At all sites where aromatic compounds were found in the ground water, with the exception of one site in Logan Township (Kozinski and others, 1990), benzene comprised the major part of the total concentration of purgeable organic compounds. Hence, the distribution of benzene within each aquifer was similar to the distribution of total purgeable organic compounds (pls. 6A-6C). The distributions of ethyl benzene and toluene in water from the upper and middle aquifers were similar to those of benzene. In the lower aquifer, however, these compounds were detected in the ground water only in wells 15-221 and 15-618. Xylenes were detected only in samples from wells at sites with known petroleum contamination of the ground water, such as wells 15-673, 15-682, and 15-683 (pl. 1A and table 1). Xylenes also were detected by means of semiquantitative methods in samples from wells 15-544, 15-549, and 15-555 (pl. 1A) in the middle aquifer in parts of Logan Township where contamination of the ground water with petroleum has been reported previously (Kozinski and others, 1990, app. 5).

Another class of purgeable organic compounds detected in the ground water in the Greenwich Township region is halogenated aliphatic compounds, which include 1,1,1-trichloroethane, TCE, dichloroethylenes, PCE, and 1,2-dichloroethane. Halogenated aliphatic compounds have many uses, such as in industrial solvents and in plastics manufacturing. Because the use of these compounds is widespread, isolation of point sources of ground-water contamination is difficult.

The most frequently detected halogenated aliphatic compounds in ground water in the region, in order of decreasing frequency of detection, were TCE, dichloroethylenes, PCE, and 1,2-dichloroethane. At least one halogenated aliphatic compound was detected in water from each of the three aquifers. The highest concentrations of TCE were detected in water samples from the upper aquifer in Logan Township (wells 15-546, 15-593 through 15-595, and 15-714) and Paulsboro Borough (well 15-673) (pl. 1A and table 2). Unpublished data from previous investigations (Kenneth DiMuzio, Greenwich Township, written commun., 1988) indicated the presence of TCE and other chlorinated solvents in water from the upper aquifer in Greenwich Township near one of the Township's public-supply wells (well 15-347) (pl. 1A and table 2). TCE was detected in water samples from the unconfined part of the middle aquifer (wells 15-69 and 15-347), and from the confined parts of the aquifer system downdip from those wells and in Paulsboro Borough (wells 15-210 and 15-212) (pl. 1A and table 2). PCE was detected in water samples from the middle aquifer in Greenwich Township and Paulsboro Borough (wells 15-69, 15-210, and 15-212), and from the upper and middle aquifers in the industrial areas of Logan Township (Kozinski and others, 1990, app. 1-4) (pl. 1A and table 2). These compounds also were detected in samples from wells 15-221 and 15-672, screened in the lower aquifer in Paulsboro Borough and Greenwich Township (pl. 1A and table 2).

During 1982-88, water samples from the six public-supply wells in Greenwich Township and Paulsboro Borough were collected by the USGS and analyzed for purgeable organic compounds. The three Greenwich Township public-supply wells were sampled in 1980, 1985, 1986, and 1988; well 15-347 also was sampled in 1987 (pl. 1A and table 2). The three Paulsboro Borough public-supply wells were sampled in 1980, 1981, 1982, 1986, 1987, and 1988; well 15-210 also was sampled in 1983, 1984, and 1985 (pl. 1A and table 2). With the exception of samples from Greenwich Township well #6 (well 15-348), samples from all of these public-supply wells contained detectable concentrations of purgeable organic compounds, all of which were halogenated alphatic compounds. Since 1982, TCE was detected in every sample from Greenwich Township well #5 (well 15-347) (pl. 1A and table 2). The concentration of TCE increased to a maximum of 2.6 μg/L in November 1987, but then decreased steadily to 1.6 μg/L in August 1988. Another halogenated aliphatic compound, 1,1,1-trichloroethane, also was detected in samples from this well. The maximum concentration measured was 0.40 μg/L (table 2), which is almost 2 orders of magnitude less than the NJDEP MCL of 26 μg/L (table 6; New Jersey Register, 1989). From November 1987 to August 1988, the compound was not detected in samples from this well.

Samples from Greenwich Township well #3 (later renamed well #4) (well 15-69) (pl. 1A) contained no detectable concentrations of purgeable organic compounds until May 1988, when PCE was detected at a concentration of 0.30 μg/L (the NJDEP MCL for PCE is 1.0 μg/L (New Jersey Register, 1989)). In August 1988, samples from the same well contained 0.50 μg/L PCE and 0.20 μg/L TCE. Although some of the water samples from the public-supply wells in Greenwich Township contained TCE in concentrations greater than the NJDEP MCL of 1.0 μg/L, the average concentration of TCE in samples collected from the water-supply system has been less than this value (John Redmond, Greenwich Township, oral commun., 1988).

Since 1986, water samples from the three public-supply wells in Paulsboro Borough have contained detectable concentrations of 11 purgeable organic compounds. Compounds that were detected consistently are 1,1-dichloroethane, 1,2-dichloroethane, PCE, and 1,2-dichloropropane. In general, concentrations of most of the purgeable organic compounds were near the detection limit and remained fairly constant from 1986 through 1988. Occasionally, however, some of these compounds have been detected in concentrations greater than their respective drinking-water regulations. For example, water samples collected from wells 15-210 and 15-213 (pl. 1A) in October 1986 and November 1987 contained 1,2-dichloroethane in concentrations at or greater than the NJDEP MCL of 2.0 μg/L (table 6; New Jersey Register, 1989). Water samples from the supply system collected and analyzed during 1984-85 contained as much as 5.6 μg/L 1,2-dichloroethane; water samples collected after June 1985, however, contained no detectable concentrations of purgeable organic compounds (John Daley, Paulsboro Borough Water Department, oral commun., 1988).

Water samples collected during 1986-88 from other public-supply wells in the region (table 2) contained no detectable purgeable organic compounds.

Phenols

Phenols, which are similar in structure to aromatic organic compounds, can be present naturally in ground water through the breakdown of organic materials. Concentrations of phenols in uncontaminated ground water typically are less than 1 μg/L (Thurman, 1985, p. 143). In the Greenwich Township region, phenols were detected in water samples from all three aquifers of the Potomac-Raritan-Magothy aquifer system. The median concentration in the 76 potable-water samples that were analyzed for total recoverable phenols was 3 μg/L--a concentration higher than the typical background concentration. An inverse relation between the concentration of phenols and well depth was not apparent.

Concentrations of phenols greater than 5 μg/L to a maximum of 570 μg/L were measured in water samples from the upper Cenozoic deposits or the middle aquifer in the industrial area in Paulsboro Borough and Greenwich and northwestern West Deptford Townships. In addition, high concentrations of phenols (10,000 μg/L in 1986 and 100 μg/L in 1988) have been reported for samples from wells screened in the middle aquifer in the industrial area in Greenwich Township (D.A. Cox, Hercules, Incorporated, written commun., 1986; D.A. Cox, Hercules, Incorporated, written commun., 1988). Samples from other wells screened in the middle aquifer at the same site did not contain detectable concentrations of phenols (D.A. Cox, Hercules, Incorporated, written commun., 1987); hence, the distribution of phenols in the middle aquifer at this site was site-specific and discontinuous.

Concentrations of phenols greater than ambient concentrations in ground water in the Greenwich Township region probably are the result of anthropogenic contamination. Although the presence of phenols in ground water can result from the natural breakdown of organic matter, they also can be produced through chemical reactions involving benzene, and they commonly are used in the production of materials such as nylon, oil additives, drugs, pesticides, explosives, dyes, and gasoline additives (Moore and Ramamoorthy, 1984, p. 142). Potential sources of phenols in the Greenwich Township region include the phenol manufacturing and discharges from numerous chemical and petroleum plants and sewage-treatment plants (table 1).

SUMMARY AND CONCLUSIONS

Regional variations in water chemistry in the Potomac-Raritan-Magothy aquifer system, the sole-source aquifer in the region of Greenwich Township in northern Gloucester County, New Jersey, were evaluated by analyzing samples from 185 wells. Results of these analyses were used to describe the effects of industrial and other urban land uses on the quality of potable-water supplies in the region.

The chemistry of the ground water in the shallow parts of the upper and middle aquifers varies with the quality of precipitation, recharge from overlying wetlands (some of which are filled with Delaware River dredge-spoils) and from the Delaware River estuary, chemical reactions with aquifer materials, and contamination from industrial and landfill sites. Although the ground-water quality varies greatly, pH, specific conductance, and the concentration of dissolved solids generally are low in the ambient ground water. The predominant dissolved cation generally is calcium or sodium, and the predominant anion is sulfate or bicarbonate. Higher pH, specific-conductance values, concentrations of dissolved solids, and proportions of dissolved sodium and bicarbonate ions were found downgradient than upgradient in the aquifer system, reflecting chemical reactions with aquifer materials (including mineral dissolution, redox reactions, cation exchange, and oxidation of lignite) and the quality of water leaking from the overlying marine deposits. Increased concentrations of sodium and chloride in the southern part of the region probably are caused by mixing with saline water from deep parts of the aquifers in southern Gloucester County. Water in most of the confined lower aquifer is slightly saline, probably because of limited recharge, but shows the effects of dilution by recharge in the northeastern part of the region, near the location of the outcrop in Pennsylvania.

The presence of contaminants in ground water was identified and investigated by the U.S. Environmental Protection Agency (USEPA) and the N.J. Department of Environmental Protection (NJDEP) at 34 industrial and landfill sites in the region. Contaminants were detected in the upper aquifer in Logan, Greenwich, and West Deptford Townships, and in Paulsboro and National Park Boroughs; in the middle aquifer in Greenwich and Logan Townships; and in the lower aquifer in Greenwich Township and Paulsboro Borough. Although the ground water commonly is potable, constituent concentrations differed from background concentrations at or near most of these sites and at additional sites near Repaupo and Repaupo Station in Logan Township, near the border of Logan and Woolwich Townships, in Woodbury, in Westville, and in northern West Deptford Township. In general, ground water collected at or near all of these sites had a lower concentration of dissolved oxygen, lower pH, higher specific conductance, and higher concentrations of chloride, sulfate, calcium, magnesium, iron, manganese, nitrate, ammonia, and dissolved organic carbon than did ambient ground water regionally. In addition, priority pollutants and purgeable organic compounds were detected most frequently in ground-water samples collected at or near these sites.

Elevated constituent concentrations were especially prevalent in water from the upper Cenozoic deposits and middle aquifer in the industrial area in Paulsboro Borough and Greenwich and northwestern West Deptford Townships. Recharge of slightly to moderately saline water from the Delaware River estuary during drought can contribute to the elevated concentrations of major ions found in the ground water in this area. Because sodium-to-chloride ratios and sulfate-to-chloride ratios in ground water from this area were higher than would be expected if concentrations were solely the result of dilution of saline recharge, however, an additional source of these constituents is indicated. In most cases, elevated concentrations of constituents relative to background concentrations can be attributed to the addition of chemicals to the ground water through leaks, spills, disposal, or reactions of contaminants with aquifer materials.

Ground-water samples from 10 percent of the wells contained concentrations of sulfate greater than the USEPA secondary maximum contaminant level (SMCL); all of these wells are in the industrial area in Paulsboro Borough or Greenwich or northwestern West Deptford Township.

Samples from 8 percent of the wells contained one or more trace elements in concentrations greater than USEPA maximum contaminant levels (MCL's). Most of the wells that contained trace elements were located at or near the industrial or landfill sites. The solubility of trace elements, which can be present as a result of redox reactions involving aquifer materials or anthropogenic contamination, is enhanced by the acidic and reducing conditions prevalent at these sites. Oxidation of reduced organic contaminants in the ground water at these sites can lower the pH and the concentration of dissolved oxygen and produce more soluble organic complexes, thereby enhancing trace-element mobility.

As in other parts of New Jersey, iron and manganese in the Greenwich Township region commonly were present at concentrations greater than USEPA SMCL's in the shallow parts of the aquifer system, where dissolved oxygen is depleted and conditions are predominantly reducing and acidic. Concentrations of iron and manganese were greater than the SMCL's in approximately 67 percent of the sampled wells. In addition, elevated concentrations of radium-226 and radium-228 in water from these parts of the aquifer system can be attributed to the local geology and the stability of iron and manganese oxyhydroxide minerals.

Samples from 7 percent of the wells contained concentrations of nitrate greater than the USEPA MCL. Concentrations of ammonia also were elevated and reached a maximum of 200 mg/L in the industrial area in Paulsboro Borough and Greenwich and northwestern West Deptford Townships. At most sites in this area, ammonia concentrations were 5 to 300 times greater than nitrate concentrations, reflecting the predominance of reduced-nitrogen sources and reducing conditions. Reduction of oxidized nitrogen through redox reactions involving reduced-sulfur species may contribute to the concentration of ammonia in the ground water. At some sites, nitrification of ammonia in the ground water can occur as water moves offsite and becomes oxidizing.

Synthetically produced purgeable organic compounds, predominantly light monocyclic aromatic hydrocarbons and halogenated aliphatic compounds, were detected in ground water from 40 percent of the sampled wells and in all three aquifers, but were detected most frequently in the middle aquifer. Samples from 22 percent of the wells contained total purgeable organic compounds in concentrations equal to or greater than USEPA or NJDEP MCL's. Twelve purgeable organic compounds were detected in concentrations equal to or greater than USEPA or NJDEP MCL's, including benzene, trichloroethylene, chlorobenzene, and cis- plus trans-1,2-dichloroethylene. Other purgeable organic compounds detected for which no regulations currently (1990) exist include ethyl benzene, toluene, chloroform, and 1,1-dichloroethane. The presence of purgeable organic compounds in the confined lower aquifer and downgradient from the recharge area in confined parts of the middle aquifer indicate both lateral and vertical transport from surface sources.

Despite the effects of local sources of ground-water contamination, most of the water in the Greenwich Township region is still potable. The detection of halogenated aliphatic purgeable organic compounds and increasing concentrations of sulfate and iron and decreasing pH through time in water samples from the Greenwich Township and Paulsboro Borough public-supply wells, which are screened in the middle aquifer less than 1 mile downgradient from the industrial area, indicate that the quality of the ground water has been degraded.

REFERENCES CITED

Ames, L.L., McGarrah, J.E., Walker, B.A., and Salter, P.F., 1983, Uranium and radium sorption on amorphous ferric oxyhydroxide: Chemical Geology, v. 40, p. 135-148.

Anderson, P.W., Faust, S.D., and McCall, J.E., 1972, Impact of drought on New Jersey's water resources: American Society of Civil Engineers, Journal of the Irrigation and Drainage Division, Proceedings Paper 9205, v. 98, no. IR3, p. 375-385.

Back, W., 1966, Hydrochemical facies and ground-water flow patterns in northern part of Atlantic Coastal Plain: Hydrology of aquifer systems: U.S. Geological Survey Professional Paper 498-A, p. A1-A42.

Balmer, W.T., and Davis, D.K., in press, Ground-water resources of Delaware County, Pennsylvania: Pennsylvania Geological Survey, 4th ser., Water Resource Report 66.

Barker, C., 1979, Organic geochemistry in petroleum exploration: American Association of Petroleum Geologists Education Course Note Series no. 10, Tulsa, Okla., American Association of Petroleum Geologists, March 1979, 159 p.

Barksdale, H.C., Greenman, D.W., Lang, S.M., Hilton, G.S., and Outlaw, D.E., 1958, Ground-water resources in the tri-state region adjacent to the lower Delaware River: New Jersey Department of Conservation and Economic Development, Division of Water Policy and Supply, Special Report 13, 190 p.

Barton, Cynthia, and Kozinski, Jane, 1991, Hydrogeology of the region of Greenwich Township, Gloucester County, New Jersey: U.S. Geological Survey Water-Resources Investigations Report 90-4198, 77 p.

Brady, N.C., 1974, The nature and properties of soils (8th ed.): New York, McMillan Publishing Co., Inc., 639 p.

Chapelle, F.H., 1983, Groundwater chemistry and calcite cementation of the Aquia aquifer in southern Maryland: Water Resources Research, v. 19, no. 2, p. 545-558.

Chapelle, F.H., and Knobel, L.L., 1983, Aqueous geochemistry and the exchangeable cation composition of glauconite in the Aquia aquifer, Maryland: Ground Water, v. 21, no. 3, p. 343-352.

_____ 1985, Stable carbon isotopes of HCO_3^- in the Aquia aquifer, Maryland: Evidence for an isotopically heavy source of CO_2: Ground Water, v. 23, no. 5, p. 592-599.

Chapelle, F.H., Zelibor, J.L., Jr., Grimes, D.J., and Knobel, L.L., 1987, Bacteria in deep coastal plain sediments of Maryland: A possible source of CO_2 to groundwater: Water Resources Research, v. 23, no. 8, p. 1625-1632.

Conover, W.J., 1980, Practical nonparametric statistics, (2d ed.): New York, John Wiley & Sons, 493 p.

Cothern, C.R., and Lappenbusch, W.L., 1984, Compliance data for the occurrence of radium and gross alpha-particle activity in drinking water supplies in the United States: Health Physics, v. 46, no. 3, p. 503-510.

Drever, J.I., 1982, The geochemistry of natural waters: Englewood Cliffs, N.J., Prentice-Hall, Inc., 388 p.

Duran, P. B., 1986, Distribution of bottom sediments and effects of proposed dredging in the ship channel of the Delaware River between northeast Philadelphia, Pennsylvania, and Wilmington, Delaware, 1984: U.S. Geological Survey Hydrologic Investigations Atlas HA-697, 1 sheet, scale 1:48,000.

Durfor, C.N. and Becker, E., 1964, Public water supplies of the 100 largest cities in the United States, 1962: U.S. Geological Survey Water-Supply Paper 1812, 364 p.

Eckel, J.A., and Walker, R.L., 1986, Water levels in major artesian aquifers of the New Jersey Coastal Plain, 1983: U.S. Geological Survey Water-Resources Investigations Report 86-4028, 62 p.

Ervin, E.M., Voronin, L.M., and Fusillo, T.V., 1994, Water quality of the Potomac-Raritan-Magothy aquifer system in the Coastal Plain, west-central New Jersey: U.S. Geological Survey Water-Resources Investigations Report 94-4113, 114 p.

Evans, C.H., Goldman, S.J., Jenner, H.H., and Lawrence, W., III, 1974, Repaupo Creek watershed, Gloucester County, New Jersey: An environmental planning study: Philadelphia, Pa., University of Pennsylvania, unpublished Master's thesis, 229 p.

Farlekas, G.M., Nemickas, Bronius, and Gill, H.E., 1976, Geology and ground-water resources of Camden County, New Jersey: U.S. Geological Survey Water-Resources Investigations 76-76, 146 p.

Feltz, H.R., Anthony, E.R., and Sadler, P., eds., 1984, 1984 water quality laboratory services catalog: U.S. Geological Survey Open-File Report 83-758, 188 p.

Fishman, M.J., and Friedman, L.C., eds., 1985, 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.

Freeze, R.A., and Cherry, J.A., 1979, Groundwater: Englewood Cliffs, N.J., Prentice-Hall, Inc., 604 p.

Friedman, L.C., and Erdmann, D.E., 1982, Quality assurance practices for the chemical and biological analyses of water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A6, 181 p.

Fusillo, T.V., Hochreiter, J.J., Jr., and Lord, D.G., 1984, Water-quality data for the Potomac-Raritan-Magothy aquifer system in southwestern New Jersey, 1923-1983: U.S. Geological Survey Open-File Report 84-737, 127 p.

_____ 1985, Distribution of volatile organic compounds in a New Jersey Coastal Plain aquifer system: Ground Water, v. 23, no. 3, p. 354-360.

Fusillo, T.V., and Voronin, L.M., 1981, Water-quality data for the Potomac-Raritan-Magothy aquifer system, Trenton to Pennsville, New Jersey, 1980: U.S. Geological Survey Open-File Report 84-737, 127 p.

Gill, H.E., and Farlekas, G.M., 1976, Geohydrologic maps of the Potomac-Raritan-Magothy aquifer system in the New Jersey Coastal Plain: U.S. Geological Survey Hydrologic Investigations Atlas HA-557, 2 sheets, 1:500,000.

Given, P.H., 1975, Environmental organic chemistry of bogs, marshes, and swamps, in Eglinton, G., senior reporter, Environmental chemistry, volume 1: A review of recent literature concerning the organic chemistry of environments published up to mid-1973: London, The Chemical Society, p. 55-80.

Greenman, D.W., Rima, D.R., Lockwood, W.N., and Meisler, Harold, 1961, Ground-water resources of the Coastal Plain area of southeastern Pennsylvania, with special reference to the effects of human activities on the quality of water in the Coastal Plain sediments: Pennsylvania Geological Survey Bulletin, 4th ser., Bulletin W13, 375 p.

Hardt, W.F., and Hilton, G.S., 1969, Water resources and geology of Gloucester County, New Jersey: New Jersey Department of Conservation and Economic Development Special Report 30, 130 p.

Harriman, D.A., and Sargent, B.P., 1985, Ground-water quality in east-central New Jersey, and a plan for sampling networks: U.S. Geological Survey Water-Resources Investigations Report 85-4243, 114 p.

Heath, R.C., 1983, Basic ground-water hydrology: U.S. Geological Survey Water-Supply Paper 220, 84 p.

Helsel, D.R., 1987, Advantages of nonparametric procedures for analysis of water-quality data: Hydrological Sciences Journal, v. 32, no. 2, June 1987, p. 179-190.

Hem, J.D., 1985, Study and interpretation of the chemical characteristics of natural water (3d ed.): U.S. Geological Survey Water-Supply Paper 2254, 263 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.

Horowitz, A.J., 1985, A primer on trace metal-sediment chemistry: U.S. Geological Survey Water-Supply Paper 2227, 67 p.

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

Keith, L.H., and Telliad, W.A., 1979, Priority pollutants, I--A perspective view: Environmental Science and Technology, v. 13, no. 4, April 1979, p. 416-423.

Kish, G.R., Macy, J.A., and Mueller, R.T., 1987, Trace-metal leaching from plumbing materials exposed to acidic ground water in three areas of the Coastal Plain of New Jersey: U.S. Geological Survey Water-Resources Investigations Report 87-4146, 19 p.

Knobel, L.L., and Phillips, S., 1988, Aqueous geochemistry of the Magothy aquifer, Maryland: U.S. Geological Survey Water-Supply Paper 2323, 28 p.

Kozinski, Jane, Lacombe, P.J., Hochreiter, J.J., Jr., and Lewis, J.C., 1990, Geophysical and chemical investigations of ground water at five industrial or waste-disposal sites in Logan Township, Gloucester County, New Jersey, 1983-87: U.S. Geological Survey Water-Resources Investigations Report 90-4004, 131 p.

Langmuir, D., 1969a, Iron in ground waters of the Magothy and Raritan Formations in Camden and Burlington Counties, New Jersey: New Jersey Department of Conservation and Economic Development, Division of Water Policy and Supply, Water Resources Circular no. 19, 29 p.

_____ 1969b, Geochemistry of iron in a Coastal Plain ground water of the Camden, New Jersey, area: U.S. Geological Survey Professional Paper 650-C, p. C224-C235.

Lewis, J.C., Hochreiter, J.J., Jr., Barton, G.J., Kozinski, Jane, and Spitz, F.J., 1991, Hydrogeology of, and ground-water quality in, the Potomac-Raritan-Magothy aquifer system in the Logan Township region, Gloucester and Salem Counties, New Jersey: U.S. Geological Survey Water-Resources Investigations Report 90-4142, 91 p.

Louis, J.B., and Vowinkel, Eric, 1989, Effect of agricultural chemicals on ground water quality in the New Jersey Coastal Plain, in Weigmann, D.L., ed., Pesticides in terrestrial and aquatic environments: Proceedings of a national research conference, May 11-12, 1989, Blacksburg, Va., Virginia Water Resources Research Center, Virginia Polytechnic Institute and State University, p. 80-89.

Luzier, J.E., 1980, Digital simulation and projection of head changes in the Potomac-Raritan-Magothy aquifer system, Coastal Plain, New Jersey: U.S. Geological Survey Water-Resources Investigations 80-11, 72 p.

Michel, J., and Moore, W.S., 1980, Ra-228 and Ra-226 content of ground water in Fall Line aquifers: Health Physics, v. 38, no. 4, p. 663-671.

Moore, J.W., and Ramamoorthy S., 1984, Heavy metals in natural waters: New York, Springer-Verlag New York, Inc., 268 p.

Navoy, A.S., and Carleton, G.B., 1995, Ground-water flow and future conditions in the Potomac-Raritan-Magothy aquifer system, Camden area, New Jersey: New Jersey Geological Survey Report GSR 38, 184 p., 2 pl.

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

Owens, J.P., and Sohl, N.F., 1969, Shelf and deltaic paleoenvironments in the Cretaceous-Tertiary formations of the New Jersey Coastal Plain, in Subitzky, Seymour, ed., Geology of selected areas in New Jersey and eastern Pennsylvania and guidebook of excursions: Geological Society of America and associated societies annual meeting, November 1969, Atlantic City, New Jersey: New Brunswick, N.J., Rutgers University Press, p. 235-278.

Parker, G.G., Hely, A.G., Keighton, W.B., and Olmsted, F.H., 1964, Water resources of the Delaware River Basin: U.S. Geological Survey Professional Paper 381, 200 p.

Peart, D.B., and Thomas, N.A., 1983, Quality-assurance data for routine water analysis in the laboratories of the U.S. Geological Survey for water year 1982: U.S. Geological Survey Water-Resources Investigations Report 83-4264, 38 p.

Piper, A.M., 1944, A graphic procedure in the geochemical interpretation of water analyses: EOS: Transactions of the American Geophysical Union, v. 25, no. 6, p. 914-928.

Plummer, L.N., Jones, B.F., and Truesdell, A.H., 1978, WATEQF-A Fortran IV version of WATEQ, a computer program for calculating chemical equilibrium of natural waters: U.S. Geological Survey Water-Resources Investigations 76-13, 66 p.

R.E. Wright Associates, 1985, Draft remedial investigation report and feasibility study of alternatives--Helen Kramer Landfill site, Mantua Township, Gloucester County, New Jersey, July 1985: Camp Hill, Pa., R.E. Wright Associates, unpublished report, unpaginated.

Robbins, G.A., and Bristol, R.D., 1988, Inorganic ground water quality attributes of subsurface gasoline contamination: EOS: Transactions of the American Geophysical Union, v. 69, no. 44, p. 1212.

Rosen, M.E., Pankow, J.F., Gibs, Jacob, and Imbrigiotta, T.E., 1992, Comparison of downhole and surface sampling for the determination of volatile organic compounds (VOCs) in ground water: Ground Water Monitoring Review, v. 12, no. 1, p. 126-133.

Rosenau, J.C., Lang, S.M., Hilton, G.S., and Rooney, J.G., 1969, Geology and ground-water resources of Salem County, New Jersey: New Jersey Department of Conservation and Economic Development Special Report 33, 142 p.

Ryan, B.F., Joiner, B.L., and Ryan, T.A., Jr., 1985, Minitab handbook (2d ed.): Boston, Mass., PWS Publishers, 374 p.

Schaefer, F.L., 1983, Distribution of chloride concentrations in the principal aquifers of the New Jersey Coastal Plain, 1977-81: U.S. Geological Survey Water-Resources Investigations Report 83-4061, 56 p.

Szabo, Zoltan, and Zapecza, O.S., 1987, Relation between natural radionuclide activities and chemical constituents in ground water in the Newark Basin, New Jersey, in Graves, Barbara, ed., Radon in ground water--Hydrogeologic impact and indoor air contamination: Chelsea, Mich., Lewis Publishers, Inc., p. 283-308.

U.S. Environmental Protection Agency, undated, Potential hazardous waste site--Site inspection report, Hercules, Inc., Greenwich Township, New Jersey: U.S. Environmental Protection Agency, unpublished report, unpaginated.

_____ 1980, Potential hazardous waste site--Identification and preliminary assessment, National Park Landfill, National Park Borough, New Jersey: U.S. Environmental Protection Agency, unpublished report, unpaginated.

_____ 1981, Potential hazardous waste site--Site inspection report, Helen Kramer Landfill, Mantua Township, New Jersey: U.S. Environmental Protection Agency, unpublished report, unpaginated.

_____ 1983a, Potential hazardous waste site--Site inspection report, E.I. DuPont, Paulsboro Borough Works, Paulsboro Borough, New Jersey: U.S. Environmental Protection Agency, unpublished report, unpaginated.

_____ 1983b, Potential hazardous waste site--Preliminary assessment, Winner Chemical, Inc., Paulsboro Borough, New Jersey: U.S. Environmental Protection Agency, unpublished report, unpaginated.

_____ 1984a, Potential hazardous waste site--Preliminary assessment, Higgins Plant (a.k.a. Hercules, Inc.), Greenwich Township, New Jersey: U.S. Environmental Protection Agency, unpublished report, unpaginated.

_____ 1984b, Potential hazardous waste site--Preliminary assessment, Air Products and Chemicals, Inc., Paulsboro Borough, New Jersey: U.S. Environmental Protection Agency, unpublished report, unpaginated.

_____ 1984c, Potential hazardous waste site--Preliminary assessment, Mantua Metal Products Co., Inc., Woodbury, New Jersey: U.S. Environmental Protection Agency, unpublished report, unpaginated.

_____ 1984d, Potential hazardous waste site--Preliminary assessment, Matlack, Inc., Swedesboro (Woolwich), New Jersey: U.S. Environmental Protection Agency, unpublished report, unpaginated.

_____ 1984e, Potential hazardous waste site--Preliminary assessment, Shell Chemical Company, Woodbury Plant, West Deptford, New Jersey: U.S. Environmental Protection Agency, unpublished report, unpaginated.

_____ 1985a, Potential hazardous waste site--Preliminary assessment, E.I. DuPont Nemours and Co., Inc., Greenwich Township, New Jersey: U.S. Environmental Protection Agency, unpublished report, unpaginated.

_____ 1985b, Potential hazardous waste site--Preliminary assessment, Dupont Repauno Plant SLF (Sanitary Landfill), Greenwich Township, New Jersey: U.S. Environmental Protection Agency, unpublished report, unpaginated.

_____ 1985c, Potential hazardous waste site--Preliminary assessment, Mobil Oil Corporation, Greenwich Township, New Jersey: U.S. Environmental Protection Agency, unpublished report, unpaginated.

_____ 1985d, Potential hazardous waste site--Preliminary assessment, BP Oil, Paulsboro Borough, New Jersey: U.S. Environmental Protection Agency, unpublished report, unpaginated.

_____ 1985e, Potential hazardous waste site--Preliminary assessment, Paulsboro Coal Gas, Paulsboro Borough, New Jersey: U.S. Environmental Protection Agency, unpublished report, unpaginated.

_____ 1985f, Potential hazardous waste site--Preliminary assessment, Timberlane Welding and Services, Inc., Paulsboro Borough, New Jersey: U.S. Environmental Protection Agency, unpublished report, unpaginated.

_____ 1985g, Potential hazardous waste site--Preliminary assessment, Colonial Pipeline, West Deptford, New Jersey: U.S. Environmental Protection Agency, unpublished report, unpaginated.

_____ 1985h, Potential hazardous waste site--Preliminary assessment, Nalco Chemical Co., Inc., West Deptford, New Jersey: U.S. Environmental Protection Agency, unpublished report, unpaginated.

_____ 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 and 586-587.

_____ 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.

Wershaw, R.L., Fishman, M.J., Grabbe, R.R., and Lowe, L.E., 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.

Zapecza, O.S., 1989, Hydrogeologic framework of the New Jersey Coastal Plain: U.S. Geological Survey Professional Paper 1404-B, 49 p., 24 pl.

Zapecza, O.S., and Szabo, Zoltan, 1988, Natural radioactivity in ground water--A review, in Moody, D.W., Carr, J., Chase, E.B., and Paulson, R.W., comp., National water summary 1986--Hydrologic events and ground-water quality: U.S. Geological Survey Water-Supply Paper 2325, p. 50-57.

Table 1. **Summary of sites and aquifers in the region of Greenwich Township, Gloucester County, New Jersey, at which ground-water contamination has been identified or is suspected by the U.S. Environmental Protection Agency and New Jersey Department of Environmental Protection; contaminant types; and sources of data**

[As used in this report, a contaminant is any organic compound detected in ground-water samples that is not present naturally, or any trace element present in the ground water at a concentration greater than the U.S. Environmental Protection Agency or N.J. Department of Environmental Protection maximum contaminant level for that element. X, organic contaminants or trace elements are present at concentrations greater than applicable maximum contaminant levels; ND, organic contaminants or trace elements are absent or concentrations of trace elements do not exceed applicable maximum contaminant levels; ?, the presence of organic contaminants or trace elements in ground water at the site is suspected by the U.S. Environmental Protection Agency and New Jersey Department of Environmental Protection; --, no information available; NA, the aquifer is not present at the site; NJDEP, New Jersey Department of Environmental Protection; USEPA, U.S. Environmental Protection Agency; table 2, data presented in table 2 at the end of this report]

		Contaminant type				Aquifers containing contaminants[3]			
		Organic compounds					Potomac-Raritan-Magothy aquifer system		
Map number	Site name[1]	Purgeable organic compounds	Oil and grease	Other hydro-carbons[2]	Trace elements	Overlying aquifers[4]	Upper aquifer	Middle aquifer	Lower aquifer
				Deptford Township					
1	Marvin Jonas, Inc.	X	?	ND	--	X	--	--	--
				East Greenwich Township					
2	EM Diagnostics	X	--	--	ND	X	--	--	--
				Greenwich Township					
3	E.I. Dupont	X	--	X	ND	--	X	X	X
4	E.I. Dupont Sanitary Landfill	X	--	?	ND	X	?	?	--
5	Hercules Chemicals, Inc.	X	--	X	X	--	X	X	?
6	Municipal Landfill	X	--	--	ND	--	NA	X	--
7	Mobil Oil Corporation	X	X	X	X	--	X	X	X
8	Mobil Oil Corp. Sanitary Landfill	X	--	--	X	--	X	?	--
				Logan Township					
9	Redcole Farm	--	--	--	?	--	?	--	--
10	Bridgeport Rental & Oil Services	X	X	X	X	--	X	?	--

Footnotes at end of table.

Table 1. Summary of sites and aquifers in the region of Greenwich Township, Gloucester County, New Jersey, at which ground-water contamination has been identified or is suspected by the U.S. Environmental Protection Agency and New Jersey Department of Environmental Protection; contaminant types; and sources of data--Continued

Use of site	Past or present known or potential sources of ground-water contamination	Reference(s)	Site name	Map number
		Deptford Township		
Hazardous-waste shipping	Leakage of unknown wastes from above-ground containers; discharge of petroleum and other, unknown wastes onto the ground	R. Gervasio, NJDEP, oral commun., 1988	Marvin Jonas Inc.	1
		East Greenwich Township		
Manufacture of chemical test kits	Landfill and other chemical-storage facilities	William Althoff, NJDEP, written commun., 1985	EM Diagnostics	
		Greenwich Township		
Manufacture of chemicals, including sulfuric, nitric, and nitrosyl-sulfuric acids; aniline and nitrobenzene; sodium nitrate; and pyromel-itic dianydribe. Formerly, production of dynamite	Chemicals stored and used onsite: benzene, sodium hydroxide, molten sulfur, and ammonia. Other sources: tarpits, five underground gasoline-storage tanks, above-ground drums, and underground anhydrous ammonia caverns	table 2; USEPA, 1985a	E.I. Dupont	3
Landfill used for burning dynamite and nitro-cellulose	Residues of dynamite and nitro-cellulose	USEPA, 1985b	E.I. Dupont Sanitary Landfill	4
Formerly, production of phenol, cresol, and other organic compounds. Currently, manufacture of cumene hydroperoxide, di-isopropyl-benzene hydro-peroxide, and dicumyl peroxide	Landfill, materials-handling and -storage areas, wastewater-treat-ment lagoons, and 12 sludge-drying beds. Superfund site	table 2; USEPA, undated; USEPA, 1984a; D.A. Cox, Hercules, Inc., written commun., 1986	Hercules Chemicals, Inc.	5
Landfill	Household waste, dried sewage sluge, vegetation, and waste oil and sludges	John Redmond, Greenwich Township, written commun., 1988	Municipal Landfill	6
Petroleum refinery, stor-age, and transfer center; research center	Leaky above-ground storage tanks, underground pipelines, 12.5-acre sanitary landfill, product-transfer areas, stormwater and emergency process-water ponds. Free petro-leum product is present in the shallow aquifer	table 2; USEPA, 1985c; D.E. Choate, Mobil Oil Corp., written commun., 1986	Mobil Oil Corporation	7
Industrial landfill	Construction waste, dry hazardous and non-hazardous chemical waste, oil-spill clean-up materials, and septic-tank sludge	D. Kaplan, NJDEP, written commun., 1979; D.E. Choate, Mobil Oil Corp., written commun., 1986	Mobil Oil Corp. Sanitary Landfill	8
		Logan Township		
Suspected former solid-waste disposal area	Buried dried chrome sludge	Kozinski and others, 1990	Redcole Farm	9
Former waste-oil pro-cessing plant	Unlined waste-oil lagoon, and above-ground and underground storage tanks. Superfund site	Kozinski and others, 1990	Bridgeport Rental & Oil Services	10

Table 1. Summary of sites and aquifers in the region of Greenwich Township, Gloucester County, New Jersey, at which ground-water contamination has been identified or is suspected by the U.S. Environmental Protection Agency and New Jersey Department of Environmental Protection; contaminant types; and sources of data--Continued

		Contaminant type				Aquifers containing contaminants[3]			
		Organic compounds					Potomac-Raritan-Magothy aquifer system		
Map number	Site name[1]	Purgeable organic compounds	Oil and grease	Other hydro-carbons[2]	Trace elements	Overlying aquifers [4]	Upper aquifer	Middle aquifer	Lower aquifer
	Logan Township--Continued								
11	Chemical Leaman Tank Lines	X	--	X	X	--	X	X	?
12	Rollins Environmental Services	X	--	X	X	--	X	X	--
13	Municipal Landfill	--	--	?	?	--	?	--	--
	Mantua Township								
14	Kramer Landfill	X	?	X	X	X	ND	--	--
15	Municipal Landfill	X	--	--	ND	X	--	--	--
	National Park Borough								
16	National Park Landfill	ND	X	--	ND	--	X	--	--
	Paulsboro Borough								
17	Air Products & Chemicals, Inc.	X	--	?	?	--	X	?	X
18	BP Oil Company	X	X	X	X	--	X	?	?
19	DuPont Paulsboro Works	--	--	--	?	--	?	--	--
20	Essex Chemical Company	X	--	--	X	--	X	?	X
21	Exxon Corporation	X	X	X	ND	--	X	?	?

Footnotes at end of table.

Table 1. Summary of sites and aquifers in the region of Greenwich Township, Gloucester County, New Jersey, at which ground-water contamination has been identified or is suspected by the U.S. Environmental Protection Agency and New Jersey Department of Environmental Protection; contaminant types; and sources of data--Continued

Use of site	Past or present known or potential sources of ground-water contamination	Reference(s)	Site name	Map number
		Logan Township--Continued		
Chemicals shipping. Onsite cleaning of tank trucks	Wastewater aeration and treatment lagoons; discharges of wastewater to ground surface. Superfund site	Kozinski and others, 1990	Chemical Leaman Tank Lines	11
Hazardous-waste treatment plant	Waste-treatment lagoons; wastewater lagoons, and above-ground storage tanks	Lewis and others, 1991	Rollins Environmental Services	12
Municipal landfill	Household waste, dried vegetation	Esther Slusarsky, Logan Township Environmental Commission, oral commun., 1988	Municipal Landfill	13
		Mantua Township		
60-acre landfill	Municipal waste, dried sewage sludge, septic-tank contents, construction debris, liquid industrial waste, and possibly more than 500,000 gallons of chemical waste	table 2; USEPA, 1981; R. E. Wright Associates, Inc., 1985	Kramer Landfill	14
Municipal landfill	Household waste, construction debris, dried vegetation, and tires	James Sickel, Mantua Township, written commun., 1988	Municipal Landfill	15
		National Park Borough		
Municipal landfill	Household waste, demolition material, junked vehicles, tires, vegetation, and agricultural and food-processing wastes	USEPA, 1980; National Park Borough, written commun., 1988	National Park Landfill	16
		Paulsboro Borough		
Manufacture of triethylenediamine, spaciality metal catalysts, and blending of organic chemicals	Underground gasoline-storage tank, stormwater lagoon, and above-ground liquid-storage tanks	table 2; USEPA, 1984b	Air Products & Chemicals, Inc.	17
Petroleum and chemical storage and transfer facility	More than 100 above-ground storage tanks, materials-handling and -storage areas, and drainage ponds. Free patroleum product is present in the unconfined aquifer	table 2; USEPA, 1985d	BP Oil Company	18
Manufacture of sulfuric acid	Lead sulfate residue discharged to surface water	USEPA, 1983a	DuPont Paulsboro Works	19
Manufacture of hydrofluoric acid and other fluorine compounds	Chemicals stored or landfilled on-site: sodium carbonate, acetylene, ammonium silicofluoride, sodium bifluorine, hydrofluoric acid, hydrofluosilicic acid, sulfuric acid, oleum, #4 fuel oil, gasoline, and gypsum. Gypsum landfill onsite	table 2; A. Soos, Essex Chemical Corp., written commun., 1986	Essex Chemical Company	20
Storage and transfer of petroleum products	Gasoline, diesel fuel, and fuel oil stored onsite. Other sources include above-ground and underground pipas, 19 above-ground storage tanks, a water/oil separator, 2 holding ponds for stormwater and spills, an underground oil tank, and materials-handling areas	table 2; L.S. Range, NJDEP, oral commun., 1988	Exxon Corporation	21

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		Contaminant type				Aquifers containing contaminants[3]			
		Organic compounds					Potomac-Raritan-Magothy aquifer system		
Map number	Site name[1]	Purgeable organic compounds	Oil and grease	Other hydro-carbons[2]	Trace elements	Overlying aquifers[4]	Upper aquifer	Middle aquifer	Lower aquifer
	Paulsboro Borough--Continued								
22	Paulsboro Coal Gas	?	?	?	?	--	?	--	--
23	Peabody Clean Industries	X	X	X	X	--	X	?	--
24	Timberlane Welding	?	?	?	?	--	?	--	--
25	Winner Chemical Company	X	X	?	?	--	X	--	--
	West Deptford Township								
26	Colonial Pipeline	X	--	--	--	X	?	--	--
27	Deptford Plating Company	?	--	--	?	?	--	--	--
28	Lilly Industrial Coating	X	--	X	X	X	--	--	--
29	Nalco	X	?	?	?	X	--	--	--
30	Shell Chemical Company	ND	--	--	ND	?	ND	ND	ND
31	Texaco (Coastal)	X	X	X	ND	X	X	?	X
	Woodbury City								
32	Polyrez Company, Inc.	X	--	X	--	X	?	--	--
	Woodbury Heights								
33	Mantua Metal Products Company, Inc.	?	--	--	--	?	--	--	--
	Woolwich Township								
34	Matlack, Inc.	X	--	--	--	X	ND	--	--

Table 1. Summary of sites and aquifers in the region of Greenwich Township, Gloucester County, New Jersey, at which ground-water contamination has been identified or is suspected by the U.S. Environmental Protection Agency and New Jersey Department of Environmental Protection; contaminant types; and sources of data--Continued

Use of site	Past or present known or potential sources of ground-water contamination	Reference(s)	Site name	Map number
		Paulsboro Borough--Continued		
Coal-gasification plant	Waste generated and disposed of in unlined pits: ammonia, ammonium sulfate, tar, light oils, coke, and sulfur	USEPA, 1985e	Paulsboro Coal Gas	22
Cleaning of oil spills and cleaning tankers and barges	Nine above-ground storage tanks, materials-handling areas, and two unlined oil-spill collection pits. Free petroleum product is present in the unconfined aquifer	D.M. Kaplan and others, NJDEP, written commun., to J. Hamilton, USEPA, 1982	Peabody Clean Industries	23
Cleaning and repairing of gasoline transportation trucks	Wastewater from cleaning operation discharged onto ground until 1983	USEPA, 1985f	Timberlane Welding	24
--	Above-ground storage tanks and one unlined surface impoundment	USEPA, 1983b	Winner Chemical Company	25
		West Deptford Township		
Petroleum storage and transfer facility	Gasoline, kerosene, and #2 fuel oil stored onsite. Other potential sources include 19 above-ground storage tanks, materials-handling areas, and an unlined wastewater lagoon	USEPA, 1985g	Colonial Pipeline	26
Metals plating	Chromium, cyanide, and acids stored in above-ground tanks. Wastewater classifier onsite	Terry Ostrander, NJDEP, oral commun., 1988	Deptford Plating Company	27
Manufacture of paints and industrial coatings	Ten above-ground storage tanks. Methyl-isobuytl ketone spilled on ground surface	A. Arcenal, NJDEP, written commun. to J.K. Hamilton and L. Miller, NJDEP, 1981	Lilly Industrial Coating	28
Manufacture of chemicals	Wastes generated onsite include metals, oils, plastics, ethyl benzene, xylene, and other organic compounds. Potential sources include spills and leaking underground wastewater line.	USEPA, 1985h	Nalco	29
Manufacture of polypropylene	Landfill that accepts organic compounds and other wastes	table 2; USEPA, 1984e	Shell Chemical Company	30
Petroleum refinery and storage facility	Stored onsite are gasoline, diesel fuel, and fuel oil. Sources of contamination: materials-handling areas and above-ground storage tanks. Free petroleum product is present in the unconfined aquifer	USEPA, 1981; Fusillo and others, 1984; A.J. Trenham, NJDEP, oral commun., 1988; J.A. Monroe, NJDEP, oral commun., 1988	Texaco (Coastal)	31
		Woodbury City		
Manufacture of phenol-based products	Sources include materials-handling area; underground and above-ground piping, unlined surface impoundment, and underground fuel tanks	G. Chuck, NJDEP, oral commun., 1988	Polyrez Company, Inc.	32
		Woodbury Heights		
--	--	USEPA, 1984c	Mantua Metal Products Company, Inc.	33
		Woolwich Township		
Cleaning of tanks and trucks	Wastewater formerly discharged into unlined lagoons	USEPA, 1984d; P.A. Lange, NJDEP, oral commun., 1988	Matlack, Inc.	34

[1] The use of firm names in this report is for identification or location purposes only and does not impute responsibility for any present or potential effects on water resources in the study area
[2] Includes acid- and base/neutral-extractable organic compounds and others
[3] Not all contaminant types may be present in each aquifer cited
[4] Includes aquifers younger than those of the Potomac-Raritan-Magothy aquifer system

Table 2. **Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88**

[--, analysis not performed; mg/L, milligrams per liter; mm of Hg, millimeters of mercury; µg/L, micrograms per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; WD, Water Department; USGS, U.S. Geological Survey; pCi/L, picocuries per liter; deg C, degrees Celsius; USEPA, U.S. Environmental Protection Agency; MUA, Municipal Utilities Authority; <, less than]

USGS well number	Owner	Well name	Station number	Sample-collection date	Alkalinity, total, field (mg/L as $CaCO_3$)	Alkalinity as bicarbonate, field (mg/L)	Barometric pressure (mm of Hg)	Dissolved oxygen (mg/L)
			East Greenwich Township					
15- 28	East Greenwich WD	2	394755075132701	10-10-86	149	181	--	0.1
15-363	Sherman, A.	1	394618075154201	11-20-86	126	154	--	<.1
15-500	Thompson, H.	1	394704075155501	11-19-86	1	2.0	--	9.2
				08-10-88	--	3.6	768	8.7
15-501	Henderson, V.	1	394632075161401	11-19-86	135	165	--	.1
			Greenwich Township					
15- 69	Greenwich WD	3(4)	394919075160201	11-05-86	4	5.0	--	4.9
				05-11-88	--	--	--	--
				08-10-88	--	--	768	.1
15- 81	E.I. DuPont	Repauno 5	394945075171701	10-07-86	49	60	--	.1
15-347	Greenwich WD	5	394932075172202	11-05-86	19	23	--	3.4
				04-23-87	--	--	--	--
				11-05-87	--	--	--	--
				02-11-88	16	39	--	3.3
				05-11-88	--	--	--	--
				08-10-88	--	--	747	3.2
15-348	Greenwich WD	6	394920075154101	11-17-86	<1	<1.0	--	1.3
				05-11-88	--	--	--	--
				02-11-88	--	--	--	1.0
				08-10-88	--	--	768	1.0
				08-29-88	--	--	764	1.1
15-357	E.I. DuPont	OBS 7	394957075173701	10-08-86	20	27	--	.1
				10-08-86	24	27	--	.1
15-634	E.I. DuPont	40	394944075175001	10-08-86	71	87	--	<.1
15-652	Hercules Chemical	MW12	395017075163901	10-28-86	103	126	--	.6
15-657	E.I. DuPont	38	394941075173702	10-07-86	3	3.0	--	6.6
				10-07-86	2	3.0	--	6.6
15-668	Hercules Chemical	MW10-C	394944075164803	10-28-86	48	58	--	.4
				10-28-86	48	58	--	.4
15-672	Air Products		395014075145901	10-30-86	25	35	--	.1
15-678	Mobil Oil Corp.	5C	394946075161201	09-23-86	59	74	--	.5
15-679	Mobil Oil Corp.	5D	394946075161202	09-23-86	11	13	--	.5
15-680	Mobil Oil Corp.	7C	395038075160501	09-22-86	95	116	770	.2
				09-22-86	95	116	765	.2
15-681	Mobil Oil Corp.		395038075160502	09-22-86	99	121	770	.1
15-682	Mobil Oil Corp.	8D	395048075151801	11-14-86	299	365	--	2.1
15-683	Mobil Oil Corp.	9D	395021075153301	11-14-86	<1	<1.0	--	1.6
15-712	U.S. Geological Survey	Stefka 1	394808075172401	12-16-86	109	133	--	<.1
				12-16-86	109	133	--	<.1
				03-19-87	90	110	760	.1

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

USGS well number	Owner	Sample-collection date	Calcium, dissolved (mg/L as Ca)	Chloride, dissolved (mg/L as Cl)	Magnesium, dissolved (mg/L as Mg)	Potassium, dissolved (mg/L as K)	Silica, dissolved (mg/L as SiO_2)	Sodium, dissolved (mg/L as Na)	Sulfate, dissolved (mg/L as SO_4)	Aluminum, dissolved (µg/L as Al)
		East Greenwich Township								
15- 28	East Greenwich WD	10-10-86	9.2	42	2.7	5.4	10	83	11	<10
15-363	Sherman, A.	11-20-86	12	76	3.6	5.6	9.9	87	11	<10
15-500	Thompson, H.	11-19-86	20	18	7.6	2.6	9.4	2.5	18	50
		08-10-88	--	--	--	--	--	--	--	--
15-501	Henderson, V.	11-19-86	11	50	3.6	5.7	10	69	15	<10
		Greenwich Township								
15- 69	Greenwich WD	11-05-86	6.9	13	4.6	1.9	15	13	56	190
		05-11-88	--	--	--	--	--	--	--	--
		08-10-88	--	--	--	--	--	--	--	--
15- 81	E.I. DuPont	10-07-86	6.7	27	7.1	3.1	5.8	25	32	<10
15-347	Greenwich WD	11-05-86	12	18	5.8	4.5	7.5	16	33	40
		04-23-87	--	--	--	--	--	--	--	--
		11-05-87	--	--	--	--	--	--	--	--
		02-11-88	--	--	--	--	--	--	--	--
		05-11-88	--	--	--	--	--	--	--	--
		08-10-88	--	--	--	--	--	--	--	--
15-348	Greenwich WD	11-17-86	5.6	11	5.4	2.3	13	13	57	1,100
		05-11-88	--	--	--	--	--	--	--	--
		02-11-88	--	--	--	--	--	--	--	--
		08-10-88	--	--	--	--	--	--	--	--
		08-29-88	7.0	13	6.6	--	14	22	77	--
15-357	E.I. DuPont	10-08-86	34	96	16	8.9	37	99	280	40
		10-08-86	--	--	--	--	--	--	--	--
15-634	E.I. DuPont	10-08-86	94	520	27	11	9.7	490	660	<10
15-652	Hercules Chemical	10-28-86	4.8	61	2.8	.70	24	58	56	380
15-657	E.I. DuPont	10-07-86	8.1	24	3.8	3.0	8.4	15	24	30
		10-07-86	--	--	--	--	--	--	--	--
15-668	Hercules Chemical	10-28-86	24	68	14	5.0	8.2	220	760	10
		10-28-86	24	64	14	5.0	8.2	220	770	<10
15-672	Air Products	10-30-86	43	150	15	6.3	15	160	49	940
15-678	Mobil Oil Corp.	09-23-86	5.8	130	1.5	2.5	8.6	94	6.9	20
15-679	Mobil Oil Corp.	09-23-86	54	120	24	9.4	16	600	1,700	50
15-680	Mobil Oil Corp.	09-22-86	27	71	2.0	9.2	10	51	7.9	60
		09-22-86	27	73	2.1	9.1	10	53	7.9	60
15-681	Mobil Oil Corp.	09-22-86	14	53	11	2.5	9.8	33	19	10
15-682	Mobil Oil Corp.	11-14-86	36	22	13	10	5.8	23	5.0	10
15-683	Mobil Oil Corp.	11-14-86	52	65	25	9.6	70	92	720	6,300
15-712	U.S. Geological Survey	12-16-86	63	670	18	12	10	370	16	<10
		12-16-86	61	670	18	12	10	360	16	<10
		03-19-87	63	660	18	13	10	360	17	<10

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

Dissolved solids, residue at 180 deg C (mg/L)	Hardness as $CaCO_3$ (mg/L)	pH (standard units)	Specific conductance field (µS/cm)	Temperature, water (deg C)	Nitrogen, ammonia dissolved (mg/L as N)	Nitrogen, nitrite dissolved (mg/L as N)	Nitrogen, ammonia + organic dis. (mg/L as N)	Nitrogen, NO2+NO3 dissolved (mg/L as N)	Phosphorus, ortho, dissolved (mg/L as P)	USGS well number
East Greenwich Township										
296	35	7.92	446	14.0	0.310	<0.010	1.2	<0.100	0.220	15- 28
293	45	7.79	506	13.5	.300	<.010	.60	<.100	.090	15-363
141	--	5.05	185	15.5	<.010	<.010	.90	11.0	<.010	15-500
--	--	5.09	246	15.0	<.010	<.010	1.0	13.0	<.010	
242	43	7.29	400	12.0	.250	<.010	1.0	<.100	.170	15-501
Greenwich Township										
116	36	4.88	186	12.5	.100	<.010	1.0	.170	.030	15- 69
--	--	5.09	221	13.0	--	--	--	--	--	
--	--	5.01	239	13.5	--	--	--	--	--	
165	46	6.02	264	16.0	.380	.020	1.0	.500	<.010	15- 81
131	54	5.71	211	12.5	.290	<.010	.80	4.80	.030	15-347
--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	
--	--	5.59	206	14.5	--	--	--	--	--	
--	--	5.78	231	15.0	--	--	--	--	--	
--	--	5.60	240	15.5	--	--	--	--	--	
123	36	4.36	197	13.5	.020	<.010	<.20	1.10	<.010	15-348
--	--	4.31	286	14.0	--	--	--	--	--	
--	--	4.08	236	13.5	--	--	--	--	--	
--	--	4.21	273	14.5	--	--	--	--	--	
--	45	4.02	280	13.5	--	--	--	--	--	
730	150	5.27	1,010	13.5	18.0	.030	17	6.90	.010	15-357
--	--	5.30	1,010	13.5	19.0	.040	20	7.10	.010	
2,100	350	6.20	2,870	13.0	.800	<.010	.80	<.100	<.010	15-634
260	--	6.60	410	13.0	2.00	.030	2.0	<.100	2.10	15-652
89	36	5.47	173	14.5	.010	<.010	.90	1.80	.020	15-657
--	--	5.50	173	14.5	<.010	<.010	.30	1.80	<.010	
1,140	120	6.90	2,370	15.0	0	<.010	--	<.100	.010	15-668
1,160	--	6.90	2,370	15.0	0	<.010	210	<.100	.010	
813	170	4.90	910	15.5	3.30	<.010	3.5	<.100	--	15-672
292	21	6.68	528	14.5	.180	<.010	.20	<.100	<.010	15-678
3,120	230	5.27	3,790	14.5	35.0	<.010	32	<.100	.020	15-679
273	77	6.58	450	18.0	.150	<.010	.20	<.100	<.010	15-680
253	78	6.60	450	18.0	.150	<.010	.30	<.100	<.010	
224	80	7.13	398	17.0	1.70	<.010	1.8	<.100	<.010	15-681
319	140	6.53	564	14.0	1.20	<.010	1.5	<.100	<.010	15-682
1,300	230	3.67	1,380	18.5	3.30	<.010	3.2	<.100	.020	15-683
1,190	240	6.80	2,250	14.0	.980	<.010	1.3	<.100	<.010	15-712
1,250	230	6.84	2,250	14.0	--	--	--	--	--	
1,240	240	6.74	2,160	14.0	.990	<.010	1.1	<.100	<.010	

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

USGS well number	Owner	Sample-collection date	Molybdenum, dissolved (µg/L as Mo)	Strontium, dissolved (µg/L as Sr)	Vanadium, dissolved (µg/L as V)	Zinc, dissolved (µg/L as Zn)	Phenols, total (µg/L)	Carbon, organic, dissolved (mg/L as C)	Benzene (µg/L)	Bromoform (µg/L)
				East Greenwich Township						
15- 28	East Greenwich WD	10-10-86	<10	360	<6	<3	4	1.3	--	--
15-363	Sherman, A.	11-20-86	<10	440	<6	6	2	.9	--	--
15-500	Thompson, H.	11-19-86	<10	78	<6	16	3	.5	--	--
		08-10-88	--	--	--	--	--	--	--	--
15-501	Henderson, V.	11-19-86	<10	410	<6	12	3	.9	--	--
				Greenwich Township						
15- 69	Greenwich WD	11-05-86	<10	190	<6	220	4	.9	--	--
		05-11-88	--	--	--	--	--	--	<.20	<.20
		08-10-88	--	--	--	--	--	--	<.20	<.20
15- 81	E.I. DuPont	10-07-86	<10	79	<6	19	2	1.8	--	--
15-347	Greenwich WD	11-05-86	<10	90	<6	67	3	1.6	<.20	<.20
		04-23-87	--	--	--	--	--	--	<.20	<.20
		11-05-87	--	--	--	--	--	--	<.20	<.20
		02-11-88	--	--	--	--	--	--	<.20	<.20
		05-11-88	--	--	--	--	--	--	<.20	<.20
		08-10-88	--	--	--	--	--	--	<.20	<.20
15-348	Greenwich WD	11-17-86	<10	93	<6	140	2	.8	--	--
		05-11-88	--	--	--	--	--	--	<.20	<.20
		02-11-88	--	--	--	--	--	--	--	--
		08-10-88	--	--	--	--	--	--	<.20	<.20
		08-29-88	<10	130	<6	210	--	--	--	--
15-357	E.I. DuPont	10-08-86	<10	610	<6	190	4	2.1	550	<30
		10-08-86	--	--	--	--	--	--	--	--
15-634	E.I. DuPont	10-08-86	<10	4,400	<6	24	10	1.1	<3.0	<3.0
15-652	Hercules Chemical	10-28-86	<10	28	9	<3	2	13	10	<3.0
15-657	E.I. DuPont	10-07-86	<10	160	<6	42	11	.7	--	--
		10-07-86	--	--	--	--	--	--	--	--
15-668	Hercules Chemical	10-28-86	<100	180	<60	56	5	21	--	--
		10-28-86	<100	170	<60	<30	--	--	--	--
15-672	Air Products	10-30-86	<30	1,500	<18	240	38	16	940	<30
15-678	Mobil Oil Corp.	09-23-86	<10	240	<6	13	2	1.0	--	--
15-679	Mobil Oil Corp.	09-23-86	<30	1,100	42	210	5	7.6	<3.0	<3.0
15-680	Mobil Oil Corp.	09-22-86	<10	1,100	12	18	3	.6	<3.0	<3.0
		09-22-86	<10	1,200	12	18	3	.7	--	--
15-681	Mobil Oil Corp.	09-22-86	<10	120	<6	6	2	2.4	--	--
15-682	Mobil Oil Corp.	11-14-86	<10	930	13	<3	570	24	34,000	<2.0
15-683	Mobil Oil Corp.	11-14-86	<10	480	510	280	61	71	54	<3.0
15-712	U.S. Geological Survey	12-16-86	<30	3,700	<18	<19	--	.8	--	--
		12-16-86	<10	3,500	<6	15	--	--	--	--
		03-19-87	<30	3,700	<18	<9	6	.6	<3.0	<3.0

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

Arsenic, dis- solved (µg/L as As)	Barium, dis- solved (µg/L as Ba)	Beryl- lium, dis- solved (µg/L as Be)	Cadmium, dis- solved (µg/L as Cd)	Chro- mium, dis- solved (µg/L as Cr)	Cobalt, dis- solved (µg/L as Co)	Copper, dis- solved (µg/L as Cu)	Iron, dis- solved (µg/L as Fe)	Lead, dis- solved (µg/L as Pb)	Lithium, dis- solved (µg/L as Li)	Manga- nese, dis- solved (µg/L as Mn)	USGS well number
						East Greenwich Township					
<1	71	<0.5	<1	<10	<3	<10	170	<10	10	5	15- 28
<1	89	<.5	<1	<10	<3	<10	750	<10	12	11	15-363
<1	320	<.5	1	10	<3	40	47	<10	5	75	15-500
--	--	--	--	--	--	--	--	--	--	--	
<1	86	<.5	1	20	<3	<10	750	<10	13	13	15-501
						Greenwich Township					
1	100	3	1	<10	3	10	6,900	<10	15	360	15- 69
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	
<1	110	<.5	1	<10	<3	<10	10,000	<10	5	260	15- 81
<1	68	<.5	<1	<10	<3	10	390	<10	6	77	15-347
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	
<1	80	2	--	<10	30	10	960	<10	16	150	15-348
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	
--	83	.6	2	<5	50	70	1,600	<10	15	220	
<1	26	<.5	3	10	140	<10	1,100	<10	44	10,000	15-357
--	--	--	--	--	--	--	--	--	--	--	
<1	91	<.5	<1	<10	10	<10	180	<10	44	860	15-634
18	5	<.5	1	20	<3	<10	26,000	<10	<4	280	15-652
<1	79	<.5	<1	<10	<3	<10	12	<10	7	49	15-657
--	--	--	--	--	--	--	--	--	--	--	
13	17	<5	13	<10	<30	<100	49,000	<100	<40	490	15-668
14	18	<5	12	40	<30	<100	50,000	<100	<40	490	
2	56	2	6	<10	<3	<10	77,000	20	39	1,300	15-672
1	44	<.5	<1	<10	<3	<10	2,500	<10	14	77	15-678
1	24	9	17	20	<9	<30	270,000	60	52	2,400	15-679
<1	140	<.5	<1	<10	5	<10	200	<10	27	110	15-680
<1	140	<.5	<1	<10	5	<10	210	<10	27	110	
20	41	<.5	<1	<10	<3	<10	17,000	<10	<4	610	15-681
13	75	<.5	6	<10	<3	<10	73,000	20	9	960	15-682
<1	20	14	<1	70	<3	<10	43,000	<10	56	2,500	15-683
<1	360	<2	<1	<10	<9	<30	18,000	<30	39	230	15-712
<1	350	<.5	2	<10	<3	<10	18,000	<10	42	220	
<1	360	<2	<3	<10	<3	<10	18,000	<30	39	200	

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

USGS well number	Owner	Sample-collection date	Di-chloro-di-fluoro-methane (µg/L)	1,1-Di-chloro-ethane (µg/L)	1,2-Di-chloro-ethane (µg/L)	1,1-Di-chloro-ethyl-ene (µg/L)	1,2-Transdi-chloro-ethyl-ene (µg/L)	1,2-Di-chloro-propane (µg/L)	1,3-Di-chloro-propane (µg/L)	Trans-1,3-Di-chloro-propane (µg/L)
				East Greenwich Township						
15- 28	East Greenwich WD	10-10-86	--	--	--	--	--	--	--	--
15-363	Sherman, A.	11-20-86	--	--	--	--	--	--	--	--
15-500	Thompson, H.	11-19-86	--	--	--	--	--	--	--	--
		08-10-88	--	--	--	--	--	--	--	--
15-501	Henderson, V.	11-19-86	--	--	--	--	--	--	--	--
				Greenwich Township						
15- 69	Greenwich WD	11-05-86	--	--	--	--	--	--	--	--
		05-11-88	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20
		08-10-88	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20
15- 81	E.I. DuPont	10-07-86	--	--	--	--	--	--	--	--
15-347	Greenwich WD	11-05-86	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20
		04-23-87	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20
		11-05-87	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20
		02-11-88	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20
		05-11-88	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20
		08-10-88	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20
15-348	Greenwich WD	11-17-86	--	--	--	--	--	--	--	--
		05-11-88	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20
		02-11-88	--	--	--	--	--	--	--	--
		08-10-88	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20
		08-29-88	--	--	--	--	--	--	--	--
15-357	E.I. DuPont	10-08-86	<30	<30	<30	<30	0	<30	<30	<30.0
		10-08-86	--	--	--	--	--	--	--	--
15-634	E.I. DuPont	10-08-86	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
15-652	Hercules Chemical	10-28-86	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
15-657	E.I. DuPont	10-07-86	--	--	--	--	--	--	--	--
		10-07-86	--	--	--	--	--	--	--	--
15-668	Hercules Chemical	10-28-86	--	--	--	--	--	--	--	--
		10-28-86	--	--	--	--	--	--	--	--
15-672	Air Products	10-30-86	<30	<30	<30	<30	<0	<30	<30	<30.0
15-678	Mobil Oil Corp.	09-23-86	--	--	--	--	--	--	--	--
15-679	Mobil Oil Corp.	09-23-86	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
15-680	Mobil Oil Corp.	09-22-86	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
		09-22-86	--	--	--	--	--	--	--	--
15-681	Mobil Oil Corp.	09-22-86	--	--	--	--	--	--	--	--
15-682	Mobil Oil Corp.	11-14-86	<.20	<2.0	<2.0	<2.0	<.20	<.20	<.20	<.20
15-683	Mobil Oil Corp.	11-14-86	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
15-712	U.S. Geological Survey	12-16-86	--	--	--	--	--	--	--	--
		12-16-86	--	--	--	--	--	--	--	--
		03-19-87	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

Carbon tetra-chlo-ride (µg/L)	Chloro-benzene (µg/L)	Chloro-di-bromo-methane (µg/L)	Chloro-ethane (µg/L)	2-Chloro-ethyl-vinyl-ether (µg/L)	Chloro-form (µg/L)	1,2-Dibromo ethyl-ene (µg/L)	1,2-Di-chloro-benzene (µg/L)	1,3-Di-chloro-benzene (µg/L)	1,4-Di-chloro-benzene (µg/L)	Di-chloro-bromo-methane (µg/L)	USGS well number
					East Greenwich Township						
--	--	--	--	--	--	--	--	--	--	--	15- 28
--	--	--	--	--	--	--	--	--	--	--	15-363
--	--	--	--	--	--	--	--	--	--	--	15-500
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	15-501
					Greenwich Township						
--	--	--	--	--	--	--	--	--	--	--	15- 69
<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	<.20	
--	--	--	--	--	--	--	--	--	--	--	15- 81
<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	<.20	15-347
<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	<.20	
--	--	--	--	--	--	--	--	--	--	--	15-348
<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	<.20	
--	--	--	--	--	--	--	--	--	--	--	
<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	<.20	
--	--	--	--	--	--	--	--	--	--	--	
<30	920	<30	<30	<30	130	<30	<30.0	<30.0	<30.0	<30	15-357
--	--	--	--	--	--	--	--	--	--	--	
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	15-634
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	15-652
--	--	--	--	--	--	--	--	--	--	--	15-657
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	15-668
--	--	--	--	--	--	--	--	--	--	--	
<30	<30	<30	<30	<30	<30	<30	<30.0	<30.0	--	<30	15-672
--	--	--	--	--	--	--	--	--	--	--	15-678
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	15-679
<3.0	<3.0	<3.0	<3.0	<3.0	6.1	<3.0	<3.0	<3.0	<3.0	<3.0	15-680
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	15-681
<2.0	<2.6	<2.0	<2.0	<.20	<2.0	<.2	<.20	<.20	<.20	<2.0	15-682
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	15-683
--	--	--	--	--	--	--	--	--	--	--	15-712
--	--	--	--	--	--	--	--	--	--	--	
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

USGS well number	Owner	Sample-collection date	Vinyl chloride (µg/L)	Xylene, tot rec (µg/L)	Gross alpha-particle[1] (pCi/L)	Gross beta-particle[1] (pCi/L)	Radium-226 dissolved[1] (pCi/L)	Radium-226, dissolved (pCi/L)	Radium-228, dissolved (pCi/L)
				East Greenwich Township					
15- 28	East Greenwich WD	10-10-86	--	--	--	--	--	--	--
15-363	Sherman, A.	11-20-86	--	--	--	--	--	--	--
15-500	Thompson, H.	11-19-86	--	--	--	--	--	--	--
		08-10-88	--	--	--	--	--	--	--
15-501	Henderson, V.	11-19-86	--	--	--	--	--	--	--
				Greenwich Township					
15- 69	Greenwich WD	11-05-86	--	--	--	--	--	--	--
		02-11-88	--	--	7.8 ± 1.2	7.2 ± .7	1.4 ± .3	--	--
		05-11-88	<.20	<.2	--	--	--	--	--
		08-10-88	<.20	<.2	--	--	--	--	--
15- 81	E.I. DuPont	10-07-86	--	--	--	--	--	--	--
15-347	Greenwich WD	11-05-86	<.20	<.2	--	--	--	--	--
		04-23-87	<.20	<.2	--	--	--	--	--
		11-05-87	<.20	<.2	--	--	--	--	--
		02-11-88	<.20	<.2	1.7 ± .7	7.5 ± .7	--	1.1	--
		05-11-88	<.20	<.2	--	--	--	--	--
		08-10-88	<.20	<.2	--	--	--	--	--
15-348	Greenwich WD	11-17-86	--	--	--	--	--	--	--
		05-11-88	<.20	<.2	--	--	--	--	--
		02-11-88	--	--	10 ± 1	16 ± 1	2.6 ± .3	3.3	7.3
		08-10-88	<.20	<.2	--	--	--	--	--
		08-29-88	--	--	--	--	--	--	--
15-357	E.I. DuPont	10-08-86	30	<30	--	--	--	--	--
		10-08-86	--	--	--	--	--	--	--
15-634	E.I. DuPont	10-08-86	<3.0	--	--	--	--	--	--
15-652	Hercules Chemical	10-28-86	<3.0	<3.0	--	--	--	--	--
15-657	E.I. DuPont	10-07-86	--	--	--	--	--	--	--
		10-07-86	--	--	--	--	--	--	--
15-668	Hercules Chemical	10-28-86	--	--	--	--	--	--	--
		10-28-86	--	--	--	--	--	--	--
15-672	Air Products	10-30-86	<30	<3.0	--	--	--	--	--
15-678	Mobil Oil Corp.	09-23-86	--	--	--	--	--	--	--
15-679	Mobil Oil Corp.	09-23-86	<3.0	<3.0	--	--	--	--	--
15-680	Mobil Oil Corp.	09-22-86	<3.0	<3.0	--	--	--	--	--
		09-22-86	--	--	--	--	--	--	--
15-681	Mobil Oil Corp.	09-22-86	--	--	--	--	--	--	--
15-682	Mobil Oil Corp.	11-14-86	<.20	1,200	--	--	--	--	--
15-683	Mobil Oil Corp.	11-14-86	<3.0	7.2	--	--	--	--	--
15-712	U.S. Geological Survey	12-16-86	--	--	--	--	--	--	--
		12-16-86	--	--	--	--	--	--	--
		03-19-87	<3.0	<3.0	--	--	--	--	--

Footnotes at end of table.

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

Ethyl benzene, (µg/L)	Methyl bromide, (µg/L)	Methyl chloride, (µg/L)	Methylene chloride, (µg/L)	1,1,2,2-Tetrachloroethane, (µg/L)	Tetrachloroethylene, (µg/L)	Toluene, (µg/L)	1,1,1-Trichloroethane, (µg/L)	1,1,2-Trichloroethane, (µg/L)	Trichloroethylene, (µg/L)	Trichlorofluoromethane (µg/L)	Styrene (µg/L	USGS well number
						East Greenwich Township						
--	--	--	--	--	--	--	--	--	--	--	--	15- 28
--	--	--	--	--	--	--	--	--	--	--	--	15-363
--	--	--	--	--	--	--	--	--	--	--	--	15-500
--	--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	--	15-501
						Greenwich Township						
--	--	--	--	--	--	--	--	--	--	--	--	15- 69
<.20	<.20	<.20	<.20	<.20	.30	<.20	<.20	<.20	<.2	--	--	
<.20	<.20	<.20	<.20	<.20	.50	<.20	<.20	<.20	.2	<.20	<.2	
--	--	--	--	--	--	--	--	--	--	<.20	<.2	15- 81
<.20	<.20	<.20	<.20	<.20	<.20	<.20	.40	<.20	2.5	--	--	15-347
<.20	<.20	<.20	<.20	<.20	<.20	<.20	.20	<.20	2.6	<.20	<.2	
<.20	<.20	<.20	<.20	<.20	<.20	<.20	.20	<.20	2.6	<.20	<.2	
<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	2.0	<.20	<.2	
<.20	<.20	<.20	<.20	--	<.20	<.20	<.20	<.20	1.8	<.20	<.2	
<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	1.6	<.20	<.2	
--	--	--	--	--	--	--	--	--	--	<.20	<.2	15-348
<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.2	--	--	
--	--	--	--	--	--	--	--	--	--	<.20	<.2	
<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.2	--	--	
--	--	--	--	--	--	--	--	--	--	<.20	<.2	
<30	<30	<30.0	<30	<30	130	<30	<30	<30	150	--	--	15-357
--	--	--	--	--	--	--	--	--	--	<30	<30	
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	15-634
<3.0	<3.0	<3.0	10	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	15-652
--	--	--	--	--	--	--	--	--	--	<3.0	<3.0	15-657
--	--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	--	15-668
--	--	--	--	--	--	--	--	--	--	--	--	
<30	<30	<30.0	<30	<30	<30	<30	<30	<30	<30.0	<30	<30	15-672
--	--	--	--	--	--	--	--	--	--	--	--	15-678
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	15-679
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	15-680
--	--	--	--	--	--	--	--	--	--	<3.0	<3.0	
--	--	--	--	--	--	--	--	--	--	--	--	15-681
1,000	<2.0	<2.0	<2.0	<.20	<2.0	700	<.20	<.20	<.2	--	--	15-682
<3.8	<3.0	<3.0	<3.0	<3.0	<3.0	3.0	<3.0	<3.0	<3.0	<2.0	<.2	15-683
--	--	--	--	--	--	--	--	--	--	<3.0	<3.0	15-712
--	--	--	--	--	--	--	--	--	--	--	--	
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

USGS well number	Owner	Well name	Station number	Sample-collection date	Alkalinity whole water total field (mg/L as $CaCO_3$)	Alkalinity as bicarbonate, field (mg/L	Barometric pressure (mm of Hg)	Dissolved oxygen (mg/L)
				Greenwich Township--Continued				
15-712	U.S. Geological Survey	Stefka-1	394808075172401	03-19-87	90	110	--	0.1
15-713	U.S. Geological Survey	Stefka-2	394808075172402	12-03-86	73	89	--	<.1
				12-03-86	73	89	--	<.1
15-728	U.S. Geological Survey	Stefka-4	394808075172404	04-22-87	78	--	--	.2
				04-22-87	74	--	--	.3
				Logan Township				
15-139	Pureland Water Company	Test well 3	394606075213301	11-10-86	131	162	--	.1
15-388	Rollins Environmental Services	DP 3	394716075204701	10-09-86	2	2.0	--	6.0
15-395	Repaupo Fire Co.		394807075172701	10-30-86	11	13	--	.3
15-398	Pettit, Louis	Test well 3	394928075194101	11-17-86	192	234	--	.1
15-564	USEPA	S-9	394802075193301	11-25-86	37	45	--	2.8
				11-25-86	37	45	--	3.0
15-569	Pureland Water Company	PWC 3	394529075204501	11-10-86	67	84	--	.4
15-575	Rollins Environmental Services	MA11-D	394719075210802	10-09-86	<1	--	--	5.4
15-615	U.S. Geological Survey	Shiveler Lower	394637075191601	12-02-86	165	165	--	<.1
				12-02-86	135	165	--	<.1
				04-17-87	--	--	--	--
15-616	U.S. Geological Survey	Shiveler Middle	394637075191602	11-26-86	41	50	--	<.1
15-617	U.S. Geological Survey	Shiveler Upper	394637075191603	12-03-86	38	46	--	.1
15-618	U.S. Geological Survey	Gaventa Deep	394804075193301	11-24-86	81	99	--	<.1
				04-22-87	--	--	--	--
15-620	U.S. Geological Survey	Gaventa Middle	394804075193302	11-25-86	8	10	--	2.7
				11-25-86	8	10	--	2.7
15-626	Logan Township	MW102S	394729075210101	12-05-86	3	4.0	--	9.6
15-627	Logan Township	MW103D	394644075213602	10-06-86	10	12	--	1
15-714	Rollins Environmental Services	GG	394707075205801	12-01-86	3	4.0	--	6.0
				Mantua Township				
15-191	Mantua Twp. MUA	2	394629075085901	12-16-86	179	218	--	.1
15-432	Kramer Landfill	1	394707075120201	10-27-86	175	214	--	.4
[2]15-676	Kramer Landfill	X-6D	394638075120101	11-13-86	141	172	--	.1
				11-13-86	141	172	--	.1
[3]15-715	Parks, T.	Domestic 1	394527075123001	11-12-86	37	45	--	4.2
				11-12-86	37	45	--	4.2
				Paulsboro Borough				
15-210	Paulsboro WD	6-1973	394921075141901	10-22-86	21	26	--	.2
				04-21-87	--	--	--	--
				11-05-87	--	--	--	--
				02-11-88	15	18	--	3.4
				05-11-88	--	--	--	--
				08-10-88	--	--	767	<.1
15-212	Paulsboro WD	4	394931075144901	10-22-86	23	28	--	.3

Footnotes at end of table.

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

Dissolved solids, residue at 180 deg C (mg/L)	Hardness, as $CaCO_3$ (mg/L)	pH (standard units)	Specific conductance (µS/cm)	Temperature, water (deg C)	Nitrogen, ammonia, dissolved (mg/L as N)	Nitrogen, nitrite, dissolved (mg/L as N)	Nitrogen, ammonia + organic, dis. (mg/L as N)	Nitrogen, NO_2+NO_3 dissolved (mg/L as N)	USGS well number
Greenwich Township--Continued									
1,320	250	6.74	2,160	14.0	--	--	--	--	15-712
98	39	6.63	168	13.5	.140	<.010	.50	<.100	15-713
--	--	6.60	168	13.5	.170	<.010	<.50	<.100	
124	62	6.23	211	14.0	.160	<.010	.30	<.100	15-728
125	61	6.19	210	--	.170	<.010	.30	<.100	
Logan Township									
1,490	130	7.49	2,680	13.0	.710	<.010	1.3	<.100	15-139
--	--	4.95	259	14.0	.050	<.010	1.5	9.30	15-388
126	--	5.56	185	13.5	.030	<.010	.60	<.100	15-395
389	85	6.50	769	13.0	5.0	<.010	20	<.100	15-398
249	140	6.50	374	14.0	.030	.150	.60	13.0	15-564
--	--	6.36	370	14.5	.030	.150	.60	13.0	
142	47	6.65	231	13.5	.190	<.010	1.0	<.100	15-569
232	130	4.42	378	15.5	.010	<.010	1.1	15.0	15-575
1,450	150	7.15	2,550	129.0	.810	<.010	.80	<.100	15-615
1,340	150	7.20	2,550	13.0	--	--	--	--	
--	--	--	--	--		--	--	--	
55	22	6.46	99	13.5	.040	<.010	<.20	<.100	15-616
125	62	6.39	241	13.0	.060	<.010	<.20	<.100	15-617
779	84	6.70	1,420	13.0	.370	<.010	.80	<.100	15-618
--	--	--	--	--		--	--	--	
34	12	5.57	49	13.0	.050	<.010	.40	1.90	15-620
--	--	5.60	49	13.0	.050	<.010	.20	2.00	
171	90	5.28	269	14.5	.020	<.010	.70	16.0	15-626
208	20	5.40	296	14.0	.140	<.010	.50	<.100	15-627
153	91	4.60	256	15.0	.010	<.010	1.1	5.50	15-714
Mantua Township									
251	26	8.28	409	14.5	.330	<.010	.30	<.100	15-191
275	45	8.10	456	14.0	.260	<.010	.50	<.100	15-432
176	--	7.98	287	13.0	.040	<.010	<.40	<.100	[2]15-676
--	--	8.00	287	13.0	.030	<.010	.40	<.100	
--	--	6.00	184	13.5	.010	<.010	.40	<.100	[3]15-715
126	--	6.03	184	13.5	.010	<.010	.40	<.100	
Paulsboro Borough									
154	--	5.95	243	14.5	.120	<.010	.40	<.100	15-210
--	--	--	--	--	--	--	.40	<.100	
--	--	--	--	--	--	--	--		
--	--	5.61	235	14.0	--	--	--	--	
--	--	--	--	--	--	--	--		
--	--	5.56	259	15.0	--	--	--	--	
157	37	6.54	217	16.5	.030	<.010	.40	<.100	15-212

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

USGS well number	Owner	Sample-collection date	Phosphorus, ortho, dissolved (mg/L as P)	Calcium, dissolved (mg/L as Ca)	Chloride, dissolved (mg/L as Cl)	Magnesium, dissolved (mg/L as Mg)	Potassium, dissolved (mg/L as K)	Silica, dissolved (mg/L as SiO_2)	Sodium, dissolved (mg/L as Na)	Sulfate, dissolved (mg/L as SO_4)
			Greenwich Township--Continued							
15-712	U.S. Geological Survey	03-19-87	--	64	660	20	13	10	370	15
15-713	U.S. Geological Survey	12-03-86	.060	9.5	7.5	3.5	4.0	16	12	14
		12-03-86	.060	--	--	--	--	--	--	--
15-728	U.S. Geological Survey	04-22-87	<.010	14	13	6.4	3.3	21	7.8	19
		04-22-87	<.010	14	12	6.2	3.3	21	7.7	19
			Logan Township							
15-139	Pureland Water Company	11-10-86	<.010	35	820	9.5	13	9.0	530	9.0
15-388	Rollins Environmental Services	10-09-86	<.010	16	23	13	6.3	7.9	4.9	39
15-395	Repaupo Fire Company	10-30-86	.030	7.1	9.4	5.1	3.9	12	3.8	62
15-398	Pettit, Louis	11-17-86	<.010	14	140	12	2.5	31	52	4.6
15-564	USEPA	11-25-86	<.010	27	12	17	21	5.5	5.8	75
		11-25-86	<.010	--	--	--	--	--	--	--
15-569	Pureland Water Company	11-10-86	<.010	12	15	3.9	3.9	14	22	29
15-575	Rollins Environmental Services	10-09-86	<.010	30	30	14	11	6.9	4.2	62
15-615	U.S. Geological Survey	12-02-86	<.010	38	790	12	11	9.6	490	12
		12-02-86	--	38	790	12	11	9.6	490	12
		04-17-87	--	--	--	--	--	--	--	--
15-616	U.S. Geological Survey	11-26-86	.190	5.4	5.2	2.1	1.8	15	2.4	12
15-617	U.S. Geological Survey	12-03-86	.030	15	11	5.9	4.1	18	3.4	61
15-618	U.S. Geological Survey	11-24-86	<.010	21	400	7.3	6.8	8.5	250	10
		04-22-87	--	--	--	--	--	--	--	--
15-620	U.S. Geological Survey	11-25-86	<.010	2.8	4.3	1.1	1.8	7.7	3.0	2.7
		11-25-86	<.010	--	--	--	--	--	--	--
15-626	Logan Township	12-05-86	<.010	23	14	8.0	16	4.5	3.2	42
15-627	Logan Township	10-06-86	<.010	4.2	77	2.3	2.5	15	38	9.7
15-714	Rollins Environmental Services	12-01-86	.020	24	14	7.6	7.8	8.7	4.7	69
			Mantua Township							
15-191	Mantua Twp. MUA	12-16-86	.180	6.7	26	2.1	5.5	9.1	82	4.5
15-432	Kramer Landfill	10-27-86	.160	13	42	3.0	6.0	9.0	85	4.9
[2]15-676	Kramer Landfill	11-13-86	.050	53	1.8	4.2	4.9	13	2.6	7.6
		11-13-86	.070	--	--	--	--	--	--	--
[3]15-715	Parks, T.	11-12-86	.100	3.9	13	1.5	3.3	22	2.5	58
		11-12-86	.070	--	--	--	--	--	--	--
			Paulsboro Borough							
15-210	Paulsboro WD	10-22-86	.020	7.2	26	4.0	3.1	9.6	25	--
		04-21-87	--	--	--	--	--	--	--	--
		11-05-87	--	--	--	--	--	--	--	--
		02-11-88	--	--	--	--	--	--	--	--
		05-11-88	--	--	--	--	--	--	--	--
		08-10-88	--	--	--	--	--	--	--	--
15-212	Paulsboro WD	10-22-86	.010	13	16	1.0	1.6	8.1	2	41

Footnotes at end of table.

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

Alum-inum, dis-solved (μg/L as Al)	Arsenic, dis-solved (μg/L as As)	Barium, dis-solved (μg/L as Ba)	Beryl-lium, dis-solved (μg/L as Be)	Cadmium, dis-solved (μg/L as Cd)	Chro-mium, dis-solved (μg/L as Cr)	Cobalt, dis-solved (μg/L as Co)	Copper, dis-solved (μg/L as Cu)	Iron, dis-solved (μg/L as Fe)	Lead, dis-solved (μg/L as Pb)	Lithium, dis-solved (μg/L as Li)	Manga-nese, dis-solved (μg/L as Mn)	USGS well number
						Greenwich Township--Continued						
<10	<1	370	<2	<3	<10	<3	<10	18,000	<30	45	200	15-712
10	1	64	<.5	1	<10	<3	<10	11,000	<10	23	170	15-713
--	--	--	--	--	--	--	--	--	--	--	--	
<10	3	94	<.5	2	<10	<3	<10	17,000	10	33	190	15-728
<10	4	89	<.5	<1	<10	<3	<10	17,000	20	29	180	
						Logan Township						
<10	<1	230	27	<3	<10	<9	<30	6,700	30	46	63	15-139
50	<1	110	<.5	<1	<10	9	10	10	<10	14	65	15-388
20	7	70	2	<3	<10	<9	<30	21,000	<30	18	360	15-395
10	36	130	1	6	<10	<4	<10	73,000	20	4	1,100	15-398
<10	<1	73	<.5	2	<10	<3	<10	65	<10	5	37	15-564
--	--	--	--	--	--	--	--	--	--	--	--	
20	<1	100	.8	2	<10	<3	<10	<12,000	<10	16	78	15-569
670	<1	55	3	1	<10	20	70	6	<10	17	300	15-575
<10	<1	250	<2	<3	<10	<9	<30	8,300	<30	35	150-	15-615
<10	<1	240	<2	<3	<10	<9	<30	8,200	<30	32	150	
--	--	--	--	--	--	--	--	--	--	--	--	
<10	<1	68	1	<1	<10	<3	<10	12,000	<10	21	92	15-616
<10	2	100	<.5	3	<10	<3	<10	25,000	<10	41	310	15-617
<10	1	150	<.5	2	<10	<3	<10	12,000	<10	28	120	15-618
--	--	--	--	--	--	--	--	--	--	--	--	
10	<1	60	<.5	<1	<10	<3	<10	320	<10	21	99	15-620
--	--	--	--	--	--	--	--	--	--	--	--	
40	<1	49	<.5	<1	<10	<3	<10	10	<10	5	19	15-626
20	1	85	<.5	<1	30	<3	<10	11,000	<10	33	370	15-627
310	<1	53	<.5	<1	<10	6	10	7	<10	5	120	15-714
						Mantua Township						
<10	<1	47	<.5	<1	<10	<3	<10	61	<10	6	3	15-191
<10	<1	74	<.5	<1	<10	<3	<10	190	<10	7	9	15-432
<10	<1	120	<.5	<1	80	<3	<10	350	<10	11	51	[2]15-676
--	--	--	--	--	--	--	--	--	--	--	--	
<10	3	<2	<.5	1	<10	<3	<10	31,000	<10	6	92	[3]15-715
--	--	--	--	--	--	--	--	--	--	--	--	
						Paulsboro Borough						
180	1	79	.7	<1	<10	<3	<10	7,800	<10	15	100	15-210
--	--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	--	
10	<1	20	<.5	<1	<10	<3	<10	910	<10	11	15	15-212

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

USGS well number	Owner	Sample-collection date	Molybdenum, dissolved (µg/L as Mo)	Strontium, dissolved (µg/L as Sr)	Vanadium, dissolved (µg/L as V)	Zinc, dissolved (µg/L as Zn)	Phenols total (µg/L)	Carbon, organic, dissolved (mg/L as C)	Benzene (µg/L)	Bromoform (µg/L)
				Greenwich Township--Continued						
15-712	U.S. Geological Survey	03-19-87	<30	3,700	<18	18	--	--	--	--
15-713	U.S. Geological Survey	12-03-86	<10	300	<6	<3	3	1.2	--	--
		12-03-86	--	--	--	--	--	--	--	--
15-728	U.S. Geological Survey	04-22-87	<10	410	<6	6	1	.9	--	--
		04-22-87	<10	400	<6	6	--	--	--	--
				Logan Township						
15-139	Pureland Water Company	11-10-86	40	2,100	24	<9	1	1.4	<3.0	<3.0
15-388	Rollins Environmental	10-09-86	<10	120	<6	38	2	.9	<3.0	<3.0
15-395	Repaupo Fire Company	10-30-86	<30	72	<18	37	5	1.3	--	--
15-398	Pettit, Louis	11-17-86	<10	140	12	<3	2	4.2	--	--
15-564	USEPA	11-25-86	<10	130	<6	8	2	1.1	--	--
		11-25-86	--	--	--	--	--	--	--	--
15-569	Pureland Water Company	11-10-86	<10	390	<6	16	<1	1.2	--	--
15-575	Rollins Environmental Services	10-09-86	<10	150	<6	73	3	1.1	<3.0	<3.0
15-615	U.S. Geological Survey	12-02-86	<30	2,000	<18	26	2	.8	<3.0	<3.0
		12-02-86	<30	1,900	<18	31	--	--	--	--
		04-17-87	--	--	--	--	--	--	.20	<.20
15-616	U.S. Geological Survey	11-26-86	<10	110	<6	<3	2	.8	--	--
15-617	U.S. Geological Survey	12-03-86	<10	470	<6	11	3	1.0	--	--
15-618	U.S. Geological Survey	11-24-86	<10	1,100	<6	13	3	.8	<3.0	<3.0
		04-22-87	--	--	--	--	--	--	.30	<.20
15-620	U.S. Geological Survey	11-25-86	<10	85	<6	32	2	.4	--	--
		11-25-86	--	--	--	--	--	--	--	--
15-626	Logan Township	12-05-86	<10	48	<6	9	1	1.2	--	--
15-627	Logan Township	10-06-86	<10	99	<6	34	4	.6	--	--
15-714	Rollins Environmental Services	12-01-86	<10	52	<6	40	1	1.7	<3.0	<3.0
				Mantua Township						
15-191	Mantua Twp. MUA	12-16-86	<10	240	<6	<3	4	1.1	--	--
15-432	Kramer Landfill	10-27-86	<10	360	<6	4	6	.9	--	--
[2]15-676	Kramer Landfill	11-13-86	<10	500	<6	<3	4	1.0	<3.0	<3.0
		11-13-86	--	--	--	--	--	--	--	--
[3]15-715	Parks, T.	11-12-86	<10	24	<6	65	2	.8	--	--
		11-12-86	--	--	--	--	--	--	--	--
				Paulsboro Borough						
15-210	Paulsboro WD	10-22-86	<10	160	<6	47	3	1.2	.20	<.20
		04-21-87	--	--	--	--	--	--	<.20	<.20
		11-05-87	--	--	--	--	--	--	<.20	<.20
		02-11-88	--	--	--	--	--	--	<.20	<.20
		05-11-88	--	--	--	--	--	--	<.20	<.20
		08-10-88	--	--	--	--	--	--	<.20	<.20
15-212	Paulsboro WD	10-22-86	<10	65	<6	37	8	1.2	<.20	.60

Footnotes at end of table.

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

Carbon tetra-chlo-ride (µg/L)	Chloro-benzene (µg/L)	Chloro-di-bromo-methane (µg/L)	Chloro-ethane (µg/L)	2-Chloro-ethyl-vinyl-ether (µg/L)	Chloro-form (µg/L)	1,2-Dibromo ethyl-ene (µg/L)	1,2-Di-chloro-benzene (µg/L)	1,3-Di-chloro-benzene (µg/L)	1,4-Di-chloro-benzene (µg/L)	Di-chloro-bromo-methane (µg/L)	USGS well number
					Greenwich Township--Continued						
--	--	--	--	--	--	--	--	--	--	--	15-712
--	--	--	--	--	--	--	--	--	--	--	15-713
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	15-728
--	--	--	--	--	--	--	--	--	--	--	
					Logan Township						
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	15-139
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	15-388
--	--	--	--	--	--	--	--	--	--	--	15-395
--	--	--	--	--	--	--	--	--	--	--	15-398
--	--	--	--	--	--	--	--	--	--	--	15-564
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	15-569
--	<3.0	<3.0	<3.0	<3.0	<3.0	10	<3.0	<3.0	<3.0	<3.0	15-575
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	15-615
--	--	--	--	--	--	--	--	--	--	--	
<.20	1.4	<.20	<.20	<.20	.20	<.2	<.20	<.20	<.20	<.20	
--	--	--	--	--	--	--	--	--	--	--	15-616
--	--	--	--	--	--	--	--	--	--	--	15-617
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	15-618
<.20	.40	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	<.20	
--	--	--	--	--	--	--	--	--	--	--	15-620
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	15-626
--	--	--	--	--	--	--	--	--	--	--	15-627
<3.0	<3.0	<3.0	<3.0	<3.0	8.5	<3.0	<3.0	<3.0	<3.0	<3.0	15-714
					Mantua Township						
--	--	--	--	--	--	--	--	--	--	--	15-191
--	--	--	--	--	--	--	--	--	--	--	15-432
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	[2]15-676
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	[3]15-715
--	--	--	--	--	--	--	--	--	--	--	
					Paulsboro Borough						
<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	<.20	15-210
<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	<.20	
<.20	<.20	.40	<.20	<.20	.20	<.2	<.20	<.20	<.20	<.20	15-212

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

USGS well number	Owner	Sample-collection date	Di-chloro-di-fluoro-methane (µg/L)	1,1-Di-chloro-ethane (µg/L)	1,2-Di-chloro-ethane (µg/L)	1,1-Di-chloro-ethyl-ene (µg/L)	1,2-Trans-di chloro-ethyl-ene (µg/L)	1,2-di-chloro-propane (µg/L)	1,3-di-chloro-propane (µg/L)	Trans-1,3-di-chloro-propene (µg/L)
			Greenwich Township--Continued							
15-712	U.S. Geological Survey	03-19-87	--	--	--	--	--	--	--	--
15-713	U.S. Geological Survey	12-03-86	--	--	--	--	--	--	--	--
		12-03-86	--	--	--	--	--	--	--	--
15-728	U.S. Geological Survey	04-22-87	--	--	--	--	--	--	--	--
		04-22-87	--	--	--	--	--	--	--	--
			Logan Township							
15-139	Pureland Water Company	11-10-86	<3.0	<3.0	<3.0	<3.0	3.0	<3.0	<3.0	<3.0
15-388	Rollins Environmental Services	10-09-86	<3.0	<3.0	<3.0	<3.0	3.0	<3.0	<3.0	<3.0
15-395	Repaupo Fire Company	10-30-86	--	--	--	--	--	--	--	--
15-398	Pettit, Louis	11-17-86	--	--	--	--	--	--	--	--
15-564	USEPA	11-25-86	--	--	--	--	--	--	--	--
		11-25-86	--	--	--	--	--	--	--	--
15-569	Pureland Water Company	11-10-86	--	--	--	--	--	--	--	--
15-575	Rollins Environmental Services	10-09-86	<3.0	<3.0	<3.0	<3.0	3.0	<3.0	<3.0	<3.0
15-615	U.S. Geological Survey	12-02-86	<3.0	<3.0	<3.0	<3.0	3.0	<3.0	<3.0	<3.0
		12-02-86	--	--	--	--	--	--	--	--
		04-17-87	<.20	.20	.80	<.20	<.20	<.20	<.20	<.20
15-616	U.S. Geological Survey	11-26-86	--	--	--	--	--	--	--	--
15-617	U.S. Geological Survey	12-03-86	--	--	--	--	--	--	--	--
15-618	U.S. Geological Survey	11-24-86	<3.0	<3.0	<3.0	<3.0	3.0	<3.0	<3.0	<3.0
		04-22-87	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20
15-620	U.S. Geological Survey	11-25-86	--	--	--	--	--	--	--	--
		11-25-86	--	--	--	--	--	--	--	--
15-626	Logan Township	12-05-86	--	--	--	--	--	--	--	--
15-627	Logan Township	10-06-86	--	--	--	--	--	--	--	--
15-714	Rollins Environmental Services	12-01-86	<3.0	<3.0	<3.0	<3.0	8	<3.0	<3.0	<3.0
			Mantua Township							
15-191	Mantua Twp. MUA	12-16-86	--	--	--	--	--	--	--	--
15-432	Kramer Landfill	10-27-86	--	--	--	--	--	--	--	--
[2]15-676	Kramer Landfill	11-13-86	<3.0	<3.0	<3.0	<3.0	3.0	<3.0	<3.0	<3.0
		11-13-86	--	--	--	--	--	--	--	--
[3]15-715	Parks, T.	11-12-86	--	--	--	--	--	--	--	--
		11-12-86	--	--	--	--	--	--	--	--
			Paulsboro Borough							
15-210	Paulsboro WD	10-22-86	<.20	.20	2.0	<.20	<.20	.60	<.20	<.20
		04-21-87	<.20	<.20	.80	<.20	<.20	.60	<.20	<.20
		11-05-87	<.20	<.20	2.0	<.20	<.20	.70	<.20	<.20
		02-11-88	<.20	<.20	1.5	<.20	<.20	.60	<.20	<.20
		05-11-88	<.20	<.20	1.6	<.20	<.20	<.20	<.20	<.20
		08-10-88	<.20	<.20	1.8	<.20	<.20	.90	<.20	<.20
15-212	Paulsboro WD	10-22-86	<.20	<.20	<1.3	<.20	<.20	.40	<.20	<.20

Footnotes at end of table.

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

Ethyl benzene (µg/L)	Methyl bromide (µg/L)	Methyl chlo-ride (µg/L)	Methyl-ene chlo-ride (µg/L)	1,1,2,2 tetra-chloro-ethane (µg/L)	Tetra-chloro-ethyl-ene (µg/L)	Toluene (µg/L)	1,1,1-Tri-chloro-ethane (µg/L)	1,1,2-Tri-chloro-ethane (µg/L)	Tri-chloro-ethyl-ene (µg/L)	Tri-chloro-fluoro-methane (µg/L)	USGS well number
					Greenwich Township--Continued						
--	--	--	--	--	--	--	--	--	--	--	15-712
--	--	--	--	--	--	--	--	--	--	--	15-713
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	15-728
--	--	--	--	--	--	--	--	--	--	--	
					Logan Township						
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	15-139
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	15-388
--	--	--	--	--	--	--	--	--	--	--	15-395
--	--	--	--	--	--	--	--	--	--	--	15-398
--	--	--	--	--	--	--	--	--	--	--	15-564
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	15-569
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	15-575
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	15-615
--	--	--	--	--	--	--	--	--	--	--	
<.20	<.20	<.20	<.20	<.20	.20	<.20	<.20	<.20	<.2	<.20	
--	--	--	--	--	--	--	--	--	--	--	15-616
--	--	--	--	--	--	--	--	--	--	--	15-617
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	15-618
<.20	<.20	<.20	<.20	<.20	<.20	.40	<.20	<.20	<.2	<.20	
--	--	--	--	--	--	--	--	--	--	--	15-620
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	15-626
--	--	--	--	--	--	--	--	--	--	--	15-627
<3.0	<3.0	<3.0	<3.0	<3.0	35	<3.0	11	<3.0	17.0	<3.0	15-714
					Mantua Township						
--	--	--	--	--	--	--	--	--	--	--	15-191
--	--	--	--	--	--	--	--	--	--	--	15-432
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	[2]15-676
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	[3]15-715
--	--	--	--	--	--	--	--	--	--	--	
					Paulsboro Borough						
<.20	<.20	<.20	<.20	<.20	.30	.40	<.20	<.20	.2	<.20	15-210
<.20	<.20	<.20	<.20	<.20	.30	<.20	<.20	<.20	<.2	<.20	
<.20	<.20	<.20	<.20	<.20	.40	<.20	<.20	<.20	<.2	<.20	
<.20	<.20	<.20	<.20	<.20	.20	<.20	<.20	<.20	<.2	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	.2	<.20	
<.20	<.20	<.20	<.20	<.20	.30	<.20	<.20	<.20	<.2	<.20	
<.20	<.20	<.20	<.20	<.20	.20	.20	<.20	<.20	<.2	<.20	15-212

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

USGS well number	Owner	Sample-collection date	Styrene (µg/L)	Vinyl chloride (µg/L)	Xylene, water whole total recoverable (µg/L)	Alachlor, total recoverable (µg/L)	Ametryne, total (µg/L)	Atrazine, total (µg/L)	Cyanazine, total (µg/L)	Metolachlor, water whole total recoverable (µg/L)
			Greenwich Township--Continued							
15-712	U.S. Geological Survey	03-19-87	--	--	--	--	--	--	--	--
15-713	U.S. Geological Survey	12-03-86	--	--	--	--	<.10	<.10	<.10	--
		12-03-86	--	--	--	--	--	--	--	--
15-728	U.S. Geological Survey	04-22-87	--	--	--	<.10	<.10	<.10	<.10	<.1
		04-22-87	--	--	--	--	--	--	--	--
			Logan Township							
15-139	Pureland Water Company	11-10-86	<3.0	<3.0	<3.0	--	--	--	--	--
15-388	Rollins Environmental Services	10-09-86	<3.0	<3.0	<3.0	--	--	--	--	--
15-395	Repaupo Fire Company	10-30-86	--	--	--	--	--	--	--	--
15-398	Pettit, Louis	11-17-86	--	--	--	--	--	--	--	--
15-564	USEPA	11-25-86	--	--	--	--	<.10	.40	<.10	--
		11-25-86	--	--	--	--	<.10	.50	<.10	--
15-569	Pureland Water Company	11-10-86	--	--	--	--	--	--	--	--
15-575	Rollins Environmental Services	10-09-86	<3.0	<3.0	<3.0	--	--	--	--	--
15-615	U.S. Geological Survey	12-02-86	<3.0	<3.0	<3.0	--	--	--	--	--
		12-02-86	--	--	--	--	--	--	--	--
		04-17-87	<.2	<.20	<.2	--	--	--	--	--
15-616	U.S. Gaological Survey	11-26-86	--	--	--	--	--	--	--	--
15-617	U.S. Geological Survey	12-03-86	--	--	--	--	--	--	--	--
15-618	U.S. Geological Survey	11-24-86	<3.0	<3.0	<3.0	--	--	--	--	--
		04-22-87	<.2	<.20	<.2	--	--	--	--	--
15-620	U.S. Geological Survey	11-25-86	--	--	--	--	--	--	--	--
		11-25-86	--	--	--	--	--	--	--	--
15-626	Logan Township	12-05-86	--	--	--	--	--	--	--	--
15-627	Logan Township	10-06-86	--	--	--	--	--	--	--	--
15-714	Rollins Environmental Services	12-01-86	<3.0	<3.0	<3.0	--	--	--	--	--
			Mantua Township							
15-191	Mantua Twp. MUA	12-16-86	--	--	--	--	--	--	--	--
15-432	Kramer Landfill	10-27-86	--	--	--	--	--	--	--	--
[2]15-676	Kramer Landfill	11-13-86	<3.0	<3.0	<3.0	--	--	--	--	--
		11-13-86	--	--	--	--	--	--	--	--
[3]15-715	Parks, T.	11-12-86	--	--	--	--	<.10	<.10	<.10	--
		11-12-86	--	--	--	--	<.10	<.10	<.10	--
			Paulsboro Borough							
15-210	Paulsboro WD	10-22-86	<.2	<.20	<.2	--	--	--	--	--
		04-21-87	<.2	<.20	<.2	--	--	--	--	--
		11-05-87	<.2	<.20	<.2	--	--	--	--	--
		02-11-88	<.2	<.20	<.2	--	--	--	--	--
		05-11-88	<.2	<.20	<.2	--	--	--	--	--
		08-10-88	<.2	<.20	<.2	--	--	--	--	--
15-212	Paulsboro WD	10-22-86	<.2	<.20	<.2	--	--	--	--	--

Footnotes at end of table.

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

Metri-buzin, water whole total (µg/L)	Prome-tone, total (µg/L)	Prome-tryne, total (µg/L)	Pro-pazine, total (µg/L)	Sima-zine, total (µg/L)	Sime-tryne, total (µg/L)	Tri-flura-lin, total recover (µg/L)	Car-baryl, water whole tot.rec (µg/L)	Metho-myl, total (µg/L)	Propham, total (µg/L)	Sevin, total (µg/L)	Gross alpha-particle[1] (pCi/L)	USGS well number
						Greenwich Township--Continued						
--	--	--	--	--	--	--	--	--	--	--	--	15-712
--	<.1	<.1	<.10	<.10	<.1	--	--	<2.0	<2.0	<2.0	--	15-713
--	--	--	--	--	--	--	--	--	--	--	--	
<.1	<.1	<.1	<.10	<.10	<.1	<.10	--	<2.0	<2.0	<2.0	--	15-728
--	--	--	--	--	--	--	--	--	--	--	--	
						Logan Township						
--	--	--	--	--	--	--	--	--	--	--	--	15-139
--	--	--	--	--	--	--	--	--	--	--	--	15-388
--	--	--	--	--	--	--	--	--	--	--	--	15-395
--	--	--	--	--	--	--	--	--	--	--	--	15-398
--	<.1	<.1	<.10	<.10	<.1	--	--	<2.0	<2.0	<2.0	--	15-564
--	<.1	<.1	<.10	<.10	<.1	--	--	<2.0	<2.0	<2.0	--	
--	--	--	--	--	--	--	--	--	--	--	--	15-569
--	--	--	--	--	--	--	--	--	--	--	--	15-575
--	--	--	--	--	--	--	--	--	--	--	--	15-615
--	--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	--	15-616
--	--	--	--	--	--	--	--	--	--	--	--	15-617
--	--	--	--	--	--	--	--	--	--	--	--	15-618
--	--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	--	15-620
--	--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	--	15-626
--	--	--	--	--	--	--	--	--	--	--	--	15-627
--	--	--	--	--	--	--	--	--	--	--	--	15-714
						Mantua Township						
--	--	--	--	--	--	--	--	--	--	--	--	15-191
--	--	--	--	--	--	--	--	--	--	--	--	15-432
--	--	--	--	--	--	--	--	--	--	--	--	[2]15-676
--	--	--	--	--	--	--	--	--	--	--	--	
--	<.1	<.1	<.10	<.10	<.1	--	--	<2.0	<2.0	<2.0	--	[3]15-715
--	<.1	<.1	<.10	<.10	<.1	--	--	<2.0	<2.0	<2.0	--	
						Paulsboro Borough						
--	--	--	--	--	--	--	--	--	--	--	--	15-210
--	--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	5.0 ± .9	
--	--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	--	15-212

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

USGS well number	Owner	Sample-collection date	Gross beta-particle[1] (pCi/L)	Radium-226, dissolved[1] (pCi/L)	Radium-226, dissolved (pCi/L)	Radium-228, dissolved (pCi/L)
		Greenwich Township--Continued				
15-712	U.S. Geological Survey	03-19-87	--	--	--	--
15-713	U.S. Geological Survey	12-03-86	--	--	--	--
		12-03-86	--	--	--	--
15-728	U.S. Geological Survey	04-22-87	--	--	--	--
		04-22-87	--	--	--	--
		Logan Township				
15-139	Pureland Water Company	11-10-86	--	--	--	--
15-388	Rollins Environmental Services	10-09-86	--	--	--	--
15-395	Repaupo Fire Company	10-30-86	--	--	--	--
15-398	Pettit, Louis	11-17-86	--	--	--	--
15-564	USEPA	11-25-86	--	--	--	--
		11-25-86	--	--	--	--
15-569	Pureland Water Company	11-10-86	--	--	--	--
15-575	Rollins Environmental Services	10-09-86	--	--	--	--
15-615	U.S. Geological Survey	12-02-86	--	--	--	--
		12-02-86	--	--	--	--
		04-17-87	--	--	--	--
15-616	U.S. Geological Survey	11-26-86	--	--	--	--
15-617	U.S. Geological Survey	12-03-86	--	--	--	--
15-618	U.S. Geological Survey	11-24-86	--	--	--	--
		04-22-87	--	--	--	--
15-620	U.S. Geological Survey	11-25-86	--	--	--	--
		11-25-86	--	--	--	--
15-626	Logan Township	12-05-86	--	--	--	--
15-627	Logan Township	10-06-86	--	--	--	--
15-714	Rollins Environmental Services	12-01-86	--	--	--	--
		Mantua Township				
15-191	Mantua Twp. MUA	12-16-86	--	--	--	--
15-432	Kramer Landfill	10-27-86	--	--	--	--
[2]15-676	Kramer Landfill	11-13-86	--	--	--	--
		11-13-86	--	--	--	--
[3]15-715	Parks, T.	11-12-86	--	--	--	--
		11-12-86	--	--	--	--
		Paulsboro Borough				
15-210	Paulsboro WD	10-22-86	--	--	--	--
		04-21-87	--	--	--	--
		11-05-87	--	--	--	--
		02-11-88	5.2 ± .6	1.1 ± .2	--	--
		05-11-88	--	--	--	--
		08-10-88	--	--	--	--
15-212	Paulsboro WD	10-22-86	--	--	--	--

Footnotes at end of table.

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

USGS well number	Owner	Well name	Station number	Sample-collection date	Alkalinity whole water total field (mg/L as $CaCO_3$)	Alkalinity as bicarbonate field (mg/L)	Barometric pressure (mm of Hg)	Dissolved oxygen (mg/L)
			Paulsboro Borough--continued					
15-212	Paulsboro WD	4	394931075144901	10-22-86	23	28	--	0.3
				04-23-87	--	--	--	--
				11-05-87	--	--	--	--
				02-11-88	49	60	--	6.8
				06-08-88	--	--	--	--
				08-10-88	--	--	767	.8
15-213	Paulsboro WD	5	394950075142201	10-24-86	<1	<1.0	--	.3
				04-21-87	--	--	--	--
				11-05-87	--	--	--	--
				02-11-88	--	--	--	0
				05-11-88	--	--	--	--
				08-10-88	--	--	770	<.1
15-221	Essex Chemicals	1	395057075134701	10-14-86	151	184	--	.2
15-673	BP Oil Company	BL-3	395100075142001	10-23-86	64	50	--	.1
15-674	Essex Chemicals	Obs. 1	395053075134601	10-14-86	151	184	--	.1
				10-14-86	64	78	--	.1
15-677	Exxon Corporation	8	395050075144901	10-21-86	<1	<1.0	--	1.1
			Swedesboro Borough					
15-240	DelMonte Corporation	9	394510075183802	11-18-86	46	56	--	.3
			West Deptford Township					
15-276	W. Deptford WD	4	394821075102601	11-03-86	133	162	--	.2
15-279	Shell Chemical Company	Obs. 7	394857075125001	10-15-86	150	183	--	<.1
15-295	Westwood Golf Course	1-1973	394939075100701	11-12-86	72	88	--	.3
15-296	Shell Chemical Company	Obs. 5	394942075131701	10-16-86	137	167	--	<.1
				10-16-86	137	167	--	<.1
15-297	Shell Chemical Company	Obs. 6	394942075131702	10-16-86	124	151	--	<.1
15-306	Pennwalt Corporation	417	395033075123301	11-03-86	110	134	--	.2
15-312	W. Deptford WD	6	395107075094601	12-17-86	103	126	--	.1
15-435	W. Deptford WD	8	394836075104601	12-05-86	142	173	--	.1
			Woodbury City					
15-332	Woodbury WD	3	395017075092801	10-29-86	161	196	--	.3
15-431	Woodbury WD	6	395034075084201	10-29-86	111	135	--	.2
			Woolwich Township					
15-345	Musumeci, P.	1	394642075182301	12-04-86	41	50	--	<.1
				12-04-86	41	50	--	<.1
15-519	Miskofsky, N.	1	394649075173801	11-18-86	98	120	--	<.1

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

USGS well number	Owner	Sample-collection date	Phosphorus, ortho, dissolved (mg/L as P)	Calcium, dissolved (mg/L as Ca)	Chloride, dissolved (mg/L as Cl)	Magnesium, dissolved (mg/L as Mg)	Potassium, dissolved (mg/L as K)	Silica, dissolved (mg/L as SiO2)	Sodium, dissolved (mg/L as Na)
			Paulsboro Borough--continued						
15-212	Paulsboro WD	10-22-86	--	13	16	1.0	1.6	8.2	27
		04-23-87	--	--	--	--	--	--	--
		11-05-87	--	--	--	--	--	--	--
		02-11-88	--	--	--	--	--	--	--
		06-08-88	--	--	--	--	--	--	--
		08-10-88	--	--	--	--	--	--	--
15-213	Paulsboro WD	10-24-86	<.010	11	29	5.3	4.3	6.2	18
		04-21-87	--	--	--	--	--	--	--
		11-05-87	--	--	--	--	--	--	--
		02-11-88	--	--	--	--	--	--	--
		05-11-88	--	--	--	--	--	--	--
		08-10-88	--	--	--	--	--	--	--
15-221	Essex Chemicals	10-14-86	<.010	24	150	5.9	5.4	11	160
15-673	BP Oil Company	10-23-86	<.010	21	170	16	2.3	4.9	33
15-674	Essex Chemicals	10-14-86	<.010	96	60	6.1	12	7.0	66
		10-14-86	<.010	--	--	--	--	--	--
15-677	Exxon Corporation	10-21-86	<.010	6.4	13	2.3	1.9	3.8	10
			Swedesboro Borough						
15-240	DelMonte Corporation	11-18-86	.040	12	22	3.9	4.0	12	14
			West Deptford Township						
15-276	West Deptford WD	11-03-86	.070	9.3	41	2.5	5.1	8.4	79
15-279	Shell Chemical Company	10-15-86	.280	6.8	140	1.8	3.6	8.9	15-
15-295	Westwood Golf Course	11-12-86	.020	21	11	4.2	5.6	8.3	27
15-296	Shell Chemical Company	10-16-86	.210	8.2	190	2.1	3.6	8.9	180
		10-16-86	--	8.2	190	2.1	3.5	8.9	180
15-297	Shell Chemical Company	10-16-86	<.010	46	14	12	6.5	18	18
15-306	Pennwalt Corporation	11-03-86	.240	6.9	74	1.8	3.5	8.6	91
15-312	West Deptford WD	12-17-86	.160	5.7	42	1.4	3.6	9.1	67
15-435	West Deptford WD	12-05-86	.180	8.4	37	2.2	4.9	8.2	74
			Woodbury City						
15-332	Woodbury WD	10-29-86	.380	6.2	31	1.8	5.5	9.2	80
15-431	Woodbury WD	10-29-86	.200	29	21	6.0	6.7	9.7	32
			Woolwich Township						
15-345	Musumeci, P.	12-04-86	<.010	15	16	5.9	3.6	23	2.1
		12-04-86	<.010	--	--	--	--	--	--
15-519	Miskofsky, N.	11-18-86	.130	22	15	7.7	4.2	21	4.1

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

Dis-solved solids, residue at 180 deg. C (mg/L)	Hardness, as $CaCO_3$ (mg/L)	pH (stand-ard units)	Specific conduc-tance (µS/cm)	Temper-ature, water (deg C)	Nitro-gen, ammonia dis-solved (mg/L as N)	Nitro-gen, nitrite, dis-solved (mg/L as N)	Nitro-gen, am-monia + organic, dis. (mg/L as N)	Nitro-gen, NO2+NO3, dis-solved (mg/L as N)	USGS well number
					Paulsboro Borough--Continued				
142	37	6.50	217	16.5	--	--	--	--	15-212
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--	--	--	--	--	--	--	--	--	
--	--	6.65	263	11.5	--	--	--	--	
--	--	--	--	--	--	--	--	--	
--	--	4.47	171	15.0	--	--	--	--	
145	49	4.41	244	15.0	.260	<.010	.40	<.100	15-213
--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	
--	--	4.37	237	14.0	--	--	--	--	
--	--	5.63	266	15.0	--	--	--	--	
--	--	4.50	277	15.5	--	--	--	--	
557	86	6.97	994	14.5	.940	<.010	1.6	<.100	15-221
391	120	5.36	705	17.0	.150	<.010	.40	<.100	15-673
835	270	6.09	1480	17.5	94.0	<.010	76	<.100	15-674
--	--	6.10	1480	17.5	75.0	<.010	66	<.100	
79	26	4.36	139	15.0	<.010	<.010	.60	1.80	15-677
					Swedesboro Borough				
102	47	6.43	179	14.0	.170	<.010	.40	<.100	15-240
					West Deptford Township				
251	34	7.72	410	14.5	.120	<.010	.50	<.100	15-276
453	25	8.04	725	13.5	.280	<.010	.90	<.100	15-279
173	71	7.08	280	13.5	.230	<.010	.50	<.100	15-295
485	30	7.80	881	13.5	.290	<.010	.60	<.100	15-296
483	30	7.80	881	13.5	--	--	--	--	
279	170	7.16	427	13.0	.360	<.010	.70	<.100	15-297
281	25	7.56	469	13.5	.210	<.010	1.1	<.100	15-306
210	20	7.89	346	14.0	.210	<.010	.30	<.100	15-312
222	31	8.03	387	14.5	.310	<.010	.40	<.100	15-435
					Woodbury City				
249	23	7.94	402	16.5	.200	.070	.60	<.100	15-332
206	98	7.52	335	14.0	.290	<.010	4.5	<.100	15-431
					Woolwich Township				
125	62	6.39	204	13.5	.080	<.010	.50	<.100	15-345
--	87	6.40	204	13.5	.050	<.010	.40	<.100	
117		6.16	209	13.0	.080	<.010	.50	<.100	15-519

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

USGS well number	Owner	Sample-collection date	Lithium, dissolved (μg/L as Li)	Manganese, dissolved (μg/L as Mn)	Molybdenum, dissolved (μg/L as Mo)	Strontium, dissolved (μg/L as Sr)	Vanadium, dissolved (μg/L as V)	Zinc, dissolved (μg/L as Zn)	Phenols, total (μg/L)	Carbon, organic, dissolved (mg/L as C)
				Paulsboro Borough--continued						
15-212	Paulsboro WD	10-22-86	12	15	<10	65	<6	37	--	--
		04-23-87	--	--	--	--	--	--	--	--
		11-05-87	--	--	--	--	--	--	--	--
		02-11-88	--	--	--	--	--	--	--	--
		06-08-88	--	--	--	--	--	--	--	--
		08-10-88	--	--	--	--	--	--	--	--
15-213	Paulsboro WD	10-24-86	11	62	<10	140	<6	95	<1	1.1
		04-21-87	--	--	--	--	--	--	--	--
		11-05-87	--	--	--	--	--	--	--	--
		02-11-88	--	--	--	--	--	--	--	--
		05-11-88	--	--	--	--	--	--	--	--
		08-10-88	--	--	--	--	--	--	--	--
15-221	Essex Chemicals	10-14-86	16	66	<10	1,300	<6	3	8	2.6
15-673	BP Oil Company	10-23-86	10	1,500	<10	280	14	69	460	32
15-674	Essex Chemicals	10-14-86	13	570	<10	250	6	140	4	6.1
		10-14-86	--	--	--	--	--	--	--	--
15-677	Exxon Corporation	10-21-86	4	160	<10	38	<6	190	5	3.0
				Swedesboro Borough						
15-240	DelMonte Corporation	11-18-86	12	44	<10	420	<6	11	2	.5
				West Deptford Township						
15-276	West Deptford WD	11-03-86	8	3	<10	410	<6	6	2	1.2
15-279	Shell Chemical Company	10-15-86	6	30	<10	420	<6	4	4	1.3
15-295	Westwood Golf Course	11-12-86	6	22	<10	660	<6	47	3	.7
15-296	Shell Chemical Company	10-16-86	8	21	<10	500	<6	4	3	1.3
		10-16-86	7	21	<10	500	<6	3	--	--
15-297	Shell Chemical Company	10-16-86	25	88	<10	1,600	<6	3	3	3.0
15-306	Pennwalt Corporation	11-03-86	8	16	<10	360	<6	5	<1	.8
15-312	West Deptford WD	12-17-86	5	11	<10	340	<6	<3	<1	.9
15-435	West Deptford WD	12-05-86	5	10	<10	400	<6	7	2	1.0
				Woodbury City						
15-332	Woodbury WD	10-29-86	5	9	<10	210	<6	17	1	1.1
15-431	Woodbury WD	10-29-86	7	18	<10	1,100	<6	4	4	.9
				Woolwich Township						
15-345	Musumeci, P.	12-04-86	50	230	<10	400	<6	5	2	.8
		12-04-86	--	--	--	--	--	--	--	--
15-519	Miskofsky, N.	11-18-86	37	98	<10	650	<6	12	3	1.2

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

Sulfate, dis-solved (mg/L as SO4)	Alum-inum, dis-solved (µg/L as Al)	Arsenic, dis-solved (µg/L as As)	Barium, dis-solved (µg/L as Ba)	Beryl-lium, dis-solved (µg/L as Be)	Cadmium, dis-solved (µg/L as Cd)	Chro-mium, dis-solved (µg/L as Cr)	Cobalt, dis-solved (µg/L as Co)	Copper, dis-solved (µg/L as Cu)	Iron, dis-solved (µg/L as Fe)	Lead, dis-solved (µg/L as Pb)	USGS well number
					Paulsboro Borough--Continued						
41	20	<1	21	<0.5	<1	<10	<3	<10	930	<10	15-212
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62	540	<1	59	3	<1	<10	10	<10	2,700	<10	15-213
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97	<10	<1	89	<.5	<1	<10	<9	<30	4,800	<10	15-221
49	940	2	56	2	6	<10	<3	<10	77,000	20	15-673
570	4,500	5	11	2	4	<10	<3	<10	39,000	<10	15-674
--	--	--	--	--	--	--	--	--	--	--	
25	350	1	68	<.5	<1	<10	5	50	71	<10	15-677
					Swedesboro Borough						
23	10	<1	86	<.5	<1	20	<3	<10	2,700	<10	15-240
					West Deptford Township						
9.7	20	<1	52	<.5	<1	<10	<3	<10	25	<10	15-276
9.1	<10	<1	34	<.5	1	<10	<3	<10	300	<10	15-279
51	<10	<1	88	<.5	<1	<10	<3	<10	45	<10	15-295
11	10	<1	34	<.5	<1	<10	<3	<10	410	<10	15-296
12	<10	<1	34	<.5	<1	<10	<3	<10	410	<10	
76	10	<1	200	<.5	1	<10	<3	<10	6,200	<10	15-297
11	<10	<1	31	<.5	1	<10	<3	<10	890	<10	15-306
12	<10	<1	21	<.5	1	<10	<3	<10	210	<10	15-312
13	<10	<1	49	<.5	<1	<10	<3	<10	250	<10	15-435
					Woodbury City						
<.2	10	<1	35	<.5	<1	<10	<3	<10	240	<10	15-332
25	<10	<1	110	<.5	<1	<10	<3	<10	410	<10	15-431
					Woolwich Township						
51	<10	<1	86	<.5	2	<10	<3	<10	17,000	<10	15-345
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5.5	<10	<1	83	<.5	1	30	<3	<10	8,000	<10	15-519

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

USGS well number	Owner	Sample-collection date	Dichloro-bromo-methane (µg/L)	Dichloro-difluoro-methane (µg/L)	1,1-Dichloro-ethane (µg/L)	1,2-Dichloro-ethane (µg/L)	1,1-Dichloro-ethylene (µg/L)	1,2-Transdichloro-ethylene (µg/L)	1,2-Dichloro-propane (µg/L)	1,3-Dichloro-propane (µg/L)
				Paulsboro Borough--continued						
15-212	Paulsboro WD	10-22-86	--	--	--	--	--	--	--	--
		04-23-87	<.20	<.20	<.20	.30	<.20	<.20	.20	<.20
		11-05-87	<.20	<.20	<.20	.90	<.20	<.20	.30	<.20
		02-11-88	<.20	<.20	<.20	.80	<.20	<.20	.30	<.20
		06-08-88	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20
		08-10-88	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20
15-213	Paulsboro WD	10-24-86	<.20	<.20	.20	3.0	<.20	<.20	3.1	<.20
		04-21-87	<.20	<.20	.20	.70	<.20	<.20	3.8	<.20
		11-05-87	<.20	<.20	.20	1.9	<.20	5.2	3.1	<.20
		02-11-88	<.20	<.20	<.20	1.2	<.20	<.20	2.3	<.20
		05-11-88	<.20	<.20	1.8	<.20	<.20	<.20	<.20	<.20
		08-10-88	<.20	<.20	.20	2.5	<.20	<.20	2.5	<.20
15-221	Essex Chemicals	10-14-86	<3.0	<3.0	<3.0	40	<3.0	72	<3.0	3.4
15-673	BP Oil Company	10-23-86	<200	<200	<200	2400	<200	<200	<200	<200
15-674	Essex Chemicals	10-14-86	<3.0	<3.0	<3.0	6.0	<3.0	<3.0	<3.0	<3.0
		10-14-86	--	--	--	--	--	--	--	--
15-677	Exxon Corporation	10-21-86	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
				Swedesboro Borough						
15-240	DelMonte Corporation	11-18-86	--	--	--	--	--	--	--	--
				West Deptford Township						
15-276	West Deptford WD	11-03-86	--	--	--	--	--	--	--	--
15-279	Shell Chemical Company	10-15-86	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
15-295	Westwood Golf Course	11-12-86	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
15-296	Shell Chemical Company	10-16-86	--	--	--	--	--	--	--	--
		10-16-86	--	--	--	--	--	--	--	--
15-297	Shell Chemical Company	10-16-86	--	--	--	--	--	--	--	--
15-306	Pennwalt Corporation	11-03-86	--	--	--	--	--	--	--	--
15-312	West Deptford WD	12-17-86	--	--	--	--	--	--	--	--
15-435	West Deptford WD	12-05-86	--	--	--	--	--	--	--	--
				Woodbury City						
15-332	Woodbury WD	10-29-86	--	--	--	--	--	--	--	--
15-431	Woodbury WD	10-29-86	--	--	--	--	--	--	--	--
				Woolwich Township						
15-345	Musumeci, P.	12-04-86	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
		12-04-86	--	--	--	--	--	--	--	--
15-519	Miskofsky, N.	11-18-86	--	--	--	--	--	--	--	--

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

Benzene (µg/L)	Bromo-form (µg/L)	Carbon tetra-chlo-ride (µg/L)	Chloro-benzene (µg/L)	Chloro-di-bromo-methane (µg/L)	Chloro-ethane (µg/L)	2-Chloro-ethyl-vinyl-ether (µg/L)	1,2-Dibromo-Chloro-form (µg/L)	1,2-Di-ethyl-ene (µg/L)	1,3-Di-chloro-benzene (µg/L)	1,4-Di-chloro-benzene (µg/L)	Chloro-benzene (µg/L)	USGS well number
						Paulsboro Borough--Continued						
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<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	15-213
<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	<.20	<.20	
66	<3.0	<3.0	710	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	15-221
7,800	<200	<200	7400	<200	<200	<200	<200	<200	<200	<200	<200	15-673
<3.0	<3.0	<3.0	10	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	15-674
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<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	15-677
						Swedesboro Borough						
--	--	--	--	--	--	--	--	--	--	--	--	15-240
						West Deptford Township						
--	--	--	--	--	--	--	--	--	--	--	--	15-276
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	15-279
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	15-295
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--	--	--	--	--	--	--	--	--	--	--	--	15-297
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--	--	--	--	--	--	--	--	--	--	--	--	15-435
						Woodbury City						
--	--	--	--	--	--	--	--	--	--	--	--	15-332
--	--	--	--	--	--	--	--	--	--	--	--	15-431
						Woolwich Township						
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	15-345
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Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

USGS well number	Owner	Sample-collection date	Styrene (μg/L)	Vinyl chloride (μg/L)	Xylene water whole total recover (μg/L)	Alachlor, total recover (μg/L)	Ametryne, total (μg/L)	Atrazine, total (μg/L)	Cyanazine, total (μg/L)	Metolachlor, water whole tot rec (μg/L)
Paulsboro Borough--continued										
15-212	Paulsboro WD	10-22-86	--	--	--	--	--	--	--	--
		04-23-87	<.2	<.20	<.2	--	--	--	--	--
		11-05-87	<.2	<.20	<.2	--	--	--	--	--
		02-11-88	<.2	<.20	<.2	--	--	--	--	--
		06-08-88	<.2	<.20	<.2	--	--	--	--	--
		08-10-88	<.2	<.20	<.2	--	--	--	--	--
15-213	Paulsboro WD	10-24-86	<.2	<.20	<.2	--	--	--	--	--
		04-21-87	<.2	<.20	<.2	--	--	--	--	--
		11-05-87	<.2	<.20	<.2	--	--	--	--	--
		02-11-88	<.2	<.20	<.2	--	--	--	--	--
		05-11-88	<.2	<.20	<.2	--	--	--	--	--
		08-10-88	<.2	<.20	<.2	--	--	--	--	--
15-221	Essex Chemicals	10-14-86	<3.0	<3.0	<3.0	--	--	--	--	--
15-673	BP Oil Company	10-23-86	<200	<200	3,100	--	--	--	--	--
15-674	Essex Chemicals	10-14-86	<3.0	<3.0	<3.0	--	--	--	--	--
		10-14-86	--	--	--	--	--	--	--	--
15-677	Exxon Corporation	10-21-86	<3.0	<3.0	<3.0	--	--	--	--	--
Swedesboro Borough										
15-240	DelMonte Corporation	11-18-86	--	--	--	--	--	--	--	--
West Deptford Township										
15-276	West Deptford WD	11-03-86	--	--	--	--	--	--	--	--
15-279	Shell Chemical Company	10-15-86	<3.0	<3.0	<3.0	--	--	--	--	--
15-295	Westwood Golf Course	11-12-86	<3.0	<3.0	<3.0	--	--	--	--	--
15-296	Shell Chemical Company	10-16-86	--	--	--	--	--	--	--	--
		10-16-86	--	--	--	--	--	--	--	--
15-297	Shell Chemical Company	10-16-86	--	--	--	--	--	--	--	--
15-306	Pennwalt Corporation	11-03-86	--	--	--	--	--	--	--	--
15-312	West Deptford WD	12-17-86	--	--	--	--	--	--	--	--
15-435	West Deptford WD	12-05-86	--	--	--	--	--	--	--	--
Woodbury City										
15-332	Woodbury WD	10-29-86	--	--	--	--	--	--	--	--
15-431	Woodbury WD	10-29-86	--	--	--	--	--	--	--	--
Woolwich Township										
15-345	Musumeci, P.	12-04-86	<3.0	<3.0	<3.0	--	<.10	<.10	<.10	--
		12-04-86	--	--	--	--	--	--	--	--
15-519	Miskofsky, N.	11-18-86	--	--	--	--	--	--	--	--

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

Trans-1,3-di-chloro-propene (µg/L)	Ethyl benzene (µg/L)	Methyl bromide (µg/L)	Methyl chlo-ride (µg/L)	Methyl-ene chlo-ride (µg/L)	1,1,2,2 Tetra-chloro-ethane (µg/L)	Tetra-chloro-ethyl-ene (µg/L)	Toluene (µg/L)	1,1,1-Tri-chloro-ethane (µg/L)	1,1,2-Tri-chloro-ethane (µg/L)	Tri-chloro-ethyl-ene (µg/L)	Tri-chloro-fluoro-methane (µg/L)	USGS well number
Paulsboro Borough--Continued												
--	--	--	--	--	--	--	--	--	--	--	--	15-212
<.20	<.20	<.20	<.20	<.20	<.20	.20	.20	<.20	<.20	<.2	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	.20	<.20	<.20	<.20	<.2	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	.20	<.20	<.20	<.20	<.2	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	<.20	.20	<.20	<.20	<.2	<.20	15-213
<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	.3	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	7.8	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	.2	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.2	<.20	
<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20	.2	<.20	
<3.0	5.6	<3.0	<3.0	<3.0	<3.0	16	<3.0	5.1	<3.0	52.0	<3.0	15-221
<200	1600	<200	<200	<200	<200	<200	360	<200	<200	<200	<200	15-673
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	15-674
--	--	--	--	--	--	--	--	--	--	--	--	
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	15-677
Swedesboro Borough												
--	--	--	--	--	--	--	--	--	--	--	--	15-240
West Deptford Township												
--	--	--	--	--	--	--	--	--	--	--	--	15-276
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	15-279
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	15-295
--	--	--	--	--	--	--	--	--	--	--	--	15-296
--	--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	--	15-297
--	--	--	--	--	--	--	--	--	--	--	--	15-306
--	--	--	--	--	--	--	--	--	--	--	--	15-312
--	--	--	--	--	--	--	--	--	--	--	--	15-435
Woodbury City												
--	--	--	--	--	--	--	--	--	--	--	--	15-332
--	--	--	--	--	--	--	--	--	--	--	--	15-431
Woolwich Township												
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	15-345
--	--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	--	15-519

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

USGS well number	Owner	Sample-collection date	Gross alpha-particle[1] (pCi/L)	Gross beta-particle[1] (pCi/L)	Radium-226, dissolved[1] (pCi/L)	Radium-226, dissolved (pCi/L)	Radium-228, dissolved (pCi/L)
			Paulsboro Borough--continued				
15-212	Paulsboro WD	10-22-86	--	--	--	--	--
		04-23-87	--	--	--	--	--
		11-05-87	--	--	--	--	--
		02-11-88	.05 ± .65	1.1 ± .46	--	.20	--
		06-08-88	--	--	--	--	--
		08-10-88	--	--	--	--	--
15-213	Paulsboro WD	10-24-86	--	--	--	--	--
		04-21-87	--	--	--	--	--
		11-05-87	--	--	--	--	--
		02-11-88	4.6 ± 1.0	7.8 ± .70	1.2 ± .3	1.3	--
		02-11-88	4.7 ± 1.0	7.9 ± .71	1.3 ± .3	--	--
		05-11-88	--	--	--	--	--
		08-10-88	--	--	--	--	--
15-221	Essex Chemicals	10-14-86	--	--	--	--	--
15-673	BP Oil Company	10-23-86	--	--	--	--	--
15-674	Essex Chemicals	10-14-86	--	--	--	--	--
		10-14-86	--	--	--	--	--
15-677	Exxon Corporation	10-21-86	--	--	--	--	--
			Swedesboro Borough				
15-240	DelMonte Corporation	11-18-86	--	--	--	--	--
			West Deptford Township				
15-276	West Deptford WD	11-03-86	--	--	--	--	--
15-279	Shell Chemical Company	10-15-86	--	--	--	--	--
15-295	Westwood Golf Course	11-12-86	--	--	--	--	--
15-296	Shell Chemical Company	10-16-86	--	--	--	--	--
		10-16-86	--	--	--	--	--
15-297	Shell Chemical Company	10-16-86	--	--	--	--	--
15-306	Pennwalt Corporation	11-03-86	--	--	--	--	--
15-312	West Deptford WD	12-17-86	--	--	--	--	--
15-435	West Deptford WD	12-05-86	--	--	--	--	--
			Woodbury City				
15-332	Woodbury WD	10-29-86	--	--	--	--	--
15-431	Woodbury WD	10-29-86	--	--	--	--	--
			Woolwich Township				
15-345	Musumeci, P.	12-04-86	--	--	--	--	--
		12-04-86	--	--	--	--	--
15-519	Miskofsky, N.	11-18-86	--	--	--	--	--

[1] Analyses performed at New Jersey Department of Environmental Protection, Bureau of Environmental Laboratories, Radiation Laboratory in Trenton, N.J.
[2] Well 15-676 is screened in the Englishtown aquifer system.
[3] Well 15-715 is screened in the Wenonah-Mount Laurel aquifer.

Table 2. Results of analyses of water samples for physical and chemical properties and inorganic and organic constituents, Potomac-Raritan-Magothy aquifer system, region of Greenwich Township, Gloucester County, New Jersey, 1986-88--Continued

Metri-buzin, water whole tot rec (µg/L)	Prome-tone, total (µg/L)	Prome-tryne, total (µg/L)	Pro-pazine, total (µg/L)	Sima-zine, total (µg/L)	Sime-tryne, total (µg/L)	Tri-flura-lin, total recover (µg/L)	Car-baryl, water whole total (µg/L)	Metho-myl, total (µg/L)	Propham, total (µg/L)	Sevin, total (µg/L)	USGS well number
					Paulsboro Borough--Continued						
--	--	--	--	--	--	--	--	--	--	--	15-212
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	15-213
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	15-221
--	--	--	--	--	--	--	--	--	--	--	15-673
--	--	--	--	--	--	--	--	--	--	--	15-674
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	15-677
					Swedesboro Borough						
--	--	--	--	--	--	--	--	--	--	--	15-240
					West Deptford Township						
--	--	--	--	--	--	--	--	--	--	--	15-276
--	--	--	--	--	--	--	--	--	--	--	15-279
--	--	--	--	--	--	--	--	--	--	--	15-295
--	--	--	--	--	--	--	--	--	--	--	15-296
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	15-297
--	--	--	--	--	--	--	--	--	--	--	15-306
--	--	--	--	--	--	--	--	--	--	--	15-312
--	--	--	--	--	--	--	--	--	--	--	15-435
					Woodbury City						
--	--	--	--	--	--	--	--	--	--	--	15-332
--	--	--	--	--	--	--	--	--	--	--	15-431
					Woolwich Township						
--	<.1	<.1	<.10	<.10	<.1	--	--	<2.0	<2.0	<2.0	15-345
--	--	--	--	--	--	--	--	--	--	--	
--	--	--	--	--	--	--	--	--	--	--	15-519

Table 3. Location, altitude, well-construction, and hydrogeologic data for wells used to assess the quality of ground water, and results of water-quality assessment, region of Greenwich Township, Gloucester County, New Jersey

[HPPM, undifferentiated Holocene, Pleistocene, Pliocene, and Miocene deposits; QRNR, undifferentiated Quaternary deposits; MLRW, Wenonah-Mt. Laurel aquifer; EGLS, Englishtown aquifer system; MRPA, Potomac-Raritan-Magothy aquifer system, undifferentiated; MRPAU, upper aquifer of the MRPA; MRPAM, middle aquifer of the MRPA; MRPAL, lower aquifer of the MRPA; --, data not available; USGS, U.S. Geological Survey]

USGS well number	Station number	Owner[1]	Well name	Latitude	Longitude
		Deptford Township			
15- 05	394627075081301	Woodbury WD	Sewell 1	394627	750813
15- 06	394627075081302	Woodbury WD	Sewell 1A	394627	750813
15- 07	394628075081301	Woodbury WD	Sewell 2	394628	750813
15- 08	394628075081303	Woodbury WD	Sewell 2A	394628	750813
15- 11	394805075091301	Deptford T MUA	DTMUA 2	394811	750914
15- 16	394839075091101	Deptford T MUA	DTMUA 1	394839	750911
		East Greenwich Township			
15- 28	394755075132701	E Greenwich WD	EGWD 2	394755	751327
15- 29	394757075133401	E Greenwich WD	EGWD 1	394757	751334
		--			
15-355	394822075124701	E Greenwich WD	EGWD 3	394822	751247
15-363	394618075154201	Sherman, A	1	394618	751542
15-366	394620075150701	Cianciulli, Tim	1	394620	751507
15-500	394704075155501	Thompson, Herbert P	1	394704	751555
15-501	394632075161401	Henderson, Virginia	1	394632	751614
		Greenwich Township			
15- 64	394838075153801	Greenwich T WD	Test well 2-59	394838	751538
15- 65	394851075152601	Greenwich T WD	GTWD 2(NEW 3)	394851	751526
15- 69	394919075160201	Greenwich T WD	GTWD 3(NEW 4)	394920	751619
15- 70	394932075172201	Greenwich T WD	5	394932	751722
15- 72	394936075174701	E I DuPont	Repauno 3	394936	751747
15- 76	394940075170901	Hercules Chemical	4 1970	394939	751704
15- 79	394944075173401	E I DuPont	Repauno 6	394944	751734
15- 81	394945075171701	E I DuPont	Repauno 5	394945	751717
15- 82	394945075173601	E I DuPont	Repauno 1	394945	751736
15- 84	394948075163901	Hercules Chemical	Gibbstown 2	394948	751639
15- 89	394952075165301	Hercules Chemical	Gibbstown 1	394952	751653
15- 93	394956075152101	Mobil Oil Company	Mobil 46	394956	751521
15- 94	394958075151201	Mobil Oil Company	Mobil 44	394958	751512
15- 96	394959075165001	Hercules Chemical	Gibbstown OB 2	394959	751650
15- 97	395000075163601	Hercules Chemical	Gibbstown TH 8	395000	751636
15- 98	395005075152301	Mobil Oil Company	Mobil 45	395006	751532
15-100	395009075170601	E I Dupont	Repauno OB 6	395009	751706
15-101	395012075152001	Mobil Oil Company	Mobil 40	395012	751520
15-102	395016075173801	E I DuPont	Repauno 20	395016	751738
15-103	395021075173001	E I DuPont	Repauno H	395021	751730
15-104	395021075174001	E I DuPont	Repauno J	395021	751740
15-107	395025075175701	E I DuPont	Repauno C	395025	751757
15-109	395027075150301	Mobil Oil Company	Mobil 41	395027	751503
15-118	395036075150101	Mobil Oil Company	Mobil 47	395036	751501
15-672	395014075145901	Air Products	2-North Well	395014	751459

Table 3. Location, altitude, well-construction, and hydrogeologic data for wells used to assess the quality of ground water, and results of water-quality assessment, region of Greenwich Township, Gloucester County, New Jersey--Continued

Elevation of land surface (feet below sea level)	Screened interval (feet below sea level) Top of screen	Bottom of screen	Diameter of screen (inches)	Casing material[2]	Date of construction	Water-quality category[3]	Aquifer code	Source of water-quality data[4]	USGS well number
				Deptford Township					
20.00	--	--	--	I	- -34		MRPAU	F	15- 05
20	263	308	12.0	S	11-07-67		MRPAU	X	15- 06
60	267	317	16.0	I	- -37		MRPAU	F	15- 07
20	244	307	12.0	S	03-28-73		MRPAU	F	15- 08
60	255	281	12.0	S	01-14-58		MRPAU	F	15- 11
70	252	273	12.0	S	12-27-55		MRPAU	F	15- 16
				East Greenwich Township					
80	191	216	10.0	S	02-17-56	2	MRPAU	E,F,G,P	15- 28
70	169	200	4.0	--	08- -31		MRPAU	F	15- 29
	183	200	10.0	--	--				
40	205	245	12.0	S	05- -77		MRPAU	F	15-355
40	145	151	--	S	05-05-60	2	MRPAU	G,P	15-363
80	209	219	3.0	S	07-14-78	2	MRPAU	F	15-366
60	24.0	29.0	3.7	S	06-14-63	1,2	HPPM	G,P	15-500
50	162	167	4.0	S	10-30-77	2	MRPAU	G,P	15-501
				Greenwich Township					
20	238	248	6.0	--	- -59		MRPAL	X	15- 64
.0	69.0	98.0	15.0	S	05-15-50	2	MRPAU	F	15- 65
10	108	168	12.0	S	07-08-59	2	MRPAM	E,F,G	15- 69
20	76.0	96.0	16.0	S	02-03-44	1,2	MRPAM	F	15- 70
5	91.0	101	12.0	-	04-15-50	2	MRPAM	F	15- 72
15	91.0	121	10.0	S	07-16-70	1,2	MRPAM	F	15- 76
10	84.0	109	12.0	S	10-24-67	1,2	MRPAM	E	15- 79
10	81.0	99.0	8.0	--	--	2	MRPAM	F,G,P	15- 81
10	75.0	105	8.0	S	- -36	2	MRPAM	F	15- 82
10	--	--	--	--	08-26-54	2	MRPAM	F	15- 84
10	--	--	--	--	04-19-54	2	MRPAM	F	15- 89
6	111	136	12.0	S	12-15-50	2	MRPAM	F	15- 93
10	116	136	16.0	S	04-04-47	1,2	MRPAM	F	15- 94
10	129	134	3.0	S	02-17-53	1,2	MRPAM	F	15- 96
5.6	102	107	3.0	S	05- -54	2	MRPAM	F,E	15- 97
.0	95.0	118	16.0	S	08- -47	1,2	MRPAM	F	15- 98
3	79	84	4.0	--	02-05-57		MRPAM	X	15-100
20	195	225	16.0	S	03-02-44	2	MRPAL	F	15-101
.0	--	--	--	--	- -40	2	MRPAL	F	15-102
.0	83.0	103	10.0	S	12-28-45	2	MRPAL	F	15-103
.0	74.0	103	10.0	S	06-30-40	2	MRPAL	F	15-104
.0	75.0	105	10.0	S	12-10-45	2	MRPAL	F	15-107
20	229	259	12.0	S	07-31-46	1,2	MRPAL	E,F	15-109
18	220	240	12.0	S	11-02-53	2	MRPAL	E,F	15-118
20	244	264	8	S	02-24-78	1,2	MRPAL	G	15-672

Footnotes at end of table.

Table 3. Location, altitude, well-construction, and hydrogeologic data for wells used to assess the quality of ground water, and results of water-quality assessment, region of Greenwich Township, Gloucester County, New Jersey--Continued

USGS well number	Station number	Owner[1]	Well name	Latitude	Longitude
		Greenwich Township--Continued			
15-347	394932075172202	Greenwich T WD	GTWD 5 (2-A)	394932	751722
15-348	394920075154101	Greenwich T WD	GTWD 6	394910	751541
15-357	394957075173701	E I DuPont	Obs 7	394957	751737
15-412	395033075174001	E I Dupont	Test 41965	395033	751740
15-423	395007075151301	Mobil Oil Company	Mobil 28	395007	751513
15-634	394944075175001	DuPont, E I	Obs 40	394944	751750
15-652	395017075163901	Hercules Chemical	MW 12	395017	751639
15-657	394941075173702	DuPont, E I	Obs 38	394941	751737
15-668	394944075164803	Hercules Chemical	MW 10C	394944	751648
15-678	394946075161201	Mobil Oil Company	W-5C	394946	751612
15-679	394946075161202	Mobil Oil Company	W-5D	394946	751612
15-680	395038075160501	Mobil Oil Company	W-7C	395038	751605
15-681	395038075160502	Mobil Oil Company	W-7D	395038	751605
15-682	395048075151801	Mobil Oil Company	W-8D	395048	751518
15-683	395021075153301	Mobil Oil Company	W-9D	395021	751533
15-712	394808075172401	US Geological Survey	STEFKA-1	394808	751724
15-713	394808075172402	US Geological Survey	STEFKA-2	394808	751724
15-728	394808075172404	US Geological Survey	STEFKA-4	394808	751724
15-1015	394944075172801	E I Dupont	34	394944	751728
		Harrison Township			
15-131	394501075122901	Clearview Bd Ed	Clearview HS 1	394501	751229
		Logan Township			
15-137	394535075205401	Pureland W Company	Pure 2(3-1973)	394535	752054
15-138	394553075214801	Muscemici, Frank	1	394553	752148
15-139	394606075213301	Pureland W Company	Test Well 3	394608	752135
15-140	394606075213302	Pureland W Company	Test Well 4	394608	752135
15-144	394611075212001	Pureland W Co	1-1973	394613	752129
15-144					
15-144					
15-165	394755075210801	Penns Grove WSC	Bridgeport 1	394755	752108
15-166	394755075210802	Penns Grove WSC	Bridgeport 2	394755	752108
15-354	394717075211701	Rollins Environmental Services	DP 2	394716	752112
15-387	394713075212101	Rollins Environmental Services	DP 1	394713	752121
15-388	394716075204701	Rollins Environmental Services	DP 3	394716	752047
15-395	394807075172701	Repaupo Fire Co	30-1972	394801	751759
15-398	394928075194101	Pettit, Louis	419	394928	751941
15-399	394900075191301	Allied Energy	NO-1 1977	394900	751913
15-417	394820075183301	S & S Auctions	1-1978	394820	751833
15-453	394832075184601	Gaventa. Al & Son	30-1946	394832	751846
15-475	394754075192001	US EPA	101	394754	751920
15-476	394800075192901	US EPA	102	394800	751929
15-478	394806075192901	US EPA	104	394806	751929

Table 3. Location, altitude, well-construction, and hydrogeologic data for wells used to assess the quality of ground water, and results of water-quality assessment, region of Greenwich Township, Gloucester County, New Jersey--Continued

Elevation of land surface (feet below sea level)	Screened interval (feet below sea level) Top of screen	Bottom of screen	Diameter of screen (inches)	Casing material[2]	Date of construction	Water-quality category[3]	Aquifer code	Source of water-quality data[4]	USGS well number
					Greenwich Township--Continued				
20	82.0	117	12.0	S	05-04-77	1,2	MRPAM	E,F,G	15-347
20	105	135	12.0	S	05-24-78	2	MRPAM	E,F,G,P	15-348
5	--	--	--	--	--	1,2	MRPAL	F,G	15-357
5	(test hole)		--	S	02-01-65		MRPAL	X	15-412
10.00	87.0	136	24.0	--	--	2	MRPAM	F	15-423
5	136	141	6	S	09-06-84	2	MRPAL	G	15-634
1.2	17	24	2	P	07-23-83	1,2	MRPAM	G	15-652
9.16	89	94	6	P	08-27-84		MRPAM	G,P	15-657
7.8	92	112	2	P	06-06-84	2	MRPAM	G,P	15-668
·9.4	194	204	4	S	06-17-85	2	MRPAL	G,P	15-678
9.7	118	128	4	S	06-19-85	2	MRPAM	G	15-679
8.7	186	196	4	S	03-28-85	2	MRPAL	G,P	15-680
8.7	60	70	4	S	04-04-85	2	MRPAM	G,P	15-681
10.8	105	115	4	S	05-13-85	1	MRPAM	G	15-682
10.7	92	102	4	S	05-01-85	1,2	MRPAM	G	15-683
5	275	290	4	S	10-10-86	2	MRPAL	G,P	15-712
5	125	155	8	S	10-23-86	2	MRPAM	G,P	15-713
5	46	56	4	S	04-01-87	2	MRPAU	G,P	15-728
10	137	142	8	P	08-21-84	1	MRPAM	R	15-1015
					Harrison Township				
130	--	--	--	--	--		MRPAU	F	15-131
					Logan Township				
37	158	208	12.0	S	11-02-73	2	MRPAM	F	15-137
20	28.0	34.0	4.0	S	11-13-51	2	HPPM	F	15-138
10	301	345	6.0	--	05-20-70	2	MRPAL	F,G,P	15-139
10	132	184	6.0	S	05-26-70	2	MRPAM	X	15-140
7.6	81.0	86.0	6.0	--	06-15-73	2	MRPAM	F	15-144
	106	113	6.0	--					15-144
	121	136	6.0	--					15-144
5	30.0	40.0	8.0	I	06-02-30	2	MRPAM	F	15-165
5	65.0	85.0	6.0	S	03-15-55		MRPAM	F	15-166
15	81.0	91.0	4.0	P	10-01-75	2	MRPAM	F,K	15-354
10	80.0	90.0	4.0	P	10-01-75	2	MRPAM	F,K	15-387
22.30	75.0	85.0	4.0	P	10-31-80	2	MRPA	F,G,K	15-388
20.5	93.0	113	6.0	P	08-04-79	2	MRPAM	F,G,P	15-395
.0	50.0	60.0	4.0	S	10-10-79	2	MRPAL	G,P	15-398
10	71.0	91.0	10.0	S	10- -77	2	MRPAM	F	15-399
10	61.0	71.0	4.0	S	12-26-78	2	MRPAM	E,F	15-417
10	51.0	61.0	4.0	P	06-08-79	1,2	MRPAM	X	15-453
9	35.0	37.0	2.0	S	03-10-81	1,2	MRPAM	K	15-475
15	36.0	38.0	2.0	S	03-09-81	1,2	MRPAM	K	15-476
10	19.0	21.0	2.0	S	03-11-81	1,2	MRPAM	K	15-478

Footnotes at end of table.

Table 3. Location, altitude, well-construction, and hydrogeologic data for wells used to assess the quality of ground water, and results of water-quality assessment, region of Greenwich Township, Gloucester County, New Jersey--Continued

USGS well number	Station number	Owner[1]	Well name	Latitude	Longitude
		Logan Township--Continued			
15-481	394814075192001	US EPA	107	394814	751920
15-539	394752075190701	Swindell, Norman	S-6	394752	751907
15-540	394800075193601	US EPA	EPA 108	394800	751936
15-543	394750075195801	Chemical Leaman	CL1	394755	751956
15-544	394752075195201	Chemical Leaman	CL4	394752	751952
15-546	394800075195001	Chemical Leaman	CL2	394759	751948
15-549	394757075194202	Chemical Leaman	DW1	394756	751947
15-550	394800075195002	Chemical Leaman	DW2	394759	751949
15-554	394809075191401	US EPA Region II	S-2A	394808	751914
15-555	394809075191402	US EPA Region II	S-2B	394808	751914
15-556	394809075191403	US EPA Region II	S-2C	394808	751914
15-564	394802075193301	US EPA-Gaventa	S-9	394802	751933
15-569	394529075204501	Pureland W Co	PWC 3	394529	752045
15-570	394705075210901	Rollins Environmental Services	W23	394705	752109
15-572	394721075205601	Rollins Environmental Services	W18	394722	752054
15-573	394715075205001	Rollins Environmental Services	U	394715	752050
15-575	394719075210802	Rollins Environmental Services	MA 11D	394719	752108
15-576	394719075210801	Rollins Environmental Services	MA 11I	394719	752108
15-577	394717075210803	Rollins Environmental Services	MA 8D	394717	752108
15-578	394717075210802	Rollins Environmental Services	MA 8I	394717	752108
15-579	394717075210801	Rollins Environmental Services	MA 8S	394717	752108
15-580	394718075210202	Rollins Environmental Services	MA 5D	394718	752102
15-581	394718075210201	Rollins Environmental Services	MA 5I	394718	752102
15-582	394715075210603	Rollins Environmental Services	MA 1D	394715	752106
15-583	394715075210602	Rollins Environmental Services	MA 1I	394715	752106
15-584	394715075210601	Rollins Environmental Services	MA 1S	394715	752106
15-585	394704075205801	Rollins Environmental Services	DP5	394704	752058
15-586	394720075205201	Rollins Environmental Services	DP4	394720	752052
15-587	394707075205501	Rollins Environmental Services	C	394707	752055
15-588	394717075210902	Rollins Environmental Services	31D	394717	752109
15-589	394717075210201	Rollins Environmental Services	31S	394717	752109
15-590	394704075211401	Rollins Environmental Services	26	394717	752112
15-591	394714075211601	Rollins Environmental Services	25	394716	752115
15-592	394710075210701	Rollins Environmental Services	22	394710	752107
15-593	394707075210201	Rollins Environmental Services	20B	394707	752102
15-594	394714075211001	Rollins Environmental Services	15	394714	752110
15-595	394714075210601	Rollins Environmental Services	4	394714	752106
15-615	394637075191601	US Geological Survey	Shiveler Lower	394637	751916
15-616	394637075191602	US Geological Survey	Shiveler Middle	394637	751916
15-617	394637075191603	US Geological Survey	Shiveler Upper	394637	751916
15-618	394804075193301	US Geological Survey	Gaventa Deep	394804	751933
15-620	394804075193302	US Geological Survey	Gaventa Middle	394804	751933
15-626	394729075210101	Logan Twp-A Pierce	MW 102 S	394729	752101
15-627	394644075213602	Logan Twp-Pureland	MW 103 D	394644	752136
15-714	394707075205801	Rollins Environmental Services	GG	394707	752058
		Mantua Township			
15-189	394602075082301	Mantua Twp MUA	MTMUA 1	394602	750823
15-191	394629075085901	Mantua Twp MUA	MTMUA 2	394629	750859
15-192	394641075110901	Mantua Twp MUA	MTMUA 5	394641	751109
15-193	394712075100801	Mantua Twp MUA	MTMUA 3	394712	751008
15-194	394732075103601	Mantua Twp MUA	MTMUA 4	394732	751037
15-432	394707075120201	Leone, Joseph	1	394707	751202
15-676	394638075120101	US EPA	Kramer Landfill X-6D	394638	751201
15-715	394527075123001	Parks, Thomas	Domestic 1	394527	751230
15-741	394652075100401	US Geological Survey	Mantua Shallow	394652	751004
15-742	394652075100402	US Geological Survey	Mantua Deep	394652	751004

Table 3. **Location, altitude, well-construction, and hydrogeologic data for wells used to assess the quality of ground water, and results of water-quality assessment, region of Greenwich Township, Gloucester County, New Jersey--Continued**

Elevation of land surface (feet below sea level)	Screened interval (feet below sea level)		Diameter of screen (inches)	Casing material[2]	Date of construction	Water-quality category[3]	Aquifer code	Source of water-quality data[4]	USGS well number
	Top of screen	Bottom of screen							
Logan Township--Continued									
9	36.0	38.0	2.0	S	03-10-81	2	MRPAM	K	15-481
5	60.0	70.0	4.0	--	09-15-83	2	MRPAM	K	15-539
7.1	87.0	97.0	4.0	P	02-23-82	2	MRPAM	X	15-540
14	15.0	30.0	2.0	--	- -81	2	MRPAM	K	15-543
8	41.0	46.0	2.0	--	- -81	1,2	MRPAM	K	15-544
10	20.0	30.0	2.0	--	07-19-81	1,2	MRPAU	K	15-546
7	94.5	97.0	4.0	S	06-16-81	1,2	MRPAM	K	15-549
10	99.5	102	4.0	S	06-19-81	2	MRPAM	K	15-550
9	4.0	14.0	4.0	--	09-15-83	2	MRPAM	K	15-554
9	40.0	50.0	4.0	--	09-15-83	1,2	MRPAM	K	15-555
9	98.0	108	4.0	--	09-15-83	1,2	MRPAM	K	15-556
6.8	42.0	52.0	--	--	08-08-83	1	MRPAU	G,P	15-564
32	161	201	12.0	S	12-09-81	2	MRPAM	G,P	15-569
0.47	8.5	13.5	2.0	G	09-09-81	2	MRPAU	K	15-570
12.95	10.1	20.1	--	--	- -81	2	MRPAU	K	15-572
22.11	19.7	22.2	--	--	- -76		MRPAU	K	15-573
1.31	45.0	55.0	1.0	P	09-04-81	1,2	MRPAM	G,K	15-575
1.22	19.0	29.0	1.0	P	09-04-81	1,2	MRPAU	K	15-576
1.89	39.0	49.0	1.0	P	08-26-81	1,2	MRPA	K	15-577
1.89	25.0	35.0	1.0	P	08-26-81	2	MRPA	K	15-578
1.84	8.5	13.5	1.0	P	08-26-81	1,2	MRPAU	K	15-579
2.45	50.0	60.0	1.0	P	08-21-81	1,2	MRPA	K	15-580
2.48	27.0	37.0	1.0	P	--	1,2	MRPAU	K	15-581
1.64	57.0	67.0	1.0	P	07-13-81	1,2	MRPA	K	15-582
1.67	25.0	35.0	2.0	P	07-13-81	1,2	MRPA	K	15-583
1.68	5.0	10.0	1.0	P	07-13-81	1,2	MRPA	K	15-584
7.50	79.0	89.0	6.0	P	06-24-81	2	MRPAM	K	15-585
11.60	95.0	125	6.0	--	- -81	2	MRPAM	K	15-586
9.60	30.0	35.0	--	--	- -72	1,2	MRPAU	K	15-587
5.60	40.0	70.0	--	--	- -82	1,2	MRPA	K	15-588
5.60	10.0	40.0	--	--	- -82	1,2	MRPA	K	15-589
7.50	15.0	25.0	--	--	- -76	1,2	MRPAU	K	15-590
3.40	9.7	19.7	--	--	--	2	MRPAU	K	15-591
5.60	9.7	19.7	--	--	--	2	MRPAU	K	15-592
4.20	15.0	25.0	--	--	--	1,2	MRPAU	K	15-593
9.10	12.0	26.0	--	--	--	1,2	MRPAU	K	15-594
--	14.0	18.5	--	--	--	1,2	MRPAU	K	15-595
29.3	378	388	4.0	S	02-28-85	2	MRPAL	G,L	15-615
30.6	230	240	4.0	S	02-28-85	2	MRPAM	G,L	15-616
30.6	60.0	70.0	4.0	S	02-28-85	2	MRPAU	G,L,P	15-617
7.0	230	240	4.0	S	02-28-85	2	MRPAL	G,L	15-618
7.0	131	141	4.0	S	06-01-85	2	MRPAM	G,L,P	15-620
11.8	9.0	19.0	4.0	P	07-11-84	1	MRPAU	G,L,P	15-626
7.4	65.0	75.0	4.0	P	07-17-84	2	MRPAU	G,L,P	15-627
8.5	10.7	13.7	4	P	11-24-86	1,2	MRPAU	G	15-714
Mantua Township									
80	352	377	10.0	S	07-16-51		MRPAU	F	15-189
60	336	368	10.0	S	04-19-65		MRPAU	F,G,P	15-191
80	315	337	12.0	S	02-22-57		MRPAU	E,F	15-192
60	295	317	8.0	S	12-08-53	2	MRPAU	F	15-193
10.00	233	265	8.0	S	03-10-69		MRPAU	F	15-194
60	222	252	10.0	S	08-09-81		MRPAU	G,P	15-432
27.5	68	78	4	S	10-19-84	2	EGLS	G	15-676
140	131	137	4	S	07-10-72		MLRW	G,P	15-715
80	293	313	4.0	S	07-11-86		MRPAU	N	15-741
80	757	777	4	S	07-31-86	2	MRPAL	N	15-742

Footnotes at end of table.

Table 3. Location, altitude, well-construction, and hydrogeologic data for wells used to assess the quality of ground water, and results of water-quality assessment, region of Greenwich Township, Gloucester County, New Jersey--Continued

USGS well number	Station number	Owner[1]	Well name	Latitude	Longitude
		National Park Borough			
15-206	395146075105301	National PK W D	NPWD 1	395146	751053
15-207	395156075105301	National PK W D	NPWD 2	395156	751053
15-770	395202075111501	US Geological Survey	National Park #1-PW-L	395202	751115
15-771	395202075111502	US Geological Survey	National Park #2-PW-M	395202	751115
15-778	395223075111701	US Geological Survey	National Park #9-OW-BL	395223	751117
15-780	395223075111703	US Geological Survey	National PK #10-OW-BM	395223	751117
		Paulsboro Borough			
15-210	394921075141901	Paulsboro WD	6-1973	394921	751417
15-212	394931075144901	Paulsboro WD	PWD 4	394929	751447
15-213	394950075142201	Paulsboro WD	PWD 5	394947	751416
15-215	395023075144201	Paulsboro WD	PWD 2	395023	751442
15-216	395023075144202	Paulsboro WD	PWD 3	395023	751442
15-218	395044075150301	Mobil Oil Company	Mobil 33	395044	7515-3
15-220	395053075141901	Essex Chemical Co	OLIN 1	395051	751349
15-221	395057075134701	Essex Chemical Co	Paulsboro 1	395057	751347
15-428	395043075150201	Mobil Oil Company	Mobil 36	395043	7515-2
15-439	395048075140101	Essex Chemical Co	Essex 2	395048	751401
15-673	395100075142001	BP Oil	BL-3	395100	751420
15-674	395053075134601	Essex Chemical Co	OBS 1	395053	751346
15-677	395050075144901	Exxon Co	MW 8	395050	751449
		Swedesboro Borough			
15-240	394510075183802	Del Monte Corp	9	394510	751838
15-242	394512075183001	Del Monte Corp	6	394512	751830
15-243	394514075183101	Del Monte Corp	4	394514	751831
		Wenonah Borough			
15-274	394743075090201	Wenonah Water Dept.	WWD 1	394743	750902
15-275	394751075091201	Wenonah Water Dept.	WWD 2	394751	750912
		West Deptford Township			
15-276	394821075102601	W Deptford T WD	WDTWD 4	394821	751026
15-279	394857075125001	Shell Chem Co	Shell OBS 7	394857	751250
15-281	394912075102601	W Deptford T WD	WDTWD 3	394912	751026
15-282	394913075110501	W Deptford T WD	5 Kings Hiway	394913	751105
15-283	394916075125301	Shell Chem Co	Shell 3	394919	751256
15-284	394916075125302	Shell Chem Co	Shell 4	394919	751256
15-285	394917075130701	Shell Chem Co	Shell 1	394917	751307
15-295	394939075100701	Westwood Golf Course	1-1973	394939	751007
15-296	394942075131701	Shell Chem Co	Shell OBS 5	394942	751317
15-297	394942075131702	Shell Chem Co	Shell OBS 6	394942	751317
15-306	395033075123301	Pennwalt Corp	417	395033	751233
15-308	395044075124201	Pennwalt Corp	Test Well 8	395044	751242
15-312	395107075094601	W Deptford T WD	6 Red Bank Ave	395107	750946
15-314	395153075094601	Texas Oil Co	Eagle Point 6	395153	750946
15-317	395200075094701	Texas Oil Co	Eagle Point 7	395200	750947
15-318	395207075093001	Texas Oil Co	Eagle Point 2	395207	750930

Table 3. Location, altitude, well-construction, and hydrogeologic data for wells used to assess the quality of ground water, and results of water-quality assessment, region of Greenwich Township, Gloucester County, New Jersey--Continued

Elevation of land surface (feet below sea level)	Screened interval (feet below sea level)		Diameter of screen (inches)	Casing material[2]	Date of construction	Water-quality category[3]	Aquifer code	Source of water-quality data[4]	USGS well number
	Top of screen	Bottom of screen							
National Park Borough									
20	64.0	85.0	8.0	S	09-01-50	2	MRPAU	F	15-206
30	241	282	8.0	S	04-27-56	2	MRPAL	F	15-207
10	204	224	4	S	03-27-87	2	MRPAL	N	15-770
10	92.3	123	8	S	04-10-87	2	MRPAM	N	15-771
20	170	190	2	P	05-06-87	2	MRPAL	N	15-778
20	75	85	2	P	05-14-87	2	MRPAM	N	15-780
Paulsboro Borough									
20	201	227	12.0	S	08-06-73	2	MRPAM	E,F,G	15-210
20	192	220	12.0	S	03-10-51	2	MRPAM	F,G	15-212
10	135	175	12.0	--	- -57	2	MRPAM	F,G	15-213
20	70.0	100	18.0	S	09-22-30	2	MRPAM	F	15-215
20	115	140	18.0	S	- -42	2	MRPAM	F	15-216
20	169	236	10.0	S	- -26		MRPAL	F	15-218
10	234	256	8.0	S	05-26-54	1,2	MRPAL	F	15-220
20	258	286	12.0	S	03-20-70	1,2	MRPAL	G	15-221
25.00	111	138	20.0	--	--	2	MRPAM	F	15-428
10.00	215	235	8.0	S	04-24-70	1,2	MRPAL	E,F	15-439
5.4	70	95	4	P	02-03-83	1,2	MRPAU	G	15-673
10	20.5	40.5	4	P	02-11-77	1,2	MRPAU	G,P	15-674
27.6	19	39	4	S	08-28-84	2	QRNR	G	15-677
Swedesboro Borough									
31.5	190	231	10.0	S	05- -63	2	MRPAU	F,G,P	15-240
30	267	298	10.0	S	- -44		MRPAM	X	15-242
20	--	--	--	--	- -42		MRPAU	F	15-243
Wenonah Borough									
80	283	320	12.0	--	05-20-44	2	MRPAU	F	15-274
50	268	310	12.0	S	02-05-51		MRPAU	F	15-275
West Deptford Township									
60	242	288	8.0	S	03-05-63		MRPAU	E,F,G,P	15-276
16.9	315	320	6.0	S	- -62	2	MRPAM	G,P	15-279
60	227	243	12.0	S	08-27-57		MRPAU	F	15-281
60	388	450	12.0	S	07- -73		MRPAL	E,F	15-282
30	358	383	12.0	S	01-11-62	2	MRPAL	E,F	15-283
30	127	157	12.0	S	01-11-62	2	MRPAU	F	15-284
10	328	358	12.0	S	10-04-61	2	MRPAL	F	15-285
20	120	140	10.0	S	01-29-73		MRPAU	G,P	15-295
20.8	321	326	6.0	S	02-27-62	2	MRPAL	G,P	15-296
20.5	113	118	6.0	S	02-27-62	2	MRPAU	G,P	15-297
10	234	276	16.0	S	03-02-70	2	MRPAL	G,P	15-306
10	231	271	8.0	--	04-21-69	2	MRPAL	E,F	15-308
20	322	372	12.0	S	10-04-73		MRPAL	E,G	15-312
15	280	318	14.0	S	01-03-49	2	MRPAL	E,F	15-314
10	261	301	12.0	S	03-16-73	2	MRPAL	F	15-317
17.0	259	289	16.0	S	01-12-48	2	MRPAL	F	15-318

Footnotes at end of table.

Table 3. Location, altitude, well-construction, and hydrogeologic data for wells used to assess the quality of ground water, and results of water-quality assessment, region of Greenwich Township, Gloucester County, New Jersey--Continued

USGS well number	Station number	Owner[1]	Well name	Latitude	Longitude
		West Deptford Township--Continued			
15-319	395213075093601	Texas Oil Co	Eagle Point 4	395213	750936
15-320	3952160750915-1	Texas Oil Co	Eagle Point 1	395216	750915
15-321	395221075085601	Texas Oil Co	Eagle Point 5	395221	750856
15-322	395222075091801	Texas Oil Co	Eagle Point 3	395222	750918
15-373	395132075083201	W Deptford T WD	WDTWD 7	395126	750856
15-390	395020075134001	Gloucester C SA	GCSA 1 71	395020	751340
15-410	395233075094001	Texas Oil Co	Eagle Point 4A	395213	750936
15-435	394836075104601	W Deptford T WD	WDTWD 8	394836	751046
		Westville Borough			
15-326	395216075073901	Westville WD	WWD 5	395216	750739
15-327	395221075073701	Westville WD	WWD 4	395221	750737
15-329	395221075073703	Westville WD	WWD 1	395221	750737
15-434	395142075071001	Westville WD	WWD 6	395224	750736
		Woodbury City			
15-331	394950075090901	Woodbury W D	Railroad 5	394955	750908
15-332	395017075092801	Woodbury W D	Parking Lot 3	395017	750928
15-333	395044075090701	Woodbury W D	TATUM 4	395044	750907
15-431	395034075084201	Woodbury W D	Red Bank 6	395034	750842
		Woolwich Township			
15-345	394642075182301	Musumeci, Peter	1	394642	751823
15-392	394527075160701	NJ Turnpike AU	1964-S-1	394527	751607
15-519	394649075173801	Miskofsky, Nicholas	1	394649	751738

Table 3. Location, altitude, well-construction, and hydrogeologic data for wells used to assess the quality of ground water, and results of water-quality assessment, region of Greenwich Township, Gloucester County, New Jersey--Continued

Elevation of land surface (feet below sea level)	Screened interval (feet below sea level)		Diameter of screen (inches)	Casing material[2]	Date of construction	Water-quality category[3]	Aquifer code	Source of water-quality data[4]	USGS well number
	Top of screen	Bottom of screen							
				West Deptford Township--Continued					
14.0	259	289	16.0	S	03-10-48	2	MRPAL	F	15-319
20.0	248	288	12.0	S	10-16-47	2	MRPAL	F	15-320
15	237	277	12.0	S	10-29-48	2	MRPAL	F	15-321
20	258	288	12.0	--	12-17-47	2	MRPAL	F	15-322
30	323	363	12.0	S	12-08-80		MRPAL	F	15-373
10	91.0	106	6.0	S	08-19-71	2	MRPAM	E,F	15-390
10	256	296	12.0	S	08-19-78	2	MRPAL	F	15-410
40	252	312	12.0	S	07-24-81		MRPAM	G	15-435
				Westville Borough					
20	243	277	12.0	S	06-15-71	2	MRPAL	F	15-326
20	286	313	10.0	S	- -57	2	MRPAL	F	15-327
20	69.0	112	8.0	S	- -30	2	MRPAU	F	15-329
15	267	--	12.0	S	06-05-80		MRPAL	F	15-434
				Woodbury City					
40	405	457	12.0	S	04-27-60		MRPAL	E,F	15-331
50	148	188	12.0	I	- -46	2	MRPAU	F,G,P	15-332
20	129	144	12.0	S	01-15-53	2	MRPAU	F	15-333
30.00	211	305	12.0	S	05- -80	2	MRPAM	E,G	15-431
				Woolwich Township					
80.00	--	--	--	--	--	2	EGLS		15-344
60	94.0	100	4.0	S	11-06-54	2	MRPAU	G,P	15-345
105	241	251	6.0	S	08-14-64	2	MRPAU	F	15-392
35	75.0	87.0	3.0	S	11-09-78	2	MRPAU	G,P	15-519

[1] The use of industry or firm names in this report is for identification or location purposes only and does not impute responsibility for any present or potential effects on water resources in the study area.

[2] I, wrought iron; G, galvanized steel; S, steel; P, polyvinyl chloride (plastic)

[3] 1, at least one ground-water sample contained at least one inorganic or organic constituent at a concentration that exceeds maximum contaminant levels; 2, at least one ground-water sample contained at least one inorganic constituent at a concentration that exceeds secondary maximum contaminant levels; a blank indicates that no constituents determined were detected at concentrations exceeding primary or secondary maximum contaminant levels.

[4] E, Ervin and others (1994); F, Fusillo and others (1984); G, data listed in table 2 in this report; K, Kozinski and others (1990); L, Lewis and others (1991); N, Navoy and Carleton (1995); R, Rosen and others (1992); X, data in WATSTORE but source unknown or only hydrogeologic data were used to construct hydrogeologic section; P, sample analyzed for 30 purgeable organic compounds at the New Jersey District laboratory by using gas chromatography with a photoionization detector--no compounds were detected at a concentration greater than 0.80 micrograms per liter.