HYDROGEOLOGIC FRAMEWORK OF THE POTOMAC-RARITAN-MAGOTHY AQUIFER SYSTEM, NORTHERN COASTAL PLAIN OF NEW JERSEY

By Jo Ann M. Gronberg, Amleto A. Pucci, Jr., and Bradley A. Birkelo

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CONVERSION FACTORS AND ABBREVIATIONS

Multiply	By	To obtain
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
foot per mile (ft/mi)	0.1894	meter per kilometer
square mile (mi^2)	2.590	square kilometer

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

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ABSTRACT

This report describes the hydrogeologic framework of the Potomac-Raritan-Magothy aquifer system in the northern Coastal Plain of New Jersey. The location and extent of the middle and upper aquifers of this aquifer system and their associated confining units are presented by means of a series of structure-contour maps, thickness maps, and hydrogeologic sections. Interpretations made from 267 geophysical and drillers' logs were used to develop a representation of this framework.

The hydrogeologic units of the Potomac-Raritan-Magothy aquifer system strike northeast-southwest and dip to the southeast, and are continuous throughout most of the study area. The middle aquifer, which is composed mainly of the Farrington Sand Member of the Raritan Formation, has a maximum known thickness of 168 feet near East Windsor but is thin or absent just south of the Raritan River between Sayreville and South Amboy. The confining unit overlying the middle aquifer, which has a maximum known thickness of 241 feet in Holmdel Township, is composed mainly of the Woodbridge Clay Member of the Raritan Formation. Because this unit is thin or sandy in the southwestern part of the study area, boundary identification in this area is difficult.

The upper aquifer, the most extensive unit of the Potomac-Raritan-Magothy aquifer system, has a maximum known thickness of 236 feet in Neptune Township. This unit consists primarily of the Old Bridge Sand Member of the Magothy Formation, but it coincides closely with the entire Magothy Formation. The Merchantville-Woodbury confining unit, which overlies the upper aquifer, has a maximum known thickness of 369 feet in Highlands Borough, where the confining unit also includes the low-permeability sediments of the underlying Magothy Formation.

INTRODUCTION

The Potomac-Raritan-Magothy aquifer system is the most productive source of ground water in the northern Coastal Plain of New Jersey. The aquifer system consists of the lower, middle, and upper aquifers and the confining units that separate them; the lower aquifer is not mappable in the study area (Zapecza, 1989, pl. 3 and 6). These units correlate with the hydrogeologic units established by the U.S. Geological Survey's Northern Atlantic Coastal Plain Regional Aquifer-System Analysis (RASA) project (Zapecza, 1989).

The middle and upper aquifers of the Potomac-Raritan-Magothy aquifer system are the major sources of ground water in Middlesex and Monmouth Counties. Ground-water withdrawals have resulted in the development of cones of depression that extended 91 ft below sea level in the middle aquifer and 59 ft below sea level in the upper aquifer in 1983 (Eckel and

Walker, 1986, p. 16 and 25). Large withdrawals also have caused local saltwater intrusion into the aquifers. Chloride concentrations as high as 950 mg/L (milligrams per liter) in the middle aquifer and 660 mg/L in the upper aquifer were measured in 1977 (Schaefer, 1983, p. 12 and 22).

The U.S. Geological Survey, in cooperation with the New Jersey Department of Environmental Protection (NJDEP), currently is assessing the ground-water resources of the northern Coastal Plain of New Jersey. This investigation is funded by the New Jersey Water Supply Bond Issues of 1981 and 1983. The purpose of the investigation is to collect and analyze hydrogeologic data in order to better understand the dynamics of the Potomac-Raritan-Magothy aquifer system. This report describes the results of the initial phase of this investigation, which focused on the hydrogeologic framework of the aquifer system.

Purpose and Scope

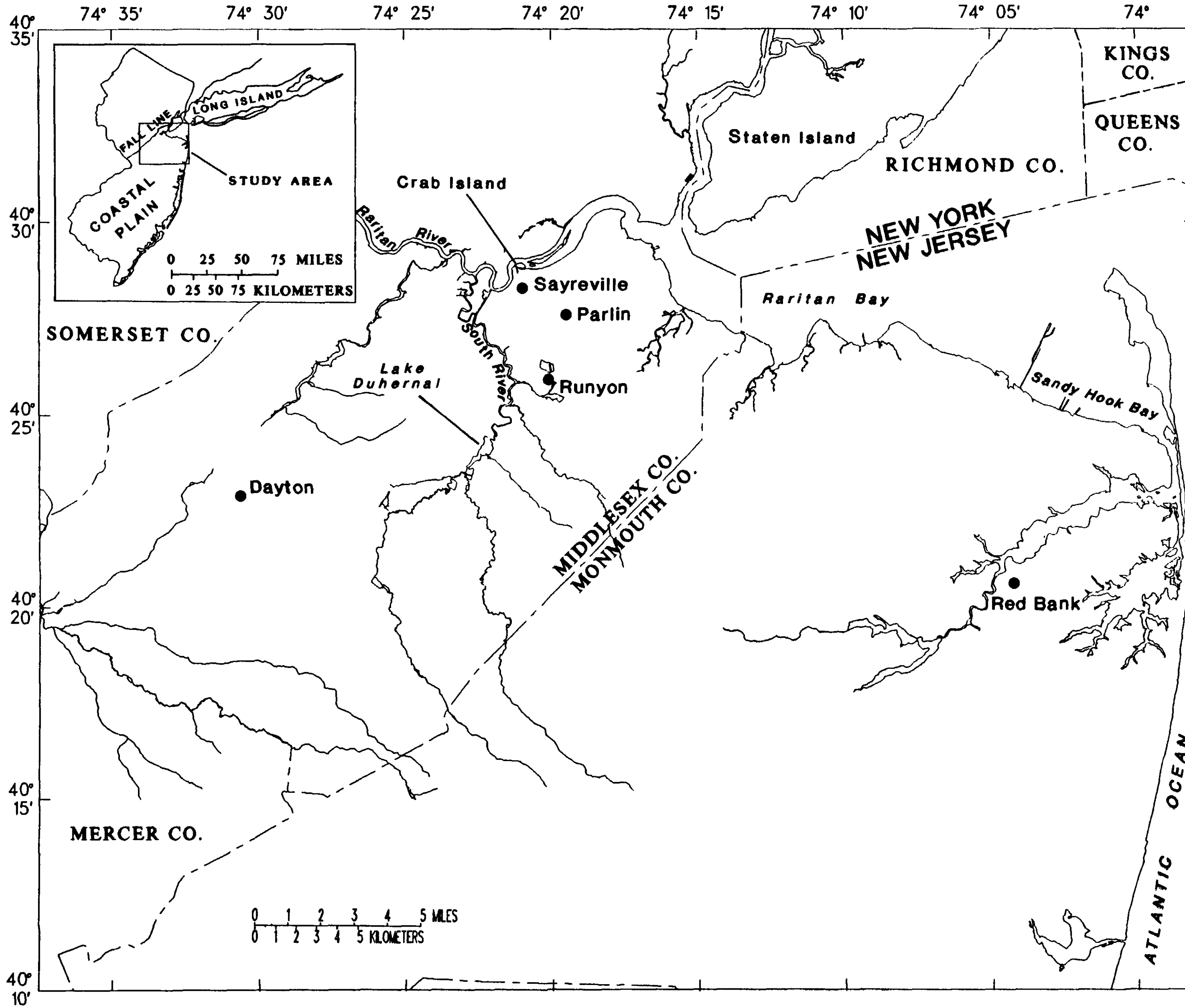
This report defines the hydrogeologic framework of the Potomac-Raritan-Magothy aquifer system in parts of Mercer, Middlesex, and Monmouth Counties. The framework is described by means of a series of structure-contour maps, thickness maps, and hydrogeologic sections. Physical characteristics and boundaries of the hydrogeologic units are presented in tables. Geophysical and drillers' logs that provided control data for this investigation are compiled in Gronberg and others (1989). The results of this study have been used to develop a hydrologic model of the aquifer system that simulates its response to various hydrologic stresses (Pucci and others, in press).

Location and Extent of the Study Area

The study area is located in east-central New Jersey and comprises the northern part of the Coastal Plain physiographic province in New Jersey (fig. 1). It covers about 820 mi^2 in parts of Mercer, Middlesex, and Monmouth Counties in New Jersey, and Queens and Richmond Counties in New York. The study area extends from the Fall Line (the northwestern extent of the Coastal Plain sediments) in the west to the Atlantic Ocean in the east, and includes Raritan Bay.

Previous Investigations

The hydrogeology and ground-water resources of the northern Coastal Plain in New Jersey have been studied since the late 1800's. The earliest work in the area was done by the New Jersey Geological Survey (NJGS). Woolman (1889-1902) reported on the artesian wells in New Jersey, presenting geologic and hydrologic information obtained from drillers and well owners, and making major contributions to the early description and correlation of the water-bearing units. Knapp (1903) described the structural features and presented a generalized structure map of the Coastal Plain of New Jersey. Kummel and Poland (1909) renamed the water-bearing horizons of the inner Coastal Plain. Epstein (1986) chronologically outlined the steps taken by the NJGS to study the aquifers of the Coastal Plain as part of an effort to ensure an adequate water supply for the area.



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

Figure 1.--Location of study area.

Several more recent investigations have focused on the stratigraphy and deposition of the Coastal Plain sediments. Owens and Sohl (1969) attributed the Cretaceous and Tertiary sediments in New Jersey to deposition in shelf and deltaic environments. Owens and Sohl (1969) and Olsson (1975) described the lithology of the New Jersey Coastal Plain sediments and discussed the deposition of the formations as a result of transgressive-regressive cycles. Owens and others (1977) discussed the sedimentary features and mineral content of the various formations that crop out in New Jersey, Delaware, and Maryland. Owens and Gohn (1985) related the Cretaceous sediments of the Atlantic Coastal Plain to six depositional sequences and described the paleoenvironments in which the deposition occurred.

Additional studies have concentrated on the ground-water resources of the major aquifers of the Coastal Plain. Barksdale (1937) reported on the geology and the water-resource potential of the No. 1 sand (Farrington Sand Member of the Raritan Formation) near Sayreville and Parlin in Middlesex County. Barksdale and others (1943) discussed the water-resource potential of the major aquifers in Middlesex County. Jablonski (1959, 1960, and 1968) collected lithologic information from large-capacity wells in Monmouth County and discussed the characteristics of the major aquifers in Monmouth County. Kasabach and Scudder (1961) presented logs from deep wells in the New Jersey Coastal Plain. Appel (1962) described the intrusion of saltwater into the Farrington and Old Bridge Sand Members of the Raritan Formation and presented logs from wells in the vicinity of South River.

Gill and Farlekas (1976) presented structure-contour maps of the bedrock surface, the Potomac-Raritan-Magothy aquifer system, and the overlying confining unit. Farlekas (1979) discussed the geohydrologic characteristics of, and simulation of ground-water flow in, the Farrington aquifer in Middlesex and Monmouth Counties. He also presented structure-contour and thickness maps of the Farrington aquifer and the overlying hydrogeologic units. Pucci (1986) summarized the available information on the hydrogeology of Raritan Bay and the occurrence of saltwater intrusion in the Farrington and Old Bridge aquifers in Middlesex and Monmouth Counties. Zapecza and others (1987) presented ground-water-withdrawal data and historic water-level data for the New Jersey Coastal Plain. Zapecza (1989) described the hydrogeologic framework of the Coastal Plain in New Jersey by using contour and thickness maps of each major aquifer, thickness maps of each confining unit, and numerous hydrogeologic sections. Martin (in press) reported on the simulation of flow in the major aquifers of the New Jersey Coastal Plain.

Well-Numbering System

The well-numbering system used in this report is based on the numbering system used by the U.S. Geological Survey in New Jersey since 1978. The first part of the number is a two-digit county code: 21 for Mercer, 23 for Middlesex, 25 for Monmouth, 81 for Queens (Long Island, New York), and 85 for Richmond (Staten Island, New York). The second part is the sequence number of the well within the county. For example, well number 23-137 represents the 137th well inventoried in Middlesex County.

Acknowledgments

The authors thank Stewart Sandberg and David Hall, New Jersey Department of Environmental Protection, Division of Water Resources, NJGS, for collecting and interpreting the surface-geophysical data; and Richard Dalton, Howard Larison, Michael McCollough, Gary Poppe, and Michael Ryan, New Jersey Department of Environmental Protection, Division of Water Resources, NJGS, for drilling test wells and boreholes during this study.

GEOLOGIC SETTING

The Coastal Plain of New Jersey is underlain by unconsolidated deposits of clay, silt, sand, and gravel that rest unconformably on Precambrian and lower Paleozoic bedrock (table 1) (Zapecza, 1989, p. B5). The sediments form a wedge-shaped mass that strikes northeast-southwest and dips to the southeast. In east-central New Jersey the thickness of these deposits, which range in age from Late Cretaceous to Holocene (Zapecza, 1989, p. B5), varies from a featheredge along the Fall Line to greater than 1,000 ft in southeastern Monmouth County.

Triassic sedimentary rocks underlie the unconsolidated sediments locally in Middlesex and Mercer Counties. A thick diabase sill of Jurassic age (Palisades sill) is intruded into the Triassic sequence (Farlekas, 1979, p. 7).

Three tectonic features--the Raritan embayment, the South New Jersey uplift, and the Salisbury embayment--dominate the basement topography beneath the Coastal Plain in New Jersey (fig. 2). The Raritan embayment, centered in the Raritan Bay area, is the main structural feature in the northern New Jersey Coastal Plain. These structural features directly influenced the deposition of the Coastal Plain sediments (Owens and Sohl, 1969, p. 237). In general, individual units are thicker in the embayment areas and depositional-facies changes are common between adjacent tectonic features (Olson, 1978, p. 941). Conversely, the uplift or high areas show thinner sequences or absence of units (Owens and Gohn, 1985, p. 26).

The Potomac Group of Early and Late Cretaceous age comprises the oldest sediments deposited on the basement surface in the New Jersey Coastal Plain. These sediments consist of alternating clay, silt, sand, and gravel (Zapecza, 1989, p. B5) and indicate continental deposition by meandering streams (Owens and Gohn, 1985, p. 41). Although the individual formations of the Potomac Group are mappable outside New Jersey, the Potomac Group sediments are considered to be a single unit in New Jersey because the boundaries of the individual formations are inconsistent (Owens and others, 1977, p. 7).

The overlying Raritan Formation consists of the Raritan fire clay, the Farrington Sand Member, the Woodbridge Clay Member, the Sayreville Sand Member, and the South Amboy Fire Clay Member (in ascending order) (table 2). The sediments of the Raritan Formation represent a wide variety of depositional conditions indicative of deposition in a subaerial deltaic plain (Owens and Sohl, 1969, p. 239). Along the coast, the Raritan Formation was deposited in a predominantly marine environment (Perry and others, 1975, p. 1535).

Table 1.--Geologic and hydrogeologic units in the Coastal Plain of New Jersey

[From Zapecza, 1989, table 2]

SYSTEM	SERIES	GEOLOGIC UNIT	LITHOLOGY	HYDROGEOLOGIC UNIT	HYDROLOGIC CHARACTERISTICS
Quaternery	Holocene	Alluvial deposits	Sand, silt, and black mud.	Undifferentiated	Surficial material, commonly hydraulically connected to underlying aquifers. Locally some units may act as confining units. Thicker sands are capable of yielding large quantities of water.
		Beach sand and gravel	Sand, quartz, light-colored, medium-to coarse-grained, pebbly.		
	Pleistocene	Cape May Formation	Sand, quartz, light-colored, heterogeneous clayey, pebbly.		
Tertiary	Miocene	Pensauken Formation			
		Bridgeton Formation		Kirkwood-Cohansey aquifer system	A major aquifer system. Ground water occurs generally under water-table conditions. In Cape May County the Cohansey Sand is under artesian conditions.
		Beacon Hill Gravel	Gravel, quartz, light colored, sandy.		
		Cohansey Sand	Sand, quartz, light-colored, medium to coarse-grained, pebbly; local clay beds.		
		Kirkwood Formation	Sand, quartz, gray and tan, very fine-to medium-grained, micaceous, and dark-colored diatomaceous clay.	Confining unit	Thick diatomaceous clay bed occurs along coast and for a short distance inland. A thin water-bearing sand is present in the middle of this unit.
				Rio Grande water bearing zone	
				Confining unit	
				Atlantic City 800-foot sand	A major aquifer along the coast.
				Composite confining unit	Poorly permeable sediments.
	Oligocene	Piney Point Formation	Sand, quartz and glauconite, fine-to coarse-grained.	Piney Point aquifer	Yields moderate quantities of water.
	Eocene	Shark River Formation			
		Manasquan Formation	Clay, silty and sandy, glauconitic, green, gray and brown, fine-grained quartz sand.		Poorly permeable sediments.
	Paleocene	Vincentown Formation	Sand, quartz, gray and green, fine-to coarse-grained, glauconitic, and brown clayey, very fossiliferous, glauconite and quartz calcarenite.	Vincentown aquifer	Yields small to moderate quantities of water in and near its outcrop area.
		Hornerstown Sand	Sand, clayey, glauconitic, dark green, fine to coarse-grained.		Poorly permeable sediments.
Cretaceous	Upper Cretaceous	Tinton Sand	Sand, quartz, and glauconite, brown and gray, fine-to coarse-grained, clayey, micaceous.		
		Red Bank Sand		Red Bank sand	Yields small quantities of water in and near its outcrop area.
		Navesink Formation	Sand, clayey, silty, glauconitic, green and black, medium-to coarse-grained.		Poorly permeable sediments.
		Mount Laurel Sand	Sand, quartz, brown and gray, fine-to coarse-grained, slightly glauconitic.	Wenonah-Mount Laurel aquifer	A major aquifer.
		Wenonah Formation	Sand, very fine-to fine-grained, gray and brown, silty, slightly glauconitic.	Marshalltown-Wenonah confining unit	A leaky confining unit.
		Marshalltown Formation	Clay, silty, dark greenish gray, glauconitic quartz sand.		
		Englishtown Formation	Sand, quartz, tan and gray, fine-to medium-grained; local clay beds.	Englishtown aquifer system	A major aquifer. Two sand units in Monmouth and Ocean Counties.
		Woodbury Clay	Clay, gray and black, micaceous silt.	Merchantville-Woodbury confining unit	A major confining unit. Locally the Merchantville Formation may contain a thin water-bearing sand.
		Merchantville Formation	Clay, glauconitic, micaceous, gray and black; locally very fine-grained quartz and glauconitic sand.		
		Magothy Formation	Sand, quartz, light-gray, fine-to coarse-grained. Local beds of dark-gray lignitic clay. Includes Old Bridge Sand Member.	Potomac-Raritan-Magothy aquifer system: Upper aquifer	A major aquifer system. In the northern Coastal Plain, the upper aquifer is equivalent to the Old Bridge aquifer and the middle aquifer is equivalent to the Farrington aquifer. In the Delaware River Valley three aquifers are recognized. In the deeper subsurface, units below the upper aquifer are undifferentiated.
		Raritan Formation	Sand, quartz, light-gray, fine-to coarse-grained, pebbly, arkosic, red, white, and variegated clay. Includes Farrington Sand Member.	Confining unit	
				Middle aquifer	
	Lower Cretaceous	Potomac Group	Alternating clay, silt, sand, and gravel.	Confining unit	
				Lower aquifer	
Pre-Cretaceous		Bedrock	Precambrian and lower Paleozic crystalline rocks, matamorphic schist and gneiss locally Triassic sandstone, shale and Jurassic diabase.	Bedrock confining unit	No wells obtain water from these consolidated rocks, except along Fall Line.

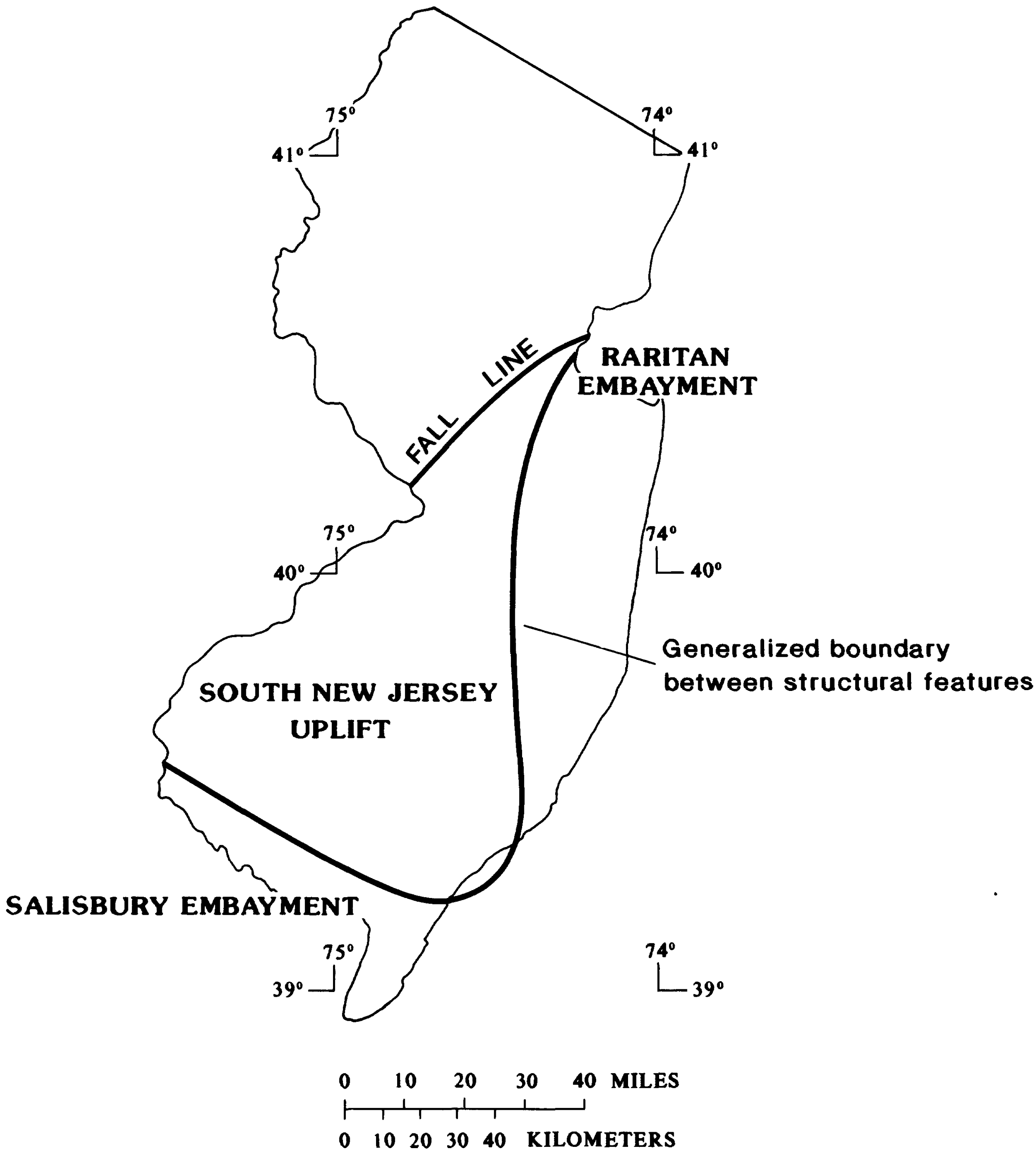


Figure 2.--Basement structural features in the New Jersey Coastal Plain (modified from Owens and Sohl, 1969, fig. 2).

Where present, the Raritan fire clay is a massive, multicolored clay that appears to form a gradational contact with the saprolite overlying consolidated bedrock (Ries and others, 1904, p. 192). The Farrington Sand Member is characterized by sand, gravel, and lenses of clay. The Woodbridge Clay Member is composed of micaceous silts and clays with woody fragments and siderite concretions. The marine fossils present in this unit indicate that the Woodbridge Clay Member was deposited in marginal-marine swamps (Owens and Sohl, 1969, p. 239).

Overlying the Woodbridge Clay Member is the Sayreville Sand Member, a light-colored, cross-stratified, medium-grained sand with interbeds of light- to dark-colored clayey silt (Owens and others, 1977, p. 16). The cross-stratification suggests deposition in river channels, possibly as point bars (Owens and Sohl, 1969, p. 239). The South Amboy Fire Clay Member is similar to the Woodbridge Clay Member but lacks siderite concretions and marine fossils (Owens and Sohl, 1969, p. 239).

The Magothy Formation, which lies unconformably on the Raritan Formation, includes the Old Bridge Sand Member, the Amboy Stoneware Clay Member, and the Morgan and Cliffwood beds. The Magothy Formation consists largely of coarse beach sand and associated marine and lagoonal sediments (Perry and others, 1975, p. 1535). Cross-stratification of the Old Bridge Sand Member suggests possible deposition in river channels (Owens and Sohl, 1969, p. 239). The Amboy Stoneware Clay Member is a dark, micaceous silt that contains lenses of white to pale-blue clay. The Morgan beds consist of interbedded clay, silt, and sand that lie unconformably on the Amboy Stoneware Clay Member. These beds grade laterally into cross-stratified sand. The Cliffwood beds range from a light-gray clayey silt to very fine sand.

The Merchantville Formation lies unconformably on the Magothy Formation (Owens and Sohl, 1969, p. 242). This marine deposit, which consists chiefly of interstratified, massive, thick glauconite sand and thinly bedded, very micaceous, carbonaceous clayey silt (Owens and Sohl, 1969, p. 242), is the oldest glauconite unit that crops out in the New Jersey Coastal Plain.

The Merchantville Formation grades upward into the Woodbury Clay. The gradational contact marks the transitional area above which glauconite is a minor constituent and clay is a major constituent (Owens and others, 1977, p. 31). The Woodbury Clay is a thick, massive, clayey silt. The calcareous fauna present in the formation indicate deposition in a marine environment (Owens and Sohl, 1969, p. 243).

METHODS OF INVESTIGATION

Correlation of Units

Most regional subsurface mapping in the New Jersey Coastal Plain has been based on formal geologic (rock-stratigraphic) and chronologic (time-stratigraphic) units that were defined by lithologic and biostratigraphic correlations of well samples (Zapecza, 1989, p. B7). This report focuses on the hydrogeologic units--the aquifers and confining units--rather than on geologic units. This approach is necessary because hydrogeologic boundaries commonly do not coincide with geologic or chronologic boundaries; a geologic formation may act as an aquifer in one area and a confining unit in another, or an aquifer may be composed of several geologic formations (Zapecza, 1989, p. B7).

In this report, hydrogeologic units are defined on a regional scale. The location and extent of these units are influenced by many factors, including rates of retreat or advance of the sea, uplift of the continental surface, amount and type of material transported, and depositional environment. In addition, erosion and compaction can affect sediments after deposition. Minor fluctuations in any of these or other factors can change the location, extent, and type of sediment deposited. Although irregularities in the surfaces and thicknesses of the hydrogeologic units are indicated by the data, these variations are viewed as local anomalies and are not included in the regional maps.

Sources of Data

The hydrogeologic framework presented in this report was interpreted on the basis of information from several sources. Geophysical and drillers' logs from more than 1,500 sites were obtained from various government and private agencies and were reviewed for lithologic information. In addition, a drilling program was conducted in cooperation with the NJGS to add lithologic information in areas where data were scarce. Details of the data-collection phase of the project are presented in Gronberg and others (1989).

Geophysical and drillers' logs from 267 sites were chosen to represent the data collected and were used as control points for the description of the framework. Most of the available lithologic data are from the northwest part of the study area, where the Potomac-Raritan-Magothy aquifer system is shallower. Interpretation of several surface-geophysical lines by the New Jersey Department of Environmental Protection (S. Sandberg, New Jersey Department of Environmental Protection, written commun., 1987) supplemented the coverage of the outcrop areas. In addition, a recent interpretation of the Coastal Plain sediments in Raritan Bay (E.P. Declercq, formerly with U.S. Geological Survey, written commun., 1987) extended the framework description into the Bay area.

All wells and test boreholes from which geophysical and drillers' logs were used in this report are part of the U.S. Geological Survey Ground-Water Site Inventory (GWSI) data base. The GWSI data base provides a means for storing and retrieving data such as well-construction information, water levels, and well locations. Selected geophysical and drillers' logs are presented in Gronberg and others (1989).

Geophysical and Geologic Logs

Two types of geophysical logs--electric and gamma-ray--were used to interpret the hydrogeologic framework. Electric logs are dual-track logs that consist of the spontaneous-potential (SP) curve on the left and a single-point resistance curve on the right. The spontaneous-potential curve records changes in voltage caused by electrochemical reactions that develop between the borehole fluid and the surrounding formation materials (Keys and McCary, 1971, p. 24). In general, sands cause a deflection to the left (negative) and clays cause a deflection to the right (positive); however, if the borehole mud is more saline than the formation water, reversals of the SP curve can occur. The single-point resistance curve records the electrical resistance of the formation materials. Sand and gravel usually are more resistant to the flow of electric current and cause a deflection to the right, whereas silt and clay are less resistant and cause a deflection to the left.

Gamma-ray logs record the rate of gamma-ray emission from the formation. Clay usually shows higher natural gamma activity than clean quartz sand and carbonates. Therefore, clay causes a deflection to the right, representing higher gamma radiation, and sand and gravel cause deflections to the left. Keys and MacCary (1971) describe the theory and application of borehole geophysical logging and the interpretation of the resulting logs, and discuss additional factors that must be considered when interpreting geophysical logs.

The gamma-ray and electric logs used in this study possess the characteristic markings that indicate the contacts between aquifers and confining units. These contacts were found to be distinctive and traceable over large distances.

Drillers' or geologic logs are descriptions of drill cuttings or samples. Davis and DeWeist (1966) describe the recording of these logs and cite various considerations related to the collection and interpretation of these logs. Although drillers' logs frequently are less reliable and more difficult to interpret than geophysical logs, they were used in this study to extend the framework description to areas where geophysical logs were not available.

HYDROGEOLOGIC FRAMEWORK

The sediments of the Potomac Group and the Raritan and Magothy Formations make up the Potomac-Raritan-Magothy aquifer system (table 1). This aquifer system is divided into lower, middle, and upper aquifers separated from each other by confining units (Zapecza, 1989, p. B10). In the study area, however, this aquifer system consists only of the middle and upper aquifers; the lower aquifer is not mappable (Zapecza, 1989, pl. 3 and 6). In the northern part of the study area, the sediments of the Raritan and Magothy Formations have been subdivided into nine distinct units on the basis of economic importance (Ries and others, 1904, p. 166; Barksdale and others, 1943, p. 18; Zapecza, 1989, fig. 3). The lithologic subdivision of the Raritan and Magothy Formations and hydrogeologic units in and near the outcrop area are shown in table 2. Locally, the middle aquifer is known as the Farrington aquifer, and the upper aquifer is known as the Old Bridge aquifer (Farlekas, 1979). In downdip parts of the study area, particularly in Monmouth County, large thicknesses of sediments below the confining unit overlying the middle aquifer remain undifferentiated.

The Potomac-Raritan-Magothy aquifer system is overlain by an extensive confining unit composed of the Merchantville Formation and the Woodbury Clay, and is underlain by pre-Cretaceous bedrock. The bedrock consists mainly of Precambrian and Lower Paleozoic rocks. Locally, near the Fall Line, Triassic-age siltstones and sandstones and a Jurassic diabase are present.

Potomac-Raritan-Magothy Aquifer System

The hydrogeologic framework of the Potomac-Raritan-Magothy aquifer system is described by means of a series of structure-contour maps, thickness maps, and hydrogeologic sections. Plate 1 shows the well and test-borehole locations, the types of logs used, and the locations of the hydrogeologic sections. Plate 2 shows a number of hydrogeologic sections through the aquifer system. Sections A-A' through E-E' (pl. 2a-2e) are located approximately along dip, whereas sections F-F' and G-G' (pl. 2f-2g) are located approximately along strike. Table 3 (a and b) summarizes available information on the wells and test boreholes and on the tops and bases of each aquifer, respectively.

Formation outcrops shown on the hydrogeologic maps were modified from those compiled by J.P. Owens (U.S. Geological Survey, 1967). Because hydrogeologic units usually consist of only the sandy or clayey parts of specific geologic formations, the formation outcrop areas shown on the structure-contour maps do not always coincide with the outcrop areas of the hydrogeologic units. However, the outcrop areas generally can be used to estimate updip limits of aquifers and confining units and to approximate lines of zero thickness (Zapecza, 1989, p. B8). In the northern Coastal Plain of New Jersey, outcrops of the Farrington Sand Member of the Raritan Formation and the Old Bridge Sand Member of the Magothy Formation (Barksdale and others, 1943, p. 21), generally coincide more closely with the aquifer outcrops. The hydrogeologic unit boundaries shown in the hydrogeologic sections were extended to land surface by using the geologic formation boundaries as a guide and are approximate.

Middle Aquifer

The middle aquifer is composed of the Farrington Sand Member of the Raritan Formation in most of the northern Coastal Plain of New Jersey (table 2). It also includes younger surficial sand and gravel at or near the outcrop (Farlekas, 1979, p. 8). Locally in Monmouth County it also can include the uppermost sands of the Potomac Group (Farlekas, 1979, p. 9). The middle aquifer is characterized by fine to course sand with lignite and pyrite (Farlekas, 1979, p. 8) that locally contains clay beds (Barksdale and others, 1943, p. 104-105).

The middle aquifer usually can be identified by the thick and continuous confining unit that lies above it. Identification of the top of the aquifer is difficult where the confining unit is sandy or contains many sandy layers.

The lower boundary of the middle aquifer is marked by the top of the underlying confining unit. In the study area, the composition of the confining unit underlying the middle aquifer varies with location. Locally, in updip parts of the study area, in Mercer and Middlesex Counties, this confining unit can consist of the Raritan fire clay, pre-Cretaceous bedrock, and saprolitic clay. Where present, the fire clay is a massive, multicolored clay that grades transitionally into the saprolitic clay that rests on bedrock (Ries and others, 1904, p. 192). In downdip areas of Monmouth County, the confining unit underlying the middle aquifer is composed primarily of fine-grained sediments of the Potomac Group.

Table 2.--Lithologic subdivisions of the Raritan and Magothy Formations and hydrogeologic units in the northern part of the study area

[Modified from Christopher, 1979, fig.2, and Zapecza, 1989, table 2.]

<table>
<tr><th>System</th><th colspan="2">Geologic unit</th><th>Lithology</th><th colspan="2">Hydrogeologic unit</th></tr>
<tr><td rowspan="9">Cretaceous</td><td rowspan="4">Magothy Formation</td><td>Cliffwood beds</td><td rowspan="4">Sand, quartz, light-gray, fine- to coarse-grained; local beds of dark-gray lignitic clay.</td><td rowspan="9">Potomac-Raritan-Magothy aquifer system[1]</td><td rowspan="3">Confining unit</td></tr>
<tr><td>Morgan beds</td></tr>
<tr><td>Amboy Stoneware Clay Member</td></tr>
<tr><td>Old Bridge Sand Member</td><td>Upper aquifer[2]</td></tr>
<tr><td rowspan="5">Raritan Formation</td><td>South Amboy Fire Clay Member</td><td rowspan="5">Sand, quartz, light-gray, fine to coarse-grained, pebbly, arkosic, red white and variegated clay, and saprolitic clay developed on bedrock.</td><td rowspan="3">Confining unit</td></tr>
<tr><td>Sayreville Sand Member</td></tr>
<tr><td>Woodbridge Clay Member</td></tr>
<tr><td>Farrington Sand Member</td><td>Middle aquifer</td></tr>
<tr><td>Raritan fire clay</td><td>Confining unit</td></tr>
<tr><td>Pre-Cretaceous</td><td colspan="2">Bedrock</td><td>Precambrian and lower Paleozoic crystalline rocks, metamorphic shist and gneiss; locally Triassic, sandstone, shale and Jurassic diabase.</td><td colspan="2">Bedrock confining unit</td></tr>
</table>

[1]To maintain consistent terminology, the aquifer-system name commonly used throughout New Jersey is used in this report. The lower aquifer is not mappable within the study area.

[2]Locally the upper aquifer can include the Sayreville Sand Member where the South Amboy Fire Clay Member is thin or absent.

Differentiation of the aquifer from great thicknesses of underlying sediments within the Potomac Group and Raritan Formation solely on the basis of geophysical data is difficult (Zapecza, 1989, p. B11), especially southeast of Freehold Township. The geophysical logs from well 25-566 (pl. 2, section D-D') show that the undifferentiated sediment in the Potomac-Raritan-Magothy aquifer system is greater than 200 ft thick.

Plate 3 shows structure contours of the top of the middle aquifer. In general, the strike is northeast-southwest and the dip is approximately 60 ft/mi to the southeast. Structure contours of the top of the middle aquifer in Raritan Bay are modified from E.P. Declercq (formerly with U.S. Geological Survey, written commun., 1987).

The thickness of the middle aquifer is shown on plate 4. In general, the thickness contours run along strike. In most places, the aquifer is less than 150 ft thick, but it is thicker near East Windsor, where it has a maximum known thickness of 168 ft (at well 21-13). In the Raritan Bay area the middle aquifer is thin, ranging from 33 ft thick (at well 25-299 in Aberdeen Township) to 81 ft thick (at well 25-565 in Union Beach Borough).

In several areas, the middle aquifer is thin or absent, possibly as a result of post-depositional erosion. During Pleistocene glaciation, when sea level was lower than it is at present, the Raritan River cut a channel to or almost to bedrock from the mouth of Lawrence Brook to Perth Amboy. Sediments ranging in size from sand and gravel to relatively impermeable river mud filled the channel as sea level rose. Where present, this mud restricts the hydraulic connection between the part of the aquifer that is north of the river and the part that is south of the river (Barksdale, 1937, p. 3-7; Farlekas, 1979, p. 8). Additionally, the presence of a ridge of trap rock (an extension of the Palisades diabase sill) may have prevented deposition of the Farrington Sand Member of the Raritan Formation (Barksdale, 1937, p. 6-7). Examination of drillers' logs of the area shows that the aquifer is absent just south of the Raritan River between Sayreville and South Amboy (pl. 2b).

Along the Washington Canal in Sayreville Borough, the alluvium that once lined the channel was dredged, leaving the middle aquifer exposed to the brackish water (Barksdale, 1937, p. 9). In other areas, such as the southwestern part of the outcrop near West Windsor and Plainsboro, the overlying confining unit thins, is absent, or becomes sandy, leaving the aquifer exposed or in connection with the overlying sediments and increasing its thickness.

Confining Unit Overlying the Middle Aquifer

The confining unit overlying the middle aquifer is composed mainly of the Woodbridge Clay Member of the Raritan Formation. Locally, the confining unit also may include the clayey lithofacies of the overlying Sayreville Sand Member and the South Amboy Fire Clay Member of the Raritan Formation (Farlekas, 1979, p. 16). This unit is characterized as a thick, continuous unit of clay and silt. Southeast of the outcrop area, the thickness of the confining unit exceeds 100 ft in most areas (pl. 5). In Holmdel Township, in the northeastern part of the study area, this unit thickens to 241 ft (at well 25-145).

In the southwestern part of the study area, the sand content of the confining unit increases, and its thickness generally is less than 100 ft. The sand content of the confining unit increases near Dayton, in South Brunswick Township. Farther downdip, the confining unit thins to 39 ft (at well 23-553). Section E-E′ (pl. 2e) illustrates this transition from a thick, sandy confining unit to a thin, finer-grained confining unit. The confining unit is thinnest (26 ft) to the southwest (at well 23-25). Drillers′ logs and surface geophysical data indicate that the confining unit again becomes sandy near the Middlesex-Mercer County line (S. Sandberg, New Jersey Department of Environmental Protection, written commun., 1987).

The change in thickness and lithology of this confining unit may be the result of one or a combination of depositional and post-depositional factors. One such factor is the influence of the basement structure on the deposition of the sediments. Proximity to a junction of the basement tectonic features may have caused a thinning of the unit or a change in the lithology of the sediments (Owens and Sohl, 1969, p. 237; Owens and Gohn, 1985, p. 26). Alternatively, the absence of the confining unit can be attributed to a post-depositional process. Reworking of the sediments may be associated with the ancestral Hudson River or one of its tributaries (Owens and Minard, 1979, p. D19).

Upper Aquifer

The upper aquifer is the most extensive unit of the Potomac-Raritan-Magothy aquifer system (Zapecza, 1989, p. B11). The upper aquifer is composed of the Old Bridge Sand Member of the Magothy Formation (table 2). Where the South Amboy Fire Clay Member is thin or absent, it also includes the Sayreville Sand Member of the Raritan Formation and the overlying younger surficial sand and gravel at or near the outcrop areas (Farlekas, 1979, p. 22). The upper aquifer is characterized by coarse-grained sediments and thin, localized clay beds (Zapecza, 1989, p. B11).

This unit can be mapped from the southeastern edge of the outcrop to the southeastern corner of the study area (pl. 6). The top of the aquifer is determined easily from geophysical and drillers′ logs because the contact with the overlying Merchantville-Woodbury confining unit is sharp. Near Raritan Bay, the Magothy Formation also includes the Amboy Stoneware Clay Member and the Cliffwood and Morgan beds. However, these units have a low permeability and are mapped with the overlying Merchantville-Woodbury confining unit. In general, the surface of the upper aquifer strikes northeast-southwest and dips to the southeast at about 50 ft/mi. Structure contours of the top of the upper aquifer in Raritan Bay are modified from E.P. Declercq (formerly with U.S. Geological Survey, written commun., 1987).

Plate 7 shows the thickness of the upper aquifer. The aquifer is greater than 100 ft thick in most areas and thickens to 236 ft (at well 25-501) downdip from the outcrop in the southeastern corner of the study area. In the southwestern part of the study area, near the outcrop of the Magothy Formation, the aquifer is less than 100 ft thick. The lower boundary of the aquifer is difficult to determine where the underlying confining unit is thin or sandy, as it is in the southwestern part of the study area. Where the confining unit is sandy, the upper aquifer may be hydraulically connected to the middle aquifer.

Merchantville-Woodbury Confining Unit

The Merchantville-Woodbury confining unit overlies the upper aquifer of the Potomac-Raritan-Magothy aquifer system. It is composed mainly of the Merchantville Formation and the Woodbury Clay (table 2). This confining unit locally includes the Amboy Stoneware Clay Member and the discontinuous Cliffwood and Morgan beds of the Magothy Formation. The Cliffwood and Morgan beds are recognized locally in outcrop and in the subsurface of the Sandy Hook Bay area (Zapecza, 1989, p. B12). These beds interfinger with and pinch out within the Merchantville Formation and the Woodbury Clay (Perry and others, 1975, fig. 11). Because these beds are part of the confining unit, the updip extent of the unit is the outcrop area of the Magothy Formation near Raritan Bay. These beds are not found to the southwest along the outcrop area; therefore, the updip extent of the confining unit coincides with the updip extent of the Merchantville Formation.

The thickness map shown on plate 8 and the hydrogeologic sections shown on plate 2 illustrate that this confining unit is the thickest and most extensive confining unit in the study area. It is effective as a confining layer between the upper aquifer of the Potomac-Raritan-Magothy aquifer system and the overlying Englishtown aquifer system (Zapecza, 1989, p. B12). The thickness of the confining unit exceeds 200 ft throughout most of the study area and increases downdip to a known maximum of 369 ft in Highlands Borough (at well 25-119).

Overlying Units

The Englishtown aquifer system (table 1), which overlies the Merchantville-Woodbury confining unit, consists of the Englishtown Formation of Late Cretaceous age, and functions as a single aquifer throughout most of the northern Coastal Plain of New Jersey. In southeastern Monmouth County, however, two sand lithofacies are separated by a clayey-silt lithofacies. The aquifer system thickens from 40 ft near the outcrop to 140 ft near Red Bank in northern Monmouth County, where it still acts as a single water-bearing unit. The thickness increases to about 180 ft in southeastern Monmouth County, where the unit includes the clayey-silt lithofacies that separates the upper from the lower sand unit (Zapecza, 1989, p. B12-B13).

The Marshalltown-Wenonah confining unit (table 1), which overlies the Englishtown aquifer system, consists of the Marshalltown Formation and the fine-grained lower section of the Wenonah Formation. The Marshalltown Formation consists of 10 to 20 ft of glauconitic silt; the Wenonah Formation generally is a dark-gray, poorly sorted, micaceous, silty, fine quartz sand. The lower section also contains abundant glauconite (Zapecza, 1989, p. B13-B14).

The Wenonah-Mount Laurel aquifer (table 1), which overlies the Marshalltown-Wenonah confining unit, consists of the coarse-grained upper part of the Wenonah Formation and the Mount Laurel Sand. The thickness of the aquifer ranges from 40 ft near the outcrop to approximately 100 ft near the shore (Zapecza, 1989, p. B14, pl. 17).

In the northern Coastal Plain of New Jersey, the composite confining unit that overlies the Wenonah-Mount Laurel aquifer consists of the Navesink Formation and, depending on the location, can include the Red Bank Sand, Tinton Sand, Hornerstown Sand, Vincentown Formation, Manasquan Formation, Shark River Formation, Piney Point Formation, and the basal clay of the Kirkwood Formation (table 1). These units are predominantly low- to moderate-permeability silty and clayey glauconitic quartz sands. The permeable sands of the Red Bank Sand and Vincentown Formation are used locally for water supply. In the study area, the thickness of this confining unit increases rapidly from 50 ft at the outcrop to more than 450 ft near the shore (Zapecza, 1989, p. B14-B15, pl. 18).

The Vincentown aquifer (table 1) is composed of the sandy part of the Vincentown Formation. These permeable sands are found in and near the outcrop and grade rapidly into finer-grained silt and clay downdip. The Vincentown aquifer ranges in thickness from approximately 50 ft in and near the outcrop area to greater than 100 ft downdip (Zapecza, 1989, p. B15-B16, pl. 19).

The Kirkwood-Cohansey aquifer system (table 1) is composed mainly of the Kirkwood Formation and Cohansey Sand. Near the coast, the Kirkwood Formation consists predominantly of clay beds with interbedded zones of sand and gravel. Updip from the coast in the subsurface, the unit is composed of fine to medium sand and silty sand; clay beds are found only in the basal part of the formation. The Cohansey Sand is composed predominantly of light-colored quartz sand that contains minor amounts of pebbly sand, fine- to coarse-grained sand, silty and clayey sand, and interbedded clay. These sediments generally are coarser-grained than those in the underlying Kirkwood Formation (Zapecza, 1989, p. B19-B20).

SUMMARY

The hydrogeologic units of the Potomac-Raritan-Magothy aquifer system in the northern Coastal Plain of New Jersey are described by means of a series of structure-contour and thickness maps of the aquifers and thickness maps of the confining units. The units mapped as part of this study are, in ascending order--

1. The middle aquifer of the Potomac-Raritan-Magothy aquifer system,
2. the confining unit overlying the middle aquifer of the Potomac-Raritan-Magothy aquifer system,
3. the upper aquifer of the Potomac-Raritan-Magothy aquifer system, and
4. the Merchantville-Woodbury confining unit.

Hydrogeologic sections that show the lateral extent and thickness of these hydrogeologic units are included.

These maps and sections show that the hydrogeologic units of the Potomac-Raritan-Magothy aquifer system strike approximately northeast-southwest and dip to the southeast. In general, the units are continuous throughout the study area, although some exceptions are noted.

The middle aquifer of the Potomac-Raritan-Magothy aquifer system is mappable throughout most of the study area. In the northern Coastal Plain of New Jersey, this unit is composed of the Farrington Sand Member of the Raritan Formation. It also includes younger surficial sand and gravel at or near the outcrop, and locally in Monmouth County it also can include the uppermost sands of the Potomac Group. The middle aquifer is characterized by fine to coarse sand with lignite and pyrite. In most places, the aquifer is less than 150 ft thick. South of the Raritan River, between Sayreville and South Amboy, the middle aquifer thins and is absent in some places, possibly because of post-depositional erosion or because of the presence of the Palisades diabase sill, which may have prevented deposition of the sediments of the middle aquifer in this area.

The confining unit overlying the middle aquifer is a relatively thick, effective confining unit of clay and silt throughout most of the study area. This unit is composed mainly of the Woodbridge Clay Member of the Raritan Formation. Locally, it also may include the clayey lithofacies of the overlying Sayreville Sand Member and the South Amboy Fire Clay Member of the Raritan Formation. Southeast of the outcrop area, the confining unit is greater than 100 ft thick in most places; in Holmdel Township, this unit thickens to 241 ft. In the southwestern part of the study area, however, it becomes thin or sandy, and the middle and upper aquifers may be hydraulically connected.

The upper aquifer of the Potomac-Raritan-Magothy aquifer system is mappable throughout the study area. Locally, this unit is composed of the Old Bridge Sand Member of the Magothy Formation and the Sayreville Sand Member of the Raritan Formation, where the South Amboy Fire Clay Member is thin or absent, and includes the overlying younger surficial sand and gravel at or near the outcrop areas. The upper aquifer is characterized by coarse-grained sediments and thin, localized clay beds. The thickness of this unit is greater than 100 ft in most places and increases to 236 ft in the southeastern corner of the study area. In the southwestern part of the study area, near the outcrop of the Magothy Formation, the aquifer is less than 100 ft thick. The surface of this unit is recognized easily by the sharp contact with the overlying Merchantville-Woodbury confining unit.

The Merchantville-Woodbury confining unit is a thick, effective confining unit that overlies the Potomac-Raritan-Magothy aquifer system. Near Raritan Bay, the confining unit includes the South Amboy Fire Clay Member and Cliffwood and Morgan beds of the Magothy Formation. The thickness of the confining unit exceeds 200 ft throughout most of the study area and increases downdip to a known maximum of 369 ft in Highlands Borough.

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GLOSSARY

Aquifer. A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Cone of depression. A depression produced in the water table or other potentiometric surface by the withdrawal of water from an aquifer; it is shaped like an inverted cone with its apex at the area of greatest concentration of pumping.

Confining unit. A body of relatively impermeable material stratigraphically adjacent to one or more aquifers. The hydraulic conductivity may range from nearly zero to some value distinctly lower than that of the aquifer.

Saltwater intrusion. The movement of saltwater or brackish water into a freshwater aquifer induced by the lowering of the freshwater head to below sea level by pumping.

Table 3a.--Records of selected wells and test boreholes

[Locations shown on plate 1]

Well number	Location Latitude	Location Longitude	Local identifier[1]	Municipality[1]
21- 1	401347	743052	SKEBA 1959	EAST WINDSOR TWP
21- 4	401408	743114	PRINCETON TURF - S.KRISTAL 1973	EAST WINDSOW TWP
21- 13	401536	742920	EAST WINDSOR MUA TEST-5	EAST WINDSOR TWP
21- 17	401604	743404	CRANSTON 1	EAST WINDSOR TWP
21- 19	401608	743354	EAST WINDSOR MUA 5	EAST WINDSOR TWP
21- 22	401702	743106	EAST WINDSOR MUA 3	EAST WINDSOR TWP
21- 85	401625	743131	HIGHTSTOWN WD TEST-3	HIGHTSTOWN BORO
21- 96	401104	743630	POTTS 1-1951	WASHINGTON TWP
21- 98	401147	743348	WILSON 1 (REED SOD FARM)	WASHINGTON TWP
21- 99	401159	743403	ENGLAND 2	WASHINGTON TWP
21- 101	401238	743448	PRINCETON MEMORIAL PARK 1	WASHINGTON TWP
21- 104	401344	743236	GELLER 1953	WASHINGTON TWP
21- 110	401433	743434	DRAKE 1-1949	WASHINGTON TWP
21- 143	401458	743152	CONOVER DAIRY	EAST WINDSOR TWP
21- 145	401717	743352	CARTER WALLACE	EAST WINDSOR TWP
21- 152	401554	743704	WEST WINDSOR WC 2-1968	WEST WINDSOR TWP
21- 154	401306	743622	MCINTYRE DOM WELL	WASHINGTON TWP
21- 241	401727	743640	USGS - CHAMBERLAIN PARK	WEST WINDSOR TWP
23- 11	401818	742932	CARTER WALLACE 1	CRANBURY TWP
23- 12	401830	742830	COUFTS 1951	MONROE TWP
23- 13	401841	743355	STULTZ 1-1954 (CLIFRD)	CRANBURY TWP
23- 14	401842	743055	CRANBURY TWP WD 1	CRANBURY TWP
23- 17	401843	743055	CRANBURY TWP WD 3	CRANBURY TWP
23- 25	401902	742912	CARTER WALLACE 6	CRANBURY TWP
23- 30	401916	742921	NJ TURNPIKE AUTHORITY 7S-2	CRANBURY TWP
23- 40	402418	742545	EAST BRUNSWICK TWP WD TEST 5-75	EAST BRUNSWICK TWP
23- 42	402421	742525	EAST BRUNSWICK TWP WD TEST 4-75	EAST BRUNSWICK TWP
23- 46	402427	742507	POLYSAR RUBBER SERV PUMPING WELL	EAST BRUNSWICK TWP
23- 47	402430	742553	EAST BRUNSWICK TWP WD TEST 7-75	EAST BRUNSWICK TWP
23- 50	402432	742212	ANHEUSER BUSCH 5	EAST BRUNSWICK TWP
23- 57	402441	742448	EAST BRUNSWICK TWP WD COLONIAL OAKS	EAST BRUNSWICK TWP
23- 58	402448	742700	MIDDLESEX WC TAMARACK 1-75	EAST BRUNSWICK TWP
23- 59	402456	742442	EAST BRUNSWICK TWP WD 2	EAST BRUNSWICK TWP
23- 61	402500	742638	NJ TURNPIKE AUTHORITY 8N-1	EAST BRUNSWICK TWP
23- 65	402520	742609	EAST BRUNSWICK TWP WD 1-69	EAST BRUNSWICK TWP
23- 66	402516	742408	COLLINS	EAST BRUNSWICK TWP
23- 71	402237	742830	SMITH 1	SOUTH BRUNSWICK TWP
23- 72	402635	742402	SMITH 2-1972	EAST BRUNSWICK TWP
23- 77	402755	742300	HERBERT SAND CO 2	EAST BRUNSWICK TWP
23- 79	402807	742302	HERBERT SAND CO 1	EAST BRUNSWICK TWP

Table 3a.--Records of selected wells and test boreholes--continued

[Locations shown on plate 1]

Well number	Location Latitude	Location Longitude	Local identifier[1]	Municipality[1]
23- 82	402836	742404	BORGESE 1	EAST BRUNSWICK TWP
23- 94	402239	742530	HELMETTA WC 5-1962 (OLD=2)	HELMETTA BORO
23- 97	402247	742503	DUHERNAL WC OBS 49F	HELMETTA BORO
23- 100	402053	742603	NJ WATER CO JAMESBURG 7	JAMESBURG BORO
23- 107	402252	742246	DUHERNAL WC OBS 54F	OLD BRIDGE TWP
23- 114	402319	742246	DUHERNAL WC 52F	OLD BRIDGE TWP
23- 127	402330	742258	DUHERNAL WC AF	OLD BRIDGE TWP
23- 131	402334	742231	DUHERNAL WC 8	OLD BRIDGE TWP
23- 132	402335	742136	DUHERNAL WC OBS 56F	OLD BRIDGE TWP
23- 133	402350	742051	OLD BRIDGE MUA 6	OLD BRIDGE TWP
23- 146	402350	741834	OLD BRIDGE MUA BROWNTOWN 3	OLD BRIDGE TWP
23- 154	402354	742212	DUHERNAL WC OBS 43F	OLD BRIDGE TWP
23- 170	402403	742405	DUHERNAL WC OBS 53F	SPOTSWOOD BORO
23- 171	402404	742204	DUHERNAL WC BF	OLD BRIDGE TWP
23- 176	402407	741924	OLD BRIDGE MUA OBS 1-1972	OLD BRIDGE TWP
23- 179	402436	742041	OLD BRIDGE MUA OBS 2-1972	OLD BRIDGE TWP
23- 191	402530	741701	CALIENDO 1	OLD BRIDGE TWP
23- 194	402536	742018	PERTH AMBOY WD RUNYON 1	OLD BRIDGE TWP
23- 201	402614	741744	OLD BRIDGE MUA MIDTOWN 1	OLD BRIDGE TWP
23- 202	402625	741611	NJ DEPT CONSERV CHEESQUAKE SP1	OLD BRIDGE TWP
23- 206	402700	741454	OLD BRIDGE MUA LAWRENCE HARBOR 9	OLD BRIDGE TWP
23- 219	401925	742620	MONROE TWP MUA 8-R	MONROE TWP
23- 230	402012	742703	FARINO BROTHERS 1	MONROE TWP
23- 231	402019	742708	FARINO BROTHERS 2-REPLACEMENT	MONROE TWP
23- 232	402023	742858	MONROE TWP MUA FORSGATE 11	MONROE TWP
23- 236	402038	742345	NJ HOME FOR BOYS 4	MONROE TWP
23- 238	402038	742755	FORSGATE FARMS FARM WELL 4-R	MONROE TWP
23- 241	402056	742516	BICA 1	MONROE TWP
23- 244	402131	742245	REESE 1971	MONROE TWP
23- 245	402202	742305	MONROE TWP MUA RELIABLE 1	MONROE TWP
23- 255	403046	741827	CARBORUNDUM CO 1	WOODBRIDGE TWP
23- 260	403129	741533	MORTON SALD	PERTH AMBOY CITY
23- 265	403211	741612	CHEVRON OIL CO 11	PERTH AMBOY CITY
23- 273	401932	743529	NJ WATER POLICH PLAINSBORO POND	PLAINSBORO TWP
23- 291	402109	743013	MONROE TWP MUA OBS 1-1961	SOUTH BRUNSWICK TWP
23- 293	402113	742922	FORSGATE WC OBS 3	SOUTH BRUNSWICK TWP
23- 297	402124	742935	QUALITY EGG CO 1 (ABEEL, J.F.)	SOUTH BRUNSWICK TWP
23- 300	402128	742824	BASF-WYANDOTTE 2	SOUTH BRUNSWICK TWP
23- 302	402138	742940	SOUTH BRUNSWICK MUA FORSGATE 14	SOUTH BRUNSWICK TWP
23- 306	402147	742847	PHELPS DODGE CO PHELPS DODGE 3	SOUTH BRUNSWICK TWP

Table 3a.--Records of selected wells and test boreholes--continued

[Locations shown on plate 1]

Well number	Location Latitude	Location Longitude	Local identifier[1]	Municipality[1]
23- 315	402204	743024	SOUTH BRUNSWICK MUA 13	SOUTH BRUNSWICK TWP
23- 319	402220	742950	SOUTH BRUNSWICK MUA 12	SOUTH BRUNSWICK TWP
23- 322	402230	743040	SOUTH BRUNSWICK MUA 11	SOUTH BRUNSWICK TWP
23- 327	402309	743134	SOUTH BRUNSWICK BD ED 1 HIGH SCHOOL	SOUTH BRUNSWICK TWP
23- 332	402319	742708	AHMED 2	SOUTH BRUNSWICK TWP
23- 352	402605	741958	SAYREVILLE WD RECHARGE 1 M	SAYREVILLE BORO
23- 365	402633	742120	DUHERNAL WC DUH SAY 4	SAYREVILLE BORO
23- 369	402630	741949	SAYREVILLE WD H	SAYREVILLE BORO
23- 370	402631	742053	HERCULES POWDER 6	SAYREVILLE BORO
23- 376	402649	742025	HERCULES POWDER 3	SAYREVILLE BORO
23- 377	402654	742043	HERCULES POWDER OBS 2	SAYREVILLE BORO
23- 379	402656	742104	DUHERNAL WC OBS 40F	SAYREVILLE BORO
23- 386	402701	741917	E I DUPONT 6	SAYREVILLE BORO
23- 391	402711	742030	HERCULES POWDER 4	SAYREVILLE BORO
23- 395	402715	742050	DUHERNAL WC OBS 33F	SAYREVILLE BORO
23- 396	402718	742213	DUHERNAL WC OBS 27F	SAYREVILLE BORO
23- 397	402728	742044	DUHERNAL WC OBS 55F	SAYREVILLE BORO
23- 404	402745	741645	SAYREVILLE WD MORGAN OBS 1	SAYREVILLE BORO
23- 409	402751	742002	DUHERNAL WC OBS 36F	SAYREVILLE BORO
23- 411	402822	741630	SOUTH AMBOY WD 8	SAYREVILLE BORO
23- 421	402905	741800	NATIONAL LEAD TEST 3	SAYREVILLE BORO
23- 424	402945	741752	DUHERNAL WC OBS 34F	SAYREVILLE BORO
23- 430	402923	741651	JERSEY CENTRAL POWER LIGHT 7-1972	SOUTH AMBOY CITY
23- 438	402559	742142	SOUTH RIVER WD 5	SOUTH RIVER BORO
23- 439	402633	742200	SOUTH RIVER WD 2R	SOUTH RIVER BORO
23- 442	402252	742432	SPOTSWOOD WD 3	SPOTSWOOD BORO
23- 445	402328	742318	SPOTSWOOD WD TW 4F-76	SPOTSWOOD BORO
23- 462	403043	741842	UNION CARBIDE 1	WOODBRIDGE TWP
23- 479	403236	741616	AMERICAN CYANIMID CO WDBRG P2	WOODBRIDGE TWP
23- 501	402347	742726	SOUTH BRUNSWICK TWP DAVID ML T	SOUTH BRUNSWICK TWP
23- 503	401938	742404	EONAITIS 1	MONROE TWP
23- 504	402047	742820	FORSGATE INC I-IRR	MONROE TWP
23- 505	401855	743229	DYAL 2-1967	CRANBURY TWP
23- 506	402358	742612	SMITH 3-1958	EAST BRUNSWICK TWP
23- 510	402234	743114	IBM CORP GW 20	SOUTH BRUNSWICK TWP
23- 538	402734	741925	E I DUPOND 2-OBS	SAYREVILLE BORO
23- 541	403231	741518	SHELL OIL CO 44	WOODBRIDGE TWP
23- 553	401950	742750	MONROE TWP MUA TEST 16	MONROE TWP
23- 573	403207	741817	CIRAKY 1	WOODBRIDGE TWP
23- 574	402737	741736	POWESAK 1	SAYREVILLE BORO

Table 3a.--Records of selected wells and test boreholes--continued

[Locations shown on plate 1]

Well number	Location Latitude	Location Longitude	Local identifier[1]	Municipality[1]
23- 576	402933	741718	SPINELLO CONST CO 1	SOUTH AMBOY CITY
23- 577	403210	741520	CHEVRON OIL CO SB-13A	PERTH AMBOY CITY
23- 578	403236	741543	CHEVRON OIL CO E15A	WOODBRIDGE TWP
23- 580	402517	742050	PERTH AMBOY WD OBS 1	OLD BRIDGE TWP
23- 582	402505	742129	MCUA MADISON CONNET	OLD BRIDGE TWP
23- 584	401610	742624	TOWN & COUNTRY METAL (GAM CHOY 1)	MONROE TWP
23- 585	402450	742330	CHIRLIAN DEEPWELL	EAST BRUNSWICK TWP
23- 587	402205	742123	KOSMO 1	OLD BRIDGE TWP
23- 590	402721	741957	E I DUPONT LAYNE 57 OBS	SAYREVILLE BORO
23- 595	402153	741915	OLD BRIDGE DEV CORP SS4	OLD BRIDGE TWP
23- 598	402400	742548	EAST BRUNSWICK TWP WD TW 2-75	EAST BRUNSWICK TWP
23- 610	402429	742421	EAST BRUNSWICK TWP WD B-2	EAST BRUNSWICK TWP
23- 612	402324	742601	EAST BRUNSWICK TWP WD B-5	EAST BRUNSWICK TWP
23- 613	402326	742414	EAST BRUNSWICK TWP WD B-7	EAST BRUNSWICK TWP
23- 619	402249	742613	EAST BRUNSWICK TWP WD B-6-2	EAST BRUNSWICK TWP
23- 623	402242	742620	EAST BRUNSWICK TWP WD B-6	EAST BRUNSWICK TWP
23- 626	402330	742436	EAST BRUNSWICK TWP WD TPW B-8	EAST BRUNSWICK TWP
23- 759	401824	742248	BROWN 1	MONROE TWP
23- 764	402422	741824	EHLER 1	OLD BRIDGE TWP
23- 766	402214	742127	SOUTH OLD BRIDGE FD ENGINE 3	OLD BRIDGE TWP
23- 769	401728	742504	MILADINOV 1	MONROE TWP
23- 770	401618	742500	JURGELSKY HOUSE WELL	MONROE TWP
23- 771	401718	742449	SCHARF 1	MONROE TWP
23- 772	402036	742706	KOKOSA 1	MONROE TWP
23- 774	401623	742819	RESNICK 1	MONROE TWP
23- 778	401834	743311	FINN 1	CRANBURY TWP
23- 779	401813	743043	BERESFORD THRIFT STORE	CRANBURY TWP
23- 781	402225	741821	JOCAMA CONST CO	OLD BRIDGE TWP
23- 783	402327	741620	OLD GRIDGE SOCCER ASSN 1	OLD BRIDGE TWP
23- 784	402327	742054	NAVEDO 1	OLD BRIDGE TWP
23- 787	402128	743055	ELY 1	SOUTH BRUNSWICK TWP
23- 790	402627	742247	USGS - SOUTH RIVER HIGH 1	SOUTH RIVER BORO
23- 791	401940	743353	USGS - LINPRO	PLAINSBORO TWP
23- 816	403039	741808	TITANIUM PIGMENT TP-T02B	WOODBRIDGE TWP
23- 817	403029	741838	TITANIUM PIGMENT TP-T03B	WOODBRIDGE TWP
23- 818	403029	741827	TITANIUM PIGMENT TP-T04	WOODBRIDGE TWP
23- 827	403013	741847	TITANIUM PIGMENT TP-T13	SAYREVILLE BORO
23- 836	403001	741853	TITANIUM PIGMENT TP-T22	SAYREVILLE BORO
23- 846	402913	742030	US ARMY CORPS DH-R-1	EDISON TWP
23- 848	402858	742024	US ARMY CORPS DH-R-3	SAYREVILLE BORO

Table 3a.--Records of selected wells and test boreholes--continued

[Locations shown on plate 1]

Well number	Location Latitude	Location Longitude	Local identifier[1]	Municipality[1]
23- 850	402846	742020	US ARMY CORPS DH-R-5	SAYREVILLE BORO
23- 858	402837	742133	US ARMY CORPS DH-26E	EDISON TWP
23- 859	402846	742115	US ARMY CORPS DH-27E	SAYREVILLE BORO
23- 944	402825	742226	MCUA L-10	SAYREVILLE BORO
23- 963	402856	742326	MCUA L-28	EAST BRUNSWICK TWP
23- 969	402855	742343	MCUA L-36	EAST BRUNSWICK TWP
23- 971	402903	742347	MCUA L-39	NEW BRUNSWICK CITY
23- 995	403028	741804	NJ HIGHWAY DEPT 23	SAYREVILLE BORO
23-1011	402833	742041	MAN. & ENG. CORP. 2	SAYREVILLE BORO
23-1012	402819	742046	MAN. & ENG. CORP. 2A	SAYREVILLE BORO
23-1013	402806	742044	MAN. & ENG. CORP. 2B	SAYREVILLE BORO
23-1016	402722	741942	E I DUPONT LAYNE #4	SAYREVILLE BORO
23-1017	402818	742127	SAYRE & FISHER 29A	SAYREVILLE BORO
23-1021	402836	742014	E I DUPONT 4-D	SAYREVILLE BORO
23-1024	402833	741942	E I DUPONT 8-H	SAYREVILLE BORO
23-1025	402834	741926	E I DUPONT 10-J	SAYREVILLE BORO
23-1027	402905	741917	E I DUPONT 13-M	SAYREVILLE BORO
23-1029	402916	741908	NATIONAL LEAD 15-O	SAYREVILLE BORO
23-1031	402926	741859	NATIONAL LEAD 17-Q	SAYREVILLE BORO
23-1033	402933	741846	NATIONAL LEAD 19-S	SAYREVILLE BORO
23-1034	402937	741840	NATIONAL LEAD 20-T	SAYREVILLE BORO
23-1037	403156	741626	CALIFORNIA REFINING TEST WELL #7	PERTH AMBOY CITY
23-1038	403214	741714	CALIFORNIA REFINING TEST WELL #8	PERTH AMBOY CITY
23-1039	403158	741608	CALIFORNIA REFINING TEST WELL #9	PERTH AMBOY CITY
23-1058	402704	742139	HESS BROTHERS #1	SAYREVILLE BORO
25- 13	401137	740121	AVON WATER DEPT 4	AVON-BY-THE-SEA BORO
25- 34	401558	740908	NAD EARLE 2(B)	COLTS NECK TWP
25- 37	401607	741209	HOMINY HILLS GOLF CLUB 2-1963	COLTS NECK TWP
25- 39	401646	740554	US ARMY FT MONMOUTH-WAYSIDE	TINTON FALLS BORO
25- 45	401810	740957	FLOCK AND SONS 1	COLTS NECK TWP
25- 53	401720	740315	R H MACY & CO BAMBERGER T-2	EATONTOWN BORO
25- 55	401744	742135	ENGLISHTOWN BORO WD 1	ENGLISHTOWN BORO
25- 82	401412	741606	FREEHOLD TWP WD KOENIG LANE 1	FREEHOLD TWP
25- 85	401436	741525	3M COMPANY 1	FREEHOLD TWP
25- 97	401625	741501	FREEHOLD TWP WD 6 OLD SOUTH GULF2	FREEHOLD TWP
25- 103	401646	741737	FREEHOLD TWP WD 7-74	FREEHOLD TWP
25- 111	402532	740932	WEST KEANSBURG WC 1	HAZLET TWP
25- 119	402403	735923	HIGHLANDS WD 3	HIGHLANDS BORO
25- 145	402313	741100	GARDEN STATE PKWY TELEGRAPH HILL	HOLMDEL TWP
25- 146	402327	741114	BELL TELE CO CRAWFORD HILL 1	HOLMDEL TWP

Table 3a.--Records of selected wells and test boreholes--continued

[Locations shown on plate 1]

Well number	Location Latitude	Location Longitude	Local identifier[1]	Municipality[1]
25- 153	402444	741010	WEST KEANSBURG WC 4	HOLMDEL TWP
25- 156	402449	740910	LILY TULIP CUP DEEP TEST WELL	HOLMDEL TWP
25- 174	401243	741520	ADELPHIA WC 2-1974	HOWELL TWP
25- 194	402623	740740	KEANSBURG MUA 2	KEANSBURG BORO
25- 196	402628	740744	KEANSBURG MUA 3	KEANSBURG BORO
25- 197	402535	741214	KEYPORT BORO WD 7	KEYPORT BORO
25- 201	402615	741055	ESSIE CONSTRUCTION CO 1	HAZLET TWP
25- 203	402626	741142	KEYPORT BORO WD 1	KEYPORT BORO
25- 210	401639	735936	MONMOUTH CON WC WEST END 1	LONG BRANCH CITY
25- 214	401429	742146	MANALAPAN TWP WD LAMBS RD 1	MANALAPAN TWP
25- 218	401557	742318	BOY SCOUTS QUAIL HILL 2	MANALAPAN TWP
25- 220	401537	742012	BATTLEGROUND CC IRRIGATION	MANALAPAN TWP
25- 228	401733	741818	GORDONS CORNER WC OBS	MANALAPAN TWP
25- 231	402004	741855	GORDONS CORNER WC 6	MANALAPAN TWP
25- 249	401859	741809	GORDONS CORNER WC 4	MANALAPAN TWP
25- 251	401908	741510	GORDONS CORNER WC 9	MARLBORO TWP
25- 259	402035	741423	MARLBORO STATE HOSP 12	MARLBORO TWP
25- 262	402102	741353	MARLBORO STATE HOSP 15	MARLBORO TWP
25- 268	402117	741511	MARLBORO TWP MUA 2-PROD	MARLBORO TWP
25- 272	402208	741452	MARLBORO TWP MUA OBS 1	MARLBORO TWP
25- 282	402507	741344	BAYSHORE SERERAGE AUTHORITY 1	MATAWAN BORO
25- 284	402515	741450	MATAWAN BORO WD 3	MATAWAN BORO
25- 292	402359	741233	ABERDEEN TWP MUA MATAWAN MUA 1	ABERDEEN TWP
25- 294	402428	741345	MATAWAN BORO WD 1	ABERDEEN TWP
25- 299	402604	741417	ABERDEEN TWP WD MATAWAN TWP 2	ABERDEEN TWP
25- 303	402106	740810	BAMM HOLLOW CC 1	MIDDLETOWN TWP
25- 316	402536	735905	STATE OF NJ SANDY HOOK SP1	MIDDLETOWN TWP
25- 320	402705	735959	NATIONAL PK SER FT HANCOCK 5A	MIDDLETOWN TWP
25- 332	401930	735841	MON BCH CLD STR 1971 DEEP	MONMOUTH BEACH BORO
25- 351	401323	740156	MONMOUTH CON WC WHITESVILLE	NEPTUNE TWP
25- 357	402021	740409	RED BANK WD 3B-1959	RED BANK BORO
25- 358	402047	740420	RED BANK WD 1B-1950	RED BANK BORO
25- 360	402054	740320	RED BANK WD 4-75	RED BANK BORO
25- 407	401005	742939	PUNK BROTHERS DEEP WELL	UPPER FREEHOLD TWP
25- 453	402632	741051	UNION BEACH WD 3 1977	UNION BEACH BORO
25- 456	402640	740904	INT FLAVOR FRAG 3R	UNION BEACH BORO
25- 457	401551	742212	KNOB HILL C C 1-74	MANALAPAN TWP
25- 459	402219	740337	NAVESINK C C 1-78	MIDDLETOWN TWP
25- 465	401107	740356	WALL TWP WD IMPERIAL 3	WALL TWP
25- 466	402610	741351	ABERDEEN TWP WD 3-77	ABERDEEN TWP

Table 3a.--Records of selected wells and test boreholes--continued

[Locations shown on plate 1]

Well number	Location Latitude	Location Longitude	Local identifier[1]	Municipality[1]
25- 467	402436	741013	WEST KEANSBURG WC 5	HOLMDEL TWP
25- 493	401231	741127	HOWELL TWP 1-1975	HOWELL TWP
25- 495	401850	740301	DEPT OF ENERGY TC-40	EATONTOWN BORO
25- 496	402441	740233	ATLANTIC HIGHLAND WD 4	ATL HIGHLANDS BORO
25- 501	401215	740358	MONMOUTH CON WC JUMPING BR 6	NEPTUNE TWP
25- 547	402313	741418	HENRIKSEN 1	MARLBORO TWP
25- 551	401258	741627	FREEHOLD TWP WD 9	FREEHOLD TWP
25- 556	401047	743527	ALLENTOWN WD 1	ALLENTOWN BORO
25- 562	402539	741214	KEYPORT BORO WD - 8 PERRY ST	KEYPORT BORO
25- 564	401918	741530	GORDONS CORNER WC 11	MARLBORO TWP
25- 565	402704	741051	USGS CONASCONK PT.	UNION BEACH BORO
25- 566	401517	741351	USGS OAK RISE DRIVE	FREEHOLD TWP
25- 568	402652	741100	USGS JCPL	UNION BEACH BORO
25- 569	402639	740324	US NAVY EARLE NF-1	MIDDLETOWN TWP
25- 570	402710	740256	US NAVY EARLE NF-2	MIDDLETOWN TWP
25- 571	402601	735916	US NAVY EARLE NF-3	MIDDLETOWN TWP
25- 572	402124	741751	MOLLICA OBS WELL	MARLBORO TWP
25- 634	401520	741712	FREEHOLD RACEWAY	FREEHOLD BORO
25- 635	401105	741202	USGS TEST WELL 1	HOWELL TWP
85- 13	403244	741210	PEOPLE'S PULPIT ASSN (R-42)	RICHMOND COUNTY, NY
85- 14	403103	741401	BEINERTS ICE CO (R-54)	RICHMOND COUNTY, NY
85- 15	403107	741432	ATLANTIC TERRACOTTA CO. R-61	RICHMOND COUNTY, NY
85- 16	403327	740740	DEPT OF WATER SUPPLY, NY (R-63)	RICHMOND COUNTY, NY
85- 17	403108	741408	NASSAU SMELTING (R-70)	RICHMOND COUNTY, NY
85- 18	403130	741204	RARITAN BAY BORING (R-71)	RICHMOND COUNTY, NY
85- 19	403042	741512	CHASSEY (R-72)	RICHMOND COUNTY, NY
85- 25	403441	740316	NEW YORK QUARANTINE STATION (R-82)	RICHMOND COUNTY, NY

[1]Abbreviations:

- ASSN - Association
- ATL - Atlantic
- BORO - Borough
- CO - Company
- CORP - Corporation
- MCUA - Middlesex County Utilities Authority
- MUA - Municipal Utilities Authority
- NJ - New Jersey
- NY - New York
- OBS - Observation well
- TWP - Township
- US - United States
- USGS - U.S. Geological Survey
- WC - Water Company
- WD - Water Department

Table 3b.--Altitudes of tops and bases of hydrogeologic units in wells and test boreholes

[--, no data available; datum is sea level]

Well number	Altitude of land surface (feet)	Log type[1]	Total depth logged (feet)	Englishtown aquifer system	Potomac-Raritan-Magothy aquifer system			
					Upper aquifer		Middle aquifer	
				Base (feet)	Top (feet)	Base (feet)	Top (feet)	Base (feet)
21- 1	125	D	315	63	-117	--	--	--
21- 4	145	D	340	70	-85	-190	--	--
21- 13	120	J	597	88	-82	-212	-278	-446
21- 17	100	D	220	--	32	--	--	--
21- 19	90	J	250	--	--	-48	-138	--
21- 22	100	D	214	--	10	-114	--	--
21- 85	95	DEJ	398	--	-3	-101	-175	-291
21- 96	105	D	200	66	-87	--	--	--
21- 98	120	D	464	60	-110	--	--	--
21- 99	118	DJ	439	62	-92	-199	-258	--
21- 101	135	DJ	498	87	-39	-125	-225	-310
21- 104	120	D	248	82	-100	--	--	--
21- 110	95	D	169	--	-5	-74	--	--
21- 143	140	J	298	87	-50	-120	--	--
21- 145	100	D	235	--	--	0	--	-126
21- 152	70	E	150	--	--	--	50	--
21- 154	90	J	275	--	-22	-68	-148	--
21- 241	100	DJ	122	--	--	--	--	18
23- 11	115	D	290	--	--	--	-140	--
23- 12	100	D	161	--	0	--	--	--
23- 13	100	D	180	--	--	45	7	-65
23- 14	90	J	260	--	40	--	--	--
23- 17	98	D	316	--	--	-42	--	-200
23- 25	120	DJ	410	--	24	-81	-107	-250
23- 30	123	DJ	158	--	43	--	--	--
23- 40	125	DE	261	--	--	45	-75	-111
23- 42	105	DE	270	--	--	45	-89	-121
23- 46	100	D	265	--	--	50	-78	-150
23- 47	95	DE	201	--	--	--	--	-106
23- 50	37	DE	270	--	--	-46	-155	-272
23- 57	122	D	241	--	--	73	-65	--
23- 58	108	DJ	125	--	--	--	28	-16
23- 59	122	DE	220	--	--	72	-42	--
23- 61	120	D	151	--	--	--	20	--
23- 65	114	DJ	160	--	--	--	39	-46
23- 66	120	D	221	--	--	47	-45	--
23- 71	90	D	172	--	--	32	-40	--
23- 72	80	D	150	--	--	--	-17	-50
23- 77	6	D	74	--	--	--	-19	-44
23- 79	5	D	69	--	--	-30	--	-48

Table 3b.--<u>Altitudes of tops and bases of hydrogeologic units in wells and test boreholes</u>--continued

[--, no data available; datum is sea level]

Well number	Altitude of land surface (feet)	Log type[1]	Total depth logged (feet)	Englishtown aquifer system	Potomac-Raritan-Magothy aquifer system			
					Upper aquifer		Middle aquifer	
				Base (feet)	Top (feet)	Base (feet)	Top (feet)	Base (feet)
23- 82	40	D	109	--	--	--	--	28
23- 94	60	D	206	--	--	-23	--	--
23- 97	39	D	320	--	--	-44	-141	--
23- 100	45	D	142	--	--	-84	--	--
23- 107	28	DJ	365	--	-28	-81	--	-317
23- 114	26	DJ	325	--	--	-74	-182	--
23- 127	12	D	312	--	--	-65	--	--
23- 131	24	D	87	--	--	-56	--	--
23- 132	25	DJ	347	--	--	-75	-215	-320
23- 133	30	DE	379	--	-10	-100	-230	-344
23- 146	80	D	481	--	-88	-154	--	--
23- 154	15	D	335	--	--	-60	-192	-284
23- 170	60	D	337	--	--	-17	-141	-244
23- 171	20	D	317	--	--	-55	-191	-284
23- 176	45	D	456	--	-59	-140	-261	-365
23- 179	10	DE	332	--	--	-80	-204	-291
23- 191	115	D	227	--	-75	--	--	--
23- 194	18	DJ	291	--	--	-46	-172	-263
23- 201	15	D	332	--	-20	-95	-223	--
23- 202	11	D	324	--	-56	-146	-277	--
23- 206	60	D	397	--	--	-150	-295	--
23- 219	167	J	312	147	7	--	--	--
23- 230	155	D	204	--	6	--	--	--
23- 231	157	D	196	--	7	--	--	--
23- 232	130	D	357	--	--	-42	-109	-198
23- 236	95	DE	525	--	-75	-153	-275	-400
23- 238	145	D	367	--	--	-69	-120	--
23- 241	80	D	106	--	-20	--	--	--
23- 244	60	D	158	--	-88	--	--	--
23- 245	55	D	163	--	-42	--	--	--
23- 255	15	D	76	--	--	--	-21	-54
23- 260	20	D	420	--	--	--	-58	-78
23- 265	14	DJ	94	--	--	--	-36	--
23- 273	76	D	80	--	--	--	--	-2
23- 291	107	DJ	212	--	--	47	-32	-105
23- 293	115	D	246	--	--	7	-74	-127
23- 297	115	D	207	--	--	32	-53	--
23- 300	130	DJ	301	--	--	-6	-80	-168
23- 302	115	D	210	--	--	43	-31	-85
23- 306	120	D	207	--	--	0	-54	--

Table 3b.--Altitudes of tops and bases of hydrogeologic units in wells and test boreholes--continued

[--, no data available; datum is sea level]

Well number	Altitude of land surface (feet)	Log type[1]	Total depth logged (feet)	Englishtown aquifer system	Potomac-Raritan-Magothy aquifer system			
					Upper aquifer		Middle aquifer	
				Base (feet)	Top (feet)	Base (feet)	Top (feet)	Base (feet)
23- 315	102	D	142	--	--	--	10	-36
23- 319	93	D	138	--	--	--	-13	--
23- 322	122	D	118	--	--	--	114	6
23- 327	85	D	41	--	--	--	--	46
23- 332	105	D	240	--	--	25	-65	-103
23- 352	34	E	298	--	14	-58	-161	-252
23- 365	6	DJ	198	--	--	-9	-109	--
23- 369	45	E	115	--	35	-55	--	--
23- 370	20	D	206	--	--	--	-139	--
23- 376	41	D	241	--	--	--	-132	-186
23- 377	40	D	254	--	--	-14	--	-194
23- 379	30	D	218	--	--	--	-70	-168
23- 386	102	D	370	--	--	-21	-144	-216
23- 391	47	D	235	--	--	22	-93	-178
23- 395	36	D	176	--	--	24	-91	--
23- 396	8	D	107	--	--	--	-64	-96
23- 397	70	D	211	--	--	--	-78	-141
23- 404	23	DE	313	--	-25	-90	-178	-267
23- 409	95	D	229	--	--	20	-100	-134
23- 411	10	D	241	--	--	--	-181	-222
23- 421	118	D	334	--	21	-4	-122	-164
23- 424	16	D	129	--	--	-2	-84	-99
23- 430	12	DEJ	230	--	--	-36	-116	-155
23- 438	20	DE	203	--	--	-2	-100	-165
23- 439	21	DEJ	181	--	--	--	-81	-124
23- 442	30	D	89	--	--	-48	--	--
23- 445	12	DEJ	328	--	--	-68	-184	--
23- 462	15	D	73	--	--	--	5	-47
23- 479	15	D	80	--	--	--	--	-60
23- 501	100	DJ	178	--	--	70	-50	--
23- 503	140	D	440	123	-75	-160	--	--
23- 504	141	D	365	--	--	-45	--	-199
23- 505	90	D	82	--	--	61	--	--
23- 506	120	D	255	--	--	--	-70	-105
23- 510	119	D	68	--	--	--	--	57
23- 538	130	J	144	--	--	9	--	--
23- 541	17	J	36	--	--	--	5	--
23- 553	125	DEJ	464	--	12	-97	-136	-300
23- 573	150	D	120	--	--	--	57	--
23- 574	100	D	140	--	-23	--	--	--

Table 3b.--Altitudes of tops and bases of hydrogeologic units in wells and test boreholes--continued

[--, no data available; datum is sea level]

Well number	Altitude of land surface (feet)	Log type[1]	Total depth logged (feet)	Englishtown aquifer system	Potomac-Raritan-Magothy aquifer system			
					Upper aquifer		Middle aquifer	
				Base (feet)	Top (feet)	Base (feet)	Top (feet)	Base (feet)
23- 576	30	D	165	--	--	7	-105	-123
23- 577	7	D	61	--	--	--	--	-52
23- 578	5	D	76	--	--	--	--	-59
23- 580	20	D	85	--	--	-45	--	--
23- 582	15	D	85	--	--	-43	--	--
23- 584	125	D	240	70	--	--	--	--
23- 585	120	D	248	--	--	9	-93	--
23- 587	90	D	185	--	-70	--	--	--
23- 590	90	D	126	--	--	4	--	--
23- 595	105	D	298	91	-119	-187	--	--
23- 598	132	E	235	--	--	12	-82	--
23- 610	86	DJ	85	--	--	42	--	--
23- 612	114	DJ	115	--	--	14	--	--
23- 613	33	J	100	--	--	-43	--	--
23- 619	112	DJ	130	--	--	-8	--	--
23- 623	105	DJ	149	--	--	-13	--	--
23- 626	41	DJ	57	--	--	-22	--	--
23- 759	120	D	274	--	-130	--	--	--
23- 764	40	D	140	--	-80	--	--	--
23- 766	80	D	180	--	-70	--	--	--
23- 769	120	D	280	55	-145	--	--	--
23- 770	140	D	325	49	-175	--	--	--
23- 771	110	D	330	55	-140	--	--	--
23- 772	145	D	151	--	5	--	--	--
23- 774	110	D	215	87	-75	--	--	--
23- 778	100	D	130	--	--	50	-5	--
23- 779	120	D	120	--	14	--	--	--
23- 781	60	D	235	--	-128	--	--	--
23- 783	90	D	265	30	-160	--	--	--
23- 784	30	D	70	--	-30	--	--	--
23- 787	100	D	120	--	--	57	12	-10
23- 790	75	DEJ	147	--	--	50	-45	--
23- 791	80	DEJ	150	--	--	--	--	-6
23- 816	0	D	50	--	--	--	-46	--
23- 817	0	D	75	--	--	--	-31	--
23- 818	0	D	60	--	--	--	--	-56
23- 827	0	D	49	--	--	--	-41	-48
23- 836	0	D	47	--	--	--	--	--
23- 846	8	D	64	--	--	--	-15	-44
23- 848	0	D	67	--	--	--	-50	-60

Table 3b.--Altitudes of tops and bases of hydrogeologic units in wells and test boreholes--continued

[--, no data available; datum is sea level]

Well number	Altitude of land surface (feet)	Log type[1]	Total depth logged (feet)	Englishtown aquifer system	Potomac-Raritan-Magothy aquifer system			
					Upper aquifer		Middle aquifer	
				Base (feet)	Top (feet)	Base (feet)	Top (feet)	Base (feet)
23- 850	5	D	82	--	--	--	-56	-62
23- 858	7	D	56	--	--	--	-17	-22
23- 859	7	D	56	--	--	--	-39	-43
23- 944	4	D	42	--	--	--	-1	-26
23- 963	7	D	30	--	--	--	--	-10
23- 969	9	D	33	--	--	--	--	-10
23- 971	6	D	28	--	--	--	--	-8
23- 995	2	D	80	--	--	--	-45	-53
23-1011	6	D	63	--	--	--	--	--
23-1012	22	D	74	--	--	--	--	--
23-1013	35	D	163	--	--	--	-60	--
23-1016	88	D	292	--	--	-14	-129	-191
23-1017	0	D	976	--	--	--	--	--
23-1021	15	D	91	--	--	--	--	--
23-1024	25	D	122	--	--	--	--	--
23-1025	10	D	126	--	--	--	--	--
23-1027	8	D	99	--	--	--	--	--
23-1029	18	D	109	--	--	--	--	--
23-1031	18	D	121	--	--	--	--	--
23-1033	18	D	111	--	--	--	--	--
23-1034	18	D	114	--	--	--	--	--
23-1037	54	D	136	--	--	--	-28	--
23-1038	66	D	113	--	--	--	-14	-36
23-1039	53	D	116	--	--	--	-35	-59
23-1058	25	DJ	173	--	--	--	-65	-135
25- 13	29	DEJ	1302	-627	-956	-1167	--	--
25- 34	135	J	837	-295	-505	--	--	--
25- 37	137	DJ	707	-235	-425	--	--	--
25- 39	102	D	719	-293	-588	--	--	--
25- 45	66	D	680	-234	--	--	--	--
25- 53	70	DE	891	-386	-671	-800	--	--
25- 55	70	EJ	598	12	-204	-311	-461	--
25- 82	130	DE	743	-184	-392	--	--	--
25- 85	120	DE	707	-190	-433	-587	--	--
25- 97	195	DEJ	682	-161	-355	--	--	--
25- 103	107	DEJ	887	-97	-315	-483	-593	-690
25- 111	59	D	513	-11	--	-350	--	--
25- 119	15	DEJ	901	-240	-609	-761	-850	--
25- 145	229	D	1045	-42	-283	-369	-610	-727
25- 146	280	D	585	0	--	--	--	--

Table 3b.--Altitudes of tops and bases of hydrogeologic units in wells and test boreholes--continued

[--, no data available; datum is sea level]

Well number	Altitude of land surface (feet)	Log type[1]	Total depth logged (feet)	Englishtown aquifer system	Potomac-Raritan-Magothy aquifer system			
					Upper aquifer		Middle aquifer	
				Base (feet)	Top (feet)	Base (feet)	Top (feet)	Base (feet)
25- 153	65	DE	672	-25	-321	-391	-567	-625
25- 156	60	DJ	788	-52	-330	-410	--	--
25- 174	102	DEJ	839	-262	-506	-658	--	--
25- 194	10	D	357	--	-285	--	--	--
25- 196	12	D	394	--	-294	--	--	--
25- 197	35	DJ	414	--	-205	-290	--	--
25- 201	20	D	282	--	-210	--	--	--
25- 203	11	J	270	--	-193	--	--	--
25- 210	10	DE	1001	-510	-755	-980	--	--
25- 214	190	EJ	753	-90	-318	-456	--	--
25- 218	250	DJ	530	-18	-194	--	--	--
25- 220	120	DJ	569	-118	-300	--	--	--
25- 228	146	EJ	815	-74	-294	-422	-534	--
25- 231	125	DEJ	759	13	-193	-298	-437	-590
25- 249	143	E	828	-31	-245	-325	-521	-667
25- 251	128	EJ	620	-83	-343	--	--	--
25- 259	155	D	616	-49	--	-441	--	--
25- 262	140	DEJ	875	-45	-280	-410	-570	-690
25- 268	114	DEJ	771	-2	-211	-352	-481	--
25- 272	117	DEJ	700	0	-213	-355	-472	--
25- 282	10	D	285	--	-153	--	--	--
25- 284	90	D	457	--	-130	-183	-330	--
25- 292	87	DE	733	37	-223	-323	-543	-613
25- 294	20	D	282	--	-184	-239	--	--
25- 299	60	DE	491	--	-100	-206	-364	-397
25- 303	70	DE	726	-170	-426	-602	--	--
25- 316	11	EJ	438	-204	--	--	--	--
25- 320	14	J	878	-102	-394	-535	-715	-851
25- 332	10	DJ	852	-414	-720	--	--	--
25- 351	18	J	777	-562	--	--	--	--
25- 357	35	D	305	-260	--	--	--	--
25- 358	40	D	702	-236	-456	-655	--	--
25- 360	146	EJ	805	-258	-458	-624	--	--
25- 407	129	DJ	951	-99	-287	-375	-457	-501
25- 453	10	DEJ	579	--	-218	-294	-452	-528
25- 456	10	DE	345	--	-203	-312	--	--
25- 457	108	EJ	710	-60	-222	-388	-542	--
25- 459	80	DEJ	761	-210	-470	--	--	--
25- 465	65	EJ	694	-579	--	--	--	--
25- 466	56	DEJ	502	--	--	--	-369	-417

Table 3b.--Altitudes of tops and bases of hydrogeologic units in wells and test boreholes--continued

[--, no data available; datum is sea level]

Well number	Altitude of land surface (feet)	Log type[1]	Total depth logged (feet)	Englishtown aquifer system	Potomac-Raritan-Magothy aquifer system			
					Upper aquifer		Middle aquifer	
				Base (feet)	Top (feet)	Base (feet)	Top (feet)	Base (feet)
25- 467	70	DE	692	-25	-313	-400	-580	--
25- 493	130	EJ	843	-422	-620	--	--	--
25- 495	10	J	1003	-327	-543	-765	-867	-967
25- 496	15	DEJ	660	-130	-415	-598	--	--
25- 501	30	DEJ	1090	-560	-810	-1046	--	--
25- 547	100	D	265	20	--	--	--	--
25- 551	105	DEJ	746	-206	-457	-607	--	--
25- 556	80	D	305	--	-110	-195	--	--
25- 562	30	D	560	--	--	--	-465	-524
25- 564	120	D	666	--	-325	-462	--	--
25- 565	10	DJ	555	--	-180	-265	-460	-541
25- 566	200	DJ	1320	-215	-450	-616	--	--
25- 568	10	DJ	283	--	-180	-266	--	--
25- 569	10	D	127	-62	--	--	--	--
25- 570	10	D	112	-72	--	--	--	--
25- 571	6	D	206	-190	--	--	--	--
25- 572	80	D	300	--	-170	--	--	--
25- 634	170	D	920	-145	-365	-526	-670	--
25- 635	110	DEJ	1670	-410	-646	-830	-924	-1024
85- 13	150	D	360	--	--	--	26	-37
85- 14	20	D	228	--	--	-33	--	--
85- 15	5	D	163	--	--	-68	-125	--
85- 16	10	D	319	--	--	--	-90	--
85- 17	15	D	353	--	--	-69	--	-235
85- 18	30	D	147	--	--	--	-94	--
85- 19	20	D	173	--	--	-50	-130	--
85- 25	5	D	1000	--	--	--	--	-445

[1] D - drillers' log
E - electric log
J - gamma-ray log