HYDROGEOLOGIC FRAMEWORK OF THE NEW JERSEY COASTAL PLAIN

REGIONAL AQUIFER-SYSTEM ANALYSIS

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Hydrogeologic Framework of the New Jersey Coastal Plain

By OTTO S. ZAPECZA

REGIONAL AQUIFER-SYSTEM ANALYSIS—
NORTHERN ATLANTIC COASTAL PLAIN

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FOREWORD

THE REGIONAL AQUIFER-SYSTEM ANALYSIS PROGRAM

The Regional Aquifer-System Analysis (RASA) Program was started in 1978 following a congressional mandate to develop quantitative appraisals of the major ground-water systems of the United States. The RASA Program represents a systematic effort to study a number of the Nation's most important aquifer systems, which in aggregate underlie much of the country and which represent an important component of the Nation's total water supply. In general, the boundaries of these studies are identified by the hydrologic extent of each system and accordingly transcend the political subdivisions to which investigations have often arbitrarily been limited in the past. The broad objective for each study is to assemble geologic, hydrologic, and geochemical information, to analyze and develop an understanding of the system, and to develop predictive capabilities that will contribute to the effective management of the system. The use of computer simulation is an important element of the RASA studies, both to develop an understanding of the natural, undisturbed hydrologic system and the changes brought about in it by human activities, and to provide a means of predicting the regional effects of future pumping or other stresses.

The final interpretive results of the RASA Program are presented in a series of U.S. Geological Survey Professional Papers that describe the geology, hydrology, and geochemistry of each regional aquifer system. Each study within the RASA Program is assigned a single Professional Paper number, and where the volume of interpretive material warrants, separate topical chapters that consider the principal elements of the investigation may be published. The series of RASA interpretive reports begins with Professional Paper 1400 and thereafter will continue in numerical sequence as the interpretive products of subsequent studies become available.

Dallas L. Peck
Director

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CONVERSION FACTORS

Factors for converting inch-pound units to the International System (SI) units are given below:

Multiply	*By*	*To obtain*
ft (feet)	0.3048	m (meter)
mi (mile)	1.609	km (kilometer)
mi^2 (square mile)	2.590	km^2 (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 "Mean Sea Level Datum of 1929."

REGIONAL AQUIFER-SYSTEM ANALYSIS

HYDROGEOLOGIC FRAMEWORK OF THE NEW JERSEY COASTAL PLAIN

By OTTO S. ZAPECZA

ABSTRACT

This report presents the results of a water-resources-oriented subsurface mapping program within the Coastal Plain of New Jersey. The occurrence and configuration of 15 regional hydrogeologic units have been defined, primarily on the basis of an interpretation of borehole geophysical data. The nine aquifers and six confining beds are composed of unconsolidated clay, silt, sand, and gravel and range in age from Cretaceous to Quaternary.

Electric and gamma-ray logs from more than 1,000 Coastal Plain wells were examined. Of these, interpretive data for 302 sites were selected, on the basis of logged depth, quality of data, and data distribution, to prepare structure contour and thickness maps for each aquifer and a thickness map for each confining bed. These maps, together with 14 hydrogeologic sections, show the geometry, lateral extent, and vertical and horizontal relationships among the 15 hydrogeologic units.

The hydrogeologic maps and sections show that distinct lower, middle, and upper aquifers are present within the Potomac-Raritan-Magothy aquifer system near the Delaware River from Burlington County to Salem County. Although the lower aquifer is recognized only in this area, the middle aquifer extends into the northeastern Coastal Plain of New Jersey, where it is stratigraphically equivalent to the Farrington aquifer. The upper aquifer extends throughout most of the New Jersey Coastal Plain and is stratigraphically equivalent to the Old Bridge aquifer in the northeastern Coastal Plain. The overlying Merchantville-Woodbury confining bed is the most regionally extensive confining bed within the New Jersey Coastal Plain. Its thickness ranges from less than 100 feet near the outcrop to more than 450 feet along the coast. The Englishtown aquifer system acts as a single aquifer throughout most of its subsurface extent, but it contains two water-bearing sands in parts of Monmouth and Ocean Counties. The overlying Marshalltown-Wenonah confining bed is a thin, leaky unit ranging in thickness from approximately 20 to 80 feet. The Wenonah-Mount Laurel aquifer is identified in the subsurface throughout the New Jersey Coastal Plain southeast of its outcrop area.

Sediments that overlie the Wenonah-Mount Laurel aquifer and that are subjacent to the major aquifers within the Kirkwood Formation and the Cohansey Sand are described hydrologically as a composite confining bed. These include the Navesink Formation, Red Bank Sand, Tinton Sand, Hornerstown Sand, Vincentown Formation, Manasquan Formation, Shark River Formation, and Piney Point Formation and the basal clay of the Kirkwood Formation. The Vincentown Formation functions as an aquifer within 3 to 10 miles downdip of its outcrop area. In areas farther downdip the Vincentown Formation functions as a confining bed. The Piney Point aquifer is laterally persistent from the southern New Jersey Coastal Plain northward into parts of Burlington and Ocean Counties. The Atlantic City 800-foot sand of the Kirkwood Formation can be recognized in the subsurface along coastal areas of Cape May, Atlantic, and southern Ocean Counties, but inland only as far west as the extent of the overlying confining bed. In areas west of the extent of the overlying confining bed, the Kirkwood Formation is in hydraulic connection with the overlying Cohansey Sand and younger surficial deposits and functions as an unconfined aquifer.

INTRODUCTION

PURPOSE AND SCOPE

This report is a product of an intensive study of New Jersey Coastal Plain borehole geophysical data made, in part, to develop a hydrogeologic framework for use in the U.S. Geological Survey's northern Atlantic Coastal Plain Regional Aquifer-System Analysis (RASA) project. A 10-layer ground-water flow model of the New Jersey Coastal Plain aquifer system was constructed on the basis of the information presented in this report. The same information forms part of the basis of the hydrogeologic framework for a 10-layer regional flow model of the northern Atlantic Coastal Plain from Long Island to North Carolina. Correlation of stratigraphic units in the various states of the northern Atlantic Coastal Plain is shown in table 1.

The purpose of this report is to define, on a regional basis, the subsurface occurrence and configuration of hydrogeologic units (aquifers and confining beds) in the New Jersey part of the Atlantic Coastal Plain. This multilayer system is shown in a series of structure contour maps, isopach maps, and hydrogeologic sections based primarily on interpretation of geophysical logs. Past efforts to understand the hydrology of the Coastal Plain's ground-water resources have been limited by the lack of a regional hydrogeologic framework. Documentation of the occurrence and geometry of the major

TABLE 1.—*Generalized stratigraphic correlation chart of the northern Atlantic Coastal Plain*

ERA	SYSTEM	SERIES	NORTH CAROLINA	VIRGINIA	MARYLAND	DELAWARE	NEW JERSEY	NEW YORK
Cenozoic	Quaternary	Pleistocene	Unnamed	Undifferentiated deposits	Undifferentiated deposits	Undifferentiated deposits	Cape May Formation Undifferentiated deposits	Upper Pleistocene deposits Gardners Clay Jameco Gravel
	Tertiary	Pliocene	Chowan River Formation Yorktown Formation	Chesapeake Group: Chowan River Formation Yorktown Formation	Chesapeake Group: Yorktown Formation	Undifferentiated deposits		Mannetto Gravel (Pliocene?)
		Miocene	Pungo River Formation Belgrade Formation	Chesapeake Group: Eastover Formation St. Marys Formation Choptank Formation Calvert Formation	Chesapeake Group: Eastover Formation / Brandywine Formation St. Marys Formation Choptank Formation Calvert Formation	Chesapeake Group undivided	Pensauken Formation Bridgeton Formation Cohansey Sand Kirkwood Formation	
		Oligocene	River Bend Formation	Unnamed				
		Eocene	Castle Hayne Formation	Chickahominy Formation Piney Point Formation Nanjemoy Formation	Piney Point Formation Nanjemoy Formation	Piney Point Formation Nanjemoy Formation	Piney Point Formation Shark River Formation Rancocas Group: Manasquan Formation	
		Paleocene	Beaufort Formation	Marlboro Clay Aquia Formation Brightseat Formation	Aquia Formation Brightseat Formation	Rancocas Group: Vincentown Formation Hornerstown Formation	Rancocas Group: Vincentown Formation Hornerstown Sand	
Mesozoic	Cretaceous	Upper Cretaceous	Peedee Formation Black Creek Formation Middendorf Formation Cape Fear Formation	Mattaponi Formation	Severn Formation Matawan Formation Magothy Formation	Severn Formation Mount Laurel Sand Marshalltown Formation Englishtown Formation Woodbury Clay Merchantville Formation Magothy Formation	Monmouth Group: Tinton Sand Red Bank Sand Navesink Formation Mount Laurel Sand Matawan Group: Wenonah Formation Marshalltown Formation Englishtown Formation Woodbury Clay Merchantville Formation Magothy Formation Raritan Formation	Monmouth Group Matawan Group Magothy Formation Raritan Formation: Clay member; Lloyd Sand member
		Lower Cretaceous	Unnamed	Potomac Group: Patapsco Formation Patuxent Formation	Potomac Group: Patapsco Formation Arundel Formation Patuxent Formation	Potomac Formation	Potomac Group	
	Jurassic (?)	Upper Jurassic (?)	Unnamed					

Modified from Meisler, 1980, fig. 4.

aquifers and confining beds provides a firmer basis for more realistic water-management decisions.

LOCATION AND EXTENT

The New Jersey Coastal Plain extends from Delaware Bay in the southwest to Raritan Bay in the northeast, and from the Fall Line in the west to the Atlantic Ocean in the east (fig. 1). It is approximately 4,200 mi^2 and is part of the larger Atlantic Coastal Plain that extends from Florida to Newfoundland and eastward to the edge of the Continental Shelf. The area of study includes all of Monmouth, Burlington, Ocean, Camden, Gloucester, Salem, Atlantic, Cumberland, and Cape May Counties and parts of Middlesex and Mercer Counties.

PREVIOUS INVESTIGATIONS

Subsurface stratigraphic relationships within the New Jersey Coastal Plain have been documented in a number of previous studies. Richards (1945) presented a series of geologic cross sections outlining the subsurface stratigraphy of the Atlantic Coastal Plain. Richards and others (1962) produced generalized structure contour maps of geologic units of the New Jersey Coastal Plain. Detailed Cretaceous subsurface stratigraphy has been delineated by Perry and others (1975) and by Petters (1976). Brown, Miller, and Swain (1972) presented structure contour maps, geohydrologic maps, and cross sections for 17 chronostratigraphic units in the Coastal Plain from North Carolina to New York.

Numerous county ground-water reports contain subsurface information, including contour maps and cross sections for local hydrogeologic systems. These include reports for Monmouth County (Jablonski, 1968), Ocean County (Anderson and Appel, 1969), Burlington County (Rush, 1968), Camden County (Farlekas and others, 1976), Gloucester County (Hardt and Hilton, 1969), Salem County (Rosenau and others, 1969), and Cape May County (Gill, 1962).

Structure contour maps for the pre-Cretaceous basement, the Potomac–Raritan–Magothy aquifer system, and the Merchantville–Woodbury confining bed were presented by Gill and Farlekas (1976). Previously mapped hydrogeologic units in the northern part of the New Jersey Coastal Plain include the Farrington aquifer (Farlekas, 1979), the Englishtown aquifer (Nichols, 1977b), and the Wenonah–Mount Laurel aquifer (Nemickas, 1976). Nemickas and Carswell (1976) presented stratigraphic and hydrogeologic data for the Piney Point aquifer in the southern Coastal Plain of New Jersey.

WELL-NUMBERING SYSTEM

The well-numbering system on the index map, tables, and hydrogeologic sections in this report is based on the numbering system used by the U.S. Geological Survey in New Jersey since 1978. The well number consists of a county code number and a sequence number assigned to the well within the county. Code numbers for the New Jersey Coastal Plain counties are:

1	Atlantic	21	Mercer
5	Burlington	23	Middlesex
7	Camden	25	Monmouth
9	Cape May	29	Ocean
11	Cumberland	33	Salem
15	Gloucester		

A representative well number is 15-137, designating the 137th well inventoried in Gloucester County.

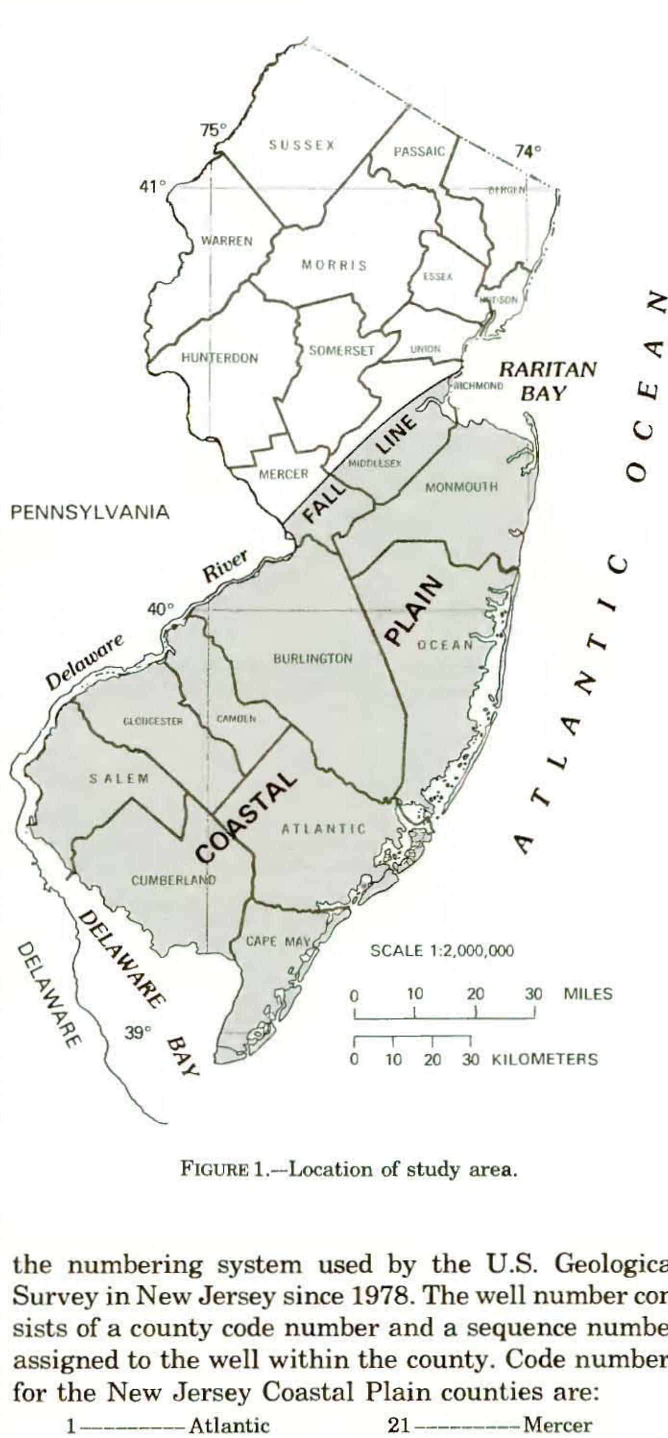

FIGURE 1.—Location of study area.

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TABLE 2.—*Geologic and hydrogeologic units in the New Jersey Coastal Plain*

SYSTEM	SERIES	GEOLOGIC UNIT	LITHOLOGY	HYDROGEOLOGIC UNIT	HYDROLOGIC CHARACTERISTICS
Quaternary	Holocene	Alluvial deposits	Sand, silt, and black mud	Undifferentiated	Surfical material, often hydraulically connected to underlying aquifers. Locally some units may act as confining beds. 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 a confined aquifer
		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 bed	Thick diatomaceous clay bed occurs along coast and for a short distance inland. A thin water-bearing sand occurs within the middle of this unit
				Rio Grande w-b[1,2]	
				Confining bed[2]	
				Atlantic City 800-foot sand	A major aquifer along the coast
				Composite confining bed	Alloway Clay Member or equivalent
	Eocene	Piney Point Formation	Sand, quartz and glauconite, fine- to coarse-grained	Piney Point aquifer	Yields moderate quantities of water locally
		Shark River Formation	Clay, silty and sandy, glauconitic, green, gray, and brown, fined-grained quartz sand		Poorly permeable sediments
		Manasquan Formation			
	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[2]	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 Formation	Clay, silty, dark greenish-gray, glauconitic quartz sand	Marshalltown-Wenonah confining bed	A leaky confining bed
		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 bed	A major confining bed. Locally the Merchantville Fm. 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	Potomac-Raritan-Magothy aquifer: 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 the equivalent of 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	Conf. bed	
				Middle aquifer	
	Lower Cretaceous	Potomac Group	Alternating clay, silt, sand, and gravel	Conf. bed	
				Lower aquifer	
Pre-Cretaceous		Bedrock	Precambrian and lower Paleozoic crystalline rocks, metamorphic schist and gneiss; locally Triassic basalt, sandstone, and shale and Jurassic diabase	Bedrock confining bed	No wells obtain water from these consolidated rocks, except along the Fall Line

[1] Rio Grande water-bearing zone
[2] Minor aquifer not mapped in this report.

Modified from Seaber, 1965, table 3

well-drilling contractors for providing borehole information, including geophysical logs, drillers logs, and well records.

SUMMARY OF NEW JERSEY COASTAL PLAIN GEOLOGY

STRUCTURAL SETTING

The New Jersey Coastal Plain is a seaward-dipping wedge of unconsolidated sediments that range in age from Cretaceous to Holocene (table 2). These sediments, for the most part, are composed of clay, silt, sand, and gravel and are classified as continental, coastal, or marine-type deposits. The Cretaceous and Tertiary sediments generally strike northeast–southwest and dip gently to the southeast 10 to 60 ft/mi. Overlying deposits of Quaternary age, where present, are essentially flat-lying. The Coastal Plain deposits thicken seaward from a featheredge at the Fall Line to more than 6,500 ft at the southern tip of Cape May County (Gill and Farlekas, 1976).

The initial deposition of Coastal Plain sediments began during the Late Jurassic or Early Cretaceous after formation of the early Atlantic Ocean (Sheridan, 1974b, p. 465). During the Mesozoic and Cenozoic Eras, block-faulting of the basement created highs and lows on the basement surface along the Atlantic continental margin (Sheridan, 1974b, p. 401). These basement highs and lows had a direct influence on sediment accumulation and dispersal patterns (Owens and Sohl, 1969, p. 237). Three basement structural elements recognized in the New Jersey Coastal Plain are the Raritan embayment, the South New Jersey uplift, and the Salisbury embayment (pl. 1). Individual units generally are thicker in the embayment areas, and depositional facies changes are common between adjacent tectonic features (Olsson, 1978, p. 941).

The pre-Cretaceous basement-bedrock complex that lies unconformably beneath the unconsolidated Coastal Plain deposits consists mainly of Precambrian and lower Paleozoic rocks. Locally, along the Fall Line (fig. 1) in Mercer and Middlesex Counties, Triassic and Jurassic rocks underlie the unconsolidated sediments. The altitude of the top of the bedrock surface is shown on plate 1. Contours showing the basement surface in areas where the depth to bedrock is 1,000 ft or less are based primarily on well and test hole data, whereas in downdip areas the primary control is based on seismic data (Gill and Farlekas, 1976).

DEPOSITIONAL HISTORY

The oldest group of sediments deposited on the basement surface within the New Jersey Coastal Plain consists of Cretaceous continental deposits of the Potomac Group (table 2). This unit consists of alternating clay, silt, sand, and gravel and is a major part of the thick sedimentary wedge in the Salisbury embayment area of extreme southern New Jersey. The overlying Raritan Formation consists of fluvial-continental deposits in outcrop and in the shallow subsurface that are lithologically similar to the Potomac Group sediments. However, in downdip areas near the coast, glauconite and shell beds indicate that the Raritan Formation is mostly marine (Richards, 1961, p. 1755; Petters, 1976, p. 92). The Magothy Formation unconformably overlies the Raritan Formation and is a sheetlike deposit composed primarily of coarse beach sand and other associated near-shore marine deposits (Perry and others, 1975, p. 1535).

Upper Cretaceous sediments and most Tertiary sediments overlying the Magothy Formation were deposited in various shelf and beach environments created by alternating transgressive and regressive seas. Glauconite is common in this part of the geologic section and is indicative of mid- to outer-shelf deposition (Owens and Sohl, 1969, p. 259). Silty and clayey glauconitic sands are generally considered to form in marine environments characterized by slow rates of clastic sedimentation (Owens and Sohl, 1973, p. 2833). According to Olsson (1975, p. 17), much of the glauconite originated from the fecal pellets of mud-burrowing organisms and formed in the mud substrates of these deeper offshore areas.

Heavy concentrations of glauconite in association with very fine grained sediments are recognized in the New Jersey Coastal Plain as transgressive deposits laid down during major incursions of the sea. Such units include the Merchantville, Marshalltown, and Navesink Formations, the Hornerstown Sand, and the Manasquan Formation. In contrast, coarsening-upward sequences that overlie the major glauconitic units are termed regressive beds. These beds were deposited in inner-shelf, near-shore, and beach areas during the slow retreat of the sea. Such units include the Englishtown Formation, Wenonah Formation, Mount Laurel Sand, Red Bank Sand, Vincentown Formation, Kirkwood Formation, and Cohansey Sand. Generally, transgressive deposits form confining beds within the Coastal Plain and regressive deposits form aquifers.

The long period of marine deposition in the study area ended after the deposition of the Miocene Cohansey Sand (Carter, 1978, p. 934). Continental deposition returned to the Coastal Plain during late Tertiary and Quaternary times. The Beacon Hill Gravel, and the Bridgeton, Pensauken, and Cape May Formations are primarily composed of fluvial sands and gravels (Owens and Minard, 1979, p. D1).

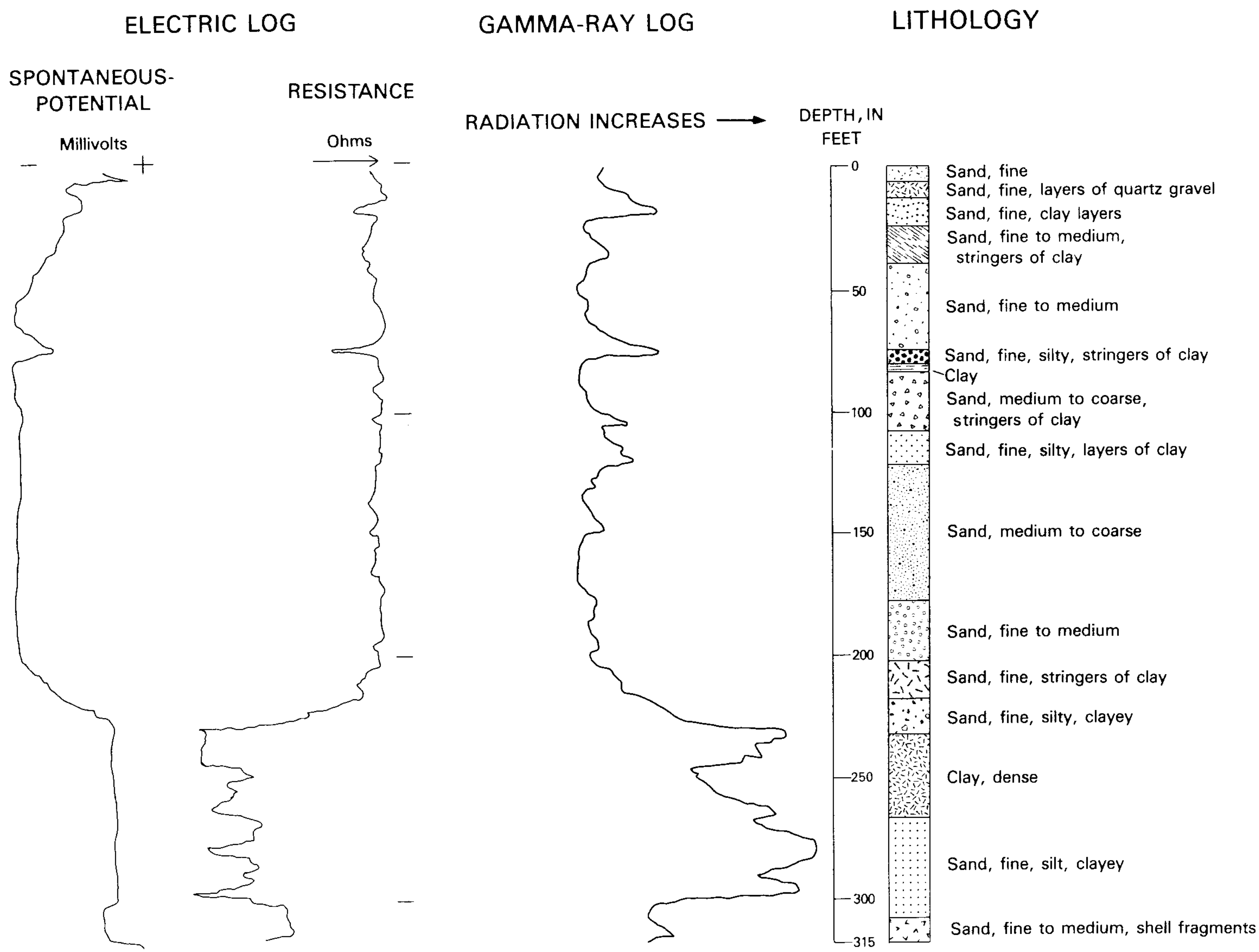

FIGURE 2.—Response of electric and gamma-ray logs to lithology.

HYDROGEOLOGIC FRAMEWORK

CORRELATION METHODS

Most regional subsurface mapping in the New Jersey Coastal Plain has been based on formal geologic (rock-stratigraphic) and chronologic (time-stratigraphic) units that have been defined by lithologic and biostratigraphic correlations from well samples. Definition of the regional hydrogeologic framework is necessary because, in many cases, hydrogeologic-unit boundaries differ from formal stratigraphic boundaries. For example, a geologic formation may contain more than one aquifer, a formation may function as an aquifer in one area and as a confining bed in another, or an aquifer or a confining bed may be composed of several geologic formations.

Geophysical data for more than 1,000 sites were reviewed. Of these, 302 sites were selected for inclusion in the framework on the basis of their location and the quality and pertinence of their associated geophysical data. Subsurface correlations are based primarily on interpretation of electric and gamma-ray logs. Distinctive signatures or patterns on electric and gamma-ray logs were found to mark contacts between aquifers and confining beds more reliably than drillers' logs or geologists' descriptions of drill cuttings.

LOG INTERPRETATION

The response of electric and gamma-ray logs to lithology is illustrated in figure 2. The electric logs used in this report are dual-track logs that include the spontaneous-potential (SP) curve on the left-hand track and a conventional single-point resistance curve on the right-hand track. The electric log is obtained by lowering an electrode into a fluid-filled uncased borehole and simultaneously recording the corresponding electrical measurements at the surface.

The spontaneous-potential curve is a record of depth versus small changes in voltage, measured in millivolts, 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 negative deflections to the left and clays cause positive deflections to the right. However, if the borehole mud is more saline than the formation water, reversals of the spontaneous-potential curve can occur, causing negative deflections opposite the clay beds and positive deflections opposite the sands.

The single-point resistance curve is a record of depth versus electrical resistance, measured in ohms, of formation materials penetrated by the borehole (Keys and McCary, 1971, p. 35). It is directly related to the quality, quantity, and distribution of formation water (Guyod, 1957, p. 2). Sand and gravel are generally more resistant to the flow of electric current and cause sharp deflections to the right on the electric log. In contrast, silt and clay are less resistant materials and cause deflections to the left. The electric log is strongly affected by brackish water and saltwater in the formations. Salinity decreases the electrical resistance of the formation and causes baseline deflections to the left on the single-point resistance curve. However, the salty aquifer can generally be determined by sharp negative-potential deflections on the spontaneous-potential log. Another extraneous factor that can affect the signature on electric logs is a change in borehole diameter, which can be caused by drilling, caving, or mud-cake buildup on the borehole wall.

Gamma-ray logs are graphical plots of the rate of emission of gamma rays emitted by the formations penetrated by the borehole. Unlike the electric log, the gamma-ray log can be obtained in a cased hole, without borehole fluid, and is unaffected by the presence of saltwater within formations. In general, silt- and clay-bearing sediments show much higher natural gamma activity than do clean quartz sands and carbonates. This is because of the ability of clays to concentrate radioactive elements through ion exchange and adsorption. Feldspars and micas, which readily decompose into clay, also contain small proportions of the gamma-emitting radioisotope potassium-40 (Keys and McCary, 1971, p. 65). Gamma radiation increases to the right on the gamma-ray log. Therefore, permeable sediments such as sand and gravel generally have low radioactivity and cause log deflections toward the left, whereas relatively higher radioactive silt and clay cause log deflections toward the right. Additional factors that must be considered in gamma-ray log interpretation are related to well construction. These include changes in borehole diameter, type of casing, multiple or single casing, gravel pack, grout along the outside wall of the casing, and well development. All of these can cause shifts on gamma-ray logs that are not necessarily related to changes in lithology.

The alternating sequences of clay, silt, sand, and gravel that are present in the unconsolidated sediments of the Coastal Plain make the use of electric and gamma-ray logs ideal for lithologic correlation. More detailed information about the application of borehole geophysics to water-resources investigations can be found in Keys and McCary (1971).

DATA PRESENTATION

The hydrogeologic framework of the New Jersey Coastal Plain is illustrated in a series of structure contour and isopach maps at a scale of 1:500,000. The maps, together with 14 hydrogeologic sections, show vertical and horizontal relationships among the 15 regional hydrogeologic units mapped.

Outcrop areas shown on the hydrogeologic maps were modified from those compiled by J.P. Owens in Miscellaneous Geologic Investigations Map I–514–B (U.S. Geological Survey, 1967). In places, subsurface hydrogeologic units mapped constitute only the sandy or clayey parts of specific geologic formations and make up an undefined part of the outcrop. Therefore it should be noted that the outcrop areas shown on the structure contour and thickness maps cannot be considered the outcrop areas for these hydrogeologic units. The outcrop areas, however, can generally be used to estimate updip limits of aquifers and confining beds and to approximate lines of zero thickness.

Information on the wells used to construct the framework is given in table 3 (at back of report). The information for each well includes the U.S. Geological Survey well number, latitude, longitude, local well identifier, municipality, and total depth logged. If a geophysical log of the well appears in a hydrogeologic section, the name of the section is given in the last column.

The location of the wells listed in table 3 and the lines of the hydrogeologic sections shown on plates 3, 4, and 5 are shown on plate 2. The hydrogeologic sections shown on plates 3, 4, and 5 are referenced throughout the section on "Aquifers and Confining Beds."

The hydrogeologic control data for each site are listed in table 4 (at back of the report). Table 4 contains the U.S. Geological Survey well number, the altitude of the land surface, and the altitude of the top and bottom of each aquifer unit penetrated by each well. This table facilitates a rapid view of the hydrogeologic section at any site and is useful for calculating thicknesses if alternative divisions of hydrogeologic units are required.

AQUIFERS AND CONFINING BEDS

POTOMAC-RARITAN-MAGOTHY AQUIFER SYSTEM

In New Jersey, sediments of the Cretaceous Potomac Group, and the Raritan and Magothy Formations have generally been combined and described as a single hydrologic unit (Barksdale and others, 1958, p. 92) or as an aquifer system (Gill and Farlekas, 1976 and Luzier, 1980). This approach has been widely used because the individual formations are lithologically indistinguishable from one another over large areas of the Coastal Plain. In addition to the problems encountered in differentiating these sediments, Barksdale and others (1958, p. 91) considered the major aquifers within these units to be interconnected over some distance, although in many areas they were locally distinct.

FIGURE 3.—Lithologic subdivision of the Raritan and Magothy Formations in the Raritan embayment. (Modified from Christopher, 1979, fig. 2.)

In the outcrop area of the Raritan and Magothy Formations near Raritan Bay, nine distinct units have been recognized (fig. 3). The lithologic subdivision of the Raritan Formation reported by Ries and others (1904) was modified by Berry (1906) and by Barksdale and others (1943, p. 18). These early reports included the Old Bridge Sand Member and the Amboy Stoneware Clay Member as part of the Raritan Formation. Owens and others (1968) redefined the Magothy Formation and, on the basis of unpublished palynological work by Wolfe and Pakiser, included the Amboy Stoneware Clay member as part of the Magothy along with the Morgan beds and the Cliffwood beds. Subsequently, Wolfe and Pakiser (1971, p. B41) reassigned the Old Bridge Sand Member as the basal member of the Magothy Formation. On the basis of spore and pollen analysis and interpretations of borehole geophysical and lithologic logs, Perry and others (1975, p. 1542) have traced the individual members of the Raritan and Magothy Formations into the deeper subsurface of Monmouth and Ocean Counties (fig. 4).

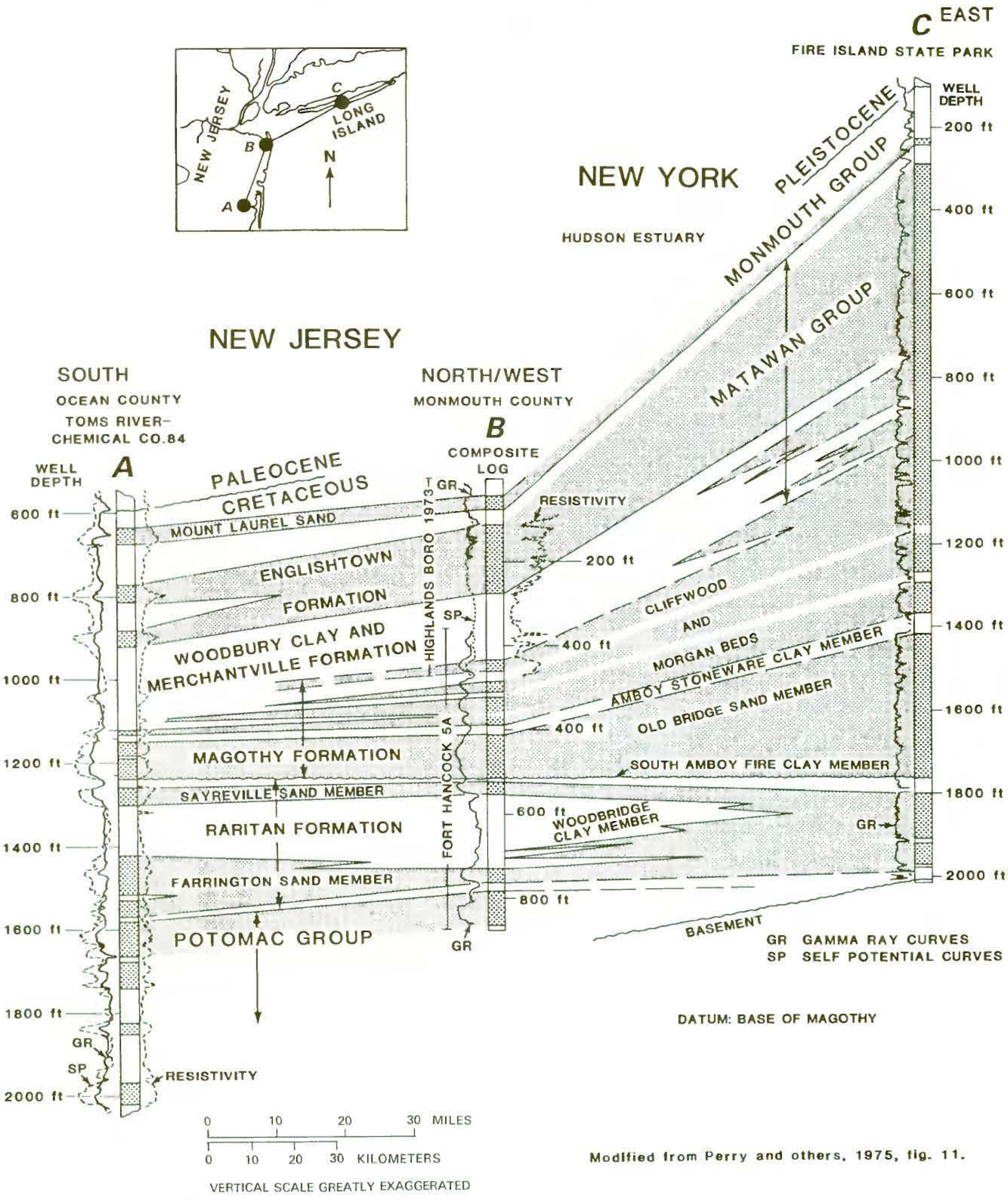

FIGURE 4.—Stratigraphic section of Cretaceous deposits, Toms River, N.J., to Fire Island, N.Y.

In the northern Coastal Plain, in parts of Mercer, Middlesex, and Monmouth Counties, two major aquifers have previously been defined within the Potomac–Raritan–Magothy aquifer system: the Farrington aquifer and the Old Bridge aquifer (Barksdale and others, 1943; Farlekas, 1979). The Farrington aquifer is composed primarily of the Farrington Sand Member of the Raritan Formation, and the Old Bridge aquifer is composed mainly of the Old Bridge Sand Member of the Magothy Formation.

In the southern Coastal Plain of New Jersey, water-bearing zones within the Potomac Group and the Raritan and Magothy Formations have generally been considered to function together as one hydrologic unit. The lithologic subdivisions of the Raritan and Magothy Formations recognized in the Raritan embayment are not evident in their outcrop area near the Delaware River (Owens and Sohl, 1969, p. 239–242). However, in an intensive study of the Potomac–Raritan–Magothy aquifer system in the Delaware Valley between Trenton and the Delaware Bay, Gill and Farlekas (written commun., 1970) subdivided the aquifer system, on the basis of geologic and geophysical well logs, into three aquifers, designated lower, middle, and upper, and two interjacent confining layers. Farlekas and others (1976) also show a three-aquifer breakdown of the system in Camden County.

Within the Potomac–Raritan–Magothy aquifer system, five mappable hydrologic units of varying extent are defined in this report. The five units include three aquifers, designated lower, middle, and upper, on the basis of stratigraphic position within the system, and two confining beds that lie interjacent to the aquifers.

Lower Aquifer

The altitude of the top of the lower aquifer and the aquifer's thickness are shown on plate 6. The lower aquifer has the most limited extent of the three aquifers within the Potomac–Raritan–Magothy aquifer system. It lies on the bedrock or weathered bedrock surface from northwestern Burlington to Salem Counties and is recognizable in the subsurface for approximately 8 to 12 mi downdip from the northwestern extent of the undifferentiated outcrop area of the Potomac Group and the Raritan Formation. In the updip direction, the aquifer thins and wedges out as successively younger beds overlap the bedrock surface (section *G–G′*, pl. 4). To the north, the lower aquifer thins and wedges out against a local basement high in the vicinity of Mount Holly in Burlington County (section *I–B*, pl. 4). In the downdip direction, the thickness of the lower aquifer increases uniformly southeastward to greater than 250 ft.

The aquifer thicknesses shown on plate 6 reflect the total thickness of the unit. Because of the fluvial depositional history of the Potomac and Raritan sediments in this area, considerable amounts of silt and clay are locally interbedded with the sand and gravel of the lower aquifer. Therefore, percentages of sand estimated from geophysical logs are also indicated on the thickness map for the lower aquifer. In most places, sand makes up more than 70 percent of the lower aquifer. Silt and clay beds within the lower aquifer are most prominent in Salem County. The lower aquifer in Salem County is similar and probably equivalent to the lower hydrologic zone of the Potomac Formation described by Sundstrom and others (1967, p. 18) within New Castle County, Del., located across the Delaware River adjacent to Salem County.

Southeast of the area contoured on plate 6, very few wells have penetrated the lower section of the Potomac–Raritan–Magothy aquifer system. Hence, the lower aquifer cannot be differentiated from overlying and underlying units in the deeper subsurface on the basis of available geophysical data (section *H–H′*, pl. 4).

The lower aquifer is used for water supply primarily in northwestern Gloucester County, northwestern Camden County, and adjoining northwestern Burlington County. In southwestern Gloucester County and Salem County, use of the lower aquifer is limited owing to higher chloride concentrations (Luzier, 1980, fig. 2; Fusillo and Voronin, 1981, table 3).

Confining Bed Between the Lower and Middle Aquifers

The confining bed overlying the lower aquifer of the Potomac–Raritan–Magothy aquifer system is composed primarily of very fine grained silt and clay sediments of the Potomac Group and the Raritan Formation. The thickness of the confining bed between the lower and middle aquifers is shown on plate 6. On geophysical logs, the confining bed is recognizable in the subsurface over approximately the same area as the lower aquifer, from southern Burlington County to Salem County and within 12 mi of the outcrop area of the Potomac Group and the Raritan Formation. This confining bed is less than 50 ft thick over half its mappable extent. Confining-bed thicknesses generally increase downdip toward the east. However, the thickening of this unit is not uniform because of local lensing between silt, sand, and clay, especially in Camden and Gloucester Counties. The confining bed exceeds 100 ft in thickness in downdip areas.

Middle Aquifer

The mappable extent of the top of the middle aquifer is shown on plate 7. The middle aquifer extends from the Delaware River adjacent to Salem County to Raritan Bay in the northeastern Coastal Plain. Between Salem County and northern Burlington County, the middle aquifer has been traced in the subsurface within a 10- to 12-mi band that parallels the outcrop area. In the uncontoured areas downdip, the middle aquifer, like the lower aquifer, cannot be distinguished from other beds within the Potomac Group and the Raritan Formation.

Northeast of Burlington County, the middle aquifer is the equivalent of the Farrington aquifer described by Farlekas (1979). Hydrogeologic section *I–B* (pl. 4) shows the lateral continuity of the middle aquifer near the Delaware River and the Farrington aquifer recognized in the northeastern Coastal Plain. In the northeastern Coastal Plain, the top of the middle aquifer is persistent in the deeper subsurface of Monmouth and northern Ocean Counties (hydrogeologic sections, pl. 3).

Aquifer thickness and percentages of sand of the middle aquifer are shown on plate 8. In the northern Coastal Plain, the thickness of the middle aquifer ranges from less than 50 ft in and near the outcrop to more than 150 ft near the junction of Mercer, Middlesex, and Monmouth Counties. Although the top of the middle aquifer can be traced into northern Ocean County, it is not possible, relying solely on geophysical data, to separate it from underlying sediments within the Potomac–Raritan–Magothy aquifer system. Therefore, thickness contours have not been extended farther downdip into Monmouth and Ocean Counties.

The predominantly sandy nature of the undifferentiated sediments between the bedrock surface and the top of the middle aquifer in northern Ocean County is evident from the geophysical logs for sections *D–D′* (pl. 3) and *K–C′* (pl. 5). This undifferentiated zone within the Potomac–Raritan–Magothy aquifer system has become important in recent years. A number of large-production public-supply wells in northern Ocean County are equipped with multiple screens so as to tap sandy beds in this zone. More detailed studies are needed to determine what effect heavy ground-water withdrawals from this zone may have on updip differentiated aquifers within the Potomac–Raritan–Magothy aquifer system.

Between Salem and Burlington Counties near the Delaware River, percentages of sand and aquifer thicknesses of the middle aquifer are more variable over shorter distances than in the northeastern Coastal Plain of New Jersey, where sand generally ranges from 75 to 85 percent. In and near the outcrop area near the Delaware River, sand ranges from 60 to 100 percent. In this area, lithologic variability and abrupt changes in the thickness of individual sand and clay beds within the unit are common.

In the Delaware Valley, the most productive and developed areas for ground-water withdrawals from the middle aquifer are located between northwestern Burlington and northwestern Gloucester Counties. As in the lower aquifer, discontinuous silt and clay beds are common within the middle aquifer in Salem County.

Confining Bed Between the Middle and Upper Aquifers

The thickness of the confining bed between the middle and upper aquifers of the aquifer system is shown on plate 9. In the northeastern Coastal Plain of New Jersey this confining bed is equivalent primarily to the Woodbridge Clay Member of the Raritan Formation. The Woodbridge Clay is a thin- to thick-bedded sequence of micaceous silts and clays (Owens and Sohl, 1969, p. 239). Locally, the confining bed may also include the clayey lithofacies of the Sayreville Sand Member and the South Amboy Fire Clay Member, both of the Raritan Formation (Farlekas, 1979, p. 16). In the downdip areas of Burlington, Ocean, and Monmouth Counties, this confining bed may be the equivalent of the Bass River Formation proposed by Petters (1976).

The thickness of the confining bed generally increases from around 50 ft in and near the outcrop to more than 150 ft toward the southeast, with some local thicknesses in excess of 200 ft. However, locally, in northern Gloucester and Camden Counties near the Delaware River, the confining bed between the middle and upper aquifers is less than 20 ft thick.

Upper Aquifer

The upper aquifer is the most extensive unit of the Potomac–Raritan–Magothy aquifer system, and it coincides most closely with a single geologic unit, the Magothy Formation. It is recognizable on geophysical logs that penetrate the section throughout the New Jersey Coastal Plain (pls. 3–5).

The altitude of the top and the thickness of the upper aquifer are shown on plates 10 and 11, respectively. In the northeastern Coastal Plain the upper aquifer is the equivalent primarily of the Old Bridge Sand Member of the Magothy Formation. Locally, the aquifer also includes the Sayreville Sand Member of the Raritan Formation, where the South Amboy Fire Clay Member is thin or missing (Farlekas, 1979, p. 22). The upper aquifer decreases in thickness from greater than 200 ft in the northeastern Coastal Plain to approximately 50 ft in Cape May County. It is composed predominately of permeable coarse-grained sediments. Clay beds are generally thin and localized. Therefore, percentages of sand are not included on the thickness map for the upper aquifer.

In the Raritan embayment, the Magothy Formation thickens rapidly and includes the interbedded sand, silt, and clay sequences of the Cliffwood and Morgan beds (Perry and others 1975, p. 1543). These beds are recognized only locally in outcrop and in the subsurface of the Sandy Hook Bay area. Perry and others (1975, fig. 11) show that downdip the Cliffwood and Morgan beds interfinger and pinch out within the Merchantville Formation and the Woodbury Clay (fig. 4). The top of the upper aquifer in the Sandy Hook area, as mapped in this report (pl. 10), is the top of the Old Bridge Sand Member of the Magothy Formation. Therefore, the thickness of the upper aquifer (pl. 11) in the Sandy Hook area does not include the overlying Cliffwood and Morgan beds of the Magothy Formation.

MERCHANTVILLE-WOODBURY CONFINING BED

The confining bed overlying the upper aquifer of the Potomac–Raritan–Magothy aquifer system is composed primarily of sediments of the Merchantville Formation and the Woodbury Clay of Late Cretaceous age. The Merchantville Formation is the oldest outcropping glauconitic unit in the New Jersey Coastal Plain. In addition to glauconite beds, the unit also contains thin- to thick-bedded sequences of micaceous clays and clayey silts. Locally within Camden County and parts of Gloucester County, Farlekas and others (1976, p. 53) mapped a sand unit within the Merchantville Formation as much as 30 ft thick that supplies water for small domestic needs. The overlying Woodbury Clay is essentially a thick, massive, clayey silt (Owens and Sohl, 1969, p. 242). The contact between the underlying upper aquifer of the Potomac–Raritan–Magothy aquifer system and the Merchantville–Woodbury confining bed is distinct and easily detected on geophysical logs (pls. 3–5).

The Merchantville–Woodbury confining bed is the most extensive confining bed within the New Jersey Coastal Plain. It functions as an effective confining layer between the upper aquifer of the Potomac–Raritan–Magothy aquifer system and the Englishtown aquifer system. It is also the major confining bed between the upper aquifer and the Wenonah–Mount Laurel aquifer in downdip areas to the southeast, where the Englishtown aquifer system is absent. The thickness of the Merchantville–Woodbury confining bed is shown on plate 12. The Merchantville Formation crops out in an irregular band between Raritan Bay and the Delaware River adjacent to Salem County. The outcrop area of the younger Woodbury Clay parallels the Merchantville outcrop but pinches out southwest of Woodbury in Gloucester County (Owens and Sohl, 1969, p. 242).

On plate 12, the line showing the approximate downdip limit of the Englishtown aquifer system divides the map into two areas. Between this line and the outcrop area, the Merchantville–Woodbury confining bed lies between the upper aquifer of the Potomac–Raritan–Magothy aquifer system and the Englishtown aquifer system. In this area, confining-bed thicknesses range from about 100 ft near the outcrop area in Salem County to greater than 350 ft in the northeastern Coastal Plain of New Jersey. In the northeastern Coastal Plain, low-permeability units of the Magothy Formation overlying the Old Bridge Sand Member are included within the Merchantville–Woodbury confining bed. These units are the Amboy Stoneware Clay Member and the thin intercalated beds of sand, silt, and clay of the Morgan and Cliffwood beds.

Downdip from the line indicating the limit of the Englishtown aquifer system, the Merchantville–Woodbury confining bed lies interjacent to the upper aquifer of the Potomac–Raritan–Magothy aquifer system and the Wenonah–Mount Laurel aquifer. Here, the confining bed also includes silty and clayey sediments of the Englishtown Formation and the Marshalltown Formation and the fine-grained lower part of the Wenonah Formation. Confining-bed thicknesses beyond the downdip limit of the Englishtown aquifer system range from less than 150 ft in Cumberland County to more than 450 ft in Ocean County.

An abrupt increase in confining-bed thickness occurs along the limit of the Englishtown aquifer system in southern Ocean County. This is attributed mainly to the greater thickness of silty and clayey sediments of the Englishtown Formation in this area and to the absence of the lower sand unit of the Englishtown aquifer system (section *E–E′*, pl. 3, and section *L′–A′*, pl. 5). The change in confining bed thickness along the edge of the downdip limit of the Englishtown aquifer system becomes less apparent toward the southwestern Coastal Plain of New Jersey. This is because of the thinning of the Englishtown, Marshalltown, and Wenonah Formations in this direction.

ENGLISHTOWN AQUIFER SYSTEM

The Englishtown Formation, of Late Cretaceous age, crops out in the western part of the New Jersey Coastal Plain in an irregular band that extends from Raritan Bay to the Delaware River adjacent to Salem County (pl. 13). Owens and Sohl (1969, p. 244) reported that several distinct lithofacies of the formation can be recognized along strike. However, in areas where the Englishtown Formation is exposed, the primary components are fine- to medium-grained sands.

Nichols (1977b) described the geohydrology of the Englishtown Formation in the northern Coastal Plain of New Jersey and recognized that the lithology of the Englishtown Formation in the shallow subsurface of Middlesex, Monmouth, and northwestern Ocean Counties was similar to the lithology in outcrop areas toward the west. In these updip areas of the northern Coastal Plain of New Jersey, the entire Englishtown Formation functions as one aquifer (sections *A–A′*, *B–B′*, and *C–C′*, pl. 3).

In the deeper subsurface of southeastern Monmouth County and northeastern Ocean County, Nichols (1977b, p. 12–15) identified three distinct lithofacies within the Englishtown Formation. These included an upper and lower sand facies separated by a clayey silt lithofacies. Nichols (1977b, p. 22) considered the upper sand lithofacies of primary importance in the areas where the two distinct sands are present. Only four production wells are known to tap the lower sand lithofacies. Two wells produce water from the lower sand near Lavallette, Ocean County (pl. 13), where the upper sand is absent. The other two wells tap both the lower and upper sand units in the Lakewood area of Ocean County (Walker, 1983, p. 32). All other major production wells that tap the Englishtown aquifer system are screened in the upper sand. Nichols (1977a, p. 20) recognized the lower sand lithofacies as being lithologically and hydrologically continuous with the upper sand in updip areas; however, because of the lack of data, he included only the upper sand as part of the Englishtown aquifer in his simulation model of the aquifer.

The subdivisions of the Englishtown aquifer system from updip areas in Ocean and Monmouth Counties, where the entire system functions as a single water-bearing unit, to downdip areas in northeastern Ocean County and southeastern Monmouth County, where three distinct lithofacies are present, are shown on sections *D–D′* and *E–E′* plate 3, and sections *K–C′* and *L′–A′*, plate 5.

The structure contours of the top of the Englishtown aquifer system are shown on plate 13. Where two sands are present within the Englishtown Formation in southeastern Monmouth and northeastern Ocean counties, the contours represent the top of the upper sand. For wells in which the lower sand has been recognized, the altitude of the top of the lower sand also is given.

The approximate downdip limit of the Englishtown aquifer system is shown on plates 13 and 14. South and east of a line paralleling Forked River in Ocean County and running through Hammonton in Atlantic County and Bridgeton in Cumberland County, the Englishtown aquifer cannot be recognized on geophysical logs that penetrate the section (well 29-19, section *E–E′*, pl. 3).

The thickness of the Englishtown aquifer system is shown on plate 14. In northern Monmouth County, the Englishtown aquifer system thickens from about 40 ft near the outcrop area of the Englishtown Formation to greater than 140 ft near Red Bank. In this area, as in most of Monmouth County, the entire Englishtown aquifer system functions as a single water-bearing unit (sections *A–A′*, *B–B′*, and *C–C′*, pl. 3).

The thickness of the aquifer system shown in southeastern Monmouth and northeastern Ocean Counties includes the clayey silt lithofacies that lies between the lower and upper sand units. For wells that penetrate the entire Englishtown section in this area, thicknesses of the upper and lower sand units are given in addition to the thickness of the entire aquifer system (pl. 14). The aquifer system is thickest where the upper and lower sand units are present in the subsurface. Thicknesses of the clayey silt lithofacies can be calculated from plate 14 by adding the thicknesses of the upper and lower sand units and subtracting the total from the thickness of the entire aquifer system at that point.

The thickness of the upper sand varies between about 40 and 110 ft in southeastern Monmouth and northeastern Ocean Counties. The upper sand thins toward the southeast and cannot be identified in the subsurface east of Toms River, Ocean County. Only the lower sand is recognizable in wells near Lavallette on the barrier beach in Ocean County (section *L′–A′*, pl. 5).

As the upper sand unit thins toward the southeast, the thickness of the underlying clayey silt lithofacies increases (sections *D–D′* and *E–E′*, pl. 3, and sections *K–C′* and *L′–A′*, pl. 5). The lower sand has a rather uniform thickness generally between 30 and 50 ft in Ocean County.

The Englishtown aquifer system thins in outcrop and in the subsurface in a southwestern direction (section *J–J′*, pl. 4). In parts of Burlington, Camden, Gloucester, and Salem Counties, the aquifer is commonly less than 40 ft thick. The sands within the Englishtown aquifer system in this area are finer grained, and local silt and clay beds within the unit are common. The aquifer is not a major source of water between Burlington County and southern Salem County, owing to the decrease in aquifer thickness, the greater proportion of fine-grained sediments, resulting in lower yields, and the presence of other more productive aquifers (Nichols, 1977b, p. 20).

MARSHALLTOWN-WENONAH CONFINING BED

The confining bed overlying the Englishtown aquifer system is composed of the Marshalltown Formation and the fine-grained lower part of the Wenonah Formation. The Marshalltown Formation and the overlying Wenonah Formation, both Late Cretaceous in age, crop out in a northeast-southwest trending belt in the western part of the New Jersey Coastal Plain (pl. 15). The Marshalltown Formation is a thin, uniform, sheetlike deposit of glauconitic silt and sand, usually ranging between 10 and 20 ft thick throughout much of the subsurface of the Coastal Plain. The Wenonah Formation is generally a dark-gray, poorly sorted, micaceous, silty, fine quartz sand. The Wenonah Formation also contains abundant glauconite in its lower part. However, glauconite content diminishes toward the top of the unit as the formation becomes coarser grained (Owens and Sohl, 1969, p. 245). The thickness of the confining bed between the Englishtown aquifer system and the Wenonah–Mount Laurel aquifer is shown on plate 15. Most of the variation in confining-bed thickness is attributed to the variable thickness of the fine-grained lower part of the Wenonah Formation. The Marshalltown–Wenonah confining bed ranges in thickness from about 20 ft in northern Monmouth County to more than 80 ft in Ocean County. The confining bed generally thins toward the southwest. This is consistent with the thinning and pinching out of the outcrop area of the Wenonah Formation in this direction.

The thickness of the Marshalltown–Wenonah confining bed is shown only over the mappable extent of the underlying Englishtown aquifer system. Beyond this limit, the sediments of the Marshalltown and Wenonah Formations become part of the extensive Merchantville–Woodbury confining bed, effectively confining the upper aquifer of the Potomac–Raritan–Magothy aquifer system from the Wenonah–Mount Laurel aquifer. In northeastern Ocean County at Lavallette, where only the lower sand of the Englishtown Formation is present, the Marshalltown–Wenonah confining bed is more than 180 ft thick (sections *D–D'* and *E–E'*, pl. 3, and section *L'–A'*, pl. 5). In this area, the Marshalltown–Wenonah confining bed includes the fine-grained, low-permeability sediments of the Englishtown Formation that overlie the lower sand of the Englishtown Formation.

The leaky nature of the Marshalltown–Wenonah confining bed has been discussed by many investigators. Nemickas (1976, p. 37) has discussed the effect of ground-water withdrawals from the Englishtown aquifer on the Mount Laurel aquifer. Walker (1983) finds similar cones of depression for both aquifers in the Lakewood area of Ocean County, where no significant pumpage from the Wenonah–Mount Laurel aquifer has been reported.

WENONAH–MOUNT LAUREL AQUIFER

The Wenonah–Mount Laurel aquifer is composed of the coarse-grained fraction of the Wenonah Formation and the Mount Laurel Sand, both Late Cretaceous in age. The sediments generally increase in grain size toward the top of the aquifer. The major component of the aquifer is the Mount Laurel Sand.

Structure contours for the top of the Wenonah–Mount Laurel aquifer are shown on plate 16. The Wenonah–Mount Laurel aquifer can be traced in the subsurface throughout the New Jersey Coastal Plain southeast of its outcrop area. The aquifer is easily identified on gamma-ray logs below the high radiation kick of the Navesink Formation (section *J–J'*, pl. 4).

The thickness of the Wenonah–Mount Laurel aquifer is shown on plate 17. In the northeastern Coastal Plain of New Jersey aquifer thicknesses generally range from 40 ft to greater than 100 ft. Thicknesses between 60 and 80 ft are common throughout wide areas of Monmouth and Ocean Counties. In the northeastern Coastal Plain of New Jersey the aquifer is used mainly in southeastern Monmouth and northern Ocean Counties. The thickest parts of the aquifer are within 10 to 15 mi of the outcrop area of the Mount Laurel Sand in Burlington, Camden, Gloucester, and Salem Counties, where thicknesses of 100 to 120 ft are common. After reaching maximum thicknesses greater than 120 ft in the southwestern Coastal Plain of New Jersey, the aquifer thins gradually toward the southeast to less than 25 ft in Cape May County.

Water in the aquifer contains more than 250 milligrams per liter (mg/L) chloride in most of Cumberland County, the southern half of Atlantic County, and all of Cape May County, based on the altitude of the 250 mg/L isochlor shown by Meisler (1981, fig. 2). All production wells that tap the Wenonah–Mount Laurel aquifer between northern Burlington County and southern Salem County are within 10 mi of the outcrop area of the Mount Laurel Sand.

COMPOSITE CONFINING BED

Overlying the Wenonah–Mount Laurel aquifer and subjacent to the major aquifers within the Kirkwood Formation and the Cohansey Sand lies a complex series of geologic units ranging in age from Late Cretaceous to Miocene. The predominant lithology of most of these units consists of silty and clayey glauconitic quartz sands. The units have low to moderate permeabilities and are generally grouped together and described hydrologically as a composite confining bed (Rush, 1968; Anderson and Appel, 1969; Nemickas, 1976). This confining bed consists of the Navesink Formation and, depending on location within the Coastal Plain, can include most or only a few of the following geologic units: Red Bank Sand, Tinton Sand, Hornerstown Sand, Vincentown Formation, Manasquan Formation, Shark River Formation, Piney Point Formation, and basal clay of the Kirkwood Formation. Parts of the Red Bank Sand, Vincentown Formation, and Piney Point Formation contain fairly permeable sands that locally are used as sources of water. Although the aquifers within the Vincentown and Piney Point Formations are considered minor, they are regionally extensive in the New Jersey Coastal Plain. Framework information for the Vincentown aquifer and the Piney Point aquifer is presented following the discussion of the composite confining bed.

The outcrop area and the total thickness of the geologic units incorporated in the composite confining bed are shown on plate 18. The northwestern edge of the outcrop is the downdip limit of the outcrop of the Mount Laurel Sand. The southeastern edge of the outcrop is bounded by the updip limit of the outcrop of the Kirkwood Formation. The clay bed at the base of the Kirkwood Formation has been excluded as part of the outcrop of the composite confining bed because its outcrop has not been mapped separately from the sand of the Kirkwood Formation. However, the clay bed is included as part of the total thickness shown on the hydrogeologic sections and on plate 18. In the downdip direction, the composite confining bed increases rapidly in thickness from less than 50 ft in outcrop to 796 ft in well 29-19 at Island Beach State Park and to more than 1,190 ft in Cape May County.

The Upper Cretaceous Navesink Formation is the basal unit of the composite confining bed throughout its extent in the New Jersey Coastal Plain. It is unconformably overlain by the Paleocene Hornerstown Sand. These two formations, which span the Cretaceous-Tertiary boundary in New Jersey, are excellent marker beds for stratigraphic correlation. Gamma-ray logs that penetrate the Navesink Formation and the Hornerstown Sand show the same high radiation signature throughout the New Jersey Coastal Plain (section *J–J′*, pl. 4). These high radiation kicks coincide with high concentrations of glauconitic sand and shell beds at the base of the Navesink Formation and near the top of the Hornerstown Sand (Rosenau and others, 1969, p. 45). The combined thickness of the Navesink Formation and the Hornerstown Sand is fairly uniform, ranging from 60 to 90 ft throughout much of the subsurface.

Hydrogeologic section *J–J′* on plate 4 shows a progressively greater separation between high radiation kicks of the Navesink Formation and the Hornerstown Sand in northwestern Ocean and Monmouth Counties. This is caused by the northeastward-thickening wedge of the Upper Cretaceous Red Bank and Tinton Sands that overlie the Navesink Formation in this area. Northeast of Freehold in Monmouth County, low radiation on logs 25-37 and 25-360 (section *J–J′*, pl. 4) indicates that the Red Bank Sand section is fairly permeable in and near the outcrop. The significant widening of the composite confining bed toward the northeast end of its outcrop area in Monmouth County (pl. 18) is caused by the presence of the Red Bank Sand. Many domestic wells tap the Red Bank Sand within its Monmouth County outcrop area. However, total withdrawals are minimal (Jablonski, 1968, p. 65). The Red Bank Sand thins rapidly southeast of its outcrop and is absent throughout most of the New Jersey Coastal Plain.

The primary factors causing the dramatic increase in thickness of the composite confining bed in the downdip direction (sections *D–D′* and *E–E′*, pl. 3) are the rapid thickening of beds within the Vincentown and Manasquan Formations and the addition of beds of the Shark River Formation and Piney Point Formation.

Vincentown Aquifer

Throughout most of its subsurface extent, the Vincentown Formation functions primarily as a confining bed. However, within its outcrop area and for approxmately 8 to 10 mi downdip, the formation is tapped by many domestic wells and, locally, by industrial and public-supply wells.

The outcrop area of the Vincentown Formation and the approximate limit, structure contours of the top, and thickness of the Vincentown aquifer are shown on plate 19. The outcrop area extends in an irregular and discontinuous band from northeastern Monmouth County to the Delaware River adjacent to Salem County. In areas where its outcrop is discontinuous, the Vincentown Formation subcrops below the overlapping Kirkwood Formation. In and near its outcrop, the Vincentown formation of Paleocene age contains two lithofacies: a massive sparsely glauconitic quartz sand and a very fossiliferous calcareous quartz sand (Parker and others, 1964, p. 58). The massive quartz sand occurs mainly in outcrop from Ocean County to eastern Monmouth County. The fossiliferous lime-sand facies crops out from Burlington to Salem Counties (Owens and Sohl, 1969, p. 249). These two lithofacies make up the moderately permeable section of the Vincentown Formation, herein referred to as the Vincentown aquifer.

The extent of the Vincentown aquifer can be traced in the subsurface from Monmouth to Salem Counties, but only in a narrow band 3 to 10 mi wide adjacent to and paralleling the outcrop area. The moderately permeable quartz and lime-sand facies in and near the outcrop grades rapidly into finer grained silts and clays downdip. This sharp facies change to less permeable beds downdip has been noted by Enright (1969, p. 15), by Parker and others (1964, p. 58), and by Rush (1968,

p. 53) and is supported by borehole geophysics data (section *D–D'*, pl. 3, and section *L–A'*, pl. 5). The Vincentown aquifer is easily recognizable above the characteristic signature of the underlying Hornerstown Sand on gamma-ray logs that penetrate the section (section *J–J'*, pl. 4). On geophysical logs from areas southeast of the limit of the aquifer, the Vincentown Formation mainly shows beds of higher radioactivity and low resistivity, indicating poor permeabilities.

The Vincentown aquifer thickens from about 20 ft in outcrop and along the southeastern limit to approximately 80 ft in Salem County and northern Burlington County. The aquifer's maximum thickness exceeds 140 ft in Monmouth County, near the outcrop area. The most productive areas of the Vincentown aquifer are in areas of greatest thickness, primarily in Monmouth and Salem Counties.

The thickness of the confining bed underlying the Vincentown aquifer, which can include sediments of the Navesink Formation and the Red Bank, Tinton, and Hornerstown Sands, can be obtained by calculating the base of the Vincentown aquifer from the top and thickness maps (pl. 19) and subtracting the base from the top of the Wenonah–Mount Laurel aquifer (pl. 16). The thickness of the confining bed overlying the Vincentown aquifer, which can include sediments of the Manasquan and basal Kirkwood Formations, can be calculated by comparing the top of the Vincentown aquifer (pl. 19) with the base of the Kirkwood–Cohansey aquifer system (pl. 23). Confining-bed thicknesses can also be calculated from table 4.

Piney Point Aquifer

The Piney Point Formation of middle and late Eocene age is composed of fine- to coarse-grained glauconitic quartz sand and shell beds. Sandy silt and clay are common within the formation and can dominate locally. The Piney Point Formation does not crop out and rests mainly on the beveled surface of the Manasquan Formation (Parker and others, 1964, p. 60) of early Eocene age (Enright, 1969, p. 17). It also overlies and may be equivalent to part of the middle Eocene Shark River Formation in the northeastern Coastal Plain of New Jersey (Enright, 1969, p. 19). The Piney Point Formation is unconformably overlain by a silty clay in the basal part of the Miocene Kirkwood Formation, locally referred to as the Alloway Clay Member in the southern Coastal Plain of New Jersey (Isphording, 1970; Nemickas and Carswell, 1976).

The name Piney Point Formation was first given by Otten (1955, p. 85) to glauconitic sand and shell beds considered to be late Eocene (Jackson) in age, from a well at Piney Point, St. Marys County, Md. The Piney Point Formation was later traced northeastward to the eastern shore of Maryland by Rasmussen and others (1957, p. 61–67) and subsequently into Delaware by Rasmussen and others (1958). Rasmussen identified the formation in sediments of Jackson age penetrated by a deep well at Atlantic City, N. J. (Richards and others, 1962, p. 31). Richards and others (1962) and Parker and others (1964) have traced the Piney Point Formation into Cumberland, Cape May, and Atlantic Counties and as far east as Atlantic City.

The supposed late Eocene (Jackson) age of the Piney Point Formation has recently been in question. Brown and others (1972, p. 49) examined original material from the type section of the Piney Point. They assigned a middle Eocene (Claiborne) age to the formation on the basis of the discovery of a characteristic middle Eocene foraminifer and several species of ostracodes. Olsson and others (1980) have recently proposed a late Oligocene age for the Piney Point Formation in Maryland and New Jersey on the basis of a study of planktonic foraminifera.

The glauconitic quartz sand and shell beds of the Piney Point Formation yield moderate supplies of water locally to Coastal Plain wells. However, the Piney Point is extensive in the New Jersey subsurface and is believed to be capable of supplying additional water. Therefore, information about aquifer extent, top, and thickness is provided herein.

Nemickas and Carswell (1976) recognized the water-bearing potential of the Piney Point Formation in southern New Jersey. They presented stratigraphic and hydrologic data for the Piney Point aquifer and the overlying Alloway Clay Member of the Kirkwood Formation. On the basis of geophysical logs, Nemickas and Carswell (1976, p. 4) mapped the aquifer in Salem, Gloucester, Cumberland, Atlantic, and Camden Counties.

The altitude of the top of the Piney Point aquifer and the approximate subsurface limit are shown on plate 20. This report redefines the extent of the Piney Point aquifer and shows that it is laterally persistent from the southern Coastal Plain of New Jersey into parts of Burlington and Ocean Counties. In Camden, Burlington, and Ocean Counties this water-bearing unit, here shown as the Piney Point aquifer, has previously been interpreted as being part of the Manasquan Formation. Herrick (1962, p. B57) showed a glauconitic shelly sand at the base of the Kirkwood Formation between an interval of approximately 219–260 ft below land surface, in a well at the U.S. Geological Survey New Brooklyn Park test well site, in Camden County (adjacent to well 7-476 of this report). He assigned a middle Eocene (Claiborne) age and the name Manasquan Formation to these sediments, on the basis of foraminifera found within this zone. The Manasquan Formation is older, being early Eocene in age, according to a more recent study by Enright (1969, p. 17). The middle Eocene age given by Herrick (1962) is consistent with the age of the Piney Point Formation determined by Brown and others (1972, p. 49) at Piney Point, Md.

Nemickas and Carswell (1976, p. 4, fig. 5) have updated Herrick's interpretation by tracing the Piney Point aquifer from Cumberland and Salem Counties northward into the same unit within the New Brooklyn Park test well (7-476) described by Herrick (1962) as the Manasquan Formation.

Hydrogeologic section *L–L'* (pl. 5) shows the continuation of the Piney Point aquifer from Atlantic City northward into the central Coastal Plain of New Jersey. The unit shown as the Piney Point aquifer in U.S. Geological Survey wells 29-425 (Webbs Mills), 5-676 (Coyle Airport), and 5-30 (Oswego Lake) has previously been reported as the Manasquan Formation by Rush (1968, p. 54) and by Anderson and Appel (1969, p. 43). Herrick (written commun., 1962) analyzed the sediments in the three Geological Survey wells listed above. He assigned a middle Eocene (Claiborne) age and the name Manasquan Formation to the sediments within the unit shown as Piney Point on section *L–L'* (pl. 5). This unit is directly correlative with the unit described by Herrick (1962, B–57) in the New Brooklyn Park well in Camden County that was later shown as the Piney Point aquifer by Nemickas and Carswell (1976, p. 4, fig. 5).

Hydrogeologic section *L'–A'* (pl. 5) shows the lateral persistence of the Piney Point aquifer along the coast from Atlantic City northward, including wells at Barnegat Light and Seaside Park in Ocean County. Production wells for local water supply tapping this zone in Ocean County have been previously described as tapping the Manasquan Formation (Anderson and Appel, 1969, p. 44).

Nemickas and Carswell (1976, p. 1) defined the Piney Point aquifer as "the upper sandy part of the Eocene sediments that is laterally continuous with the Piney Point aquifer in Delaware." This report follows the same convention. Regardless of previous formation names or disputes in time-stratigraphic correlations, moderately permeable glauconitic sand and shell beds that lie below the basal clay of the Kirkwood Formation, and that are laterally continuous with the Piney Point aquifer of the Delaware and Maryland Coastal Plain, are herein described as the Piney Point aquifer.

The thickness of the Piney Point aquifer is shown on plate 21. Downdip, two major areas of sand accumulation are evident. In the southwestern Coastal Plain of New Jersey, aquifer thickness increases toward the south and downdip from the northwestern limit of the aquifer. Thicknesses of more than 200 ft occur in southwestern Cumberland County. The other area of thick sand accumulation lies within the east-central Coastal Plain in Burlington and Ocean Counties. Here, maximum thicknesses exceed 130 ft. The Piney Point aquifer thins updip (section *F–F'*, pl. 4) where it wedges out between sediments of the underlying Manasquan Formation and the overlying Kirkwood Formation.

The thickness of the confining-bed material underlying and overlying the Piney Point aquifer can be calculated from table 3, from the hydrogeologic sections, and from comparisons of the maps of the Piney Point aquifer with those of vertically adjacent aquifers.

ATLANTIC CITY 800-FOOT SAND

The Atlantic City 800-foot sand is a major water-bearing unit that lies within the lower part of the Kirkwood Formation of middle Miocene age. It is the principal confined aquifer supplying water along the barrier beaches from Stone Harbor in Cape May County to Harvey Cedars in Ocean County. The Atlantic City 800-foot sand is composed of gray, medium- to coarse-grained quartz sands and gravel with a considerable amount of interspersed fragmented shell material.

Structure contours of the top of the Atlantic City 800-foot sand, its thickness, and its approximate limits are shown on plate 22. The approximate updip limit of the 800-foot sand is based on the approximate updip limit of the overlying confining bed. The Atlantic City 800-foot sand is recognizable in the subsurface only where it is overlain by the thick massive clay bed southeast of the double-dashed line (pl. 22). This confining bed is described in detail in the following section. In areas northwest of the limit of the confining bed, the Kirkwood Formation is composed primarily of fine- to medium-grained sand that is hydraulically connected to the overlying Cohansey Sand and younger deposits, forming a relatively thick water-table aquifer.

It is not known whether the 800-foot sand continues beyond the western edge of the overlying confining bed and forms part of the larger water-table system to the west. This is significant because if a lateral connection exists, most of the recharge to the 800-foot sand would be from unconfined areas to the west. The presumed relationship of the Atlantic City 800-foot sand to the underlying and overlying confining beds and the unconfined Kirkwood–Cohansey aquifer system is illustrated in figure 5.

The Atlantic City 800-foot sand overlies a clay bed at the base of the Kirkwood Formation that is the uppermost unit of the composite confining bed described previously. This basal clay appears to be the equivalent

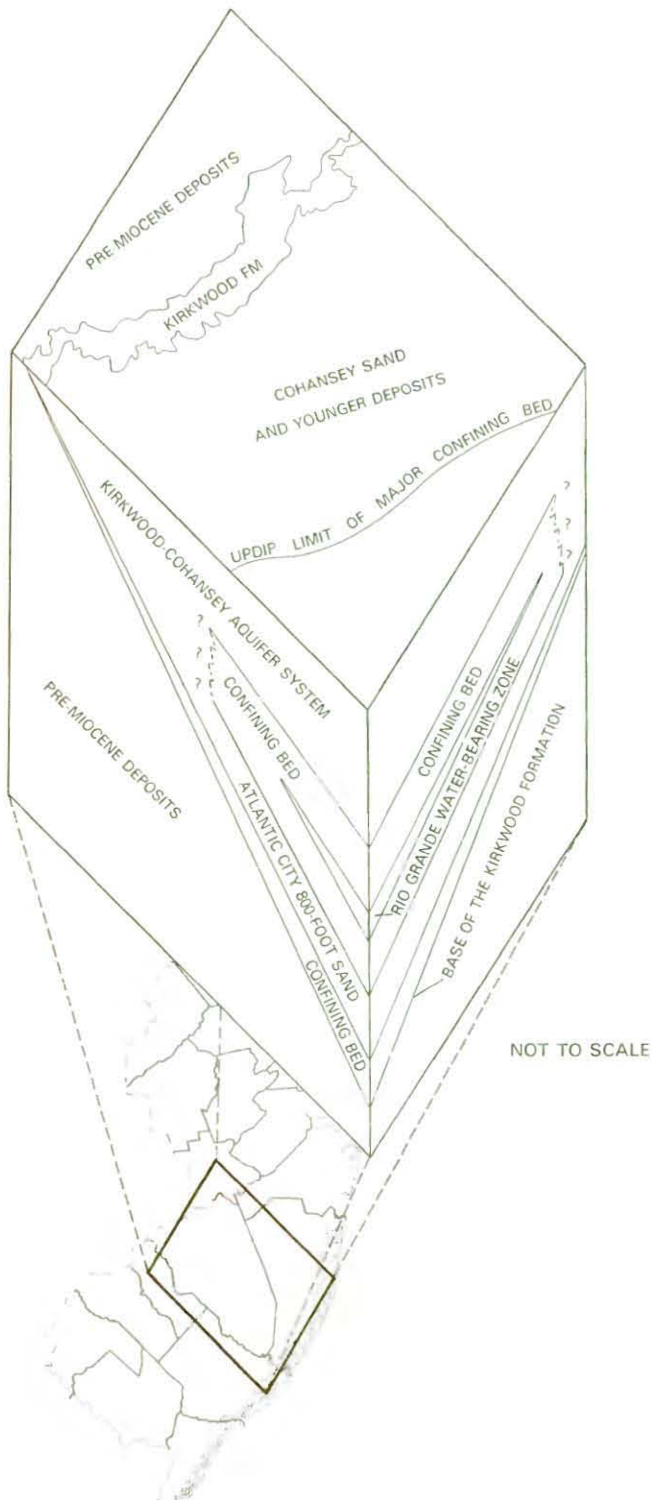

FIGURE 5.—Block diagram showing the presumed stratigraphic relationship between the Kirkwood–Cohansey aquifer system and the Atlantic City 800-foot sand.

of the Alloway Clay Member of the Kirkwood Formation described by Nemickas and Carswell (1976). This underlying clay bed can be traced laterally updip beyond the limit of the thick clay bed that overlies the Atlantic City 800-foot sand (section *F–F′*, pl. 4, and sections *L–L′* and *L′–A′*, pl. 5).

The Atlantic City 800-foot sand generally thickens downdip. The aquifer also thickens toward the south, from approximately 40 ft at Barnegat Light, Ocean County, to greater than 200 ft at Cape May City, Cape May County. The aquifer thickness at Atlantic City is more than 150 ft.

A relatively thin clay bed within the Atlantic City 800-foot sand, with thicknesses generally ranging from 10 to 30 ft, is recognized on geophysical logs from Ocean City, Cape May County, to Beach Haven, Ocean County (section *M–M′*, pl. 5). Most of the production wells along the coast are screened in the lower part of the double sand separated by this thin clay bed. According to unpublished results from an aquifer test in 1980 at Atlantic City, Atlantic County, significant leakage from the upper sandy zone of the aquifer can occur (Tilley and Straus, written commun., 1978).

CONFINING BED OVERLYING THE ATLANTIC CITY 800-FOOT SAND

The thickness and extent of the confining bed that overlies the Atlantic City 800-foot sand is shown on plate 22. This massive clay bed within the Kirkwood Formation is commonly described as being rich in diatoms. Woolman (1895) often referred to this unit as the "Great Diatom Bed."

The confining-bed thickness increases in the downdip direction from less than 100 ft in the vicinity of Mays Landing, Atlantic County, to more than 300 ft beneath the Atlantic City area. The confining bed is thickest along the barrier beaches of Cape May County, where thicknesses of 400 to 450 ft are common. However, sandy zones within the confining bed are common in the Cape May area. The confining bed thins toward the line approximating its westernmost limit in the subsurface. It cannot be identified in wells located less than 5 mi updip from the limit shown on the map (pl. 22). This indicates either that the clay bed is truncated or that an abrupt lithologic change from silt and clay to sand occurs over a relatively short distance. No evidence for a gradual pinchout of the unit has been observed.

The updip limit of this confining bed could only be approximated because of limited geophysical data. However, water-level data indicate that water-bearing sands of the Kirkwood Formation are largely unconfined west of the limit of the confining bed shown on plate 22 (Walker, 1983), supporting the given interpretation.

Rio Grande Water-Bearing Zone

Midway within the confining bed that overlies the Atlantic City 800-foot sand lies a relatively thin confined aquifer (sections *L–L'*, *L'–A*, and *M–M'*, pl. 5). Gill (1962) described this unit in Cape May County and referred to it as the Rio Grande water-bearing zone, after the town in Cape May County that uses it for public supply. The same unit was recognized as early as 1890 in the Atlantic City region and on the southern barrier beaches of Ocean County, where it was generally referred to as the 550-foot horizon (Woolman, 1891, p. 269; 1892, p. 224). The lateral persistence of the Rio Grande water-bearing zone from Cape May County to Ocean County is shown on section *M–M'* (pl. 5). Thickness and structure contour maps of this unit are not given in this report. Tops and thicknesses of the Rio Grande water-bearing zone can be calculated from the hydrogeologic sections.

The Rio Grande water-bearing zone is used mainly in southern Cape May County, where aquifer thicknesses can exceed 100 ft. It is generally less than 40 ft thick throughout much of the coastal area in southern Ocean and Atlantic Counties. The aquifer is seldom used outside of southern Cape May County and is of minor importance. Therefore, in this report, the Rio Grande water-bearing zone has been included as part of the confining bed overlying the 800-foot sand shown on plate 22.

KIRKWOOD-COHANSEY AQUIFER SYSTEM

The Kirkwood–Cohansey aquifer system is predominantly a water-table aquifer that underlies an area of approximately 3,000 mi² southeast of the updip limit of the outcrop of the Kirkwood Formation. This aquifer system is composed of the Kirkwood Formation and the Cohansey Sand and, depending on location, can include overlying deposits of the Beacon Hill Gravel, the Bridgeton Formation, and the Cape May Formation (Rhodehamel, 1973). The Kirkwood–Cohansey aquifer system is confined by overlying Pleistocene deposits on the peninsular part of Cape May County.

The lithology of the Kirkwood Formation, as indicated previously, is variable. Along coastal areas thick clay beds are dominant, with interbedded zones of sand and gravel. In the subsurface updip from the coast, fine to medium sand and silty sand are common, and regionally extensive clay beds occur only in the basal part of the formation.

The Cohansey Sand, also of Miocene age, is coarser grained than the underlying Kirkwood Formation. It is predominantly a light-colored quartz sand containing minor amounts of pebbly sand, fine- to coarse-grained sand, silty and clayey sand, and interbedded clay (Rhodehamel, 1973, p. 24). Some local clay beds within the Cohansey Sand are relatively thick. Locally, perched water tables and semiconfined conditions can exist in the Kirkwood–Cohansey aquifer system.

Overlying the Cohansey Sand are the Beacon Hill Gravel and the Bridgeton Formation, both considered Miocene fluvial deposits (Owens and Minard, 1979). The Beacon Hill Gravel overlies the Cohansey Sand only in remnant patches on the highest hills between Clarksburg, Monmouth County, and Warren Grove, Ocean County, where it can be as much as 40 ft thick (Owens and Minard, 1979, p. D6). The coarse-grained sand and gravel of the Bridgeton Formation are more widespread and can generally add 30 to 50 ft of thickness to the aquifer system in parts of Camden, Gloucester, Salem, Cumberland, Atlantic, and Cape May Counties (Owens and Minard, 1979, p. D14).

Throughout most of Cape May County, the Pleistocene Cape May Formation directly overlies the Cohansey Sand. Gill (1962, p. 21) divided the Cape May Formation into four distinct environmental facies. In order of deposition they are estuarine sand, estuarine clay, marine sand, and deltaic sand. Gill (1962, fig. 2) has shown that in the northern half of Cape May County and along the coast as far south as Stone Harbor, the Cohansey Sand is in hydraulic connection with the overlying marine and deltaic sand facies. The marine sand facies of the Cape May Formation adds as much as 100 ft to the thickness of the Kirkwood–Cohansey aquifer system in the northern half of Cape May County. On the peninsular part of Cape May County, the Cohansey Sand is generally in hydraulic connection with the estuarine sand facies but is confined by the overlying estuarine clay facies (Gill, 1962, fig. 2). The estuarine clay facies generally ranges from 25 to 125 ft in thickness (Gill, 1962, p. 27).

The base of the Kirkwood–Cohansey aquifer system is shown on plate 23. The map illustrates two major regional basal surfaces for the water-table aquifer. The two surfaces are differentiated by the double-dashed line representing the approximate westward limit of the major confining bed overlying the Atlantic City 800-foot sand. The basal surface for the Kirkwood–Cohansey aquifer system west of this line is the top of the clay bed lying within the lower part of the Kirkwood Formation. This clay bed, as shown on hydrogeologic sections *F–F'* (pl. 4) and *L–L'* (pl. 5), is the updip extension of the confining bed underlying the 800-foot sand and is probably the equivalent of the Alloway Clay Member of the Kirkwood Formation described by Nemickas and Carswell (1976).

The basal surface east of the double-dashed line is the top of the thick diatomaceous clay bed that overlies the Atlantic City 800-foot sand. The discontinuity in the structure contours on the base of the unconfined system at the double-dashed line is caused by the presence of this clay bed. The base of the aquifer system directly updip from the northwestern limit of the confining bed generally lies more than 350 ft below sea level. At Egg Harbor City, Atlantic County, several miles downdip from the western limit of the confining bed, the base of the water-table aquifer is only 160 ft below sea level. The difference in altitudes of the two basal surfaces of the Kirkwood–Cohansey aquifer system is shown diagrammatically in figure 5.

The thickness of the confining bed underlying the Kirkwood–Cohansey aquifer system west of the double-dashed line is shown on plate 18 as the composite confining bed. If, in more detailed studies, the Vincentown and Piney Point aquifers are considered important, the thickness of the confining bed between the base of the unconfined aquifer and these minor aquifers can be calculated by comparing the maps of the tops of the Vincentown (pl. 19) and Piney Point (pl. 20) aquifers with the base of the Kirkwood–Cohansey aquifer system west of the double-dashed line (pl. 23).

It is important to note that the Cohansey Sand is a confined aquifer beneath the peninsular portion of Cape May County. However, on plate 23, structure contours have been extended throughout Cape May County to illustrate the base of the confined Cohansey Sand. Information regarding the water-table system in Cape May County can be found in Gill (1962).

The extent of the confining bed overlying the Atlantic City 800-foot sand partly determines the thickness of the Kirkwood–Cohansey aquifer system. An abrupt change in the thickness of the Kirkwood–Cohansey aquifer system at the double-dashed line is shown on plate 24. The water-table aquifer thickens downdip from less than 50 ft at the Kirkwood outcrop to more than 400 ft near the edge of the upper confining bed of the Atlantic City 800-foot sand. In areas where this clay bed occurs in the subsurface, the aquifer thickness ranges from about 140 ft along the northwestern extent of the clay bed to approximately 400 ft in the Atlantic City area.

The aquifer-thickness map for the Kirkwood–Cohansey aquifer system represents not only the saturated thickness of the water-table aquifer but also the unsaturated section. The thickness of the aquifer at each control point represents the total thickness of the unit calculated by subtracting the depth of the basal confining bed from the altitude of the land surface.

SUMMARY AND CONCLUSIONS

The New Jersey Coastal Plain is a seaward-dipping wedge of unconsolidated sediments that range in age from Cretaceous to Quaternary. These sediments are composed of clay, silt, sand, and gravel and include continental, coastal, and marine-type deposits.

Hydrogeologic units described in this report can differ from formal stratigraphic units because a geologic formation may contain more than one aquifer, a formation may function as an aquifer in one area and as a confining bed in another, or an aquifer or a confining bed may be composed of several geologic formations.

The occurrence and configuration of 15 regional hydrogeologic units within the New Jersey Coastal Plain have been defined on the basis of interpretation of borehole geophysics data. Structure contour maps and aquifer thickness maps are provided for nine aquifers. In ascending order they are

1. Lower aquifer of the Potomac–Raritan–Magothy aquifer system
2. Middle aquifer of the Potomac–Raritan–Magothy aquifer system
3. Upper aquifer of the Potomac–Raritan–Magothy aquifer system
4. Englishtown aquifer system
5. Wenonah–Mount Laurel aquifer
6. Vincentown aquifer
7. Piney Point aquifer
8. Atlantic City 800-foot sand
9. Kirkwood–Cohansey aquifer system

Thickness maps are provided for six confining beds. In ascending order they are

1. Confining bed between the lower and middle aquifers of the Potomac–Raritan–Magothy aquifer system
2. Confining bed between the middle and upper aquifers of the Potomac–Raritan–Magothy aquifer system
3. Merchantville–Woodbury confining bed
4. Marshalltown–Wenonah confining bed
5. Composite confining bed
6. Confining bed overlying the Atlantic City 800-foot sand

The structure contour and thickness maps are supplemented by 14 hydrogeologic sections that show vertical and horizontal relationships among the 15 hydrogeologic units.

The major points presented by this hydrogeologic framework are as follows:

1. The Potomac–Raritan–Magothy aquifer system is divided into five mappable units of varying extent. The five units include three aquifers, designated lower, middle, and upper, and two confining beds that lie interjacent to the aquifers.

2. The lower aquifer of the Potomac–Raritan–Magothy aquifer system is defined in the subsurface near the outcrop area between Burlington and Salem Counties.

3. The middle aquifer of the Potomac–Raritan–Magothy aquifer system occurs over the same area as the lower aquifer but is also laterally continuous in the subsurface of the northern Coastal Plain of New Jersey, where it is equivalent to the Farrington aquifer.

4. The upper aquifer of the Potomac–Raritan–Magothy aquifer system is mapped in the subsurface throughout the Coastal Plain southeast of the outcrop area of the Magothy Formation. The upper aquifer is equivalent to the Old Bridge aquifer in the northeastern Coastal Plain of New Jersey.

5. The Merchantville–Woodbury confining bed is the most extensive confining bed within the Coastal Plain. This unit functions as an effective confining bed between the upper aquifer of the Potomac–Raritan–Magothy aquifer system and the Englishtown aquifer system. In areas where the Englishtown aquifer system is absent, the Merchantville–Woodbury confining bed effectively confines the upper aquifer of the Potomac–Raritan–Magothy aquifer system from the Wenonah–Mount Laurel aquifer.

6. The Englishtown aquifer system functions primarily as a single aquifer but contains two water-bearing sands in parts of Monmouth and Ocean Counties. South of a line paralleling Forked River (Ocean County) and running through Hammonton (Atlantic County), and Bridgeton (Cumberland County), the Englishtown aquifer system is not recognized on geophysical logs that penetrate the section.

7. The Marshalltown–Wenonah confining bed is a thin, leaky unit that ranges in thickness from 20 to 80 ft. This confining bed lies between the Englishtown aquifer system and the Wenonah–Mount Laurel aquifer.

8. The Wenonah–Mount Laurel aquifer is identified in the subsurface throughout the New Jersey Coastal Plain southeast of the outcrop of the Mount Laurel Sand.

9. Sediments that overlie the Wenonah–Mount Laurel aquifer and that are subjacent to the major aquifers within the Kirkwood Formation and the Cohansey Sand function primarily as a composite confining bed but include minor aquifers, namely the Vincentown and Piney Point.

10. The Vincentown Formation functions as an aquifer within its outcrop area and for 8 to 10 mi downdip. In areas farther downdip, the Vincentown Formation functions as a confining bed.

11. The Piney Point aquifer is laterally persistent from the southern Coastal Plain northward into Burlington and Ocean Counties. The name Piney Point aquifer replaces the name Manasquan Formation for this water-bearing unit in Burlington and Ocean Counties.

12. The Atlantic City 800-foot sand of the Kirkwood Formation can be recognized in the subsurface along coastal areas of Cape May, Atlantic, and southern Ocean Counties, but only as far west as the limit of the overlying confining bed. In areas west of the limit of the overlying confining bed, the Kirkwood Formation is in hydraulic connection with the overlying Cohansey Sand and younger surficial deposits and is an unconfined aquifer.

13. The Kirkwood-Cohansey aquifer system is predominantly a water-table aquifer that underlies an area of approximately 3,000 mi^2 southeast of the updip limit of the outcrop of the Kirkwood Formation. The aquifer system is composed of the Kirkwood Formation, the Cohansey Sand, and overlying deposits of the Beacon Hill Gravel, the Bridgeton Formation, and the Cape May Formation.

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TABLES 3, 4

TABLE 3.—*Record of wells used to construct the hydrogeologic framework of the New Jersey Coastal Plain*

U.S.G.S. number	Location Latitude	Longitude	Local well identifier	Municipality	Total depth logged (feet)	Hydrogeologic section (see pl. 2)
1- 22	39°21'24"	74°25'48"	Traymore Hotel 1	Atlantic City	820	
1- 37	39°21'51"	74°24'59"	Atlantic City Water Dept. Galen Hall	do.	811	
1- 39	39°23'36"	74°23'30"	Brigantine Water Dept. New 4	Brigantine City	840	M–M'
1-116	39°32'11"	74°38'29"	Egg Harbor Water Works 3	Egg Harbor City	429	
1-117	39°32'06"	74°38'36"	Egg Harbor Water Works 5	do.	457	
1-180	39°27'54"	74°27'01"	U.S.G.S. Oceanville 1	Galloway Township	958	L–L'
1-219	39°26'25"	74°41'56"	Hamilton Township Water Dept. Test Hole 2–73	Hamilton Township	378	
1-227	39°27'09"	74°44'39"	Hamilton Township Water Dept. 5	do.	367	
1-349	39°40'41"	74°46'04"	State of N.J. Mullica 2D	Hammonton Town	214	
1-366	39°18'21"	74°32'07"	Longport Water Dept., Observation Well	Longport Borough	720	
1-369	39°19'05"	74°31'27"	Longport Water Dept. 3	do.	832	M–M'
1-566	39°24'34"	74°30'32"	Atlantic City Water Dept., 600	Pleasantville City	558	
1-578	39°18'26"	74°37'09"	U.S.G.S. Jobs Point	Somers Point City	1,000	
1-605	39°38'25"	74°49'29"	Hammonton Water Dept. 5	Hammonton Town	294	
1-648	39°21'25"	74°26'04"	Bally Park Place 1	Atlantic City	851	M–M'
1-649	39°22'46"	74°27'14"	U.S. Dept. of Energy Test Hole 4–78	do.	1,002	L–L',L'–A'
1-650	39°26'53"	74°42'54"	Hamilton Township Water Dept. Test Hole 1–73	Hamilton Township	381	
1-700	39°29'33"	74°46'04"	U.S.G.S. Atlantic City Girl Scouts 4	do.	925	
1-701	39°31'48"	74°56'17"	Buena Borough Municipal Utilities Authority T–1	Buena Borough	550	
5- 5	39°38'47"	74°30'36"	Transcontinental Gas Test Hole 16	Bass River Township	1,612	
5- 11	39°39'25"	74°31'04"	Transcontinental Gas Test Hole 15	do.	1,630	
5- 30	39°42'08"	74°26'45"	U.S.G.S. Oswego Lake 2	do.	345	L–L'
5-105	40°06'12"	74°48'53"	Hooker Chemical Co. Test Hole 1–66	Burlington Township	227	F–F'
5-117	40°07'49"	74°36'30"	Gray, Francis 1	Chesterfield Township	314	
5-127	39°59'38"	74°58'10"	N.J. Water Co. Riverton 14	Cinnaminson Township	342	
5-164	39°52'33"	74°54'18"	Evesham Municipal Utilities Authority	Evesham Township	809	
5-198	39°57'20"	74°48'22"	Mount Holly Water Co. LLWS 2	Lumberton Township	355	
5-209	40°04'12"	74°43'23"	Columbus Water Co. 3–1969	Mansfield Township	318	
5-212	40°05'15"	74°41'09"	North Burlington County High School 1	do.	344	
5-221	40°07'50"	74°45'49"	Public Service E–G Newbold Island	do.	232	
5-228	39°56'30"	74°58'55"	Maple Shade Water Dept. 10	Maple Shade Township	508	
5-249	39°52'09"	74°50'43"	Medford Township Water Dept. 3–1968	Medford Township	546	
5-262	39°55'24"	74°50'25"	U.S.G.S. Medford 4	do.	1,132	G–G'
5-274	39°58'38"	74°59'05"	Campbell Soup 1	Moorestown Township	249	
5-290	39°59'36"	74°46'55"	Mount Holly Water Co. 6	Mount Holly Township	628	I–B

TABLE 3.—*Record of wells used to construct the hydrogeologic framework of the New Jersey Coastal Plain*—Continued

U.S.G.S. number	Location		Local well identifier	Municipality	Total depth logged (feet)	Hydrogeologic section (see pl. 2)
	Latitude	Longitude				
5–293	40°00'21"	74°47'37"	Acme Food Store 1	Mount Holly Township	424	
5–303	39°56'07"	74°56'48"	Mount Laurel Municipal Utilities Authority 1	Mount Laurel Township	593	
5–332	40°01'06"	74°37'20"	U.S. Army Fort Dix 5	New Hanover Township	1,133	
5–334	40°01'38"	74°37'53"	U.S. Army Fort Dix 3	do.	852	
5–340	40°03'00"	74°35'14"	U.S. Air Force McGuire B	do.	1,008	
5–344	40°05'46"	74°34'46"	Hoffman-Laroche 1974 Well	North Hanover Township	891	
5–368	39°57'55"	74°32'39"	Pemberton Township Water Dept. 7	Pemberton Township	368	
5–378	39°58'15"	74°38'40"	Burlington County Institution 5	do.	420	
5–385	39°58'39"	74°42'49"	Ionac Chemical Corp. 5	do.	840	
5–388	39°59'39"	74°37'42"	U.S. Army Fort Dix 6	do.	1,140	F–F',J–J'
5–417	39°46'08"	74°40'54"	State of N.J. Mullica 10D	Shamong Township	244	
5–436	40°01'18"	74°40'10"	Helis, WM. G. Stock Farm 1	Springfield Township	657	
5–440	40°02'42"	74°42'23"	Rhodia Corp. 1	do.	634	F–F',I–B
5–448	40°03'55"	74°48'09"	State of N.J. 1–Rest Area	do.	211	
5–451	39°45'36"	74°35'42"	State of N.J. Mullica 5D	Tabernacle Township	216	
5–454	39°48'12"	74°40'31"	State of N.J. Mullica 3D	do.	224	
5–464	39°51'14"	74°45'42"	Amos Allen Park 1	do.	382	
5–465	39°51'23"	74°38'35"	Transcontinental Gas Test Hole 9	do.	852	
5–485	39°38'32"	74°36'08"	State of N.J. Mullica 12D	Washington Township	370	
5–488	39°38'44"	74°38'55"	State of N.J. Batsto 2	do.	546	
5–598	39°42'23"	74°41'53"	State of N.J. Mullica 11D	do.	209	
5–608	39°43'00"	74°38'30"	State of N.J. Mullica 4D	do.	314	
5–612	39°43'05"	74°33'57"	State of N.J. Mullica 13D	do.	303	
5–635	40°00'41"	74°50'49"	Inductotherm 1	Westampton Township	436	
5–644	40°00'05"	74°52'37"	Willingboro Municipal Utilities Authority DCB 12	Willingboro Township	524	G–G'
5–648	40°01'03"	74°54'09"	Willingboro Municipal Utilities Authority 3–OBS	do.	315	
5–658	40°01'58"	74°53'07"	Willingboro Municipal Utilities Authority 7	do.	304	G–G'
5–668	40°03'08"	74°53'25"	Willingboro Municipal Utilities Authority DCB 28	do.	240	
5–672	39°45'58"	74°29'50"	Transcontinental Gas Test Hole 13	Woodland Township	1,513	
5–676	39°49'14"	74°25'44"	U.S.G.S. Coyle Airport	do.	590	F–F',L–L'
5–678	39°49'40"	74°31'43"	State of N.J. Mullica 8S	do.	225	
5–681	39°50'19"	74°31'06"	Transcontinental Gas Test Hole 1	do.	1,147	
5–683	39°51'22"	74°30'17"	U.S.G.S. Butler Place 1	do.	2,275	F–F'
5–691	39°52'10"	74°37'26"	Transcontinental Gas Test Hole 11	do.	949	
5–695	39°53'28"	74°37'20"	Sunny Pines Construction Test Hole 1–74	do.	546	

TABLE 3.—*Record of wells used to construct the hydrogeologic framework of the New Jersey Coastal Plain*—Continued

U.S.G.S. number	Location: Latitude	Location: Longitude	Local well identifier	Municipality	Total depth logged (feet)	Hydrogeologic section (see pl. 2)
5-696	39°53'30"	74°29'46"	Transcontinental Gas Test Hole 5	Woodland Township	897	
5-697	39°53'51"	74°30'48"	Transcontinental Gas Test Hole 6	do.	900	
5-699	39°54'42"	74°29'50"	Transcontinental Gas Test Hole 7	do.	908	
5-724	39°54'13"	74°42'31"	Hampton Lake Water Co. 3	Southampton Township	366	
5-737	39°57'49"	74°34'48"	Jenkins & Sons 1961 Well	Pemberton Township	284	
5-739	40°01'50"	74°48'20"	Burlington County Country Club 2-1966	Westampton Township	314	
5-741	40°02'18"	74°46'04"	Laurel Oaks Enterprises 1-1973	Springfield Township	285	
5-752	39°52'47"	74°51'57"	Evesham Municipal Utilities Authority Test Hole 13	Evesham Township	510	J-J'
5-767	40°04'20"	74°52'45"	Tenneco Chemical Test Hole 4	Burlington Township	162	G-G'
7- 8	39°51'48"	75°05'42"	Bellmawr Borough Water Dept. 4	Bellmawr Borough	588	
7- 19	39°51'46"	74°56'14"	Berlin Water Dept. 10	Berlin Borough	785	
7- 78	39°56'16"	75°06'32"	Camden City Water Dept. City 5N	Camden City	183	
7-117	39°52'29"	74°57'12"	N.J. Water Co. Hutton Hill 1	Cherry Hill Township	602	
7-121	39°52'52"	74°59'43"	N.J. Water Co. Browning Test Hole 1	do.	819	
7-130	39°53'53"	74°57'08"	N.J. Water Co. Old Orchard A	do.	801	I-B
7-146	39°54'55"	74°59'24"	N.J. Water Co. Kingston 27	do.	540	
7-163	39°56'09"	75°00'28"	N.J. Water Co. Columbia 22	do.	463	
7-170	39°48'32"	74°59'15"	Clementon Water Dept. Abandoned Well	Clementon Borough	172	
7-172	39°54'26"	75°05'14"	Collingswood Water Dept. 6	Collingswood Borough	334	
7-184	39°49'50"	74°58'55"	N.J. Water Co. Gibbsboro Observation Well 1	Gibbsboro Borough	1,160	
7-221	39°53'56"	75°07'38"	U.S.G.S. Coast Guard 1	Gloucester City	254	
7-228	39°45'56"	74°58'35"	Camden Co. Bd. of Educ. Voc. & Tech. H.S. 1	Gloucester Township	471	
7-251	39°47'59"	75°01'58"	Garden State Water Co. Test Hole 1	do.	518	
7-257	39°48'29"	75°03'47"	Sun Temp Industries	do.	388	
7-278	39°52'38"	75°03'16"	N.J. Water Co. Haddon 15	Haddon Heights Borough	596	
7-283	39°52'46"	75°04'33"	N.J. Water Co. Egbert Observation Well	do.	462	
7-299	39°53'22"	75°01'54"	Haddonfield Water Dept. Layne 2	Haddonfield Borough	620	
7-303	39°54'04"	75°02'02"	Haddonfield Water Dept. Test Hole 1965	do.	551	H-H'
7-317	39°51'34"	75°02'51"	Owens Corning Test Hole 2	Magnolia Borough	675	H-H', I-B
7-320	39°56'52"	75°03'07"	Merchantville-Pennsauken Water Co. Woodbine 1	Merchantville Borough	283	H-H'
7-363	39°58'42"	75°03'12"	Camden City Water Dept. Puchack 2	Pennsauken Township	158	
7-392	39°46'41"	74°59'09"	Pine Hill Municipal Utilities Authority 1	Pine Hill Borough	715	
7-412	39°49'22"	74°56'30"	N.J. Water Co. Elm Tree 2	Voorhees Township	1,356	H-H'
7-430	39°42'04"	74°49'21"	State of N.J. Mullica 7D	Waterford Township	270	
7-451	39°46'28"	74°49'23"	State of N.J. Mullica 1D	do.	225	

TABLE 3.—*Record of wells used to construct the hydrogeologic framework of the New Jersey Coastal Plain*—Continued

U.S.G.S. number	Location		Local well identifier	Municipality	Total depth logged (feet)	Hydrogeologic section (see pl. 2)
	Latitude	Longitude				
7–469	39°41'04"	74°51'34"	Ancora State Hospital 3	Winslow Township	352	
7–476	39°42'15"	74°56'17"	U.S.G.S. New Brooklyn Park 1	do.	2,081	H–H'
7–512	39°45'22"	74°56'25"	Johns-Manville Test Hole 1	do.	892	
7–516	39°53'45"	75°06'53"	Gloucester City Water Dept. 43	Gloucester Township	281	
9– 2	39°04'20"	74°44'35"	Avalon Water Dept. 7–71	Avalon Borough	898	
9– 13	38°56'13"	74°54'57"	Cape May City Water Dept. Test Hole 10	Cape May City	1,002	
9– 19	38°55'57"	74°57'38"	Cape May Point Water Dept. Lighthouse 1	Cape May Point Borough	568	
9– 24	38°54'04"	74°57'42"	U.S.G.S. Higbee 2	Lower Township	389	
9– 33	38°56'50"	74°55'35"	Cape May County Water Dept. Cold Springs Pumping Station	do.	DL[1]	
9– 66	39°01'35"	74°53'49"	Wildwood Water Dept. Rio Grande 22	Middle Township	500	
9– 89	39°04'25"	74°54'46"	U.S.G.S. Oyster Lab. 4	do.	192	
9– 93	39°05'25"	74°48'51"	N.J. Water Co. Neptunus Test Hole 1	do.	807	M–M'
9–110	39°16'04"	74°35'39"	N.J. Water Co. Ocean City 12	Ocean City	878	M–M'
9–125	39°17'26"	74°33'52"	N.J. Water Co. Ocean City 11	do.	910	
9–126	39°07'47"	74°42'41"	Sea Isle City Water Dept. 5	Sea Isle City	860	
9–132	39°03'01"	74°45'45"	Stone Harbor Water Dept. 4	Stone Harbor Borough	966	
9–148	39°17'07"	74°37'56"	Atlantic City Electric Layne 4	Upper Township	716	
9–149	39°18'16"	74°49'53"	Morris April Bros.	do.	DL[1]	
9–159	38°58'30"	74°50'21"	Wildwood Water Dept. 35	Wildwood Crest Borough	979	
9–166	39°03'51"	74°45'04"	Stone Harbor Water Dept. 5	Stone Harbor Borough	899	
9–177	39°06'42"	74°42'48"	Wonder Ice Co. Abandoned	Avalon Borough	896	
9–181	38°57'18"	74°57'00"	Anchor Gas Dickinson 1	Lower Township	6,402	
11– 44	39°27'33"	75°09'24"	Cumberland County Vocational School 3	Deerfield Township	625	
11– 72	39°24'42"	75°19'16"	Cumberland County Sheppards 1	Greenwich Township	624	
11– 96	39°18'29"	75°12'08"	Cumberland County Jones Island 2	Lawrence Township	570	
11–116	39°11'18"	74°57'05"	Moores Beach Fire Dept.	do.	DL[1]	
11–132	39°25'12"	74°52'12"	U.S.G.S. Ragovin 1	Maurice River Township	3,738	
11–163	39°25'28"	75°06'41"	Cumberland County Fair Grounds 3	Millville City	550	
15– 1	39°39'12"	75°05'22"	Clayton Water Dept. 3	Clayton Borough	1,000	
15– 3	39°40'15"	75°05'59"	Clayton Water Dept. 4–1973	do.	938	
15– 6	39°46'27"	75°08'13"	Woodbury Water Dept. Sewell 1A	Deptford Township	345	
15– 27	39°47'51"	75°12'48"	East Greenwich Water Dept. Test 3	East Greenwich Township	238	
15–131	39°45'01"	75°12'29"	Clearview Bd. Educ. High Schl. 1	Harrison Township	440	
15–137	39°45'35"	75°20'54"	Pureland Water Co. 2(3–1973)	Logan Township	236	
15–139	39°46'08"	75°21'35"	Pureland Water Co. Test Hole 3	do.	345	I–B

[1]DL, Drillers' log.

TABLE 3.—*Record of wells used to construct the hydrogeologic framework of the New Jersey Coastal Plain*—Continued

U.S.G.S. number	Location		Local well identifier	Municipality	Total depth logged (feet)	Hydrogeologic section (see pl. 2)
	Latitude	Longitude				
15–154	39°47'15"	75°20'48"	Rollins Environmental 1	Logan Township	279	
15–157	39°47'28"	75°22'19"	Landtect Corp. Test Hole 7	do.	202	
15–183	39°44'31"	75°09'11"	Pitman Country Club 1	Mantua Township	445	
15–192	39°46'41"	75°11'09"	Mantua Township Municipal Utilities Authority 5	do.	470	
15–194	39°47'32"	75°10'37"	Mantua Township Municipal Utilities Authority 4	do.	336	
15–227	39°44'26"	75°07'47"	Pitman Water Dept. P3	Pitman Borough	516	
15–253	39°44'37"	75°02'49"	Washington Township Municipal Utilities Authority 6 (Fries Mills 1)	Washington Township	730	
15–267	39°45'46"	75°04'00"	Washington Township Municipal Utilities Authority 3	do.	642	
15–282	39°49'13"	75°11'05"	West Deptford Township Water Dept. 5 Kings Highway	West Deptford Township	482	
15–287	39°49'20"	75°12'26"	Shell Chemical Co. Test Hole 1	do.	442	
15–296	39°49'42"	75°13'17"	Shell Chemical Co. Observation Well 5	do.	329	
15–308	39°50'44"	75°12'42"	Pennwalt Corp. Test Hole 8	do.	270	
15–312	39°51'07"	75°09'46"	West Deptford Township Water Dept. 6 Red Bank Ave.	do.	384	
15–323	39°52'32"	75°09'42"	Texaco Eagle Point Observation Well 3	do.	271	
15–330	39°48'58"	75°08'45"	Woodbury Heights Borough 1 Helen Ave.	Woodbury Heights Borough	247	
15–331	39°49'55"	75°09'08"	Woodbury Water Dept. Railroad 5	Woodbury City	481	I–B
15–379	39°46'01"	75°10'05"	Mantua Township Municipal Utilities Authority 6	Mantua Township	410	
15–383	39°47'50"	75°12'49"	East Greenwich Water Dept. Test Hole 3	East Greenwich Township	308	
15–414	39°51'27"	75°08'53"	West Deptford Township Water Dept. Test Hole 7–79	West Deptford Township	361	
15–422	39°42'59"	75°08'53"	Zee Orchards 1–1980	Harrison Township	606	J–J'
15–430	39°51'53"	75°09'49"	Texaco Eagle Point 6A	West Deptford Township	342	
21– 13	40°15'36"	74°29'20"	East Windsor Municipal Utilities Authority Test Hole 5	East Windsor Township	674	D–D'
21– 30	40°09'54"	74°38'53"	Garden State Water Co. Crosswicks Water Co. 1	Hamilton Township	292	
21– 75	40°15'00"	74°40'02"	Garden State Water Co. Paxson Ave. 12	do.	150	
21– 85	40°16'25"	74°31'31"	Hightstown Water Dept. Test Hole 3	Hightstown Borough	392	D–D', I–B
21– 99	40°11'59"	74°34'03"	England, Robert 2	Washington Township	428	
21–101	40°12'38"	74°34'48"	Princeton Memorial Park 1	do.	500	E–E', I–B
21–134	40°15'35"	74°37'03"	West Windsor Water Co. Test Hole C	West Windsor Township	176	
23– 25	40°19'02"	74°29'12"	Carter Wallace 6	Cranbury Township	397	
23– 50	40°24'32"	74°22'12"	Anheuser Busch 5	East Brunswick Township	290	
23– 59	40°24'56"	74°24'42"	East Brunswick Township Water Dept. 2	do.	234	
23–114	40°23'19"	74°22'46"	Duhernal Water Co. Observation Well 52F	Old Bridge Township	224	
23–146	40°23'50"	74°18'34"	Old Bridge Municipal Utilities Authority Browntown 3	do.	510	
23–179	40°24'36"	74°20'41"	Old Bridge Municipal Utilities Authority Observation Well 2–1972	do.	329	
23–236	40°20'38"	74°23'45"	N.J. Home For Boys 4	Monroe Township	496	C–C', I–B

TABLE 3.—*Record of wells used to construct the hydrogeologic framework of the New Jersey Coastal Plain*—Continued

U.S.G.S. number	Location: Latitude	Location: Longitude	Local well identifier	Municipality	Total depth logged (feet)	Hydrogeologic section (see pl. 2)
23-291	40°21'09"	74°30'13"	Monroe Township Municipal Utilities Authority Observation Well 1	South Brunswick Township	207	
23-348	40°26'05"	74°19'57"	Sayreville Water Dept. Observation Well 101	Sayreville Borough	290	B–B', I–B
23-404	40°27'45"	74°16'45"	Sayreville Water Dept. Morgan Observation Well 1	do.	315	A–A'
23-430	40°29'23"	74°16'51"	Jersey Central Power and Light 7–1972	South Amboy City	206	
23-553	40°19'50"	74°27'50"	Monroe Township Municipal Utilities Authority Test Hole 16	Monroe Township	463	
25- 13	40°11'37"	74°01'21"	Avon Water Dept. 4	Avon By The Sea Borough	1,298	C–C', K–C', L'–A'
25- 34	40°15'58"	74°09'08"	U.S. Navy Earle 2 (B)	Colts Neck Township	837	
25- 37	40°16'10"	74°12'05"	Hominy Hills Golf Club 2–1963	do.	671	C–C', J–J'
25- 52	40°17'20"	74°03'15"	R. H. Macy & Co. Test Hole	Eatontown Borough	892	
25- 55	40°17'44"	74°21'35"	Englishtown Water Dept. 1	Englishtown Borough	598	
25- 82	40°14'12"	74°16'06"	Freehold Township Water Dept. Koenig Lane 1	Freehold Township	666	
25- 97	40°16'25"	74°15'01"	Freehold Township Water Dept. 6–Old So. Gulf 2	do.	654	
25-103	40°16'46"	74°17'37"	Freehold Township Water Dept. 7–74	do.	882	C–C'
25-119	40°24'03"	73°59'23"	Highlands Borough Water Dept. 3	Highlands Borough	895	
25-153	40°24'44"	74°10'15"	West Keansburg Water Co. 4	Holmdel Township	665	
25-156	40°24'49"	74°09'10"	Lily Tulip Test Hole–Deep	do.	793	
25-162	40°08'15"	74°10'43"	N.J. Natural Gas 1–1973	Howell Township	676	
25-168	40°09'57"	74°13'05"	Aldrich Water Co. 2	do.	609	
25-174	40°12'45"	74°15'20"	Adelphia Water Co. 2–1974	do.	843	
25-207	40°26'26"	74°11'42"	Keyport Borough Water Dept. 6	Keyport Borough	300	
25-210	40°16'39"	73°59'36"	Monmouth Consolidated Water Co. West End 1	Long Branch City	995	B–B', L'–A'
25-214	40°14'29"	74°21'46"	Manalapan Township Water Dept. Lambs Rd. 1	Manalapan Township	753	
25-218	40°15'57"	74°23'18"	Boy Scouts America Quail Hill 2	do.	482	
25-220	40°15'37"	74°20'12"	Battleground Country Club Irrigation	do.	492	
25-228	40°17'33"	74°18'18"	Gordons Corner Water Co. Observation Well	do.	815	
25-231	40°20'04"	74°18'55"	Gordons Corner Water Co. 6	do.	714	
25-249	40°19'02"	74°18'11"	Gordons Corner Water Co. 4	Marlboro Township	828	
25-251	40°19'08"	74°15'10"	Gordons Corner Water Co. 9	do.	620	
25-262	40°21'02"	74°13'53"	Marlboro State Hospital 15	do.	870	B–B'
25-272	40°22'08"	74°14'52"	Marlboro Township Municipal Utitilties Authority Observation Well 1	do.	698	
25-303	40°21'06"	74°08'10"	Bamm Hollow Country Club 1	Middletown Township	729	
25-320	40°27'05"	73°59'59"	National Park Service Fort Hancock 5A	do.	878	
25-332	40°19'30"	73°58'41"	Monmouth Beach Cold Storage 1971–Deep	Monmouth Beach Borough	845	A–A', L'–A'
25-351	40°13'23"	74°01'56"	Monmouth Consolidated Water Co. Whitesville	Neptune Township	777	L'–A'
25-360	40°20'54"	74°03'20"	Red Bank Water Dept. 4	Red Bank Borough	805	A–A', J–J'

TABLE 3.—*Record of wells used to construct the hydrogeologic framework of the New Jersey Coastal Plain*—Continued

U.S.G.S. number	Location: Latitude	Location: Longitude	Local well identifier	Municipality	Total depth logged (feet)	Hydrogeologic section (see pl. 2)
25–374	40°08'04"	74°02'27"	Sea Girt Water Dept. 5	Sea Girt Borough	755	
25–391	40°09'28"	74°02'11"	Spring Lake Hights Water Dept. 4	Spring Lk Hgts Borough	719	L'–A'
25–407	40°10'05"	74°29'39"	Punk Bros. Deep Well	Upper Freehold Township	950	
25–428	40°08'23"	74°04'55"	Wall Township Water Dept. Allenwood 1	Wall Township	755	
25–429	40°08'34"	74°08'34"	U.S.G.S. Allaire State Park C	do.	575	
25–436	40°09'52"	74°07'25"	Brisbane Child Treatment Center 3–71	do.	1,040	
25–453	40°26'32"	74°10'51"	Union Beach Water Dept. 3–77	Union Beach Borough	579	A–A'
25–456	40°26'40"	74°09'04"	International Flavor and Fragrance 3R	do.	582	
25–486	40°07'11"	74°02'02"	U.S. Dept. of Energy Test Hole 2–78	Manasquan Borough	974	L'–A'
25–487	40°09'08"	74°13'30"	Aldrich Water Co. Test Hole 4	Howell Township	622	
25–492	40°11'34"	74°10'14"	Rokeach & Sons Test Hole	Farmingdale Borough	495	
25–493	40°12'31"	74°11'27"	Howell Township 1–75	Howell Township	843	
25–495	40°18'50"	74°03'01"	U.S. Dept. of Energy Test Hole 40	Eatontown Borough	1,003	B–B'
29– 9	39°33'46"	74°14'30"	Beach Haven Water Dept. 8	Beach Haven Borough	656	
29– 19	39°48'29"	74°05'35"	U.S.G.S. Island Beach Observation Well 3 Test Well 1	Berkeley Township	3,878	E–E', L'–A'
29– 25	39°54'48"	74°14'44"	Transcontinental Gas Test Hole 20	Berkeley Township	1,426	
29– 45	40°04'31"	74°08'32"	Brick Township Municipal Utilities Authority FP 9	Brick Township	1,807	D–D', K–C'
29– 70	39°59'05"	74°03'59"	N.J. Water Co. Normandy 4	Dover Township	1,500	D–D', L'–A'
29– 85	39°59'29"	74°14'21"	Toms River Chemical 84	do.	2,242	E–E', K–C'
29–118	40°02'00"	74°21'10"	U.S. Navy Lakehurst 32	do.	1,732	
29–134	40°03'20"	74°19'54"	Jackson Township Municipal Utilities Authority SCM 1	do.	1,109	E–E'
29–138	40°04'14"	74°27'02"	U.S.G.S. Colliers Mills 1	do.	403	
29–233	40°07'42"	74°16'39"	Jackson Township Municipal Utilities Authority 4	do.	565	
29–238	40°08'19"	74°26'25"	Jackson Township Municipal Utilities Authority 7	do.	800	D–D', E–E', J–J'
29–240	40°08'47"	74°15'31"	Jackson Township Municipal Utilities Authority 5	do.	224	
29–425	39°53'23"	74°22'55"	U.S.G.S. Webbs Mills 2	Lacey Township	388	L–L'
29–429	40°00'46"	74°18'38"	Lakehurst Water Dept. 1	Lakehurst Borough	1,017	
29–433	40°03'12"	74°11'23"	Lakewood Township Municipal Utilities Authority South Lakewood 3	Lakewood Township	720	
29–440	40°05'04"	74°13'24"	N.J. Water Co. Lakewood 10	do.	1,614	D–D'
29–441	40°05'05"	74°11'14"	N.J. Water Co. Lakewood Observation Well	do.	759	
29–449	40°06'14"	74°11'57"	N.J. Water Co. Lakewood 9	do.	740	
29–453	39°58'08"	74°04'16"	Lavallette Water Dept. 4	Lavallette Borough	1,467	
29–457	39°35'10"	74°13'27"	Long Beach Water Co. Terrace 3	Long Beach Township	698	M–M'
29–462	39°32'53"	74°23'08"	Little Egg Harbor Municipal Utilities Authority Mystic 3	Little Egg Harbor Township	587	
29–464	39°34'28"	74°22'02"	Little Egg Harbor Municipal Utilities Authority Mystic 2	do.	664	

TABLE 3.—*Record of wells used to construct the hydrogeologic framework of the New Jersey Coastal Plain*—Continued

U.S.G.S. number	Location: Latitude	Location: Longitude	Local well identifier	Municipality	Total depth logged (feet)	Hydrogeologic section (see pl. 2)
29–488	39°57'29"	74°23'43"	Cedar Glen Lakes Water Co. 1	Manchester Township	208	
29–491	39°59'00"	74°21'02"	Am. Smelting & Refining 1	do.	1,700	
29–492	39°59'06"	74°21'38"	Am. Smelting & Refining Observation Well 1	do.	1,599	
29–504	40°02'10"	74°03'10"	N.J. Water Co. Mantoloking 7	Mantoloking Borough	1,375	
29–514	39°47'42"	74°14'20"	U.S.G.S. Garden State Parkway Observation Well 2	Ocean Township	462	
29–515	39°55'58"	74°10'13"	Pine Beach Water Utility 1	Pine Beach Borough	392	
29–534	39°56'09"	74°12'40"	U.S.G.S. Toms River Test Hole 2	South Toms River Borough	1,230	
29–542	39°55'47"	74°04'34"	Seaside Park Water Dept. 4	Seaside Park Borough	446	L'–A'
29–547	39°38'45"	74°10'53"	Ship Bottom Water Dept. Test Hole 1973	Ship Bottom Borough	993	F–F', L'–A'
29–560	39°39'38"	74°10'06"	Surf City Water Dept. 4	Surf City Borough	546	
29–561	39°39'48"	74°09'54"	Surf City Water Dept. 5	do.	610	
29–565	39°36'10"	74°20'31"	Tuckerton Municipal Utilities Authority 4	Tuckerton Borough	492	
29–572	39°46'17"	74°19'33"	Transcontinental Gas Test Hole 18	Union Township	1,737	F–F'
29–573	39°46'47"	74°20'25"	Transcontinental Gas Test Hole 17	do.	1,619	
29–575	40°06'52"	74°17'17"	Jackson Township Municipal Utilities Authority 9	Jackson Township	1,655	D–D'
29–583	39°44'54"	74°06'55"	Barnegat Light Water Dept. Test Hole 19–78	Barnegat Light Borough	639	L'–A'
29–585	39°50'28"	74°10'44"	U.S. Dept. of Energy Test Hole C–39	Lacey Township	967	
29–598	39°42'01"	74°12'12"	American Telephone and Telegraph Test Hole 1960	Stafford Township	440	
29–601	40°02'06"	74°12'53"	Mar Vac Building Co. House 1–74	Lakewood Township	231	
29–604	40°03'48"	74°21'19"	Powers, Ed, Domestic T–79	Jackson Township	140	
29–771	39°43'30"	73°58'36"	Amcor 6011	Offshore	958	
29–774	39°40'42"	74°14'11"	Stafford Township Municipal Utilities Authority 4	Stafford Township	520	
29–809	39°55'27"	74°08'26"	Ocean Gate Borough 4	Ocean Gate Borough	398	
33– 2	39°32'02"	75°16'30"	Cumberland County Bostwick 3	Alloway Township	562	
33– 9	39°33'30"	75°18'26"	Alger, Paul 1	do.	375	
33– 15	39°34'06"	75°20'56"	Seligman, J. R. 1	do.	91	
33– 20	39°35'34"	75°17'52"	Horner, Ephraim	do.	280	J–J'
33– 22	39°35'34"	75°10'18"	Elmer Water Co. Test Hole 3	Elmer Borough	523	
33– 33	39°27'51"	75°24'41"	L. Alloways Creek Elementary School 1	Lower Alloways Creek Township	378	
33– 64	39°39'12"	75°24'36"	E. I. DuPont Test Hole 3	Mannington Township	830	
33– 69	39°41'39"	75°23'49"	N.J. Turnpike Authority IN–1	Oldmans Township	331	
33–106	39°35'14"	75°29'11"	Linski, Alex	Pennsville Township	366	
33–107	39°36'20"	75°33'10"	State of N.J. Fort Mott SP 1	do.	118	
33–108	39°36'41"	75°33'22"	U.S. Army Finns Point	do.	319	
33–111	39°37'46"	75°29'55"	Pennsville Township Water Dept. Hook Rd. Observation Well	do.	196	

TABLE 3.—*Record of wells used to construct the hydrogeologic framework of the New Jersey Coastal Plain*—Continued

U.S.G.S. number	Location		Local well identifier	Municipality	Total depth logged (feet)	Hydrogeologic section (see pl. 2)
	Latitude	Longitude				
33-115	39°39'38"	75°30'36"	Pennsville Township Water Dept. Test Hole 2	Pennsville Township	244	
33-117	39°39'54"	75°30'13"	Pennsville Township Water Dept. 3	do.	325	
33-139	39°41'31"	75°30'09"	E. I. DuPont Chambers Observation Well 1	do.	488	
33-148	39°37'51"	75°18'48"	McBride, Gordon	Pilesgrove Township	69	
33-158	39°38'48"	75°20'10"	Acme Markets Co. 1	do.	578	
33-187	39°40'37"	75°19'15"	U.S.G.S. Point Airy Observation Well	do.	672	
33-194	39°41'02"	75°19'43"	Kelly W. F.	do.	475	
33-198	39°41'17"	75°22'07"	DuBois Brothers Irrigation 74	do.	417	
33-209	39°30'13"	75°08'16"	Parvin State Park B	Pittsgrove Township	220	
33-236	39°30'04"	75°20'26"	Calls Trailer Camp	Quinton Township	330	
33-241	39°32'53"	75°24'22"	Salem City Water Dept. Quinton St	do.	294	
33-251	39°33'48"	75°27'55"	U.S.G.S. Salem 1	Salem City	800	
33-280	39°36'25"	75°15'13"	Daretown Public School 1	Upper Pittsgrove Township	441	
33-302	39°40'00"	75°24'39"	E. I. DuPont Courses Landing 2A	Upper Penns Neck	804	I-B
33-346	39°42'56"	75°27'18"	Penns Grove Water Supply Co. Layne 1	do.	368	
33-384	39°31'37"	75°24'58"	Wild Oak Country Club 1-IRR-73	Quinton Township	268	J-J'
33-389	39°32'23"	75°04'42"	E. I. DuPont Test Hole 2-66	Pittsgrove Township	1,042	
33-391	39°33'38"	75°27'01"	Boscos Diner	Quinton Township	326	
33-393	39°37'50"	75°31'49"	Pennsville Township Water Dept. Test Hole 1-64	Pennsville Township	809	I-B
33-394	39°38'35"	75°16'55"	Lautenbach, Wm. House Well	Pilesgrove Township	134	
33-401	39°27'51"	75°32'07"	Public Service E-G Test Hole 1-80	Lower Alloways Creek Township	1,800	
PH-19	39°53'14"	75°10'10"	U.S. Naval Base	Philadelphia, Pa.	248	

TABLE 4.—*Altitudes of top and*

[In feet above

U.S.G.S. number	Altitude of land surface	Kirkwood–Cohansey aquifer system	Atlantic City 800-foot sand		Piney Point aquifer		Vincentown aquifer	
		Base	Top	Base	Top	Base	Top	Base
1– 22	10	−398	−698	—	—	—	—	—
1– 37	10	−399	−692	—	—	—	—	—
1– 39	10	−326	−651	−785	—	—	—	—
1–116	45	−160	—	—	—	—	—	—
1–117	45	−157	−304	−393	—	—	—	—
1–180	27	−200	−491	−627	−717	−767	—	—
1–219	60	−248	—	—	—	—	—	—
1–227	10	−200	−278	—	—	—	—	—
1–349	59	−143	—	—	—	—	—	—
1–366	5	−280	—	—	—	—	—	—
1–369	5	−303	−645	−800	—	—	—	—
1–566	12	−258	−512	—	—	—	—	—
1–578	10	−266	−560	−692	−808	−862	—	—
1–605	110	−173	—	—	—	—	—	—
1–648	7	−393	−681	−835	—	—	—	—
1–649	5	−312	−647	−780	−902	−964	—	—
1–650	20	−221	−300	—	—	—	—	—
1–700	40	−136	−200	−298	−446	−531	—	—
1–701	118	−154	—	—	−272	—	—	—
5– 5	18	—	—	—	—	—	—	—
5– 11	19	−307	—	—	—	—	—	—
5– 30	92	−268	—	—	−367	−504	—	—
5–105	33	—	—	—	—	—	—	—
5–117	95	—	—	—	—	—	—	—
5–127	35	—	—	—	—	—	—	—
5–164	110	—	—	—	—	—	80	30
5–198	10	—	—	—	—	—	—	—
5–209	73	—	—	—	—	—	—	—
5–212	82	—	—	—	—	—	—	—
5–221	10	—	—	—	—	—	—	—
5–228	40	—	—	—	—	—	—	—
5–249	55	—	—	—	—	—	—	—
5–262	74	—	—	—	—	—	—	—
5–274	40	—	—	—	—	—	—	—
5–290	15	—	—	—	—	—	—	—
5–293	60	—	—	—	—	—	—	—
5–303	20	—	—	—	—	—	—	—
5–332	150	—	—	—	—	—	—	40
5–334	165	—	—	—	—	—	135	50
5–340	126	—	—	—	—	—	—	—
5–344	136	—	—	—	—	—	—	—
5–368	90	10	—	—	—	—	—	—
5–378	65	—	—	—	—	—	—	—
5–385	30	—	—	—	—	—	—	—
5–388	160	44	—	—	—	—	1	−28
5–417	48	−137	—	—	−164	—	—	—
5–436	96	—	—	—	—	—	—	—
5–440	75	—	—	—	—	—	—	—
5–448	40	—	—	—	—	—	—	—
5–451	67	−116	—	—	—	—	—	—

base of hydrogeologic units

or below sea level]

Wenonah-Mount Laurel aquifer		Englishtown aquifer system		Potomac-Raritan-Magothy aquifer system					
				Upper aquifer		Middle aquifer		Lower aquifer	
Top	Base	Top	Base	Top	Base	Top	Base	Top	Base
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
-980	-1,076	—	—	-1,401	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	-75	-165	—	—
—	—	41	-3	-171	—	—	—	—	—
—	—	—	—	—	-22	-65	-167	-239	-287
-34	-98	-146	-162	-350	-450	-560	-635	—	—
-24	-72	-92	-140	-322	—	—	—	—	—
—	—	—	39	-123	-207	—	—	—	—
—	—	60	17	-142	-231	—	—	—	—
—	—	—	—	—	—	-157	-203	—	—
—	—	—	—	-93	-176	-232	-282	-390	-471
-95	-165	-223	-241	-453	—	—	—	—	—
6	-79	-108	-192	-322	-414	-544	-703	-764	-1,022
—	—	—	—	-10	-90	—	—	—	—
—	—	—	-73	-240	-360	-511	-613	—	—
—	34	-3	-73	-224	-306	—	—	—	—
—	—	—	-30	-142	-207	-250	-376	-460	—
-26	-90	-153	-178	-384	-516	—	—	—	—
-29	-98	-137	-191	-363	—	-670	—	—	—
6	-68	-124	-174	-354	-507	-654	-710	—	—
74	6	-34	-113	-288	-344	-454	-528	—	—
-200	—	—	—	—	—	—	—	—	—
-123	-227	-263	-298	—	—	—	—	—	—
-30	-130	-170	-212	-450	-500	-710	-818	—	—
-98	-180	-233	-259	-476	-592	-740	—	—	—
—	—	—	—	—	—	—	—	—	—
32	-60	-95	-141	-315	-422	—	—	—	—
—	33	8	-36	-206	-325	-434	-566	—	—
—	—	—	—	-22	-104	-153	—	—	—
—	—	—	—	—	—	—	—	—	—

TABLE 4.—*Altitudes of top and base*

[In feet above

U.S.G.S. number	Altitude of land surface	Kirkwood–Cohansey aquifer system	Atlantic City 800-foot sand		Piney Point aquifer		Vincentown aquifer	
		Base	Top	Base	Top	Base	Top	Base
5–454	67	−100	—	—	−135	—	—	—
5–464	130	—	—	—	—	—	—	—
5–465	98	−53	—	—	—	—	—	—
5–485	51	−305	—	—	—	—	—	—
5–488	35	−269	—	—	−340	−429	—	—
5–598	34	−150	—	—	—	—	—	—
5–608	63	−165	—	—	−234	—	—	—
5–612	41	−183	—	—	—	—	—	—
5–635	65	—	—	—	—	—	—	—
5–644	18	—	—	—	—	—	—	—
5–648	34	—	—	—	—	—	—	—
5–658	19	—	—	—	—	—	—	—
5–668	48	—	—	—	—	—	—	—
5–672	90	−135	—	—	−266	−361	—	—
5–676	197	−111	—	—	−231	−350	—	—
5–678	112	−88	—	—	—	—	—	—
5–681	108	−102	—	—	—	—	—	—
5–683	132	−90	—	—	−175	−240	—	—
5–691	109	−56	—	—	—	—	—	—
5–695	111	−47	—	—	—	—	—	—
5–696	124	−56	—	—	—	—	—	—
5–697	144	−56	—	—	—	—	—	—
5–699	117	−56	—	—	—	—	—	—
5–724	43	—	—	—	—	—	—	—
5–737	75	25	—	—	—	—	—	—
5–739	80	—	—	—	—	—	—	—
5–741	35	—	—	—	—	—	—	—
5–752	45	—	—	—	—	—	35	−11
5–767	10	—	—	—	—	—	—	—
7– 8	80	—	—	—	—	—	—	—
7– 19	145	−10	—	—	—	—	—	—
7– 78	22	—	—	—	—	—	—	—
7–117	156	—	—	—	—	—	112	78
7–121	80	—	—	—	—	—	—	—
7–130	71	—	—	—	—	—	—	—
7–146	40	—	—	—	—	—	—	—
7–163	32	—	—	—	—	—	—	—
7–170	55	—	—	—	—	—	25	−21
7–172	10	—	—	—	—	—	—	—
7–184	70	—	—	—	—	—	40	17
7–221	10	—	—	—	—	—	—	—
7–228	145	−15	—	—	—	—	—	—
7–251	75	—	—	—	—	—	45	29
7–257	75	—	—	—	—	—	—	49
7–278	65	—	—	—	—	—	—	—
7–283	24	—	—	—	—	—	—	—
7–299	75	—	—	—	—	—	—	—
7–303	55	—	—	—	—	—	—	—
7–317	68	—	—	—	—	—	—	—
7–320	65	—	—	—	—	—	—	—

of hydrogeologic units—Continued

or below sea level]

Wenonah–Mount Laurel aquifer		Englishtown aquifer system		Potomac–Raritan–Magothy aquifer system					
				Upper aquifer		Middle aquifer		Lower aquifer	
Top	Base	Top	Base	Top	Base	Top	Base	Top	Base
—	—	—	—	—	—	—	—	—	—
−230	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	5	−130	−177	−223	—	—	—
—	—	—	−2	−132	−175	−222	−370	−401	−498
—	—	—	—	−81	−120	−168	—	—	—
—	—	—	—	−12	−29	−62	−238	—	—
—	—	—	—	—	−17	−44	−200	—	—
−750	−840	−860	—	−1,182	−1,291	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
−558	−662	−681	−750	−948	−1,074	—	—	—	—
−347	−461	−501	−543	−751	—	—	—	—	—
−297	−401	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
−436	−530	−592	−638	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	−147	−257	−294	—	—	—	—	—	—
−195	—	—	—	—	—	—	—	—	—
—	—	50	−10	−146	−230	—	—	—	—
—	—	—	−28	−165	—	—	—	—	—
−61	−151	−182	−194	−393	—	—	—	—	—
—	—	—	—	—	—	−13	−129	—	—
—	—	—	—	−101	−189	−242	−320	−370	−480
−151	−225	−285	−315	−485	−568	—	—	—	—
—	—	—	—	—	−1	−19	−57	−80	−149
24	−8	−80	−94	−271	−417	—	—	—	—
—	4	−32	−47	−210	−282	−377	−548	−568	−682
—	17	−36	−79	−216	−292	−380	−521	−577	−676
—	—	—	10	−126	−198	−226	−390	−425	−483
—	—	—	—	−71	−142	−183	−278	−338	−438
−69	—	—	—	—	—	—	—	—	—
—	—	—	—	−56	−91	−105	−141	−178	−298
−38	−93	−147	−176	−348	−420	−452	−630	−800	1,027
—	—	—	—	—	−82	−106	−162	−192	−237
−165	−271	−309	—	—	—	—	—	—	—
−17	−97	−131	−155	−316	—	—	—	—	—
10	−77	−109	−143	−284	—	—	—	—	—
—	34	8	−23	−127	−215	−231	−301	−388	−535
—	—	—	—	−83	−164	−176	−233	−343	−468
—	—	—	—	−119	−214	−254	−388	−472	−535
—	—	—	—	−98	−188	−229	−325	−387	−461
—	38	−1	−57	−184	−302	−336	−426	−501	—
—	—	—	—	—	−21	−59	−123	−153	—

TABLE 4.—*Altitudes of top and base*

[In feet above

U.S.G.S. number	Altitude of land surface	Kirkwood-Cohansey aquifer system	Atlantic City 800-foot sand		Piney Point aquifer		Vincentown aquifer	
		Base	Top	Base	Top	Base	Top	Base
7-363	14	—	—	—	—	—	—	—
7-392	150	—	—	—	—	—	—	—
7-412	150	60	—	—	—	—	20	-24
7-430	94	-86	—	—	-162	—	—	—
7-451	122	-56	—	—	—	—	—	—
7-469	105	-101	—	—	-167	—	—	—
7-476	111	-38	—	—	-100	-135	—	—
7-512	160	-25	—	—	—	—	—	—
7-516	10	—	—	—	—	—	—	—
9- 2	5	-367	-795	-918	—	—	—	—
9- 13	10	-315	-666	-886	—	—	—	—
9- 19	6	-280	—	—	—	—	—	—
9- 24	9	-241	—	—	—	—	—	—
9- 33	15	-295	-645	-810	—	—	—	—
9- 66	5	-247	—	—	—	—	—	—
9- 89	7	-202	—	—	—	—	—	—
9- 93	6	-264	-635	-790	—	—	—	—
9-110	6	-280	-643	-809	—	—	—	—
9-125	10	-300	-643	-803	—	—	—	—
9-126	7	-324	—	—	—	—	—	—
9-132	7	-377	-820	-954	—	—	—	—
9-148	9	-281	-569	—	—	—	—	—
9-149	12	-145	—	—	—	—	—	—
9-159	5	-337	-784	-927	—	—	—	—
9-166	5	-340	-789	—	—	—	—	—
9-177	5	-346	-750	-905	—	—	—	—
9-181	22	—	-588	-768	-923	-1,013	—	—
11- 44	80	-88	—	—	-196	-330	—	—
11- 72	12	-38	—	—	-146	-281	—	—
11- 96	10	-264	—	—	-343	-555	—	—
11-116	5	-165	—	—	—	—	—	—
11-132	91	-400	—	—	-479	-505	—	—
11-163	80	-149	—	—	-258	-424	—	—
15- 1	133	28	—	—	-68	-157	—	—
15- 3	140	56	—	—	—	—	—	—
15- 6	20	—	—	—	—	—	—	—
15- 27	47	—	—	—	—	—	—	—
15-131	130	—	—	—	—	—	—	80
15-137	29	—	—	—	—	—	—	—
15-139	8	—	—	—	—	—	—	—
15-154	20	—	—	—	—	—	—	—
15-157	5	—	—	—	—	—	—	—
15-183	85	—	—	—	—	—	—	52
15-192	88	—	—	—	—	—	—	—
15-194	10	—	—	—	—	—	—	—
15-227	100	—	—	—	—	—	—	36
15-253	152	66	—	—	—	—	—	—
15-267	150	70	—	—	—	—	-10	-34
15-282	55	—	—	—	—	—	—	—
15-287	30	—	—	—	—	—	—	—

of hydrogeologic units—Continued

or below sea level]

Wenonah–Mount Laurel aquifer		Englishtown aquifer system		Potomac–Raritan–Magothy aquifer system					
				Upper aquifer		Middle aquifer		Lower aquifer	
Top	Base	Top	Base	Top	Base	Top	Base	Top	Base
—	—	—	—	—	−4	−19	−48	−66	−144
−112	−204	−246	−282	−443	−535	—	—	—	—
−71	−161	−184	−246	−398	−504	−532	−660	−802	−1,076
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
−378	−477	−502	−561	−687	−789	—	—	—	—
−238	−360	−386	−410	−578	−660	—	—	—	—
—	—	—	—	—	−112	−124	−167	−203	−262
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
−1,964	−1,988	—	—	−2,179	−2,230	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
−1,205	−1,271	—	—	−1,385	−1,477	—	—	—	—
—	—	—	—	—	—	—	—	—	—
−287	−415	−445	−465	−609	—	—	—	—	—
−226	−340	−368	−391	−529	—	—	—	—	—
—	—	−54	−98	−200	—	—	—	—	—
—	—	—	—	−89	—	—	—	—	—
20	−60	−86	−108	−230	—	—	—	—	—
—	—	—	—	−16	−89	−132	—	—	—
—	—	—	—	—	−50	−113	−188	−262	−340
—	—	—	—	—	—	—	−138	−177	−249
—	—	—	—	—	—	—	−105	−145	−202
3	−79	−103	−120	−259	—	—	—	—	—
—	—	—	—	−202	−302	—	—	—	—
—	—	—	—	−166	−285	—	—	—	—
−20	−106	−126	−146	−293	−388	—	—	—	—
−112	−206	−232	−264	−430	−566	—	—	—	—
−80	−170	−205	−236	−395	—	—	—	—	—
—	—	—	—	−54	−181	−234	−305	−329	—
—	—	—	—	−35	−123	−199	−242	−276	−360

TABLE 4.—*Altitudes of top and base*

[In feet above

U.S.G.S. number	Altitude of land surface	Kirkwood-Cohansey aquifer system	Atlantic City 800-foot sand		Piney Point aquifer		Vincentown aquifer	
		Base	Top	Base	Top	Base	Top	Base
15–296	17	—	—	—	—	—	—	—
15–308	10	—	—	—	—	—	—	—
15–312	20	—	—	—	—	—	—	—
15–323	21	—	—	—	—	—	—	—
15–330	40	—	—	—	—	—	—	—
15–331	30	—	—	—	—	—	—	—
15–379	125	—	—	—	—	—	—	71
15–383	51	—	—	—	—	—	—	—
15–414	30	—	—	—	—	—	—	—
15–422	140	90	—	—	—	—	19	−3
15–430	15	—	—	—	—	—	—	—
21– 13	120	—	—	—	—	—	—	—
21– 30	25	—	—	—	—	—	—	—
21– 75	76	—	—	—	—	—	—	—
21– 85	100	—	—	—	—	—	—	—
21– 99	118	—	—	—	—	—	—	—
21–101	135	—	—	—	—	—	—	—
21–134	65	—	—	—	—	—	—	—
23– 25	120	—	—	—	—	—	—	—
23– 50	76	—	—	—	—	—	—	—
23– 59	122	—	—	—	—	—	—	—
23–114	25	—	—	—	—	—	—	—
23–146	80	—	—	—	—	—	—	—
23–179	10	—	—	—	—	—	—	—
23–236	90	—	—	—	—	—	—	—
23–291	107	—	—	—	—	—	—	—
23–348	34	—	—	—	—	—	—	—
23–404	23	—	—	—	—	—	—	—
23–430	12	—	—	—	—	—	—	—
23–553	130	—	—	—	—	—	—	—
25– 13	29	—	—	—	—	−172	—	—
25– 34	135	—	—	—	—	—	67	29
25– 37	135	—	—	—	—	—	—	108
25– 52	70	—	—	—	—	—	70	−48
25– 55	70	—	—	—	—	—	—	—
25– 82	130	—	—	—	—	—	—	—
25– 97	200	—	—	—	—	—	—	—
25–103	107	—	—	—	—	—	—	—
25–119	20	—	—	—	—	—	—	—
25–153	65	—	—	—	—	—	—	—
25–156	60	—	—	—	—	—	—	—
25–162	69	−11	—	—	—	—	—	—
25–168	150	42	—	—	—	—	−64	−113
25–174	102	—	—	—	—	—	—	44
25–207	11	—	—	—	—	—	—	—
25–210	10	—	—	—	—	—	10	−136
25–214	190	—	—	—	—	—	—	—
25–218	258	—	—	—	—	—	—	—
25–220	140	—	—	—	—	—	—	—
25–228	148	—	—	—	—	—	—	—

of hydrogeologic units—Continued

or below sea level]

Wenonah–Mount Laurel aquifer		Englishtown aquifer system		Potomac–Raritan–Magothy aquifer system					
				Upper aquifer		Middle aquifer		Lower aquifer	
Top	Base	Top	Base	Top	Base	Top	Base	Top	Base
—	—	—	—	−23	−117	−183	−233	−269	—
—	—	—	—	—	−91	−156	−186	−225	—
—	—	—	—	−61	−135	−160	−190	−291	−356
—	—	—	—	—	−91	−111	−164	−224	—
—	—	—	—	−104	−194	—	—	—	—
—	—	—	—	−96	−182	−230	−308	−337	−450
29	−51	−75	−99	−234	—	—	—	—	—
—	—	—	—	−83	—	—	—	—	—
—	—	—	—	−32	−119	−130	−199	−252	—
−53	−154	−175	−205	−338	−438	—	—	—	—
—	—	—	—	—	—	—	—	−240	−315
—	—	—	88	−82	−212	−278	−446	—	—
—	—	—	—	−65	−121	−215	—	—	—
—	—	—	—	—	—	−38	—	—	—
—	—	—	—	2	−96	−170	−286	—	—
—	—	—	62	−92	−199	−268	—	—	—
—	—	—	—	−39	−125	−225	−310	—	—
—	—	—	—	—	—	−61	−100	—	—
—	—	—	—	24	−81	−107	−250	—	—
—	—	—	—	—	—	−153	−233	—	—
—	—	—	—	—	—	−42	—	—	—
—	—	—	—	—	−75	−183	—	—	—
—	—	—	—	—	—	−251	—	—	—
—	—	—	—	—	−80	−204	−291	—	—
—	—	—	—	−80	−158	−280	—	—	—
—	—	—	—	—	—	−32	—	—	—
—	—	—	—	—	−56	−159	−251	—	—
—	—	—	—	—	−90	−178	−267	—	—
—	—	—	—	—	—	−116	−155	—	—
—	—	—	—	17	−92	−131	−295	—	—
−395	−443	−510	−627	−956	−1,167	—	—	—	—
−101	−174	−205	−295	−505	—	—	—	—	—
−44	−124	−137	−235	−425	—	—	—	—	—
−174	−232	−282	−386	−671	—	—	—	—	—
—	—	—	12	−204	−311	−461	—	—	—
−4	−56	−107	−184	−392	—	—	—	—	—
20	−30	−66	−156	−350	—	—	—	—	—
81	17	−9	−97	−315	−483	−593	−690	—	—
—	—	—	−235	−604	−756	—	—	—	—
—	—	—	—	−321	−391	−567	−625	—	—
—	—	—	−52	−334	−412	—	—	—	—
−275	−384	−435	−583	—	—	—	—	—	—
−207	−292	−330	—	—	—	—	—	—	—
−74	−146	−186	−262	−506	−658	—	—	—	—
—	—	—	—	−182	−269	—	—	—	—
−238	−346	−385	−510	−756	−980	—	—	—	—
94	4	−40	−90	−318	−456	—	—	—	—
184	106	55	−10	−186	—	—	—	—	—
100	10	−8	−99	−280	—	—	—	—	—
131	73	38	−72	−294	−420	—	—	—	—

TABLE 4.—*Altitudes of top and base*
[In feet above

U.S.G.S. number	Altitude of land surface	Kirkwood–Cohansey aquifer system	Atlantic City 800-foot sand		Piney Point aquifer		Vincentown aquifer	
		Base	Top	Base	Top	Base	Top	Base
25–231	121	—	—	—	—	—	—	—
25–249	140	—	—	—	—	—	—	—
25–251	125	—	—	—	—	—	—	—
25–262	135	—	—	—	—	—	—	—
25–272	118	—	—	—	—	—	—	—
25–303	70	—	—	—	—	—	—	—
25–320	14	—	—	—	—	—	—	—
25–332	10	—	—	—	—	—	—	—
25–351	18	—	—	—	—	—	−112	−206
25–360	146	—	—	—	—	—	—	—
25–374	20	—	—	—	—	—	—	—
25–391	20	−16	—	—	—	—	—	—
25–407	129	—	—	—	—	—	—	—
25–428	112	—	—	—	—	—	—	—
25–429	95	—	—	—	—	—	—	—
25–436	60	—	—	—	—	—	—	—
25–453	10	—	—	—	—	—	—	—
25–456	10	—	—	—	—	—	—	—
25–486	10	−110	—	—	—	—	—	—
25–487	130	20	—	—	—	—	−100	−140
25–492	80	—	—	—	—	—	−52	−99
25–493	130	—	—	—	—	—	98	−40
25–495	15	—	—	—	—	—	—	—
29– 9	5	−268	−554	−675	—	—	—	—
29– 19	10	−394	—	—	−518	−565	—	—
29– 25	41	—	—	—	—	—	—	—
29– 45	8	−136	—	—	—	—	—	—
29– 70	5	—	—	−235	—	—	—	—
29– 85	65	−140	—	—	—	—	—	—
29–118	100	—	—	—	—	—	—	—
29–134	95	20	—	—	—	—	—	—
29–138	137	79	—	—	—	—	7	−43
29–233	80	—	—	—	—	—	−82	−124
29–238	133	—	—	—	—	—	—	87
29–240	75	41	—	—	—	—	−45	−135
29–425	126	−106	—	—	−190	−261	—	—
29–429	65	−35	—	—	—	—	—	—
29–433	50	−68	—	—	—	—	—	—
29–440	72	−24	—	—	—	—	—	—
29–441	30	—	—	—	—	—	—	—
29–449	55	—	—	—	—	—	—	—
29–453	10	—	—	—	—	—	—	—
29–457	8	−247	−530	−651	—	—	—	—
29–462	8	—	−453	−562	—	—	—	—
29–464	25	−150	−447	−523	—	—	—	—

of hydrogeologic units—Continued

or below sea level]

Wenonah–Mount Laurel aquifer		Englishtown aquifer system		Potomac–Raritan–Magothy aquifer system					
				Upper aquifer		Middle aquifer		Lower aquifer	
Top	Base	Top	Base	Top	Base	Top	Base	Top	Base
—	—	—	9	−197	−302	−441	−594	—	—
—	86	60	−34	−248	−328	−524	−670	—	—
73	2	−27	−83	−343	−443	—	—	—	—
66	29	17	−53	−289	−419	−575	−695	—	—
—	102	66	28	−212	−354	−471	—	—	—
—	—	−52	−170	−426	−602	—	—	—	—
—	—	—	−102	−394	−535	−715	−851	—	—
−182	−236	−286	−414	−720	—	—	—	—	—
−318	−390	−442	−562	—	—	—	—	—	—
−34	−94	−110	−258	−458	−624	—	—	—	—
—	—	−626	—	—	—	—	—	—	—
−469	−541	−584	—	—	—	—	—	—	—
88	68	−17	−99	−281	−375	−457	−501	—	—
—	—	—	—	—	—	—	—	—	—
−351	−410	−471	—	—	—	—	—	—	—
−328	−398	−446	−632	−824	—	—	—	—	—
—	—	—	—	−218	−294	−452	−528	—	—
—	—	—	—	−204	−316	—	—	—	—
−541	−602	−657	−857	—	—	—	—	—	—
−228	−298	−345	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
−146	−257	−314	−422	−620	—	—	—	—	—
−117	−157	−235	−327	−543	−765	−867	−967	—	—
—	—	—	—	—	—	—	—	—	—
−1,190	−1,250	—	—	−1,742	−1,910	—	—	—	—
−808	−863	−943	−1,040	−1,260	−1,379	—	—	—	—
−496	−562	−614	−794	−1,004	−1,188	−1,322	—	—	—
−798	−865	—	−1,086	−1,307	−1,473	—	—	—	—
−589	−635	−717	−851	−1,052	−1,235	−1,357	—	—	—
−296	−360	−420	−565	−742	−862	−950	—	—	—
−275	−361	−417	−560	−743	−871	−990	—	—	—
−119	−209	−249	—	—	—	—	—	—	—
−210	−296	−350	—	—	—	—	—	—	—
−17	−74	−124	−223	−433	−511	−610	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
−433	−499	−559	−709	−905	—	—	—	—	—
−497	−573	−618	—	—	—	—	—	—	—
−358	−453	−505	−668	−904	−1,052	−1,166	—	—	—
−427	−506	−554	−722	—	—	—	—	—	—
−345	−435	−493	−655	—	—	—	—	—	—
−810	−880	—	−1,115	−1,334	−1,500	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—

TABLE 4.—*Altitudes of top and base*

[In feet above

U.S.G.S. number	Altitude of land surface	Kirkwood–Cohansey aquifer system	Atlantic City 800-foot sand		Piney Point aquifer		Vincentown aquifer	
		Base	Top	Base	Top	Base	Top	Base
29–488	170	−20	—	—	—	—	—	—
29–491	89	−50	—	—	—	—	—	—
29–492	97	−40	—	—	—	—	—	—
29–504	5	−180	—	—	—	—	—	—
29–514	44	−290	—	—	—	—	—	—
29–515	30	−196	—	—	—	—	—	—
29–534	18	—	—	—	—	—	—	—
29–542	12	−248	—	—	−428	—	—	—
29–547	7	−221	−453	−579	−675	−803	—	—
29–560	10	−200	−430	−536	—	—	—	—
29–561	10	−200	—	—	—	—	—	—
29–565	10	−180	−445	—	—	—	—	—
29–572	148	−299	—	—	—	—	—	—
29–573	156	−253	—	—	−394	−504	—	—
29–575	135	55	—	—	—	—	−99	−141
29–583	5	−157	−379	−419	−590	—	—	—
29–585	15	−267	—	—	−361	−433	—	—
29–598	5	−193	−405	—	—	—	—	—
29–601	95	−33	—	—	—	—	—	—
29–604	115	58	—	—	—	—	—	—
29–771	0	−258	−523	−599	−706	—	—	—
29–774	8	−202	−374	−481	—	—	—	—
29–809	8	−204	—	—	−314	—	—	—
33– 2	85	25	—	—	−85	−175	—	—
33– 9	77	—	—	—	—	—	−167	−206
33– 15	30	—	—	—	—	—	−52	—
33– 20	77	—	—	—	—	—	−107	−129
33– 22	105	—	—	—	—	—	—	—
33– 33	12	—	—	—	−79	−119	−208	−240
33– 64	20	—	—	—	—	—	—	—
33– 69	40	—	—	—	—	—	—	—
33–106	10	—	—	—	—	—	—	—
33–107	8	—	—	—	—	—	—	—
33–108	7	—	—	—	—	—	—	—
33–111	10	—	—	—	—	—	—	—
33–115	7	—	—	—	—	—	—	—
33–117	7	—	—	—	—	—	—	—
33–139	5	—	—	—	—	—	—	—
33–148	69	—	—	—	—	—	16	—
33–158	57	—	—	—	—	—	37	12
33–187	71	—	—	—	—	—	—	—
33–194	90	—	—	—	—	—	—	—
33–198	51	—	—	—	—	—	—	—
33–209	75	−79	—	—	—	—	—	—
33–236	60	—	—	—	−88	−165	—	—
33–241	10	—	—	—	—	—	−15	−94
33–251	6	—	—	—	—	—	—	—
33–280	133	87	—	—	—	—	−134	−150
33–302	30	—	—	—	—	—	—	—
33–346	12	—	—	—	—	—	—	—

of hydrogeologic units—Continued

or below sea level]

Wenonah–Mount Laurel aquifer		Englishtown aquifer system		Potomac–Raritan–Magothy aquifer system					
				Upper aquifer		Middle aquifer		Lower aquifer	
Top	Base	Top	Base	Top	Base	Top	Base	Top	Base
—	—	—	—	—	—	—	—	—	—
-449	-531	-585	-729	-900	-1,055	—	—	—	—
—	—	—	—	—	—	—	—	—	—
-695	-765	-841	—	-1,278	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
-748	-845	-891	-1,012	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
-978	-1,042	-1,092	-1,187	-1,468	—	—	—	—	—
-942	-1,010	—	—	-1,428	—	—	—	—	—
-233	-277	-357	-507	-695	-812	-945	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
-307	-443	—	—	—	—	—	—	—	—
-246	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
-178	—	—	—	—	—	—	—	—	—
-309	-415	—	—	—	—	—	—	—	—
-302	—	—	—	—	—	—	—	—	—
—	—	—	—	-154	-220	—	-563	-640	—
—	—	—	—	-116	—	-250	—	—	—
—	-80	-94	-106	-215	-265	—	—	—	—
—	—	—	—	-102	—	—	—	—	—
—	—	—	—	-99	-139	-189	—	—	—
—	—	—	—	-128	-170	—	—	—	—
—	—	—	—	—	-99	-139	—	—	—
—	—	—	—	—	-98	-140	-277	—	—
—	—	—	—	—	—	-35	-185	-255	-440
—	—	—	—	—	—	—	—	—	—
-26	-103	-133	-180	-284	-300	-482	—	—	—
19	-64	-82	-119	-223	-269	-365	—	—	—
36	-42	-62	-94	-199	-225	-326	—	—	—
—	1	-39	-70	-159	-185	-272	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
-165	—	—	—	—	—	—	—	—	—
-54	-142	-174	-194	-309	-354	-534	-775	—	—
-188	-301	—	—	—	—	—	—	—	—
—	-18	-25	-62	-149	-200	-270	-493	-615	—
—	—	—	—	—	—	-79	-188	-218	—

TABLE 4.—*Altitudes of top and base*

[In feet above

U.S.G.S. number	Altitude of land surface	Kirkwood–Cohansey aquifer system	Atlantic City 800-foot sand		Piney Point aquifer		Vincentown aquifer	
		Base	Top	Base	Top	Base	Top	Base
33–384	22	—	—	—	—	—	−64	−131
33–389	80	−72	—	—	−193	−336	—	—
33–391	14	—	—	—	—	—	—	—
33–393	9	—	—	—	—	—	—	—
33–394	130	—	—	—	—	—	21	—
33–401	20	—	—	—	—	—	−48	−118
PH–19	10	—	—	—	—	—	—	—

of hydrogeologic units—Continued

or below sea level]

Wenonah–Mount Laurel aquifer		Englishtown aquifer system		Potomac–Raritan–Magothy aquifer system					
				Upper aquifer		Middle aquifer		Lower aquifer	
Top	Base	Top	Base	Top	Base	Top	Base	Top	Base
−188	—	—	—	—	—	—	—	—	—
—	—	−630	−670	−860	−923	—	—	—	—
−77	−186	—	—	—	—	—	—	—	—
—	—	—	—	−102	−149	−187	−365	−476	−766
—	—	—	—	—	—	—	—	—	—
−146	−252	—	—	−410	−470	—	—	—	—
—	—	—	—	—	−51	−90	−118	−179	—

SELECTED SERIES OF U.S. GEOLOGICAL SURVEY PUBLICATIONS

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Bulletins contain significant data and interpretations that are of lasting scientific interest but are generally more limited in scope or geographic coverage than Professional Papers. They include the results of resource studies and of geologic and topographic investigations; as well as collections of short papers related to a specific topic.

Water-Supply Papers are comprehensive reports that present significant interpretive results of hydrologic investigations of wide interest to professional geologists, hydrologists, and engineers. The series covers investigations in all phases of hydrology, including hydrogeology, availability of water, quality of water, and use of water.

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Maps

Geologic Quadrangle Maps are multicolor geologic maps on topographic bases in 7 1/2- or 15-minute quadrangle formats (scales mainly 1:24,000 or 1:62,500) showing bedrock, surficial, or engineering geology. Maps generally include brief texts; some maps include structure and columnar sections only.

Geophysical Investigations Maps are on topographic or planimetric bases at various scales; they show results of surveys using geophysical techniques, such as gravity, magnetic, seismic, or radioactivity, which reflect subsurface structures that are of economic or geologic significance. Many maps include correlations with the geology.

Miscellaneous Investigations Series Maps are on planimetric or topographic bases of regular and irregular areas at various scales; they present a wide variety of format and subject matter. The series also includes 7 1/2-minute quadrangle photogeologic maps on planimetric bases which show geology as interpreted from aerial photographs. Series also includes maps of Mars and the Moon.

Coal Investigations Maps are geologic maps on topographic or planimetric bases at various scales showing bedrock or surficial geology, stratigraphy, and structural relations in certain coal-resource areas.

Oil and Gas Investigations Charts show stratigraphic information for certain oil and gas fields and other areas having petroleum potential.

Miscellaneous Field Studies Maps are multicolor or black-and-white maps on topographic or planimetric bases on quadrangle or irregular areas at various scales. Pre-1971 maps show bedrock geology in relation to specific mining or mineral-deposit problems; post-1971 maps are primarily black-and-white maps on various subjects such as environmental studies or wilderness mineral investigations.

Hydrologic Investigations Atlases are multicolored or black-and-white maps on topographic or planimetric bases presenting a wide range of geohydrologic data of both regular and irregular areas; principal scale is 1:24,000 and regional studies are at 1:250,000 scale or smaller.

Catalogs

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