STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT

DIVISION OF WATER POLICY AND SUPPLY

SPECIAL REPORT 29

GEOLOGY AND GROUND-WATER RESOURCES OF OCEAN COUNTY, NEW JERSEY

Prepared in Cooperation With
United States Department of the Interior
Geological Survey
1969

GEOLOGY AND GROUND-WATER RESOURCES OF OCEAN COUNTY, NEW JERSEY

By

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and

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U. S. Geological Survey

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AND ECONOMIC DEVELOPMENT

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LETTER OF TRANSMITTAL

HONORABLE ROBERT A. ROE, *Commissioner*
Department of Conservation and
Economic Development
John Fitch Plaza
Trenton, New Jersey

Dear Sir:

I am transmitting a report entitled "Geology and Ground-Water Resources of Ocean County, New Jersey" which was completed under the cooperation agreement with the Ground Water Branch, Water Resources Division, U. S. Geological Survey, as part of the Statewide Ground Water Investigation Program authorized by the 1958 Water Supply Law.

The report evaluates the geologic and hydrologic factors affecting the occurrence, movement, availability, and chemical quality of ground water in Ocean County. It indicates that large amounts of ground water are available for public and industrial supplies in Ocean County. Surface water supplies, largely derived from ground water discharge, also are plentiful.

The information in this report is of vital interest and importance to the growth of the County and provides a basis for the safe development and protection of adequate water resources essential for such growth. I therefore recommend that this report be published as a Special Report of the Division of Water Policy and Supply.

Respectfully submitted,
George R. Shanklin
Director and Chief Engineer

January 23, 1969

GEOLOGY AND GROUND-WATER RESOURCES OF OCEAN COUNTY, NEW JERSEY

ABSTRACT

Ocean County is in east-central New Jersey in the Atlantic Coastal Plain physiographic province. The Coastal Plain sediments dip gently seaward (southeast), increasing in total thickness downdip from 1,000 to 4,000 feet in Ocean County. The aquifers are continental, near-shore marine, beach, or deltaic deposits of porous sand and gravel; the confining beds are chiefly deeper water marine deposits of clay and glauconite. Generally, the Coastal Plain formations are more permeable near their outcrop, where shallow-water deposits occur, than downdip where marine clays and glauconites occur.

Ground water in Ocean County is obtained principally from four artesian aquifer systems and a water-table aquifer. The artesian aquifers in ascending stratigraphic order are: the Raritan and Magothy Formations, the Englishtown Formation, the Wenonah Formation and Mount Laurel Sand, and the Kirkwood Formation.

The Raritan and Magothy Formations of Cretaceous age form an artesian aquifer system 600 to 2,000 feet thick. Well yields of 500 to 1,000 gpm (gallons per minute) can be expected, but yields as high as 1,850 gpm have been obtained. Potable water in the aquifer system is soft (28 to 51 ppm [parts per million] hardness) and is generally high in iron content (0.66 to 3.2 ppm). Temperatures of 70° to 90°F make the water less desirable than shallow water for cooling purposes. In southern Ocean County, the Raritan and Magothy Formations generally contain brackish water below a depth of 2,500 feet below land surface.

The aquifer in the Englishtown Formation is heavily pumped in northeastern Ocean County and in the coastal part of Monmouth County. In this area, water levels in wells have declined from above sea level to more than 75 feet below sea level since 1900. Maximum well yields are less than 500 gpm, and the average is 260 gpm. Water from the Englishtown Formation is soft to moderately hard (30 to 82 ppm hardness) and the pH ranges from 7.5 to 8.3. The aquifer thins to the southeast and is absent in southern Ocean County.

The aquifer of the Wenonah Formation and Mount Laurel Sand yields small quantities of water to wells (less than 100 gpm) and is relatively undeveloped in northern Ocean County. The water is generally soft. It contains high iron concentrations locally. Downdip, the Wenonah Formation and Mount Laurel Sand becomes a confining bed.

The Atlantic City 800-foot sand of the Kirkwood Formation is the most heavily pumped (average 12 mgd) (million gallons per day) aquifer on the New Jersey coast south of Monmouth County. Since 1900, water levels in wells tapping this aquifer have declined to as much as 30 feet below sea level on Long Beach Island. Well yields as much as 1,225 gpm have been obtained from the Kirkwood Formation, but the average is about 420 gpm. The coefficient of transmissibility of the aquifer determined from an aquifer test at Ocean Gate is 11,000 gpd per ft. (gallons per day per foot). At Atlantic City, in Atlantic County, calculated coefficients of transmissibility range from 66,000 to 99,000 gpd per ft. Recharge to the Kirkwood Formation occurs in the topographic high areas of the inner Coastal Plain by vertical leakage from the overlying water-table aquifer. Water from the aquifer in the Kirkwood Formation is suitable for most uses but may require treatment for removal of iron. It is generally soft to moderately hard (2.9 to 105 ppm hardness) and generally low in dissolved solids content (4 to 180 ppm).

The water-table aquifer is pumped heavily in the Toms River and Lakehurst areas where the average well yield is 320 gpm and the maximum reported is 665 gpm. About 6.5 mgd is the maximum amount pumped for domestic, industrial, and public suuply use. An estimated 0.8 mgd per sq mi or 100 mgd, equal to the ground-water flow to Toms River, may be pumped from the water-table aquifer in the Toms River basin without seriously depleting ground water storage. Such pumpage will, however, substantially diminish the flow of Toms River. The coefficient of transmissibility of the water-table aquifer ranges from 30,000 (at Toms River) to 100,000 gpd per ft (at Batsto, Burlington County). Water from the water-table aquifer has a low pH (4.4 to 6.7), high iron content (0.09 to 22 ppm), and an unpleasant odor. Near Barnegat Bay and on the barrier beach, the aquifer contains brackish water.

Surface-water resources, largely derived from ground-water discharge, are plentiful in Ocean County. The average discharge of Toms River (1929 to 1962) was 211 cfs; the minimum was 56 cfs and the maximum was 2,000 cfs. Ground-water inflow contributes about 70 percent of the flow of Toms River.

INTRODUCTION

PURPOSE AND SCOPE

The investigation of the water resources of Ocean County is one of a series of county studies by the U. S. Geological Survey in cooperation with the New Jersey Department of Conservation and Economic Development, Division of Water Policy and Supply. The principal purpose of this study is to evaluate the geologic and hydrologic factors affecting the occurrence, movement, availability, and chemical quality of ground water in Ocean County. Estimates are made of the surface-water resources with particular reference to its availability in the Toms River drainage basin.

The investigation was made under the general direction of Allen Sinnott, formerly district geologist of the New Jersey District of the Ground Water Branch, U. S. Geological Survey.

GEOGRAPHY

Ocean County lies within the Coastal Plain in east-central New Jersey (fig. 1) between latitude 39°30′ and 40°10′ N. and between longitude 74°02′ and 74°33′ W. The Atlantic Ocean forms the eastern boundary of the county. The county has a total area of 750 square miles, of which 639 square miles is land. Barnegat Bay along the eastern margin of the county comprises most of the water area.

Of the 563-square mile upland area (excludes salt marsh and beach area) in Ocean County, approximately 87 percent was forested with stands of pine, oak, and cedar in 1939 (Moore, 1939).

The soil of Ocean County is chiefly a true podsol, called the Lakewood series (Tedrow, 1951). Sodium, calcium, and magnesium are dissolved from the soil and the less soluble iron, aluminum, and titanium are partly leached and are precipitated in the subsoil. The coarseness of the soil is conducive to rapid percolation and low soil moisture retention.

Agriculture is a minor factor in land area utilization in Ocean County. In 1959, 7 percent of the land area was devoted to agriculture. The importance of agriculture declined as the poultry industry declined from 1954 to 1959. The poultry industry accounted for 11 million of the 12 million dollars in farm products sold in 1959. Among the variety of farm products raised are such specialty crops as cranberries and blueberries.

Manufacturing is at present of minor importance with regard to employment and income in Ocean County. According to the 1958 census

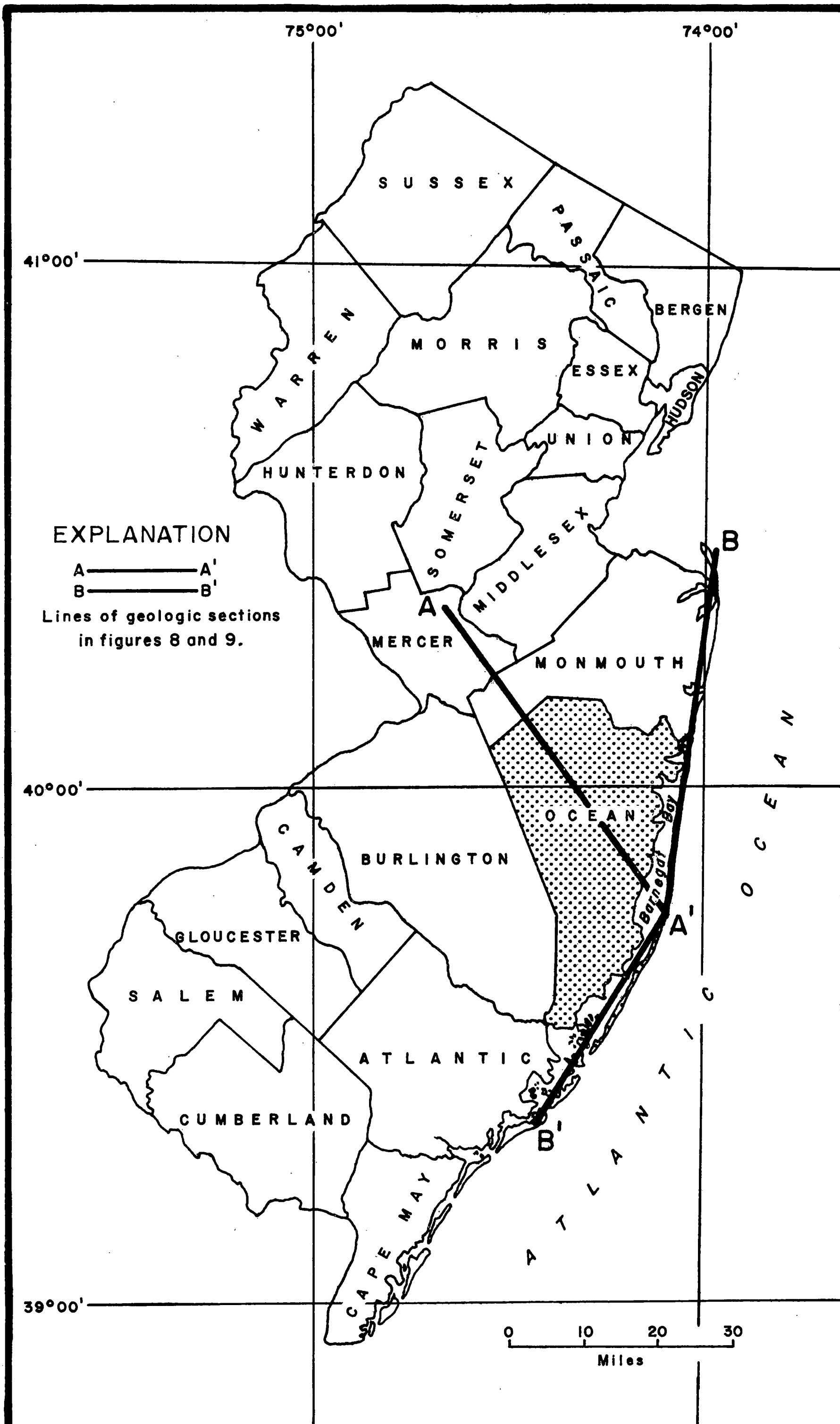

Figure 1.—Map of New Jersey showing the location of Ocean County.

of manufacturers, there were 147 manufacturing establishments in Ocean County, employing a total of only 2,008 persons. Other industries include clay, sand and gravel products, forest products, boatbuilding, construction, fishing, and oyster harvesting. By far the largest influx of currency, up to $200 million a year, comes from vacationers in the resort areas along the seashore and in the interior near Lakewood.

From 1950 to 1960, Ocean County had the greatest percentage increase in population of any county in the State. The population increased from 56,222 in 1950 to 108,241 in 1960, an increase of about 90 percent as compared to a State population increase of about 25 percent. The northeastern part of the county is the most densely populated and also the fastest growing. This rapid growth is attributed to the county's attraction as a residential area rather than to its employment opportunities. More than one-third of the labor force of about 37,000 commute to employment outside the county, primarily to northern New Jersey and New York. About 300,000 persons reside in the county through the summer season, and a maximum of 1,200,000 persons may be in the county at any one time during the summer.

TOPOGRAPHY

The topography of Ocean County, which is typical of the Coastal Plain province, is a gently undulating plain having low relief. It rises from sea level along the coast to an altitude of 220 feet in the northwestern corner of the county (fig. 2). Isolated hilltops such as those above 200 feet in altitude in the pine region are veneered with gravels. More than three-fourths of the land area of the county lies below an altitude of 150 feet, and much of this is occupied by swamps, streams, and salt marsh.

The most significant physiographic feature of the county, a barrier beach extending south from Point Pleasant to the southern tip of Long Beach Island, separates the mainland from the ocean. This feature, according to Johnson (1919), is indicative of a young shoreline of emergence. The barrier beach is an unstable geologic feature, formed from sands transported southward by longshore currents and maintained in the shape of a bar by waves breaking offshore. Dunes are built, fronting the ocean, from sand blown in from the beach. These serve to stabilize and protect the bar from erosion during storms. The erosive effects of storm waves and unusually high tides were demonstrated in the storm off the New Jersey coast of March 1962. The beach and dune sands on Long Beach Island and Island Beach State Park were in places eroded and transported seaward, forming small bars off shore. These later were forced shoreward by waves to join the main bar. A storm inlet at Harvey Cedars

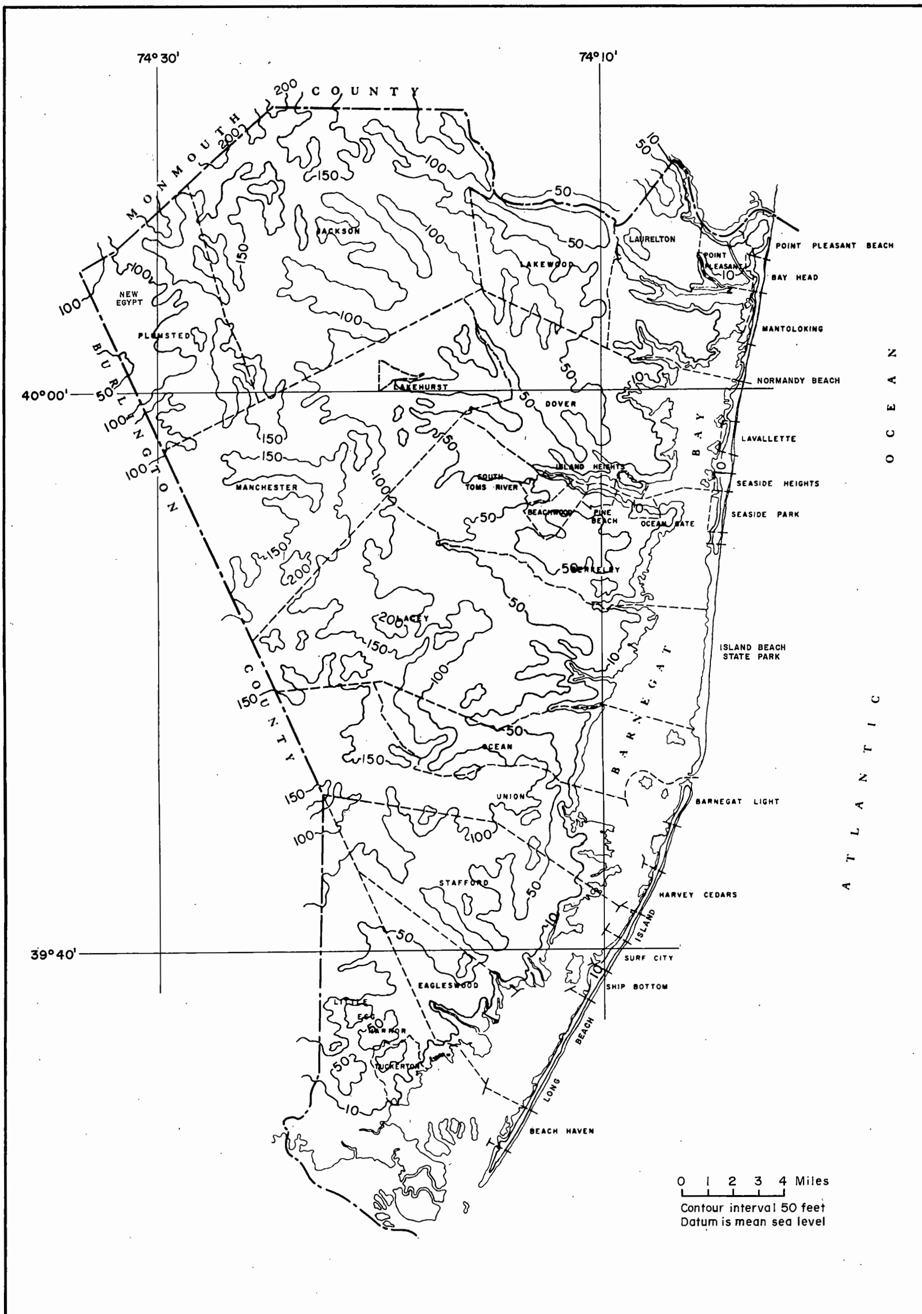

Figure 2.—Topographic map of Ocean County.

on Long Beach Island was cut as a result of this storm and was later filled in. Johnson (1919) states that "Waves cut inlets, tidal currents preserve them, and longshore currents close them." If man had not closed the inlet at Harvey Cedars, longshore currents would tend to do so, according to Johnson. If the inlet had remained open to the ocean, the salinity in the bay areas would have increased, thus favoring greater shellfish populations and marine grass growth. However, the salt water would contaminate shallow wells near the bay if the inlet were not closed.

DRAINAGE

The county is drained principally by east and southeast flowing consequent streams of the coastal drainage area. These streams have a dendritic drainage pattern (fig. 3). From north to south, the most important streams are: the Manasquan River, the Metedeconk River, Toms River, Cedar Creek, Forked River, Oyster Creek, and Mill Creek. The northern streams, the Manasquan, Metedeconk, and Toms Rivers have larger flows than the southern streams, and their tidal reaches or estuaries are "drowned," making them ideal harbors. Other streams, such as Crosswicks Creek, flow northward into the Delaware River. The divide separating the Delaware River drainage from the Atlantic coastal drainage trends irregularly north-south through the western part of the county and generally follows the hills capped with Beacon Hill gravel. The coastal streams drain into Barnegat Bay, Little Egg Harbor, and Great Bay which are connected to the ocean through Barnegat, Beach Haven, and Little Egg Harbor Inlets.

Numerous shallow lakes and ponds, usually less than 100 acres in area, are scattered throughout the county.

CLIMATE

The climate of Ocean County is characterized by moderate temperatures and precipitation. The monthly distribution of precipitation at Laurelton, Toms River, and Tuckerton and temperature at Laurelton and Tuckerton (fig. 3) are given in table 1.

Although the annual precipitation is similar for these stations, the areal distribution of rainfall for short-term periods, particularly in summer, is erratic. The greatest precipitation occurs in the Toms River area and decreases southward. The first killing frost is usually at the end of October, and the last killing frost occurs about the last week in April, allowing a growing season of about 180 days.

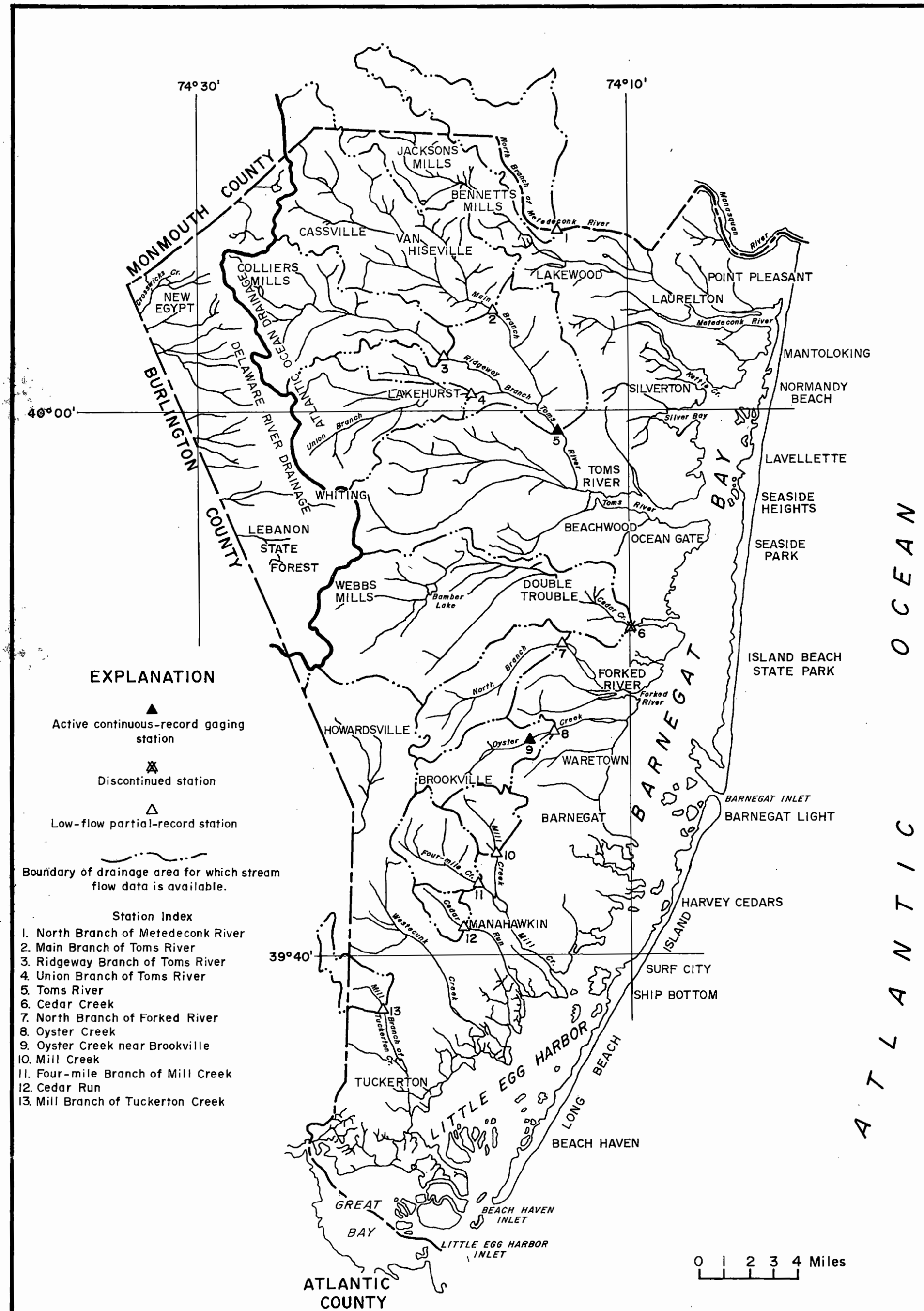

Figure 3.—Drainage map showing areas with streamflow records.

Table 1.—Precipitation and temperature at Laurelton, Toms River, and Tuckerton, Ocean County
(Data from U. S. Weather Bureau)

STATION						
Average monthly precipitation (inches)				*Mean monthly temperature (°F)*		
	Laurelton (54 years record to 1958)	*Toms River (34 years record to 1955)*	*Tuckerton (59 years record to 1955)*		*Laurelton (54 years record to 1958)*	*Tuckerton (54 years record to 1955)*
January	3.85	3.71	3.59	January	33.7	33.9
February	3.10	3.93	3.42	February	33.4	33.4
March	4.27	4.54	3.90	March	40.8	41.4
April	3.72	3.88	3.62	April	50.6	49.7
May	4.16	4.09	3.24	May	61.4	60.2
June	3.51	3.81	3.51	June	69.9	69.2
July	3.80	5.24	3.96	July	74.7	74.3
August	5.14	5.71	5.53	August	72.5	72.7
September	3.74	3.94	3.38	September	65.8	66.9
October	3.91	4.26	3.59	October	55.5	56.5
November	4.21	3.67	3.12	November	45.1	45.7
December	3.29	3.97	3.83	December	28.8	36.1
Average annual precipitation	46.70	50.75	44.69	Mean annual temperature	49.0	53.3

WELL-NUMBERING SYSTEM

Wells are assigned grid numbers according to a system based upon the New Jersey topographic atlas sheets. A diagrammatic explanation is shown in figure 4. Ocean County is included in parts of atlas sheets 28, 29, 32, 33, and 36. The numbering system was described by Kümmel (1913, p. 13 and 14) as follows: "Each atlas sheet is divided into rectangles measuring 6-minutes of latitude and 6-minutes of longitude. Beginning in the upper left-hand corner, these are numbered across the sheet from 1 to 5, inclusive, number 5 being an incomplete rectangle comprising 2-minutes of longitude at the right. Those on the second row are numbered 11 to 15, those on the third 21 to 25, those on the fourth 31 to 35 and on the fifth 41 to 45. The rectangles numbered 41 to 44, inclusive, differ from the others in comprising 6-minutes of longitude and 4-minutes of latitude. Number 45 embraces 2-minutes of longitude and 4-minutes of latitude. Each of these rectangles is divided into smaller rectangles measuring 2-minutes of latitude and 2-minutes of longitude by lines already engraved upon the sheet. The 2-minute rectangles in each of the 6-minute rectangles are numbered from 1 to 9 beginning in the upper left-hand corner and numbering to the right, number 4 being on the left under number 1. The subdivisions of the incomplete 6-minute rectangles on the right of the sheet, i.e., those numbered 5, 15, 25, 35, are numbered 1, 4, 7, of those at the bottom, i.e., numbers 41, 42, 43, 44, the subdivisions are numbered 1, 2, 3, 4, 5, 6. The subdivisions of the incomplete rectangle in the lower right-hand corner, number 45, are numbered 1, 4. It is evident that by writing first the number of the atlas sheet; second, the number of the 6-minute rectangle; and third, the number of any 2-minute rectangle, we can form a combination of numbers peculiar to any 2-minute rectangle within the State. In order to locate points more accurately each of the 2-minute rectangles is divided into nine equal parts, numbered from 1 to 9, beginning in the upper left-hand corner, and each of these is again divided into nine, numbered similarly. The smallest rectangles represent areas about 330 yards from east to west and 440 yards from north to south. By adding the appropriate numbers of these two smaller divisions to the three already written, it is possible to get a combination which represents the exact location of any area 330 x 440 yards."

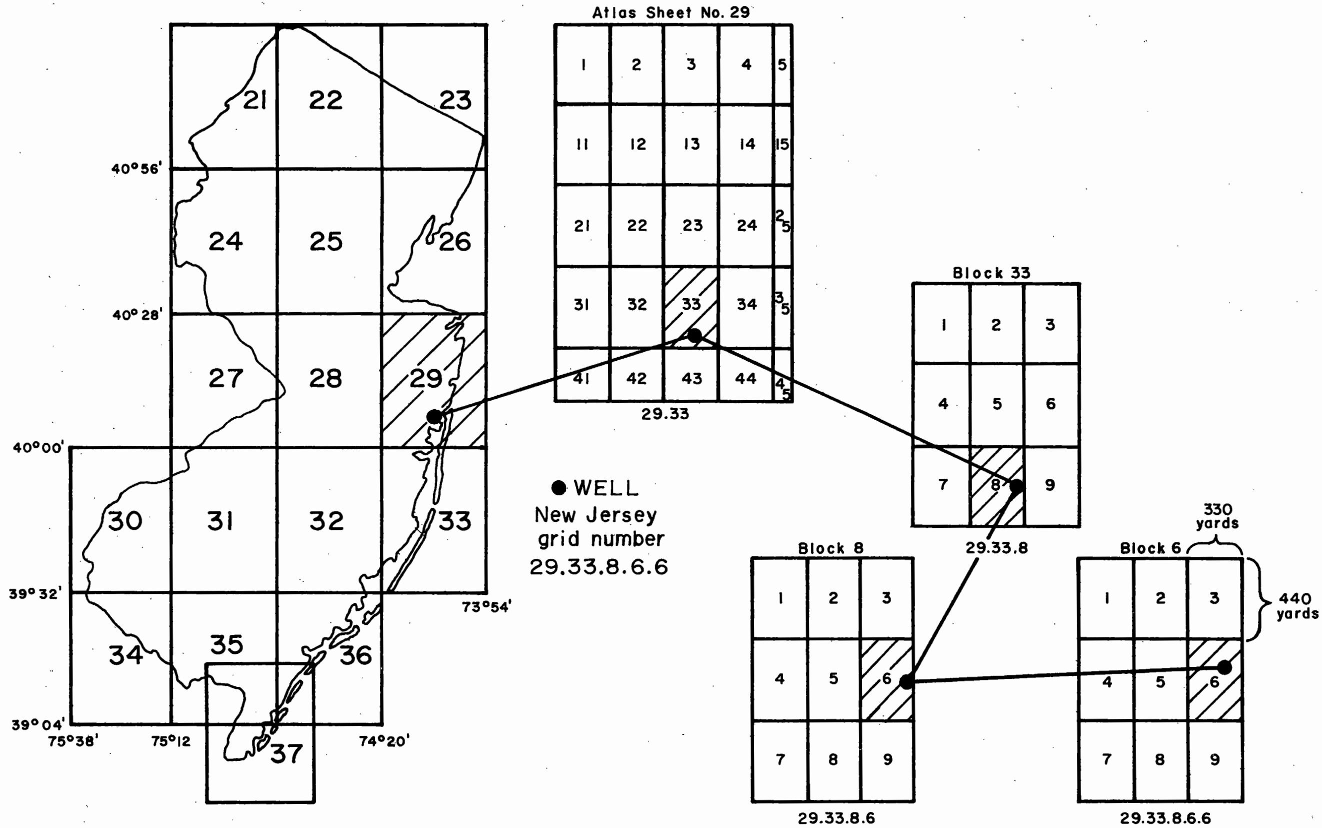

Figure 4.—Method of numbering wells according to the New Jersey grid system.

GROUND-WATER HYDROLOGY

SOURCE, OCCURRENCE AND MOVEMENT

Ground water is defined as that part of the water beneath the surface of the earth that occurs in the zone of saturation. The water table is near the upper surface of the zone of saturation. In the zone of saturation, all the connected pores, crevices, and voids in the rock are filled with water which in the capillary fringe is under pressure less than atmospheric and below the water table is under pressure greater than atmospheric. In Ocean County, virtually all available ground water occurs in the pore spaces of the Coastal Plain sediments, which overlie consolidated crystalline bedrock.

The quantity of water in storage in the Coastal Plain sediments is appreciable and can be calculated from the porosity and volume of material. The average thickness of the unconsolidated sediments underlying Ocean County is about 3,000 feet. The average porosity of the materials is about 30 percent. The product of these figures times the area of Ocean County, 750 square miles, gives an estimate of ground water in storage in the county of 140 x 10^3 billions of gallons. Of course all water in storage is not available for recovery. Some of it would be retained in the aquifer even if the aquifer were dewatered. Furthermore it is not desirable or economically feasible to withdraw all available water in storage.

Precipitation is the source of all ground water in Ocean County. About two-fifths of the precipitation falling on the county infiltrates to the zone of saturation. The sandy surface materials are highly permeable permitting rainfall to infiltrate rapidly.

As water seeps into the ground, some is evaporated, some is taken into the roots of plants and eventually transpired, and some is held by surface tension and capillary forces in pore spaces of the zone of aeration. As the soil becomes saturated, the weight of the water overcomes the capillary forces holding the water in the soil and water percolates to the water table.

The amount of the precipitation that infiltrates to the zone of saturation depends on several factors. During the growing season, plants create soil-moisture deficiencies which must be satisfied before appreciable amounts of water infiltrate to the water table. The growing season from May to October is a period of high evapotranspiration, whereas from November to April little evapotranspiration occurs. Hence, ground-water recharge occurs largely in the November to April period.

Formations capable of yielding water to a well are called aquifers. Depending on the location in Ocean County, there are from 1 (Long Beach Island) to 5 (New Egypt) principal aquifers available as a source of fresh ground water. Formations that are relatively impermeable and do not yield water readily to wells are termed aquitards or confining beds.

A quantitative measure of the water-bearing ability of a rock material is its field coefficient of permeability. As defined and used by the U. S. Geological Survey, it is the rate of flow of water in gallons per day through a cross-sectional area of materials of one square foot under a hydraulic gradient of one foot per foot at the prevailing temperature. The laboratory coefficients of permeability for sediment samples of formations exposed in the county are given in table 5. The measure of an aquifer's ability to transmit water is its coefficient of transmissibility which is the product of the field coefficient of permeability times the saturated thickness of the aquifer.

A measure of an aquifer's capacity to store water is its coefficient of storage. This is defined as the amount of water released from storage in a unit vertical prism of the aquifer as the hydraulic head declines one foot.

Ground water occurs either under water-table or artesian conditions. Under water-table conditions, the aquifer is unconfined and the static water level in a well is at or below the top of the aquifer. Under artesian conditions, the aquifer is confined by beds of low permeability and the piezometric surface or level at which water will stand in a well is above the top of the aquifer.

When a well tapping an unconfined aquifer is pumped, water is withdrawn largely from storage in the vicinity of the well. The pumping effect is transmitted slowly to other parts of the aquifer, and the water table declines as a result of gravity drainage. The ratio of the volume of water released by gravity drainage to the volume of the aquifer dewatered is the specific yield of the materials and is expressed in percent. Specific yield is approximately equal to the coefficient of storage for a water-table aquifer. The porosity or the percentage of void space in a material is always greater than the specific yield. The average porosity of the unconsolidated materials underlying Ocean County is relatively uniform—about 30 percent for sands and gravels as well as for clays. However, the specific yields of the different sediments differ widely. Values appear to be related to the grain-size distribution and degree of compaction. Fine-grained materials have a large surface area; therefore, surface-tension forces will retain a large portion of water from gravity drainage. The specific yield of clays and silts may be at most a few percent, whereas for a uniform sand it may be more than 20 percent.

Rhodehamel (1966, p. 44) estimated the specific yield of the Cohansey Sand to average 21 percent.

When a well tapping a confined aquifer is pumped, the aquifer remains saturated during pumping. Water is taken from storage until the cone of depression intercepts recharge that equals the rate of withdrawal. The volume of water released from storage per unit volume of aquifer in a confined aquifer is small compared to a volume released from a water-table aquifer in response to an equivalent decline in head. The confined aquifer is not dewatered as is the unconfined aquifer and water released from storage is attributed to compression of the aquifer. The coefficient of storage in most confined aquifers is less than about 0.001. The effect of pumping is transmitted to distant parts of the aquifer much faster in confined aquifers than in unconfined aquifers. Changes in head occur more quickly over more extensive areas in confined aquifers than in unconfined aquifers for a given rate of withdrawal. Generally, in any aquifer, it is desirable to withdraw water from an aquifer close to a recharge source so that a minimum lowering of the water level in the aquifer occurs.

WATER-LEVEL FLUCTUATIONS

Ground-water levels fluctuate in response to recharge from precipitation and discharge by springs, streams, plants, and wells. Water levels in wells tapping water-table aquifers respond to recharge more rapidly than wells tapping artesian aquifers.

In water-table aquifers, generally the deeper the water table the longer the time required for water to percolate to it. In observation wells in Ocean County where the water table is less than 5 feet below land surface, water levels may rise within a few days after a rainfall, but where the water table is, for example, 30 feet below land surface, several weeks or even months may pass before water levels rise after the same rainfall. Also, as depth to the water table increases, the magnitude of the water-level rise may decrease. An example of this is shown in water-level fluctuations of two water-table wells in the Cassville area. One has a static water level of 2 feet and the other has a level of 27 feet below land surface. In July 1959, in response to 13 inches of rainfall, the level in the shallow water-level well rose 1.5 feet while the level in the deeper water-level well rose only 0.4 feet.

Water-level fluctuations are influenced by the hydraulic properties of the aquifer. Hence, water-level fluctuations are greater in water-table wells tapping the Kirkwood Formation (in its outcrop area) than water-table wells tapping the Cohansey Sand because the fine sands of the

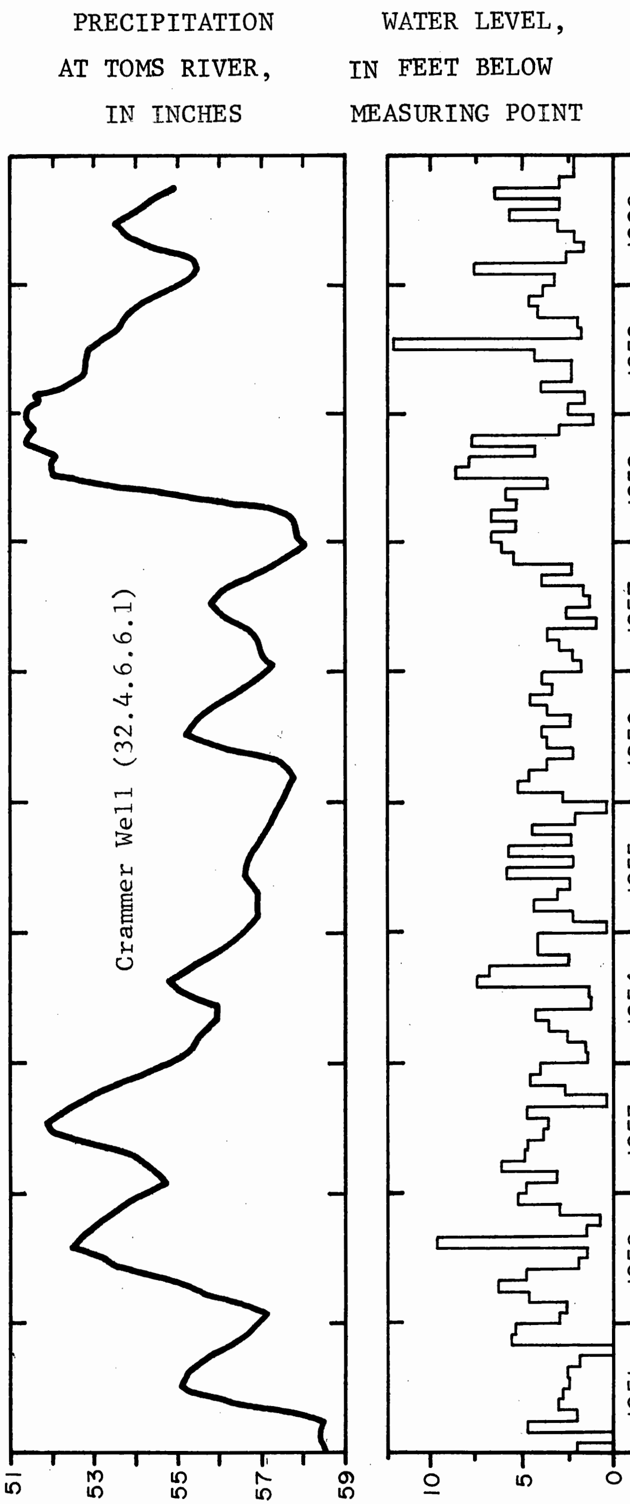

Figure 5.—Graphs showing fluctuations in a water-table observation well and precipitation at Toms River, 1951-60.

Kirkwood are less permeable and have a lower specific yield than the sands and gravels of the Cohansey.

Water levels generally decline during the growing season because much of the precipitation is intercepted by vegetation before it can reach the water table. However, the seasonal rise and fall of water levels in wells where the water table is deep may lag several months behind the change in seasons. Hence, in the Crammer well (32.4.6.6.1) at Whitings the seasonal decline generally starts in July or August, whereas the growing season in this area starts in April (figure 5). This lag is beneficial in areas of heavy pumpage because the water-table high occurs in the summer months when pumpage is greatest. Hence, the danger of wells "going dry" because the water level falls below the intake pipe is minimized. The hydrograph in figure 5 illustrates also that water levels in wells where the water table is deep reflect primarily general seasonal and climatic changes and not increments of reharge from single rainfalls.

Variations in lowest annual ground-water level in the Crammer well can be correlated with variations in annual precipitation. In figure 6, the difference in precipitation in a given water year from that of the preceding year is plotted as the abscissa and the difference in lowest water level in the Crammer well from the lowest water level of the preceding year is plotted as the ordinate. The period selected is the January or February low following the specified water year. The correlation between these two parameters suggests that for each 12-inch increase or decrease in precipitation, there is approximately a 2-foot rise or fall in the lowest annual water level in the Crammer well. As specific yield values for similar Coastal Plain sediments in the Pine Barrens region of New Jersey average 21 percent (Rhodehamel, 1966, p. 44) then 5 inches of the 12-inch change in precipitation percolates to the water table.

WATER USE

Public-water supplies in Ocean County are obtained entirely from ground-water sources. Pumpage for public supplies is subject to significant seasonal variation. For example, pumpage in July 1960 was about triple that of February 1960 and the average daily pumpage in July 1960 was almost double the average daily pumpage in 1960 (Table 2). These increases reflect the tremendous influx of tourists to the resort areas in the summer.

Toms River Chemical Company, which pumps about 2.5 mgd (million gallons per day), and the Glidden Co., near Lakehurst, which pumps about 5 mgd, are the significant industrial users of ground water in the county. Use of ground water by these companies is comparable to the

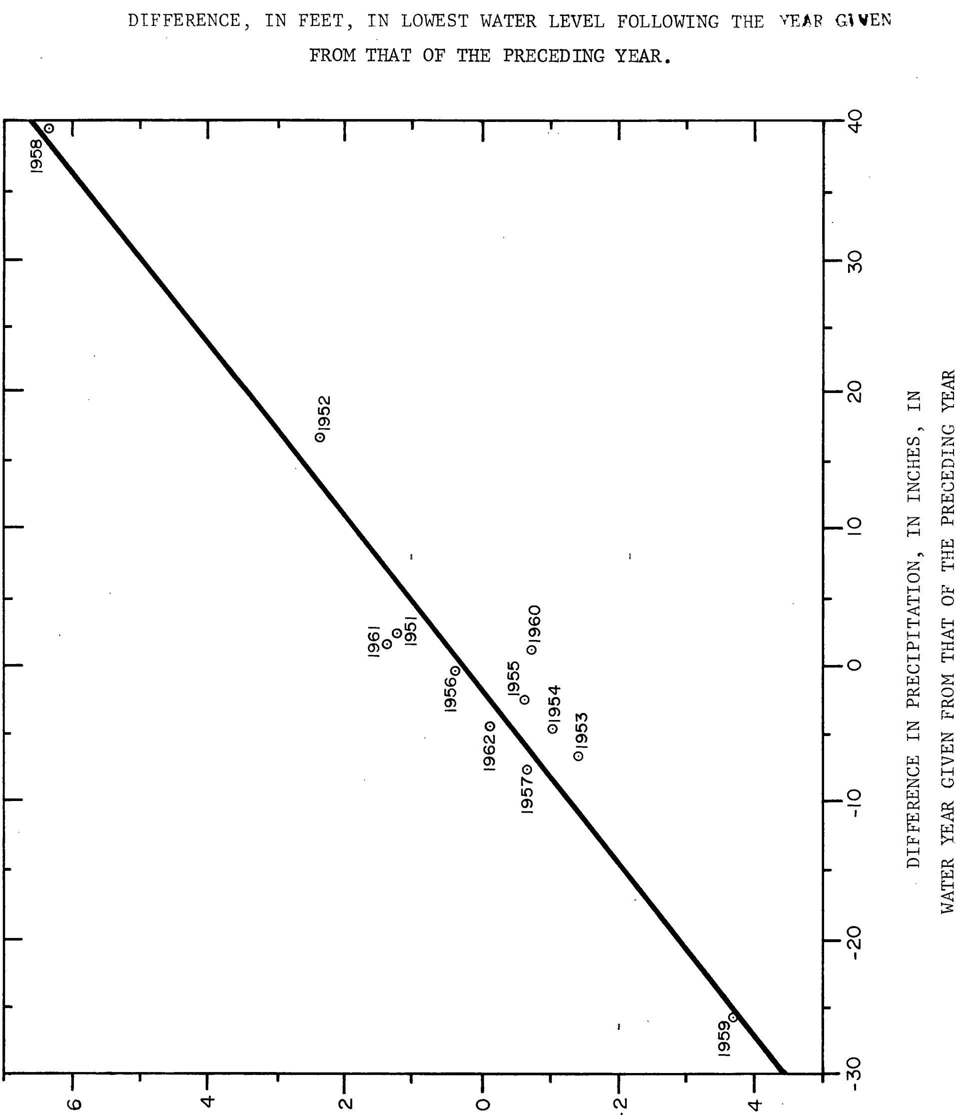

Figure 6.—Graph showing relation of changes in annual precipitation at Toms River to annual changes in lowest ground-water level of the Crammer well, 1951-62.

total average use by public-water supply companies of 7.8 mgd. In addition to these, Lakehurst Naval Air Station withdraws approximately 0.65 mgd from wells in the water-table aquifer to serve the installation.

According to the 1959 agricultural census, 1,402 acres on 53 farms were irrigated in 1953. In 1959, 476 acres on 14 farms were irrigated. Of the 14 farms, three obtained water from wells, the remainder used surface water. No estimates are available of the water used but because the irrigated land area is small and is decreasing, the water resources of the county are not appreciably affected by withdrawals for this purpose.

A large number of residents maintain privately owned wells, particularly in the cottage developments near the shore. The exact number of wells and their pumpage is unknown. However, assuming that most of the rural population (69,575 persons in 1960) obtains water from wells, a withdrawal of 5 mgd is a reasonable estimate.

The average quantity of ground water utilized in the county for public supply, industrial, and domestic purposes is estimated to be 23 mgd or 213 gallons per resident per day. This is equivalent to 36,000 gpd per square mile of land area or about three-fourths of an inch a year.

TABLE 2.—MONTHLY DISTRIBUTION OF PUMPAGE BY PUBLIC WATER SUPPLIES IN OCEAN COUNTY, N. J. 1960

(In million gallons)

Supply	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Total Annual*	*Average Annual (mgd)*
New Egypt Water Co.	2.852	3.112	3.090	3.595	3.346	3.806	3.570	3.121	3.340	3.344	3.225	3.306	39.707	0.108
Lakehurst Water Dept.	a 7.000	a 7.000	a 7.000	7.500	8.259	8.401	10.250	12.230	10.475	7.750	7.375	6.518	99.758	.273
Lakewood Water Co.	31.934	31.786	30.167	32.002	28.789	31.788	32.120	28.502	30.201	29.207	32.324	34.888	373.708	1.021
Parkway Water Co.	.569	.528	.575	.840	1.059	1.362	1.118	.748	.654	.648	.556	.624	9.281	.025
Hollywood Manor Water Co.	.043	.013	.025	.105	.143	.267	.613	.516	.537	.472	.285	.294	3.313	.009
Point Pleasant Water Dept.	14.659	13.403	15.058	19.466	24.541	29.578	36.591	31.557	18.042	16.405	17.180	16.757	253.237	.692
Point Pleasant Beach Water Dept.	19.353	18.863	22.327	22.842	31.687	32.924	36.078	31.714	27.506	19.270	16.123	25.528	304.215	.831
Ocean County Water Co.	8.780	7.776	10.404	9.574	14.479	23.545	44.141	40.935	21.376	12.985	8.315	12.389	214.699	.587
Pineland Water Co.	.480	.524	.547	.779	1.011	1.087	1.204	1.099	.957	.935	.849	.957	10.429	.028
Shore Acres Water Co.	.260	.260	.270	.350	.400	.600	1.000	1.200	.500	.400	.350	.300	5.890	.016
Silverton Water Co.	.650	.230	.245	.375	.375	b .375	.308	.352	.374	.198	.246	.194	3.922	.011
Lavallette Water Dept.	4.100	3.412	3.699	5.329	8.495	13.178	23.481	23.548	11.439	5.948	4.220	5.830	112.679	.308
Seaside Heights Water Dept.	5.294	4.858	6.227	7.450	11.737	15.191	32.000	29.513	12.358	6.333	5.706	7.452	144.119	.394
Seaside Park Water Dept.	6.450	6.782	6.380	6.580	7.800	8.600	21.640	23.621	14.320	5.800	6.260	6.300	120.533	.329
Shore Water Co.	.396	.310	.542	.708	1.436	1.604	4.032	3.696	1.374	.454	.178	.488	15.218	.042
Island Heights Water Dept.	3.389	3.215	3.596	4.402	5.478	7.436	8.925	6.474	5.179	4.298	3.762	4.034	60.188	.164
Toms River Water Co.	15.212	14.492	16.110	19.125	22.663	27.355	31.981	25.256	21.544	20.164	18.865	19.505	252.272	.689
Beachwood Water Dept.	4.003	3.709	4.195	5.802	7.434	9.881	8.875	6.729	5.582	4.760	4.196	4.436	69.602	.191
Ocean Gate Water Dept.	1.364	1.240	1.630	1.712	2.683	4.586	7.877	4.549	4.165	1.755	2.217	2.170	35.948	.098
Stafford Water Co.	1.162	1.087	1.162	1.125	1.162	3.715	11.625	11.625	3.937	1.162	1.125	1.162	40.049	.109
Barnegat Light Water Co.	1.110	1.255	1.819	1.255	1.819	2.097	7.587	5.884	3.488	2.128	1.576	1.314	31.332	.086
Harvey Cedars Water Dept.	.891	.616	.808	.952	1.202	2.935	5.604	3.860	2.122	2.122	1.289	.989	23.390	.064
Surf City Water Dept.	1.595	1.845	2.344	3.149	2.656	5.540	10.856	10.991	5.290	2.700	2.459	3.045	52.470	.143
Ship Bottom Water Dept.	3.490	3.257	3.988	4.435	6.613	10.788	18.617	18.580	9.950	7.045	6.301	4.926	97.990	.268
Long Beach Water Co.	11.974	5.306	7.256	9.029	13.724	24.597	47.675	41.398	21.292	11.384	7.194	9.654	210.483	.575
Beach Haven Water Dept.	5.043	6.143	4.624	7.281	11.196	20.924	31.739	24.182	15.230	9.220	5.197	6.090	146.869	.401
Long Beach Twp. Water Dept.	.160	.100	.221	.344	.737	1.010	.844	.547	.200	.586	.178	.150	5.077	.014
Tuckerton Water Co.	9.000	9.000	8.000	10.500	16.000	18.500	10.700	8.800	6.600	9.728	7.700	6.500	121.028	.331
Monthly Total	161.213	150.122	162.309	186.606	236.924	311.670	451.051	401.227	258.032	187.201	165.251	185.800	2,857.406	7.807
Average mgd	5.2	5.4	5.2	6.3	7.6	10.4	14.5	13.0	8.4	6.2	5.5	6.0		

a – estimated by USGS; b — estimated by N.J. Division of Water Policy & Supply

System	Series	Group	Formation	Lithology	Thickness	Water-bearing character
Quaternary	Holocene		Alluvium, beach sand and gravel	Gravel, sand, and clay	0-50	Unconfined water-table aquifer. Capable of yielding moderate to large quantities of water. Locally acidic, high in iron, and may have an odor. Contains saline water along the barrier bar and adjacent to Barnegat Bay. Utilized principally in Lakehurst and Toms River area where the average well yields are 320 gpm. Average specific capacity 12.8 gpm per foot. Confined water encountered beneath black clay layer along coast.
	Pleistocene		Cape May Formation		0-20	
			Pensauken Formation			
			Bridgeton Formation			
Tertiary	Pliocene(?)		Beacon Hill Gravel			
	Miocene(?) and Pliocene(?)		Cohansey Sand	Sand, quartz, fine-to coarse-grained; locally clayey and clay.	0-200	
	Miocene		Kirkwood Formation	Sand, quartz, very fine to medium and coarse grained, micaceous, lignitic, silt, gray clay, and fine gravel lenses.	0-500	Confined aquifer. Yields moderate quantities of water. Locally may be acidic and high in iron content. Average well yield 420 gpm. Average specific capacity 10.6. Utilized chiefly on Long Beach Island and along coast north to Point Pleasant.
	Eocene		Manasquan Formation	Sand, Quartz-glauconite medium to coarse-grained, clayey, fossiliferous.	18-392	Aquitard — locally water bearing.
	Paleocene	Rancocas	Vincentown Formation	Upper — calcarenite, fine to medium-grained, glauconitic, quartzitic, fossiliferous. Lower—sand, quartz, glauconitic, fine to coarse-grained, clayey. Downdip—clay, glauconitic, fossiliferous.	25-328	Near outcrop, aquifer yields small quantities of water to domestic wells. Average yield 50 gpm. Average specific capacity 1. Water high in calcium, bicarbonate, and hardness. Downdip unit is an aquitard.
			Hornerstown Sand	Sand, glauconite, medium- to coarse-grained, clayey. fossiliferous.	30-50	Aquitard containing shell beds that yield small quantities of water.
Cretaceous	Upper Cretaceous	Monmouth	Red Bank Sand	Sand, quartz—glauconite, fine- to coarse-grained, clayey, lignitic.	10-50	
			Navesink Formation	Sand, glauconite, fine- to coarse-grained, clayey, fossiliferous.	?-100	
			Mount Laurel Sand	Sand, quartz, fine- to coarse-grained, glauconitic, fossiliferous.	40-128	Confined aquifer. Yields small quantities of water. Average well yield 70 gpm. Non-water bearing in southern half of county.
		Matawan	Wenonah Formation	Sand, quartz, fine-grained, micaceous, lignitic and silt, clayey.		
			Marshalltown Formation	Sand, glauconite and quartz, fine- to medium-grained, clayey, fossiliferous.	10-25	Aquitard.
			Englishtown Formation	Sand, quartz, fine- to medium-grained, micaceous, lignitic, clay seams.	0-75	Confined aquifer. Absent in southern half of county. Yields moderate quantities of water. Average well yield 260 gpm. Average specific capacity 2.6 gpm per foot.
			Woodbury Clay	Clay and silt, glauconitic, fossiliferous.	100-212	Aquitard.
			Merchantville Formation			
			Magothy Formation	Sand, quartz, very fine- to medium-grained, glauconitic, micaceous, clay.	600-2,000	Several confined aquifers. Yields large quantities of water high in iron content. Average well yield 660 gpm. Average specific capacity 20.0 gpm per foot. Ground-water temperature above 70°F. Saline water below 2,500-foot depth.
			Raritan Formation	Sand, quartz, fine- to coarse-grained arkosic, sideritic, clay. Calcareous and kaolinitic downdip.		
Pre-Cretaceous	Precambrian and early Paleozoic rocks — schist, gneiss, pegmatite, and gabbro. Triassic sandstone, shale, and basalt.			Weathered gneiss	65	
				Biotite gneiss with pegmatite veins	------------	

GROUND-WATER GEOLOGY

The Atlantic Coastal Plain in New Jersey is composed of a series of gently seaward dipping beds of clay, sand, and gravel of Cretaceous to Holocene age. Locally, the beds are glauconitic and fossiliferous. Coastal Plain sediments in Ocean County thicken from about 1,000 feet at New Egypt in the northern part of the county to about 4,000 feet at Tuckerton in the southern part of the county. Underlying this sedimentary sequence is crystalline bedrock, a metamorphic gneissic and schistose sequence of early Paleozoic and Precambrian age. The southeastward dip of the beds decreases upward in the section from about 120 feet per mile on the "basement complex" surface to about 10 feet per mile at the Kirkwood Formation-Cohansey Sand contact. The strike also changes upward in the section from N. 40° E. in the Raritan Formation to N. 70° E. in the Kirkwood Formation. The sequence of Coastal Plain units and their water-bearing properties in Ocean County are given in table 3.

The surficial geology of Ocean County is shown in figure 7. Parts of the Vincentown, Manasquan and Kirkwood Formations crop out in the northwest corner of the county, but the Cohansey Sand is exposed throughout most of the county (fig. 7). The Cohansey is capped by the Beacon Hill Gravel of Pliocene(?) age, mostly on hilltops; in valleys along the coast the Cohansey is overlain by the Bridgeton, Pensauken, and Cape May Formations of Pleistocene age. Holocene deposits include swamp and marsh muds as well as beach and dune sands of the barrier beach from Point Pleasant to Beach Haven.

The subsurface geology of Ocean County and along the coast in Monmouth and Ocean Counties and in part of Atlantic County is shown in the geohydrologic sections in figures 8 and 9.

The availability of ground water in Ocean County is summarized in table 4. The county is subdivided into four geographic areas which differ from one another in their availability of ground water and aquifers tapped by wells (fig. 13).

The Kirkwood Formation and Cohansey Sand, and to some extent the Raritan and Magothy Formations maintain downdip the near-shore marine and terrestrial characteristics found in outcrop. The intervening formations are more glauconitic and clayey downdip than in outcrop, as they represent a deeper water marine environment than found in outcrop. The Kirkwood Formation, Cohansey Sand, and the Raritan and Magothy Formations, hence, are more permeable and constitute the principal aquifers in the county.

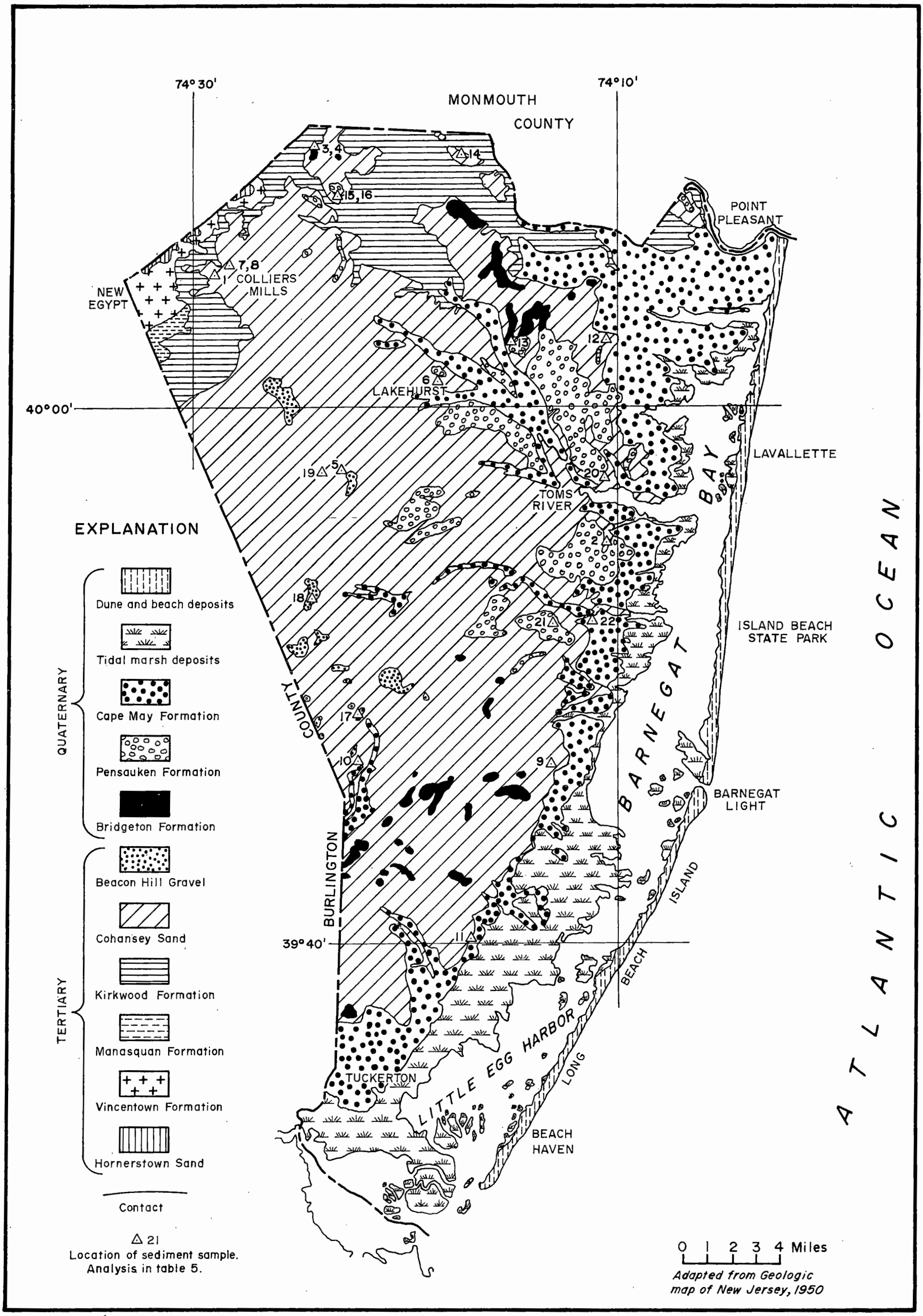

Figure 7.—Geologic map of Ocean County.

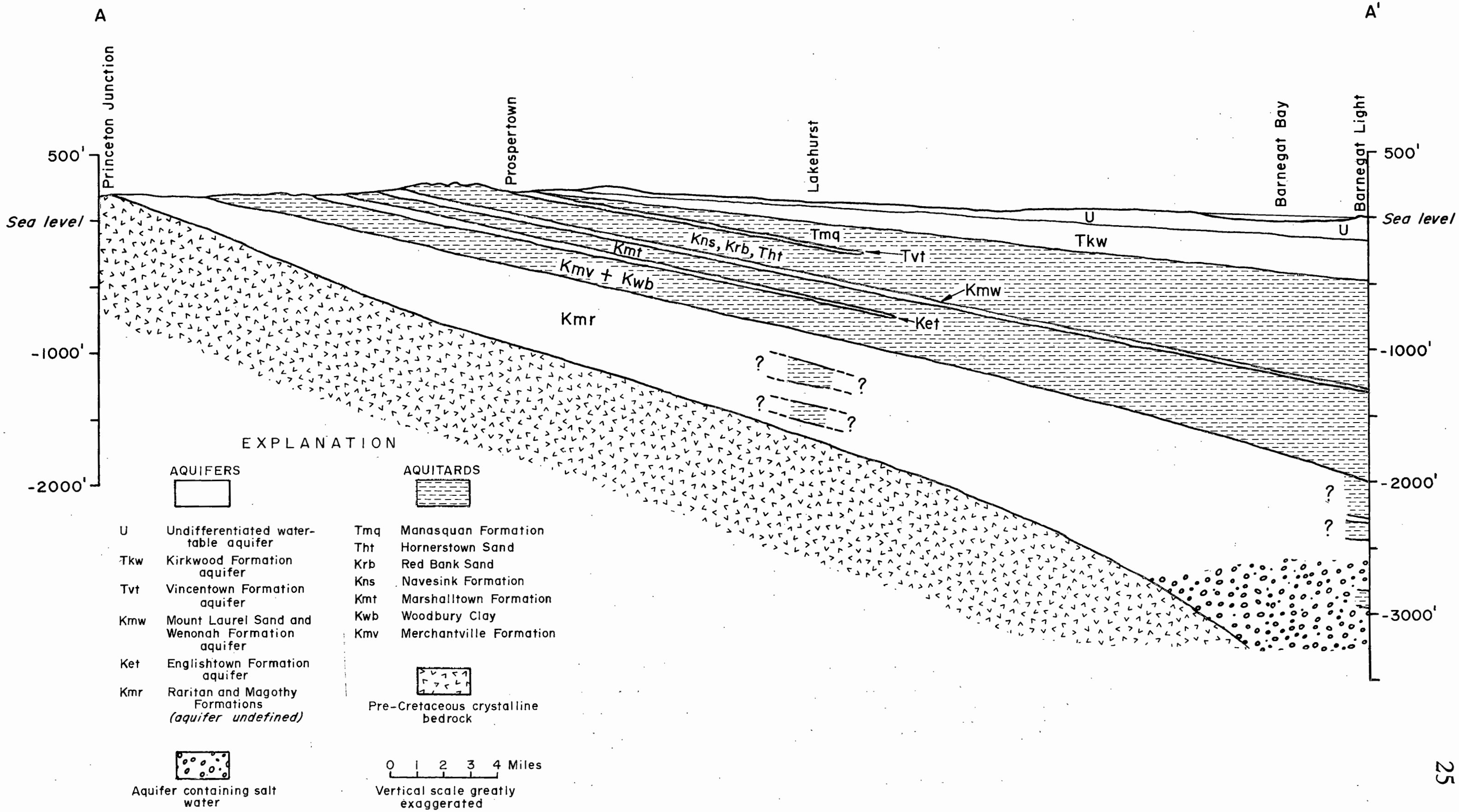

Figure 8.—Geohydrologic section, Ocean County.

Table 4.—Summary of availability of ground water in Ocean County.

Aquifers: U, undifferentiated water-table aquifer; K, aquifer in the Kirkwood Formation; V, aquifer in the Vincentown Formation; W, aquifer in the Wenonah Formation and Mount Laurel Sand; E, aquifer in the Englishtown Formation; R, aquifer in the Raritan and Magothy Formations. Areas are shown in figure 13.

	Area	*Aquifers*	*Availability of ground water*
1	Summer Coastal Resort	K	K, yields as much as 500 gpm. Used for public supply. Potential sea-water intrusion as water levels are below sea level. Summer pumpage, 5 mgd. R and U contain saline water, E, W, and V are absent.
2	Undeveloped Pine Barrens	R, K, U	R, yields as much as 2,000 gpm possible. Saline water in southern part of area. K, well yields less than in Area 1. Water locally acidic and high in iron content. U, yields as much as 1,000 gpm possible. Water may be high in iron content, acidic, and odoriferous. E, W, and V are absent.
3	Urban	R, E, W, K, U	R, same as in area 2. Pumpage 5 to 8 mgd. E, yields up to 500 gpm. Highly developed. Pumpage, 3 mgd. Sea-water intrusion possible as water levels have declined as much as 90 feet. W, yields less than 100 gpm. Relatively undeveloped. Pumpage less than 1 mgd. K, yields up to several hundred gpm. U, same as in area 2. V, absent.
4	Rural	R, E, W, V, K, U	Small amounts pumped for domestic use. R, E, K, and W yields up to several hundred gpm are possible.

The Englishtown Formation, the Wenonah Formation-Mount Laurel Sand and Vincentown Formation are water bearing near their outcrop but in southern Ocean County they grade into relatively impermeable glauconitic marls. At a test well at Island Beach State Park, the relatively impermeable clay and glauconite sequence occurs from 400 to 2,000 feet in depth.

RARITAN AND MAGOTHY FORMATIONS

Geology

The Raritan and Magothy Formations are discussed as a single geohydrologic unit because of similar geologic and hydrologic characteristics in the subsurface. Together they constitute the oldest, deepest, and thickest unconsolidated unit in the county, composing half the thickness of the Coastal Plain sediments. They range in thickness from 600 feet at the northwest corner of the county to almost 2,000 feet at Island Beach State Park. The basal Raritan Formation overlies unconformably the early pre-Cretaceous metamorphic and igneous basement rocks. The Magothy Formation is overlain disconformably by black micaceous, glauconitic clay of the Merchantville Formation. In the subsurface, the Merchantville-Magothy contact is best shown in electric well logs (fig. 10) by the sharp increase in resistivity and spontaneous potential for the more porous Magothy (at 1,750 feet in fig. 10).

The Magothy Formation in its outcrop is characteristically a micaceous, fine-grained, lignitic sand interbedded with clays. The Raritan Formation in its outcrop is usually a lenticular, light-colored, medium-to coarse-grained, subangular, and arkosic quartz sand interbedded with varicolored kaolinitic clays. Fine gravel lenses also occur. Also common in the Raritan are lignite, iron sulfides, siderite, ironstone nodules, and fossil dicotyledon flora. In drillers' well logs, the Raritan and Magothy Formations are commonly described as a series of "sand-silt-sand beds." The Raritan and Magothy Formations in their outcrop area represent continental and marine deposition, but downdip beneath Ocean County, the sequence is predominently marine. Glauconite and marine fossils were found in wells at Point Pleasant, Normandy Beach, Lavallette, Lakehurst, Double Trouble, Island Beach State Park (fig. 3). Marine limestones occur at Point Pleasant, Double Trouble, and Island Beach State Park in the upper part of the Raritan and Magothy Formations.

The regional strike of the top of the Magothy Formation is approximately N. 45° E.; the dip is 50 feet per mile to the southeast. A structure contour and thickness map of the Raritan and Magothy Formations is shown in figure 11. The bedrock surface or the base of the Raritan Formation dips more than 100 feet per mile to the southeast as shown by the contour map in figure 12.

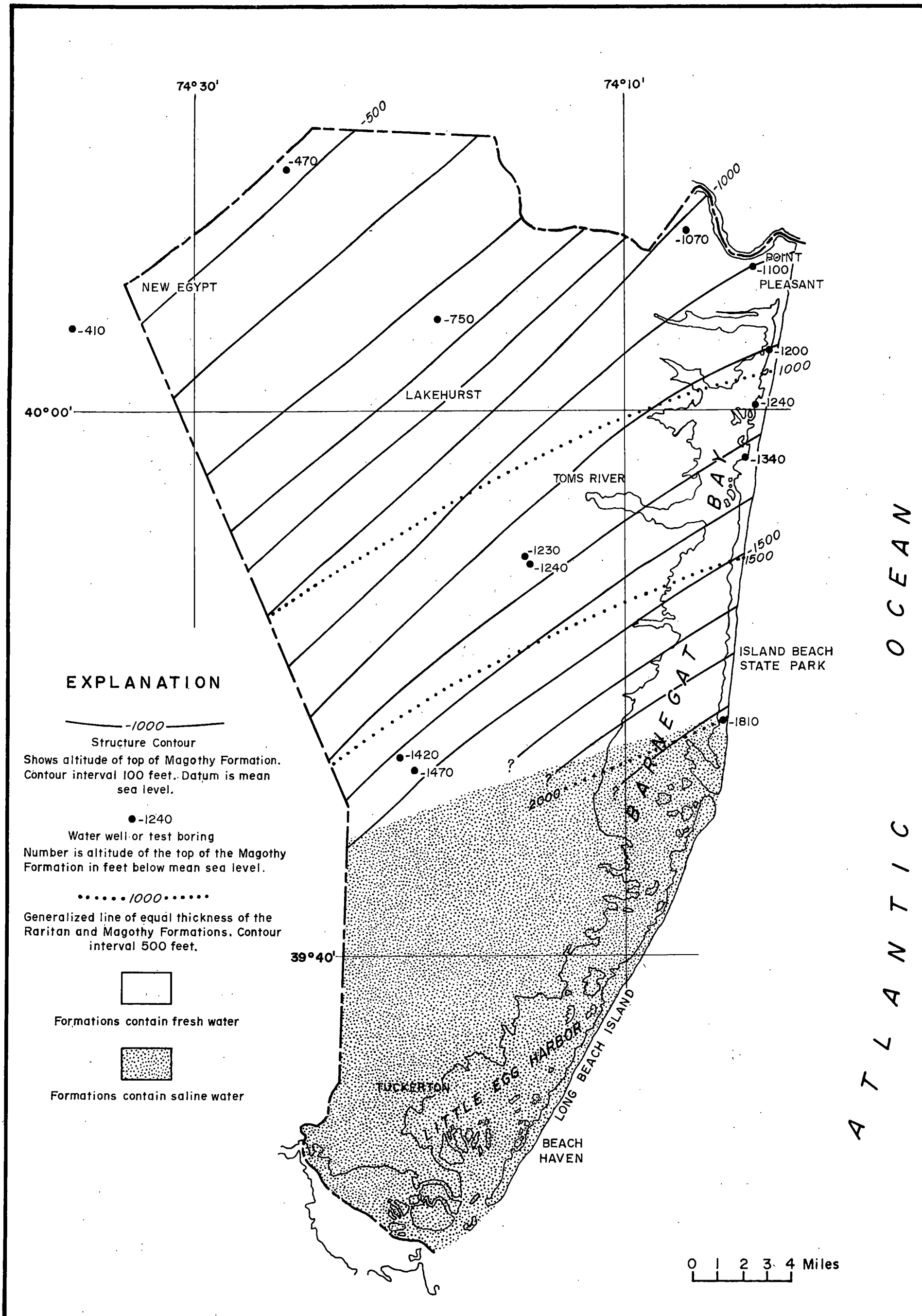

Figure 11.—Structure contour and thickness map of the Raritan and Magothy Formations.

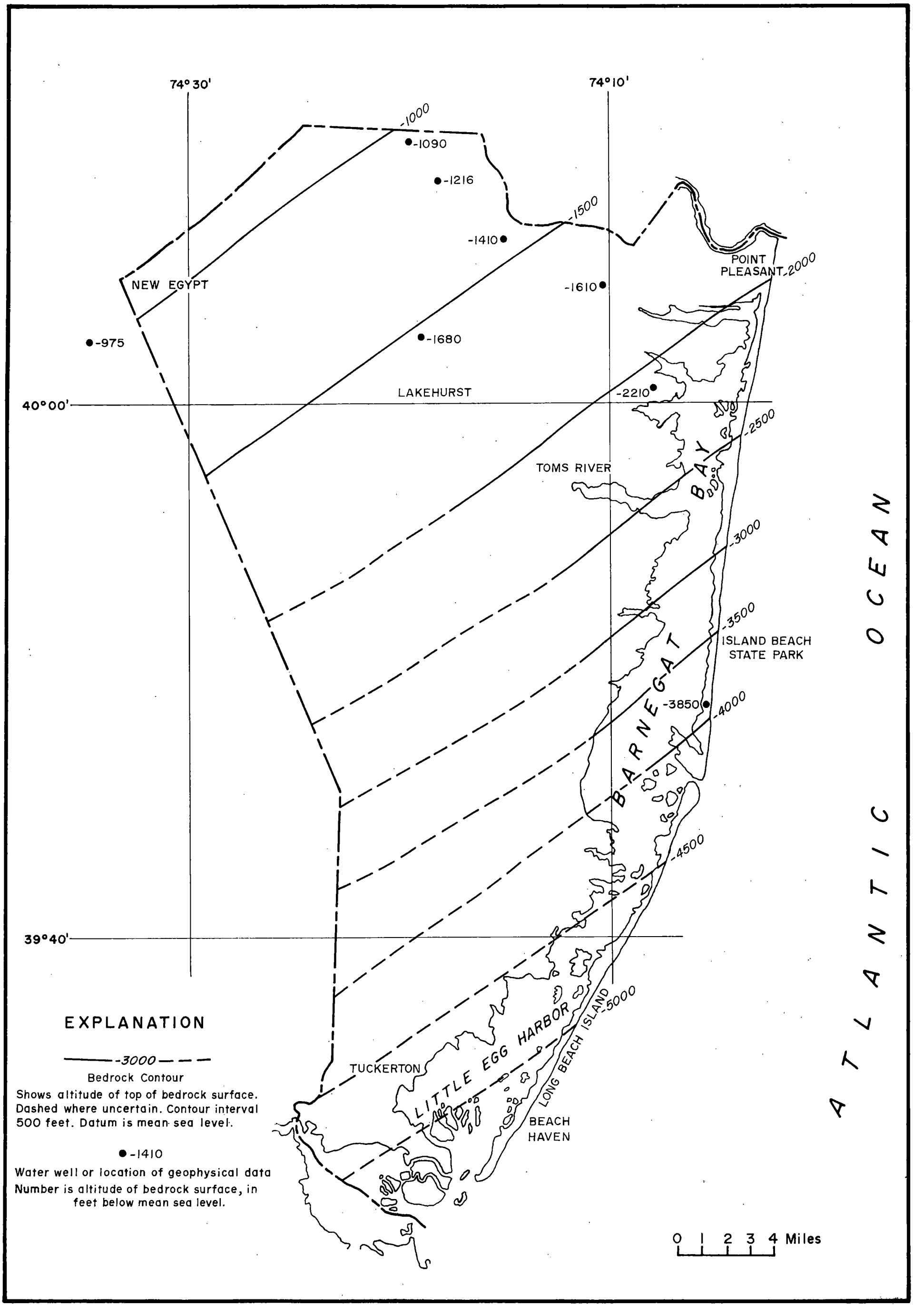

Figure 12.—Configuration of the pre-Cretaceous bedrock surface.

Hydrology

Because the top of the Magothy Formation in Ocean County is more than 600 feet deep, the use of the Raritan and Magothy Formations as a source of ground water is practical only to large industrial and public water-supply companies. This aquifer system contains the largest amount of ground water in storage in the Coastal Plain in Ocean County. It is comparatively undeveloped and, therefore, is an important future source of ground water in the county. At present, wells withdraw more than 5 mgd from the Raritan and Magothy Formations. Most of this is pumped by the Glidden Company near Lakehurst.

At least two aquifers occur within the aquifer system, but more test-well data are needed to determine the exact number and hydraulic relationship of these aquifers. The public water-supply wells (table 7) near the coast in Ocean County utilize only the upper aquifer, whereas three water-bearing zones are tapped near Lakehurst and at Sandy Hook in northeastern Monmouth County (fig. 9). At Lakehurst, the full 900-foot sequence of the Raritan and Magothy Formations was penetrated by wells (grid number 29.41.1.5.2) belonging to the Glidden Company. The water-bearing zones are the upper aquifer from 850 to 970 feet; the most productive aquifer from 1,280 to 1,480 feet; and the least productive aquifer immediately above the bedrock at 1,600 to 1,728 feet below land surface. The land surface is about 95 feet above sea level. Static water levels in the three aquifers before development in March 1962 were at or near sea level. After 15 months of pumping from the three aquifers at about 5 mgd, static water levels declined 20 feet in the upper and middle aquifers and 35 feet in the basal aquifer. The water-level difference suggests that the basal aquifer is hydraulically separate from the upper two, which appear interconnected.

An observation well at Island Beach State Park (33.13.8.7.2), drilled to bedrock, 3,886 feet deep, is screened from 2,736 to 2,757 feet in the middle of the Raritan and Magothy Formations. The well flowed about 6 gpm (September 1962) and had a static head of 28 feet above mean sea level.

The yields of wells tapping the Raritan and Magothy Formations range from 35 to 1,850 gpm and the average is 660 gpm. The average specific capacity is 20 gpm per foot (table 7).

The locations of selected wells tapping the Raritan and Magothy Formations and other aquifers in Ocean County are shown in figure 13.

Recharge to the aquifers occurs from precipitation, mainly in the high-level intake area from Trenton in southern Mercer County northeast to

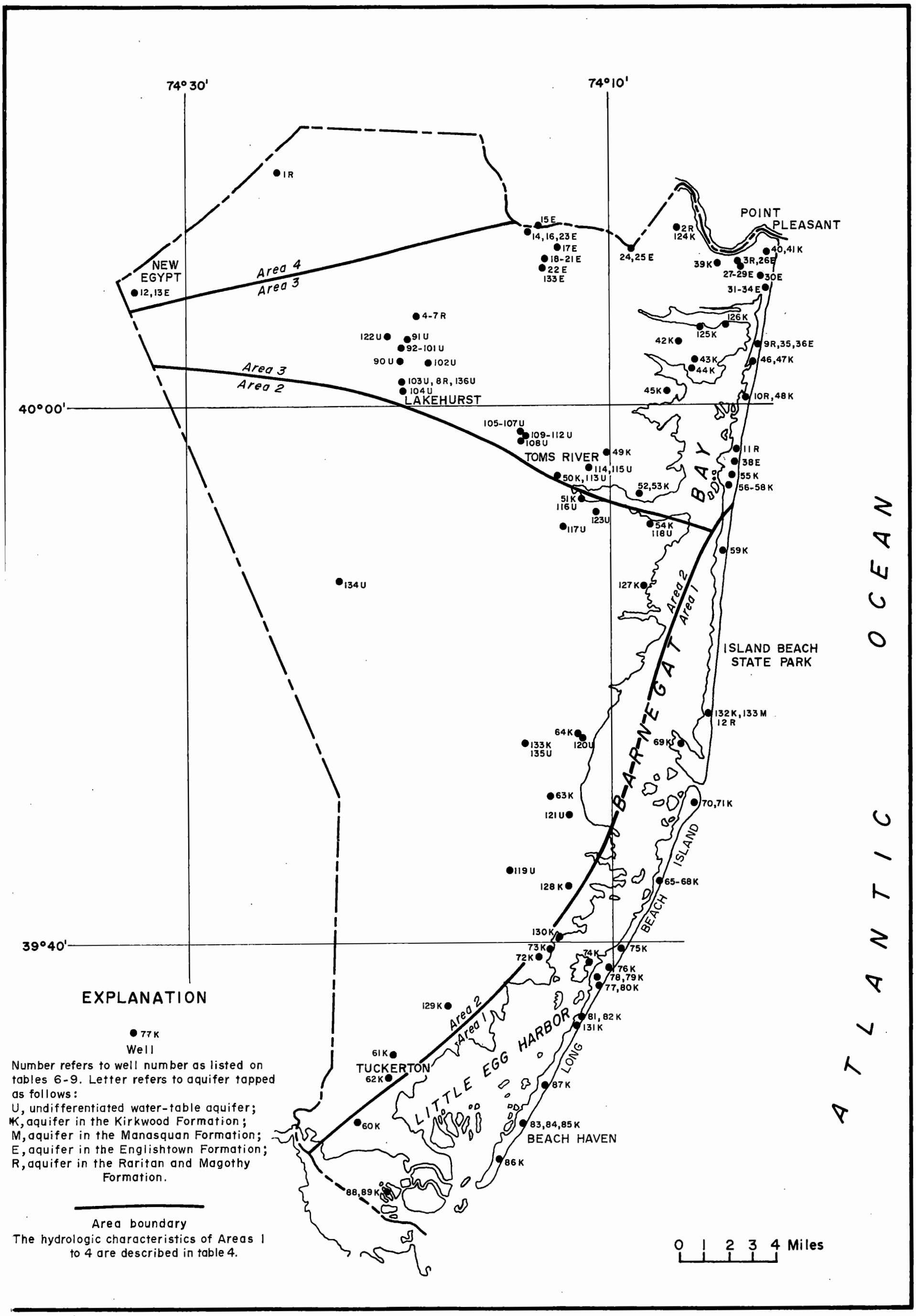

Figure 13.—Map showing location of selected wells in Ocean County.

Metuchen in northern Middlesex Counties (Barksdale and others, 1958, p. 102). An estimated 155 mgd or 1 mgd per sq mi is recharged to the Raritan and Magothy Formations in the intake area. If this quantity is distributed over the area where the Raritan and Magothy Formations contain fresh water (about half of the 4,400 square mile Coastal Plain) an average of 70,000 gpd (gallons per day) per square mile is available. In Ocean County, present withdrawals from the Raritan and Magothy Formations average only about 10,000 gallons per square mile. Withdrawals from the aquifer system in other areas may decrease the amount of water available in Ocean County to less than 70,000 gpd per square mile.

In northern Ocean County, small amounts of water probably discharge through vertical leakage into the Englishtown Formation, which has a lower piezometric head than the Raritan and Magothy Formations in this area. Additional development of the Raritan and Magothy Formations would reduce the amount of leakage from this aquifer to the Englishtown Formation.

Quality of Water

Fresh water in the Raritan and Magothy Formations is soft (28 to 51 ppm hardness) and generally of good quality except for high iron concentrations (0.66 to 3.2 ppm) (table 6). The temperature of the water is from 75°F to 86°F. The water is slightly basic (pH 7.3 to 7.8).

According to Barksdale and others (1958), the salt water-fresh water interface zone in the Raritan and Magothy Formations trends through the Island Beach State Park area. Electric logs and quality-of-water analyses (chloride concentrations of 700-1,000 ppm) indicate that the Island Beach well is screened near the top of the salt water-fresh water interface. Salinity increases below 2,750 feet as shown by the increase in conductivity and negative spontaneous potential and the decrease in resistivity on the geophysical logs (fig. 10). In the southern third of Ocean County, all aquifers in the Raritan and Magothy Formations probably contain saline water.

MERCHANTVILLE FORMATION AND WOODBURY CLAY

Geology

Merchantville Formation

The Merchantville Formation overlies the Magothy Formation disconformably. It is a black or dark green fossiliferous, glauconitic, micaceous clay, silt, or sandy clay which is locally indurated. The Merchantville can be distinguished from the overlying Woodbury Clay by the high glauconite content of the Merchantville and the sparsity or absence of glauconite from the Woodbury and by paleontological evidence. The Merchantville Formation contains a marine fauna, primarily a *Cucullaea* suite (Weller, 1907), which suggests deposition in a shallow water marine environment. Littoral and terrestial sediments of the Merchantville Formation were probably present northwest of the outcrop, but have since been eroded. The formation thickens southwestward along the outcrop from 35 feet in Monmouth County to 60 feet in Salem County.

Woodbury Clay

In the outcrop area, the Merchantville Formation grades upward into the Woodbury Clay (Owens and Minard, 1960). The Woodbury Clay is characteristically a 50-foot thick dark-gray or black non-glauconitic, lignitic, fossiliferous blocky clay containing interbedded white sand lenses. Downdip beneath Ocean County, the unit tends to contain more glauconite clayey sand. The Woodbury Clay and Merchantville Formation as a unit ranges in thickness from 160 feet at Lakehurst to 250 feet thick downdip at Lavallette. At Butler Place in Burlington County the Woodbury Clay is 130 feet thick. The predominant clay minerals determined by Groot and Glass (1960) from outcrop samples are kaolinite, chlorite, and mica which are indicative of non-marine deposition. Downdip montmorillonite, glauconite, and marine fossils were found in well samples suggesting a change to a marine facies.

Hydrology

The Woodbury Clay and Merchantville Formation are relatively impermeable compared to the underlying Raritan and Magothy Formations and the overlying Englishtown Formation and act as a confining layer for these aquifers. No recorded wells in the county tap the Merchantville or Woodbury Formations.

ENGLISHTOWN FORMATION

Geology

The Englishtown Formation is a gray micaceous quartz sand that weathers white, yellow, or brown. It is locally cross bedded and contains cemented iron-oxide, lignite, pyrite, and clay lenses. Near Trenton, in Mercer County, where the Englishtown Formation crops out, it contains feldspar and is defined as a subgraywacke (Owens and others, 1961). Downdip, in the southern part of the county, the sand facies of the Englishtown Formation wedges out or grades into a clayey lithology resembling the overlying Marshalltown and underlying Woodbury Formations.

Clay in the Englishtown Formation in the outcrop area is predominantly kaolinite, which is generally considered to be characteristic of continental deposition, but minor amounts of illite are also present (Groot and Glass, 1960). Downdip from the outcrop area, montmorillonite and illite clays are found; the former is considered indicative of marine deposition. Seaber (1962) considered the sandy facies of the Englishtown Formation to represent a delta and beach sand deposit. The sand was probably transported from a northern source area and reworked by longshore currents into the highly sorted fine sands and silts characteristic of the formation. The glauconitic clay facies, which is the downdip equivalent of the sand facies, was deposited in a deeper water marine environment.

The top of the aquifer or sandy facies of the Englishtown Formation has a strike of N. 50° E. and dips 50 feet per mile to the southeast in Ocean County. A structure contour map of the Englishtown Formation in Ocean County is shown in figure 14. The sandy facies of the Englishtown Formation has a thickness of approximately 75 feet in northeastern Ocean County. It thins southward and is considered to be absent at Island Beach State Park (Seaber and Vecchioli, 1963, p. B103).

Hydrology

The Englishtown Formation is fourth in importance in quantity of water yielded in Ocean County. The major users, public water-supply companies (table 8), pump approximately 3 mgd from this formation in Ocean County. The hydrologic characteristics of this artesian aquifer can be summarized from an aquifer study by Seaber (1962). Recharge to the formation occurs predominantly from vertical leakage down through the overlying younger formations in the topographic high areas of Monmouth and Camden Counties, 5 to 10 miles southeast of the Englishtown outcrop area.

The most intensive development of this aquifer is in the coastal areas of Monmouth County and northeastern Ocean County where pumping has lowered static water levels as much as 145 feet (at Allaire State Park in southeastern Monmouth County) from 1910 to 1967. Water levels at Allaire State Park declined 27.4 feet from April 1964 to April 1967. As water levels in the Englishtown Formation in this area are lower than in either the Kirkwood, Raritan, or Magothy Formations, water may leak vertically into the Englishtown from these formations. However, continued decline in water levels in observation wells tapping the Englishtown Formation indicates that much of the yield of wells is

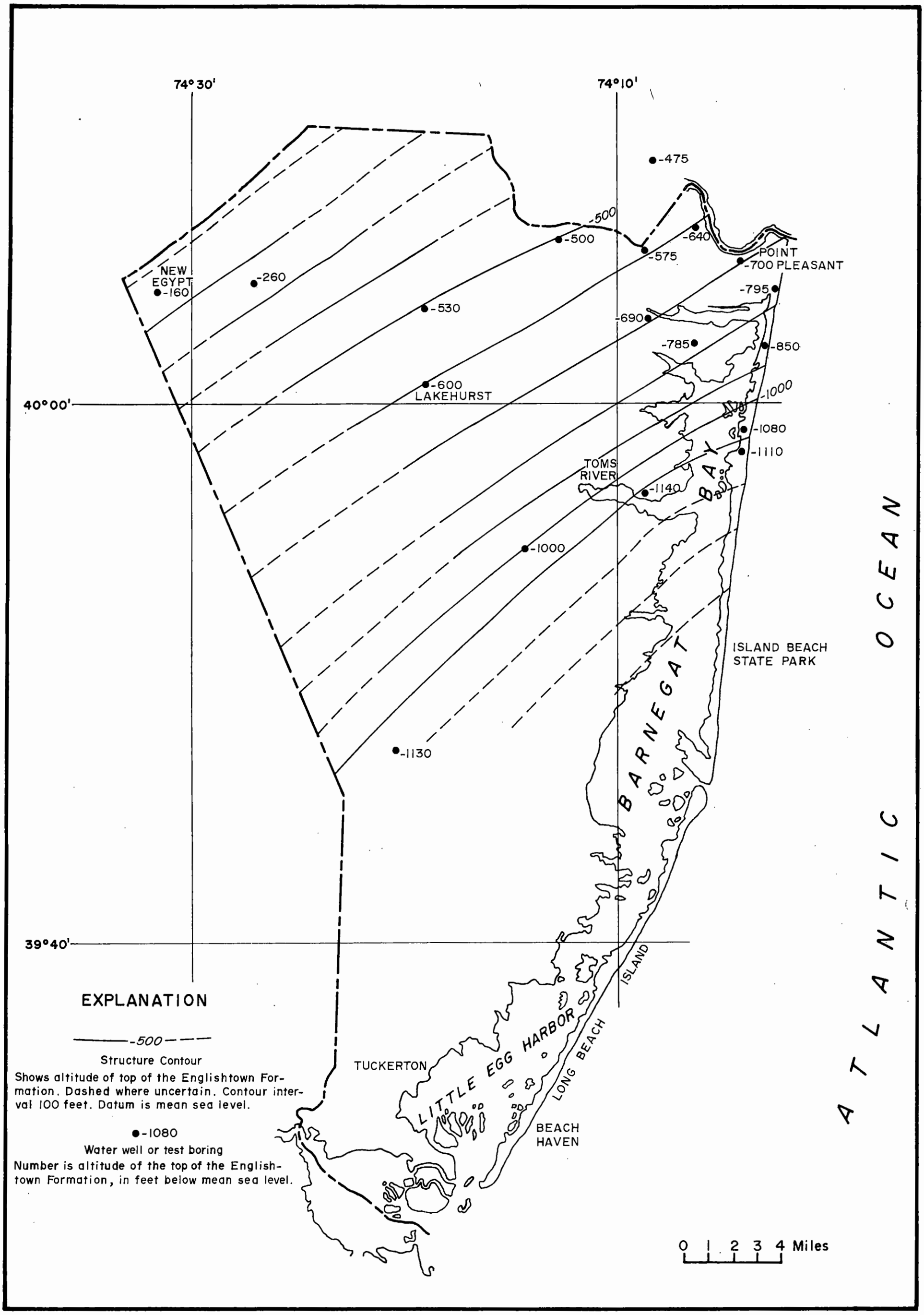

Figure 14.—Structure contour map of the Englishtown Formation.

coming from storage. Water levels in an observation well at Colliers Mills have declined approximately 30 feet from 1910 to 1967 and 5 feet from April 1964 to April 1967. Water levels in an observation well at Toms River have declined approximately 90 feet from 1910 to 1967 and 2 feet from April 1966 to April 1967.

Analysis of the pumping phase of a pumping test at Lakewood (Seaber, 1962) in May 1959 indicated a coefficient of transmissibility of 10,000 gpd/ft and a coefficient of storage of 2.7×10^{-4} for the Englishtown Formation, which is 52 feet thick there. From the recovery phase of this test, the coefficient of transmissibility calculated was 16,000 gpd/ft, and the coefficient of storage was 2.0×10^{-4}. The computed average permeability was about 300 gpd/ft^2. Laboratory analyses of permeability for 10 sand samples from the Englishtown outcrop ranged from 90 to 500 and averaged 273 gpd/ft^2 (Seaber, 1962).

Reported yields of wells in the Englishtown Formation range from 19 to 503 gpm and the average is 260 gpm (table 8). Specific capacities range from 1 to 5 gpm per ft and the average specific capacity is 3 gpm per ft.

Quality of Water

Ground water in the Englishtown Formation requires no special treatment for most industrial or public-supply uses. The water is soft to moderately hard (30 to 82 ppm hardness) and the pH ranges from 7.5 to 8.3. The composition of ground water changes downdip from a calcium-sodium hydrochemical facies to a sodium-calcium facies, as a result of ion exchange and adsorption of calcium by lignite (Seaber, 1962, p. B30). Changes in sodium, bicarbonate, nitrate, and temperature occur locally in addition to the expected downdip change of hydrochemical facies. Along the coast of Ocean County, high concentrations of sodium, bicarbonate, and total dissolved solids are common. No significant changes in the chemistry of the water have occurred with time in Ocean County. Chemical analyses from Englishtown wells are included in table 6.

The aquifer in the Englishtown Formation has little potential for further ground-water development mainly because water levels are already far below altitudes at which sea-water intrusion could occur. However, there is no evidence that sea water has intruded the aquifer.

MARSHALLTOWN FORMATION

Geology

The Marshalltown Formation varies in lithology from a black sandy micaceous glauconite clay to a clayey greensand. In the outcrop area in

Monmouth County, a laminated micaceous clay with seams of sand and scattered glauconite predominates, whereas toward the southwest, clayey glauconite sands are characteristic. Lignite is abundant in the basal part of the formation but decreases upward. Chlorite is abundant throughout the formation near Trenton in southern Mercer County (Owens and Minard, 1960). Downdip from the outcrop area, the formation coarsens somewhat into clayey silts and sands similar to the downdip lithology of the overlying Wenonah Formation and Mount Laurel Sand. The abundance of glauconite distinguishes the Marshalltown from the overlying and underlying formations. It is differentiated in electric and gamma-ray logs from the overlying and underlying aquifers by its low self potential and resistivity response and its strong gamma-ray response.

The Marshalltown Formation is typically 10 to 20 feet thick and attains a maximum thickness of about 25 feet in New Jersey.

The formation was deposited in a shallow-water marine environment. It contains a predominantly *Cucculaea* and *Exogyra ponderosa* fauna. *Exogyra ponderosa* is the characteristic index fossil (Weller, 1907) as it is restricted in New Jersey to this formation.

Hydrology

In general, the Marshalltown is considered a confining bed for the underlying Englishtown and overlying Wenonah and Mount Laurel aquifers. Downdip, in the southern half of Ocean County, the aquifers of the Englishtown and Wenonah and Mount Laurel Formations pinch out or become clayey and form part of the aquitard system which lies between the Magothy and Kirkwood Formations. Although no wells are reported to tap this formation in Ocean County, yields of 40 gpm to domestic wells have been obtained from the more sandy phases of the formation in other areas of the State (Barksdale and others, 1958).

WENONAH FORMATION AND MOUNT LAUREL SAND

Geology

Wenonah Formation

The Wenonah Formation, which does not crop out in Ocean County is typically a silt to medium-grained, yellow micaceous, and chloritic sand. It thins in outcrop from 100 feet in Salem County to less than 40 feet in the Atlantic Highlands in northeastern Monmouth County and generally becomes finer grained and more micaceous to the northeast. Locally, the formation is distinctly laminated with thin black clays and indurated ferruginous sandstone beds. Lignite and traces of glauconite also are present. In the subsurface beneath Ocean County, the Wenonah Formation grades into glauconitic sand and silt similar in lithology to the overlying Mount Laurel Sand. Because of the similarity, the two form one geohydrologic unit. Near Trenton, in outcrop, the Wenonah is differentiated from the Marshalltown by the former's lower content of clay and glauconite and greater amounts of mica, lignite, and fine-grained sand (Minard and Owens, 1962).

The fossil fauna of the Wenonah Formation is largely recurrent from the Woodbury and is dissimilar from the Marshalltown and overlying Mount Laurel fauna.

Mount Laurel Sand

In the northeastern part of the outcrop area, the Mount Laurel Sand is lithologically similar to the Wenonah, but toward the southwest the two are more distinct. The Mount Laurel characteristically is a glauconitic, fine-to coarse-grained quartz sand, having a salt-and-pepper appearance. Locally, as in the New Egypt area, the formation is semi-indurated, dense, and compacted. The Mount Laurel fauna is of marine origin and is smilar to that of the Navesink Formation. Where the Mount Laurel is distinguished from the Wenonah Formation in the outcrop area, the Mount Laurel is more fossiliferous, coarser grained, and contains more brown, yellow and dark green glauconite. The Wenonah is fine grained and micaceous and contains lignite and little glauconite. The combined thickness of the Wenonah Formation and Mount Laurel Sand in outcrop ranges from 60 to 100 feet and thins downdip to about 15 feet at Island Beach State Park where the Mount Laurel is a well-sorted, medium-grained, glauconitic quartz sand.

The top of the Mount Laurel Sand in Ocean County has a strike of N. 55° E. and a southeastward dip of 44 feet per mile. Figure 15 shows contours on top of the aquifer in the Wenonah Formation and Mount Laurel Sand.

Hydrology

Throughout most of the outcrop area and for some distance downdip, the Wenonah Formation and Mount Laurel Sand are porous sands which form one aquifer. In the south and central parts of the New Jersey Coastal Plain, it is extensively developed but in the northeast where its thickness and permeability decreases it is less important.

In Ocean County, approximately 1 mgd is pumped from this aquifer. Several public water-supply company wells along the coast obtain moderate quantities of water from the Wenonah Formation and Mount Laurel Sand. In the New Egypt area, a number of domestic wells,

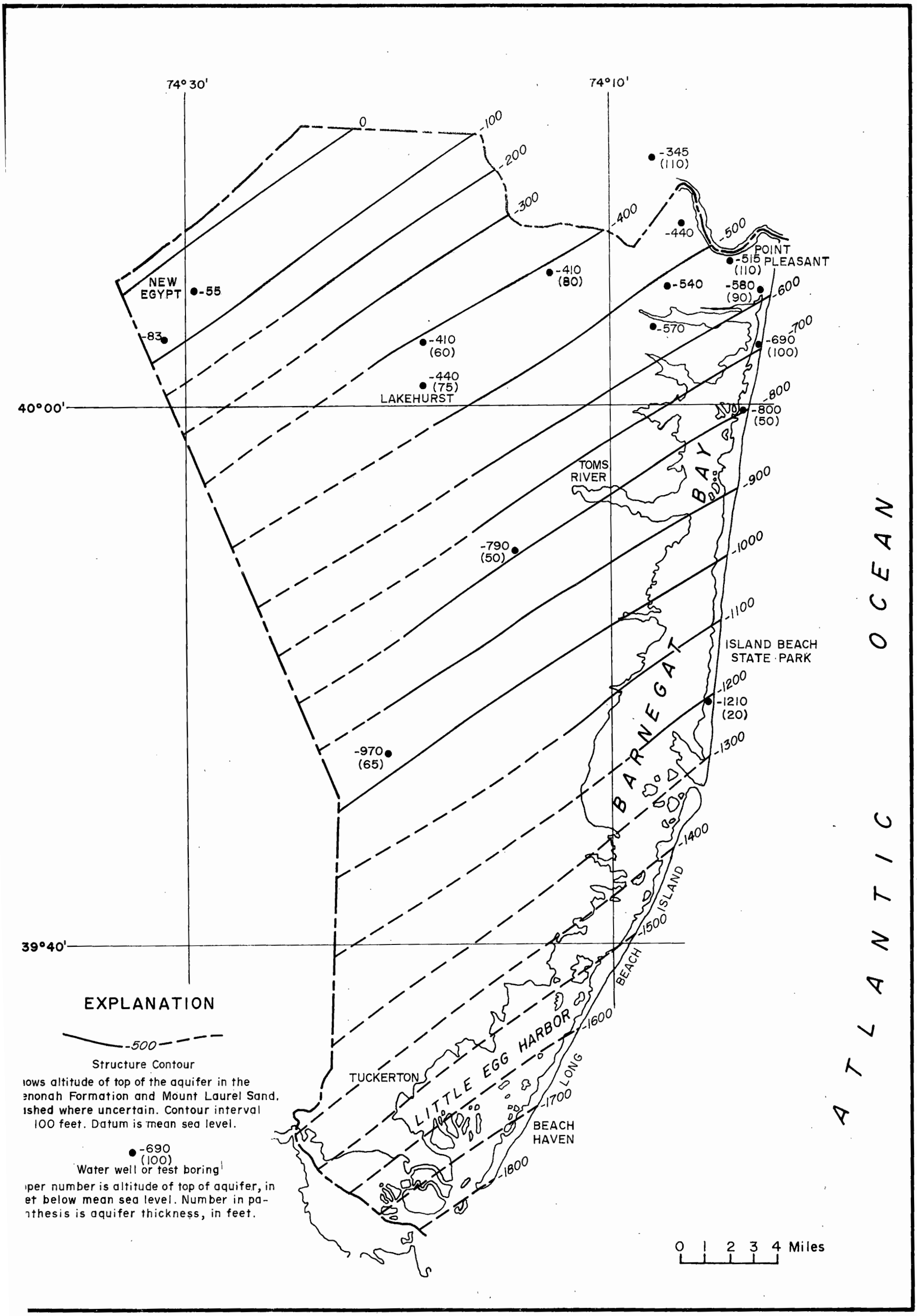

Figure 15.—Structure contour map of top of the aquifer in the Wenonah Formation and Mount Laurel Sand.

ranging from 100 to 150 feet in depth obtain small quantities of water from this aquifer. Although not as important an aquifer as the Kirkwood or Englishtown Formations, nevertheless its potential for development of small to moderately yielding wells is greater than that of either the Kirkwood or Englishtown Formations. Because the permeable sandy facies thins and grades into a glauconitic marl, this unit would probably not yield appreciable amounts of water downdip. However, in a test well at Island Beach State Park, a 12-foot section of the Mount Laurel Sand capable of yielding small quantities of water, was encountered at a depth of 1,200 feet.

The average yield of public water-supply wells tapping the Wenonah and Mount Laurel in Ocean County is 70 gpm. None yield more than 100 gpm. However, in Monmouth County, several wells yield 200 to 300 gpm.

Laboratory analyses of two outcrop samples from the Wenonah and Mount Laurel in Monmouth County (Thompson, 1930) indicated permeabilities of 566 and 887 gpd per ft^2 and porosities of 34 and 30 percent for the upper and lower parts of the aquifer, respectively. Barksdale and others (1958) report that the aquifer has an average permeability of 500 gpd per ft^2.

Water from the Wenonah Formation and Mount Laurel Sand is neutral in acidity and is generally soft but may contain excessive amounts of iron. The temperature of well water is higher than 60°F. in northern Ocean County.

NAVESINK FORMATION, RED BANK SAND, HORNERSTOWN SAND, VINCENTOWN FORMATION AND MANASQUAN FORMATION

Geology

Navesink Formation

The Navesink Formation is a greenish-black, semiconsolidated, greensand marl. It consists predominantly of fine- to coarse-grained, rounded glauconite and some quartz grains. The interstices are filled with finely divided glauconite, calcium carbonate, and clay. Generally, the upper part of the formation is clayey and micaceous and contains pyrite. The basal beds are coarser, more glauconitic, and contain polished quartz pebbles. The lithology of the Navesink Formation downdip, like most of the glauconite formations, is similar to its outcrop lithology. It is a marine formation which was deposited on the continental self. The Navesink forms part of the thick glauconite sand and clay sequence between the Magothy and Kirkwood Formations in the southern part of the county.

The maximum thickness of the Navesink in outcrop is 40 feet and the formation thins southwestward. The maximum thickness is about 100 feet in subsurface.

The variety of fossil fauna is large—121 species identified—and is similar to that of the Marshalltown Formation. Locally, pelecypod and cephalopod assemblages are abundant in hard indurated layers in the lower part of the formation. A basal shell bed found in outcrop and some distance downdip forms a consistent marker zone in the Coastal Plain of New Jersey.

Red Bank Sand

The Red Bank Sand in its outcrop area consists of an upper member of yellow or reddish-brown, medium-to coarse-grained, micaceous sand containing partly pyritized lignite; and a lower dark gray clayey member composed of a clayey, micaceous, fossiliferous, glauconite sand or sandy clay. A section of the lower member is exposed in Ocean County on the banks of Crosswicks Creek. The formation attains a maximum thickness of 140 feet in northeastern Monmouth County. The formation thins southwestward and wedges out at Sykesville in northern Burlington County. Lithologies found in outcrop are not continuous downdip. Generally, where the Red Bank is present in subsurface, it resembles the Navesink and Hornerstown greensand marls.

Hornerstown Sand

The Hornerstown Sand, the oldest Tertiary formation in Ocean County, is a massive green semiconsolidated medium-to coarse-grained, glauconite sand, silt, and clay containing interbedded shell layers. It is similar lithologically to the Navesink Formation but contains less clay, more glauconite, and is lighter green in color. The unit crops out in a small area in northwestern Ocean County and forms banks along Crosswicks Creek and its tributaries north of New Egypt. A discontinuous brachiopod shell bed several feet thick at the top of the formation forms the resistant stream bank ledges. The thickness and the lithology remain relatively constant downdip. The unit is typically 30 to 50 feet thick. At the Island Beach State Park test well, the Hornerstown is a dark green fossiliferous glauconite sandy silt that is 42 feet thick. The top of the unit here is at 1,120 feet in depth.

Vincentown Formation

The Vincentown Formation forms lowlands in northwestern Ocean County. It is of Paleocene age and is a highly fossiliferous and calcareous sand that can be divided into two distinct members.

The lowest member is a glauconite and quartz sand facies that crops out only in Ocean and Monmouth Counties. In the New Egypt area, the lower member is a greenish-gray, slightly micaceous, clayey, glauconitic, fine-to medium-grained angular to subrounded quartz sand (Minard and Owens, 1962). Above the water table, the clay is commonly eluviated, the fossils are dissolved, and the green color is altered to yellow.

The upper member is a lime sand facies, composed of sand-sized fragments of bryozoa, echinoids, and coral that are locally indurated into limestone lenses several inches thick. This member crops out southwest of Monmouth County. In the New Egypt area, the upper member is a clayey, micaceous, glauconitic, calcareous, fossiliferous, fine-to medium-grained quartz sand to clayey lime sand. The lime sand facies extend beneath Ocean County in the vicinity of Van Hiseville and Jackson Mills (fig. 3).

The thickness of the Vincentown Formation in the outcrop area ranges from several feet in the New Egypt area, where it has been subject to pre-Kirkwood erosion, to 130 feet. The formation increases in thickness downdip.

At the Island Beach State Park test well, it is represented by the upper limy member consisting of 192 feet of green, calcareous, microfossiliferous, sparingly glauconitic clay and silt. The top of the formation here is 792 feet below land surface.

Manasquan Formation

The Manasquan Formation of Eocene age crops out in Burlington County and in northwestern Ocean County (fig. 7). It is 40 feet thick north of Asbury Park in eastern Monmouth County and thins to the southwest. It thickens downdip; at Atlantic City in Atlantic County a 200-foot section of greensand marl contains fossils of Manasquan age. Near Asbury Park, the formation consists of a lower member of glauconitic sand and an upper member of fine-grained sand to greenish-white clay. At New Egypt, the lower member is a dark greenish-gray clayey glauconitic quartz sand and the upper member is a glauconitic quartz sand, silt, and clay (Minard and Owens, 1962). The members in New Egypt total 18 feet in thickness. Downdip the formation becomes generally a clayey glauconitic quartz sand in which the glauconite content increases downdip. Manasquan fossils include sharks' teeth and ostracods and pelecypod shells.

The contact with the overlying Kirkwood is gradational at Waretown. Both are a glauconitic clayey silt or very fine-grained sand but the Manasquan is green, fossiliferous (echinoids and ostracods), calcareous, and contains less mica and heavy minerals. At Webbs Mills (fig. 3) the grain size increases downward from a fine-grained sand in the Kirkwood Formation to a coarse-grained sand in the Manasquan Formation.

Hydrology

Navesink Formation

The Navesink Formation acts as a confining unit to the Vincentown and Wenonah and Mount Laurel aquifers.

Downdip from the outcrop of the Navesink in the northwestern part of Ocean County, a ten-foot thick basal shell bed yields small quantities of water to domestic wells. The lower part of this shell bed may include a shell bed from the top of the Mount Laurel Sand. The bed is indurated so that wells do not require a well screen and are cased only to the top of the bed.

Red Bank Sand

Few wells obtain water from the Red Bank in Ocean County. In Monmouth County where its area of outcrop is more extensive, the Red Bank yields from 3 to 30 gpm of water high in iron content to domestic wells.

Hornerstown Sand

The hydrology of the Hornerstown is similar to that of the Navesink and other glauconitic marl formations. It is relatively impermeable and serves as a confining bed. Downdip it forms part of the thick greensand marl sequence between the Magothy and Kirkwood Formations. Locally, in the Jackson Mills, Van Hiseville and Cassville areas (fig. 3), water is obtained for domestic supply from indurated shell beds within the formation. Well screens are not required here.

Vincentown Formation

The withdrawal of water from the Vincentown Formation is limited to areas near its outcrop from New Egypt to Bennetts Mills (fig. 3) where the formation is tapped by domestic wells yielding less than 50 gpm and having specific capacities of less than one gpm/ft drawdown. Downdip where the glauconitic clayey facies predominates, the Vincentown Formation is less permeable, and its value as an aquifer decreases. This decrease in permeability downdip is characteristic of all Cretaceous and Tertiary Coastal Plain formations except the basal Raritan and uppermost Kirkwood and Cohansey Formations.

Yields of up to 300 gpm have been obtained from the lime sand facies of the Vincentown Formation in Burlington and Salem Counties. No yields greater than 50 gpm are obtained from the glauconite and quartz sand facies in Ocean and Monmouth Counties. Attempts to develop wells in the Vincentown yielding more than 50 gpm should be restricted to areas within or near the outcrop. Shallow wells drilled adjacent to Crosswicks Creek could probably obtain water by induced infiltration of stream water into the aquifer.

Manasquan Formation

The Mansaquan Formation is not considered an important aquifer in Ocean County as less than 1 mgd of ground water is withdrawn. The Seaside Heights, Seaside Park, and Barnegat Light water departments (fig. 3) obtain water from fine sands in the Manasquan Formation and probably from underlying sands of the Vincentown Formation. The average yield from six wells in these areas is 260 gpm and the average specific capacity is 3.4 gpm per ft.

Lithologic samples analyzed from a test well at Webbs Mills indicate that the upper part of the Manasquan is more permeable than the Kirkwood Formation in this area. Here, the sands in the upper part of the Manasquan Formation are comparable in permeability to coarse sands in the Cohansey Sand. However, at Waretown (fig. 3) the upper part of the Manasquan contains more clay and is relatively impermeable.

Pumping tests of wells at Webbs Mills and of the public-supply wells on the coast indicate that locally the Manasquan is a better aquifer than the Kirkwood Formation and can yield moderate quantities of water. The Manasquan Formation changes downdip into a highly glauconitic clayey marl that is relatively impermeable and acts as a confining bed.

Chemical analyses of water from the Manasquan Formation are available from one U. S. Geological Survey observation well in Ocean County and two wells in Burlington County. Water in these wells is soft (17 to 24 ppm hardness), variable in iron content (0.02 to 1.4 ppm), and the pH ranges from 7.4 to 9.3. Water in the three wells sampled is of the sodium bicarbonate type.

KIRKWOOD FORMATION

Geology

The Kirkwood Formation crops out along the northern part of Ocean County. The formation is composed of two lithologic members. The lower unit, in the New Egypt area, is dark-brown, pebbly, lignitic, micaceous, ilmenitic, fine to very fine grained quartz sand and silt containing some fine-grained glauconite. It is described by drillers as a black lignitic micaceous clay. The upper unit consists of a light-gray to yellow-brown micaceous ilmenitic, lignitic, very fine to fine grained quartz sand. Weathered Kirkwood above the water table is medium gray, yellow brown, or red brown in color.

The two members of the Kirkwood Formation are not continuous from Laurelton to Point Pleasant. Here, the following sequence, from top to bottom, is present: clay, sand, clay, coarse-grained sand, and clay. The lower sand unit, 30 to 50 feet thick, is considered to be correlative with the Atlantic City 800-foot sand, the most important water-bearing unit on Long Beach Island and in Atlantic City in southeastern Atlantic County.

At Laurelton, a thin gray lignitic micaceous coarse-grained sand is encountered at the base of the Kirkwood Formation. This sand may be the equivalent of the Atlantic City 800-foot sand.

In the southern part of Ocean County, several water-bearing sands are interbedded with thin clays. The sands are equivalent to the Atlantic City 800-foot sand and crop out in the lower part of the Kirkwood near Point Pleasant.

The thin elongate 800-foot sand paralleling the coast can be described as a "shoestring sand" and may be a barrier beach deposit. The sand consists of gray and brown, medium grained to granule size, subangular quartz grains with finely divided lignite and gray and black chert grains. Overlying the sand lenses along the coast are discontinuous beds of clay, silt, and fine-grained sand.

Toward the outcrop of the Kirkwood Formation, silt and fine-grained sand facies predominate whereas thick clays and shoestring-sand beds predominate downdip along the coast. At the base of the Kirkwood Formation in Ocean County, the strike is N. 60° E. and the average dip is 22 feet per mile to the southeast as determined from structure contours shown in figure 16.

The Kirkwood Formation ranges in thickness from a minimum of 50 feet in the outcrop area to a maximum reported thickness of about 800 feet in Atlantic City. The rate of thickening increases from 10 feet per mile where the formation is less than 400 feet thick, to 30 feet per mile where the formation is thicker than 400 feet. Figure 17 shows the thickness of the Kirkwood Formation in Ocean County.

Hydrology

The Kirkwood Formation contains the most intensely developed aquifers in Ocean County. The Kirkwood Formation supplies ground water to all public water supply company wells on Long Beach Island and

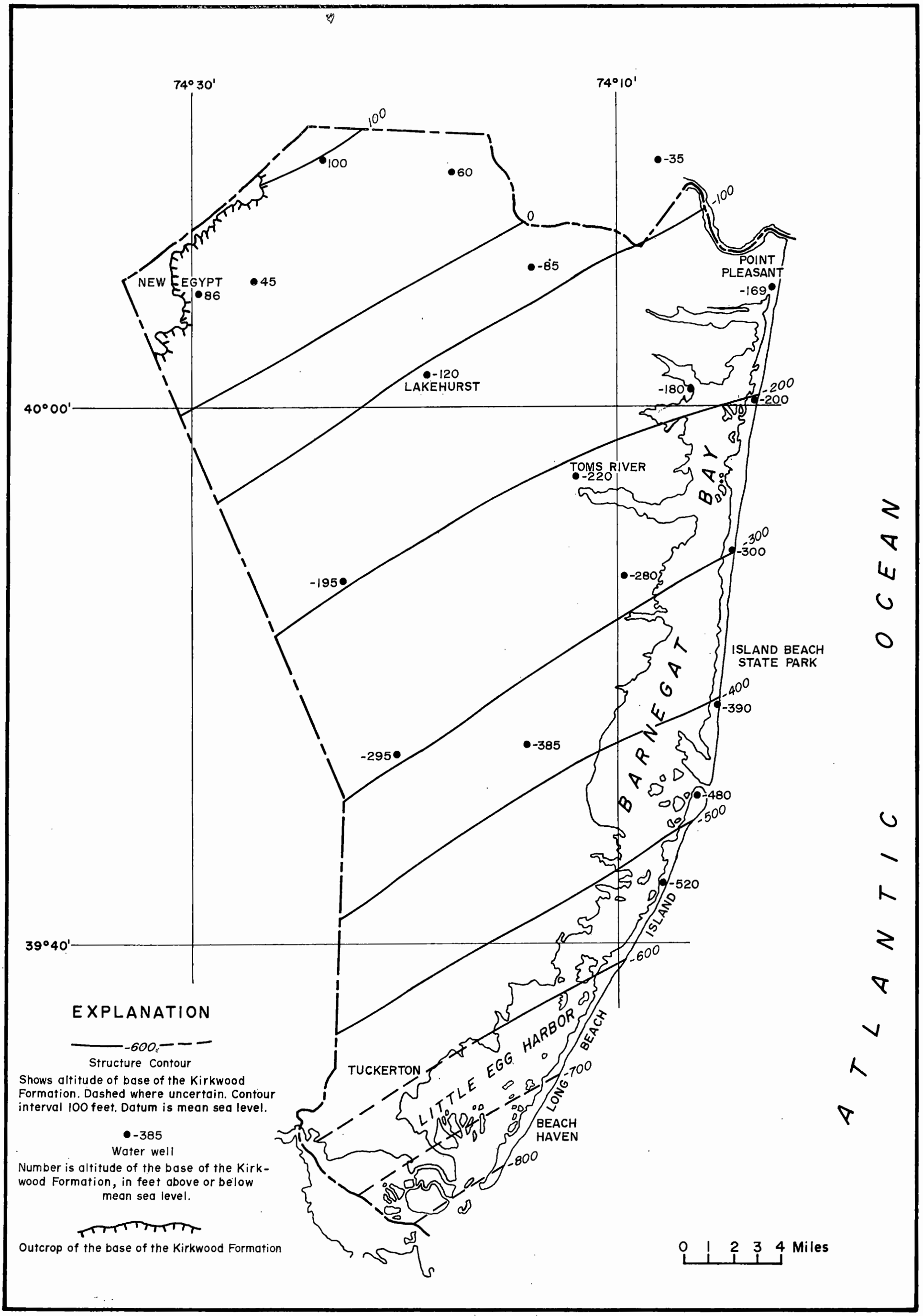

Figure 16.—Structure contour map of the base of the Kirkwood Formation.

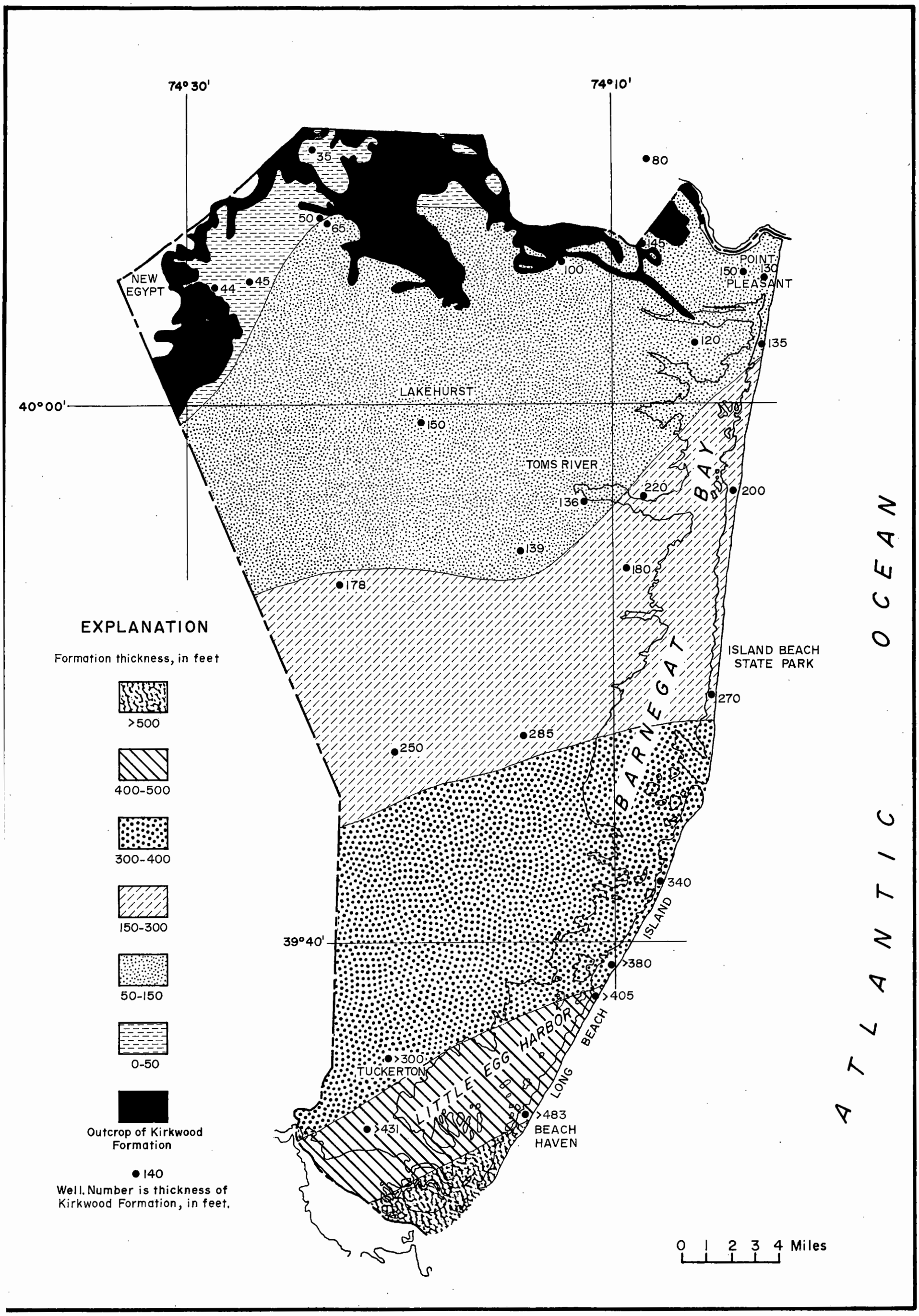

Figure 17.—Thickness map of Kirkwood Formation.

part of the water to public supplies northward to Point Pleasant. The most important aquifer in the Kirkwood is the Atlantic City 800-foot sand which can be traced continuously along the coast northward from Cape May to Barnegat Light and discontinuously northward to Point Pleasant.

Along the coast from Beach Haven to Point Pleasant, the yields of 44 public supply wells tapping the Kirkwood Formation range from 38 to 1,225 gpm and average 417 gpm (table 9). Specific capacities computed from 37 of the wells range from 1 to 30 gpm per ft and average 11 gpm per ft of drawdown. Diameters of the wells range from 4.5 inches to 16 inches. Screens range in length from 9 to 83 feet and average 30 feet. Most of these wells tap the Atlantic City 800-foot sand. The total yield of the 44 wells, if pumped at full capacity simultaneously, is 26 mgd, a rate which may be approached during the peak summer months of July and August. However, the average daily pumpage from the Kirkwood Formation in the entire county is only 5 mgd.

The increased demand for water during the summer months is typified by pumpage on Long Beach Island. In 1960, an average of 1.55 mgd was pumped from wells that tap the Kirkwood Formation on this island. In July, the average pumpage was 4 mgd and in February the average pumpage was 0.6 mgd, about one-seventh of the July pumpage. The summer population is at least seven or more times the winter population.

Prior to the intensive resort development and consequent ground water development after 1900, most wells tapping the artesian aquifers in the coastal plain were flowing wells. Some had static levels of 50 feet or more above sea level. Few wells tapping these aquifers flow today. Pumping from the Kirkwood has depressed water levels more than 30 feet in the southern tip of Ocean County and to as much as 80 feet below sea level in the Atlantic City area. Contours on the piezometric surface and the decline in piezometric head since 1910 are shown in figure 18.

Recharge to the Kirkwood is principally by leakage from the water-table aquifer in areas of high elevation inland. Recharge also occurs in the Kirkwood outcrop area in Monmouth County. On Long Beach Island, Kirkwood water levels are much lower than those of the water-table aquifer (see fig. 18), but vertical leakage is probably insignificant as indicated by the fact that salt water in the barrier beach has not contaminated the Kirkwood aquifer.

From a pumping test in the Kirkwood Formation at Ocean Gate, a coefficient of transmissibility of 11,000 gpd per foot and a coefficient of storage of 6×10^{-4} were computed.

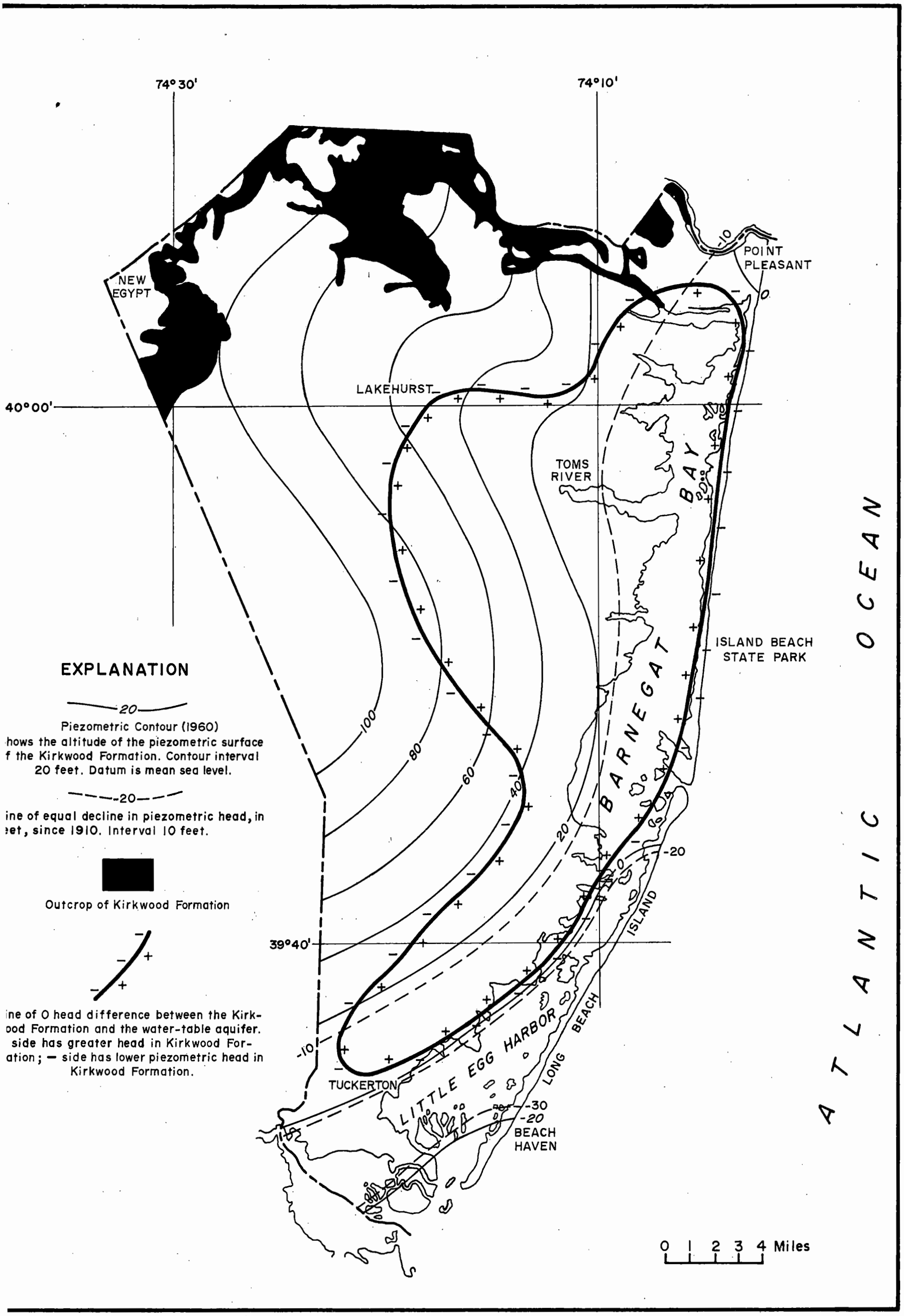

Figure 18.—Map showing piezometric contours and water level drawdown of the Kirkwood Formation.

Quality of Water

The quality of ground water from the Kirkwood aquifer is suitable for most uses. It is generally soft to moderately hard (2.9 to 105 ppm except one sample with 269 ppm hardness) and is low in dissolved solids content (40 to 180 ppm except one sample with 688 ppm). Locally, excessive concentrations of iron (0.04 to 7.2 ppm) and acidic water (pH 4.0 to 8.3) are encountered (table 6). In the Point Pleasant area where the Kirkwood crops out, salt water was found in one well (No. 48K). The temperature of ground water in the Kirkwood is lower than 62°F, which makes it suitable for cooling purposes. The quality of ground water in the Kirkwood is similar to that of the water-table aquifer except that the water from the Kirkwood contains more silica (range 15-32 ppm), than the unconfined water (range 2.8 to 5.8 ppm except one sample with 17 ppm).

THE WATER-TABLE AQUIFER

Geology

Cohansey Sand

The Cohansey Sand is exposed throughout Ocean County (fig. 7) except along the north and east borders. It is characteristically a yellowish-brown, unfossiliferous, cross-stratified, pebbly, ilmenitic, fine- to very coarse-grained quartz sand that is locally cemented with iron oxide. White, dark gray, and red kaolinitic clays are interbedded with the sands. Individual beds are difficult to trace as the clays and sands are lenticular and discontinuous. Generally at any one site several sand and clay beds are found. The clay beds are 8 to 10 feet thick but may be as much as 30 feet thick. According to Minard and Owens (1962), clay and silt eluviated from overlying Quaternary deposits have caused the upper beds of the Cohansey Sand to become less porous and permeable.

Markewicz and others (1958) believe the Cohansey to be a large alluvial fan deposit, whereas Owens and Minard (1960) postulate a beach origin and consider the formation too widespread for alluvial deposition. The yellow-brown color suggests deposition in an oxidizing environment such as terrestrial or near shore marine. However, oxidation may be from post-depositional weathering.

The Cohansey Sand is of Miocene(?) and Pliocene(?) age. Poorly preserved plant fossils found near Bridgeton in west-central Cumberland County are correlated with European flora of late Miocene age.

The Cohansey thickens southward to about 200 feet at Tuckerton. The base of the formation dips about 10 feet per mile southeastward.

Beacon Hill Gravel

The Beacon Hill Gravel of Pliocene(?) age occurs as erosional remnants capping hilltops in the western part of Ocean County. (See fig. 7.) It is the oldest, highest in altitude, and coarsest of the gravel deposits in the county. It is composed of quartz, chert and rock fragment pebbles, and sand.

Bridgeton Formation

The Bridgeton gravel of Pleistocene age is divided into the Glassboro phase found in the southwestern part of New Jersey and the Woodmansie phase found in Ocean County (Salisbury and Knapp, 1917). The Woodmansie phase forms scattered veneers on hilltops in the northern and southern sections of the county and consists chiefly of sand derived from the Kirkwood and Cohansey Formations. It was deposited on a southeast sloping plain that ranges in altitude from 130 feet at Lakewood to 60 feet at Barnegat (fig. 3). The deposit is about 20 feet thick. Southward at lower elevations more ironstone and less weathered chert is present. It differs from the Glassboro phase in that it is non-arkosic and without pebbles of crystalline rock, red shale, or sandstone derived from the Piedmont Plateau province.

Pensauken Formation

The Pensauken Formation is similar in lithology to the Bridgeton Formation but occurs mainly in the Toms River area. It is slightly glaucontic and contains abundant ironstone fragments. Toward the southeast, the quartz pebble content increases. The Pensauken Formation differs from the Cape May Formation in the greater amount of cementation, oxidation of the glauconite grains, higher percentage of iron oxide grains and greater weathering of the chert of the Pensauken (Salisbury and Knapp, 1917). Pebbles or boulders of granite, Triassic red shale and sandstone, and Paleozoic quartzites from a northwest origin are absent from the Pensauken Formation.

Cape May Formation

The Cape May Formation of Pleistocene age is a terrace and marine deposit found at altitudes of less than 50 feet along the coast and as high as 150 feet in inland stream valleys. The marine phase is found along the coast and fluvial deposits occur in stream valleys. In general, the Cape May Formation is less compact and contains fewer weathered chert and iron oxide coated pebbles than the older gravels. Much of the Cape May Formation is material reworked from older deposits. In the marine phase of the Cape May, a thin shallow black-clay bed occurs commonly in tidal inlet areas such as at Toms River.

Holocene Series

Holocene deposits consist of dune and related beach deposits, swamp and tidal marsh deposits, and stream alluvium. Dune and related beach deposits from the barrier beach extending from Beach Haven to Point Pleasant. The sediments are typically well sorted, fine- to medium-grained quartz sands and are usually less than 50 feet thick.

Silt and clay that are high in organic matter compose the swamp and salt-marsh deposits. Cedar swamps are found inland near streams in Ocean County and salt marshes are common to the Barnegat Bay area.

Stream alluvium consists of thin sand deposits confined to stream channels.

Hydrology

The water-table aquifer is composed of the Cohansey Sand, the Beacon Hill Gravel, and the Bridgeton, Pensauken, and Cape May Formations. It is important as a future source of ground water. At present, the water-table aquifer is pumped moderately in the vicinity of Toms River and Lakehurst and to a lesser extent along the bayside coast of Ocean County. Locally, the water-table aquifer contains confined beds along the coast. Wells along the coast obtaining water from below a thin black clay bed of the Cape May Formation are artesian and commonly flow. In this area, artesian heads in the Kirkwood Formation are higher than the water table (fig. 18) so water is discharged upward into the water-table aquifer. In the pinelands area, where large quantities of water are in storage, the aquifer is virtually untapped (fig. 13).

Recharge to the water-table aquifer in Ocean County is directly from precipitation although locally, recharge can be induced from nearby streams. The depth to the water table in most of the county can be estimated from the altitude of nearby streams that are hydraulically connected and fed by the water-table aquifer. Figure 19 is a water-table map compiled largely from surface-water altitude data. In general, the depth of the water table below land surface is greatest where the altitude of the land is highest.

The outcrop area of this aquifer and recharge to it are the largest of the Coastal Plain aquifers. The water-table aquifer is also most affected by losses from evapotranspiration and baseflow runoff. As much as 50 percent of the precipitation is transpired by the pine-oak-cedar forest and evaporated from cranberry bogs, cedar swamps, lakes, streams, and shallow water-table areas. At least 70 percent of stream water flowing to the ocean is ground-water baseflow derived from this aquifer. Ground-water

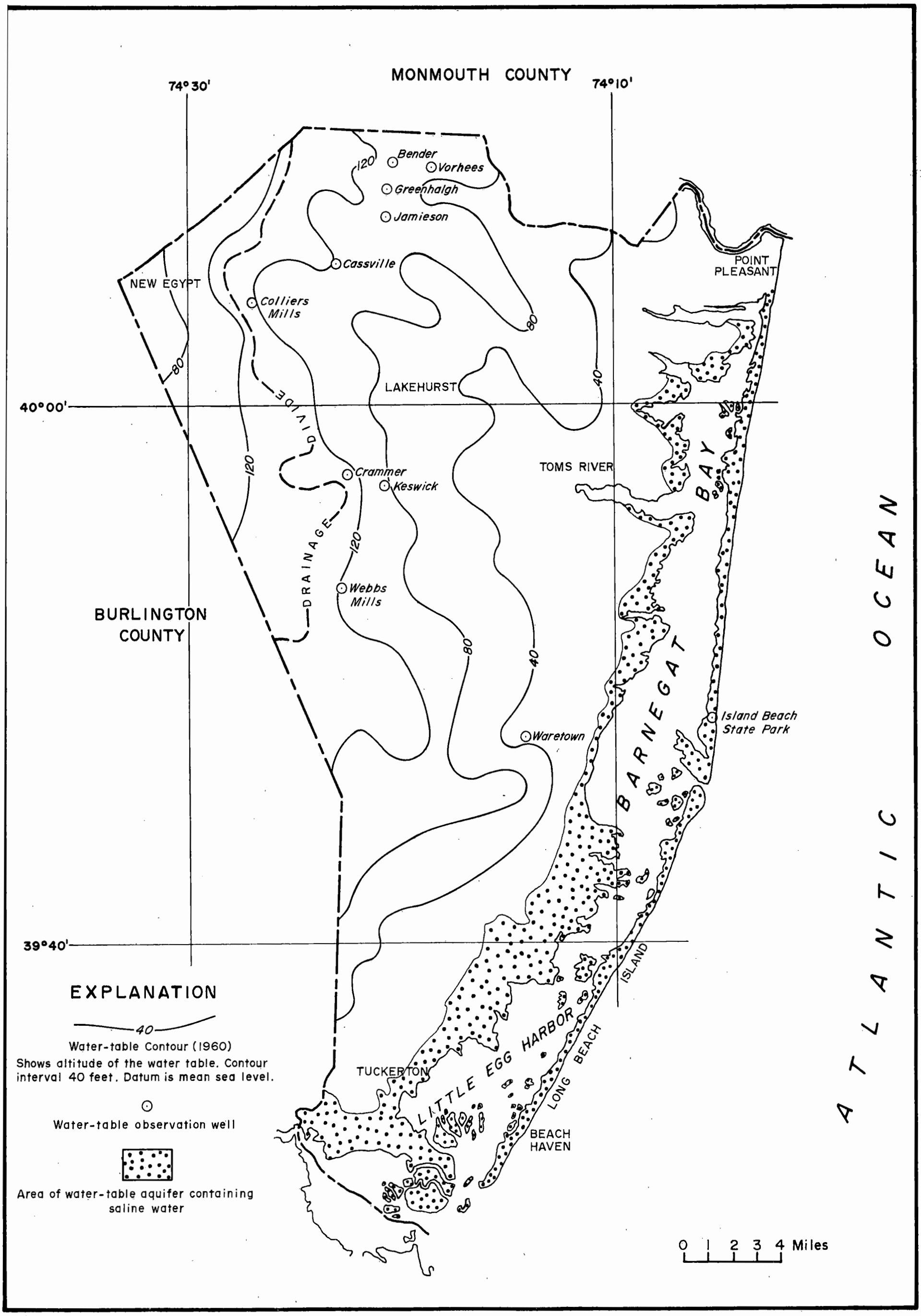

Figure 19.—Water table contour map of Ocean County.

baseflow from this aquifer in the Toms River drainage basin is approximately 0.8 mgd per sq mi or 100 mgd for the total basin area. This is about 80 times the present daily pumpage from the aquifer in Ocean County.

In the southern half of Ocean County, the water-table aquifer and the Kirkwood Formation are the only sources of fresh ground water. Here, the Raritan and Magothy Formations contain saline water, and aquifers of the Englishtown, Mount Laurel, Wenonah, and Vincentown are absent. The Kirkwood is intensely developed along the coast, particularly on the barrier beach, as indicated by water levels that are below sea level. Inland, the Kirkwood yields only small quantities of water. Hence, the water-table aquifer is the most important future source of fresh ground water in the southern part of the county.

In the areas of concentrated pumpage, at Toms River and Lakehurst, yields of 30 industrial and public-supply wells tapping the water-table aquifer (table 10) range from 65 to 665 gpm and the average is 323 gpm. Specific capacities range from 2 to 39 gpm per ft and the average is 13 gpm per ft. The coefficient of transmissibilty computed from an infiltration gallery aquifer test near Toms River is 28,400 gpd per ft. Permeabilities determined in the U. S. Geological Survey laboratory of sands and gravels in the water-table aquifer range from less than 1 to about 4,500 gpd per sq ft (table 5).

The Cohansey Sand is the thickest formation and constitutes most of the zone of saturation in the water-table aquifer. The overlying deposits of the Beacon Hill Gravel, Bridgeton, Pensauken, and Cape May Formations act primarily as permeable receptors of precipitation for recharge to the zone of saturation. Most of the units overlying the Cohansey Sand are above the water table, but locally, along the coast, and in stream valleys parts are saturated. The salt marsh and swamp deposits of Holocene age are relatively impermeable. The beach sands contain mostly saline water.

About 4 mgd are pumped from the water-table aquifer by industry and public-water supply companies, and about 2.5 mgd are pumped for domestic use. The natural discharge to streams, or base flow, is about 0.8 mgd per sq mi.

Quality of Water

Ground water in the water-table aquifer is commonly acidic (pH 4.4 to 6.7) and therefore corrosive. It may contain excessive iron (0.09 to 22 ppm), and may have a hydrogen sulfide odor. Because of these

Table 5.—Physical characteristics and permeability of sediments exposed in Ocean County. (Locations on fig. 7) (values are laboratory determinations)

No.	*Geologic unit*	*Median diameter millimeters*	*Coarsest grade size millimeters*	*Coefficient of sorting*	*Skewness*	*Coefficient of permeability (gpd/sq ft Meinzer units)*
1	Cohansey Sand	0.24	8 -16	1.67	1.58	110
2	do.	.16	8 -16	2.37	.85	.2
3	do.	.19	2 - 4	2.12	1.80	67
4	do.	.21	1 - 2	2.10	1.98	110
5	do.	.65	4 - 8	1.74	1.14	320
6	do.	.23	.5- 1	1.43	1.04	200
7	do.	.66	4 - 8	2.08	1.22	550*
8	do.	1.0	4 - 8	1.70	.87	3,300†
9	do.	1.8	16 -32	1.68	1.03	34
10	do.	.37	4 - 8	1.35	.92	240
11	do.	.18	.5- 1	1.52	1.03	30
12	do.	.4	2 - 4	1.68	1.09	300
13	do.	.52	2 - 4	1.35	1.07	710
14	do.	.7	16 -32	2.00	.82	400
15	do.	.45	4 - 8	2.50	1.30	170
16	do.	.6	8 -16	5.00	1.36	4
17	Beacon Hill Gravel	.44	2 - 4	1.65	1.09	400
18	do.	1.1	16 -32	2.76	1.17	110
19	do.	7.0	16 -32	2.50	.29	3,600
20	Pensauken Formation	5.0	16 -32	2.76	.59	4,500
21	do.	2.5	16 -32	4.00	1.44	560
22	Cape May Formation	.33	1 - 2	1.31	1.08	340
						730 ‡

*horizontal †vertical ‡average

characteristics, the water-table aquifer contains the poorest quality fresh water of the Coastal Plain aquifers. It differs in quality from surface water in that it is cooler, less acidic, and does not have the brown color characteristic of the streams. Surface water, however, does not have the hydrogen-sulfide odor and the excessive iron content of the ground water. Table 6 contains chemical analyses of water from water-table wells.

SURFACE WATER

Streamflow in the Coastal Plain consists largely of base flow derived from ground-water discharge. During periods of little or no precipitation, base flow accounts for virtually all the streamflow in Ocean County. The location of stream-gaging stations in Ocean County are shown in figure 3.

A stream hydrograph reflects flow contributions from base flow and from direct runoff and generally can be separated empirically into these components. Following a rainfall, a large part of the stream discharge is direct runoff, and is indicated by a sudden increase in discharge on the hydrograph. After the peak flow passes, the curve decreases rapidly at first, then more gradually as stream discharge becomes entirely base flow. A period of five days after a rainfall are sufficient for direct runoff to be discharged from the Toms River basin. After that time, the hydrograph shows the depletion of the ground-water reservoir.

The period of 5 days for surface runoff to drain from the Toms River basin was determined by relating runoff on the hydrograph to the average daily precipitation at Toms River, Lakewood, and at Pemberton in northern Burlington County for the years 1940-62. The peak discharge of the stream usually occurs 2 to 3 days after a rainfall. Surface runoff terminates about 2.6 days after the peak, according to the formula (Linsley, Kohler, and Paulhus, 1958) $t = A^{0.2}$ where A is the drainage area in square miles of the basin, and t is the time in days after the hydrograph peak.

BASE FLOW

Base flow for Toms River was estimated by separating the hydrograph for the relatively dry water year of 1957 (34 inches precipitation at Toms River) into surface runoff and base flow. The average base flow computed for 1957 was 124 cfs (13.59 inches) or 67 percent of the annual mean streamflow for 1957 of 184 cfs (20.17 inches).

Base flow for Toms River was computed also for the exceptionally wet water year of 1958, when 74 inches of precipitation fell. By the hydrograph separation method, base flow was found to be 202 cfs (22.14 inches) or 68.5 percent of the annual mean streamflow for 1958 of 295 cfs (32.34 inches).

STREAMFLOW

A continuous record of streamflow is available for Toms River (fig. 4) from 1928 to the present. The gaging station at Toms River includes a drainage area of 124 square miles. The average discharge for the 1929-62 period is 211 cfs (cubic feet per second), equal to about 23.13 inches of water a year over the drainage basin. The minimum discharge of 56 cfs

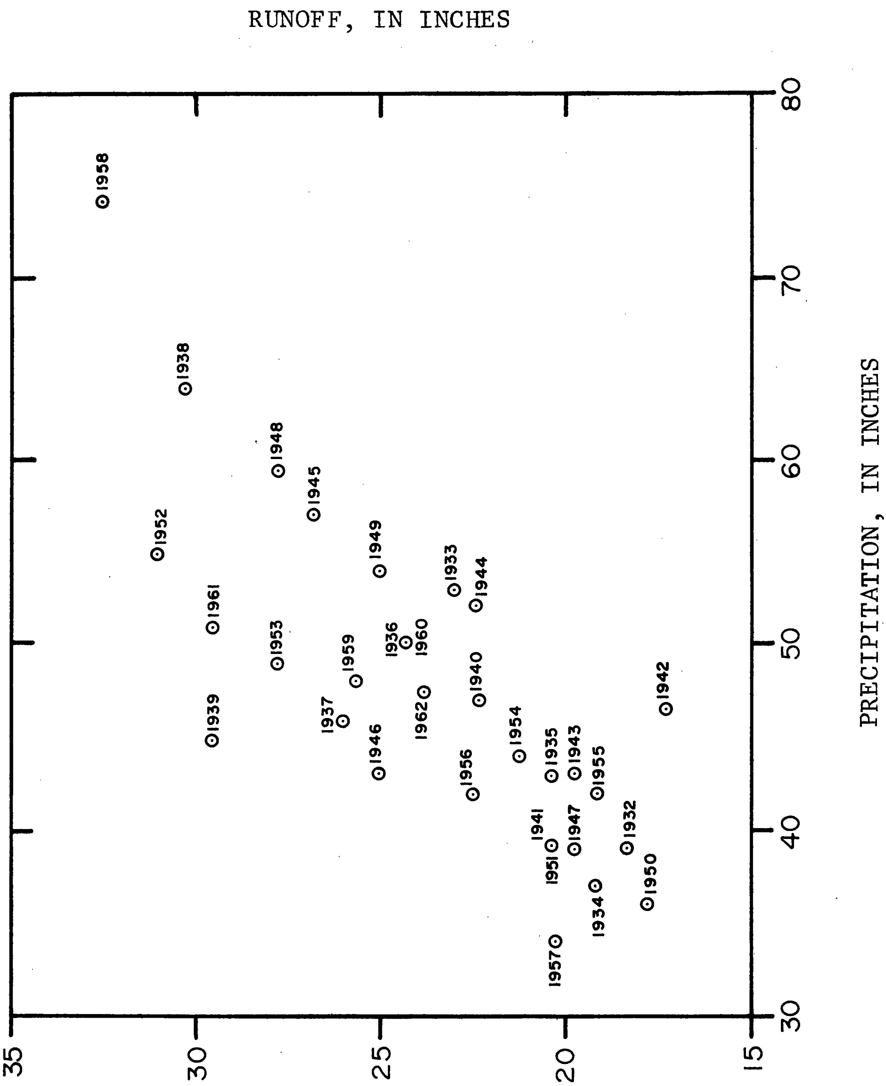

Figure 20.—Graph showing rainfall-runoff relationship for Toms River near Toms River (1932-62).

occurred on July 5, 1944 and on September 6, 1957. The maximum flow of 2,000 cfs occurred on September 23, 1938 and is 36 times the minimum.

Runoff is related to precipitation in the Toms River basin as shown in figure 20. Although runoff increases with precipitation, the trend is not perfectly linear. After a wet year such as 1938, runoff for 1939 was greater than normal because ground-water storage and soil moisture were at a high at the end of 1938. After a dry year such as 1941, (39 inches of precipitation) the runoff for 1942 was less than normal because of lower than normal ground-water storage and because much of the 1942 precipitation replenished the depleted storage and soil moisture.

A relation between the lowest daily streamflow in Toms River and the lowest ground-water level in the Crammer well (32.4.6.6.1) is suggested by the graph in figure 21. As the lowest daily flow of Toms River usually occurs between August and October, several months prior to the water-level low in the Crammer well, the latter can be predicted several months in advance.

A flow-duration curve is a cumulative frequency curve that shows the percentage of time during which specified discharges are equaled or exceeded in a given period of time. The daily mean flow of Toms River for the period 1929-60 (fig. 22) was 100 cfs or greater (0.807 cfs per square mile) during 90 percent of the time. The period upon which the curve is based covers a relatively wide range of climatic conditions and, therefore, is useful in predicting flows for planning water power and supply and dam or bridge construction projects. The amount of streamflow available for any percentage of the time can be read directly from the flow-duration curve.

The shape of the flow-duration curve is determined by the hydrologic and geologic characteristics of the drainage basin. Searcy (1959, p. 22) stated that "a curve with a steep slope throughout denotes a highly variable stream whose flow is largely from direct runoff, whereas a curve with a flat slope reveals the presence of surface- or ground-water storage, which tends to equalize flow. The slope of the lower end of the duration curve shows the characteristics of the perennial storage in the drainage basin; flat slope at the lower end indicates a large amount of storage; and a steep slope indicates a negligible amount." A flat curve indicates a river with few floods whereas a steep curve represents a flashy stream subject to extreme high and low flows.

The flow-duration curve for Toms River is relatively flat which indicates large ground-water storage that will support a dependable sustained yield.

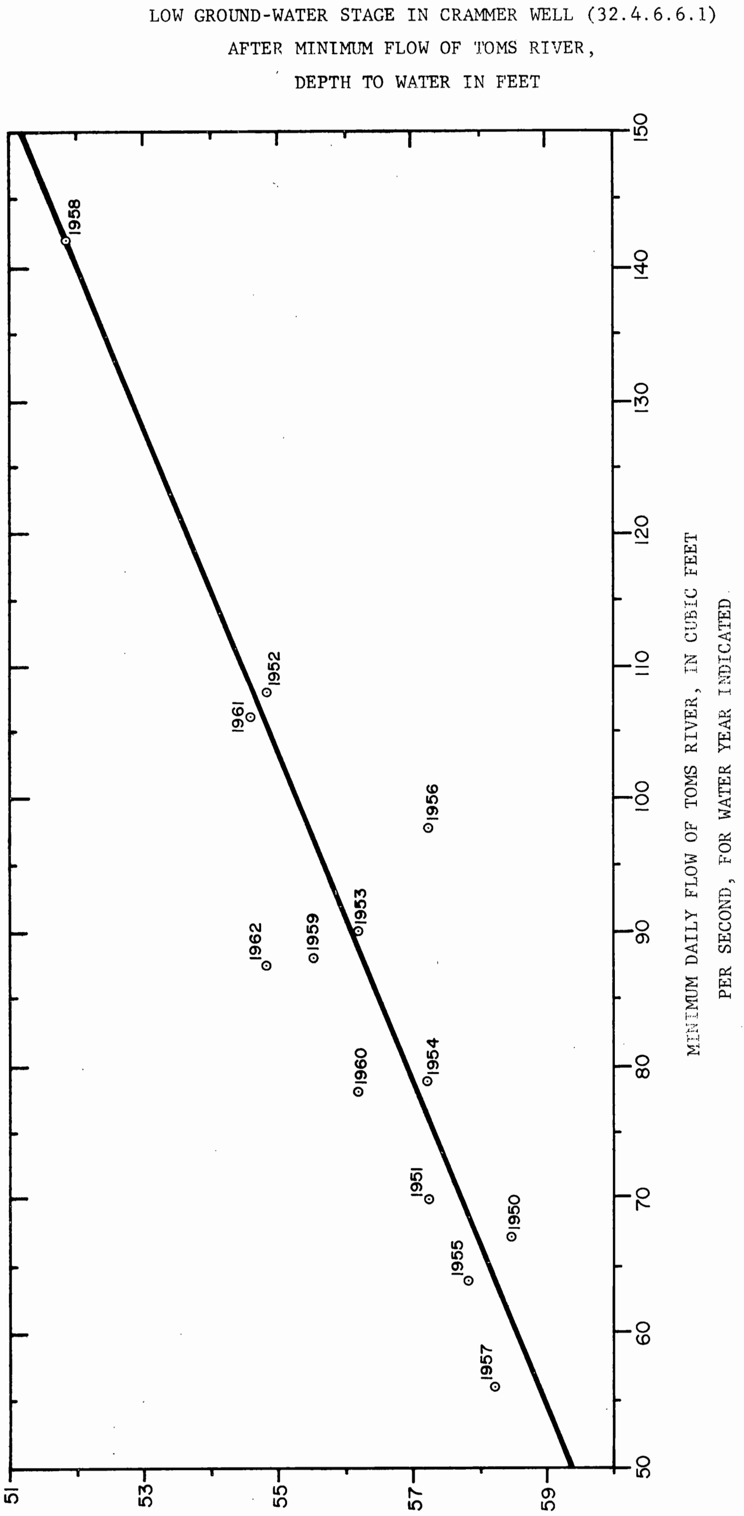

Figure 21.—Graph showing relation of lowest daily ground-water stage in the Crammer well to minimum daily flow of Toms River for years 1951-62.

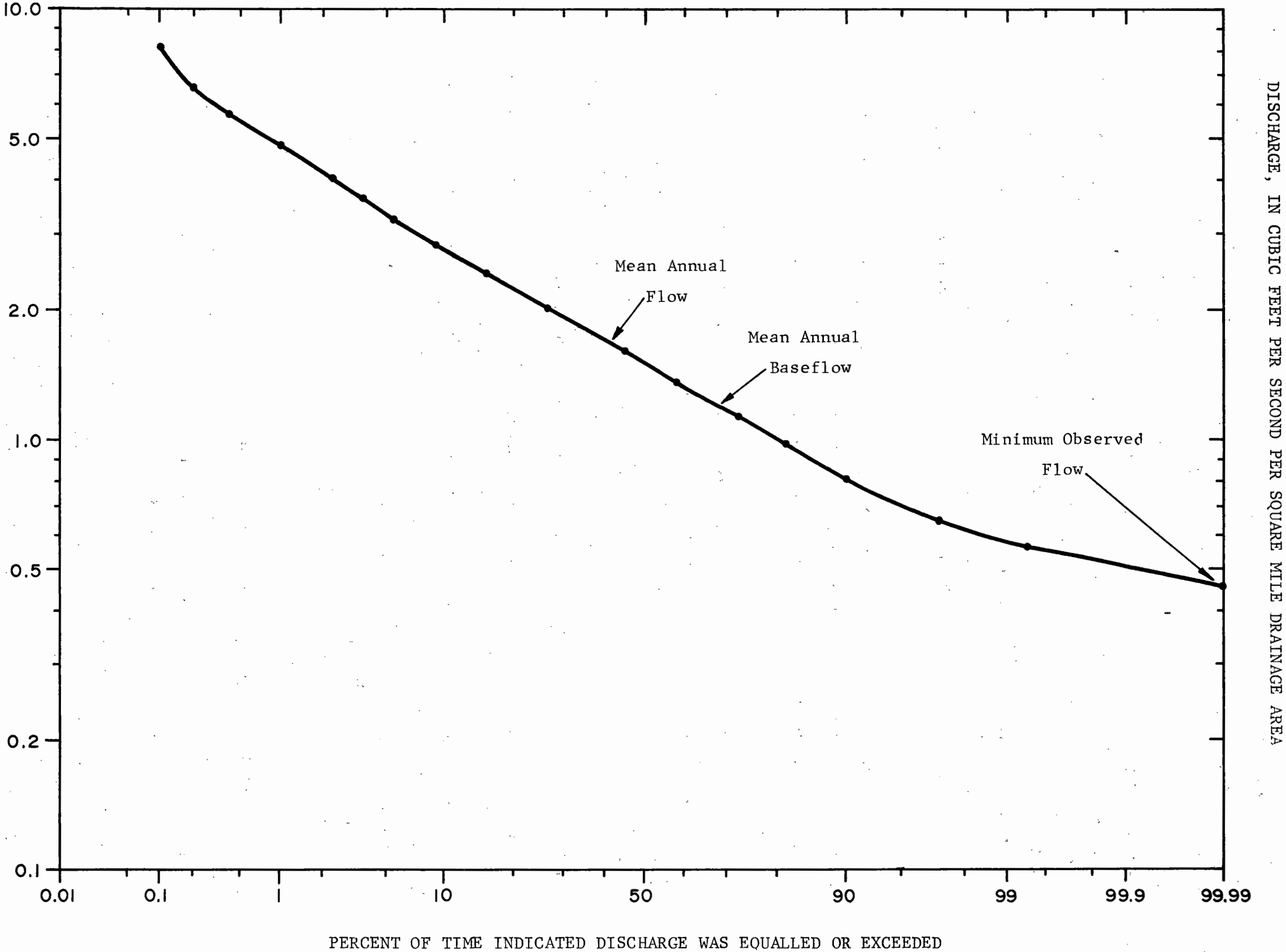

Figure 22.—Flow-duration curve of Toms River near Toms River for water years 1929-60.

To illustrate how the flow-duration curves may be used, let us suppose that an industry wants to build a plant adjacent to the Toms River where the drainage area is 60 square miles. The plant plans to pump 25 mgd (39 cfs) from Toms River, and no ground-water diversion or storage reservoirs are planned. Assume the flow here in cfs per square mile is equal to that at the gaging station downstream so that 39 cfs flow at the plant site would be equivalent of 80 cfs at the Toms River gaging station. From the flow-duration curve (fig. 22) for the period 1929-60, a flow of 80 cfs (0.65 cfs per square mile) or more at Toms River occurs 97 percent of the time. Hence, for a period of five years for example, there will probably be a deficit in flow during approximately 55 days.

If the deficit is not supplemented from ground-water sources or a storage reservoir, then the plant may have to be built farther downstream, so as to include a larger drainage area and, consequently, obtain a greater streamflow.

Often the demands of a supply are seasonal and it is useful to know the seasonal variations of discharge in a stream. The monthly mean duration flows for the period 1930-62 for Toms River show pronounced low flows in the summer and early fall and high flows in the late winter and early spring (fig. 23). The plant site that requires 0.65 cfs per sq mi may have shortages during the summer and early fall.

Precipitation-duration curves for Lakewood, N. J., for the period 1930-62 (fig. 24) show that seasonal streamflow variations were not related to seasonal variations in precipitation. The precipitation is about the same for the months of March and August, whereas the mean discharge of Toms River is more than 1.7 cfs per sq mi 80 percent of the time during March and less than 1 cfs per sq mi 80 percent of the time during August. Streamflow is less in August because of the high evapotranspiration rates and the decreased ground-water discharge to streams.

The maximum periods of deficient discharge for Toms River for the period, 1928-62, are shown in figure 25. This figure shows, for example, that the flow at the gaging station on Toms River will be less than 80 cfs for not more than 30 consecutive days.

Annual minimum 5-consecutive-day average discharges are indicative of low-flow conditons. The annual minimum 5-day average discharge for the period 1930-62 was 80 cfs or less about 55 percent of the years of record (fig. 26). For the plant site example previously discussed, deficient flows for 5 consecutive days can be expected during more than half the years of operation.

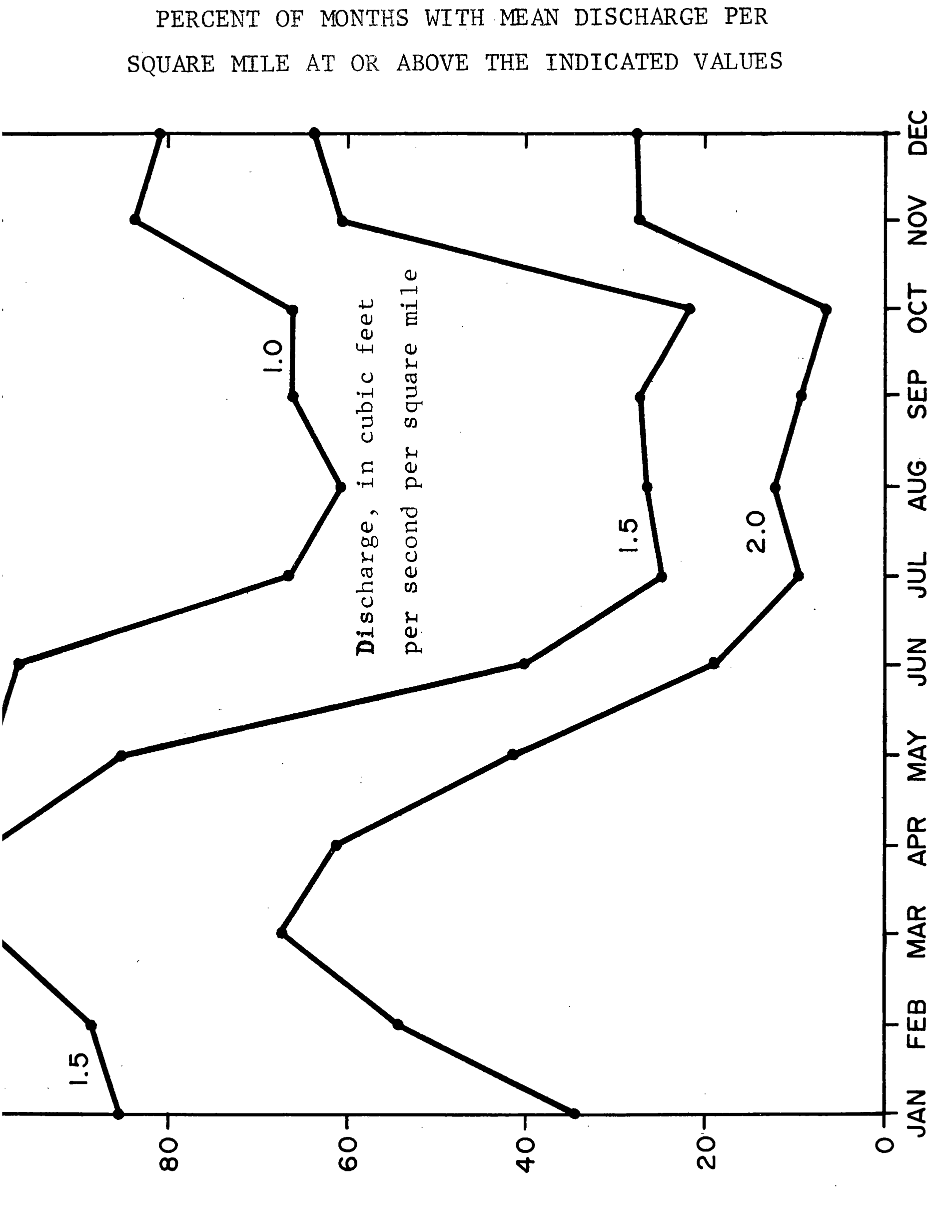

Figure 23.—Mean discharge duration curves, by months, for Toms River near Toms River, 1930-62.

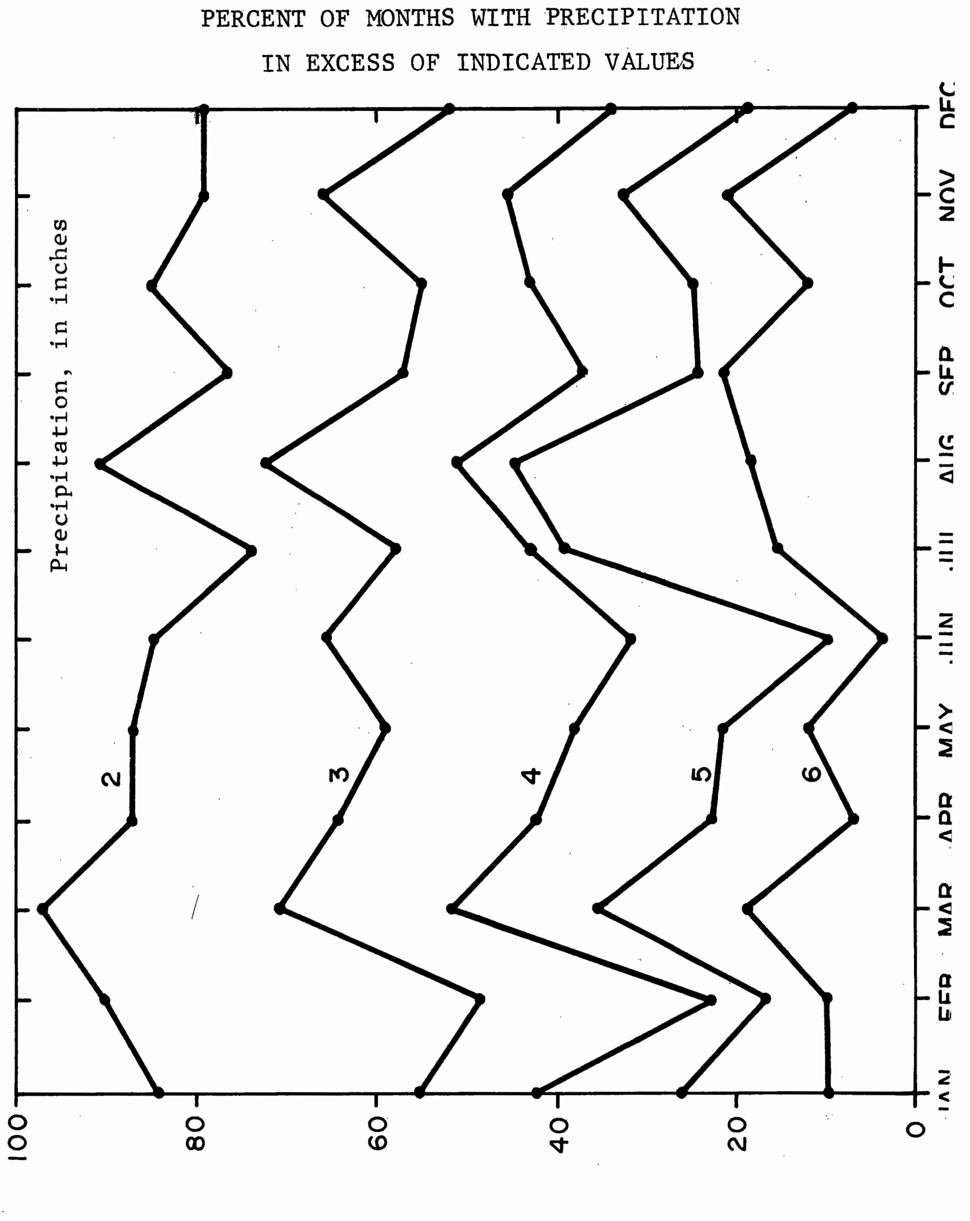

Figure 24.—Precipitation-duration curves for Lakewood, N. J., 1930-62.

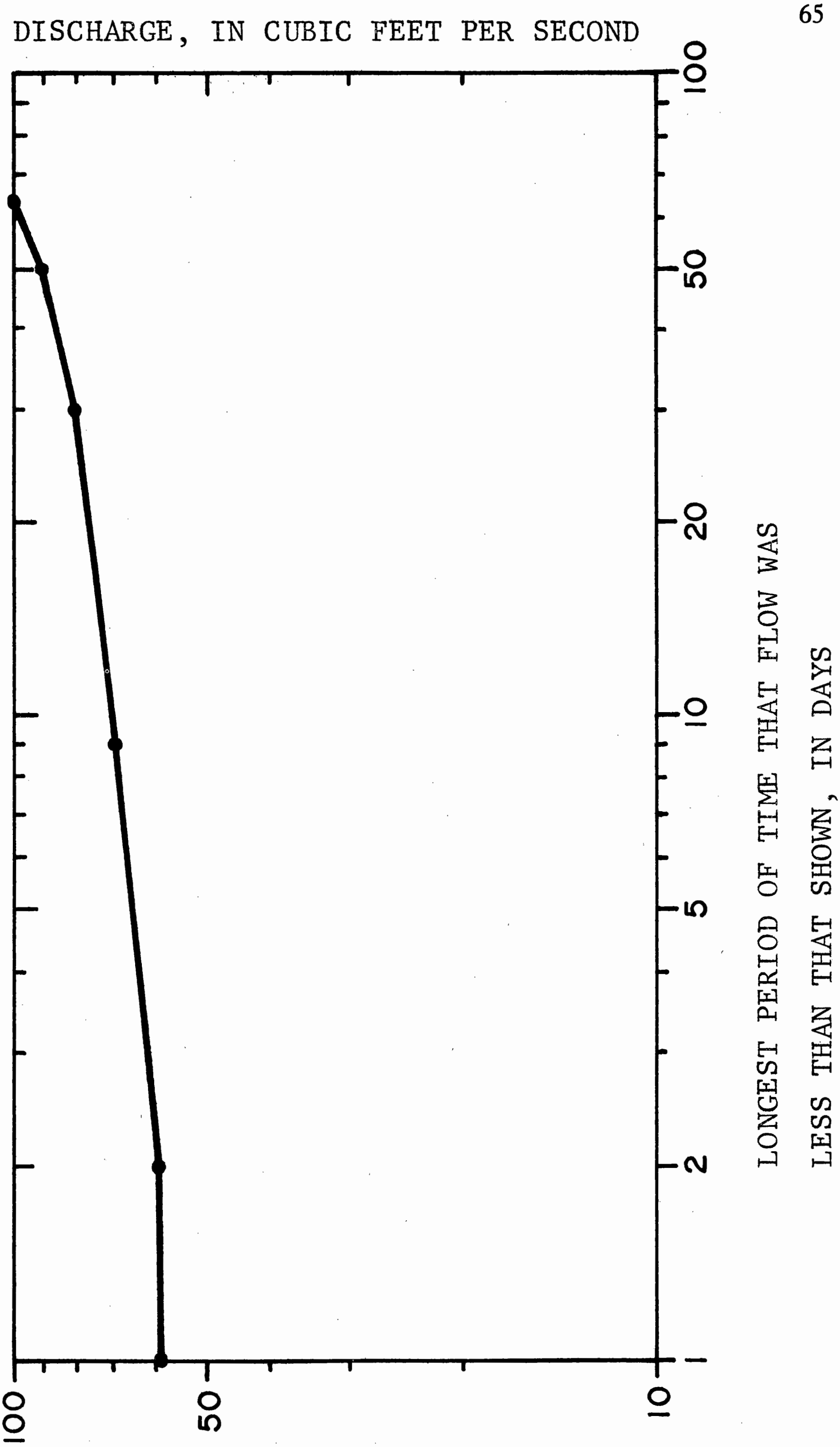

Figure 25.—Graph showing maximum periods of deficient discharge, Toms River, 1928-62.

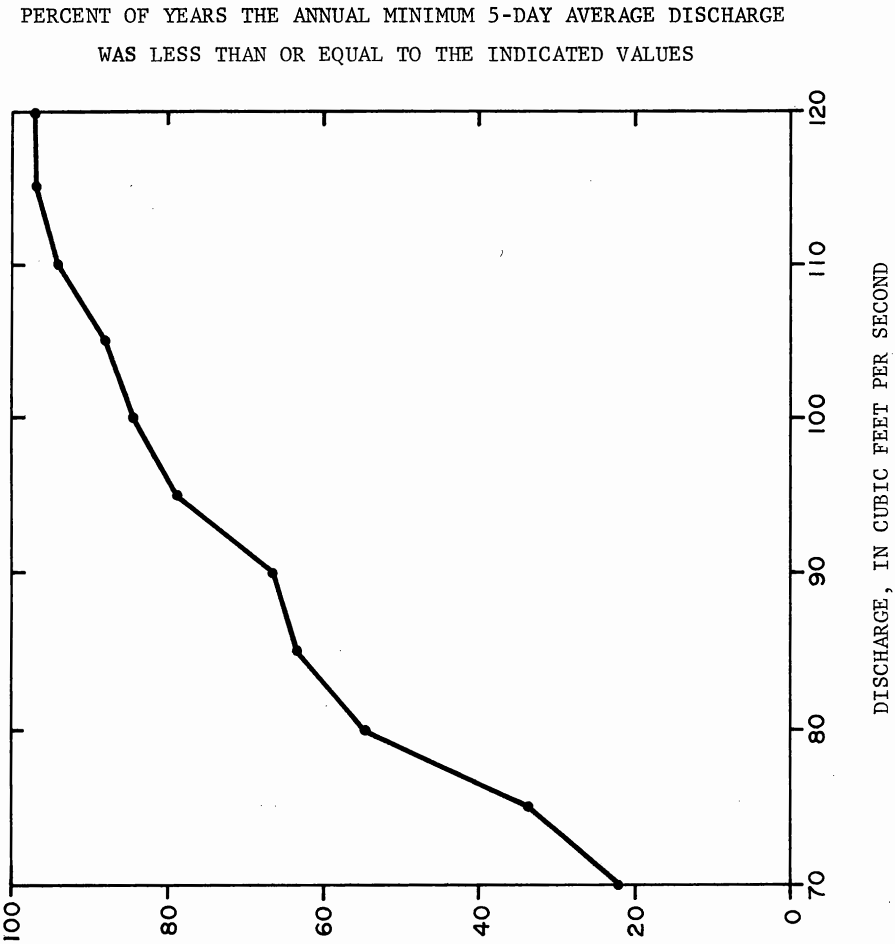

Figure 26.—Graph showing frequency of annual minimum 5-day average discharges for Toms River near Toms River 1930-62.

A depletion rating curve (fig. 27) was prepared for Toms River from values of base flow. Values from December to March were not used in the analysis because snowmelt may intermittently add to base flow. Also, evapotranspiration losses during the winter are lowest, so that the average annual depletion hydrograph would suggest a lower rate of depletion than occurs during the rest of the year. Because long periods without precipitation seldom occur in Ocean County, it was necessary to superimpose hydrograph segments for a number of rainless periods. Only periods when there was less than 0.01 inch of rainfall for 9 days or more were considered. The precipitation stations used were Pemberton, Lakewood, and Toms River. The mean daily discharge 5 days after the last day of precipitation was plotted on the ordinate and the mean daily discharge 9 days after precipitation was plotted on the abscissa. The range of discharge in this analysis for the period 1940-62 was from 65 cfs to 275 cfs.

A base-flow recession curve (fig. 28) was prepared from the depletion rating curve by plotting the depletion discharges in 4-day intervals. The base-flow recession curve is useful for predicting streamflow during extended periods of drought. Starting at a discharge, for example, of 160 cfs, the discharge after a 10-day drought is about 115 cfs, and after 30 days of drought may decline to about 65 cfs.

FLOODS

The magnitude and frequency of floods must be known for the design of construction projects such as bridges, highways, railroads, and hydroelectric plants located near streams. Also, flood-frequency analysis may be important to a community for insurance and zoning problems.

The flood-frequency curve for Toms River near Toms River is given in figure 29. This curve is based on the mean annual flood for the period 1922-60 and the regionalized frequency curve developed by Thomas (1964). The recurrence interval is the average interval of time in which a flood of a given magnitude will be equalled or exceeded once. A flood of 1,000 cfs has a recurrence interval of about 4.5 years.

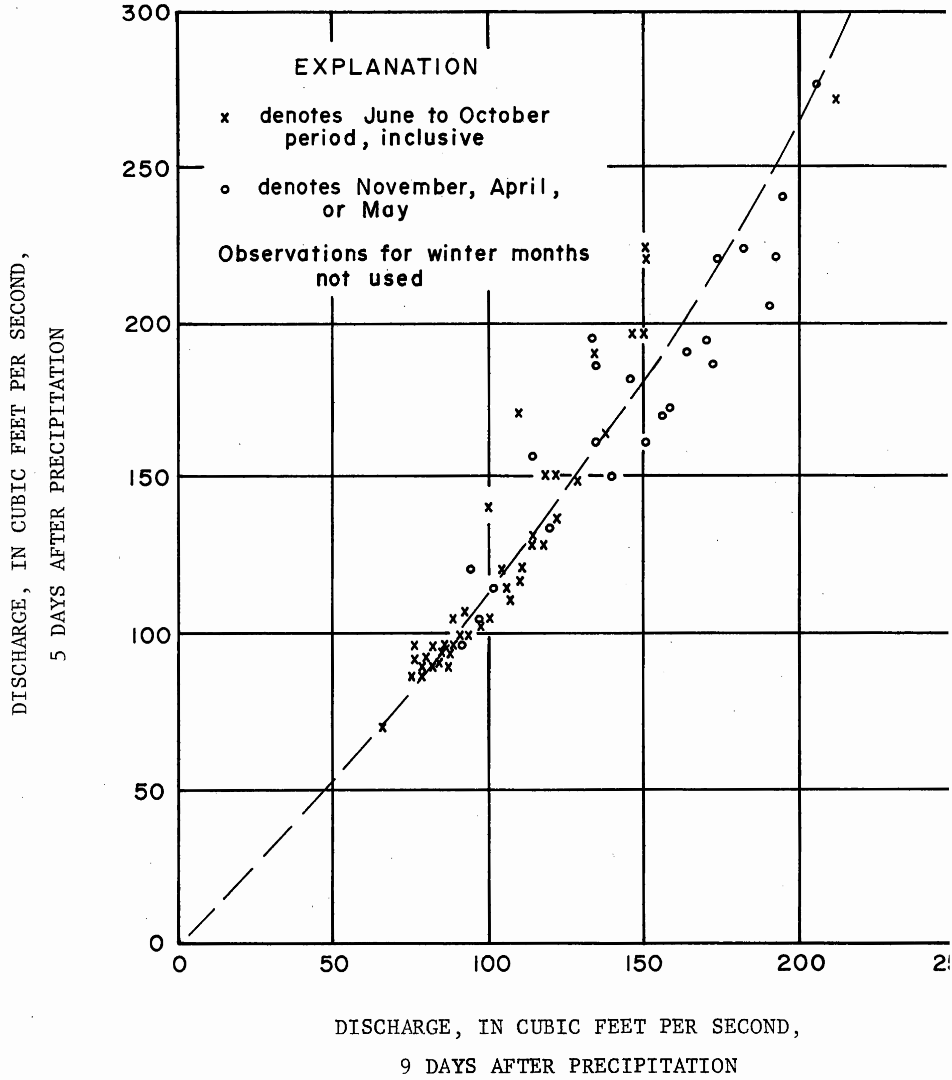

Figure 27.—Average depletion rating curve for flows less than 300 cfs for Toms River near Toms River, 1940-62.

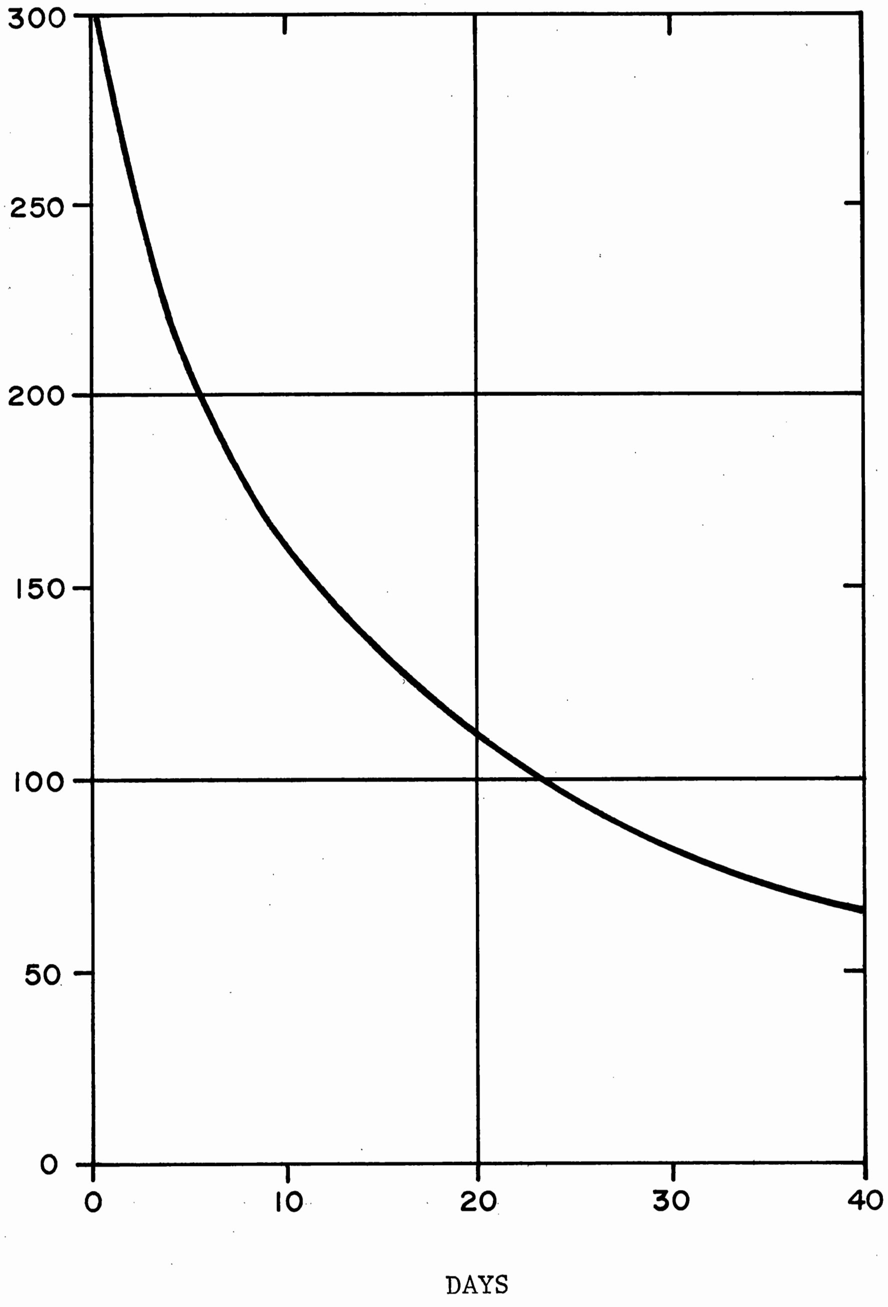

Figure 28.—Base-flow recession curve for Toms River near Toms River, 1940-62.

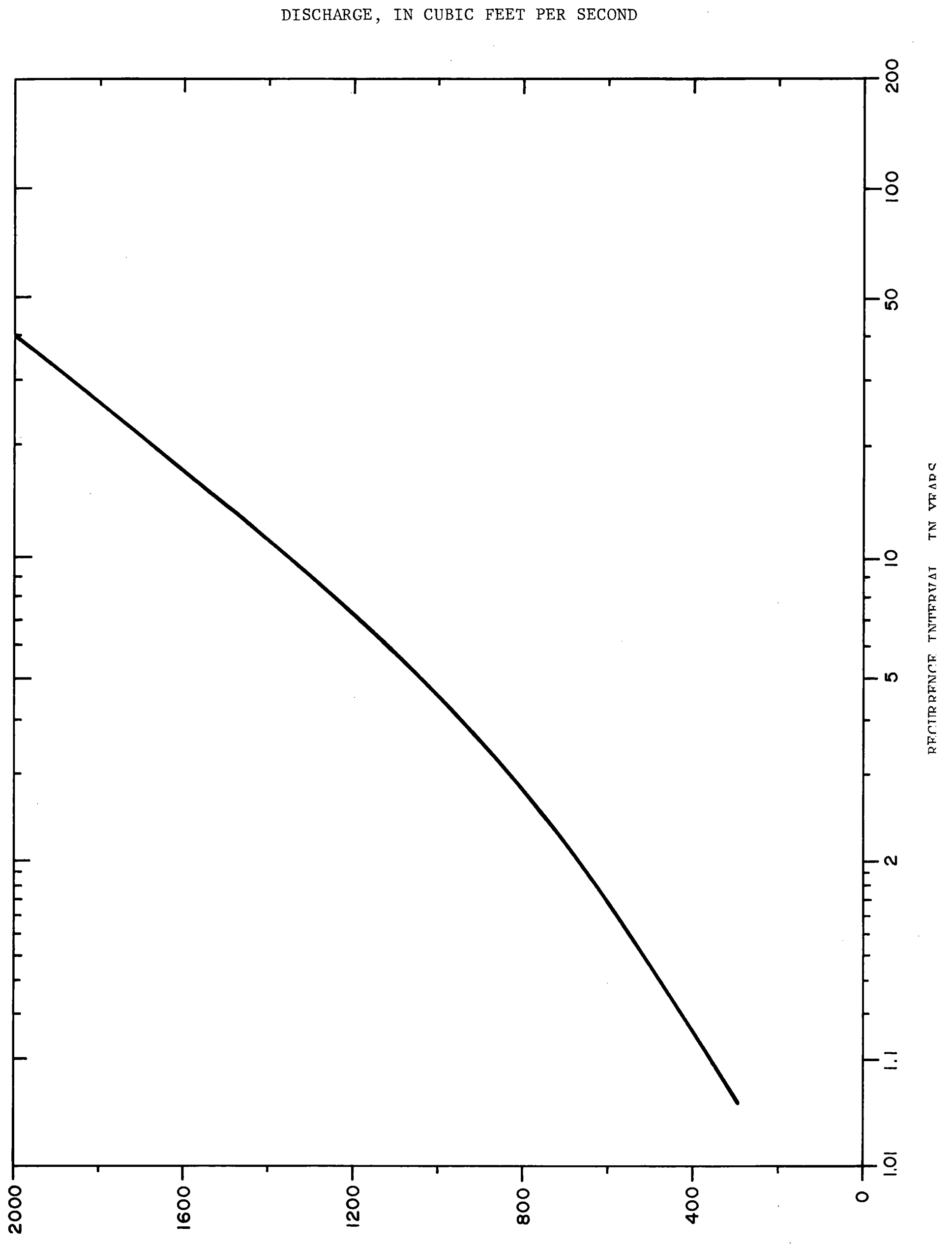

Figure 29.—Graph showing flood frequency of Toms River near Toms River, 1922-60.

SUUMMARY AND CONCLUSIONS

Artesian aquifers of the Raritan and Magothy, Englishtown, Wenonah and Mount Laurel, and Kirkwood Formations and the water-table aquifer supply the present water needs of Ocean County. Of these, the Raritan and Magothy and the water-table aquifer are the largest and least utilized ground-water reservoirs in the county and are the most suitable for future large-scale development.

The Raritan and Magothy Formations contain several water-bearing zones which together constitute the largest aquifer system in southern New Jersey, comprising half the thickness of the Coastal Plain sediments. Because the top of the Magothy is deeper than 600 feet, the expense of well construction restricts use to mostly the uppermost aquifer. Near Lakehurst, three water-bearing zones are utilized. The middle zone is the most productive and yields up to 1,850 gpm. In the southern part of the county, saline water is contained below 2,500 feet in depth in the Raritan and Magothy Formations, so wells approaching this depth may include saline water. Elsewhere in the county, water from the Raritan and Magothy Formations contains objectionable amounts of iron and temperatures above 70°F.

The water-table aquifer is heavily pumped only in the vicinity of Toms River and Lakehurst where wells yield up to 600 gpm. In the sparsely settled Pine Barrens, 0.8 mgd per sq mi theoretically can be withdrawn from the aquifer without depleting storage. In southern Ocean County, the water-table aquifer and the Kirkwood Formation are the only ground-water sources available, but treatment of the water for excessive iron, acidity, and odor may be required. Brackish water occurs in the water-table aquifer along the barrier beach and adjacent to Barnegat Bay.

Water levels in the Englishtown Formation, the most intensely developed aquifer in northern Ocean County, have declined to more than 75 feet below sea level near Point Pleasant so that conditions for seawater intrusion are present. Inland, however, where few wells obtain water from the Englishtown Formation, further development is possible.

The Wenonah Formation and Mount Laurel Sand yield small to moderate quantities of ground water in the northern part of the county and are capable of further development. Downdip, in the southern half of the county, both the aquifer in the Englishtown Formation and Wenonah Formation and Mount Laurel Sand are absent.

The Vincentown Formation which is tapped locally in the northwestern part of Ocean County for domestic supply could yield water in quantity to large-diameter wells near the outcrop area. Elsewhere, it offers little potential for further development.

The Manasquan Formation is generally considered an aquitard, but it yields up to 500 gpm to wells along the coast. The Manasquan Formation can be tapped further in Ocean County for small to moderate water supplies.

The artesian aquifer of the Kirkwood Formation is approaching its maximum development. Since the turn of the century, water levels have declined more than 30 feet in Long Beach Island and more than 80 feet in Atlantic City, the centers of greatest withdrawals. Further development along the coast would add to the already existent danger of salt-water encroachment. Inland, where the piezometric surface of the Kirkwood Formation increases from 20 to 120 feet above sea level, the aquifer can be further developed although aquifer permeabilities and well yields are less than in the 800-foot sand on the coast. Water from the Kirkwood Formation generally contains few objectionable mineral concentrations; however, it may be acidic and high in iron.

Streamflow is derived largely from ground-water flow from the water-table aquifer so that development of this aquifer will affect stream discharge. The average discharge from the Toms River basin is about 136 mgd. Water can either be pumped directly from streams or induced into pumping wells near the streams.

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APPENDIX

TABLE 6.—CHEMICAL ANALYSES OF WATER FROM WELLS IN THE AQUIFERS OF OCEAN COUNTY, N. J.

(Analyses in parts per million, except as noted.)

Analyses by U. S. Geological Survey

Map No.	Owner	Temperature (°F)	Silica (SiO_2)	Total Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids: Residue on evaporation at 180°C	Dissolved solids: Sum	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	pH	Specific conductance (micromhos at 25°C)	Date of collection
								Raritan and Magothy Formation													
5R	Glidden Co. Well 2	--	11	3.2	11	2.8	6.8	2.2	48	0	8.8	4.4	0.0	0.2	72	71	39	0	7.4	111	2/62
9R	Ocean County Water, County Well 7	75	11	1.5	15	3.3	1.0	6.0	88	0	7.8	1.4	.1	.3	111	-----	51	0	7.3	158	8/61
11R	Lavallette Water Dept. Well 4	75	11	.66	7.8	2.1	27	6.5	107	0	5.9	1.4	.1	1.2	128	-----	28	0	7.8	182	8/61
12R	Island Beach State Park Observation well	86	16	1.8	31	6.1	485	8.2	188	0	2.5	670	1.0	.2	---	1,430	103	0	7.3	2,750	9/62
								Englishtown Formation													
12E	New Egypt Water Co. Well 1	55	13	.56	30	1.8	2.3	3.3	97	1.0	7.5	3.3	.1	.1	----	110	82	1	8.3	181	3/57
27E	Point Pleasant Water Dept. Well 3	68	12	.17	20	6.1	6.0	7.0	109	0	7.6	1.1	.1	1.0	120	-----	75	0	8.0	193	8/61
38E	Lavallette Water Dept. Well 3	71	11	----	4.9	4.4	72	8.0	218	0	4.2	3.0	.2	.2	218	-----	30	0	7.5	351	7/61
133E	Glendale Farms Dairy (Lakehurst)	--	9.0	.7	----	.0	----	----	----	---	20.0	----	----	----	---	-----	72	0	7.7	----	11/49
								Manasquan Formation													
133M	U. S. Geological Survey Island Beach test well	62	34	0.87	4.8	1.9	74	7.3	192	0	16	8.2	1.2	.0	238	242	20	0	7.4	365	9/62
								Kirkwood Formation													
39K	Point Pleasant Water Dept. 4	55	4.9	.04	3.3	2.2	10	2.0	5.0	0	11	15.0	.0	10	80	-----	17	13	5.2	118	8/61
40K	Point Pleasant Beach Water Dept. 9	57	26	.95	8.2	3.8	7.1	2.5	40	0	2.5	13.0	.1	.7	88	-----	36	3.0	6.9	113	6/61
43K	Shore Acres Corp.	55	32	.47	9.0	2.3c	12.0	6.0	66	0	5.5	3.6	.2	.7	110	-----	32	0	7.1	126	6/61
44K	Shore Acres Corp.	--	---	1.40	----	----	----	----	----	---	----	6.0	.1	0	120	-----	46	-----	7.0	----	1/60
48K	Ocean County Water Co. at Normandy Beach	55	24	1.3	73	21	65	10	36	0	13	264	.1	.6	688	-----	269	239	7.2	962	8/61
50K	Toms River Water Co.	--	---	2.6	----	----	----	----	----	---	----	7.0	----	.08	52	-----	24	----	6.1	----	3/59
54K	Ocean Gate Water Dept.	--	---	.5	----	----	----	----	----	---	----	7.0	----	-----	110	-----	46	----	7.7	----	6/61
56K	Seaside Heights Water Dept. 1	58	20	1.0	2.4	1.5	12	4.0	36	0	8.8	4.2	.2	.7	80	-----	12	0	6.5	88	6/61
56K	Seaside Heights Water Dept. 1	57	18	.91	2.0	1.7	11	3.5	34	0	8.6	4.4	.2	.4	84	-----	12	0	6.7	86	8/61

TABLE 6.—CHEMICAL ANALYSES OF WATER FROM WELLS IN THE AQUIFERS OF OCEAN COUNTY, N. J. —Continued

(Analyses in parts per million, except as noted.)

Analyses by U. S. Geological Survey

Map No.	Owner	Temperature (°F)	Silica (SiO_2)	Total Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids: Residue on evaporation at 180°C	Dissolved solids: Sum	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	pH	Specific conductance (micromhos at 25°C)	Date of collection
	Kirkwood Formation (Continued)																				
59K	Shore Water Co.	--	---	1.2	----	----	----	----	----	---	----	6.2	0.2	----	---	-----	24	----	6.4	----	8/57
60K	Mystic Island Water Co.	--	---	2.6	----	----	----	----	----	---	----	5.0	.1	.27	90	-----	26	0	6.3	----	7/60
68K	Harvey Cedars Water Dept.	--	---	.16	----	----	----	----	----	---	----	4.0	----	----	---	-----	34	----	6.1	----	11/56
71K	Barnegat Light & Water Co. 2 wells	--	---	0.28	----	----	----	----	----	---	----	3.0	----	----	---	-----	38	----	8.3	----	5/61
75K	Surf City Water Dept. 2	--	---	1.5	----	----	----	----	----	---	----	6.0	----	----	---	-----	26	----	6.2	----	2/53
75K	Boro. Surf City Water Dept.	--	---	-----	----	----	----	----	20	---	8.0	4.0	0.1	0.0	---	-----	---	----	6.5	----	9/45
76K	Surf City Water Dept. 3	--	---	1.75	----	----	----	----	----	---	----	5.0	----	-----	---	-----	34	----	6.1	----	2/53
81K	Long Beach Water Co.	62	24	25	2.8	1.2	3.5	3.0	14	0	8.2	3.3	.1	.1	86	53	12	0.5	6.1	52	8/63
82K	Long Beach Water Co.	--	---	-----	----	----	----	----	18	---	12	3.6	----	.1	----	-----	---	-----	6.0	59	9/48
86K	Long Beach Township Water Dept.	--	---	.3	----	----	----	----	----	---	----	4.0	.1	----	----	-----	24	-----	7.8	------	9/58
87K	Long Beach Water Co.	--	---	1.7	----	----	----	----	6.0	---	11	3.8	----	.0	----	-----	---	-----	5.8	51.4	8/49
89K	Fish Products Co.	--	30	-----	3.0	1.0	----	----	18	---	10	3.0	----	----	----	-----	12	-----	6.5	------	5/48
124K	Hollywood Manor Water Co.	56	17	.99	1.2	.7	3.2	2.5	4.0	0	5.9	5.2	.0	.2	40	-----	6.0	2.0	5.2	41	6/61
125K	Nejecho Corp.	--	---	7.2	----	----	----	----	----	---	----	12	0	.15	118	-----	66	-----	7.2	------	1/60
126K	West Mantoloking Sandy Point Yacht Club	55	25	3.1	24	11	14	1.5	141	0	0	14	.9	.7	180	-----	105	0	7.3	264	6/61
127K	Flowing well near Pinewald	--	---	1.5	----	----	----	----	0	---	15	----	----	.1	----	-----	Total 7.5	-----	4.3	74	9/48
128K	A T & T Radio Station	56	---	.07	----	----	----	----	0	---	----	6.0	----	.5	----	-----	-----	-----	4.4	50.6	8/51
129K	Charles E. Johnson	57	---	.7	----	----	----	----	20	0	----	4.0	----	.6	----	-----	-----	-----	5.5	67.7	8/51
129K	Charles E. Johnson	57	---	----	----	----	----	----	20	---	----	3.4	----	.1	----	-----	-----	-----	6.4	65.9	8/50
130K	E. Tonnesen	55	---	2.4	----	----	----	----	----	---	6.0	17	----	.5	----	-----	-----	-----	4.0	112	4/52
130K	E. Tonnesen	56	32	4.7	4.0	3.4	6.5	3.5	0	0	6.8	28	.1	.1	80	85	24	24	4.0	159	8/63

TABLE 6.—CHEMICAL ANALYSES OF WATER FROM WELLS IN THE AQUIFERS OF OCEAN COUNTY, N. J. —Continued

(Analyses in parts per million, except as noted.)

Analyses by U. S. Geological Survey

Map No.	Owner	Temperature (°F)	Silica (SiO_2)	Total Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids: Residue on evaporation at 180°C	Dissolved solids: Sum	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	pH	Specific conductance (micromhos at 25°C)	Date of collection
	Kirkwood Formation (Continued)																				
131K	Beach Haven Ice & Cold Storage Co. 2	--	---	----	----	----	----	----	15	---	7.0	4.5	0.1	0.0	-----	-----	-----	-----	6.0	------	5/46
132K	U. S. Geological Survey Island Beach Test well	62	29	1.7	16	1.5c	12	4.2	70	0	12	7.0	.1	.4	-----	115	Total 46	-----	7.4	179	9/62
133K	U. S. Geological Survey Waretown Observation well	54	15	.81	2.3	1.2	3.4	2.5	6	0	10	4.1	.0	.0	40	42	2.9	-----	5.9	51	3/62
	Undifferentiated water-table aquifer																				
90U	Lakehurst N.A.S. — Average for wells 5-8	--	3.6	.20	1.7	1.0	----	----	2	0	2.3	6.1	.1	3.0	-----	21	-----	-----	5.0	52.5	12/48
92U	Lakehurst N.A.S. — Average for wells 1-4	--	3.5	.17	.8	.6	----	----	4	0	4.2	3.1	.1	.5	----	14	-----	-----	5.5	22.5	12/48
102U	Lakehurst N.A.S	--	3.0	3.4	.8	.2	2.0	.2	11	0	3.4	3.6	.0	.0	----	26.	Total 12	-----	6.2	33	7/58
103U	Lakehurst N.A.S.	--	4.6	6.8	.8	.2	2.0	.2	4.0	0	2.8	3.6	.0	.1	----	23.	Total 8	-----	5.9	25	7/58
108U	Toms River Chemical Co.	--	5.0	.1	4.0	2.0	----	----	----	---	.0	7.0	----	Trace	14	-----	6.0	-----	6.7	-----	1/56
111U	Toms River Chemical Co.	--	4.8	----	8.0	6.0	----	----	----	---	14.8	34	----	----	----	-----	14	-----		-----	6/60
120U	Mid-Jersey Water Co.	54	17	22	.8	1.0	2.8	2.5	0	0	10.0	4.8	0.1	0.4	45	-----	6.0	6.0	4.4	60	6/61
121U	Barnegat Water Co.	--	---	.3	----	----	----	----	----	---	----	6.0	.1	----	37	-----	14	-----	4.7	-----	1/56
121U	Barnegat Water Co.	56	18	.5	1.3	.2	3.7	.5	0	0	7.2	5.2	.1	.0	35	37	4	4	4.4	55	8/63
121U	Barnegat Water Co.	--	---	----	----	----	----	----	0	---	8	4.6	.1	----	----	-----	Total 6	-----	4.5	-----	4/46
122U	Lakehurst N.A.S.	--	3.0	3.4	.8	.2	2.0	.2	11	0	3.4	3.6	.0	.0	26	20	12	3.0	6.2	33	7/58
123U	Berkeley Water Co. 1	--	----	.16	----	----	----	----	----	---	----	10	.1	----	----	-----	26	-----	5.2	-----	8/60
134U	U. S. Geological Survey Webbs Mills Observation well 1	--	2.8	.09	.8	1.0	1.9	.8	2.0	0	4.6	3.6	.0	.2	19	17	6	2	5.8	26	8/61
135U	U. S. Geological Survey Waretown Observation well 1	58	5.8	.10	.8	1.0	4.0	.8	5.0	0	.0	7.6	.1	.2	23	23	6	2	5.8	35	10/61
136U	Bomarc, U.S.A.F.	61	4.4	.12	1.6	.5	1.5	.1	4	0	.4	3.2	.1	.9	18	15	6	3	5.2	23	8/63

TABLE 7.—RECORDS OF WELLS TAPPING THE RARITAN AND MAGOTHY FORMATIONS IN OCEAN COUNTY, N. J.

Use of water: D, domestic; I, industrial; P.S., public supply

Remarks: E, electric log; G, gamma-ray log; L, geologic log; Q, chemical analysis

Map No.	Location	Owner's name and well number	N. J. Grid number	Year completed	Altitude above mean sea level (ft)	Depth (ft)	Diameter (in)	Screen setting (ft)	Static water level above (+) or below land surface (feet)	Yield (gpm)	Draw-down (ft)	Specific capacity (gpm/ft)	Use of water	Remarks
1R	Prospertown	Trenton Girl Scouts 1	28.34.2.7.2	1951	130	642	6 & 4	632- 642	98	35	54	1	D.	L.
2	Herbertsville	Hollywood Manor Water Co. 1	29.33.4.8.5	1959	28	1,133	10-8	1,123-1,133	20	137	225	1	P.S.	G., L.
3	Pt. Pleasant	Pt. Pleasant Water Dept. 5	29.33.8.6.6	1960	18	1,414	16-10	1,255-1,342	10	812	46	18	P.S.	E., G., L.
4	Lakehurst	Glidden Co. 1	29.41.1.5.2	1961	95	962	12-8	846- 962	95.	1,000	170	6	I.	E., G., L.
5	Lakehurst	Glidden Co. 3	29.41.1.5.2	1961		1,728			90	583	170	3	I.	E., L.
6	Lakehurst	Glidden Co. 2	29.41.1.5.2	1961		1,477	12-8	1,320-1,350 1,362-1,383 1,415-1,477	86	1,850	50	36	I.	L.
7	Lakehurst	Glidden Co. 4	29.41.1.5.2	1962		1,552			83	1,500	34	44	I.	L.
8	Lakehurst	Borough of Lakehurst 1	29.41.4.5.9	1928	65	1,037	12-10, 8-6	1,010-1035	43	250	2	125	P.S.	L. Temp. 63°F. Abandoned because high iron.
9	Mantoloking	Ocean City Water Co. 7	29.43.3.8.7	1960	10	1,427	12-8	1,263-1,278, 1,296-1,306, 1,320-1,331, 1,337-1,368		805	133	6	P.S.	E., G., L., Q(?). Flowed 30 gpm.
10	Normandy Beach	Ocean County Water Co. 3	29.43.6.7.8	1954	10	1,479	8-4	1,427-1,479	+6	348	155	2	P.S.	E., L., Q. Flowed 80 gpm.
11	Lavallette	Lavallette Water Dept. 4	33.3.2.9.8	1960	7	1,515	12-8	1,355-1,397, 1,484-1,515	+1	818	153	5	P.S.	E., G., L., Q. Flowed 10 gpm.
12	Island Beach State Park	State of New Jersey	33.13.8.7.2	1962	8	3,886	8-4	2,736-2,757	+20	40				E., G., L., Q.

TABLE 8.—RECORDS OF SELECTED WELLS TAPPING THE ENGLISHTOWN FORMATION IN OCEAN COUNTY, N. J.

Use of water: D, domestic; P.S., public supply

Remarks: E, electric log; G, gamma-ray log; L, geologic log; Q, chemical analysis

Map No.	Location	Owner's name and well number	N. J. Grid number	Year completed	Altitude above mean sea level (ft)	Depth (ft)	Diameter (in)	Screen setting (ft)	Static water level above (+) or below land surface (feet)	Yield (gpm)	Draw-down (ft)	Specific capacity (gpm/ft)	Use of water	Remarks
12E	New Egypt	New Egypt Water Co. 1	28.33.7.9.9	1907	75	239	6	214- 239	+25	70			P.S.	L., Q. Flowing well. Static level +15' above land surface in Jan. 1959.
13	New Egypt	New Egypt Water Co. 1	28.33.7.9.9	----	75	238	8	218- 238	----	250	70	4	P.S.	Flowed 90 gpm.
14	Lakewood	Lakewood Water Co. 6	29.32.4.7.4	1960	70	582	12-8	521- 582	93	503	109	5	P.S.	E., G., L.
15	Lakewood	St. Gabriel's Junior College 1	29.32.4.7.3	1957		530	8	510- 530	34	130	166	1	D.	
16	Lakewood	Lakewood Water Co. 5	29.32.4.7.4	1957	40	604	12-8	542- 604	90	500	160	3	P.S.	
17	Lakewood	Lakeshore Laundry 1	29.32.7.3.4	1950	50	612	6	596- 612	50	70	135	1	D.	
18	Lakewood	Lakewood Water Co. 2	29.32.7.5.2	1921	60	625	8	575- 625	+20	300	---	---	P.S.	Q.
19	Lakewood	Laurel in the Pines	29.32.7.5.2	1898	60	606	6						D.	Flowed 20 gpm.
20	Lakewood		29.32.7.5.2	1898	40	625	3							Flowed 45 gpm.
21	Lakewood	Lakewood Hotel & Land Assoc.	29.32.7.5.2	1899	30	600	6		+20	200			D.	Flowed 100 gpm.
22	Lakewood	Lakewood Water Co.	29.32.7.5.2	1900	35	621	6						P.S.	Flowed 60 gpm.
23	Lakewood	Lakewood Water Co.	29.32.4.7.4	1899	30	600	6		20				P.S.	Flowed 150 gpm.
24	Parkway Pines	Parkway Water Co. 1	29.32.9.2.5	1958	25	646	8	605- 646	81	179	85	2	P.S.	
25	Lanes Mills	Parkway Water Co. 2	29.32.9.2.5	1958	35	739	8	647- 688	75	300	125	2	P.S.	L.
26	Point Pleasant	Point Pleasant Water Dept. 1	29.33.8.6.6	1936	20	825	10-8	745- 770	30	277	57	5	P.S.	L., Q.
27	Point Pleasant	Point Pleasant Water Dept. 3	29.33.9.4.4	1946	15	805	12-10-6	748- 798	56	300	117	3	P.S.	L., Q.
28	Point Pleasant	Point Pleasant Water Dept. 2	29.33.9.4.4	1936	15	775	10-8-6	715- 745	34	265	83	3	P.S.	
29	Point Pleasant	Point Pleasant Water Dept.	29.33.9.4.4	1893	10	806		746- 806	+35					Flowed 45 gpm.
30	Bay Head	Central Railroad of N. J.	29.33.9.8.2	1930	9	813	8-5	793- 813	20	250	65	4	D.	
31	Bay Head		29.33.9.8.9	1902	10	870	6							Flowed 100 gpm.
32	Bay Head		29.33.9.8.9	1896	10	813	4.5-3		+35					Flowed 85 gpm.
33	Bay Head	Ocean County Water Co. 5	29.33.9.8.9	1947	10	834	10-8, 6-3	775- 834	64	220	75	3	P.S.	L., Q.
34	Bay Head	Ocean County Water Co. 6	29.33.9.8.9	1950	10	818	10-8	778- 818	104	338	139	2	P.S.	L., Q.
35	Mantoloking	Ocean City Water Co. 6	29.43.3.8.7	1955	10	1,052	12-8	844- 906	58	230	230	1.0	P.S.	E., L., Q.
36	Mantoloking	Ocean City Water Co. 4	29.43.3.8.7	1924		922			+42					Flowed 60 gpm.
37	Normandy Beach	Normandie Beach Water Works 1	33.3.3.1.1	Prior 1929	3	1,038	8-4.5		+8.5	19	23.5	1	P.S.	Flowed 7 gpm.
38	Lavallette	Lavallette Water Dept. 3	33.3.5.3.4	1948	7	1,180	12-8	1,120-1,180	58	500	240	2	P.S.	L., Q.

TABLE 9.—RECORDS OF LARGE CAPACITY WELLS TAPPING THE KIRKWOOD FORMATION IN OCEAN COUNTY, N. J.

Use of water: D, domestic; P.S., public supply

Remarks: E, electric log; L, geologic log; Q, chemical analysis

Map No.	Location	Owner's name and well number	N. J. Grid number	Year completed	Altitude above mean sea level (ft)	Depth (ft)	Diameter (in)	Screen setting (ft)	Static water level above (+) or below land surface (feet)	Yield (gpm)	Draw-down (ft)	Specific capacity (gpm/ft)	Use of water	Remarks
39K	Point Pleasant	Point Pleasant Water Co. 4	29.33.8.5.5	1952	15	75	16	45-75	7	700	23	30	P.S.	L, Q, Depth 175 or 75 (?)
40	Point Pleasant Beach	Point Pleasant Beach Water Dept. 9	29.33.9.5.3	1950	9	134	20-12	122-134	18	1,225	82	15	P.S.	L, Q
41	Point Pleasant Beach	Point Pleasant Beach Water Dept. 8	29.33.9.5.3	1942		142	16-12	128-142	15	640	83	8	---	
42	Osbornville	Pineland Water Co. 1	29.43.1.8.9	1959	12	103	12-6	90-103	7	210	66	3	P.S.	E, L; Log to 809
43	Shore Acres	Shore Acres Corp. 2	29.43.4.6.9	1959	6	210			2	120	70	2	P.S.	L, Q; Log to 210
44	Shore Acres	Shore Acres Corp. 1	29.43.4.6.2	1947	7	213	8	202-208	5	38	73	1	P.S.	L
45	Silverton	Silverton Water Co. 1	29.43.4.7.6	1956	6	237	8	205-237	+2	232	44	5	P.S.	L; flowed 10 gpm.
46	Monterey Beach	Ocean County Water Co.	29.43.6.1.9	1953	7	135	18-10	104-135	3	227				
47	Monterey Beach	Ocean County Water Co.	29.43.6.1.9	1953		133	6	111-133	55	150	66	2		
48	Normandy Beach	Ocean County Water Co. 2	29.43.6.7.8	1938	10	110	10-8	90-110	3	300	30	10.0	P.S.	Q
49	Toms River	Toms River Water Co. 15	33.2.2.9.8	1958	6	230	10	195-225	7	700	29	24	P.S.	L, Q
50	Toms River	Toms River Water Co. 12	33.2.4.6.1	1942	6	236	10	212-236	+5	125			P.S.	L; flowed 5 gpm.
51	Beachwood	Beachwood Water Dept. 1	33.2.5.7.3	1941	15	280	12-6	150-170	0	200	135	2	P.S.	L
52	Island Heights	Island Heights Water Dept. 7	33.2.6.8.3	1948	10	298	10-6	267-293	+1	675	100	7	P.S.	L; flowed 2 gpm.
53	Island Heights	Island Heights Water Dept. 7	33.2.6.8.3	1910		339	4.5	299-339		250				Flowed 50 gpm.
54	Ocean Gate	Ocean Gate Water Dept. 2	33.2.9.3.8	1936	10	366	16-8	340-360	2	498	92	5	P.S.	L, Q
55	Ortley Beach	Seaside Heights Water Dept. 4	33.3.5.6.1	1920	5	133	12-6	123-133	0	650	40	16	P.S.	
56	Seaside Heights	Seaside Heights Water Dept. 1	33.3.5.5.9	1921	5	174	12-6		5	550	20	28	P.S.	
57	Seaside Heights	Seaside Heights Water Dept. 3	33.3.5.5.9	1949	5	156	12	146-156	8	650	52	13	P.S.	L, Q
58	Seaside Heights	Seaside Heights Water Dept. 5	33.3.5.5.9	1963	5	175	12	144-175	10	900	23	40	P.S.	
59	South Seaside Park	Shore Water Co. 1	33.3.8.8.5	1954	8	200	10	175-200	2	425	20	21	P.S.	L
60	Tuckerton	Mystic Isles Water Co. 1	32.44.6.3.8	1952	5	547	6	526-547	10	382	75	5	P.S.	L, Q
61	Tuckerton	Tuckerton Water Co. 4	32.35.7.9.7	1949	6	486	6	460-481	±4	600	669	9	P.S.	L; flowed 20 gpm.
62	Tuckerton	Tuckerton Water Co. 4	32.45.1.5.6	1956	20	340	8-5.5	308-329	18	300	50	6.0	P.S.	L
63	Barnegat	Barnegat Water Co. 2	33.22.4.2.7	1955	34	148							P.S.	Flowing well
64	Waretown		33.22.2.1	1892	110	280			+2				P.S.	Flowed 20 gpm.
65	Harvey Cedars		33.22.9.9.6	1896	3	500	4.5		+6				P.S.	Flowed 120 gpm.

TABLE 9.—RECORDS OF LARGE CAPACITY WELLS TAPPING THE KIRKWOOD FORMATION IN OCEAN COUNTY, N. J. —Continued

Use of water: D, domestic; P.S., public supply

Remarks: E, electric log; L, geologic log; Q, chemical analysis

Map No.	Location	Owner's name and well number	N. J. Grid number	Year completed	Altitude above mean sea level (ft)	Depth (ft)	Diameter (in)	Screen setting (ft)	Static water level above (+) or below land surface (feet)	Yield (gpm)	Drawdown (ft)	Specific capacity (gpm/ft)	Use of water	Remarks
66	Harvey Cedars	Harvey Cedars Boro Water Dept. 1	33.22.9.9.6	1922	6	205	8-4	160-205					P.S.	Q; flowed 10 gpm.
67	Harvey Cedars	Harvey Cedars Boro Water Dept. 2	33.22.9.9.6	1931	6	502	8-6	442-502	+5	350			P.S.	Abandoned because of high chlorides. (Leaky casing); flowed 50 gpm.
68	Harvey Cedars	Harvey Cedars Boro Water Dept. 3	33.22.9.9.6	1956	6	492	10	450-492	13	703	103	7	P.S.	L, Q
69	Great Sedge Island		33.23.1.2	1892	5	320			+9					Flowed 60 gpm.
70	Barnegat Light	J. Haddock	33.23.4.6.1	1909	5	440				80				Flowed 20 gpm.
71	Barnegat Light	Barnegat Light Boro Water Dept. 1	33.23.4.6.1	1931	6	590	8	470-490 535-570	+3	200	54q	4	P.S.	L, Q
72K	Manahawkin	Stafford Water Co. 1	33.32.4.1.5	1953	5	235	4	226-235	+5	60	20	3.0	P.S.	Flowed 15 gpm.
73	Manahawkin	Stafford Water Co. 2	33.32.4.2.1	1957	5	234	6	219-234	+2	100	17	6	P.S.	L; flowed 20 gpm.
74	Cedar Bonnet Island	Cedar Bonnet Civic Assoc.	33.32.5.5.1	1948		262	4	253-262	+7	75	32	2		Flowed 10 gpm.
75	Surf City	Surf City Boro Water Dept. 2	33.32.6.1.1	1938	6	551	8	510-538	4	230	46	5.0	P.S.	L
76	Surf City	Surf City Boro Water Dept. 3	33.32.5.6.2	1947	5	562	8	516-557	11	610	35	17	P.S.	L, Q
77	Ship Bottom	Ship Bottom Water Dept. 1	33.32.5.8.2	1926	5	589	8-6	514-578		500		7	P.S.	Flowed 30 gpm.
78	Ship Bottom	Ship Bottom Water Dept. 2	33.32.5.5.8	1921	5	388	4.5	353-383						Flowed
79	Ship Bottom	Ship Bottom Water Dept. 3	33.32.5.5.8	1947	4	563	8-6	522-563	15	530	32	17	P.S.	
80	Ship Bottom	Ship Bottom Water Dept. 4	33.32.5.8.2	1953	5	590	12-10	536-578	15	940	72	13.0	P.S.	Q
81	Brant Beach	Long Beach Water Co. 2	33.32.8.1.7	1951	6	580	10-8	530-580	18	650	36	18	P.S.	L
82	Brant Beach	Long Beach Water Co. 1	33.32.8.1.7	1946	9	615	10-6	534-615	11	600	37	16		
83	Beach Haven	Beach Haven Water Dept. 8	33.41.6.3.4	1957	6	656	10	570-612 634-655	22	754	29	26.0	P.S.	E
84	Beach Haven	Beach Haven Water Dept. 1	33.41.6.3.4	1921		675	8-6	550-600 620-670	+5	250			P.S.	
85	Beach Haven	Beach Haven Water Dept. 1	33.41.6.3.4	1911			6-4.5	543-593		250			D	
86	Beach Haven Heights	Long Beach Township Water Dept.	33.41.6.7.7	1939	5	458	6	427-449	1	325	66	5	P.S.	L
87	Beach Haven Terrace	Long Beach Water Co. 1	33.42.1.4.6	1949	5	627	10-8	561-623	15	475	46	10	P.S.	
88	Crab Island		32.45.7.5	1893	5	535			+22				D.	Flowed 60 gpm.
89	Crab Island	Fish Products Co. of New Jersey	32.45.7.5	1948	4	536	6	536-566	16	480	28	17	D.	

TABLE 10.—RECORDS OF LARGE CAPACITY WELLS TAPPING THE UNDIFFERENTIATED WATER-TABLE AQUIFER IN OCEAN COUNTY, N. J.

Use of water: D, domestic; I, industrial; Irr., Irrigation; P.S., public supply

Remarks: E, electric log; L, geologic log; Q, chemical analysis

Map No.	Location	Owner's name and well number	N. J. Grid number	Year completed	Altitude above mean sea level (ft)	Depth (ft)	Diameter (in)	Screen setting (ft)	Static water level above (+) or below land surface (feet)	Yield (gpm)	Drawdown (ft)	Specific capacity (gpm/ft)	Use of water	Remarks
90U	Lakehurst	Lakehurst Naval Air Station 7	29.41.4.1.4	1942			10	40- 47 21- 30	8	140			D,	Q
91	Lakehurst	Lakehurst Naval Air Station 8	29.41.1.7.6	1942		51	10	41- 51	12	150	23	7	D.	Q.
92	Lakehurst	Lakehurst Naval Air Station 4	29.41.1.7.7	1942	95	100	10	60- 80	33	230	37	6	D.	Q.
93	Lakehurst	Lakehurst Naval Air Station 2	29.41.1.7.7	1944		41	10	30- 41	6	65	35	2	D.	
94	Lakehurst	Lakehurst Naval Air Station 8	29.41.1.7.7	1944		51	10	41- 51	15	250	45	6	D.	
95	Lakehurst	Lakehurst Naval Air Station 3	29.41.1.7.7	1947		45	6	32- 42	9	170	26	7	D.	Q.
96	Lakehurst	Lakehurst Naval Air Station 10	29.41.1.7.7	1957	80	53	10	30- 50	12	265	16	17	D.	Gravel packed.
97	Lakehurst	Lakehurst Naval Air Station 9	29.41.1.7.7	1950	82	72	10	41- 56	26	270	10	27.0	D.	Gravel packed.
98	Lakehurst	Lakehurst Naval Air Station	29.41.1.7.7	1960		52	10	32- 52	11	300	17	18	D.	
99	Lakehurst	Lakehurst Naval Air Station 2	29.41.1.7.7	1959		62	8	48- 59	14	195	22	8	D.	
100	Lakehurst	Lakehurst Naval Air Station 1	29.41.1.7.7	1958	65	54	8	41- 51	3	112	13	9	D.	
101	Lakehurst	Lakehurst Naval Air Station 16	29.41.1.7.7	1958		55	10	45- 55	18	320	20	9	D.	
102	Lakehurst	Lakehurst Naval Air Station 2	29.41.4.3.4	1958	65	61	6	48- 58	4	94	17	6	D.	
103	Lakehurst	Lakehurst Naval Air Station 1	29.41.4.4.7	1957		56	12	36- 56	9	264	30	9	D.	
104	Lakehurst	Borough of Lakehurst 1	29.41.4.7.2	1954	64	36	10	26- 36	6	100	19	5	P.S.	L.
105	Toms River	Toms River Chemical Co. 6	33.1.3.6.5	1955	63	97	12	82- 97	38	665	37	18.0	I.	
106	Toms River	Toms River Chemical Co. 5	33.1.3.6	1955	38	76	12	60- 75	19	500	56	9	I.	
107	Toms River	Toms River Chemical Co.	33.1.3.6.5	1955	53	75	18		19	510	35	15	I.	
108	Toms River	Toms River Chemical Co. 3	33.1.3.6.9	1952	53	103	16		29	253	50	5	I.	
109	Toms River	Toms River Chemical Co. 2	33.1.3.6.6	1952	54	102	16		33	407	45	9	I.	
110	Toms River	Toms River Chemical Co. 4	33.2.1.4.4	1952	52	111	16		39	421	50	8	I.	
111	Toms River	Toms River Chemical Co. 1	33.2.1.4.4	1950	63	110	12	59- 70 95-110	35	520	37	14.0	I.	Q.

TABLE 10.—RECORDS OF LARGE CAPACITY WELLS TAPPING THE UNDIFFERENTIATED WATER-TABLE AQUIFER IN OCEAN COUNTY, N. J. —Continued

Use of water: D, domestic; I, industrial; Irr., Irrigation; P.S., public supply

Remarks: E, electric log; L, geologic log; Q, chemical analysis

Map No.	Location	Owner's name and well number	N. J. Grid number	Year completed	Altitude above mean sea level (ft)	Depth (ft)	Diameter (in)	Screen setting (ft)	Static water level above (+) or below land surface (feet)	Yield (gpm)	Draw-down (ft)	Specific capacity (gpm/ft)	Use of water	Remarks
112	Toms River	Toms River Chemical Co.	33.2.1.4.4	1952	52	103			36	608	45	14	I.	
113	Toms River	Toms River Water Co. 13	33.2.4.6.1	1946	6	61	18-12	41- 61	5	680	29	24	P.S.	
114	Toms River	Toms River Water Co. 14	33.2.5.2	1953		51	12	40- 50	6	608	24	25	P.S.	
115	Toms River	Toms River Water Co. T.W.3	33.2.5.2	1953		50	6	36- 46	3	400	27	15	P.S.	
116	Beechwood	Beechwood Water Dept. 2	33.2.5.7.6	1944	25	68	6		35	325			P.S.	
117	Beechwood	Beechwood Water Dept. 3	33.2.7.3.8	1953	60	75	10	55- 75	36	150	34	4	P.S.	L.
118	Ocean Gate	Ocean Gate Water Dept. 3	33.2.9.3.8	1959		158	6	132-153	3	500	13	39	P.S.	
119	Barnegat	M. Welsch	33.21.9.5.8	1955	55	145	6 4	65- 90 125-145	36	230	8	29.0	Irr.	L.
120	Waretown	Mid-Jersey Water Co. 1	33.22.2.1.6										P.S.	Q.
121	Barnegat	Barnegat Water Co.	33.22.4.6.9	1887	5	Less than 100								Q. Flowing well.

Radioactivity and electric logs to a depth of 3,891 feet and cores to a depth of 2,300 feet are from test hole 1. The cores below 2,300 feet are from test hole 2.

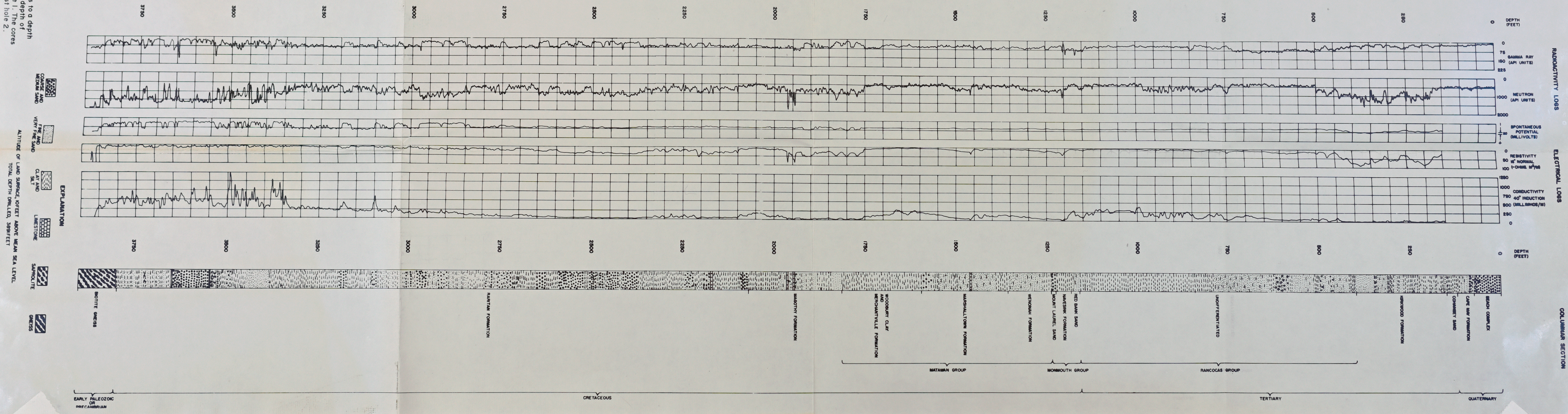

Figure 10.—Geophysical and geologic logs of test holes at Island Beach State Park.

Figure 9.—Geohydrologic section from Sandy Hook to Atlantic City.