Water-Transmitting Properties of Aquifers on Long Island, New York

By N. E. McCLYMONDS *and* O. L. FRANKE

HYDROLOGY AND SOME EFFECTS OF URBANIZATION ON LONG ISLAND, NEW YORK

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By N. E. McClymonds and O. L. Franke

ABSTRACT

Data on the aquifers of Long Island, N.Y., have been collected for the past 30 years as part of a series of studies conducted by the U.S. Geological Survey in cooperation with New York State and county agencies. Since 1900, more than 50,000 wells have been constructed on Long Island. For at least 2,500 of these wells, some information was recorded that is of value in interpreting the hydrologic character of one or more of the four principal aquifers—the upper glacial, the Jameco, the Magothy, and the Lloyd. Although the data for the deeper aquifers—the Magothy and Lloyd—are concentrated largely in the western part of Long Island, enough information is available to make a general interpretation of the hydraulic conductivity and the transmissivity of all aquifers throughout most of the island.

Estimates of the average hydraulic conductivity of the screened interval in the aquifers were obtained by multiplying the specific capacity of the well by the inverse of the well-screen length and by a constant which was estimated from the Theis nonequilibrium formula. Based on the estimated average hydraulic conductivities of different lithologies in many screened intervals, a value of hydraulic conductivity was assigned to each lithology in each aquifer. Using these values, an average aquifer hydraulic conductivity was obtained from drillers' logs, and maps of average hydraulic conductivity were developed for each aquifer on Long Island. Maps of total aquifer transmissivity were developed by combining maps of average aquifer hydraulic conductivity and total aquifer thickness.

The estimated average hydraulic conductivity values obtained in this study were about 1,700 gpd per sq ft (gallons per day per square foot), for the upper glacial aquifer, about 1,300 gpd per sq ft for the Jameco, about 420 gpd per sq ft for the Magothy, and about 360 gpd per sq ft for the Lloyd. Average transmissivity values were about 200,000 gpd per ft (gallons per day per foot) for the upper glacial aquifer, about 100,000 gpd per ft for the Jameco, about 240,000 gpd per ft for the Magothy, and about 90,000 gpd per ft for the Lloyd.

INTRODUCTION

BACKGROUND, PURPOSE, AND SCOPE OF THE WATER-BUDGET STUDY

Long Island, which extends from the southeastern part of the mainland of New York State eastward about 120 miles into the Atlantic Ocean, has a total area of about 1,400 square miles (fig. 1). Kings and Queens Counties, which are part of New York City, occupy slightly less than 200 square miles of the western part of the island and have a combined population of about 4.5 million people. Nassau and Suffolk Counties, with areas of about 290 and 920 square miles, respectively, had a population of about 2.5 million people in 1965.

Although Kings and Queens Counties obtain most of their water supply from New York City's system, which is derived from parts of the Delaware and Hudson River basins in upstate New York, Nassau and tapping the underlying ground-water reservoir. Because of present large demands on the local ground-water system and because of the prospect of increased demands as the population of Long Island continues to grow, knowledge about the hydrologic system—with special emphasis on that needed for water conservation and management purposes—is a matter of vital concern now as well as in the future.

Considerable information on the water resources of Long Island is available as a result of more than 30 years of study by the U.S. Geological Survey in cooperation with New York State and county agencies. Although the studies met many of the needs for information on specific problems and areas of Long Island, more quantitative information about the island-wide hydrologic system and the relations between the various components of the system is needed for water-management purposes. To provide that information, a comprehensive water-budget study presently is being made by the Geological Survey in cooperation with the New York State Department of Conservation, Division of Water Resources; the Nassau County Department of Public Works; the Suffolk County Board of Supervisors; and the Suffolk County Water Authority.

The major objectives of the water-budget study are (1) to summarize and interpret pertinent existing in-

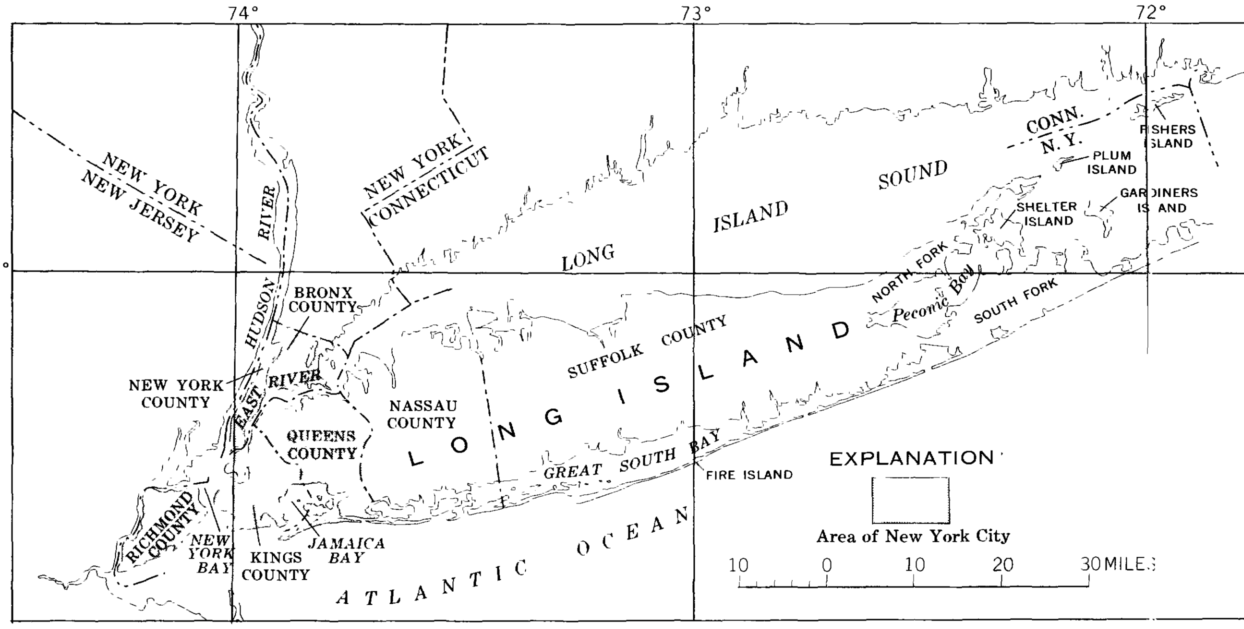


Figure 1.—Location and political boundaries of Long Island.

formation about the hydrologic system of Long Island and (2) to fill several gaps in the knowledge of the hydrologic system. The results of these studies are being published in a series of coordinated reports. In some of the reports, including this one, information is developed for all of Long Island; in others the primary area of concern is limited to Nassau and Suffolk Counties.

PURPOSE AND SCOPE OF THIS REPORT

To evaluate, by means of mathematical or physical models, the response of a ground-water flow system to either natural or manmade changes in the hydrologic regimen, a knowledge of the three-dimensional variation in transmissivity is essential. In addition, a knowledge of transmissivity is necessary to calculate the quantities of ground water flowing in the subsurface. Calculating subsurface flow is particularly important on Long Island because a significant percentage of the total natural outflow of water from the hydrologic system occurs as subsurface outflow to the sea.

The purpose of this report is (1) to summarize existing information on the transmissivity and hydraulic conductivity of Long Island's aquifers and (2) to prepare, for the first time, preliminary maps showing the estimated average hydraulic conductivity and transmissivity of each of the principal aquifers.

LOCATION AND GENERAL GEOGRAPHIC FEATURES OF THE AREA

Long Island is bounded on the north by Long Island Sound, on the east and south by the Atlantic Ocean, and on the west by New York Bay and the East River (fig. 1). Several smaller islands are included in the political boundaries of Long Island; the larger of these are Shelter, Gardiners, Fishers, and Plum Islands. The total land area of Long Island is about 1,400 square miles, including the smaller islands within the political boundaries of the island. The four counties—Kings, Queens, Nassau, and Suffolk—have areas of 78 square miles, 115 square miles, 291 square miles, and 922 square miles, respectively.

Several barrier beaches extend along the south shore of Long Island; the longest of these is Fire Island in southern Suffolk County. The northern and eastern coast lines of the island are indented by deep bays that form excellent harbors. Peconic Bay, which is about 30 miles long, divides the eastern end of the island into two long, narrow peninsulas that are locally referred to as the north and south forks.

PHYSIOGRAPHIC FEATURES

Most of the major features of the present-day topography of Long Island (fig. 2) are related to Pleistocene glaciation. The most prominent physiographic features are (1) the east-trending hills in the northern and central parts of the island and their eastward extensions, which form the north and south forks, (2) the gently sloping plain that extends southward from the hills, (3) the deeply eroded headlands along the north shore, and (4) the barrier beaches along the south shore.

The Harbor Hill Moraine forms the northern line of east-trending hills, which extend from Kings County to northern Nassau County and eastward to the north fork. The Ronkonkoma Moraine forms the southern line of

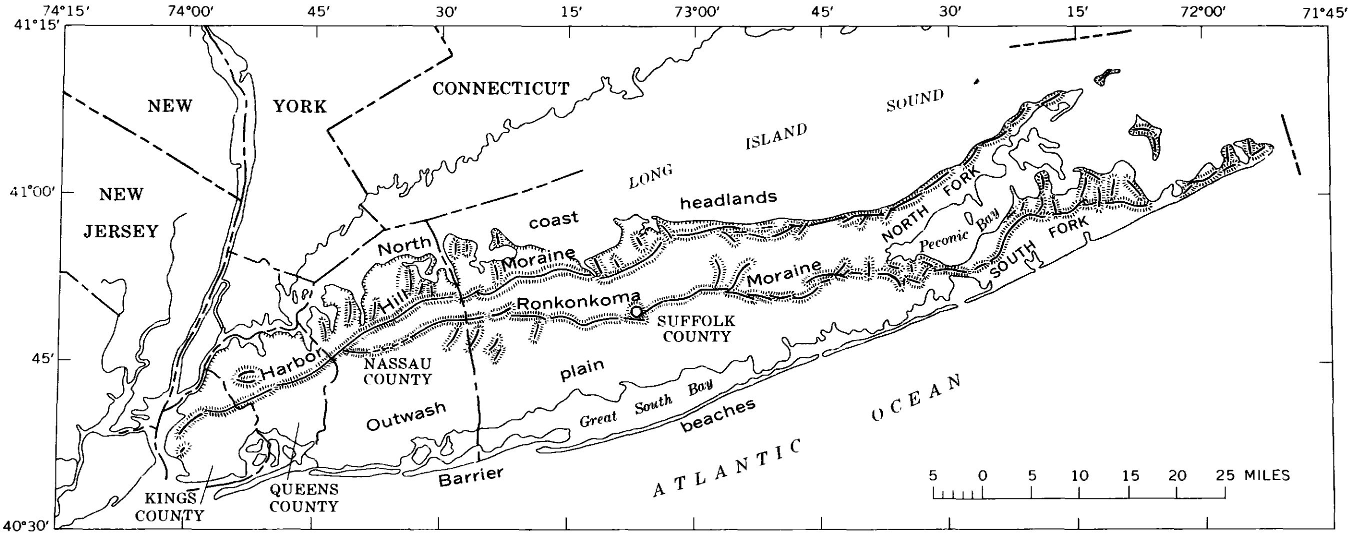


FIGURE 2.—Major physiographic features.

hills and extends from northwestern Nassau County eastward across central Suffolk County to the south fork. These moraines were deposited at the southernmost extension of the glacial ice sheets and have an altitude of about 200 to 300 feet in most of Long Island. The Ronkonkoma Moraine has a maximum altitude of about 400 feet in western Suffolk County.

The moderately even, gently sloping surface that extends southward to the south-shore bays from the Harbor Hill Moraine in Kings and Queens Counties and from the Ronkonkoma Moraine in Nassau and Suffolk Counties is underlain by glacial outwash deposits. This surface has an altitude of about 100 to 150 feet along its inland border and slopes southward at about 20 feet per mile.

The eroded headlands along the north coast are composed mainly of sand, gravel, and clayey till of glacial origin. Wave action has steepened the slopes and cut into the headlands, so that nearly vertical bluffs now exist, some as much as 100 feet high. The bays and harbors of the western part of the north shore were formed during glacial advance and retreat (fig. 2).

Along the south shore, waves and ocean currents formed offshore bars (barrier beaches). Sand and silt, as well as organic deposits, have partly filled and are continuing to fill the shallow bays behind the barrier beaches.

ACKNOWLEDGMENTS

Most of the lithologic and well data in this report were obtained from the files of the New York Water Resources Commission. The authors wish to express their thanks to Walter G. Waterman, associate engineer of the Water Resources Commission, and his colleagues for making these records available.

The report was prepared under the immediate supervision of B. L. Foxworthy, former hydrologist-in-charge, and Philip Cohen, hydrologist-in-charge of the Geological Survey subdistrict office on Long Island; and under the general supervision of Ralph C. Heath and Garald G. Parker, former district chiefs, and Robert J. Dingman, district chief, U.S. Geological Survey, Albany, N.Y.

HYDROGEOLOGIC SETTING

The hydrogeologic setting of Long Island was described in comprehensive reports by several authors (Veatch and others, 1906; Fuller, 1914; Suter and others 1949). In addition, the geology and hydrology of several smaller areas of Long Island were studied in detail by Isbister (1966), Lubke (1964), Lusczynski and Swarzenski (1966), Perlmutter and Geraghty (1963), Pluhowski and Kantrowitz (1964), and Swarzenski (1963). The general hydrologic situation on Long Island was reviewed by Cohen, Franke, and Foxworthy (1968).

Long Island is underlain by consolidated bedrock (fig. 3), which in turn is overlain by a wedge-shaped mass of unconsolidated sedimentary materials. The top of the bedrock, which is at or near the land surface in the northwestern part of the island, slopes to the southeast to a depth of about 2,000 feet below sea level in south-central Suffolk County (fig. 4). The average slope of the bedrock surface is about 65 feet per mile.

The materials that overlie the bedrock and constitute the ground-water reservoir consist of Pleistocene deposits and Cretaceous unconsolidated fluvial and deltaic deposits composed of gravel, sand, silt, clay, and mixtures thereof. The Cretaceous deposits were moderately

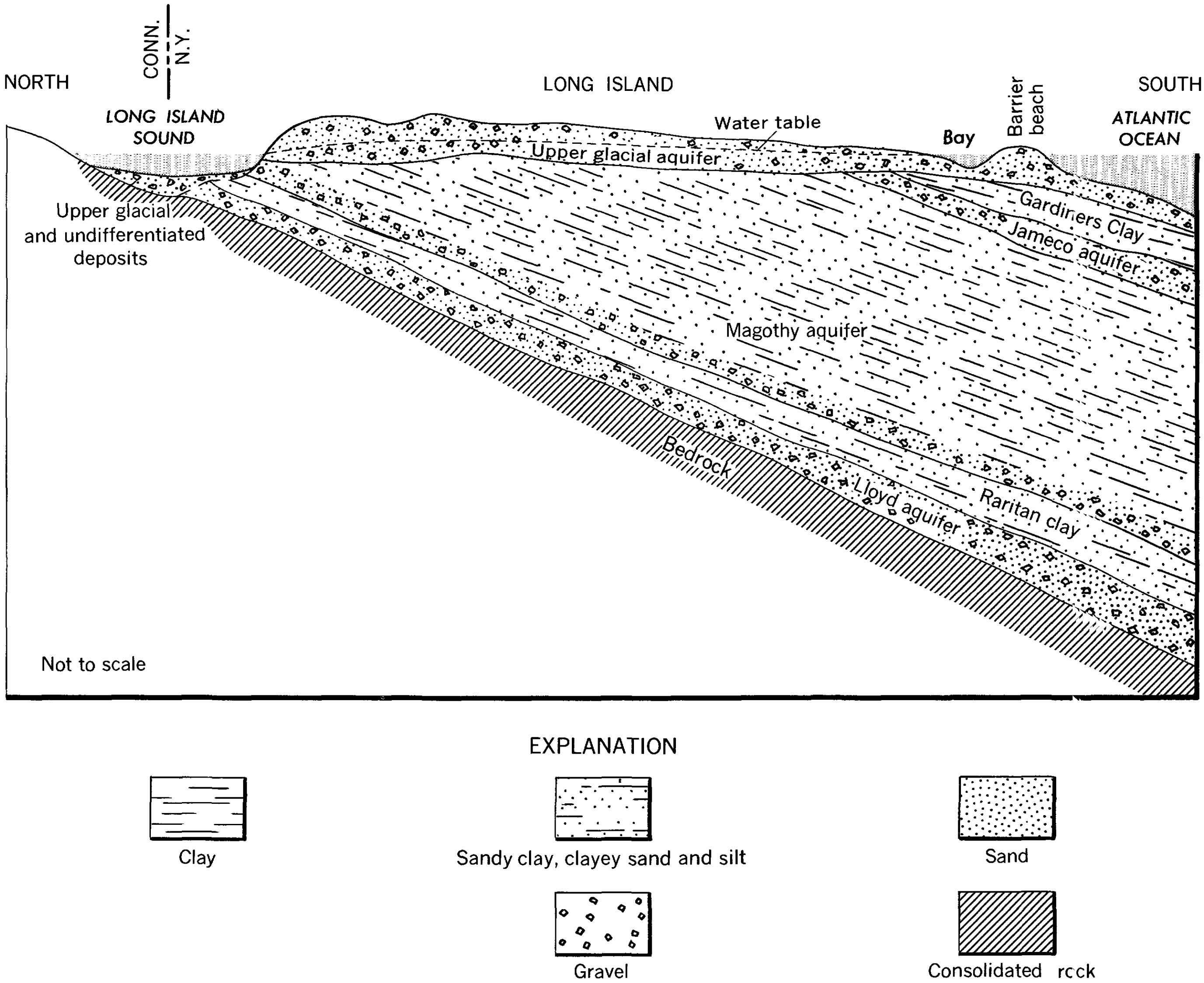


FIGURE 3.—Generalized geologic section showing relative positions of four principal aquifers.

to deeply eroded by streams and glaciers, and therefore, the Pleistocene materials were deposited on an irregular surface that locally was characterized by moderate relief. Data from the numerous wells drilled in Kings, Queens, Nassau, and northwestern Suffolk Counties are sufficient to define the general outlines of the preglacial valleys. In central and eastern Suffolk County, however, the valleys are less well defined.

The upper surface of the Cretaceous deposits generally is below sea level except in several areas in northeastern Nassau and northwestern Suffolk Counties. In all but a few small areas the Pleistocene deposits cover the Cretaceous deposits.

Pertinent information concerning the principal hydrogeologic units of Long Island's ground-water reservoir is summarized in table 1.

Ground water in the uppermost part of the zone of saturation on Long Island, mainly in the upper glacial aquifer but locally also in the Magothy aquifer, is generally under water-table (unconfined) conditions. Artesian (confined) conditions predominate in most of the other parts of the ground-water reservoir of Long Island, where the saturated deposits are overlain by silty and clayey layers of low hydraulic conductivity. Locally, the hydraulic head in the confined aquifers ranges from 30 to 40 feet below the water table in the central part of the island to nearly 20 feet above the water table near the margins of the island. At places along the north and south shores and on the barrier beaches, the head in the Lloyd aquifer is high enough to cause wells that tap the aquifer to flow.

The most significant confining layers in the ground-water reservoir are the Raritan clay, which overlies the Lloyd aquifer; the many discontinuous clay and silt

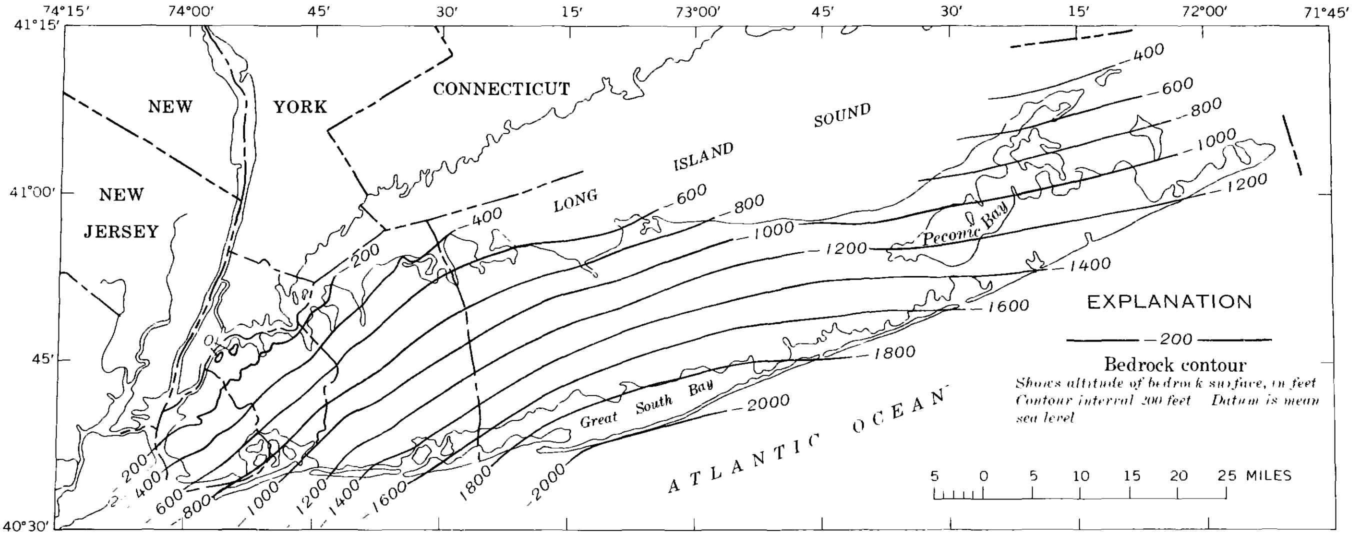


FIGURE 4.—Contour map of the bedrock surface. (Modified from Suter and others, 1949, pls. 8, 9, and 10.)

TABLE 1.—*Summary of the rock units and their water-bearing properties, Long Island*

System	Series	Geologic unit [1]	Hydrogeologic unit	Approximate maximum thickness (feet)	Depth from land surface to top (feet)	Character of deposits	Water-bearing properties
	Holocene	Recent deposits: Artificial fill, salt marsh deposits, stream alluvium, and shoreline deposits.	Recent deposits	50	0	Sand, gravel, clay, silt, organic mud, peat, loam, and shells. Colors are gray, brown, green, black, and yellow. Recent artificial-fill deposits of gravel, sand, clay, and rubbish.	Permeable sandy beds beneath barrier beaches yield fresh water at shallow depths, brackish to salty water at greater depth. Clay and silt beneath bays retard salt-water encroachment and confine underlying aquifers. Stream floodplain and marsh deposits may yield small quantities of water but are generally clayey or silty and much less permeable than the underlying upper glacial aquifer.
Quaternary	Pleistocene	Upper Pleistocene deposits	Upper glacial aquifer	600	0–50	Till (mostly along north shore and in moraines) composed of clay, sand, gravel, and boulders forms Harbor Hill and Ronkonkoma terminal moraines. Outwash deposits (mostly between and south of terminal moraines, but also interlayered with till) consist of quartzose sand, fine to very coarse, and gravel, pebble to boulder sized. Glaciolacustrine deposits (mostly in central and eastern Long Island) and marine clay (locally along south shore) consist of silt, clay, and some sand and gravel layers; includes the "20-foot clay" in southern Nassau and Queens Counties. Colors are mainly gray, brown, and yellow; silt and clay locally are grayish green. Contains shells and plant remains, generally in finer grained beds; also contains Foraminifera. Contains chlorite, biotite, muscovite, hornblende, olivine, and feldspar as accessory minerals; "20-foot clay" commonly contains glauconite.	Till is poorly permeable; commonly causes perched-water bodies and impedes downward percolation of water to underlying beds Outwash deposits are moderately to highly permeable; specific capacities of wells tapping them range from about 10 to more than 200 gpm per ft (gallons per minute per foot) of drawdown. Good to excellent infiltration characteristics. Glaciolacustrine and marine clay deposits are mostly poorly permeable but locally have thin, moderately permeable layers of sand and gravel; generally retard downward percolation of ground water. Contains fresh water except near the shore lines. Till and marine deposits locally retard salt-water encroachment.
		—— Unconformity? ——					
		Gardiners Clay	Gardiners Clay	300	50–400	Clay, silt, and few layers of sand and gravel Colors are grayish green and brown. Contains marine shells, Foraminifera, and lignite; also locally contains glauconite. Altitude of top generally is 50–80 feet below mean sea level. Occurs in Kings, Queens, and southern Nassau and Suffolk Counties; similar clay occurs in buried valleys near north shore.	Poorly permeable; constitutes confining layer for underlying Jameco aquifer. Locally, sand layers yield small quantities of water.
		—— Unconformity? ——					
		Jameco Gravel	Jameco aquifer	300	50–550	Sand, fine to very coarse, and gravel to large-pebble size; few layers of clay and silt. Gravel is composed of crystalline and sedimentary rocks. Color is mostly dark brown. Contains chlorite, biotite, muscovite, hornblende, and feldspar as accessory minerals. Occurs in Kings, Queens, and southern Nassau Counties; similar deposits occur in buried valleys near north shore.	Moderately to highly permeable; contains mostly fresh water, but brackish water and water with high iron content occurs locally in southeastern Nassau and southern Queens Counties. Specific capacities of wells in the Jameco range from about 20 to 150 gpm per ft of drawdown.

See footnotes at end of table.

TABLE 1.—*Summary of the rock units and their water-bearing properties, Long Island*—Continued

System	Series	Geologic unit [1]		Hydrogeologic unit	Approximate maximum thickness (feet)	Depth from land surface to top (feet)	Character of deposits	Water-bearing properties
		Unconformity						
Tertiary (?)	Pliocene(?)	Mannetto Gravel		(Commonly included with upper glacial aquifer.)	300	0–120	Gravel, fine to coarse, and lenses of sand; scattered clay lenses. Colors are white, yellow, and brown. Occurs only near Nassau-Suffolk County border near center of island.	Highly permeable, but occurs mostly above water table. Excellent infiltration characteristics.
		Unconformity						
Cretaceous	Upper Cretaceous	Magothy(?) Formation [2]		Magothy aquifer	1,100	0–600	Sand, fine to medium, clayey in part; interbedded with lenses and layers of coarse sand and sandy and solid clay. Gravel is common in basal 50–200 feet. Sand and gravel are quartzose. Lignite, pyrite, and iron oxide concretions are common; contains muscovite, magnetite, rutile, and garnet as accessory minerals. Colors are gray, white, red, brown, and yellow.	Most layers are poorly to moderately permeable; some are highly permeable locally. Specific capacities of wells in the Magothy generally range from 1 to about 30 gpm per ft of drawdown, rarely are as much as 80 gpm per ft of drawdown. Water is unconfined in uppermost parts, elsewhere is confined. Water is generally of excellent quality but has high iron content locally along north and south shores. Constitutes principal aquifer for public-supply wells in western Long Island except Kings County, where it is mostly absent. Has been invaded by salty ground water locally in southwestern Nassau and southern Queens Counties and in small areas along north shore.
		Unconformity						
		Raritan Formation	Clay member	Raritan clay	300	70–1,500	Clay, solid and silty; few lenses and layers of sand; little gravel. Lignite and pyrite are common. Colors are gray, red, and white, commonly variegated.	Poorly to very poorly permeable; constitutes confining layer for underlying Lloyd aquifer. Very few wells produce appreciable water from these deposits.
			Lloyd Sand Member	Lloyd aquifer	500	200–1,800	Sand, fine to coarse, and gravel, commonly with clayey matrix; some lenses and layers of solid and silty clay; locally contains thin lignite layers and iron concretions. Locally has gradational contact with overlying Raritan clay. Sand and most of gravel are quartzose. Colors are yellow, gray, and white; clay is red locally.	Poorly to moderately permeable. Specific capacities of wells in the Lloyd generally range from 1 to about 25 gpm per ft of drawdown, rarely are as much as 50 gpm per ft of drawdown. Water is confined under artesian pressure by overlying Raritan clay; generally of excellent quality but locally has high iron content. Has been invaded by salty ground water locally in necks near north shore, where aquifer is mostly shallow and overlying clay is discontinuous. Called "deep confined aquifer" in some earlier reports.
		Unconformity						
Precambrian		Bedrock		Bedrock		0–2,700	Crystalline metamorphic and igneous rocks; muscovite-biotite schist, gneiss, and granite. A soft, clayey zone of weathered bedrock locally is more than 100 feet thick.	Poorly permeable to virtually impermeable; constitutes virtually the lower boundary of ground-water reservoir. Some hard, fresh water is contained in joints and fractures but is impractical to develop at most places; however, a few wells near the western edges of Queens and Kings Counties obtain water from the bedrock.

[1] Names are those used in reports by the Geological Survey.
[2] The use of the term "Magothy(?) Formation" has been abandoned. The post-Raritan Cretaceous deposits are divided into the Magothy Formation and Matawan Group undifferentiated and the Monmouth Group undifferentiated.

lenses in the Magothy deposits; and the Gardiners Clay, which overlies the Jameco aquifer and locally overlies the Magothy aquifer. The clayey and silty layers in the Magothy aquifer become increasingly effective as confining layers with depth, particularly in the southern part of Long Island where the Magothy reaches its maximum thickness—about 1,100 feet in southern Suffolk County. Clayey beds in the upper glacial aquifer are found mainly in the northern part of the island and in parts of central Suffolk County; some are interbedded with glacial outwash deposits near the south shore.

DEFINITION OF HYDRAULIC CONDUCTIVITY AND TRANSMISSIVITY

The hydraulic conductivity, K, of material comprising an aquifer is a measure of the material's capacity to transmit water. In units of meinzers, commonly used by the Geological Survey, hydraulic conductivity is defined as the rate of flow of water in gallons per day through a cross-sectional area of 1 square foot under a hydraulic gradient of 1 foot per foot at a temperature of 60° F. In field practice the adjustment to the standard temperature of 60° F commonly is ignored, and hydraulic conductivity is then understood to be related to the prevailing water temperature.

The transmissivity of material comprising an aquifer is defined as the number of gallons of water that will move in 1 day through a vertical strip of the aquifer having a width of 1 foot and having the height of the aquifer, when the hydraulic gradient is unity. It is equal to the hydraulic conductivity multiplied by the thickness of the aquifer in feet, and it is expressed by the following equation:

$$T=Km, \qquad (1)$$

in which T= transmissivity of the aquifer, in gallons per day per foot,
K=hydraulic conductivity of the aquifer, in gallons per day per square foot, and
m= thickness of the aquifer, in feet.

Strictly speaking, the preceding definition of transmissivity applies only to a homogeneous and isotropic aquifer. Under these ideal conditions the transmissivity is constant at all times and places within the aquifer. A generalization of this definition that is useful for defining the transmissivity of multilayered sequences in which both thickness and hydraulic conductivity vary widely in adjacent layers is

$$T=\sum_{i=1}^{n} K_i m_i, \qquad (2)$$

in which T= total transmissivity of i layers, in gallons per day per foot,
K_i= hydraulic conductivity of the ith layer, in gallons per day per square foot, and
m_i= thickness of the ith layer, in feet.

With reference to equations 1 and 2, the average hydraulic conductivity $\overline{K}$ of a sequence of layers may be defined as

$$\overline{K}=\frac{T}{M} \qquad (3)$$

in which $\overline{K}$= average hydraulic conductivity of a multilayered sequence, in gallons per day per square foot,
T= total transmissivity; in gallons per day per foot, and
M= total thickness of the sequence of layers, in feet.

The definitions of hydraulic conductivity and transmissivity in equations 1, 2, and 3 are strictly valid only for the hydraulic conductivity in the direction parallel to the direction of flow, which, for most of Long Island, is parallel to the bedding or stratification of the aquifers. This direction commonly corresponds to the direction of greatest hydraulic conductivity and transmissivity in nature. Thus, where the bedding is horizontal or almost so, as on Long Island, equations 1, 2, and 3 are used to define the horizontal hydraulic conductivity and transmissivity.

PREVIOUS ESTIMATES OF HYDRAULIC CONDUCTIVITY AND TRANSMISSIVITY OF LONG ISLAND'S AQUIFERS

Previous investigators estimated transmissivity and hydraulic conductivity values for parts of individual aquifers on Long Island primarily from data derived from aquifer tests and driller's well-acceptance tests (specific-capacity tests). Pertinent data concerning the aquifer tests for which information is available are listed in table 2, and the locations of the wells that were tested are shown in figure 5. In most of the tests, it was assumed that the thickness of the aquifer tested was equal to the thickness of the material between the first well-defined clay layer below and above the screened interval or the first well-defined clay layer below the screened interval and the water table.

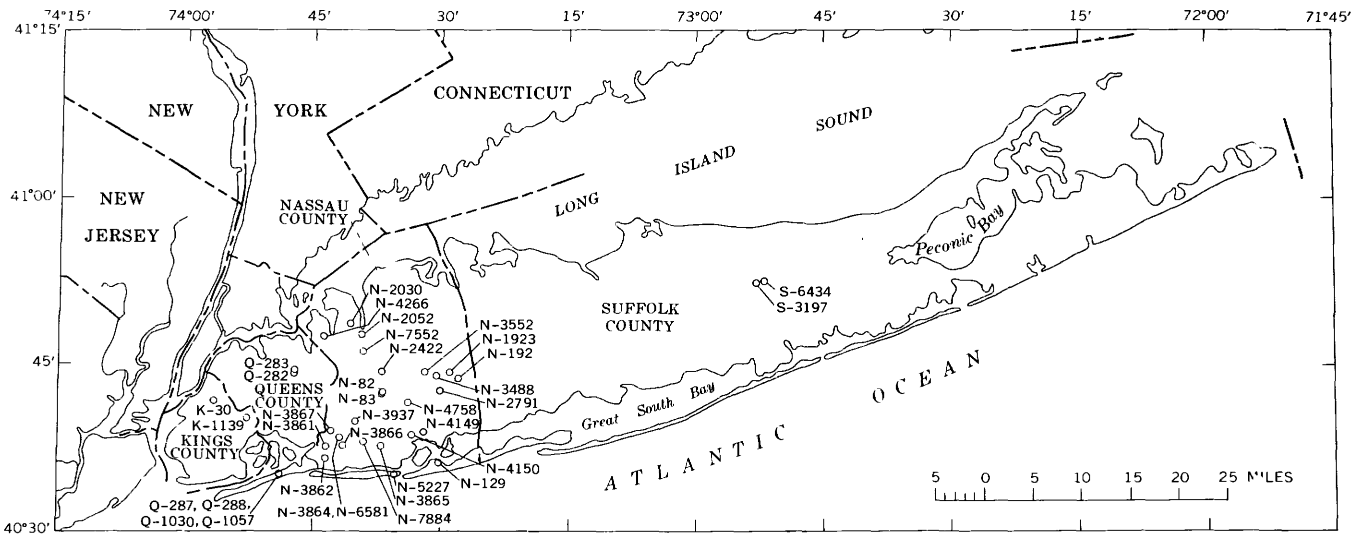


FIGURE 5.—Location of wells for which aquifer-test data are available. Data summarized in table 2.

TABLE 2.—*Estimates of transmissivity and hydraulic conductivity of Long Island's aquifers derived from aquifer tests*

Aquifer	Well	Date of test	Well discharge (gpm)	Drawdown in pumped well (feet)	Screen length (feet)	Estimated thickness of interval tested (feet)	Transmissivity (gpd per ft)	Hydraulic conductivity (gpd per sq ft)	Source of information[1]
Upper glacial	K-30	1947					375,000		U.S.G.S. file.
	S-3197	Dec. 1950	460	50	20	145	190,000	1,300	M. A. Warren and N. Lusczynski.
Jameco	K-1139	June 1941	220			80	110,000	1,400	J. G. Ferris.
Magothy	N-82	Sept. 1935	1,000	28	50	50	140,000	2,800	U.S.G.S. file.
	N-83	Sept. 1935	1,010	34	60	60	140,000	2,300	Do.
	N-129	Nov. 1953	1,220	54	50	50	50,000	1,000	Do.
	N-192	Dec. 1940	530		50	100	350,000	3,500	C. E. Jacob.
	N-1923	Aug. 1943	1,360	70	55	70	60,000	850	Do.
	N-2030	Apr. 1946	540	87	25	32	115,000	3,600	Do.
	N-2052	Aug. 1947	920	39	20	20	30,000	1,500	W. V. Swarzenski.
	N-2422	Oct. 1947	205	40	31	50	240,000	4,800	N. J. Lusczynski.
	N-2791	Sept. 1949	790	20	31	100	240,000	2,400	Do.
	N-3488	July 1950	1,120	35	52	100	150,000	1,500	Do.
	N-3552	Sept. 1950	1,150	24	53	100	360,000	3,600	Do.
	N-3861	Oct. 1952	130	21	11	155	150,000	1,000	Do.
	N-3862	Oct. 1952	82	19	10	45	40,000	900	Do.
	N-3864	Oct. 1952	95	91	11	145	30,000	200	Do.
	N-3865	Oct. 1952	86	91	10	80	24,000	300	Do.
	N-3866	Oct. 1952	113	31	10	60	100,000	1,700	Do.
	N-3867	Dec. 1952	83	10	11	60	80,000	1,300	Do.
	N-3937	Sept. 1952	1,600	50	73	67	140,000	2,100	Do.
	N-4149	Oct. 1953	140	23	16	180	300,000	1,600	Do.
	N-4150	Feb. 1954	120	9	16	70	140,000	2,000	Do.
	N-4758	Dec. 1954	1,300		62	100	220,000	2,200	N. M. Perlmutter and J. J. Geraghty.
	N-6581	Oct. 1958	130	38	10	60	30,000	500	N. J. Lusczynski.
	N-7552	Aug. 1964	1,500	114	95	95	70,000	740	U.S.G.S. file.
	N-7884	Apr. 1967	1,000	32	62	50	60,000	1,200	Do.
	S-6434	Jan. 1949	410	33	20	100	40,000	400	M. A. Warren and N. J. Lusczynski.
Lloyd	Q-282	Jan. 1942			84	80	50,000	600	C. E. Jacob.
	Q-283	Jan. 1942			85	80	50,000	600	Do.
	Q-287	Feb. 1940	2,100			100	160,000	1,600	Do.
	Q-288	Feb. 1940	2,100			100	180,000	1,800	Do.
	Q-1030	Feb. 1940	2,100	52	65	100	160,000	1,600	Do.
	Q-1057	Feb. 1940	2,100			100	170,000	1,700	Do.
	N-4266	Sept. 1954	78	41	15	15	10,000	660	N. J. Lusczynski.
	N-5227	June 1955	1,200	50	60	60	30,000	500	N. J. Lusczynski and W. V. Swarzenski.
	S-6434	June 1949	460	185	80	65	12,500	200	M. A. Warren and N. J. Lusczynski.

[1] From original data in the files of the U.S. Geological Survey, Mineola, N.Y.; some interpretive results based on these data were later published.

Estimates of hydraulic conductivity by previous investigators, which were derived from specific-capacity data obtained from drillers' acceptance tests, are listed in table 3, and the locations of the wells that were studied are shown in figure 6. Usually one of two methods was used to calculate the transmissivity of part of the aquifer. The first method was developed by Theis, Brown, and Meyer (1954) for water-table aquifers. The second method, devised by R. R. Meyer (Bentall, 1963), is also based on the method developed by Theis, but it provides a technique for estimating the transmissivity of both artesian and water-table aquifers. The hydraulic conductivity was in turn calculated by dividing the transmissivity by an estimated value of the thickness of aquifer material that was tested at the well site.

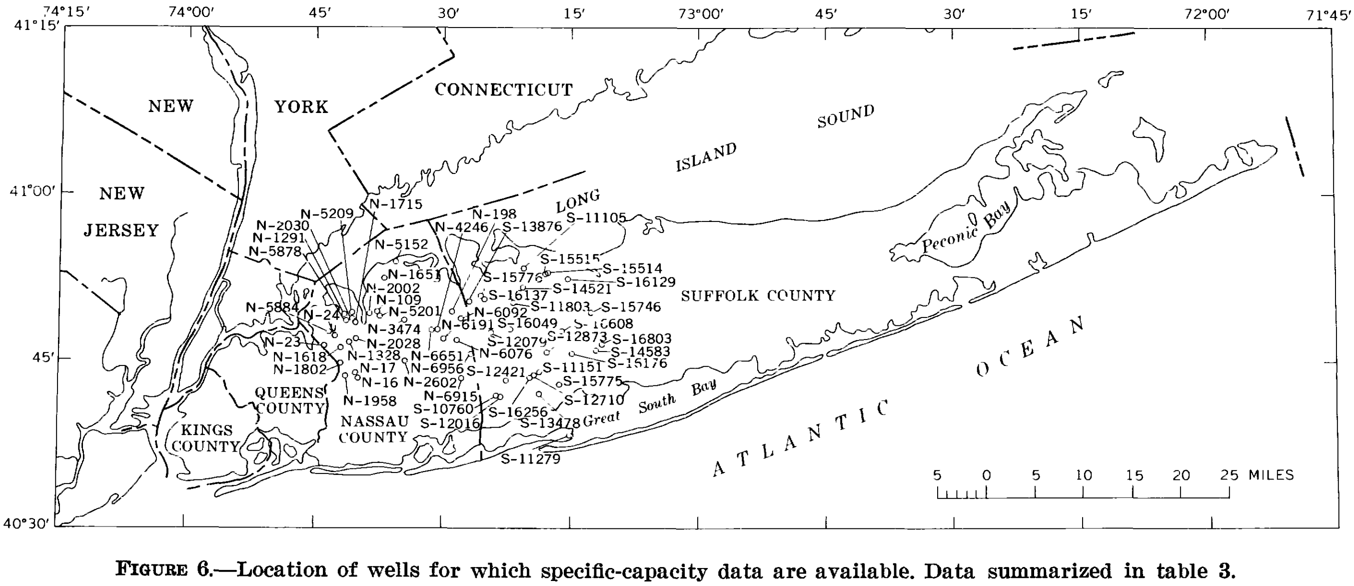


FIGURE 6.—Location of wells for which specific-capacity data are available. Data summarized in table 3.

TABLE 3.—*Estimates of average hydraulic conductivity for parts of Long Island's aquifers derived from specific-capacity data*

Aquifer	Well	Screen length (feet)	Estimated thickness of nterval tested (feet)	Estimated average hydraulic conductivity of interval tested (gpd per sq ft)	Source of information
Upper glacial	S-10760	22	73	800	Pluhowski and Kantrowitz (1964, p. 16).
	S-11105	48	48	900	Lubke (1964, p. 19).
	S-11151	11	84	300	Pluhowski and Kantrowitz (1964, p. 16),
	S-11803	53	53	1, 500	Lubke (1964, p. 19).
	S-12016	35	67	2, 200	Pluhowski and Kantrowitz (1964, p. 16).
	S-12421	21	70	1, 000	Do.
	S-12710	30	75	1, 600	Do.
	S-12873	25	91	1, 100	Do.
	S-13478	25	70	900	Do.
	S-15746	41	41	900	Lubke (1964, p. 19).
	S-15776	63	63	1, 200	Do.
	S-16049	62	62	1, 000	Do.
	S-16137	62	62	750	Do.
	S-16176	36	85	1, 200	Pluhowski and Kantrowitz (1964, p. 16).
	S-16608	30	88	1, 200	Do.
	S-16803	5	----------	700	Pluhowski and Kantrowitz (1964, p. 17).
Average				1, 080	
Magothy	N-16	60	150	280	Swarzenski (1963, p. 17).
	N-17	60	80	350	Do.
	N-198	50	70	1, 200	Isbister (1966, p. 24).
	N-2028	60	190	400	Swarzenski (1963, p. 17).
	N-2030	25	80	440	Do.
	N-3474	60	70	1, 000	Isbister (1966, p. 24).
	N-4246	50	100	700	Do.
	N-5209	40	100	540	Swarzenski (1963, p. 17).
	N-5876	70	110	270	Do.
	N-5884	71	110	870	Do.
	N-6076	62	70	1, 200	Isbister (1966, p. 24).
	N-6092	70	110	1, 100	Do.
	N-6191	99	130	600	Do.
	N-6651	50	60	1, 100	Do.
	N-6915	53	90	1, 100	Do.
	N-6956	62	110	800	Do.
	S-11279	30	59	400	Pluhowski and Kantrowitz (1964, p. 18),
	S-12079	72	72	550	Lubke (1964, p. 19).
	S-13876	52	52	450	Do.
	S-14521	62	62	750	Do.
	S-14583	26	89	400	Pluhowski and Kantrowitz (1964, p. 18).
	S-15514	60	60	650	Lubke (1964, p. 19).
	S-15515	40	40	450	Do.
	S-15775	40	88	800	Pluhowski and Kantrowitz (1964, p. 18).
	S-16129	76	76	650	Lubke (1964, p. 19).
	S-16256	52	76	1, 200	Pluhowski and Kantrowitz (1964, p. 18).
Average				700	
Lloyd	N-23	30	140	200	Swarzenski (1963, p. 15).
	N-24	68	150	270	Do.
	N-109	70	128	400	Isbister (1966, p. 20).
	N-1291	25	40	300	Swarzenski (1963, p. 15).
	N-1328	90	210	330	Do.
	N-1618	80	150	380	Do.
	N-1651	80	210	300	Isbister (1966, p. 20).
	N-1715	50	140	210	Swarzenski (1963, p. 15).
	N-1802	50	190	260	Do.
	N-1958	60	150	560	Do.
	N-2002	31	80	370	Do.
	N-2602	40	230	100	Isbister (1966, p. 20).
	N-5152	50	220	100	Do.
	N-5201	70	126	500	Do.
Average				310	

As shown in table 2, only two estimates of transmissivity derived from aquifer tests were available for the upper glacial aquifer. Neither of the two wells tested penetrates the highly permeable outwash deposits that cover most of the southern half of Long Island. The only available estimate of the hydraulic conductivity of the upper glacial aquifer based on aquifer-test data (well S3197, table 2) is from an area where morainal till and lakebed clay deposits are part of the upper glacial aquifer. Therefore, the hydraulic conductivity value obtained from this test is probably less than the average hydraulic conductivity of the aquifer.

Well K1139 in eastern Kings County is the only well tapping the Jameco aquifer for which aquifer-test data were available (table 2). The calculated transmissivity of the Jameco at this well is about 110,000 gpd per ft (gallons per day per foot). If the thickness of the aquifer that was tested is assumed to be 80 feet, the average hydraulic conductivity for that interval would be about 1,400 gpd per sq ft (gallons per day per square foot).

More estimates of transmissivity have been obtained from aquifer tests for the Magothy aquifer than for any other aquifer on Long Island (table 2). However, these estimates are of small thicknesses of the aquifer, and these materials probably include the more permeable parts of the aquifer penetrated by the well. Therefore, the estimates of average hydraulic conductivity obtained from these tests are undoubtedly higher than the average hydraulic conductivity of the whole aquifer. Most of the estimates of transmissivity of the Magothy aquifer based on data from aquifer tests range from 30,000 to more than 300,000 gpd per ft (table 2). Most values of hydraulic conductivity for the materials tested range from about 1,000 to 3,000 gpd per sq ft, and the average hydraulic conductivity is about 1,700 gpd per sq ft.

Average hydraulic conductivities of the intervals tested in the Magothy aquifer, as computed by previous investigators from specific-capacity data (table 3), are considerably less than the hydraulic conductivities calculated from aquifer-test data (table 2). Computed hydraulic conductivities of the aquifer in northern Nassau and western Suffolk Counties range from about 300 to 1,200 gpd per sq ft and average about 700 gpd per sq ft. These hydraulic conductivities were derived from estimated transmissivities divided by estimated thicknesses of the aquifer determined from lithologic logs. Because most of these wells probably were also screened in the most permeable zones, the apparent discrepancy between the average hydraulic conductivity values calculated from specific-capacity data (700 gpd per sq ft) and the values calculated from aquifer-test data (1,700 gpd per sq ft) probably is related to the different methods of evaluation that were used rather than to actual differences in hydraulic conductivity.

Data were available for nine aquifer tests using wells that were screened in the Lloyd aquifer (table 2). Lithologic logs of the Lloyd aquifer suggest that the percentage of clay in the aquifer increases eastward. This, however, does not explain the large difference between the hydraulic conductivities calculated in several wells in Queens County and well S6434 in central Suffolk County. Lusczynski and Swarzenski (1966, p. 19) report that a reevaluation of the test for well Q1030 indicated that the average hydraulic conductivity was probably only about 500 gpd per sq ft. Furthermore, well S6434 possibly was not sufficiently developed to obtain a meaningful value for the transmissivity and hydraulic conductivity of the Lloyd aquifer from an aquifer test. The average hydraulic conductivity of the Lloyd aquifer calculated from specific-capacity data (table 3) was about 300 gpd per sq ft in Nassau County.

DERIVATION OF HYDRAULIC CONDUCTIVITY AND TRANSMISSIVITY VALUES IN THE PRESENT INVESTIGATION

One of the major objectives of this investigation was to prepare maps showing the average hydraulic conductivity and transmissivity of Long Island's aquifers. The method used to develop the hydraulic conductivity and transmissivity values mainly involved an analysis of specific-capacity and lithologic data.

THEORY

Theis and others (1954) suggested procedures for using specific-capacity data to estimate transmissivity of aquifers by means of the Theis nonequilibrium equation. A convenient form of that equation for this purpose (expressed in units used by the Geological Survey) is

$$\frac{Q}{s}=\frac{T}{114.6W(u)}, \qquad (4)$$

where Q/s=specific capacity of the well, in gallons per minute per foot of drawdown,

Q=discharge of the pumping well, in gallons per minute,

s=drawdown in the pumping well, in feet,

T=transmissivity of the aquifer, in gallons per day per foot,

$W(u)$= well function of $u=1.87\ r^2\ S/Tt$,
r= distance from the pumping well to the point of observation, in feet,
S= coefficient of storage, expressed as a decimal fraction, and
t= time since pumping started, in days.

The assumptions made in deriving this formula and the sensitivity of the various parameters to changes in the magnitude of other parameters are discussed at length by Bredehoeft (1963).

In this report, equation 4 was used in a modified form that was more amenable to the direct use of well data. By substituting $\overline{K}L$ for T and rearranging terms, then

$$\overline{K}=114.6W(u)\ \frac{Q}{sL}, \qquad (5)$$

where $\overline{K}$= average hydraulic conductivity of the materials opposite the well screen, in gallons per day per square foot, and
L= length of well screen, in feet.

Implicit in this substitution is the assumption that the length of the well screen is equal to the thickness of aquifer material that contributes all the water to the well.

The factor Q/sL is the specific capacity of the well per foot of well screen. Because this factor takes into account the length of the well screen, its value for different wells commonly can be compared more meaningfully than can specific-capacity values, particularly where the lengths of well screens differ considerably.

Most aquifers are highly anisotropic to fluid flow, and the average hydraulic conductivity of an aquifer parallel to the bedding generally is many times greater than the average hydraulic conductivity perpendicular to the bedding. Therefore, in horizontally bedded deposits, such as those of the Long Island ground-water reservoir, most of the flow into a well commonly is derived from the materials directly opposite the well screen. Thus, the length of well screen, L, generally is a reasonable estimate of the thickness of aquifer that contributes most of the water to the well. However, because of some across-bed flow originating in beds above or below a well screen and because some wells are packed with gravel which forms a conduit for water from above and below the screen, equation 5 may give values of $\overline{K}$ that are somewhat greater than the average hydraulic conductivity of the materials opposite the well screen. In general, the error involved in using equation 5 decreases as the length of the well screen increases. Except for wells with very short screens (for example, less than 15 feet), the error in average hydraulic conductivity determination due to water entering the well from above and below the well screen is generally less than 25 percent.

To apply equation 5, a value for the factor $114.6W(u)$ must also be estimated. By inserting, for the variables in the expression $114.6W(u)$ in equation 4, the most extreme values for conditions that might occur in Long Island's aquifers, this expression was found to range from 1,500 to 2,500 and to average about 2,000. In other words,

$$\overline{K}\approx 2{,}000\ Q/sL \qquad (6)$$

is a valid approximation. Equation 6, therefore, was used to estimate the average hydraulic conductivity of the materials opposite the screened interval of most wells analyzed for this report.

As outlined in the previous paragraphs, the method of pumping-test analysis used in this report differs from the approach of previous investigators, who assumed that the tested thickness of the aquifer comprised the interval between the first "well-defined" clay layers above and below the well screen. The approach by previous investigators was not adopted because only a fraction of the wells on Long Island have geophysical logs, core data, or sufficiently detailed lithologic logs to make such an approach generally feasible on an island-wide basis. In addition, the present method has the advantage that it is quick and requires no judgment regarding the nature and extent of "well-defined" clay layers.

In the simplest case, if the lithology of the entire screened interval of each well was the same and if many wells were screened throughout all the different lithologies in an aquifer, then a compilation of values calculated from equation 6 would give a good estimate of the average hydraulic conductivity for the aquifer. In many areas, however, the screened intervals commonly are comprised of several layers of different lithology and, therefore, of different hydraulic conductivity. Jenkins (1963) developed a technique using multiple-regression analysis to deal with the problem of multiple lithologies in the screened interval. In this investigation, as is described subsequently in the report, a sufficiently large number of screened intervals in each aquifer on Long Island are characterized by a single lithologic type, so that Jenkins' procedure was not used.

The lithologic descriptions of the screened intervals used in this study were derived mainly from drillers' lithologic logs. Therefore, the validity of the procedures described in the following section and the accuracy of the analysis are, at least partly, contingent upon the validity of the assumption that the drillers were consistent in their descriptions of the materials.

GENERAL PROCEDURE

Completion reports were available for about 45,000 wells on Long Island in 1967. However, most of these wells are shallow-driven well points, and no lithologic and very little hydrologic information is available for them. For the purpose of this study, data were recorded according to the format shown in table 4 for about 2,500 wells for which pertinent data were available. These wells include about 70 percent of all the wells that tap the upper glacial and Jameco aquifers for which pertinent hydrologic information is available and more than 80 percent of all known wells that tap the Magothy and Lloyd aquifers. Furthermore, these 2,500 wells included nearly all the large-yield (500 gallons per minute or more) wells on Long Island.

TABLE 4.—*Information recorded for each well*

Information	*Remarks*
Well number	Number assigned by the New York State Water Resources Commission. The initial letter designates the appropriate county—that is, K, Q, N, and S refer to Kings, Queens, Nassau, and Suffolk Counties, respectively. This numbering system has no relation to location.
Date of well-acceptance test	Generally well was drilled several months prior to the test.
Aquifer in which well is screened.	One of four principal aquifers on Long Island—upper glacial, Jameco, Magothy, or Lloyd.
Location of well	An arbitrary numbering system was assigned to the latitude-longitude grid which permitted each well to be located within a 2½ minute rectangle. This rectangle is approximately 2.2 miles by 2.9 miles or nearly 6.4 square miles.
Source of information	The source of information was usually a bulletin of the New York State Department of Conservation, Division of Water Resources, the files of the Division, or the files of the U.S. Geological Survey.
Screen diameter, in inches	Inside diameter.
Screen length, in feet	The "L" of the Q/sL number.
Screened interval, in feet below land-surface datum.	The depths of the top and bottom of the well screen.
Acceptance test data:	
Duration of test, in hours	
Drawdown in pumping well, in feet.	The drawdown is generally measured at the end of the test; the "s" of the Q/sL number.
Discharge of pumping well, in gallons per minute.	Discharge generally maintained as constant as possible throughout the test; the "Q" of the Q/sL number.
Q/sL number, in gallons per minute (per) square foot.	Computed from tabulated data.
Lithologic description(s) of the screened interval.	Complete drillers' description of the screened interval, and unit thicknesses.
Depth of well, in feet	Drilled depth is sometimes considerably greater than bottom of the well screen.
Approximate elevation of land-surface datum at well location, in feet above mean sea level.	Taken mostly from topographic maps; generally accurate to within 5 feet, except where location of well is not known exactly.
Elevation of aquifer boundaries, in feet above or below mean sea level.	Estimated from the drillers' log and regional geologic correlations.

The procedures used in this report to obtain estimated values of transmissivity and average hydraulic conductivity from well data were somewhat similar to those described by Bredehoeft (1963). Although the analytical procedures varied slightly for each of the four major aquifers, hydraulic conductivity and transmissivity maps were prepared for the aquifers in accordance with the following major steps. First, the numerous lithologic descriptions of the screened intervals were grouped into three general classes: (1) Gravel, sand and gravel, and coarse sand, (2) medium to very fine sand, and sand with silt or clay layers, and (3) clay, sandy, clay, and silty clay. Initially, the lithologic descriptions were divided into six classes, but the differences between the median Q/sL numbers of each of these classes were insignificant; therefore, the broader grouping was adopted. Only wells that had sufficient information to calculate Q/sL numbers were used in this phase of the analysis. The median values for the Q/sL numbers were determined for each of the three lithologic classes for each aquifer, as shown in tables 5, 7, 9, and 11.

The second step in the procedure involved assigning hydraulic conductivity values to all the materials encountered by wells that penetrated or nearly penetrated the entire thickness of each major aquifer. In this step, all wells with drillers' logs were used, whether or not Q/sL data were available. Each lithologic type in a well log was grouped into one of the three lithologic classes, each class was assigned a Q/sL number within the range set for each aquifer, and a corresponding approximate hydraulic conductivity value was calculated using equation 6. The range assigned to each lithologic class for all aquifers, except for class 1 of the Magothy and Lloyd aquifers, is purposely less than the median Q/sL values determined from the lithologic analysis of the screened intervals, partly in an effort to reflect the fact that many of the drillers' descriptions seem to overestimate the coarseness and degree of sorting of the materials and partly because the drillers commonly placed the screen in one of the most permeable intervals. Also, the use of a range provided latitude for judgment in interpreting the hydrologic significance of the individual lithologic descriptions in the drillers' logs. Finally, the range applied to each class emphasized Q/sL values from logs with the best available information, in contrast to the computed median values, which did not take into account the quality of the logs.

Inasmuch as virtually no wells were screened in the materials assigned to class 3, Q/sL and hydraulic conductivity values could not be determined for these materials. However, the very fine materials in this class contribute only slightly to the total transmissivity of the aquifers, and accordingly, the hydraulic conductivity of class 3 was assumed to be zero. The error involved in this assumption was considered to be well within the error involved in the overall computations of transmissivity.

In the third step, the average hydraulic conductivity of the materials penetrated by each well (average point hydraulic conductivity) was computed by means of equations 2 and 3. Where a well did not penetrate the entire thickness of the aquifer but did penetrate a substantial part, the computed average hydraulic conductivity was assumed to equal that of the total thickness of the aquifer at the well site.

The average point hydraulic conductivities then were plotted and contoured in the fourth and final step (pls. 1*B*, 2*B*, 3*B*, and fig. 14). Commonly, the point hydraulic conductivities ranged widely, even between nearby wells. Thus, the contour lines were drawn to follow the general trend of the plotted data; however, their positions were also influenced by available information on the areal changes in lithologic character of the aquifers in various parts of Long Island.

Regional transmissivity maps of each aquifer (pls. 1*C*, 2*C*, 3*C*, and fig. 15) were developed from the average hydraulic conductivity and thickness maps by multiplying the aquifer thickness by the average hydraulic conductivity at a network of points and contouring the resulting values.

HYDRAULIC CONDUCTIVITY AND TRANSMISSIVITY OF THE PRINCIPAL AQUIFERS

UPPER GLACIAL AQUIFER

The Q/sL numbers of wells screened in the upper glacial aquifer range from less than 0.1 to more than 4.0 gpm per sq ft (gallons per minute per square foot) (fig. 7). About three-fourths of the Q/sL numbers in figure 7 are between 0.5 and 2.5 gpm per sq ft, and

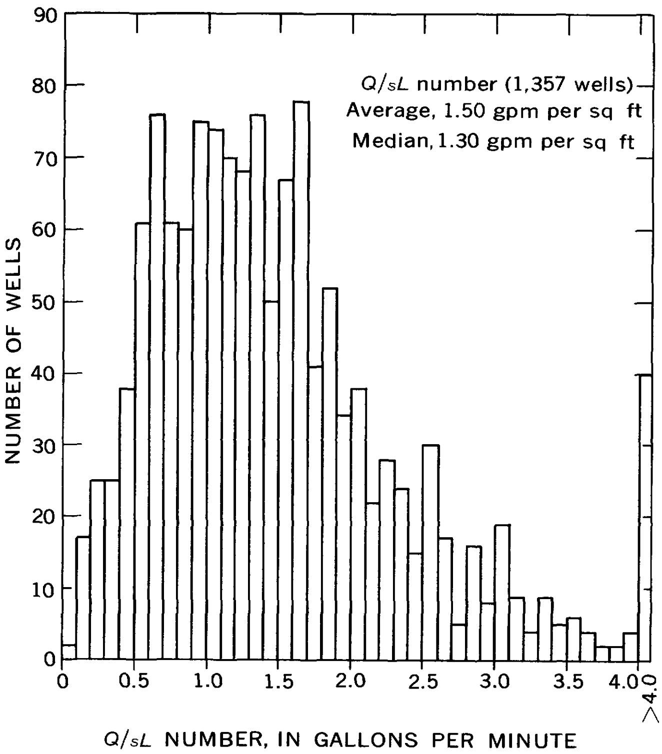


FIGURE 7.—Distribution of Q/sL numbers of wells screened in the upper glacial aquifer. (Average hydraulic conductivity of screened intervals approximates 2,000 Q/sL; see text discussion.)

the median Q/sL number for all wells tabulated is about 1.3 gpm per sq ft. Q/sL numbers greater than 2.5 gpm per sq ft were commonly determined for wells with short screen lengths (15 feet or less) of which the upper glacial aquifer (fig. 8) has a larger proportion than

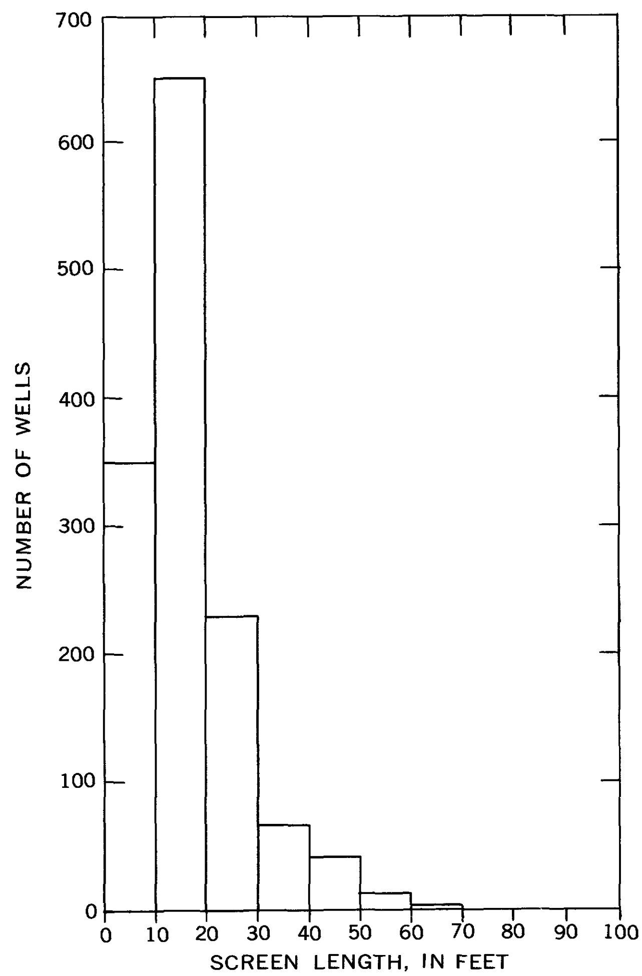


FIGURE 8.—Distribution of screen lengths of wells in the upper glacial aquifer.

any other aquifer on Long Island. (Compare figs. 8, 11, 17, and 20.) Vertical flow components probably account for an appreciable part of the discharge from these wells.

Lithologic descriptions of the screened intervals were available for most wells that were screened in the upper glacial aquifer and for which test data were available. Moreover, most of the screened intervals were either described as one lithology or the different lithologic descriptions belonged to a single lithologic class as defined earlier. The median Q/sL numbers determined for each lithologic class are listed in table 5, along with the range in Q/sL numbers assigned to each litho-

TABLE 5.—*Assigned range of Q/sL numbers and calculated hydraulic conductivity values for selected lithologic classes in the upper glacial aquifer*

Lithologic class		Number of wells	Median *Q/sL* number of screened intervals (gpm per sq ft)	Assigned range of *Q/sL* numbers (gpm per sq ft)	Calculated range of hydraulic conductivity (gpd per sq ft)
No.	Description				
1	Gravel, sand and gravel, and coarse sand	924	1.5	1.0–1.5	2,000–3,000
2	Medium, fine, and very fine sand, and sand with silt or clay layers.	408	1.1	0.2–0.9	400–1,800
3	Clay, sandy clay, and silty clay			[1] 0	0

[1] Assumed; see text discussion.

logic class and the corresponding range of calculated hydraulic conductivity values for each class.

Lithologic logs from about 620 wells penetrating the upper glacial aquifer were analyzed to determine point values of average aquifer hydraulic conductivity. These wells were fairly well distributed in the subareas of Long Island (fig. 9). Although in Kings, Queens, and

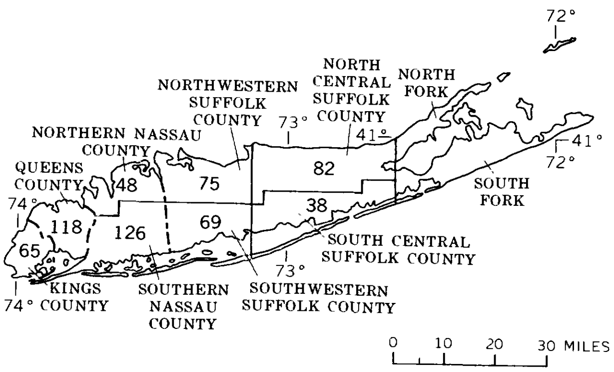


FIGURE 9.—Number of wells for which lithologic logs were available for the upper glacial aquifer in the indicated subareas in 1967.

Nassau Counties most wells that were analyzed completely penetrated the aquifer, progressively fewer wells penetrated the entire aquifer toward eastern Suffolk County.

A map showing thickness of the saturated upper glacial aquifer [1] (pl. 1*A*) was prepared from an unpublished map of the September 1965 water table, from well logs, and from maps and data contained in several reports (Isbister, 1966; Lubke, 1964; Perlmutter and Geraghty, 1963; Pluhowski and Kantrowitz, 1964; Swarzenski, 1963; Julian Soren, written commun., 1968). Maps showing lines of equal average hydraulic conductivity (pl. 1*B*) and equal transmissivity (pl. 1*C*) were constructed according to the procedures outlined previously.

Noteworthy features of the map showing thickness of the saturated upper glacial aquifer (pl. 1*A*) are (1) the areas near the north shore of the island in which the aquifer locally is more than 500 feet thick, and (2) the increasing thickness of the aquifer in eastern Suffolk County. The great thickness near the north shore reflects buried valleys in the underlying Cretaceous deposits. Buried valleys are not as pronounced near the south shore of Long Island.

The distribution of the lines of equal average hydraulic conductivity (pl. 1*B*) reflects to some extent the geologic origin of the glacial material on Long Island. Average hydraulic conductivities of 2,000 gpd per sq ft and higher occur through much of the outwash-plain deposits in southern Queens, Nassau, and Suffolk Counties. Beds of lower average hydraulic conductivity (about 1,000 gpd per sq ft) are found in north-central Nassau and Suffolk Counties, where the glacial deposits contain more silt and clay.

The trends of the lines of equal transmissivity in the upper glacial aquifer (pl. 1*C*) are similar to the trends of the lines of equal saturated thickness (pl. 1*A*). This similarity reflects the fact that the variation in thickness of the aquifer is generally greater than the variation in estimated average hydraulic conductivity (pl. 1*B*). The highest values of transmissivity in plate 1*C* are associated with the greatest aquifer thicknesses, which occur in the buried valleys along the north shore of the island and in central Suffolk County.

The average thickness, hydraulic conductivity, and transmissivity of the upper glacial aquifer in subareas of Long Island, as derived from plate 1*A*, *B*, and *C*, are listed in table 6.

[1] In numerous places on Long Island, deep channels were cut into the Cretaceous deposits and subsequently filled with Pleistocene deposits. Along the north shore, the basal deposits have been included in the Jameco Gravel by some workers (Isbister, 1966; Swarzenski, 1963) and in the upper glacial deposits by others (Lubke, 1964; Julian Soren, oral commun., 1968). In this report, all the deep buried-valley deposits along the north shore have been included in the upper glacial aquifer.

TABLE 6.—*Average thickness, hydraulic conductivity and transmissivity of the upper glacial aquifer in subareas of Long Island*

Subarea	Area (sq mi)	Average total thickness (feet)	Average hydraulic conductivity (gpd per sq ft)	Average transmissibity (gpd per ft)
Kings County	69	130	1,400	180,000
Queens County	97	80	1,600	120,000
Northern Nassau County	72	120	1,700	210,000
Southern Nassau County	138	50	1,900	95,000
Northwestern Suffolk County	135	160	1,400	230,000
Southwestern Suffolk County	110	100	1,900	190,000
North central Suffolk County	254	160	1,500	240,000
South central Suffolk County	141	120	1,900	230,000
Subareas studies	1,016	120	1,700	200,000

JAMECO AQUIFER

About 75 wells are screened in the Jameco aquifer. Q/sL numbers of wells screened in this aquifer range from less than 0.1 to more than 4.0 gpm per sq ft, and the median Q/sL number is about 1.0 gpm per sq ft (fig. 10). About one-third of the well screens in the compilation (fig. 11) are short (15 feet or less), which suggests that vertical flow components probably contribute measurably to the discharge of such wells.

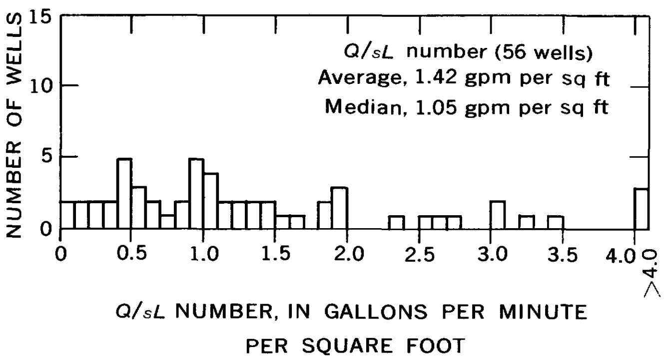


FIGURE 10.—Distribution of Q/sL numbers for wells screened in the Jameco aquifer. (Average hydraulic conductivity of screened intervals approximates 2,000 Q/sL; see text discussion.)

Lithologic descriptions of the screened interval were available for 56 of the wells for which test data were available. Generally the material in individual screened intervals belonged to a single lithologic class. The median Q/sL numbers determined for each lithologic class, the range in Q/sL numbers assigned to each class, and the corresponding range of calculated hydraulic conductivity values for each class are listed in table 7.

Lithologic logs describing the Jameco aquifer in 109 wells were analyzed to determine point values of average hydraulic conductivity. These wells were almost evenly distributed in the three counties in which the

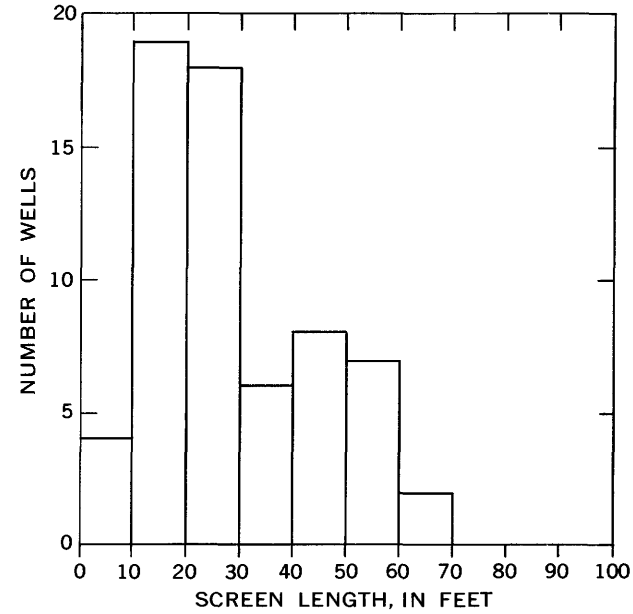


FIGURE 11.—Distribution of screen lengths of wells in the Jameco aquifer.

Jameco occurs and include more than 90 percent of the wells that completely or almost completely penetrate the aquifer. The distribution by subarea is shown in figure 12.

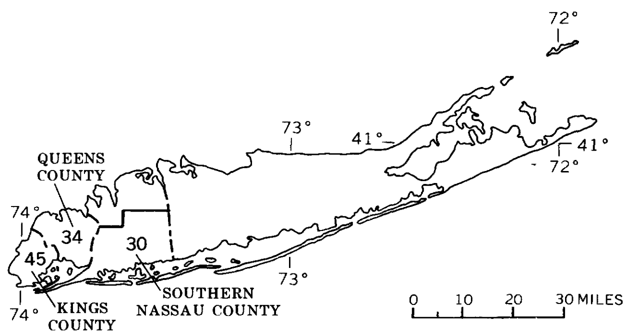
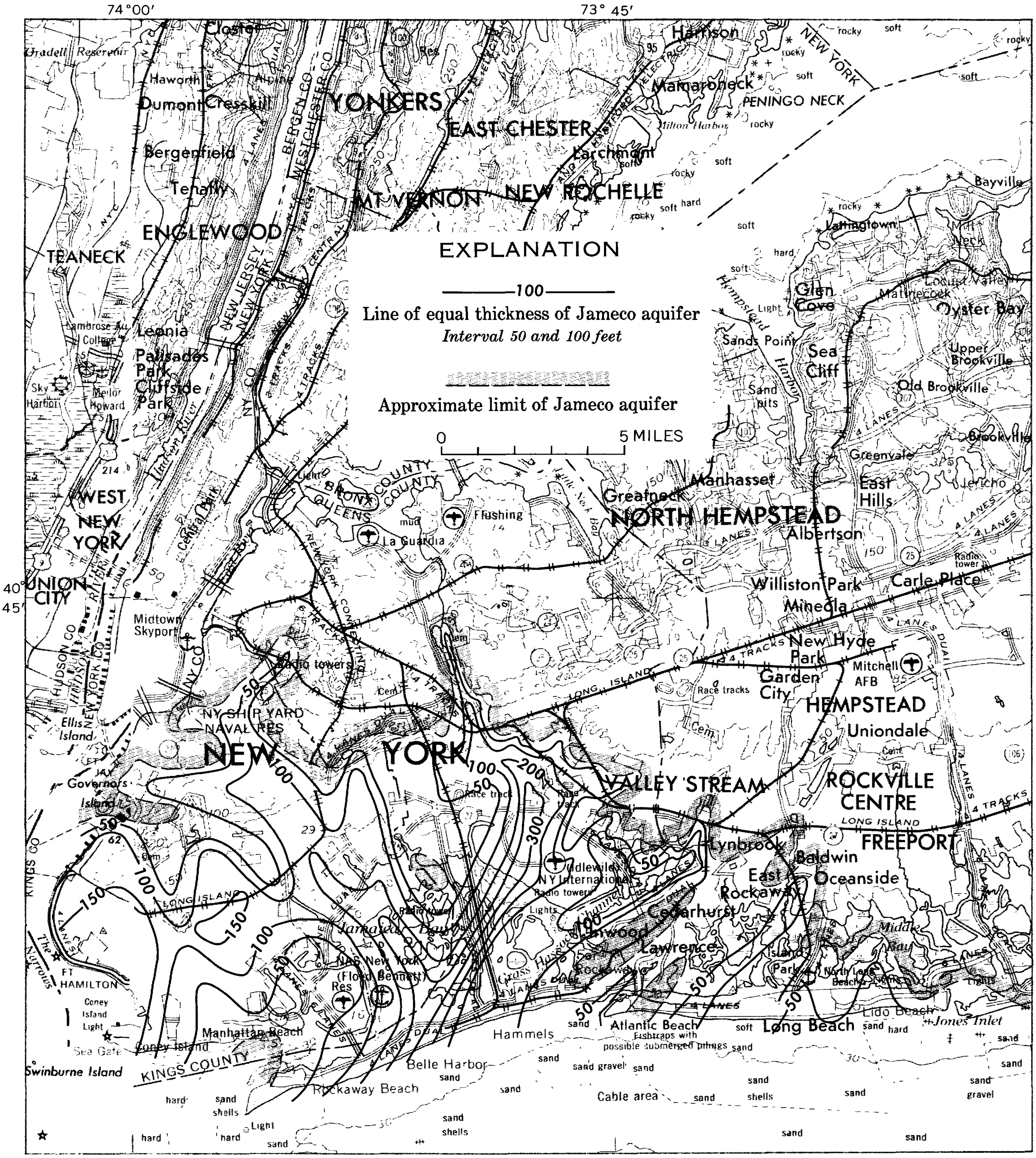


FIGURE 12.—Number of wells for which lithologic logs were available for the Jameco aquifer in the indicated subareas in 1967.

A map showing thickness of the Jameco aquifer (fig. 13) was prepared from well logs and maps and data contained in two reports (Perlmutter and Geraghty, 1963; Julian Soren, written commun., 1968). Maps showing lines of equal average hydraulic conductivity (fig. 14) and equal transmissivity (fig. 15) were constructed according to the procedures outlined previously.

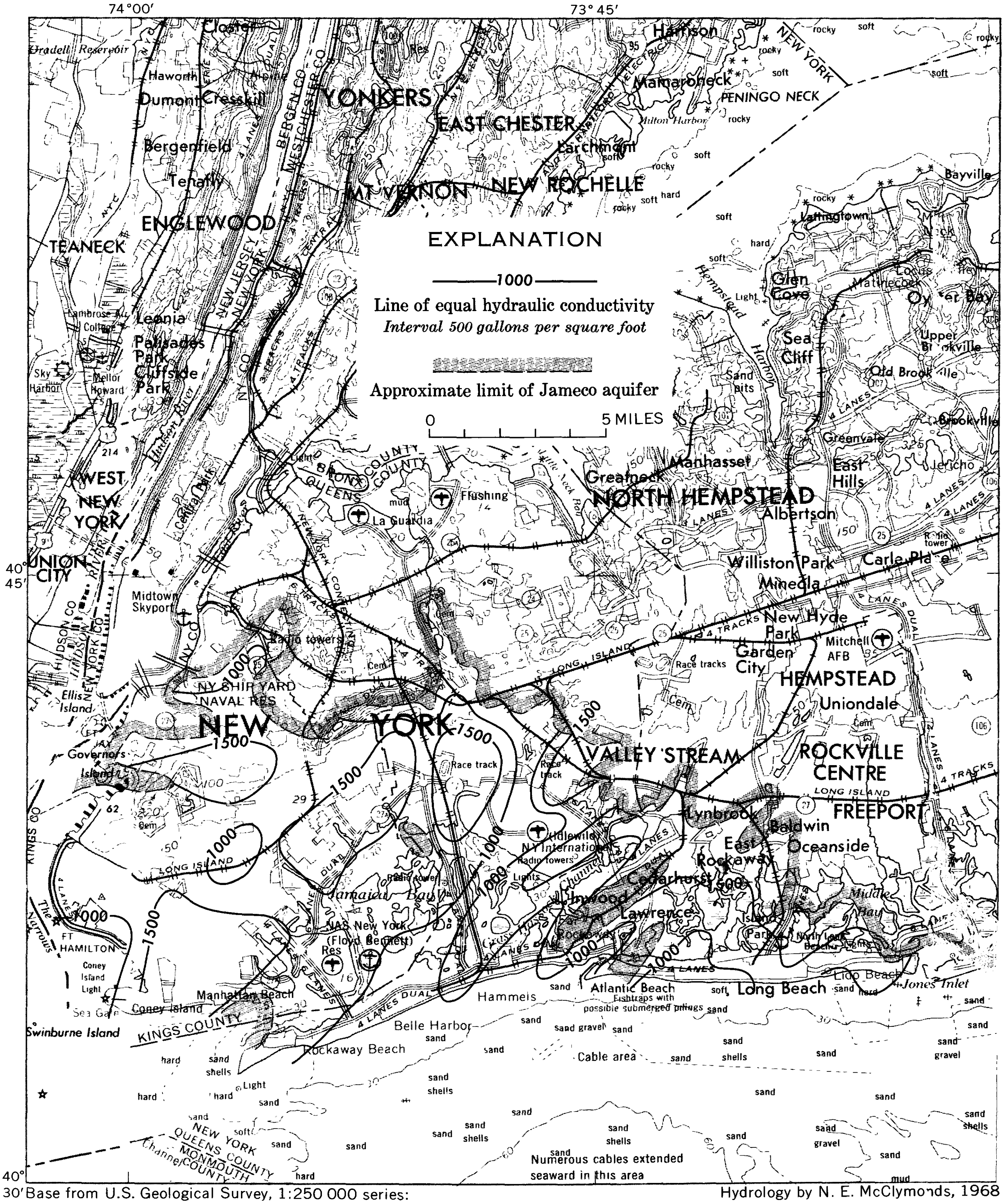
The Jameco aquifer attains its maximum thickness of more than 300 feet in a buried valley cut into the underlying Cretaceous deposits in southwestern Queens County (fig. 13). Generally, the aquifer is thicker in



Base from U.S. Geological Survey, 1:250 000 series: New York, 1957; Newark, 1947

Hydrology by N. E. McClymonds, 1968; in part adapted from John Isbister (written commun., 1968), Perlmutter and Geraghty (1963), and Julian Soren (written commun., 1968)

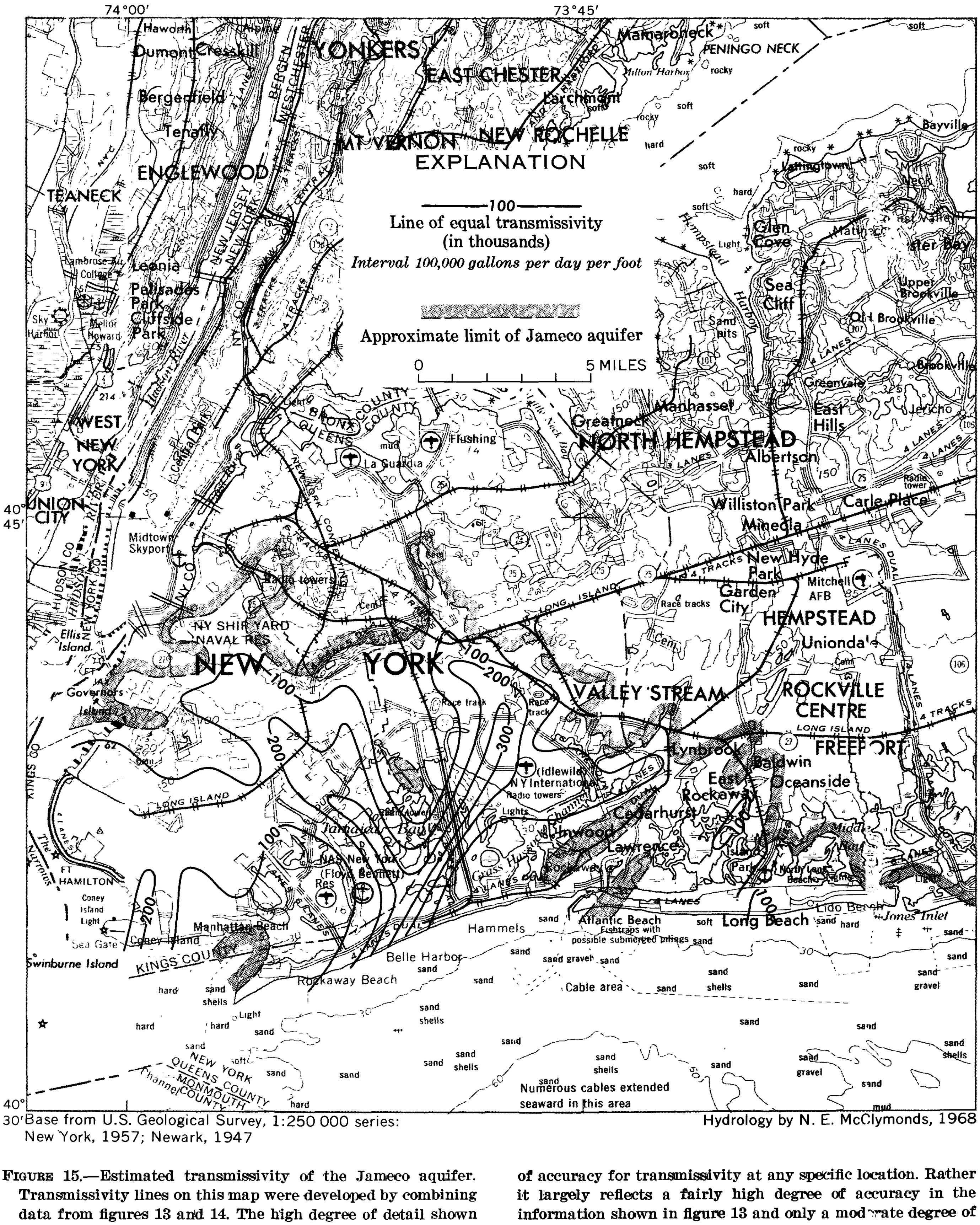
FIGURE 13.—Thickness of the Jameco aquifer.



30'Base from U.S. Geological Survey, 1:250 000 series: New York, 1957; Newark, 1947

Hydrology by N. E. McClymonds, 1968

FIGURE 14.—Estimated average hydraulic conductivity of the Jameco aquifer.



Base from U.S. Geological Survey, 1:250 000 series: New York, 1957; Newark, 1947

Hydrology by N. E. McClymonds, 1968

FIGURE 15.—Estimated transmissivity of the Jameco aquifer. Transmissivity lines on this map were developed by combining data from figures 13 and 14. The high degree of detail shown for the transmissivity lines is not meant to imply a high degree of accuracy for transmissivity at any specific location. Rather it largely reflects a fairly high degree of accuracy in the information shown in figure 13 and only a moderate degree of accuracy in the information shown in figure 14.

TABLE 7.—*Assigned range of Q/sL numbers and calculated hydraulic conductivity values for selected lithologic classes in the Jameco aquifer*

Lithologic class		Number of wells	Median *Q/sL* number of screened intervals (gpm per sq ft)	Assigned range of *Q/sL* numbers (gpm per sq ft)	Calculated range of hydraulic conductivity (gpd per sq ft)
No.	Description				
1	Gravel, sand and gravel, and coarse sand	37	1. 1	0. 8–1. 1	1, 600–2, 200
2	Medium, fine, and very fine sand, and sand with silt or clay layers.	19	. 9	0. 1–0. 7	200–1, 400
3	Clay, sandy clay, and silty clay			[1] 0	0

[1] Assumed; see text discussion.

central and eastern Kings County than in southeastern Queens and southwestern Nassau Counties.

The computed average hydraulic conductivity of the Jameco aquifer (fig. 14) generally is slightly more than 1,000 gpd per sq ft. However, in several small areas near the northern boundary of the aquifer, the average hydraulic conductivity is about 1,500 gpd per sq ft. These areas with more permeable material probably reflect the somewhat coarser materials deposited in the narrower part of the buried valley.

Because the estimated average hydraulic conductivity of the Jameco aquifer shows very little areal variation, the gross pattern of the lines of equal transmissivity (fig. 15) closely reflects the pattern of the thickness map (fig. 13). The maximum transmissivity is about 300,000 gpd per ft and occurs in southwestern Queens County.

The average thickness, hydraulic conductivity, and transmissivity of the Jameco aquifer in subareas of Long Island, derived from figures 13, 14, and 15, are listed in table 8. The greatest average thickness and greatest average transmissivity of the Jameco aquifer occur in Kings County, although the maximum transmissivity occurs in Queens County.

TABLE 8.—*Average thickness, hydraulic conductivity, and transmissivity of the Jameco aquifer in subareas of Long Island*

Subarea	Area (sq mi)	Average total thickness (feet)	Average hydraulic conductivity (gpd per sq ft)	Average transmissivity (gpd per ft)
Kings County	60	95	1, 300	120, 000
Queens County	28	80	1, 200	100, 000
Southern Nassau County	14	35	1, 400	50, 000
Three subareas	102	80	1, 300	110, 000

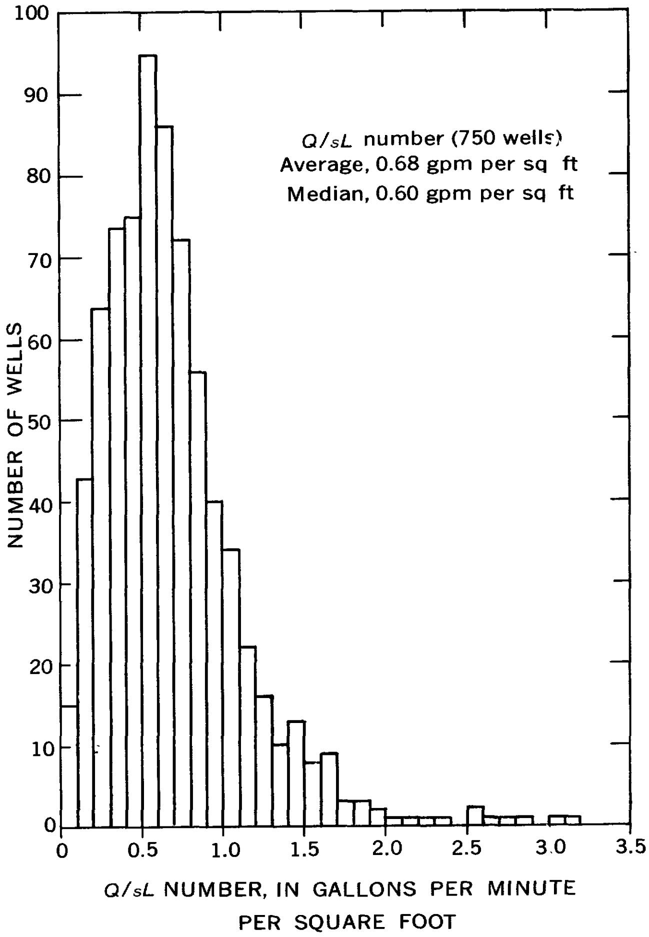


FIGURE 16.—Distribution of *Q/sL* numbers for wells screened in the Magothy aquifer. (Average hydraulic conductivity of screened intervals approximates 2,000 *Q/sL*; see text discussion.)

MAGOTHY AQUIFER

Q/sL numbers of wells screened in the Magothy aquifer range from less than 0.1 to 3.2 gpm per sq ft (fig. 16). This compilation includes more than 85 percent of all wells screened in the Magothy aquifer for which test data are available. More than 90 percent of the *Q/sL* numbers are less than 1.7 gpm per sq ft, and the median *Q/sL* number is 0.6 gpm per sq ft. The screen lengths in many of the Magothy wells are greater than 50 feet (fig. 17), and the average screen length is about 40 feet. Therefore, the effects of across-bed flow on the *Q/sL* numbers of most wells screened in this aquifer are probably less than in the upper glacial aquifer.

Lithologic descriptions of the screened intervals were available for all 750 Magothy wells with test data. More than half of these descriptions consisted of a single lithology, and many of the remaining screened intervals

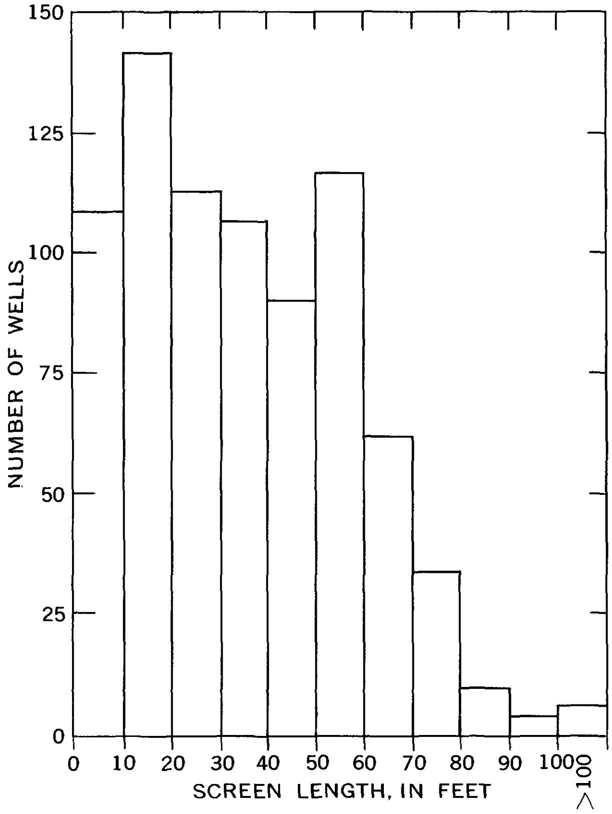


FIGURE 17.—Distribution of screen lengths of wells in the Magothy aquifer.

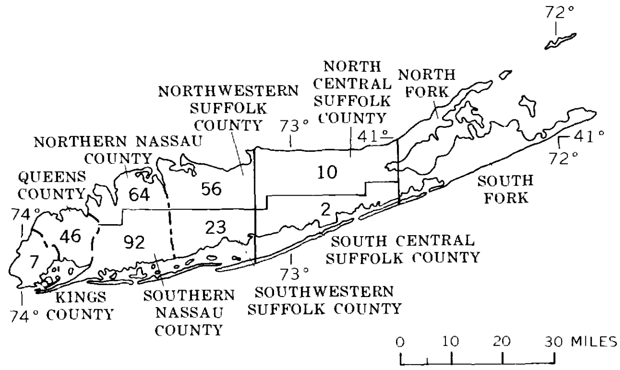


FIGURE 18.—Number of wells for which lithologic logs were available for the Magothy aquifer in the indicated subareas in 1967.

were described as predominantly one lithology. The median Q/sL numbers determined for each lithologic class from the descriptions of the screened intervals, the range in Q/sL numbers assigned to each lithologic class, and the corresponding range of calculated hydraulic conductivity values for each class are listed in table 9.

Lithologic logs describing the Magothy aquifer in 300 wells were analyzed to determine point values of average hydraulic conductivity. The distribution of these wells (fig. 18) was fairly uniform in Queens, Nassau, and western Suffolk Counties, but the number of wells for which logs were available is much less in central Suffolk County. In addition, the proportion of wells penetrating the entire Magothy aquifer becomes progressively smaller proceeding eastward in Suffolk County.

A map showing thickness of the saturated Magothy aquifer (pl. 2*A*) was prepared from an unpublished map of the September 1965 water table, from well logs, and from maps and data contained in several reports (Isbister, 1966; Lubke, 1964; Perlmutter and Geraghty, 1963; Pluhowski and Kantrowitz, 1964; Swarzenski, 1963; Julian Soren, written commun., 1968). Maps showing lines of equal average hydraulic conductivity (pl. 2*B*) and equal transmissivity (pl. 2*C*) were constructed according to the procedures outlined previously.

The Magothy aquifer thickens gradually toward the southeast and attains its maximum recorded thickness of about 1,000 feet beneath the barrier beaches in south-central and southeastern Suffolk County (pl. 2*A*). The aquifer thins markedly and locally is absent in buried valleys along the northern shore and in western Long Island.

The lines designating the highest values of estimated average hydraulic conductivity generally occur in the northern and northwestern parts of the island (pl. 2*B*) where the aquifer is thinnest and where a basal gravel deposit makes up most of the section. The smallest values of average hydraulic conductivity occur in the south-central and southeastern parts of the island, where the aquifer is thickest. The decrease in average hydraulic conductivity towards the southeast is related to an increase in the percentage of fine materials such as silt and clay in the aquifer in those areas.

TABLE 9.—*Assigned range of* Q/sL *numbers and calculated hydraulic conductivity values for selected lithologic classes in the Magothy aquifer*

Lithologic class No.	Lithologic class Description	Number of wells	Median Q/sL number of screened intervals (gpm per sq ft)	Assigned range of Q/sL numbers (gpm per sq ft)	Calculated range of hydraulic conductivity (gpd per sq ft)
1	Gravel, sand and gravel, and coarse sand	219	0.7	0.6–0.8	1,200–1,600
2	Medium, fine, and very fine sand, and sand with silt or clay layers.	531	.5	0.1–0.5	200–1,000
3	Clay, sandy clay, and silty clay			[1] 0	0

[1] Assumed; see text discussion.

The transmissivity of the Magothy aquifer (pl. 2*C*) tends to increase towards the south and southeast. Although the estimated average hydraulic conductivity tends to decrease in this direction, the greater percentage increase in aquifer thickness results in an increased transmissivity. The estimated maximum transmissivity of the Magothy aquifer is about 400,000 gpd per ft near the barrier beach in south-central Suffolk County.

Average thickness, hydraulic conductivity, and transmissivity of the Magothy aquifer in subareas of Long Island are derived from plate 2*A*, *B*, and *C* and are listed in table 10. The average hydraulic conductivity for each subarea is lowest in south-central Suffolk County (360 gpd per sq ft) and is highest in Kings County (over 600 gpd per sq ft). The average transmissivity by subarea is highest in south-central Suffolk County (320,000 gpd per ft), where the Magothy aquifer is thickest.

TABLE 10.—*Average thickness, hydraulic conductivity, and transmissivity of the Magothy aquifer in subareas of Long Island*

Subarea	Area (sq mi)	Average total thickness (feet)	Average hydraulic conductivity (gpd per sq ft)	Average transmissivity (gpd per ft)
Kings County	18	140	630	85,000
Queens County	61	170	460	80,000
Northern Nassau County	93	300	450	140,000
Southern Nassau County	154	600	420	250,000
Northwestern Suffolk County	150	430	420	180,000
Southwestern Suffolk County	115	770	410	320,000
North central Suffolk County	254	650	400	260,000
South central Suffolk County	141	900	360	320,000
Subareas studied	986	580	410	240,000

LLOYD AQUIFER

Q/sL numbers of wells screened in the Lloyd aquifer range from less than 0.1 to 2.1 gpm per sq ft (fig. 19). This compilation includes virtually all the wells screened in the Lloyd aquifer for which test data are available. About four-fifths of the Q/sL numbers are between 0.1 and 0.6 gpm per sq ft and the median Q/sL number for all wells is 0.35 gpm per sq ft. Screens of wells in this aquifer range from less than 10 to 90 feet in length (fig. 20). About one-third of the screens are short (15 feet or less), which suggests that vertical flow components may have materially affected the discharge of some of these wells.

Lithologic descriptions of the screened interval were available for all 94 Lloyd wells with test data. Almost half the screened intervals were described as one lithology, and most of the remaining screened intervals were described as predominantly one lithology. The

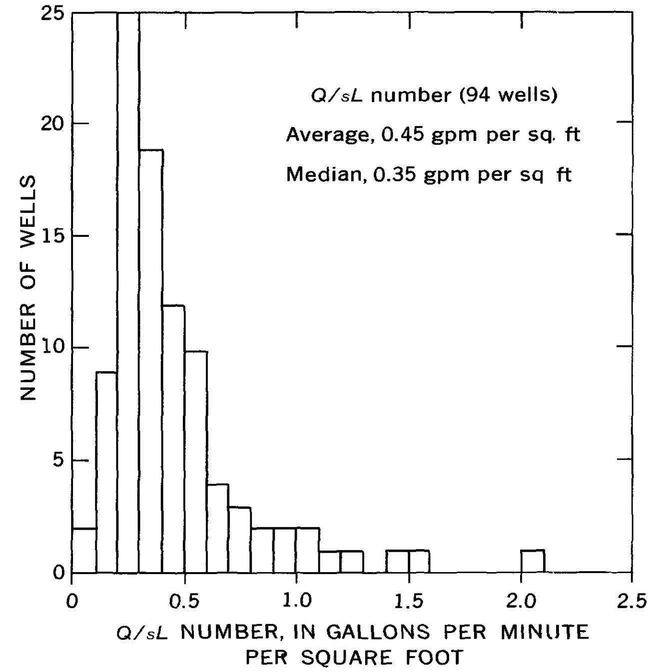


FIGURE 19.—Distribution of Q/sL numbers for wells screened in the Lloyd aquifer. (Average hydraulic conductivity of screened intervals approximates 2,000 Q/sL; see text discussion.)

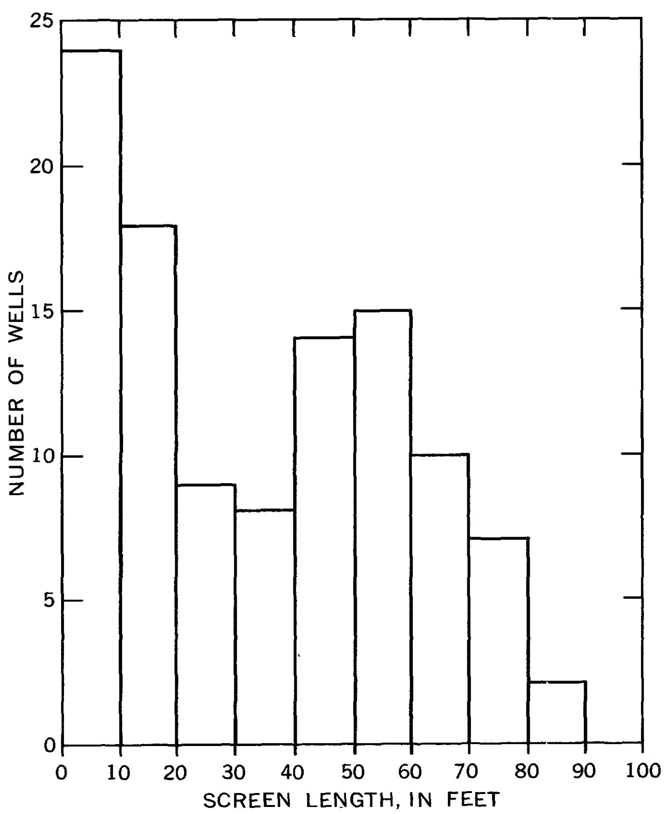


FIGURE 20.—Distribution of screen lengths of wells in the Lloyd aquifer.

TABLE 11.—*Assigned range of* Q/sL *numbers and calculated hydraulic conductivity values for selected lithologic classes in the Lloyd aquifer*

Lithologic class: No.	Lithologic class: Description	Number of wells	Median *Q/sL* number of screened (gpm per sq ft)	Assigned range of *Q/sL* numbers intervals (gpm per sq ft)	Calculated range of hydraulic conductivity (gpd per sq ft)
1	Gravel, sand and gravel, and coarse sand	48	0. 35	0. 3–0. 4	600–800
2	Medium, fine, and very fine sand, and sand with silt or clay layers.	46	. 30	0. 05–0. 2	100–400
3	Clay, sandy clay, and silty clay			[1] 0	0

[1] Assumed; see text discussion.

median Q/sL numbers determined for each lithologic class, the range in Q/sL numbers assigned to each class, and the corresponding range of calculated hydraulic conductivity values for each class are listed in table 11.

Lithologic logs in 132 wells tapping the Lloyd aquifer were analyzed to obtain point values of average hydraulic conductivity, and most of these wells almost completely penetrated the aquifer (fig. 21). Logs from only 10 Lloyd wells are available for all of Suffolk County, and most of these are in the northwestern part of the county. Furthremore the Llyod wells in Nassau County are concentrated near the shorelines.

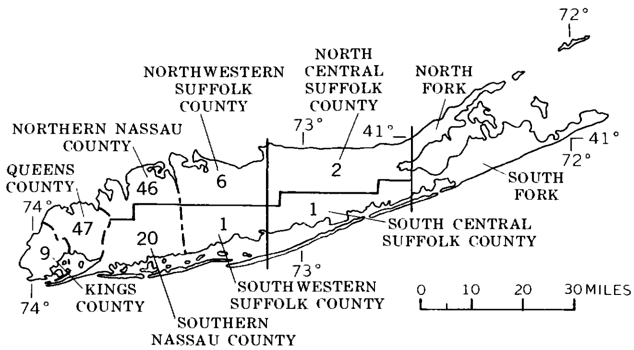


FIGURE 21.—Number of wells for which lithologic logs were available for the Lloyd aquifer in the indicated subareas in 1967.

A thickness map of the Lloyd aquifer (pl. 3*A*) was prepared from well logs and maps and data contained in several reports (Isbister, 1966; Lubke, 1964; Perlmutter and Geraghty, 1963; Pluhowski and Kantrowitz, 1964; Swarzenski, 1963; and Julian Soren, written commun., 1968). Maps showing lines of equal average hydraulic conductivity (pl. 3*B*) and equal transmissivity (pl. 3*C*) were constructed according to the procedures outlined previously.

The Lloyd aquifer thickens gradually to the south and southeast (pl. 3*A*). The maximum recorded thickness of about 450 feet occurs beneath the barrier beaches in southern Nassau County. The irregular pattern of the northern boundary of the aquifer in Queens and Nassau Counties indicates erosion of the aquifer before deposition of the overlying glacial materials.

The lines of estimated equal average hydraulic conductivity indicate that the material in the Lloyd aquifer (pl. 3*B*) is less permeable toward the southeast; however, the position of these lines is based on very little well data.

The lines of equal transmissivity (pl. 3*C*) exhibit the same gross pattern as the lines on the map showing thickness and exhibit increasing values toward the south. This similarity in pattern reflects the fact that the percentage increase in the thickness of the aquifer (pl. 3*A*) is greater than the percentage decrease in estimated average hydraulic conductivity (pl. 3*B*). The maximum estimated transmissivity, 140,000 gpd per ft, occurs where the aquifer is thickest in southern Nassau County.

Average thickness, hydraulic conductivity, and transmissivity of the Lloyd aquifer in subareas of Long Island are derived from plate 3*A*, *B*, and *C* and are listed in table 12. As noted previously, many of the values in table 12 are based on very few well data.

TABLE 12.—*Average thickness, hydraulic conductivity, and transmissivity of the Lloyd aquifer in subareas of Long Island*

Subarea	Area (sq mi)	Average total thickness (feet)	Average hydraulic conductivity (gpd per sq ft)	Average transmissivity (gpd per ft)
Kings County	39	80	420	35,000
Queens County	81	140	430	60,000
Northern Nassau County	106	200	440	90,000
Southern Nassau County	154	300	400	120,000
Northwestern Suffolk County	160	220	410	90,000
Southwestern Suffolk County	115	320	280	90,000
North central Suffolk County	254	240	320	75,000
South central Suffolk County	141	300	270	80,000
Subareas studied	1,050	240	360	90,000

COMPARISON OF THE PRINCIPAL AQUIFERS

The curves representing the distribution of Q/sL numbers of the four principal aquifers (fig. 22) are of roughly comparable slope, but vary in position with respect to the ordinate, owing to the different ranges and distributions of Q/sL numbers in the different aquifers. Because the Q/sL number is related to the hydraulic conductivity of the deposits near the well screen, the curves in figure 22 provide a visual comparison of the distribution of average hydraulic conductivities of what are, in general, the more permeable zones in the respective aquifers.

CONCLUSIONS

The principal results of this investigation are a series of island-wide maps of estimated average hydraulic conductivity and transmissivity for each of the aquifers on Long Island (figs. 14 and 15, and pls. 1*B*, *C*, 2*B*, *C*, and 3*B*, *C*). Average values, derived from these maps for the mainland of Long Island, of thickness, hydraulic conductivity, and transmissivity for the aquifers are listed in table 13. The Magothy aquifer has the highest average transmissivity (240,000 gpd per ft) and the greatest average thickness (580 feet) of any of Long Island's aquifers, although the upper glacial aquifer has the greatest average hydraulic conductivity (1,700 gpd per sq ft). The Lloyd aquifer has the lowest average hydraulic conductivity (360 gpd per sq ft) and lowest average transmissivity (90,000 gpd per ft) of the four principal aquifers. The possible errors in these values locally may be on the order of plus or minus 50 percent, and in certain areas, such as the deep buried valleys near the north shore of Long Island, the possible error in the estimates may be greater than 50 percent. Despite these possible errors, the mapped values are believed to represent a reasonable initial definition of the average hydraulic conductivity and transmissivity of Long Island's aquifers.

TABLE 13.—*Average thickness, hydraulic conductivity, and transmissivity of the principal aquifers of Long Island*

[Values were determined for the mainland of Long Island excluding the forks]

Aquifer	Average thickness (feet)	Average hydraulic conductivity (gpd per sq ft)	Average transmissivity (gpd per ft)
Upper glacial	120	1, 700	200, 000
Jameco	80	1, 300	100, 000
Magothy	580	420	240, 000
Lloyd	240	360	90, 000

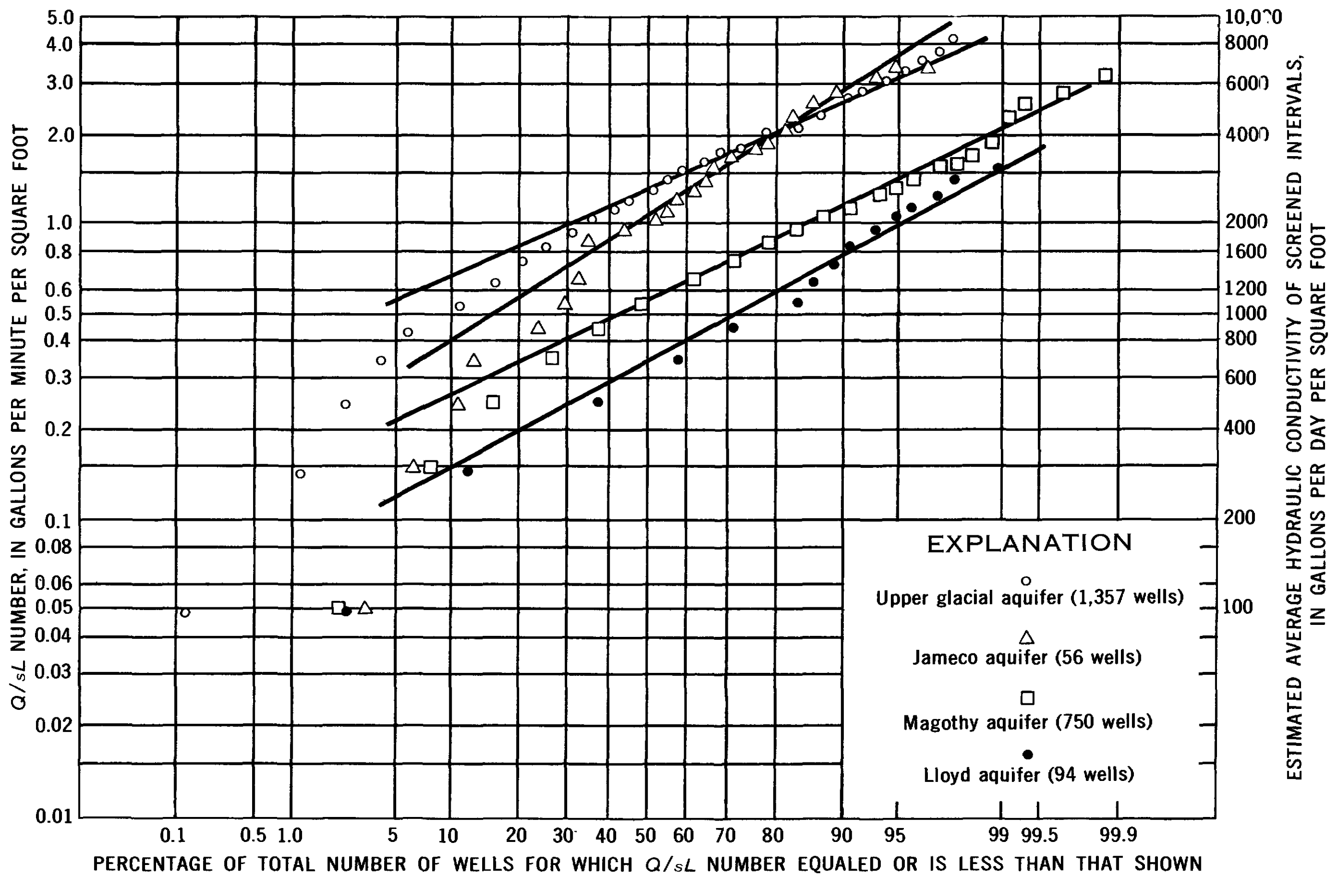


FIGURE 22.—Relation between Q/sL numbers and percentage of total number of wells for the four principal aquifers. (Average hydraulic conductivity of screened intervals approximates 2,000 Q/sL; see text discussion.)

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