Hydrology of the Babylon-Islip Area Suffolk County Long Island, New York

By E. J. PLUHOWSKI and I. H. KANTROWITZ

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1768

Prepared in cooperation with the Suffolk County Board of Supervisors, Suffolk County Water Authority, and the New York State Water Resources Commission

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1964

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

The U.S. Geological Survey Library catalog card for this publication appears after index.

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

CONTENTS

ILLUSTRATIONS

[Plates are in separate volume]

TABLES

HYDROLOGY OF THE BABYLON-ISLIP AREA, SUFFOLK COUNTY, LONG ISLAND, N.Y.

By E. J. Pluhowski and I. H. Kantrowitz

ABSTRACT

The report area comprises 270 square miles, and includes most of the Towns of Babylon and Islip, and parts of the Towns of Huntington, Smithtown, and Brookhaven, in southwestern Suffolk County, New York.

Almost all the water used in the area is obtained from wells screened in permeable zones of the ground-water reservoir which consists of unconsolidated deposits of gravel, sand, silt, and clay as much as 1,800 feet thick. The ground-water reservoir contains three principal aquifers. From the surface down these are (a) surficial deposits of sand and gravel of Pleistocene age, (b) sands of the Magothy(?) Formation of Cretaceous age, and (c) the Lloyd Sand Member of the Raritan Formation of Cretaceous age. At present only the upper two aquifers are tapped by wells.

Natural replenishment of the ground-water reservoir in the area takes place entirely by infiltration of precipitation and averages about 215 mgd (million gallons per day). Average ground-water runoff to streams above tidewater is 114 mgd, and it is estimated that an additional 54 mgd is discharged into tidal reaches of streams. Ground-water evapotranspiration is computed to be about 10 mgd and submarine outflow from the area is estimated to be 18 mgd.

The average streamflow of the area above tidewater is 120 mgd. Because of the permeable soils and low relief, direct runoff is only about 5 percent of the average streamflow. Streams are perennial along their middle and lower reaches and exhibit well-sustained low flows. Flooding rarely occurs although continued urbanization may result in minor flooding problems as additional storm sewers are constructed.

Water in most of the area is generally of good quality; however, it may be contaminated locally. Some streams and parts of the water-table aquifer contain low concentrations of synthetic detergents and other dissolved constituents from domestic and industrial wastes. Salty water occurs in parts of the water-table aquifer in the area under and bordering Great South Bay and under the barrier beaches. Present information, however, indicates that submarine outflow in the artesian aquifers is sufficient to maintain the fresh water-salt water interface some distance seaward of the barrier beaches.

Ground-water withdrawals in 1960 averaged 39 mgd, most of which was returned to the ground through cesspools, leaching beds, and recharge wells; pumpage did not appreciably affect the natural water balance of the ground-water reservoir. If withdrawals continue to be artificially recharged, pumpage can be increased at least fivefold before consumptive losses materially reduce ground-water levels. However, if the area were completely sewered in the future, an adequate supply of ground water for a substantially increased population could not be obtained without (a) reducing the amount of ground water in storage in the reservoir or (b) recharging treated-sewage effluent.

INTRODUCTION

PURPOSE

The rapid expansion of population and industry in southwestern Suffolk County, particularly since 1950 (fig. 2), has resulted in sharply increased withdrawals from the ground-water reservoir which, at present, supplies all water used in the area. However, the fact that there is substantial streamflow from the area indicates that additional development of the water resources is possible. Because an adequate water supply is essential to the continued growth of the area, knowledge of the occurrence, quality, and availability of water, both underground and in streams, is required by industry and the public. Because the source of all water on Long Island is precipitation, evaluation of the water potential of the area requires following the path of water from its inception as precipitation to its ultimate return to the atmosphere.

The objectives of the investigation were (a) to evaluate and summarize present data on quantity, quality, and availability of both ground water and surface water; (b) to determine the interrelation of ground water and surface water; (c) to evaluate the water balance for the ground-water reservoir, and (d) to evaluate any existing or potential water-supply problems.

This report is part of a continuing cooperative program sponsored jointly by the U.S. Geological Survey, the Suffolk County Water Authority, the Suffolk County Board of Supervisors, and the New York State Water Resources Commission.

LOCATION AND EXTENT OF AREA

The report area includes the Town of Babylon, virtually all of the Town of Islip, and small parts of the Towns of Huntington, Smithtown, and Brookhaven in southwestern Suffolk County, and a small area in the southeastern part of Nassau County (fig. 1). The area comprises about 270 square miles, of which 190 square miles are on the main part of Long Island; the barrier beaches, islands, and Great South Bay comprise the remainder. The area is roughly rectangular in shape; it is about 20 miles long and from 11 to 13 miles wide. The western boundary is mainly along the interstream ground-water divide west of Carman Creek near Amityville (pl. 7). The eastern boundary is mainly along the interstream ground-water divide east of Tuthills Creek near Patchogue (pl. 7). Both eastern and western boundaries extend south to the barrier beaches. The northern boundary is along the main ground-water divide that traverses Long Island and the southern boundary is the Atlantic Ocean.

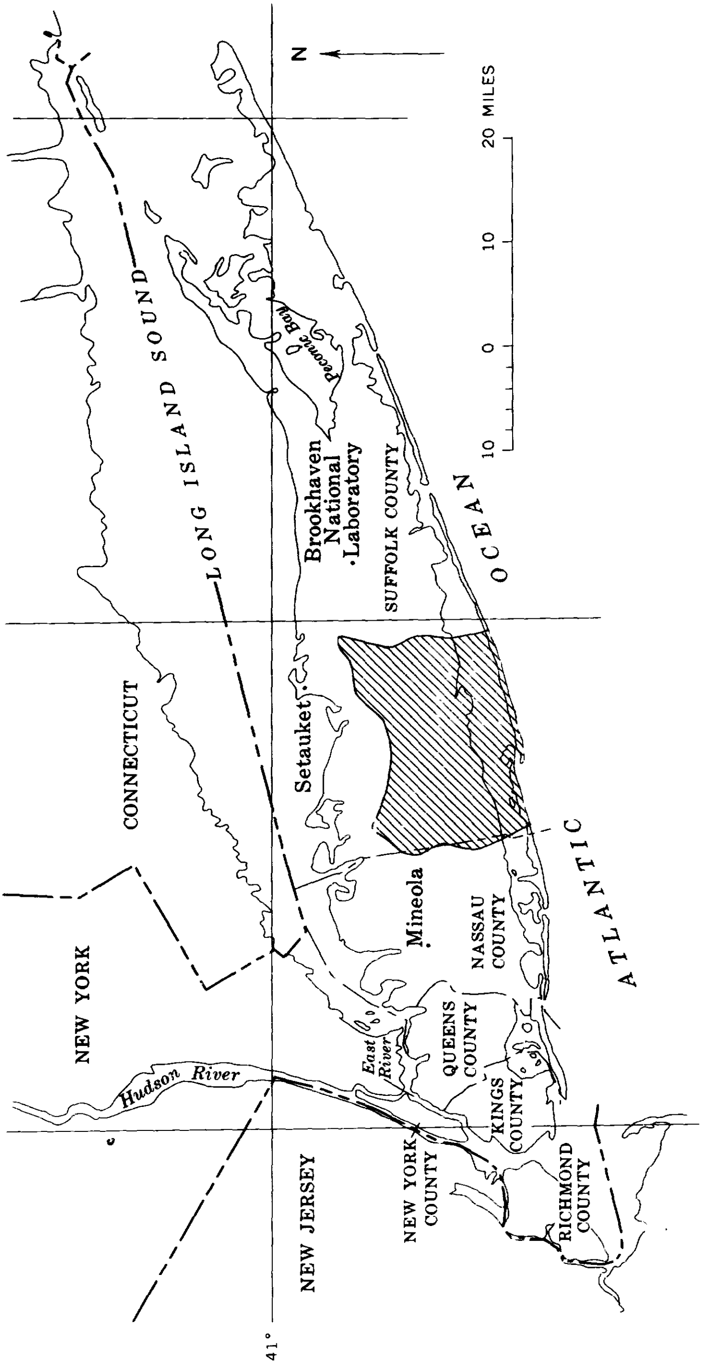


FIGURE 1.—Map of Long Island, New York, showing area of investigation.

METHODS OF INVESTIGATION

Fieldwork began in July 1958 and was completed in March 1961. Well and geologic data were obtained from the files of the New York State Water Resources Commission and from records collected in the field. During the summer of 1958, 44 water-table observation wells were driven in areas where data were scanty. Water-level measurements were obtained at all available observation wells and at several public, industrial, and institutional supply wells. Water samples were collected from the observation wells and analyzed for selected constituents. In October 1958, a water-temperature and water-stage recorder was installed at Champlin Creek at Islip. In November 1958, four temporary recorders were placed in operation on streams for which continuous records of stage were not previously available. The partial-record stream-gaging program in Suffolk County was expanded to include several streams that had never been measured. Three streams, Santapogue River at Lindenhurst, Sampawams Creek at Babylon, and Champlin Creek at Islip, were selected for seepage studies, and discharge measurements were obtained bimonthly at selected sites. In December 1958, a three-element thermograph was placed in operation at Sampawams Creek at Babylon to obtain stream, air, and ground-water temperatures simultaneously.

During May 1959, three lines of shallow observation wells, each line consisting of four wells, were driven adjacent to Champlin Creek to study the relation of ground water to surface water. In addition, three wells were driven directly into the streambed at selected sites to study vertical changes in hydraulic head below the stream. Another line of four wells was driven, in October 1960, just upstream from the gaging station to aid in preparation of a water-table map and to provide additional sampling points for obtaining data on quality of water. To study the effect of ground-water evapotranspiration, a shallow water-table well was dug in August 1960 adjacent to Sampawams Creek, and a recorder was installed to detect water-level fluctuations.

Water samples were collected from selected wells and streams in August 1959, March 1960, September 1960, and March 1961 for determination of synthetic-detergent content. Water samples from four selected wells tapping different aquifers were collected for chemical analysis.

To facilitate office computations of streamflow data, the records of six primary gaging stations in the area and the records for Massapequa Creek at Massapequa in Nassau County were processed by an electronic computer. The processed data included duration tables of daily flow by water years and minimum-mean discharges for selected periods within each climatic year (April 1–March 31).

PREVIOUS INVESTIGATIONS

A study of the water resources of Long Island by Veatch and others (1906), contains some descriptive data on ground water and surface water in the Babylon-Islip area. Maps of the water table of Long Island including the report area have been prepared by Burr and others (1904), Veatch (1906), Suter (1937), Jacob (1945), and Lusczynski and Johnson (1952). A map of the surficial geology of Long Island (Fuller, 1914) and contour maps of the subsurface formations (Suter, deLaguna, and Perlmutter, 1949) contain geologic data on the report area. A report on the geology and hydrology of the nearby Towns of Huntington and Smithtown (Lubke, 1961) has been freely drawn upon for data in the parts of those towns included in the area covered by this report. Perlmutter and Crandell (1959) have described geologic conditions and the occurrence of ground water beneath the barrier beaches. Many of the well logs utilized in the subsurface mapping of geologic units are included in publications of the New York State Water Resources Commission (Leggette and others, 1938; Roberts and Brashears, 1945; and Johnson and others, 1952). Water-level measurements for some observation wells, records of daily discharge for gaging stations, and results of discharge measurements made at partial-record sites, are published in annual water-supply papers and open-file reports of the U.S. Geological Survey.

ACKNOWLEDGMENTS

The writers acknowledge the assistance of well drillers, the New York State Department of Public Works, and the Suffolk County Water Authority, in furnishing hydrologic and geologic data. The New York State Department of Health, the Suffolk County Department of Health, the Suffolk County Water Authority, and several privately owned laboratories furnished much of the chemical data included in the report. R. L. Barnell, formerly of the U.S. Geological Survey, supervised the construction of observation wells, and prepared a preliminary map of the water table.

GEOGRAPHY

TOPOGRAPHY

The Babylon-Islip area lies within the Atlantic Coastal Plain physiographic province and may be subdivided into a small northern region of irregular hills and a large southern region composed of a broad gently sloping plain. These topographic features are mostly depositional in origin and are only slightly modified by stream erosion.

The region of hilly topography corresponds to the distribution of geologic units mapped as Ronkonkoma terminal moraine and Manetto Gravel (pl. 1). The highest land surface altitude on Long Island, about 400 feet above sea level, is on the Ronkonkoma terminal moraine, about 3 miles southwest of Huntington Station. Summit altitudes on the terminal moraine and adjacent hills are commonly as much as 150 feet or more above the outwash plain, which abuts the hills at an altitude of about 120 feet above sea level. The outwash plain is characterized by a gently rolling land surface, which slopes southward at about 20 feet per mile.

Marshlands, at or slightly above mean sea level, fringe the south shore of the area, adjacent to Great South Bay. The bay, which separates the main part of Long Island from the narrow low-lying barrier beaches, is generally less than 3 feet deep in the western part of the area and less than 10 feet deep in the eastern part. In boat channels the depth may be as much as 30 feet.

POPULATION

The substantial population upsurge in Suffolk County since 1950 is primarily the result of migration from New York City. Figure 2 illustrates the rate of population growth in the Towns of Babylon and Islip. The combined population of both towns was 117,021 in 1950, and 315,268 in 1960, an increase of nearly 170 percent. The Town of Babylon had a slightly greater rate of growth than the Town of Islip between 1950 and 1960, which was probably due to its closer location to New York City. The major factor contributing to urbanization of western Suffolk County is the improved rail and highway transportation.

With the exception of the northwestern part which is largely an area of cemeteries, population density in the Town of Babylon is fairly uniform (pl. 6). Centers of greatest population are near the south shore and in eastern parts of the town. In the Town of Islip, population density is greatest west of Connetquot River. Pilgrim State Hospital, the largest hospital in the world, is in the extreme northwestern part of the Town of Islip. Another center of high population density is Central Islip State Hospital, northeast of the headwaters of Champlin Creek. Large areas adjacent to and east of Connetquot River are still in their natural state. The extensive construction activity in western Suffolk County has just begun to reach the eastern part of the Town of Islip, which is still predominantly rural (1961).

INDUSTRY

Industrial growth in the Towns of Babylon and Islip has paralleled population growth. Industrialization of the area has resulted in large measure from decentralization of New York City's industrial core.

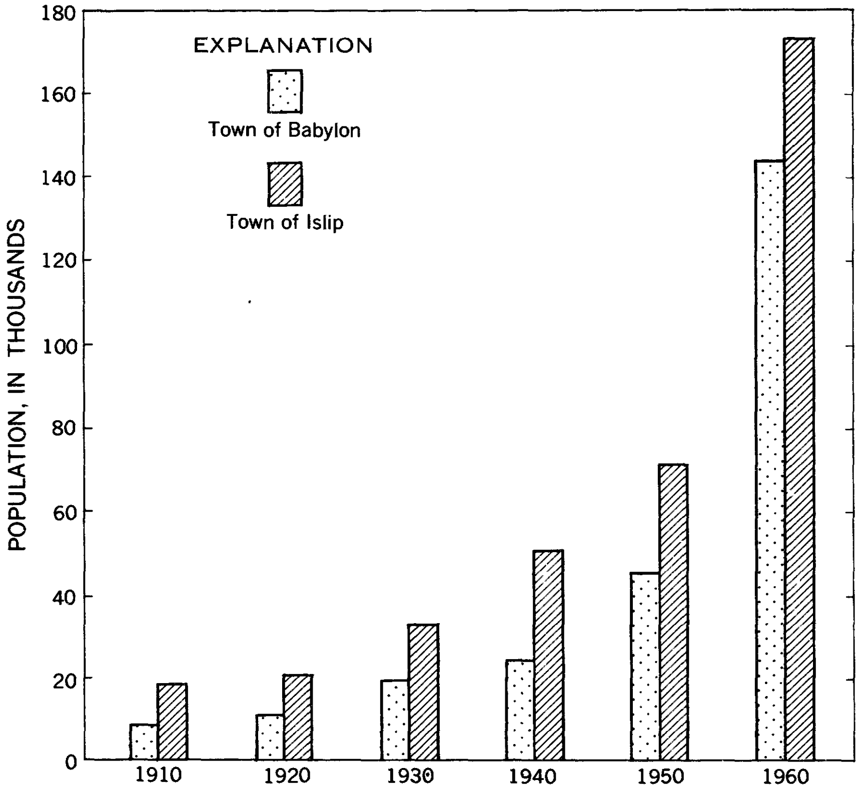


FIGURE 2.—Population of the Towns of Babylon and Islip, 1910–60.

Nearly two-thirds of the companies in the area have been established since the end of World War II. Most concerns are small, employing fewer than 100 people; however, two large plants, Republic Aviation Corp. and Fairchild Engine and Aircraft Co., each employ several thousand. Republic Aviation Corp., which is in the northwestern part of the Town of Babylon, is the largest industrial concern in Suffolk County, and employed 16,000 persons in 1958. Of the 625 industrial plants in Suffolk County in June 1956, nearly 60 percent were in the Towns of Babylon and Islip (Leonard and Stonier, 1956, p. 51).

The major industries in Suffolk County are aviation, instruments, electronics, and fabrication of metals; smaller industries include furniture, printing and publishing, textiles, and apparel. The aviation industry has been well established on Long Island since the end of World War I. Production of scientific and professional instruments came as a natural adjunct to the aviation industry. Similarly, the development of the all-metal airplane created a need for metal-fabricating shops. The post-World War II boom in electronics and electrical equipment found Suffolk County well prepared for the new industry owing to its established aviation firms, and the presence of the required skilled personnel.

AGRICULTURE AND VEGETATION

Although the value of crops produced and marketed in Suffolk County ranks highest of all the counties in New York State, agricultural production in the Babylon-Islip area is relatively small. The soils in the southern and eastern parts of the area have been classified by Lounsberry and others (1928, p. 13) as Sassafras Sandy Loam and Dukes Loamy Sand. These soils are not as productive as the soils in the northern and eastern parts of the county. The Sassafras Loam soils in the northwestern and north-central parts of the area are fairly productive. Proximity of this area to metropolitan markets spurred the development of numerous truck farms. The major crops produced by these farms are tomatoes, cauliflower, corn, string beans, peas, and cucumbers. Intensive urbanization, however, has reduced farm acreage so sharply that only a few farms remained in 1961.

Extensive tracts of natural vegetation are limited principally to the northern and eastern parts of the area. Much of the hilly area of the Ronkonkoma terminal moraine is forested with well-developed stands of deciduous trees. Low moisture retention characterizes the sandy, well-drained soils of the eastern part of the area and thereby precludes extensive forest development. Stands of scrub oak or pitch pine are common here in conjunction with an undergrowth of huckleberry, sweetfern, and wintergreen.

GEOLOGY

The composition, thickness, and geologic history of the deposits underlying the Babylon-Islip area determine the water-bearing characteristics, and the lateral and vertical extent of aquifers and aquicludes that form the hydrologic environment. The stratigraphy of the geologic formations is known almost exclusively from well records and samples, as outcrops, especially those of Cretaceous age, are rare.

STRATIGRAPHY

The Babylon-Islip area is underlain by unconsolidated sediments of Cretaceous, Tertiary, and Quaternary age, which lie on crystalline bedrock of Precambrian or early Paleozoic(?) age (table 1 and pl. 1). Directly overlying the bedrock is the Raritan Formation of Cretaceous age consisting of the Lloyd Sand Member and an unnamed clay member. Above the Raritan Formation is a thick sequence of deposits of late Cretaceous age which is in part, correlative with the Magothy Formation of New Jersey, but also includes some formations that are younger than the Magothy (Perlmutter and Crandell, 1959, p. 1066). Pending a more specific identification, these beds are referred to as the Magothy(?) Formation. Deposits of Quaternary, and possibly Tertiary age overlie the Cretaceous deposits. These consist, from oldest to youngest, of the Mannetto Gravel of doubtful Tertiary (Pliocene ?) age, the Gardiners Clay, and the upper Pleistocene and Recent deposits.

TABLE 1.—*Summary of stratigraphy of the Babylon-Islip area*

Era	Period	Epoch	Geologic unit		Remarks
Cenozoic	Quaternary	Recent	Recent deposits		Stream, beach, and marsh deposits; small areal extent.
		Pleistocene	Upper Pleistocene deposits		Till and outwash deposits of the Wisconsin Glaciation.
			Gardiners Clay		Fossiliferous marine clay of probable Sangamon age.
	Tertiary(?)	Pliocene(?)	Mannetto Gravel		Formerly believed to be an outwash deposit but now regarded as a stream-terrace deposit; small areal extent.
Mesozoic	Cretaceous	Late Cretaceous	Magothy(?) Formation		Interbedded sand, silt, and clay.
			Raritan Formation	Clay member	Dominantly clay but may contain some silty and sandy zones locally.
				Lloyd Sand Member	Sand, gravel, and interbedded clay and silt.
Precambrian and early Paleozoic(?)			Bedrock		Schist and gneiss containing some granitic intrusions.

THE BEDROCK

No wells in the Babylon-Islip area have reached bedrock. However, information obtained from wells in nearby parts of Long Island (Suter and others, 1949, p. 30–32, pls. 8 and 9) suggests that the bedrock in the area consists chiefly of schist and gneiss and contains some granitic intrusions. The bedrock is probably correlative in part with igneous and metamorphic rocks of Connecticut.

The bedrock surface dips southeastward at a rate of approximately 50 to 100 feet per mile. The altitude of the surface ranges from about 1,200 feet below sea level in the northwestern part of the area to about 1,800 feet below sea level in the extreme southeastern part. This bedrock surface represents the lower limit of the ground-water reservoir.

RARITAN FORMATION

The Raritan Formation of Late Cretaceous age directly overlies the bedrock. It is divided into the Lloyd Sand Member below and an unnamed clay member above, and has been correlated with the Raritan Formation of New Jersey on the basis of lithology and stratigraphic position. Because the Raritan Formation has been penetrated by only one test well in the area, its lithology, thickness, and altitude are inferred from data obtained in adjacent areas.

LLOYD SAND MEMBER

The Lloyd Sand Member of the Raritan Formation lies directly on the bedrock surface. It has an estimated thickness of 150 to 300 feet, and is thickest in the southern part of the area. The altitude of the top of the Lloyd is estimated to be approximately 800 to 1,500 feet below sea level, being lowest in the southeast, under Fire Island. It is inferred from examination of cores from wells N3355 [1] and S6409 (1½ miles northwest of the northwest corner of the Town of Babylon, and approximately 15 miles east of Lake Ronkonkoma, respectively), and the log of well S42 (pl. 1) that the Lloyd Sand Member underlying the area is probably composed of light-colored sand and gravel and lenses of clay and silty clay. Logs of several wells in eastern Suffolk County, indicate that the Lloyd Sand Member may be more clayey in that area, possibly because of a facies change along the northeasterly strike of the formation.

CLAY MEMBER

On the basis of descriptions of samples from wells in other parts of Long Island and the log of well S42 in the area, the clay member of the Raritan Formation probably consists of 170 to 300 feet of gray, blue, black, red and white clay, silt, and some very fine to fine sand. The altitude of the top of the clay member at well S42 in the northwest corner of the Town of Islip is 670 feet below sea level, and under Fire Island the clay member may be as much as 1,300 feet below sea level.

MAGOTHY(?) FORMATION

The Magothy(?) Formation of Late Cretaceous age has been completely penetrated by only one well (S42) in the area; therefore, its thickness and the nature of its contact with the underlying clay member of the Raritan Formation is known only approximately. The Magothy(?) is about 600 to 700 feet thick in the northern part of the area, and 1,000 to 1,200 feet thick in the southern part. The

[1] Wells in each county on Long Island are numbered serially by the New York State Water Resources Commission. The well number is prefixed by the initial letter of the county in which the well is located Thus, well N3355 is in Nassau County and well S6409 is in Suffolk County.

altitude of the top of the formation ranges from 200 feet above to more than 100 feet below sea level. Relief on the Magothy(?) surface is due to stream erosion, mostly during late Pliocene and Pleistocene time. Contour lines on the Magothy(?) surface are shown on plate 2.

The Magothy(?) Formation consists mostly of nonfossiliferous beds and lenses of gray and white fine quartz sand, clayey and silty sand, and clay. However, the upper 50 to 200 feet of the formation beneath the barrier beaches consists of beds of fossiliferous green and gray glauconitic clay and sandy clay, which have been tentatively correlated with the Monmouth Group of New Jersey (Perlmutter and Crandell, 1959, p. 1066). Layers of lignite, pyrite, and iron-oxide concretions are common. Medium to coarse sand occurs in lenses irregularly throughout the formation, particularly in the upper and lower zones. West and north of the Babylon-Islip area, where the formation has been more fully explored, a gravel-bearing zone as much as 200 feet thick is found in the lower (basal) zone of the Magothy(?). Records of a few wells suggest that the gravelly zone occurs also in the area.

MANNETTO GRAVEL

The Mannetto Gravel, which consists of stratified and crossbedded quartz gravel, containing some highly weathered erratic material, was considered by Veatch (1906) and Fuller (1914) to represent the earliest deposit of Pleistocene age on Long Island. Currently it is considered to be of doubtful Tertiary (Pliocene(?)) age (Suter and other, 1949, p. 9) and probably correlative with the Bryn Mawr terrace-gravel deposits of Pennsylvania (Cooke, Gardiner, and Woodring, 1943).

The Mannetto Gravel has been recognized only in the northwestern part of the Babylon-Islip area where it crops out in the West and the Half Hollow Hills. It is difficult to distinguish the Mannetto in drillers' logs from the overlying glacial deposits, and its subsurface distribution is not well known.

PLEISTOCENE DEPOSITS

Deposits of Pleistocene age comprise the uppermost 50 to 150 feet of sediments in most of the area. The Jameco Gravel, a major aquifer in western Long Island, is not found in the Babylon-Islip area. The oldest formation of Pleistocene age is the Gardiners Clay, an interglacial deposit. The Gardiners Clay is overlain by upper Pleistocene deposits of Wisconsin age.

GARDINERS CLAY

The Gardiners Clay is a marine interglacial deposit of probable Sangamon age and has been recognized in wells along the south shore of the area (pl. 2). Generally it is not found more than a mile north of Great South Bay, although it occurs in the middle of Long Island, at Brookhaven National Laboratory (Weiss, 1954), 11 miles east of the Babylon-Islip area. The Gardiners Clay is overlain by upper Pleistocene deposits of Wisconsin age. It is difficult to determine the lower boundary of the Gardiners Clay from drillers' logs in some places because the underlying Magothy(?) Formation contains beds of similar lithology. The abundance of biotite and chlorite and the presence of foraminifers are used to differentiate the Gardiners from the Magothy(?) Formation where samples are available.

The Gardiners Clay is generally 20 to 40 feet thick, and the altitude of the top of the formation ranges from about 50 to 110 feet below sea level (p. 2). The formation consists of dark-colored clay, lenses of green silt and very fine sand, and thin layers of fine gravel. The layers of clay and silt are generally fossiliferous.

UPPER PLEISTOCENE DEPOSITS

The upper Pleistocene deposits include (a) outwash deposits of stratified medium to coarse sand and gravel, (b) terminal moraine deposits consisting of till and ice-contact deposits of stratified sand and gravel, (c) till, composed of unstratified clay, sand, gravel, and boulders in the form of ground moraine (not exposed), and (d) glaciolacustrine deposits of clay and silt (not exposed). The surficial distribution of the till and outwash deposits is shown on Plate 1.

Outwash is the most extensive upper Pleistocene deposit in the area. The outwash is underlain by the Gardiners Clay and Magothy(?) Formation, and is partly overlain by younger glacial and Recent deposits. The thickness of the outwash ranges from zero where it abuts Cretaceous and Tertiary sediments in the northwestern part of the area, to more than 100 feet in the eastern part. In parts of the area as much as 120 feet of poorly to well stratified ice-contact deposits are found above the outwash. These deposits form the bulk of the Ronkonkoma terminal moraine, a discontinuous ridge marking the maximum advance of a continental glacier. Quartz is by far the most abundant mineral in the outwash and ice-contact deposits; however, igneous and metamorphic rock particles, muscovite, biotite, and some heavy minerals are common in many beds.

A buried till sheet probably underlies the outwash deposits north of the Ronkonkoma moraine, but the till has not been definitely identified (Lubke, 1961, p. 38). A glacial clay, which underlies much of the Town of Smithtown (Lubke, 1961, p. 39), extends into the northeastern part of the area, but the data are too scanty to define the southern limit.

RECENT DEPOSITS

Deposits of Recent age are found along stream channels, in marshes and ponds, on the barrier beaches, and under Great South Bay. Stream channel deposits consist of a veneer of discontinuous reworked outwash deposits. Beds of very fine sand, silt, and clay are accumulating in marshes and ponds, and under Great South Bay. The barrier beaches consist of beach and dune sands as much as 50 feet thick. The Recent deposits commonly contain shells of mollusks.

GEOLOGIC HISTORY

A knowledge of the geologic history is important in understanding the nature and distribution of the geologic formations. The following summary is adapted largely from a report by Suter, and others (1949, p. 29–46).

During the Cretaceous Period, sediments derived from highlands in northeastern North America were deposited on a relatively flat bedrock surface sloping in a general southeasterly direction. The sediments thus deposited form a part of the present-day coastal plain extending from Long Island to the Gulf of Mexico. Long Island, which was approximately at the strand line of the Cretaceous sea, received mostly continental deposits. The great thickness of sediments deposited near sea level suggest concurrent depression of the bedrock surface during deposition. The variable and lenticular nature of the Cretaceous sediments indicates that deposition took place in shifting river channels, flood plains, swamps, and marshes.

The apparent absence of deposits of Tertiary age on Long Island, except for the nonmarine Mannetto Gravel, suggests either nondeposition or deposition followed by extensive erosion. The present distribution of the Mannetto Gravel is a remnant of the formerly extensive stream deposit.

Large continental glaciers, which were formed at the beginning of the Pleistocene Epoch, resulted in a general lowering of sea level. This lowering, in turn, caused stream rejuvenation and widespread erosion of pre-Pleistocene sediments and deepening of existing valleys. The area was drained then, as now, primarily by southward flowing streams, which cut partly into the Magothy(?) deposits but probably nowhere removed them completely. The eroded surface of the Magothy(?) is shown by contours on plate 2. The high area on the Cretaceous surface in the northwestern part of the area is a remnant of a dissected former divide between northward- and southward-flowing streams.

It is generally believed that the Pleistocene Epoch included four major glaciations, and therefore four cycles of eustatic sea level changes. The first three glacial advances did not reach Long Island.

The only evidence of their presence near Long Island is the Jameco Gravel, an outwash deposit found in some parts of the island, but not in the Babylon-Islip area. The Gardiners Clay was deposited in shallow water during an interglaciation (Sangamon) when sea level was relatively high, but about 50 feet below its present altitude. The final, or Wisconsin glaciation of the Pleistocene Epoch, consisted of the Ronkonkoma and Harbor Hill stades. During the first Wisconsin ice advance, meltwater deposited outwash, which was partially overridden by the ice until stagnation occurred. During this stagnation period, stratified sand and gravel in the form of outwash was deposited south of the glacier by meltwater streams, and stratified ice-contact deposits were deposited along the southern terminus of the glacier to form the Ronkonkoma terminal moraine. Melting of the ice left a thin sheet of unstratified ground moraine, which was subsequently buried by younger outwash. The second Wisconsin ice advance did not move as far south as the first. Meltwater streams from the second advance deposited stratified sand and gravel north of the Ronkonkoma terminal moraine and, in places, breached the moraine so that Harbor Hill outwash may be found above the outwash of the Ronkonkoma Stade from which it cannot be distinguished readily.

Some of the large streams in the area did not erode their present valleys, but occupy valleys eroded by streams which issued from glaciers during the Pleistocene Epoch. The largest valleys in the area, those of Carlls River, Connetquot River, and Sampawams Creek, can be traced northward to breaches in the Ronkonkoma moraine (pl. 1).

Melting of the continental glaciers was accompanied by a rise in sea level to its present position. Erosion by stream and wave action is presently occurring simultaneously with deposition by these same agents.

HYDROLOGY

HYDROLOGIC ENVIRONMENT

Water in the Babylon-Islip area occurs in the interstices of unconsolidated sediments and in streams and ponds. The ground-water reservoir consists of saturated unconsolidated deposits ranging in thickness from 1,300 to 1,800 feet. The water table, which forms the boundary between the zone of saturation and the overlying zone of aeration (unsaturated zone), is the upper limit of the reservoir, and the impervious bedrock is the lower limit. Water in marshes, ponds, or streams in the Babylon-Islip area is nearly always hydraulically connected with the water table. The availability of ground water and surface water for man's use is controlled to a large extent by the physical characteristics of the aquifers, streams, and ponds. These characteristics include the capacity of ponds, size and gradient of streams, and the extent, nature of boundaries, and water-bearing properties of aquifers.

AQUIFERS

Three aquifers of wide areal extent are recognized in the deposits underlying the Babylon-Islip area: (a) a shallow water-table aquifer, (b) an intermediate artesian aquifer, and (c) a deep artesian aquifer. Perched water may occur locally in the northern part of the area in lenses of sand and gravel separated from the main water table by deposits of clay or glacial till. The hydrologic environment of perched-water bodies is similar to that of the water-table aquifer; except that perched-water bodies are small and localized and generally are not a dependable source of supply.

WATER-TABLE AQUIFER

The water-table aquifer is composed almost entirely of highly permeable upper Pleistocene deposits that constitute the uppermost zone of the ground-water reservoir. The upper surface of this aquifer is the water table, or top of the zone of saturation. The configuration of the water table (pl. 3) is controlled by the topography, and by the thickness, water-bearing properties, and quantity of recharge to and discharge from the aquifer.

The water table is a subdued replica of the topography. A conspicuous "high" on the water table occurs under the West Hills, south of Huntington Station, where the land surface reaches altitudes as high as 400 feet. Another "high" northeast of Lake Ronkonkoma is coincident in part with the Ronkonkoma terminal moraine where the land surface altitude is commonly as high as 300 feet. The saddle in the ground-water divide south of Hauppauge is probably largely the result of substantial quantities of ground-water discharge into the relatively deep valleys of the Nissequogue and Connetquot rivers, situated north and south of the divide, respectively.

Depth of the water table below land surface is shown on plate 4. In general, the depth to water increases northward from zero along Great South Bay and stream channels to as much as 200 to 300 feet beneath parts of the Ronkonkoma terminal moraine, West Hills, and Half Hollow Hills. The southern half of the area is drained by many effluent streams and depths to water are commonly 25 feet or less.

The lower boundary of the water-table aquifer is defined in most of the area by the occurrence of beds of predominantly low permeability in the upper part of the Magothy(?) Formation. Where the upper part of the Magothy(?) is composed of permeable material, these beds form a part of the water-table aquifer, and the lower surface of the aquifer is at the first impermeable zone below the top of the Magothy(?). In the extreme southern part of the area, the Gardiners Clay forms the lower boundary of the water-table aquifer.

The water-table aquifer is present everywhere in the Babylon-Islip area, but it very thin in some places and contains salt water in others. In the northwestern part of the area, the water table is mainly in the Magothy(?) Formation rather than in upper Pleistocene deposits. As a result, the water-table aquifer is thin, owing to the clayey nature of most of the saturated beds. The Recent and upper Pleistocene deposits which compose the water-table aquifer beneath Great South Bay contain only salt water. Beneath the barrier beaches, fresh water in the water-table aquifer occurs in small discontinuous lenses in beach and dune deposits of Recent age. These fresh-water lenses are underlain by salt water.

The approximate thickness of the water-table aquifer may be determined by subtracting algebraically the altitude of the top of the Magothy(?) Formation, or Gardiners Clay where it is present (pl. 2), from that of the water table (pl. 3). The thickness of the water-table aquifer ranges from almost zero in the northwestern part of the Babylon-Islip area to more than 100 feet in the eastern part. The average thickness is about 75 feet. Wells screened in the outwash deposits yield as much as 1,500 gpm (gallons per minute). Specific capacities may be as high as 135 gpm per foot of drawdown, but are commonly 40 to 75 in thoroughly developed, large-diameter wells. The specific capacity of a well is a useful parameter for estimating water-bearing properties of an aquifer. Coefficients of transmissibility estimated from specific capacities (Theis and others, 1954) were used to compute the approximate coefficients of permeability of the outwash deposits given in the following table:

Estimated permeabilities of outwash deposits in the water-table aquifer

Well	Screened zone (ft below land)	Yield (gpm)	Specific capacity (gpm per ft)	Approximate thickness of aquifer (feet)	Field coefficient of permeability (gpd per sq ft)
S10,760T	59-81	500	37	73	800
S11,151	50-61	60	20	84	300
S12,016	50-85	1,525	98	67	2,200
S12,421	54-75	360	45	70	1,000
S12,710	40-70	1,500	100	75	1,600
S12,873	78-103	1,212	76	91	1,100
S13,478	35-60	830	42	70	900
S16,176	81-117	1,529	71	85	1,200
S16,608	110-140	1,000	77	88	1,200

The hydraulic coefficients of the water-table aquifer at one well near Central Islip State Hospital are given below:

Hydraulic coefficients of outwash deposits in the water-table aquifer

[Determination by the Hydrologic Laboratory, U.S. Geol. Survey]

Well	Depth (feet)	Specific retention (percent)	Specific yield (percent)	Porosity (percent)	Coefficient of permeability (gpd per sq ft)
S16,803	27-32	2.2	25	27.2	700

Because of the high permeability of the beds and generally shallow depth to the water table, wells are both productive and economical in most of the area underlain by outwash deposits (pl. 1). The water-table aquifer presently (1961) supplies approximately 84 percent of the total pumpage of ground water in the Babylon-Islip area.

INTERMEDIATE ARTESIAN AQUIFER

The intermediate artesian aquifer is composed of lenticular permeable deposits of the Magothy(?) Formation. The upper surface of the clay member of the Raritan Formation defines the lower boundary of the aquifer. Clayey and silty lenses in the upper part of the Magothy(?) Formation and the Gardiners Clay, where present, constitute the upper boundary. Unlike the top of the water-table aquifer, the upper boundary of the intermediate artesian aquifer generally is not a sharply defined surface such as the water table, but is a transitional zone of relatively low permeability. Where clayey confining beds are replaced by sandy zones, hydraulic continuity exists between the water-table and intermediate artesian aquifers.

Because permeable zones in the Magothy(?) Formation are lenticular, it is difficult to predict their occurrence and thickness, except for a basal zone. As in many parts of western Long Island, an extensive zone of sand and gravel about 100 feet thick probably lies immediately above the clay member of the Raritan Formation in the Babylon-Islip area but the data are too scanty to permit mapping the zone as a separate unit. (See well S42, pl. 1.) Test drilling is generally necessary to locate permeable zones which can yield as much as 1,500 gpm to individual wells. Specific capacities of wells range from 1 to 49 gpm per foot of drawdown. Those wells tapping zones composed chiefly of sand and gravel commonly have specific capacities ranging from 20 to 40 gpm per ft. The method of computing transmissibilities from specific capacities (Theis and others, 1954) yields only approximate values for the intermediate artesian aquifer because of the unknown effects of partial penetration and the heterogeneous nature of the aquifer. However, in the absence of other laboratory or field determinations, the specific capacity is used as a means of estimating the coefficients of transmissibility of the aquifer. Coefficients of transmissibility estimated from specific capacities of four wells screened in various zones of the aquifer were used to compute the coefficients of permeability listed in the following table:

Estimated permeabilities of water-bearing zones in the intermediate artesian aquifer

[Thickness of water-bearing zone determined from well log]

Well	Screened zone (feet below mean sea level)	Thickness of water-bearing zone (feet)	Specific capacity (gpm per ft)	Field coefficient of permeability (gpd per sq ft)
S11279	276–306	59	9.5	400
S14583	106–132	89	13.9	400
S15775	180–220	88	31.7	800
S16256	500–552	76	35.7	1,200

Wells S15775 and S16256 are screened in coarse sand and gravel whereas wells S11279 and S14583 are screened in fine to medium sand. Hence on the basis of data in the above table, approximate coefficients of permeability of 1,000 gpd (gallons per day) per square foot and 400 gpd per sq ft may be assumed for coarse sand and gravel and for fine to medium sand, respectively. The aquifer also consists of lenses of very fine to fine sand, silt, and clay, for which an average permeability of 20 gpd per sq ft may be assumed (Wenzel, 1942, p. 13). Based on the geologist's log of well S42 (Leggette and others, 1938, p. 30–32) 29 percent of the intermediate aquifer is sand and gravel, 52 percent is predominantly sand, and 19 percent is fine sand, silt, and clay. On the basis of these data, the average coefficient of permeability of the intermediate aquifer is estimated to be about 500 gpd per sq ft.

DEEP ARTESIAN AQUIFER

The deep artesian aquifer is the lowermost water-bearing zone in the ground-water reservoir. Its boundaries coincide with those of the Lloyd Sand Member of the Raritan Formation. Although no wells penetrate the deep artesian aquifer, it probably underlies the entire area. The bedrock, which contains only small quantities of water, marks the lower limit of the deep aquifer. The upper limit is at the base of the clay member of the Raritan Formation which acts as an effective confining unit for the deep artesian aquifer.

Specific capacities of 10 to 20 gpm per ft of drawdown are commonly reported for wells tapping the Lloyd Sand Member in Nassau

County. Test wells screened in the Lloyd in central Suffolk County at Brookhaven National Laboratory had specific capacities of only 2.0 and 2.5 gpm per ft. If the Lloyd becomes increasingly clayey to the east (as the scanty data suggest), specific capacities of wells may range from about 10 to 20 gpm per ft in the western part of the area and 5 to 15 gpm per ft in the eastern part.

STREAMS AND PONDS

Surface-water resources have played a significant role in the growth of Long Island since its original settlement. Early industrial requirements focused on a need for power to operate sawmills and gristmills. The first gristmill in the Babylon-Islip area was constructed about 1860 on Connetquot River (Sander, 1954, p. 64). Artificial ponds were developed on many streams to supply the head required to drive water wheels. When steam and electric power came into use, gristmills and sawmills were abandoned, and now the principal use of streams and ponds is for recreation.

To meet demands for water by New York City, the surface-water resources of Nassau County were intensively developed in the early 1900's. A plan was proposed shortly thereafter to tap about 10 large streams in Suffolk County for additional supplies. The plan was abandoned only after strong protests were voiced throughout the county, especially by officials who envisioned the day when this invaluable resource might be required for local use. A county-wide plan is now in effect to purchase and preserve, in its natural state, land bordering on the few remaining undeveloped streams to be used for recreation and conservation.

All major streams in the area flow in a southerly direction, and, in general, are less than 3 miles long. The largest streams are Carlls River in the Town of Babylon, and Connetquot River in the Town of Islip. Both streams have fairly well developed tributary systems, and extend approximately 5 miles above the head of tidewater. All streams have gentle gradients that average about 2 feet per 1,000 feet.

With the exception of Lake Ronkonkoma, almost all ponds in the area are manmade. In the late 1800's ponds were utilized for industrial purposes; however, most are used only for recreation at present. Lake Ronkonkoma occupies a kettle hole whose bottom extends about 60 feet below the water table. The lake has a surface area of about 220 acres. The total area of all ponds and lakes is about 1.4 square miles or 0.7 percent of the total Babylon-Islip area.

HYDROLOGIC CYCLE

The term "hydrologic cycle" denotes the general circulation of water in its various states (liquid, solid, or gaseous) from ocean to atmosphere, from the atmosphere over and through the ground, and back to the ocean again.

Atmospheric water vapor will, if favorable conditions exist, condense into tiny droplets which increase in size until they can no longer be supported by air currents. If temperatures are above freezing, water vapor will precipitate as rain. If temperatures are at or below freezing during the condensation process, water vapor will precipitate as snow, sleet, or hail.

The time required for precipitation to return to the atmosphere depends principally upon the nature of the incident surface. Impervious or water-saturated surficial deposits cause precipitation to flow overland into streams or ponds. Precipitation falling upon and retained by vegetal surfaces will evaporate and return directly to the atmosphere. Some of the precipitation reaching the land surface will also evaporate; however, a substantial part will infiltrate into the ground if the soil is permeable. The first demand the infiltrating water must satisfy is that of the soil. Soil moisture is depleted primarily by vegetation and direct-surface evaporation. After soil-moisture requirements are fulfilled, residual water percolates slowly downward through interstices in the earth materials underlying the soil zone until it reaches the ground-water reservoir. While in the ground-water reservoir, the water moves slowly down gradient and is discharged into streams, bays, and the ocean. After discharge into the ocean, water completes the hydrologic cycle by eventually returning to the atmosphere by evaporation.

QUANTITATIVE HYDROLOGY

One of the principal objectives of this report was to evaluate the water balance for the ground-water reservoir. The accomplishment of this objective requires the collection and interpretation of data on precipitation, ground-water levels, and streamflow. These data are discussed in subsequent sections of the report within the framework of the hydrologic cycle.

In evaluating the water balance, the inflow or recharge to the ground-water reservoir is equated to the outflow or discharge, plus or minus changes in the reservoir storage. Recharge is essentially equal to discharge if the period of study selected is long enough to minimize the effect of changes in ground-water storage. The hydrologic factors affecting the water balance include precipitation, ground-water runoff, direct runoff, evapotranspiration, and underflow.

Precipitation, the largest factor, is fortunately the easiest to measure. Five U.S. Weather Bureau cooperative stations in or near the area have records of sufficient length to be of value in determining average precipitation. The average streamflow of the area was computed from the existing network of primary, secondary, and partial-record gaging stations. That part of total streamflow which reflects direct runoff was computed from an anlaysis of the discharge hydrographs of the primary gaging stations; the remainder of the streamflow represents ground-water runoff. Precipitation and streamflow are the factors most amenable to quantitative analysis. Estimates of evapotranspiration losses are much more difficult to obtain. These estimates depend on studies made in nearby areas where geologic conditions do not preclude computing evapotranspiration indirectly. Ground-water evapotranspiration was computed from an analysis of water-table fluctuations in a part of the area where such losses are significant. The only unknown factor in the water-balance equation for the area is underflow at the north shore of Great South Bay (submarine outflow) which, therefore, may be computed from the equation.

To evaluate the various hydrologic factors, it is desirable to compute data for a period common to all. Too, as previously noted, it is essential to choose a period of sufficient length to eliminate the effect of change in storage in the ground-water reservoir. The period selected for study was the 1944–59 water years which corresponds to the length of the longest streamflow record in the Babylon-Islip area. Hence, all computations represent the averages for this period and may be assumed to be approximately equivalent to the true long-term averages.

PRECIPITATION

Precipitation in its various forms is the source of all water on Long Island. A favorable geographic location with respect to available sources of moisture provides Long Island with an abundant and fairly uniform supply of precipitation throughout the year. The two principal meteorological factors which produce precipitation on Long Island are the active extra-tropical cyclonic disturbances, most prevalent from November through April, and local convective summer storms. A secondary source of precipitation is tropical cyclones, often of spectacular size, but fortunately of infrequent occurrence. The primary sources of moisture for all storms affecting Long Island are the Gulf of Mexico and the southwestern part of the North Atlantic Ocean.

There are no long-term rainfall stations within the Babylon-Islip area; however, the records for Farmingdale, Babylon, and Brentwood (pl. 7), are of sufficient length to be of value in computing the mean annual precipitation for the base period. In addition, the rainfall stations at Patchogue (pl. 7) and Setauket (fig. 1), although outside the area, are considered to be sufficiently close that their records may be given some weight in determination of mean annual precipitation. With the exception of the records for Setauket, which data back to 1886, the records of these stations go back less than 25 years.

Precipitation is heaviest in the south-central part of the Babylon-Islip area, as comparison of the mean annual precipitation at Babylon with other stations in or near the area shows (table 2). Somewhat heavier precipitation than that recorded at Babylon may occur in the hilly region of the northern part of the area; however, owing to lack of data, the orographic influence is not known. The apparent heavier rainfall at Babylon may be due to any one, or to a combination of, the following reasons: (a) proximity to the ocean, (b) local effects such as rain-gage exposure, or (c) to chance. A comparison of the mean annual precipitation at New York City and Setauket for the base period (1944–59 water years) with the long-term averages in table 2 indicates only slight variations. For example, average preciptation during the base period was about three-quarters of an inch greater than that for the long-term period at New York City, and less than a quarter of an inch lower than at Setauket. It may be inferred, therefore, that a water balance computed for the base period will be representative of the long-term averages. For the Babylon-Islip area, the mean annual precipitation for the base period was computed to be 46.3 inches by the Thiessen method (Williams, 1950, p. 276–278). Only slight weight was given to the Setauket record in the computations and none at all to that of New York City, which is too distant from the area.

TABLE 2.—*Mean, maximum, and minimum annual precipitation, in inches, for selected stations*

Station	Period of record	Mean	Maximum	Minimum	Mean for base period (1944–59)
New York City	1826–1959	42.2	59.7	28.8	43.0
Setauket	1886–1959	45.0	59.3	33.6	44.8
Farmingdale	(1)	45.9	56.6	39.4	[2] 46.3
Babylon	1939–59	48.6	56.7	35.7	48.7
Brentwood	1942–59	46.0	60.0	36.4	45.9
Patchogue	1938–59	45.0	58.5	36.0	45.0

[1] 1921-22, 1926-33, 1940-56.
[2] Adjusted to base period.

On the basis of the records for Setauket and New York City for the period 1886–1960, annual precipitation may be expected to range from 30 to 60 inches in the area (fig. 3). If the 74-year record at Setauket is considered representative of average precipitation in the area, the curve in figure 3 may be used to predict future rainfall. For example, the probability is about three chances in five that annual precipitation in any one year will be between 40 and 50 inches.

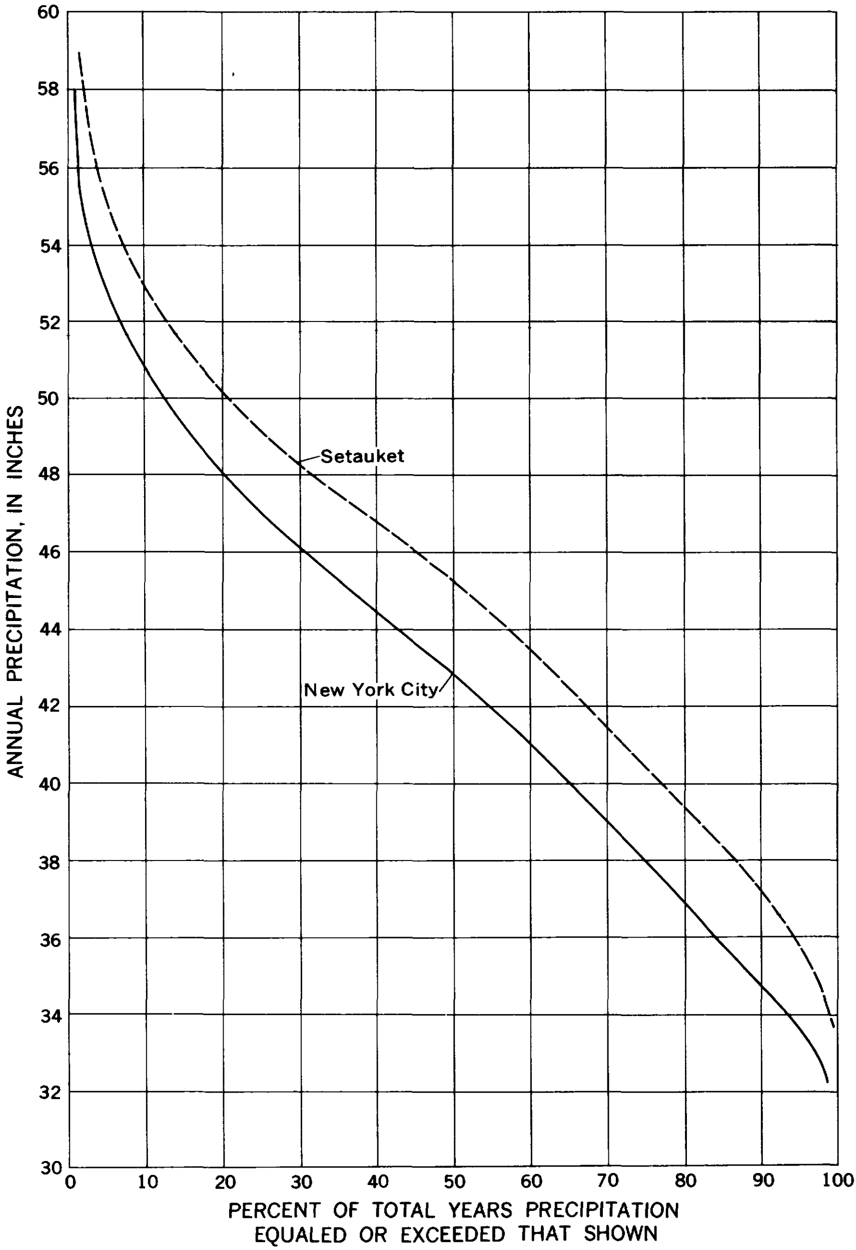


FIGURE 3.—Annual precipitation-duration curves for New York City and Setauket, 1886–1960.

The 5-year moving average for the long-term precipitation records at New York City and Setauket (fig. 4) indicates three periods of excessive rainfall, all occurring in the 19th century, and two outstanding droughts, 1831–40 and 1908–18. Plotted on the same time scale, for comparison, are annual discharges for Sampawams Creek and the average water levels in 14 selected wells in Nassau and Suffolk Counties. The graphs show some correlation between ground-water levels and precipitation. A comparison of annual discharge at Sampawams Creek, ground-water levels, and precipitation indicates a lesser degree of correlation. Many factors affect the correlation between streamflow, ground-water levels, and precipitation. For example, the sharp rise in the 5-year moving average of streamflow at Sampawams Creek from 1950 to 1955 is not reflected in any of the other parameters. This apparent anomaly is probably the result of a sharp rise in population which occurred within the Sampawams Creek drainage basin during that period. Urbanization of the basin increased the storm discharge to the stream thereby causing the indicated rise in the 5-year moving average. Furthermore, several months may be required for precipitation to reach the ground-water reservoir, in areas where depth to the water table is appreciable. Thus, the precipitation recorded in any particular year may not be reflected as ground-water runoff until the following year. The absence of a high degree of correlation between the parameters makes it difficult, if not impossible, to predict the effect on available water resources of an outstanding drought, such as that of 1831–40.

Mean monthly precipitation ranges from 3 to 5 inches throughout the year over much of Long Island. August is the wettest month and June is generally the driest. The greater precipitation in August results from thunderstorms and from tropical storm activity, both of which attain maximum intensity during the month. June represents a transitional month when extra-tropical storm activity approaches a minimum, and convective (thunder) storms are not yet a significant source of moisture. It is this combination of events that tends to reduce rainfall during June. The maximum recorded monthly rainfall in the Babylon-Islip area is 14.45 inches in October 1955 and the minimum is 0.04 inch in June 1949, both at Brentwood.

On Long Island, the rainfalls of greatest intensity usually occur during the summer. Winter storms do not have correspondingly high rainfall intensities because lower temperatures limit the amount of water the air can hold. For example, there is a 50-50 chance that the maximum annual rainfall during a 24-hour period will exceed 3.5 inches in any particular year in the Babylon-Islip area; the probability that this particular event will occur in any of the winter months is about one chance in a hundred (U.S. Dept. Commerce, 1961, p. 95,

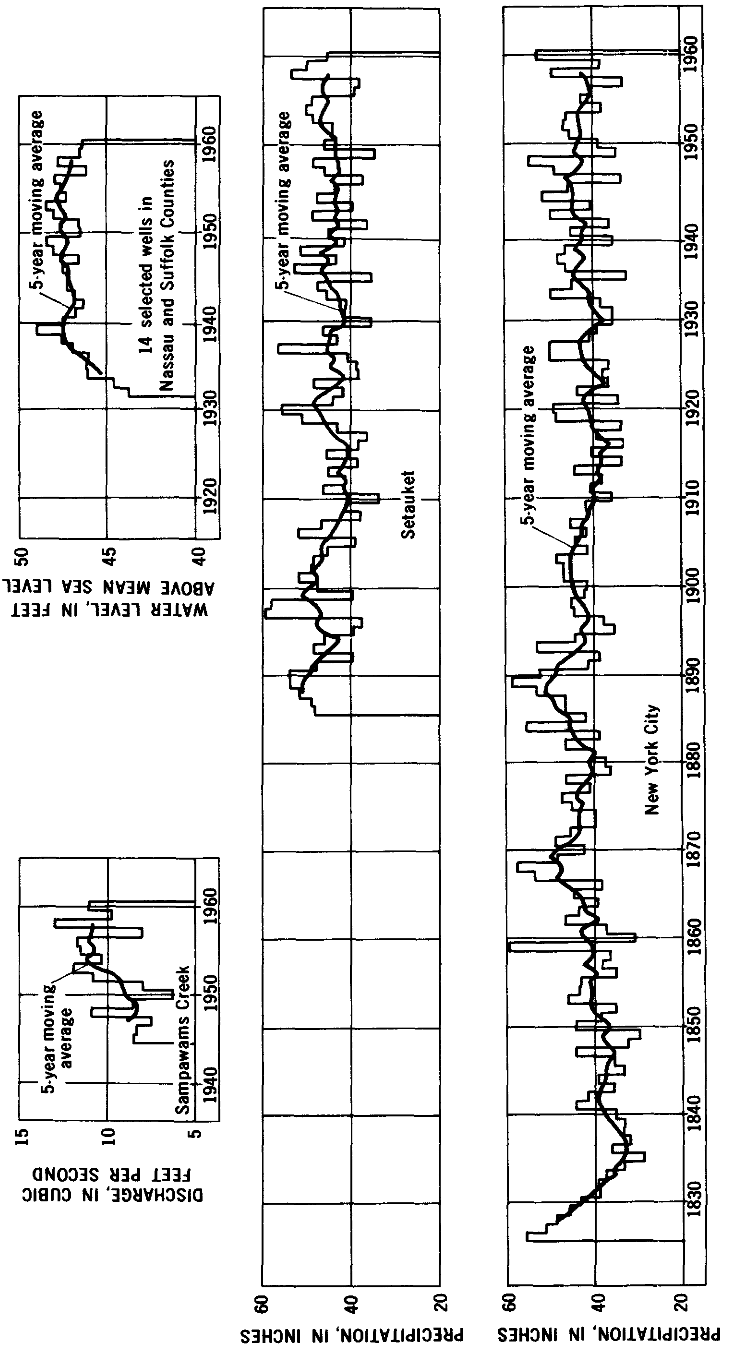


FIGURE 4.—Comparison of long-term records of precipitation, water levels, and streamflow with 5-year moving averages superimposed.

115), whereas the probability that the same event will occur in any summer month is more than 10 times as great. As temperatures rise with approaching summer, air masses off the southern and southeastern coasts of the United States absorb progressively larger quantities of moisture. When these air masses move over the North American continent, they may yield copious quantities of moisture.

The hurricane of August 11–14, 1955, and the extra-tropical storm of October 14–16, 1955, produced some outstanding rates of precipitation on Long Island, as indicated below:

Maximum recorded precipitation, in inches, at Brentwood and Mineola

Date	Accumulated rainfall during number of hours shown					
	3	6	12	24	48	72
Brentwood						
Aug. 11-14, 1955	2.51	2.59	3.85	5.98	9.09	9.79
Oct. 14-16, 1955	4.10	6.20	7.53	8.88	10.22	10.81
Mineola						
Aug. 11-14, 1955	3.35	4.25	5.05	7.95	10.[illegible]	12.19
Oct. 14-16, 1955	1.35	1.68	2.05	2.26	3.56	3.78

The maximum 12-hour rainfall to be expected once in 100 years on Long Island is about 6.5 inches (U.S. Dept. Commerce, 1961, p. 91, 105), and the maximum 24-hour rainfall with the same probability is about 7.5 inches. These intensities were exceeded at Brentwood for the 12- and 24-hour periods during the October 1955 storm and at Mineola for a 24-hour period during the August 1955 hurricane. The occurrence of two major storms in a period of three months in 1955 was an extremely rare event.

Snowfall in the area averages about 25 inches annually. The heaviest snowstorms generally result from low-pressure systems that form south of Long Island. Only on rare occasions does snow remain on the ground longer than a week.

EVAPOTRANSPIRATION

Evapotranspiration is the withdrawal of water from a land area by direct evaporation from water surfaces and moist soil and by plant transpiration. Evapotranspiration has first call on precipitation; it reduces the amount of water available as streamflow or as recharge to the ground-water reservoir. It may be considered "Nature's take" or that part of precipitation which is unavailable to man. The rate of evapotranspiration depends chiefly upon air temperature, wind movement, solar radiation, humidity, availability of moisture, and character of the land surface and plant cover. Many of the climatic parameters affecting evapotranspiration are so interrelated that it is virtually impossible to isolate them. In addition to climatic factors numerous other variables such as plant cover, land management, degree of urbanization, and type of soil affect the rate of water loss. Because the interrelation of these variables is complex, direct field measurement of evapotranspiration is very difficult and is subject to large errors.

The rate of evaporation from a body of water is a function of the moisture-carrying capacity of the air immediately above it, which in turn, is governed directly by the temperature of the air. Air temperature determines the length of the growing season and, to some extent, the type of plant life a region will support; it thereby also affects the rate of vegetal transpiration.

Variations of air temperature on Long Island are not as large as those in nearby inland areas to the north and west. Although the climate of Long Island is chiefly continental, modifying maritime effects are shown by the fact that temperatures higher than 90°F or lower than 10°F are infrequent. For example, as shown in the upper part of figure 5, maximum daily temperatures can be expected

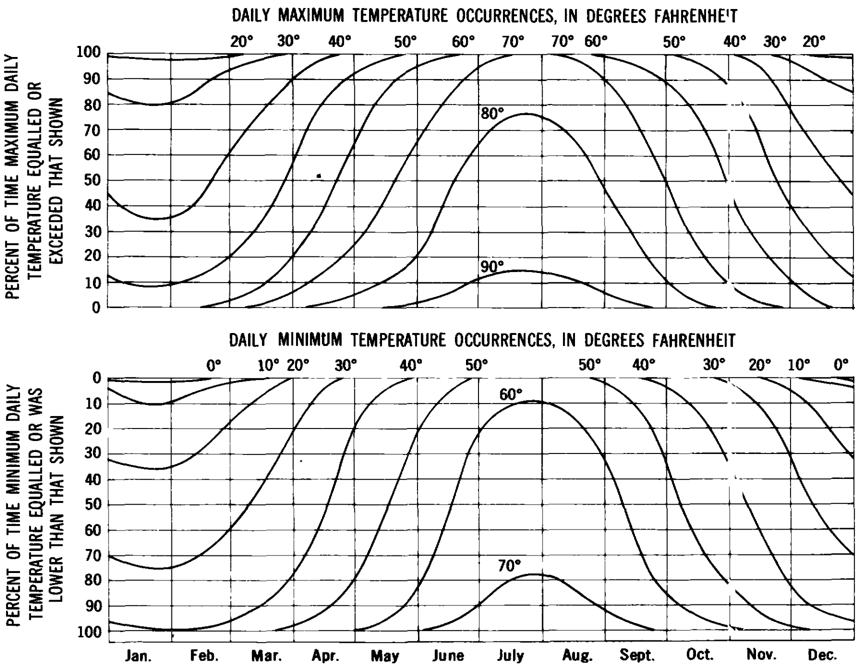


FIGURE 5.—Daily air temperature-duration curves for Mineola, March 1938 to May 1961.

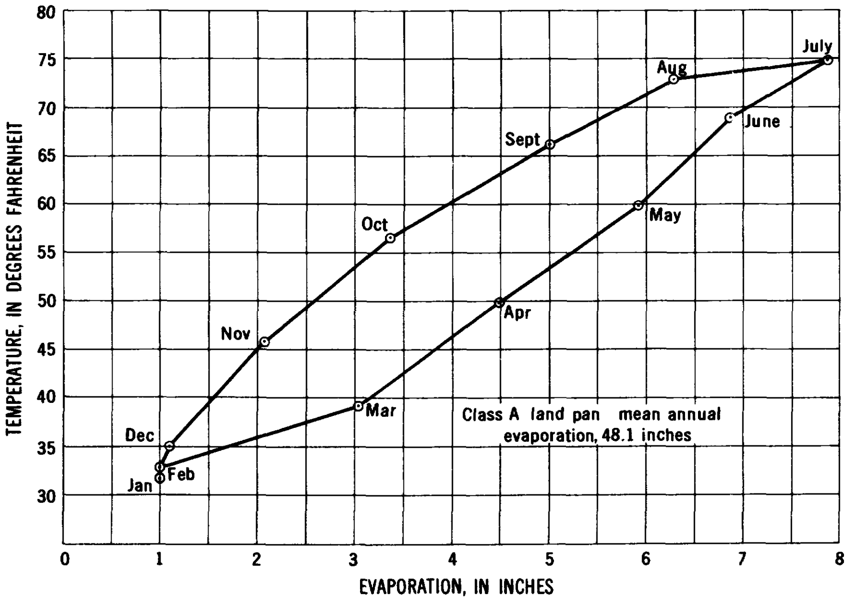


FIGURE 6.—Variation of mean monthly temperature and evaporation near Mineola, 1949–60.

to be 90°F or higher only 15 percent of the time during July, and, as shown in the lower part of the figure, minimum daily temperatures of 10°F or lower can be expected less than 10 percent of the time during the coldest period of the year.

Temperatures at Mineola (fig. 5), in central Nassau County, may be considered representative of the northern and central parts of the Babylon-Islip area. The south shore has lower maximum temperatures during the summer, a factor which tends to decrease evaporation. Sheltered interior valleys have lower minimum temperatures throughout much of the year; however, maximum temperatures are similar to those at Mineola. The warmest and coldest periods of the year generally occur during the latter parts of July and January, respectively. Killing frost may occur as late as May 1 and as early as mid-October. The average length of the growing season at Mineola is 195 days, whereas in the Babylon-Islip area it probably ranges from 170 days in sheltered interior valleys to 210 days along the barrier beaches. The mean annual air temperature ranges from about 50°F inland to 52°F along the south shore.

Although temperature is the major parameter in controlling evaporation, other factors are significant as indicated by the elliptical-shaped graph in figure 6. The evaporation data shown are land-pan observations collected by the U.S. Geological Survey at the Rockaway Road recharge basin near Mineola. Mean monthly evaporation is plotted against mean monthly temperature on this figure, and consecutive months are connected by straight lines. Because of subfreezing temperatures, pan observations were suspended during December, January, and February. Estimates for these months are based on the Meyer formula (Meyer, 1944, p. 238) for evaporation losses from shallow bodies of water. If temperature were the only factor affecting evaporation, the plotted points would lie along a straight line. Another significant factor causing variation in the plotted points is solar radiation. Long days and a high angle of incident sunlight permit greater absorption of solar energy during the spring and early summer. This additional energy causes higher water temperatures, which in turn increase evaporation rates above those of the late summer and fall.

Mean annual evaporation from the land pan near Mineola is 48 inches. By applying the standard coefficient of 0.7 to land-pan evaporation near Mineola, the mean annual evaporation from shallow bodies of water in the area is estimated to be about 34 inches. This estimate may be considered to be the maximum annual water loss which could result on Long Island under conditions of continuous soil saturation. However, free water surfaces and areas where the land surface is sufficiently close to the water table to be continuously saturated total less than 5 percent of the area (pl. 4). In the remainder of the area, evapotranspiration at any particular time may range from a maximum rate equivalent to that in saturated soils immediately after heavy precipitation to none during a protracted dry period. Conceivably, annual evapotranspiration may be as low as 10 to 15 inches in parts of the area having well-drained sandy soils.

It is practically impossible to measure evapotranspiration losses directly. Even if some method could be devised which would reflect natural conditions, it would still be difficult to determine the average annual evapotranspiration loss for a basin. The wide range of soil types and varying land uses found in most areas limits a direct approach to the problem of computing evapotranspiration losses. Therefore, indirect methods such as computing the difference between precipitation and runoff are frequently applied. In areas where the geologic and hydrologic environment is such that virtually the entire water yield of a basin appears as streamflow, the difference between precipitation and runoff is practically equivalent to evapotranspiration. On Long Island, streamflow represents only a part of the water yield because the extensive body of highly permeable material underlying the stream permits an unknown, but significant, quantity of water to move under and past the gaging stations. Thus, quantitative evaluation of the average annual evapotranspiration in the report area was necessarily based largely on precipitation-runoff studies made in areas adjacent to Long Island. Several other indirect methods of determining evapotranspiration are available. These methods, based primarily on a selection of coefficients, were not used for they appear to be more subjective than objective in their approach to the problem.

An estimate of annual evapotranspiration ranging from 22 to 24 inches for the area corresponding to a mean annual temperature of 51°F was obtained from a graph based on precipitation-runoff studies in Pennsylvania and Massachusetts (Williams and others, 1940, p. 53). M. A. Warren and N. J. Lusczynski (U.S. Geol. Survey, written communication, 1955) suggest an average annual evapotranspiration rate of 20 to 22 inches for central Suffolk County on the basis of an estimated value for total ground-water discharge. Rasmussen and Andreasen (1959, table 10, p. 97) computed an annual mean evapotranspiration of 25 inches in Beaverdam Creek basin, Maryland, for the period April 1950 through March 1952. Evapotranspiration computed for the Beaverdam Creek basin is probably slightly higher than that for Long Island because mean annual air temperature in the basin is about 5° higher and the average depth to the water table in the Beaverdam Creek basin is less than that in the Babylon-Islip area. A study in the Delaware River basin and in New Jersey (Hely, Nordenson, and others, 1961, pl. 3), shows that the annual water loss in the near-shore area of the northern coastal plain of New Jersey averages about 23 to 24 inches; however, annual evapotranspiration in the area is probably several inches less owning to the movement of ground water under and past the streams. The Babylon-Islip area and the northern coastal section of New Jersey are both in the Atlantic Coastal Plain and both have similar soil types, relief, climate, and geology. On the basis of the studies mentioned, particularly the Delaware River basin and the New Jersey studies, annual evapotranspiration in the area is estimated to be about 21 inches.

DIRECT RUNOFF

Precipitation on the land surface may evaporate, infiltrate into the soil, or move over the surface of the ground to a nearby stream or pond. Direct runoff is precipitation that falls directly on a surface-water body or that reaches a surface-water body by flowing over the land surface. Discharge into streams from storm sewers, although generally conveyed below land surface, is also considered to be direct runoff.

Soil permeability, rainfall intensity, and ground slope are the principal factors affecting direct runoff. The loam and sandy loam soils in the area are highly permeable. In addition, the relatively thin soils drain readily, for they contain little or no clay and generally are underlain by coarse sand and gravel. This combination of thick beds of highly permeable sand and gravel overlain by thin permeable soil provides the area with a natural storm-water disposal system. In an experimental storm-water recharge basin near Mineola, infiltration rates as high as 1.3 inches per hour under a head of less than 0.1 foot were noted after 97 hours of continuous flooding (Brice, Whitaker, and Sawyer, 1956, fig. 11). This high infiltration rate occurred despite the presence of a thin layer of silt covering the natural sand and gravel of the basin. Gentle surface slopes, which characterize much of the area, also favor a high rate of infiltration.

On Long Island, direct runoff is usually a significant part of streamflow for only a day or two after precipitation ceases. As a result, storm periods appear as fairly well defined rises on the hydrographs of all nonregulated streams and make it possible to separate streamflow into its two components, direct runoff and ground-water runoff. Direct runoff may then be computed by calculating the volume of storm discharge directly on the hydrographs. For example, the graphs of figure 7 show direct runoff (shaded area) and ground-water runoff (base flow) at Champlin Creek during an unusually wet month. The extraordinary storm of October 14–17, 1955, yielded an average rainfall of 10 inches over the topographic drainage area. The resultant volume of storm water is estimated from the stream hydrograph to be 97 cfs-days (see "Glossary," p. 93) which is equivalent to a direct runoff of 0.6 inch from the 5.9-square-mile topographic drainage area of Champlin Creek, or only 6 percent of the total storm rainfall. Discharge hydrographs are available for all streams where a continuous record of stage is obtained. Direct runoff may be estimated for other streams from that computed at nearby recording stations. This procedure was followed and estimates of direct runoff were made for all but the smallest streams.

The ratio of direct runoff to average precipitation on the drainage area rises sharply with increasing precipitation. Figure 8 indicates that direct runoff is about 2 percent of total storm rainfall for storms of 2 to 3 inches in magnitude, and 5 to 6 percent for storms of about 10 inches. The intense rates of precipitation associated with larger storms increase the probability of soil saturation, and therefor the likelihood of greater direct runoff.

Increasing urbanization of the western part of the area, since 1950, has reduced natural infiltration of storm water. Extensive construction in an area decreases its capacity to absorb rainfall, and, in consequence, increases direct runoff. The problem of increased direct runoff may be resolved by construction of storm-water recharge

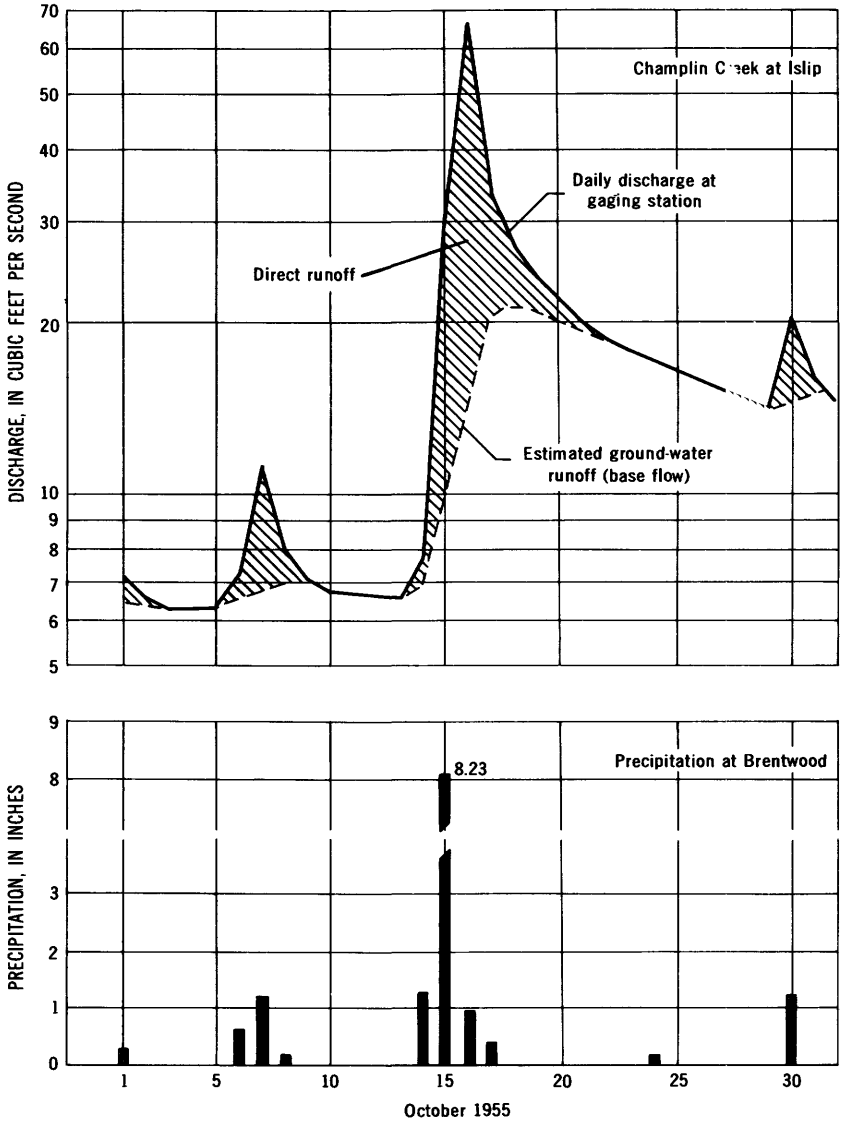


FIGURE 7.—Hydrograph for Champlin Creek at Islip and daily precipitation at Brentwood, October 1955.

basins where the depth to the water table is great enough to permit their excavation. In places where the depth to water table is small, storm water can be disposed of by directing excess precipitation either to streams and thence to tidewater, or by discharging it directly into tidewater through storm sewers. For reasons of economy, large amounts of storm water are discharged into streams. Because of this practice, flood characteristics of many streams along the highly urbanized south shore of Long Island have been significantly altered, as for example, Massapequa Creek at Massapequa (fig. 9). The graph of the ratio of storm-water discharge to total stream discharge indicates an overall upward trend since 1950. The graph of annual precipitation at Farmingdale does not show a corresponding change during the same period. Hence, the increase in stormwater discharge is directly attributable to increased urbanization within the drainage basin. The total population of the Massapequa and Farmingdale school districts, which are largely in the Massapequa Creek drainage basin, was 16,580 in 1950, 63,610 in 1955, 80,560 in 1958 (Nassau County Planning Commission, 1959, pl. K), the increase between 1950 and 1958 was almost 400 percent.

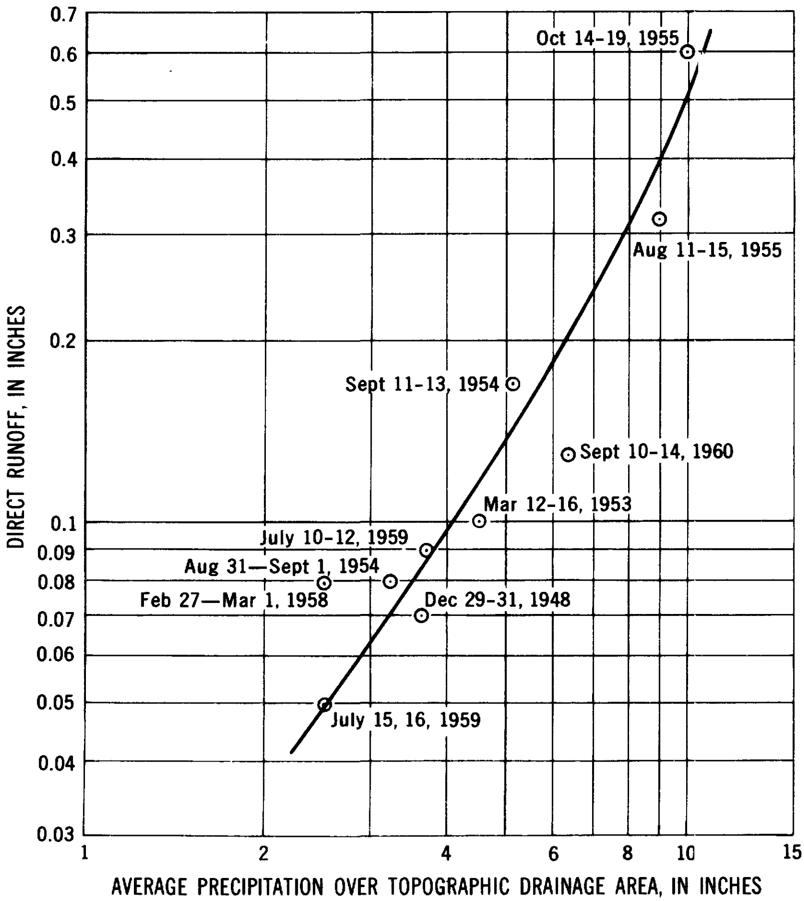


FIGURE 8.—Relation of direct runoff to average precipitation at Champlin Creek for outstanding storms, July 1, 1948, to September 30, 1960.

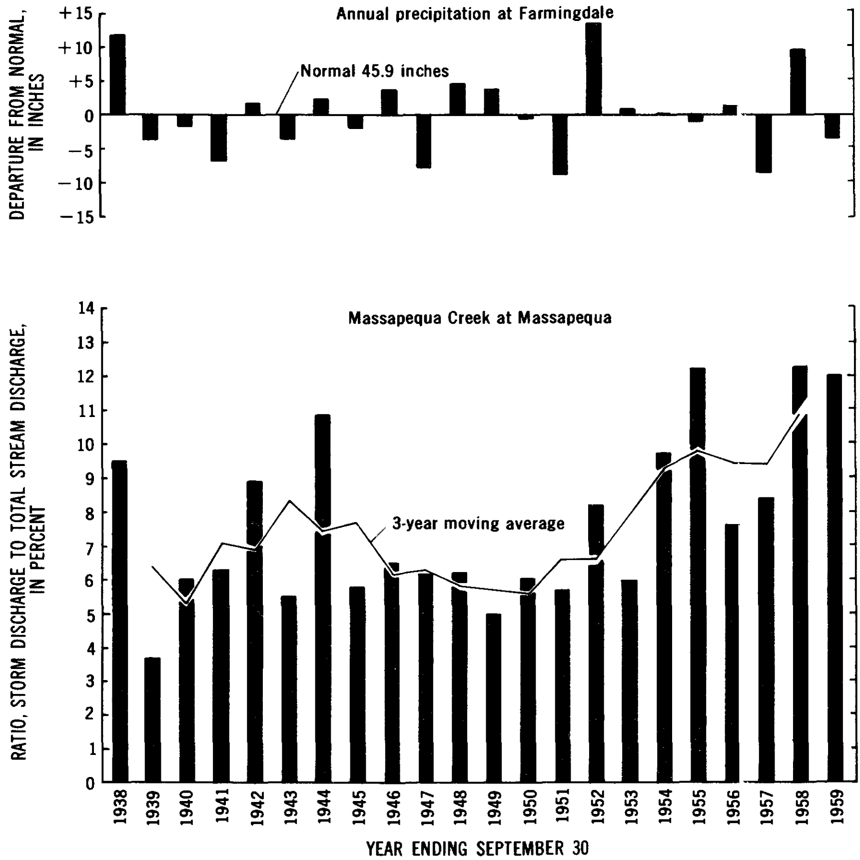


FIGURE 9.—Ratio of storm-water discharge to total discharge of Massapequa Creek at Massapequa, 1938–59, and departure from normal annual precipitation at Farmingdale.

Drainage basins in the Babylon-Islip area range in degree of development from those practically in a natural state to those nearly completely urbanized. Streams in the eastern part of the Town of Islip are mainly in their natural state; however, other streams in the area are affected by varying amounts of urbanization. The ratio of storm-water discharge to total discharge, in percent, was computed for five of the six permanent stream-gaging stations. The ratio for Santapoque River at Lindenhurst was not determined because of heavy upstream ground-water withdrawal that materially reduces the streamflow. The ratio ranges from 2.9 percent at Connetquot River near Oakdale in the eastern, least urbanized part of the area to 5.7 percent at Sampawams Creek at Babylon in the western part of the area. Ratios for four secondary gages range from 3.0 percent at West

Brook near Great River to 11.5 percent at Awixa Creek at Islip. The drainage basins of Connetquot River and West Brook are virtually in a natural state and, therefore, have low ratios. Awixa Creek, because it receives considerable storm discharge from upstream urbanized areas, has a relatively high ratio.

The average ratio of direct runoff to total streamflow for all streams in the area was computed as 4.7 percent. On the basis of an average measured streamflow of 185 cfs from a ground-water contributing area of 150 square miles, direct runoff was computed as 0.8 inch. Direct runoff in the ungaged southernmost part of the area is probably somewhat higher because of the greater degree of urbanization. The direct runoff for the entire Babylon-Islip area is estimated at about 1 inch.

RECHARGE OF THE GROUND-WATER RESERVOIR

The ultimate source of all ground water in the Babylon-Islip area is precipitation that infiltrates downward through the soil zone and the zone of aeration. In addition to this natural source, water is recharged artificially by recharge basins, leaching beds, cesspools, and diffusion wells.

The water-table aquifer is the only one of the three aquifers in the area that is recharged directly by precipitation; the other two aquifers are artesian, and are recharged by ground water that moves downward from overlying aquifers. The intermediate artesian aquifer is recharged by water from the overlying water-table aquifer which moves downward through lenticular confining beds. Similarly, the deep artesian aquifer is recharged by slow downward movement of water from the intermediate aquifer through the clay member of the Raritan Formation.

Fluctuations of the water table and of the piezometric surfaces of the artesian aquifers indicate relative rates of recharge to or discharge from the ground-water reservoir. When recharge exceeds discharge, water levels rise; conversely, when recharge is less than discharge, water levels decline. Figure 10 shows the response of the water table and streamflow to precipitation. Although the well shown on figure 10, well S58, is 468 feet deep, it is reportedly perforated opposite several water-bearing zones including the water-table aquifer, and long-term records show that it reflects water-table conditions.

Figure 11 shows hydrographs of well S2314, screened in the intermediate artesian aquifer, and of well S1817, the nearest well screened in the water-table aquifer (about 1 mile southwest of S2314) having a comparable period of record. The hydrographs are generally similar; however, close inspection reveals that peaks and troughs in the water-level fluctuations in the intermediate artesian aquifer lag behind those

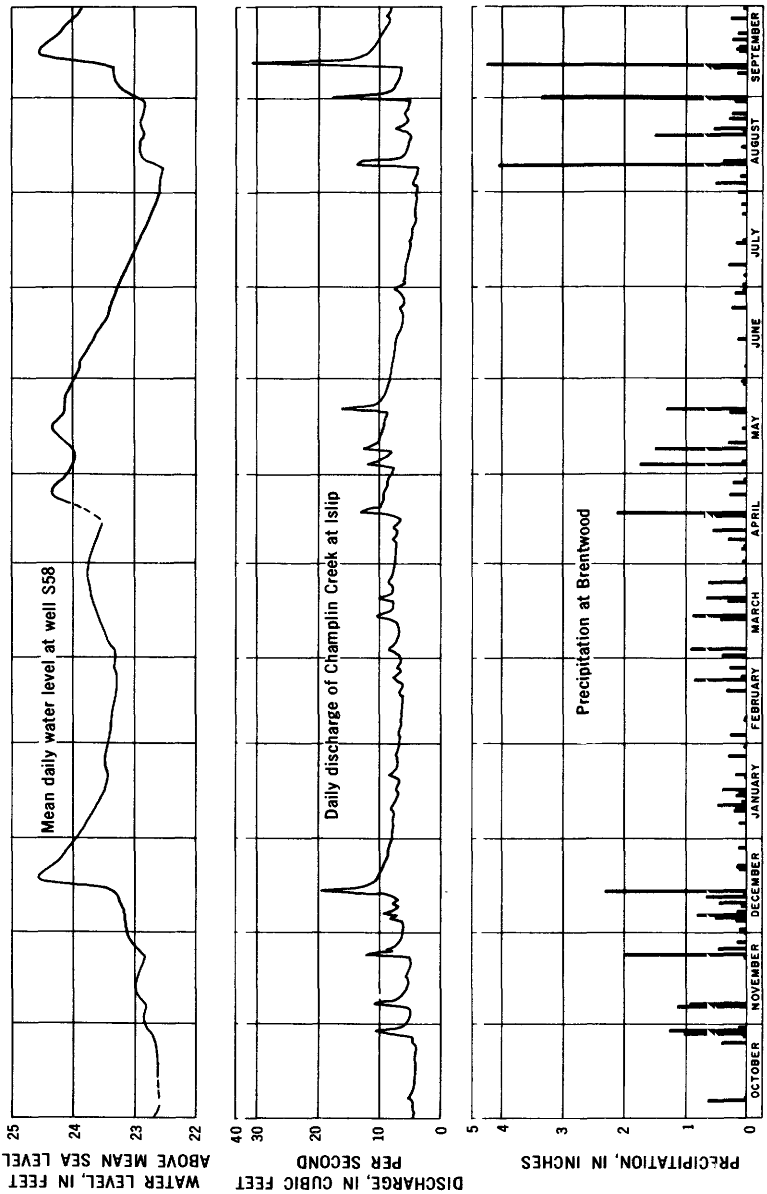


FIGURE 10.—Comparative hydrographs of well S58, Champlin Creek, and precipitation at Brentwood, for the year ending September 30, 1954.

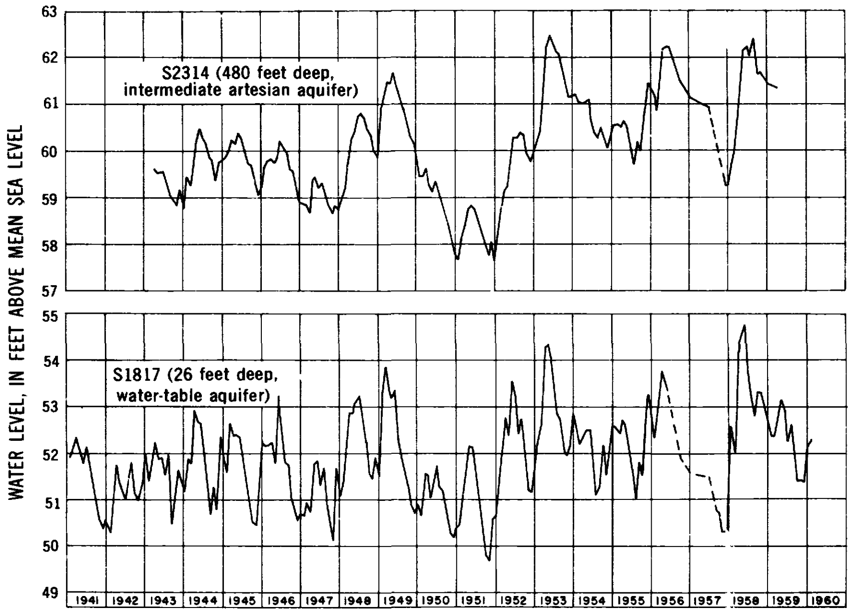


FIGURE 11.—Hydrographs of wells screened in the intermediate artesian and water-table aquifers.

of the water-table aquifer by approximately 1 month. This lag is due to the greater time required for water to reach the deeper aquifer.

Examination of the hydrograph of the shallow well (fig. 11) reveals a cyclic annual fluctuation of the water table. In most years, water levels are highest in March and April; they decline until about September and then begin to recover. The yearly decline in water levels between March and September coincides with the growing season. During this period, evapotranspiration reduces considerably the amount of water available for recharge. A sharp reduction in plant use and evaporation during the fall permits greater infiltration of rainfall into the ground-water reservoir, as shown by the rise in water levels.

Artificial methods of recharge on Long Island fall into two broad categories: those facilitating infiltration of precipitation and those returning water previously withdrawn from the ground-water reservoir. In the first category are storm-water recharge basins and, in the second, leaching beds, diffusion wells, and cesspools.

Storm-water recharge basins receive storm water from sewers and permit infiltration of precipitation from paved areas where natural infiltration has been reduced. Results of experiments in a recharge basin near Mineola in Nassau County indicate that as much as 400 gpd per sq ft may infiltrate into the ground under a head of 1 foot

(Brice, Whitaker, and Sawyer, 1956, p. 32). Infiltration rates apparently depend chiefly on the interval between successive floodings, depth of water, and permeability of the basin surface. There are now more than 80 storm-water recharge basins in the Babylon-Islip area, and the number may be expected to increase as urbanization continues. The effectiveness of the basins as a means of recharging storm water to the ground-water reservoir from a suburban area is probably comparable to that of natural surface conditions prior to urbanization (Brice, Whitaker, and Sawyer, 1956, p. 2).

Public sanitary-sewer systems on Long Island discharge their effluent directly into tidewater. Because there are no such systems in the Babylon-Islip area (1961), theoretically all water withdrawn from the ground-water reservoir is returned to the ground. Two large sewage-leaching beds serve Pilgrim and Central Islip State Hospitals, and several smaller ones are at other institutions. The balance of domestic sewage is returned to the ground through cesspools. Water pumped for industrial purposes is usually returned through diffusion wells and cesspools. A small amount of industrial pumpage containing contaminants is discharged into tidewater to avoid pollution of ground-water supplies.

Artificial recharge in the Babylon-Islip area counters the effect of urbanization by restoring the natural rate of infiltration of precipitation through the use of recharge basins and by returning most of the water pumped.

Because it is not practical to measure directly the rate of recharge to the ground-water reservoir, recharge must be determined by indirect methods. An approximate value for recharge is obtained by subtracting evapotranspiration losses and direct runoff from precipitation. The recharge to the ground-water reservoir in the Babylon Islip area as determined by this method is:

	Approximate annual rate (inches)	
Precipitation		46
Evapotranspiration	21	
Direct runoff	1	
Total water loss		22
Recharge to ground-water reservoir		24

A recharge rate of 24 inches per year is equivalent to 1.1 mgd (million gallons per day) per sq mi or an annual total of about 215 mgd for the Babylon-Islip area. The bulk of this recharge occurs during late fall, winter, and early spring, when evapotranspiration is at a minimum.

MOVEMENT OF GROUND WATER

Upon reaching the zone of saturation by downward percolation, water moves in directions and at rates governed by head differences and hydraulic characteristics of the beds. Ground water moves from areas of higher hydrostatic head to areas of lower hydrostatic head in the direction of the steepest hydraulic gradient. The hydraulic gradient and the permeability and porosity of the beds determine the rate of ground-water movement. Hydrostatic head is shown on, and hydraulic gradient can be computed from, contour maps of the water-table and piezometric surfaces. A knowledge of the configuration of these surfaces is therefore essential in determining the direction and rate of ground-water movement. The water table (pl. 3) slopes in a general southerly direction from altitudes of about 40 to 90 feet above sea level at the ground-water divide to sea level at Great South Bay. Water in the water-table aquifer moves down gradient in the general direction of the arrows shown in plate 3.

A piezometric surface is an imaginary surface to which water in an artesian aquifer would rise in a tightly cased well. This surface is mapped by measurement of water levels in wells tapping the aquifer. The attitude and shape of the piezometric surface is controlled principally by the thickness and permeability of the aquifer and by the rate of recharge to and discharge from the aquifer. The piezometric surface of the intermediate artesian aquifer is generalized in figure 12 because only a few wells are available as control points, especially in the eastern part of the area, and the head in the aquifer varies with depth, arrows show approximate directions of ground-water flow.

No wells in the area are screened in the deep artesian aquifer. Data collected in other parts of Long Island indicate that, in the northern part of the area, heads in the deep aquifer are lower than heads in the intermediate aquifer, and, in the southern part, are higher.

The arrows on plate 3 and figure 12 indicate the direction of the horizontal component of flow. Although this is commonly the principal flow direction, head differences in the vertical dimension in parts of the area cause directions of flow that are either inclined or perpendicular to the directions shown on the water-level maps. A comparison of the water-table and piezometric maps reveals the existence of vertical head differences. In the northern part of the area, heads in the water-table aquifer are greater than those in the intermediate artesian aquifer. Therefore, water in the water-table aquifer moves downward, and recharges the intermediate artesian aquifer. It may be inferred also that water in the northern part of the area has a downward component of flow from the intermediate to the deep artesian

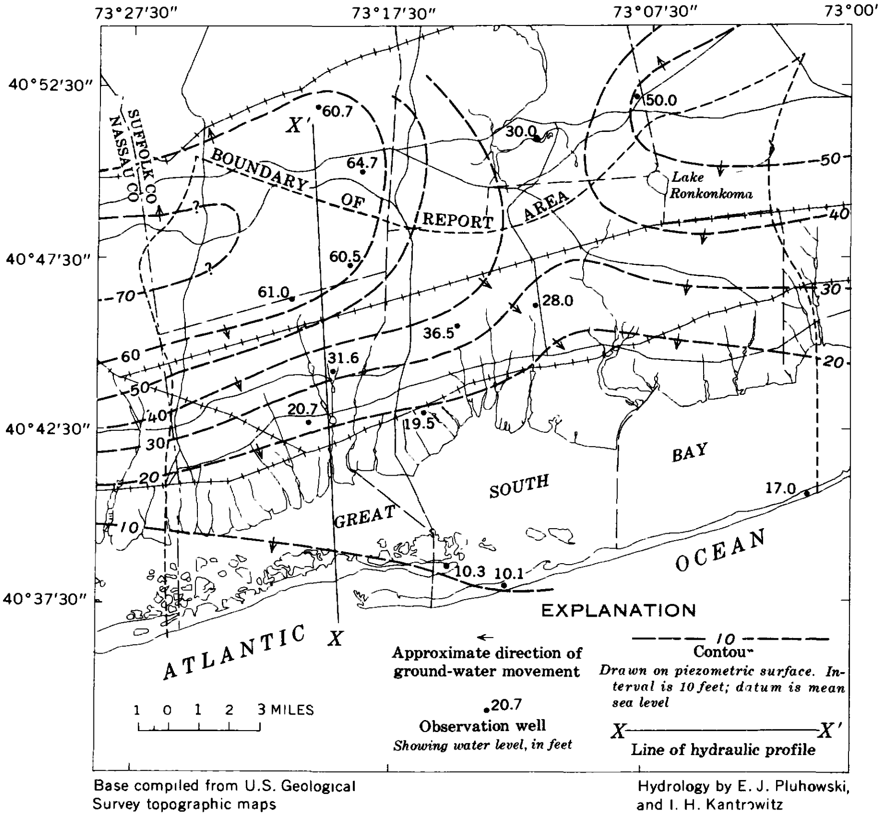


FIGURE 12.—Map of the Babylon-Islip area showing approximate contours on the piezometric surface of the intermediate artesian aquifer, October 1960.

aquifer. Conversely, in the southern part of the area, heads in the water-table aquifer are less than those in the intermediate artesian aquifer, and the water moves upward into the water-table aquifer. Water is probably moving upward also from the deep aquifer to the intermediate aquifer in the southern part of the area.

Contour lines on the water-table and the piezometric surface mark the intersection of these surfaces and equipotential surfaces. To determine the direction of ground-water flow within the reservoir, it is necessary first to determine the configuration of the equipotential surfaces, because flow lines are oriented perpendicular to these surfaces. Figure 13 is a north-south profile across the area showing approximate equipotential lines and flow directions, based on water-level measurements in wells screened at different depths.

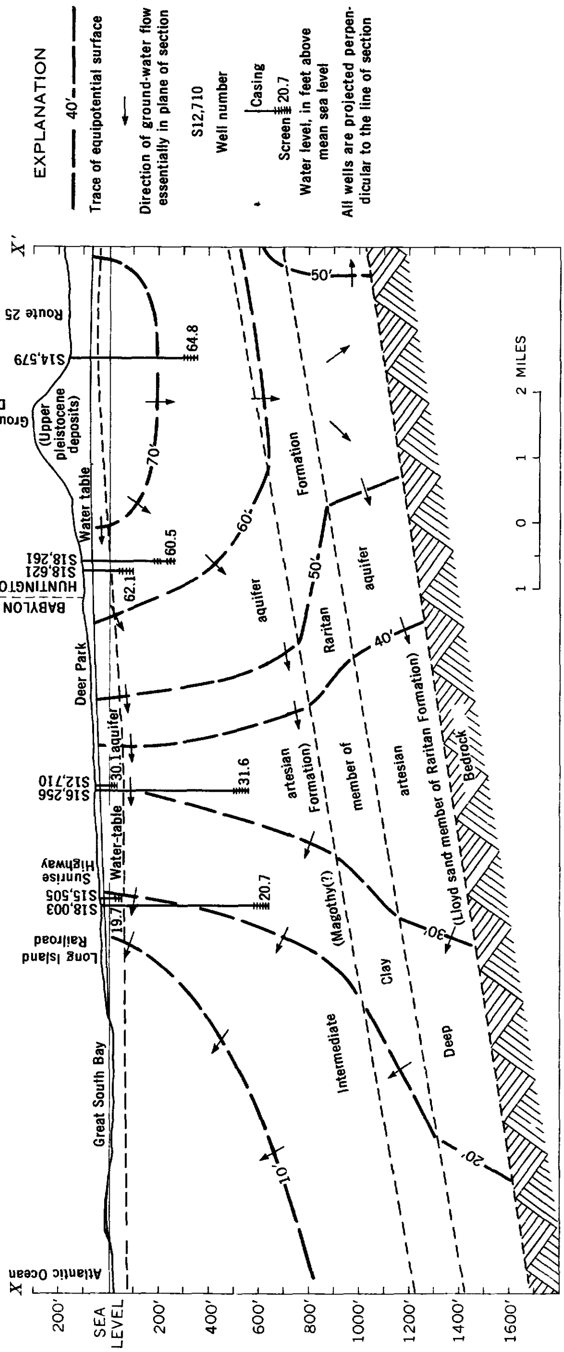


FIGURE 13.—Approximate hydraulic profile of the ground-water reservoir underlying the Babylon-Islip area, October, 1960.

The velocity of ground-water movement is a function of permeability, porosity of the saturated material, and the hydraulic gradient. The velocity is expressed mathematically (Wenzel, 1942, p. 71) as:

$$v=\frac{PI}{7.48p}$$

where v=velocity of ground water (feet per day),
P=permeability of the saturated material (gallons per day per square foot),
I=hydraulic gradient (feet per foot), and
p=porosity of the saturated material (as a decimal).

On the basis of the above formula it is estimated that under natural conditions, water in the Babylon-Islip area moves at rates ranging from 0.5 to 2.0 feet per day in the water-table aquifer and from 0.1 to 0.5 foot per day in the intermediate artesian aquifer, and at less than 0.1 foot per day in the deep artesian aquifer. Water in the immediate vicinity of a pumping well moves at faster rates because of the steep hydraulic gradient developed in the vicinity of pumping wells.

DISCHARGE FROM THE GROUND-WATER RESERVOIR

Ground water is discharged naturally from the area by evapotranspiration, seepage into streams, and submarine outflow, and artifically by pumping wells. Artificial withdrawal results in negligible net loss from the reservoir, for nearly all the water is returned to the ground through cesspools, diffusion wells, and leaching beds. Some of the water pumped for irrigation represents a net loss due to evapotranspiration, but such pumpage is negligible in the area and its effect may be ignored.

Water-level records indicate that, over a long period, recharge equals discharge in the area. However, during and shortly after heavy precipitation, recharge exceeds discharge, water levels rise, and, therefore, the hydraulic gradient increases. Because the rate of ground-water movement varies directly with the hydraulic gradient, an increase in gradient causes an increase in seepage to streams (ground-water runoff) and submarine outflow. Increased ground-water runoff after periods of precipitation is reflected by higher base flow in streams (fig. 10). Similarly, during periods when recharge is negligible, water levels gradually decline, the decline causes a decrease in the hydraulic gradient and a reduction in base flow and underflow.

GROUND-WATER EVAPOTRANSPIRATION

The loss of water from the ground-water reservoir by direct evaporation and plant transpiration is called "ground-water evapotranspiration." Ground-water evapotranspiration probably occurs in the Babylon-Islip area wherever the depth to the water table is less than 5 feet (pl. 4).

Water may be withdrawn from the ground-water reservoir by direct evaporation if the depth to the water table is within the limit of capillary rise. Under these conditions, direct evaporation takes place at land surface and ground water continually replaces the evaporated water. Direct evaporation of ground water may occur wherever the water table is within about 4 feet of land surface (Lee, 1949, p. 291). The rate at which ground water will be lost to the atmosphere is governed by the same climatic factors that affect evaporation from free water surfaces. If the water table is near enough to land surface that plant roots penetrate the zone of saturation or the capillary zone, water may also be drawn directly from the ground-water reservoir by plants for their daily needs. The effective depth of root systems is believed to be generally less than 3 feet and seldom more than 6 feet (Lee, 1949, p. 263).

Figure 14 illustrates the effect of evapotranspiration on water levels in a shallow observation well about 10 feet west of gaging station 19a on Sampawams Creek at Babylon (pl. 7). Water levels in shallow wells affected by ground-water evapotranspiration show well-defined cyclical fluctuations and are highest in the late morning and lowest in the early evening. Discharge from the ground-water reservoir, reflected by decline of the water table, takes place during and immediately after the hours of active plant growth and greatest evaporation as shown on June 6, 7 and July 1–4 in figure 14. After sunset, when plant activity practically ceases and evaporation approaches a minimum, water levels recover until the rate of evapotranspiration increases the following morning.

The climatic factors most closely associated with plant activity and evaporation are air temperature, humidity, and solar radiation. Because these factors are primarily or wholly dependent upon the duration and intensity of sunlight, the amount of ground-water evapotranspiration which will occur on any particular day is largely governed by the amount of sky cover. For example, on June 9 (fig. 14), an overcast day, water levels remained almost constant; little, if any, water was lost due to ground-water evapotranspiration. On the other hand, during July 1–4, under practically cloudless skies, a definite daily fluctuation indicates high ground-water evapotranspiration.

In areas which are subject to ground-water evapotranspiration, it is probable that plant growth rather than direct evaporation largely governs the water loss from the ground-water reservoir. In April and early May ground-water levels are normally high; thus, the area

716-826 O—64——4

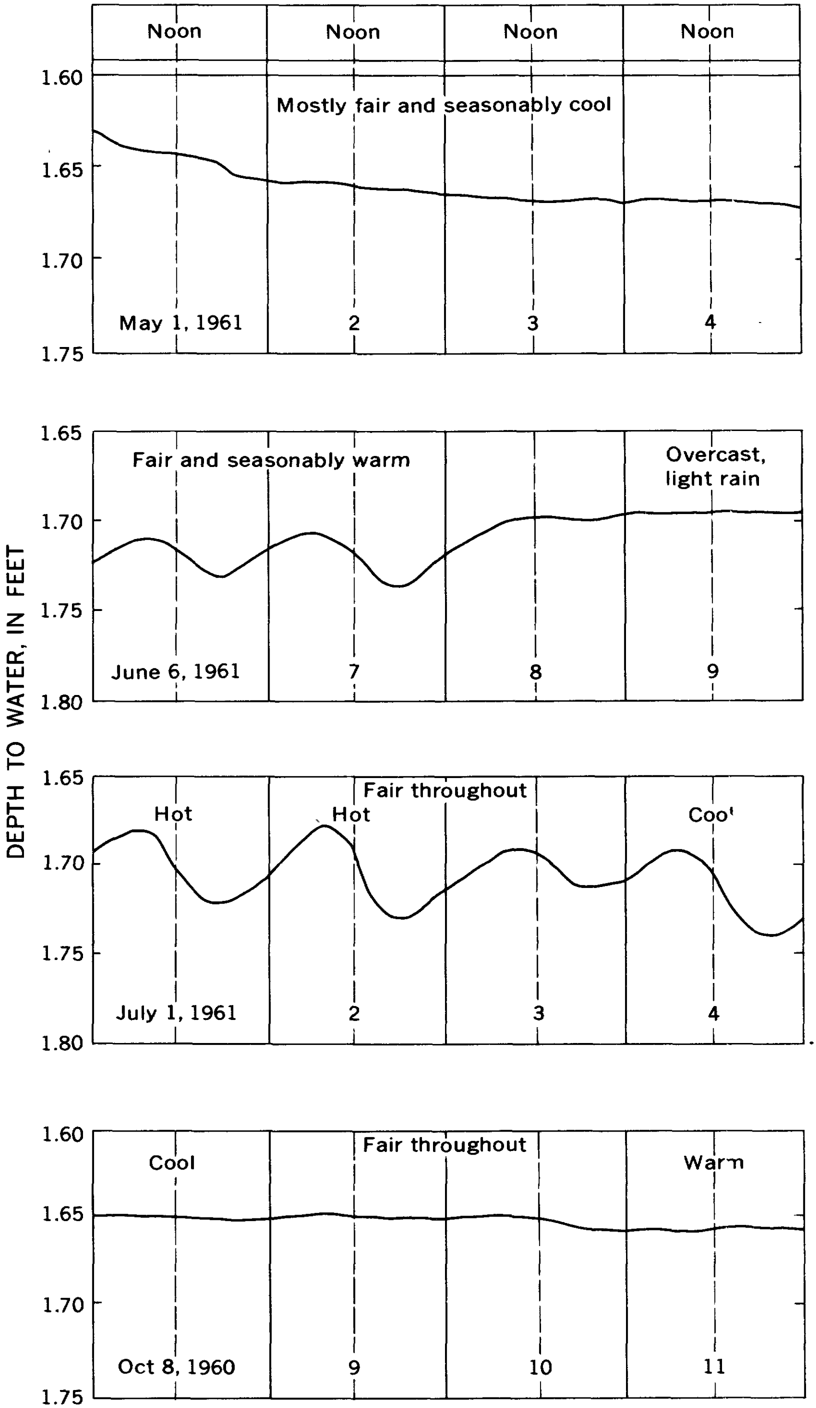


FIGURE 14.—Hydrograph of a shallow well illustrating ground-water discharge by evapotranspiration.

subject to direct evaporation from the ground-water reservoir is enlarged. This factor should increase water losses from the ground-water reservoir. However, the well-defined diurnal fluctuations in water levels which characterize ground-water evapotranspiration do not appear until late May or June when plant growth begins. For example, on May 3 and 4 when fair weather and above-normal rates of evaporation prevailed, water levels declined gradually with but minor interruptions (fig. 14). On the other hand, on June 6 and 7, the presence of a definite cyclical water-level pattern indicates significant ground-water evapotranspiration. The fact that weather conditions during both periods were similar suggests that the water loss from the ground-water reservoir during June was due to increased plant activity. The nearly constant water levels during October 8–11 indicate that plant growth had practically ceased by that time.

The quantity of water discharged from the zone of saturation by ground-water evapotranspiration during a 24-hour period may be calculated from records of automatic water-stage recorders by using the following formula (White, 1932, p. 61):

$$q=y(24r\pm s)$$

where q=the depth of ground water withdrawn, in inches,
y=the specific yield of the soil, as a decimal,
r=the hourly rate of rise of the water table, in inches, from midnight to 4 a.m., and
s=the net rise or fall of the water table during the 24-hour period, in inches.

Values for r and s were obtained from recorder charts and a value of 0.25 was assumed for y, on the basis of a laboratory determination. The calculated amount of ground water withdrawn daily during the growing season ranged from zero on rainy or overcast days to as much as a quarter of an inch on several sunny days at the Sampawams Creek site. Analyses of records of water levels adjacent to Sampawams Creek shows that ground-water evapotranspiration may be as much as 8 inches a year in the 30 square miles of the Babylon-Islip area where the water table is within 5 feet of land surface. This loss of ground-water is equivalent to a discharge of approximately 1.3 inches from the entire area or about 11 mgd.

SEEPAGE INTO STREAMS

The streams on Long Island are, in effect, ground-water drains, being characteristically effluent throughout their entire length. Influent conditions are noted along reaches near pumping wells and occasionally near ponds; however, these conditions are not common in the area and the flow of most streams increases downstream owing to inflow of ground water from the zone of saturation. Because seasonal water-table fluctuations seldom exceed a few feet at the headwaters of most streams, intermittent streamflow is limited to short reaches near the source. The physical characteristics of the ground-water reservoir in combination with abundant recharge produce the well-sustained low-flow characteristics typical of most Long Island streams.

To determine the rate of change of ground-water runoff per unit of channel length (pickup), seepage investigations were made on three streams in the area. These investigations consisted of bimonthly measurements under base-flow conditions at selected sites on each stream over a 2-year period starting November 1958. In selecting the streams to be investigated, preference was given to those having the fewest tributaries; the number of discharge measurements required was thus reduced to a minimum, and a possible source of error was eliminated. The streams selected were Champlin Creek at Islip, Santapogue River at Lindenhurst, and Sampawams Creek at Babylon. In addition pickup was computed for a single channel reach of both Carlls River at Babylon and Neguntatogue Creek at Lindenhurst.

Champlin Creek.—Eight sites were chosen on Champlin Creek to determine the pickup in mean annual discharge. Mean annual discharges were computed by correlating discharge measurements made at each site with those made at the primary stream-gaging station at Islip. Pickup was then computed for the reaches between gaging sites and expressed in cfs per 1,000 feet of channel length, as shown on plate 5.

Because the upward component of ground-water movement increases toward the south shore in the vicinity of Champlin Creek, pickup theoretically should increase from source to mouth. However, plate 5 indicates that the greatest pickup was along the middle reaches; the rates were substantially lower downstream. The high pickup in the reach between Beach Street and the gaging station (pl. 5) may be attributed to increased lateral ground-water discharge, to upward movement of water from within the ground-water reservoir, or to both.

To determine the relative amount of lateral ground-water discharge, a series of shallow wells were driven along three lines oriented approximately perpendicular to the stream. These lines, labeled *A*, *B*, and *C* on figure 15, cross the stream at the Poplar Street, Beech Street, and Islip Boulevard gaging sites (pl. 5); they consist of four wells each, two on either bank of the stream. From monthly observations during the period May 1959 to December 1960, average water-table gradients of 0.7, 0.8, and 1.3 feet per 1,000 feet were obtained at lines *A*, *B*, and *C*,

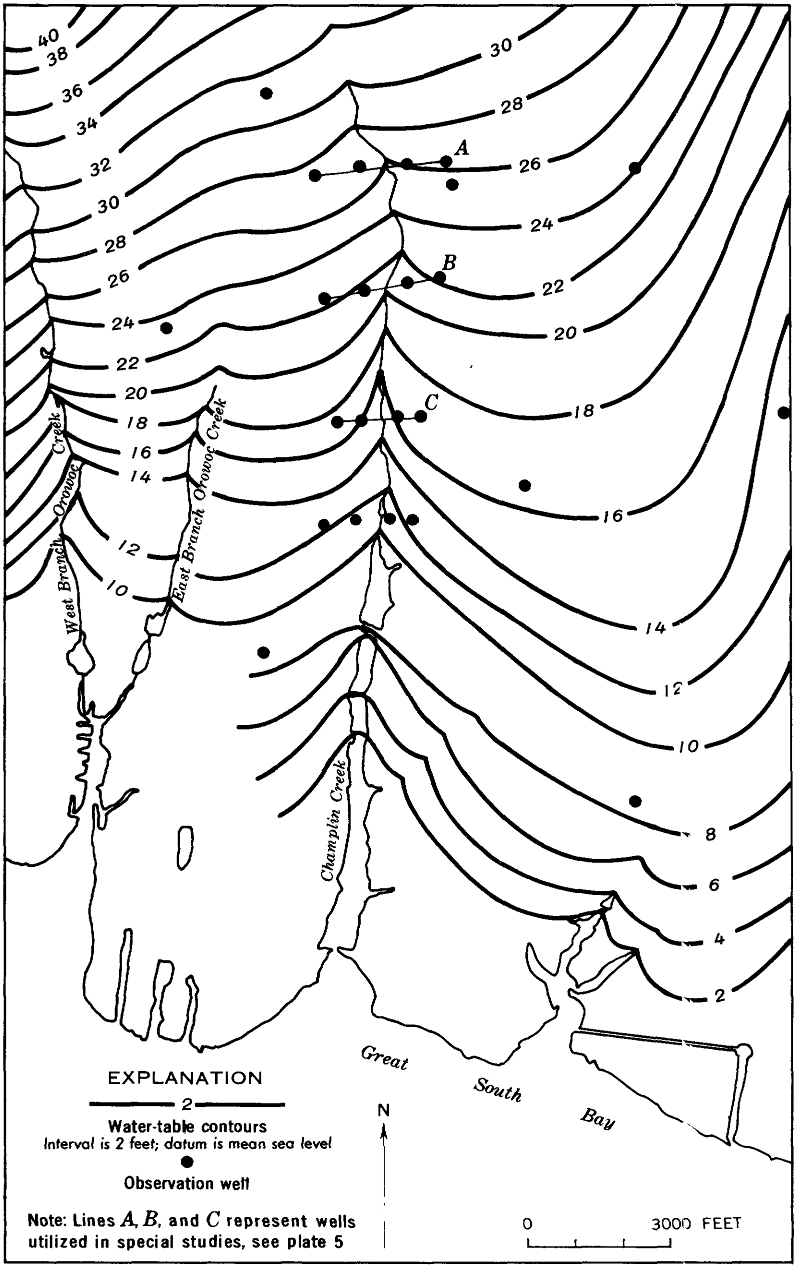


FIGURE 15.—Map of Champlin Creek area showing contours on the water table, November 1960.

respectively. In order to avoid the effect of variations in stream stage on the altitude of the adjacent water table, the hydraulic gradients were computed only between pairs of inner and outer wells. The steeper water-table slope at line *C*, illustrated by the sharp reentrant of the 16-foot water-table contour (fig. 15) corresponds to the reach of greatest pickup in streamflow. The almost uniform slope of Champlin Creek (pl. 5), in combination with the natural convex profile of the water table, tends to increase the hydraulic gradient between the aquifer and the middle reaches of the stream.

The observed changes in hydraulic gradient toward the stream may also be a result of variations in the transmissibility of the aquifer underlying the stream or in the permeability of the streambed material. Field investigations, however, indicate that the streambed is composed of sand and gravel; there is little or no silt. Moreover, from the limited data available, the assumption is made that the water-table aquifer is homogeneous and that its thickness remains about constant from the source to the mouth of Champlin Creek.

Base flow is directly related to the altitude of the water table as shown in figure 16. The points represent the average altitude of the water table in 12 wells near the stream, plotted against concurrent discharge at the gaging station on Champlin Creek. The wells are on lines *A*, *B*, and *C* and are 400 to 1,600 feet from the stream. Inasmuch as all measurements were made during periods of dry weather, the stream discharge is virtually all ground-water runoff. Because the altitude of the stream surface remains almost constant, water-table fluctuations result in changes in the hydraulic gradient toward the stream.

The distribution of plotted points about the regression line (fig. 16) is probably attributable in large measure to the slow rate of water movement through the zone of aeration. Because of differences in depth to the water table among the profile wells, if the vertical permeability is uniform throughout the area, the time required for recharge to move through the zone of aeration may vary considerably. These differences doubtless cause much of the scatter in the plotted points about the regression line.

As the water-table altitude and hence the hydraulic gradient increases, ground-water runoff increases (fig. 16). Part of the increase in streamflow pickup noted between lines *B* and *C* is caused by the steeper gradients of the water table adjacent to this reach.

Wells driven directly into the streambed at lines A, B, and C were used to determine the relative amount of upward ground-water movement into the stream. All wells were screened in the uniform glacial outwash deposits of the water-table aquifer. At each site, driving was stopped about every foot for the first 10 feet and about

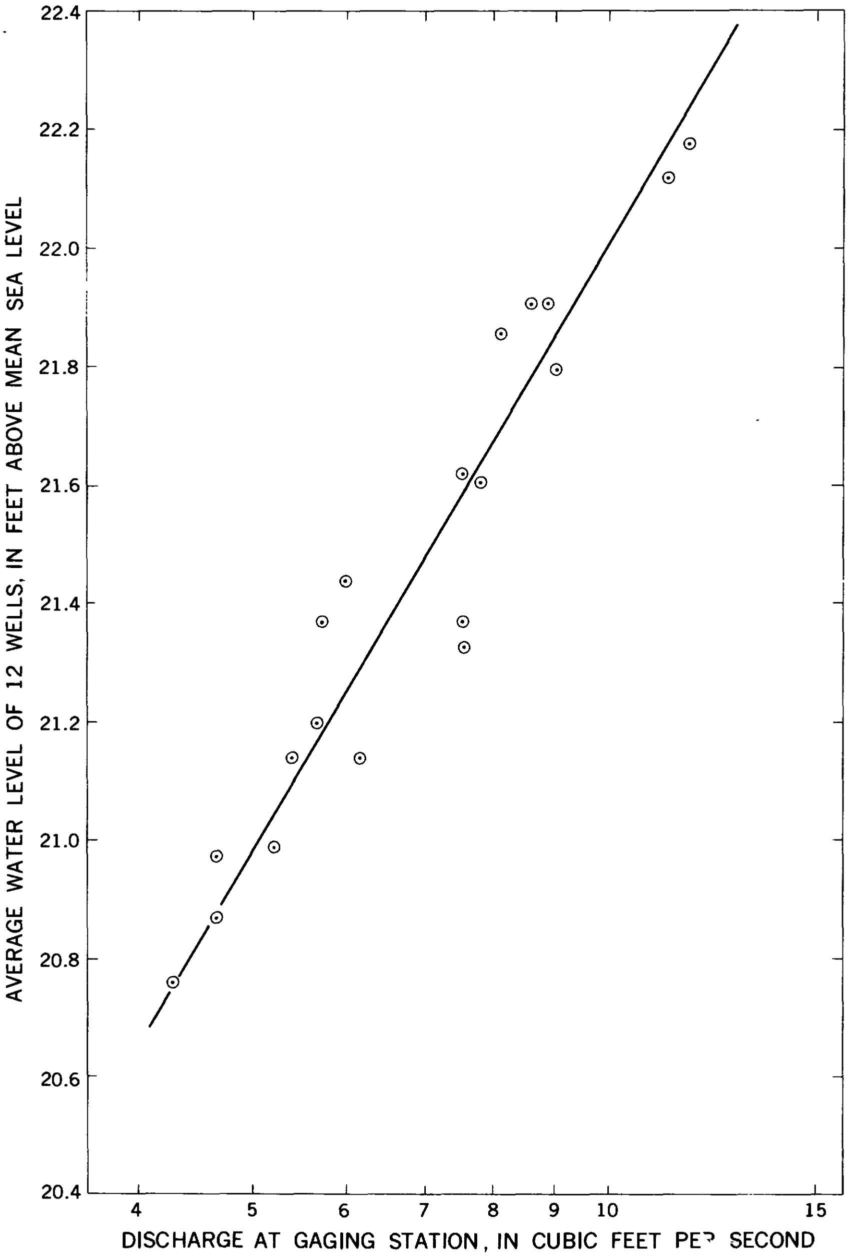


Figure 16.—Relation of average water level of 12 observation wells to discharge of Champlin Creek at Islip.

every 5 feet thereafter. The well was pumped, and after the water recovered to its static level, observations of head were made and were referred to a common datum. The head as indicated by water levels in the wells increased from about equal to the stream stage in a thin zone immediately below the streambed to half a foot higher than the stream stage at a depth of 5 feet. Below the 5-foot depth, the head in the aquifer at each site was nearly constant to a depth of at least 60 feet, where driving was stopped.

Analysis of these data suggests that, in the uppermost zone of the water-table aquifer, ground water moves toward the stream both laterally and from below and that below this upper zone the flow is nearly parallel to the stream. The absence of a measurable difference in head between 5 feet and 60 feet suggests that in this zone ground water moves almost horizontally and southward under the regional hydraulic gradient.

The stream acts as a ground-water drain that causes a reduction in hydrostatic head adjacent to its channel. The hydraulic gradient thus established between the aquifer and the stream induces water to flow toward the stream. The limiting distance from which water moves toward the stream, both laterally and from below, is controlled by the difference in head between the water table and the stream and by the permeability of the aquifer. Because the stream is shallow, most ground water discharges through the streambed.

Results of the investigation along Champlin Creek indicate that the rate of ground-water runoff is controlled largely by the height of the water table adjacent to the stream. Ground-water movement into the stream channel along the middle and upper reaches of Champlin Creek is principally lateral; little or no upward flow reaches the stream from deep within the aquifer.

Santapoque River and Sampawams Creek.—Annual discharges and pickup along selected reaches of Santapogue River and Sampawams Creek are shown on plate 5. Reaches of both streams are influenced by nearby pumping wells, and pickup has been adjusted accordingly. Adjustments were based on the average daily pumpage prior to the discharge measurements and apportioned to the affected reaches. The pickup along these streams appears similar in some respects to that of Champlin Creek. The pickup gradually increases along the upper reaches of both streams and culminates in a maximum at mid-length; thereafter the rate of pickup slowly declines. By intercepting ground water that normally would have entered the stream, the nearby pumping wells materially affect stream regimen. This effect is especially noticeable at Santapogue River when heavy pumping occurs during periods of low flow. The hydrograph for Santapogue River at such times shows a sharp downward slope, rather than the normal gentle decline typical of most Long Island streams.

Guggenheim Lake, near the upper end of Sampawams Creek, causes influent flow curing periods of low water table. Flashboards, placed at the outlet of the lake, cause an abrupt rise of about 6 feet in the stream level. This artificially high level causes a reduction in the natural water-table gradient toward the lake. When the water table falls below the relatively constant lake level, the aquifer is recharged by the lake. Influent conditions due to ponding are less common along the lower reaches of streams where water-table fluctuations are small, and the low relief precludes the construction of high-head ponds.

Carlls River and Neguntatogue Creek.—Pickup along the lower reach of Neguntatogue Creek, which is a small stream, averages about 0.6 cfs per 1,000 feet; in a 3,400-foot reach along Carlls River between the gaging station and Railroad Avenue in Babylon, pickup averages about 2.3 cfs per 1,000 feet. Carlls River, the second largest stream in the area, occupies a deeply cut valley relative to other streams on Long Island. Hence, the high inflow of ground water is due primarily to an increase in hydraulic gradient between aquifer and stream, as indicated by the sharp reentrants of the water-table contour lines (pl. 3).

Total stream discharge.—Generally, in small streams on Long Island (that is, those having mean annual discharges at head of tidewater of less than 5 cfs), pickup along middle and lower reaches may be expected to average about 0.5 cfs per 1,000 feet, in medium-size streams (mean annual discharge at head of tidewater of 5 to 20 cfs) about 1 cfs per 1,000 feet, and in large streams (mean annual discharge at head of tidewater of more than 20 cfs) about 2 cfs per 1,000 feet. Because of the normally high rate of streamflow pickup, discharge measurements had to be made at or near the mouths of all streams in order to estimate the quantity of water available in the area. A comprehensive partial-record stream-gaging program begun in Suffolk County in 1953 provided part of these data. By correlation of periodic discharge measurements obtained at partial-record sites with nearby long-term stream-gaging stations, a fairly reliable estimate of streamflow was obtained for every significant stream in the area. On the basis of these correlations, total annual streamflow from the area at the head of tidewater is estimated to be 185 cfs. After deducting that part attributable to direct runoff, the total annual base flow or annual ground-water runoff was computed to be 176 cfs, which is equivalent to about 16 inches or 114 mgd. This amount represents that part of the total annual ground-water discharge that appears as streamflow at the stream-gaging sites.

Nearly every stream in the area has tidal flow in its lower reaches. The unsteady flow conditions caused by tidal fluctuations precludes an accurate evaluation of fresh-water discharge at the mouth of each stream. The existing network of stream-gaging stations provided data for the points where the streams empty into tidewater. An assumption concerning pickup in the tidal reaches must be made in order to estimate the total ground-water runoff above the points where the streams enter Great South Bay. Examination of discharge data obtained for three streams in the area (pl. 5) indicates that pickup stabilizes in the reaches just above tidewater. The assumption was made that pickup in the tidal reaches is equivalent to pickup in the reaches just above tidewater. By determining the length of tidewater channel and multiplying by the appropriate value of pickup, an estimate of mean annual fresh-water discharge at the mouth of each stream may be obtained. Ground-water runoff to streams in the Babylon-Islip area is estimated, by this procedure, to be 21 inches or about 260 cfs.

Ground-water runoff in the area ranges from a composite annual average of 15 inches in the drainage basins west of Santapogue River to 24 inches in the Carlls River and Connetquot River basins. The range in runoff is attributed primarily to differences in the lengths of streams and the depths and widths of the valleys. The longer the stream the greater the opportunity for ground-water inflow. Deeply cut valleys increase the aquifer-stream head differential thereby extending the area from which water will move toward the stream. Connetquot River and Carlls River are the largest streams in the area and both occupy fairly well-defined valleys. These characteristics cause a convergence of ground-water flow toward both streams from a wide area.

SUBMARINE OUTFLOW

Streamflow leaving the area represents only a part of the total fresh-water discharge. An unmeasurable quantity of ground water moving through the intermediate and deep artesian aquifers never reaches the streams but is discharged offshore as submarine outflow. Submarine outflow represents the quantity of fresh ground water moving seaward beneath the north shore of Great South Bay and is a special case of underflow. Because the fresh water-salt water interface in the water-table aquifer is at the shoreline, none of the water in this aquifer is discharged as submarine outflow but rather is discharged into streams as ground-water runoff or is lost to the atmosphere by evapotranspiration.

Submarine outflow represents that part of the natural ground-water discharge which is maintaining the fresh water-salt water interface in its present (1961) position some unknown distance offshore in the intermediate-artesian and deep-artesian aquifers. A reduction in submarine outflow from the area, if maintained for a protracted period, would result in landward movement of the interface and possible salt-water contamination of part of the ground-water reservoir. A quantitative evaluation of this factor is necessary to determine the effects on the ground-water reservoir of a reduction of natural discharge resulting from pumping and environmental changes caused by urbanization.

Submarine outflow cannot be measured directly but may be computed indirectly by considering the water-balance equation of the ground-water reservoir:

$$\text{Total recharge} = \text{total discharge} \pm \Delta GW_s \qquad (1)$$

where ΔGW_s is the change in ground-water storage during a specified period. Because withdrawal from wells in the area is virtually balanced by return of water through cesspools, leaching beds, and diffusion wells and because consumptive use is negligible, these terms have been eliminated for simplicity in the following equations.

Recharge to the ground-water reservoir is defined as follows:

$$\text{Recharge} = Pr - ET - SW_x \qquad (2)$$

where Pr = precipitation,
ET = evapotranspiration, and
SW_x = direct runoff.

Discharge from the ground-water reservoir is defined as follows:

$$\text{Discharge} = GW_d + GW_u + GW_{et} \qquad (3)$$

where GW_d = ground-water discharge to streams (mean annual base flow),
GW_u = submarine outflow, and
GW_{et} = ground-water evapotranspiration.

Substituting equations (2) and (3) in equation (1):

$$Pr - ET - SW_x = GW_d + GW_u + GW_{et} \pm \Delta GW_s. \qquad (4)$$

Solving for GW_u:

$$GW_u = Pr - ET - SW_x - GW_d - GW_{et} \pm \Delta GW_s. \qquad (5)$$

All the items in equation 5 have been discussed quantitatively in previous sections except submarine outflow (GW_u) and change in ground-water storage (ΔGW_s). The change in ground-water storage from the start of the base period in October 1943 to the end of the period in September 1959 was determined from the change in the average altitude of the water level in 14 representative shallow wells. The average altitude was 46.07 feet at the start of the base period and 45.95 feet at the end, a net decline of 0.12 foot, or 1.44 inches. To determine ΔGW_s, this decline in ground-water level was multiplied by the average specific yield of the water-bearing deposits (assumed to be 0.25) and then divided by 16, the span of the base period in years. The resultant change in ground-water storage of .02 inch is insignificant, for the values of the terms in equation 5 were rounded to the nearest inch.

Mean annual precipitation on the Babylon-Islip area was computed to be 46 inches; average evapotranspiration was estimated at 21 inches; direct runoff and ground-water runoff (at the shoreline) were computed to be 1 inch and 21 inches, respectively; ground-water evapotranspiration was estimated at 1 inch. Substituting the above figures in equation 5 gives an approximate average annual submarine outflow from the area of 2 inches, which is equivalent to about 18 mgd.

Submarine outflow is equivalent to underflow at the shoreline and represents the quantity of fresh ground water discharged directly into Great South Bay or the Atlantic Ocean. Underflow at the stream-gaging stations includes not only ground water which is to be discharged as submarine outflow but also a substantial quantity of ground water which is discharged into the tidal reaches of the streams and into marshes along the shore. Mean annual ground-water runoff at the stream-gaging stations, at the head of tidewater generally about 1 mile inland from the shoreline, was computed to be 16 inches. Because water losses due to ground-water evapotranspiration occur primarily in the area within 1 mile of the shoreline, such losses may be neglected from the water-balance equation at the gaging stations. Assuming that all other factors in equation 5 remain constant, underflow at the gaging stations is estimated to be 8 inches, or about 57 mgd. More than half of this water is in the water-table aquifer and is primarily discharged, together with some upward leakage from the intermediate artesian aquifer, into tidal reaches of streams. Only about 2 inches (18 mgd) remains in the ground-water reservoir at the northern shoreline of Great South Bay. Because of upward leakage of fresh water into Great South Bay, possibly less than 10 mgd of this reaches the barrier beaches through the artesian aquifers.

An estimate of the volume of water discharged as submarine outflow south of the north shore of Great South Bay may be made also from estimated values of permeability, hydraulic gradient, and cross-sectional area of the aquifers. These parameters are mathematically related by Darcy's Law:

$$Q=PIA$$

where Q=quantity of water in gallons per day,

P=permeability of saturated material in gallons per day per square foot,

I=hydraulic gradient in feet per foot, and

A=cross-sectional area of flow in square feet (saturated thickness multiplied by width of aquifer).

The total quantity of water discharged as submarine outflow is estimated in the table below to be about 19 mgd, which is only 1 mgd more than was computed from the water-balance equation.

Aquifer	Average permeability (gpd per sq ft)	Hydraulic gradient (feet per foot)	Thickness (feet)	Width (feet)	Quantity of water (mgd)
Intermediate artesian	500	0.0003	900	110,000	14.9
Deep artesian	[1] 350	[1] .0004	[1] 250	110,000	3.8

[1] Estimated from date in Nassau County.

Because of insufficient data, the permeabilities and hydraulic gradients used in this application of Darcy's Law are subject to considerable error. The gradients were measured in a horizontal plane, and neglect vertical components of flow. On the basis of both methods, however, submarine outflow at the north shore of Great South Bay is estimated to be about 2 inches (about 18 mgd), 80 percent of which is moving in the intermediate artesian aquifer and 20 percent in the deep artesian aquifer.

QUALITY OF WATER

NATURAL CHARACTERISTICS

Fresh ground water in the Babylon-Islip area is generally soft, slightly acidic, and has a low content of dissolved solids. It is of suitable quality for most domestic and industrial uses. Table 3, a summary of the chemical quality of the ground water, is based largely on analyses made by the New York State Department of Health, the Suffolk County Water Authority, and the U.S. Geological Survey.

Hardness (expressed as calcium carbonate) of fresh water in the intermediate artesian aquifer is usually less than 10 ppm (parts per million) and in the water-table aquifer the hardness generally ranges from 10 to 50 ppm. The low hardness of the water in the intermediate artesian aquifer probably is due largely to ion exchange resulting from percolation of water through clayey zones in the aquifer. Water in the deep artesian aquifer also is probably soft, but no analyses are available.

The pH of ground water in the area ranges from 5.3 to 8.9 and is commonly about 6.0. To reduce corrosiveness, addition of alkali chemicals to the public-water supply is often necessary.

The specific conductance of 11 uncontaminated ground-water samples, which ranges from 31 to 144 micromhos at 25°C, and averages about 45 micromhos, indicates that the water has a low mineral content.

The syndet (synthetic detergent) contents shown in table 3 were determined by the Suffolk County Water Authority; they represent parts per million of alkyl benzene sulfonate (ABS), the most common anionic surfactant. Syndets are reported in parts per million to maintain consistency with common usage in the literature.

TABLE 3.—*Summary of selected chemical characteristics of ground water in the Babylon-Islip area*

[In parts per million, except pH]

	Water-table aquifer			Intermediate artesian aquifer		
	Range	Median	Wells sampled	Range	Median	Wells sampled
Iron (Fe)	0–2.50	0.05	53	0–1.72	0.46	14
Manganese (Mn)	0–.51	.10	29	none	.00	9
Chloride (Cl)	1.6–15,900	6.2	150	2.0–10.0	3.0	16
Nitrate (NO_3)	.30	2.4	69	0–17	0.05	9
Hardness (as $CaCO_3$)	5–228	20	57	0–51	5	15
pH	5.3–7.6	6.0	54	5.3–8.9	5.9	12
Syndets (ABS)	[1] <.03–2.80	.10	59	?–<.03	[1] <.03	7

[1] Lower limit of syndet determinations is 0.03 ppm.

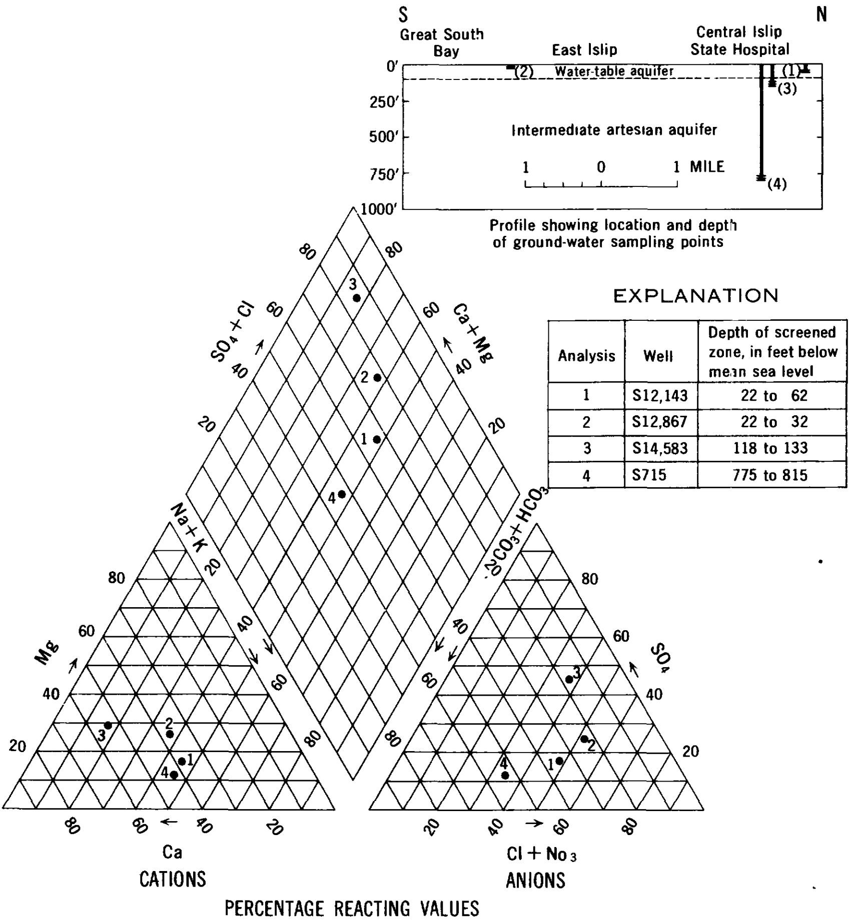
The presence of iron and manganese in ground water is due to the solvent action of water on minerals containing these elements. At shallow depths, the activity of bacteria plays an important role in the solution of iron and manganese. Iron, one of the most abundant elements in the earth's crust, is usually present in ground water in varying concentrations. Manganese is much less abundant, and its presence in ground water is generally attributable to bacterial action. Water from some shallow wells along the south shore of the area has iron and manganese concentrations in excess of 0.3 ppm and 0.05 ppm, respectively, the preferred limits prescribed by the U.S. Public Health Service (1961, table 1). Concentrations of iron in excess of 0.3 ppm with no associated manganese may occur at places in all aquifers (for example, analysis 4, table 4), and are probably attributable to the presence of iron-bearing minerals or iron oxide within the aquifers. Water containing combined iron and manganese concentrations greater than 0.3 ppm may discolor fabrics and plumbing fixtures.

Because of proximity to salt water, precipitation falling on the area generally contains chloride concentrations ranging from 2 to 10 ppm, but under unusual conditions the concentrations may be greater. Normally, ground water may be expected to have a range in chloride content similar to that of precipitation. The chloride content of water in the water-table aquifer is generally 5 to 6 ppm in areas more than about 2 miles inland from Great South Bay. Closer to the bay, concentrations of 10 to 15 ppm are common. As much as 16,000 ppm of chloride may occur in water in the water-table aquifer under and bordering Great South Bay and the tidewater reaches of streams. Salt water also underlies the fresh-water bodies in the water-table aquifer under the barrier beaches. In areas remote from natural salt-water bodies, chloride concentrations greater than normal in the water-table aquifer may represent contamination from sewage, fertilizers, or from rock salt used for deicing highways.

The chloride content of water in the artesian aquifers is generally lower than that in the water-table aquifer. However, salt water is probably present in the artesian aquifers some distance seaward from the barrier beaches. The record of well S12 (Leggette and others, 1938, p. 16) illustrates the relation of fresh to salty water under the barrier beaches. In drilling this well, fresh water of poor quality was found immediately below land surface to a depth of 31 feet. The fresh water was underlain by salt water which extended to a depth of 90 feet. The Gardiners Clay and the clay of the Magothy(?) Formation from 90 to 149 feet prevented downward leakage of salt water, and fresh water under artesian pressure was found beneath the clay to a depth of 315 feet, where drilling was terminated.

Nitrates (NO_3) in ground water are initially introduced into the soil by nitrogen-fixing plants, plant debris, animal wastes, and by most inorganic fertilizers. Nitrate concentrations as high as 30 ppm have been found in ground water in the area; however, the nitrate content in the water-table aquifer is commonly about 2.5 ppm, and in the intermediate artesian aquifer about 0.05 ppm. Nitrate concentrations in excess of 44 ppm are believed to be injurious to infants (Hem, 1959, p. 239).

The results of four chemical analyses of ground water are shown in table 4. Analysis 1 is probably typical of water obtained from the water-table aquifer in inland portions of the area. Analysis 2 represents water from the water-table aquifer in the area close to Great South Bay. Analyses 3 and 4 represent water from the upper and lower



Analysis	Well	Depth of screened zone, in feet below mean sea level
1	S12,143	22 to 62
2	S12,867	22 to 32
3	S14,583	118 to 133
4	S715	775 to 815

FIGURE 17.—Water-analysis diagram of four samples of ground water from the Babylon-Islip area.

zones of the intermediate artesian aquifer. Slightly higher than normal concentrations of sulfate, nitrate, and some other constituents reported in analysis 3 suggest local contamination. The four wells sampled lie approximately on a straight line in the general direction of ground-water flow. Figure 17 shows the relationship of the wells and a water-analysis diagram of the principal anions and cations in each sample. In a trilinear plot such as figure 17, the analysis of a mixture of two waters should plot on a straight line between the parent waters in all three fields. Movement and mixing of water within the ground-water reservoir is not strictly analogous to the mixing of two original waters because water moving through the ground may change in chemical composition. Nevertheless, the trilinear plot affords a graphic method for comparing quality of water data.

Although lack of data precludes definite conclusions, the general pattern of flow within the ground-water reservoir (fig. 13) and the chemical data on figure 17 suggest that water represented by analysis 2 may be an approximate mixture of waters represented by analyses 1 and 3. That is to say, water in the water-table aquifer near the south shore may be chemically altered from that normally found inland by the addition of water from the upper part of the intermediate artesian aquifer. Water from the lower part of the ground-water reservoir discharges primarily into Great South Bay and the Atlantic Ocean.

TABLE 4.—*Chemical analyses of four ground-water samples from the Babylon-Islip area*

[Analyses by U.S. Geol. Survey; chemical constituents in parts per million; all samples collected March 7, 1961]

Constituent	1	2	3	4
Silica (SiO_2)	10	9.6	15	7.8
Iron (Fe)	.01	.41	.01	.47
Manganese (Mn)	.0	.1	.0	.0
Calcium (Ca)	3.6	5.8	13	2.6
Magnesium (Mg)	.8	2.3	4.4	.4
Sodium (Na)	4.4	5.9	4.8	2.9
Potassium (K)	.7	1.2	.8	.5
Bicarbonate (HCO_3)	10	11	11	10
Carbonate (CO_3)	0	0	0	0
Sulfate (SO_4)	3.5	9.4	25	1.6
Chloride (Cl)	5.8	10	9.0	3.8
Fluoride (F)	.0	.0	.0	.0
Nitrate (NO_3)	3.8	6.4	17	.0
Dissolved solids (residue on evaporation at 180° C)	37	56	97	24
Hardness as $CaCO_3$	13	24	5[illegible]	8
Noncarbonate hardness as $CaCO_3$	5	15	42	0
Specific conductance (micromhos at 25° C)	51	90	144	31
pH	6.0	5.7	6.2	5.9
Color	1	1	1	2
Temperature (°F)	50.8	54.8	53.0	55.6

1: S12143; depth 117 feet; screened in water-table aquifer.
2: S12867; depth 47 feet; screened in water-table aquifer.
3: S14583; depth 180 feet; screened in upper part of intermediate artesian aquifer.
4: S715; depth 865 feet; screened in lower part of intermediate artesian aquifer.

CONTAMINATION

Contamination of the ground-water reservoir may take place by landward movement of naturally occurring salt water within the aquifers or by the introduction of contaminants at the surface. Because salt water is found under natural conditions in parts of all three aquifers, salt-water encroachment may occur wherever fresh and salt water are not in hydrodynamic balance. If the water table or piezometric surfaces are lowered so that heads at the fresh water-salt water interface are reduced, the interface will move landward, and salt water may eventually reach wells being utilized for water supply. Sea-water contamination has not yet occurred in the area, but a substantial increase in net withdrawal could eventually cause sea water to move landward over a wide area along the south shore.

Such encroachment probably would occur first in the lower part of the intermediate artesian aquifer beneath the barrier beaches.

Contamination of ground water has already occurred as a result of the introduction of waste products from sewage and industrial waste disposal systems. Minor amounts of arsenic, cadmium, chromic acid, copper, cyanide, hexavalent chromium, muriatic acid, nickel, nitric acid, phosphoric acid, potash, synthetic detergents, and zinc have been introduced into the ground locally by industrial wastes (J. Flynn and A. Andreoli, Suffolk County Health Department, written communication, 1958). Disposal of industrial wastes is under the jurisdiction of the Suffolk County Department of Health, and efforts are being made to reduce or eliminate the discharge of toxic contaminants into the ground. Chloride, nitrate, bacteria, viruses, synthetic detergents, and other contaminants are introduced into the ground by domestic sewage disposal. Because of the natural filtering action of the aquifers, contamination of a water supply by sewage can be generally reduced or avoided by locating domestic and public-supply wells as far as possible from sources of contamination.

As of June 1960, the principal source of industrial contamination in the area was 46 laundries that collectively discharged more than 8,500 pounds of syndets per month into the ground-water reservoir in concentrations ranging from 50 to 150 ppm (New York State Water Pollution Control Board, 1960). In addition to this source of syndets, it is estimated that the average household laundry unit utilizes 8.5 pounds of syndets per month (Flynn, and others, 1959, p. 1560), all of which is discharged into the ground through cesspools.

Synthetic detergents consist of a surface-active agent or surfactant, a dehydrated phosphate, sodium silicate, bleaches, and other minor constituents (Flynn and others, 1959, p. 1554–1555). The surfactants, comprising 20 to 40 percent of the detergent, are not subject to biochemical degradation and thus persist in the ground-water reservoir once they are introduced. Surfactants may be classified as anionic, cationic, or nonionic. Anionic surfactants are most common and their presence in a water sample is detectable by several analytical methods. Cationic and nonionic surfactants are not detectable by laboratory methods currently employed. Because use of nonionic surfactants in commercial detergents is increasing because of their low-foam characteristics, syndet analyses are actually minimum figures for total surfactant concentrations.

Concentrations of 1.5 ppm or greater of syndets in water cause foaming and generally are unpleasant to taste (Flynn and others, 1959, p. 1559). The U.S. Public Health Service (1961, table 1) has set 0.5 ppm as the maximum concentration of syndet in drinking water wherever more suitable supplies are available; however, it does not consider syndets to be directly injurious to health (Hopkins, 1961, p. 947).

Plate 6 illustrates the relation of syndet concentrations in streams and selected wells to population density. The syndet concentrations are the average of three samples collected in March and September 1960 and in March 1961. Shaded areas adjacent to stream channels indicate the approximate area contributing ground water to the streams during a 5-year period; hence, under natural conditions, ground water may require an average of about 5 years to reach the stream from a point on the periphery of the shaded area. Since 1946, synthetic detergents have progressively replaced soap for laundry use. This fact, in combination with a rapidly expanding population in the area, especially since 1950, has greatly increased the amount of syndets added to the ground-water reservoir. Owing to the slow movement of ground water, the bulk of these syndets probably has not yet reached the streams, and an increase of both syndet concentration and load in the streams may occur in the future.

Wells in populated areas in general have higher syndet concentrations than those in less densely populated areas. Because of the pattern of movement of the contaminated water, scattered sampling of wells shows only a casual relation of syndet contamination to population density. From their point of introduction, syndets move with ground water in the direction of the natural hydraulic gradient. Because these slugs of syndets travel with ground water, lateral spreading has probably been limited in the short time since their introduction, and wells not directly in the path of such slugs would give no indication of contamination. On the other hand, a random stream sample is an integration of all the ground water entering the stream above the sampling site. Therefore, a stream sample provides a fairly good indication of contamination in the drainage basin, but does not reveal the specific course.

The concentration of syndets in streams (pl. 6) is greatest in the western part of the area and decreases to the east, where the population is smaller. An exception to the high syndet concentration noted in the western part of the area is the concentration in Carlls River. Although syndet concentrations average 0.3 ppm or slightly more in adjacent streams, Carlls River has an average concentration of only 0.15 ppm. The river flows for nearly its entire length through a park, and therefore population density is considerably less than in nearby, highly urbanized drainage basins. Furthermore, the stream receives considerable inflow from the thinly populated northern part of the area. The lower density of population manifests itself in the relatively low concentrations of syndets in the river. Paradoxically, Carlls

River carried the largest syndet load (32 lb per day) of any single stream in the area despite the relatively low concentration, for the syndet load is a function not only of the concentration of syndets but also of the discharge of the stream. The large ground-water runoff to the stream substantially offsets the effect of the lower concentration of syndets.

The syndet concentrations in ground water adjacent to Champlin Creek and in the creek are illustrated in figure 18. The syndet concentration of water in the stream is a function of the concentration in the ground water which is seeping into the stream channel above the sampling point. For example, ground water along Islip Boulevard, which has a high syndet concentration and moves toward the stream in the directions shown by the arrows in figure 18, causes the sharp increase of syndet concentration in the stream at the gaging station. On the other hand, the slight decrease in syndet concentration in the stream at Beech Street apparently is the result of an absence of syndets in the ground water between Poplar Street and Beech Street. Generally, syndet concentrations in streams of the area increase toward the mouths because population densities are higher near the south shore.

Samples of ground water obtained a short distance apart may show a high variability in syndet concentration, but stream samples exhibit far more uniformity. The maximum difference in ground-water syndet concentration in wells along Islip Boulevard is about 1.5 ppm in a distance of less than half a mile (fig. 18); however, the extreme difference in stream samples is about one-tenth as much in a distance of almost 2 miles.

Syndet load is a function of both syndet concentration and stream discharge. Therefore, the rate of increase in syndet load along the stream is, in part, governed by the rate of ground-water seepage (pickup) into the stream. Owing to the high rate of ground-water seepage into the stream, syndet load increased at a faster rate than syndet concentration from the source to the mouth of Champlin Creek. Because all streams in the area are characteristically effluent, syndet load will increase downstream as long as some syndets are present in the ground-water runoff.

A study by the New York State Water Pollution Control Board (1960, p. 14) and results of analyses of water in U.S. Geological Survey observation wells in the Town of Babylon indicate that syndet contamination is confined to the water-table aquifer. (See also table 3.) It is estimated that about 6,000 pounds of syndets per month are discharged to streams and that as much as 1,000 pounds of syndets per month are discharged as underflow from the water-table aquifer in the area, a total discharge of 7,000 pounds of syndets per month.

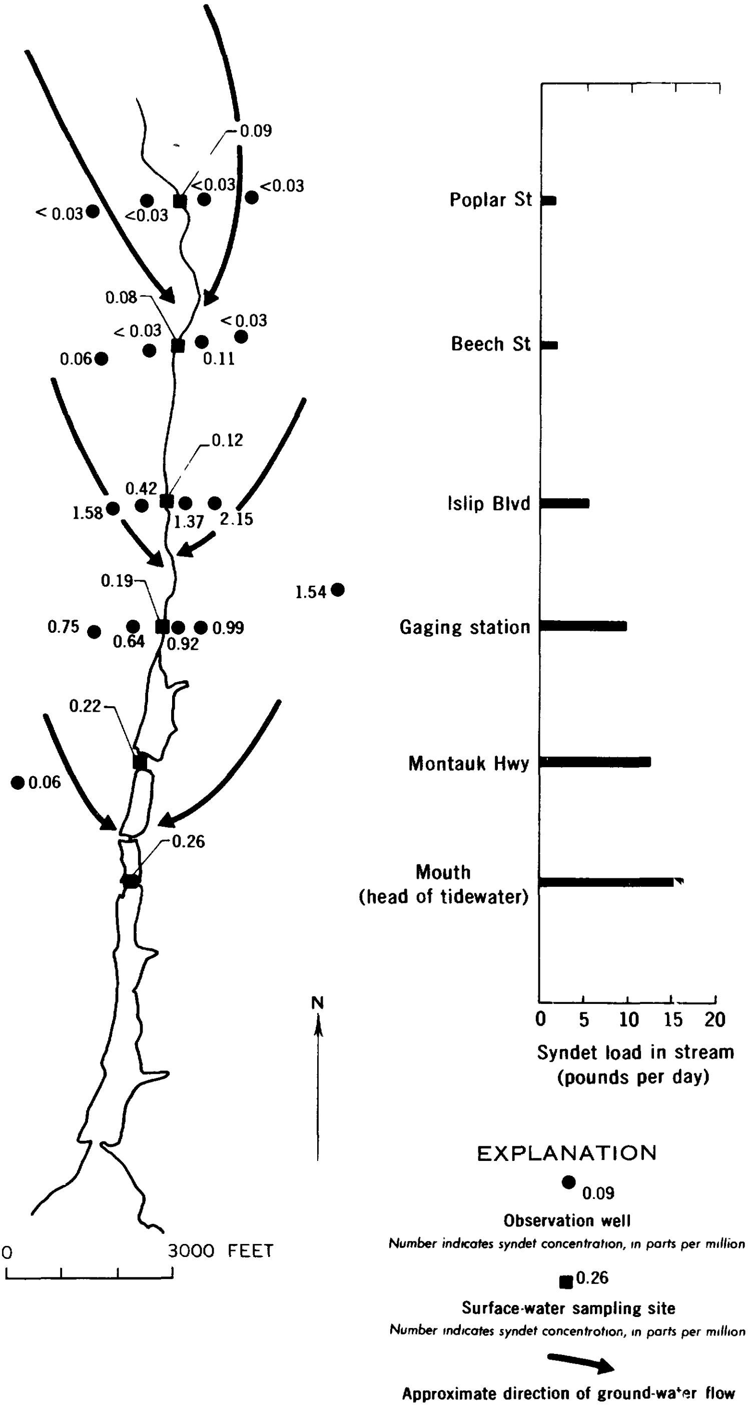


FIGURE 18.—Average syndet concentration and load of Champlin Creek at Islip, and average syndet concentration of water in nearby wells.

This discharge, however, is much less than the amount of syndets introduced, for more than 8,000 pounds of syndets are used by commercial laundries per month, and probably a far greater amount is used in home laundries. Part of the discrepancy between the amount of syndets introduced and discharged may be explained by the inability to detect the presence of nonionic and cationic surfactants by current laboratory techniques. Because of the low velocity of ground-water flow, however, it is a reasonable assumption that the syndet concentration will gradually increase at the sampling points for some years to come.

TEMPERATURE

GROUND WATER

The temperature of ground water depends upon numerous interrelated factors, of which the most important are internal heat of the earth, air temperature, depth below land surface, quantity and seasonal distribution of recharge, and pattern of movement of the ground water.

The geothermal gradient at Brookhaven National Laboratory in central Suffolk County is equaivalent to an increase in temperature of about 1°F per 100 feet of vertical descent (Wallace deLaguna, written communication, 1956). The studies at Brookhaven suggest also that internal heat of the earth is the predominant factor governing the temperature of ground water below depths of about 300 to 400 feet; however, above these depths, the warming effect of the atmosphere and of recharge becomes increasingly significant.

The insulating effect of the overlying material sharply reduces the effect of large diurnal and seasonal changes in air temperature on the temperature of the ground water, and causes extremes of ground-water temperature at shallow depths to lag extremes of air temperature by about 2 months. As the depth to the water table increases, greater insulation is provided by the zone of aeration; however, this zone is never completely effective in eliminating the effects of air temperature.

To determine the effect of depth and other factors on seasonal gound-water temperatures, monthly observations were obtained during a 2-year period beginning May 1959 at the 12 shallow profile wells adjacent to Champlin Creek and also at a 60-feet well driven in the streambed at line *B* (fig. 15). Temperatures were obtained from a specially designed minimum-maximum thermometer fabricated to pass into a 1½-inch well casing. The 12 profile wells were screened at depths ranging from 8 to 17 feet below land surface. Three of the wells (A–2, A–3, B–2 in fig. 19) are in wooded areas, and the others are primarily in residential areas.

The decrease in the magnitude of the annual temperature fluctuations with depth is shown in the graph in the lower left corner of figure

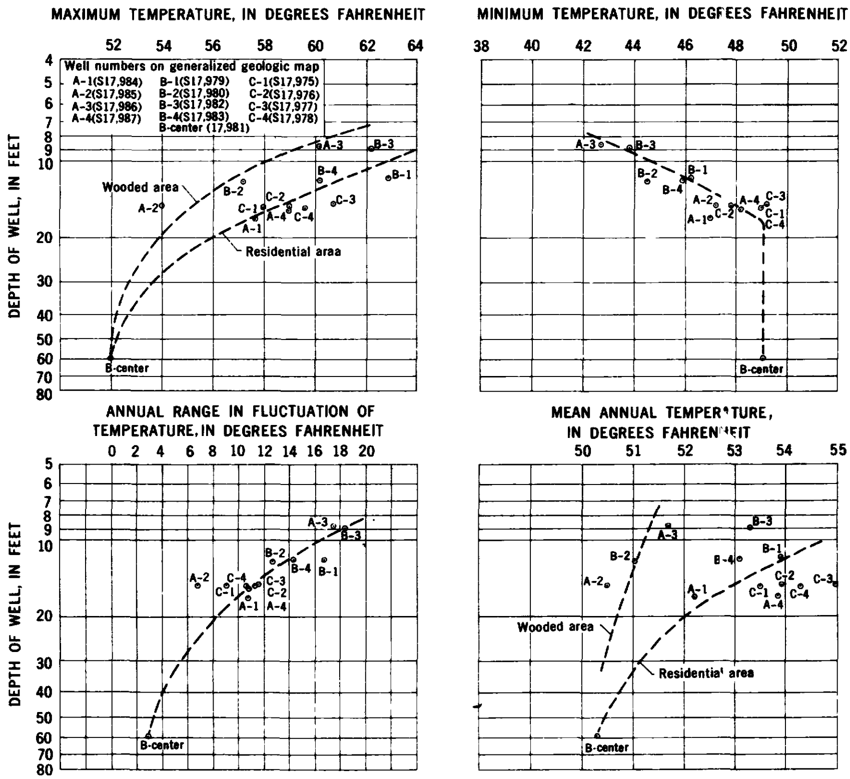


FIGURE 19.—Relation of ground-water temperature to depth of wells near Champlin Creek.

19. The annual range in fluctuation of temperature decreases from about 18°F at 9 feet below land surface to about 3°F at 60 feet below land surface. The insulating effect of the earth material is evident from the fact that the air temperature may have an annual range of about 100°F. The annual range in temperature of the water probably continues to decrease below the 60-foot depth and, at some unknown depth, the temperature probably is nearly constant throughout the year.

Mean annual air temperature in the area is about 51°F and mean annual ground-water temperature in wooded areas is about the same; however, mean annual ground-water temperature in residential areas is 1° to 4°F higher. This discrepancy is the result of higher ground-water temperatures in residential areas during the summer.

The graphs in the upper left corner of figure 19 show that the maximum temperature of ground water under wooded areas, to depths of about 20 feet below land surface, may be 3° to 5°F cooler than the temperature under residential areas. Opportunity for absorption of solar energy by soils in residential zones is greater, principally because of the relative absence of shade and the insulating layer of organic material commonly on the land surface in wooded areas. Higher soil temperatures increase the amount of heat exchange between the zones of aeration and saturation under residential areas, and thereby cause higher ground-water temperatures. Recharge of the aquifer by cesspools may also raise ground-water temperatures in residential areas; however, inasmuch as appreciable amounts of natural recharge are required to cause even slight changes in temperatures, the relatively small contribution from cesspools probably has little effect.

Variation in minimum ground-water temperatures among the wells, shown by the graph in the upper right corner of figure 19, is much less than that noted for maximum temperatures. Although the water in wells A-2, A-3, and B-2, which are in wooded areas, generally has lower minimum temperatures than the water in wells of comparable depths in residential areas, the differences are not significant. During the winter, the sun's low altitude, short length of day, higher percentage of cloudiness, and occasional snow cover, tend to minimize variations in absorbed solar energy between wooded and residential areas. Consequently, the heat exchange between the zones of aeration and saturation is not altered to any great extent, and only small differences are noted in minimum temperatures of ground water under both types of land surface. These minor thermal variations further indicate that cesspool effluent has little effect on ground-water temperature.

To determine the factors which may cause interruptions of short duration on the normally smooth ground-water temperature regimen, a continuous record of temperature in a 7-foot well adjacent to the Sampawams Creek gaging station was obtained. Depth to water at this point is only 1.8 feet, and the probe of the recording instrument was placed 5.5 feet below ground surface. The recorder was in operation for a 2-year period beginning December 1958.

Records obtained from this well demonstrate that diurnal fluctuations in ground-water temperature occur only on days having large variations in air temperature during the spring and summer. The maximum range in ground-water temperature on these days is about 1°F. The relatively high altitude of the sun in spring and summer permits greater absorption of solar radiation by the soil thereby raising the temperature of the soil and, at shallow depths, causes a slight rise in the temperature of the ground-water reservoir. Lesser amounts of solar radiation and occasional periods of snow cover result in a small diurnal range in soil temperatures during fall and winter. This small range of soil temperature does not permit sufficient variation in the heat exchange between soil and ground water to cause noticeable changes in ground-water temperature.

In general, ground-water temperature at shallow depths is unaffected by the alternate passage of warm and cold air masses. A notable exception occurred during September 1959 when record-high air temperatures early in the month raised the ground-water temperature in the shallow well at Sampawams Creek to its highest level of the season (64°F). A sharp drop in air temperature during a period of 7 days in mid-September lowered ground-water temperatures by 4°F. Another period of unseasonably high air temperature extending over a 10-day period at the end of the month and persisting into early October resulted in a rise of nearly 3°F in ground-water temperature.

Water recharging the water table may also cause temperature changes in the upper part of the zone of saturation. The amount of change depends primarily upon the temperature and quantity of the recharge. The temperature of natural recharge is dependent on air temperature and on heat gained or lost in passing through the zone of aeration. Initially, the temperature of precipitation infiltrating into the ground may be significantly different from that of normal ground water; however, as it moves through the zone of aeration its temperature is doubtless modified considerably. This modification generally tends to reduce the difference in temperature between the recharge and the ground water. If, however, the seasonal distribution of recharge is such that disproportionate amounts occur either in the summer or winter, then the regimen of ground-water temperature will be affected. For example, if heavy recharge occurs during the winter, then ground-water temperature at shallow depths may be lower than normal; conversely, heavy recharge during the summer may result in higher than normal ground-water temperature.

Fewer abrupt changes in ground-water temperature due to recharge were noted than might be expected. The excessive rainfall in connection with the hurricane of September 12, 1960, occurred when the air temperatures ranged from 65° to 69°F and when the temperature of the ground water in the shallow well near Sampawams Creek was about 59°F. If it is assumed that the temperature of rain approximates that of a wet-bulb thermometer, it may be concluded that the temperature of rain during the hurricane was equivalent to air temperature, for relative humidity was almost 100 percent. It is inferred from this relation that the temperature differential between precipitation and ground water may have been about 6° to 10°F. Despite this difference, the ground-water temperature rose only about half a degree in the shallow well. Modification in the temperature of water in its passage through the zone of aeration and mixing with the main body of ground water are factors which tend to minimize variations in ground-water temperature resulting from recharge.

Recharge due to influent conditions, noted in a few places near ponds along the upper reaches of some streams, may affect local ground-water temperatures. These conditions, although rare, are most pronounced during periods of low flow, which usually occur during the late summer or early fall. Because pond temperatures at that time are generally higher than the temperature of water in the upper part of the zone of saturation, infiltration from ponds may raise ground-water temperature locally.

Artificial recharge by diffusion wells also tends to raise ground-water temperatures locally. Because most water recharged in this manner has passed through air-conditioning systems, hence the warming effect is most pronounced during the summer.

The rapid industrialization occurring in many parts of Long Island has caused an increase in the use of ground water for air-conditioning. Because ground-water temperatures at shallow depths average about 51°F and show only minor fluctuations throughout the year, well water is commonly used as a coolant in air-conditioning systems. The maximum water temperature desirable for a cooling and dehumidifying system utilizing well water is about 55° to 60°F. The graph of maximum temperature on figure 19 shows that, to ensure a supply of ground water of suitable temperature for use as a coolant, wells should be screened below the uppermost part of the zone of saturation. Some wells screened as deep as 45 feet below land surface in highly urbanized parts of the area have yielded water having a temperature as high as 61°F. However, such anomalies are rare and wells screened in the water-table aquifer below a depth of 50 feet generally yield water having a temperature suitable for cooling.

Water pumped for cooling purposes at rates greater than 40 gpm must be returned to the aquifer tapped by the supply well according to regulations of the New York State Water Resources Commission. Because the temperature of this recirculated water is increased, the recharge well should be placed as far down the hydraulic gradient from the supply well as possible, and should be screened at a different depth to prevent or retard the recirculation of the warm water.

SURFACE WATER

Temperatures of streams on Long Island occasionally vary widely on the same day, and significant temperature variations have been noted also between points on the same stream. Large ground-water inflow characterizes all streams, and stream temperatures are greatly influenced by ground-water temperatures. Two representative streams in the area, Sampawams Creek at Babylon and Champlin

Creek at Islip, were studied to determine the relative effects of air and ground-water temperatures on stream temperatures.

At the Sampawams Creek gaging station a thermograph was installed to obtain air, stream, and ground-water temperatures simultaneously; at the Champlin Creek gaging station a continuous recorder was installed to obtain stream temperature and water stage. Expanded scale thermometers were used to obtain water-temperature observations manually at other sites.

The size and location of ponds, amount of ground-water inflow, and channel slopes of Champlin and Sampawams Creeks are indicated on figure 21. Pondage is mainly confined to the lower reaches of Champlin Creek below the gaging station. On Sampawams Creek one large pond and several smaller ones lie upstream from the gaging station, and there is a large one downstream at Montauk Highway. Ground-water inflow is small in the upper reaches of both streams; however, pickup increases sharply along the middle reaches and then gradually decreases downstream.

Because of the direct contact between atmosphere and stream surfaces the highest stream and air temperatures occur in the same month, as do the lowest stream and air temperatures. The insulating effect of the soil causes extremes in ground-water temperature to lag by two months behind extremes in air temperatures. For example, as indicated in figure 20, air temperatures were highest in July and August, stream temperatures in July, and ground-water temperatures in September. Air and stream temperatures were lowest in January, and ground-water temperatures were lowest in March.

The larger total area of ponds above the Sampawams Creek gage resulted in a variation in mean monthly temperature of 28°F in contrast to a variation of 18°F at the Champlin Creek gage. The variation in absolute extreme temperatures for the period of record at the Sampawams Creek gage was 45°F and at the Champlin Creek gage 33°F. During the summer, ponds cause a rise in stream temperature by absorbing greater quantities of heat from the sun, but during the winter ponds cause a decline in stream temperatures because of increased loss of heat to the colder air.

Large ground-water inflow sharply reduces the seasonal variation of temperature along the middle reaches of both streams. This effect is shown by temperature observations made on Champlin Creek (fig. 21). These observations indicate that the variation in stream temperature is less than 20°F at Walnut Street and at Islip Boulevard where the rate of ground-water inflow is high and that the variation is greater upstream and downstream from these points. For example, a low rate of ground-water inflow resulted in a variation of stream temperature of 30°F at Poplar Street. Reduced ground-water

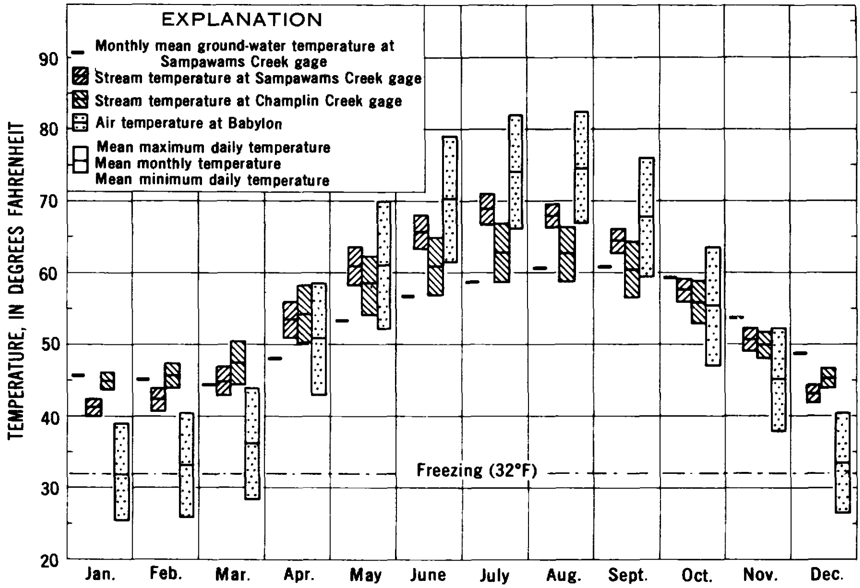


FIGURE 20.—Comparison of monthly and daily temperatures of Sampawams and Champl'n Creeks with temperatures of air and ground water.

inflow, combined with a large increase in ponded area, resulted in a variation in temperature of 43°F at the mouth of the stream.

Variations in solar radiation during the year cause a greater diurnal fluctuation in stream temperature in the spring and summer than in the fall and winter. In the fall and winter, when days are short and cloud cover is at a maximum, temperature fluctuations are small. In the spring, when days lengthen and cloudiness decreases, greater absorption of solar energy produces higher stream temperatures in the daytime, whereas inflow of cold ground water depresses temperatures of the streams at night.

The frequent passage of air masses of contrasting temperature over Long Island produce almost immediate reactions in stream temperature, the widest temperature changes being noted in streams having the largest ponded area. For example, movement of a cold air mass over the area on June 10, 1959, brought an abrupt end to an early-season heat wave and also caused stream temperatures to decline. The drop in mean daily air temperature in Babylon of nearly 20°F resulted in a decline of 10°F in the temperature of Sampawams Creek and a decline of only 5°F in Champlin Creek, which has a smaller total ponded area upstream.

The diurnal temperature pattern which a stream develops is governed principally by the amount of cloud cover, particularly during daylight hours. On a cloudy day, July 14, 1959, stream

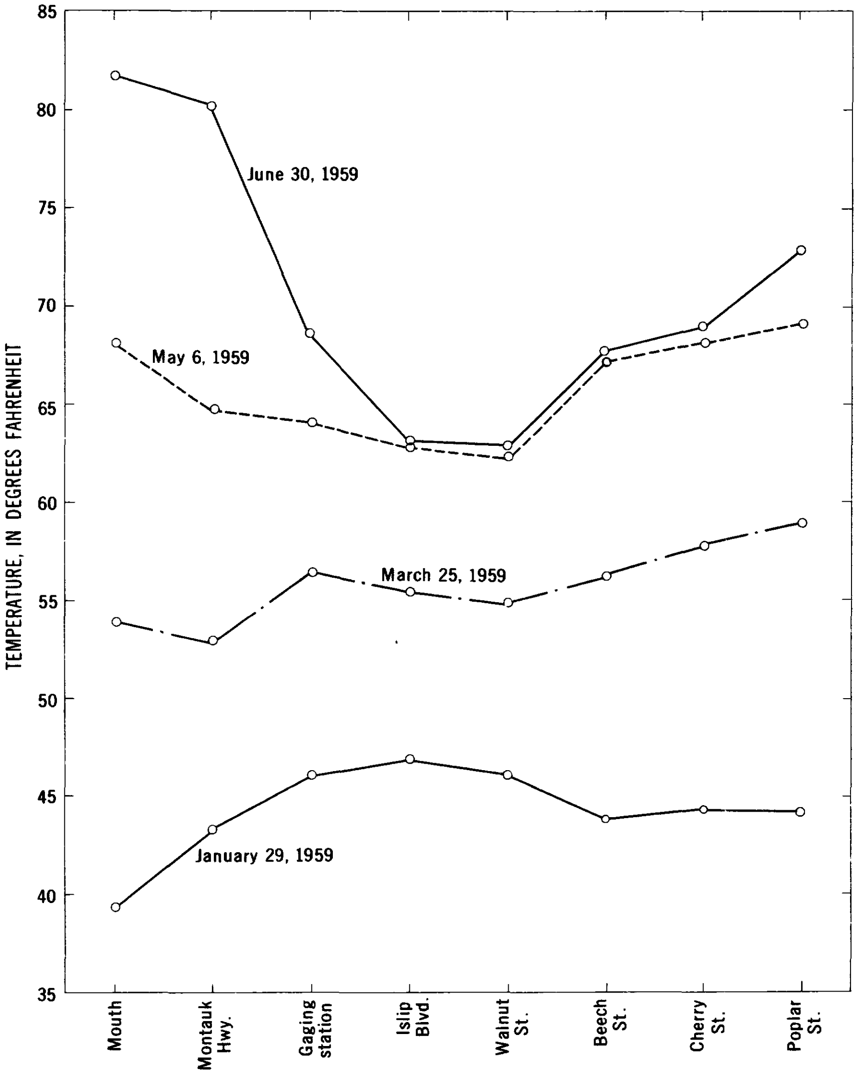


FIGURE 21.—Temperature of Champlin Creek in the early afternoon on selected days.

temperatures of Sampawams Creek at two of the three sites (fig. 22) dropped gradually throughout most of the day, but at one site they increased slightly. On a sunny day, August 13, 1959, a definite warming of the air at each site between 8 a.m. and 3 p.m. was followed by a gradual drop in temperature. The large range in stream temperature of 17°F observed at Bay Shore Road on August 13 was due to the influence of a small shallow pond just upstream. The pond is small enough to have its contents completely replaced overnight

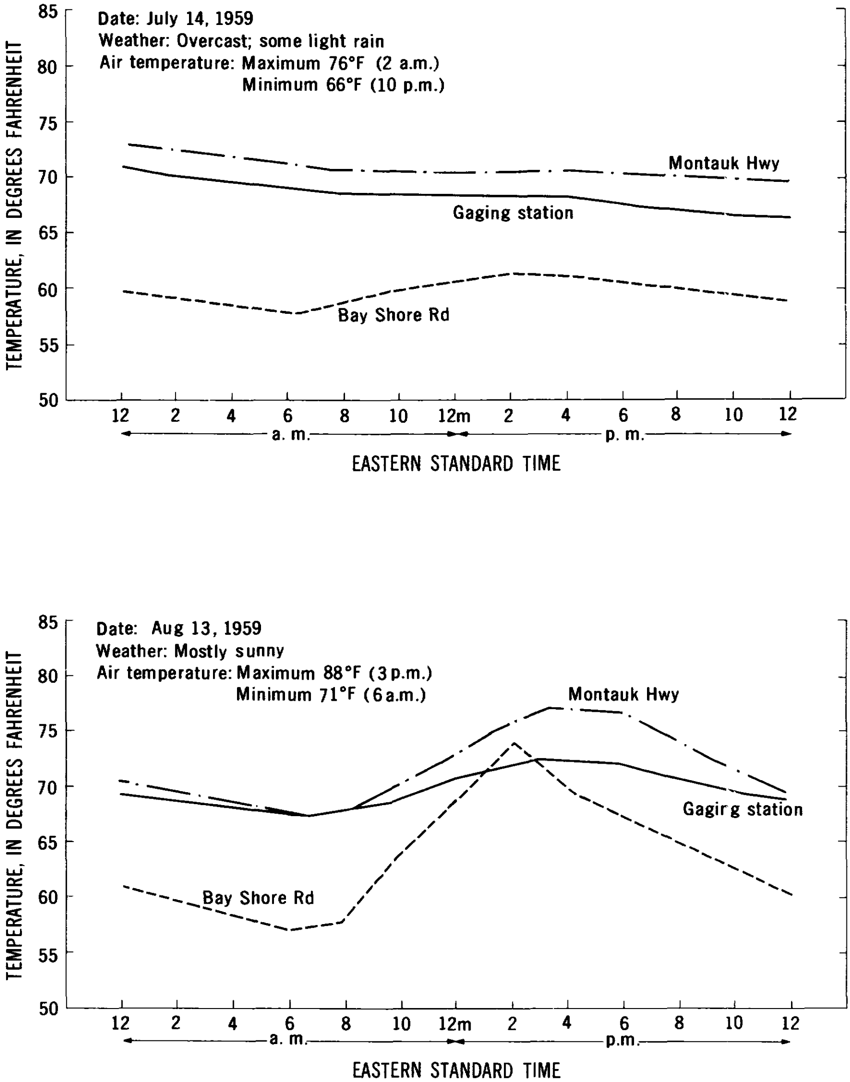


FIGURE 22.—Daily temperature variations of Sampawams Creek.

by cool ground-water inflow. On sunny days the upper part of the pond is rapidly heated and its discharge produces a sharp temperature rise.

Storm-sewer discharge just upstream from the Champlin Creek gage produces minor variations in stream temperature, but similar changes do not appear at Sampawams Creek because little, if any, storm water enters the stream for some distance above the gage.

Rainfall intensity, relative quantity and differences in temperature of storm water and streamflow, and distance between upstream storm-water outlets and the measurement site are the principal factors affecting variations in stream temperature due to direct runoff.

Sharp interruptions in the normally smooth diurnal stream temperature regimen have been noted at Champlin Creek at times when upstream regulation abruptly reduces streamflow. The magnitude of these variations may exceed 10°F when the regulation occurs during daylight hours on sunny days. Regulation effectively decreases streamflow and thereby partially drains the reach just upstream from the gage. The relatively cool ground-water inflow between the point of regulation and the gage rapidly becomes the principal source of flow past the gage, and temperature in the stream declines sharply. Stream temperatures quickly recover to normal levels after the stored water is released.

The combination of high rate of ground-water inflow and little or no upstream pondage tends to raise stream temperatures in winter and lower them during the summer; low inflow and pondage produce the opposite effect. The diurnal fluctuation in stream temperature depends on the absorption of solar energy; however, ground-water inflow tends to minimize temperature fluctuation. Minor interruptions in the natural pattern of stream temperature may result from nearby upstream regulation or from storm-sewer discharge.

LOW-FLOW CHARACTERISTICS OF STREAMS

Although streams have not so far been utilized for water supply in the area, the large flow suggests their potential use as a supplementary source of water in the future. To determine the capability of the streams to provide adequate quantities of water involves detailed studies of existing streamflow records, particularly for periods of low flow. Because these periods normally occur in the late summer or early fall, low-flow studies are based on the climatic year starting April 1.

Records of streamflow in the area consist of six primary gaging stations providing continuous records of flow, four secondary gaging stations having 1 to 2 years of continuous record and occasional discharge measurements for several additional years, and 33 partial-record stations at which occasional discharge measurements during base-flow periods only are available. The length and type of record available at each site is shown in figure 23. Locations of the discharge-measurement sites are indicated in plate 7, and pertinent descriptive data are shown in tables 5 and 6. Daily discharge records for gaging stations on Long Island and results of discharge measurements made at partial-record stations are published in U.S. Geological

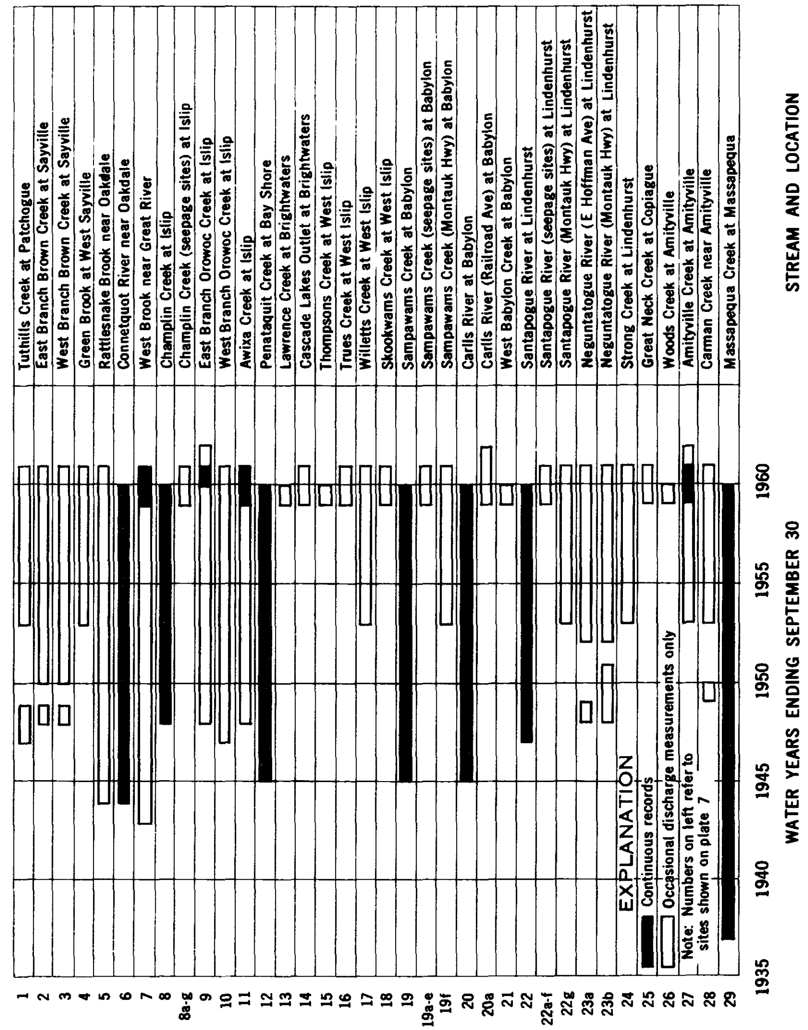


FIGURE 23.—Bar graph showing length of stream-gaging records.

Survey water-supply papers on "Surface Water Supply of the United States."

Owing to the high porosity of the soil and lack of relief on Long Island, direct runoff is confined to the immediate vicinity of stream channels except where it is conveyed by storm sewers. Hence, topographic drainage basins are difficult to define and, because ground water is the chief source of streamflow, ground-water contributing areas have been utilized in this report. Plate 7 also shows the outline of the ground-water contributing area for the furthest downstream measuring site on the two major streams in the study area, Carlls River and Connetquot River.

The physical features of Long Island also preclude the possibility of severe flooding. Streams rarely overflow their banks, and the flooding that does occur is usually due to high tides along the south shore or to poor local drainage.

Studies of low-flow are based on the 15-year period April 1, 1944, to March 31, 1959 (1944–58 climatic years). Several droughts have been experienced during the base period, notably that of 1957; however, owing to their relatively short length, streamflow records on Long Island have never recorded a severe drought. One of the longest records on Long Island, Massapequa Creek at Massapequa, in eastern Nassau County, has been utilized in correlative studies of streamflow in the area. Records at this station, which were started Dec. 12, 1936, indicate also that the drought of 1957 was the most severe since 1936.

The limited data collected to date at most partial-record stations are not of much practical value as individual measurements; however, the records at the partial-record stations may be correlated with the records of streamflow at the long-term gaging stations to obtain estimates of long-term discharges. Discharges thus determined for the partial-record stations are estimates and may be in substantial error. For this reason, streamflow data determined for partial-record sites is presented in abbreviated form in table 6.

In order to strengthen the correlation between some of the partial-record and the primary gaging stations, continuous records of stage were obtained at four sites for periods of as much as 2 years. Owing to the resulting improved correlation, data presented for each site, called "secondary gaging stations" in this report, are somewhat more detailed than those shown for partial-record stations. The discharge records obtained at the secondary gaging stations are summarized in table 9.

Data presented for primary gaging stations could also have been computed from the observed record at each site. This procedure would have precluded the possibility of extending the records to cover the base period and, more importantly, it would have ignored the experience of nearby stations. By statistical methods, data for all stations except Santapogue River at Lindenhurst, have been extended to include the base period. Heavy withdrawal of ground water in the immediate vicinity of Santapogue River upstream from the gaging station materially affects the natural flow of the stream. For this reason, it was impossible to ascertain natural streamflow characteristics; the analysis for that station is based on observed records only.

The records for the six remaining primary gaging stations were correlated with each other, and the hydrologic characteristics of all were then transferred to each station. The adjusted record was thereby improved by reducing the effect of random meteorologic events that might cause unnatural temporary streamflow conditions. Data for partial-record and secondary gaging stations were also adjusted by correlation with one or two primary gaging stations.

The major problem in evaluating the adequacy of streams in a specific area to supply a water system is to determine their ability to meet peak demands imposed by the system. The percent of time that natural streamflow will be inadequate, the frequency with which these inadequate periods may be expected to recur, and the improvement in streamflow supply which may be expected from the construction of storage facilities are problems that require an appraisal. An attempt is made in this report to provide answers to some of these problems and, although the records are short, the data are useful as preliminary estimates. The statistical analysis of streamflow data for all stations are in tables 7 and 8. The data in these tables are discussed in the following sections.

SUMMARY OF MONTHLY DISCHARGE

A summary of monthly discharge for the period of record, including the year of each maximum and minimum, is presented immediately below the descriptive material for each primary gaging station (table 7). These tables indicate that, in general, monthly discharge is highest in April and lowest in September; these extremes coincides with periods of highest and lowest water-table levels.

FLOW-DURATION CURVES

A convenient way to show the pattern of streamflow for a gaging station is to group daily discharges for the period of record into class intervals according to magnitude. If the number of occurrences in each interval is cumulated from the highest values to the lowest, then the proportion of the total time that flow was equal to or greater than the lower limit of each class may be computed. A flow-duration curve may then be prepared by plotting discharge as ordinate and time in percent of total period as abscissa, as shown in figure 24.

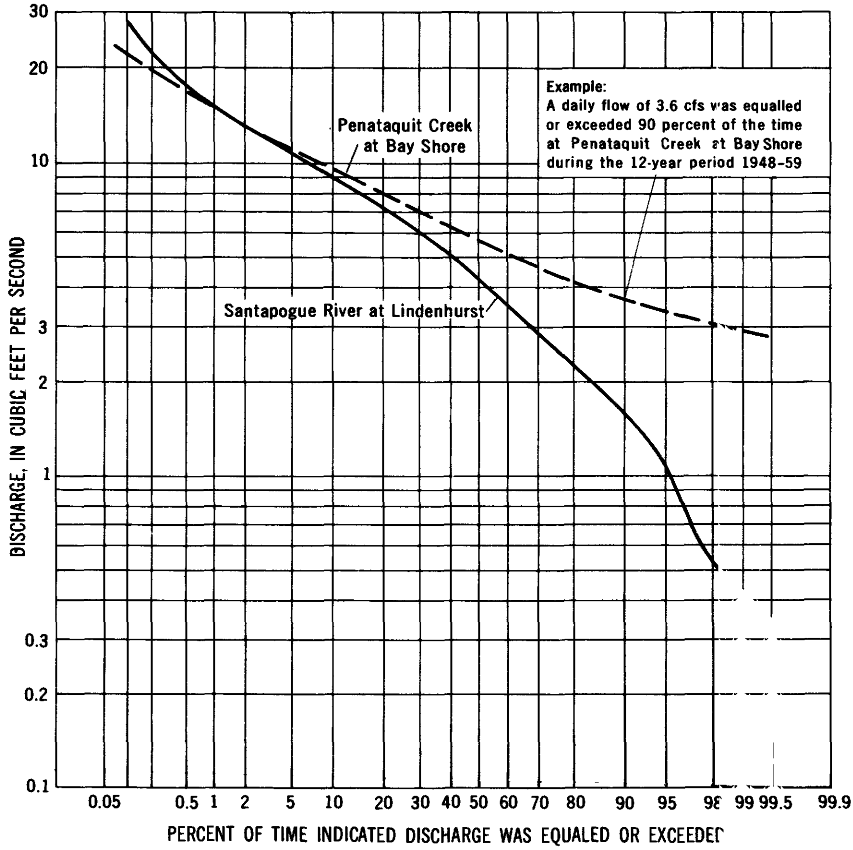


FIGURE 24.—Duration curves of daily flow of Penataquit Creek at Bay Shore and Santapogue River at Lindenhurst, 1948–59.

Duration curves are prepared by the analysis of past data, which may or may not be duplicated in the future. If the record covers a representative span of meteorological events over a long period, the data may be used to estimate the probability of the occurrence of a specified discharge. The slopes of duration curves are particularly useful as an index of the extent of ground-water runoff. Long Island streams have a fairly uniform flow, even during extended periods of drought. The relatively flat duration curve for Penataquit Creek at Bay Shore (fig. 24) is representative of the shape of most duration curves of streams on Long Island. The sharp downward trend of the curve for Santapogue River at Lindenhurst below the 95 percent duration point is the result of heavy ground-water withdrawal at a well upstream from the gaging station.

Flow-duration information has been prepared in tabular form for all gaging stations in the area. Owing to limited data, the range of percentiles shown for partial-record sites is only 30 to 90. More complete data at secondary gaging stations permitted computation of percentiles ranging from 5 to 98, and at primary gaging stations from 1 to 99.

Chronological information for days of insufficient flow cannot be obtained from flow-duration curves. For example, a duration curve does not indicate whether the daily discharges below that indicated for some small percentile were the result of some outstanding drought or whether they were scattered through the period of record. For answers to these questions, other statistical methods must be employed.

LOW-FLOW FREQUENCY CURVES

Low-flow frequency curves are designed to provide data on droughts by considering consecutive days as a unit and thereby to overcome the deficiency inherent in duration curves. Low-flow frequency curves indicate how often the average discharge for prestated periods of consecutive days may be expected to equal or be lower than a specified value.

Figure 25 shows the family of low-flow frequency curves for Penataquit Creek at Bay Shore for a range of selected periods of 1 to 274 days. Curves similar to this have been prepared for all primary gaging stations except Santapogue River at Lindenhurst, the data are presented in table 7. At stations affected by occasional regulation,

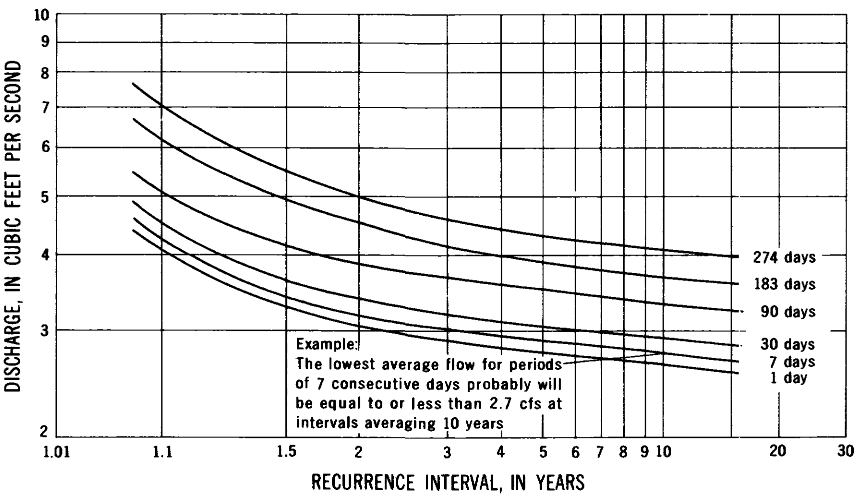


FIGURE 25.—Magnitude and frequency of annual low flows for Penataquit Creek at Bay Shore, adjusted to 15-year (1944–58) base period.

1-day low flows were not computed because the values were adversely affected. At secondary gaging stations, the range of selected periods computed was 7 to 183 days, and at partial-record stations only 7-day and 30-day periods at the 2-year and 10-year recurrence intervals were tabulated.

Probability on these curves is expressed by recurrence intervals in years and should not be considered as a fixed value. For example, graphs on figure 25 show that the average flow for a 90-day period will be 3.3 cfs or less at intervals averaging 10 years. This does not preclude the possibility of having a minimum annual low flow of less than 3.3 cfs in successive years. In other words, if a very long record of flow were available for this station, the average length of all intervals between annual low-flows of 3.3 cfs or less would be 10 years.

DAYS OF DEFICIENT DISCHARGE

A water-supply engineer frequently must design for a peak demand which will last for a specified period. If the natural flow of the stream is to supply the demand, low-flow frequency data will be inadequate to solve the problem because during each low-flow period, discharge is less than the average value given for part of the period. Hence there will be periods during which the stream will be unable to supply the demand. Figure 26 for Penataquit Creek at Bay Shore was prepared to show how often, on the average, the minimum flow for selected periods can be expected to remain below any specified discharge. These data have been computed for all primary gaging stations except Santapogue River at Lindenhurst, and are included in table 7 for intervals of 1.1, 1.5, 2, 5, and 15 years.

STORAGE-REQUIRED FREQUENCY

If the peak demand of a water system cannot be met by the natural flow of a stream, then storage must be provided. Storage required to maintain specific rates of demand (drafts) may be computed for the most severe drought of record by use of a mass curve. The storage thus computed may be too large because of economic or physical considerations. Then it becomes particularly important to weigh the cost of a smaller facility against loss of revenue during periods of insufficient flow. Storage-required frequency data, presented for the six primary stations used in the regional analysis, will provide the necessary information needed to prepare a cost analysis for this type of water problem.

The preparation of storage-required frequency data is based upon frequency-mass curves for 2-, 5-, and 15-year droughts, as indicated in figure 27. The circles plotted on figure 27 represent the low-flow frequency for the 5-year drought multiplied by the number of days in

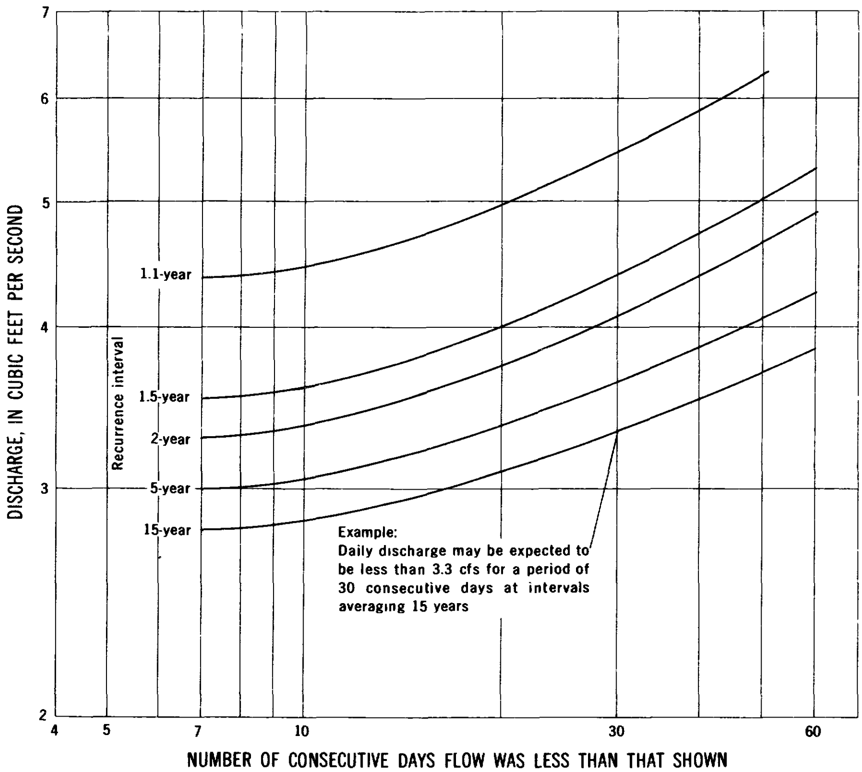


FIGURE 26.—Frequency of maximum period of deficient discharge for Penataquit Creek at Bay Shore, adjusted to 15-year (1944–58) base period.

the period and plotted at that number of days. The slopes of the straight lines represent the allowable draft, which can be maintained during a specified drought by the indicated storage. Where the slope of the discharge-volume-available curve is less than the allowable draft, then streamflow is less than draft. At the point of tangency to the discharge-volume-available curve of a line parallel to the draft rate, streamflow is just equal to the draft rate and the vertical distance between the curve and line is equal to the storage required to meet the deficiency in natural streamflow. At the point of intersection of the draft rate and the volume-available curve, the reservoir has been refilled by streamflow.

Data from figure 27 were used to develop curves of storage-required frequency shown in figure 28, and are summarized for each of the six primary gaging stations used in the regional analysis (table 7). No allowance was made in the analysis for reservoir losses due to evaporation or seepage, and, therefore, allowance for these losses must be made in designs based on these tables.

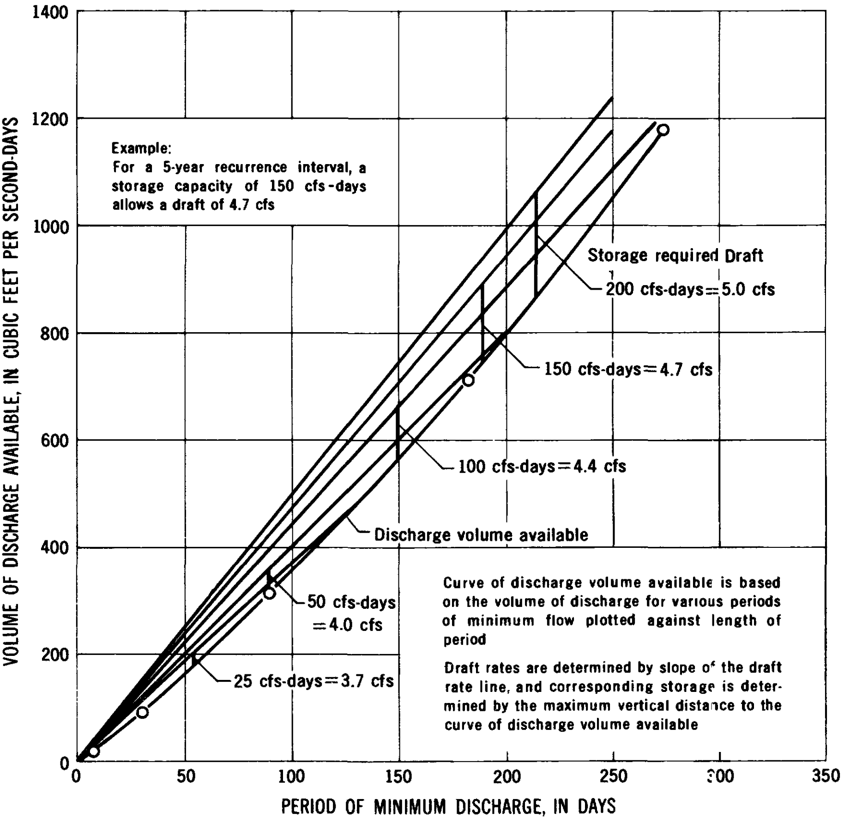


FIGURE 27.—Frequency-mass curve and storage-draft lines for Penataquit Creek at Bay Shore for the 5-year recurrence interval, adjusted to 15-year (1944–58) base period.

FRESH-WATER OUTFLOW FROM THE BABYLON-ISLIP AREA

The average annual streamflow from the Babylon-Islip area at the head of tidewater is 185 cfs, of which 176 cfs (16 inches) represents ground-water runoff. The total average annual fresh-water outflow (water yield) at the north shore of Great South Bay is estimated to be about 290 cfs, and is equivalent to the total annual streamflow plus submarine outflow.

The total streamflow from the area on any particular day may be considerably more or less than the computed average. To indicate the variation in streamflow to be expected, the data for all streams were summarized with respect to duration and frequency. The statistical presentation of the streamflow data was necessarily limited to

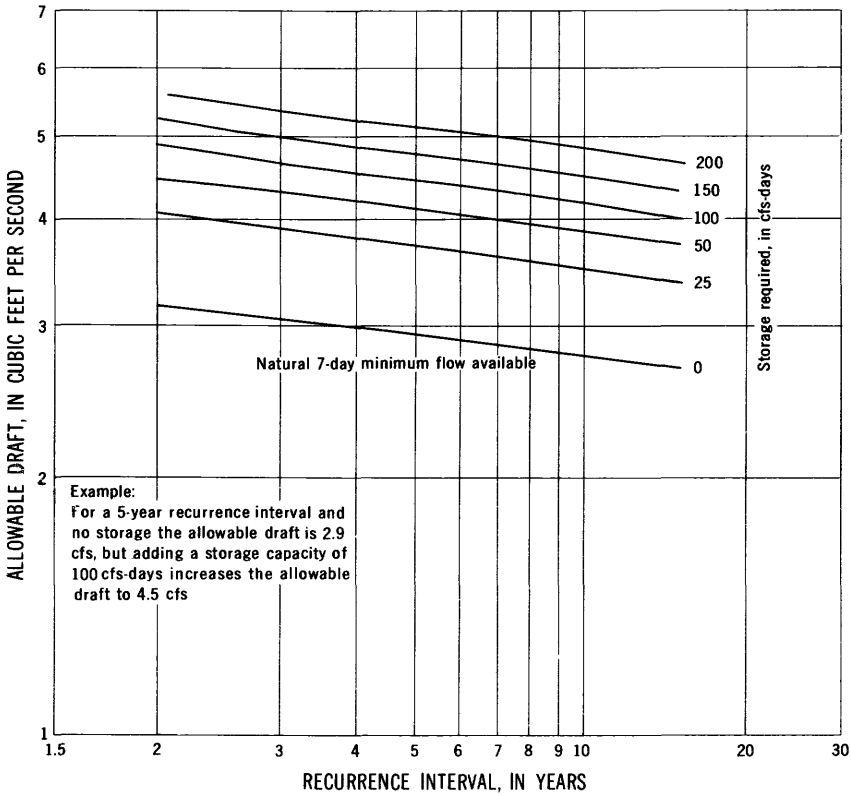


FIGURE 28.—Allowable draft-frequency curve of storage required on Penataquit Creek at Bay Shore, adjusted to 15-year (1944–58) base period.

the percentages shown for the partial-record stations. The streamflow from the Babylon-Islip area, which was equalled or exceeded for indicated percentages of time is shown in the following table:

Discharge	Percent of time discharge equaled or exceeded that shown			
	30	50	70	90
Cubic feet per second	207	173	143	112
Million gallons per day	134	112	92	72

The low-flow characteristics of streamflow and total outflow from the area indicate the minimum annual streamflow and minimum annual total outflow of the Babylon-Islip area for 7-day and 30-day periods at 2- and 10-year recurrence intervals (table 5). Total minimum annual streamflow shown in this table represents base flow because the indicated discharges reflect drought conditions when there is no direct runoff. The total outflow was estimated on the assumption that the ratio of the computed average ground-water runoff (16 inches) to average underflow (8 inches) at the head of tidewater is maintained throughout the year. From table 5, it may be observed that there is a probability of one in ten that the minimum streamflow of the area will average 55 mgd or less during any 30-day period of any particular year. Furthermore, there is a probability of one in two that the minimum annual total outflow will average 95 mgd or less for a period of 7 days in any particular year.

TABLE 5.—*Magnitude and frequency of minimum annual streamflow and total outflow from the Babylon-Islip area*

Period (days)	Recurrence interval (years)	Minimum average annual streamflow		Estimated minimum average total outflow [1]	
		Cu ft per sec	Million gal per day	Cu ft per sec	Million gal per day
7	2	102	66	147	95
	10	80	52	116	75
30	2	107	69	155	100
	10	85	55	124	80

[1] Streamflow plus submarine outflow.

DEVELOPMENT OF WATER RESOURCES

PRESENT USE

A total of about 39 mgd of ground water, or slightly more than half of the total withdrawal in Suffolk County, was pumped in 1960 in the Babylon-Islip area for public supply, industrial, institutional, and agricultural use. No surface water is used for public supply and only small amounts are used for other purposes. Plate 8 shows the location of major centers of withdrawal, and the amount and source of water pumped in 1960. Pumpage for public supply was 12.8 mgd. The largest single supplier was the Suffolk County Water Authority, which pumped 10.3 mgd from 14 well fields in the project area. The remainder was supplied by 26 municipal or privately owned water systems.

Industrial and institutional pumpage totaled 12.8 mgd and was concentrated mostly at five centers of withdrawal (pl. 8). The largest industrial withdrawal, 2.8 mgd, was made by Republic Aviation Corp. and the largest institutional user was Pilgrim State Hospital, which pumped 2.2 mgd. Agricultural and domestic pumpage was estimated to be about 0.03 mgd and 13 mgd, respectively. Table 6 summarizes the pumpage by public-supply systems and major industrial and institutional suppliers in the area, in 1960.

TABLE 6.—*Public-supply systems and principal industrial and institutional supplies in the Babylon-Islip area, 1960*

Symbol (pl. 8)	Owner of supply — Name	Annual pumpage (millions of gallons)	Symbol (pl. 8)	Owner of supply — Name	Annual pumpage (millions of gallons)
A	Suffolk County Water Authority	3,785.5	T	Blue Point Community Association Inc	3.0
B	East Farmingdale Water District	0	U	Fire Island Pines Water District	0
C	Colonial Springs Water Co	0	V	Cherry Grove Water District	0
D	South Huntington Water District	312.3	W	Point O' Woods Association	11.0
E	Dix Hills Water District	75.1	X	Ocean Bay Park Water Corp	10.1
F	Green Turf Water Co	23.0	Y	Sea View Utilities	9.0
G	Brentwood Water District	333.3	Z	Village of Ocean Beach	25.1
H	John T. Murtha	.5	AA	Dune Realty	1.0
I	Lakeview Beach	.1	BB	Dunewood Water Co., Inc	1.6
J	Lakoma Manor, Inc	.1	CC	Fair Harbor Water District	0
K	Cedar Grove Park	1.5	DD	Village of Saltaire	7.2
L	Shorehaven Water Corp	3.0	EE	Kismet Water District	1.3
M	Ann K. Molin	1.0	FF	West Gilgo Beach Association	2.4
N	Ronkonkoma Water Co	9.3	GG	Republic Aviation Corporation	1,036.4
O	Green Meadows Water Co	30.5	HH	Fairchild Engine & Aircraft Co	240.9
P	Sunnyside Water Corp	11.0	II	Pilgrim State Hospital	788.3
Q	Farmingville Water Corp	10.5	JJ	Central Islip State Hospital	582.7
R	Sunhill Water Corp	6.3	KK	Stratos Division, Fairchild Engine and Aircraft Co.	230.4
S	Bevon Holding Corp	13.8			

Approximately 35 mgd was pumped from the water-table aquifer and about 4 mgd from the intermediate artesian aquifer. The fact that, in much of the Babylon-Islip area, the top of the water-table aquifer is less than 25 feet below land surface (pl. 4), permits economical withdrawal of water. However, some of the water may be of poor quality locally, owing to contamination resulting from increasing urbanization and proximity to salt water.

Withdrawal from the intermediate artesian aquifer was relatively small in 1960. Increased withdrawal from this aquifer is anticipated, for it contains a substantial quantity of untapped water of good quality in much of the area. Although no water is pumped from the deep artesian aquifer, it could supply moderate amounts of water especially in areas remote from the fresh water-salt water interface.

FUTURE DEVELOPMENT

Because of the many variables involved, it is difficult to make long-range estimates of the amount of water that may be available in the Babylon-Islip area. For the purpose of simplicity in making estimates, it has been assumed that the ground-water divides bounding the area will be unchanged in the future. That is to say, no additional quantities of water will enter or leave the area other than those accounted for in the equation of water balance described previously.

UNSEWERED CONDITIONS

Under natural conditions the quantity of fresh water recharged to the ground-water reservoir in the Babylon-Islip area is, over a long period of time, almost equal to the discharge from the reservoir. The present system of water usage does not affect the overall water balance because almost all water pumped from the ground-water reservoir is returned through cesspools, leaching beds, or diffusion wells. There is, however, some consumptive loss of water from the system through evapotranspiration during the growing season when much of the water pumped to residential areas is used for lawn sprinkling and other outdoor activities. Withdrawal of water for domestic use is currently (1960) estimated to be at the rate of 30 to 35 mgd during the period May through September, of which about 3 mgd may be lost through plant transpiration or direct evaporation. This consumptive loss of water is equivalent to less than one-quarter of an inch annually from the area and is too small to be considered in the water-balance equation. However, a continuation of the present rapid rate of population growth may result in significant water losses from the ground-water reservoir. On the basis of projections supplied by the Suffolk County Department of Planning (written communications, 1962), it is estimated that the probable maximum future population of the Babylon-Islip area will be five times as great as the 1960 population and that the consumptive loss of water during the growing season may eventually be 15 mgd or more. If the bulk of future water withdrawals is made from the water-table aquifer and the area remains unsewered, then a major effect of the consumptive loss will be a reduction of streamflow. A water loss of 15 mgd would result in almost a 25 percent reduction in the total streamflow of the area during periods of moderate drought occurring within the growing season. On an annual basis, the net effect of the anticipated reduction in streamflow would probably be minor, although the loss of fresh-water recharge may result in a slight increase in the concentration of contaminants in the ground water and surface water. Quantitatively, therefore, the present system of water supply and sewage disposal may be expanded to provide for a population at least five times as great as that of 1960, without any appreciable effect on the natural water balance of the area.

In addition to an increase in consumptive losses, additional development of the water resources will result in the following undesirable effects: (a) an increase in the net loss of water from the intermediate aquifer due to artificial withdrawals which are not recharged to the source aquifer, and (b) an increase in contamination due to the artificial recharge of sewage effluent through cesspools and leaching beds.

Net loss of water from the intermediate artesian aquifer will reduce the rate of natural discharge from the aquifer and, if substantial, will cause significant landward movement of salty ground water. It is particularly imperative to avoid heavy withdrawals near the south shore and along the barrier beaches because cones of depression caused by such pumping may eventually extend to the fresh water-salt water interface. Some landward movement of salty ground water, however, is a necessary consequence of the full development of the water resources of the area. Some of the 18 mgd which is now lost as submarine outflow from the artesian aquifers could be salvaged by increasing the pumpage from these aquifers and inducing the interface to move to a new position of stability closer to the shoreline. An estimate of the rate of withdrawal possible under this proposal would require additional information on the hydraulic characteristics of the aquifers and a more precise knowledge of the position of the interface. This position is presently (1960) estimated to be within 2 miles of the barrier beaches. In addition to the salvage of part of the submarine outflow now being lost, several hundred billion gallons of fresh water could be "mined" during the time the interface was moving to its new position.

Domestic and industrial waste products returned to the ground represent a potential threat to the quality of the water resources of the area. Owing to the natural purifying action of the deposits comprising the ground-water reservoir, the water generally will remain free of bacterial pollution provided adequate separation between cesspools and supply wells is maintained. Chemical contamination, particularly by constituents not subject to rapid decomposition, may make some of the ground water unpalatable, if not toxic. The occurrence of synthetic detergents in the ground water is an example of such contamination. Contamination may be prevented by the construction of sanitary sewers that would eliminate the recharge of untreated domestic and industrial wastes. Treated effluent may be discharged either to tidewater or returned to the ground through leaching beds or diffusion wells.

SEWERED CONDITIONS

EFFLUENT DISCHARGED TO TIDEWATER

Although safeguarding water quality, sanitary sewers discharging effluent to tidewater would result in a net reduction in recharge to the ground-water reservoir. The subsequent lowering of ground-water levels would result in some reduction in streamflow and submarine outflow. Ultimately this lowering of water levels may cause a substantial depletion of the fresh-water resources of the area.

If the 1960 ground-water withdrawals of about 40 mgd were discharged to tidewater, natural discharge would be reduced by this amount. The depletion of natural discharge would be reflected primarily in a reduction in streamflow because most withdrawals are from the water-table aquifer. Therefore, a loss of 40 mgd from the ground-water reservoir may reduce average streamflow by as much as 20 percent. From table 5, it is apparent that a loss of this magnitude would not completely deplete streamflow in the area even during extended droughts. However, if the present pumpage were doubled, the resulting reduction of natural discharge of about 80 mgd would totally deplete the flow in every stream for extended periods. An increase in population to the estimated maximum would would result in a reduction of about 200 mgd in the natural discharge. Under these conditions, the streams probably would be dry at all times except for short periods during and immediately following heavy rainstorms. Moreover, pumping at the rate of 200 mgd and discharging all sewage effluent to tidewater probably would result in some "mining" of ground water, reduction in submarine outflow, and landward movement of salty ground water.

Even under conditions of moderate pumpage, the discharge of sewage effluent to tidewater could cause a potentially harmful decline of the water table. A lowering of the water table and a decrease in storage in the water-table aquifer would result in a reduction in head in the artesian aquifers (Warren and Lusczynski, written communication, 1956). This reduction in head would result from the removal of a part of the load on the artesian aquifers owing to the decrease in storage in the water-table aquifer. The decline of the water table would cause reduction of recharge to the artesian aquifers and would further decrease hydrostatic heads. However, the magnitude of the reduction in head in the artesian aquifers and the resulting encroachment of salt water cannot be estimated from the available data.

The base flow of the streams in the area as measured at the gaging sites may be considered the minimum total safe withdrawal from the ground-water reservoir, if sewage effluent is discharged to tidewater. The removal of this quantity of water immediately before it enters the streams probably would not cause a serious lowering of the water table and would not disturb the existing equilibrium between fresh and salty ground water in the water-table and artesian aquifers. If it were possible to design and construct a system of wells or infiltration galleries which could intercept most of the surplus ground water from the water-table aquifer that now seeps into streams, the system could safely pump at a rate of 114 mgd (mean annual streamflow at the gaging sites) provided no other significant withdrawals were made from the water-table aquifer. Some additional water could be pumped from the deeper aquifers so long as the landward movement of the fresh-salt water interface were controlled.

Streamflow could also be used directly as a source of supply wherever land was available for the construction of reservoirs. Despite the relatively flat topography, the construction of small reservoirs would substantially improve the low-flow yield of most streams. Inasmuch as most droughts generally coincide with periods of maximum water demand, the construction of reservoirs would act to provide water at the most critical time. However, analysis of costs, construction problems, evaporation losses, and the danger of pollution require considerable additional study before the feasibility of this proposal can be determined.

EFFLUENT RECHARGED TO GROUND-WATER RESERVOIR

To prevent depletion of the ground-water reservoir if the area were to be completely sewered, consideration should be given to artificially recharging treated sewage effluent. For conservation of available fresh water, artificial recharge in areas just south of the main ground-water divide would be the most desirable method of effluent disposal. A system of leaching beds and possibly shallow diffusion wells could be utilized to return the used ground water to the area of natural recharge and would help maintain the existing pattern of ground-water movement. Because of the recirculation of the water inherent in this method of effluent disposal, a considerable degree of treatment would be required. Too, the esthetic objections to leaching beds and the possible pollution of the upper part of the ground-water reservoir are disadvantages which may outweigh the advantages.

Another method of recharging treated effluent in interior parts of the area is by diffusion wells screened in the lower part of the intermediate artesian aquifer. No supply wells are presently screened in this zone in the Babylon-Islip area and the flow pattern within the ground-water reservoir suggests that most of the water is discharged as submarine outflow. Treated sewage effluent injected in the basal zone would supplement natural submarine outflow and would thereby prevent salt-water encroachment. However, the cost of pumping the effluent to the interior may be prohibitive: the economic justification of this method must be studied.

The most economical method of sewage disposal consistent with the conservation of fresh water would be a system of leaching beds or diffusion wells spaced uniformly along the south shore. Artificial recharge of treated effluent into leaching beds along the south shore would protect the water-table aquifer from salt-water encroachment but would be ineffective in protecting the artesian aquifers. Too, the efficiency of the beds as a means of disposal would be greatly reduced by the shallow depth to the water table near the shore.

A system of diffusion wells screened in zones of high permeability in the intermediate artesian aquifer would overcome these objections by injecting treated effluent directly into strata most susceptible to salt-water encroachment. By properly spacing the diffusion wells along the shoreline, a pressure ridge could be created which would act as a barrier to the landward movement of salt water. Too, some water would flow landward and would supplement natural recharge to the aquifer. Streamflow, as well as sewage effluent, can be utilized as a source of recharge. Among the technical problems requiring further study are methods for treating the recharged water, the optimum height of the proposed pressure ridge, the amount of water needed to maintain the ridge permanently, and the location, number, depth, diameter, and spacing of the recharge wells.

SUMMARY AND CONCLUSIONS

Unconsolidated sediments of Cretaceous, Tertiary, and Quaternary age, 1,300 to 1,800 feet thick, underlie the Babylon-Islip area and constitute the ground-water reservoir. The ground-water reservoir consists of three distinct aquifers, the water-table aquifer, the intermediate artesian aquifer, and the deep artesian aquifer. The water-table aquifer, which consists primarily of upper Pleistocene deposits in the uppermost part of the zone of saturation, has an average coefficient of permeability of about 1,200 gpd per sq ft. It is an abundant source of fresh water except in the northwestern part of the area, where the Pleistocene deposits are thin or missing, and under the barrier beaches in the southern part, where the aquifer contains salty water. The intermediate artesian aquifer consists of deposits of the Magothy(?) Formation, and has an average coefficient of permeability of 500 gpd per sq ft. This aquifer is the principal source of water on the barrier beaches and a potential source in the remainder of the area. The deep artesian aquifer consists of the Lloyd Sand Member of the Raritan Formation. It is not tapped by wells in the area because abundant supplies of water are available in the overlying aquifers.

In preparing a water-balance equation for the area, hydrologic data were analyzed for a common base period, October 1, 1943, to September 30, 1959 (1944–59 water years), equivalent to the longest available streamflow record. Mean annual precipitation on the area during the base period was 46 inches. Mean annual evapotranspiration was about 21 inches, and direct runoff was slightly less than an inch, a total water loss of about 22 inches. Therefore, recharge to the ground-water reservoir (precipitation minus water loss) was about 24 inches or 1.1 mgd per sq mi. Because of the negligible change in ground-water storage during the base period, recharge was about equal to discharge. Observed ground-water runoff above tidewater, as computed from gaging-station records, was 16 inches (nearly 70 percent of the total ground-water recharge). Estimated total ground-water runoff above the point where streams discharge into Great South Bay was about 21 inches, and evapotranspiration of ground water amounted to 1 inch. Submarine outflow in the artesian aquifers was about 2 inches.

Heavy ground-water inflow characterizes all streams, and base flow (ground-water runoff) was found to be proportional to the average altitude of the water table adjacent to the streams. The rate of change of ground-water inflow (pickup) varies widely among streams, ranging from about 0.5 cfs per 1,000 feet of channel length along the middle and lower reaches of small streams (average annual discharge at head of tidewater less than 5 cfs) to about 2 cfs per 1,000 feet of channel length along large streams (average annual discharge at head of tidewater more than 20 cfs). The greater length and depth of the valleys occupied by the larger streams enable them to drain proportionately greater areas than small streams. Significant variations in pickup are also noted along individual streams. Pickup along Champlin Creek at Islip varies from less than 0.5 cfs per 1,000 feet near the source to about 1.5 cfs per 1,000 feet along the middle reaches, then tapers off to about 0.8 cfs per 1,000 feet near the head of tidewater. From wells driven adjacent to and directly into the streambed, it was demonstrated that the large inflow along middle reaches of the streams was attributable largely to an increase of lateral seepage of ground water and little or no upward movement of water from deep within the ground-water reservoir.

Because streamflow in the area is largely dependent upon ground-water runoff, streams exhibit well-sustained low-flow characteristics. For example, at Connetquot River near Oakdale, the largest stream in the area, the flow is equal to or exceeds 75 percent of the mean annual discharge more than 90 percent of the time. Streams in the area never go dry in their middle and lower reaches even during extended periods of drought. Because of the highly permeable soils and subdued topographic relief in the area, direct runoff is greatly restricted and streams rarely overflow their banks.

Water supply in the Babylon-Islip area is obtained almost entirely from the ground-water reservoir. Generally, ground water of excellent quality may be obtained from wells almost anywhere in the area. The major source of ground-water contamination in 1961 stems from increased use of synthetic detergents in commercial and home laundries. Water having concentrations of 1.5 ppm or greater foams and generally has an unpleasant taste. Concentrations as high as 2.8 ppm have been noted in the area; however, concentrations above 1.5 ppm are rare. Syndet load carried by streams is greatest in the densely populated western part of the area. The total load for all streams was 186 pounds per day based on the average of three samples obtained during 1960–61. The heaviest load in any one stream was noted at Carlls River at Babylon, which averaged 32 pounds per day for the three samples.

The mean annual ground-water temperature in the area is about 51° F, and ground water is generally suitable for use in air-conditioning units. However, temperature gradients within the ground-water reservoir indicate intake wells should be screened at least 45 feet below the water table to insure a steady supply of water at suitable temperatures during the summer. Ground water at shallow depths reaches its highest temperature in September and October, and may exceed 65°F, particularly in urbanized areas. Greater absorption of solar radiation by exposed soils in urbanized areas may raise maximum ground-water temperature 3° to 5°F higher than that observed under nearby forested areas. Annual range in fluctuation of ground-water temperature diminishes rapidly with depth, being only 2° to 3°F at a depth of 60 feet.

Temperature variations exceeding 20°F have occasionally been observed in different streams on the same date, and significant temperature variations have also been observed at the same time between points on the same stream. From analyses of temperature data at selected sites along three streams, it was concluded that the combination of a high rate of ground-water inflow and little or no upstream pondage tends to raise stream temperatures in the winter and lower them in summer; low inflow and extensive pondage produces the opposite effect. The diurnal fluctuation in stream temperature depends on the absorption of solar energy; however, ground-water inflow tends to minimize temperature fluctuation.

Gross pumpage from wells in the area averaged about 39 mgd in 1960. The bulk of this water was pumped from the water-table aquifer because it is capable of yielding large quantities of water to individual wells, and the water table is generally at shallow depths, a factor which permits economical construction and pumping of wells. Consumptive losses, due primarily to evapotranspiration, are presently small and practically all water pumped from the water-table aquifer is subsequently recharged by means of cesspools and basins. Under the present system of sewage disposal and provided supply wells are properly, located withdrawals may be increased about fivefold to accommodate the maximum anticipated population of the area.

In 1960, the heaviest pumpage from the water-table aquifer was in the western and central parts of the area. The most promising areas for future development of this aquifer are the central part of the Town of Babylon and the eastern part of the Town of Islip.

Pumpage from the intermediate artesian aquifer to some extent represents a net water loss because of the water pumped is recharged through cesspools into the water-table aquifer and therefore a significant part does not return to the source aquifer. Such withdrawal of water from the intermediate aquifer has doubtless resulted in a significant decline of the piezometric surface. If the reduction in pressure eventually reaches the fresh water-salt water interface, some landward movement of salt water may occur. No evidence of large cones of depression or landward movement of salt water has been noted in the artesian aquifers in the area, doubtless as a result of the fact that only 4 mgd was pumped from the intermediate artesian aquifer and none from the deep artesian aquifer in 1960. The amount of pumpage and the location of supply wellls in the artesian aquifers require careful planning to minimize the possibility of salt-water encroachment. Some landward movement of salty ground water, however, may be tolerated to allow for increased pumpage from the artesian aquifers.

In order to insure an adequate supply of ground water in the face of increased urbanization and water use, the ground-water reservoir must be protected from excessive pollution by sewage disposal and contamination by salt-water encroachment. It appears likely that in the future an extensive sanitary sewer system will be constructed to eliminate pollution. The design of such system should be accompanied by a study of the effects of the alternate methods of treated-effluent disposal on the hydrologic balance now existing in the ground-water reservoir.

It is estimated that the maximum future water supply required in the area may be about 200 mgd. If the area were completely sewered, this quantity of water could not be obtained without (a) mining water and allowing the ground-water reservoir to deteriorate or (b) recharging treated sewage effluent and conserving ground-water runoff. Treated effluent may be recharged just south of the ground-water divided where it would maintain the natural water balance of the area. Treated effluent may also be recharged by wells along the south shore where, if properly injected, it would prevent salt-water encroachment. Salvage of ground-water runoff, which averages about 114 mgd, may be accomplished by any one or a combination of the following methods: (a) creation of influent conditions by locating supply wells adjacent to streams or installing horizontal wells under the streams; (b) construction of small reservoirs along streams from which water could be pumped directly; (c) recharging the artesian aquifers along the south shore with water from streams.

In connection with more extensive development of the water resources of the area, the observation-well and stream-gaging programs should be continued and expanded to detect the occurrence of large permanent cones of depression, regional lowering of the water table and piezometric surfaces, or a reduction in streamflow. Such conditions are indicative of overpumping which would promote salt-water encroachment. Observation wells and stream-gaging stations, some of which were constructed during the present investigation, are useful also as sampling points for observing changes in the chemical quality of water. Streamflow data are also important in determining changes in the quantity of water perennially available in the area.

Groups of observation wells (outpost wells) screened at different depths in the intermediate and deep artesian aquifers should be installed at intervals along the entire length of the barrier beaches to monitor heads and chloride content of the water in the aquifers. These outpost wells would provide early warning of impending encroachment of salt water such as is occurring in southwestern Nassau County (Perlmutter and Geraghty, 1959; Lusczynski and Swarzenski, 1961). Deep observation wells are needed also in the recharge areas of the artesian aquifers to detect the effects of withdrawal from both shallow and deep wells upon the piezometric surfaces.

GLOSSARY OF HYDROLOGIC TERMS USED IN THIS REPORT

Aeration, zone of: The zone in which the interstices of a deposit are not completely filled with water, except temporarily.

Aquiclude: A formation which, although porous and capable of absorbing water slowly, will not transmit it fast enough to furnish an appreciable supply for a well or spring.

Aquifer: A formation, group of formations, or part of a formation that is water bearing.

Artesian aquifer: An aquifer overlain by an aquiclude and containing water under artesian conditions.

Artesian conditions: The occurrence of ground water under sufficient hydrostatic head to rise above the upper surface of the aquifer.

Base flow: Discharge entering stream channels as effluent from the ground-water reservoir, the "fair-weather" flow of streams.

Cubic feet per second: The discharge of a stream of rectangular cross section, 1 foot wide and 1 foot deep, whose average velocity is 1 foot per second.

Cfs-day: The volume of water represented by a flow of 1 cubic foot per second for 24 hours. It equals 86,400 cubic feet, or 646,317 gallons.

Climatic year: The 12-month period from April 1 to March 31.

Cone of depression: A conical depression on a water table or piezometric surface produced by pumping.

Direct runoff: The water that moves over the land surface directly to streams promptly after rainfall or snowmelt.

Discharge, ground-water: The process by which water is removed from from the zone of saturation; also, the quantity of water removed.

Drainage area: The area drained by a stream above a specified location (for example, a gaging station), measured in a horizontal plane which is enclosed by a drainage divide.

Effluent stream: A stream or reach of a stream that receives water from the zone of saturation.

Equipotential surface: A surface on which all points have equal hydrostatic head.

Evapotranspiration: Water withdrawn from a land area by direct evaporation from water surfaces and moist soil and by plant transpiration.

Ground-water contributing area: The part of a ground-water reservoir, measured in a horizontal plane, drained by a stream above a specified point. It is bounded by a ground-water divide.

Ground-water reservoir: An aquifer or group of related aquifers.

Ground-water runoff: That part of the streamflow which consists of water discharged into a stream channel by seepage from the ground-water reservoir; same as base flow.

Head: See "hydrostatic head."

Hydraulic gradient: The rate of change of hydrostatic head per unit of distance of flow at a given point and in a given direction.

Hydrograph: A graph showing changes in stage, flow, velocity or other aspect of water with respect to time.

Hydrologic environment: The size and configuration of ponds and streams, and the extent, boundaries, and water-bearing properties of aquifers.

Hydrostatic head: The height of a vertical column of water, the weight of which, in a unit cross section, is equal to the hydrostatic pressure at a point.

Influent stream: A stream that contributes water to the zone of saturation.

Part per million: One milligram of solute in 1 kilogram of solution.

Perched ground water: Ground water separated from an underlying body of ground water by unsaturated deposits.

Permeability: The capacity of a material to transmit a fluid.

Permeability, coefficient of: The rate of flow of water in gallons a day, through a cross-section of 1 square foot under a hydraulic gradient of 1 foot in 1 foot at a temperature of 60°F; also referred to as the "field coefficient of permeability" when the units are given in terms of the prevailing temperature of the water. It is equal to the coefficient of transmissibility divided by the thickness of aquifer.

Piezometric surface: The surface to which the water in an artesian aquifer will rise under its full head.

Porosity: The ratio of the aggregate volume of interstices in a rock or deposit to its total volume expressed as a percent.

Recharge, ground-water: The process by which water is added to the zone of saturation; also, the quantity of water added.

Runoff: The water draining from an area. When expressed in inches, it is the depth to which an area would be covered if all the water draining from it in a given period were uniformly distributed on its surface. The term is used to compare runoff with precipitation, which is also usually expressed in inches.

Saturation, zone of: The zone in which interconnected interstices are saturated with water under pressure equal to or greater than atmospheric.

Soil moisture: Water diffused in the soil or in the upper part of the zone of aeration from which water is discharged by the transpiration of plants or by soil evaporation.

Specific capacity: The yield of a well, in gallons per minute, divided by the drawdown in the well, in feet.

Specific conductance: The conductance of a cube of a substance 1 centimeter on a side, measured as reciprical ohms or "mhos." Commonly reported as millionths of mhos or micromhos, at 25°C.

Specific retention: The ratio of (a) the volume of water retained in a saturated deposit against the pull of gravity to (b) the volume of the deposit.

Specific yield: The ratio of (a) the volume of water drained from a saturated deposit by gravity to (b) the volume of the deposit.

Submarine outflow: That part of underflow that is discharged directly into oceans or bays. As used in this report the term is equivalent to underflow at the north shore of Great South Bay.

Transmissibility, coefficient of: The rate of flow of water in gallons a day, at the prevailing water temperature, through each vertical strip of aquifer 1 foot wide having a height equal to the thickness of the aquifer and under a unit hydraulic gradient.

Underflow: The movement of water in the ground-water reservoir; also, the quantity of water moving in the ground-water reservoir through any vertical plane.

Water table: The upper surface of the zone of saturation, except where the surface is formed by an impermeable body.

Water-table aquifer: An aquifer containing water under water-table conditions.

Water-table conditions: The condition under which water occurs in an aquifer that is not overlain by an aquiclude and that has a water table.

Water year: A 12-month period beginning October 1 and ending the following September 30. Designated as the year ending September 30.

Water yield: The runoff from a drainage basin, including ground-water runoff that appears in streams, plus ground water that bypasses the gaging station and leaves the basin as underflow.

REFERENCES CITED

Brice, H. D., Whitaker, C. L., and Sawyer, R. M., 1956, A progress report on the disposal of storm water at an experimental seepage basin near Mineola, N.Y.: U.S. Geol. Survey, open-file rept., 34 p.

Burr, W. H., Hering, R., and Freeman, J. R., 1904, Report of the Commission on Additional Water Supply for the City of New York: New York, Martin B. Brown Co., 980 p.

Cooke, C. W., Gardiner, J., and Woodring, W. P., 1943, Correlation of the Cenozoic formations of the Atlantic and Gulf Coastal Plain and the Caribbean Region: Geol. Soc. America Bull., v. 54, p. 1713–1723.

Flynn, J., Andreoli, A., and Guerrera, A., 1959, Study of synthetic detergents in ground water: Am. Water Works Assoc. Jour., v. 50, p. 1551–1562.

Fuller, M. L., 1914, The geology of Long Island, New York: U.S. Geol. Survey Prof. Paper 82, 231 p.

Hely, A. G., Nordenson, T. J., and others, 1961, Precipitation, water loss, and runoff in the Delaware River basin and New Jersey: U.S. Geol. Survey Hydrol. Inv. Atlas HA–11.

Hem, John D., 1959, Study and interpretation of the chemical characteristics of natural water: U.S. Geol. Survey Water-Supply Paper 1473, 269 p.

Hopkins, O. C., 1961, Attitude of U.S. Public Health Service in development of drinking water standards, 1961: Am. Water Works Assoc. Jour., v. 53, p. 946–950.

Jacob, C. E., 1945, The water table in the western and central parts of Long Island, New York: New York State Water Power and Control Comm.[1] Bull. GW–12, 24 p.

Johnson, A. H., and others, 1952, Record of wells in Suffolk County, N.Y.—Supp. 2: New York State Water Power and Control Comm.[1] Bull. GW–31, 137 p.

Lee, Charles H., 1949, Transpiration and Total Evaporation, *in* Meinzer, O. E., Hydrology: Dover Publications, Inc., p. 259–330.

Leggette, R. M., and others, 1938, Record of wells in Suffolk County, N.Y.: New York State Water Power and Control Comm.[1] Bull. GW–4, 108 p.

Leonard, W. N., and Stonier, C. E., 1956, Industry looks at Long Island: Hempstead, N.Y., Hofstra College, Bureau of Business and Community Research, 120 p.

Lounsbury, C., and others, 1928, Soil survey of Suffolk and Nassau Counties, New York: U.S. Dept. Agriculture, ser. 1928, no. 28, 46 p.

Lubke, E. R., 1963, Geohydrology of the Huntington-Smithtown area, Suffolk County, Long Island, N.Y.: U.S. Geol. Survey Water-Supply Paper 1669–D (in press).

Lusczynski, N. J., and Johnson, A. H., 1952, The water table in Long Island, N.Y. in January, 1951: New York State Water Power and Control Comm.[1] Bull. GW–27, 28 p.

[1] See footnote at end of references.

Lusczynski, N. J., and Swarzenski, W. V., 1962, Fresh and salty ground water beneath the barrier beaches of southwestern Long Island, N.Y.: Am. Soc. Civil Engineers Trans. (in press).

Meyer, A. F., 1944, The elements of hydrology: New York, John Wiley & Sons, Inc., 522 p.

Nassau County Planning Commission, 1959, Planning Nassau County: Nassau County Planning Comm., 26 p.

New York State Water Pollution Control Board, 1960, Effect of synthetic detergents on the ground waters of Long Island, New York: Research Report 6, 17 p.

Perlmutter, N. M., and Crandell, H. C., 1959, Geology and ground-water supplies of the south-shore beaches of Long Island, N.Y.: Annals New York Acad. Sci., art. 4, v. 80, p. 1060–1076.

Perlmutter, N. M., and Geraghty, J. J., 1963, Geology and ground-water conditions in southern Nassau and southeastern Queens County, Long Island, N.Y.: U.S. Geol. Survey Water-Supply Paper 1613–A, p. A1–A205.

Rasmussen, W. C., and Andreasen, G. E., 1958, Hydrologic budget of the Beaverdam Creek basin, Maryland: U.S. Geol. Survey Water-Supply Paper 1472, 106 p.

Roberts, C. M., and Brashears, M. L., Jr., 1945, Record of wells in Suffolk County, N.Y.—Supp. 1: New York State Water Power and Control Comm.[1] Bull. GW–9, 155 p.

Sander, William, 1954, The early uses of water power on Long Island: Nassau County Historical Journal, v. 15, p. 62–75.

Suter, Russel, 1937, Engineering Report on the water supplies of Long Island: New York State Water Power and Control Comm.[1] Bull. GW–2, 64 p.

Suter, Russel, deLaguna, Wallace, and Perlmutter, N. M., 1949, Mapping of geologic formations and aquifers of Long Island, New York: New York State Water Power and Control Comm.[1] Bull. GW–18, 212 p.

Theis, C. V., and others, 1954, Estimating transmissibility from specific capacity: U.S. Geol. Survey open-file rept., 11 p.

U.S. Dept. Commerce, 1961, Rainfall frequency atlas of the United States: Weather Bureau Tech. Paper 40, 115 p.

U.S. Public Health Service, 1962, Drinking water standards: Federal Register, Mar. 6, p. 2152–2155.

Veatch, A. C., and others, 1906, Underground water resources of Long Island, New York: U.S. Geol. Survey Prof. Paper 44, 394 p.

Weiss, Lawrence, 1954, Foraminifera and origin of the Gardiners Clay (Pleistocene), Eastern Long Island, New York: U.S. Geol. Survey Prof. Paper 254–G, p. 143–162.

Wells, F. G., 1935, Reconsideration of the Pleistocene geology of Long Island [abs.]: Geol. Soc. America, Proc. 1934, p. 121–122.

Wenzel, L. K., 1942, Methods for determining permeability of water bearing materials: U.S. Geol. Survey Water-Supply Paper 887, 192 p.

White, Walter N., 1932, A method of estimating ground-water supplies based on discharge by plants and evaporation from soil: U.S. Geol. Survey Water-Supply Paper 659–A, 105 p.

Williams, G. R., and others, 1940, Natural water loss in selected drainage basins: U.S. Geol. Survey Water-Supply Paper 846, 62 p.

——— 1950, Hydrology, *in* Rouse, Hunter, Engineering hydraulics: New York, John Wiley & Sons, Inc., p. 229–320.

[1] Name changed to the New York State Water Resources Commission, February 1961.

TABLE 7.—*Streamflow characteristics at primary and secondary gaging stations adjusted to base period, 1944–59*

CARLLS RIVER AT BABYLON (NO. 20. PL. 7)

Location: Lat 40°42′30″, long 73°19′50″, on left bank in Babylon, Suffolk County, 130 ft downstream from outlet of Southards Pond and 0.9 mile upstream from head of tidewater.
Drainage area (ground water): About 20 square miles.
Records analyzed: October 1944 to September 1959.
Average discharge: 15 years (1945–59), 28.24 cfs; base period (1944–59), 28.17 cfs.
Extremes: Maximum daily discharge, 122 cfs, Aug. 13, 1955; minimum daily, 12.0 cfs, Aug. 3, 1957.
Remarks: Primary gaging station. Occasional regulation by several ponds above station.

Summary of monthly discharge, 1945-59 water years

Month	Mean (cfs)	Maximum		Minimum	
		Cubic feet per second	Calendar year	Cubic feet per second	Calendar year
October	21.1	40.6	1955	15.4	1957
November	26.3	50.3	1955	17.4	1950
December	28.5	35.8	1954	20.2	1946
January	30.2	46.6	1949	22.2	1950
February	31.7	43.6	1949	2[illegible].8	1947
March	35.9	51.5	1953	25.2	1947
April	36.4	56.5	1953	23.8	1950
May	32.7	45.2	1958	24.9	1955
June	27.8	38.0	1952	18.3	1957
July	23.6	35.2	1948	14.0	1957
August	23.8	35.9	1955	14.4	1957
September	21.0	35.9	1954	14.3	1957

Duration of daily flow, in cfs

Water years	Percent of time discharge equalled or exceeded that shown												
	1	2	5	10	20	30	50	70	80	90	95	98	99
1944–59	61	54	46.5	41	35	31.5	26.5	22.5	20.5	18	16.5	14.5	13.5

Low-flow frequency for base period, 1944–58 (climatic years)

Recurrence interval (years)	Average discharge, in cfs, for length of minimum period indicated					
	1 day	7 day	30 day	90 day	183 day	274 day
1.1	20	21	22.5	24.5	29.5	32.5
1.5	16	17	18.5	21	24.5	27
2	15	15.5	17	19.5	22	24.5
5	13	14	15	17.5	19	2[illegible]
15	12	12.5	13.5	15.5	17	1[illegible]

Annual low-flow frequency for days of deficient discharge for base period, 1944–58 (climatic years)

Recurrence interval (years)	Discharge, in cfs, below which flow remained continuous for length of minimum period indicated				
	1 day	7 day	14 day	30 day	60 day
1.1	20	21.5	23.5	27	35.5
1.5	16	17.5	18.5	21	26
2	15	16	17.5	19.5	23.5
5	13	14.5	15.5	17.5	21
15	12	13	14	16	19

TABLE 7.—*Streamflow characteristics at primary and secondary gaging stations adjusted to base period, 1944–59*—Continued

CARLLS RIVER AT BABYLON (NO. 20. PL. 7)—Continued

Storage-required frequency for base period, 1944-58 (climatic years)

Recurrence interval (years)	Natural 7-day flow (cfs)	Allowable draft, in cfs, for the amount of storage indicated, uncorrected for seepage and evaporation				
		50-cfs-days	100-cfs-days	200-cfs-days	400-cfs-days	600-cfs-days
2	15	18.5	20	21.5	23.5	25
5	13	16.5	18	19.5	21	22.5
15	12	15	16	17.5	19	20.5

CHAMPLIN CREEK AT ISLIP (NO. 8, PL. 7)

Location: Lat 40°44′15″, long 73°12′05″, on right bank just upstream from Long Island Railroad bridge, 220 ft downstream from Moffitt Boulevard, at Islip, Suffolk County, and 4,500 ft upstream from head of tidewater.
Drainage area (ground water): About 8 square miles.
Records analyzed: October 1948 to September 1959.
Average discharge: 11 years (1949–59), 7.82 cfs; base period (1944–59) 7.6 cfs.
Extremes: Maximum daily discharge, 67 cfs, Oct. 16, 1955; minimum daily, 2.97 cfs, Oct. 26–28, 1952.
Remarks: Primary gaging station. Occasional minor regulation at upstream culverts.

Summary of monthly discharge, 1949–59 water years

Month	Mean (cfs)	Maximum		Minimum	
		Cubic feet per second	Calendar year	Cubic feet per second	Calendar year
October	6.06	15.8	1955	3.73	1957
November	7.00	17.7	1955	4.05	1957
December	7.39	11.2	1955	4.46	1949
January	8.15	11.8	1949	4.78	1950
February	8.98	13.0	1956	6.62	1954
March	10.4	15.2	1956	6.85	1950
April	10.6	16.0	1953	6.50	1950
May	9.46	14.7	1958	6.81	1950
June	7.79	10.8	1952	5.17	1957
July	6.23	8.12	1958	4.11	1957
August	6.19	9.96	1955	3.78	1957
September	5.60	9.76	1954	3.60	1957

Duration of daily flow, in cfs

Water years	Percent of time discharge equalled or exceeded that shown												
	1	2	5	10	20	30	50	70	80	90	95	98	99
1944–59	18	16	13.5	12	9.6	8.6	7.1	5.8	5.2	4.5	4.0	3.7	3.4
1949–59	18	16.5	14.5	12	10	8.8	7.2	5.9	5.2	4.4	3.9	3.6	3.4

Low-flow frequency for base period, 1944–58 (climatic years)

Recurrence interval (years)	Average discharge, in cfs, for length of minimum period indicated					
	1 day	7 day	30 day	90 day	183 day	274 day
1.1	5.3	5.6	6.0	6.6	7.8	8.9
1.5	4.1	4.4	4.7	5.3	6.3	7.1
2	3.8	4.0	4.3	4.9	5.7	6.5
5	3.3	3.5	3.8	4.3	4.8	5.4
15	3.0	3.2	3.5	4.0	4.4	5.0

TABLE 7.—*Streamflow characteristics at primary and secondary gaging stations adjusted to base period, 1944–59*—Continued

CHAMPLIN CREEK AT ISLIP (NO. 8. PL. 7)—Continued

Annual low-flow frequency for days of deficient discharge for base period, 1944–58 (climatic years)

Recurrence interval (years)	Discharge, in cfs, below which flow remained continuous for length of minimum period indicated				
	1 day	7 day	14 day	30 day	60 day
1.1	5.3	5.7	6.3	7.3	9.6
1.5	4.1	4.5	4.8	5.5	6.9
2	3.8	4.1	4.4	5.0	6.2
5	3.3	3.7	3.9	4.5	5.4
15	3.0	3.4	3.6	4.0	4.8

Storage-required frequency for base period, 1944–58 (climatic years)

Recurrence interval (years)	Natural 7-day flow (cfs)	Allowable draft, in cfs, for the amount of storage indicated, uncorrected for seepage and evaporation				
		25-cfs-days	50-cfs-days	100-cfs-days	150-cfs-days	200-cfs-days
2	3.8	5.0	5.5	6.0	6.4	6.8
5	3.3	4.5	4.8	5.3	5.7	6.0
15	3.0	4.2	4.5	5.0	5.3	5.5

CONNETQUOT RIVER NEAR OAKDALE (NO. 6, PL. 7)

Location: Lat. 40°44′50″, long. 73°09′00″, on left bank just downstream from highway bridge at head of tide water, 1 mile west of Oakdale, Suffolk County.
Drainage area (ground water): about 27 square miles.
Records analyzed: October 1943 to September 1959.
Average discharge: 16 years, 40.17 cfs.
Extremes: Maximum daily discharge, 263 cfs, Oct 16, 1955; minimum daily, 22.3 cfs, Sept. 6, 1957.
Remarks: Primary gaging station. Occasional regulation at outlets of ponds above station. Discharge figures given are those of combined flows in main and secondary channels.

Summary of monthly discharge, 1944–59 water years

Month	Mean (cfs)	Maximum		Minimum	
		Cubic feet per second	Calendar year	Cubic feet per second	Calendar year
October	35.8	65.2	1955	27.2	1957
November	39.0	67.3	1955	2[illegible].3	1957
December	39.3	50.4	1955	3[illegible].4	1950
January	40.7	52.5	1949	33.5	1951
February	41.5	58.0	1956	32.6	1947
March	45.5	59.9	1953	32.3	1947
April	45.6	64.7	1953	32.7	1950
May	43.9	62.2	1958	3[illegible].1	1950
June	41.2	54.6	1948	3[illegible].3	1957
July	37.8	52.1	1948	27.6	1957
August	37.1	49.2	1946	2[illegible].0	1957
September	34.8	46.0	1954	2[illegible].2	1957

TABLE 7.—*Streamflow characteristics at primary and secondary gaging stations adjusted to base period, 1944–59*—Continued

CONNETQUOT RIVER NEAR OAKDALE (NO. 6, PL. 7)—Continued

Duration of daily flow, in cfs

Water years	Percent of time discharge equalled or exceeded that shown												
	1	2	5	10	20	30	50	70	80	90	95	98	99
1944–59	72	64	56	52	46.5	44	39	35	33	30.5	28.5	26.5	25

Low-flow frequency for base period, 1944–58 (climatic years)

Recurrence interval (years)	Average discharge, in cfs, for length of minimum period indicated				
	7-day	30-day	90-day	183-day	274-day
1.1	34	35.5	38.5	42	44.5
1.5	29.5	31	34	37	40
2	28	29.5	32	35	37.5
5	25.5	27.5	29.5	32.5	34
15	24	25.5	28	30.5	32

Annual low-flow frequency for days of deficient discharge for base period, 1944–58 (climatic years)

Recurrence interval (years)	Discharge, in cfs, below which flow remained continuous for length of mimum period indicated			
	7-day	14-day	30-day	60-day
1.1	34.5	36.5	40	46.5
1.5	30	31	34	39
2	28.5	29.5	32	37
5	26.5	27.5	30	34
15	24.5	26	28	31.5

Storage-required frequency for base period, 1944–58 (climatic years)

Recurrence interval (years)	Natural 7-day flow (cfs)	Allowable draft, in cfs, for the amount of storage indicated, uncorrected for seepage and evaporation				
		50-cfs-days	100-cfs-days	200-cfs-days	400-cfs-days	600-cfs-days
2	28	30	32	34	37	38
5	25.5	28.5	30	32	34	35.5
15	24	26.5	28	29.5	32	33.5

TABLE 7.—*Streamflow characteristics at primary and secondary gaging stations adjusted to base period, 1944–59*—Continued

MASSAPEQUA CREEK AT MASSAPEQUA (NO. 29, PL. 7)

Location: Lat 40°41′20″, long 73°27′20″, on left bank 350 ft west of Garfield Street at Lake Shore Drive, Massapequa, Nassau County, a quarter of a mile north of Massapequa Park, and 1¾ miles above head of tidewater.
Drainage area (ground water): About 11 square miles.
Records analyzed: October 1937 to September 1959.
Average discharge: 22 years (1938–59), 12.26 cfs; base period (1944–59), 12.85 cfs.
Extremes: Maximum daily discharge, 111 cfs, Aug. 12, 1955; minimum daily, 2.98 cfs, Aug. 3, 1957.
Remarks: Primary gaging station.

Summary of monthly discharge, 1938–59 water years

Month	Mean (cfs)	Maximum		Minimum	
		Cubic feet per second	Calendar year	Cubic feet per second	Calendar year
October	8.53	18.6	1955	3.98	1941
November	10.3	24.6	1955	4.53	1941
December	11.0	16.9	1938	5.21	1941
January	12.3	23.1	1949	4.33	1942
February	13.7	24.0	1939	6.57	1947
March	16.5	28.6	1939	7.99	1947
April	17.4	33.5	1953	8.10	1950
May	15.1	26.2	1958	7.57	1942
June	12.7	28.8	1952	5.85	1957
July	10.5	21.1	1948	4.05	1957
August	10.4	23.0	1955	4.89	1957
September	8.84	18.3	1938	4.16	1941

Duration of daily flow, in cfs

Water years	Percent of time discharge equalled or exceeded that shown												
	1	2	5	10	20	30	50	70	80	90	95	98	99
1938–59	36	30	24.5	21	16.5	14	10.5	8.2	7.1	5.8	4.8	4.1	3.7
1944–59	37	31	25	21	17.5	15	11.5	8.8	7.4	6.0	5.1	4.3	3.9

Low-flow frequency for base period, 1944–58 (climatic years)

Recurrence interval (years)	Average discharge, in cfs, for length of minimum period indicated					
	1 day	7 day	30 day	90 day	183 day	274 day
1.1	6.4	6.8	8.0	10	13	15
1.5	5.0	5.4	6.3	7.8	10	11.5
2	4.4	4.8	5.6	7.0	8.7	10
5	3.6	3.9	4.5	5.7	7.0	8.2
15	2.9	3.2	3.7	4.7	5.7	6.7

Annual low-flow frequency for days of deficient discharge for base period, 1944–58 (climatic years)

Recurrence interval (years)	Discharge, in cfs, below which flow remained continuous for length of minimum period indicated				
	1 day	7 day	14 day	30 day	60 day
1.1	6.4	8.2	9.5	11.5	17
1.5	5.0	5.8	6.6	8.0	11.5
2	4.4	5.2	5.8	7.4	9.8
5	3.6	4.2	4.8	6.1	8.0
15	2.9	3.5	4.0	5.0	6.6

TABLE 7.—*Streamflow characteristics at primary and secondary gaging stations adjusted to base period, 1944-59*—Continued

MASSAPEQUA CREEK AT MASSAPEQUA (NO. 20, PL. 7)—Continued

Storage-required frequency for base period, 1944-58 (climatic years)

Recurrence interval (years)	Natural 7-day flow (cfs)	Allowable draft, in cfs, for the amount of storage indicated, uncorrected for seepage and evaporation				
		50-cfs-days	100-cfs-days	200-cfs-days	300-cfs-days	400-cfs-days
2	4.4	7.0	7.8	9.2	10	11
5	3.6	5.9	6.7	7.8	8.6	9.2
15	2.9	5.0	5.8	6.6	7.3	7.8

PENATAQUIT CREEK AT BAY SHORE (NO. 12, PL. 7)

Location: Lat 40°43'40", long 73°14'40", on right bank just upstream from Union Avenue in Bay Shore, Suffolk County, 1,300 ft upstream from head of tidewater.
Drainage area (ground water): About 5.5 square miles.
Records analyzed: October 1945 to September 1959.
Average discharge: 14 years (1946-59), 6.16 cfs; base period (1944-59), 6.07 cfs.
Extremes: Maximum daily discharge, 48 cfs, Oct. 16, 1955; minimum daily, 2.6 cfs Aug. 3, 6, 1955.
Remarks: Primary gaging station. Occasional minor regulation at upstream culverts.

Summary of monthly discharge, 1946-59 water years

Month	Mean (cfs)	Maximum		Minimum	
		Cubic feet per second	Calendar year	Cubic feet per second	Calendar year
October	4.57	11.1	1955	3.32	1947
November	5.56	12.7	1955	3.50	1946
December	5.95	8.06	1955	3.86	1946
January	6.50	9.35	1949	4.03	1950
February	7.01	9.71	1956	4.06	1947
March	7.98	11.1	1953	4.80	1947
April	8.32	12.9	1953	5.04	1950
May	7.30	10.6	1958	5.40	1950
June	6.13	8.58	1946	4.17	1955
July	5.12	8.34	1948	3.19	1955
August	5.11	8.74	1955	3.53	1949
September	4.37	8.07	1954	3.28	1951

Duration of daily flow, in cfs

Water years	Percent of time discharge equalled or exceeded that shown												
	1	2	5	10	20	30	50	70	80	90	95	98	99
1944-59	14.5	12	10	8.9	7.6	6.8	5.5	4.6	4.1	3.6	3.3	3.0	2.9
1946-59	15	13	11	9.2	7.7	6.9	5.6	4.6	4.1	3.5	3.3	3.0	2.8

Low-flow frequency for base period, 1944-58 (climatic years)

Recurrence interval (years)	Average discharge, in cfs, for length of minimum period indicated					
	1-day	7-day	30-day	90-day	183-day	274-day
1.1	4.1	4.3	4.6	5.1	6.2	7.1
1.5	3.3	3.5	3.7	4.2	5.0	5.6
2	3.1	3.2	3.4	3.9	4.5	5.1
5	2.8	2.9	3.1	3.5	3.9	4.3
15	2.6	2.7	2.9	3.2	3.6	4.0

TABLE 7.—*Streamflow characteristics at primary and secondary gaging stations adjusted to base period, 1944–59*—Continued

PENATAQUIT CREEK AT BAY SHORE (NO. 12, PL. 7)—Continued

Annual low-flow frequency for days of deficient discharge for base period, 1944–58 (climatic years)

Recurrence interval (years)	Discharge, in cfs, below which flow remained continuous for length of minimum period indicated				
	1-day	7-day	14-day	30-day	60-day
1.1	4.1	4.4	4.7	5.4	6.6
1.5	3.3	3.6	3.8	4.4	5.3
2	3.1	3.3	3.5	4.1	4.9
5	2.8	3.0	3.2	3.6	4.2
15	2.6	2.8	2.9	3.3	3.9

Storage-required frequency for base period, 1944–58 (climatic years)

Recurrence interval (years)	Natural 7-day flow (cfs)	Allowable draft, in cfs, for the amount of storage indicated, uncorrected for seepage and evaporation				
		25-cfs-days	50-cfs-days	100-cfs-days	150-cfs-days	200-cfs-
2	3.1	4.1	4.5	4.9	5.3	5.6
5	2.8	3.7	4.0	4.4	4.7	5.0
15	2.6	3.4	3.7	4.0	4.3	4.7

SAMPAWAMS CREEK AT BABYLON (NO. 19, PL. 7)

Location: Lat. 40°42′15″, long. 73°18′50″, on left bank at upstream side of John Street bridge in Babylon, Suffolk County, 180 ft. downstream from Long Island Railroad and 3,100 ft. upstream from head of tidewater.
Drainage area (ground water): About 7.5 square miles.
Records analyzed: October 1944 to September 1959.
Average discharge: 15 years (1945–59), 9.75 cfs; base period (1944–59), 9.69 cfs.
Extremes: Maximum daily discharge, 78 cfs, Oct. 16, 1955; minimum daily, 3.35 cfs, Aug. 3, 1955, Aug. 2, 1957.
Remarks: Primary gaging station. Slight regulation by pumping operations at railroad and occasionally by ponds above station. Slight diversion caused by Long Island Water Authority's Smith Street substation a quarter of a mile northwest of gage.

Summary of monthly discharge, 1945–59 water years

Month	Mean (cfs)	Maximum		Minimum	
		Cubic feet per second	Calendar year	Cubic feet per second	Calendar year
October	6.55	15.8	1955	4.08	1950
November	8.18	19.8	1955	4.33	1950
December	9.30	13.2	1955	4.92	1946
January	10.3	14.9	1949	5.64	1950
February	11.1	15.2	1956	5.77	1947
March	13.3	20.2	1958	7.09	1947
April	13.7	22.0	1958	7.08	1950
May	12.1	20.2	1958	7.25	1950
June	9.79	14.6	1958	5.75	1955
July	7.94	13.8	1948	4.28	1957
August	8.16	15.1	1955	4.88	1957
September	6.84	14.6	1954	4.04	1951

Duration of daily flow, in cfs

Water years	Percent of time discharge equalled or exceeded that shown												
	1	2	5	10	20	30	50	70	80	90	95	98	99
1944–59	25	21	18	15.5	12.5	11	8.6	6.8	5.9	5.0	4.4	3.9	3.7

TABLE 7.—*Streamflow characteristics at primary and secondary gaging stations adjusted to base period, 1944–59*—Continued

SAMPAWAMS CREEK AT BABYLON (NO. 19. PL. 7)—Continued

Low-flow frequency for base period, 1944-58 (climatic years)

Recurrence interval (years)	Average discharge, in cfs, for length of minimum period indicated				
	7-day	30-day	90-day	183-day	274-day
1.1	6.5	7.1	8.2	10	11.5
1 5	4.8	5.2	6.2	7.7	8.7
2	4.3	4.7	5.6	6.8	7.8
5	3.8	4.2	4.9	5.6	6.5
15	3.4	3.8	4.4	5.0	5.8

Annual low-flow frequency for days of deficient discharge for base period, 1944-58 (climatic years)

Recurrence interval (years)	Discharge, in cfs, below which flow remained continuous for length of mimum period indicated			
	7-day	14-day	30-day	60-day
1.1	6.5	7.4	8.8	12.5
1.5	4.9	5.3	6.5	8.7
2	4.5	4.9	5.9	7.7
5	4.0	4.3	5.0	6.3
15	3.6	3.9	4.5	5.6

Storage-required frequency for base period, 1944-58 (climatic years)

Recurrence interval (years)	Natural 7-day flow (cfs)	Allowable draft, in cfs, for the amount of storage, uncorrected for seepage and evaporation, indicated				
		50-cfs-days	100-cfs-days	150-cfs-days	200-cfs-days	300-cfs-days
2	4.3	6.2	6.8	7.3	7.8	8.4
5	3.8	5.4	5.9	6.3	6.6	7.3
15	3.4	4.9	5.4	5.7	6.0	6.6

SANTAPOGUE RIVER AT LINDENHURST (NO. 22, PL. 7)

Location: Lat 40°41′30″, long 73°21′20″, on left bank just upstream from East Hoffman Avenue, 3,000 ft upstream from head of tidewater, and 1 mile east of Long Island Railroad station in Lindenhurst, Suffolk County.
Drainage area (ground water): About 8 square miles.
Records analyzed: October 1947 to September 1959.
Average discharge: 12 years (1948-59), 4.96 cfs.
Extremes: Maximum daily discharge, 30.6 cfs, Aug. 13, 1955; minimum daily, 0.22 cfs, July 31, Aug. 1, 1954.
Remarks: Primary gaging station. Substantial depletion of flow during periods of heavy ground-water withdrawal by the West Babylon pumping station located 2,500 ft upstream.

Summary of monthly discharge, 1948–59 water years

Month	Mean (cfs)	Maximum		Minimum	
		Cubic feet per second	Calendar year	Cubic feet per second	Calendar year
October	2.63	6.05	1955	0.86	1957
November	4.10	9.21	1955	1.32	1957
December	4.65	7.37	1954	2.33	1949
January	5.54	10.4	1949	2.90	1950
February	6.31	10.3	1949	3.48	1957
March	7.69	12.6	1953	3.72	1957
April	7.90	15.5	1953	4.03	1950
May	6.61	10.4	1953	2.93	1957
June	4.84	9.55	1952	1.11	1957
July	3.24	9.26	1948	0.42	1957
August	3.39	6.27	1948	0.58	1957
September	2.69	6.70	1954	0.67	1957

TABLE 7.—*Streamflow characteristics at primary and secondary gaging stations adjusted to base period, 1944–59*—Continued

SANTAPOGUE RIVER AT LINDENHURST (NO. 22. PL. 7)—Continued

Duration of daily flow, in cfs

Water years	Percent of time discharge equalled or exceeded that shown												
	1	2	5	10	20	30	50	70	80	90	95	98	99
1948–59	15	13	11	9.1	7.4	6.1	4.3	2.9	2.3	1.6	1.1	0.5	0.4

AMITYVILLE CREEK AT AMITYVILLE (NO. 27, PL. 7)

Location: Lat 40°40′15″, long 73°24′50″, 100 ft above State Highway 27A, 150 ft above head of tidewater, at Amityville, Suffolk County.
Drainage area (ground water): About 4.5 square miles.
Records analyzed: November 1958 to October 1960 (water-stage recorder). July 1954 to October 1958 station operated as a partial-record site (discharge measurements only).
Average discharge: November 1958 to October 1960, 4.05 cfs; base period (1944–59), 3.6 cfs.
Extremes: Maximum daily discharge, 52 cfs, Sept. 12, 1960; minimum daily, 1.7 cfs, Oct. 22, 1959.
Remarks: Secondary gaging station. See table 9 for values of daily discharge during the period November 1958 to October 1960.

Duration of daily flow, in cfs

Period	Percent of time discharge equalled or exceeded that shown									
	5	10	20	30	50	70	80	90	95	98
Nov. 1, 1958–Oct. 31, 1960	6.2	5.2	4.5	4.2	3.7	3.2	2.9	2.6	2.3	2.0
1944–59 water years	6.7	5.7	4.7	4.1	3.2	2.5	2.2	1.8	1.5	1.3

Low-flow frequency for base period, 1944–58 (climatic years)

Recurrence interval (years)	Average discharge, in cfs, for length of minimum period indicated			
	7-day	30-day	90-day	183-day
1.5	1.7	1.9	2.3	2.8
2	1.5	1.7	2.1	2.5
5	1.2	1.4	1.7	2.0
15	1.1	1.2	1.5	1.8

AWIXA CREEK AT ISLIP (NO. 11, PL. 7)

Location: Lat 40°43′40″, long 73°13′50″, at culvert on State Highway 27A, 1,100 ft above head of tidewater, and ¾ mile west of Islip, Suffolk County.
Drainage area (ground water): About 2 square miles.
Records analyzed: November 1958 to October 1960 (water-stage recorder). February 1948 to October 1958 station operated as a partial-record site (discharge measurements only).
Average discharge: November 1958 to October 1960, 2.07 cfs; base period (1944–59), 2.1 cfs.
Extremes: Maximum daily discharge, 14 cfs, Sept. 12, 1960; minimum daily, 0.86 cfs Sept. 28–30, Oct. 2–6, 1959.
Remarks: Secondary gaging station. See table 9 for values of daily discharge during the period November 1958 to October 1960.

Duration of daily flow, in cfs

Period	Percent of time discharge equalled or exceeded that shown									
	5	10	20	30	50	70	80	90	95	98
Nov. 1, 1958–Oct. 31, 1960	4.2	3.2	2.5	2.2	1.8	1.5	1.3	1.1	1.0	0.94
1944–59 water years	4.9	4.0	3.0	2.5	1.9	1.4	1.2	.9[illegible]	.84	.72

Low-flow frequency for base period, 1944–58 (climatic years)

Recurrence interval (years)	Average discharge, in cfs, for length of minimum period indicated			
	7-day	30-day	90-day	183-day
1.5	0.9	1.0	1.2	1.5
2	.8	.95	1.1	1.4
5	.65	.75	.9	1.1
15	.55	.65	.8	.95

TABLE 7.—*Streamflow characteristics at primary and secondary gaging stations adjusted to base period, 1944–59*—Continued

EAST BRANCH OROWOC CREEK AT ISLIP (NO. 9, PL. 7)

Location: Lat 40°43'40", long 73°13'20", at culvert on State Highway 27A, 200 ft above head of tidewater, in Islip, Suffolk County.
Drainage area (ground water): About 3 square miles.
Records analyzed: November 1959 to October 1960 (water-stage recorder). January 194? to October 1959 station operated as a partial-record site (discharge measurements only).
Average discharge: November 1959 to October 1960, 2.63 cfs; base period (1944–59), 2.7 cfs.
Extremes: Maximum daily discharge, 11 cfs, Sept. 12, 13, 1960; minimum daily, 0.97 cfs, Nov. 3, 4, 6, 1959.
Remarks: Secondary gaging station. Occasional regulation by several ponds upstream. See table 9 for values of daily discharge during the period November 1959 to October 1960.

Duration of daily flow, in cfs

Period	Percent of time discharge equalled or exceeded that shown									
	5	10	20	30	50	70	80	90	95	98
Nov. 1, 1959–Oct. 31, 1960	4.7	4.1	3.4	3.0	2.4	1.9	1.6	1.3	1.2	1.1
1944–59 water years	5.6	4.7	3.8	3.2	2.3	1.5	1.2	.76	.56	.43

Low-flow frequency for base period, 1944–58 (climatic years)

Recurrence interval (years)	Average discharge, in cfs, for length of minimum period indicated			
	7-day	30-day	90-day	183-day
1.5	0.65	0.80	1.2	1.8
2	.5	.65	1.0	1.4
5	.35	.45	.7	.95
15	.3	.35	.55	.75

WEST BROOK NEAR GREAT RIVER (NO. 7, PL. 7)

Location: Lat 40°44'40", long 73°09'25", at pond outlet, 80 ft above State Highway 27A, 400 ft above head of tidewater, and 1¾ miles north of Great River, Suffolk County.
Drainage area (ground water): About 3.5 square miles.
Records analyzed: November 1958 to August 1960 (water-stage recorder). October 1943 to October 1958 station operated as a partial-record site (discharge measurements only).
Average discharge: November 1958 to August 1960, 4.57 cfs; base period (1944–59), 4.5 cfs.
Extremes: Maximum daily discharge, 9.4 cfs, July 15, 1959; minimum daily, 2.9 cfs, July 7–9, 1959, Oct. 2–5, 1959.
Remarks: Secondary gaging station. See table 9 for values of daily discharge during the period November 1958 to August 1960.

Duration of daily flow, in cfs

Period	Percent of time discharge equalled or exceeded that shown									
	5	10	20	30	50	70	80	90	95	98
Nov. 1, 1958–Aug. 31, 1960	6.1	5.8	5.5	5.1	4.5	4.0	3.7	3.3	3.1	2.9
1944–59 water years	7.3	6.4	5.6	5.1	4.3	3.6	3.2	2.8	2.5	2.3

Low-flow frequency for base period, 1944–58 (climatic years)

Recurrence interval (years)	Average discharge, in cfs, for length of minimum period indicated			
	7-day	30-day	90-day	183-day
1.5	2.7	3.0	3.4	3.9
2	2.5	2.7	3.1	3.6
5	2.1	2.4	2.7	3.1
15	1.9	2.1	2.5	2.8

TABLE 8.—*Streamflow characteristics of partial-record stations adjusted to base period, 1944–59*

Station			Period of measurements (water years)	Mean annual discharge (cfs)	Flow, in cfs, which was equalled or exceeded for indicated percent of time				Lowest average discharge, in cfs, for indicated period of consecutive days and indicated recurrence interval			
No. (pl. 7)	Stream name and location	Remarks on site			30	50	70	90	7-day 2-year	7-day 10-year	30-day 2-year	30-day 10-year
1	Tuthills Creek at Patchogue.	At culvert on State Highway 27A, 600 ft above head of tidewater.	1947–49, 1953–59.	6.0	6.5	5.7	5.1	4.3	3.9	3.4	4.2	3.6
2	East Branch Brown Creek at Sayville.	At L.I.R.R. culvert, 300 ft above head of tidewater.	1948, 1950–59.	3.0	3.7	2.7	2.0	1.4	1.2	.8	1.3	1.0
3	West Branch Brown Creek at Sayville.	At L.I.R.R. culvert, 100 ft above head of tidewater.	1948, 1950–59.	5.1	5.7	4.7	3.8	2.9	2.6	2.2	2.9	2.4
4	Green Brook at West Sayville.	At head of tidewater, 50 ft above Montauk Highway.	1953–59	4.5	4.9	4.3	3.8	3.2	2.9	2.5	3.1	2.7
5	Rattlesnake Brook at Oakdale.	50 ft below State Highway 27; 200 ft above head of tidewater.	1944–59	10.0	11.1	9.5	8.2	6.7	5.9	5.0	6.4	5.5
8a	Champlin Creek at Islip	300 ft northeast of east end of Poplar St., 2.4 miles above head of tidewater.	1959–60	.68	.9	.6	.35	.17	.13	.08	.16	.10
8b	do	150 ft northeast of east end of Cherry St., 2.2 miles above head of tidewater.	1959–60	.84	1.1	.7	.45	.23	.18	.11	.22	.14
8c	do	75 ft below Beech St., 1.8 miles above head of tidewater.	1959–60	1.9	2.5	1.7	1.1	.6	.45	.28	.5	.35
8d	do	400 ft east of east end of Walnut St., 1.5 miles above head of tidewater.	1959–60	3.6	4.3	3.3	2.5	1.8	1.5	1.2	1.7	1.3
8e	do	At Islip Boulevard, 1.3 miles above head of tidewater.	1959–60	5.3	6.4	4.8	3.7	2.5	2.1	1.6	2.3	1.8
8f	do	At Montauk Highway, 0.4 mile above head of tidewater.	1959–60	8.9	10.1	8.1	6.5	4.8	4.1	3.3	4.6	3.7
8g	do	At head of tidewater, 0.9 mile above entrance to Great South Bay.	1959–60	10.3	12.0	9.3	7.3	5.2	4.5	3.5	5.0	3.9
10	West Branch Orowoc Creek at Islip.	At culvert on State Highway 27A, 200 ft above head of tidewater.	1948–59	5.9	6.6	5.3	4.4	3.4	3.0	2.5	3.2	2.7
13	Lawrence Creek at Brightwaters.	At head of tidewater, 1,000 ft below State Highway 27A.	1959	.7								
14	Cascade Lakes Outlet at Brightwaters.	At culvert on State Highway 27A, 100 ft above head of tidewater.	1958–60	2.5	2.9	2.1	1.6	1.0	.8	.6	.9	.7
15	Thompsons Creek at Brightwaters.	At State Highway 27A, 1,700 ft above head of tidewater.	1959	.7								

16	Trues Creek at West Islip	At State Highway 27A, 800 ft above head of tidewater.	1958–60	1.9	2.3	1.7	1.2	.9	.7	.5	.8	.6
17	Willetts Creek at West Islip.	At State Highway 27A, at head of tidewater	1953–59	2.6	3.0	2.3	1.8	1.2	1.0	.8	1.2	.9
18	Skookwams Creek at Babylon.	At Magoun Road, 20 ft above head of tidewater, 1,600 ft below State Highway 27A.	1959–60	1.1								
19a	Sampawams Creek at Babylon.	At Bay Shore Road, 3.2 miles above head of tidewater.	1959–60	2.3	2.6	2.1	1.7	1.3	1.1	.9	1.2	1.0
19b	do	50 ft below Southern State Parkway, 2.7 miles above head of tidewater.	1959–60	2.1	2.8	1.5	.8	.4	.25	.15	.35	.2
19c	do	At Hunter Ave., 2.2 miles above head of tidewater.	1959–60	3.7	4.5	3.0	2.1	1.2	1.0	.7	1.1	.8
19d	do	At Sunrise Highway, 1.6 miles above head of tidewater.	1959–60	5.5	6.5	4.7	3.3	2.1	1.8	1.4	2.0	1.6
19e	do	300 ft east of east end of Wyandanch Ave., 1.1 miles above head of tidewater.	1959–60	8.5	9.7	7.4	5.6	3.9	3.3	2.7	3.7	3.0
19f	do	At State Highway 27A, at head of tidewater	1953–60	12.5	14.0	11.0	8.9	6.5	5.6	4.6	6.2	5.1
20a	Carlls River at Babylon	150 ft above Railroad Ave., 1,700 ft above head of tidewater.	1959–60	36	40.5	33.5	28	22	18.5	15.5	20.5	16.5
21	West Babylon Creek at Babylon.	At head of tidewater, 1,200 ft below State Highway 27A.	1959	0.7								
22g	Santapogue River at Lindenhurst.	At State Highway 27A, at head of tidewater	1953–60	9.5	10.7	8.6	6.8	5.1	4.6	3.9	5.0	4.2
23a	Neguntatogue Creek at Lindenhurst.	At East Hoffman Ave., 3,800 ft above head of tidewater.	1948, 1952–60	1.4	1.7	1.2	.8	.5	.4	.3	.5	.4
23b	do	At State Highway 27A, at head of tidewater	1948–50, 1952–60.	3.7	4.1	3.4	2.7	2.1	1.9	1.6	2.0	1.7
24	Strong Creek at Lindenhurst.	At State Highway 27A, at head of tidewater	1953–60	1.7	1.9	1.6	1.4	1.2	1.15	1.0	1.2	1.1
25	Great Neck Creek at Copiague.	At State Highway 27A, at head of tidewater	1958–60	2.4	2.7	2.2	1.8	1.3	1.2	1.0	1.3	1.1
26	Woods Creek at Amityville	1,100 ft above State Highway 27A, and head of tidewater.	1959	.5								
28	Carman Creek near Amityville.	At State Highway 27A, in Nassau County, at head of tidewater.	1949, 1953–60	4.3	5.0	3.8	2.9	2.0	1.6	1.3	1.8	1.4

TABLE 9.—*Daily and monthly discharge of selected streams*

AMITYVILLE CREEK AT AMITYVILLE, N.Y.—Continued

Discharge, in cfs period November 1, 1958 to October 31, 1959

Day	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
1	5.1	4.0	3.8	3.4	3.8	4.6	4.7	3.3	3.6	3.8	2.8	2.7
2	5.2	3.9	7.2	3.4	3.8	8.3	4.3	3.6	3.5	3.6	2.8	2.7
3	5.7	3.9	4.5	3.4	3.6	9.1	4.1	6.1	3.5	3.6	2.8	2.6
4	5.4	6.0	4.5	4.4	3.6	5.9	4.0	4.3	3.3	3.5	2.8	2.6
5	5.3	4.8	3.8	3.8	3.4	5.7	3.9	4.1	3.3	7.8	2.7	2.5
6	4.9	4.3	3.7	3.7	6.4	5.6	4.0	3.8	3.3	4.4	2.7	2.4
7	4.7	4.2	3.7	3.6	4.1	5.6	4.2	3.6	3.3	3.9	2.6	2.3
8	4.5	4.3	3.7	3.6	3.9	5.5	5.9	3.6	3.2	3.8	2.6	2.1
9	4.4	4.3	3.6	3.6	3.9	5.4	3.8	3.3	3.2	8.9	2.7	2.3
10	4.3	4.2	3.6	5.3	4.0	5.5	3.7	3.3	3.6	4.6	2.8	1.9
11	4.2	4.1	3.6	4.1	3.9	5.4	3.7	3.3	14	4.2	2.7	1.9
12	4.1	4.3	3.6	3.7	5.3	5.4	3.6	3.2	4.6	3.9	2.7	1.9
13	4.1	4.3	3.6	4.0	4.6	5.3	5.1	4.9	4.4	3.8	2.6	1.8
14	4.1	4.2	3.6	3.9	4.4	5.1	6.5	3.6	4.4	3.7	2.6	2.1
15	4.1	4.3	3.6	4.6	4.5	4.9	4.3	3.3	11	3.6	2.7	1.9
16	4.1	4.2	3.8	4.1	4.5	4.8	4.0	3.2	5.1	3.6	2.6	2.0
17	4.1	4.0	3.7	4.0	4.6	4.8	3.8	3.2	4.5	3.5	2.7	2.0
18	4.1	3.9	3.6	3.9	4.5	4.7	3.8	3.2	4.4	3.4	2.7	2.0
19	4.1	3.8	3.5	3.8	4.6	4.8	3.6	3.2	4.4	3.4	2.7	1.9
20	4.1	3.8	3.8	3.7	4.6	5.1	3.6	3.2	4.5	3.2	2.6	1.9
21	4.0	3.6	4.0	3.7	4.8	4.8	3.6	3.2	4.4	3.2	2.8	1.8
22	4.0	3.6	3.9	3.7	5.2	4.6	3.7	3.2	4.2	3.2	2.8	1.7
23	3.9	3.6	3.7	3.9	4.8	4.7	3.6	3.5	4.1	3.1	2.7	1.8
24	3.8	3.6	3.6	3.9	4.8	4.4	3.6	3.1	4.0	3.0	2.7	7.2
25	3.8	3.4	3.5	3.8	4.7	4.3	3.6	3.2	3.9	3.0	2.7	3.7
26	3.7	3.4	3.6	3.9	4.5	4.3	3.6	3.2	3.9	3.0	2.7	3.0
27	3.6	3.4	3.6	3.7	4.9	4.3	3.5	3.0	3.8	2.9	2.6	3.1
28	4.1	3.4	3.6	3.7	4.8	4.2	3.5	8.7	3.8	2.9	2.6	3.0
29	7.1	3.5	3.5	------	4.3	5.2	3.4	4.0	3.7	2.9	2.6	2.6
30	4.3	3.9	3.6	------	4.9	4.6	3.5	3.5	3.8	2.9	2.6	2.3
31	------	3.8	3.5	------	5.2	------	3.3	------	3.8	2.8	------	2.2

Month	Cfs-days	Maximum	Minimum	Mean
November	132.9	7.1	3.6	4.43
December	124.0	6.0	3.4	4.00
January	118.4	7.2	3.5	3.82
February	108.3	5.3	3.4	3.87
March	138.9	6.4	3.4	4.48
April	156.9	9.1	4.2	5.23
May	121.3	6.5	3.3	3.91
June	111.9	8.7	3.0	3.73
July	138.5	14	3.2	4.47
August	117.1	8.9	2.8	3.78
September	80.7	2.8	2.6	2.69
October	75.9	7.2	1.7	2.45
Period 365 days	1,424.8	14	1.7	3.90

TABLE 9.—*Daily and monthly discharge of selected streams*—Continued

AMITYVILLE CREEK AT AMITYVILLE, N.Y.

Discharge, in cfs, period November 1, 1959 to October 31, 1960

Day	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
1	2.1	2.4	3.6	4.0	4.9	4.0	7.9	3.4	2.4	3.4	3.2	4.6
2	2.0	2.6	3.6	3.7	4.9	3.4	5.3	3.3	2.9	3.2	3.0	4.4
3	2.0	2.6	7.2	3.4	5.4	3.6	4.4	3.2	2.2	3.2	2.7	4.4
4	2.1	2.6	4.3	3.4	5.4	7.7	4.3	3.3	9.4	2.8	2.4	4.6
5	2.1	2.6	3.8	3.4	4.9	9.5	4.1	3.2	2.9	3.0	2.7	4.7
6	2.1	2.6	3.8	5.5	4.7	6.4	3.8	2.9	2.4	2.8	2.7	4.7
7	3.1	5.0	3.7	4.0	4.6	6.0	4.0	2.6	2.4	2.8	2.8	4.7
8	2.9	3.1	3.6	3.7	4.6	5.8	4.3	2.7	2.3	2.9	2.9	4.6
9	2.4	2.9	3.7	3.8	4.6	6.2	5.3	2.6	2.2	2.9	2.9	4.4
10	2.4	2.8	3.7	3.8	4.4	6.2	4.1	2.8	2.1	2.9	2.8	4.7
11	2.4	2.8	3.7	4.7	4.4	6.0	3.7	3.1	2.2	2.7	8.7	4.4
12	2.4	4.3	3.8	4.1	4.4	6.0	3.6	4.3	2.2	2.6	52	4.3
13	2.4	5.3	4.3	3.8	4.3	5.3	4.1	3.2	2.2	2.8	18	4.1
14	2.4	3.7	4.1	4.7	4.4	4.9	3.7	3.1	22	2.9	6.7	4.0
15	2.6	3.6	4.7	4.1	4.3	4.7	3.3	3.2	5.8	5.0	5.8	3.8
16	2.4	3.4	4.7	3.8	4.6	4.1	3.0	3.0	2.9	3.4	5.3	3.8
17	3.1	3.3	4.3	3.7	5.1	3.8	2.9	2.9	2.8	3.4	4.9	3.7
18	2.7	3.3	4.6	4.3	4.9	3.7	4.9	2.9	2.8	3.3	4.7	3.7
19	2.4	3.4	5.1	8.9	4.4	2.9	3.4	2.7	2.9	15	6.3	4.0
20	2.4	3.2	4.1	4.4	4.4	7.2	3.7	2.8	2.8	4.9	14	7.0
21	2.4	3.2	3.8	4.3	4.3	4.1	3.7	2.6	2.6	3.6	5.4	4.6
22	2.4	3.4	3.8	4.3	4.1	3.6	3.8	2.4	2.4	3.6	4.9	4.1
23	2.4	3.2	3.8	4.3	4.0	3.6	9.3	2.4	2.6	3.3	4.6	4.3
24	3.0	3.1	3.7	4.1	4.0	3.7	5.3	3.6	2.6	2.9	4.4	5.6
25	4.1	3.1	3.7	4.4	3.0	4.7	4.4	2.6	2.4	3.1	4.1	4.1
26	2.8	3.2	3.7	17	3.2	5.1	4.4	2.4	2.2	3.0	4.0	4.3
27	2.6	3.3	3.7	5.6	3.3	4.6	4.3	2.8	2.6	3.0	3.8	4.1
28	2.9	3.6	5.3	5.1	4.3	4.1	3.3	2.3	5.8	2.6	3.7	4.1
29	2.6	4.9	4.3	5.4	3.6	3.8	3.1	2.2	3.3	3.7	3.8	4.7
30	2.4	3.8	3.8	-------	3.4	3.7	3.2	1.9	22	2.9	5.8	4.0
31	-------	3.7	3.8	-------	6.2	-------	4.2	-------	4.9	3.9	-------	4.4

Month	Cfs-days	Maximum	Minimum	Mean
November	76.0	4.1	2.0	2.53
December	104.0	5.3	2.4	3.35
January	127.8	7.2	3.6	4.12
February	139.7	17	3.4	4.82
March	137.0	6.2	3.0	4.42
April	148.4	9.5	2.9	4.95
May	132.8	9.3	2.9	4.28
June	86.4	4.3	1.9	2.88
July	133.2	22	2.1	4.30
August	111.5	15	2.6	3.60
September	199.0	52	2.4	6.63
October	136.9	7.0	3.7	4.42
Period 366 days	1,532.7	52	1.9	4.19

TABLE 9.—*Daily and monthly discharge of selected streams*—Continued

AWIXA CREEK AT ISLIP, N.Y.—Continued

Discharge, in cfs, period November 1, 1958 to October 31, 1959

Day	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
1	2.1	1.9	1.8	1.6	1.7	3.4	2.4	1.5	1.3	1.8	1.8	0.90
2	2.6	1.8	7.4	1.6	1.7	6.0	2.1	2.1	1.3	1.8	1.3	.86
3	2.6	1.8	2.6	1.6	1.7	7.0	2.0	4.6	1.3	1.8	1.3	.86
4	2.0	6.0	2.3	2.6	2.0	4.6	1.9	1.8	1.2	1.7	1.2	.86
5	2.0	2.9	2.0	1.9	1.7	4.2	1.9	1.6	1.2	5.9	1.2	.86
6	2.0	2.4	1.8	1.8	7.8	4.0	1.8	1.6	1.2	2.3	1.1	.86
7	1.9	2.3	1.8	1.7	3.1	3.9	1.8	1.6	1.2	2.1	1.1	.98
8	1.9	2.1	1.8	1.6	2.6	3.9	1.8	1.5	1.2	2.1	1.1	.98
9	2.0	2.1	1.8	1.7	2.4	3.7	1.8	1.4	1.2	4.8	1.1	1.3
10	2.1	2.0	1.8	3.6	2.4	4.1	1.8	1.4	2.8	2.3	1.1	1.0
11	1.9	2.0	1.8	2.3	2.3	5.2	1.7	1.4	11	1.8	1.1	1.0
12	1.8	1.9	1.7	2.0	5.0	4.7	1.7	1.4	2.7	1.7	1.0	.98
13	1.8	1.8	1.6	2.3	3.3	3.9	4.8	4.8	2.1	1.5	1.0	.98
14	1.8	1.8	1.6	2.4	2.9	3.5	3.6	2.2	2.3	1.5	1.0	1.3
15	1.8	1.8	1.6	2.9	3.3	3.3	2.4	2.0	9.4	1.5	.98	1.0
16	1.8	1.7	2.0	2.3	3.3	2.9	2.3	1.8	4.2	1.5	.98	1.0
17	1.7	1.7	1.9	2.1	3.1	2.7	2.0	1.8	2.9	1.5	.98	.98
18	1.6	1.6	1.6	2.0	2.9	2.7	1.9	1.7	2.7	1.5	.98	.98
19	1.6	1.6	1.6	1.9	3.5	2.6	1.8	1.6	2.6	1.4	.94	.94
20	1.6	1.7	1.9	1.8	3.5	3.3	1.8	1.5	2.5	1.4	.94	.94
21	1.6	1.6	1.8	1.8	3.8	2.7	1.7	1.5	2.3	1.4	.94	.90
22	1.6	1.6	1.9	1.7	3.5	2.6	1.7	1.5	2.2	1.4	.90	.90
23	1.6	1.6	1.7	1.7	3.1	2.4	1.6	2.0	2.2	1.4	.90	.90
24	1.5	1.6	1.6	1.7	3.1	2.3	1.6	1.5	2.1	1.5	.90	3.8
25	1.5	1.6	1.6	1.6	2.9	2.3	1.6	1.5	2.1	1.4	.90	1.4
26	1.5	1.6	1.6	1.6	2.9	2.3	1.5	1.4	2.0	1.2	.90	1.1
27	1.4	1.6	1.6	1.6	4.0	2.3	1.6	1.4	1.9	1.2	.90	1.2
28	3.0	1.6	1.6	1.6	3.5	2.3	1.6	1.6	1.8	1.2	.86	1.1
29	5.3	2.0	1.6	-------	3.1	3.1	1.6	1.4	1.8	1.2	.86	1.1
30	2.0	1.8	1.6	-------	4.0	2.1	1.5	1.4	1.8	1.2	.86	1.1
31	-------	1.7	1.6	-------	4.2	-----	1.5	-------	1.8	1.1	-------	1.2

Month	Cfs-days	Maximum	Minimum	Mean
November	59.6	5.3	1.4	1.99
December	61.2	6.0	1.6	1.97
January	60.6	7.4	1.6	1.95
February	55.0	3.6	1.6	1.96
March	98.3	7.8	1.7	3.17
April	104.0	7.0	2.1	3.47
May	60.8	4.8	1.5	1.96
June	54.5	4.8	1.4	1.82
July	78.3	11	1.2	2.53
August	56.1	5.9	1.1	1.81
September	31.12	1.8	.86	1.04
October	34.26	3.8	.86	1.11
Period 365 days	753.78	11	.86	2.07

TABLE 9.—*Daily and monthly discharge of selected streams*—Continued

AWIXA CREEK AT ISLIP, N.Y.

Discharge, in cfs period November 1, 1959 to October 31, 1960

Day	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
1	1.2	1.7	2.1	2.0	3.2	2.1	4.3	1.6	1.8	1.7	1.1	1.6
2	1.1	1.6	2.1	1.9	3.0	1.9	2.1	1.6	1.3	1.6	1.1	1.6
3	1.1	1.6	4.7	2.0	3.0	2.5	2.0	1.7	3.5	1.5	1.1	1.6
4	1.1	1.6	2.6	2.0	3.0	2.8	1.9	1.6	4.5	1.5	1.1	1.6
5	1.0	1.6	2.3	1.9	2.9	5.3	1.9	1.6	1.7	1.5	1.1	1.4
6	1.1	1.7	2.1	4.0	2.9	2.9	1.8	1.6	1.4	1.4	1.1	1.4
7	2.2	3.9	2.0	2.2	2.7	2.7	1.8	1.6	1.4	1.4	1.1	1.4
8	1.5	1.8	1.9	2.0	2.7	2.6	1.8	1.6	1.3	1.4	1.1	1.4
9	1.4	1.7	1.9	1.9	2.7	2.7	2.4	1.6	1.3	1.3	1.1	1.5
10	1.2	1.6	1.9	1.9	2.7	2.5	1.9	1.6	1.3	1.3	1.2	1.4
11	1.2	1.6	1.9	2.3	2.6	2.5	1.9	1.6	1.2	1.2	1.4	1.4
12	1.2	5.0	1.9	2.0	2.6	2.6	1.9	2.2	1.3	1.2	14	1.4
13	1.2	5.1	2.2	1.9	2.7	2.6	1.9	1.7	1.2	1.4	6.9	1.5
14	1.2	2.7	2.2	2.4	2.7	2.6	1.8	1.4	6.2	1.3	1.8	1.4
15	1.8	2.5	2.9	2.0	2.6	2.5	1.8	1.4	2.6	1.2	1.6	1.4
16	1.3	2.2	2.0	1.9	3.0	2.5	1.8	1.4	1.8	1.2	1.6	1.4
17	1.5	2.1	2.1	1.9	3.9	2.5	1.8	1.4	1.7	1.2	1.5	1.5
18	1.4	2.1	3.4	3.1	3.7	2.6	1.9	1.4	1.5	1.1	1.5	1.4
19	1.2	2.1	2.7	5.9	3.4	2.5	1.8	1.3	1.4	3.6	1.8	1.6
20	1.2	2.1	2.5	2.9	2.9	2.3	1.7	1.2	1.4	1.5	3.2	4.9
21	1.2	2.0	2.2	2.7	2.7	2.3	1.6	1.2	1.4	1.4	2.0	2.1
22	1.2	2.0	2.1	2.6	2.6	2.2	1.6	1.2	1.3	1.4	1.8	1.8
23	1.2	1.9	2.0	2.6	2.6	2.1	6.1	1.2	1.2	1.3	1.8	1.7
24	4.4	1.9	1.9	2.6	2.3	2.1	2.1	1.2	1.2	1.2	1.7	1.9
25	4.5	1.9	1.9	3.0	2.3	2.0	1.8	1.2	1.2	1.2	1.7	1.4
26	2.0	1.9	1.9	9.7	2.1	2.0	1.8	1.2	1.2	1.2	1.7	1.4
27	1.9	2.2	1.9	4.2	2.1	2.1	1.8	1.2	1.2	1.2	1.6	1.4
28	2.2	2.3	3.7	3.5	2.0	1.9	1.8	1.1	1.4	1.1	1.6	1.4
29	1.9	3.9	2.3	3.4	2.0	1.8	1.8	1.1	1.2	1.1	1.6	2.8
30	1.8	2.6	2.2	-------	1.9	1.8	1.9	1.1	7.0	1.1	1.9	1.8
31	-------	2.2	2.1	-------	3.9	-------	1.8	-------	2.1	1.2	-------	1.7

Month	Cfs-days	Maximum	Minimum	Mean
November	48.4	4.5	1.0	1.61
December	71.1	5.1	1.6	2.29
January	71.6	4.7	1.9	2.31
February	82.4	9.7	1.9	2.84
March	85.4	3.9	1.9	2.75
April	73.5	5.3	1.8	2.45
May	64.3	6.1	1.6	2.07
June	42.8	2.2	1.1	1.43
July	60.2	7.0	1.2	1.94
August	42.9	3.6	1.1	1.38
September	63.8	14	1.1	2.13
October	52.2	4.9	1.4	1.68
Period 366 days	758.6	14	1.0	2.07

TABLE 9.—*Daily and monthly discharge of selected streams*—Continued

EAST BRANCH OROWOC CREEK AT ISLIP, N.Y.

Discharge, in cfs, period November 1, 1959 to October 31, 1960

Day	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
1	1.1	2.1	3.1	3.0	4.3	3.6	3.9	2.0	1.4	2.3	1.5	2.6
2	1.0	2.0	3.3	2.7	4.2	3.3	3.7	1.9	2.2	2.2	1.3	2.2
3	.97	2.0	4.3	2.5	4.4	3.1	3.0	1.8	1.8	2.1	1.2	2.1
4	.97	1.8	4.4	2.4	4.5	4.3	2.9	1.8	7.0	1.9	1.3	2.0
5	1.2	1.9	3.8	2.4	4.0	5.8	2.8	1.7	2.8	1.8	1.2	2.0
6	.97	2.0	3.7	3.6	3.8	5.3	2.6	1.8	2.1	1.8	1.2	2.0
7	1.6	3.8	3.8	3.2	3.6	4.6	2.8	1.7	1.9	1.6	1.2	1.9
8	1.8	2.7	3.3	2.8	3.5	4.4	2.4	1.5	1.8	1.6	1.2	1.8
9	1.2	2.3	3.0	2.8	3.4	4.1	2.8	1.5	1.6	1.6	1.2	1.8
10	1.2	2.2	3.0	2.8	3.3	4.3	2.6	1.6	1.6	1.7	1.3	1.9
11	1.4	2.2	2.8	3.0	3.3	4.3	2.6	1.6	1.6	1.6	1.6	1.7
12	1.3	3.8	2.7	2.8	3.1	3.9	2.5	1.8	1.4	1.6	11	1.6
13	1.0	6.0	3.0	2.6	3.1	3.6	2.4	2.0	1.4	1.6	11	1.6
14	1.2	4.1	2.8	3.0	3.1	3.5	2.4	1.8	4.9	1.6	5.1	1.6
15	1.6	3.7	3.8	3.0	3.1	3.4	2.3	1.8	5.2	1.4	4.3	1.6
16	1.3	3.6	3.7	2.8	3.1	3.2	2.2	1.8	2.5	1.4	3.8	1.6
17	1.4	3.4	3.0	2.8	3.5	2.8	2.2	1.7	2.2	1.3	3.4	1.6
18	1.4	3.3	3.1	2.9	3.8	3.0	2.2	1.6	2.0	1.3	3.3	1.4
19	1.3	3.3	4.1	6.3	3.6	3.3	2.1	1.6	2.0	3.1	3.6	1.4
20	1.2	2.6	3.5	4.6	3.6	3.2	2.0	1.4	1.9	2.2	5.8	3.2
21	1.0	2.6	3.2	4.1	3.4	3.0	2.0	1.3	1.8	1.8	4.3	2.8
22	1.1	2.8	3.1	4.0	3.2	2.8	1.9	1.3	1.6	1.6	3.6	2.2
23	1.1	2.5	3.0	3.6	2.9	2.9	4.2	1.2	1.6	1.6	3.1	2.0
24	2.0	2.4	2.9	3.6	2.9	2.7	3.4	1.4	1.5	1.4	3.0	2.3
25	5.6	2.6	2.8	3.6	2.7	2.4	2.8	1.4	1.3	1.4	2.8	2.0
26	3.0	2.6	2.7	9.1	2.8	2.6	2.6	1.2	1.2	1.4	2.6	1.9
27	2.6	2.6	2.6	6.0	2.8	3.0	2.3	1.1	1.3	1.3	2.6	1.9
28	2.5	2.8	3.6	4.9	2.7	2.6	2.1	1.1	1.6	1.3	2.6	1.8
29	2.3	4.5	3.7	4.7	2.8	2.8	1.7	1.1	1.4	1.2	2.6	2.7
30	2.2	3.9	3.2	-------	2.8	2.4	1.9	1.2	5.6	1.2	2.8	2.3
31	-------	3.8	3.1	-------	4.1	-------	2.1	-------	3.6	1.4	-------	2.2

Month	Cfs-days	Maximum	Minimum	Mean
November	48.51	5.6	0.97	1.62
December	91.9	6.0	1.8	2.96
January	102.1	4.4	2.6	3.29
February	105.6	9.1	2.4	3.64
March	105.4	4.5	2.7	3.40
April	104.2	5.8	2.4	3.47
May	79.4	4.2	1.7	2.56
June	46.7	2.0	1.1	1.56
Jnly	71.8	7.0	1.2	2.32
August	51.3	3.1	1.2	1.65
September	95.6	11	1.2	3.19
October	61.7	3.2	1.4	1.99
Period 366 days	964.21	11	.97	2.63

TABLE 9.—*Daily and monthly discharge of selected streams*—Continued

WEST BROOK NEAR GREAT RIVER, N.Y.—Continued

Discharge, in cfs, period November 1, 1958 to September 30, 1959

Day	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	4.4	4.3	3.7	3.9	4.0	5.4	5.2	4.0	3.1	4.5	4.3
2	4.5	4.1	5.9	3.9	4.0	6.6	5.0	4.3	3.1	4.2	4.0
3	4.8	4.0	5.3	3.9	3.9	7.5	4.9	5.9	3.0	4.2	3.7
4	4.7	5.4	4.9	4.5	4.1	6.4	4.7	4.6	3.0	4.1	3.5
5	4.6	5.4	4.5	4.5	4.0	5.9	4.6	4.3	3.0	6.2	3.4
6	4.6	4.8	4.3	4.2	5.8	5.7	4.6	4.1	3.0	5.8	3.3
7	4.6	4.6	4.3	3.9	5.6	5.6	4.6	3.9	2.9	5.0	3.3
8	4.7	4.4	4.2	3.8	5.0	5.5	4.5	3.8	2.9	4.8	3.3
9	4.8	4.4	4.2	3.9	4.9	5.6	4.4	3.8	2.9	5.5	3.3
10	4.7	4.4	4.2	4.8	4.9	5.6	4.4	3.7	3.7	5.0	3.2
11	4.4	4.3	4.2	4.8	4.7	5.7	4.4	3.6	9.1	4.7	3.0
12	4.3	4.3	4.2	4.7	5.8	5.7	4.4	3.6	5.6	4.4	2.9
13	4.2	4.2	4.2	4.7	5.6	5.6	5.1	4.6	4.8	4.3	2.9
14	4.2	4.2	4.2	4.9	5.3	5.4	6.2	4.3	4.7	4.2	2.9
15	4.2	4.1	4.2	5.2	5.2	5.4	5.3	4.1	9.4	4.1	2.9
16	4.3	4.0	4.4	5.0	5.5	5.4	4.9	4.0	8.4	4.1	2.9
17	4.2	3.9	4.6	4.9	5.3	5.2	4.8	4.0	6.5	4.0	2.8
18	4.2	3.8	4.4	4.7	5.2	5.2	4.7	3.7	6.0	4.0	2.8
19	4.2	3.8	4.2	4.3	5.1	5.1	4.7	3.6	5.8	3.9	2.8
20	4.1	3.8	4.2	4.1	5.0	5.5	4.6	3.6	5.7	3.8	2.8
21	3.9	3.8	4.2	4.1	5.0	5.2	4.6	3.6	5.5	3.8	2.8
22	3.8	3.8	4.2	4.1	5.0	5.1	4.6	3.4	5.4	3.7	2.8
23	3.8	3.8	4.1	4.1	4.7	5.0	4.6	3.8	5.3	3.6	2.9
24	3.8	3.8	4.0	4.1	4.7	5.0	4.4	3.5	5.2	3.7	2.9
25	3.6	3.8	3.9	4.0	4.6	4.9	4.2	3.5	5.0	3.8	2.9
26	3.6	3.7	3.8	3.9	4.5	4.9	4.2	3.6	4.8	3.7	2.8
27	3.6	3.7	3.9	3.9	5.0	4.9	4.2	3.4	4.8	3.6	2.9
28	3.9	3.7	4.0	3.9	5.0	4.9	4.3	3.4	4.7	3.6	2.9
29	5.5	3.9	4.1	-------	4.8	5.3	4.3	3.3	4.6	3.5	2.9
30	4.5	4.1	4.1	-------	5.1	5.0	4.2	3.2	4.6	3.6	2.9
31	-------	3.7	4.0	-------	5.7	-------	4.1	-------	4.6	3.7	-------

Month	Cfs-days	Maximum	Minimum	Mean
November	128.7	5.5	3.6	4.29
December	128.0	5.4	3.7	4.13
January	132.6	5.9	3.7	4.28
February	120.7	5.2	3.8	4.31
March	153.0	5.8	3.9	4.94
April	164.2	7.5	4.9	5.47
May	143.7	6.2	4.1	4.64
June	116.2	5.9	3.2	3.87
July	151.1	9.4	2.9	4.87
August	131.1	6.2	3.5	4.23
September	92.7	4.3	2.8	3.09
Period 334 days	1,462.0	9.4	2.8	4.38

TABLE 9.—*Daily and monthly discharge of selected streams*—Continued

WEST BROOK NEAR GREAT RIVER, N.Y.

Discharge, in cfs, period October 1, 1959 to Aug. 31, 1960

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
1	3.2	3.5	4.6	5.6	5.6	6.1	5.6	6.0	4.6	3.8	3.8
2	2.9	3.3	4.5	5.5	5.6	5.7	5.3	6.2	4.5	4.1	3.9
3	2.9	3.2	4.4	6.4	5.2	6.1	5.4	5.6	4.6	4.2	3.8
4	2.9	3.2	4.4	6.4	5.1	6.2	6.0	5.5	4.5	6.8	3.8
5	2.9	3.3	4.3	6.0	5.1	6.0	7.2	5.2	4.5	4.8	3.8
6	3.0	3.3	4.4	5.8	6.1	5.8	6.7	5.2	4.4	4.1	3.8
7	3.4	4.2	5.9	5.8	5.7	5.7	6.3	5.1	4.2	3.9	3.8
8	3.4	4.2	5.2	5.7	5.4	5.6	6.2	5.1	4.2	3.8	3.7
9	4.0	3.8	4.9	5.4	5.4	5.6	6.0	5.1	4.2	3.7	3.6
10	3.5	3.7	4.7	5.4	5.4	5.5	5.8	5.0	4.2	3.6	3.7
11	3.3	3.6	4.6	5.4	5.9	5.5	5.6	5.0	4.0	3.7	3.7
12	3.2	3.5	5.8	5.4	5.9	5.4	5.6	5.0	4.4	3.6	3.6
13	3.0	3.5	7.4	5.5	5.8	5.4	5.6	5.0	4.7	3.5	3.8
14	3.6	3.6	6.4	5.3	5.7	5.4	5.6	4.9	4.3	6.1	3.8
15	3.4	4.2	5.9	5.4	5.7	5.4	5.6	4.9	4.2	6.3	3.7
16	3.3	3.6	5.6	5.3	5.6	5.5	5.5	4.8	4.1	5.0	3.6
17	3.3	3.9	5.4	5.1	5.5	5.9	5.4	4.8	4.1	4.5	3.5
18	3.2	3.7	5.3	5.0	7.8	5.9	5.4	5.0	4.2	4.3	3.4
19	3.2	3.5	5.2	5.6	6.4	5.8	5.5	4.9	3.9	4.2	4.9
20	3.0	3.5	5.1	5.3	6.0	5.8	5.5	4.8	3.8	4.2	4.3
21	3.0	3.5	5.0	5.1	5.9	5.7	5.4	4.7	3.7	3.9	3.9
22	3.0	3.5	5.2	5.1	5.7	5.7	5.3	4.7	3.6	3.8	3.8
23	3.2	3.4	5.0	5.1	5.5	5.6	5.3	6.1	3.6	3.8	3.7
24	4.9	4.5	4.9	5.0	5.5	5.6	5.4	5.7	3.7	3.7	3.6
25	5.0	7.0	4.9	4.9	8.8	5.5	5.4	5.4	3.6	3.6	3.6
26	4.1	5.8	4.8	4.9	7.2	5.4	5.4	5.2	3.6	3.5	3.5
27	3.9	5.5	4.8	4.9	6.5	5.4	5.7	5.1	3.5	3.7	3.5
28	3.7	5.4	5.0	5.8	6.4	5.3	5.4	4.9	3.5	4.0	3.4
29	3.5	5.2	6.0	5.6	6.4	5.3	5.3	4.8	3.5	3.7	3.3
30	3.5	4.9	6.0	5.4	-------	5.2	5.2	4.8	3.5	4.3	3.4
31	3.5	-------	5.8	5.5	-------	5.9	-------	4.9	-------	4.0	3.6

Month	Cfs-days	Maximum	Minimum	Mean
October	105.9	5.0	2.9	3.42
November	121.0	7.0	3.2	4.03
December	161.4	7.4	4.3	5.21
January	168.6	6.4	4.9	5.44
February	172.8	8.8	5.1	5.96
March	174.9	6.2	5.2	5.64
April	169.6	7.2	5.2	5.65
May	159.4	6.2	4.7	5.14
June	121.4	4.7	3.5	4.05
July	130.2	6.8	3.5	4.20
August	115.3	4.9	3.3	3.72
Period 336 days	1,600.5	8.8	2.9	4.76

INDEX

[Major references are in italic]

U. S. GOVERNMENT PRINTING OFFICE : 1964 O - 716-826

The U.S. Geological Survey Library has cataloged this publication as follows:

Pluhowski, Edward J 1927–

Hydrology of the Babylon-Islip area, Suffolk County, Long Island, New York, by E. J. Pluhowski and I. H. Kantrowitz. Washington, U.S. Govt. Print. Off., 1964.

v, 119 p. maps, diagrs., profile, tables, and portfolio (maps, diagrs., profiles) 24 cm. (U.S. Geological Survey Water-supply paper 1768)

Prepared in cooperation with the Suffolk County Board of Supervisors, Suffolk County Water Authority, and the New York State Water Resources Commission.

Bibliography: p. 96–97.

(Continued on next card)

Pluhowski, Edward J 1927– Hydrology of the Babylon-Islip area, Suffolk County, Long Island, New York. 1964. (Card 2)

1. Hydrology—Long Island—Suffolk Co. 2. Water-supply—Long Island—Suffolk Co. I. Kantrowitz, Irwin H 1927– joint author. II. Suffolk Co., N.Y. Board of Supervisors. III. Suffolk Co., N.Y. Water Authority. IV. New York (State) Wate Resources Commission. V. Title. VI. Title: Babylon-Islip area, Suffolk County, Long Island, New York. (Series)