Geology and Ground-Water Resources of the Bristol-Plainville-Southington Area, Connecticut

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GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1578

Prepared in cooperation with the Connecticut 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

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By A. M. La Sala, Jr.

ABSTRACT

The Bristol-Plainville-Southington area straddles the boundary between the New England Upland and the Connecticut Valley Lowland sections of the New England physiographic province. The western parts of Bristol and Southington lie in the New England Upland section, an area of rugged topography underlain by metamorphic rocks of Palezoic age. The eastern part of the area, to the east of a prominent scarp marking the limit of the metamorphic rocks, is in the Connecticut Valley Lowland and is underlain by sedimentary rocks and interbedded basaltic lava flows of Triassic age. The lowland is characterized for the most part by broad valleys and low intervening linear hills, but in the eastern parts of Plainville and Southington, basaltic rocks form a rugged highland. The bedrock is largely mantled by glacial deposits of Wisconsin age. On hills the glacial deposits are mainly ground moraine, and in valleys mainly stratified.

The metamorphic rocks comprise the Hartland Formation, Bristol Granite Gneiss of Gregory (1906), and Prospect Gneiss. These formations contain water in fractures, principally joints occurring in regular sets. The rocks generally yield supplies of 5 to 15 gpm (gallons per minute) to drilled wells averaging about 140 feet in depth.

The rocks of Triassic age in the area are the New Haven Arkose, Talcott Basalt, Shuttle Meadow Formation, Holyoke Basalt, and East Berlin Formation. The formations contain water principally in joints and other fractures and, to a lesser extent, in bedding-plane openings and pore spaces. Drilled wells penetrating these rocks generally range from 100 to 200 feet in depth and yield an average of nearly 20 gpm. The maximum yield obtained from a well in these rocks is 180 gpm.

The ground moraine of Pleistocene age is composed principally of till. The deposit averages about 24 feet in thickness, and wells penetrating it average about 16 feet in depth. The ground moraine yields small supplies of water suitable for household use when tapped by shallow large-diameter wells.

The stratified glacial deposits, which are as much as 300 feet thick, comprise ice-contact and proglacial deposits and deposits of generally obscure origin termed "undifferentiated stratified deposits." The ice-contact and undifferentiated stratified deposits, some of which underlie proglacial deposits, are coarse grained and contain gravel beds from which supplies of as much as 1,400 gpm can be obtained. The proglacial deposits are, on the whole, finer grained than the other stratified deposits, but in places they allow development of wells producing as much as 500 gpm. However, the stratified glacial deposits throughout much of the Bristol-Plainville-Southington area are fine grained and provide only small supplies.

The three main areas of deposition of stratified glacial deposits are the New England Upland in the Pequabuck River valley, the valley of Copper Mine Brook and Eightmile River, and the Quinnipiac-Pequabuck lowland. The deposits in the New England Upland section consist principally of ice-contact deposits. Near the Pequabuck River the deposits are sufficiently coarse and have enough saturated thickness to produce large quantities of water.

The deposits in the valley of Copper Mine Brook and Eightmile River are principally ice-contact deposits interspersed with extensive undifferentiated deposits in the northern part of Bristol in the vicinity of Copper Mine Brook. The undifferentiated deposits provide yields of as much as 1,400 gpm. The ice-contact deposits become progressively finer grained southward. In Bristol they can support withdrawals of a few hundred gallons per minute, but to the south in Southington they have poorer water-bearing properties.

The thickest and most extensive group of stratified glacial deposits lies in the Quinnipiac-Pequabuck lowland in Plainville and Southington. The ice-contact deposits there will yield as much as 1,000 gpm from wells and the proglacial deposits as much as 500 gpm.

Pumping tests and specific-capacity data for the more productive supply wells and test wells penetrating stratified deposits indicate that transmissibility generally ranges from 5,000 to 100,000 gpd per ft (gallons per day per foot).

Ground water is generally under water-table conditions, though artesian conditions occur locally. The water table is generally within 20 feet of the surface except beneath well-drained terraces underlain by stratified deposits, where it is deeper. Water levels fluctuate seasonally; they reach their highest stages in early spring and their lowest in early fall.

Precipitation in the area averages 49 inches per year. About 23 inches of water per year is discharged by evapotranspiration. The remainder of the precipitation, about 26 inches, is discharged mainly through the Pequabuck and Quinnipiac Rivers. Seepage of ground water into river channels provides about 11½ inches of the average annual stream runoff from the area. Thus, ground-water recharge is at least 11½ inches, or 15 billion gallons per year.

The chemical quality of the ground water is generally good. Dissolved solids range from 38 to 280 ppm (parts per million) and hardness from 14 to 167 ppm in samples analyzed. Iron is generally less than 0.3 ppm.

Total ground-water pumpage in 1958 was about 1.7 billion gallons. Public-supply systems pumped about 1.15 billion gallons and industrial firms about 275 million gallons. It is estimated that another 250 to 300 million gallons was pumped from private domestic wells.

INTRODUCTION

LOCATION OF THE AREA

Bristol, Plainville, and Southington are three adjoining towns in west-central Connecticut. They constitute an irregular area of 72.9 square miles in the southwestern part of Hartford County. The center of the area is about 13 miles southwest of Hartford and 23 miles north of New Haven (fig. 1). Except for a small part of the southern boundary of Southington that follows the Quinnipiac River, the towns were laid out without regard to natural features. Southington, which occupies the southern part of the area, is the largest town, being 36.2

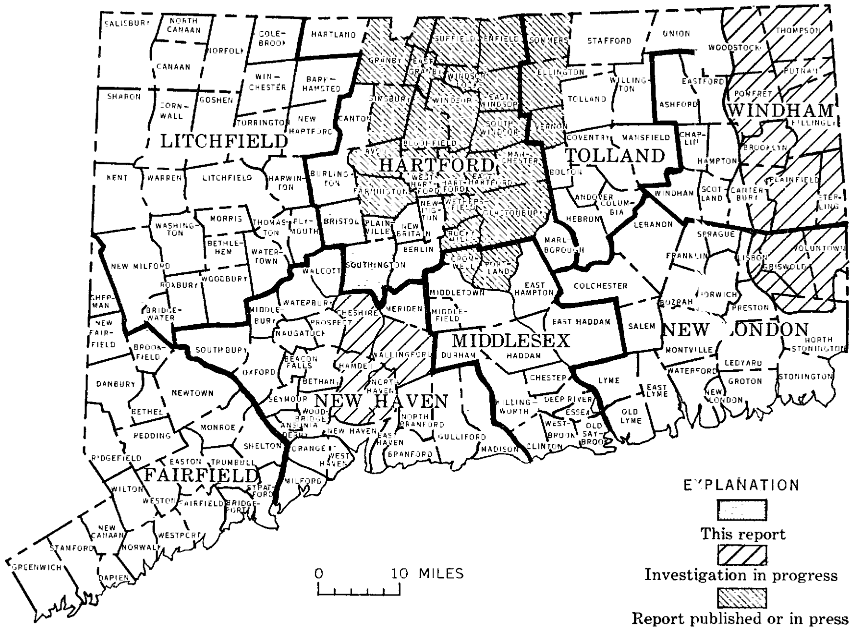

FIGURE 1.—Index map showing the Bristol-Plainville-Southington area and status of ground-water investigations in Connecticut.

square miles in area. Bristol forms a large askew square of 27.1 square miles that overbalances the area to the northwest. Plainville, in the northeastern part of the area, occupies only 9.6 square miles.

PURPOSE AND SCOPE OF THE INVESTIGATION

The investigation of the ground-water resources of the towns of Bristol, Plainville, and Southington is part of a general program begun in 1939 to evaluate the ground-water resources of Connecticut. The program is conducted by the U.S. Geological Survey in cooperation with the Connecticut Water Resources Commission, and individual projects include adjoining towns that generally have similarities in geologic environment and ground-water occurrence. Areas where ground-water investigations are now in progress or have been completed are shown on figure 1.

A growing need exists for information on the ground-water resources of the area. Present trends point to an increasing use of ground water, which results from both a rising per capita use and an expanding population. Additional water supplies for the three public water-supply systems that serve the towns will probably come mostly from ground-water sources, because the better sites for surface reservoirs have already been developed. The latest supplies developed are from wells. Much ground water and surface water is also withdrawn from the area for use in the industrial city of New Britain, which adjoins Plainville on the east (fig. 1). It is possible that New Britain also will search for additional ground-water supplies in the area. Considerable ground water is used presently for domestic and industrial supplies. The number of domestic wells probably will increase as more new houses are built in the outlying sections of the towns. More large industrial supplies probably will be needed also.

The report is designed to supply information on the occurrence, availability, and quality of ground water, and on the yields of wells. Included are descriptions of the extent, thickness, and character of the water-yielding formations. The movement of ground water in the area and the recharge and discharge of ground water also are described.

METHODS OF INVESTIGATION

Fieldwork, which was conducted from April to November 1956, consisted primarily of geologic mapping and the collection of data on wells. The surficial geology of the Southington quadrangle was mapped in detail (La Sala, 1961) in coordination with surficial mapping done for other projects of the U.S. Geological Survey in the New Britain and Bristol quadrangles (Simpson, 1959 and 1961) and the Meriden quadrangle (Hanshaw, 1962). These four quadrangles include the towns of Bristol, Plainville, and Southington. The surficial geologic contacts shown on plate 1 were generalized from parts of the detailed surficial geologic maps of these quadrangles (pl. 1, inset). Fritts (1962) mapped the Triassic and pre-Triassic rocks in the Southington quadrangle and provided data on some wells along the contact. The contacts on plate 1 between the Hartland Formation and the Bristol Granite Gneiss of Gregory (1906) and between the New Haven Arkose and the middle part of the Newark Group are those of Rodgers and others (1956).

Well data were collected from well owners, drillers, and other interested parties. Locations of wells were plotted by inspection on 7.5-minute topographic quadrangle maps. However, the sites of some wells and test borings could not be located in the field because the casings had been pulled shortly after drilling and traces of the wells were obliterated; furthermore, some well sites were inaccessible or were altered by the works of man, which made identification unsure. Reported locations for such wells on plate 1 are generally accurate, however.

Data on many wells and borings were available only from the memories of the drillers or owners. Nevertheless, the records of the wells published here (table 3) are believed to be reliable. Wherever possible the depths of wells and static water levels were measured. However, access could not be gained to most drilled and driven wells because they were tightly capped and buried beneath ground level. Most dug wells were accessible for measurements.

Logs of wells and borings were obtained wherever possible. Selected logs are given in table 4. In general, detailed logs were available for wells drilled by industries and public water-supply organizations and for test borings of the State Highway Department. For most other wells, no logs or only generalized logs were obtainable.

Water levels were measured periodically in six wells to determine the general trends of the water table (fig. 3). Chemical analyses were made by the U.S. Geological Survey on samples of water collected from nine wells that penetrated different types of water-bearing formations (table 6). Such chemical data as was available from private sources was obtained during the course of the work.

WELL-NUMBERING AND LOCATION SYSTEMS

Wells are numbered consecutively within each town in the order in which they were recorded. The town in which the well is located is designated by a letter symbol as follows: Bs, Bristol; Pv, Plainville; and S, Southington. Thus, well Bs 1 is in Bristol and was the first well recorded in the inventory in that town. A similar but separate system of numbering is used for springs. In the text, springs are indicated by the symbol "sp" following the number, such as Bs 4sp. The locations of selected wells and springs are plotted on plate 1 but are indicated by number only. The letter symbols are omitted because the town names and boundaries are shown on the map. Records of all wells shown are available in the files of the Middletown subdistrict office of the Ground Water Branch of the Geological Survey.

As an aid in finding the wells on the map, locations are given in the report according to a uniform grid in use for most of the New England states by the Ground Water Branch. The basic divisions of the grid are 7.5-minute quadrangles, which are designated by letters and numbers. The letters are assigned in alphabetical order starting from the west, and the numbers are assigned in increasing order starting from the south. The Bristol, Southington, New Britain, and Meriden quadrangles thus are designated G6, G5, H6, and H5, respectively. Each 7.5-minute quadrangle is divided into nine quadrangles of 2.5 minutes each, which are numbered across starting with the upper left hand quadrangle. The 2.5-minute quadrangles are divided similarly into nine quadrangles of 50 seconds each, which are given letter designations. Plate 1 shows the location system by means of an inset map and provides a reference grid for use in locating wells.

ACKNOWLEDGMENTS

Many well owners and drilling contractors supplied data on wells and springs. Mr. W. B. Duncan, of Stephen B. Church Co., and Mr. R. W. Sullivan, of R. E. Chapman Co., supplied extensive information on their firms' drilling activities in the area. Permission was granted by several individuals for the collection of water samples and for the periodic measurements of water levels in their wells. The late Mr. Myrl Limeburner, former superintendent of the Bristol Water Department, gave data on test wells, chemical analyses, and pumping tests. Further information on the department's wells was obtained from Mr. John L. Bean, present superintendent. Mr. James Prior, of the Plainville Water Co., supplied data on his company's wells and gave assistance in collection of a water sample. Mr. George Wood, of the New Britain Water Department, and Mr. S. W. Bowers, of the Southington Water Department, gave information on the wells they operate and on details of subsurface exploration. The plant engineers and managers of various manufacturing concerns supplied data on industrial ground-water supplies. Especially helpful were Mr. V. C. Geckler, of New Departure Division, of General Motors Corp., and Mr. William DeMaria, of Superior Electric Co.

PREVIOUS GROUND-WATER INVESTIGATIONS

The first systematic study of the ground-water resources of Connecticut was begun in 1903 under a program directed by H. E. Gregory for the U.S. Geological Survey (Gregory 1909). The report dealt with the broad fundamental problems relating to Connecticut, but it was little concerned with particular ground-water conditions affecting specific areas of the State.

In 1911 a cooperative agreement was made between the U.S. Geological Survey and the Connecticut Geological and Natural History Survey for the purpose of investigating the availability of ground water for municipal and private use. One of the reports (Palmer, 1921) resulting from these investigations described briefly the occurrence and availability of ground water in the towns of Bristol, Plainville, and Southington.

The State Water Commission (now Water Resources Comm.) sponsored an investigation of the ground-water resources of Connecticut by the Works Progress Administration between 1934 and 1939. A small number of well records, relating to Bristol, Plainville, and Southington now on file at the Middletown subdistrict office of the Ground Water Branch, were collected from drilling contractors.

GEOGRAPHY

TOPOGRAPHY AND DRAINAGE

The Bristol-Plainville-Southington area is divided between the New England Upland and the Connecticut Valley Lowland sections of the New England physiographic province (Fenneman, 1938, p. 358, 368, 373–376). The two sections are separated by a scarp that parallels the west border of Southington and extends from the vicinity of Marion to Lake Compounce and northward into Bristol. The scarp approximately follows the contact of metamorphic rocks of Paleozoic age and sedimentary rocks of the New Haven Arkose (pl. 1; fig. 2).

The area west of the scarp is in the New England Upland and is characterized by hilly, irregular topography. In the Upland, most summits are about 900 feet in altitude; few are below 600 feet. The summit of South Mountain in Bristol, at an altitude of 1,040 feet, is the highest point in the area. The irregular hill masses in the upland are cut by numerous small narrow valleys. In Bristol most of these small valleys are tributary to the east-trending Pequabuck River valley, which is the major drainage feature in the Upland. The Pequabuck River valley is broad and deep. The valley bottom drops from an altitude of about 510 feet at the west border of Bristol to about 250 feet at a point south of Hurley Hill, where the valley leaves the upland.

The area east of the scarp is part of the Connecticut Valley Lowland that extends northward through central Connecticut and into Massachusetts. In the area of study the lowland consists of broad valleys separated by linear north-trending ridges. At the western margin of the lowland a valley averaging about a mile in width extends from the vicinity of Copper Mine Brook southward through Bristol and Southington to the vicinity of Judd Brook. The valley is underlain by stratified glacial deposits whose upper surfaces generally range in altitude from about 140 feet in the south to 300 feet in the north. Bordering this valley on the east is a line of smooth regular hills that extend from the northeastern part of Bristol to a point about three-fourths of a mile west of Milldale and include Campground and Redstone Hills. The summit altitudes of these hills range from about 220 feet in the south to about 420 feet in the north.

To the east of this line of hills, the lowland of the Pequabuck and Quinnipiac Rivers, about 2 miles in width, extends southward through Plainville and Southington. The lowland contains stratified glacial deposits that range in altitude from 120 to 250 feet. For the most part, the deposits have smooth surfaces and are separated by low swampy areas. The lowland is bordered to the east by a highland that occupies an irregular strip a mile or so wide along the eastern boundaries of Plainville and Southington. This highland has two

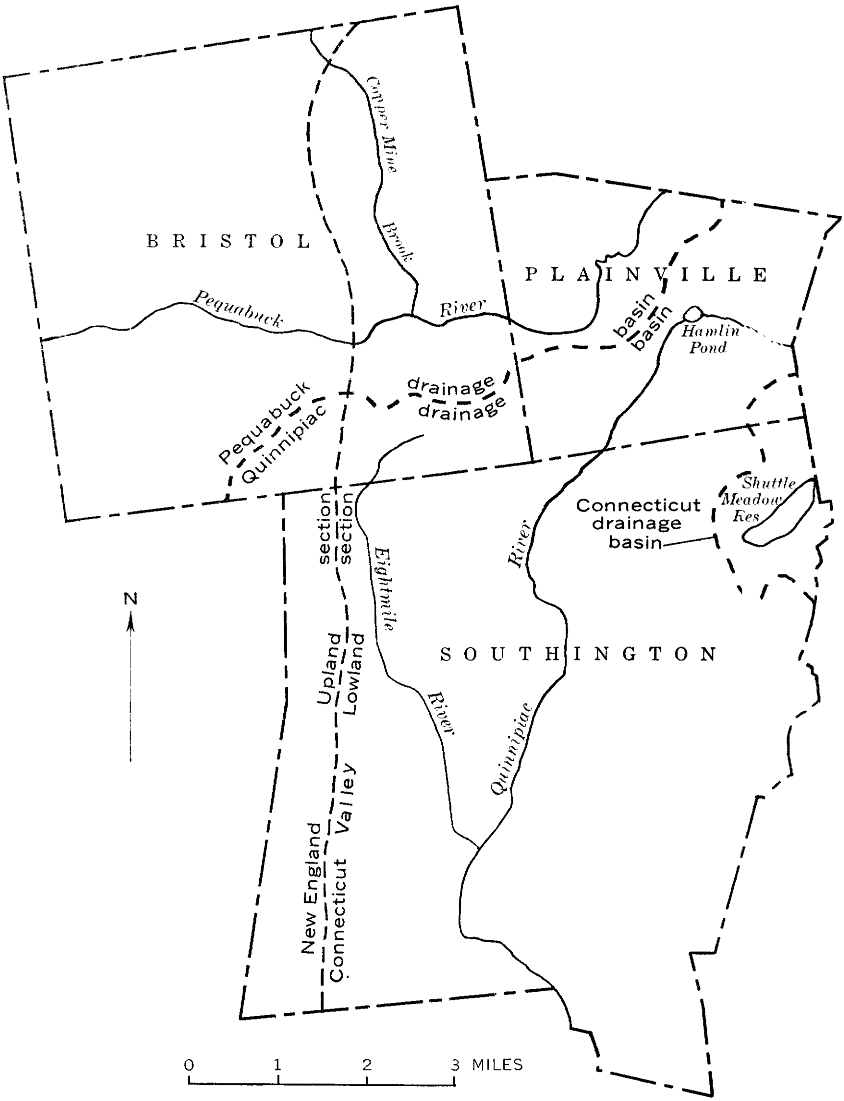

FIGURE 2.—Sketch map of the Bristol-Plainville-Southington area, Connecticut, showing physiographic divisions and drainage.

prominent west-facing scarps where basaltic rocks crop out, but it is otherwise irregular. The more westerly scarp ranges from about 250 to 500 feet in altitude, and the more easterly one ranges from about 500 to 950 feet in altitude.

Total relief within the three towns is about 920 feet, which is the difference in altitude between South Mountain (altitude 1,040 feet) in Bristol and the Quinnipiac River (altitude 120 feet), where it leaves

Southington. Generally, however, the relief between adjacent valleys and summits ranges only from 50 to 300 feet.

The area is drained by two major stream systems. Most of Bristol and the northern part of Plainville are drained by the Pequabuck River, which flows northward to the Farmington River. The extreme southeast part of Bristol, the southern part of Plainville, and most of Southington are drained by the Quinnipiac River. In the lowland section, the divide between these two drainage basins is for the most part poorly defined and lies on the stratified glacial deposits. The streams flowing from Shuttle Meadow Reservoir and a few small streams to the north flowing eastward off Bradley Mountain are eventually directed to a small basin in the town of Berlin, east of Southington, which drains to the Connecticut River (fig. 2).

CLIMATE

The climate of the Bristol-Plainville-Southington area is affected by two conflicting influences: cold dry air moving out of the subpolar regions from the northwest and warm moist air moving from the south. The area, in common with Connecticut as a whole, lies between the two main tracks for eastward-moving cyclonic storms, but it is affected by storms in either track. It also lies in the general track for northward-moving coastal storms and hurricanes (Kirk, 1939, p. 14, 15). Day-to-day changes in the weather are usual and sometimes extreme. Nevertheless, average precipitation is rather uniformly distributed throughout the year. Table 1 contains a summary of climatic data for the Bristol-Plainville-Southington area.

The average annual precipitation in the area is about 49 inches. During 1957, precipitation was at a record low and totaled 38.19, 37.00, and 42.27 inches at Shuttle Meadow Reservoir, Whigville Reservoir (1½ miles north of Bristol), and Wolcott (New Britain) Reservoir, respectively. The greatest yearly precipitation was in 1955, a year of heavy hurricane rains, and totaled 64.50, 69.98, and 69.04 inches at the same stations. During August 1955, in which two hurricanes passed over the area, a total of 22.64 inches of rain fell at Whigville Reservoir, 19.32 inches at Wolcott (New Britain) Reservoir, and 18.08 inches at Shuttle Meadow Reservoir. The hurricane rains of August 19, 1955, amounted to 12.10 inches at Whigville Reservoir.

Long-term temperature records are not available within the area, but the record at Bradley Field in Windsor Locks, about 20 miles northeast of the area, is indicative. There the average annual temperature is about 50° F, and the average monthly temperatures range from about 27° F in January to 74° F in July. The length of the frost-free season ranges from 130 to 214 days and averages 181 days. The depth of frost penetration is generally less than 2 feet.

TABLE 1.—*Summary of meteorological data for the Bristol-Plainville-Southington area, Connecticut*

[U.S. Weather Bur., 1958]

	Jan.	Feb.	Mar.	Apr.	May	June	July
Shuttle Meadow Reservoir, Southington [1]							
Record mean precipitation inches..	3.98	3.32	4.12	3.73	4.69	3.98	3.67
Wolcott (New Britain) Reservoir, Wolcott [1]							
Record mean precipitation inches..	4.22	3.61	4.69	4.28	5.45	4.17	4.37
Whigville Reservoir, Burlington [1]							
Record mean precipitation inches..	3.70	3.09	3.81	3.53	4.82	4.47	3.94
Bradley Field, Windsor Locks [2]							
Record mean precipitation inches [3]..	3.62	3.16	3.73	3.70	3.56	3.47	3.67
Record mean temperature °F [3]..	27.8	28.0	37.1	47.8	58.7	67.6	73.0
Mean date of last killing frost..	----------	----------	----------	----------	----------	----------	----------
Mean date of first killing frost..	----------	----------	----------	----------	----------	----------	----------
Mean length of growing season days..	----------	----------	----------	----------	----------	----------	----------

	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Shuttle Meadow Reservoir, Southington [1]—Continued						
Record mean precipitation........inches..	4.25	2.99	2.78	5.44	4.42	47.38
Wolcott (New Britain) Reservoir, Wolcott [1]—Continued						
Reocrd mean precipitation........inches..	4.34	3.38	3.03	6.16	5.28	52.98
Whigville Reservoir, Burlington [1]—Continued						
Record mean precipitation........inches..	3.44	3.13	2.64	5.23	4.26	46.06
Bradley Field, Windsor Locks [2]—Continued						
Record mean precipitation......inches [3]..	4.01	3.43	3.00	3.70	3.60	42.65
Record mean temperature..........°F [3]..	70.7	63.6	53.5	42.2	30.9	50.1
Mean date of last killing frost............	----------	----------	----------	----------	----------	Apr. 19.
Mean date of first killing frost............	----------	----------	----------	----------	----------	Oct. 17.
Mean length of growing season.....days..	----------	----------	----------	----------	----------	181

[1] Includes record for 1941–52. Dr. B. S. Pack, State Climatologist, U.S. Weather Bur. (oral commun).
[2] Includes record for 1905–58.
[3] Record mean values are based on the entire period of record; they are not corrected for changes in instrument location.

SUMMARY OF STRATIGRAPHY

The geologic units in the area of study range in age from early Paleozoic to Recent (table 2). The Paleozoic formations are the Hartland Formation, the Bristol Granite Gneiss of Gregory (1906), and the Prospect Gneiss. The Bristol and Prospect are both considered to be intrusive into the Hartland Formation, but they are not correlated in age (Gregory, 1906, p. 96, 102–105).

During Triassic time, both sedimentary rocks and igneous extrusive and intrusive rocks of the Newark Group were deposited unconformably upon the Paleozoic rocks. In the Bristol-Plainville-Southington area are the New Haven Arkose, which is the oldest formation of the group, the Talcott Basalt, the Shuttle Meadow Formation, the Holyoke Basalt, and the East Berlin Formation. Three-fourths of a mile northeast of Milldale several outcrops of diabase mark the northernmost extent of the West Rock Diabase that intrudes the New Haven Arkose.

Unconsolidated glacial deposits of Pleistocene age overlie the earlier geologic formations and consist of two main stratigraphic units—ground moraine and stratified drift. The ground moraine was formed principally during the advance of the Wisconsin ice and is older than the stratified drift, which was formed principally during the retreat of the ice. For purposes of discussion in this report, the stratified drift has been divided, according to lithology and morphology, into ice-contact, proglacial, and undifferentiated stratified deposits. A thin irregular mantle of eolian deposits overlies the glacial deposits. It marks the period of Pleistocene and perhaps early Recent time when the glacial deposits were bare to wind erosion and redeposition. Later deposits of Recent age consist of stream alluvium and include early stream terrace and swamp deposits.

WATER-BEARING FORMATIONS

Ground water fills the interconnected pore spaces and fractures of the geologic formations occurring within the zone of saturation, and moves in response to gravity and changes in pressure. In most of the area, ground water is unconfined. The top of the unconfined zone of saturation is called the water table. At some places, where it is confined by relatively impermeable materials, the water is artesian. Artesian water is under pressure and will rise in a well above the bottom of the confining layer. The level to which the water rises, or could rise, is the piezometric surface.

The water-bearing properties of a rock depend primarily on the rock's porosity, which is the ratio of volume of its primary pore spaces and fracture openings to its total volume, and on the size and degree

TABLE 2.—*Geologic units in the Bristol-Plainville-Southington area and their water-bearing properties*

Age			Geologic unit; thickness, in feet	Lithology	Water-bearing properties
Era	System	Series or group			
Cenozoic	Quaternary	Recent	Swamp deposits; 0–10	Sand, silt, clay, and decayed organic matter.	Not known to be tapped by water wells. Thin and not extensive, therefore capable of yielding only small supplies of water. Suitable in places for the digging of fire ponds. Water is of poor quality because of organic content.
			Alluvium; 0–10	Sand, silt, clay, and some gravel. Generally colored gray by contained organic matter.	Not known to be tapped by water wells. Thin and low in permeability, therefore will yield only small supplies of water. Water has noticeable organic content at most places.
		Recent and Pleistocene.	Eolian deposits; 0–6	Silt and sand, structureless. Composed of sandy loess throughout much of area.	Not water bearing. Lies above the water table.
		Pleistocene	Proglacial deposits; 0–300	Stratified gravel, sand, silt, and clay. Gravel confined mostly to upper few feet of deposits.	Yield small to large supplies of water depending on proportion of coarser material found locally. Yield abundant supplies of ground water in Plainville and northern Southington. Interbedded fine material makes stabilization of the formation difficult at some well sites.
			Ice-contact deposits; 0–240	Stratified sand and gravel, some silt. Coarser material generally occurs in irregular lenses. Many deposits are capped by several feet of coarse gravel.	Yield small to large supplies. Prospecting required to locate thicker gravel lenses, which generally yield an abundance of water.
			Undifferentiated stratified deposits; 0–100.	Stratified sand and gravel with lenticular bedding. Large proportion of coarse material.	Yield large supplies to properly constructed wells. Supplies much of the water pumped in Bristol and Southington.

			Ground-moraine deposits; 0–50	Heterogeneous mixture of gravel, sand, silt, and clay; contains large boulders in many places. Generally gray, sandy, and loose in western half of Bristol and extreme western part of Southington. Elsewhere, red or brown, generally clayey, and compact.	Yield small supplies to large-diameter wells.
Mesozoic	Triassic	Newark	East Berlin Formation	Red and gray shale, sandstone, arkose, conglomerate, and subordinate limestone in New Haven Arkose and Shuttle Meadow and East Berlin Formations. Diabase in Talcott and Holyoke Basalt.	Yield small to moderate supplies, mainly from fractures, to drilled wells.
			Holyoke Basalt		
			Shuttle Meadow Formation		
			Talcott Basalt		
			New Haven Arkose		
Paleozoic			Prospect Geniss	Metamorphosed igneous rocks, consisting principally of gneiss. Compositional banding of light- and dark-colored minerals. Quartz, feldspar, and biotite are principal minerals.	Fracture openings yield small supplies to drilled wells. Yields are generally smaller than those obtained from rocks of Triassic age.
			Bristol Granite Geniss of Gregory (1906)		
			Hartland Formation	Metamorphosed sedimentary rocks, consisting principally of schist. Muscovite, biotite, quartz, and feldspar are principal minerals.	

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of interconnection of the openings. A large porosity indicates that the rock contains a large volume of openings in which water may be stored. Of two rocks having equal porosity, the rock with the larger openings transmits water more rapidly. If a rock is capable of transmitting water rapidly, it will provide large yields from wells.

The ability of a rock to transmit water is stated as the coefficient of permeability. The coefficient of permeability is defined as the volume of water in gallons per day that will pass through an area of the rock of 1 square foot under a hydraulic gradient of 1 foot per foot. The ability of a water-bearing formation or aquifer to transmit water is represented by the coefficient of transmissibility, which is defined as the volume of water in gallons per day that will move through a vertical strip of the formation 1-foot in width and equal in height to the saturated thickness under a hydraulic gradient of 1 foot per foot. (Theis, 1935, p. 520). For a formation composed of one type of rock or of rocks equal in permeability, the coefficient of transmissibility is equal to the product of the coefficient of permeability and the thickness of the formation.

The coefficient of transmissibility can be used to calculate the flow of water through an aquifer and to predict the yields of wells and the effects of pumping on the ground-water body.

Based on their water-bearing properties, the rocks in the Bristol-Plainville-Southington area are divided into two main categories: the consolidated rocks, hereafter referred to as bedrock, and the unconsolidated deposits.

BEDROCK

METAMORPHIC ROCKS OF PALEOZOIC AGE

The Hartland Formation, Bristol Granite Gneiss of Gregory (1906), and Prospect Gneiss of Paleozoic age underlie the parts of Bristol and Southington in the New England Upland section. The rocks consist principally of mica schist and granite gneiss.

HARTLAND FORMATION

The Hartland Formation (Gregory, 1906, p. 96–100) consists principally of quartz-muscovite schist and biotite schist; it was formed through metamorphism of early Paleozoic sediments. As used in this report, the Hartland Formation includes the Southington Mountain Schist and the Straits Schist (Fritts, 1962). The formation underlies most of the hilly terrain of the western part of Bristol and the extreme northwestern part of Southington. In Southington it forms north-trending cliffs and crops out extensively. Closely spaced outcrops occur around Cedar Swamp Pond in Bristol, but elsewhere in Bristol the formation is largely concealed beneath glacial deposits.

The Hartland forms the scarp of the New England Upland section and is in contact with the New Haven Arkose, which lies to the east of the scarp. At most places the contact lies along the Mixville fault (Fritts, 1962), which has dropped the New Haven Arkose to the east (Wheeler, 1937, p. 22–27). At Roaring Brook in Southington the contact is disconformable and lies to the west of the fault. The Hartland Formation surrounds the Bristol Granite Gneiss of Gregory in west-central Bristol and is in contact with the Prospect Gneiss in southwestern Southington.

BRISTOL GRANITE GNEISS OF GREGORY (1906)

The Bristol Granite Gneiss (Gregory, 1906, p. 104–105) is characterized by biotite banding. It underlies the broad valley of the Pequabuck River in the west-central part of Bristol, west of Hurley Hill. The granite gneiss forms a roughly elliptical body that intrudes the Hartland Formation; it contains more feldspar and iron-bearing minerals than the Hartland and therefore weathers more easily. Because of this characteristic, it forms a broad oval valley surrounded by hills underlain by the more resistant schist. The subdued topographic expression of the formation facilitated the deposition of thick continuous glacial drift. The formation is well exposed only in a railroad cut one-fourth of a mile southeast of Birge Pond.

PROSPECT GNEISS

The Prospect Gneiss is a metamorphosed granite that consists predominantly of light-gray gneiss, and lesser amounts of granite and mica schist. It crops out in the area south and southeast of Southington Reservoir No. 3 in the extreme southwestern part of Southington and is in contact with the Hartland Formation to the north, west, and south and with the New Haven Arkose on the east.

The Prospect is intrusive into the Hartland Formation and was probably emplaced before the Taconian(?) orogeny, but is not correlated with the Bristol Granite Gneiss of Gregory (1906) because of lack of evidence.

WATER-BEARING PROPERTIES

The metamorphic rocks in Bristol and Southington are composed of tightly intergrown mineral grains formed through crushing and recrystallization of the original mineral constituents. Primary pore spaces formed by the shrinkage of some mineral grains as the extreme conditions of metamorphism were relieved. The primary pore spaces are less than 1 percent of the volume and are too minute to transmit ground water. However, the rocks are extensively fractured, the openings along the fractures forming paths for movement of ground water. The fractures are spaced generally from a few inches to a few tens of feet apart and tend to cut the rock into separate masses of irregular size and shape, not unlike rude masonry. The many fractures that are open wide enough to transmit water are the only water-bearing openings in the metamorphic rocks. The principles of the occurrence of water in fractures in the metamorphic and igneous rocks of Connecticut were described by Ellis (in Gregory, 1909, p. 54–101).

Joints are the most common fractures in the metamorphic rocks of Bristol and Southington. They occur in sets, the members of which are approximately parallel. The orientation and spacing of joints vary from place to place. Gradually increasing pressure with depth decreases the size and number of open joints. Well records indicate that at most places the rocks will not transmit water at depths below 250 to 300 feet.

Faults—breaks along which the rock has been displaced—also cut the metamorphic rocks but are much less common than joints. The extent of ground-water circulation through faults is not known. The Mixville fault, which forms the contact of the metamorphic rocks and the New Haven Arkose in southwestern Southington, was excavated near Marion by C. E. Fritts of the U.S. Geological Survey. The fault is filled with gouge and contains no apparent water-transmitting openings.

At most places the metamorphic rocks are overlain by glacial deposits that are saturated with ground water in their lower part. The fractures at the bedrock surface are therefore channels for the interchange of water with the glacial deposits. The fractures that intersect the surfaces of exposed bedrock are poorly situated to receive water, because only when rain is falling or snow is melting can water enter them. Water enters the fractures mainly in the hilly areas and moves down gradient under the influence of gravity. However, in detail the course of ground-water movement is circuitous because it is deflected and influenced by the attitudes of the fractures.

A large number of wells in Bristol penetrate the metamorphic rocks, particularly in areas not served by the public distribution system. Few wells penetrate the metamorphic rocks of southwestern Southington.

An analysis of the records of 58 wells penetrating metamorphic rocks shows that the wells vary greatly in construction and water-producing characteristics. They range from 40 to 405 feet in depth and average 140 feet. Thirty-six wells are between 100 and 200 feet and 14 wells are less than 100 feet in depth; only 8 are more than 200 feet in depth. The rates at which the wells yield water range from less than 1 to about 90 gpm. Moreover, the yields of wells do not correlate with the depths; some of the deeper wells yield little water, and, conversely, some of the shallower wells produce much water. The static water levels of wells range from about land surface to about 60 feet below the surface. Generally, water levels in bedrock wells are closer to the surface in valleys than on hills. The depth to the bedrock surface averages about 40 feet but is as much as 225 feet.

The depth and yield of a bedrock well at a specific site cannot be predicted because the position of joints in rocks below the surface cannot be predicted. Because joints tend to die out within short distances, those exposed in outcrops reveal little about the position of buried joints. However, water-bearing joints are spaced closely enough that a well drilled almost anywhere will obtain at least a supply of water sufficient for household use. Dry holes and wells with insufficient yields are few.

Although the metamorphic rock units in the area apparently do not differ significantly in water-bearing properties, well records indicate that the Bristol Granite Gneiss of Gregory (1906) yields somewhat more water to individual wells than does the Hartland Formation. Data from 16 wells penetrating the Bristol and 39 wells penetrating the Hartland are given in the following table. The data in the table are not conclusive because of the small number of wells in the Bristol Granite Gneiss for which records are available. Few wells penetrate the Bristol because most of the area underlain by this formation is served by the Bristol Water Department.

A well (No. 69) listed by Palmer (1921, p. 93) provided a yield of 85 to 90 gpm from the Bristol Granite Gneiss, the largest known yield obtained from the metamorphic rocks. Other wells in both the Bristol and Hartland Formations yield about 30 gpm at most. A higher proportion of wells in the Hartland Formation have small yields than in the Bristol Granite Gneiss; therefore, both the average and the median yield of wells in the Bristol Granite Gneiss is larger than for wells in the Hartland Formation.

Wells penetrating the Bristol and the Hartland Formations

[a, average; m, median; r, range]

Formation	Wells recorded	Depth of wells (feet)	Depth to rock (feet)	Water level (feet below surface)	Yield (gallons per minute)
Bristol Granite Gneiss	16	134a 138m 40–258r	72a 0–225r	27a 4–60r	16a 9m 1–90r
Hartland Formation	39	149a 132m 60–405r	30a 0–90r	21a 0–60r	7a 5m 0–32r

The Prospect Gneiss, which underlies a small, sparsely populated area of Southington, is little used for water supplies. Therefore, the available well records provide insufficient data to compare the water-yielding properties of the Prospect with the Hartland and Bristol.

SEDIMENTARY AND IGNEOUS ROCKS OF TRIASSIC AGE

East of the scarp marking the western margin of the Connecticut Valley Lowland (see p. 7), the bedrock consists of sedimentary and basaltic rocks of Triassic age. These rocks are part of a broad north-trending belt of Triassic rocks that underlie the central lowland of Connecticut and Massachusetts.

The sedimentary and basaltic rocks in the area comprise the New Haven Arkose, Talcott Basalt, Shuttle Meadow Formation, Holyoke Basalt, and the East Berlin Formation. These rocks are part of the Newark Group of Late Triassic age, which also includes the younger Hampden Basalt and Portland Arkose. The rocks were deposited in a basin formed west of a major fault (the Triassic border fault) that strikes north and lies several miles east of the report area (Barrell, 1915, p. 26–32).

The rocks that crop out in the Bristol-Plainville-Southington area are described below under two main headings, New Haven Arkose and middle part of the Newark Group.

NEW HAVEN ARKOSE

The New Haven Arkose is characterized by red beds of continental origin composed of sandstone, arkose, conglomerate, and shale. The New Haven overlaps Paleozoic rocks in the vicinity of Roaring Brook in Southington. At other places it is in contact with Paleozoic rocks along the Mixville fault (pl. 1). The formation is overlain by the Talcott Basalt. The outcrop area of the New Haven Arkose extends eastward from the Mixville fault to the irregular scrap formed by the Talcott Basalt that trends north and south from Hamlin Pond in Plainville. Despite its broad outcrop area, the New Haven is largely concealed by glacial deposits and is exposed only sporadically. The age of the New Haven Arkose is Late Triassic, on the basis of reptilian fossils.

The New Haven Arkose consists of three separate facies in the area of this report. The basal facies is composed of light gray conglomrate and conglomeratic arkose. It overlies the beveled surface of the Hartland Formation and is about 200 to 300 feet thick. A middle facies contains coarse grayish arkose and subordinate black shale and probably is limited in extent to the broad valley of Dayton Brook, Eightmile River, and Copper Mine Brook. The upper facies is characterized by red fine-grained micaceous feldspathic sandstone, commonly called redstone, but it also contains siltstone, shale, and other fine-grained sandstone. The redstone contains a ferruginous clayey matrix that averages 25 to 30 percent, and in places is as much as 45 percent of the rock (Krynine, 1950, p. 103). The upper facies underlies the north-trending line of hills that includes Redstone Hill and extends eastward to the longitude of Hamlin Pond.

West Rock Diabase forms a sill that intrudes the New Haven Arkose (Rice, 1906, p. 192, pl. 24) and is exposed in scattered outcrops in the southern part of Southington. The most northerly outcrop of the West Rock Diabase is three-fourths of a mile northeast of Milldale.

MIDDLE PART OF THE NEWARK GROUP

Two lava flows and two sedimentary units are described here as the middle part of the Newark Group. The rock units, in ascending order, are the Talcott Basalt, Shuttle Meadow Formation, Holyoke Basalt, and East Berlin Formation. They form a belt of prominent scarps and rugged topography that extends in a line north and south from Hamlin Pond in Plainville and becomes scalloped and irregular southward through the eastern part of Southington (pl. 1). The lower lava flow (Talcott) overlies the New Haven Arkose and serves as a prominent marker bed. The thickness of the middle part of the Newark is about 1,500 feet (Krynine, 1950, p. 32). The beds dip westward. Block faulting has offset the outcrop belt, most conspicously near Shuttle Meadow Reservoir.

The Talcott and Holyoke Basalts are similar in lithology. They are composed of dark-gray or greenish-black basalt. The flows have columnar jointing, which is produced by close-spaced vertical joints that tend to break the rock into hexagonal columns. The Talcott also contains pillow structures. The Holyoke in places consists of two separate flows.

The two sedimentary units in the middle part of the Newark Group consist primarily of shale. The Shuttle Meadow Formation is about 300 feet thick and consists principally of maroon and red fissile shale, dark laminated shale, and subordinate amounts of pink dolomite and blue siliceous limestone. The East Berlin Formation is about 750 to 900 feet thick. It consists principally of red fissile shale and siltstone, dark shale, red siliceous sandy shale, and subordinate amounts of dark siliceous limestone (Krynine, 1950, p. 32, 60–66).

WATER-BEARING PROPERTIES

The rocks of Triassic age provide small supplies sufficient for domestic use almost anywhere. Few supplies exceed 30 gpm, however. Records of 143 wells that penetrate the rocks of Triassic age are available. The wells range from 50 to 1,008 feet in depth and average about 150 feet. The deepest well is considerably deeper than most wells. Ninety-eight of the wells, or about 70 percent, range from 100 to 200 feet in depth. Only 23 wells are less than 100 feet deep, and only 21 are deeper than 200 feet. The depth of one well is not known. Yields range from about 1 to 180 gpm, and the higher yields are not correlated with the deeper wells. Well Pv 5a (H6–4h), the deepest well known to penetrate the sedimentary rocks in the area, yielded only about 16 gpm, and yields of several other of the deeper wells, such as Pv 37 (G6–6j), which has a yield of 2 gpm and a depth of 358 feet, were also low (table 3). On the other hand, wells Bs 3(G6–6h) and Pv 22 (H6–5g) obtain 110 and 180 gpm and are 256 and 200 feet deep, respectively.

The variation, from place to place, in water-bearing properties of the rocks is in a large measure attributed to the types and occurrence of the water-bearing openings in them. Ground water is contained in intergranular pore spaces, bedding-plane openings, and in fractures comprising joints and faults.

Intergranular pore spaces in the sedimentary rocks are small and will transmit water at slow rates. Even the coarse-grained arkose and conglomerate have small pore spaces because of the angularity and poor sorting of the grains. The shale and siltstone are nearly impermeable because they contain such minute pores. The fine-grained feldspathic sandstone, particularly redstone, has such a high clay content that it also is probably almost impermeable. The drillers' reports that in the sedimentary rocks increments in the water supply generally are obtained intermittently indicate that water-bearing openings are widely separated and that appreciable water is not obtained by seepage into the well from pore spaces.

Movement of ground water probably occurs along at least some bedding planes in the sedimentary rocks. Drillers working in the area do not distinguish bedding planes from other water-bearing openings. The fact that water is not consistently produced from the same stratigraphic horizons in closely spaced wells indicates that bedding planes are not everywhere water bearing. However, Gregory (1909, p. 107–109) cites both field observation and drillers' reports as indicating that bedding planes locally are important avenues of circulation.

Because of the open condition of many joints in bedrock exposures and the apparently random occurrence of water-bearing openings in the rocks of Triassic age, joints are believed to be the most important water-bearing openings. Joints occur in the basaltic rocks as well as in the sedimentary rocks. Closely spaced joints that break the rock into polygonal columns were formed during contraction of the basaltic rock as it cooled. These joints are perpendicular to the contacts of the lava sheets and may be a few inches to a few feet apart. Stress that accompanied postdepositional tilting and faulting formed other joints, which generally cut across both the sedimentary and the flow rocks. Most of these joints are steeply inclined; some are flat lying. They vary in orientation and spacing from place to place depending on the type and direction of the stress and on the physical characteristics of the rock. The more competent beds, such as conglomerate, may have joints spaced several feet apart. Shale beds, however, in some places, have separated into splinters along closely spaced joints. Some steeply inclined joints end abruptly at bedding planes rather than dying out gradually. The movement of water through open joints in rocks of Triassic age is probably similar in principle to that already described for the metamorphic rocks.

Data are sparse but those available indicate that few water-bearing fractures extend below a depth of about 300 feet. Well Pv 5a, 0.5 mile west of Hamlin Pond, was drilled to a depth of 1,008 feet after penetrating bedrock at 218 feet, but obtained only about 16 gpm. All the yield is provided by a fracture at a depth of about 300 feet (Palmer, 1921, p. 174). Well Bs 147, about 600 feet deep, yields 20 gpm; little or no water was obtained below 200 feet.

The extent of ground-water circulation through faults is not known. No wells are known definitely to penetrate faults. The Mixville fault (see p. 16) is filled with gouge near Marion, but at least some faults probably contain water-bearing openings.

The New Haven Arkose is the formation of Triassic age most utilized for ground-water supplies. Records of 126 wells penetrating the New Haven Arkose indicate the average yield to be about 15 gpm. Yields generally range from 10 to 20 gpm; few are less than 5 gpm or more than 30 gpm. The highest yield obtained is 110 gpm at well Bs 3(G6–6h).

Water in the New Haven Arkose, in common with that in the other bedrock formations, is under a head that causes it to rise in a well above the depth at which the water-bearing opening is penetrated. On hills, water levels in the wells average 22 feet below the land surface and about 2 feet above the surface of the rock, which is covered with an average thickness of 24 feet of ground moraine. In those wells located in valleys the water level averages 16 feet below land surface and about 54 feet above the bedrock surface, which has a cover of stratified glacial deposits averaging 70 feet in thickness at the well sites.

Drilling in the New Haven Arkose is uneconomical at places where the stratified glacial deposits are unusually thick. In the central part of Plainville and in the Quinnipiac and Eightmile River valleys in Southington, the glacial deposits are 100 to 300 feet thick (pl. 1). At these places supplies may generally be more economically obtained from the glacial deposits.

TABLE 3.—*Records of selected wells and test holes in the Bristol-Plainville-Southington area, Connecticut*

Well and location: See text page 5 for explanation of well-numbering system and location grid.
Altitude above sea level: Given to the nearest 5-foot interval where interpolated from contour map, and to the nearest foot where obtained by leveling.
Type of well or hole: Csn, caisson; Drl, drilled; Drv, driven; Wb, wash boring.
Water-bearing formation: See table 2 for lithologic descriptions and summary of water-bearing properties.
Water level: Lsd, land-surface datum; measured water levels are given in feet, tenths, and hundredths; reported levels are given in feet or in feet and tenths.
Use of well: Abd, abandoned or destroyed; Com, commercial; Dom, domestic or household; Ind, industrial; Obs, observation; Ps, public supply; S, livestock; T, test.

Well	Location	Owner	Year completed	Altitude above sea level (feet)	Type of well or hole	Depth of well (feet)	Diameter of well (inches)	Depth to bedrock (feet)	Water-bearing formation	Water level: Feet below lsd	Water level: Date of measurement	Yield (gallons per minute)	Drawdown (feet)	Use	Remarks
							City of Bristol								
Bs 3	G6-6h	Johnny's Restaurant.	1954	200	Drl	256	8	17	New Haven Arkose.	4	June 1954.	110	--------	Com	Water used for air-conditioning. Temperature, 49°F. Chemical analysis in table 7.
4	G6-4h	Bristol Water Dept.	1948	430	Drl	75	12	--------	Ice-contact deposits.	6.3	Feb. 26, 1948.	800	32.3	Ps	Screen, 20 ft of 250-slot set at bottom.
4a	G6-4h	do	1948	430	Wb	77	2½	77	do	7.2	Jan. 27, 1948.	200	--------	T	Log in table 4. Screen, 10 ft of 100-slot at 76 ft and 10 ft of 200-slot at 66 ft.
46	G6-4c	L. D. Minor	1941	785	Drl	255	6	70	Hartland Formation.	60	Nov. 16, 1956.	5	--------	Dom, S	Chemical analysis in table 7.
74	G6-8b	H. Peters	1946	570	Dug	28	30	28	Ground-moraine deposits.	26.2	Nov. 21, 1956	--------	--------	Dom	--------
78	G6-4j	N. Monbleu	--------	400	Dug	7.5	36	--------	Ice-contact deposits.	6.3	Nov. 28, 1956.	--------	--------	Dom	Chemical analysis in table 7.
79	G6-4h	Pratt	1941	645	Drl	115	6	66	Hartland Formation.	30	1941	--------	--------	Dom	--------
92	G6-5j	Bristol Brass Corp.	1934	235	Drl	40	30	40	Ice-contact deposits.	7	1934	300	22	Ind	Casing slotted for 25 ft from bottom.
123	G6-6g	Wallace Barnes Co.	1938	215	Drl	39	10	--------	Undifferentiated stratified deposits.	8	1938	200	12	Ind	Slotted casing. Yield 150 gpm in 1956. Chemical analysis in table 7.
148	G6-6d	Bristol Water Dept.	1957	235	Drl	72	24-18	--------	do	2	Apr. 3, 1958.	1,400	28	Ps	Log in table 4. Screen, 15 ft of 125-slot, 5 ft of 250-slot, set at bottom. Chemical analysis in table 7.

149	G6-5c	do	1958	255	Drl	49	8	49	do	4.3	Jan. 7, 1958.	300	11	T	Screen, 10 ft of 100-slot, set at 38 ft. J. L. Bean, managing engineer of the department, rates yield at 460 gpm. Chemical analysis in table 7.
150	G6-5c	Bristol Water Dept.	1957	255	Drl	66	8	66	Undifferentiated stratified deposits.	1	Dec. 23, 1958.	300	20	T	Screen, 10 ft of 100-slot, set with bottom at 45 ft. Temperature, 49° F. J. L. Bean rates yield at 320 gpm. Chemical analysis in table 7.
161	G6-5c	do	1957	255	Drv	48	2½	48	do					T	Chemical analysis in table 7.
164	G6-6d	do	1957	240	Drv	70	2½		do			110	4	T	Log in table 4. Finished with open-end casing. Chemical analysis in table 7.
168	G6-6d	do	1957	240	Drv	40	2½		do			40		T	Screen, 8 ft of No. 20. Chemical analysis in table 7.
180	G6-8c	Jacobson	1957	260	Drl	244	6	32	Hartland Formation.	30	June 27, 1957.	1	170	Dom	
196a	G6-8c	Superior Electric Co.	1958	257	Drv	39	2½		Ice-contact deposits.	10.5	Feb. 3, 1958.	50		T	Chemical analysis in table 7.
196b	G6-8c	do	1958	250	Drv	43	2½	43	do	7.3	May 7, 1958.	15		T	Do.
197	G6-6g	Bristol Brass Corp.	1953	240	Drl	47	8	47	do	14.7	Oct. 24, 1953.	100	9	T	Screen, 20 ft of 150-slot.
198	G6-5f	do	1953	235	Drl	41	8	41	do	8.8	Nov. 4, 1953.	150	14	T	Screen, 15 ft of 150-slot.
210	G6-6a	New Britain Water Dept.	1922	255	Csn	30	600	>50	Undifferentiated stratified deposits.	4			9	Ps	Part of White Bridge Development which also includes 20 drilled wells having a total combined yield of 3.3 mgd. See figure 5. Chemical analysis in table 7.

TABLE 3.—*Records of selected wells and test holes in the Bristol-Plainville-Southington area, Connecticut*—Continued

Well	Location	Owner	Year completed	Altitude above sea level (feet)	Type of well or hole	Depth of well (feet)	Diameter of well (inches)	Depth to bedrock (feet)	Water-bearing formation	Water level		Yield (gallons per minute)	Drawdown (feet)	Use	Remarks
										Feet below lsd	Date of measurement				
						Town of Plainville									
Pv 1	H6-4h	Plainville Water Co.	1944	180	Drl	66.5	10	--------	Proglacial deposits.	2.9	1944	500	13.7	Ps	Temperature, 51°F on Mar. 6, 1957. Screen, 60-slot, 12-in. diameter, 11 ft long, set at 65 ft. Gravel-packed. Chemical analysis in table 7. Discharge and drawdown for a well performance test are given in table 5.
2	H6-4h	do	1946	180	Drl	63.5	16	--------	do	3.7	1946	750	20.3	Ps	Screen, 80-slot, 16-in. diameter, 10 ft long. Gravel-packed. Discharge and drawdown for a well performance test are given in table 5.
5	H6-4h	Trumbull Div., General Electric Corp.	1947	190	Drl	50	10	--------	do	17	Nov. 16, 1954.	225	15	Ind	Two 12-in., 60-slot screens, 6 ft in length, set with bottoms at 48 ft and 34 ft, respectively. Gravel-packed.
5a	H6-4h	do	1911	190	Drl	1,008	10-6	218	New Haven Arkose.	--------	----------	16	--------	Abd	Drilled to obtain industrial supply. Yield was insufficient.

19	H6-4f	Walter Sullivan	1939	410	Drl	220	8	10	Middle part of Newark Group.	--------	----------	6	--------	Dom	Chemical analysis in table 7.
22	H6-5g	Tomasso, Inc.	1953	245	Drl	200	8	150	do	20–25	Aug. 1953.	180	75	Ind	Drilled to 220 ft and backfilled 10 ft.
23	H6-5g	do	1950	250	Drl	169	8	62	do	14–15	1950	60	124	Ind	Chemical analysis in table 7.
23a	H6-5g	do	--------	250	Drl	62	8	62	Ice-contact deposits.	12–15	----------	30	--------	Ind	Water level affected by pumping of well Pv 23. Drilled in late 1940's.
24	H6-4h	Trumbull Div., General Electric Corp.	1954	190	Drl	161	12	--------	Proglacial deposits.	16	Nov. 16, 1954.	265	74	Abd	Log in table 4. Drilled to 215 ft by reverse-rotary method, 30-in. diameter. Set 150 ft of 12-in. casing. Annular space filled with fine gravel. Screen, 10 ft long, set at 161 ft. Well drew in silt and clay. Formation could not be stabilized.
33	H6-4h	Trumbull Div., General Electric Corp.	1954	190	Drl	74	12	--------	do	17	Apr. 1, 1955.	240	29	Ind	Screen, 10 ft long, set at bottom. Underreamed around screen and gravel-packed.
37	G6-6i	W. Chamberlain.	1956	230	Drl	358	6	158	New Haven Arkose.	42	Oct. 29, 1956.	2	158	Dom	Fine sand, 0 to 158 ft.
41	H6-5g	Acme Spring Co.	1956	230	Drl	176	8	108	Middle part of Newark Group.	5	Sept. 17, 1956.	30	19	Ind	Hardpan, 0 to 108 ft; red rock, 108 to 176 ft.
48	H6-5d	W. Neidwiecki	1958	355	Drl	85	6	1	do	Flowing.	Jan. 25, 1958.	40	10	Dom	Trap rock, 1 to 85 ft.
55	H6-4j	New Britain Water Dept.	1952	180	Wb	149	----------	--------	Ice-contact deposits.	--------	----------	----------	--------	T	Map location approximate.
57	H6-4d	Plainville Water Co.	1958	180	Drl	94	8	--------	do	2.7	May 7, 1958.	500	19.3	Ps	Chemical analysis in table 7.

TABLE 3.—*Records of selected wells and test holes in the Bristol-Plainville-Southington area, Connecticut*—Continued

Well	Location	Owner	Year completed	Altitude above sea level (feet)	Type of well or hole	Depth of well (feet)	Diameter of well (inches)	Depth to bedrock (feet)	Water-bearing formation	Water level		Yield (gallons per minute)	Drawdown (feet)	Use	Remarks
										Feet below lsd	Date of measurement				
Town of Southington															
S 8	G5-3g	F. Madin	1937	210	Dug	22	24		Ice-contact deposits.	18.64	May 7, 1956.			Dom	Chemical analysis in table 7.
16	G5-3g	S. Suchar	1922	195	Drl	95	6	12	New Haven Arkose.	4.21	May 7, 1956.			Dom, obs	See figure 3 for hydrograph.
16a	G5-3g	do	1917	195	Dug	12	24	12	Ice-contact deposits.	3.94	May 7, 1956.			Obs	
18	G5-3f	Southington Water Dept.	1943	150	Drl	55.2	16		Undifferentiated stratified deposits.	7	July 21, 1943.	500	15	Ps	Screen, 16-in diameter, 15 ft long, set at 55.2 ft.
19	G5-6f	do	1953	124	Drl	93.5	16		do	10.7	June 18, 1953.	500	17	Ps	Log in table 4. Screen, 16-in. diameter, 15 ft long, set at 90 ft.
76	G5-5c	Jacobowski	1952	280	Drl	88	6	10	Prospect Gneiss.	15.20	July 23, 1956.			Dom, obs	Chemical analysis in table 7. See figure 3 for hydrograph.
82	G5-3g	W. Kaiser		200	Dug	14.5	36		Ice-contact deposits.	10.05	July 23, 1956.			Obs	Temperature, 55° F. See figure 3 for hydrograph.
96	G5-6c	R. Brayfield		130	Dug	11	24		Proglacial deposits.	8.54	July 25, 1956.			Dom, obs	Temperature, 54° F. See figure 3 for hydrograph.
102	G5-3e	Cunningham		270	Dug	28	30	28	Ground-moraine deposits.	24.40	July 25, 1956.			Obs	See figure 3 for hydrograph.
130	H5-1c	J. Welch	1928	225	Drl	202	6	12	New Haven Arkose.	10	Aug. 3, 1956.			Dom	Chemical analysis in table 7.
144	H5-1e	R. Mongillo	1952	220	Drl	140	6		Ice-contact deposits.			14		Dom	Do.
235	H6-9h	New Britain Water Dept.	1950	200	Drl	32.5	12	60	do	4.5	Aug. 15, 1956.	1,250	10.2	Ps	Log in table 4. Screen, 12-in., 10 ft long, set at 32.5 ft. Gravel-packed.

256	G5-6d	A. Hubeny	1957	140	Drl	100	6	90	New Haven Arkose.	Flowing.	Jan. 3, 1957.			Dom	Sand and gravel, 1 to 90 ft. Chemical analysis in table 7.
296	H6-7h	New Britain Water Dept.	1950	210	Drl	68	6		Ice-contact deposits.			430	16	T	Slotted casing set at 58 ft.
298	H6-7d	Pratt & Whitney Aircraft Corp.		170	Drl	66	10		Proglacial deposits.			250		Ind	One of a group of four wells. These wells have 60-slot screw-on screens, 12-in. diameter, 12 ft long. On each well one screen is set at bottom and one screen is set about 20 ft above bottom. Chemical analysis in table 7.
302	G6-9f	do		160	Drl	83	12		do	3		500	61	Ind	Screen, 60-slot, 12-in. diameter, 12 ft long. Gravel-packed.
331	H5-1d	Southington Water Dept.	1959	175	Drl	74	24-16		Ice-contact deposits.	13.0	Dec. 3, 1959.	510	13.5	Ps	Screen, 15 ft of No. 5 set at 53 ft.

Domestic supplies of water are generally obtainable from the middle part of the Newark Group. However, because the rocks underlie a rugged, sparsely settled highland in the eastern areas of Plainville and Southington, few wells penetrate them. The Shuttle Meadow Formation is the unit of the middle part of the Newark penetrated by most wells. The East Berlin Formation occurs within the area only in the extreme northeast corner of Plainville where no wells have been drilled. The occurrence of water-bearing joints in these rocks depends to a greater or lesser degree on lithology. Columnar jointing occurs only in the lava flows, but varies greatly in degree from place to place. Large joints cut across sedimentary rocks and lava flows alike, but less continuous joints result from the difference in resistance to fracturing between the Shuttle Meadow Formation and the underlying and overlying flows. The Shuttle Meadow was buttressed between two flows and was, at places, intensely jointed by stresses that did not produce comparable effects in the basalt. The interlayering of sedimentary rocks and flows and differences in the degree of jointing give rise to variable ground-water conditions, as illustrated in the following comparison. The Holyoke Basalt at the site of well Pv 48 is closely jointed. The well will produce at least 40 gpm when pumped and, despite its location high on a gentle slope, overflows several gallons per minute. On the other hand, the Holyoke Basalt at the site of well Pv 19 was unproductive. This well penetrates 200 feet through the flow and an additional 20 feet into the underlying sedimentary rock (table 3). It produces 12 to 15 gpm from the 10 feet or so of sediments immediately under the flow. Thus, the flow may act either as a water-bearing formation, as in well Pv 48, or an impenetrable barrier that confines water in the underlying sedimentary rocks, as in well Pv 19.

Wells Pv 22, 23, and 41, which are located within a small area in Cooks Gap, obtain yields of 180, 60, and 30 gpm, respectively, from the Shuttle Meadow Formation. The large yields of these wells suggest that the Shuttle Meadow is exceptionally fractured in Cooks Gap and may be a likely source of additional large supplies.

THE BEDROCK SURFACE

In preglacial time, during the Tertiary Period, the surface of the bedrock was eroded by streams that cut deep valleys. During glaciation the valleys may have been overdeepened by glacial erosion. Preglacial valleys in the bedrock extend through the present Quinnipiac River valley, Cooks Gap, the Pequabuck River valley, and through Eightmile River and Judd Brook valleys. The present major streams correspond generally to the positions of their preglacial valleys, but they flow on glacial deposits at altitutes much above the bedrock surface.

The character of the preglacial erosion surface greatly affects the ground-water resources of the area. The stratified glacial deposits, the most permeable water-bearing units, were deposited in the valleys. Where they overlie the deeper preglacial valleys, the deposits are exceptionally thick and also exceptionally favorable for obtaining large supplies of ground water. Therefore, knowledge of the location and extent of preglacial valleys serves as a guide to the systematic exploration for large ground-water supplies.

The positions and shapes of the preglacial valleys are indicated in plate 1 by contours drawn on the buried bedrock surface. The contours are generalized because data on the depth to rock are sparse. In detail, the bedrock surface probably is as irregular where it is deeply buried as where it is exposed, or nearly exposed, on hills.

Cooks Gap, at the eastern border of Plainville, is stream-cut. Johnson (1931, p. 31–32) proposed that the ancestral Farmington-Connecticut River flowed southeastward on the sloping surface of Cretaceous sediments and cut down through the sediments into the underlying rocks of Triassic age transverse to their structural trend. Cooks Gap is a part of the ancient stream valley. The stream must have been diverted from the gap before Tertiary erosion ended, because the preglacial valley of the ancestral Pequabuck-Quinnipiac River, which trends southward between wells Pv 5a and 53 (pls. 1, 3) is more than 100 feet lower in altitude than the bedrock floor of Cooks Gap. The ancestral Pequabuck-Quinnipiac River cut the deepest valley in the area and undoubtedly was the last major preglacial stream.

The deepest buried valleys are narrow and the deep valley of the ancestral Pequabuck River west of Hurley Hill is almost straight. The buried valleys beneath the lowland of Eightmile River and the lowland of the Pequabuck and Quinnipiac Rivers in Southington and Plainville are sinuous, but they also are narrow and steep sided.

Benchlike rock terraces that are concealed by stratified glacial deposits border the thalwegs of the buried valleys. Erosional remnants of the terraces at places jut through the glacial deposits. Other erosion features are narrow valleys, which were abandoned by streams in favor of other courses. A good example is the small valley east and northeast of Hurley Hill in Bristol. This valley was cut to its lowest known bedrock altitude of 214 feet at well Bs 171 (G5–5f) by a preglacial stream that later abandoned it (well is on line *B–B′*, pl. 1). The stream probably was diverted through the small valley to the east, which is now occupied by Copper Mine Brook (pl. 3) and which has a minimum bedrock altitude of 149 feet at well Bs 166 (G6–6d).

UNCONSOLIDATED DEPOSITS

The unconsolidated deposits consist of glacial deposits of Pleistocene age and eolian, alluvial, and swamp deposits of Pleistocene(?) and Recent age. The glacial deposits are divided into ground-moraine deposits and stratified deposits. The stratified deposits are divided further into ice-contact, undifferentiated stratified, and proglacial deposits.

The most important occurrence of the Pleistocene Epoch was a south-moving ice sheet that entirely covered Connecticut during Wisconsin time. Although moraines of Iowan and Tazewell age occur to the south on Long Island, the glacial deposits in the Bristol-Plainville-Southington area are probably of the later Cary Stade (Flint, 1953; Denny, 1956). Erosion by the ice removed the mantle of weathered rock that had formed during the Tertiary. Masses of solid rock also were plucked or torn out of place. Rock that would not yield in this way was abraded by rock fragments carried in the ice. The rock material picked up by the ice was eventually redeposited, in part directly from the ice as ground moraine and in part by glacial streams as stratified drift.

As the ice retreated, the bare glacial deposits were eroded by the wind. Silt and fine sand were swept up by the wind and redeposited as a thin discontinuous mantle. Eolian deposition probably continued into Recent time but was retarded as vegetation took hold. Alluvium was deposited on the flood plains. Organic debris, silt, and sand were deposited in the swamps that occupied poorly drained depressions.

GROUND-MORAINE DEPOSITS OF PLEISTOCENE AGE

Ground-moraine deposits of Pleistocene age are extensive but generally thin deposits of unconsolidated material that mantle the bedrock. They are composed of till—unsorted rock material deposited directly from the ice—and some scattered small lenses of stratified sand and gravel. The ground-moraine deposits probably were formed mainly by accretion of till as the ice advanced, but some were formed later as a residuum of stagnant ice. They are fairly thick and persistent on hills and are concealed beneath later glacial sand and gravel deposits in the valleys. However, the deposits of till in the valleys must be both thinner and less persistent than the ground moraine on the hills, for they are logged by drillers in few wells that penetrate thick stratified drift.

CHARACTER AND OCCURRENCE

The ground-moraine deposits are composed of two lithologic types of till: a red till derived principally from the sedimentary rocks and a gray till derived from the metamorphic rocks. The two types are little intermixed; in general they overlie the rock types from which they were derived.

The ground moraine in the Lowland section, which is generally east of the Mixville fault, is composed of red till. The character of the red till varies from place to place, being either red and clayey, light red and sandy, or reddish brown and sandy. Pebbles, cobbles, and boulders, generally not exceeding 1½ feet in diameter, are abundant. A large proportion of the stones is composed of basaltic rocks. Most stones, however, are of arkose and fine-grained sandstone.

In the upland section the ground moraine is composed of gray to light olive gray, very sandy till. The till is weakly cohesive. Sand grains of quartz and mica commonly form a dominant proportion of the matrix, and clay and silt occur in small amounts. Stones range in size from pebbles to large boulders, and the proportion of the different sizes vary from place to place. The stones show all degrees of rounding but semi-angular or angular ones are most common. Angular boulders at places are thickly distributed on the ground moraine. Some boulders are as much as 6 to 8 feet across.

Data from 85 drilled wells and 5 dug wells completely penetrating the ground-moraine deposits in the Lowland indicate that the deposits average about 24 feet in thickness. In the upland section, 33 drilled wells and 4 dug wells reaching bedrock penetrate an average thickness of 22 feet of deposits. The thickness in both upland and lowland varies greatly from place to place and depends much on irregularities in the bedrock surface underlying the deposits. Generally, the thickest ground-moraine deposits are on gently sloping hillsides.

WATER-BEARING PROPERTIES

The water-bearing characteristics of the ground-moraine deposits are determined generally by the till that makes up the bulk of the deposits. Till is poorly sorted, and the fine sand, silt, and clay that it contains fill in the spaces between the coarser material. Thus, most pore spaces in the till are small and will permit only very slow movement of water. The gray till, which has a higher proportion of sand in its matrix, is probably a somewhat better water-bearing material than the red till, which generally has a clayey matrix. Small sand and gravel lenses locally enhance the water-bearing properties of the ground-moraine deposits.

Precipitation that enters the soil and percolates downward is the source of the water. The ground water in the deposits is unconfined and is free to move, under the influence of gravity, through the pore spaces. In general, the water table follows the contour of the land surface, and the water in the deposits moves downslope from upland areas to the streams.

Information is available on a total of 35 wells that draw water from ground-moraine deposits. Their average depth is 16 feet and the average depth to water is 10 feet. In general, large-diameter dug wells, which present a large wall area to allow infiltration from the formation, probably can sustain a yield of 1 to 2 gpm. Large-diameter wells also store a large volume of water and are therefore able to meet short-term withdrawals that exceed their sustained yields. In this way, ground-moraine deposits can provide adequate supplies of water to many households. On the other hand, small-diameter driven, drilled, or bored wells are too small in wall area to obtain sufficient supplies of water. At many places till is too thin or impermeable to supply sufficient amounts, or wells are subject to contamination. For these reasons drilled wells penetrating bedrock have replaced dug wells in ground-moraine deposits at many places.

A few seepage springs provide small supplies from till. The springs generally are located on the lower slopes of hills or in small drainage ways.

STRATIFIED GLACIAL DEPOSITS OF PLEISTOCENE AGE

The stratified glacial deposits were deposited during retreat of the ice sheet when large volumes of meltwater were released and flowed southward. Retreat came about by downwasting of the ice and subsequent stagnation in zones along the margin of the ice. During the early stages of retreat, stratified drift was deposited mainly in contact with stagnant ice; these deposits are called "ice-contact deposits." Later, when little stagnant ice remained in the area, the stratified drift was deposited mainly in glacial lakes in the Pequabuck and Quinnipiac River valleys. When the lakes were destroyed, the latest deposits of stratified drift were laid down by a glacial stream flowing through the Pequabuck and Quinnipiac valleys; these stratified glacial deposits formed in nearly ice-free areas in front of the ice sheet are called "proglacial deposits."

The ice-contact and proglacial deposits occur mainly in sequences. Each sequence was deposited within a separate glacial-stream system that was controlled by a gap or spillway on bedrock, on earlier glacial deposits, or on stagnant ice masses. The streams deposited sediment and graded their beds to the particular spillway. At the completion of its formation, a sequence was a series of smooth-topped deposits whose surface ideally was graded and was broken only by bodies of ice and earlier deposits rising above its level. In those sequences that formed in contact with stagnant bodies of ice, the deposits collapsed as the ice melted away. Parts of the depositional surfaces are preserved only on the broader ice-contact features. In general, the deposits of the same sequence, regardless of morphologic type, are similar in composition. However, deposits of adjacent sequences may vary widely in lithology, topographic expression, and internal structure.

The stratified glacial deposits are grouped below as ice-contact deposits, proglacial deposits, and undifferentiated stratified deposits, according to morphology and lithology.

ICE-CONTACT DEPOSITS

Ice-contact deposits were laid down by glacial streams and consist principally of sand and gravel. They overlie the ground-moraine deposits in valleys and along hillsides and, in general, thicken toward the center of valleys. They exceed 200 feet in thickness at places but generally are thinner. A few lenses of till occur in ice-contact deposits and are presumed to have flowed off the surfaces of adjacent wasting ice masses in the manner described by Hartshorn (1958).

The morphology of the ice-contact deposits was determined principally by the form of the stagnant ice against which they were laid down. Several morphologic types that are present are kames, kame plains, kame terraces, ice-channel fillings and a kame delta. These deposits are closely related in origin, and many examples of each abut or coalesce. The deposits can be defined as follows: A kame is a hillock or mound of sand and gravel having ice-contact slopes. A kame plain is a more extensive feature having a smooth top and peripheral ice-contact slopes. A terrace along a hillside or valley wall whose valleyward edge is of ice-contact origin is a kame terrace. An ice-channel filling is a linear deposit formed in a channel in stagnant ice and includes landforms called both crevasse fillings and eskers. A kame delta is a delta formed in contact with stagnant ice where a glacial stream flows into a glacial lake. The ice-contact slopes of a kame delta are on its upstream side. Large ice-channel fillings have a tendency to be coarser, and the kame delta is on the whole finer, than correlated deposits. Low, intervening ice-contact deposits having no distinct topographic form occur adjacent to the deposits just described.

Ice-contact deposits in the Pequabuck-Quinnipiac lowland consist of red sand and gravel derived from the Triassic sedimentary rocks. The ice-contact deposits in Southington, with some exceptions, constitute a single sequence. A zone of stagnant ice extended northward from the approximate latitude of Plantsville to Patton Brook, and southward-flowing glacial streams laid down kames, ice-channel fillings, and kame terraces among the stagnant ice masses. Near Broad Acres, southeast of Milldale, the streams flowed into a glacial lake and deposited a kame delta. Ice-contact deposits in Cooks Gap and along the sides of Redstone and Campground Hills are probably close in age to those in Southington, but most likely the two are deposits of separate stream systems.

The ice-contact deposits are in general significantly coarser grained than the proglacial deposits in the Quinnipiac-Pequabuck lowland. A representative section of exposed ice-contact materials is about 15 to 20 feet of cobble gravel (which includes some lenses of sand and, near or at the top of the section, some lenses of boulder gravel) overlying 20 to 30 feet of medium and coarse sand interbedded with some pebble and cobble gravel. The uppermost 6 to 8 feet of gravel in many places is particularly coarse and poorly sorted. A few lenses of flowtill occur in the deposits. The bedding is horizontal except where it collapsed along the ice-contact margins and around kettle holes; however, beds generally are continuous for no more than about 200 feet, and much of the coarser material occurs in thick lenses a few tens of feet across. The kame delta, near Broad Acres southeast of Milldale, is distinctive in structure and texture. It is composed of 5 to 10 feet of horizontally bedded sand and gravel that overlies southward dipping even-bedded medium sand. The foreset or dipping sand beds contain scattered pebbles but no interbedded gravel.

The logs of wells indicate the ice-contact deposits in the part of the lowland in Southington consist of interbedded sand and gravel at depth. In these deposits are thick zones of fine material, such as the 25.5-foot thickness of fine sand and clay in well S 288 (H5–1d, 0.15 mile east of the village of Southington). However, gravel was penetrated in the other zones described in this well log, both above and below the zone of fine material. The logs available and verbal reports of drillers indicate no consistent vertical gradation in these deposits. Gravel or fine sand may be struck at any depth during drilling.

The terms used in well logs to describe these deposits need some explanation. The term "clay balls" used in the log of well S 288 may refer to stones of decayed red shale that are common in exposed gravel beds. Many of the stones are soft enough to crumble in the hand, and they probably wash up out of a drill hole as minute fragments. The term "hardpan" is applied by many drillers to fine-grained hard-packed stratified sand and silt. By other drillers the term is used for poorly sorted gravel that is similar to till. In logs of wells S 235 and 296, the term refers to fine material.

The ice-contact deposits exposed in Cooks Gap are mostly coarse-grained, poorly sorted cobble gravel containing lenses of sand. Information on the subsurface character of the material indicates that the gravel generally caps the deposits. At well Pv 22 (H6–5g) the gravel is 30 feet thick and overlies fine material. At wells Pv 23 (H6–5g) and 23a, however, gravel persists downward to bedrock. Wells Pv 41 (H6–5g) and 55 (H6–4j) are at altitudes below the constructional terrace level and penetrate fine-grained material.

The group of ice-contact deposits along the east sides of Campground and Redstone Hills is varied in texture. West of Johnson Avenue in Plainville, the deposits consist of southward-dipping beds of red pebble and cobble gravel and sand overlain by a thin mantle of yellow sand and, in places, gravel. The log of well Pv 46 (H6–4a, on the northern border of Plainville) shows the material is mostly fine grained at depth but contains gravel beds at various places in the section. Exposures in the parts of the terraces both north and south of the Pequabuck River show crossbedded sand, in places contorted by collapse. A thin discontinuous mantle of yellow sand also overlies the terraces at these exposures. Wells Pv 37 and 39 (see line B–B′ pl. 3) reportedly penetrated fine sand overlying bedrock. Slightly southwest of these, well Bs 172 (G6–6h) penetrated gravel. The deposits forming the kame terrace extending southward along the east side of Redstone Hill are not well exposed. Records of wells Pv 13 (G6–9f), Pv 52 (G6–9c), and S 263 (G6–9f) indicate that the terrace materials are 20 to 35 feet thick.

In Copper Mine Brook and Eightmile River valleys, the ice-contact deposits were laid down by glacial streams flowing principally from the small valleys tributary to Copper Mine Brook and, to a lesser extent, from the Pequabuck River valley. The material supplied from these valleys was derived from the metamorphic rocks and is white, light gray, or yellow. Red or pink sand and gravel derived locally from the Triassic rocks occur in the southern part of Copper Mine Brook valley and at depth throughout much of the area.

The ice-contact deposits in Copper Mine Brook and Eightmile River valleys are composed of sand and gravel. Discontinuous beds and lenses of pebble and cobble gravel are numerous in the upper 10 to 20 feet of the deposits, but are fewer at greater depths. Beds of sand, mostly medium and fine, commonly make up the lower parts of exposures. Most individual beds of materials are continuous for a few tens of feet and range in thickness from about one-sixteenth of an inch to generally no more than a foot.

In the New England Upland part of Bristol, ice-contact deposits were formed against stagnant ice masses that lay along the Pequabuck River and Polkville Brook and in the vicinity of Birge Pond. Successive sequences of ice-contact deposits were formed as the ice shrank and lower base levels were established.

The stratified deposits in the New England Upland are composed of white or light-gray sand and gravel. Stones are of metamorphic rock. The upper parts of the deposits contain many lenticular bodies of cobble and finer gravel. Much of the gravel occurs as a discontinuous capping generally 10 to 20 feet thick but perhaps as much as 40 feet thick. The logs of wells generally indicate the deposits to be sand and some interbedded gravel at depth. At well Bs 4a, a test well immediately adjacent to supply well Bs 4 (G6–4h), sand was the only stratified material logged (table 4). Well Bs 57 (G6–4h) penetrated 225 feet of sand that contained little gravel, and well Bs 50 (G6–4h) reportedly was drilled through 90 feet of sand. Except near the surface, gravel is spottily distributed in these deposits, according to the available information.

PROGLACIAL DEPOSITS

Proglacial deposits consist of glacial-lake deposits and valley-train deposits. Glacial-lake deposits were laid down in bodies of open water in Plainville and the southern part of Southington. The valley-train deposits consist of sand and gravel deposited by glacial streams in the Pequabuck River valley in Plainville and in the Quinnipiac River valley after the valleys were largely free of ice. Proglacial deposits are stratigraphically higher or later in age than ice-contact deposits, but they lie at lower altitudes than the ice-contact deposits.

The proglacial deposits in the Quinnipiac-Pequabuck lowland are extensive and are more than 300 feet thick at well Pv 58 (pl. 3). They lie at lower altitudes than and overlap the margins of the ice-contact deposits. They may rest directly on bedrock or an intervening layer of till, or on undifferentiated stratified deposits. The proglacial deposits exhibit a uniform stratigraphic succession. Generally, sand and gravel of valley-train deposits overlie fine sand, silt, and clay of lake deposits.

The valley-train deposits range from fine sand to cobble gravel within short distances, both horizontally and vertically. Cut-and-fill structures and crossbedding are common. The lithologic variations are attributable to deposition in rather narrow, shifting channels in which the velocity of meltwater flow varied greatly.

In the Milldale area the lake deposits underlying the valley train are only a few feet thick (pl. 3). At well S 19 the lake deposits are described as 5 feet of clay, and at a nearby test boring, S 240 (G5–6f), probably the uppermost 23.5 feet of fine red sand and silt are lake deposits. In Plainville the lake deposits are much thicker and consist of thin uniform beds of clay, silt, and fine sand. Wells Pv 24 and 53 (H6–4j) penetrated them to depths of 215 and 227 feet, respectively. The log of well Pv 24 (table 4) gives the best available information on the nature of the lake deposits found at depth.

TABLE 4.—*Drillers' logs of geologic materials penetrated by representative wells and test borings in the Bristol-Plainville-Southington area*

[Stratigraphic interpretations by the author]

Bs 4a (G6–4h)

[Bristol Water Department. Drilled by R. E. Chapman Co. in 1948. Screened from 56 to 76 feet. Altitude 430 feet]

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Ice-contact deposits:			Hartland(?) Formation:		
Water-bearing sand	76	76	Ledge	------	77
Ground-moraine deposits:					
Hardpan	1	77			

Bs 132 (G6–4h)

[P. Perrault. Drilled by M. S. Buczko in 1957. Altitude 625 feet]

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Ice-contact deposits:			Hartland(?) Formation:		
Hardpan	40	40	Shalestone	57	142
Sand	45	85			

Bs 148 (G6–6d)

[Bristol Water Department. Drilled by R. E. Chapman Co. in 1957. Screened from 52 to 72 feet. Altitude 240 feet]

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Artificial fill:			Undifferentiated stratified deposits:		
Gravel fill	6	6	Red sand	17	25
Swamp deposits:			Water-bearing medium sand	20	45
Black peat	2	8	Water-bearing coarse sand	21	66
			Water-bearing gravel	6	72
			Ground-moraine deposits:		
			Hardpan	------	72

Bs 164 (G6–6d)

[Bristol Water Department. Drilled by R. E. Chapman Co. in 1957. Altitude 240 feet]

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Undifferentiated stratified deposits:			Undifferentiated stratified deposits—Continued		
Coarse gravel	10	10	Coarse gravel	5	70
Fine gravel	13	23			
Gray silt	42	65			

Pv 24 (H6–4h)

[General Electric Co., Trumbull Division. Drilled by Layne-New York Co. in 1954. Screen set at 161 feet. Altitude 195 feet]

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Proglacial deposits:			Proglacial deposits—Continued		
Buff sand and gravel	36	36	Fine sand	2	142
Sand, gravel, and red clay	12	48	Clay	7	149
Fine muddy sand (mica flakes)	7	55	Sand (clean)	12	161
Fine sand	12	67	Brownish-red clay	6	167
Red clay	1	68	Fine sand	5	172
Fine sand	20	88	Reddish clay	2	174
Sand and red clay	34	122	Fine sand and clay	20	194
Fine muddy sand	9	131	Reddish clay	2	196
Gray clay	9	140	Fine sand and silt	19	215

Pv 34 (H6–4g)

[Strand Theatre. Drilled by Francis Flood in 1941. Altitude 185 feet]

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Proglacial deposits:			New Haven Arkose:		
Red clay and quicksand	115	115	Rock	375	500
Gravel	10	125			

TABLE 4.—*Drillers' logs of geologic materials penetrated by representative wells and test borings in the Bristol-Plainville-Southington area*—Continued

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Pv 42 (H6-4e)					
[New Britain Water Department. Drilled by R. E. Chapman Co. in 1952. Altitude 180 feet]					
Proglacial deposits:			Proglacial deposits—Continued		
Gravel	6	6	Silt and clay	253	259
Pv 46 (H6-4a)					
[New Britain Water Department. Drilled by R. E. Chapman Co. in 1954. Altitude 170 feet]					
Ice-contact deposits:			Ice-contact deposits—Continued		
Sand and gravel	12	12	Fine sand, scattered gravel	13	93
Fine sand and clay	8	20	Medium sand	17	110
Brown clay	36	56	Fine sand and clay	5	115
No record	16	72	Refusal	------	115
Clay and hardpan	8	80			
S 19 (Gf-6f)					
[Southington Water Department. Drilled by Layne-New York Co. in 1953. Screened from 75.5 to 93.5 feet. Altitude 123.5 feet]					
Topsoil	1	1	Undifferentiated, etc.—Continued		
Proglacial deposits:			Sand	12	35
Sand	4	5	Boulder	1	36
Clay	5	10	Medium sand	34	70
Undifferentiated stratified deposits:			Sand and gravel	22	92
Sand and clay	3	13	Hard-packed sand and gravel	5	97
S 235 (H6-9h)					
[New Britain Water Department. Drilled by Stephen B. Church Co. in 1950. Screened from 22.5 to 32.5 feet. Altitude 200 feet]					
Ice-contact deposits:			Ice-contact deposits—Continued		
Medium to coarse sand and boulders	25	25	Sand	1	60
Coarse sand	7	32	New Haven Arkose:		
Hardpan	27	59	Rock	------	60
S 281 (H6-7d)					
[Southington Water Department. Drilled by Layne-New York Co. in 1957. Altitude 165 feet]					
Topsoil	1	1	Proglacial deposits—Continued		
Proglacial deposits:			Red clay and fine sand	84	90
Medium-coarse sand and gravel	5	6	Refusal	------	90
S 282 (H6-7d)					
[Southington Water Department. Drilled by Layne-New York Co. in 1957. Altitude 170 feet]					
Proglacial deposits:			Proglacial deposits—Continued		
Medium coarse sand and gravel	5	5	Refusal		44.6
Red clay and fine sand	39.6	44.6			
S 283 (H6-7e)					
[Southington Water Department. Drilled by Layne-New York Co. in 1957. Altitude 175 feet]					
Proglacial deposits:			Undifferentiated stratified deposits:		
Medium-brown sand and gravel	14	14	Medium and coarse sand and gravel	11	106
Red clay and fine sand	38	52			
Red clay and fine sand; traces of gravel	43	95			

TABLE 4.—*Drillers' logs of geologic materials penetrated by representative wells and test borings in the Bristol-Plainville-Southington area*—Continued

S 288 (H5-1d)

[Southington Water Department. Drilled by Layne-New York Co. in 1957. Altitude 170 feet]

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Topsoil and clay	2	2	Ice-contact deposits—Continued		
Ice-contact deposits:					
Medium sand, gravel, and clay	13	15	Fine, medium, and coarse sand and gravel—traces of clay balls	15	66
Fine red sand and clay	25.5	40.5	Refusal		66
Fine and medium sand and gravel	10.5	51			

S 296 (H6-7h)

[New Britain Water Department. Drilled by Stephen B. Church Co. in 1950. Altitude 210 feet]

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Soil	2	2	Ice-contact deposits—Continued		
Ice-contact deposits:			Hardpan	3	48
Coarse sand	18	20	Medium sand	7	55
Medium sand	25	45	Fine sand	13	68

S 297 (H6-7g)

[New Britain Water Department. Drilled by Layne-New York Co. in 1950. Altitude 160 feet]

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Proglacial deposits:			Proglacial deposits—Continued		
Coarse sand to medium gravel	20	20	Medium to coarse sand	5	50
Fine sand, red	5	25	Fine sand	5	55
Medium sand, red	10	35	Red sand	40	95
Fine sand	10	45			

The red lake deposits around Milldale and Southington Recreation Park were derived from the sedimentary rocks. The material was probably supplied by the glacial streams in which the ice-contact deposits immediately to the north were deposited. However, as the ice sheet continued to retreat, the source of the meltwater was more distant ice in the New England Upland part of the Farmington River valley to the north of the area. Thus, the higher part of the lake deposits in Plainville and the valley-train deposits in both Plainville and Southington are composed mostly of white, yellow, or gray material derived from metamorphic rocks.

In most well logs the valley-train deposits and the lake deposits can be separated with reasonable certainty. Generally, the valley-train deposits are recorded as sand or sand and gravel, whereas the lake deposits are fine sand, silt, and clay. At well S 19 the valley-train deposits consist of 4 feet of sand; however, they are 36 feet thick at well Pv 24, where they are logged as buff sand and gravel (table 4). At this well they also apparently grade down into the lake deposits through a 12-foot zone of sand, gravel, and red clay. Intermediate thicknesses of valley-train deposits are recorded at other wells, including wells Pv 42, S 281, S 282, and S 297 (table 4); at some wells they are either absent or were not logged.

UNDIFFERENTIATED STRATIFIED DEPOSITS

Stratified deposits that can be classed neither as ice-contact nor proglacial deposits are shown on the map as undifferentiated deposits. The deposits include: (1) Sand and gravel having no distinctive form that were deposited over stagnant ice masses and subsequently let down as the ice melted away; such deposits are commonly interspersed with ice-contact deposits, but they have been mapped separately only where extensive. (2) Deposits formed by local streams after deglaciation was largely completed and possessing no distinctive form. (3) Deposits of obscure origin, principally discontinuous beds of sand and gravel, which occur at depth beneath lake deposits and which may have been deposited beneath the ice sheet or at its margin by subglacial streams.

The extensive undifferentiated stratified deposits in Copper Mine Brook valley were, for the most part, deposited on top of stagnant ice. They are probably contemporaneous with adjoining ice-contact deposits. When the ice melted, they were let down to about their present altitudes. Their surface was planed off by Copper Mine Brook and its tributaries and veneered with alluvium.

Logs of wells indicate that the stratified glacial deposits at depth consist principally of sand but contain some lenses or beds of gravel having few pebbles exceeding 2 inches in diameter. The material varies both vertically and horizontally. For example, wells Bs 148 (G6–6d) and 164, 0.5 mile north of Forestville, are located about 200 feet apart, but the gray silt penetrated from 23 to 65 feet in depth at well Bs 164 does not extend to well Bs 148 (table 4).

Mechanical analyses of samples of materials from wells in Copper Mine Brook valley, in the eastern part of Bristol, are shown in the following table.

Mechanical analyses of samples from wells in Copper Mine Brook Valley and related calculations

[Analyses and calculations by The Henry Souther Engineering Co., Hartford, Conn., February 27 and March 5, 1957. Results expressed as cumulative percent passing]

Sieve No.	Grain size (mm)	Bs 159 (depth of sample 35 feet)	Pilot hole for Bs 148 (depth of sample 53 feet)	Bs 164 (depth of sample 70 feet)	Bs 165 (depth of sample 49 feet)	Pilot holes for Bs 148 (depth of sample 65–72 feet)
¼	6.25	76.7	98.9	98.6	79.9	63.3
10	1.9	72.3	92.8	64.8	49.3	20.9
14	1.3	67.2	88.1	39.5	34.1	16.0
20	.95	60.9	81.8	25.4	22.9	11.2
30	.65	50.8	68.2	14.7	12.0	7.1
40	.46	38.1	49.2	8.4	5.6	4.3
50	.33	22.6	28.1	5.6	2.4	2.2
70	.24	11.2	13.5	4.3	1.1	.6
100	.15	4.8	4.3	2.9	.4	.2
Effective size mm		0.22	0.20	0.47	0.54	0.85
Type 10 percent passing		Fine sand	Fine sand	Coarse sand	Coarse sand	Sandy gravel
Field velocity of water under 1 percent hydraulic gradient feet per day		.065	.065	6.33	6.33	6.33

Undifferentiated stratified deposits that consist of interbedded sand and gravel underlie the proglacial deposits near Milldale. In Plainville and the northern part of Southington, the undifferentiated stratified deposits are for the most part thin and discontinuous. Presumably they include both deposits laid over ice and subsequently lowered as the ice melted away and deposits formed by subglacial streams. Well S 19 in the Milldale area penetrates a thickness of 87 feet of undifferentiated deposits below a clay zone. The variable character of the deposits is illustrated by the log of this well and the logs of borings S 239 and 240. In northern Southington and in Plainville, gravel beds of the undifferentiated deposits underlie lake deposits at, among other places, wells S 283, Pv 53 (H6–4j), Pv 34, and Pv 58 (H6–7d). Indications are that, generally, the gravel directly overlies the bedrock.

HYDRAULIC PROPERTIES OF THE STRATIFIED GLACIAL DEPOSITS

The wide variation in the lithology of the stratified glacial deposits suggests that there is also a wide variation in their water-bearing properties. Data summarized in table 5 from 19 wells finished in stratified glacial deposits indicate the good water-bearing properties of the deposits. Coefficients of transmissibility calculated from the specific capacities—specific capacity is the yield per foot of drawdown in a well—of these wells ranged from about 5,000 gpd per ft to about 100,000 gpd per ft. The calculations of transmissibility from specific capacity were based on a method described by Theis and others (1954) and are considered to be sufficiently accurate to indicate the general water-bearing excellence of the deposits.

TABLE 5.—*Specific-capacity data for selected wells finished in stratified glacial deposits and estimated coefficients of transmissibility for the deposits*

Well	Discharge Q (gallons per minute)	Drawdown s (feet)	Duration of pumping (hours)	Specific capacity (Q/s)	Transmissibility (gpd per ft. rounded)
Bs 4	800	32.3	48	25	20,000
92 [1]	300	22		14	10,000
123 [1]	200	12		17	25,000
148	1,400	28	72	50	40,000
149	300	11		27	40,000
150	300	20		15	20,000
197	100	9	18	12	10,000
198	150	14	7	11	10,000
Pv 1	680	14		50	70,000
2	1,000	20		49	70,000
5	225	15		15	25,000
24	265	74		4	5,000
33	240	29		8	10,000
S 18	500	15	48	33	50,000
19	500	17	146	29	40,000
235	1,250	10.2	12	123	110,000
296 [1]	430	16	96	27	40,000
302 [1]	500	61		8	10,000
331	510	13.5	168	38	40,000

[1] Slotted casing.

Coefficients of transmissibility also were computed from drillers' pumping test data for 3 of the 19 wells listed in table 5. The calculations, based on nonequilibrium methods of analysis, gave values of about 6,000 gpd per ft, 11,000 gpd per ft, and 40,000 to 50,000 gpd per ft for the coefficients of transmissibility at wells Bs 197, Bs 4, and Bs 148, respectively. These values for the coefficient of transmissibility are of the same general order of magnitude as the values computed from specific capacities.

The coefficients of transmissibility given above probably are representative of the more permeable deposits in the Bristol-Plainville-Southington area. Before most of these wells were constructed, however, test wells were driven to locate suitable water-bearing materials. Most test wells penetrated materials of low or moderate permeability that did not yield the desired amount of water.

Ground water in the stratified glacial deposits occurs mostly under water-table conditions. Recharge is provided mainly by water of precipitation that infiltrates the ground and percolates to the water table. Ground water moves toward the streams, where it is discharged. The depth to the water table ranges from a few feet near streams and swamps to probably about 100 feet in some highstanding ice-contact deposits. Generally the water table is within 25 feet of the surface. At places ground water may be confined in the stratified glacial deposits by relatively impermeable strata. Confined ground water probably occurs to some extent in the deposits underlying the clay around Milldale.

Some flowing wells have been constructed in the stratified glacial deposits near streams, but, these wells probably do not flow as a result of artesian conditions. For instance, wells S 259 to 261, 1 mile northeast of Churchill Hill, are among a group of shallow driven wells, 20 to 40 feet deep, that supply a fish hatchery by natural flow. The wells are driven either through the bed of Patton Brook or a short distance from the brook. The natural flow probably results from head differentials brought about by lateral subsurface movement of water in the vicinity of the brook, rather than by artesian conditions.

GROUND-WATER HYDROLOGY

The preceding descriptions of the water-bearing formations were concerned with the individual formations as reservoirs of ground water and sources of supply. The broader aspects of the ground-water resources of the area require consideration of the relationship of the geologic formations to one another and their occurrence in a hydrologic environment affected by many factors.

WATER TABLE AND MOVEMENT OF GROUND WATER

The ground water in the area accommodates itself to the framework provided by the geologic and physical features. Ground water moves slowly through intergranular openings and fractures in the rocks. The general direction of subsurface flow is along the slope of the water table.

The slope of the water table approximates that of the land surface, but it differs principally in being more subdued. Thus, the ground water moves from the uplands towards the streams. For the most part, the water table intersects or closely approaches the surfaces of streams and ponds, which can be considered to be outcrops of the water table. Where streams flow over impermeable materials, however, the stream levels may not be related to the water table.

The slope of the water table depends on variations in the permeability and thickness of the formations, on the structural and stratigraphic relationships of the formations, on the distribution of areas of recharge and discharge, and on the topography. The water table tends to have a steeper slope in less permeable materials than in the more permeable ones. It also tends to be close to the land surface in places. For example, the water table in till on many steep slopes lies close to the surface because the downward percolation of water is retarded by the underlying bedrock (pl. 3). In the ice-contact deposits, water percolates downward rapidly, and the water table has a nearly uniform slope and only a slight tendency to follow the local irregularities in the surfaces of the deposits.

Plate 2 is a generalized contour map showing the shape and slope of the water table in the Bristol-Plainville-Southington area. The contours are based on altitudes of water levels in wells finished in the glacial deposits and on surface expressions of the water table. They are generalized for several reasons: (1) the land-surface altitudes used as controls were interpolated from topographic maps and are only approximate; (2) the water-level altitudes in some wells tapping the deeper parts of the stratified drift may be responding to local artesian conditions and may not correspond exactly to the water table; (3) measurements of water levels were made at various times and no compensations were made for the fluctuations that accompany changes in ground-water storage. Many water-level altitudes were obtained from records of wells collected in 1914 by Palmer (1921, p. 90–92, 171–174, 204). Water levels in a few wells visited by Palmer were remeasured in 1956, and the water levels were about the same as those in 1914. The water levels of 1914 probably were not significantly different from those of 1956, when most data for the present report were collected, and the 1914 levels also were used to prepare plate 2.

Despite the limitations stated above, the water-table map is sufficiently accurate to define the areas of recharge and discharge and the general direction of ground-water movement. Plate 2 shows that recharge is obtained mostly within the area and also from narrow strips of highland bordering it. Ground-water divides lie in the stratified deposits between the Quinnipiac and Pequabuck Rivers, the Eightmile and Pequabuck Rivers, and between Dayton and Judd Brooks. Ground water enters Bristol from outside the area by underflow along the valleys of Copper Mine Brook and the Pequabuck River. Ground water flows out of the area by underflow through the valleys of Pequabuck and Quinnipiac Rivers in Plainville and Southington.

FLUCTUATIONS OF WATER LEVELS

The water table fluctuates upward or downward as water is added to or taken from the ground-water reservoirs. A rise in water level indicates an increase, and a lowering of water level indicates a decrease in the amount of ground water in storage.

Water levels in observation wells in Connecticut generally fluctuate seasonally with changes in ground-water storage. A seasonal trend was observed also at wells S 16, 16a, 76, 82, 96, and 102, at which water levels were measured monthly (fig. 3). Water levels generally begin to rise in October or November and to decline in March or April. The rise in level is caused by an excess of ground-water recharge over ground-water discharge, and, conversely, the decline in levels is caused by an excess of ground-water discharge over recharge.

Discharge of ground water goes on throughout the year, although the rate of discharge increases as water levels rise. Ground-water recharge, however, varies substantially with the seasons. It is reduced by evapotranspiration during the growing season. Evapotranspiration so depletes the moisture in the soil that precipitation entering the ground during the growing season is used mostly to replenish soil moisture, and recharge is slight or nonexistent. At the end of the growing season, infiltration generally produces ground-water recharge in excess of ground-water runoff, and water levels rise.

Short-term fluctuations of water level are most obviously correlated with variations in the weather, particularly the amount of precipitation received. For example, during most months of 1957 precipitation was below average. In addition, most rains were light and of short duration, and hence little water penetrated below the dried-out soil zone. The water levels declined to very low altitudes at the observation wells in Southington. (See fig. 3). An upward trend started

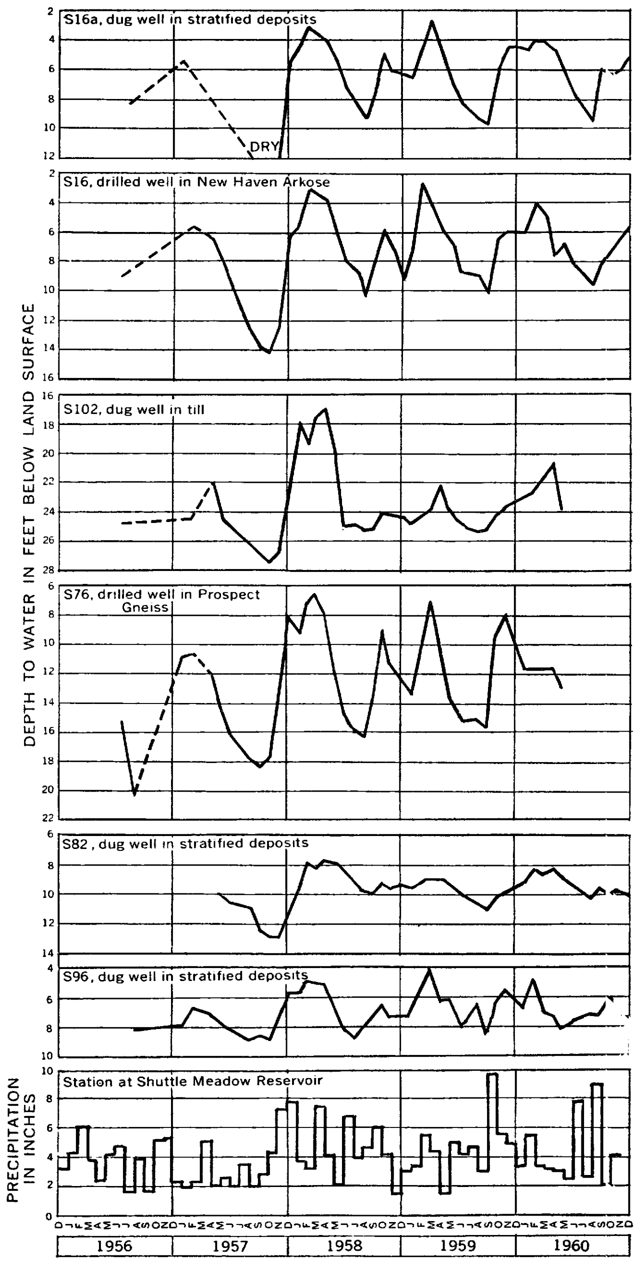

FIGURE 3.—Hydrographs showing fluctuations of water levels in observation wells in Southington, and bar graph of mont'ly precipitation at Shuttle Meadow Reservoir.

during November when rainfall was greater than average. The levels rose rapidly when heavy rains and wet snow fell during December 1957 and January 1958. Once high levels were attained, however, fluctuations were slight until the seasonal decline began in April 1958 at most wells. The hydrographs during this period illustrate that the ground-water reservoirs will accept recharge at a high rate when levels are depressed. However, when water levels are high, the ground-water reservoirs will accept less recharge because they are filled, or nearly filled, to capacity.

Colder-than-average weather during the winter of 1958–59 caused a reversal in the usual seasonal trend of the water table. Extremely low temperatures, particularly during December, caused the formation of thick ground frost, which greatly reduced the rate of infiltration of water into the ground. Precipitation during this period was light and occurred mostly as snow and freezing rain, which melted and evaporated during the sunny hours of the day. The cold temperatures thus reduced the rate of recharge below the average, and a slight decline in water level resulted.

The hydrographs of observation wells (fig. 3) show the same general trends, but these trends do not coincide exactly, either in amplitude or direction. Besides variation in the weather, the fluctuation of the water table is also affected by such factors as the porosity and permeability of the water-bearing materials, the slope of the water table and land surface, vegetation, and ground-water pumpage. The effect of each factor cannot be evaluated from the available information.

RECHARGE AND DISCHARGE

Recharge to the ground-water reservoirs is equal to discharge adjusted by the gain or loss in ground-water storage. A precise evaluation of the recharge and discharge occurring in the Bristol-Plainville-Southington area requires knowledge of many factors that affect the hydrologic regime, but these factors can be gaged only by detailed study and long observation. Infiltration, for example, is affected by such things as the type of soil and whether or not the soil is cultivated; variations in soil moisture from time to time; the slope of the land surface; the volume, rate, and distribution of precipitation; the depth of frost penetration; and the depth to the water table. A detailed appraisal of recharge and discharge in a quantitative sense is therefore beyond the scope of this study. From data at hand, however, ground-water recharge and discharge can be estimated within broad limits.

Recharge is supplied mostly by infiltration from precipitation within the area, but water is also received by subsurface downslope movement from narrow highlands bordering the area and by underflow through the stream valleys at the western and northern boundaries of Bristol. Discharge takes place by ground-water runoff; by evapotranspiration, where the water table is close to the surface; by pumpage from wells; and by underflow, principally at the northern boundary of Plainville and the southern boundary of Southington.

In estimating the gains and losses of ground water in the area, it was assumed that the different segments of the Pequabuck and Quinnipiac basins have similar hydrologic characteristics. Inasmuch as the values for average yearly precipitation and stream runoff were selected from records covering many years, the effects of intermittent variations were negligible. The amount of ground water in storage was assumed to be the same at the beginning and end of the period of record, because the water levels of 1914 were not significantly different from those of 1956. The average yearly recharge was therefore considered equal to the average yearly discharge, and estimates of discharge could be applied to recharge.

EVAPOTRANSPIRATION

The average yearly precipitation in the area is about 49 inches, as indicated by the records of the U.S. Weather Bureau for the stations at Whigville, Wolcott, and Shuttle Meadow Reservoirs. The average discharge of the Pequabuck River at Forestville in Bristol for the period 1941-58 (Wells and others, 1960, p. 224) is 87.3 cfs (cubic feet per second) from the drainage area of 45.2 square miles above the gage. The flow of the stream, therefore, averages about 26 inches per square mile per year. The flow of the Quinnipiac River for 1930-58 (Wells and others, 1960, p. 241) averaged 208 cfs, or 134 mgd (million gallons per day), at Wallingford from an area of 109 square miles, or also 26 inches per square mile per year. In other words, of the 49 inches of precipitation falling on each square mile of the Pequabuck and Quinnipiac basins, about 26 inches enters the rivers. The remaining 23 inches of precipitation that does not appear as stream runoff presumably is discharged mostly by evapotranspiration and to a lesser extent by pumping and underflow. Some of the water that is discharged by evapotranspiration probably was recharge to the ground-water body that went into temporary storage.

GROUND-WATER RUNOFF

An estimate of ground-water runoff from the area was made from records of streamflow for the Pequabuck River at Forestville. Ground-water runoff at Forestville is reasonably representative of ground-water runoff from the area as a whole.

Ground-water runoff was estimated by the following method: The hydrograph of mean daily flow for the Pequabuck River was plotted on a natural scale for both a dry period and a wet period. The periods chosen were the 1952–53 water year (October 1952 through September 1953), when streamflow was high, and the 1956–57 water year, when streamflow was low. Curves representing ground-water runoff then were sketched by inspection from the streamflow hydrograph. Figure 4 is a part of the hydrograph for the Pequabuck River at Forestville. The curve represents ground-water runoff or base flow; it is sketched in and is included for illustrative purposes.

The sketches were made on the following assumptions: The low flows of the river were assumed to be sustained entirely by ground-water runoff with the exception of minor changes in flow caused by light precipitation or artificial diversions of water. Ground-water runoff increased rapidly following high flows of the river, and then receded gradually. The recession in ground-water runoff should be indicated by the part of the streamflow hydrograph curving downward to the right during the period several days after the high flow of the stream, if no additional precipitation occurs. The resulting curves representing ground-water runoff were used to compute the ground-water discharge for the 1952–53 and 1956–57 water years. The discharges were then averaged to arrive at an approximate figure for the average yearly ground-water runoff.

Ground-water runoff in the Pequabuck River averages about 39 cfs 25 mgd) or 11.7 inches per square mile per year. Thus, 45 percent of the flow of the river represents discharge from the ground-water reservoirs. In the 1957 water year, in which rainfall was exceptionally light, ground-water runoff averaged 27 cfs (17 mgd), and in the 1953 water year, when rainfall was heavy, ground-water runoff averaged 50 cfs (32 mgd).

UNDERFLOW

The general downstream movement of ground water in deposits adjacent to a stream is called "underflow." Ground water enters Bristol by underflow through the stratified glacial deposits adjacent to the Pequabuck River, Copper Mine Brook and its tributaries, and Tenmile River, where they flow into the area. Water leaves the area by underflow along the Pequabuck and Quinnipiac Rivers and Judd Brook.

The volume of underflow can be calculated by Darcy's law, written as:

$$Q=P_fIA$$

where Q is underflow in gallons per day, P_f is the field coefficient of permeability of the geologic formation in gallons per day per square

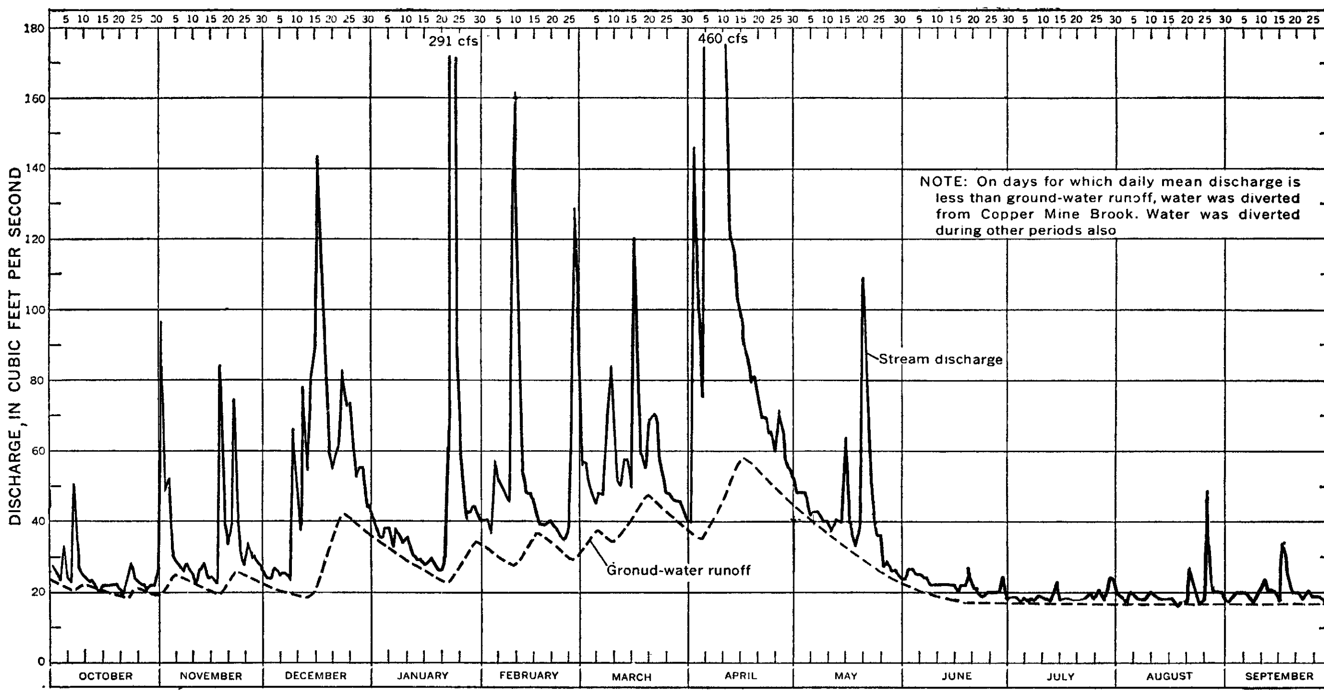

FIGURE 4.—Hydrograph of daily mean discharge and estimated ground-water runoff of Pequabuck River at Forestville from October 1956 to September 1957.

foot, I is the hydraulic gradient in feet per foot, and A is the cross-sectional area through which flow occurs in square feet. The field coefficient of permeability can be derived by dividing the coefficient of transmissibility (table 5) by the thickness of the formation. The factors I and A can be estimated from the generalized water-table map (pl. 2) and the generalized bedrock contours (pl. 1).

Along the Pequabuck River at the western edge of Bristol, water entering the area by underflow is estimated to be about 200,000 gpd or 0.31 cfs. Water entering the area by underflow along Copper Mine Brook and its tributaries is probably about 100,000 gpd or 0.15 cfs. Water leaving the area by underflow at the northern boundary of Plainville through the Pequabuck lowland is probably about 200,000 gpd or 0.31 cfs.

The underflow conduits across Bristol and Plainville are not continuous. The underflow entering Bristol along the Pequabuck River cannot persist through the gap south of Hurley Hill. The water must therefore be discharged by both ground-water runoff and evapotranspiration. The underflow through Copper Mine Brook valley is largely discharged above Forestville, where the underflow conduit is very narrow. The underflow moving out of Plainville parallel to the Pequabuck River is derived locally from the proglacial deposits in the town.

The gain in underflow through the Pequabuck River and Copper Mine Brook valleys in Bristol is apparently about 100,000 gpd in excess of the loss through the Pequabuck River valley in Plainville. The calculations of underflow probably contain large errors, however, but they show that the magnitude of underflow in Bristol and Plainville is small compared to discharge by streams and evapotranspiration.

In the Quinnipiac River valley, underflow is not amenable to quantitative treatment because of lack of data. Underflow probably occurs southward along the Quinnipiac River, but the permeability, extent, and thickness of the deposits through which the water passes cannot be determined with reasonable accuracy. The hydraulic gradients are low, probably about 10 feet per mile. Some underflow along Judd Brook probably discharges water southward out of Southington, but this water probably enters the underflow conduit along Tenmile River. Underflow along Tenmile River is directed into Southington at Milldale, where it joins the underflow moving out of the area parallel to the Quinnipiac River. The volume of underflow in the Quinnipiac valley at Southington is probably small compared to the total discharge from the valley.

GROUND-WATER PUMPAGE

An average of 4.7 mgd of ground water was pumped in the area in 1958. Most of this water is not returned to the ground, and perhaps as much as half is consumed or is discharged into another drainage basin in New Britain. The pumpage has had no appreciable effect on the amount of water in storage in the area. Temporary decline of ground-water levels has been observed only around large-capacity wells. The ground water withdrawn is therefore being replaced by recharge. The effect of the withdrawal on the hydrologic regimen is difficult to judge, though obviously the effect is small, for total ground-water discharge is many times the pumpage from wells. The pumpage probably reduces the amount of water that eventually appears as ground-water runoff. Some wells also draw water from the streams by induced infiltration. Because much of the pumpage is consumed or is discharged into another drainage basin, the ground-water pumpage slightly reduces the streamflow. However, wells may salvage some water that would ordinarily be discharged by evapotranspiration, particularly in areas where the water table is near the surface.

RECHARGE

Discounting the small amount of underflow, the volume of recharge is equal to the ground-water runoff plus the evapotranspiration drain on the ground-water body. The ground-water runoff is approximately 11.7 inches per square mile per year in the area. Thus, recharge amounts to at least 550,000 gpd on each square mile or about 200 million gallons each year on each square mile of the area. The amount of additional recharge subsequently discharged through evapotranspiration cannot be estimated. It may well be that several of the 23 inches per square mile per year discharged by evapotranspiration was drawn from the ground-water reservoirs.

QUALITY OF WATER

Chemical analyses of 28 samples of well water from the area are given in table 6. The U.S. Geological Survey analyzed nine samples of ground water from representative wells. The other analyses were made by the Connecticut Department of Health, Henry Souther Engineering Co., and other private laboratories. The analyses done outside the Geological Survey were made only to check on the suitability of certain ground-water supplies for specific uses, and are less comprehensive than those of the Survey. The analyses listed in table 6, with the exception of those for wells Bs 196a and 196b, did not show any serious chemical contamination and probably are representative for the ground water of the area.

TABLE 6.—*Chemical analyses of water from wells*

[Sample analyzed by: a, Connecticut Department of Health; b, U.S. Geological Survey; c, Henry

Well; sample analyzed by—	Owner	Depth (feet)	Water-bearing formation	Date of collection	Temperature (°F)			
						Silica (SiO_2)	Iron (Fe)	Manganese (Mn)
Bs 3; a	Johnny's Restaurant.	256	New Haven Arkose	4-11-56	------	------	------	------
46; b	L. D. Minor	255	Hartland Formation	9-23-57	53	27	0.06	0.01
78; b	N. Monbleu	7.5	Ice-contact deposits	9-23-57	54	24	.08	.01
123; c	Wallace Barnes Co.	39	Undifferentiated stratified deposits.	8- 3-39	------	------	.3	------
123; d	do	------	------	11- 8-39	------	------	.3	------
148; a	Bristol Water Dept.	72	Undifferentiated stratified deposits.	11- 1-57	------	------	.1	------
148; d	do	------	------	4- 4-57	------	------	.04	------
148; d	do	------	------	4-15-57	------	------	.02	------
149; d	do	49	Undifferentiated stratified deposits.	1-58	------	------	------	------
150; d	do	66	do	1-58	------	------	------	------
161; d	do	48	do	3-20-57	------	------	------	------
164; d	do	70	do	2-14-57	------	------	------	------
165; d	do	49	do	------	------	------	------	------
168; d	do	40	do	2-25-57	------	------	------	------
196a; d [2]	Superior Electric Co.	39	Ice-contact deposits	2-19-58	------	------	.14	3.3
196b; d [2]	do	43	do	3-12-58	------	------	.54	1.0
210; a	New Britain Water Dept.	30	Undifferentiated stratified deposits.	9-26-36	------	------	.1	------
Pv 1; b [3]	Plainville Water Co.	66.5	Proglacial deposits	3- 6-57	51	17	.00	.00
19; b	W. Sullivan	220	Middle part of the Newark Group.	9-23-57	55	20	.04	.00
23; e	Tomasso, Inc.	169	do	1950	------	11.5	Tr.	------
57; a	Plainville Water Co.	94	Ice-contact deposits	5- 6-58	------	------	<.1	------
57; c	do	94	do	5- 6-58	------	------	.14	.00
S 8; b	F. Madin	22	do	9-23-57	55	13	.08	.05
76; b	Jacobowsky	88	Prospect Gneiss	9-23-57	52	8.7	.60	.05
130; b	J. Welch	202	New Haven Arkose	9-23-57	50	24	.22	.00
144; b	R. Mongillo	140	Ice-contact deposits	9-23-57	51	22	.16	.00
256; b	A. Hubeny	100	New Haven Arkose	9-23-57	------	5.5	1.2	.03
298-302; f [4]	Pratt & Whitney Aircraft Corp.	------	Proglacial deposits	2-14-55	------	16	.1	------

[1] Calculated on the basis of $CaCO_3$ alkalinity.
[2] Ground water is contaminated by industrial waste.

NATURAL CHEMICAL CONSTITUENTS

The few available chemical analyses indicate that the ground water is of the calcium bicarbonate type and is of reasonably good chemical quality. Dissolved solids range from 38 to 280 ppm, which is well below the U.S. Public Health Service (1946) standard of 500 ppm for drinking water. Hardness of the water ranges from 23 to 154 ppm (as $CaCO_3$). Iron does not occur in concentrations greater than 0.3 ppm, except in the samples from wells Bs 196b, S 76, and S 256. Manganese does not exceed 0.05 ppm, except in samples from wells Bs 196a and 196b, which were probably contaminated. The combined iron and magnanese content of only four samples (from wells Bs 196a, *in the Bristol-Plainville-Southington area*

Souther Engineering Co.; d, Wm. B. Scaife & Sons Co.; e, Dominion Chemical Co.; f, The Permutit Co.]

Chemical constituents (parts per million)														Specific conductance (micromhos at 25°C)	pH
Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Alkalinity as $CaCO_3$	Dissolved solids	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate		
------	------	------	------	[1] 65	------	------	3.2	------	------	53	------	------	------	------	------
17	7.8	6.7	1.4	76	0	11	9.8	0.1	4.7	------	119	75	12	179	6.9
9.6	3.3	7.1	2.6	36	0	11	7.3	.2	5.7	------	86	38	8	117	6.0
------	------	------	------	[1] 45	------	15	------	------	------	37	------	59	[1] 22	------	------
------	------	------	------	[1] 48	------	------	------	------	------	39	------	58	[1] 19	------	6.3
------	------	------	------	[1] 28	------	------	3.0	------	6.7	23	------	36	[1] 13	------	6.7
------	------	------	------	[1] 29	------	------	4.0	------	------	24	------	30	[1] 6	------	6.6
------	------	------	------	[1] 27	------	------	4.6	------	------	22	83	38	[1] 16	------	6.4
------	------	------	------	[1] 26	------	------	3.0	------	7.1	21	65	39	[1] 18	------	6.4
------	------	------	------	[1] 28	------	------	2.8	------	2.6	23	76	45	[1] 22	------	6.6
------	------	------	------	[1] 50	------	------	3.4	------	------	41	103	51	[1] 10	------	6.8
------	------	------	------	[1] 48	------	------	3.4	------	------	39	88	40	[1] 1	------	7.0
------	------	------	------	[1] 45	------	------	4.0	------	------	37	93	40	[1] 3	------	6.9
------	------	------	------	[1] 28	------	------	2.8	------	------	23	62	23	[1] 0	------	6.7
------	------	------	------	[1] 79	------	------	21	------	------	65	280	167	[1] 102	------	6.5
------	------	------	------	[1] 16	------	------	5.8	------	18	13	88	40	[1] 27	------	6.2
------	------	------	------	[1] 27	------	------	3.0	------	.2	22	77	30	[1] 8	------	6.5
31	7.9	4.6	1.3	114	0	20	5.4	.1	.6	------	136	110	16	202	8.2
35	16	10	1.4	175	0	24	5.7	.2	6.1	------	204	154	10	336	8.1
14.3	1.2	------	------	67	------	13	9.5	------	------	------	125	40	------	------	7.0
------	------	------	------	[1] 49	------	------	3.4	------	4.0	40	------	76	[1] 36	------	7.4
------	------	------	------	[1] 49	------	------	3.4	------	5.8	40	------	64	[1] 24	------	------
3.5	1.2	2.8	.4	8	0	6.8	2.5	.1	2.8	------	38	14	7	43	6.8
13	4.2	4.2	2.0	47	0	9.5	2.8	.1	8.2	------	77	50	12	125	6.7
35	6.8	5.5	3.6	108	0	28	4.1	.1	5.7	------	164	116	28	257	6.8
26	5.2	3.8	.6	79	0	16	4.2	.1	9.5	------	123	87	22	187	7.6
16	1.7	8.1	.2	69	0	4.7	3.4	.1	.5	------	73	47	0	126	7.7
32	4.9	4.9	------	59	0	33	5.6	------	14	48	------	100	[1] 52	------	------

[3] Minor constituents in ppm: Al, 0; Li, 0.1; Cu, 0.00; Zn, 0.00; PO_4, 0.1.
[4] Sample includes a mixture of water from wells S 298, 299, 301, 302.

Bs 196b, S 76, and S 256) exceed the U.S. Public Health Service's standard (1946, p. 13) of 0.3 ppm for drinking water. Except for these four samples, the constituents listed in table 6 are not excessive for domestic or most industrial uses of ground water.

The dissolved solids in ground water are obtained principally from the rocks through which the water moves. The amount and type of mineral matter that the water dissolves depend mostly on the type of rock and on the length of time that the ground water is in contact with it.

If the sample of contaminated water from well Bs 196a is excluded, the samples highest in dissolved solids and alkalinity are from the rocks of Triassic age. Water flowing through the rocks dissolves calcium carbonate, which is present as a cementing material in the clastic sediments and as a major constituent of the limestone beds in the middle part of the Newark Group. Most of the stratified glacial deposits were derived from Triassic sedimentary rocks, but glacial and meltwater transport probably removed much of the calcium carbonate cement from the rock particles. The water in the stratified glacial deposits is shallower than the water in the bedrock and is probably flushed out of the ground sooner. These factors probably are responsible for the lower concentration of dissolved solids and alkalinity in the stratified glacial deposits. Water samples from these deposits showing the highest concentrations of dissolved solids were taken from wells Pv 1 and S 298–302, where the deposits are exceptionally thick. The sample with the lowest concentration of dissolved solids was taken from well S 8, a shallow water table well penetrating stratified glacial deposits derived from the metamorphic rocks.

CONTAMINATION

Contamination is not a widespread problem in the area, but it has affected some well supplies. Wastes enter ground water both by direct discharge into the ground from septic tanks and industrial slush pits and by discharge into streams and subsequent infiltration into the ground. Some water in the area has been contaminated by metallic and acidic wastes, detergents, and bacteria. Samples from wells Bs 91–94 showed contamination by industrial wastes, as illustrated in the following table.

Chemical analyses of well water samples showing industrial contamination

[Analyses by Henry Souther Engineering Co., Hartford, Conn., Aug. 3, 1956. Chemical constituents in parts per million]

Well	pH	Sulfate (SO_4)	Iron (Fe)	Chromium (Cr)	Copper (Cu)	Zinc (Zn)
Bs91	4.9	161	145	0	16	4.2
92	5.8	90	85	0	.05	2.0
93	4.9	178	55	0	0	1
94	6.7	50	58	0	0	0

The contamination was caused by acid wastes from a brass fabrication plant. Thus, the low pH values and the unusual amounts of constituents listed are not surprising. Corrective measures have been taken to protect the wells from further contamination by wastes from the plant.

Another example of industrial contamination occurred at a manufacturing plant 0.4 mile west of Hamlin Pond in Plainville. Industrial water was obtained prior to 1922 from 6 wells, each about 30 feet deep. Contamination by metallic industrial wastes being disposed of in slush pits near the well field was among the factors that caused the supply to be abandoned.

Analyses of water from wells Bs 196a and 196b also indicate possible contamination by metallic wastes and sewage. The wells are among a group driven to locate a source of water for a proposed manufacturing plant. The high iron and manganese contents of the water make treatment necessary before the water can be used for air conditioning or cooling. Removal of the manganese will be required if water is to be used for plating.

The contamination of wells by sewage from septic tanks has occurred at a few places in the area. This contamination is recognized by the growth of bacteria in the water and by unusual concentrations of chloride, nitrite, or nitrate ions. Detergents are usually also a feature of contamination caused by septic-tank effluent.

Detergents entered public supply wells Pv 1 and 2 and caused the temporary shutdown of one well. The source of the detergents was an industrial waste pit near the well field. The use of the detergents was discontinued when the contamination was discovered. However, a considerable volume of detergent-laden water was still in the ground and moving toward the supply wells. A line of small-diameter interceptor wells was installed to cut off the flow and to pump the contaminated water out of the aquifer and into a nearby stream. In addition to contaminating water, detergents cause foaming, which interferes with the operation of pumps and boilers.

The few wells that have been polluted show the necessity of protecting the ground-water reservoirs from contamination. So far (1958), contamination has occurred only in proximity to places of waste discharge. Much reliance has been placed on destruction or at least dilution of contaminants by passage through the ground. Ordinarily, organic pollution of sewage discharge is rendered harmless by natural filtration, but some chemical compounds such as detergents and some ions are capable of persisting unchanged after traveling for a considerable distance through the ground.

UTILIZATION OF GROUND WATER

In the towns of Bristol, Plainville, and Southington, ground water is used for public water supplies and for industrial, commercial, domestic, and farm supplies. Pumpage for public supplies depends much on the availability of water in the surface reservoirs, and pumpage for private supplies is partly seasonal. For 1958, the total pumpage is estimated to be about 1.7 billion gallons.

PUBLIC WATER SUPPLIES

Bristol and Southington have municipally owned public supply systems, each of which is administered by a water department. Plainville is served by the privately owned Plainville Water Company. The sources of water for these systems lie within the boundaries of the towns or in nearby parts of the Quinnipiac and Pequabuck River basins. Water is also withdrawn from the area by the New Britain Water Department for use in New Britain. Most water for public supplies comes from surface reservoirs. Nevertheless, pumpage from wells for public supplies amounts to the largest single use of ground water in the area. In 1958, pumpage for public supply was about 1.15 billion gallons (Connecticut Public Utilities Commission and New Britain Water Dept., oral, written commun.). Future annual pumpage probably will be greater than this.

BRISTOL

The city of Bristol is supplied by six reservoirs in Bristol, Plymouth, Harwinton, and Burlington and by two gravel-developed wells, Bs 4 and 148. A seventh reservoir (No. 6) is proposed and two additional gravel-developed wells, Bs 149 and 150, have been installed but are not in use. The ground-water pumpage varies, depending on the availability of water in the surface reservoirs and on demand. Usually ground-water pumpage is at its maximum rate during the summer. In 1958 the two wells generally were pumped 10 to 12 hours per day for a total pumpage of 495 million gallons (Connecticut Public Utilities Commission, oral communs.). Well Bs 4, which is pumped mostly during the summer, provided 95 million gallons, and well Bs 148 provided 400 million gallons. Ground water, thus, was about 28 percent of the total of 1,761 million gallons supplied by the department in 1958, which was the first full year of operation for well Bs 148.

NEW BRITAIN

The water supply for New Britain comes principally from Shuttle Meadow Reservoir in Southington, Wolcott Reservoir in Wolcott, and Whigville Reservoir in Burlington. Large supplies are also drawn from Copper Mine Brook in Bristol, from wells at White Bridge and Upper White Bridge in Bristol, and from well S 235. Some water is obtained also from the Hartford Metropolitan Water District. Shuttle Meadow and Wolcott Reservoirs have large storage capacities but small catchment areas, and they become seriously depleted in times of sustained dry weather. Whigville Reservoir is small and does not impound much of the flow of Whigville Brook, which is tributary to

Copper Mine Brook. However, at the White Bridge installation an intake from Copper Mine Brook will allow a maximum withdrawal of 3½ mgd of brook water. Water from all sources is pumped to Shuttle Meadow Reservoir, where the treatment plant is, and from there the water is distributed. However, ground water from White Bridge can be pumped directly to distribution lines when it is not mixed with water drawn from Copper Mine Brook.

The White Bridge wells, which are southeast of the intersection of Maltby and Mix Streets in Bristol, depend substantially on induced recharge from a ditch constructed parallel to a line formed by the wells (fig. 5). The wells average about 35 feet in depth and extend in line across the interfluve between Copper Mine Brook and Polkville Brook.

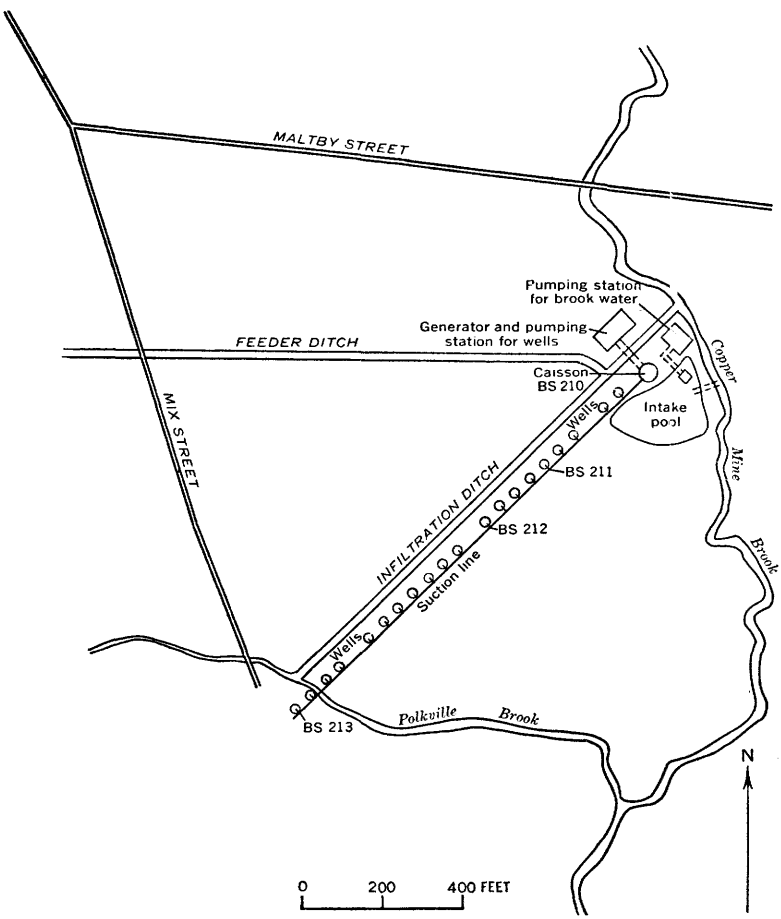

Figure 5.—Map of New Britain well field at White Bridge in Bristol.

The infiltration ditch paralleling the wells connects these two streams. Another ditch extends from Polkville Brook eastward to a large infiltration pond. A large-diameter concrete caisson, well Bs 210 (G6–6a), is located near the pond at the northeast end of the line of wells. The gradient of the water table is approximately normal to the line of wells. The flow of ground water southeastward in the interfluve and the water infiltrating the ground from the ditches, artificial pond, and the two brooks supply the well system. Pumpage usually is about 2.5 mgd, but the sustained yield of the system is probably 3.5 mgd or more. The wells are placed about 50 to 100 feet apart and perhaps interfere with one another. Interference, which is brought about by the intersection of the cones of depression (depressions of the water table caused by pumping from wells) of neighboring wells, does not appear to be a serious problem, however, because excessive drawdown has not resulted. The wells are pumped by suction into the caisson from which the water is pumped into the pipeline. The caisson has an open bottom and itself acts as a well. Inasmuch as the geologic and hydrologic data available at the time of the construction of the well system are not known, the specific conditions that made necessary or encouraged the construction of this type of installation are also unknown. The system has stood the test of time, however, having been in operation since 1923. (See Wood, 1951, p. 146–150.)

Upper White Bridge, which is about half a mile south of Stevens Street, was first utilized for a supply in 1941, when 66 driven wells 2½ inches in diameter were constructed. The wells were connected in series by suction lines and originally yielded about 1 mgd. Declining yields of most of the wells due to clogging eventually caused the system to be abandoned. Six 8-inch-diameter drilled wells about 25 feet deep were constructed in 1955 to replace the original system. They include wells Bs 214 and 215. In 1959, four of the drilled wells and one driven well of the original system were in use: their combined yield was 1 mgd. (See Wood, 1951, p. 148-149).

The amount of ground-water pumpage varies an unusual amount from year to year because the water available from Shuttle Meadow and Wolcott Reservoirs is greatly reduced in times of dry weather. In 1958, a wet year, pumpage from the White Bridge and Upper White Bridge wells was about 290 million gallons and from well S 235 about 8 million gallons (New Britain Water Dept., written comm.). Pumpage thus amounted to 10 percent of the total consumption of 3,150 million gallons. In the comparatively dry year of 1957, however, pumpage was 640 million gallons from the White Bridge and Upper White Bridge wells and 220 million gallons from well S 235. Pumpage was 27 percent of the total consumption of 3,200 million gallons. Even with this large withdrawal of ground water and with enforcement of restrictions on water use, the regular New Britain sources of supply were unable to provide sufficient water in 1957, and the New Britain Water Department was forced to use emergency supplies for several months. Ground water was pumped from well Pv 22, with a temporary pump installation, at the rate of 0.5 mgd. The Plainville Water Co.'s wells (Pv 1 and 2) supplied 0.5 million gallons each night through a temporary connection. Water was obtained also from industrial ponds in Berlin, east of Southington, at the rate of 1.5 mgd and from Eightmile River in Southington at the rate of 1.5 mgd.

The drought of 1957 pointed up inadequacies in the New Britain supply system. These inadequacies have long been recognized, but their remedy is difficult. New Britain is poor in water resources and must obtain its supply principally from nearby towns. Additional water sources are difficult to obtain now. The desirable reservoir sites have already been developed or have been reserved by other towns, and additional ground-water sources that will not interfere with other public-supply wells and reservoirs must be located.

PLAINVILLE

Plainville receives water from a reservoir in Southington and from wells Pv 1 and 2. During 1958, pumpage from wells Pv 1 and 2 amounted to 25 million gallons and 150 million gallons, respectively (Connecticut Public Utilities Commission, oral commun.). Total ground-water pumpage was about 87 percent of the total consumption of about 200 million gallons. Well Pv 1 operated about 16 hours per week and well Pv 2 operated an average of 8 hours per day. The Plainville Water Co. has by far the smallest water requirements of the public supply systems operating in the area. With the addition of well Pv 57, its supplies should be adequate for the demand. Even during the drought in 1957, before well Pv 57 was installed, Plainville was able to supply the New Britain Water Department with 0.5 mgd from wells Pv 1 and 2.

SOUTHINGTON

The Southington Water Department obtains water from three reservoirs, one of which is located in Wolcott, and from three wells (S 18, 19, and 331). During 1958, well S 18 was operated an average of 15 hours per day year round and supplied about 164 million gallons, and well S 19 was operated about 8 hours per day through the period of June to September and supplied almost 18 million gallons (Connecticut Public Utilities Commission, oral commun.). The total supply of ground water amounted to more than 30 percent of the total 1958 consumption of 575,840,000 gallons. A test-drilling program conducted by the water department in 1957 and 1958 resulted in the completion of well S 331 in 1959. The present sources of supply are expected to be adequate for the town and to allow for expansion of service.

INDUSTRIAL SUPPLIES

Pumpage of ground water for industrial use averages about 275 million gallons per year. Industrial firms also use considerably more water than this from the public supply systems and from streams. Ground water is used mostly for processing, principally in plating and washing operations. Large amounts are also used for cooling and, at some plants, for air conditioning. Use for sanitation is a minor part of the pumpage. The principal industrial users of ground water in the area are shown in the following table.

Principal industrial users of ground water

Industrial concern	Source of water (well or spring)	Pumpage (gallons per day)	Use
Bristol Brass Corp	Bs 95, 198	150,000	Washing, cooling.
New Departure Division, General Motors Corp	Bs 4sp	100,000	Process cooling.
Pratt & Whitney Aircraft	S 298, 299, 301, 302	530,000	Plating.
Trumbull Division, General Electric Corp	Pv 5, 33	200,000	Process cooling, air conditioning.

Several smaller plants use from 1,000 to 36,000 gpd. Most ground water used by industries is eventually discharged into the Pequabuck and Quinnipiac Rivers. Some water is returned to the ground, such as at the Trumbull Division plant in Plainville where a disposal pit is used.

Some industrial firms that formerly used ground water have abandoned their wells in favor of a public supply, mostly because the wells declined in yield due to clogging of screens by sand. Most abandoned wells are of the driven well-point type.

DOMESTIC SUPPLIES

Probably 15,000, or 20 percent, of the combined population of 77,000 in Bristol, Plainville, and Southington are served by privately owned wells. On the basis of an assumed per capita use of 50 gpd, the total yearly use from private domestic wells is estimated to be 250 to 300 million gallons.

Most houses in sections not served by public water-distribution systems are single family dwellings and are supplied by individual wells.

At some farms the wells also supply water to the livestock, though other farms have separate wells for stock watering. A few wells provide private communal supplies.

Most domestic wells are drilled into bedrock, but a few are finished in stratified glacial deposits. Driven wells provide some supplies from stratified deposits. Many dug wells are in use, though most of these were constructed in the days before drilled wells were in general use. Dug wells will provide dependable supplies in areas where the water table does not decline greatly in dry periods during the summer and fall. But because dug wells are believed to be subject to contamination, dug wells have fallen into general disfavor. This belief arises because many dug wells are not properly constructed with tight casings, compact back fill around the casing, and a tight cover at the surface.

SUMMARY OF GROUND-WATER POTENTIAL

Ground-water development can be increased greatly by utilizing water that presently goes unsalvaged and is discharged from the area as ground-water runoff, evapotranspiration, or underflow. An average of 11.7 inches of water per year is discharged by ground-water runoff and leaves the area in the Pequabuck and Quinnipiac Rivers. Thus, for each square mile of the area, water discharged by ground-water runoff is about 550,000 gpd or 200 million gallons per year. In addition, an indeterminate amount of ground water is lost through evapotranspiration. The amount probably is a small fraction of the total of 23 inches of water discharged from all sources by evapotranspiration. Ground water that is discharged by evapotranspiration may be salvaged if the water table is significantly lowered by pumping in areas where it is now close to the surface. Water leaving the area as underflow through the Quinnipiac and Pequabuck River valleys may also be salvaged. In the Pequabuck valley, underflow may amount to 200,000 gpd or 75 million gallons per year.

Development of additional ground-water supplies from the large resources available is subject to practical considerations of the rate at which the different water-bearing formations will yield water. Additional small supplies can be developed from ground moraine and the bedrock formations. Ground moraine will produce the lowest yields of the water-bearing formations. The bedrock formations will generally produce supplies of 5 to 20 gpm from individual wells. In places the New Haven Arkose and the middle part of the Newark Group, particularly in Cooks Gap, will provide more than 100 gpm from individual wells. The stratified glacial deposits offer possibili-

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ties for large withdrawals of 500 to 1,400 gpm, as well as many additional smaller supplies.

The large ground-water resources available from the stratified glacial deposits warrant detailed discussion of their ground-water potential. For purposes of the discussion, the ground-water potential is considered in terms of three subareas: (1) the New England Upland, (2) Copper Mine Brook-Eightmile River valleys, and (3) the Quinnipiac-Pequabuck lowland.

THE NEW ENGLAND UPLAND

Ice-contact deposits, mostly kame terraces, lie in the Pequabuck River valley west of Hurley Hill in Bristol and extend northward along the east side of the hill mass that includes Chippen Hill (pl. 1). Stratified drift deposits also underlie the alluvium along the Pequabuck River and north and south of Birge Pond. The greatest known thickness of the stratified deposits in the Upland is 225 feet at well Bs 57 (G6–4j, 1 mile west of Bristol), which penetrates the kame-terrace deposits in the Pequabuck River valley. The deposits feather out against the ground moraine at the valley sides. The bedrock floor beneath the deposits is irregular in profile; this irregularity causes the deposits to vary considerably in thickness within short distances. For instance, well Bs 139 (G6–4h) penetrated 30 feet before striking bedrock, but, only short distances away, wells Bs 50 (G6–4h) and 132 (G6–4h) penetrate 90- and 85-foot thicknesses of kame-terrace deposits (pl. 3).

The deposits receive a substantial amount of recharge because of their lithology, form, and location. The extensive flat terrace tops and the relatively high permeability of the materials are favorable for a high rate of infiltration. Besides the precipitation falling directly on the deposits, water is received by runoff from the ground moraine.

Ground water moves through the deposits toward the valley bottoms, where the water table lies close to the surface. At well Bs 4 (G6–4h) the depth to water is about 6 feet. Springs are formed where the water table occurs at the surface at the toe of ice-contact slopes. Springs Bs 4sp (G6–5d) and S 5sp (G6–4h), which flow at about 100 gpm each, are the highest yielding springs in the report area. The water table also lies close to the surface near the contact of the terraces with the higher lying ground moraine. At well Bs 80 (G6–7b) the water table is within 7 feet of the surface. However, the slope of the water table in the stratified deposits is uniform and does not follow the profile of the kame terraces. Thus, near the tops of the steep ice-contact slopes of the terraces, the water table lies far below the surface. At well Bs 50 (G6–4h) and at other places along the road to the south, the terrace materials are not utilized for water because the water table lies deep beneath the surface.

The stratified deposits in the upland are capable of yielding small to large supplies of water, though few supplies are obtained from these deposits. Some large-diameter dug wells yield supplies of a few gallons per minute. These wells are best located where the water table lies close to the surface at the valley bottoms and near the valley walls. Well Bs 80 (G6–7b, 0.2 mile south of the Pequabuck River), which is about 12.5 feet deep, penetrates about 6 feet of saturated thickness and provides a dependable supply of water. Well Bs 51 (G6–4g, 0.4 mile to the north), which has a depth of 36 feet and intercepts only a 1-foot saturated thickness, is less favorably located.

The stratified deposits adjacent to the Pequabuck River are favorable for development of large supplies. The water table lies close to the surface, and the stratified materials fill the deep preglacial channel of the Pequabuck River. Well Bs 4 (G6–4h) penetrates 75 feet of stratified material that is saturated below a depth of 6 feet. The well yields 800 gpm. Much greater thicknesses of stratified material occur beneath the higher terraces, but the depth to water is very great. Wells near the Pequabuck River can also draw on water that is in transit through the area as streamflow and underflow. Wells on the higher terraces could not induce infiltration from the Pequabuck River, because the bedrock surface under the terraces is above river level. (See pl. 3.) Large supplies may also be obtained from stratified glacial deposits around Birge Pond and Polkville Brook, but these deposits are not as thick as those in the Pequabuck River valley. Test wells Bs 200–202 (G6–5d), 0.2 mile south of Birge Pond, penetrated no material suitable for finishing wells of large yield. However, favorable material may be distributed spottily in this area; the results of these particular test wells should not discourage further exploration.

COPPER MINE BROOK-EIGHTMILE RIVER VALLEYS

Stratified glacial deposits extend southward from the Bristol-Burlington town line to the Southington-Cheshire town line through a long, broad lowland that lies between the New England Upland on the west and a line of north-trending hills, including Redstone Hill, on the east. The lowland is occupied by Copper Mine Brook, tributary to the Pequabuck River, and Eightmile River and Judd Brook, tributaries to the Quinnipiac. The deposits overlie red till and sedimentary rocks, except along their western margins where they abut gray till and metamorphic rocks. Plate 3 illustrates the relationships of these deposits to other geologic formations.

Ice-contact deposits occupy most of the area, but extensive undifferentiated deposits occur north of the Pequabuck River in Bristol. Two small areas of proglacial lake deposits lie east of Marion near the southern edge of Southington. Alluvium of the Pequabuck River, Judd Brook, and Eightmile River in places conceals the stratified glacial deposits. The deposits vary in thickness owing to considerable relief in both the topographic surface of the deposits and the surface of the underlying bedrock. The greatest proven thickness is 240 feet near well S 327 (G5–3g) at the western part of Prospect Street, 0.2 mile south of Dayton Brook, in Southington. Seismic exploration for the New Britain Water Department indicates that bedrock is 160 feet deep a short distance west of where the New Britain pipeline crosses Eightmile River (pl. 3). The contour of the bedrock surface is poorly defined south of the Pequabuck River, but sufficient well data are available to indicate the presence of a buried preglacial channel that trends generally north beneath the deposits in Southington (pl. 1). The bedrock channel lies somewhat below sea level where it crosses Prospect Street. Its position is indicated by the low bedrock elevations at wells S 48 (G5–3a, 0.5 mile north of *C–C′*), S 327, S 293 (G5–6a, 0.5 mile north of *D–D′*), S 256 (G5–6d, on line *D–D′*), and S 328 (G5–6d, 0.35 mile south of *D–D′*).

The deposits in Copper Mine Brook-Eightmile River valleys yield small to large supplies of water. Except for the lake clay half a mile east of Marion, the stratified deposits almost anywhere will yield small supplies of water to wells. The lake clay is, however, thin enough that wells can be dug into the underlying sand and gravel. The construction of dug and driven wells is not feasible where the water level lies far below the surface, as in high-standing kames and in the parts of kame terraces near their ice-contact slopes.

The deposits of high permeability will yield large supplies of water to wells. Extensive test drilling has been required to locate coarse beds before construction of large-yield wells in these deposits, because well-sorted coarse sand and gravel occurs in sufficient thicknesses only at scattered locations.

Three large-yield well installations are located near Copper Mine Brook. The wells are finished in permeable stratified material and are placed so as to salvage some of the water being discharged by streamflow and underflow from the drainage basin. Well Bs 148 is located in a narrow valley north of Forestville. (See wells S 166, 167, and 168, on line *B–B′* in pl. 3 which are 1,000 feet to the north.) It has a yield of 1,400 gpm and a specific capacity (yield per foot of drawdown) of 50 gpm per foot. The stratified deposits penetrated by the well are limited in east and west extent by the ground moraine at the valley sides, which tends to restrict radial flow from these directions toward the well. However, the well is advantageously placed to induce infiltration from the brook and to receive water by subsurface movement from the deposits to the north.

The multiple well installations of the New Britain Water Department at White Bridge and Upper White Bridge yield 2.5 mgd and 1 mgd, respectively. Much of the water they produce infiltrates from Copper Mine Brook.

The deposits in Copper Mine Brook valley have been intensely developed. Additional supplies of ground water probably are available there, but further development should be done cautiously so as not to interfere with existing ground-water supplies.

Wells and test wells in the stratified glacial deposits along the Pequabuck River and to the south in Bristol indicate that additional wells with yields of a few hundred gallons per minute can be developed. Farther south, in the Eightmile River valley in Southington, the deposits are apparently not as favorable.

The deposits in the Eightmile River valley have so far not provided any large supplies. Many drilled and driven wells that have been finished in them, however, provide small supplies for domestic use. At places tested by the water departments of New Britain and Southington the deposits are principally fine-grained sand and silt. Fine-grained materials were also penetrated by most wells drilled through the deposits into the underlying New Haven Arkose. The deposits in Eightmile River valley, however, have not been test drilled intensively enough to be eliminated as possible sources of large supplies.

THE QUINNIPIAC-PEQUABUCK LOWLAND

Stratified deposits occupy the broad lowland of the Quinnipiac and Pequabuck Rivers in Plainville and Southington. Ice-contact deposits lie in Cooks Gap, in the broad area east of the Quinnipiac River and south of Patton Brook in Southington, and along the east sides of Campground and Redstone Hill. Proglacial deposits, which underlie the plains and low terraces adjacent to the streams, conceal undifferentiated deposits.

The thickness of the stratified deposits varies greatly owing to irregularities in both topography and the surface of the underlying bedrock. The deposits are thickest where they overlie a northward-trending buried valley. At well Pv 56 (H6–4e, 0.5 mile north of Hamlin Pond) they exceed 300 feet in thickness, but at most places they are thinner (pl. 3).

Throughout the Quinnipiac-Pequabuck lowland in Plainville and Southington, the stratified glacial deposits yield small supplies of ground water to wells almost anywhere, and the coarse-grained well-sorted materials supply large quantities of water to screened wells. Clay beds of the lake deposits are not water-bearing, but water generally is obtainable from sand and gravel above or below them.

Good water-bearing materials generally occur within a depth of 100 feet in the ice-contact deposits and the undifferentiated deposits underlying thin proglacial deposits around Milldale. Well S 235 (H6–9h), finished in ice-contact deposits near Patton Brook, has a yield of 1,000 gpm and is only 32.5 feet deep. Ice-contact deposits in northern Plainville provide a supply of 500 gpm from well Pv 57 (H6–4d), which is 94 feet deep. Near the Quinnipiac River in the southern half of Southington, good water-bearing materials have been found in the undifferentiated deposits underlying valley-train deposits. Wells S 18 (G5–3f) and 19 (G5–6f), finished at depths of 55 and 90 feet, respectively, each yield 500 gpm, and test well S 284 (G5–3f), which is 82 feet deep, penetrates materials that can supply an estimated 1 mgd.

The thick proglacial deposits in Plainville and in the northern part of Southington are, on the whole, less favorable water-bearing deposits than the ice-contact deposits. The sand and gravel unit in the upper part that was deposited as a valley train is generally too thin for development of large-yield wells. The underlying fine-grained lake deposits limit the development of wells in two ways: First, because their interstitial pore spaces are small, they transmit water slowly; second, the fine-grained material does not stabilize and tends to be drawn into a well during pumping and also to clog the screen. However, wells Pv 5 and 33 (H6–4h) each yield more than 200 gpm from the proglacial deposits. Well Pv 24 yielded more than 200 gpm from the proglacial deposits, but proved unsuccessful because the water-bearing material would not stabilize and the well pumped sand. Near Hamlin Pond wells Pv 1 (H6–4h) and 2 penetrate the proglacial deposits, but they may be finished in underlying undifferentiated sand and gravel deposits.

The records of wells Pv 53 (0.3 mile north of Hamlin Pond) and Pv 58 (1.7 mile southwest of the pond) indicate that the undifferentiated stratified deposits beneath thick proglacial deposits may have a good potential. Well Pv 58 penetrated a 4-foot-thick gravel zone at 118 feet; the zone yielded 240 gpm. The gravel was cased off and the well finished in bedrock. Well Pv 53 was finished with an open-end casing in gravel underlying proglacial deposits at a depth of 240 feet. The maximum yield possible from the gravel zone there is unknown. A sample obtained at 240 feet consists of pebbles as much as 2 inches in diameter and fine and medium sand. Other wells also were reported to have struck gravel beneath the proglacial deposits. The undifferentiated stratified deposits are little used as sources of supply, and, generally, the few wells that penetrated them were planned as bedrock wells before drilling started. Many of the test wells driven for the public supply systems were not deep enough to penetrate these deposits.

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[Italic page numbers indicate major references]

U.S. GOVERNMENT PRINTING OFFICE: 1965

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

LaSala, Albert Mario, 1931–
Geology and ground-water resources of the Bristol-Plainville-Southington area, Connecticut. Washington, U.S. Govt. Print. Off., 1965.

iv, 70 p. maps (2 col.) diagrs., tables. 24 cm. (U.S Geological Survey. Water-Supply Paper 1578)
Prepared in cooperation with the Connecticut Water Resources Commission.
Bibliography: p. 67–68.

(Continued on next card)

LaSala, Albert Mario, 1931– Geology and ground-water resources of the Bristol-Plainville-Southington area, Connecticut. 1965. (Card 2)

1. Geology—Connecticut—Hartford Co. 2. Water, Underground—Connecticut—Hartford Co. 3. Water-supply—Connecticut—Hartford Co. I. Connecticut. Water Resources Commission. II. Title: Bristol-Plainville-Southington area, Connecticut. (Series)