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GROUND-WATER DATA ON THE HUDSON RIVER BASIN, NEW YORK

by Deborah S. Hammond, Ralph C. Heath, and Roger M. Waller

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(in pocket)

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FACTORS FOR CONVERTING ENGLISH UNITS TO INTERNATIONAL SYSTEM (SI) UNITS

Multiply English Units	by	To obtain SI Units
inches (in.)	2.540	centimeters (cm)
feet (ft)	0.3048	meters (m)
gallons (gal)	3.785	liters (L)
gallons per minute (gal/min)	0.06308	liters per second (L/s)
gallons per day (gal/d)	3.785	liters per day (L/d)
miles (mi)	1.609	kilometers (k)
square miles (mi^2)	2.59	square kilometers (km^2)

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ABSTRACT

Ground water in the Hudson River basin occurs in unconsolidated deposits and consolidated rock. Sand and gravel units of the unconsolidated deposits, which occur principally in valley bottoms, form the best aquifers and commonly provide well yields of several hundred gallons per minute. Carbonate aquifers are the most productive consolidated rock units and have average yields of a few tens of gallons per minute to wells but may occasionally yield several hundred gallons per minute. Ground water in the Hudson River basin is generally hard and may contain appreciable amounts of iron, salts in solution, or sulfur locally.

Basic data on the availability of ground water in the Hudson River drainage area are compiled in (1) a hydrogeologic map of the drainage basin; (2) a table of well depths, yields, concentrations of selected chemical constituents, and hardness of ground water, listed by county and aquifer type; (3) a short text describing the occurrence of ground water in the basin; and (4) a bibliography of ground-water reports pertinent to the area studied.

The basic data presented give a first appraisal as to the probable potential for individual wells anywhere in the basin. The bibliography refers to investigations, by county or basin, that provide more detailed information on the availability of ground water for public supplies or industrial use. Specific studies of long-term or maximum yield of ground water have been made only in the Schenectady-Rotterdam area.

INTRODUCTION

The U.S. Water Resources Council directed the New York State Department of Environmental Conservation to evaluate the water needs and problems in the Hudson River basin. As part of the study, the U.S. Geological Survey, in cooperation with the New York State Department of Health, compiled data on the availability of ground water for public water supplies. The study entailed compilation of data that had been obtained during other water-resources studies by the Geological Survey that covered most of the Hudson River basin by county or subbasin. The information from these studies was supplemented by data from a statewide water-resources report by Heath (1964) and by information from more recent investigations. The data from more than 6,000 drillers' logs and the results of about 500 chemical analyses are tabulated (table 1). Most of the table and parts of the aquifer map (pl. 1) and the text are from Geological Survey reports and project investigations; much of the following text is quoted or paraphrased from Heath (1964).

The aquifer units of Heath (1964) were extended into the adjacent New England States and into New Jersey wherever the Hudson River basin boundary lies outside New York (pl. 1). District offices of the U.S. Geological Survey in these bordering States provided the data necessary to complete these units on the map. Well and water-quality data for areas beyond New York State boundaries are not included, nor are data given on the several New York counties that lie mostly outside the basin. Where data are not available but are believed to be similar to those of an adjacent county, this is so indicated. All reports used to compile this volume, as well as other reports that may be useful to the reader, are listed in the section, "Selected Bibliography."

GROUND-WATER RESERVOIRS

Water-bearing formations (aquifers) may be classified into two groups on the basis of their composition. The first group consists of sediment composed of a loose aggregation of individual grains, such as sand or gravel, which are collectively referred to as unconsolidated deposits. The second group consists of compact, hard rock layers referred to as bedrock. The unconsolidated deposits lie on top of the bedrock except where bedrock is exposed locally at land surface. Thickness of the unconsolidated deposits ranges from less than a foot to hundreds of feet.

Ground water in the Hudson River basin is obtained from either the bedrock or the unconsolidated deposits overlying it. The three most common types of unconsolidated deposits are (1) clay and silt; (2) sand and gravel (either glacial or recent stream deposits); and (3) till, the name given to glacial deposits consisting of a poorly sorted mixture of grains ranging in size from clay through silt and sand to cobbles and boulders. Of the three types of deposits, sand and gravel produces the most significant amount of water; till generally yields water only in small amounts, and clay and silt yield very little water. The two unconsolidated aquifer units in the basin are sand and gravel, and till.

Bedrock in the basin can be divided into four general rock types--shale, carbonate rocks, sandstone, and crystalline rock. For the purpose of this report, each rock type will be considered as an aquifer unit. Plate 1 shows the areal extent of the different types of aquifers in the basin.

OCCURRENCE OF GROUND WATER

Ground water occurs in unconsolidated and consolidated deposits in spaces between the solid mineral matter. These spaces are known as voids, interstices, or pores. Primary porosity refers to the spaces created when a rock or unconsolidated deposit was formed. Secondary porosity includes solution openings and fractures such as joints, faults, and openings along planes of bedding in consolidated rocks.

The amount of ground water in a given area is related to the size and quantity of pore spaces or other openings, whereas the rate of ground-water movement is largely dependent on the size of the openings and their degree of interconnection. The rate at which water will move through an aquifer is referred to as the aquifer's hydraulic conductivity.

Unconsolidated Deposits

Sand and gravel is the most productive water-bearing material in the Hudson River basin. Sand and gravel yields water to several different types of wells. Where the deposit is near land surface and consists largely of sand, supplies of up to 50 gal/min may be obtained from driven wells of 2-in. diameter or less. Such wells consist of a screened drive point attached to the lower end of a line of pipe.

Where the deposit is more than about 50 ft below land surface or where large quantities of water are needed, drilled wells are constructed. The yield of screened drilled wells drawing from sand and gravel depends in large part on the hydraulic conductivity of the deposit and the diameter and length of the screen. Many such wells have sustained yields of more than 2,000 gal/min. Such wells range in diameter from 4 in. to more than 24 in. and are finished with screens or slotted casing at the most permeable layers. Most wells drilled in sand and gravel deposits for domestic use are 6 in. in diameter.

Till contains water in intergranular pores, as do the other unconsolidated deposits. However, because till consists of a mixture of grains ranging in size from clay to boulders, the smaller grains tend to occupy the spaces between larger grains and thereby decrease the deposit's ability to transmit water. Water from till is usually obtained through dug wells ranging from 2 ft to more than 10 ft in diameter. The large diameter of wells in till provides an extensive area through which water can seep and also provides a large reservoir for storage of water between periods of use. Water from wells in till may be derived mainly from thin sand layers that occur in many till deposits. Yields from wells in till seldom exceed 1 gal/min.

Bedrock Aquifers

The processes of compaction, cementation, or metamorphism may reduce or obliterate primary porosity in consolidated rock. In such cases, secondary porosity affords the only means for the storage and movement of ground water.

Openings of all types tend to be more open near the top of the bedrock and are also more abundant within a few hundred feet of land surface than at greater depths, although fractures and other openings may penetrate much deeper locally. At great depths, the mass of overlying rock may prevent the formation of openings through which water can readily circulate. Although crystalline rocks and shales contain few openings below depths of about 100 and 200 ft, respectively, sandstone and carbonate rocks may contain openings to depths of more than 500 ft. This explains why wells in some areas have been drilled through as much as 300 ft of shale without encountering water but have then penetrated an underlying carbonate rock with a copious supply. The low yields usually obtained from shale and the great number of "dry wells" in areas of shale bedrock result from the fact that horizontal joints in shale may be tight, of limited lateral extent, or discontinuous, and transmit water slowly.

Water from bedrock is obtained through wells that are generally cased with steel pipe down to bedrock and drilled as open holes from 25 ft to more than 500 ft into the rock. However, the depth of most bedrock wells is between 100 and 200 ft. The reported yield of bedrock wells varies widely; many such reports are based on short bailing or pumping tests and indicate higher yields than would be sustained on a long-term basis.

The yield of bedrock wells also varies according to rock type. Yields of wells in shale range from less than 1 gal/min to approximately 400 gal/min and average 15 gal/min. Wells in carbonate aquifers may also yield only a few gal/min, but yields as high as 450 gal/min have been obtained, and the average is 65 gal/min. Yields of wells in crystalline rocks and sandstone range from less than 1 gal/min to approximately 700 gal/min, although the average is less than 20 gal/min. Data on well depths and yields in the various types of aquifer materials are given in table 1.

GROUND WATER AND TOPOGRAPHY

The preceding sections explain why the occurrence and development of ground water vary according to type of aquifer unit. Similarly, the occurrence and development of ground water are influenced by local topography. The ridge-and-valley physiography of the Hudson River basin illustrates some of the interrelationships of topography, rock type, and ground water.

In hilly and mountainous areas, bedrock is generally within 25 ft of land surface on the hilltops and hillsides but is deeper in the valleys and at many places is 300 or 400 ft deep. Thus, the bedrock surface generally has a greater relief than the land surface. Figure 1 depicts this relationship. On the hilltops and hillsides, bedrock is covered by a nearly continuous blanket of till and is also overlain by till in parts of the valley. The yield of drilled bedrock wells 200 to 300 ft deep on hilltops and hillsides seldom exceeds 5 gal/min.

The amount of water available from shallow wells on hillsides is approximately equivalent to the amount that reaches the zone of saturation from precipitation uphill from the well. Water in shallow wells on till-covered hilltops is available from only a small area around the well. The amount of water available on hills is small because the low permeability of the till and the moderate to steep slopes of the land surface result in a high rate of overland runoff and a low rate of infiltration, or recharge. It is estimated that recharge on till-covered hills ranges from 0.2 to 2.0 in./yr, or from 10,000 to 100,000 (gal/day)/mi^2 (Heath, 1964).

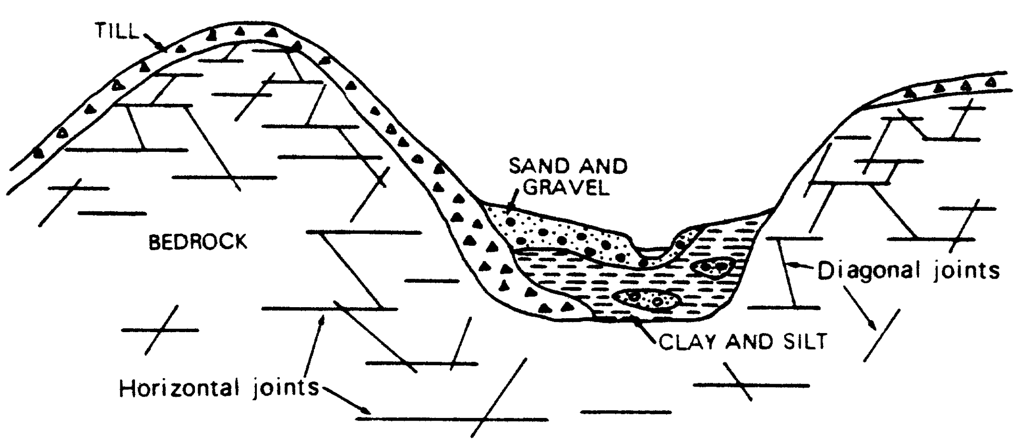

Figure 1.--Geologic section in a hilly area of the Hudson River basin. (Modified from Heath, 1964.)

Distribution of sand and gravel differs from valley to valley and from place to place within the same valley. At land surface, sand and gravel occur irregularly; in parts of some valleys unconsolidated sediment forms a continuous blanket 20 to 50 ft thick, whereas in other parts of the same valley the unit may be absent or may be found only along the valley sides where streams enter from adjoining hills. Laterally discontinuous deposits of sand and gravel surrounded by clay and silt are not uncommon.

Sand and gravel deposits occur not only in modern valleys, but in buried preglacial valleys of the Hudson River basin. These sand and gravel deposits were derived from melting glaciers and were subsequently covered. The principal preglacial valleys, although not necessarily containing a continuous sand and gravel deposit, are indicated in plate 1 (R. J. Dineen, New York State Geological Survey, written commun., 1977).

Large sustained yields of water in the basin are obtainable principally from the sand and gravel deposits in the valleys. The larger yields obtainable from these deposits result from their high hydraulic conductivity and their higher rate of recharge. Ground water from the adjacent hills moves downslope and enters the sand and gravel deposits in the valley; also, the rate of recharge from precipitation on a sand and gravel deposit at land surface is several times that on the till-covered hills. Studies in upstate New York suggest that the average rate of recharge from precipitation on sand and gravel is about 10 in./yr or 500,000 (gal/day)/mi^2 (Heath, 1964).

Where sand and gravel deposits are in hydraulic contact with a stream flowing through a valley and are at lower altitude than the streambed, pumpage may safely exceed the amount of recharge from precipitation in the valley. The additional volume available is supplied by water that infiltrates the deposits from the stream. Most of the large ground-water supplies pumped from sand and gravel in the upstate area are derived to some extent from nearby streams. One of the most notable examples is the well fields of Schenectady and the adjacent well fields of the Town of Rotterdam, which are about half a mile from the Mohawk River (pl. 1). Of the average combined pumpage of about 20 Mgal/day from the two well fields, about 18 Mgal/day, or 90 percent, infiltrates from the Mohawk River (Winslow and others, 1965).

Infiltration from streams is, of course, desirable only where the streams are unpolluted. The deposits through which the stream water moves toward supply wells are generally able to filter out most or all bacterial pollution; however, the deposits have little or no effect on some chemicals dissolved in the stream water.

GROUND-WATER PROBLEMS

Ground-water problems may relate either to the chemical content of the water (commonly referred to as its quality), its temperature, or to fluctuations of the water level. Aspects of the more important problems are described in the following sections, and chemical data are given in table 1.

Hard Water

Water is said to be "hard" when a large quantity of soap is required to produce a lather. The hardness of water is caused principally by calcium and magnesium ions in the water. Although most ground water in the basin is hard or very hard, the degree varies considerably among the different water-bearing units. Water from the crystalline rocks and from sand and gravel is generally softer, whereas water from the carbonate rocks and shale is the hardest.

Salty Water

Water that tastes salty (containing large quantities of chloride) underlies nearly all the basin. However, it occurs at depths greater than 500 to 1,000 feet and therefore is not normally encountered in the construction or pumping of water wells. The salty water is almost invariably overlain by zones containing freshwater.

Iron Water

Excessive iron in ground water forms a rust-colored stain on porcelain fixtures, gives the water a disagreeable taste, and discolors clothes. Such iron is most frequently encountered in shallow wells tapping unconsolidated deposits. Iron may be naturally present in the water as a result of the dissolution of iron-bearing minerals or through the action of iron-forming bacteria. It may also result from corrosion of iron pipes used in the water system.

Sulfur Water

Water from many wells tapping carbonate rocks and shale contains hydrogen sulfide. This gas gives the water a disagreeable taste and an odor similar to that of rotten eggs. It can be eliminated by aerating the water or by adding chlorine. Chlorinators suitable for home use are obtainable from several manufacturers. Aeration is generally economically feasible only in large water systems.

Flammable Gas

A small percentage of water wells drilled into the carbonate and shale bedrock units yield flammable gas. In nearly all such wells, the gas is trapped in small cavities in the rock and is quickly exhausted through the well.

Changes in Ground-Water Level

The water table rises and falls in response to changes in the rates of recharge and discharge of ground water. During the spring, when recharge from snowmelt and rainfall exceeds discharge, the water in storage in the ground increases and the water table rises. During the late spring and summer, when most of the precipitation is lost through evapotranspiration, the discharge of ground water to springs and streams exceeds the recharge and the water table declines. Figure 2 is a typical graph of changes in ground-water level in relation to precipitation.

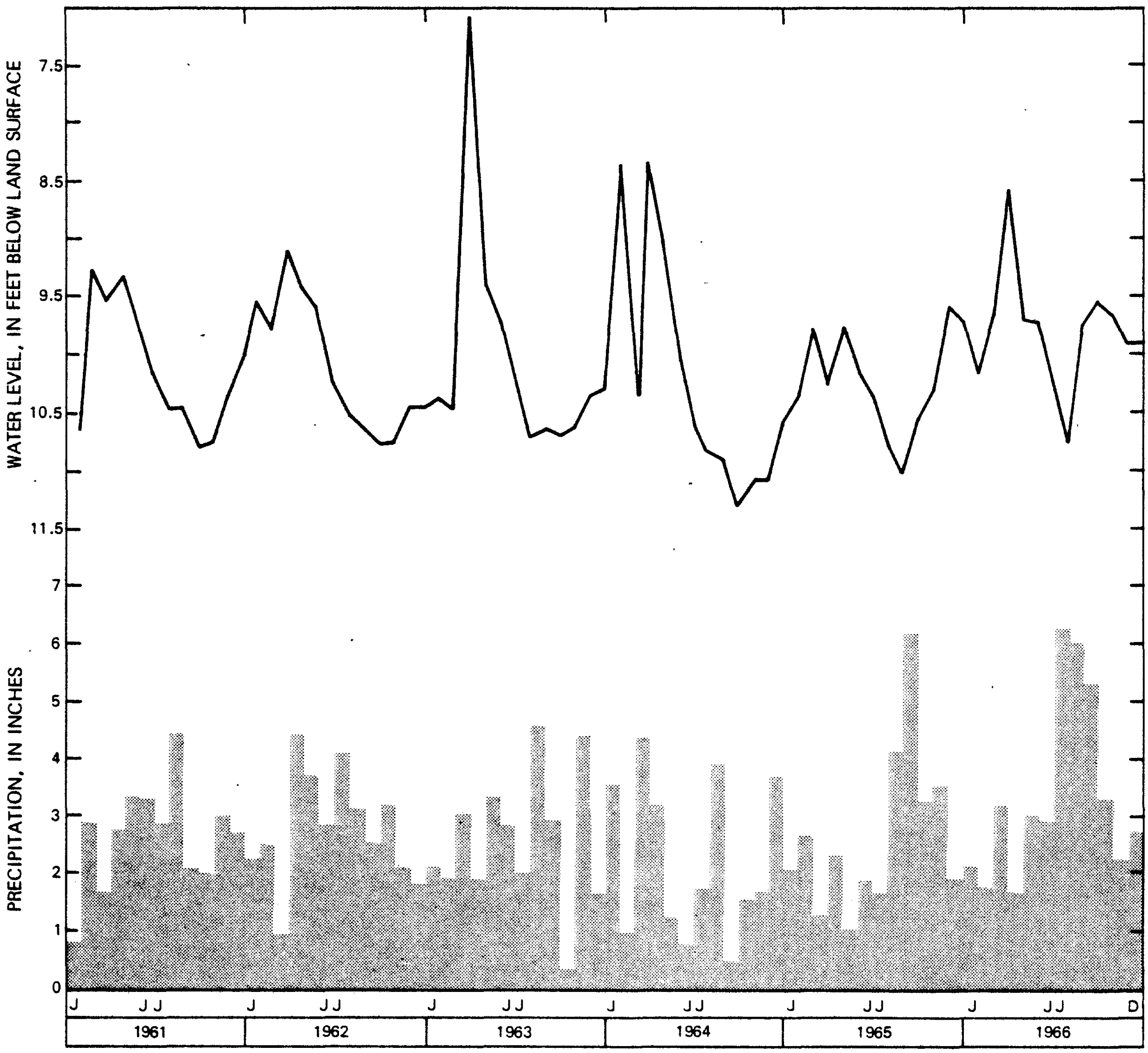

Figure 2.--Maximum observed monthly water level at an observation well and total recorded monthly precipitation at Salem, Washington County (from Giese and Hobba, 1970, fig. 20).

The seasonal change of ground-water levels is largest on hills and commonly may be as much as 20 ft. In contrast, the change in valleys and in the level lowlands seldom exceeds 5 ft.

The U.S. Geological Survey maintains several observation wells in the Hudson River basin in cooperation with State agencies. These sites are shown in plate 1. The water-level record for each well on the map represents the general water-level trend for a specific aquifer type. The water table in the basin changes seasonally and in response to changes in the amount of pumping in any specific aquifer. Although the water table is not undergoing a continuous regional decline, water in any local area may be pumped from the ground faster than it can be replaced, which will cause a temporary local decline in water levels.

DISCUSSION

Ground water is one of the most valuable natural resources of the Hudson River basin. It is used by hundreds of thousands of people in cities, villages, and rural areas. It differs from most other natural mineral resources (such as coal, petroleum, iron ore) in that it is replaceable and occurs nearly everywhere. Thus, water in a usable quantity can be obtained from wells in nearly every part of the basin, and, if the supply is nearly exhausted through excessive use during the summer and fall, it will be replaced during the winter and spring. These desirable features sometimes lead to undesirable practices. Water is often taken for granted and wasted without thought of the consequence or the rights of others. In many instances, ground water is contaminated by industrial wastes, domestic sewage, or agricultural uses and may be made unusable for hundreds of years. The shallow sand and gravel aquifers and those bedrock aquifers covered with a thin till layer are most susceptible to contamination.

Table 1. Depth and yield of wells and chemical quality of water in water-bearing units, by county

[Upper numbers are means; lower numbers are ranges]

County	Depth of wells (ft)	Yield of wells (gal/min)	No. of wells	Dissolved solids	Total hardness	Sulfate	Chloride	Bicarbonate	No. of analyses
				SAND AND GRAVEL					
Albany[1/]	115 43-225	4 1-40	--	342 254-534	280 128-360	30 17-55	15 0.2-37	321 150-380	--
Columbia	64 6-165	61 0.5-300	38	145 67-232	82 32-148	35 12-93	3.6 2.6-4.6	66 10-177	6
Delaware	--	--	--	No data available - Greene Co. data considered similar					--
Dutchess[1/]	37 8-600	18 2-625	--	174 72-472	188 64-336	29 0-78	3.6 1.6-22	210 83-388	--
Essex	70 5-258	21 2-105	30	307 144-625	331 100-733	87 12-227	0.8 0.1-1.2	223 138-389	3
Fulton	73 7-220	43 1-690	106	73 44-116	89 22-230	8.3 3.6-15	2.3 0.6-8.4	99 9-274	7
Greene	90 11-230	29 0.1-250	43	104 44-213	46 16-96	5.6 3.2-8	2.3 0.6-46	69 21-156	5
Hamilton	49 6-97	58 3-325	13	No data available					--
Herkimer	74 10-278	19 2-125	56	69 47-90	36 17-54	11 2.5-23	3.0 1.2-5.0	51 30-71	3
Montgomery	75 4-388	15 1.3-52	78	640 175-1230	273 140-400	64 7.2-140	134.8 12-460	224 96-354	4
Oneida	83 42-120	25 4-40	8	255 142-358	380 96-928	38 0.6-140	3.2 0.9-6	241 166-349	5
Orange	61 2-300	149 3-1500	147	206 123-293	188 86-290	36.1 22-58	7.9 4.5-17	139 22-232	6
Putnam[1/]	22 3-210	33 1-450	--	192 115-600	88 6.8-480	23 6.6-46	4.0 1.6-29	96 16-487	--
Rensselaer	61 5-260	95 0-1000	72	227 29-497	133 34-290	34.3 6.5-104	14.6 0.8-68	130 15-289	7
Rockland[1/]	26 5-170	183 8-1700	--	215 119-1321	116 56-450	37 20-190	9 4-480	109 31-212	--
Saratoga	42 6-290	68 1-750	269	130 99-186	116 56-171	12.0 7.5-23	3.1 0.8-6.8	118.6 48-177	11
Schenectady	71 5-375	584 2-3600	268	205 164-636	171 72-440	33 0-106	14.8 0.8-76	203 66-594	40
Schoharie	127 11-387	19 0.3-310	132	393 272-635	200 180-220	11.7 0.2-23	61.9 0.2-180	320 277-392	3
Sullivan	70 20-205	27 2-65	7	No data available - Orange Co. and Ulster Co. data considered similar					--
Ulster	60 2-331	111 1-1000	153	196 70-367	No data	25.5 10-50	15.5 2-44	No data	3
Warren	62 4-146	75 10-390	26	No data available					--

1/ Data from Heath (1964)

Table 1. Depth and yield of wells and chemical quality of water in water-bearing units, by county
[Upper numbers are means; lower numbers are ranges]

County	Depth of wells (ft)	Yield of wells (gal/min)	No. of wells	Dissolved solids	Total hardness	Sulfate	Chloride	Bicarbonate	No. of analyses
				SAND AND GRAVEL (Continued)					
Washington	40 9-195	16 3-100	54	152 56-267	123 34-460	26.4 9.5-66	6.6 0.2-28	121 22-368	10
Westchester	59 5-199	96 5-600	89	No data available - Putnam Co. data considered similar					—
				TILL					
Albany	25 10-135	3 0.75-5	27	No data available					—
Columbia	—	—	—	No data available - Dutchess Co. data considered similar					—
Delaware	—	—	—	No data available - Schoharie Co. data considered similar					—
Dutchess	29 8-330	6 1-20	37	No data available					—
Essex	—	—	—	No data available - Warren Co. data considered similar					—
Fulton	27 5-265	3 0-7.5	51	407 126-687	197 84-310	29 4.9-53	24 0.2-48	173 120-226	3
Greene	17 7-30	No data	10	328 66-874	198 34-480	28 11-62	54 2.8-205	132 9-256	4
Hamilton	26 6-62	—	7	No data available					—
Herkimer	71 15-255	6 2-11	29	180 116-244	98 84-112	26 17-35	3.3 2.1-4.5	160 99-220	3
Lewis	—	—	—	No data available					—
Madison	—	—	—	No data available					—
Montgomery	32 6-310	4 3-8	81	No data available					—
Oneida	—	—	—	No data available					—
Orange	21 2-115	—	25	No data available					—
Otsego	—	—	—	No data available - Schoharie Co. data considered similar					—
Rensselaer	48 6-200	5 1-14	28	208 45-359	96 30-176	30.2 6.8-46	6.1 0.4-20	122 20-280	5
Rockland	46 8-101	—	13	No data available					—
Saratoga	25 2-180	3 1-5	86	No data available			2.6 2.0-5.2	No data	3
Schenectady	46 4-249	—	41	No data available	358 50-666	No data	31.0 2.6-198	225 27-428	6
Schoharie	110 12-360	—	18	No data available					—
Sullivan	17 13-25	—	4	No data available					—

Table 1. Depth and yield of wells and chemical quality of water in water-bearing units, by county
[Upper numbers are means; lower numbers are ranges]

County	Depth of wells (ft)	Yield of wells (gal/min)	No. of wells	Dissolved solids	Total hardness	Sulfate	Chloride	Bicarbonate	No. of analyses
				TILL (Continued)					
Ulster	15 3-31	--	23	No data available					--
Warren	30 4-100	4 3-5	4	No data available					--
Washington	26 20-31	--	3	No data available					--
				SHALE					
Albany[1/]	120 10-1000	5 0-40	--	243 39-957	108 4-440	20 0-302	9.4 0.2-180	199 22-514	--
Columbia	147 33-1056	8 0.05-100	316	523 59-2840	258 20-1700	190 10-1540	15.7 1.2-78	204 17-481	9
Delaware	102 62-154	20 5-30	3	No data available - Schoherie Co. data considered similar					--
Dutchess[1/]	125 15-1200	16 0-135	--	234 36-427	138 20-513	30 7.0-119	3.2 0.6-11	181 22-336	--
Fulton	139 13-365	7 0.6-22	46	261 251-268	240 220-260	16 12-18	1.5 0.6-2.6	263 254-271	3
Greene	170 58-600	8 0.5-30	50	625 279-1120	279 100-510	135 41-421	12.8 4.8-33	296 168-522	8
Herkimer	130 10-560	8 0.08-35	149	276 171-341	258 137-339	45 18-103	4.8 1.0-10	252 167-325	4
Lewis	--	--	--	No data available - Oneida Co. data considered similar					--
Madison	--	--	--	No data available - Oneida Co. data considered similar					--
Montgomery	166 14-589	8 0-60	142	593 384-978	248 50-460	56.7 16-112	47.4 1.8-175	445 330-640	11
Oneida	85 37-134	17 1-50	15	1175 326-2310	1283 253-2600	705 68-1630	37.3 3.8-84	239 146-320	3
Orange	162 14-2010	22 0-400	427	251 56-650	163 2-329	33.8 0.7-187	8.5 0.2-197	163 41-360	96
Otsego	--	--	--	No data available - Montgomery Co. data considered similar					--
Putnam	179 75-423	14 1.5-40	18	211 86-370	125 56-280	46.8 5.8-209	7.3 0.8-19	109 22-238	9
Rensselaer	136 25-504	6 0.2-40	232	264 105-535	125 30-300	41.1 11-131	18.8 0.4-180	167 29-298	21
Saratoga	149 7-2157	8 0.5-60	199	397 214-612	174 43-468	83 3-221	14.1 2-88	286 219-339	30
Schenectady	135 9-1000	13 0.5-150	190	575 136-1140	154 1-540	84.4 0-461	67.5 2-450	390 149-809	18
Schoharie	156 30-700	14 0-150	148	360 94-858	190 20-370	49.5 1.7-274	40.9 0.2-390	237 84-533	16
Sullivan	171 48-552	27 10-40	12	No data available - Ulster Co. data considered similar					--

1/ Data from Heath (1964)

Table 1. Depth and yield of wells and chemical quality of water in water-bearing units, by county
[Upper numbers are means; lower numbers are ranges]

County	Depth of wells (ft)	Yield of wells (gal/min)	No. of wells	Dissolved solids	Total hardness	Sulfate	Chloride	Bicarbonate	No. of analyses
				SHALE (Continued)					
Ulster	154 12-605	14 0-230	294	306 88-1470	131 10-348	59.2 2.9-525	9.4 2.2-40	204 161-286	10
Weshington	133 10-590	11 0.5-60	158	986 118-3150	372 66-1700	150.3 0-1250	96.4 0.2-480	626 28-2560	11
Westchester	235 40-750	26 0-100	197	No data available					—
				CARBONATE					
Albany[1/]	115 43-225	4 1-40	--	342 254-534	280 128-360	30 17-55	15 0.2-37	321 150-380	—
Columbia	135 6-352	8 0.1-40	47	350 139-569	285 104-430	59 13-156	5.6 1.0-18	261 154-351	8
Dutchess[1/]	141 35-1270	22 1-220	—	316 178-431	220 62-590	29 9.5-103	3.6 0.7-60	251 63-395	—
Fulton	114 15-301	16 1.5-100	30	279 113-547	190 84-370	16.8 8.9-31	24.5 1.0-175	202 111-343	8
Greene	116 39-228	10 1-40	13	436 138-1050	235 66-540	155 17-499	15.8 1.8-35	179 59-256	5
Herkimer	189 43-452	15 1-100	36	283 120-502	118 8-238	24 12-36	19.1 0.5-64	248 114-382	4
Madison	—	—	--	No data available - Oneida Co. data considered similar					—
Montgomery	141 24-860	33 0.5-200	94	1142 250-8660	343 20-1200	46.4 0-120	340 2.2-3750	263 27-350	12
Oneida	125 70-169	10 0.5-24	11	No data available					—
Orange	149 50-520	24 1-200	60	No data available					—
Otsego	215 210-220	—	2	No data available - Schoharie Co. data considered similar					--
Putnam	179 53-400	12 0.5-38	17	403 293-513	180 140-236	46.0 4-182	5.0 2.0-17	238 174-334	6
Rensselaer	205 165-267	29 4-75	5	No data available					--
Rockland	176 100-345	7 2-10	5	No data available					--
Saratoga	147 16-635	32 1-300	41	No data available					—
Schenectady	91 72-108	No data	3	No data	280 270-320	No data	3.0 2.2-3.8	313 288-338	2
Schoharie	167 35-435	10 0-30	74	499 250-1159	338 210-580	88.5 1.8-434	29 0.6-140	251 284-455	7
Ulster	181 45-487	21 1-110	67	No data available					—
Washington	163 54-361	15 1-2000	18	No data	240 116-365	No data	7.8 3.6-12	246.5 138-355	3
Westchester	254 70-1000	47 0-450	63	No data available					—

1/ Data from Heath (1964)

Table 1. Depth and yield of wells and chemical quality of water in water-bearing units, by county

[Upper numbers are means; lower numbers are ranges]

County	Depth of wells (ft)	Yield of wells (gal/min)	No. of wells	Dissolved solids	Total hardness	Sulfate	Chloride	Bicarbonate	No. of analyses
				CRYSTALLINE ROCK					
Dutchess	128 50-400	10 1-45	26	139 36-276	51 18-104	22.5 11-62	3.5 0.6-11	61 10-151	5
Essex	138 48-365	32 1-190	10	No data available					--
Fulton	89 39-197	7 1-20	11	94 79-108	49 46-52	5.3 2.4-8.2	1 0.8-1.2	77 49-104	3
Hamilton	146 55-300	8 2-20	9	No data available					--
Herkimer	103 29-184	7 2-20	10	No data available					--
Orange	244 55-833	44 0-200	18	No data available					--
Putnam[1/]	125 13-400	11 0-120	--	120 43-255	72 16-390	15 5.0-44	4.0 0.8-29	48 5.0-375	--
Rockland[1/]	105 25-640	12 0-180	--	170 130-195	80 48-154	19 13-40	6 2-3	98 48-175	--
Saratoga	76 24-140	6 1-20	22	No data available					
Ulster	151 27-300	15 2-40	24	142 95-189	No data	19 18-20	4.2 0.5-8	No data	6
Warren	124 30-256	16 4-30	14	No data available					--
Westchester	185 38-750	15 0-100	267	No data available					--
				SANDSTONE					
Albany[2/]	110 8-217	12 1-100	42	159 39-282	130 30-280	14 9.4-20	5.6 0.2-15	141 22-235	5
Greene	138 21-600	15 0-150	206	165 61-360	81 24-190	23.5 2-68	6.2 1.2-46	118 18-317	23
Orange[1/]	166 45-400	22 4-50	13	No data available					--
Rensselaer	113 56-200	5 0.8-15	15	148 60-261	109 50-200	16.4 2.6-32	1.4 0.8-2.2	125 59-236	4
Rockland[1/]	165 13-805	30 3-700	--	170 52-276	112 18-256	21 5.9-64	18.2 2-2000	110 21-198	--
Ulster[2/]	151 2-400	18 1-100	97	110 83-136	No data	6.7 13-30	0.7 0.2-1.1	No data	6

1/ Data from Heath (1964)
2/ Sandstone units occur in conjunction with shale.

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