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STATE OF DELAWARE
DELAWARE GEOLOGICAL SURVEY
REPORT OF INVESTIGATIONS NO. 9

GROUND-WATER LEVELS IN DELAWARE
JANUARY, 1962 - JUNE, 1966

By
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ABSTRACT

This report deals with fluctuations in nine observation wells during the period 1960 - 1966. These wells are part of a state-wide ground-water monitoring network and are located in areas of little or no pumping. Eight of the wells respond to water-table conditions; the ninth well appears to reflect artesian conditions.

Although precipitation throughout Delaware was generally below average during the period covered by this report, annual average water levels declined very little in the wells reported on here. There is some evidence, however, for a lowering of water-table levels by three to four feet during the period 1960 - 1962.

INTRODUCTION

Purpose and Scope

Ground-water levels fluctuate in response to changes in precipitation, runoff, and pumping. Regular measurement and analysis of these levels helps to determine the relative amount of ground water in storage and the changes in storage through time. Such information is basic to the evaluation of Delaware's water supply situation. The last six years of generally deficient rainfall throughout the northeastern United States are especially important because new lows for streamflow and ground-water levels were established. This report assesses the effects of the 1961-66 drought on ground-water levels in Delaware within the limits of available data.

Ground-water levels in eight observation wells are presented for the period January, 1962 through June, 1966, and ground-water levels in one well are given for January, 1960 through June, 1966. These wells are presently operational within the State and form a permanent network of observation wells that will be utilized in the future. Some additional data from discontinued wells are given for years prior to 1960 in order to make comparisons with data from the presently used wells.

Eight of the wells reported on are located in the Coastal Plain Geologic Province, an area of low relief, underlain mainly by sands, gravels, and clays. The ninth well is located in a region of hard crystalline rock in northern Delaware known as the Piedmont Geologic Province. Wells in the Coastal Plain are shallow, mostly less than 25 feet deep, and their water levels are a measure of the depth to the water table. The Piedmont well, near Greenwood, Delaware, is a 165 feet deep, uncased well in hard rock. Levels in this well may be influenced by flow in joints, fractures, or other planes, and apparently respond very rapidly to undefined local influences.

The nine wells described in this report are not the only ones presently being monitored. Levels in a number of wells throughout the State are being measured on a temporary basis, usually in connection with a water supply study for a municipality or industry. Wells that reflect only local pumping, have maintenance problems, or have only very short periods of record are not used in this report.

Previous Reports

Ground-water measurements in Delaware were first published for the year 1952 (Marine, 1954). Levels for 1953 and 1954 were given in Water Level Reports No. 2 and 3 respectively of the Delaware Geological Survey, both by Boggess and Coskery. Water Level Reports No. 4 through 7, all by Coskery, give data for the years 1955 through 1958. This particular series of publications ended with Water Level Report No. 7. The present report is an extension of that series.

Levels in various Sussex County wells are given in Delaware Geological Survey Bulletin No. 8, "Water Resources of Sussex County, Delaware," by Rasmussen, Wilkens, and Beall, 1960. A report on a portion of northern Delaware was published in March, 1964 as Delaware Geological Survey Bulletin No. 11, "Ground-Water Resources of Southern New Castle County, Delaware" by Rima, Coskery, and Anderson.

A 1966 report of the U. S. Geological Survey by Rasmussen, Odell, and Beamer entitled "Delaware Water" and published as U. S. Geological Survey Water-Supply Paper 1767 reviews the general ground-water situation in the State. It concludes that sound planning and wise utilization of this resource will be necessary in the future.

In March, 1966, a report by Baker, Varrin, Groot, and Jordan entitled "Evaluation of the Water Resources of Delaware" was published both as Delaware Geological Survey Report of Investigations No. 8 and as a Delaware State Planning Office Report. This report describes the water supply characteristics of Delaware regionally and on a municipal basis.

The Coastal Plain wells described in this report were originally installed as part of a cooperative program of the Delaware State Highway Department, the U. S. Geological Survey, and the Delaware Geological Survey. This program resulted in a series of thirty-three maps, published from 1963 through 1965, that show the average depth to the water table, surface drainage, and engineering soils types. These maps were prepared by Boggess, Adams, Davis, and Coskery and cover the entire Coastal Plain portion of the State.

Well-Numbering System

For the purpose of locating and recording well locations, a map of the State is divided into 5-minute quadrangles of latitude and longitude as show in Figure 1. The quadrangles are lettered from north to south with upper case letters and from east to west with lower case letters. Each quadrangle is thus designated by an upper case and lower case letter, the upper case letter being given first. The 5-minute quadrangles are further subdivided into 25 one-minute quadrangles. The one-minute quadrangles are numbered by series of tens from north to south and by units 1 to 5 in a west to east direction. Within each one-minute block, the wells are further numbered according to the order in which information for a particular well is entered into the records of the Delaware Geological Survey. Thus, a well is designated by an upper case letter, a lower case letter and a two-digit number

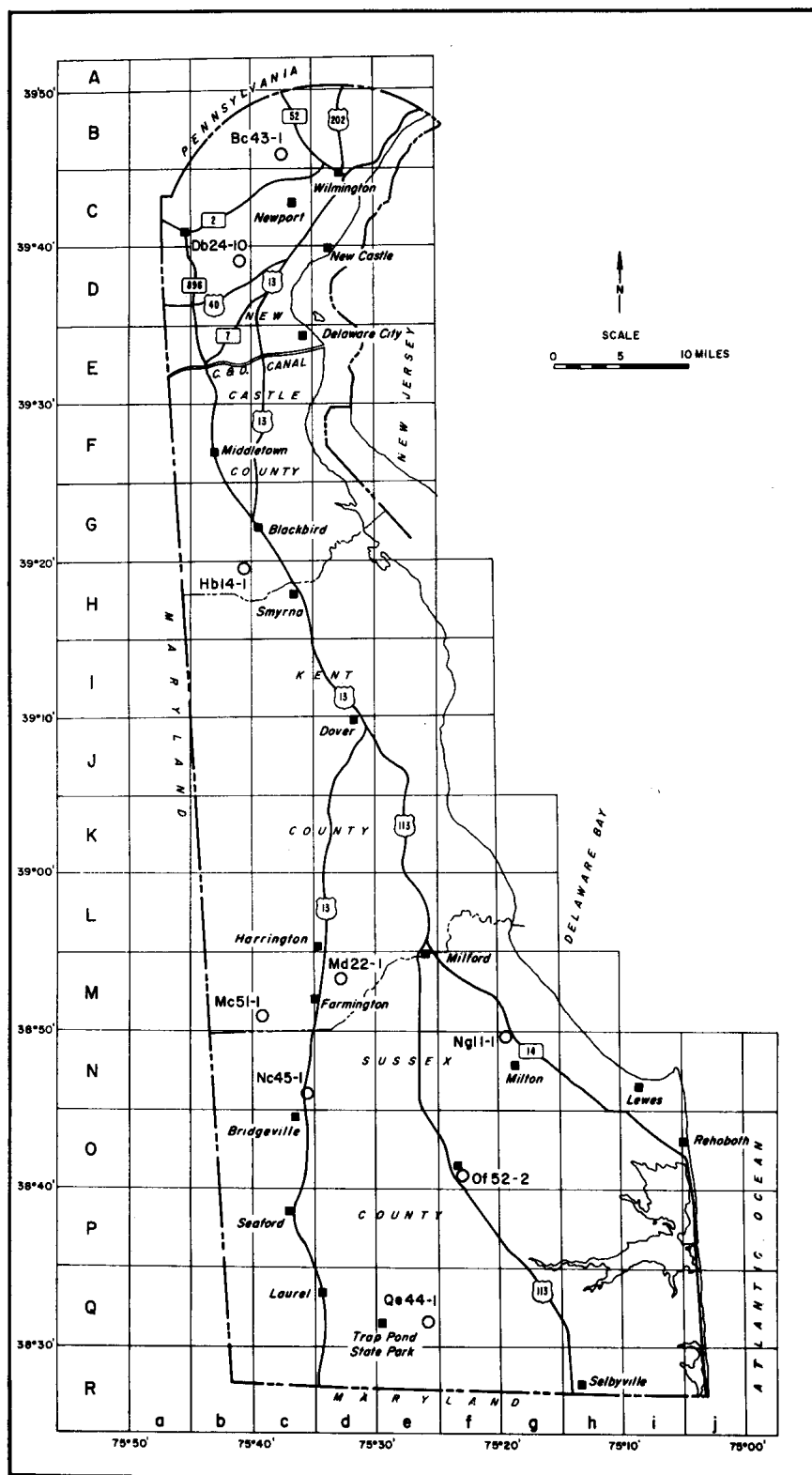


Figure 1 Index map of observation wells

followed by a dash and one or more numbers. For example, Gc 52-1 designates the first well scheduled in block 52 of quadrangle Gc.

Acknowledgements

Nearly all water-level measurements, except those for the well near Greenwood after March 1963, were made by the U. S. Geological Survey in cooperation with the Delaware Geological Survey. After this date, measurements for this well (Bc 43-1) were made under the direction of the Red Clay Valley Association. The U. S. Geological Survey, in cooperation with the Delaware Geological Survey, is continuing monthly level measurements in eight Delaware observation wells as part of the current surface water cooperative program.

HYDROLOGIC FACTORS IN DELAWARE

Precipitation

Delaware's water is derived from rainfall which averages slightly over 44 inches per year. Table 1 shows that precipitation has generally been below average for five of the last six years.

It can be seen that New Castle County has had deficient rainfall from 1961 through June, 1966, with the greatest deficiency occurring in 1965. In 1966 above normal precipitation occurred only in February. The total deficiency for New Castle County from January, 1960 through June, 1966 was 56.30 inches.

Precipitation in Kent and Sussex Counties was below normal in 1960 and from 1962 through 1965, but deficiencies were not as great in any one year as were those for New Castle County. The total precipitation deficiency for southern Delaware from 1960 through June, 1966 was 39.50 inches.

Table 1

Precipitation in Delaware, 1960-66
(Data are average figures from a number of
stations for the time and area specified)

	New Castle County		Kent & Sussex Counties	
Year	inches precip.	inches above or below avg.	inches precip.	inches above or below avg.
1960	45.75	+1.35	44.59	-2.17
1961	40.55	-3.89	49.79	+3.03
1962	36.10	-8.38	39.69	-7.06
1963	33.02	-11.46	37.79	-8.96
1964	33.10	-11.38	36.84	-9.91
1965	27.78	-16.70	32.55	-14.20
1966				
Jan.	3.12	-0.36	3.16	-0.60
Feb.	4.17	+1.32	3.57	+0.49
Mar.	1.19	-2.76	1.62	-2.57
April	3.26	-0.30	4.41	+0.91
May	3.34	-0.66	4.81	+0.92
June	0.65	-3.18	4.23	+0.62
1966 total				
Jan.-June	15.73	-5.94	21.80	-0.23

Ground-Water Occurrence

Ground water may occur in basically two ways: (1) under water-table conditions and (2) under artesian conditions. Under water-table conditions, the top of the zone below which the ground is essentially saturated is at atmospheric pressure and under no hydrostatic pressure. Artesian conditions prevail when water at the top of the aquifer is under hydrostatic pressure greater than atmospheric pressure. This is caused by an overlying confining layer, such as a clay or silt, and by the water-table in the aquifer recharge area having a higher elevation than the downdip part of the aquifer. There are,

of course, gradations between artesian and water-table conditions. In reality, the so-called artesian aquifers are probably quite leaky. Such cases can usually be demonstrated by properly controlled pump tests.

Yearly rainfall in Delaware averages about 44 inches. In the Coastal Plain, about 29 inches of a 44 inch rainfall are lost by evaporation and by plant transpiration and therefore are not available for human use. Water loss by evaporation and transpiration in the Piedmont portion of Delaware may be slightly less than that in the Coastal Plain. Of the remaining precipitation, between three and four inches find its way into streams by direct overland flow. The rest, about 12 inches, percolates into the ground and, moving underground, eventually reaches surface streams. Indeed, during a dry season, stream flow is sustained almost entirely by ground-water discharge. During a wet period, when stream flow is excessive, surface water will infiltrate into the ground to replenish ground-water supplies. A small amount of that precipitation that becomes ground water is also lost by subterranean flow to the ocean. The exact amount of such underground flow is not completely known for Delaware at the present time.

Water levels in individual wells are influenced by factors other than variations in precipitation. One of the more important factors is interference caused by pumping of nearby wells. When a water-table well is pumped, the drawdown effect extends for some distance. Theoretically, the water-table created in such an area of drawdown assumes the shape of an inverted cone, with the lowest water level being in the pumping well. This in itself is not always harmful and may even be specifically designed to induce recharge from some known recharge sources. However, when several wells in a limited area are pumped, the individual cones of depression may overlap, causing additional drawdown in any one well. In such a case the total drawdown of an individual well is equal to its own drawdown plus the drawdown introduced by one or more nearby wells. The amount of additional drawdown depends on several things, among which are the permeability and porosity of the aquifer, pumping rates, and distance to the pumping wells.

Wells located near tidal bodies of water are also influenced by tidal variations. Fluctuations in water levels correspond to

changes in the tidal cycle and are superimposed on the changes due to other causes. In somewhat similar manner, changes in barometric pressure may also be reflected in wells tapping artesian aquifers. These affects are minor, but usually detectable.

Occasionally, construction projects may change well levels by upsetting the local water table. A new gradient may be established towards a cut, for instance, or, intentional draining of a water body or paving may destroy a local recharge source.

WATER-LEVEL MEASUREMENTS

All level measurements, except those for well Bc 43-1, were made by periodic tape measurements and are assumed to be correct as reported. In 1961 a continuous recorder was installed in well Bc 43-1 and subsequent adjustments to the record were found to be necessary. Tape measurements made just before the installation of every chart were used as the standard to compute any apparent error that occurred on the recorder chart. It was assumed that such errors were cumulative over a specified time period, and corrections were applied accordingly. Readings were then rounded off to the nearest 0.05 foot. Because of such possible errors in (1) accuracy of the readings, (2) the correction factor, and (3) the exact times of the readings, a precision of more than 0.05 foot is probably meaningless.

All levels were referred to the same datum plane for a given well. A datum plane is an exact reference elevation, such as sea level or ground surface, from which depths to the water table can be either measured or calculated. In the

case of this report, all measurements are referred to the ground surface.

ANALYSIS OF MEASUREMENTS

Six of the nine wells for which data are given for the period 1962 through June 1966 were found to have their highest average level in calendar year 1964. The reasons for this are not entirely clear but may be partially due to the considerable amount of precipitation received in November, 1963. Total annual precipitation for the year 1964 still generally showed a downward trend and levels began to drop rather sharply during that summer. The lowest average level occurred in four, or almost half, of the wells in 1962. Moreover, the lowest composite average level for eight wells, excluding Bc 43-1, also occurred in 1962. However, data are available for only the last part of 1962 so the results should be interpreted with caution. Yearly average levels in feet below land surface are given in table 2.

Table 2

Yearly average ground-water levels in feet below land surface datum for nine water-table wells

Well	1960*	1961*	1962*	1963	1964	1965	1966*	
Bc 43-1	24.97	26.19	26.71	28.01	28.19	27.99	26.67	
Db 24-10	-	-	14.12	14.79	13.10	14.83	16.75	
Hb 14-1	-	-	9.12	8.59	7.50	9.48	11.40	
Of 52-2	-	-	6.96	4.60	3.99	5.34	4.98	
Mc 51-1	-	-	13.74	12.26	10.83	12.98	13.20	
Md 22-1	-	-	9.22	6.45	6.32	8.34	7.73	
Nc 45-1	8.32	-	12.44	12.56	11.08	11.71	11.44	
Ng 11-1	-	-	12.85	12.48	11.66	13.45	13.29	
Qe 44-1	-	-	11.70	8.55	8.36	8.92	8.13	
average of eight wells excluding Bc 43-1				12.88	11.47	10.40	12.15	12.42

* Data incomplete

Well Nc 45-1, near Greenwood in Sussex County has the longest period of record of the wells included in this report, approximately thirteen years. The yearly average water levels for this period of record are given in Table 2. Between 1960 and 1962 the yearly average level dropped slightly over four feet. It is unfortunate that no data exists for 1961 as this would enable the response time to drought conditions to be determined fairly accurately. Unpublished data for other water-table wells, discontinued at the end of calendar year 1961, do not show this drop by the end of December, 1961. One possible exception is a well (Bb 44-11) in the weathered rock zone of the Piedmont near Hockessin. Levels fell over four feet between June and December of 1961. However, levels in this well were lower in early 1955 so no new record lows were established.

Table 3

Yearly average ground-water levels in feet below land surface datum for well Nc 45-1, Greenwood, Delaware

Year	Average level	Year	Average level	Year	Average level
1952	8.50	1959	8.81	1966	12.42
1953	8.70	1960	8.32		
1954	9.09	1961	-		
1955	8.89	1962	12.44		
1956	8.88	1963	12.56		
1957	8.91	1964	11.08		
1958	8.11	1965	11.71		

Figures 2, 3, and 4 show the normal seasonal fluctuations of ground-water levels rather markedly. Also, these data point out that seasonal recharge, which usually occurs in the fall of the year, has not been occurring in the last few years until January or even later. This is undoubtedly due to the generally low precipitation during the fall months. Also, correlation of well levels with rainfall is better during the late fall and winter months than during late spring and summer. Evapotranspiration losses are naturally higher during the warmer weather and in many cases a rainfall during the growing season may

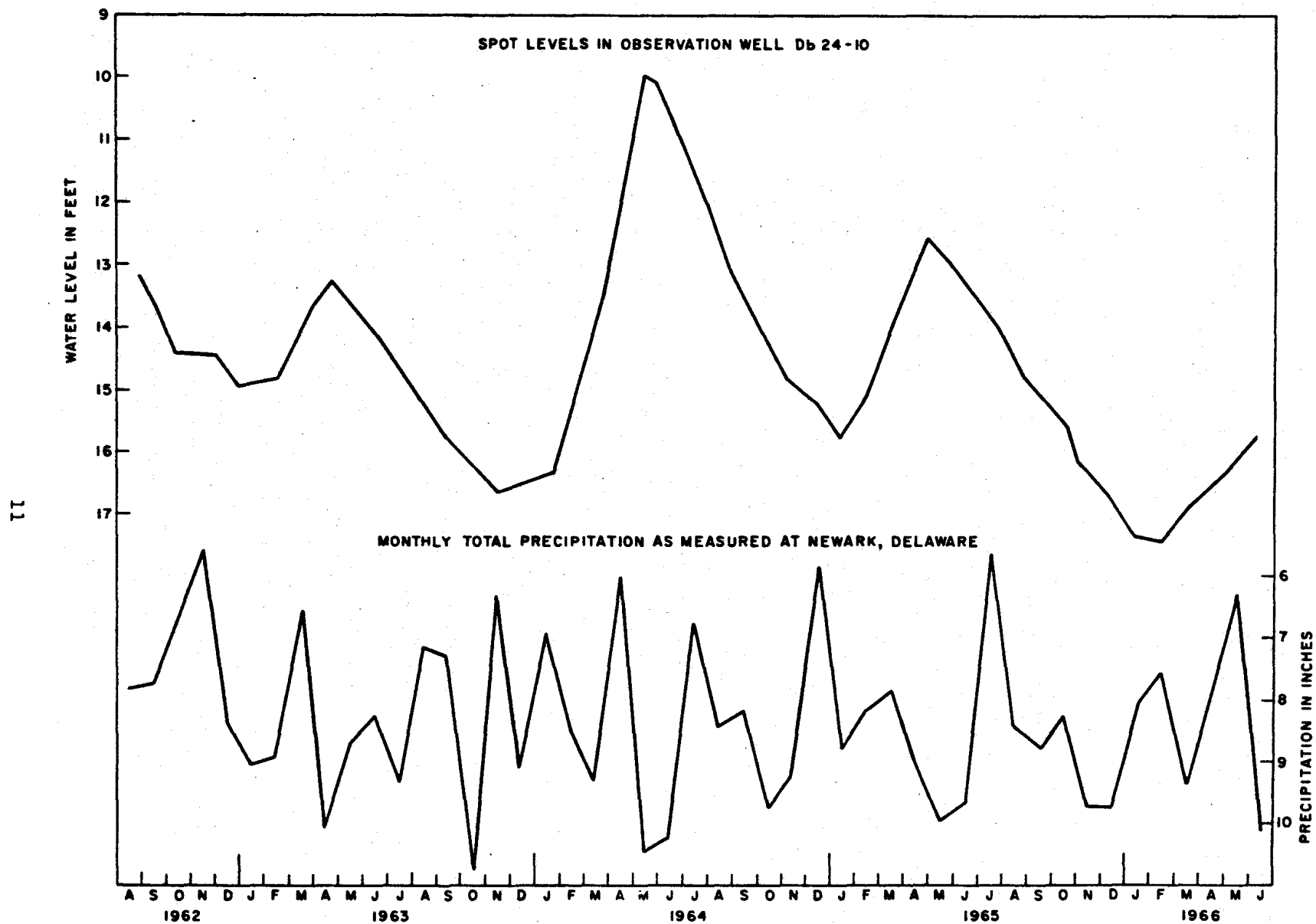


Figure 2. Levels in observation well Db 24-10 and precipitation near Newark, Delaware, New Castle Co.

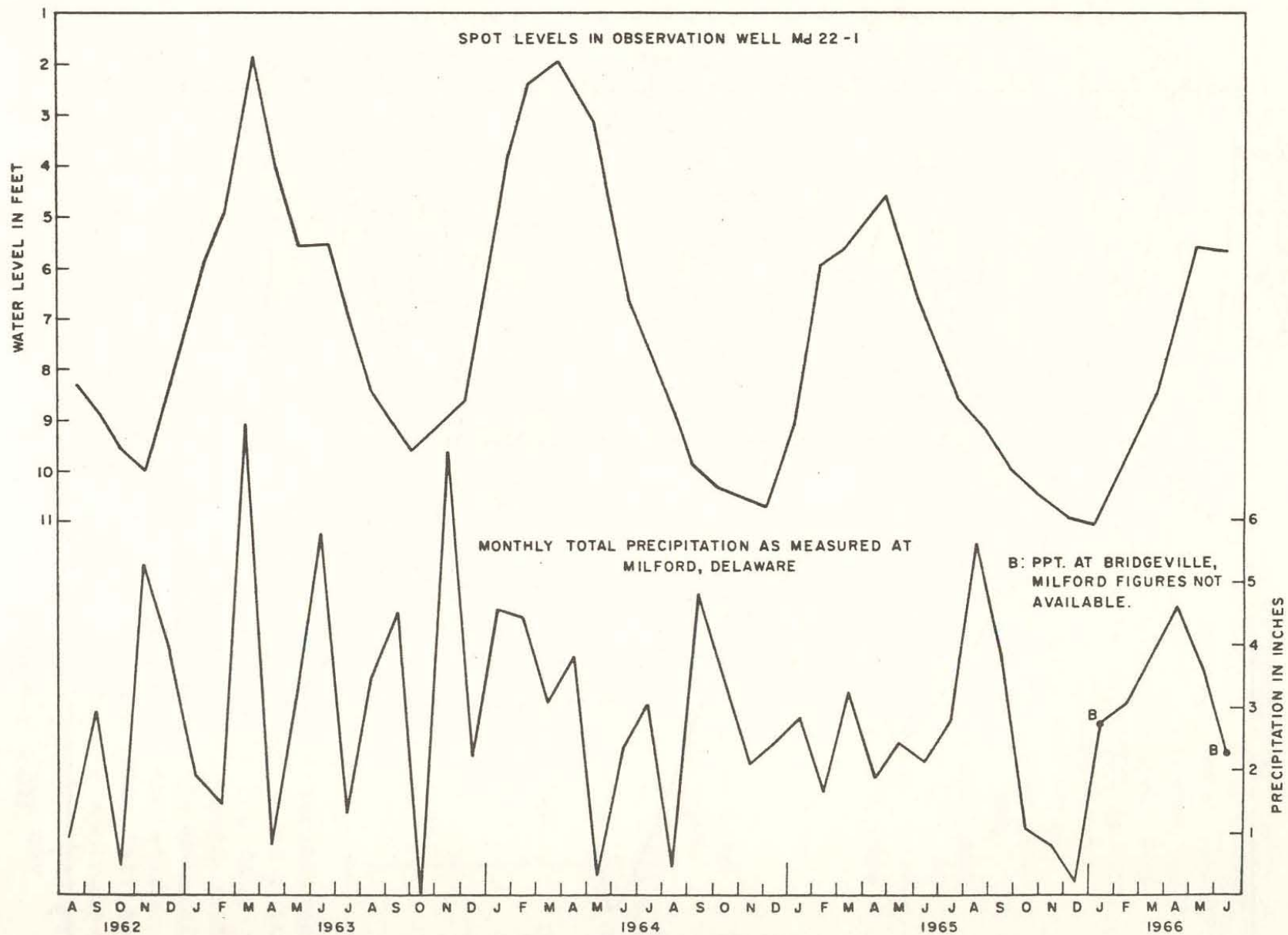


Figure 3. Levels in observation well Md 22-1 and precipitation near Harrington, Delaware, Kent Co.

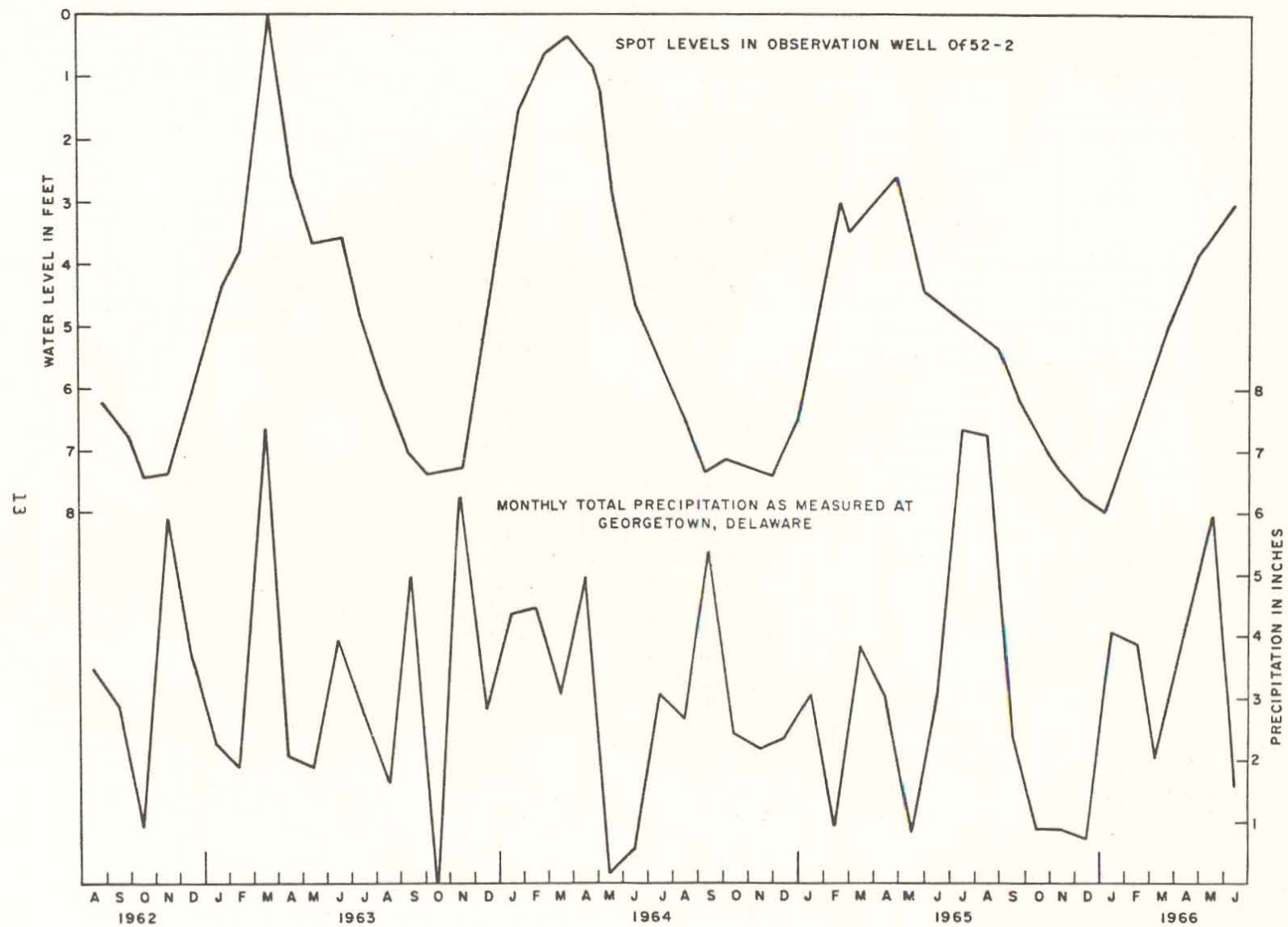


Figure 4. Levels in observation well Of 52-2 and precipitation near Georgetown, Delaware, Sussex Co.

have little, if any, effect on ground-water levels. During colder months, the response of the water level to rainfall appears to be quite marked except when the ground is frozen.

More sophisticated statistical methods do exist for treating data of this general nature. However, such methods are probably not justified and may not be meaningful in view of the generally short-term data available for this report.

WELL DESCRIPTIONS AND WATER-LEVEL DATA

The caption for each well record presents certain information about the well necessary to any study of well levels. The well number, as assigned by the method described above, is given first followed by the owner's name. The location is defined exactly by latitude and longitude and more generally by reference to a nearby geographic feature. Technical data on the well construction, the extremes and extent of records, and any pertinent comments are also recorded. Abbreviations used are listed below:

lat.	-latitude	mp	-measuring point
long.	-longitude	msl	-mean sea level
lsd	-land surface datum		

Bc 43-1. Mrs. W. A. Worth. Lat. 39° 46' 52", long. 75° 37' 30". Near Hoopes Reservoir. Drilled unused well in Wissahickon Formation. Diameter 6", depth 165.35 feet. Lsd about 330 feet above msl. MP, recorder platform 0.96 feet above lsd. Highest water level 21.28 feet below lsd, April 13, 1961; lowest, 34.35 feet below lsd, Nov. 25, 1964. Records available: Aug. 1950, Jan. 1956 to Sept. 1960, April 1961 to 1966. Records to April 1961 represent tape measurements, records after that date are corrected recorder readings.

Date	Water Level	Date	Water Level	Date	Water Level	Date	Water Level
<u>1960</u>		<u>1960</u>		<u>1961</u>		<u>1961</u>	
Jan. 1	24.75	June 1	24.24	Apr. 20	23.10	Aug. 10	26.70
8	24.46	3	24.25	25	23.50	15	27.10
15	24.53	10	24.50	30	23.90	20	27.40
22	24.45	17	25.14	May 5	24.30	25	25.70
29	25.02	24	24.74	10	24.15	31	26.40
Feb. 5	25.09	July 1	25.92	15	24.35	Sept. 5	27.05
12	24.64	8	26.17	20	24.65	10	27.40
19	24.19	15	25.20	25	24.90	15	26.55
26	23.63	22	25.42	31	25.05	20	27.00
Mar. 4	24.19	29	25.86	June 5	25.35	25	26.65
11	24.45	Aug. 5	26.44	10	25.50	30	27.11
18	23.99	12	26.94	15	25.30	Oct. 5	27.20
25	24.17	19	27.19	20	25.90	10	27.70
Apr. 1	24.59	26	27.09	25	25.35	15	N.A.
8	22.61	Sept. 2	27.36	30	25.85	20	27.50
15	22.86	9	28.18	July 5	26.35	25	27.20
22	24.36	16	26.34	10	26.60	31	27.95
29	24.18	23	24.75	15	23.30	Nov. 5	28.30
May 6	24.68	30	24.86	20	24.95	10	28.40
13	24.45	<u>1961</u>		25	25.45	15	28.50
20	24.50	Apr. 11	23.67	31	24.90	20	28.70
27	23.70	15	22.10	Aug. 5	26.25	25	27.05

Well Bc 43-1 continued -

Date	Water Level	Date	Water Level	Date	Water Level	Date	Water Level
<u>1961</u>		<u>1962</u>		<u>1962</u>		<u>1963</u>	
Nov. 30	28.14	Apr. 20	23.40*	Sept. 15	29.35	Feb. 5	27.45
Dec. 5	28.35	25	23.80*	20	30.25	10	27.65
10	28.65	30	23.70*	25	30.50	15	26.60
15	28.30	May 5	23.95*	30	29.60	20	26.70
20	25.60	10	24.10*	Oct. 5	29.70	25	26.60
25	27.05	15	24.35*	10	30.10	28	26.95
31	27.60	20	24.55*	15	30.35	Mar. 5	26.80
<u>1962</u>		25	25.00*	20	30.65	10	24.70
Jan. 5	28.00	31	25.90	25	30.95	15	24.50
10	24.50	June 5	23.80	31	31.25	20	23.90
15	25.30	10	26.00	Nov. 5	30.20	25	24.40
20	25.75	15	24.95	10	28.35	31	24.50
25	26.35	20	26.05	15	28.65	Apr. 5	24.75
31	26.65	25	26.45	20	26.60	10	24.95
Feb. 5	27.05	30	26.85	25	26.10*	15	25.30
10	27.40	July 5	27.20	30	26.95*	20	25.60
15	27.75	10	27.20	Dec. 5	27.25*	25	25.85
20	27.15	15	25.25	10	26.80*	30	25.85
25	24.60	20	27.55	15	27.35	May 5	25.80
28	23.05	25	28.00	20	27.80	10	26.20
Mar. 5	23.65	31	28.40	25	28.00	15	26.40
10	24.00	Aug. 5	28.25	31	28.30	20	26.00
15	22.65	10	27.30	<u>1963</u>		25	26.55
20	23.50	15	28.35	Jan. 5	28.65	31	26.75
25	23.40	20	28.65	10	28.90	June 5	26.85
31	24.05*	25	28.10	15	26.50	10	N.A.
Apr. 5	23.60*	31	29.15	20	27.10	15	27.00
10	23.25*	Sept. 5	29.20	25	27.25	20	27.40
15	23.00*	10	29.55	31	27.65	25	25.80

Well Bc 43-1 continued -

Date	Water Level	Date	Water Level	Date	Water Level	Date	Water Level
<u>1963</u>		<u>1963</u>		<u>1964</u>		<u>1964</u>	
June 30	28.20	Nov. 25	29.10	Apr. 15	23.30	Sept. 10	32.70
July 5	28.50	30	26.75	20	23.60	15	32.95
10	28.90	Dec. 5	28.20	25	23.75	20	32.75
15	29.15	10	26.75	30	22.50	25	32.35
20	29.50	15	27.30	May 5	23.15	30	32.55
25	29.90	20	27.90	10	23.65	Oct. 5	32.75
31	30.25	25	28.40	15	24.15	10	33.00
Aug. 5	30.30	31	28.95	20	24.60	15	32.25
10	30.55	<u>1964</u>		25	24.90	20	32.85
15	30.70	Jan. 5	27.70	31	N.A.	25	33.15
20	30.85	10	23.30	June 5	25.65	31	33.50
25	30.75	15	24.15	10	26.35	Nov. 5	33.70
31	31.05	20	24.70	15	26.90	10	33.85
Sept. 5	31.25	25	23.40	20	27.45	15	34.10
10	31.40	31	23.95	25	27.95	20	34.30
15	31.70	Feb. 5	24.40	30	28.55	25	34.35
20	31.50	10	24.05	July 5	N.A.	30	33.30
25	31.80	15	24.40	10	28.50	Dec. 5	33.00
30	30.85	20	24.10	15	28.50	10	32.10
Oct. 5	31.40	25	24.55	20	29.30	15	29.70
10	31.70	28	24.70	25	29.70	20	30.70
15	32.00	Mar. 5	24.15	31	30.10	25	30.85
20	32.25	10	23.30	Aug. 5	30.20	31	26.75
25	32.50	15	24.15	10	30.55	<u>1965</u>	
31	32.70	20	24.35	15	30.95	Jan. 5	27.65
Nov. 5	32.65	25	23.50	20	30.35	10	26.80
10	29.35	31	23.85	25	31.75	15	26.70
15	30.00	Apr. 5	24.25	31	32.10	20	27.50
20	30.40	10	22.85	Sept. 5	32.35	25	26.05

Well Bc 43-1 continued -

Date	Water Level	Date	Water Level	Date	Water Level	Date	Water Level
<u>1965</u>		<u>1965</u>		<u>1965</u>			
Jan. 31	25.20	June 5	26.55	Oct. 10	31.65	Feb. 10	33.25
Feb. 5	26.30	10	26.90	15	31.70	15	24.10
10	23.60	15	27.35	20	32.00	20	25.70
15	23.85	20	27.70	25	32.25	25	N.A.
20	24.40	25	28.65	31	32.55	28	N.A.
25	24.70	30	28.50	Nov. 5	32.80	Mar. 5	23.60
28	24.45	July 5	N.A.	10	33.00	10	24.50
Mar. 5	25.05	10	28.95	15	33.15	15	25.10
10	24.35	15	26.85	20	33.30	20	25.85
15	24.75	20	27.75	25	33.30	25	26.20
20	24.85	25	28.25	30	30.35	31	26.85
25	25.10	31	28.75	Dec. 5	33.50	Apr. 5	27.15
31	24.05	Aug. 5	28.90	10	33.65	10	27.55
Apr. 5	24.15	10	29.40	15	33.50	15	26.70
10	24.25	15	29.75	20	33.65	20	27.40
15	24.55	20	30.10	25	33.80	25	26.10
20	24.40	25	30.15	31	33.60	30	24.75
25	24.70	31	30.50	<u>1966</u>		May 5	24.80
30	24.70	Sept. 5	30.80	Jan. 5	33.20	10	25.45
May 5	25.15	10	31.05	10	32.55	15	25.85
10	24.50	15	31.15	15	32.75	20	24.85
15	25.85	20	31.55	20	32.90	25	24.95
20	26.20	25	31.85	25	32.85	31	25.35
25	26.55	30	32.10	31	32.95	June 5	26.00
31	26.75	Oct. 5	32.25	Feb. 5	33.15	10	N.A.

* Levels tentative, records not clear.

N.A. - Not available.

Db 24-10. Delaware State Highway Department. Lat. $39^{\circ} 38' 56''$, long. $75^{\circ} 41' 56''$. Near Newark. Driven observation water-table well in sand of Pleistocene age. Diameter 1 inch, depth 24.0 feet. Well point 21.0 - 24.0 feet. Lsd about 77 feet above msl. MP top of casing at lsd. Highest water level 9.94 feet below lsd, May 9, 1964; lowest 17.43 feet below lsd, Feb. 10, 1966. Records available 1962-1966.

Date	Water Level	Date	Water Level	Date	Water Level	Date	Water Level
<u>1962</u>		<u>1964</u>		<u>1965</u>		<u>1966</u>	
Aug. 24	13.15	Jan. 22	16.31	Jan. 10	15.80	Jan. 6	17.37
Sept. 11	13.67	Feb. 17	15.15	Feb. 13	15.10	Feb. 10	17.43
Oct. 9	14.42	Mar. 20	13.59	Mar. 7	14.24	Mar. 16	16.87
Dec. 6	14.46	Apr. 18	11.62	Apr. 30	12.60	Apr. 29	16.37
	14.95	May 9	9.94	June 3	12.97	June 7	15.72
<u>1963</u>			10.07	July 30	14.09		
Feb. 13	14.82	June 18	10.74	Sept. 1	14.80		
Mar. 22	13.78	Aug. 2	12.15		15.12		
Apr. 20	13.29	Sept. 3	13.13	Oct. 12	15.63		
May 14	13.62	Oct. 10	14.15	Nov. 8	16.17		
June 12	14.14	Nov. 7	14.84	Dec. 6	16.65		
July 11	14.62	Dec. 8	15.88				
Aug. 8	15.14						
Sept. 10	15.72						
Oct. 7	16.13						
Nov. 14	16.66						

Hb 14-1. Delaware State Highway Department. Lat. 39° 19' 49", long. 75° 41' 08". Near Blackbird. Driven observation water table well in sand of Pleistocene age. Diameter 1 inch, depth 18.6 feet. Well point 15.6 - 18.6 feet. Lsd about 72' above msl. MP top of casing at lsd. Highest water level 4.35 feet below lsd, March 13, 1963; lowest 11.59 feet below lsd, Feb. 9, 1966. Records available: 1962-1966. Well is inclined to vertical and therefore levels reflect relative changes and not true distance from lsd.

Date	Water Level	Date	Water Level	Date	Water Level	Date	Water Level
<u>1962</u>		<u>1964</u>		<u>1965</u>		<u>1966</u>	
Aug. 24	8.10	Jan. 26	8.65	Jan. 13	9.84	Jan. 5	11.40
Sept. 13	8.84	Feb. 17	7.86	Mar. 7	8.20	Feb. 9	11.59
Oct. 10	9.33	Mar. 27	5.77	Apr. 30	7.48	Mar. 17	11.02
Nov. 28	9.58	Apr. 15	5.11	June 3	8.10	Apr. 29	11.14
Dec. 26	9.74	May 9	4.51	Aug. 9	9.33	June 10	11.34
<u>1963</u>		23	5.45	Sept. 14	9.95	Aug. 3	11.92
Feb. 13	9.06	June 18	6.68	Oct. 11	10.46		
Mar. 13	4.35	Aug. 11	8.00	Nov. 16	10.86		
Apr. 19	7.67	Sept. 2	8.60	Dec. 6	11.07		
May 15	8.07	Oct. 14	9.37				
June 13	8.38	Nov. 5	9.79				
July 10	8.85	Dec. 1	10.16				
Aug. 9	9.31						
Sept. 10	9.82						
Oct. 7	10.17						
Nov. 14	10.25						

Mc 51-1. Delaware State Highway Department. Lat. $38^{\circ} 50' 42''$, long. $75^{\circ} 39' 57''$.
Near Farmington. Driven observation water table well in sand of Pleistocene age.
Diameter 1 inch, depth 18.1 feet. Well point 16.1 - 18.1 feet. Lsd about 55' above
msl. MP top of casing at lsd. Highest water level 6.61 feet below lsd, March 25,
1964; lowest 14.94 feet below lsd, Jan. 6, 1966. Records available 1962-1966.

Date	Water Level	Date	Water Level	Date	Water Level	Date	Water Level
<u>1962</u>		<u>1964</u>		<u>1965</u>		<u>1966</u>	
Aug. 24	12.97	Jan. 23	10.98	Jan. 4	14.18	Jan. 6	14.94
Sept. 12	13.45	Feb. 18	8.12	Feb. 18	12.13	Mar. 16	13.76
Oct. 12	14.04	Mar. 25	6.61	Mar. 4	11.86	May 3	12.97
Nov. 13	14.52	Apr. 23	7.22	Apr. 28	10.23	June 6	11.15
<u>1963</u>		May 5	8.08	June 2	11.49		
Jan. 3	14.10	19	8.88	July 16	12.90		
Feb. 15	12.98	June 16	10.22	Aug. 27	13.34		
Mar. 13	9.77	Aug. 17	12.86	Sept. 21	13.74		
Apr. 18	9.24	Sept. 8	13.54	Oct. 25	14.09		
May 15	10.93	Oct. 7	14.12	Nov. 4	14.26		
June 21	11.05	Nov. 9	14.55	Dec. 6	14.70		
July 15	14.32	Dec. 2	14.73				
Aug. 13	12.38						
Sept. 5	13.14						
Oct. 3	13.62						
Dec. 3	13.30						

Md 22-1. Delaware State Highway Department. Lat. $38^{\circ} 53' 10''$, long. $75^{\circ} 33' 15''$. Near Harrington. Driven observation water table well in sand of Pleistocene age. Diameter 1 inch, depth 17.2 feet. Well point 14.2 - 17.2 feet. Lsd, about 58 feet above msl. MP, top of casing at lsd. Highest water level 1.83 feet below lsd, March 21, 1963; lowest 11.14 feet below lsd, Jan. 6, 1966. Records available: 1962-1966.

Date	Water Level	Date	Water Level	Date	Water Level	Date	Water Level
<u>1962</u>		<u>1964</u>		<u>1965</u>		<u>1966</u>	
Aug. 24	8.34	Jan. 23	3.88	Jan. 4	9.14	Jan. 6	11.14
Sept. 14	8.98	Feb. 18	2.45	Feb. 6	5.98	Mar. 16	8.43
Oct. 12	9.56	Mar. 25	1.97	Mar. 4	5.62	May 3	5.66
Nov. 13	10.00	Apr. 23	2.71	Apr. 28	4.56	June 6	5.70
<u>1963</u>		May 5	3.05	June 2	6.60		
Jan. 23	5.88	20	4.49	July 19	8.59		
Feb. 14	4.98	June 16	6.64	Aug. 27	9.35		
Mar. 21	1.83	Aug. 17	9.11	Sept. 21	9.95		
Apr. 18	4.01	Sept. 8	9.09	Oct. 25	10.46		
May 15	5.56	Oct. 5	10.37	Nov. 4	10.60		
June 21	5.53	Nov. 9	10.56	Dec. 6	10.95		
July 15	7.16	Dec. 2	10.71				
Aug. 13	8.39						
Sept. 5	9.19						
Oct. 1	9.70						
Dec. 3	8.71						

Nc 45-1. Delaware State Highway Department. Lat. $38^{\circ} 46' 40''$, long. $75^{\circ} 35' 29''$.
 Near Greenwood. Driven observation water table well in sand of Pleistocene age.
 Diameter 1 inch, depth 15.45 feet. Well point 12.95 - 15.45 feet. Lsd about 43 feet
 above msl. MP 1.05 feet above lsd. Highest water level 8.90 feet below lsd, Feb. 21,
 1964; lowest 14.00 feet below lsd, Sept. 10, 1963. Records available 1952 - 1966.

Date	Water Level	Date	Water Level	Date	Water Level	Date	Water Level
<u>1962</u>		<u>1964</u>		<u>1965</u>		<u>1966</u>	
Aug. 24	12.17	Jan. 23	9.65	Jan. 8	11.65	Jan. 6	12.64
Sept. 14	12.45	Feb. 21	8.90	Feb. 18	10.50	Mar. 16	11.19
Oct. 15	12.70	Mar. 25	9.25	Mar. 4	10.87	Apr. 26	11.17
Nov. 13	12.44	Apr. 23	9.56	Apr. 28	10.64	June 8	10.76
<u>1963</u>		May 5	10.03	June 2	11.59		
Jan. 4	11.22	19	10.57	July 16	12.68		
Feb. 15	11.76	June 16	11.56	Aug. 12	12.04		
Mar. 22	---	Aug. 17	12.70	27	11.73		
Apr. 19	---	Sept. 9	13.07	Sept. 21	11.89		
May 15	12.30	Oct. 5	12.60	Oct. 23	12.30		
July 11	12.88	Nov. 9	12.58	Nov. 4	12.35		
Aug. 13	13.53	Dec. 2	12.47	Dec. 7	12.54		
Sept. 10	14.00						
Oct. 3	12.59						
Nov. 15	12.24						

Ng 11-1. Delaware State Highway Department. Lat. $38^{\circ} 49' 55''$, long. $75^{\circ} 18' 29''$. Near Milton. Driven observation water table well in sand of Pleistocene age. Diameter 1 inch, depth 19.1 feet. Well point 17.1 - 19.1 feet. Lsd, about 24 feet above msl. MP top of casing at lsd. Highest water level 9.36 feet below lsd April 23, 1964; lowest 14.64 feet below lsd, Jan. 7, 1966. Records available: 1962-1966

Date	Water Level	Date	Water Level	Date	Water Level	Date	Water Level
<u>1962</u>		<u>1964</u>		<u>1965</u>		<u>1966</u>	
Aug. 24	12.31	Jan. 23	11.84	Jan. 6	14.03	Jan. 7	14.64
Sept. 25	12.90	Feb. 24	10.23	Feb. 18	12.68	Mar. 21	13.16
Oct. 16	13.33	Mar. 25	9.77	Mar. 4	12.58	Apr. 29	12.98
<u>1963</u>		Apr. 23	9.36	Apr. 28	12.12	June 9	12.39
Jan. 23	12.62	May 3	9.66	June 2	12.61		
Feb. 13	12.04	19	10.10	July 15	13.33		
Mar. 19	10.60	June 16	11.09	Aug. 27	13.65		
Apr. 17	10.50	Aug. 7	12.62	Sept. 22	13.88		
May 14	11.38	Sept. 8	13.36	Oct. 24	14.30		
June 19	12.19	Oct. 5	13.68	Nov. 8	14.29		
July 10	12.68	Nov. 2	13.99	Dec. 7	14.52		
Aug. 12	13.35	Dec. 2	14.17				
Sept. 10	13.83						
Oct. 10	14.03						
Nov. 15	14.02						

Of 52-2. Delaware State Highway Department. Lat. $38^{\circ} 40' 56''$, long. $75^{\circ} 23' 47''$. Near Georgetown. Driven observation water table well in sand of Pleistocene age. Diameter 1 inch, depth 17.2 feet. Well point 15.2 - 17.2 feet. Lsd, about 49 feet above msl. MP, top of casing at lsd. Highest water level 0 feet below lsd, March 20, 1963; lowest 8.00 feet below lsd, Jan, 7, 1966. Records available 1962-1966.

Date	Water Level	Date	Water Level	Date	Water Level	Date	Water Level
<u>1962</u>		<u>1964</u>		<u>1965</u>		<u>1966</u>	
Aug. 24	6.24	Jan. 23	1.57	Jan. 6	6.51	Jan. 7	8.00
Sept. 25	6.75	Feb. 24	0.65	Feb. 18	3.09	Mar. 21	4.97
Oct. 16	7.48	Mar. 25	0.34	Mar. 4	3.51	Apr. 29	3.84
Nov. 20	7.39	Apr. 23	0.89	Apr. 28	2.53	June 9	3.10
<u>1963</u>		May 3	1.23	June 2	4.46		
Jan. 23	4.34	May 19	2.84	July 15	4.95		
Feb. 13	3.82	June 16	4.62	Aug. 27	5.39		
Mar. 20	0	Aug. 17	6.58	Sept. 22	6.24		
Apr. 17	2.58	Sept. 8	7.38	Oct. 24	7.03		
May 14	3.63	Oct. 5	7.13	Nov. 8	7.28		
June 19	3.60	Nov. 2	7.27	Dec. 7	7.75		
July 10	4.79	Dec. 2	7.41				
Aug. 12	6.09						
Sept. 10	7.09						
Oct. 9	7.38						
Nov. 15	7.28						

Qe 44-1. State Highway Department. Lat. $38^{\circ} 31' 39''$. long. $75^{\circ} 26' 02''$. Near Trap Pond. Driven observation water table well in sand of Pleistocene age. Diameter 1 inch, depth 25.0 feet. Well point 22 - 23 feet. Lsd, about 50 feet above msl. MP top of casing at lsd. Highest water level 5.07 feet below lsd, March 25, 1964; lowest, 12.18 feet below lsd, Oct. 16, 1962 and on Sept. 8, 1964. Records available: 1962-1966.

Date	Water Level	Date	Water Level	Date	Water Level	Date	Water Level
<u>1962</u>		<u>1964</u>		<u>1965</u>		<u>1966</u>	
Aug. 24	11.29	Jan. 23	5.58	Jan. 8	9.05	Jan. 11	11.12
Sept. 18	11.99	Feb. 24	5.33	Feb. 18	6.83	Mar. 18	7.32
Oct. 16	12.18	Mar. 25	5.07	Mar. 4	7.38	Apr. 26	7.11
Nov. 19	11.32	Apr. 23	5.36	Apr. 28	6.81	June 8	6.97
<u>1963</u>		May 5	6.17	June 2	9.04		
Jan. 23	7.12	20	7.40	July 19	9.09		
Feb. 25	7.02	June 16	9.37	Aug. 27	8.26		
Mar. 20	4.99	Aug. 17	11.57	Sept. 22	9.64		
Apr. 16	7.47	Sept. 8	12.18	Oct. 23	10.30		
May 13	7.89	Oct. 5	11.14	Nov. 8	10.62		
June 17	7.13	Nov. 2	10.75	Dec. 7	11.09		
July 10	Not Read	Dec. 2	10.39				
Aug. 12	10.64						
Sept. 10	11.47						
Oct. 9	11.32						
Nov. 15	10.49						

CONCLUSIONS

Water level data included in this report indicate that, on a state-wide basis, ground-water levels in Delaware, for areas of little pumping, have not dropped substantially during the last four years. Data from one and possibly two wells indicate that a drop in levels of between three and four feet did occur in two wells between 1960 and 1962. Recovery to pre-1960 levels has apparently not yet taken place in at least one of these wells. Several factors should be considered, however, before applying these findings too broadly or using them as a standard for future predictions.

(1) Except for one well (Nc 45-1) the records in this report are not of sufficient length to determine any long term trends. It is possible that levels in presently used wells could have showed the same drop around 1961 as did the levels in well Nc 45-1. However, lack of records prior to 1962 makes this difficult to confirm. Moreover, data through 1961 for wells discontinued at the end of 1961 do not show this drop. Ground-water response to a drought, neglecting seasonal change in well levels, usually lags considerably behind surface water response. An over-all change in levels may take months or possibly years to be detected. Data for the rest of 1966, when they are available will probably have an influence on the general record.

(2) Owners of shallow wells have indeed, in some instances, experienced supply difficulties. In some cases, such wells were located in water-poor areas originally, or, may have been affected by construction projects or pumping of nearby wells.

(3) In the last few years some municipalities and industries have experienced difficulties in meeting demands. The problem is often due to increased population and increased demand for water during a period when local recharge is naturally deficient.

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