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In cooperation with the Chester County Water Resources Authority

Drought-Trigger Ground-Water Levels in Chester County, Pennsylvania, for the Period of Record Ending May 2006

Data Series 292

U.S. Department of the Interior
U.S. Geological Survey

Cover. View of Tributary to Trout Creek, Chester County, Pennsylvania, summer 2007.
(Photograph by Kirk E. White, U.S. Geological Survey).

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Conversion Factors

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)

Drought-Trigger Ground-Water Levels in Chester County, Pennsylvania, for the Period of Record Ending May 2006

By Peter J. Cinotto

Abstract

This report presents the results of a study by the U.S. Geological Survey (USGS), in cooperation with the Chester County Water Resources Authority (CCWRA), to update the drought-trigger water levels for the Chester County observation-well network. The Chester County observation-well network was established in 1973 through a cooperative agreement between the CCWRA and the USGS to monitor local ground-water levels and trends and to determine drought conditions.

In 1990 and again in 1997, drought-warning and drought-emergency water-level triggers were determined for the majority of wells in the existing Chester County observation-well network of 23 wells. Since 1997, the Chester County observation-well network expanded to 29 wells, some of the original wells were destroyed, and additional monthly water-level observations were made to allow for better statistical relations. Because of these changes, new statistics for water-level triggers were required.

For this study, 19 of the 29 wells in the observation-well network were used to compute drought-trigger water levels. An additional "drought-watch water-level trigger" category was developed to make the Chester County drought-trigger water-level categories consistent with those implemented by the Pennsylvania Department of Environmental Protection (PaDEP). The three drought-trigger water-level categories, as defined by PaDEP are 1) "drought watch" when at the 75th-percentile level; 2) "drought warning" when at the 90th-percentile level; and 3) "drought emergency" when at the 95th-percentile level.

A revised methodology, resulting from longer periods of record representing ground-water and climatic conditions and changes in local water use, has resulted in some observed differences in drought-trigger water levels. A comparison of current drought-trigger water levels to those calculated in 1997 shows the largest mean annual change in percentile values was in northeastern Chester County. In this northeastern region, the average 90th-percentile water levels changed by as much as 1.84 feet (17.5 percent) from those determined in 1997. Other observation wells in the county generally exhibited a smaller mean annual change in percentile values; a typical change was less than 0.5 foot. While most revisions in the drought-trigger water levels generally can be attributed to different methodology and (or) the additional years of data collected under existing climatic conditions, anthropogenic influences, such as the cessation of local pumping stresses, also were shown to cause changes in the drought-trigger water levels determined in this study.

Introduction

In 1990, a set of monthly drought-trigger water levels were developed for wells in the Chester County observation-well network with the exception of wells CH-89 and CH-2561, which were affected by nearby quarries (Sloto, 1991). These same monthly drought-trigger water levels were updated in 1997 (using data collected through December 1996) so that more recent climatic influences would be reflected in the defining statistics (Schreffler, 1997). This study by the U.S. Geological Survey (USGS), in cooperation with the Chester County Water Resources Authority (CCWRA), began in 2006 to update the drought-trigger water levels for the Chester County observation-well network with data through May 2006.

Purpose and Scope

This study updates previously developed drought-trigger water levels, further strengthens the statistical relations by the addition of recent data (through May 2006), and computes additional drought-trigger water-level categories to coincide with those implemented by the Pennsylvania Department of Environmental Protection (PaDEP). Wells throughout Chester County meeting established criteria were included in the analysis.

Overview of the Chester County Observation-Well Network

The Chester County observation-well network was established in 1973 and currently (2007) consists of 29 wells (table 1 and fig. 1). These 29 wells are distributed throughout the county in various geologic units and are used to assess natural and (or) anthropogenic influences that cause fluctuations in ground-water levels. Water levels are measured monthly, except at well CH-10, which is also part of a statewide ground-water observation-well network, where water levels are recorded on an hourly basis.

Table 1. Wells in the Chester County, Pennsylvania, observation-well network as of May 2006.

Well number	Type of bedrock in which wells are completed	Well depth, in feet	Year measurements started	Period of record for analysis
CH-2	Gneiss	15	1973	10/73-5/06
CH-10	Carbonate rock	34	1951	8/51-5/06
CH-12	Gneiss	38	1973	10/73-5/06
CH-38	Schist, phyllite, and quartzite	18	1974	9/74-5/06
CH-89	Carbonate rock	265	1988	No analysis
CH-210	Carbonate rock	600	1978	6/78-5/06
CH-254	Schist, phyllite, and quartzite	250	1987	1/87-5/06
CH-1201	Carbonate rock	83	1973	10/73-5/06
CH-1229	Gneiss	165	1974	2/74-5/06
CH-1247	Gneiss	75	1973	12/73-5/06
CH-1387	Gneiss	159	1974	7/74-5/06
CH-1571	Sandstone and shale	16	1974	6/74-5/06
CH-1921	Schist, phyllite, and quartzite	65	1974	[1]8/74-5/06
CH-2273	Gneiss	298	1975	3/75-5/06
CH-2313	Carbonate rock	507	1978	4/78-5/06
CH-2328	Gneiss	323	1975	4/75-5/06
CH-2456	Gneiss	225	1982	2/82-5/06
CH-2457	Schist, phyllite, and quartzite	285	1982	[1]1/87-5/06
CH-2561	Carbonate rock	240	1984	No analysis
CH-2584	Carbonate rock	Not available	2002	No analysis
CH-2663	Carbonate rock	150	1984	1/84-5/06
CH-3289	Carbonate rock	202	1988	4/88-5/06
CH-5422	Schist, phyllite, and quartzite	49	2000	No analysis
CH-6513	Sandstone and shale	Not available	2002	No analysis
CH-6516	Gneiss	100	2001	No analysis
CH-6517	Quartzite	Not available	2001	No analysis
CH-6518	Schist, phyllite, and quartzite	37	2001	No analysis
CH-6519	Schist, phyllite, and quartzite	400	2001	No analysis
CH-7007	Gneiss	Not available	2001	No analysis

[1]Only post-pumping data used.

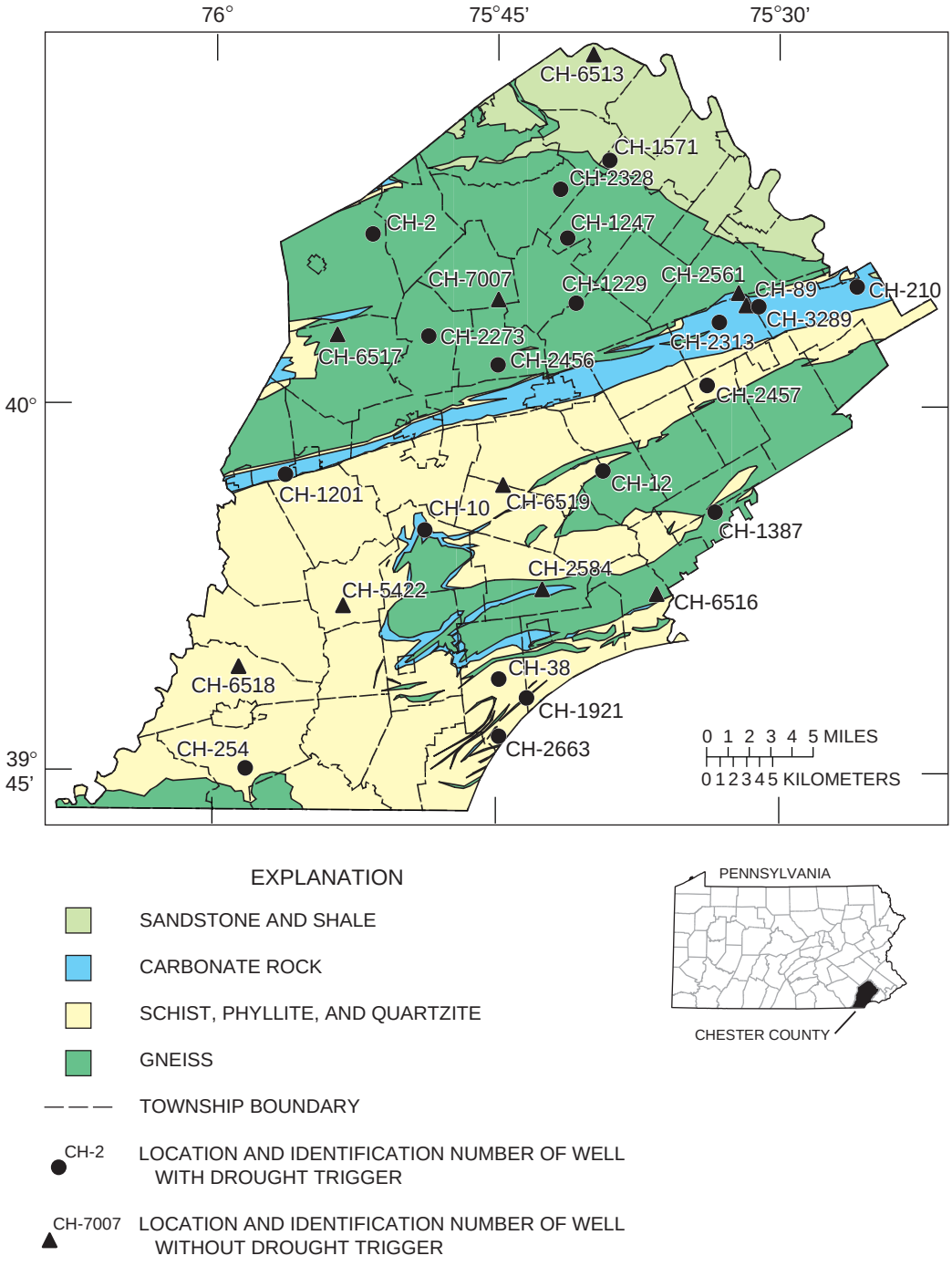

Figure 1. Location of wells in the Chester County observation-well network, Pennsylvania.

Water-level measurements from these wells provide water-resource managers with the ability to apply ground-water data to decisions regarding drought conditions, to monitor long-term trends in ground-water levels, and to gauge the effects of anthropogenic influences on ground-water levels. Most wells in the network assess natural fluctuations in water levels; however, wells CH-89 and CH-2561 are monitored to gauge the effects of pumping by nearby quarries.

With the exception of well CH-10, as noted previously, ground-water levels usually are measured during the middle of each month over a 1- to 2-day period, allowing for comparison of water levels among wells in the observation-well network. To measure the water level in wells, a measuring tape that detects the water surface is lowered down the well (fig. 2). The water level is the distance between the water surface and the land surface (depth from land surface) and is reported in feet below land surface. Artesian conditions are measured in the same manner but are noted by a negative (-) sign.

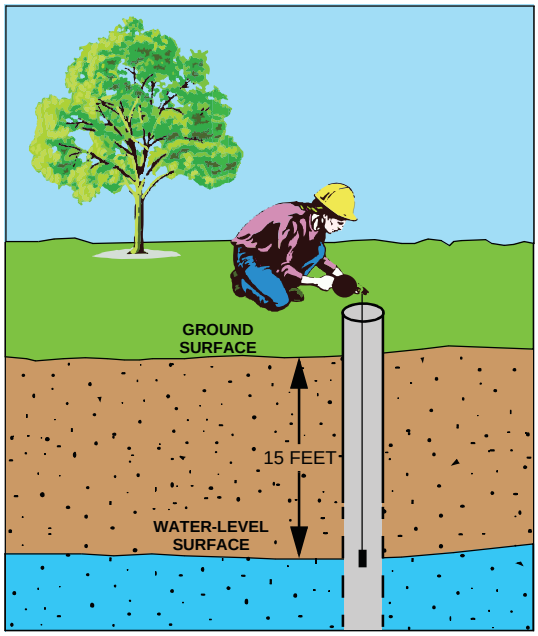

Figure 2. Hydrologic technician making a water-level measurement in an observation well (from Schreffler, 1997).

Methods for Determination of Drought-Trigger Water Levels

The monthly drought-trigger water levels used in 1990 by Sloto and again in 1997 by Schreffler included drought-warning and drought-emergency water-level triggers; by definition, these drought triggers were the same, respectively, as the drought-watch (75th percentile) and drought-warning (90th percentile) triggers used in the statewide ground-water observation-well network by the PaDEP (Pennsylvania Department of Environmental Protection, 2006). For this study, the definitions for monthly drought-trigger water levels established for the Chester County observation-well network will be identical to those defined for the PaDEP statewide observation-well network and will include the median, drought-watch (75th percentile), drought-warning (90th percentile), and drought-emergency (95th percentile) water-level triggers.

The previous studies conducted by Sloto (1991) and Schreffler (1997) were limited due to the large percentage of observation wells with short periods of record. This lack of data resulted in some data sets that were not well suited for direct analysis and, consequently, required that water-level data in certain observation wells be related to a long-term index well in order to estimate drought-trigger water levels. Under certain circumstances, this regression method, while often required, may lead to errors. A primary reason for the potential error in this regression method is the potential for differences in hydrologic response between wells in different hydrogeologic settings; in effect, some wells respond to recharge more quickly than others because the surrounding rocks, soil, and surface cover transmit water to and through the aquifer system more efficiently. This difference in hydrologic response may be consistent enough to provide a fairly strong relation between two wells when based only on discrete monthly measurements; however, the slope of the regression line that relates the two wells may not be totally accurate at any point in time because of the relative lag in response of a given well. Small changes in the slope of the regression line relating two wells can have the effect of under- or over-estimating peak values and can cause potential errors in the determination of percentiles; this can, consequently, cause errors in the estimated drought-trigger water levels.

To determine monthly drought-trigger water levels for specific wells in the Chester County observation-well network for this study, it was determined that at least 15 years of monthly water-level measurements must have been collected from a well. During the required 15-year period, the hydrologic properties of the well must have remained stable, and the well must not have been affected by outside factors, such as pumping stress. Nineteen of 29 possible wells in the Chester County observation-well network met these requirements; these wells are CH-2, CH-10, CH-12, CH-38, CH-210, CH-254, CH-1201, CH-1229, CH-1247, CH-1387, CH-1571, CH-1921, CH-2273, CH-2313, CH-2328, CH-2456, CH-2457, CH-2663, and CH-3289. Wells within the Chester County observation-well

network for which drought-trigger water levels could not be determined are presented in table 2.

For each of the 19 selected wells, the monthly water-level measurements were entered into a Microsoft Excel 2002 spreadsheet with which the selected percentages equal to the drought thresholds were determined. Data from wells with periods of continuous record were edited to include only one water-level measurement per month to eliminate any analytical bias resulting from more data representing drier or wetter periods. The water level collected closest to the 20th of the month was selected for the analysis. In the case of CH-10, when continuous record was available, the mean daily value on the 20th of the month was used. The median water level, drought-watch water level, drought-warning water level, and drought-emergency water level were then chosen to be the 50th percentile, 75th percentile, 90th percentile, and 95th percentile, respectively, of the water-level measurements. These percentiles relate the percentage of the time the water level measured in a specific well was above a certain level during the period of record. For example, the 75th percentile of ranked measurements means that over the entire period of record the water level was higher than that level 75 percent of the time and, conversely, was lower than that level 25 percent of the time.

Use of Drought-Trigger Water Levels

Drought-trigger water levels provide Chester County water-resource managers with an effective alert system for impending drought conditions and also with an effective way to monitor the duration and severity of an existing drought. This information allows water-resource managers to be proactive in their management approach and to begin to conserve water and take appropriate actions prior to any reduction in the availability of water for critical uses. For example, the restricted use of water for nonessential uses (such as washing cars) early in a drought can help ensure ample supplies of water for essential uses (such as drinking water) should the drought continue. Additionally, internet distribution of county water levels and associated drought triggers serves as a mechanism for educating and alerting the public about the condition of ground-water resources.

Drought-Trigger Water Levels for Wells in the Chester County Observation-Well Network

The monthly median, drought-watch, drought-warning, and drought-emergency water levels for the 19 wells in the Chester County observation-well network are shown in tables 3 through 6, respectively. For example, if the water level in well CH-1387 measures 35.9 ft below land surface on July 15th of an arbitrary year, this value would then classify the well as being within the range of a “drought-warning.” It must be noted that water-resource managers consider not just ground-water levels but the response of multiple indicators that include streamflow, precipitation, reservoir storage, and soil moisture in the determination of a drought condition.

Table 2. Wells in the Chester County observation-well network, Pennsylvania, for which drought-trigger water levels could not be determined.

[bls, below land surface]

Well number	Reason for exclusion from drought-trigger determination
CH-28	CH-28 was destroyed and consequently removed from observation-well network
CH-89	Quarry pumping affects water levels in CH-89
CH-249	CH-249 was destroyed and consequently removed from observation-well network
CH-2561	Quarry pumping affects water levels in CH-2561
CH-2584	Insufficient data; CH-2584 added to network in 2002
CH-5422	Insufficient data; CH-5422 added to network in 2000
CH-6513	Insufficient data; CH-6513 added to network in 2002
CH-6516	Well is artesian with insufficient data; CH-6516 added to network in 2001
CH-6517	Insufficient data; CH-6517 added to network in 2001
CH-6518	Insufficient data; CH-6518 added to network in 2001
CH-6519	Fracture opened at approximately 72 feet bls during 2004, changing the hydrologic character of the well
CH-7007	Insufficient data; CH-7007 added to network in 2005

Table 3. Monthly median water levels (50th percentile) for wells with at least 15 years of measurements in the Chester County observation-well network, Pennsylvania, period of record ending May 2006.

[A negative value indicates a water level that is above the land surface]

Well	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
CH-2	8.63	8.31	8.12	8.01	8.48	8.89	9.47	10.09	10.65	10.24	10.18	8.54
CH-10	12.67	12.28	11.62	11.58	12.51	12.98	13.52	13.93	14.32	14.44	14.13	13.07
CH-12	37.08	36.31	35.45	33.57	33.85	34.56	35.46	36.06	36.50	37.30	38.25	37.50
CH-38	7.34	6.78	6.80	6.03	7.30	7.51	9.05	10.07	10.38	11.24	10.79	9.00
CH-210	20.45	19.50	19.30	18.84	19.74	21.00	22.07	22.98	23.20	23.83	23.15	21.24
CH-254	23.89	23.07	22.23	21.00	20.95	21.00	21.66	22.36	22.44	22.17	23.13	23.81
CH-1201	5.16	5.07	4.87	4.72	5.13	5.33	5.78	6.01	6.18	6.22	6.13	5.66
CH-1229	37.64	36.65	35.09	34.33	34.92	35.84	37.10	38.50	39.48	39.86	38.95	37.95
CH-1247	30.46	29.22	28.45	27.77	28.10	28.49	29.22	29.86	30.70	31.30	32.35	31.22
CH-1387	33.61	33.11	32.44	32.29	32.09	32.95	34.06	34.53	35.19	35.39	35.31	34.88
CH-1571	6.40	6.03	5.72	5.77	6.34	7.25	8.90	9.96	10.25	9.95	8.27	6.50
CH-1921	45.71	44.72	44.58	42.11	40.88	40.29	40.73	41.89	42.95	43.84	44.63	44.98
CH-2273	-.36	-.88	-1.52	-2.02	-1.37	-.97	-.24	.51	1.01	1.29	.80	-.09
CH-2313	9.09	6.83	5.06	4.14	4.86	5.54	7.50	9.11	10.12	11.22	11.36	9.50
CH-2328	2.19	1.96	1.59	1.62	1.74	2.07	2.68	3.04	3.69	3.37	2.93	2.46
CH-2456	19.36	19.29	19.10	19.00	19.24	19.45	19.71	19.89	19.94	19.99	19.70	19.56
CH-2457	19.42	17.71	17.24	16.83	18.08	19.02	20.64	21.60	21.92	22.09	21.59	19.52
CH-2663	10.04	9.97	9.94	9.90	10.05	10.39	10.58	10.68	10.67	10.60	10.44	10.03
CH-3289	20.20	20.00	19.41	18.69	20.95	21.93	23.65	24.76	25.24	24.51	23.23	20.23

Table 4. Monthly drought-watch water levels (75th percentile) for wells with at least 15 years of measurements in the Chester County observation-well network, Pennsylvania, period of record ending May 2006.

[A negative value indicates a water level that is above the land surface]

Well	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
CH-2	9.64	9.27	8.57	8.52	9.06	9.57	10.21	10.71	11.50	11.23	11.08	9.88
CH-10	13.68	13.12	12.53	12.38	13.49	14.12	14.40	14.80	14.99	15.10	14.80	14.20
CH-12	[1]38.50	[1]38.50	36.92	36.25	36.11	35.76	36.43	36.95	37.52	[1]38.50	[1]38.50	[1]38.50
CH-38	10.17	8.62	7.35	7.70	8.10	8.84	10.20	11.41	12.56	12.35	12.16	11.12
CH-210	21.72	20.96	20.26	20.01	20.87	21.63	22.42	23.80	25.07	25.10	24.15	21.94
CH-254	25.30	25.11	24.71	24.04	23.44	23.95	23.40	23.96	24.24	24.84	25.36	25.37
CH-1201	6.09	5.73	5.44	5.35	5.60	6.00	6.29	6.57	6.79	6.65	6.67	6.12
CH-1229	39.52	37.26	38.10	36.23	36.64	38.05	38.85	39.87	40.16	40.87	41.01	39.84
CH-1247	31.79	31.50	29.28	28.80	28.47	29.25	30.22	31.23	32.23	32.47	33.16	32.45
CH-1387	35.81	34.64	34.18	33.94	33.67	34.66	35.05	35.46	36.13	36.25	36.32	36.01
CH-1571	7.00	6.81	6.09	6.06	6.70	8.64	10.04	10.44	10.56	10.51	9.80	7.79
CH-1921	47.05	47.03	45.80	44.11	43.75	44.65	44.80	45.15	45.89	46.35	46.58	47.06
CH-2273	.98	.23	-.83	-.91	-.55	-.37	.79	1.75	2.19	2.65	2.47	1.37
CH-2313	10.85	9.06	7.35	6.10	7.42	6.87	9.07	10.68	11.91	12.57	12.71	11.52
CH-2328	3.10	2.45	2.03	1.96	2.26	2.61	3.14	3.98	4.54	4.50	4.25	3.00
CH-2456	19.77	19.52	19.39	19.27	19.39	19.63	19.95	20.14	20.35	20.29	20.06	19.98
CH-2457	20.59	18.99	18.37	18.12	19.22	20.14	21.22	22.12	22.72	22.60	22.36	21.09
CH-2663	10.45	10.32	10.05	10.14	10.39	10.45	10.74	10.82	10.91	10.82	10.74	10.68
CH-3289	21.04	21.00	20.50	20.35	21.41	22.50	23.99	26.81	27.93	26.06	24.67	22.22

[1]Well dry.

Table 5. Monthly drought-warning water levels (90th percentile) for wells with at least 15 years of measurements in the Chester County observation-well network, Pennsylvania, period of record ending May 2006.

Well	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
CH-2	10.65	10.16	9.44	9.39	9.70	10.70	11.29	12.10	12.07	12.42	12.05	11.93
CH-10	14.57	13.72	13.45	13.40	14.11	14.75	15.03	15.22	15.45	15.39	15.44	14.82
CH-12	[1]38.50	[1]38.50	[1]38.50	38.11	37.29	37.84	[1]38.50	[1]38.50	[1]38.50	[1]38.50	[1]38.50	[1]38.50
CH-38	12.93	11.53	10.13	8.60	9.49	10.29	11.06	12.20	12.79	13.52	14.13	14.45
CH-210	24.77	22.58	22.37	22.17	21.86	22.99	24.26	24.84	25.79	25.99	25.21	25.06
CH-254	27.51	26.55	26.27	25.30	25.09	24.79	25.25	26.12	26.50	27.12	27.56	26.63
CH-1201	7.00	6.29	6.04	5.83	6.02	6.28	6.57	7.20	7.30	7.05	6.91	6.76
CH-1229	41.18	40.22	39.51	38.64	38.29	39.72	40.60	41.09	41.07	41.69	41.62	41.43
CH-1247	34.02	31.99	31.50	31.15	30.60	30.52	31.42	32.43	33.29	33.89	33.80	33.33
CH-1387	36.45	35.78	35.81	35.07	35.46	35.71	35.76	36.63	36.63	37.58	37.03	36.76
CH-1571	8.78	7.27	6.47	6.64	7.12	8.84	10.12	10.60	10.75	10.82	10.74	10.00
CH-1921	47.95	47.96	47.56	46.73	45.99	46.43	46.81	47.61	48.47	48.80	48.00	48.26
CH-2273	3.75	2.60	2.00	1.05	1.20	1.54	1.56	2.95	3.31	3.96	3.62	3.56
CH-2313	12.41	11.82	11.07	9.32	9.35	10.47	11.70	13.62	14.17	14.73	15.08	14.47
CH-2328	4.04	3.64	3.27	2.58	2.87	3.62	3.83	4.75	5.09	5.38	4.78	5.03
CH-2456	19.95	19.86	19.67	19.50	19.59	19.79	20.19	20.38	20.59	20.61	20.27	20.25
CH-2457	21.29	20.35	19.20	19.48	19.97	21.15	21.82	22.91	23.10	22.96	23.46	22.56
CH-2663	10.89	10.45	10.29	10.61	10.55	10.72	10.92	11.08	11.07	10.95	10.99	10.94
CH-3289	21.94	22.29	21.37	21.65	21.63	23.16	25.56	29.22	30.46	30.32	27.03	26.75

[1]Well dry.

Table 6. Monthly drought-emergency water levels (95th percentile) for wells with at least 15 years of measurements in the Chester County observation-well network, Pennsylvania, period of record ending May 2006.

Well	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
CH-2	11.89	11.15	10.05	9.89	9.86	10.83	12.02	12.52	12.97	12.89	12.52	12.86
CH-10	15.10	14.10	14.03	14.05	14.70	14.90	15.29	15.61	15.82	15.55	15.63	15.00
CH-12	[1]38.50	[1]38.50	[1]38.50	[1]38.50	37.95	[1]38.50	[1]38.50	[1]38.50	[1]38.50	[1]38.50	[1]38.50	[1]38.50
CH-38	14.24	14.20	12.84	11.54	10.75	11.25	11.91	12.27	13.26	13.86	14.29	14.98
CH-210	26.29	25.02	24.27	23.10	22.18	23.90	25.29	26.17	26.19	26.24	26.60	27.14
CH-254	28.52	27.58	27.16	26.43	25.82	26.22	26.57	27.23	27.55	28.04	28.08	28.60
CH-1201	7.20	6.44	6.40	6.35	6.73	6.90	7.23	7.41	7.80	7.08	6.92	6.83
CH-1229	41.62	41.63	40.75	40.29	39.14	39.95	41.63	42.15	41.57	42.26	42.04	41.71
CH-1247	34.50	32.91	33.53	32.60	31.26	31.03	32.30	33.13	33.69	33.96	34.64	34.16
CH-1387	37.27	37.13	36.72	36.37	35.69	36.38	36.29	37.47	37.57	38.50	37.17	37.14
CH-1571	10.74	9.37	6.83	7.01	7.35	9.06	10.26	10.68	11.09	11.11	11.04	10.94
CH-1921	48.85	48.31	47.83	47.29	46.82	48.02	47.89	48.47	48.68	49.91	48.82	49.37
CH-2273	4.36	3.84	3.20	2.37	1.87	1.99	2.09	2.97	4.43	4.29	4.18	4.33
CH-2313	12.76	12.75	11.68	10.66	9.70	11.18	12.43	14.88	15.47	15.68	15.89	15.96
CH-2328	4.94	3.96	3.94	3.80	3.72	4.02	4.64	5.33	5.70	5.47	4.97	5.24
CH-2456	21.36	20.56	19.79	19.50	19.64	19.80	20.24	20.51	20.65	20.69	20.39	20.53
CH-2457	22.01	20.92	19.52	19.78	20.21	21.30	22.11	22.96	23.55	23.17	23.57	23.56
CH-2663	11.20	10.92	10.44	10.71	10.67	10.83	11.20	11.20	11.25	11.03	11.12	11.07
CH-3289	23.58	23.37	22.06	22.09	21.88	24.35	26.42	29.66	31.39	30.95	30.32	30.15

[1]Well dry.

Comparison to Previous Studies

Differences in methodology, local water use, and changes in climatic conditions resulted in differences between the drought-trigger water levels determined by Schreffler (1997) and those determined by this study; also, Schreffler did not determine the 95th-percentile statistic in 1997. Annual mean water levels for the 75th and 90th percentiles, which are considered general indicators of water level, were determined for each of the 18 wells included in both Schreffler (1997) and this study for comparison of observed changes throughout the Chester County observation-well network. On the basis of these mean annual percentiles, the largest changes were mainly in the northeastern part of Chester County; relative changes were smaller elsewhere (table 7). Differences in the annual mean 75th-percentile water level ranged from a decline of 0.65 ft (7.3 percent) in well CH-2313 to a rise of 1.00 ft (4.6 percent) in CH-2457. Differences in the annual mean 90th-percentile water level ranged from a decline of 1.84 ft (17.5 percent) in well CH-2313 to a rise of 1.05 ft (4.7 percent) in well CH-2457. The large relative change in well CH-2457 is primarily because of the cessation of nearby pumping in 1986, which caused a rise in local water levels; the relative change in well CH-2313 is primarily because of differences in methodology. A rise in the annual mean water level indicates that the water level in a well is at a higher elevation for a specific percentile than was originally estimated and that exceedence of that drought threshold would have occurred earlier during a period of declining ground-water levels and more frequently than previous studies would suggest. A decline in annual mean water level indicates that water levels are lower for a specific percentile and that exceedence of that drought threshold would have occurred later during a period of declining ground-water levels and less frequently than previously estimated.

Annual mean water levels in table 7 generally appear to have risen between 1997 and 2006, which may be due to wetter conditions or a change in the methodology used to determine drought triggers. However, these values are intended for comparative purposes and additional statistical tests (such as the seasonal Kendall trend test) should be used to determine actual trends in local water levels.

Table 7. Comparison of historical percentiles and methods to current determinations of the annual mean 75th-percentile and 90th-percentile water levels in the Chester County observation-well network, Pennsylvania.

Well	Method used by Schreffler (1997)	Mean annual change in 75th-percentile water level (feet)[1]	Mean annual change in 90th-percentile water level (feet)[1]
CH-2	S[2]	0.00	0.10
CH-10	S	.09	.07
CH-12	S	.38	.33
CH-38	S	.04	.38
CH-210	R[3]	-.04	-.87
CH-1201	S	.14	.31
CH-1229	S	.22	.44
CH-1247	S	.19	.32
CH-1387	S	.27	.44
CH-1571	S	.03	.13
CH-1921	S	.14	.03
CH-2273	S	.11	.33
CH-2313	R	-.67	-1.84
CH-2328	S	.04	.08
CH-2456	R	.13	.08
CH-2457	R	1.00	1.05
CH-2663	R	.01	-.06
CH-3289	R	.25	-.45

[1]A negative value indicates a decline (lower) in the respective water-level percentile; a positive value indicates a rise (higher) in the water-level percentile.

[2]Percentiles determined in 1997 by statistical analysis of direct measurements.

[3]Percentiles determined in 1997 by regression analysis with a local index well (CH-10); these fields are shaded.

Summary

Monthly drought-trigger water levels were determined for 19 of the 29 wells in the Chester County observation-well network. The drought-trigger water-level categories of drought watch, drought warning, and drought emergency are consistent with the PaDEP statewide drought-management water-level categories and are used by Chester County and PaDEP officials to assess and manage water resources throughout the year. Differences in methodology, local water use, and changes in climatic conditions resulted in variations between the drought-trigger water levels that were previously published and those determined by this study. Annual means for the 75th and 90th percentiles generally increased between 1997 and 2006; however, these values are intended for comparative purposes and additional statistical test should be used to determine actual trends in local water levels.

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