Johnson, M.L., and Charles, E.G., 1997, Hydrology of the unconfined aquifer system, Salem River area: Salem River and Raccoon, Oldmans, Alloway, and Stow Creek Basins, New Jersey, 1993-94

SURFACE WATER

This section describes the surface-water system in the Salem River study area. Discharge, base-flow, and flow-duration data for streamflow-gaging stations and the results of low-flow correlations for 12 low-flow partial-record sites in the study area are presented.

Discharge at Gaging Stations

The surface-water system in the study area consists of the many tributaries, lakes, and wetland areas of the Salem River and the Raccoon, Oldmans, Alloway, and Stow Creek drainage systems. From their headwaters these five streams flow about 15 to 18 mi to the west, northwest, and southwest, and empty into the Delaware River and Delaware Bay. Discharge of water from the unconfined ground-water system contributes flow to these streams along most of the length of their channels.

At various times, the USGS has maintained four continuous-record streamflow-gaging stations in the study area (fig. 3-1): Salem River at Woodstown, N.J. (01482500), during 1940-90; Raccoon Creek near Swedesboro, N.J. (01477120), since 1966; Oldmans Creek near Woodstown, N.J. (01477500), during 1932-40; and Alloway Creek at Alloway, N.J. (01483000), during 1953-72. The minimum and maximum monthly mean discharge and the mean monthly discharge for these streamflow-gaging stations are shown in figures 3-2 through 3-5. The minimum and maximum daily discharge, the mean annual discharge, and the 30-day, 5-year and 7-day, 10-year low-flow discharges for the period of record at the three stations with the most recent data are listed in table 3-1. Low-flow data for the Oldmans Creek station are not shown because the station has only a 9-year period of record that ended more than 50 years ago.

A base-flow-separation technique described by Pettyjohn and Henning (1979) and adapted for use by the USGS by Sloto (1988) makes use of a computer program that uses three different methods to divide stream discharge into direct-runoff and base-flow components. Direct runoff consists of overland runoff and precipitation that falls directly on the stream; base flow consists of ground water that is discharged into the stream. In this study, the 3-day sliding-interval method (Sloto, 1988, p. 102) was used to perform base-flow separations. The annual mean base flow of the Salem River at Woodstown ranged from 4.2 ft^3/s in 1966 to 18 ft^3/s in 1984, with a mean of 12 ft^3/s, and on a percentage basis ranged from 48 percent of total flow in 1944 to 79 percent in 1947, with a mean of 64 percent. The annual mean base flow of Raccoon Creek near Swedesboro ranged from 18 ft^3/s in 1981 to 47 ft^3/s in 1973, with a mean of 30 ft^3/s, and from 64 percent of total flow in 1971 to 84 percent in 1992, with a mean of 73 percent. The annual mean base flow of Oldmans Creek near Woodstown ranged from 12.77 ft^3/s in 1932 to 28.85 ft^3/s in 1939, with a mean of 21.14 ft^3/s, and from 59 percent of total flow in 1940 to 80 percent in 1935, with a mean of 74 percent. For Alloway Creek at Alloway, annual mean base flow ranged from 6.6 ft^3/s in 1966 to 26.6 ft^3/s in 1972, with a mean of 16.4 ft^3/s, and from 59 percent of total flow in 1971 to 80 percent in 1965, with a mean of 70 percent. Annual mean discharges at all four streamflow-gaging stations, divided into direct runoff and base flow, are shown in figures 3-6 through 3-9.

A flow-duration curve for a stream is a cumulative-frequency curve that shows the percentage of time that any specified discharge is equaled or exceeded (Langbein and Iseri, 1960, p. 11). The shape of the curve is determined by the hydrologic and geologic characteristics of the drainage basin. A curve with a gentle slope indicates that streamflow is derived largely from a steady supply of water from storage and, therefore, varies little. Water from storage can come from the ground-water system through the steady release of water from permeable deposits in hydraulic connection with the stream, from surface water by the steady release of water from lakes and wetlands, or from a combination of the two sources. A steep curve indicates that a relatively small proportion of streamflow is from storage (negligible steady release of water from ground- and surface-water) sources, and that flow is derived largely from direct runoff and tends to be variable. A streamflow-variability index for flow-duration curves, calculated as the 20-percent-exceedance discharge divided by the 80-percent-exceedance discharge, was proposed by Miller (1966, p. 24). Miller reported that the streamflow-variability index for New Jersey streams with drainage areas greater than 25 mi^2 ranged from approximately 2 (low variability) to 20 (high variability). The streamflow-variability index for Coastal Plain streams ranged from 2.2 to 3.6 (Miller, 1966).

Flow-duration curves for the streamflow-gaging stations at Raccoon Creek near Swedesboro during water years 1967-92 and at Oldmans Creek near Woodstown during water years 1932-40 are shown in figure 3-10. The streamflow-variability indexes at these gaging stations were 2.6 and 3.0, respectively, which indicates that these streams are typical of Coastal Plain streams in that flow is relatively uniform and is derived mostly from ground-water discharge. Curves for the Salem River at Woodstown and Alloway Creek at Alloway are not presented because these streams are gaged at impoundments. The 5-percent-exceedance discharge is the discharge that is likely to be exceeded 5 percent of the time. Similarly, the 95-percent-exceedance discharge is the discharge that is likely to be exceeded 95 percent of the time. The 5-percent- and 95-percent-exceedance discharges at Raccoon Creek near Swedesboro are 99 ft^3/s and 13 ft^3/s, respectively; those for Oldmans Creek near Woodstown are 70 ft^3/s and 9 ft^3/s, respectively. The median-exceedance discharges (50 percent) are 30 ft^3/s for Raccoon Creek near Swedesboro and 21 ft^3/s for Oldmans Creek near Woodstown.

Discharge at Low-Flow Partial-Record Stations

The magnitude and frequency of streamflow at stations for which a continuous record is unavailable commonly are estimated by correlating instantaneous low-flow discharge at the low-flow partial-record station with the concurrent mean daily discharge at the streamflow-gaging station, or index station. Twelve low-flow partial-record stations in the study area were selected for use in low-flow-correlation analyses. Measured discharge values at each low-flow partial-record station were correlated with mean discharge at three index gaging stations within the study area and four index gaging stations adjacent to the study area. The locations of the index gaging stations and low-flow partial-record stations are shown in figure 3-1.

The low-flow correlations reported here were developed by using the MOVE.1 (Maintenance of Variance Extension, Type 1) method, which makes use of geometric means to eliminate the bias of ordinary-least-squares regression (Hirsch, 1982). An example of a low-flow correlation is shown in figure 3-11. The "best-fit" line, $QP_R = (0.03833)QI^{(1.1452)}$, is drawn through the data points that represent the measured discharge at the low-flow partial-record station, QP_M, plotted against the mean daily discharge at the index gaging station, QI. The equation of the best-fit line is then used to estimate, or predict, specific discharge statistics at the low-flow partial-record station, QP_R, on the basis of the values of the same discharge statistics measured at the index gaging station, QI. The low-flow partial-record stations and their associated correlation equations are shown in table 3-2.

Two statistical indicators, the correlation coefficient and the standard error of estimation, are included in table 3-2 as an indication of the accuracy of the predicted discharge. The correlation coefficient is a number from -1.0 to 1.0 that measures the strength of the linear relation between the logarithm (base 10) of the discharge at the low-flow partial-record station and that at the index gaging station. For low-flow correlations in this report, the nearer the correlation coefficient is to 1.0, the more reliable the predicted discharge, QP_R. Although the correlation coefficient typically is used to describe the linear strength of ordinary-least-squares regressions, it is computed here for comparison purposes. The standard error of estimation listed in table 3-2 was calculated for the 7-day, 10-year low-flow discharge (lowest mean discharge for a 7-day period that occurs, on average, once every 10 years) by using an equation developed specifically for MOVE.1 low-flow correlations by Thomas (Telis, 1991). This equation allows the standard error of estimation to be calculated from the standard error of prediction and the time-sampling error for the index gaging station. The nearer the value (which is a percent) is to zero, the more reliable the predicted discharge, QP_R. This indicator of reliability is calculated only for the 7-day, 10-year low-flow discharge, but also is a useful measure of reliability for other MOVE.1-predicted discharges (R.G. Reiser, U.S. Geological Survey, oral commun., 1994). For each low-flow partial-record site, the three index gaging stations for which the standard errors of estimation were lowest were selected for use in the low-flow correlation analyses.

From these correlations, the 30-day, 5-year low-flow discharge; the 7-day, 10-year low-flow discharge; and the mean annual discharge were calculated for the 12 low-flow partial-record stations. For example, to estimate the 30-day, 5-year low-flow discharge at the low-flow partial-record station Raccoon Creek at Mullica Hill (01477100) shown in figure 3-11, the 30-day, 5-year low-flow discharge at the index gaging station Maurice River at Norma (01411500), 51.9 ft^3/s, is substituted in the correlation equation and solved for the 30-day, 5-year low-flow discharge at the low-flow partial-record station (QP_R).

$$QP_R = (0.03833)\ 51.9\ ft^3/s^{(1.1452)};\ \text{and}$$

$$QP_R = 3.53\ ft^3/s\ .$$

By substituting the index-gaging-station discharge values for 7-day, 10-year low flow (37.856 ft^3/s) and mean annual flow (167 ft^3/s) in the correlation equation, the appropriate respective flows, 2.46 ft^3/s and 13.46 ft^3/s, are also estimated for the low-flow partial-record station. This same approach could be used to estimate the mean annual base flow at a low-flow partial-record station for a drought year. For example, figure 3-7 shows that the mean base flow in water year 1981 was the lowest on record for Raccoon Creek near Swedesboro (01477120). The 1981 mean base flow can be estimated for the low-flow partial-record station Major Run at Sharptown (01482530) by using the appropriate prediction equation from table 3-2, $QP_R = 0.01815\ QI^{(1.2971)}$. First, the 1981 mean base flow for the index gaging station is estimated from the bar graph (fig. 3-7) to be 18 ft^3/s. This value is substituted for QI in the prediction equation to yield a drought-year base-flow estimate of 0.77 ft^3/s for Major Run at Sharptown.

Low-flow-correlation prediction equations were developed and used to estimate discharge statistics for all low-flow partial-record stations listed in table 3-2. Mean base flow was estimated in this way only for those low-flow partial-record stations that were paired with an index gaging station within the Salem River study area.

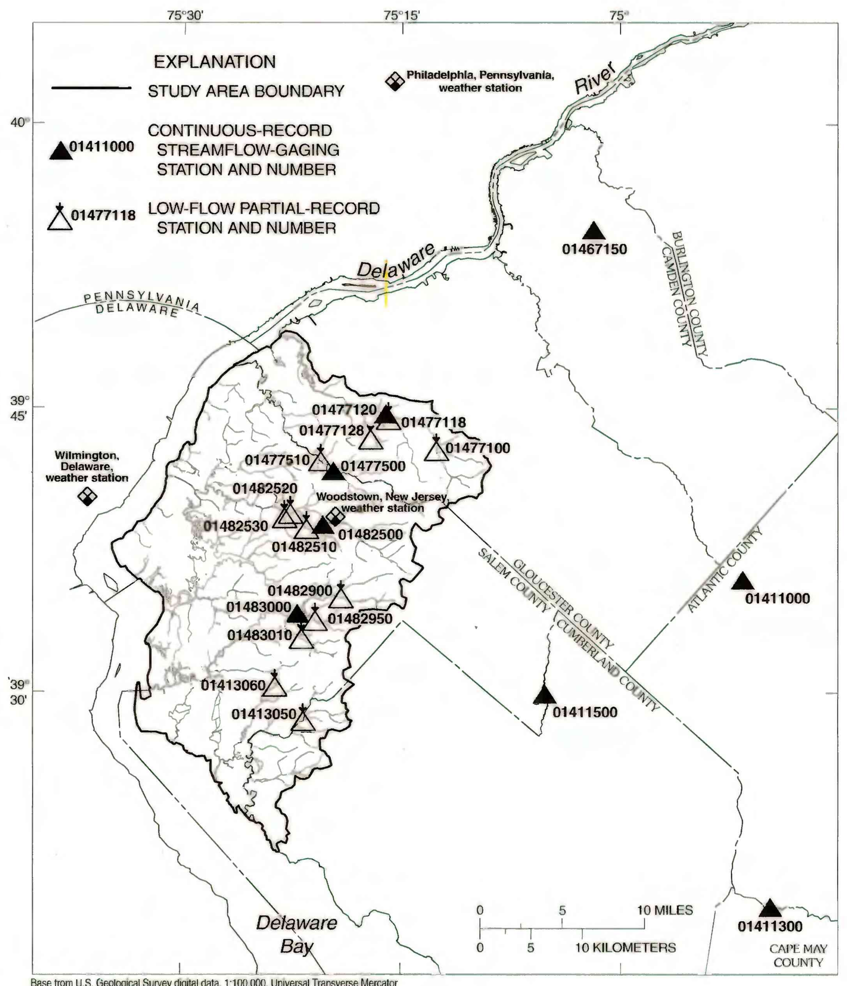


Figure 3-1. Locations of continuous-record streamflow-gaging stations, low-flow partial-record stations, and weather stations in and near the Salem River study area, New Jersey.

Table 3-1. Summary of discharge statistics for continuous-record streamflow-gaging stations in and near the Salem River study area, New Jersey
[Station locations shown in fig. 3.1.]

Streamflow-gaging-station number	Streamflow-gaging-station name	Drainage area (square miles)	Period of record	Period of record used for statistical analysis[1]	Discharge (cubic feet per second): 30-day, 5-year	7-day, 10-year	Maximum daily	Mean annual	Minimum daily
01411000	Great Egg Harbor River at Folsom, N.J.	57.1	September 1925 through September 1992	April 1926 through March 1990	28.3	22.231	1,300	86.3	15
01411300	Tuckahoe River at Head of River, N.J.	30.8	December 1969 through September 1992	April 1970 through March 1990	10.7	6.044	464	43.8	1.3
01411500	Maurice River at Norma, N.J.	112	July 1932 through September 1992	April 1933 through March 1990	51.9	37.856	5,260	167	23
01467150	Cooper River at Haddonfield, N.J.	17.0	October 1963 through September 1992	April 1964 through March 1990	12.6	8.367	1,510	35.5	1.2
01477120	Raccoon Creek near Swedesboro, N.J.	26.9	May 1966 through September 1992	April 1967 through March 1990	11.9	9.123	1,260	41.2	2.9
01482500	Salem River at Woodstown, N.J.	14.6	March through September 1940; December 1941 through January 1985; June through December 1989	April 1942 through March 1984	2.40	.633	4,460	19.3	0
01483000	Alloway Creek at Alloway, N.J.	20.3	October 1952 through September 1972	April 1953 through March 1972	1.93	0	1,860	23.7	0

[1] Low-flow statistics were calculated by using data for the climatic year. The climatic year is the 12-month period from April 1 through March 30, and is designated by the calendar year in which it begins. This period allows the entire low-water season to occur in one year.

Table 3-2. Correlation equations relating instantaneous low-flow measurements at low-flow partial-record stations to concurrent mean daily flow at continuous-record streamflow-gaging stations (index stations) in and near the Salem River study area, New Jersey
[Station locations shown in fig. 3-1; QP_R, predicted discharge at partial-record station; QI, measured discharge at index station; N.J., New Jersey; --, discharge was not calculated because either data were not calculated for the index station or there was zero flow at the index station]

Low-flow partial-record-station number	Low-flow partial-record-station name	Drainage area (square miles)	Index-gaging-station number	Number of measurements used in analysis	Correlation coefficient	Standard error of estimation for 7-day, 10-year low-flow discharge (percent)[1]	Correlation equation	Predicted discharge (QP_R) (cubic feet per second): 30-day, 5-year QP_R	7-day, 10-year QP_R	Mean annual QP_R	Mean base flow
01413050	Stow Creek at Jericho, N.J.	8.00	01411300	8	0.8787	18.27	$QP_R = 1.48762\ QI^{(0.5932)}$	6.07	4.33	14.00	--
			01477120	14	.8757	22.02	$QP_R = .12753\ QI^{(1.3250)}$	3.39	2.39	17.60	11.56
			01483000	11	.9108	28.40	$QP_R = .81346\ QI^{(0.9942)}$	1.56	--	18.93	13.13
01413060	Canton Ditch near Canton, N.J.	2.50	01411000	9	.9306	10.05	$QP_R = .01046\ QI^{(1.3169)}$	.85	.62	3.71	--
			01411500	9	.9060	14.63	$QP_R = .00865\ QI^{(1.1472)}$	.80	.56	3.07	--
			01483000	9	.9743	7.95	$QP_R = .35993\ QI^{(0.8003)}$	.61	--	4.53	3.38
01477100	Raccoon Creek at Mullica Hill, N.J.	10.1	01411000	11	.9154	12.58	$QP_R = .03162\ QI^{(1.3872)}$	3.26	2.34	15.33	--
			01411500	11	.9267	10.53	$QP_R = .03833\ QI^{(1.1452)}$	3.53	2.46	13.46	--
			01483000	9	.9736	19.64	$QP_R = 1.54487\ QI^{(0.7868)}$	2.59	--	18.65	13.96
01477118	South Branch Raccoon Creek near Mullica Hill, N.J.	8.30	01411500	11	.9403	8.77	$QP_R = .01797\ QI^{(1.1411)}$	1.63	1.14	6.18	--
			01467150	11	.9404	8.68	$QP_R = .01906\ QI^{(1.9295)}$	2.53	1.15	18.67	--
			01477120	11	.9716	5.54	$QP_R = .10859\ QI^{(1.2070)}$	2.16	1.57	9.66	6.59
01477128	Basgalore Creek near Swedesboro, N.J.	3.00	01411000	5	.9690	1.77	$QP_R = .33914\ QI^{(0.4724)}$	1.65	1.47	2.79	--
			01411500	5	.9549	3.01	$QP_R = .22108\ QI^{(0.4948)}$	1.56	1.33	2.78	--
			01477120	4	.9207	4.85	$QP_R = .51413\ QI^{(0.5059)}$	1.80	1.57	3.37	2.87
01477510	Oldmans Creek at Porches Mill, N.J.	21.0	01411000	7	.8416	20.90	$QP_R = .0112\ QI^{(1.8371)}$	5.20	3.34	40.34	--
			01411500	7	.8730	14.30	$QP_R = .02657\ QI^{(1.3825)}$	6.25	4.04	31.42	--
			01477120	8	.9270	15.26	$QP_R = .31171\ QI^{(1.2704)}$	7.25	5.17	35.11	23.46
01482510	Nichomus Run near Woodstown, N.J.	3.76	01411000	14	.9760	6.45	$QP_R = .0001418\ QI^{(2.1170)}$	.17	.10	1.78	--
			01411300	7	.9876	4.80	$QP_R = .00328\ QI^{(1.7170)}$	.19	.07	2.16	--
			01411500	14	.9700	7.98	$QP_R = .0001131\ QI^{(1.8790)}$	.19	.10	1.70	--
01482520	Salem River at Sharptown, N.J.	27.3	01411000	13	.9537	5.51	$QP_R = .12276\ QI^{(1.1189)}$	5.17	3.95	18.00	--
			01411500	13	.9619	4.60	$QP_R = .10426\ QI^{(1.0029)}$	5.47	3.99	17.67	--
			01467150	13	.9649	4.18	$QP_R = .11438\ QI^{(1.6573)}$	7.62	3.87	42.42	--
01482530	Major Run at Sharptown, N.J.	3.04	01467150	14	.9654	5.47	$QP_R = .00280\ QI^{(2.0559)}$	.51	.22	4.30	--
			01477120	14	.9580	5.38	$QP_R = .01815\ QI^{(1.2971)}$	.45	.32	2.26	1.50
			01483000	12	.9826	6.28	$QP_R = .15881\ QI^{(0.8073)}$	.27	--	2.04	1.52
01482900	Cool Run near Alloway, N.J.	4.92	01411500	9	.9379	5.23	$QP_R = .17851\ QI^{(0.6624)}$	2.44	1.98	5.30	--
			01482500	9	.9212	12.76	$QP_R = 1.21514\ QI^{(0.6048)}$	2.06	.92	7.28	5.46
			01483000	9	.9280	10.46	$QP_R = 1.52668\ QI^{(0.4586)}$	2.06	--	6.52	1.90
01482950	Cedar Brook near Alloway, N.J.	3.76	01411500	8	.9741	4.44	$QP_R = .00825\ QI^{(1.2272)}$	1.05	.71	4.40	--
			01482500	8	.9784	6.82	$QP_R = .29165\ QI^{(1.1163)}$	.77	.18	7.94	4.67
			01483000	8	.9790	8.80	$QP_R = .37285\ QI^{(0.9021)}$	.67	--	6.48	4.65
01483010	Deep Run near Alloway, N.J.	5.30	01411000	11	.8321	14.36	$QP_R = .05736\ QI^{(1.0752)}$	2.09	1.61	6.92	--
			01411500	11	.9360	5.18	$QP_R = .06784\ QI^{(0.8843)}$	2.23	1.69	6.27	--
			01477120	11	.7697	20.66	$QP_R = .07801\ QI^{(1.3591)}$	2.26	1.57	12.21	7.94

[1] Calculated for the 7-day, 10-year low-flow discharge by using an equation developed specifically for MOVE.1 low-flow correlations by Thomas (Telis, 1991). This indicator of reliability is calculated only for the 7-day, 10-year low flow discharge, but also is a useful measure of reliability for other MOVE.1-predicted discharges (R.G. Reiser, U.S. Geological Survey, oral commun., 1994).

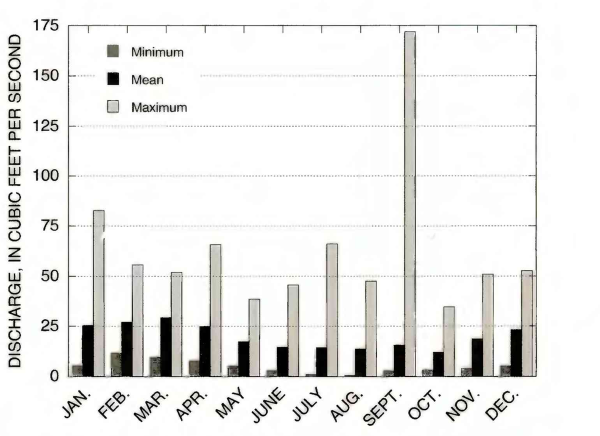


Figure 3-2. Minimum and maximum monthly mean, and mean monthly discharge at Salem River at Woodstown, N.J. (01482500), water years 1943-84.

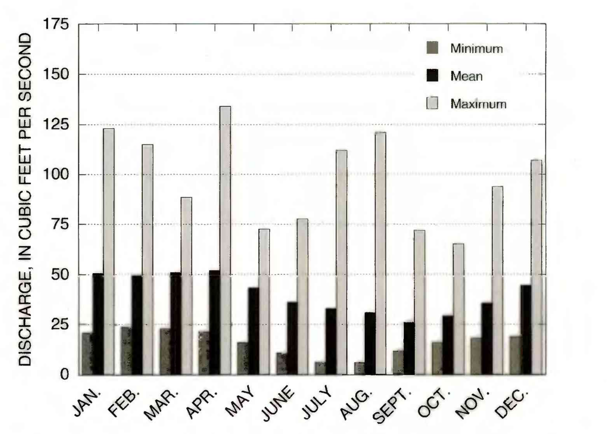


Figure 3-3. Minimum and maximum monthly mean, and mean monthly discharge at Raccoon Creek near Swedesboro, N.J. (01477120), water years 1967-92.

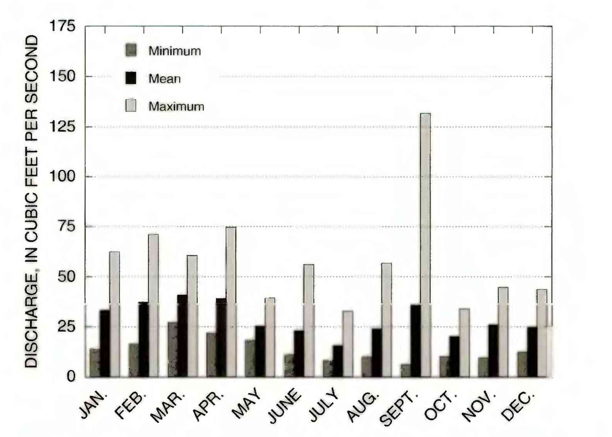


Figure 3-4. Minimum and maximum monthly mean, and mean monthly discharge at Oldmans Creek near Woodstown, N.J. (01477500), water years 1932-40.

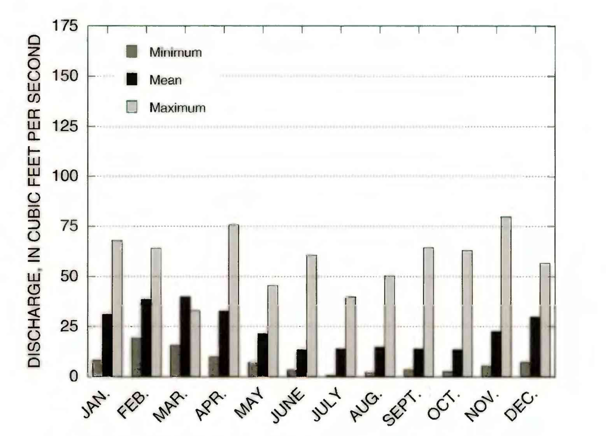


Figure 3-5. Minimum and maximum monthly mean, and mean monthly discharge at Alloway Creek at Alloway, N.J. (01483000), water years 1953-72.

QI - Discharge, measured in cubic feet per second, at index gaging station Maurice River at Norma, N.J. (01411500)

QP_M - Discharge, measured in cubic feet per second, at partial-record station Raccoon Creek near Mullica Hill, N.J. (01477100)

DATE	QI	QP_M
05/06/59	151	16.70
09/10/59	118	7.54
04/21/60	176	15.40
09/07/60	116	6.08
04/25/61	299	23.60
09/08/61	99	7.26
03/28/62	234	17.70
10/24/62	91	6.47
09/11/63	49	3.92
12/04/80	95	6.46
05/20/82	108	11.50

A low-flow correlation was made by correlating low-flow discharge at the partial-record station with discharge at the index station.

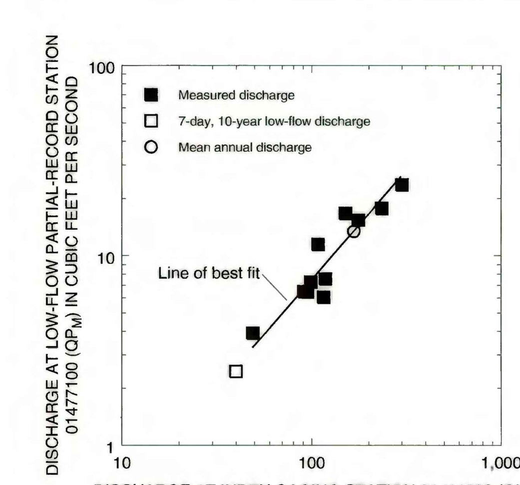
CORRELATION COEFFICIENT: 0.9267

EQUATION OF "BEST-FIT" LINE DRAWN THROUGH DATA:

$$QP_R = (0.03833)\ QI^{(1.1452)}$$

where

QI = Discharge at index gaging station, and
QP_R = Predicted discharge at low-flow partial-record station.



ESTIMATED STREAMFLOW STATISTICS FOR THE 7-DAY, 10-YEAR LOW-FLOW DISCHARGE:

Standard error of prediction for index gaging station = 5.14 percent

Standard error of prediction for low-flow partial-record station = 10.46 percent

Standard error of estimation for low-flow partial-record station = 10.53 percent

Figure 3-11. Low-flow correlation of Raccoon Creek at Mullica Hill, N.J., partial-record station (01477100) with Maurice River at Norma, N.J., index gaging station (01411500).

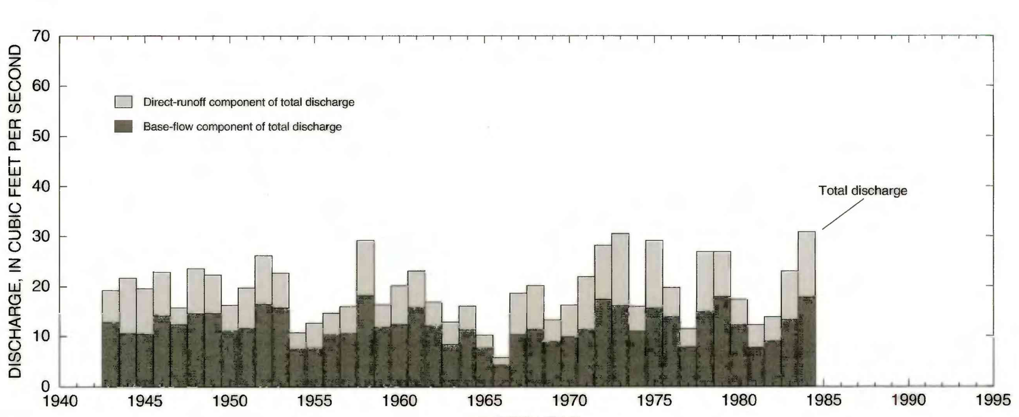


Figure 3-6. Annual mean discharge, base flow, and direct runoff at Salem River at Woodstown, N.J. (01482500), water years 1943-84.

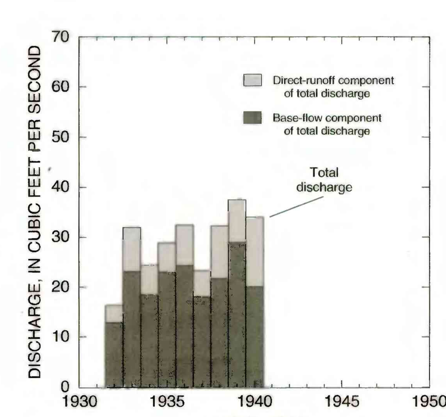


Figure 3-8. Annual mean discharge, base flow, and direct runoff at Oldmans Creek near Woodstown, N.J. (01477500), water years 1932-40.

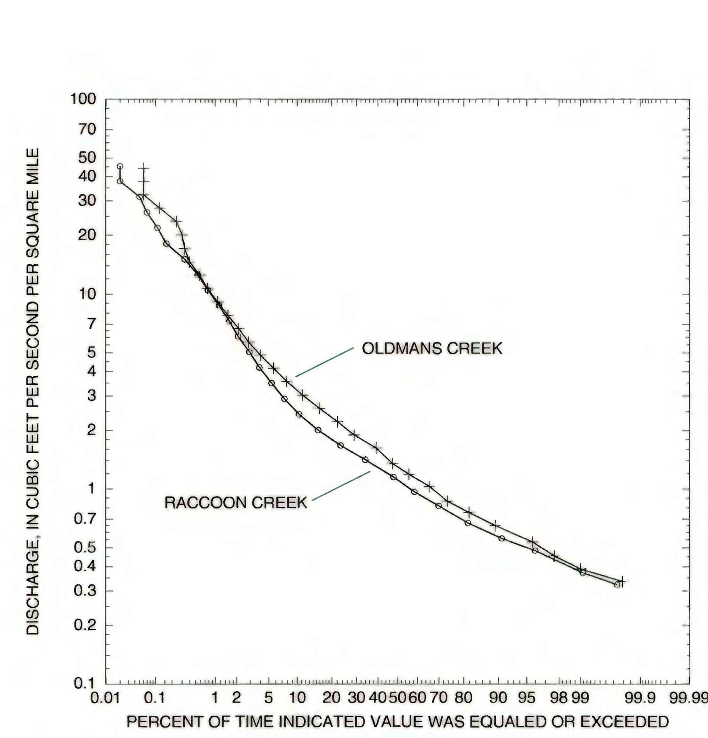


Figure 3-10. Duration curves of daily flow, Raccoon Creek near Swedesboro, N.J. (01477120), water years 1967-92, and Oldmans Creek near Woodstown, N.J. (01477500), water years 1932-40.

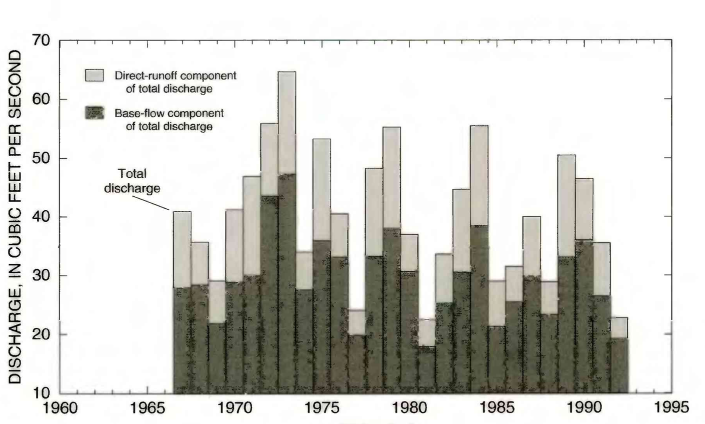


Figure 3-7. Annual mean discharge, base flow, and direct runoff at Raccoon Creek near Swedesboro, N.J. (01477120), water years 1967-92.

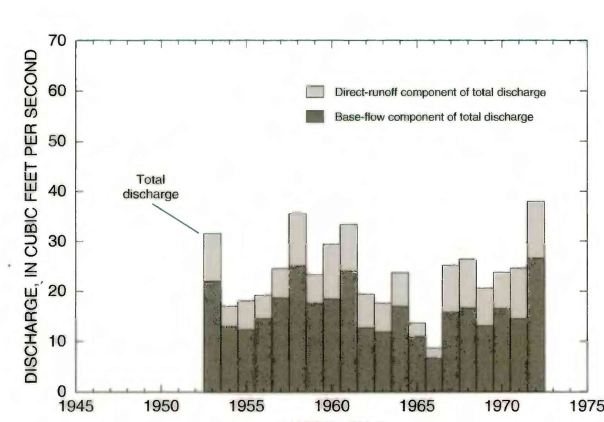


Figure 3-9. Annual mean discharge, base flow, and direct runoff at Alloway Creek at Alloway, N.J. (01483000), water years 1953-72.

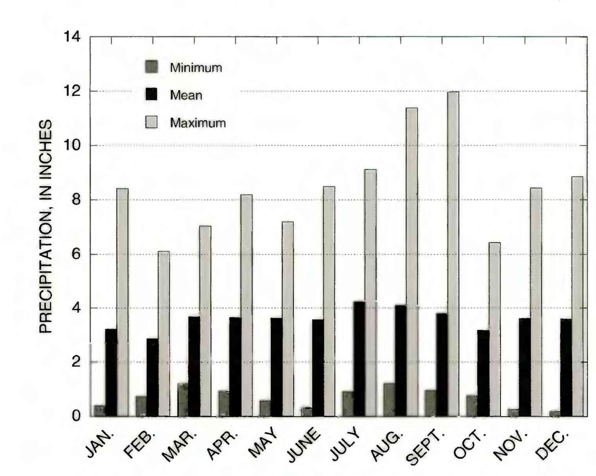


Figure 3-16. Minimum, mean, and maximum monthly precipitation at the Woodstown, N.J., weather station, water years 1983-92 (Climatedata, 1992).

PRECIPITATION, DISCHARGE, AND EVAPOTRANSPIRATION

This section describes the influence of climatic factors on the hydrology of the unconfined-aquifer and surface-water system in the Salem River study area. Precipitation is compared to discharge, and estimates of potential evapotranspiration are presented.

Precipitation data in this report are from the National Oceanic and Atmospheric Administration weather station at Woodstown, N.J., for water years 1949-92, and from the Wilmington, Del., station for the few months of the Woodstown record for which data were missing (fig. 3-12 through 3-15). Annual precipitation at Woodstown during 1949-92 ranged from a minimum of 29.35 inches in water year 1965 to a maximum of 59.66 inches in water year 1989, with a mean of 43.10 inches (Climatedata, 1992). Minimum, mean, and maximum monthly precipitation values for the Woodstown weather station during water years 1983-92 are shown in figure 3-16. Monthly precipitation ranged from a minimum of 0.18 inches in December 1955 to a maximum of 11.97 inches in September 1960, with a mean of 3.60 inches (Climatedata, 1992). Precipitation values from the Philadelphia, Pa., weather station for water years 1932-40 were used for comparison with discharge at Oldmans Creek near Woodstown (01477500) during the same period.

Much of the precipitation that falls on the Salem River study area leaves the area as stream discharge. Annual discharge at the four streamflow-gaging stations in the study area was compared with total annual precipitation. All values are presented in units of inches of water over the area of the basin to facilitate comparison. The annual discharge of Salem River at Woodstown, N.J. (01482500), ranged from 5.31 inches in water year 1966 to 28.64 inches in water year 1984 (fig. 3-12). The mean annual discharge was 17.92 inches, or 41 percent of the mean annual precipitation for water years 1949-84 at the Woodstown weather station. The annual discharge of Raccoon Creek near Swedesboro, N.J. (01477120), ranged from 11.35 inches in water year 1981 to 32.65 inches in water year 1973 (fig. 3-13). The mean annual discharge was 20.34 inches, or 45 percent of the mean annual precipitation for water years 1967-92 at the Woodstown weather station. The annual discharge of Oldmans Creek near Woodstown, N.J. (01477500), ranged from 11.96 inches in water year 1932 to 27.52 inches in water year 1939 (fig. 3-14). The mean annual discharge was 21.26 inches, or 49 percent of the mean annual precipitation for water years 1932-40 at the Philadelphia weather station. The annual discharge of Alloway Creek at Alloway, N.J. (01483000), ranged from 5.75 inches in water year 1966 to 25.41 inches in water year 1972 (fig. 3-15). The mean annual discharge was 15.83 inches, or 38 percent of the mean annual precipitation for water years 1953-72 at the Woodstown weather station. Proportions of mean annual streamflow to mean annual precipitation range from 38 to 49 percent over the study area. This difference can be explained by variations in the natural-stream-drainage system, or by significant manmade or natural transfers of water among basins.

Most of the precipitation that does not discharge as streamflow leaves the Salem River study area as evapotranspiration. Potential evapotranspiration was estimated by using the Thornthwaite equation (Thornthwaite and Mather, 1957), which uses mean monthly air temperature and latitude as an index of the energy available for evapotranspiration. Potential evapotranspiration is the amount of water that would be lost through transpiration from plants and evaporation from the soil if water were always unlimited. The mean monthly air temperature at the Woodstown weather station during 1983-92 is shown in figure 3-17. Estimated mean monthly potential evapotranspiration is shown in figure 3-18. The calculated mean annual potential evapotranspiration at the Woodstown weather station during 1983-92 is 29.72 inches.

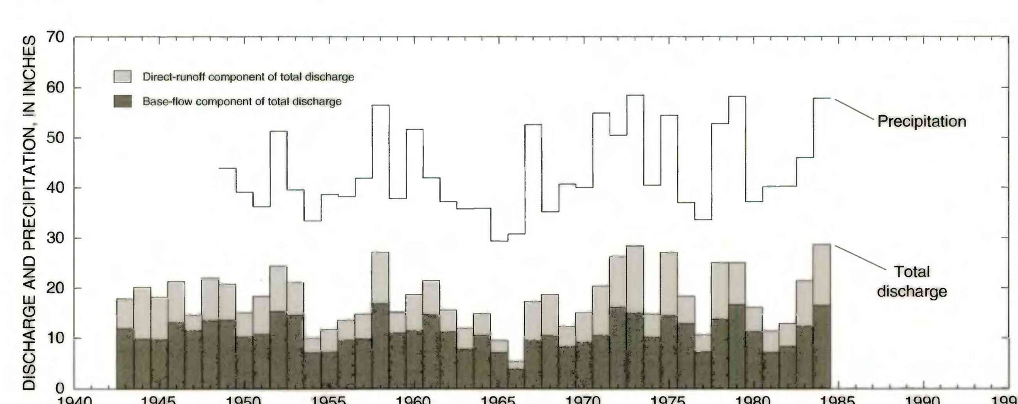


Figure 3-12. Total annual precipitation at the Woodstown, N.J., weather station, water years 1949-84 (Climatedata, 1992), and discharge, base flow, and direct runoff at Salem River at Woodstown, N.J. (01482500), water years 1943-84.

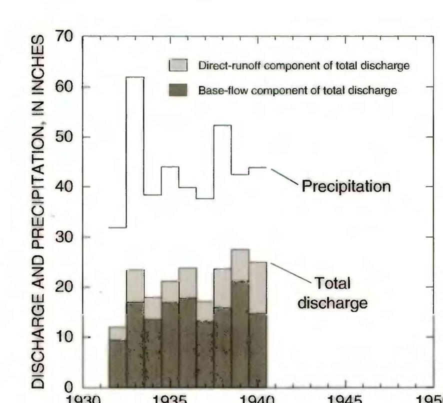


Figure 3-14. Total annual precipitation at the Philadelphia, Pa., weather station, water years 1932-40 (Climatedata, 1992), and discharge, base flow, and direct runoff at Oldmans Creek near Woodstown, N.J. (01477500), water years 1932-40.

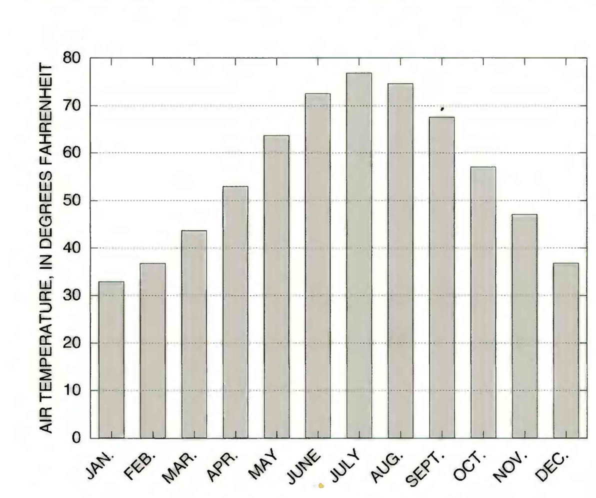


Figure 3-17. Mean monthly air temperature at the Woodstown, N.J., weather station, water years 1983-92 (Climatedata, 1992).

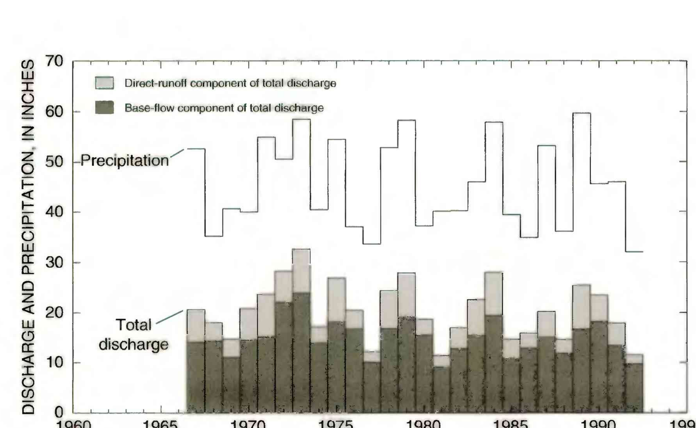


Figure 3-13. Total annual precipitation at the Woodstown, N.J., weather station, water years 1967-92 (Climatedata, 1992), and discharge, base flow, and direct runoff at Raccoon Creek near Swedesboro, N.J. (01477120), water years 1967-92.

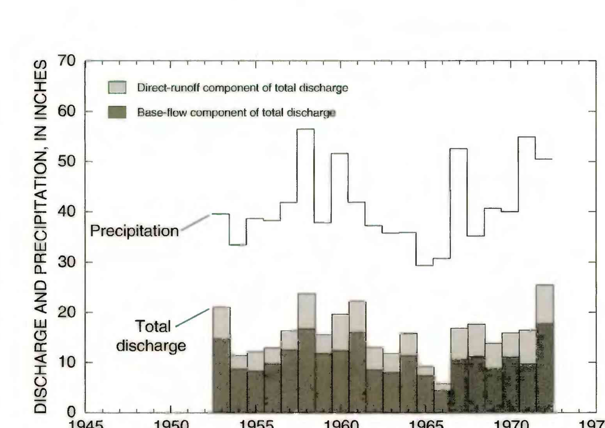


Figure 3-15. Total annual precipitation at the Woodstown, N.J., weather station, water years 1953-72 (Climatedata, 1992), and discharge, base flow, and direct runoff at Alloway Creek at Alloway, N.J. (01483000), water years 1953-72.

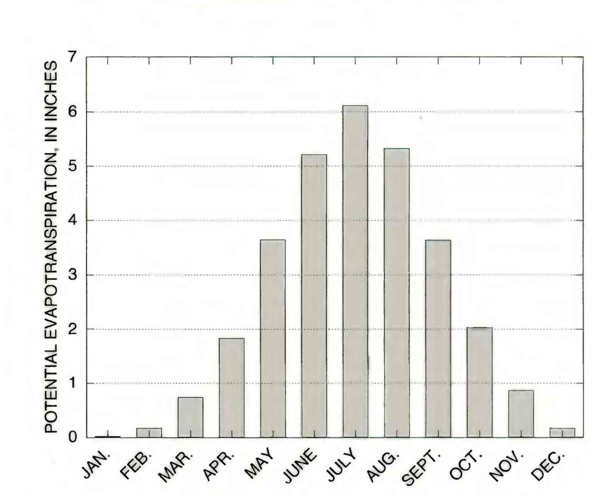


Figure 3-18. Mean monthly potential evapotranspiration at the Woodstown, N.J., weather station, water years 1983-92.

HYDROLOGY OF THE UNCONFINED AQUIFER SYSTEM, SALEM RIVER AREA: SALEM RIVER AND RACCOON, OLDMANS, ALLOWAY, AND STOW CREEK BASINS, NEW JERSEY, 1993-94

by
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