

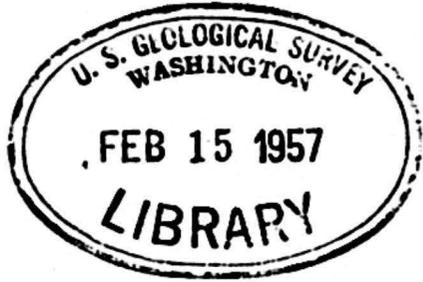
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DEPARTMENT OF THE INTERIOR
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Water Resources in Delaware Basin

RECORDS AVAILABLE TO SEPTEMBER 30, 1956, ON USE OF
WATER IN THE DELAWARE BASIN PROJECT AREA

by J. C. Kamerer 1957



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By J. C. Kammerer

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Introduction

The purpose of this report is to summarize data on the use of water in the Delaware Basin Project area (fig. 2) and to list the principal data sources that are available in published form. The tables and bibliography will assist Geological Survey personnel assigned to the Delaware Basin Project in evaluating the scope and deficiencies of previous studies of the basin. Information is also given on the use of water by public supplies in the New York-New Jersey region comprising the New York City Metropolitan Area and in the remaining north-central and south-eastern parts of New Jersey. These regions may depend increasingly on water from the Delaware River basin for part of their public supplies.

The Geological Survey has the responsibility for appraising and describing the water resources of the Nation as a guide to use, development, control, and conservation of these resources. Cooperative Federal-State water-resources investigations in the Delaware Basin States have been carried on by the Geological Survey for more than 50 years. In July 1956 the Survey began the "Delaware Basin Project," a hydrologic study of the Delaware River basin in order to: 1) Determine present status and trends in water availability, quality, and use, 2) assess and improve the adequacy of the Survey's basic water data program in the basin, 3) interpret and evaluate the water-resources data in terms of past and possible future water-use and land-use practices, and 4) disseminate promptly the results of this investigation for the benefit of all interested agencies and the general public. The Geological Survey is working closely with the U. S. Corps of Engineers and other cooperating Federal and State agencies in providing water data which will contribute to the present coordinated investigation aimed at developing a plan for long-range water development in the Delaware River basin.

Estimates of quantities of water used are given for water withdrawn from streams and aquifers during calendar year 1955, as compiled or estimated from publications and manuscripts prepared between 1950 and 1956. All quantities are given in millions of gallons per day (mgd). The source of the water

used, ground or surface, and the type of use to which it was put -- public supply, industrial supply, irrigation, or rural use -- is given. Use of water for hydroelectric power was not compiled for this report. Most tables in this report do not subdivide withdrawals into fresh and saline water; however, most supplies are fresh, except some of those withdrawn directly from the Delaware River downstream from Philadelphia, Pa. All quantities are expressed as an average rate for a full year and are lower, therefore, than rates resulting from the increased demand for water during the summer for air conditioning and supplemental irrigation.

The primary emphasis of this study was to get an over-all picture of water use throughout large parts of the basin. Therefore, publications relating to a single city or county, other than New York City, seldom were used; revisions and refinements based on such sources of information are best made by the field personnel most familiar with locally filed publications and unpublished data.

Areas Defined

The drainage area of the Delaware River basin is 12,765 square miles, including the tributary basin of Delaware Bay but excluding the surface area of the bay. County-outline and general-location maps of the basin are shown in figures 1 and 2. The basin comprises parts of the States of Delaware, New Jersey, New York, and Pennsylvania, and less than 10 square miles in Maryland. The basin areas of these States are given in table 1, and the counties are listed in table 2.

Table 1. - State areas comprising Delaware River basin

State	Area within Delaware River basin ^{1/} (square miles)	Part of State within basin (percent)	Part of basin occupied by State ^{1/} (percent)	Number of counties in basin
Delaware	1,004	51	7.9	3
Maryland	8	-	-	1
New Jersey	2,969	40	23.3	14
New York	2,362	5	18.5	8
Pennsylvania	6,422	14	50.3	17
Total	12,765	-	100	43

^{1/} U. S. Corps of Engineers (1934, p. 36 and 104); Interstate Commission on the Delaware River Basin (1940, p. 2).

Table 2. - Counties partly or wholly within Delaware River basin

[An asterisk preceding a name indicates that the county contains no civil unit having a population greater than 2,000 within the Delaware River basin]

State	Counties	Counties sometimes omitted in computations when data are available only by counties
Delaware	Kent New Castle Sussex	Sussex (or Kent and Sussex, when lower limit of Basin is considered to be Woodland Beach, Del.)
Maryland	*Cecil	Cecil
New Jersey	*Atlantic Burlington Camden *Cape May Cumberland Gloucester Hunterdon	Mercer *Monmouth Morris *Ocean Salem Sussex Warren
New York	*Broome *Chenango Delaware *Greene	Orange *Schoharie Sullivan *Ulster
Pennsylvania	Berks Bucks Carbon Chester Delaware *Lackawanna *Lancaster *Lebanon Lehigh	Luzerne Monroe Montgomery Northampton Philadelphia Pike Schuylkill Wayne

The Philadelphia Metropolitan Area as defined in 1950 by the U. S. Census Bureau consists of the following counties:

<u>Pennsylvania</u>		<u>New Jersey</u>
Bucks	Montgomery	Burlington
Chester	Philadelphia	Camden
Delaware		Gloucester

The above areas plus Mercer and Salem Counties, N. J., and New Castle County, Del., has been known variously as the Philadelphia Tri-State District (1932), Greater Philadelphia area or Greater Philadelphia-Delaware-South Jersey region, 11-county region, and Delaware Valley, U. S. A. This 11-county region is largely within the Delaware River basin and is the most highly developed part of the basin in terms of population density, industrial activity, and extent of public and private water-supply facilities.

The New York City Metropolitan Area as defined in 1950 by the U. S. Census Bureau consists of the following counties:

<u>New York</u>		<u>New Jersey</u>
Bronx	)	Bergen
Kings (Brooklyn)	)	Essex
New York (Manhattan)	) New York	Hudson
Queens	) City	Middlesex
Richmond (Staten Island)	)	Morris
Nassau		Passaic
Rockland		Somerset
Suffolk		Union
Westchester		

Long Island, N. Y. is entirely within the New York metropolitan area noted above, and consists of the following counties, in order from west to east: Kings, Queens, Nassau, and Suffolk.

The following counties in north-central and southeastern New Jersey are not part of the New York City Metropolitan Area and are at least partly outside the Delaware River basin:

<u>New Jersey</u>		
Atlantic	Cumberland	Monmouth
Burlington	Gloucester	Ocean
Camden	Hunterdon	Sussex
Cape May	Mercer	

Table 3 gives the area and population of each county comprising the several regions described in this report, including southeastern New Jersey and the metropolitan area of New York City.

Table 3. - Area and population of counties in Delaware Basin Project, including southeastern New Jersey and the metropolitan area of New York City

[Source: U. S. Bureau of the Census, 1942, 1953]

State and county	Total area (square miles)	Land area (square miles)	Population 1950	State and county	Total area (square miles)	Land area (square miles)	Population 1950
Delaware:				New York-Con.			
Kent	599	595	37,870	Delaware	1,472	1,470	44,420
New Castle	471	437	218,879	Greene	663	653	28,745
Sussex	987	946	61,336	Kings	89	76	2,738,175
Maryland:				Nassau	330	300	672,765
Cecil	386	352	33,356	New York	31	22	1,960,101
New Jersey:				Orange	846	829	152,255
Atlantic	613	575	132,399	Queens	127	113	1,550,849
Bergen	243	233	539,139	Richmond	64	60	191,555
Burlington	830	819	135,910	Rockland	201	178	89,276
Camden	225	221	300,743	Schoharie	626	625	22,703
Cape May	290	267	37,131	Suffolk	1,177	922	276,129
Cumberland	507	503	88,597	Sullivan	1,001	986	40,731
Essex	132	128	905,949	Ulster	1,172	1,143	92,621
Gloucester	339	329	91,727	Westchester	487	435	625,816
Hudson	63	45	647,437	Pennsylvania:			
Hunterdon	435	435	42,736	Berks	864	864	255,740
Mercer	230	228	229,781	Bucks	625	617	144,620
Middlesex	318	312	264,872	Carbon	406	405	57,558
Monmouth	487	477	225,327	Chester	762	760	159,141
Morris	478	468	164,371	Delaware	191	185	411,234
Ocean	756	639	56,622	Lackawanna	458	454	257,396
Passaic	202	194	337,093	Lancaster	974	945	234,717
Salem	376	350	49,508	Lebanon	363	363	81,683
Somerset	307	307	99,052	Lehigh	348	347	198,207
Sussex	538	528	34,423	Luzerne	902	891	392,241
Union	105	103	398,138	Monroe	618	611	33,773
Warren	362	361	54,374	Montgomery	496	492	353,068
New York:				Northampton	377	374	185,243
Bronx	54	43	1,451,277	Philadelphia	135	127	2,071,605
Broome	715	710	184,698	Pike	558	545	8,425
Chenango	910	908	39,138	Schuylkill	784	783	200,577
				Wayne	760	744	28,478

General Summary

An average of about 5,700 mgd of water was withdrawn from streams, lakes, wells, and springs within the Delaware River basin for use within the basin in 1955. More than 90 percent was from streams and lakes. If the population of the basin is assumed to have been about 5,900,000^{1/} in 1955, the withdrawal of water for all purposes (except hydroelectric power) was nearly 1,000 gallons per day per person. This per capita use of water in the basin is higher than the average for the eastern half of the United States, but less than one-third of the average for the western half. The withdrawal of water per square mile of river basin is nearly 6 times as much as that in the United States, but less than one-third of the average for the western half. The withdrawal of water per square mile of river basin is nearly 6 times as much as that in the United States as a whole (see table 4).

Nearly three-quarters of the water used in the basin is withdrawn in the 11-county region (including the cities of Philadelphia, Trenton, Wilmington, Camden, and Chester), which is less than one-third of the area of the total basin. In addition to the water used within the Delaware River basin, 350 mgd was withdrawn from the basin in 1955 for the water supply of New York City. That city also used about 750 mgd from sources outside the Delaware River basin. In west-central New Jersey a withdrawal of water between 5 and 50 mgd has been made from the Delaware River since 1951 through the Delaware and Raritan Canal (Friel, 1954, p. 2; Tippetts and others, 1955, p. II-34), largely or entirely for use outside the Delaware River basin. A maximum of 100 mgd is permitted by Supreme Court decree.

Public water supplies in the basin use an average of about 1,100 mgd, about 90 percent of which is derived from streams, lakes, and reservoirs. Many public supplies furnish water to local industrial plants. Most of the water used in the basin by other than public-supply systems is withdrawn by private industrial water systems, usually from the larger streams; water for stream-electric power plants accounts for more than half of this withdrawal. Water use for irrigation in the Delaware River basin was probably less than 50 mgd in 1955 when averaged for the entire year. However, it appears likely that the amount of water used for this purpose will be increasing significantly within the next few years.

By way of comparison with data on average water use, the average flow of the Delaware River at Trenton, N. J., representing available runoff from the upper half of the basin, is about 8,000 mgd. However, the flow varies considerably from month to month, and monthly average flows of less than 1,200 mgd have been recorded 7 times in the past 26 years.

^{1/}Interpolated between the Pennsylvania Water Resources Committee (1953, p. 24) estimates of population for 1950 and 1960.

Table 4.--Comparison of water withdrawals in the Delaware River basin with withdrawals in eastern and western United States, 1955

Region	Area (1,000 square miles)	Estimated population, 1955 ^{1/} (1,000 persons)	Average annual runoff, 1921-45 ^{2/}		Total water withdrawn ^{3/} (excluding water for waterpower)			
			Inches	Mgd	Amount (mgd)	Per capita (gpd)	Per square mile (mgd)	Percentage of runoff (percent)
Delaware River basin Including diver- sion for New York City	13	---	21	12,000	6,000	---	0.46	50
Excluding diver- sion for New York City	--	5,900	---	---	5,700	970	---	---
Eastern United States	1,190	125,000	15	840,000	110,000	890	.09	13
Western United States ^{4/}	1,630	38,600	4.5	390,000	130,000	3,300	.07	33
United States	3,020	164,000	8.5	1,200,000	240,000	1,500	.06	20

^{1/} Population of Delaware River basin interpolated between estimates for 1950 and 1960 made by Pennsylvania Water Resources Committee, 1953 (p.24); other population data from U. S. Bureau of the Census, 1956, Statistical abstract of the United States, 1956 (p. 10).

^{2/} Modified by J. K. Searcy from Langbein, W. B., 1949, Annual runoff in the United States: U. S. Geol. Survey Circ. 52, 14 p. Average annual runoff indicates in a general way the upper limit of the amount of water available for consumptive use during a year having average precipitation.

^{3/} Source of data on other than the Delaware River basin is MacKichan, K. A., 1957, Estimated use of water in the United States - 1955: U. S. Geol. Survey Circ. 398 (in press).

^{4/} Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming.

Of the published records of various types of water use, information on public supplies is the most readily available and the most completely documented in Federal, State, and privately issued publications. Published records on industrial use of water are incomplete and dispersed among many publications. There appear to have been published no regional records of rural use and irrigation use of water in the Delaware River basin other than those compiled by the Geological Survey.

Tabular Summaries of Water Use, By States and Basinwide

Quantitative data on withdrawals of water in the Delaware River basin during 1955, subdivided by States, is shown on figure 3, and in table 5. Information on withdrawals of water compiled by MacKichan (1951 and 1957) for the years 1950 and 1955 is given in tables 6 and 7.

Largest Users of Water

Public Supplies

The nine largest public-supply systems in the Delaware River basin are given in table 8. These systems, while constituting only about 4 percent of the total number of public-supply systems in the basin, accounted for about 550 mgd, or 50 percent of the water supplied from public systems in 1955, including 15 mgd for the city of Chester, Pa., diverted from the Susquehanna River basin.

New York City is withdrawing increasing amounts of water from the Delaware River basin, as permitted by decree of the United States Supreme Court, amended June 7, 1954, to allow diversion of up to 800 mgd upon completion of Cannonsville Dam and Reservoir, Delaware County, N. Y., within the next 10 years. The sources and amounts of water supplied to New York City in 1954 and 1955 are given in table 9a and the total amount of water supplied annually from all the city's sources, 1946-55, is given in table 9b. The years of highest use during that period were 1948 and 1949, when withdrawals averaged slightly over 1,200 mgd.

Table 5.--Estimated withdrawal of water in the Delaware River basin by State parts of the basin, and by the New York City Metropolitan Area and by southeastern New Jersey, 1955

[No data are given to more than two significant figures; quantities less than 0.5 mgd are shown as "0"]

Region and State	Public supplies			Self-supplied industrial supplies		Rural use		Irrigation supplies		Total supplies		
	Ground water (mgd)	Surface water (mgd)	Total (mgd)	Ground water (mgd)	Surface water (mgd)	Ground water (mgd)	Surface water (mgd)	Ground water (mgd)	Surface water (mgd)	Ground water (mgd)	Surface water (mgd)	Total (mgd)
<u>Delaware River Basin</u>	130	950	1,100	260	4,600	24	6	16	16	430	5,600	6,000
Delaware	7	25	32	20	300	2	1	1	2	30	330	360
New Jersey	70	45	120	130	1,200	4	1	14	9	220	1,300	1,500
New York	3	360	360	1	1	3	1	0	0	7	360	370
Pennsylvania	46	520	570	110	3,100	15	3	1	6	170	3,600	3,800
<u>New York City Metropolitan Area:</u>												
New York City	50	1/700	1/750									
New York counties outside	140	40	180									
New York City												
New Jersey counties	90	360	450									
<u>Southeastern New Jersey</u> ^{2/}	40	20	60									

1/ Not including 350 mgd withdrawn by New York City from the Delaware River basin; shown above as major part of public-supply withdrawal from New York State part of basin.

2/ Parts of counties outside Delaware River basin, excluding New York City Metropolitan Area, but including parts of Sussex, Hunterdon, and Mercer Counties.

Table 6.--Estimated withdrawal of water in the Delaware River basin, basinwide totals, 1955

[Source: K. A. MacKichan, 1957]

Type of supply and use	Fresh ground water (mgd)	Saline ground water ^{a/} (mgd)	Fresh surface water (mgd)	Saline surface water ^{a/} (mgd)	Total from all sources (mgd)
Public supplies	130	0	<u>b/</u> 590	0	<u>b/</u> 720
Domestic, public, commercial					<u>b/</u> 470
Industrial--air conditioning					20
Industrial--other uses					230
Self-supplied industrial supplies ^{c/}	270	4	3,300	1,300	4,900
Fuel-electric power--condenser cooling	0	0	2,000	480	2,500
Fuel-electric power--other uses	16	0	140	0	160
Other industries--air conditioning	21	0	13	0	34
Other industries--other uses	230	4	1,100	850	2,200
Rural supplies	24	0	6	0	30
Irrigation supplies	16	0	16	0	32
Total supplies ^{c/}	440 440	4	<u>b/</u> 3,900	1,300	<u>b/</u> 5,700
Water for waterpower	0	0	1,700	0	1,700

^{a/} Saline water is defined as water containing more than 1,000 parts per million of dissolved solids.

^{b/} Excluding 350 mgd diverted from the Delaware River basin to the Hudson River basin for part of the public water supply of New York City.

^{c/} Excluding water for waterpower.

Table 7.--Estimated withdrawal of water in Delaware, New Jersey, New York, and Pennsylvania, Statewide totals, 1950 and 1955

[Source of data: K. A. MacKichan, 1951, 1957]

State and year	Public supplies			Self-supplied industrial supplies			
	Ground water (mgd)	Surface water (mgd)	Total (mgd)	Ground water (mgd)	Surface water (mgd)	Total (mgd)	
Delaware:							
1950	8	15	23	5	90	95	
1955	11	33	44	25	296	321	
New Jersey:							
1950	170	340	510	260	1,500	1,760	
1955	160	420	580	296	3,400	3,700	
New York:							
1950	250	1,640	1,890	280	¹ / _{5,000}	¹ / _{5,280}	
1955	260	1,700	1,960	257	6,500	6,760	
Pennsylvania:							
1950	100	970	1,070	300	5,500	5,800	
1955	120	1,300	1,420	340	9,160	9,500	
State and year	Rural supplies		Irrigation supplies		Total supplies		
	Ground water (mgd)	Surface water (mgd)	Ground water (mgd)	Surface water (mgd)	Ground water (mgd)	Surface water (mgd)	Total (mgd)
Delaware:							
1950	6	2	0	0	19	107	126
1955	3	1	1	2	40	332	372
New Jersey:							
1950	65	2	31	1	526	1,840	2,370
1955	8	2	22	15	486	3,840	4,320
New York:							
1950	160	10	27	1	717	¹ / _{6,650}	¹ / _{7,370}
1955	110	10	22	25	649	8,240	8,890
Pennsylvania:							
1950	80	70	4	4	484	6,540	7,030
1955	60	17	2	14	522	10,500	11,000

¹/ _{Revised estimate.}

Table 8.--Largest public water supplies in the Delaware River basin, 1955

Source of data: U. S. Public Health Service, 1955; and Tippetts and others, 1955

Order of size	City or system	County and State	Withdrawal of water in 1955 (mgd)	Source of water
1	Philadelphia	Philadelphia, Pa.	370	Delaware and Schuylkill Rivers
2	Philadelphia Suburban Water Co.	Chester, Delaware, and Montgomery, Pa.	40	Crum, Pennypack, Neshaminy, and Pickering Creeks
3	Trenton	Mercer, N. J.	26	Delaware River
4	Wilmington	New Castle, Del.	24	Brandywine Creek
5	Camden (Partly municipal and partly the New Jersey Water Co.)	Camden, N. J.	20	Wells
6	Bethlehem	Northampton, Pa.	20	Wild Creek
7	Allentown	Lehigh, Pa.	18	Springs, wells, and Little Lehigh River
8	Reading	Berks, Pa.	17	Antietam and Maiden Creeks
9	Chester	Delaware, Pa.	15	Octoraro Creek (Susquehanna River basin)
Total			580	

Table 9a.--Sources and amount of water supplied to New York City, 1954 and 1955

Source of data: New York City Board of Water Supply, 1956, p. 27, 51-52, 56^{1/}

Name of source	River basin	Type of source	Water supplied (mgd)	
			1954	1955
Catskill system (Ashokan and Schoharie Reservoirs)	Hudson	Surface	576	453
Delaware system (Neversink, Pepacton and Roundout Reservoirs)....	Delaware	Surface	152	365 ^{1/}
West Branch (Croton) watershed	Hudson	Surface	39	72
Bronx and Byram watershed.	Hudson and Byram	Surface	3	12
Croton aqueducts (Croton watershed)	Hudson	Surface	199	158
Long Island municipal sources.....	Long Island	Ground	49	2
Richmond municipal supply.	Staten Island	Ground	3	2
Jamaica Water Supply Co.	Long Island	Ground	43	46
New York Water Service Corp. (Woodhaven plant)	Long Island	Ground		
Total supplied to New York City			1,064	1,110

^{1/} Of the 365 mgd supplied by the "Delaware system," 350 mgd was from the Delaware River basin, diverted to Roundout Reservoir (Hudson River basin) from Neversink Reservoir (230 mgd) and Pepacton Reservoir (120 mgd) located in Sullivan and Delaware Counties, N. Y., respectively.

Table 9b.--Total water supplied to New York City from all sources 1946-55 ^{1/}

Year	Mgd	Year	Mgd
1946	1,141	1951	1,070
1947	1,189	1952	1,120
1948	1,204	1953	1,138
1949	1,203	1954	1,110
1950	982	1955	1,156

^{1/} Includes ~~24-47~~ mgd supplied to outside communities.

Self-Supplied Industrial Supplies

An estimated average of about 4,600 mgd was withdrawn in 1955 from streams by private industrial water systems in the Delaware River basin, largely from the Delaware River and its tributaries in the southern half of the basin. Although this is the largest single type of water use in the Delaware River basin, relatively little information was published prior to 1953 classifying use by specific counties, sub-basins, or State parts of the total basin.

An inventory and appraisal of water facilities in southeastern Pennsylvania was made in 1955 by the Interstate Commission on the Delaware River Basin (INCODEL) at the request of the Southeastern Pennsylvania Regional Planning Commission. The inventory report contained water-use records for public and industrial supplies in the five southeastern counties, including the data on industrial use given in table 10, which shows an industrial use of about 2,600 mgd. The data on use of ground water for self-supplied industrial supplies were furnished to the Interstate Commission by the U. S. Geological Survey as part of water investigations made in cooperation with State agencies in Pennsylvania.

The following statement by F. S. Friel (1954, p. 3) indicates for the lower Delaware River basin the magnitude of surface-water use, of which all but about 500 mgd is by private industrial water systems:

The Chamber of Commerce of Greater Philadelphia estimated that the five Pennsylvania counties in the Delaware Valley, U. S. A., draw approximately 2,736 million gallons of water daily from the Delaware River for municipal and industrial use. This estimate includes private industries, public water supplies, and electric powerplants. This figure is comparable to the 827 million gallons daily take by the 88 groups (in the 5 adjacent counties) in the State of New Jersey.

The use of water by the 88 groups referred to above by Mr. Friel is given in table 11 (Friel, 1954, p. 2).

Authority for use of water from the Delaware and Raritan Canal (see table 11) for potable supplies has been granted to the Elizabethtown Water Co. and the city of New Brunswick, and for industrial supplies has been granted to American Cyanamid Co. (Bound Brook), Johnson and Johnson (New Brunswick), Bakelite Co., a division of Union Carbide and Carbon Corp. (Bound Brook), and Public Service Electric and Gas Co. (Tippetts and others, 1955, p. II-34). All or most of the water withdrawn from the canal by these municipalities and industries is used outside the Delaware River basin.

Table 10a.--Estimated average use of water by industries in southeastern Pennsylvania, by counties, 1954

[Source of data: Interstate Commission on the Delaware River Basin, 1955, p. IV-1, IV-2]

County	Industrial supplies from public systems		Self-supplied industrial supplies		Total industrial supplies
	Ground water (mgd)	Surface water (mgd)	Ground water (mgd)	Surface water (mgd)	All sources (mgd)
Bucks.....	2.3	0.8	12.0	293.2	308.3
Chester.....	.0	1.2	2.0	34.6	37.8
Delaware.....	.0	5.2	.1	591.4	596.7
Montgomery .....	.5	3.2	22.6	157.5	183.8
Philadelphia .....	.0	66.4	20.5	1,379.5	1,466.4

Table 10b.--Type of use of industrial supplies in "Philadelphia area"

Use	Percent of total industrial supply
Cooling.....	90.5
Processing.....	7.5
Boiler feed.....	1.4
Domestic.....	.6
	<u>100.0</u>

Table 11.--Use of water in 1952 from the Delaware River and from wells along the river in New Jersey, from Trenton southward

[Source of data: Friel, 1954, p. 2]

Type of group	Number in group	Water from Delaware River (mgd)	Water from wells (mgd)	Total (mgd)
Public supplies	23	27.44	37.47	64.91
Private industries....	50	150.04	95.11	245.15
Electric powerplants.	3	619.56	.85	620.41
Total	76	797.04	133.43	930.47
Customers supplied through Delaware and Raritan Canal	12	30.18	-	30.18
Grand Total	88	827.22	133.43	960.65

The subject of self-supplied industrial use of water from the Delaware River also was considered by the Pennsylvania Water Resources Committee in its report published in 1953, based on data collected in 1952. The following quotations and table 12 are from that report (Pennsylvania Water Resources Committee, 1953, p. 34):

Many industries along the river below Morrisville (Pa.) take large quantities of water directly from the river ... It is estimated that they take an annual average quantity of water from the river of over 3,200 mgd. Most of this water is used for cooling and condensing, and all of the spent water is returned to the river near the intakes ...

This stretch of the river may be considered in three parts ...

The second, or middle part, comprises the Philadelphia water front along which are located many industries, the largest user being the Philadelphia Electric Company which is said to use almost 1,000 mgd for cooling and condensing.

Estimates of self-supplied industrial water from wells in the lower Delaware River basin by counties are available from several sources. Estimates prepared by Barksdale and others on the 11-county region between Trenton, N. J., and Wilmington, Del., most of which is within the Delaware River basin, are given in table 13. They estimated a withdrawal of 100 mgd of ground water in 1954 by private industrial water systems in the 11 counties.

A study of New Jersey water resources was made by consulting engineers in 1955 for the State Legislative Commission on Water Supply (Tippetts and others, 1955). These engineers sent a detailed questionnaire on industrial water use to approximately 1,000 of the largest industrial firms in New Jersey. The replies that were received came from companies whose employees total almost 30 percent of the State's industrial labor force, including companies representing a substantial portion of the plants using 55,000 or more gallons per day. The consumption of self-supplied water for nonpotable uses as reported by the companies replying to the questionnaire is given in table 14. Although the source, ground or surface water, was not differentiated, most of the water was probably from surface sources. The engineers estimated that approximately 30 mgd of potable water was supplied by

Table 12. - Private supplies of Delaware River water used by industries between Philadelphia, Pa. and Wilmington, Del., 1952

[Source of data: Pennsylvania Water Resources Committee, 1953, p. 35]

Location	Company	Use of Delaware River water, 1952 (mgd)	
New Jersey: Gloucester County	Du Pont--Repauno Works	200	
	Socony-Vacuum Oil Co.	50	
	Salem County	Deepwater Generating Co.	300
		Du Pont--Chambers Works	73
Pennsylvania: Delaware County	American Viscose Corp.	7	
	Baldwin-Lima-Hamilton Corp.	2	
	Eddystone Manufacturing Co.	2	
	General Chemical Corp.	25	
	Heppenstall-Eddystone Co.	20	
	Scott Paper Co.	13	
	Sinclair Refining Co.	102	
	South Chester Tube Co.	1	
	Sun Oil Co.	80	
	Sun Shipbuilding Co.	3	
Westinghouse Electric Corp.	5		

Table 13. - Estimated use of ground water during 1954 in the 11-county region, Trenton, N. J. to Wilmington, Del.

[Source: Personal communication from Barksdale, H. C. and others, 1956]

State and county	Municipal (mgd)	Industrial (self-supplied) (mgd)	Other (mgd)	Total (mgd)
Delaware:				
New Castle	5	3	1	9
New Jersey:				
Burlington	7	4	6	17
Camden	37	16	3	56
Gloucester	5	13	3	21
Mercer	4	4	4	12
Salem	2	3	3	8
Pennsylvania:				
Bucks	7	12	5	24
Chester	1	2	4	7
Delaware	0	0	1	1
Montgomery	5	23	2	30
Philadelphia	0	20	0	20
Total	73	100	32	205

Table 14. - Reported self-supplied industrial water use for nonpetable purposes in New Jersey, 1955

[Source: Replies to questionnaires received by Tippetts and others, 1955, p. IV-17]

Region	Industrial use other than electric and gas utilities (mgd)	Electric and gas utilities (mgd)
Northeastern (Bergen, Essex, , Hudson, Middlesex, Morris, Passaic, Somerset, and Union Counties)	327	1,644
Southwestern (Burlington, Camden, Gloucester, Mercer, and Salem counties)	219	651
Coastal (Atlantic, Cape May, Cumberland, Monmouth, and Ocean Counties)	3	92
Northwestern (Hunterdon, Sussex, and Warren Counties)	0	0

private industry-owned water systems throughout the State "largely from ground-water sources," in addition to the much larger quantities withdrawn for nonpotable purposes. They also estimated that industries purchased from public supplies "about 50 percent of all of the public potable water consumed in the entire State" (Tippetts and others, 1955, p. IV-14).

A survey of industrial water use in the New Jersey part of the Delaware River basin was made in 1952 by the South Jersey Port Commission, Camden, N. J. The Commission did not publish the results of this survey; however, a part of the information was printed as testimony in the New York City water diversion case concluded in 1954.

The largest single type of industrial use of water in the Delaware River basin is probably for cooling and condensing in stream-electric powerplants. Such plants are usually located on the larger streams, which are the source of all or most of the water used. In order to obtain specific information on the location of stream-electric plants in the Delaware River basin, publications of the Federal Power Commission were reviewed. A summary of the location and size of the plants for which annual generation data are available is given in table 15.

Irrigation Supplies

The broad study of New Jersey water resources made by consultants for the State Legislature (Tippetts and others, 1955) included a study of present and potential use of water for supplemental irrigation. The report of this study includes data on the irrigated acreage in 1950 and 1954 by counties, and corresponding estimates of maximum annual irrigation requirements, assuming a dry-year consumption of 11 inches or 0.3 million gallons per acre (Tippetts and others, 1955, p. IV-18). These figures are given in table 16 in terms of uniform rates for a full year.

Table 15. - Major steam-electric plants in Delaware River basin

[Source of data: U. S. Federal Power Commission, 1955, Steam-electric plant construction cost and annual production expenses, 1953: Federal Power Comm. Bull. 5-109]

Name of utility	Powerplant		Installed generating capacity (1,000 kw)	Net generation 1953 (million kwhr)
	Name	City and county		
Delaware:				
Delaware Power and Light Co.	Edge Moor	Wilmington, New Castle	120	943
New Jersey:				
New Jersey Power and Light Co.	Gilbert	Holland, Hunterdon	121	659
Public Service Electric & Gas Co.	Burlington	Burlington, Burlington	290	1,395
Pennsylvania:				
Metropolitan Edison Co.	Eyler (West Reading)	West Reading, Berks	103	354
Do.	Titus	Reading, Berks	225	1,542
Pennsylvania Power and Light Co.	Hauto	Nesquehoning, Carbon	101	438
Philadelphia Electric Co.	Chester	Chester, Delaware	256	1,062
	Delaware	Philadelphia, Philadelphia	437	1,135
	Richmond	Do.	452	2,388
	Schuylkill	Do.	179	491
	Southwark	Do.	325	2,157

Table 16.--Irrigated acreage and maximum irrigation water requirements
in New Jersey, 1950 and 1954

[Source: Tippetts-Abbott-McCarthy-Stratton, 1955, p. IV-18]

County	Area irrigated (acres)		Maximum annual irrigation requirements ^{1/} (mgd-year)	
	1950	1954	1950	1954
Atlantic.....	2,987	15,000	2.5	12.3
Bergen.....	1,537	1,200	1.3	1.0
Burlington.....	8,387	10,000	6.9	8.2
Camden.....	862	2,200	.7	1.8
Cape May.....	81	1,200	.1	1.0
Cumberland.....	4,418	11,000	3.6	9.0
Essex.....	467	490	.4	.4
Gloucester.....	1,690	1,900	1.4	1.6
Hudson.....	145	145	.1	.1
Hunterdon.....	203	500	.2	.4
Mercer.....	1,478	2,500	1.2	1.2
Middlesex.....	488	6,000	.4	4.9
Monmouth.....	2,140	8,900	1.8	7.3
Morris.....	616	2,300	.5	1.9
Ocean.....	933	340	.8	.3
Passaic.....	856	900	.7	.7
Salem.....	147	3,000	.1	2.5
Somerset.....	5	135	.0	.1
Sussex.....	122	200	.1	.2
Union.....	14	425	.0	.3
Warren.....	541	1,500	.4	1.2

^{1/} Assuming dry-year consumption of 11 inches or 0.3 million gallons per acre.

Principal references

Fourteen reports published or prepared between 1950 and 1956 are the principal sources of information on the water-use data compiled for this report. These reports are listed alphabetically by author under two subject headings: Withdrawal of water for all purposes, including public supplies; and withdrawal of water for public supplies. Following these lists is an additional one under the heading, "General references," which contains the 12 publications and bibliographies that were most helpful in providing introductory and background information on the economic and geologic setting and the water resources and problems of the Delaware River basin. Complete citations of all these publications are given in the selected bibliography which is the last section of this report.

The single report most useful in making this brief study is the one by MacKichan (1957). His report classifies withdrawals by type of use, listed both by States and by regions, the "Delaware region" corresponding to the Delaware River basin. His report is based mainly on data furnished by Geological Survey field offices responsible for water-resources investigations in the Delaware River basin, and partly on data compiled and computed by him from publications of the Departments of Agriculture and Commerce and the Federal Power Commission.

Withdrawal of water for all purposes, including public supplies

- Friel, F. S., 1954, Water supply problems. (Lower part of basin.)**
- Interstate Commission on the Delaware River Basin, 1955, Inventory and appraisal of the water supply facilities in southeastern Pennsylvania. (Lower part of basin, Pennsylvania only.)**
- Mackichan, K. A., 1957, Estimated use of water in the United States - 1955.**
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- Pennsylvania Topographic and Geologic Survey, 1956, the Ground-water program for Pennsylvania. (Ground water only.)**
- Pennsylvania Water Resources Committee, 1953, Delaware River basin report. (Mainly Pennsylvania.)**
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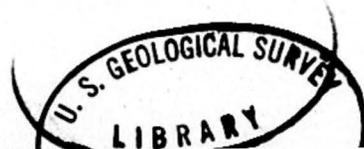
The bibliography that follows contains 68 items describing water use, water sources, and geographic setting of the area of study, including 18 books or maps on the regional geology of the Delaware River basin. A knowledge of the geology is a prerequisite to classification of withdrawal of water by name or type of water-bearing formation. The bibliography is selective in the sense that publications are omitted which are merely repetitions or rearrangements of previously published information. Also, most studies of water use by a single city or county are omitted, with the principal exception of New York City. The list includes only one publication issued prior to 1931.

In order to assist the reader in his use of the bibliography, letter-symbols are given in the left margin for each reference to identify the type and State location of information contained in the publication -- water use, general background, or regional geology. The letter symbols are as follows:

<u>Letter-symbol</u>	<u>Type of information</u>
Use	Water-use data for:
Use-Basin	Delaware River basin (2 or more States)
Use-B-Del	Delaware (State)
Use-B-NJ	New Jersey, within Delaware River basin
Use-B-NY	New York, within Delaware River basin
Use-B-Pa	Pennsylvania, within Delaware River basin
Use-SENJ	New Jersey, outside Delaware River basin
Use-MNYC	New York State part of New York City metropolitan area
(Pub)	Public-supply data only
Gen	General background reference or bibliography
Geol	Regional geology or geologic map index

- Use-Basin (Pub)** American Water Works Association, 1953, A survey of operating data for water works in 1950; Journ. Am. Water Works Assoc., v. 45, no. 6, p. 583-678
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March 11, 1957

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 -SENJ) water facilities, communities of 25,000
 -MNYC) population and over, continental United States,
 (Pub)) as of December 31, 1954; U. S. Public Health
 Service, 153 p.

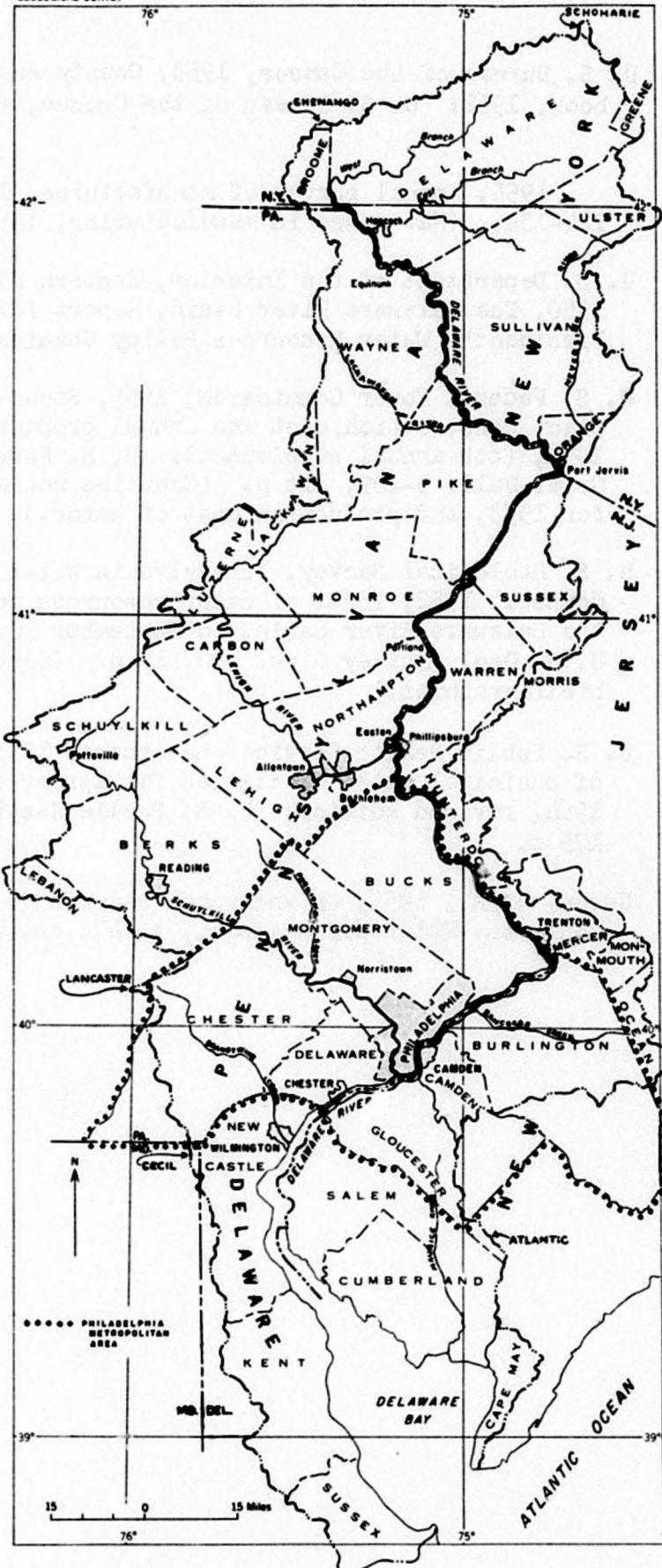


Figure 1.—County outline map of Delaware River basin.

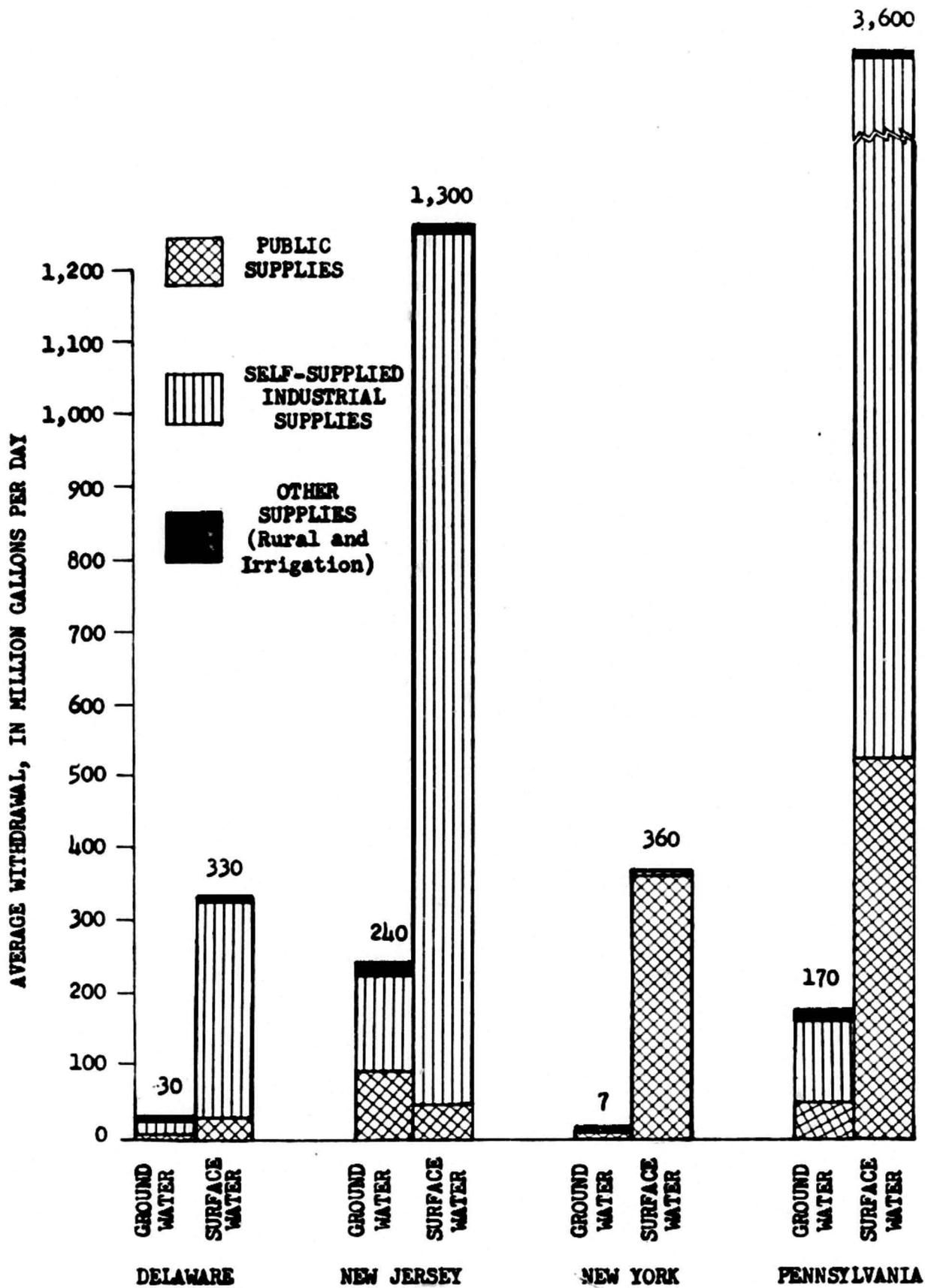


Figure 3. QUANTITY OF WATER WITHDRAWN FOR PUBLIC, INDUSTRIAL, AND OTHER SUPPLIES IN THE DELAWARE RIVER BASIN IN 1955, BY STATES.