WITHDRAWALS OF GROUND WATER AND SURFACE WATER IN NEW JERSEY, 1991-92

By John P. Nawyn

Open-File Report 98-282

Prepared in cooperation with the

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

West Trenton, New Jersey

1998

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CONVERSION FACTORSS

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter
mile (mi)	1.609	kilometer
	Area	
acre	4,047	square meter
square foot (ft^2)	0.09294	square meter
square mile (mi^2)	2.590	square kilometer
	Volume	
gallon (gal)	0.003785	cubic meter
million gallons (Mgal)	3,785	cubic meter
cubic feet (ft^3)	0.02832	cubic meter
	Flow	
gallon per day (gal/d)	0.003785	cubic meter per day
gallon per minute (gal/min)	0.06308	liters per second
million gallons per day (Mgal/d)	0.0438	cubic meter per second
gigawatt-hour	1,000,000	kilowatt-hour
	Temperature	
degree Fahrenheit (°F)	°C= 5/9 x (°F - 32)	degree Celsius (°C)

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ABSTRACT

Withdrawals of ground water and surface water in New Jersey were compiled from monthly withdrawal data provided to the New Jersey Department of Environmental Protection by water users with pumping equipment capable of producing 100,000 gallons per day or more. In 1991, withdrawals in New Jersey totaled about 2,110 Mgal/d (million gallons per day)--576 Mgal/d of ground water and 1,534 Mgal/d of surface water. In 1992, withdrawals totaled about 2,090 Mgal/d--571 Mgal/d of ground water and 1,519 Mgal/d of surface water.

During 1991-92, withdrawals for public supply averaged 1,099 Mgal/d and supplied 6.8 million residents of the State. Domestic water use averaged 639 Mgal/d, including ground-water withdrawals of 79 Mgal/d and water deliveries from public suppliers of 560 Mgal/d. Commercial water use averaged 227 Mgal/d, including withdrawals of 17 Mgal/d of ground water, 1 Mgal/d of surface water, and water deliveries from public suppliers of 209 Mgal/d. Withdrawals for irrigation averaged 123 Mgal/d, including 22 Mgal/d of ground water and 101 Mgal/d of surface water. Industrial water use in New Jersey averaged 342 Mgal/d during 1991-92, including ground-water withdrawals of 50 Mgal/d, surface-water withdrawals of 193 Mgal/d, and water deliveries from public suppliers of 99 Mgal/d. During 1991-92, average withdrawals for mining use in New Jersey were 33 Mgal/d, including 4 Mgal/d of ground water and 29 Mgal/d of surface water. Withdrawals for thermoelectric-power use averaged 532 Mgal/d, including ground-water withdrawals of 2 Mgal/d, surface-water withdrawals of 508 Mgal/d, and water deliveries from public suppliers of 22 Mgal/d.

INTRODUCTION

The water resources of New Jersey have contributed to the diversity of agricultural and industrial development of the State. Water in New Jersey was used for America's first brewery (1642) and to manufacture the Nation's first railroad (1824), revolver (1836), telephone (1838), light bulb (1879), and transistor (1948). The first water allocation for industrial use was issued in 1791 to the Society for Establishing Useful Manufactures, under the aegis of Alexander Hamilton, to develop the first planned industrial development in the United States. From this beginning, many important industries of the 20th century were commercially developed in the State, including plastics (1869), oil refining (1875), and pharmaceuticals (1885). In addition, the research facilities in the State contributed significantly to the development of radio, television, and computer technology (Kennedy and others, 1963; Federal Writers' Project of the Works Project Administration for the State of New Jersey, 1986).

Rapid industrialization and immigrant populations transformed the economy of New Jersey from a chiefly agricultural to an industrial-based economy. From 1860 to 1890, the urban population of the State increased 40 percent in each decade (Vermeule, 1894). Public officials were concerned about the contamination of existing water resources and the availability of potable water in the future (Vermeule, 1894). During the new century, New Jersey initiated a comprehensive management program for its water resources, including monitoring the withdrawals of surface water for public supply (1907) and the withdrawals of ground water for public supply (1910); registering the drilling of all new wells and permitting the withdrawals of 100,00 gallons or more during a 24-hour period (1947); and regulating the withdrawals of surface water by non-public-supply users (1963) (Capen, 1937; New Jersey Commission on Efficiency and Economy in State Government, 1967; Goldshore, 1983; Deitch, 1992).

This report is a product of the Cooperative Water-Use Program of the U.S. Geological Survey (USGS) and the New Jersey Department of Environmental Protection (NJDEP). The study was conducted as part of this water-use program, which includes the collection of water-use data and its storage in the Site Specific Water-Use Data System (SSWUDS) and the Aggregate Water-Use Data System (AWUDS) data bases of the Water-Use Data System component of the National Water Information System, the USGS national water-data storage and retrieval system.

Purpose and Scope

This report presents data on the withdrawals of ground water and surface water in New Jersey during 1991-92. All withdrawal data are presented by type of water (ground water or surface water), category of use (public supply, domestic, commercial, industrial, irrigation, mining, and thermoelectric power), county, and hydrologic cataloging unit (HUC). In addition, data on ground-water withdrawals (except self-supplied domestic withdrawals) are compiled by aquifer and physiographic province.

Most withdrawal data in this report were compiled from monthly pumpage data submitted by water users to the NJDEP. Withdrawal data on self-supplied domestic users and small community public-supply systems were estimated and compiled by county.

Description of Study Area

New Jersey is a mid-Atlantic state that consists of 7,419 mi^2 of land area and 1,303 mi^2 of water area (Horner, 1992, p. 243), and is divided into 21 counties (fig. 1). In 1992, the population of New Jersey was estimated to be 7.8 million (U.S. Bureau of the Census, 1994b). New Jersey is an important center for commerce, manufacturing, recreation, and scientific research.

Hydrogeology

The Coastal Plain, Piedmont, Highlands, and Valley and Ridge are the physiographic provinces in New Jersey (fig. 2; table 1). The Fall Line (fig. 2) separates the Coastal Plain, an area of about 4,200 mi^2, from the consolidated rocks of the three northern provinces, an area of about 3,300 mi^2 (Qualls and Horn, 1990, p. 368).

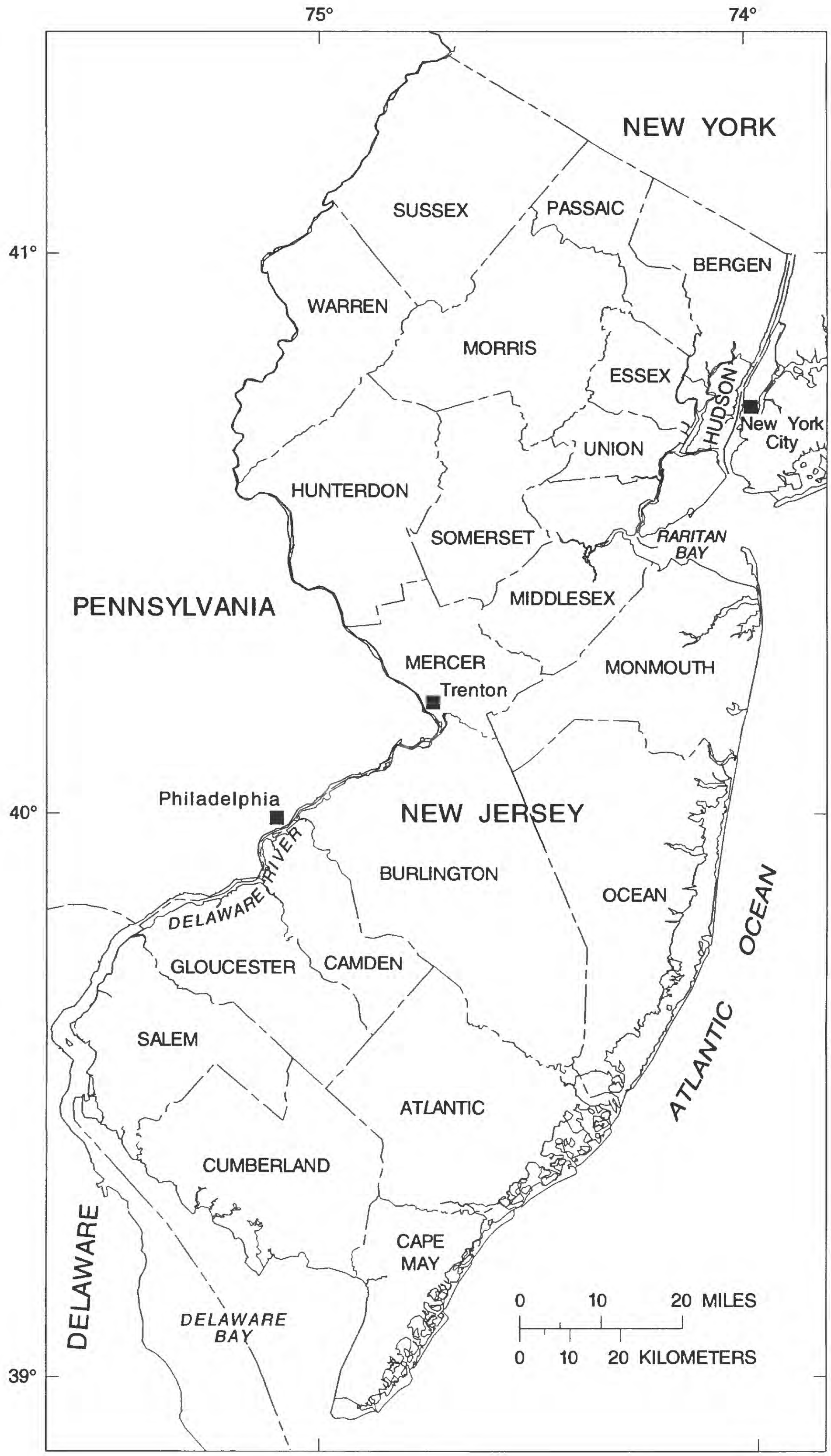


Figure 1. Counties in New Jersey.

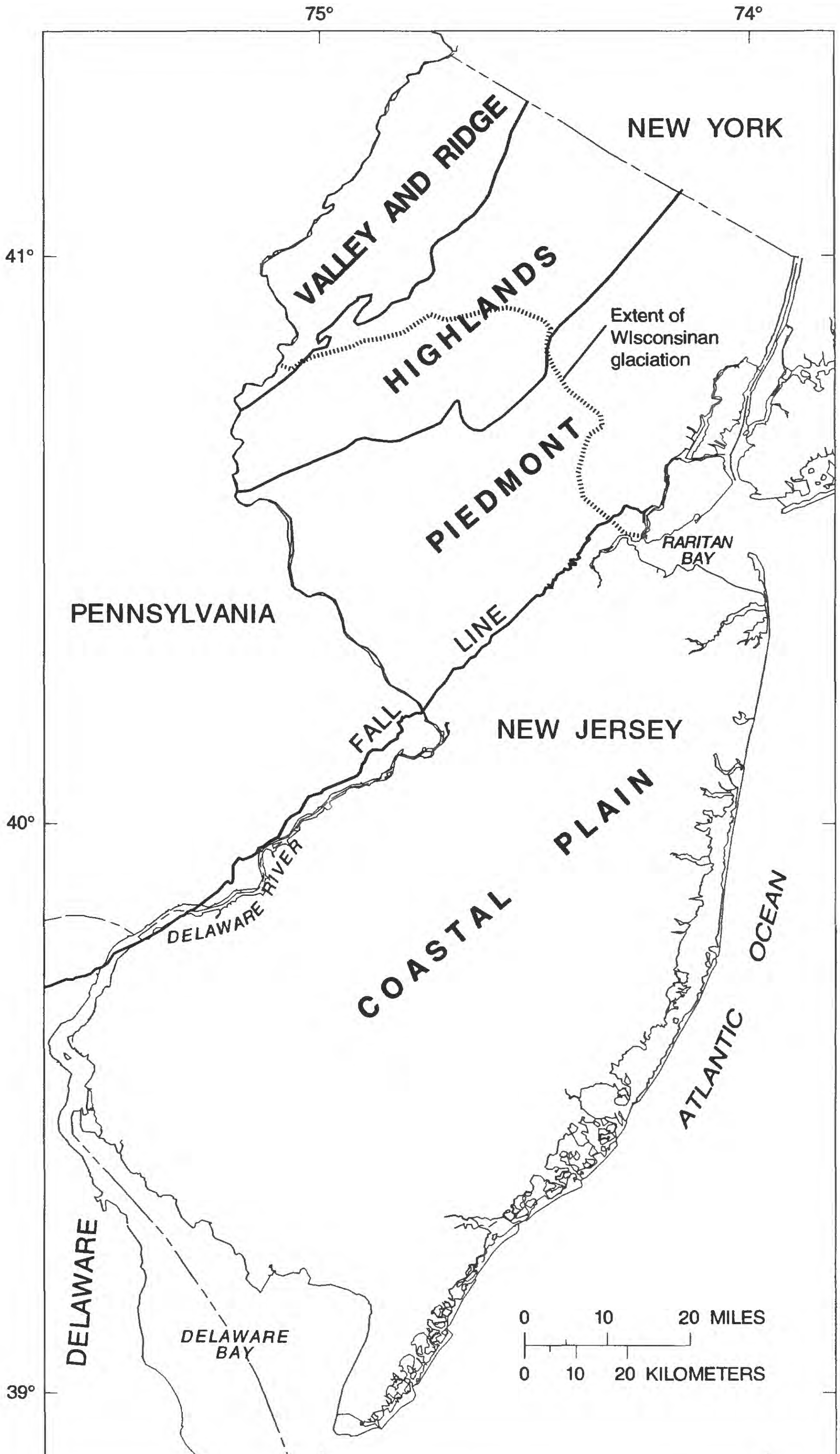


Figure 2. Physiographic provinces in New Jersey.

Table 1. Characteristics of aquifers and wells in New Jersey

[Data from Zapecza, 1989; Lyttle and Epstein, 1987; Sargent and others, 1985; Miller, 1974; Drake, 1969; and Vecchioli and Palmer, 1962; Mgal/d, million gallons per day; gal/min, gallons per minute; ft, feet]

Physiographic province Aquifer and aquifer characteristics	Well characteristics: Depth (ft) (Common range)	Well characteristics: Yield (gal/min) (Common range)	Remarks
	Coastal Plain aquifers		
Coastal Plain			
Kirkwood-Cohansey aquifer system: Sand, quartz, fine- to coarse-grained, pebbly; local clay beds. Unconfined.	20 - 350	500 - 1,000	Major withdrawals are for public supply in Cumberland, Ocean, and Atlantic Counties. Chief source of water for agricultural and domestic-supply users in the Coastal Plain.
Rio Grande water-bearing zone: Medium- to coarse-grained sand. Thin aquifer within confining unit that overlies the Atlantic City 800-foot sand. Confined.	240 - 650	100 - 1,000	Most withdrawals are for public supply in southern Cape May County. Also present in coastal areas of southern Ocean and Atlantic Counties.
Atlantic City 800-foot sand: Sand, quartz, medium- to coarse-grained; gravel, with considerable amount of fragmented shell material. Confined.	450 - 950	600 - 800	Major confined aquifer along the barrier beaches in Ocean, Atlantic, and Cape May Counties.
Piney Point aquifer: Glauconitic quartz sand and shell beds, fine- to coarse-grained. Confined.	200 - 1,000	50 - 800	Locally important aquifer in the Coastal Plain. The aquifer does not crop out, but is extensive in the subsurface and extends from Salem and Cumberland Counties to Ocean County.
Vincentown aquifer: Sand, quartz, gray and green, fine- to coarse-grained, glauconitic. Chiefly confined.	20 - 250	10 - 900	Yields small to moderate quantities of water in or near the outcrop area. The aquifer extends from northeastern Monmouth County to the Delaware River adjacent to Salem County.
Wenonah-Mount Laurel aquifer: Sand, quartz, slightly glauconitic, very fine to coarse grained. Confined.	50 - 600	50 - 250	Most withdrawals are for public supply in Burlington and Ocean Counties.
Englishtown aquifer system: Sand, quartz, fine- to medium-grained, local clay beds. Confined.	50 - 1,000	300 - 500	Locally important aquifer. Withdrawals are used for public supply in Monmouth and Ocean Counties.
Potomac-Raritan-Magothy aquifer system: Three units (Upper, Middle, and Lower aquifers) recognized in Delaware River Valley. In the deep subsurface, the unit below the Upper aquifer is undifferentiated. Light-gray sand and quartz with interbedded material (clay, silt, or gravel) in areas. Confined and unconfined.	20 - 1,700	20 - 2,000	The most heavily pumped aquifer system in New Jersey. Extends from Raritan Bay to Delaware Bay. Present in all counties in the Coastal Plain except Atlantic and Cape May.

Table 1. Characteristics of aquifers and wells in New Jersey--Continued

Physiographic province Aquifer and aquifer characteristics	Well characteristics: Depth (ft) (Common range)	Well characteristics: Yield (gal/min) (Common range)	Remarks
Upper aquifer	20 - 1,500	20 - 1,500	The most extensive unit of the aquifer system and the source of the largest withdrawals of ground water for public supply in the Coastal Plain. Also known as the Old Bridge aquifer in Middlesex and Monmouth Counties.
Middle aquifer	20 - 1,700	20 - 1,500	Major source of public-supply withdrawals in northwestern Burlington and Gloucester Counties. Major source of industrial withdrawals in the Coastal Plain. Also known as the Farrington aquifer in Middlesex and Monmouth Counties.
Lower aquifer	60 - 1,110	50 - 2,000	The most limited in extent of the three aquifers of the Potomac-Raritan-Magothy aquifer system. Major source of public-supply withdrawals in northwestern Camden, Gloucester, and Burlington Counties.
	Non-Coastal Plain aquifers		
Piedmont Province, Highlands Province, and Valley and Ridge Province			
Glacial-deposit aquifers: Wisconsin and pre-Wisconsin glacial deposits consisting of sand and gravel with interbedded silt and clay. Unconfined except where overlain by lake silt and clay or till.	10 - 300	100 - 1,000	Includes glacial buried-valley aquifer in northern New Jersey. Productive and widely used aquifers in Morris and Warren Counties.
Piedmont Province			
Aquifers of the Brunswick Group: Very fine- to coarse-grained sandstone, shale, siltstone, and red-matrix conglomerate, and fine-grained rock in extensive flows (basalt). Unconfined to partially confined in upper 200 ft; confined at greater depths.	30 - 1,500	10 - 500	The most heavily pumped of the consolidated-rock aquifers in New Jersey. Part of the Passaic Formation previously known as the Brunswick Formation. Low yields from the basalt, suitable for domestic-supply withdrawals.
Lockatong Formation: Gray and black siltstone and shale; argillite.	50 - 500	2 - 250	Generally, wells have low yields and are used for domestic-supply withdrawals.
Stockton Formation: Arkosic sandstone, siltstone, shale, conglomerate.	15 - 500	15 - 900	Highest yields of rock aquifers in Mercer County. Not extensive in New Jersey.
Highlands Province and Valley and Ridge Province			
Aquifers of the Kittatinny Supergroup: Dolomite, limestone. Unconfined and semiconfined.	20 - 700	5 - 2,000	Ground water is present along bedding surfaces, joints, faults, solution cavities, intergranular space, and other openings. Yields are variable.
Franklin Limestone: Coarse white marble, crystalline limestone, magnesian in part.	35 - 500	15 - 800	Present in Sussex and Warren Counties. Wells with largest yields intersect caverns.
Precambrian crystalline-rock aquifers: Complex igneous and metamorphic rocks; gneiss.	35 - 400	10 - 150	Most water obtained from upper 300 ft of weathered and fractured rock; highest yields in or near major fault zones.

Salisbury (1898) and Lewis and Kummel (1940) provide detailed information on the topography and geology of New Jersey. Zapecza (1989) presents a detailed description of the aquifer systems in the Coastal Plain. Drake (1969) and Lyttle and Epstein (1987) describe the geology of the non-Coastal Plain physiographic provinces. Characteristics of aquifers and wells in New Jersey are summarized in table 1.

Hydrologic Cataloging Units

Seaber and others (1987) designated 13 hydrologic cataloging units (HUC's) that lie either partly or entirely within the borders of New Jersey (fig. 3; table 2). The HUC is a geographic area that represents a surface drainage basin, such as the Raritan River Basin, or a distinct hydrologic feature, such as the Delaware Bay. The 8-digit HUC code and name associated with each unit are part of the national system for locating, storing, retrieving, and exchanging hydrologic data. Streams that flow within the major HUC's are listed in table 2. Withdrawals in three HUC's--02030101, Lower Hudson; 02040104, Middle Delaware-Mongaup-Brodhead; and 02040202, Delaware Bay--were less than 0.005 Mgal/d, the reporting level; consequently, these HUC's are not included in tables presenting HUC data.

The Delaware River has the largest drainage area of the streams in New Jersey and delineates the 254-mi western border of the State (Schopp and Bauersfeld, 1986). The Raritan, Passaic, and Hackensack Rivers are other major rivers in New Jersey. Most of the water-supply reservoirs are located in the northern and central regions of the State (fig. 4). The Hackensack-Passaic HUC contains many public-supply reservoirs that serve the urban areas of northeastern New Jersey (Schopp and Bauersfeld, 1986) (figs. 3 and 4). Two water-supply reservoirs lie within the Raritan HUC, and five reservoirs lie within the HUC's in the Coastal Plain.

Climate

The climate of New Jersey differs from north to south because of the differences in topography and the presence or absence of water bodies. For this reason, the National Climatic Data Center (1992, 1993) reports New Jersey climatological data by three major divisions--Northern, Southern, and Coastal. The Northern division includes most of the area north of the Fall Line (fig. 2). The Coastal Plain is divided into the Coastal and Southern divisions. Average annual precipitation in New Jersey during 1951-80 was 45 in. (National Climatic Center, 1992; 1993) and ranged from 40 in. in the southeast to 52 in. in the northwest (Bauersfeld and others, 1991). Precipitation is almost uniform throughout the year.

Annual precipitation in New Jersey during 1991-92 was less than the average annual precipitation (1951-80)--3 in. less in 1991 and 4 in. less in 1992. Annual precipitation in 1991 and 1992 was 42 in. and 41 in., respectively (fig. 5a). Total annual precipitation in 1991 was about the same in each climatological division. In 1992, annual precipitation was 5 in. greater in the Northern climatological division (44 in.) than in the Coastal climatological division (39 in.).

The average annual temperature in New Jersey during 1951-80 was 53 °F, and annual temperatures averaged 3 °F greater in the south than in the north. The average annual temperature was 55 °F in 1991 and 52 °F in 1992 (fig. 5b) (National Climatic Data Center, 1992; 1993).

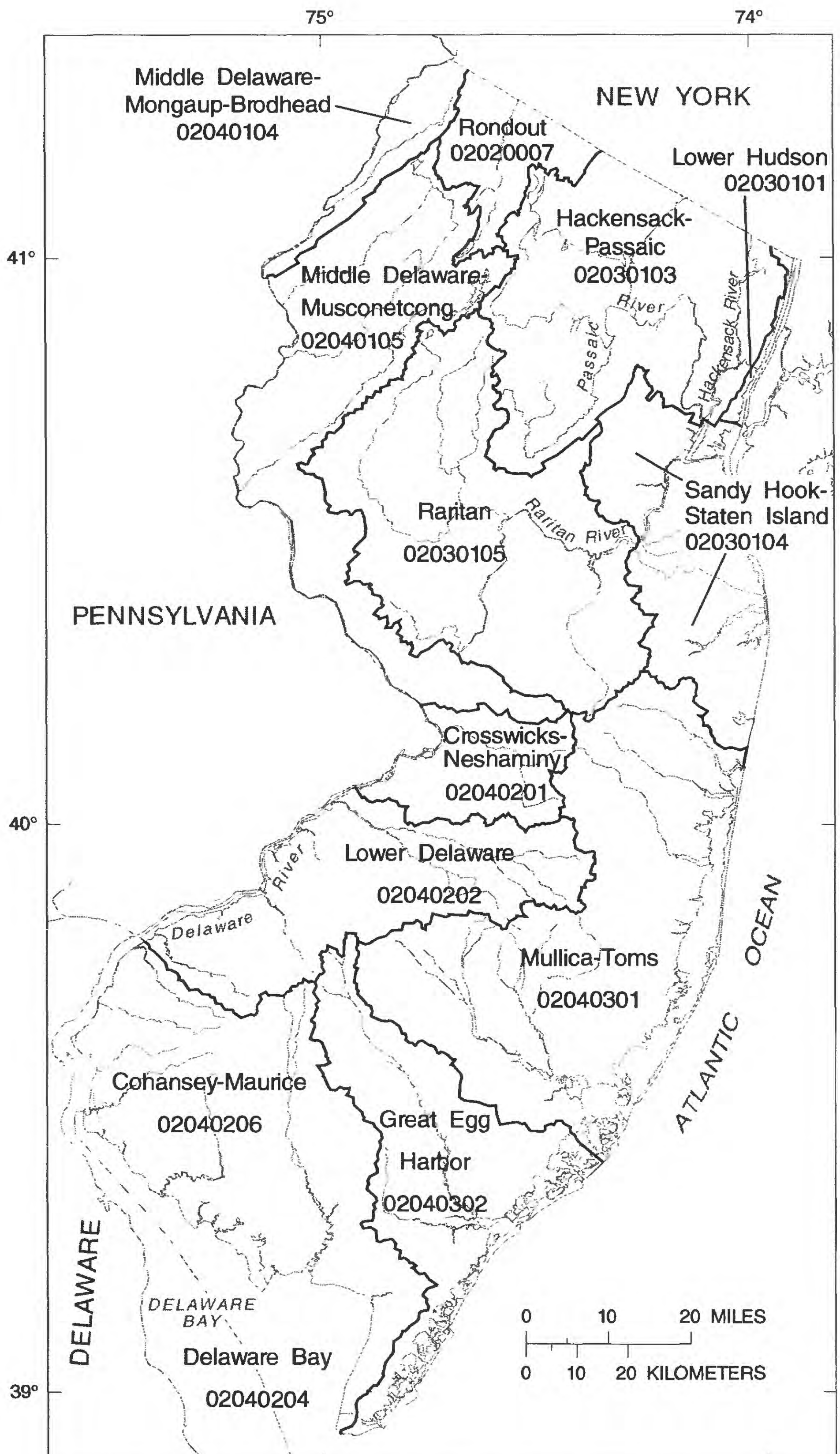


Figure 3. Hydrologic cataloging units and codes in New Jersey. (Modified from Seaber and others, 1987)

Table 2. Selected streams in New Jersey by hydrologic cataloging unit

[Modified from Seaber and others, 1987; mi^2, square miles; RWRPA, Regional Water Resources Planning Areas]

Hydrologic cataloging unit **Hydrologic unit code** (Drainage area)	*New Jersey Water Resources Planning Areas, RWRPA*	Selected streams	
Rondout[1] **02020007** (1,190 mi^2)	*RWRPA 3 Wallkill River/ Pequest River/ Paulins Kill (part)*	Papakating Creek Pochuck Creek	Wallkill River
Lower Hudson[1] **02030101** (720 mi^2)	*RWRPA 6 Hackensack River (part)*	Green Brook	Hudson River
Hackensack-Passaic[1] **02030103** (1,120 mi^2)	*RWRPA 4, Upper Passaic River and tributaries* *RWRPA 6 Hackensack River (part)* *RWRPA 5 Lower Passaic River/ Rahway River (part)*	Hackensack River Passaic River Pascack Brook Pequannock River Pompton River	Rockaway River Ramapo River Saddle River Wanaque River Whippany River
Sandy Hook-Staten Island[1] **02030104** (679 mi^2)	*RWRPA 5 Lower Passaic River/ Rahway River (part)* *RWRPA 12 Navesink River/ Swimming River*	Rahway River Elizabeth River Matawan Creek Morses Creek Navesink River	Shark River Shrewsbury River Swimming River Woodbridge Creek Whale Pond Brook Wreck Pond Brook
Raritan **02030105** (1,080 mi^2)	*RWRPA 10 Raritan River* *RWRPA 11 South River*	Raritan River Bound Brook Lamington River Lawrence Brook	Middle Brook Millstone River Stony Brook South River
Middle Delaware-Mongaup-Brodhead[1,2] **02040104** (1,520 mi^2)	*RWRPA 1 Middle Delaware River (part)* *RWRPA 2 Flat Brook*	Delaware River Flat Brook	Shimers Brook
Middle Delaware-Musconetcong[2] **02040105** (1,330 mi^2)	*RWRPA 1 Middle Delaware River (part)* *RWRPA 3 Wallkill River/ Pequest River/ Paulins Kill (part)* *RWRPA 7 Pohatcong Creek* *RWRPA 8 Musconetcong River* *RWRPA 9 Trenton Delaware tributaries* *RWRPA 14 Rancocas Creek (part)*	Delaware River Musconetcong River Assunpink Creek Delawanna Creek Lockatong Creek	Lopatcong Creek Paulins Kill Pohatcong Creek Pequest River

Table 2. Selected streams in New Jersey by hydrologic cataloging unit--Continued

Hydrologic cataloging unit **Hydrologic unit code** (Drainage area)	*New Jersey Water Resources Planning Areas, RWRPA*	Stream	
Crosswicks-Neshaminy[2] **02040201** (521 mi^2)	*RWRPA 14 Rancocas Creek (part)*	Crosswicks Creek Assiscunk Creek Delaware River	Blacks Creek Crafts Creek
Lower Delaware[2] **02040202** (1,050 mi^2)	*RWRPA 14 Rancocas Creek (part)* *RWRPA 17 Camden Delaware tributaries (part)*	Delaware River Big Timber Creek Baldwin Run Birch Creek Cooper River Mantua Creek Mill Creek	Newton Creek Pennsauken Creek Pompeston Creek Raccoon Creek Rancocas Creek Repaupo Creek Woodbury Creek
Delaware Bay **02040204** (744 mi^2)	*No designation*	Surface area of the Delaware Bay	
Cohansey-Maurice **02040206** (1,060 mi^2)	*RWRPA 17 Camden Delaware tributaries (part)* *RWRPA 20 Salem River* *RWRPA 21 Maurice River* *RWRPA 23 Cape May Coastal (part)*	Cohansey River Maurice River Alloway Creek Dennis Creek Dividing Creek Mamumuskin River	Menantico Creek Oldmans Creek Salem River Stow Creek Whooping John Creek
Mullica-Toms **02040301** (1,350 mi^2)	*RWRPA 13 Manasquan River* *RWRPA 15 Metedeconk River* *RWRPA 16 Toms River* *RWRPA 18 Mullica River (part)* *RWRPA 19 Atlantic Coastal*	Mullica River Toms River Batsto River Cedar Creek Kettle Creek Manasquan River	Metedeconk River Nescochague Creek Oswego River Oyster Creek Sleeper Branch Wading River Wastecunk Creek
Great Egg Harbor **02040302** (717 mi^2)	*RWRPA 18 Mullica River (part)* *RWRPA 22 Great Egg Harbor River* *RWRPA 23 Cape May Coastal (part)*	Great Egg Harbor River Absecon Creek Doughty Creek	Jones Creek Patcong Creek Tuckahoe River

[1] Includes drainage area in New York.

[2] Includes drainage area in Pennsylvania.

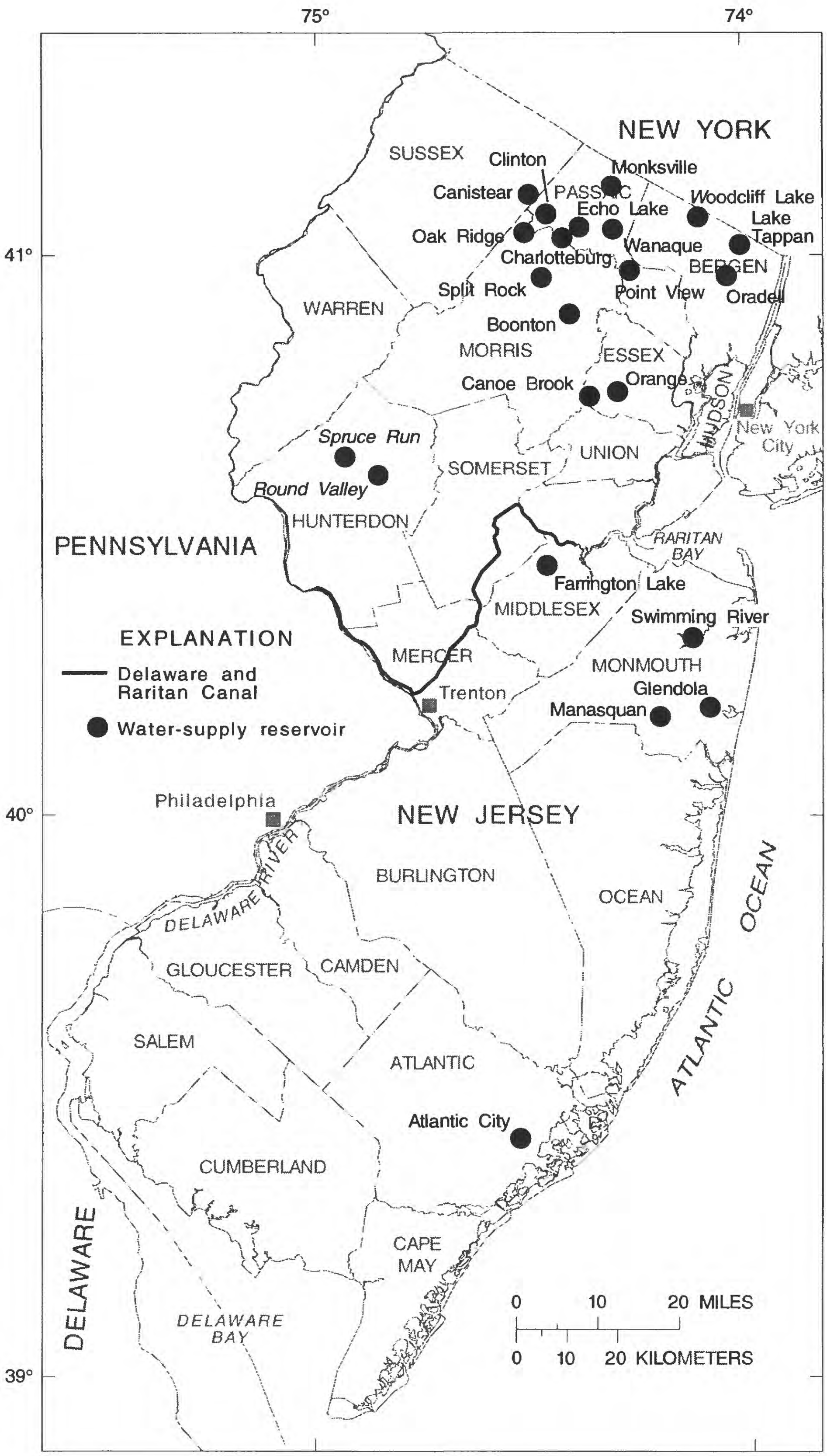


Figure 4. Water-supply reservoirs and the Delaware and Raritan Canal in New Jersey.

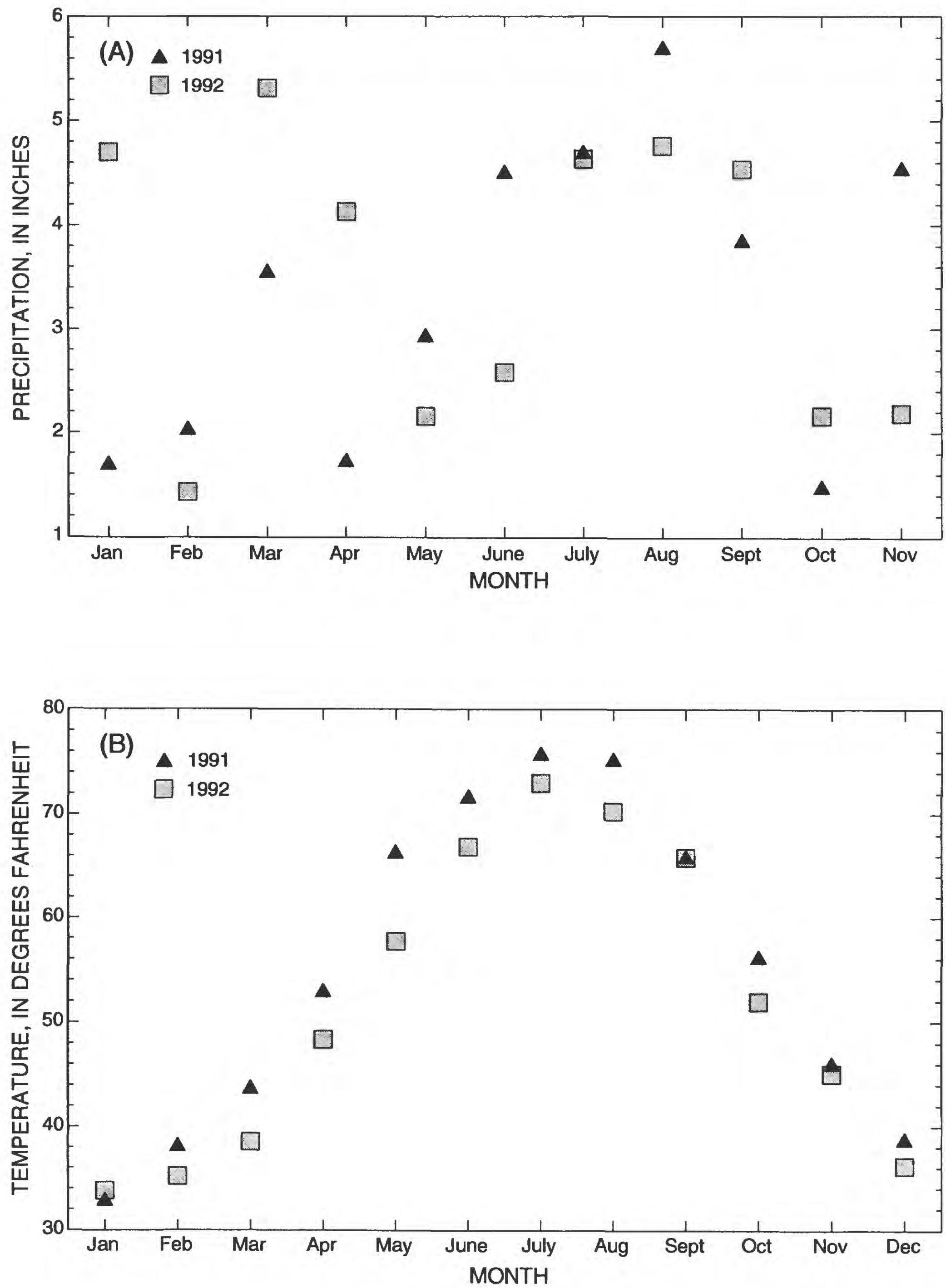


Figure 5. Average monthly (A) precipitation and (B) temperature in New Jersey, 1991 and 1992. (Modified from National Climatic Data Center, 1992, 1993)

Collection of Withdrawal Data

By the 1890's, the rapid urban and industrial growth in New Jersey had caused local degradation of water quality and insufficient water supplies (Capen, 1937; New Jersey Commission on Efficiency and Economy in State Government, 1967). The State government responded to these problems by initiating water regulations and water-resources-management programs. The current water-allocation program is a comprehensive system for monitoring withdrawals of water.

Data Sources and Compilation

The 1981 Water Supply Management Act authorizes the NJDEP to monitor withdrawals of ground water and surface water in New Jersey (Saarela, 1992, p. 6). Water users must obtain permission in the form of a permit, registration, or certification (Principi, 1991). Water-allocation permits are issued to users who withdraw 100,000 gal/d or more. During a 24-hour period, the amount of water withdrawn by pumping equipment producing 70 gal/min is about 100,000 gal. Permit holders must submit quarterly reports of monthly withdrawal data and must recalibrate in-line flowmeters during their permitting period of 4 to 7 years. In 1995, there were about 3,900 water-allocation permits including 2,100 public-supply (5,000-series permits), 1,700 industrial and commercial (2,000P-series permits), and 70 surface-water-only permits (4,000PS-series permits).

Well registrants, water users whose pumping equipment is capable of producing 70 gal/min but who withdraw less than 100,000 gal/d, must submit annual reports of monthly withdrawals. About 1,440 water users are classified as well registrants (10,000W-series).

Agricultural/horticultural certification and registrations are issued through the County Agricultural Agent, who collects information on crop type and amount of irrigated acreage and determines the maximum monthly withdrawals for each applicant. Agricultural/horticultural water users who withdraw 100,000 gal/d or more must apply for agricultural/horticultural certifications. Agricultural/horticultural registrants use pumping equipment capable of producing 70 gal/min, but withdraw less than 100,000 gal/d. Withdrawals for agricultural/horticultural purposes rarely are metered; water users submit monthly withdrawal data that are estimated by multiplying the number of hours of use by the pump capacity. Monthly withdrawals are reported annually to the NJDEP. Non-agricultural irrigation users, such as golf courses, must obtain a water-allocation permit or well registration. These users must meter their withdrawals and report monthly withdrawal data according to their permit or registration requirements. There are about 2,800 agricultural/horticultural certifications and registrations.

For most sites, NJDEP staff entered site-specific monthly withdrawal data into a computerized data base. The NJDEP reviewed annual withdrawal data and compared the data for the current year with the annual withdrawal data for the preceding 5 years for water users renewing their permit, registration, or certification. Water-withdrawal data were provided as computer files by the NJDEP to the USGS as part of the Cooperative Water-Use Program.

The USGS reconfigured and tested the withdrawal and site data before they were entered into the SSWUDS data base. USGS software was used to compare site characteristics and annual withdrawal values in the NJDEP data base with those in the SSWUDS data base by using the NJDEP water-allocation identifier (permit, registration, or certification number) of the water user, the NJDEP well-permit number of the ground-water site, and the NJDEP identifier of the surface-water site.

The annual withdrawal value reported by the NJDEP was compared with the annual value that was entered for the preceding year in the SSWUDS data base for the site; values that differed by less than 1 percent were considered to match. Data-collection forms and diagnostic messages were generated for unmatched site and withdrawal data. Unmatched data included (1) a miscoded NJDEP water-allocation identifier, well-permit number, or surface-water identifier; (2) a change in withdrawals greater than 1 percent; or (3) a new withdrawal site or disaggregation of previously combined withdrawal data.

After site and withdrawal data in the NJDEP and SSWUDS data bases were compared, a second USGS software program was used to reformat the withdrawal data into standard SSWUDS input configuration. Unmatched site and withdrawal data generated on data-collection forms were compared with the NJDEP data files; corrected information was entered into the SSWUDS data base.

Methods Used to Estimate Water Withdrawals

In this report, a per capita use coefficient for domestic self-supplied withdrawals was developed by analyzing data on domestic deliveries (water sales) by public suppliers (fig. 6). The per capita use by publicly supplied and self-supplied domestic users was assumed to be similar. Domestic deliveries were estimated from coefficients that were developed by the author (Nawyn, 1997a) from data reported in the Water Industry Data Base of the American Water Works Association (1992) and from data obtained from large public-supply systems in New Jersey, such as the New Jersey-American Water Company[1] (James Scott, New Jersey-American Water Company, written commun., 1993) and the Elizabethtown Water Company (Edward Cash, Elizabethtown Water Company, written commun., 1994). Data on the population served were estimated from reports of public suppliers and data from the U.S. Bureau of the Census (1992, 1994b). To estimate the per capita use by publicly supplied domestic users, the value estimated for domestic deliveries was divided by the population served. The per capita coefficient of 82 gal/d that resulted from this calculation was used to estimate the withdrawals by self-supplied domestic users.

Reliability of Data

Non-agricultural withdrawal data collected by the NJDEP are highly reliable because the withdrawals were metered and many of the in-line flowmeters were periodically recalibrated. In

[1] The use of firm names in this report is for identification purposes only and does not impute responsibility for any present or potential effects on water resources in the study area.

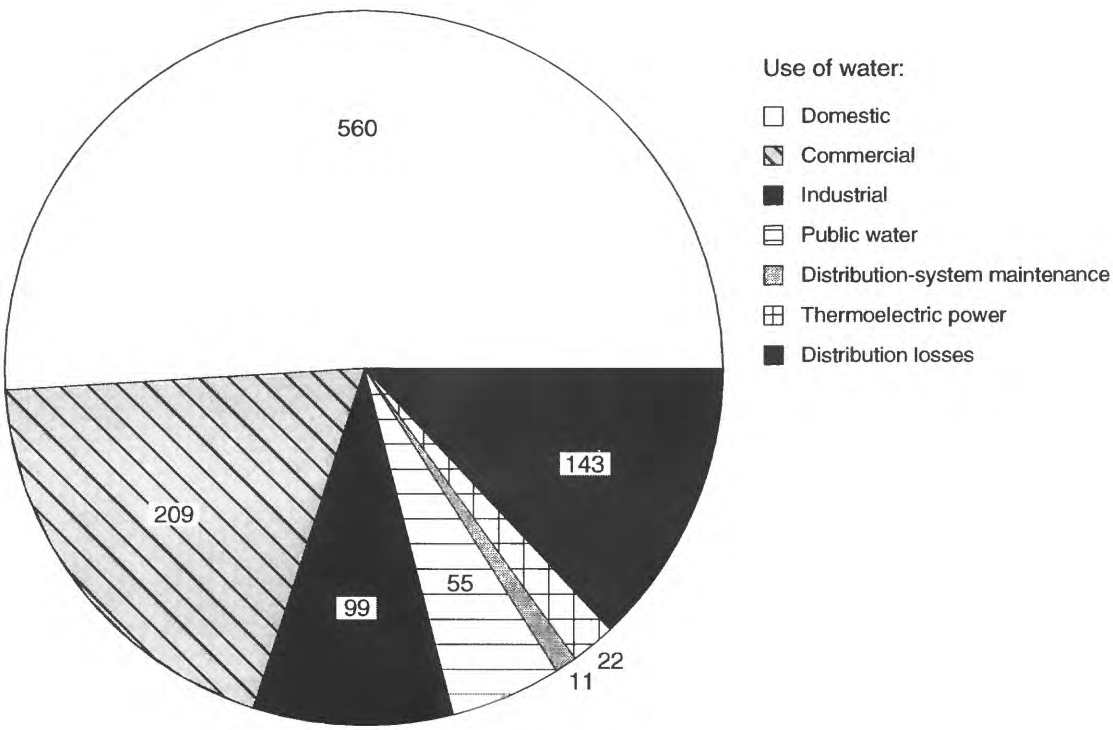


Figure 6. Estimated average annual water deliveries, distribution-system maintenance, and distribution losses by public suppliers in New Jersey, 1991-92. (Values in million gallons per day)

addition, the NJDEP and USGS staff reviewed annual withdrawal data for consistency. Summaries of aggregated data (aquifer, county, HUC, and category of use) were checked by USGS staff for consistency with previously reported information; inconsistencies were investigated by contacting the NJDEP or the water user.

Agricultural withdrawal data include non-metered values estimated by the water user and reported to NJDEP. The reliability of the withdrawal data varies depending on the accuracy of the determination of the pump capacity and the number of hours of pumping. Pump capacity can decrease when pumping equipment ages or when water levels are lowered because of regional water-level changes (Eckel and Walker, 1983). Pumping time can be determined from time-totalizing meters attached to discharge pipes, running-time meters on gas- or diesel-powered generators or tractors, and electric-utility records.

In 1991, the USGS conducted a field study to verify withdrawals for irrigation use reported by 10 agricultural/horticultural users. Eighteen digital vibration-time totalizers that measure the time of pump operation were attached to irrigation pipes. Withdrawal data calculated from vibration-time totalizer readings and estimated data reported by the water user to NJDEP were found to have a positive correlation ($r = 0.905$). At one site, the volume determined from vibration-time totalizers readings was compared with the volume determined from in-line flowmeter readings, and the volumes were consistent (Clawges and Titus, 1993).

Withdrawal data on self-supplied domestic users have the largest margin of error of the data included in this report. Both population and water-use coefficients were estimated. Population data were compared with the most recent U.S. Bureau of the Census (1991a, 1991b) data to identify any large errors. The water-use coefficient used in this report represents the most recent estimate of per capita use.

Presentation of Data

Most of the data included in this report are metered withdrawals and are reported by the type of water (ground water or surface water), category of use, county, and HUC. Withdrawals of ground water also are reported by aquifer and physiographic province. Data on unmetered withdrawals by self-supplied domestic users are presented by county and type of water.

Numerical water-use data are the average quantities used and are reported in million gallons per day (Mgal/d). Irrigation water is applied seasonally and at variable rates; therefore, the actual rate of application is at times much greater than the average daily rate presented in this report. Population data are shown to the nearest thousand. Withdrawal data presented as total values for the State and by county, aquifer, and HUC are rounded to the nearest whole number.

Withdrawal data compiled by county (tables 3-5) include all categories of use; however, the average withdrawals for 1991-92, listed in table 5, may not equal the average of the values listed in tables 3 (1991 withdrawals) and 4 (1992 withdrawals) as a result of independent rounding. In addition, withdrawal data on self-supplied domestic users and other users for which HUC and aquifer designations were not available are reported in the tables as "Unclassified withdrawals" or "Unclassified aquifers."

Previous Investigations

Vermeule (1894) discussed withdrawals for public supply in the first comprehensive report on withdrawals of ground water and surface water in the State. Hazen and others (1922) and the New Jersey Water Policy Commission (1926) describe sources, consumption, and development of potable water supplies in New Jersey. Tippetts-Abbett-McCartney-Stratton (1955) compiled public-supply withdrawal data for the New Jersey Legislative Commission on Water Supply. Major withdrawals of surface water for public supply in New Jersey are presented in the annual surface-water data reports (since 1961) prepared by the USGS (Bauersfeld and others, 1992, 1993, 1994). Agricultural water demands in New Jersey were estimated by Titus and others (1992) for field-grown crops and by Clawges and Titus (1993) for crops, livestock, and selected sectors of the food-processing industry.

Previous studies of withdrawals in New Jersey investigated the ground-water resources of the Coastal Plain. Withdrawal data for the Coastal Plain are summarized in reports by Vowinkel (1984) and Vowinkel and Foster (1981). Horn and Bratton (1991) compiled historical (1901-85) withdrawal data for Middlesex and Monmouth Counties. Earlier studies of the Coastal Plain presented withdrawal data for individual counties, aquifers, or local areas. Water-resources investigations that report ground-water withdrawal data for counties in the Coastal Plain include Clark and others (1968), Atlantic County; Rush (1968), Burlington County; Farlekas and others (1976), Navoy and Carleton (1995), and Nawyn (1997a), Camden County; Gill (1962), Cape May County; Rooney (1971), Cumberland County; Hardt and Hilton (1969), Gloucester County; Vecchioli and Palmer (1962), Mercer County; Barksdale and others (1943), Middlesex County; Jablonski (1968), Monmouth County; Anderson and Appel (1969), Ocean County; and Rosenau and others (1969), Salem County.

Results of ground-water-flow simulation are described, and ground-water-withdrawal data are presented, for aquifers in the Coastal Plain in reports on the Potomac-Raritan-Magothy aquifer system (Luzier, 1980), the Farrington aquifer (Farlekas, 1979), the Englishtown aquifer system (Nichols, 1977), and the Wenonah-Mount Laurel aquifer (Nemickas, 1976). Zapecza and others (1987) reported ground-water-withdrawal data for the major aquifers in the Coastal Plain.

Withdrawal data were compiled by Sargent and others (1985) for ground water, by Schopp and Bauersfeld (1986) for surface water, and by Qualls and Horn (1990) for ground water and surface water. Horn and Bratton (1991) compiled withdrawal data (1901-85) on Middlesex and Monmouth Counties. The NJDEP compiled data on withdrawals of ground water and surface water in New Jersey during 1987 (Merend, 1989), 1988 (Saarela, 1992), and 1995 (Hoffman and Mennel, 1997). Zripko and Hasan (1994) studied depletive water use (water and wastewater transfers among water basins) in New Jersey and compiled data on the average annual water withdrawals and wastewater discharges during 1986-88. Withdrawal data on ground water and surface water in New Jersey during 1989-90, 1993, and 1994 are found in Nawyn and Clawges (1995), Nawyn (1997b), and Nawyn (1997c), respectively.

The USGS published national water-use reports at 5-year intervals from 1950 through 1992 that included water withdrawals in New Jersey (MacKichan, 1951, 1957; MacKichan and Kammerer, 1961; Murray, 1968; Murray and Reeves, 1972, 1977; Solley and others, 1983, 1988, 1993; Solley and Pierce, 1992). In addition, data on the source, use, and disposition of water throughout the United States were compiled by Carr and others (1992) as part of the USGS's series of annual reports on national water resources.

Acknowledgments

The author gratefully acknowledges Helve Saarela, Nicole Griscom, and Richard Kropp of the NJDEP for their professional guidance in preparing this report. The author also thanks the NJDEP staff for collecting and entering monthly withdrawal data into computer files.

WITHDRAWALS OF GROUND WATER AND SURFACE WATER

For this report, withdrawals of ground water and surface water are grouped into seven categories--public supply, domestic, commercial, irrigation, industrial, mining, and thermoelectric power. Withdrawal data in this report represent withdrawals of freshwater. Most withdrawal data were compiled from monthly withdrawal data that were reported by water users as part of the water-allocation program in New Jersey.

In 1991, withdrawals in New Jersey totaled about 2,110 Mgal/d--576 Mgal/d of ground water and 1,534 Mgal/d of surface water (table 3). In 1992, withdrawals totaled about 2,090 Mgal/d--571 Mgal/d of ground water and 1,519 Mgal/d of surface water (table 4). Ground-water withdrawals accounted for about one-quarter of all withdrawals in the State; surface-water withdrawals accounted for about three-quarters. Hereafter, "average" represents the arithmetic mean of withdrawals reported in 1991 and 1992.

Public Supply

Withdrawals for public supply accounted for about one-half of all withdrawals in the State. In 1991, withdrawals for public supply were about 1,100 Mgal/d--401 Mgal/d of ground water and 699 Mgal/d of surface water (table 3). In 1992, withdrawals for public supply totaled about 1,095 Mgal/d--400 Mgal/d of ground water and 695 Mgal/d of surface water (table 4). Ground water accounted for about 36 percent of average (1991-92) withdrawals for public supply, and surface water provided about 64 percent (table 5).

Average withdrawals of ground water for public supply during 1991-92 (401 Mgal/d) were 6 Mgal/d greater than 1989-90 withdrawals (395 Mgal/d); average surface-water withdrawals for public supply in 1991-92 (698 Mgal/d) were 68 Mgal/d greater than withdrawals in 1989-90 (630 Mgal/d) (table 5; Nawyn and Clawges, 1995). The increase in surface-water withdrawals is related to a new source of water, the Manasquan Reservoir (fig. 4), in Critical Water-Supply Management Area (CWSMA) No. 1, which is composed of eastern Middlesex County and the northeastern parts of Monmouth and Ocean Counties. Overpumping of ground water by water users in CWSMA No. 1 has resulted in saltwater intrusion. To protect existing freshwater, ground-water users were mandated to explore alternative sources of supply (Qualls and Horn, 1990).

Table 3. Withdrawals of ground water and surface water in New Jersey by county and category of use, 1991

[Values may not add to totals because of independent rounding. Withdrawal data are metered values, except as noted. Values are rounded to nearest whole number. All values in million gallons per day; **, withdrawals less than 1 million gallons per day; --, withdrawals less than reporting level of 0.005 million gallons per day

County	Public supply		Domestic[1]		Commercial		Irrigation[2]		Industrial		Mining		Thermoelectric power		Total[2]	
	Ground water	Surface water	Ground water	Surface water	Ground water	Surface water	Ground water	Surface water	Ground water	Surface water	Ground water	Surface water	Ground water	Surface water	Ground water	Surface water
Atlantic	28	--	6	--	2	--	9	5	**	--	--	--	--	--	45	5
Bergen	20	90	2	--	1	--	**	**	6	13	--	--	--	--	29	103
Burlington	33	3	7	--	1	--	3	90	5	**	--	4	--	26	49	123
Camden	67	--	2	--	**	--	2	**	**	4	**	1	--	--	71	5
Cape May	17	--	4	--	**	--	1	**	**	--	--	3	**	--	22	3
Cumberland	14	--	4	--	**	--	8	3	6	--	**	11	--	--	32	14
Essex	22	10	**	--	1	--	**	**	1	--	--	--	--	--	24	10
Gloucester	21	--	4	--	--	**	1	9	8	55	--	1	--	--	34	65
Hudson	--	--	--	--	**	--	--	--	**	--	--	--	--	--	**	--
Hunterdon	3	[3]87	6	--	--	--	**	--	2	35	--	--	**	21	11	143
Mercer	10	34	2	--	**	**	**	**	1	4	--	--	--	450	13	488
Middlesex	30	2	2	--	**	**	1	**	7	**	**	2	--	--	40	4
Monmouth	21	34	4	--	**	--	**	1	1	--	--	--	--	--	26	35
Morris	41	51	7	--	**	--	**	**	3	1	--	1	--	--	51	53
Ocean	39	3	9	--	**	**	**	1	**	1	--	5	--	--	48	10
Passaic	7	281	3	--	--	--	**	**	**	**	--	--	--	--	10	281
Salem	4	1	2	--	--	--	2	2	3	14	**	--	1	--	12	17
Somerset	4	[3]97	5	--	**	**	**	**	1	--	--	--	--	--	10	97
Sussex	2	1	7	--	**	--	--	--	--	--	**	--	--	--	9	1
Union	12	5	**	--	1	--	**	**	2	13	**	--	--	--	15	18
Warren	6	--	3	--	8	--	**	1	5	57	--	--	--	--	22	58
State	401	699	[1]79	--	14	1	[2]27	[2]112	51	197	2	28	2	497	[2]576	[2]1,534

[1] Estimated water-use value.
[2] Includes withdrawal values estimated by water user.
[3] Includes water transfer from Delaware River in Hunterdon County to Raritan River in Somerset County.

Table 4. Withdrawals of ground water and surface water in New Jersey by county and category of use, 1992

[Values may not add to totals because of independent rounding. Withdrawal data are metered values, except as noted. Values are rounded to nearest whole number. All values in million gallons per day; **, withdrawals less than 1 million gallons per day; --, withdrawals less than reporting level of 0.005 million gallons per day]

County	Public supply		Domestic[1]		Commercial		Irrigation[2]		Industrial		Mining		Thermoelectric power		Total[2]	
	Ground water	Surface water	Ground water	Surface water	Ground water	Surface water	Ground water	Surface water	Ground water	Surface water	Ground water	Surface water	Ground water	Surface water	Ground water	Surface water
Atlantic	27	--	6	--	2	--	4	2	**	--	--	--	--	--	39	2
Bergen	22	102	2	--	1	--	**	**	7	14	--	--	--	--	32	116
Burlington	32	1	7	--	**	--	1	78	5	**	--	4	--	8	45	91
Camden	64	--	3	--	1	--	2	**	**	2	**	1	--	--	70	3
Cape May	16	--	4	--	**	--	1	**	**	--	4	6	**	--	25	6
Cumberland	15	--	4	--	**	--	6	2	5	--	**	11	--	--	30	13
Essex	21	8	**	--	1	--	**	**	1	--	--	--	--	--	23	8
Gloucester	22	--	4	--	--	**	1	2	8	52	--	1	--	--	35	55
Hudson	--	--	--	--	**	--	--	--	**	--	--	--	--	--	**	--
Hunterdon	4	[3]85	6	--	--	--	**	--	3	25	--	--	**	17	13	127
Mercer	10	30	2	--	**	**	**	**	1	13	--	--	--	493	13	536
Middlesex	32	1	2	--	**	**	1	**	7	**	**	**	--	--	42	1
Monmouth	15	30	4	--	1	--	**	1	1	--	--	--	--	--	21	31
Morris	38	49	7	--	1	--	**	**	3	1	--	1	--	--	49	51
Ocean	39	2	9	--	**	**	**	1	**	**	--	6	--	--	48	9
Passaic	6	286	3	--	--	--	**	**	**	1	--	--	--	--	9	287
Salem	4	2	2	--	--	--	1	2	3	12	**	--	1	--	11	16
Somerset	5	[3]93	5	--	**	**	**	**	1	--	--	--	--	--	11	93
Sussex	2	1	7	--	**	--	--	--	--	--	**	--	--	--	9	1
Union	20	5	**	--	1	--	**	**	3	8	**	--	--	--	24	13
Warren	6	--	3	--	8	--	**	**	3	59	--	--	--	--	20	59
State	400	695	[1]80	--	17	1	[2]16	[2]88	51	187	5	30	2	518	[2]571	[2]1,519

[1] Estimated water-use value.
[2] Includes withdrawal values estimated by water user.
[3] Includes water transfer from Delaware River in Hunterdon County to Raritan River in Somerset County.

Table 5. Average withdrawals of ground water and surface water in New Jersey by county and category of use, 1991-92

[Values may not add to totals because of independent rounding. Values in this table may not equal the average of values in tables 3 and 4 as a result of independent rounding. Withdrawal data are metered values, except as noted. Values are rounded to nearest whole number, and values greater than 1,000 are rounded to three significant figures. All values in million gallons per day; **, withdrawals less than 1 million gallons per day; --, withdrawals less than reporting level of 0.005 million gallons per day]

County	Public supply		Domestic[1]		Commercial		Irrigation[2]		Industrial		Mining		Thermoelectric power		Total[2]	
	Ground water	Surface water	Ground water	Surface water	Ground water	Surface water	Ground water	Surface water	Ground water	Surface water	Ground water	Surface water	Ground water	Surface water	Ground water[1]	Surface water[1]
Atlantic	28	--	6	--	2	--	6	4	--	--	--	--	--	--	42	4
Bergen	21	96	2	--	1	--	**	**	6	14	--	--	--	--	30	110
Burlington	32	2	7	--	1	--	2	84	5	**	--	4	--	17	47	107
Camden	66	--	2	--	1	--	2	**	**	3	**	1	--	--	71	4
Cape May	16	--	4	--	**	--	1	**	**	--	2	4	**	--	23	4
Cumberland	14	--	4	--	**	--	7	2	6	--	**	11	--	--	31	13
Essex	22	9	**	--	1	--	**	**	1	--	--	--	--	--	24	9
Gloucester	22	--	4	--	**	**	1	6	8	54	--	1	--	--	35	61
Hudson	--	--	--	--	**	--	--	--	**	--	--	--	--	--	**	--
Hunterdon	4	[3]86	6	--	--	--	**	--	2	30	--	--	**	19	12	135
Mercer	10	32	2	--	**	**	**	**	1	8	--	--	--	472	13	512
Middlesex	31	2	2	--	**	**	1	**	7	**	**	1	--	--	41	3
Monmouth	18	32	4	--	1	--	**	1	1	--	--	--	--	--	24	33
Morris	40	50	7	--	1	--	**	**	3	1	--	1	--	--	51	52
Ocean	39	2	9	--	**	**	**	1	--	1	--	6	--	--	48	10
Passaic	6	284	3	--	--	--	**	**	**	1	--	--	--	--	9	285
Salem	4	2	2	--	--	--	2	2	3	13	--	--	1	--	12	17
Somerset	4	[3]95	5	--	**	**	**	**	1	--	**	--	--	--	10	95
Sussex	2	1	7	--	**	--	--	--	--	--	**	--	--	--	9	1
Union	16	5	**	--	1	--	**	**	2	10	**	--	--	--	19	15
Warren	6	--	3	--	8	--	**	1	4	58	--	--	--	--	21	59
State	401	698	[1]79	--	17	1	[2]22	[2]101	50	193	4	29	2	508	[2]575	[2]1,530

[1] Estimated water-use value.
[2] Includes withdrawal values estimated by water user.
[3] Includes water transfer from Delaware River in Hunterdon County to Raritan River in Somerset County.

A public-supply system serves at least 25 people or has a minimum of 15 service connections (Solley and others, 1988, p. 10). New Jersey has 638 public-supply systems, including 314 municipal systems, 102 investor-owned systems, 193 small community public-supply systems (homeowner associations, mobile home parks, real estate developers, and apartment owners), and 29 self-supplied institutions including military, hospitals, and correctional facilities (unpublished data on file at New Jersey Department of Environmental Protection, Trenton, N.J.).

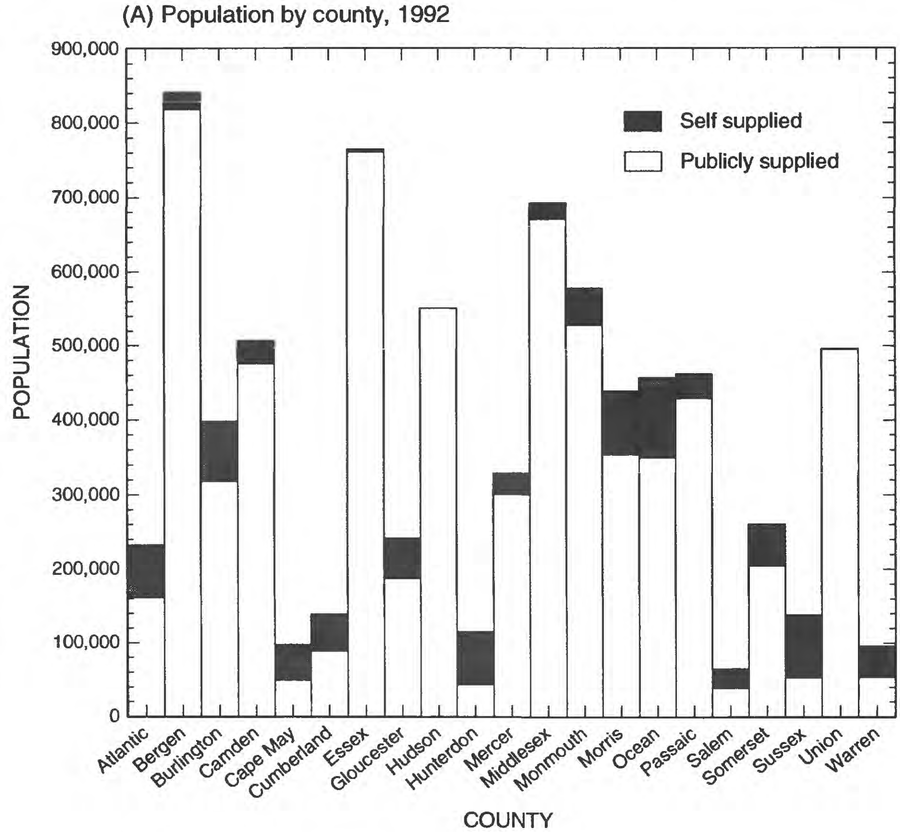
Most residents of New Jersey are served by public suppliers, although the distribution of publicly supplied residents is not uniform throughout the State. It was estimated in this study that about 6.8 million people, or 88 percent of the residents of the State, are served by public-supply systems (fig. 7a; table 6). Urban counties in northeastern and central New Jersey, such as Bergen, Essex, Hudson, Middlesex, and Union (fig. 1), are almost totally (96 percent or greater) served by public-supply systems (table 6). In contrast, less than 40 percent of the population of rural Hunterdon and Sussex Counties in the northwestern part of New Jersey is served by public-supply systems.

Deliveries by Public Suppliers

A previously developed method to estimate coefficients of water deliveries (Nawyn, 1997a) was applied to data on public-supply withdrawals in each county during 1991-92. Coefficients of water deliveries for each county were estimated for this study. Although water withdrawn by public suppliers is used for many purposes in homes, offices, industrial facilities, schools, and parks, water deliveries are chiefly to local residences for domestic use. About 51 percent of the total withdrawals for public supply is estimated to be delivered to domestic users (fig. 6). Commercial deliveries represent about 19 percent of total public-supply withdrawals. Industrial users are estimated to receive about 9 percent of publicly supplied water, and thermoelectric-power customers use about 2 percent. The balance of the water (about 19 percent) is estimated to be used for distribution-system maintenance (1 percent), distribution-system losses (13 percent), and public water use (5 percent) (fig. 6). Distribution-system maintenance is the backwashing of filters and well screens. Distribution losses include water lost through damaged water pipes, improperly registering water meters, and unauthorized water connections. Public water use includes water, metered or unmetered, used for schools, municipal buildings, recreational facilities, and firefighting.

Per Capita Use

Per capita use by publicly supplied residents was estimated from data on domestic deliveries by public suppliers. In 1991-92, total public-supply withdrawals averaged 1,099 Mgal/d (table 5), and domestic deliveries were estimated to average 560 Mgal/d, or about 51 percent of total public-supply withdrawals (fig. 6). The average per capita domestic use was estimated to be 82 gal/d. Average monthly domestic deliveries in 1991-92 were lowest in February and were estimated to be 526 Mgal/d (per capita use, 77 gal/d); average monthly domestic deliveries were greatest in July and were estimated to be 609 Mgal/d (per capita use, 89 gal/d). In 1991-92, therefore, water use averaged about 12 gal/d per person greater in July than in February.



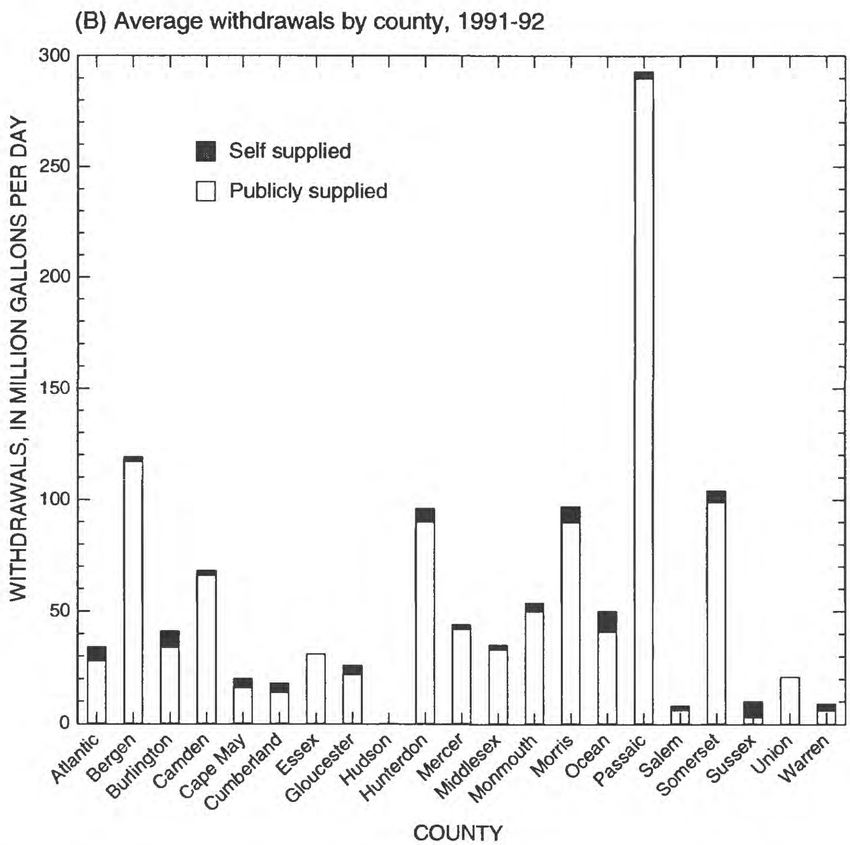


Figure 7. Estimated population and average annual withdrawals by publicly supplied and self-supplied domestic users in New Jersey: (A) population by county, 1992, and (B) average withdrawals by county, 1991-92.

Table 6. Estimated population of New Jersey by county and type of water supply, 1992

[Figures may not add to totals because of independent rounding. Population data from U.S. Bureau of the Census (1992,1994c) and data on file at the New Jersey Department of Environmental Protection, Trenton, New Jersey; all withdrawal values in million gallons per day; --, no value reported; <, less than]

County	Total population	Domestic supply		Public supply	
		Population served[1]	Percent of county population	Population served[1]	Percent of county population
Atlantic	229,000	71,000	31	158,000	69
Bergen	835,000	23,000	3	812,000	97
Burlington	397,000	80,000	20	317,000	80
Camden	508,000	31,000	6	477,000	94
Cape May	97,000	48,000	49	49,000	51
Cumberland	138,000	50,000	36	88,000	64
Essex	773,000	4,000	1	769,000	99
Gloucester	237,000	54,000	23	183,000	77
Hudson	555,000	--	--	555,000	100
Hunterdon	112,000	72,000	64	40,000	36
Mercer	328,000	29,000	9	299,000	91
Middlesex	684,000	22,000	3	662,000	97
Monmouth	566,000	50,000	9	516,000	91
Morris	428,000	85,000	20	343,000	80
Ocean	438,000	107,000	24	331,000	76
Passaic	456,000	33,000	7	423,000	93
Salem	65,000	26,000	40	39,000	60
Somerset	250,000	56,000	22	194,000	78
Sussex	135,000	85,000	63	50,000	37
Union	493,000	1,000	<1	492,000	100
Warren	94,000	42,000	45	52,000	55
State	[2]7,820,000	[1]969,000	12	[1]6,849,000	88

[1] Estimated data.

[2] Value reported by U.S. Bureau of the Census. The sum of the county values may not equal the total value reported for the State as a result of rounding to the nearest thousand.

Transfer of Surface-Water Withdrawals

Early in this century, potable water was not available in sufficient quantity near the large population centers in northern New Jersey; consequently, water-supply reservoirs and water-distribution systems were constructed to deliver surface water from rural areas to urban areas (Capen, 1937). Hunterdon, Morris, Passaic, and Somerset Counties export water to Essex, Hudson, and Union Counties. Bergen County imports and exports public water supplies (fig. 8). Withdrawals for public supply in Hunterdon, Morris, Passaic, and Somerset Counties are higher than would be expected if withdrawals were evaluated on the basis of population; withdrawals in Essex, Hudson, and Union Counties are lower than would be expected because of transfers of water (table 6).

Withdrawals of surface water for public supply in one county can be widely distributed among several counties through interconnected water systems. The North Jersey District Water Supply Commission administers the Wanaque Reservoir system (in Passaic County) (fig. 8), one of the largest water-supply reservoirs in the State. Water from the Wanaque system is distributed to communities throughout northeastern New Jersey. In Bergen County, the Hackensack Water Company withdraws water for delivery to other counties and receives water from the Wanaque Reservoir system in Passaic County. Water from water-supply reservoirs in Morris County is distributed to water utilities in Essex (for the City of Newark) and Hudson (for Jersey City) Counties (Tedeschi, 1993) (fig. 8).

In central New Jersey, as much as 100 Mgal/d may be diverted from the Delaware River in Hunterdon County through the Delaware and Raritan (D&R) Canal (Saarela, 1992, p. 9) (fig. 8). The New Jersey Water Supply Authority (NJWSA) administers withdrawals from the D&R Canal, the Spruce Run-Round Valley reservoir system in Hunterdon County, and the Raritan River in Somerset County. The Elizabethtown Water Company withdraws water from the D&R Canal and the Raritan River in Somerset County for delivery to other counties (Edward Mullen, Elizabethtown Water Company, oral commun., 1992). During 1991-92, about 85 Mgal/d of surface water was transferred from Hunterdon County to Somerset County through the D&R Canal.

The other large surface-water transfer in New Jersey is in Monmouth County, where the NJWSA administers the Manasquan Reservoir, a public-supply reservoir serving the multi-county area of CWSMA No. 1. In addition, New Jersey-American Water Company is constructing a pipeline to divert water from the Delaware River at Delanco, N.J., to supply communities in CWSMA No. 2, which is composed of Camden County and most of Burlington and Gloucester Counties.

Withdrawals by County

More than one-quarter of all publicly supplied water in New Jersey is withdrawn in Passaic County (290 Mgal/d). Withdrawals for public supply averaged 117 Mgal/d in Bergen County, 99 Mgal/d in Somerset County, and 90 Mgal/d each in Morris and Hunterdon Counties (fig. 9; table 5).

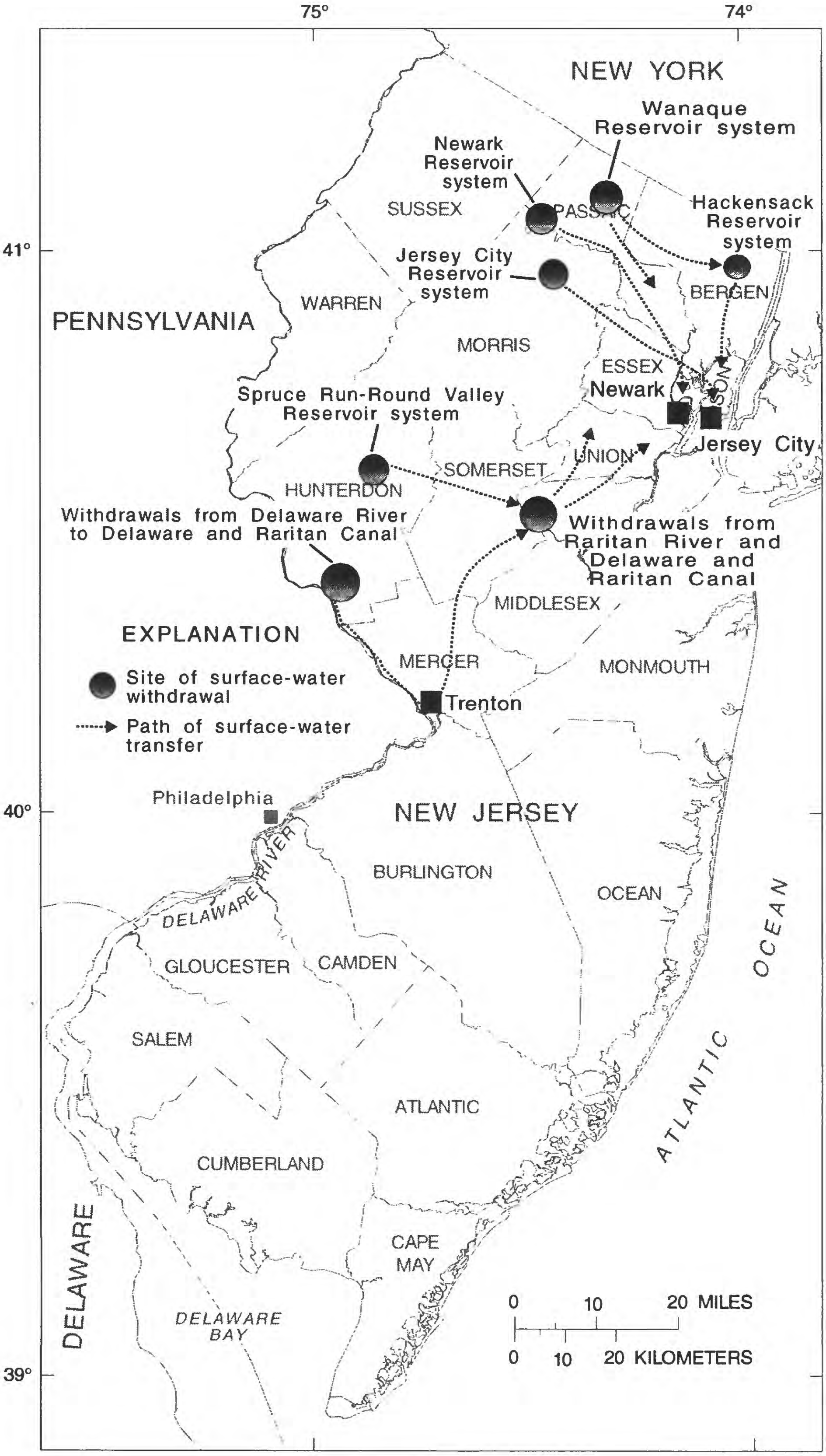


Figure 8. Transfers of surface water among public-supply systems in New Jersey.

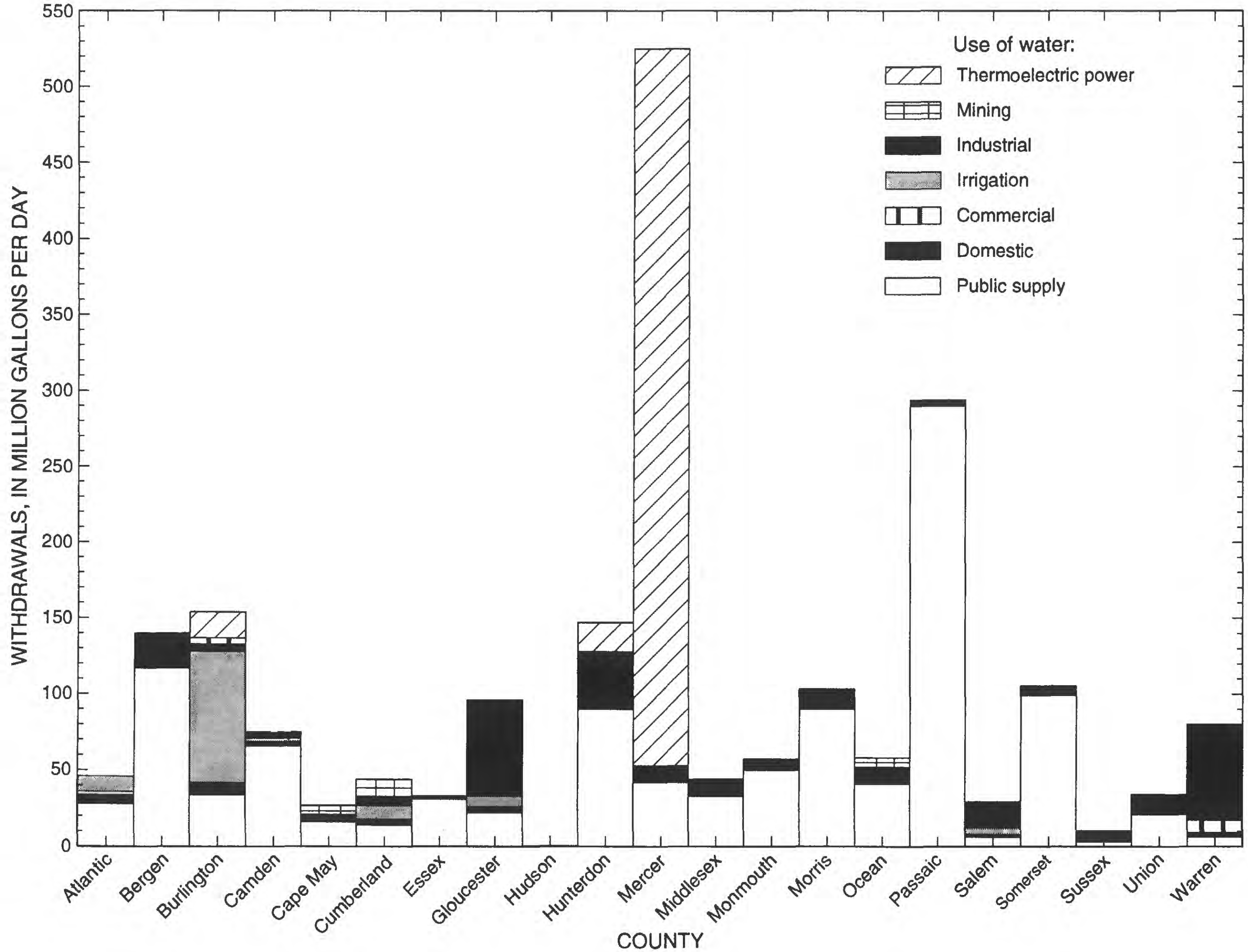


Figure 9. Average withdrawals of ground water and surface water in New Jersey by county and category of use, 1991-92.

Ground water is the principal type of water used by water utilities located in the Coastal Plain. Withdrawals in Camden County accounted for 16 percent (average 66 Mgal/d) of all public-supply withdrawals of ground water in New Jersey (table 5). Withdrawals of ground water for public supply averaged 40 Mgal/d in Morris County, 39 Mgal/d in Ocean County, 32 Mgal/d in Burlington County, and 31 Mgal/d in Middlesex County (table 5).

Surface water is the primary source of water for the urban counties in northeastern and central New Jersey (fig. 1; table 5). Withdrawals from water-supply reservoirs in Passaic County (fig. 4) averaged 284 Mgal/d (table 5). Withdrawals of surface water for public supply averaged 96 Mgal/d in Bergen County, 95 Mgal/d in Somerset County, and 86 Mgal/d in Hunterdon County (table 5).

Withdrawals by Hydrologic Cataloging Unit

Withdrawals for public supply in the Hackensack-Passaic HUC averaged 516 Mgal/d (figs. 3 and 10; table 7). Withdrawals for public supply averaged 152 Mgal/d in the Raritan HUC, 133 Mgal/d in the Middle Delaware-Musconetcong HUC, and 104 Mgal/d in the Lower Delaware HUC (figs. 3 and 10; table 7).

Withdrawals of ground water for public supply in the Lower Delaware HUC averaged 104 Mgal/d. Average ground-water withdrawals by public suppliers in the Hackensack-Passaic, Raritan, and Mullica-Toms HUC's were 77 Mgal/d, 57 Mgal/d, and 46 Mgal/d, respectively (table 7). Unclassified withdrawals of ground water totaled 6 Mgal/d.

Withdrawals for public supply from the public-supply reservoirs in the Hackensack-Passaic HUC accounted for about 63 percent (average 439 Mgal/d) of the average withdrawals of surface water for public supply in the State (table 7). Withdrawals from the Delaware River in the Middle Delaware-Musconetcong HUC averaged 119 Mgal/d, including withdrawals for the City of Trenton (fig. 1) and water transfers to the D & R Canal (figs. 4 and 8). Average withdrawals of surface water for public supply were 95 Mgal/d in the Raritan HUC and 30 Mgal/d in the Sandy Hook-Staten Island HUC (table 7). Unclassified withdrawals of surface water totaled 3 Mgal/d.

Withdrawals by Aquifer and Physiographic Province

During 1991-92, withdrawals for public supply averaged 272 Mgal/d from aquifers in the Coastal Plain and 129 Mgal/d from aquifers in the non-Coastal Plain physiographic provinces (fig. 2; table 8). Withdrawals from the Potomac-Raritan-Magothy aquifer system, the primary source of ground water for public supply in New Jersey, averaged 167 Mgal/d. Average withdrawals from the Upper, Middle, Lower, and undifferentiated aquifers of the Potomac-Raritan-Magothy aquifer system were 58 Mgal/d, 43 Mgal/d, 52 Mgal/d, and 14 Mgal/d, respectively (fig. 11a; table 8). Withdrawals for public supply averaged 68 Mgal/d from the Kirkwood-Cohansey aquifer system and 18 Mgal/d from the Atlantic City 800-foot sand. Public-supply withdrawals from unclassified aquifers totaled 3 Mgal/d (table 8). Average withdrawals by county and by aquifers within those counties are shown in figure 11b and listed in table 9.

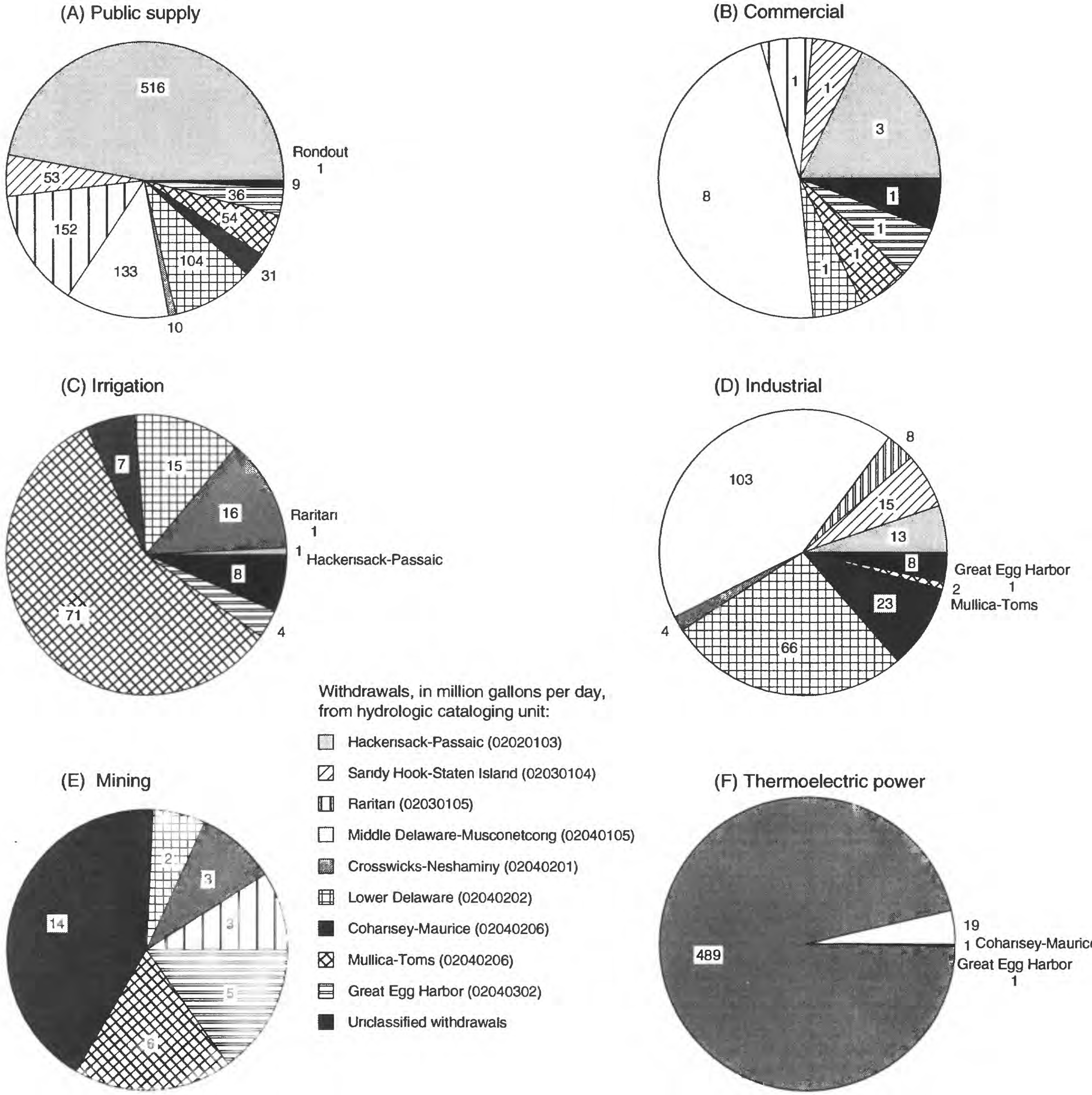


Figure 10. Average withdrawals of ground water and surface water in New Jersey by hydrologic cataloging unit, 1991-92, for: (A) public supply, (B) commercial use, (C) irrigation use, (D) industrial use, (E) mining use, and (F) thermoelectric-power use. (Withdrawals in the Rondout (02020007), Middle-Delaware-Mongaup-Brodhead (02040104), Lower Hudson (02030101), and Delaware Bay (02030101) hydrologic cataloging units are not shown because values were 1 million gallons per day or less)

Table 7. Average withdrawals of ground water and surface water in New Jersey by hydrologic cataloging unit and category of use, 1991-92

[Values may not add to totals because of independent rounding. Withdrawals in the Middle Delaware-Mongaup-Brodhead (02040104), Lower Hudson (02030101), and Delaware Bay (02030101) hydrologic cataloging units averaged less than 1 million gallons per day and are not included. Withdrawals for self-supplied domestic users are not included. All values in million gallons per day; **, withdrawals less than 1 million gallons per day; --, withdrawals less than reporting level of 0.005 million gallons per day]

Hydrologic cataloging unit and code	Public supply		Commercial		Irrigation		Industrial		Mining		Thermoelectric power		Total	
	Ground water	Surface water	Ground water	Surface water	Ground water	Surface water	Ground water	Surface water	Ground water	Surface water	Ground water	Surface water	Ground water	Surface water
Rondout (02020007)	1	**	**	--	--	--	**	--	**	--	--	--	1	**
Hackensack-Passaic (02030103)	77	439	3	--	1	**	7	6	--	**	--	--	88	445
Sandy Hook-Staten Island (02030104)	23	30	1	--	**	**	4	11	1	--	--	--	28	41
Raritan (02030105)	57	95	1	**	1	**	7	1	**	2	--	--	67	98
Middle Delaware-Musconetcong (02040105)	14	119	8	**	**	**	6	97	--	--	**	19	28	235
Crosswicks-Neshaminy (02040201)	8	2	**	--	**	16	4	--	--	3	--	489	12	510
Lower Delaware (02040202)	104	--	1	**	1	14	9	57	**	2	--	--	115	73
Cohansey-Maurice (02040206)	29	2	**	--	7	**	10	13	3	11	1	--	50	26
Mullica-Toms (02040301)	46	8	1	**	4	67	1	1	--	6	**	--	52	82
Great Egg Harbor (02040302)	36	--	1	--	3	1	1	--	**	5	1	--	42	6
Unclassified withdrawals	6	3	2	--	5	3	1	7	--	--	--	--	13	13
State	401	698	17	1	22	101	50	193	4	29	2	-- 508	496	1,530

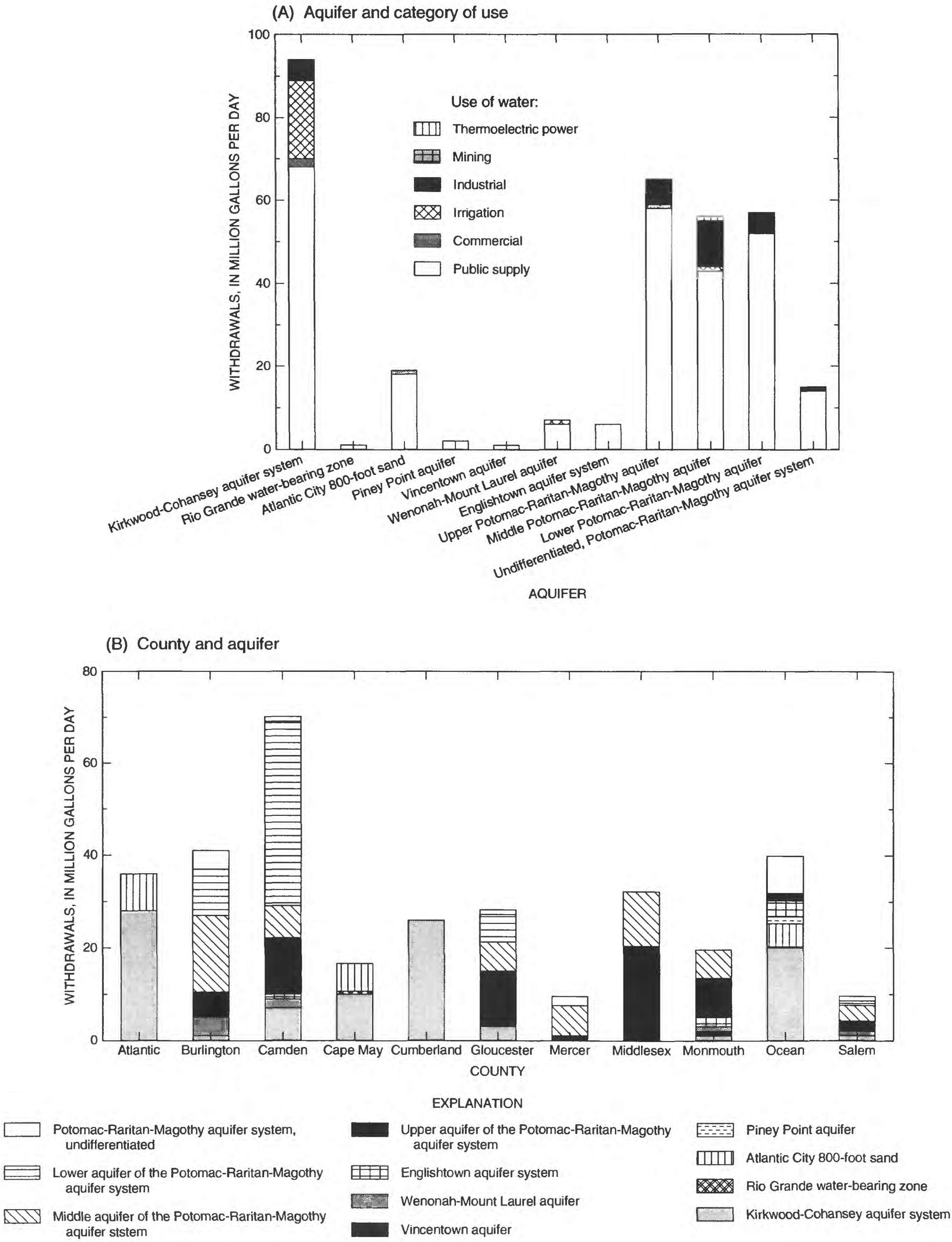


Figure 11. Average withdrawals of ground water in the Coastal Plain of New Jersey, 1991-92 by: (A) aquifer and category of use, and (B) county and aquifer. (Withdrawals from unclassified aquifers are not shown.)

Table 8. Average withdrawals of ground water from Coastal Plain and non-Coastal Plain physiographic provinces in New Jersey by aquifer and category of use, 1991-92

[Values may not add to totals because of independent rounding. All values in million gallons per day--, withdrawals less than 0.005 million gallons per day; ##, aquifer not present; <, less than]

Aquifer	Public Supply	Commercial	Irrigation	Industrial	Mining	Thermoelectric power	Self-supplied domestic users	Total
Coastal Plain aquifers								
Kirkwood-Cohansey aquifer system	68	2	19	5	<1	<1	--	94
Rio Grande water-bearing zone	1	--	--	--	--	--	--	1
Atlantic City 800-foot sand	18	1	--	--	--	<1	--	19
Piney Point aquifer	2	<1	<1	<1	--	--	--	2
Vincentown aquifer	1	<1	<1	--	--	--	--	1
Wenonah-Mount Laurel aquifer	6	<1	1	<1	<1	<1	--	8
Englishtown aquifer system	6	<1	<1	<1	--	--	--	7
Upper Potomac-Raritan-Magothy aquifer	58	1	<1	6	--	--	--	65
Middle Potomac-Raritan-Magothy aquifer	43	<1	1	11	<1	1	--	58
Lower Potomac-Raritan-Magothy aquifer	52	--	<1	5	--	--	--	57
Undifferentiated, Potomac-Raritan-Magothy aquifer system	14	<1	<1	1	<1	<1	--	15
Unclassified aquifers	3	1	--	3	1	--	44	52
Coastal Plain total	272	5	21	31	2	2	44	378
Non-Coastal Plain aquifers								
Glacial-deposit aquifers	64	6	<1	3	<1	--	--	73
Brunswick Group	49	3	<1	10	1	<1	--	63
Lockatong and Stockton Formations	4	<1	<1	<1	<1	--	--	4
Aquifers of the Kittatinny Supergroup, Franklin Limestone, and Precambrian crystalline-rock aquifers	12	<1	<1	6	1	--	--	18
Unclassified aquifers	--	3	<1	--	--	--	35	39
Non-Coastal Plain total	129	12	1	19	2	<1	35	197
State	401	17	22	50	4	2	79	575

Table 9. Average withdrawals of ground water in New Jersey by physiographic province, aquifer, and county, 1991-92

[Values may not add to totals because of independent rounding. Withdrawals for self-supplied domestic users are included in unclassified aquifers. All values in million gallons per day; --, withdrawals less than 0.005 million gallons per day; ##, aquifer not present; <, less than]

Physiographic province Aquifer	County											
	Atlantic	Burlington	Camden	Cape May	Cumberland	Gloucester	Mercer[1]	Middlesex[1]	Monmouth	Ocean	Salem	Total
	Coastal Plain aquifers											
Coastal Plain												
Kirkwood-Cohansey aquifer system	25	1	7	10	26	3	##	##	1	20	1	94
Rio Grande water-bearing zone	--	##	##	1	##	##	##	##	##	<1	##	1
Atlantic City 800-foot sand	8	##	##	6	##	##	##	##	##	5	##	19
Piney Point aquifer	<1	<1	--	--	--	--	##	##	##	2	--	2
Vincentown aquifer	##	--	--	##	##	--	##	##	1	<1	--	1
Wenonah-Mount Laurel aquifer	--	4	2	--	--	<1	##	##	1	--	1	8
Englishtown aquifer system	--	<1	1	##	--	--	##	##	2	4	--	7
Upper Potomac-Raritan-Magothy aquifer	--	5	12	--	--	12	1	20	9	2	2	63
Middle Potomac-Raritan-Magothy aquifer	##	17	7	##	##	6	7	12	6	<1	3	58
Lower Potomac-Raritan-Magothy aquifer	##	10	40	##	##	6	##	##	##	##	1	57
Undifferentiated, Potomac-Raritan-Magothy aquifer system	--	4	1	--	--	1	2	--	--	8	1	17
Unclassified aquifers	9	6	1	6	5	7	--	2	4	7	3	50
Coastal Plain total	42	47	71	23	31	35	10	34	24	48	12	377

Table 9. Average withdrawals of ground water in New Jersey by physiographic province, aquifer, and county, 1991-92--Continued

Physiographic province / Aquifer	County												
	Bergen	Essex	Hudson	Hunterdon	Mercer	Middlesex	Morris	Passaic	Somerset	Sussex	Union	Warren	Total
	Non-Coastal Plain aquifers												
Piedmont, Highlands, and Valley and Ridge Provinces													
Glacial-deposit aquifers	7	13	##	<1	##	##	37	3	--	1	3	8	72
Piedmont Province													
Aquifers of the Brunswick Group	21	11	<1	4	<1	6	1	3	6	##	13	##	65
Other aquifers including Lockatong and Stockton Formations	<1	<1	--	<1	2	<1	##	##	<1	##	1	##	3
Highlands and Valley and Ridge Province													
Aquifers of the Kittatinny Supergroup, Franklin Limestone, and Precambrian crystalline-rock aquifers	##	##	##	1	##	##	5	1	##	2	##	7	16
Unclassified aquifers	2	--	--	7	1	1	8	2	4	6	2	6	39
Non-Coastal Plain total	30	24	<1	12	3	7	51	9	10	9	19	21	195

[1] Mercer and Middlesex Counties are in both Coastal Plain and non-Coastal Plain physiographic provinces.

In the non-Coastal Plain physiographic provinces (Piedmont, Highlands, and Valley and Ridge) north of the Fall Line (fig. 2), the primary source of ground-water withdrawals for public supply was the glacial-deposit aquifers (average 64 Mgal/d) (fig. 12a). Withdrawals for public supply averaged 53 Mgal/d from aquifers of the Brunswick Group and the Lockatong and Stockton Formations combined, and 12 Mgal/d from the aquifers of the Kittatinny Supergroup and the Precambrian crystalline-rock aquifers (fig. 12a). Average withdrawals from aquifers in the non-Coastal Plain physiographic provinces by county and aquifer are shown in figure 12b.

Domestic

Domestic water use was estimated to average 639 Mgal/d during 1991-92, including self-supplied ground-water withdrawals of 79 Mgal/d and water deliveries from public suppliers estimated to be 560 Mgal/d (fig. 6 and table 5). Withdrawals by self-supplied domestic users during 1991-92 were estimated to average 44 Mgal/d in the Coastal Plain and 35 Mgal/d from the non-Coastal Plain physiographic provinces (table 8). The estimated distribution of the 969,000 self-supplied domestic users in New Jersey by county is shown in table 6.

Almost one in eight New Jersey residents maintains a private well (table 6). Most residents of Hunterdon (64 percent) and Sussex (63 percent) Counties and about one-half the population of Cape May (49 percent) and Warren (45 percent) Counties are supplied by domestic wells (fig. 7 and table 6). During 1991-92, the largest average withdrawals by self-supplied domestic users were estimated to be 9 Mgal/d from wells in Ocean County (figs. 7b and 9; table 5). Average withdrawals by self-supplied domestic users were 7 Mgal/d each in Burlington, Morris, and Sussex Counties and 6 Mgal/d each in Atlantic and Hunterdon Counties (figs. 7b and 9; table 5).

The per capita use of water by self-supplied domestic users in New Jersey reported in previous studies was 75 gal/d (Solley and others, 1993; Saarela, 1992; Nawyn and Clawges, 1995), 83 gal/d (Nawyn, 1997b, 1997c), 84 gal/d (Nawyn, 1997a), and 100 gal/d (Merend, 1989). The estimated per capita value used in this report is 82 gal/d. Estimated average withdrawals by self-supplied domestic users in 1991-92 (79 Mgal/d) were 13 percent greater than the average withdrawals in 1989-90 (70 Mgal/d), when the per capita value was estimated to be 75 gal/d (Nawyn and Clawges, 1995). This increase is the result of the method of estimating per capita use.

Commercial

Commercial water use averaged 227 Mgal/d during 1991-92, including ground-water withdrawals of 17 Mgal/d, surface-water withdrawals of 1 Mgal/d, and water deliveries from public suppliers of 209 Mgal/d (fig. 6 and table 5). In 1991, withdrawals for commercial use totaled 15 Mgal/d, including 1 Mgal/d of surface water (table 3). In 1992, withdrawals for commercial use totaled 18 Mgal/d, including 1 Mgal/d of surface water (table 4). Average total withdrawals during 1991-92 for commercial users totaled 18 Mgal/d, about 2 Mgal/d greater than during 1989-90 (16 Mgal/d) (Nawyn and Clawges, 1995).[2]

[2] Ground-water withdrawals for commercial use in 1991 (14 Mgal/d, table 3) and ground-water withdrawals for commercial use in 1992 (17 Mgal/d, table 4) appear to average to 17 Mgal/d (table 5) as a result of the averaging method used: The average of 1 Mgal/d and <1 Mgal/d was considered to be 1 Mgal/d.

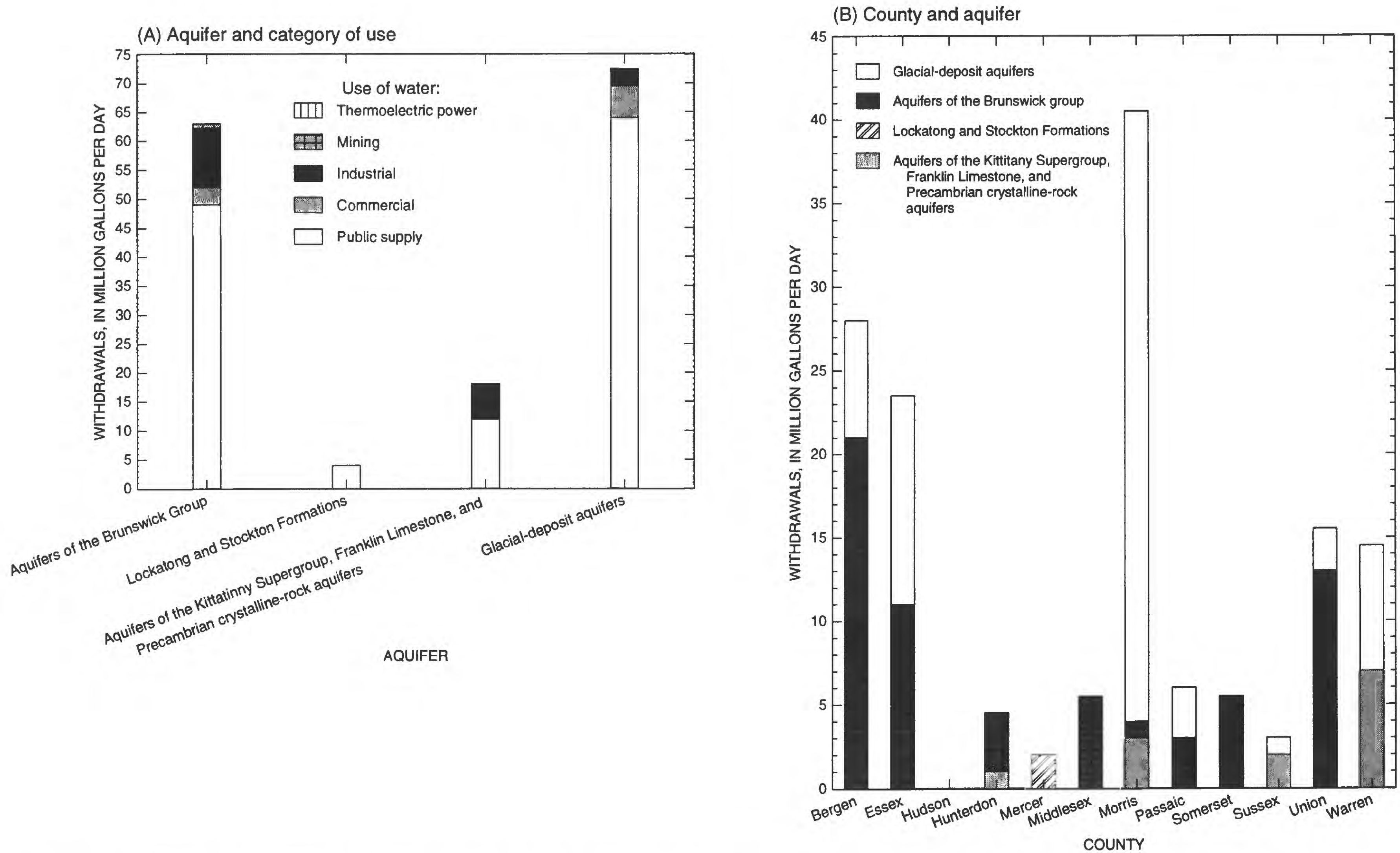


Figure 12. Average withdrawals of ground water in the non-Coastal Plain (Piedmont, Highlands, and Valley and Ridge) physiographic provinces in New Jersey, 1991-92, by: (A) aquifer and category of use, and (B) county and aquifer. (Withdrawals from unclassified aquifers are not shown.)

In 1991, there were about 160,500 commercial establishments in New Jersey (Horner, 1992, p. 249). Most commercial users are located within the water service areas of public suppliers, and these users receive chiefly publicly supplied water (209 Mgal/d). Typically, self-supplied commercial users are schools, colleges, parks, and toll-road service areas distant from the distribution system of public suppliers. Large self-supplied commercial users, such as hospitals, hotels, and research centers, may purchase water from public suppliers and use the self-supplied withdrawals for building and lawn maintenance.

Withdrawals by County

During 1991-92, withdrawals for commercial use in Warren County averaged 8 Mgal/d, accounting for nearly one-half of all withdrawals for commercial use in New Jersey (fig. 9; table 5). Average commercial withdrawals in Atlantic County during this period were 2 Mgal/d. Withdrawals by commercial users in Bergen, Burlington, Camden, Essex, Monmouth, Morris, and Union Counties averaged 1 Mgal/d each during 1991-92. Withdrawals for commercial use consisted almost entirely of ground water; most withdrawals were in Warren County where the Pequest (State-operated) fish hatcheries are located. Surface-water withdrawals for commercial use in the State were 1 Mgal/d each in 1991 and 1992 (tables 3 and 4).

Withdrawals by Hydrologic Cataloging Unit

The largest withdrawals by commercial users (average 8 Mgal/d) in the State were in the Middle Delaware-Musconetcong HUC. Withdrawals by commercial facilities averaged 3 Mgal/d in the Hackensack-Passaic HUC and 1 Mgal/d each in the Great Egg Harbor, Lower Delaware, Mullica-Toms, Raritan, and Sandy Hook-Staten Island HUC's (figs. 3 and 10; table 7). Unclassified withdrawals of ground water totaled 2 Mgal/d.

Withdrawals by Aquifer and Physiographic Province

During 1991-92, withdrawals for commercial use averaged 5 Mgal/d from aquifers in the Coastal Plain and 12 Mgal/d from aquifers in the non-Coastal Plain physiographic provinces. Withdrawals averaged 2 Mgal/d from the Kirkwood-Cohansey aquifer system, and 1 Mgal/d each from the Atlantic City 800-foot sand, Upper Potomac-Raritan-Magothy aquifer, and unclassified aquifers in the Coastal Plain (fig. 11a; table 8). Withdrawals for commercial use in the non-Coastal Plain physiographic provinces averaged 6 Mgal/d from glacial-deposit aquifers, 3 Mgal/d from aquifers of the Brunswick Group, and 3 Mgal/d from unclassified aquifers (fig. 12a; table 8).

Irrigation

Withdrawals for irrigation during 1991-92 averaged 123 Mgal/d, including 22 Mgal/d of ground water and 101 Mgal/d of surface water (table 5). In 1991, withdrawals for irrigation use totaled 139 Mgal/d--27 Mgal/d of ground water and 112 Mgal/d of surface water (table 3). In 1992, withdrawals for irrigation use were 104 Mgal/d--16 Mgal/d of ground water and 88 Mgal/d of surface water (table 4).

New Jersey, the Garden State, supports a viable agricultural trade because of the State's productive soils, proximity to major markets, and abundant water resources. In 1992, about 9,000 farms occupied 17 percent (848,000 acres or 1,330 mi^2) (U.S. Bureau of the Census, 1994a) of the land area of the State. Vegetables, tree fruits (peaches), small fruit or nut crops (blueberries), and sod (turf) are the chief crops that are irrigated. Irrigation withdrawals for crop and orchard cultivation are chiefly in counties located in the Coastal Plain (figs. 2 and 9; tables 5 and 10). The largest concentrations of irrigated acres (excluding cranberry acreage) are in Cumberland, Salem, Gloucester, and Atlantic Counties. Most irrigation systems in New Jersey are sprinkler systems rather than low-flow systems such as micro-spray or drip irrigation (table 10). Characteristics of farms were compiled from 1992 and 1993 data (U.S. Bureau of the Census, 1994a). Characteristics of irrigation methods were compiled from 1993 data (Irrigation Journal, 1994).

Agricultural irrigation data were compiled from NJDEP data, independently of the SSWUDS data base, because not all agricultural withdrawal data are in the USGS data base. Withdrawals for non-agricultural irrigation purposes, such as golf courses, accounted for about 1 percent of all withdrawals for irrigation use. Non-agricultural irrigation data were compiled from the SSWUDS data base. Withdrawals for livestock, commonly associated with agricultural water use, are not included in this report.

The amount of water attributed to agricultural irrigation in New Jersey is misleading because (1) water is applied to crops chiefly during the growing season (June - August), and withdrawals are reported as a yearly average; and (2) agricultural withdrawals include the non-consumptive use of water in cranberry production. In addition, climatological conditions, such as precipitation, temperature, and solar radiation, in the agricultural areas can affect the amount of water that is required by crops and applied by irrigators (Clawges and Titus, 1993). Temperature and solar radiation affect evapotranspiration, which is the direct loss of water from the soil surface and the loss of water vapor from plant leaves. More water is lost from the soil surface with a newly planted crop because the surface area that is exposed to solar radiation is larger than that of a mature crop with leaf cover. Increased temperature will increase water loss early in the growing season, when the amount of solar radiation is high, and late in the season, when plant leaves transpire at high rates in response to high temperatures.

Average monthly precipitation during the growing season in 1991-92 in the Southern climatological division (National Climatic Data Center, 1992, 1993), an area that includes most of the irrigated acres in the State, was more than 2 in. greater than the average monthly precipitation during the growing season in 1951-80 (National Climatic Data Center, 1992, 1993). Average monthly precipitation during the growing season in 1989-90 in the Southern division was more than 4 in. greater than that in 1951-80 (National Climatic Data Center, 1990, 1991).

Temperatures during the growing season in the Southern division in 1991 and 1992 were about 2 °F greater than and about 2 °F less than, respectively, the average temperature for the growing season during 1951-80 (National Climatic Data Center, 1992, 1993). Temperatures during the growing season in the Southern division in 1989 and 1990 were about 1 °F greater than and 1 °F less than, respectively, the average temperature for the growing season during 1951-80 (National Climatic Data Center, 1990, 1991).

Table 10. Characteristics of farms in New Jersey, 1992 and 1993

[Values may not add to totals because of independent rounding. Data on characteristics of farms in 1992 from U.S. Bureau of the Census (1994a). Data on characteristics of farms in 1993 from Irrigation Journal (1994)]

Characteristic	Number, percent, or acres
Farms (1992)	
With irrigated acres	1,200
Total	9,032
Land in farms (1992)	894,000 acres
Average size	99 acres
Size of farms (1992)	
Less than 50 acres	60 %
Greater than 500 acres	4 %
Irrigated acres (1992)	
Cumberland County	18,000
Salem County	14,000
Gloucester County	13,000
Atlantic County	12.000
Burlington County	8,800
All other counties	14,600
Total for State	80,400

Irrigated acres by crop (1993)	Number	Percent
Vegetables	57,170	61%
Tree fruits	12,300	13%
Small fruit or nuts	7,035	8%
Sod (turf)	6,715	7%
Nursery	5,190	5%
Field crops	4,680	5%

Irrigation methods (1993)	Percent
Sprinkler	
Center pivot or linear move	4 %
Traveler	50 %
Solid set	17 %
Hand move	23 %
Low-flow	
Micro-spray (surface)	0.1%
Drip (surface)	6 %

As a result, in part, of the lower average precipitation in 1991-92 than in 1989-90 during the growing season in the Southern division, withdrawals for irrigation use averaged 123 Mgal/d during 1991-92, an increase of 18 Mgal/d, or 17 percent, from the 105 Mgal/d withdrawn during 1989-90 (Nawyn and Clawges, 1995).

In 1991, New Jersey ranked third in the United States in cranberry production (U.S. Bureau of the Census, 1991b). Cranberry bogs, which cover about 3,000 acres (Clawges and Titus, 1993), are flooded twice a year for harvesting and frost protection (Titus and others, 1992, p. 2, 17). Withdrawals for cranberry production in the State were estimated to be about 76 Mgal/d in 1986 (unpublished data on file at New Jersey Department of Environmental Protection, Trenton, N.J.), and in 1992, 91 percent of total acres in cranberry production in the State was in Burlington County (U.S. Bureau of the Census, 1994a). If water demand for cranberry production is assumed to be about the same every year, agricultural withdrawals in New Jersey for non-cranberry irrigation are estimated to have been 63 Mgal/d in 1991 and 28 Mgal/d in 1992.

Withdrawals by County

Most of the withdrawals for irrigation use were from counties in the Coastal Plain. Withdrawals of ground water for irrigation use averaged 7 Mgal/d in Cumberland County, 6 Mgal/d in Atlantic County, and 2 Mgal/d each in Burlington, Camden, and Salem Counties (table 5). Withdrawals of surface water in Burlington County, chiefly for cranberry production, averaged 84 Mgal/d, or 68 percent of total withdrawals for irrigation use. Withdrawals in Gloucester, Atlantic, and Cumberland Counties averaged 6 Mgal/d, 4 Mgal/d, and 2 Mgal/d, respectively (table 5).

Withdrawals by Hydrologic Cataloging Unit

The largest average withdrawals (71 Mgal/d) for irrigation use were in the Mullica-Toms HUC. Withdrawals in the Crosswicks-Neshaminy, Lower Delaware, and Cohansey-Maurice HUC's averaged 16 Mgal/d, 15 Mgal/d, and 7 Mgal/d, respectively (figs. 3 and 10; table 7). Ground-water withdrawals averaged 7 Mgal/d in the Cohansey-Maurice HUC, 4 Mgal/d in the Mullica-Toms HUC, and 3 Mgal/d in the Great Egg Harbor HUC. Unclassified withdrawals of ground water averaged 5 Mgal/d. Surface-water withdrawals averaged 67 Mgal/d in the Mullica-Toms HUC. Withdrawals of surface water for irrigation use in the Crosswicks-Neshaminy and Lower Delaware HUC's averaged 16 Mgal/d and 14 Mgal/d, respectively (table 7).

Withdrawals by Aquifer and Physiographic Province

During 1991-92, withdrawals for irrigation use averaged 21 Mgal/d from aquifers in the Coastal Plain and 1 Mgal/d from aquifers in the non-Coastal Plain physiographic provinces (table 8). The Kirkwood-Cohansey aquifer system is the chief source of ground water for irrigation use in New Jersey. Average withdrawals from this aquifer system during 1991-92 were 19 Mgal/d, or 86 percent of total withdrawals of ground water for irrigation use (table 8). Irrigation withdrawals averaged 1 Mgal/d each from the Wenonah-Mount Laurel aquifer and the Middle Potomac-Raritan-Magothy aquifer.

Industrial

Industrial water use in New Jersey averaged 342 Mgal/d during 1991-92, including ground-water withdrawals of 50 Mgal/d, surface-water withdrawals of 193 Mgal/d, and water deliveries from public suppliers of 99 Mgal/d (fig. 6 and table 5). In 1991, withdrawals for industrial use were 248 Mgal/d--51 Mgal/d of ground water and 197 Mgal/d of surface water (table 3). In 1992, withdrawals for industrial use were 238 Mgal/d--51 Mgal/d of ground water and 187 Mgal/d of surface water (table 4). Average withdrawals of ground water during 1991-92 (50 Mgal/d) for industrial users were 3 Mgal/d less than withdrawals during 1989-90 (53 Mgal/d); however, average withdrawals of surface water during 1991-92 (193 Mgal/d) decreased 16 percent from withdrawals during 1989-90 (230 Mgal/d) (Nawyn and Clawges, 1995). This change is related to decreased withdrawals for industrial use in Hunterdon and Warren Counties.

Withdrawals for industrial use are reported for facilities that supply all or part of their water requirements. The U.S. Bureau of the Census (1994b) reported that about 12,800 industrial facilities operated in New Jersey in 1992. About 84 percent of all industrial facilities in the State employed fewer than 50 employees, and about 36 percent of all industrial facilities were small (one to four employees) manufacturing operations, located chiefly in urban areas that are served by water utilities (table 11) (U.S. Bureau of the Census, 1986, 1994b).

During 1991-92, the number of self-supplied industrial users in New Jersey totaled about 300 facilities, including chemical, petroleum, and paper-manufacturing facilities; however, self-supplied industrial users accounted for only about 2 percent of all industrial facilities in New Jersey. The most recent (1983) data on water use in manufacturing from the U.S. Bureau of the Census (1986) indicate that self-supplied industrial users withdrawing 0.05 Mgal/d or greater accounted for 86 percent (541 Mgal/d) of total industrial water use (632 Mgal/d). Industrial deliveries from public suppliers accounted for 14 percent (91 Mgal/d) of total industrial water use. During 1991-92, self-supplied withdrawals were estimated to be 71 percent (243 Mgal/d) of total industrial water use (342 Mgal/d), and industrial deliveries (99 Mgal/d) from public suppliers were estimated to be 29 percent of total industrial water use (fig. 6; table 5).

From 1983 to 1992, total industrial use in New Jersey decreased 290 Mgal/d (U.S. Bureau of the Census, 1986). The use of publicly supplied water increased 8 Mgal/d; however, the use of self-supplied water decreased 298 Mgal/d. These changes can be attributed to the loss or decrease in size of water-intensive manufacturing facilities (dyeing and finishing, primary metals, chemical and paper manufacturing) and to increased water efficiency in many manufacturing processes. In New Jersey, the number of small (less than 50 employees) industrial facilities within areas served by public suppliers has increased (U.S. Bureau of the Census, 1990, 1994c), and the volume of supplemental water purchased by self-supplied industrial users also has increased. In response to the increased cost of wastewater treatment and NJDEP water-conservation regulations, most industrial users have increased their water efficiency by installing water-conserving plumbing fixtures, increasing water recycling, modifying industrial processes, and replacing machinery with more water-efficient equipment (Ploesner and others, 1992).

Table 11. Characteristics of industrial establishments in New Jersey, 1992

[Valuez may not add to totals because of independent rounding; --, no value reported. Values greater than 1,000 are rounded to three significant figures. Employee and establishment data from U.S. Bureau of the Census (1994b); Standard Industrial Classification codes from Office of Management and Budget (1987)]

Standard Industrial Classification (SIC) code and associated industry		Characteristic					
		Number of employees	Number of establishments	Number of establishments by employment-size class			
				1 to 4	5 to 49	50 to 249	250 or more
28	Chemical and allied products	72,300	818	162	398	207	51
27	Printing and polishing	54,500	2,500	1,215	1,070	182	30
34	Fabricated metals	37,600	1,250	367	710	155	14
35	Industrial machinery and equipment	37,300	1,760	704	908	128	18
36	Electronic equipment	36,000	717	211	321	159	26
38	Instrument and related products	35,800	519	162	246	87	24
20	Food and kindred products	32,000	562	143	272	117	30
30	Rubber and plastic	31,000	669	112	370	170	17
23	Apparel and other textile products	30,700	1,240	499	573	155	12
26	Paper and allied products	20,800	304	34	72	185	13
32	Stone, clay, and glass	17,000	411	138	207	54	12
33	Primary metal industries	12,700	222	53	109	46	14
39	Miscellaneous manufacturing	14,700	577	237	263	68	9
22	Textile mill products	11,000	352	96	185	71	--
37	Transportation equipment	8,700	219	98	88	25	8
25	Furniture and fixtures	6,360	304	120	149	34	1
29	Petroleum and coal	4,500	73	22	30	18	3
24	Lumber and wood products	3,700	333	170	150	13	--
All SIC codes		466,700	12,800	4,540	6,120	1,900	280
Percent of total establishments				36	48	15	2

Water use by industries in New Jersey is chiefly nonconsumptive use. More than one-half the gross water (the sum of water intake plus water recirculated and reused without regard to evaporation) used by industrial facilities is recycled within the facility (U.S. Bureau of the Census, 1986). Recycled water commonly is used for cooling, industrial processes, and lawn watering (Ploeser and others, 1992); therefore, additional consumptive use is possible. Data on the use of water by industries in New Jersey in 1983 show that cooling and condensing (69 percent), production or processing (25 percent), sanitary services (2 percent), and boiler feed (3 percent) were the chief uses of water in industrial facilities (U.S. Bureau of the Census, 1986).

Withdrawals by County

Withdrawals for industrial use averaged 62 Mgal/d each in Warren and Gloucester Counties and 32 Mgal/d in Hunterdon County (fig. 9; table 5). Paper-products manufacturing and chemical production in Warren and Hunterdon Counties accounted for nearly all withdrawals for industrial use in these counties. Chemical and oil refinery facilities accounted for the large withdrawals for industrial use reported in Gloucester County.

Industries located in counties in the Coastal Plain withdrew the largest volume of ground water for industrial operations (table 8). Withdrawals of ground water for industrial use in the Coastal Plain area averaged 8 Mgal/d in Gloucester County, 7 Mgal/d in Middlesex County, and 6 Mgal/d in Cumberland County. In other areas of the State, the average withdrawals of ground water for industrial use were 6 Mgal/d in Bergen County, 4 Mgal/d in Warren County, and 3 Mgal/d each in Morris and Salem Counties (table 5).

Withdrawals of surface water in Warren County averaged 58 Mgal/d and accounted for 30 percent of all surface-water withdrawals for industrial use in New Jersey. Withdrawals of surface water averaged 54 Mgal/d in Gloucester County, 30 Mgal/d in Hunterdon County, 14 Mgal/d in Bergen County, and 13 Mgal/d in Salem County (table 5).

Withdrawals by Hydrologic Cataloging Unit

During 1991-92, withdrawals by industrial facilities in the Middle Delaware-Musconetcong HUC averaged 103 Mgal/d (figs. 3 and 10; table 7). Withdrawals in the Lower Delaware, Cohansey-Maurice, Sandy Hook-Staten Island, and Hackensack-Passaic HUC's averaged 66 Mgal/d, 23 Mgal/d, 15 Mgal/d, and 13 Mgal/d, respectively.

Ground-water withdrawals averaged 10 Mgal/d in the Cohansey-Maurice HUC, 9 Mgal/d in the Lower Delaware HUC, and 7 Mgal/d each in the Hackensack-Passaic and Raritan HUC's (table 7). Unclassified withdrawals of ground water averaged 1 Mgal/d. Average surface-water withdrawals in the Middle Delaware-Musconetcong were 97 Mgal/d and accounted for the largest volume of water used by New Jersey industries. Withdrawals of surface water in the Lower Delaware, Cohansey-Maurice, and Sandy Hook-Staten Island HUC's averaged 57 Mgal/d, 13 Mgal/d, and 11 Mgal/d, respectively. Unclassified withdrawals of surface water for industrial use averaged 7 Mgal/d (table 7).

Withdrawals by Aquifer and Physiographic Province

During 1991-92, withdrawals of ground water by industrial users averaged 31 Mgal/d in the Coastal Plain and 19 Mgal/d in the non-Coastal Plain physiographic provinces (table 8). Withdrawals from the Potomac-Raritan-Magothy aquifer system (average 23 Mgal/d) were among the largest ground-water withdrawals for industrial use in New Jersey (fig. 11a). Average withdrawals were 11 Mgal/d from the Middle aquifer, 6 Mgal/d from the Upper aquifer, 5 Mgal/d from the Lower aquifer, and 1 Mgal/d from the undifferentiated aquifers of the Potomac-Raritan-Magothy aquifer system. Withdrawals for industrial use from the Kirkwood-Cohansey aquifer system averaged 5 Mgal/d. Withdrawals from unclassified aquifers in the Coastal Plain averaged 3 Mgal/d (table 8).

In the non-Coastal Plain physiographic provinces, ground-water withdrawals for industrial use averaged 3 Mgal/d from glacial-deposit aquifers, 10 Mgal/d from aquifers of the Brunswick Group, and 6 Mgal/d from aquifers of the Kittatinny Supergroup, Franklin Limestone, and Precambrian crystalline-rock aquifers. (fig. 12a; table 8).

Mining

Withdrawals for mining use in New Jersey averaged 33 Mgal/d during 1991-92, including 4 Mgal/d of ground water and 29 Mgal/d of surface water (table 5). In 1991, withdrawals for mining operations were 30 Mgal/d--2 Mgal/d of ground water and 28 Mgal/d of surface water (table 3). In 1992, withdrawals for mining use were 35 Mgal/d--5 Mgal/d of ground water and 30 Mgal/d of surface water (table 4). Average withdrawals of both ground water and surface water declined sharply during 1991-92 from the average withdrawals for mining use during 1989-90 (82 Mgal/d) (Nawyn and Clawges, 1995). The decrease in ground-water withdrawals for mining use can be traced to the closing of a mining operation in Sussex County. This facility was the largest user of ground water for mining in the State. The decrease in surface-water withdrawals can be traced to reduced production, beginning in 1990, at the largest user of surface water for mining activities in the State.

The geologic resources of New Jersey support a diversity of mining activities for the 158 mining facilities in the State (Horner, 1992, p. 249). Crushed stone, consisting of basalt and granite, is extracted throughout the Piedmont, Highlands, and Valley and Ridge physiographic provinces. Shale is quarried in the Piedmont physiographic province. Among the states, New Jersey ranks third in the production of industrial sand and gravel (U.S. Bureau of Mines, 1995). The Coastal Plain yields sand and gravel for housing and road construction, industrial sand for glass making, and fire clay for furnaces and ceramics. New Jersey is the only state to produce greensand, a water softening, filtration medium to remove soluble iron and manganese from ground water and as an organic conditioner for soils (Harrison, 1988; U.S. Bureau of Mines, 1995).

Withdrawals by County

During 1991-92, the largest withdrawals for mining activities averaged 11 Mgal/d in Cumberland County (fig. 9; table 5). Average withdrawals were 6 Mgal/d in Ocean County and 4 Mgal/d each in Burlington and Cape May Counties (table 5).

Withdrawals by Hydrologic Cataloging Unit

Average withdrawals for mining use were 14 Mgal/d in the Cohansey-Maurice HUC, 6 Mgal/d in the Mullica-Toms HUC, and 5 Mgal/d in the Great Egg Harbor HUC (fig. 10; table 7). Ground-water withdrawals for mining use in the Cohansey-Maurice and Sandy Hook-Staten Island HUC's averaged 3 Mgal/d and 1 Mgal/d, respectively. Surface-water withdrawals in the Cohansey-Maurice HUC averaged 11 Mgal/d. Withdrawals of surface water for mining use averaged 6 Mgal/d in the Mullica-Toms HUC and 5 Mgal/d in the Great Egg Harbor HUC (table 7).

Withdrawals by Aquifer and Physiographic Province

During 1991-92, withdrawals for mining use from aquifers in the Coastal Plain and from aquifers in the non-Coastal Plain physiographic provinces averaged 2 Mgal/d each. Withdrawals from the Kirkwood-Cohansey aquifer system, Wenonah-Mount Laurel aquifer, Middle Potomac-Raritan-Magothy aquifer, and unclassified aquifers in the Coastal Plain averaged 1 Mgal/d or less each (table 8). Withdrawals averaged 1 Mgal/d each from aquifers of the Brunswick Group and aquifers of the Kittatinny Supergroup, Franklin Limestone, and Precambrian crystalline-rock aquifers. (table 8).

Thermoelectric Power

Withdrawals for thermoelectric-power use in New Jersey averaged 532 Mgal/d during 1991-92, including ground-water withdrawals of 2 Mgal/d, surface-water withdrawals of 508 Mgal/d, and water deliveries from public suppliers of 22 Mgal/d. In 1991, withdrawals for thermoelectric-power use totaled 499 Mgal/d--2 Mgal/d of ground water and 497 Mgal/d of surface water (table 3). In 1992, withdrawals for thermoelectric-power use were 520 Mgal/d--2 Mgal/d of ground water and 518 Mgal/d of surface water (table 4). About 24 percent of total withdrawals of freshwater in New Jersey during 1991-92 was used for generation of thermoelectric power.

Water provided the power for industrial development in New Jersey. Early mills used paddle wheels to harness the waterpower of streams and canals. In the 20th century, electric power replaced waterpower; however, power generation is still largely dependent on water. Most thermoelectric-power plants in the State withdraw surface water for cooling purposes and steam generation.

Electricity was produced at 30 generating plants in New Jersey, including four nuclear power units (U.S. Bureau of the Census, 1994d, p. 599). The surface-water withdrawals are chiefly (about 99 percent) nonconsumptive; water is used for once-through cooling of condensers and is returned chiefly to the Delaware River (Paul Mensing, Public Service Electric and Gas Company, Newark, N.J., written commun., 1996). Ground-water withdrawals are used for steam generation, potable water, and other non-cooling purposes. Withdrawals of saline water and deliveries of reclaimed wastewater for thermoelectric-power use in New Jersey are not included in this report. More than 90 percent of all water used for electric-power generation in New Jersey is saline water (Solley and others, 1993, p. 53).

Withdrawals for thermoelectric-power use in New Jersey are variable and are related to three factors--climatological conditions, the number of operating electric generating units, and the price of electricity produced outside the State--and therefore may not be directly related to energy demands. Energy demands of customers in New Jersey are most directly related to climatological conditions. Conditions such as above-average summer temperatures and humidity increase the energy demand for air conditioning; similarly, below-average winter temperatures increase the energy demand for heating. In New Jersey, electric-power demands during the summer are greater than those during the other seasons (Paul Mensing, Public Service Electric and Gas Company, Newark, N.J., oral commun., 1996). In 1991 and 1992, average summer (June-August) temperatures in New Jersey were about 2 °F greater than and about 2 °F less than, respectively, the average temperature for the summer months during 1951-80 (National Climatic Data Center, 1990, 1991, 1992, 1993); consequently, the electric-power demand for air conditioning was greater in 1991 than in 1992.

Another important factor that can affect withdrawals for thermoelectric-power use is the number of operating electric generating units at each facility. At any given time, one or more of the steam-turbine generating units at an electric utility plant may be idle because of repairs or rehabilitation. During 1991-92, major rehabilitation work was occurring at the electric-power generating station in Mercer County (Donald McCoskey, Public Service Gas and Electric Company, Trenton, N.J., oral commun., 1996). This generating station accounts for more than 90 percent of all withdrawals of non-saline water for thermoelectric-power use.

About 40 percent of the electricity used in New Jersey is generated outside of the State (New Jersey Board of Public Utilities, 1996, http://www.njin.net/njbpu). For example, in 1992, electric-energy sales in New Jersey totaled 63.1gigawatt-hours (U.S. Bureau of the Census, 1994d); however, about 31 gigawatt-hours of electricity was generated from thermoelectric-power facilities in the State (Karen McDaniel, U.S. Department of Energy, Washington, D.C., oral commun., 1995). The additional electric power was generated from thermoelectric-power facilities located beyond the State's borders; however, if the price of electricity from outside the State is greater than the cost of producing electricity within the State, electric utilities may choose to generate more electricity within the State.

During 1991-92, average surface-water withdrawals for thermoelectric-power use (510 Mgal/d) were 22 percent less than average withdrawals during 1989-90 (657 Mgal/d) (Nawyn and Clawges, 1995). This decrease in withdrawals for thermoelectric-power use can be attributed, in part, to the rehabilitation work at the electric-power generating station in Mercer County.

Withdrawals by County

The Delaware River is the primary source of non-saline water for thermoelectric facilities in New Jersey. Electric utilities operate fossil-fuel generating stations along the Delaware River in Mercer, Hunterdon, and Burlington Counties; surface-water withdrawals in these counties during 1991-92 averaged 472 Mgal/d, 19 Mgal/d, and 17 Mgal/d, respectively (fig. 9; table 5). Withdrawals of ground water for thermoelectric-power use in Salem County averaged 1 Mgal/d for the combined pumpage of three electric-power-generating stations. Withdrawals of ground water in Cape May and Hunterdon Counties were less than 1 Mgal/d (table 5).

Withdrawals by Hydrologic Cataloging Unit

Ground-water withdrawals for thermoelectric-power use were largest in the Cohansey-Maurice HUC, averaging 1 Mgal/d. Withdrawals of ground water in the Great Egg Harbor HUC averaged slightly less than 1 Mgal/d. Surface-water withdrawals in the Crosswicks-Neshaminy HUC accounted for about 95 percent (average 489 Mgal/d) of withdrawals for thermoelectric-power generation in the State. Withdrawals of surface water in the Middle Delaware-Musconetcong HUC averaged 19 Mgal/d (figs. 3 and 10; table 7).

Withdrawals by Aquifer and Physiographic Province

Withdrawals of ground water by nuclear power-plant facilities located in the Coastal Plain accounted for most of the withdrawals of ground water for thermoelectric-power use. The Middle Potomac-Raritan-Magothy aquifer provided 1 Mgal/d for the generation of thermoelectric power (fig. 11a; table 8), and the Atlantic City 800-foot sand, Kirkwood-Cohansey aquifer system, Wenonah-Mount Laurel aquifer, and undifferentiated aquifers of the Potomac-Raritan-Magothy aquifer system provided less than 1 Mgal/d each (table 8).

SUMMARY

Withdrawals of ground water and surface water in New Jersey were compiled from monthly withdrawal data provided to the New Jersey Department of Environmental Protection by water users with pumping equipment capable of producing 100,000 gal/d (gallons per day) or greater. In 1991, withdrawals in New Jersey totaled about 2,110 Mgal/d (million gallons per day)--576 Mgal/d of ground water and 1,534 Mgal/d of surface water. In 1992, withdrawals totaled about 2,090 Mgal/d--571 Mgal/d of ground water and 1,519 Mgal/d of surface water.

During 1991-92, withdrawals for public supply averaged about 1,099 Mgal/d for 6.8 million residents of the State. Ground-water withdrawals for public supply averaged 401 Mgal/d and surface-water withdrawals averaged 698 Mgal/d. About one-quarter of all publicly supplied water in New Jersey is withdrawn in Passaic County, where withdrawals for public supply averaged about 290 Mgal/d (about 6 Mgal/d of ground water and about 284 Mgal/d of surface water). Withdrawals for public supply from aquifers in the Coastal Plain averaged 272 Mgal/d. Public-supply withdrawals from the Potomac-Raritan-Magothy aquifer system, the primary source of ground water for public supply in New Jersey, averaged 167 Mgal/d. Average withdrawals from the Upper, Middle, Lower, and undifferentiated aquifers of the Potomac-Raritan-Magothy aquifer system were 58 Mgal/d, 43 Mgal/d, 52 Mgal/d, and 14 Mgal/d, respectively.

Domestic water use averaged 639 Mgal/d during 1991-92, including ground-water withdrawals of 79 Mgal/d by self-supplied domestic users (969,000 residents) and water deliveries from public suppliers of 560 Mgal/d. The domestic per capita use by self-supplied domestic users was estimated to be 82 gal/d. Withdrawals by self-supplied domestic users were estimated to average 9 Mgal/d in Ocean County, 7 Mgal/d each in Burlington, Morris, and Sussex Counties, and 6 Mgal/d each in Atlantic and Hunterdon Counties.

Commercial water use averaged 227 Mgal/d during 1991-92, including withdrawals of 17 Mgal/d of ground water, 1 Mgal/d of surface water, and water deliveries from public suppliers of 209 Mgal/d. State-operated fish hatcheries in Warren County were the largest commercial water users in New Jersey. Ground-water withdrawals for commercial use in Warren County averaged 8 Mgal/d.

Withdrawals for irrigation use during 1991-92 averaged 123 Mgal/d--22 Mgal/d of ground water and 101 Mgal/d of surface water. Withdrawals in Burlington County, chiefly surface water for cranberry production, averaged 86 Mgal/d, accounting for about 70 percent of total withdrawals for irrigation use in the State. The largest average withdrawals of ground water for irrigation use were in Cumberland County (7 Mgal/d) and Atlantic County (6 Mgal/d).

Industrial water use in New Jersey averaged 342 Mgal/d during 1991-92, including ground-water withdrawals of 50 Mgal/d, surface-water withdrawals of 193 Mgal/d, and water deliveries from public suppliers of 99 Mgal/d. During 1991-92, average withdrawals for industrial use, chiefly of surface water, were 62 Mgal/d each in Gloucester and Warren Counties, and 32 Mgal/d in Hunterdon County.

During 1991-92, average withdrawals, chiefly of surface water, for mining use in New Jersey totaled 33 Mgal/d, including 4 Mgal/d of ground water and 29 Mgal/d of surface water. Withdrawals for mining use in Cumberland County averaged 11 Mgal/d. Average withdrawals of both ground water and surface water declined sharply during 1991-92 from the average withdrawals for mining use during 1989-90. This decrease is attributed to the closing of a mining facility that was the largest user of ground water and to reduced production at another mining facility that is the largest user of surface water.

Withdrawals for thermoelectric-power use in New Jersey averaged 532 Mgal/d during 1991-92, including ground-water withdrawals of 2 Mgal/d, surface-water withdrawals of 508 Mgal/d, and water deliveries from public suppliers of 22 Mgal/d. Surface-water withdrawals for thermoelectric-power use in Mercer County averaged 472 Mgal/d, the largest volume among the counties in the State. Withdrawals for thermoelectric-power use are chiefly nonconsumptive.

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GLOSSARY

Aquifer: A geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Commercial use: Ground water or surface water withdrawn by commercial facilities, or delivered by public suppliers. Hotels, non-residential schools, retail stores, and shopping centers are examples of commercial users. Publicly operated fish hatcheries also are included in this category.

Domestic use: Ground water obtained from domestic wells and used for general household purposes, home landscaping, and recreation, and water delivered by public suppliers to residents for household use.

Establishment: An economic unit, generally within a single location, where business activities are conducted or where services or industrial activities are performed.

Freshwater: Water that contains less than 1,000 milligrams per liter (mg/L) of dissolved solids; water containing more than 500 mg/L of dissolved solids is undesirable for drinking and many industrial uses.

Ground water: Subsurface water as distinct from surface water; specifically, that part of subsurface water that is in the zone of saturation (an area in which voids are filled with water).

Hydrologic cataloging unit: A geographic area representing all or part of a surface drainage basin or a distinct hydrologic feature. An eight-digit code and hydrologic unit name, assigned by the U.S. Geological Survey, provides a standardized base for locating, storing, retrieving, and exchanging hydrologic data.

Industrial use: Ground water or surface water withdrawn by industrial facilities or delivered by public suppliers. Examples of industrial establishments are facilities that manufacture chemical, steel, or paper products and facilities that refine petroleum.

Irrigation use: Ground water or surface water artificially applied to farm, orchard, and horticultural crops, and for landscaping (golf courses).

Mining use: Ground water or surface water withdrawn by mining facilities. Water is used in mineral extraction and quarrying, well operations (dewatering), and milling (crushing, screening, washing, and flotation).

Per capita use: The average amount of water used per person per day.

Public water use: Water supplied from a public supplier and used for municipal services such as administration buildings, schools, firefighting, street washing, and municipal parks and swimming pools.

Public supply: Ground water or surface water withdrawn by public and private water-supply systems and delivered to domestic, commercial, industrial, and other users.

Saline water: Water that contains more than 1,000 mg/L of dissolved solids.

Surface water: An open body of water such as a river, stream, lake, or pond.

Thermoelectric-power use: Ground water or surface water (excluding saline water) withdrawn in the process of generating electricity with fossil fuel (coal, oil, or natural gas), geothermal, or nuclear energy. Water can be self-supplied or publicly supplied.