

Estimated Water Use in Puerto Rico, 2005



Open-File Report 2008-1286

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By Wanda L. Molina-Rivera and Fernando Gómez-Gómez

Prepared in cooperation with the

Puerto Rico Aqueduct and Sewer Authority,
Puerto Rico Department of Natural and Environmental Resources, and
Puerto Rico Environmental Quality Board

Open-File Report 2008–1286

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

U.S. Department of the Interior
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U.S. Geological Survey
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Suggested citation:
Molina-Rivera, W.L., and Gómez-Gómez, Fernando, 2008, Estimated water use in Puerto Rico, 2005: U.S. Geological Survey Open-File Report 2008-1286, 37 p.

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Conversion Factors, Datum, Energy Unit, and Acronyms

Multiply	By	To obtain
Area		
acre	4,047	square meter (m ²)
Volume		
gallon (gal)	3.785	liter (L)
acre-foot (acre-ft)	1,233.489	cubic meter (m ³)
Flow rate		
acre-foot per year (acre-ft/yr)	0.001233	cubic hectometer per year (hm ³ /yr)
gallon per day (gal/d)	0.003785	cubic meter per day (m ³ /d)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m ³ /s)

Datum:

Horizontal Datum - Puerto Rico Datum, 1940

Adjustment Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929) - a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called "Sea Level Datum of 1929".

Abbreviated energy unit used in this report:

gWh Gigawatt-hour

Acronyms used in this report:

PRASA Puerto Rico Aqueduct and Sewer Authority
 PRDNER Puerto Rico Department of Natural and Environmental Resources
 PRDOH Puerto Rico Department of Health
 PREPA Puerto Rico Electric Power Authority
 PREQB Puerto Rico Environmental Quality Board
 PWS Public-water supply
 USGS United States Geological Survey

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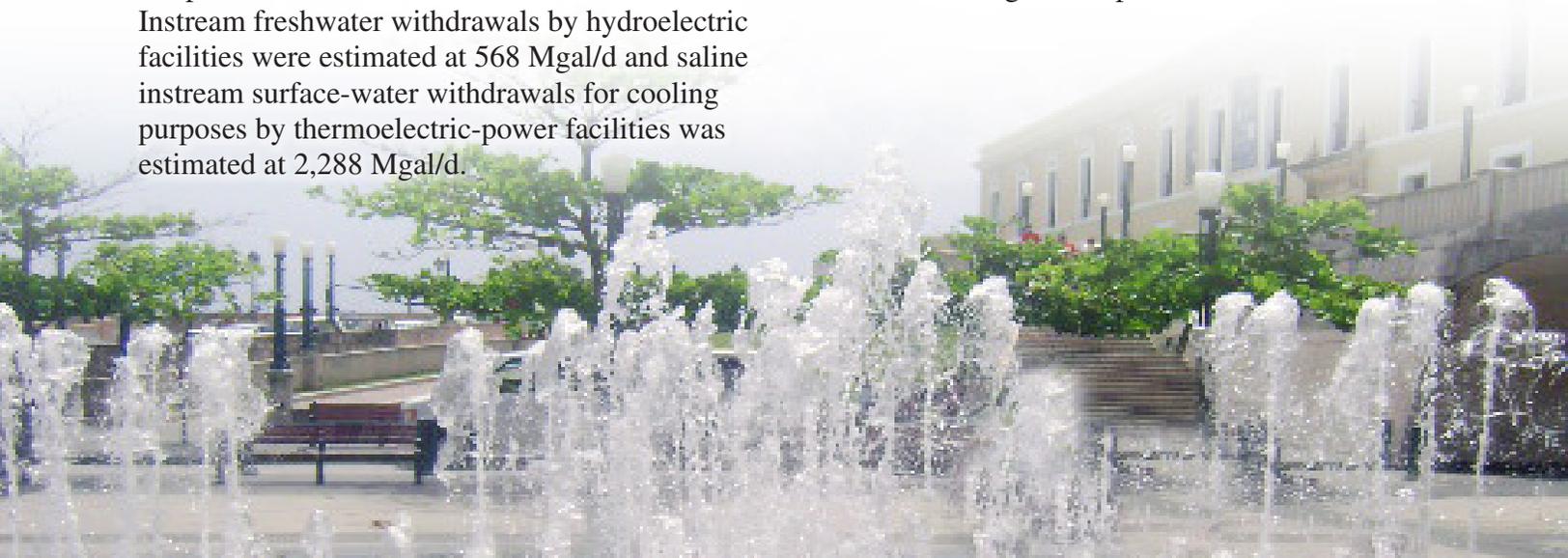
Abstract

Water-use data were compiled for the 78 municipios of the Commonwealth of Puerto Rico for 2005. Five offstream categories were considered: public-supply water withdrawals and deliveries, domestic self-supplied water use, industrial self-supplied ground-water withdrawals, crop irrigation water use, and thermoelectric power freshwater use. One water-use category also was considered: power-generation instream water use (thermoelectric-saline withdrawals and hydroelectric power). Freshwater withdrawals and deliveries for offstream use from surface- and ground-water sources in Puerto Rico were estimated at 712 million gallons per day (Mgal/d). The largest amount of freshwater withdrawn was by public-supply water facilities and was estimated at 652 Mgal/d. The public-supply domestic water use was estimated at 347 Mgal/d. Fresh surface- and ground-water withdrawals by domestic self-supplied users were estimated at 2.1 Mgal/d and the industrial self-supplied withdrawals were estimated at 9.4 Mgal/d. Withdrawals for crop irrigation purposes were estimated at 45.2 Mgal/d, or approximately 6.3 percent of all offstream freshwater withdrawals. Instream freshwater withdrawals by hydroelectric facilities were estimated at 568 Mgal/d and saline instream surface-water withdrawals for cooling purposes by thermoelectric-power facilities was estimated at 2,288 Mgal/d.

Introduction

The National Water-Use Information Program of the U.S. Geological Survey (USGS) is a cooperative program designed to compile, store, and disseminate water-use information locally and nationwide. Since 1950, the USGS has compiled data at 5-year intervals on amounts of water used in homes, businesses, and on farms in the United States, and has described how that use changed with time. The program was implemented in Puerto Rico in 1980 to provide data for the management of the Commonwealth's water resources. Water-resources planners and managers must have information regarding the amount of water used, and where and how it is used, to adequately assess many of the critical water problems facing Puerto Rico.

The USGS maintains cooperative agreements with the Puerto Rico Aqueduct and Sewer Authority (PRASA), the Puerto Rico Department of Natural and Environmental Resources (PRDNER), and the Puerto Rico Environmental Quality Board (PREQB) to compile water-use data and maintain an adequate database for major use categories of importance to water-resources managers and planners in Puerto Rico.



Purpose and Scope

The purpose of this report is to present water-use data estimates in Puerto Rico for 2005. Estimates were determined for the following categories: (1) surface-and ground-water withdrawals and their deliveries by public-supply facilities, (2) ground-water withdrawals for domestic use, (3) industrial self-supplied ground-water withdrawals, (4) surface-and ground-water withdrawals for crop irrigation, and (5) ground-water withdrawals and public-supply deliveries for thermoelectric-power use. In addition, instream water-use and saline withdrawals were estimated for hydroelectric-power generation and for cooling purposes at thermoelectric power plants.

Water-use estimates were categorized by municipios, irrigation districts, principal aquifer provinces, and by public-supply water withdrawals in areas where 80 percent or more of the water withdrawn for public-supply was used within a particular geographic area. Figure 1 illustrates 46 geographic areas categorized in this study: a municipio, an aggregate of municipios, or some of the “barrios” of an adjacent municipio.

Acknowledgments

The authors gratefully acknowledge the following Commonwealth agencies for their cooperation in making the data available: the Puerto Rico Aqueduct and Sewer Authority (PRASA) regional and area offices, Permit and Franchise Division of the Puerto Rico Department of Natural and Environmental Resources (PRDNER), the Puerto Rico Electric Power Authority (PREPA), the Puerto Rico Department of Health (PRDOH) and the Puerto Rico Land Authority.

Data-Compilation Procedures

Water-use data for major offstream categories were compiled for: 46 public-supply water aggregated service areas (fig. 1); domestic self-supplied by aggregated service areas, industrial self-supplied use by municipios (fig. 2); crop irrigation by PREPA irrigation districts (fig. 3); and by ground-water provinces (fig. 4). Also, the thermoelectric and hydroelectric-power water-use categories were compiled by municipios. The sources of data and the methods used to compile water use differ for each category and are described in the following sections.

Public-Supply Water Withdrawals and Deliveries

In this report, public-supply water withdrawal is water withdrawn by public and private suppliers that furnish water for at least 25 people or have a minimum of 15 service connections. Data documenting freshwater withdrawals from PRASA surface-water facilities and wells, by municipio, during 2005 were obtained from the Puerto Rico Aqueduct and Sewer Authority (2005). Data documenting withdrawals from non-PRASA systems were obtained from Puerto Rico Department of Health (2000). Data are aggregated into 46 public-supply water service areas (fig. 1) and sub-divided as PRASA or non-PRASA.

The combined total of all users of freshwater served by the PRASA, non-PRASA, and domestic self-supplied users was considered in this report to equal the 2005 total population estimate obtained by the U.S. Census Bureau (2006). The sum of non-PRASA and domestic self-supplied users was estimated in this report to be 3 percent of the combined total. By subtracting 3 percent from the combined total, the estimated number of PRASA users was obtained.

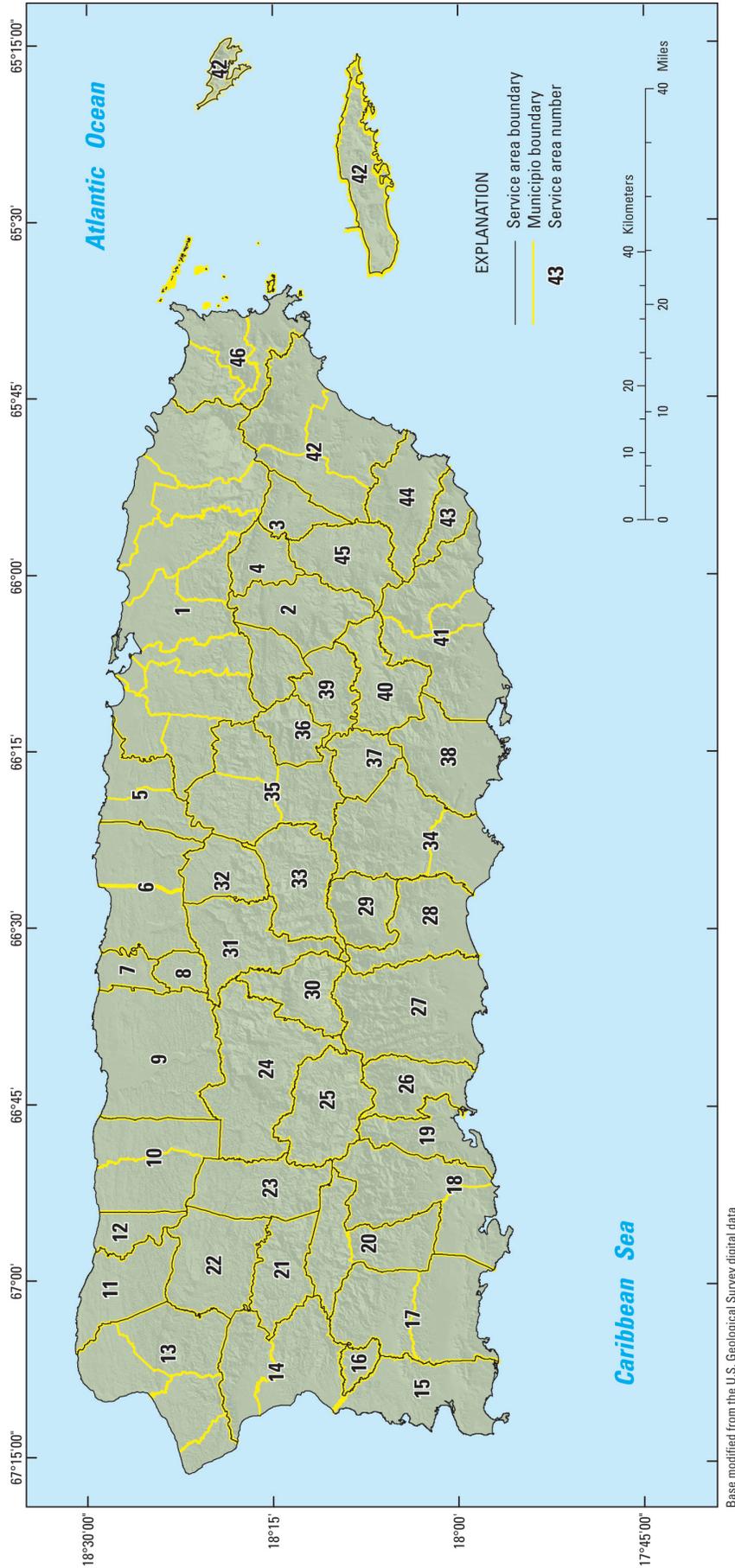


Figure 1.— Location of public-supply water aggregated service areas in Puerto Rico, as used in this report, 2005.

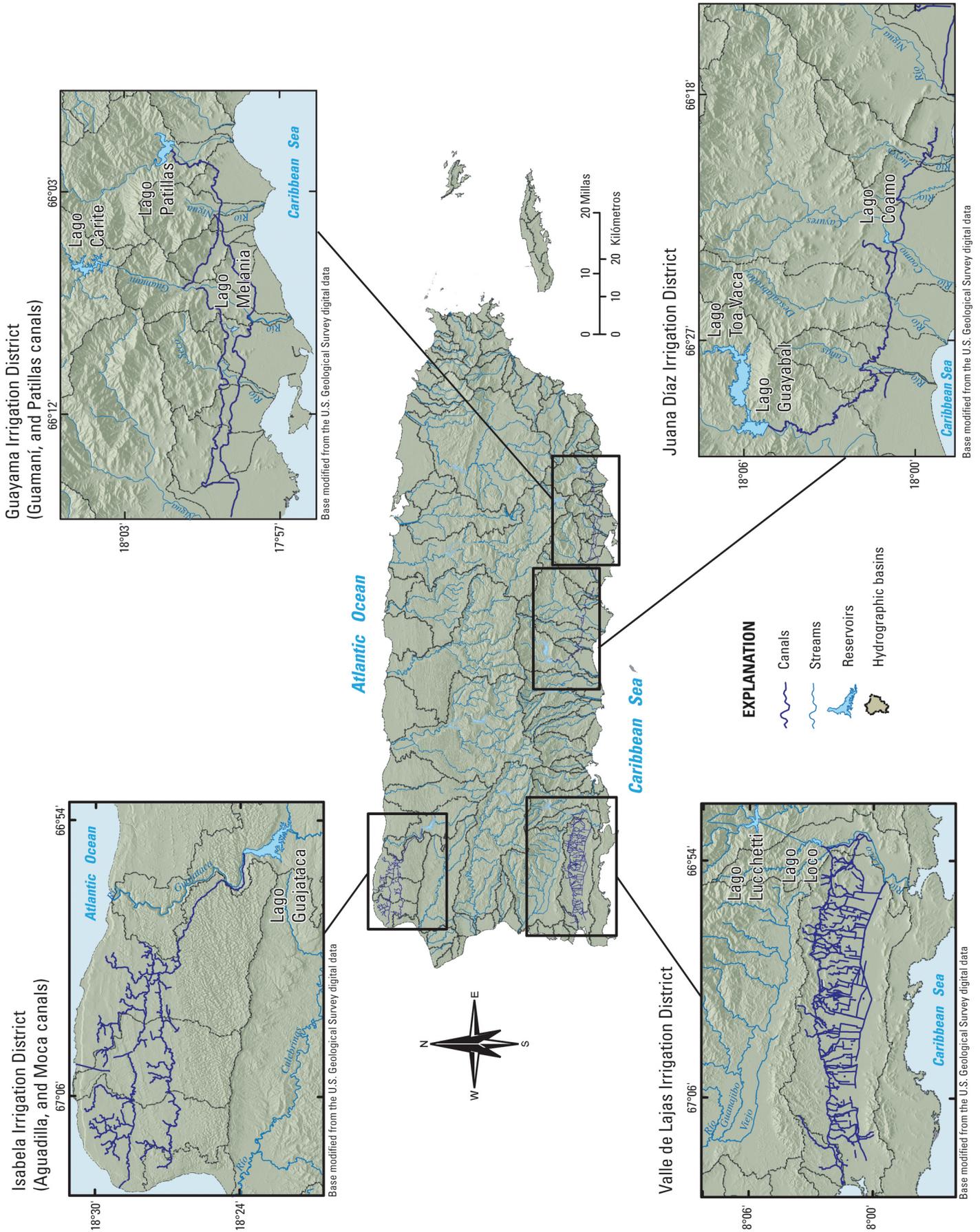
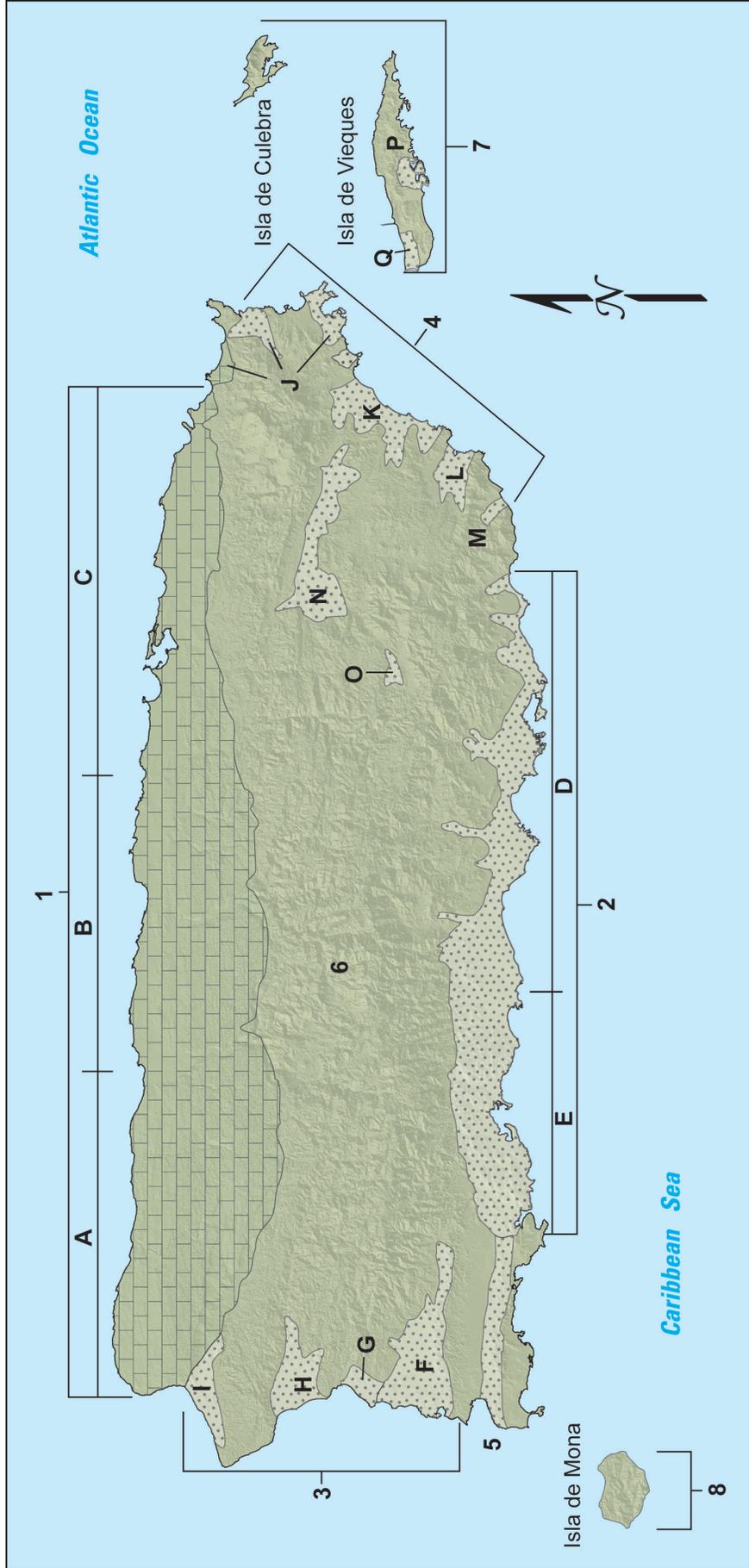


Figure 3.— Location of the Puerto Rico Electric Power Authority Irrigation Districts in Puerto Rico, 2005.



Base modified from the U.S. Geological Survey digital data

EXPLANATION

GROUND-WATER PROVINCES

- 1. North Coast Province
- 2. South Coast Province
- 3. West Coast Province
- 4. East Coast Province
- 5. Lajas Valley
- 6. Interior Province
- 7. Isla de Vieques and Culebra
- 8. Isla de Mona

AQUIFER NAMES

NORTH COAST LIMESTONE AQUIFER SYSTEM:

- A. West Coast to Río Grande de Arecibo area
- B. Río Grande de Arecibo to Río de la Plata area
- C. Río de la Plata to Río Espíritu Santo area

- D. South Coastal Alluvial Plain aquifer system
- E. Tallaboa-Guayanilla-Yauco-Guánica Valleys
- F. Río Guanajibo Valley
- G. Río Yagüez Valley
- H. Río Grande de Añasco Valley
- I. Río Culebrinas Valley
- J. Fajardo area

- K. Naguabo-Humacao area
- L. Yabucoa Valley
- M. Maunabo Valley
- N. Caguas-Juncos Valley
- O. Cayey Valley
- P. Esperanza
- Q. Resolución

Figure 4.— Ground-water provinces and aquifers of Puerto Rico and outlying islands.

The North Coast Aqueduct, commonly referred to as the “Superaqueduct”, a major public-supply facility, entered into operation about September 2000. This facility transfers water from the Río Grande de Arecibo basin to the San Juan metropolitan area of Puerto Rico. The U.S. Census Bureau defines a metropolitan area as a large population nucleus that, combined with adjacent communities, maintains a high degree of economic and social integration (U.S. Department of Commerce, 1991). Public-supply water deliveries from the Superaqueduct to municipios along the pipeline service area between the Río Grande de Arecibo and the San Juan metropolitan area were obtained from an annual report prepared by Thames Water of Puerto Rico (2005), the company that operates the Superaqueduct. The report contains the annual average public-supply water delivered through seven (7) interconnections: (1) Miraflores, (2) Sabana Hoyos, (3) Barceloneta, (4) Manatí, (5) Vega Baja, (6) Dorado/Vega Alta, (7) Bayamón (fig.5).

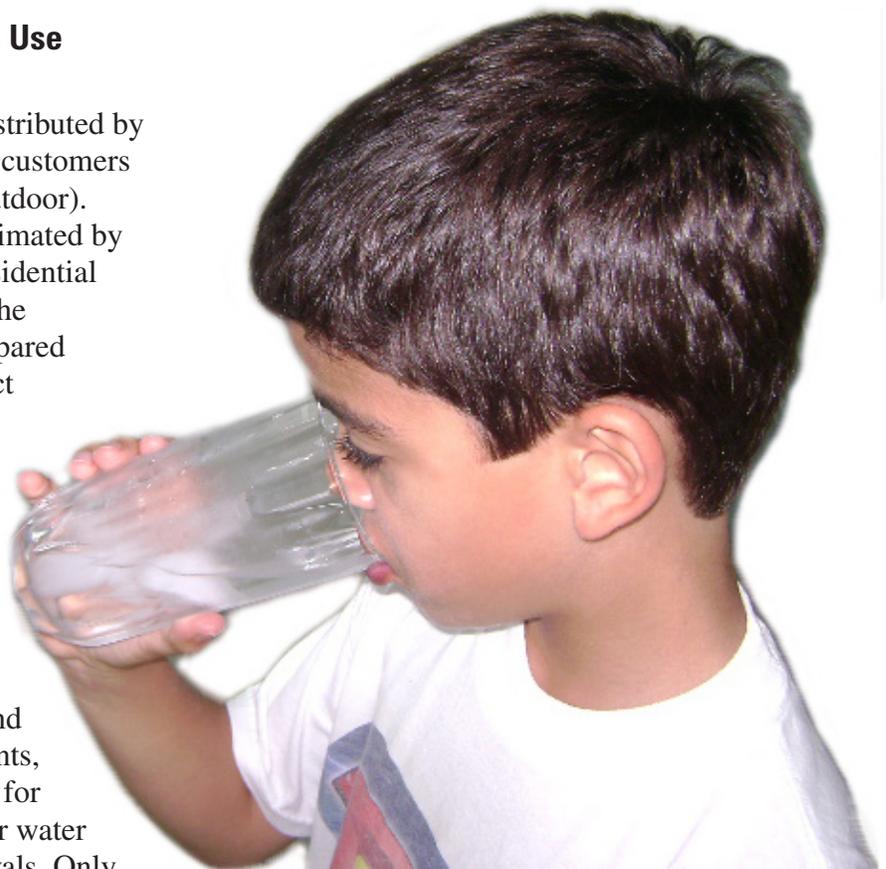
the metered accounts were used in this report to obtain the residential percentage of total water use within each municipio.

By applying the PRASA 1990 residential water-use percentage to the 2005 estimated public-supply water deliveries, a residential percentage was calculated. Percentages of total residential water deliveries above 60 percent were used to obtain an estimate. Because the monthly calculated percentages had disparities between 20 to 100 percent, the highest and lowest monthly values were not calculated as part of the average. As a result, the average residential water-use estimate for Puerto Rico was 79 percent.

Reported residential water use included in this report is for normal indoor, and outdoor household purposes. Common indoor uses include drinking, preparing food, bathing, washing clothes and dishes, and flushing toilets. Major outdoor uses include watering lawns and garden and automobile washing. Puerto Rico residential indoor water use is significant. The average family of four can use 365 gallons of water every day, of which more than

Public-Supply Water for Domestic Use

Domestic delivery is water distributed by a public-supply facility to residential customers for domestic purposes (indoor and outdoor). Data for domestic deliveries were estimated by calculating the percentage of total residential water use within a municipio, using the values presented in a 1990 report prepared by the PRASA (Puerto Rico Aqueduct and Sewer Authority, 1990). Because of certain variables in recent years, such as large, unmetered water withdrawals, the 1990 report is considered to be the best source of data. The aforementioned reports, prepared on a monthly basis, contain summarized information on residential, commercial, industrial, and institutional PRASA customer accounts, which are aggregated by service area for metered and unmetered water, and for water and sewer service at bimonthly intervals. Only



80 percent is indoor use; while the remaining 20 percent is outdoor use.

Residential use varies from household to household; however, households served by the same public-supply system were found to correlate with the municipio median household income. The literature indicates that an increase in household income corresponds to an increase in water demand. A report by the California Department of Water Resources in 1998 calculated an elasticity estimate based on almost 25 percent of California's population. The model estimated that an increase in income of 10 percent generated a corresponding 2.5-percent increase in average household monthly water demand (Renwick, and others, 1998).

To obtain a total for public-supply domestic water use the following equation was applied:

Public-water supply (PWS) Domestic Use = Water Withdrawals * 0.85 * Average of calculated water use percentage.

The following factors were considered when applied to the equation: the PWS deliveries that were estimated for the same public-supply service area and for most municipios are equivalent to public-supply withdrawals, except for service areas consisting of several interconnected municipios, and municipios at which water is transferred from other areas. A water loss of 15 percent, due to leaks and ruptures in the water distribution system was applied, thus the withdrawal-delivery in the service area was multiplied by 85 percent. To obtain the domestic delivery in million gallons per day for the service area, the PWS domestic water use calculated was multiplied by the PRASA estimated population served.

Domestic Self-Supplied Water Use

Domestic self-supplied water use refers to water used by individual households that are not served by public-supply water systems—PRASA and non-PRASA. Data on freshwater withdrawals and population served were not available for the domestic self-supplied water-use estimates. The domestic self-supplied population within the 46 public-supply water service areas used in this report was estimated by assuming that about 3 percent of the population in Puerto Rico is not served by the PRASA systems (F. Gómez-Gómez, U.S.

Geological Survey, written commun., 2004). On this basis, about 2.25 percent of the population is served by non-PRASA systems and thus, about 0.75 percent is domestic self-supplied. To obtain an estimate of the domestic self-supplied population within each public-supply water service area, the PRASA and non-PRASA population served in the water-use service area was subtracted from the total population. The 2005 population was estimated by the U.S. Bureau of Census to be 3,912,054 people (U.S. Bureau of Census, 2006). Therefore, the estimated total population for the domestic self-supplied use category is about 30,722 people.

Self-supplied domestic water withdrawals were estimated by multiplying self-supplied population by a per capita-use coefficient of 68 gallons per day (gal/d) per person, based on 250 gal/d per household with 3.02 persons per household (302 persons per 100 household units). The domestic self-supplied use is strictly an estimate and should not be used to infer absolute changes in the unit area of data aggregation (municipio).

Industrial Self-Supplied Withdrawals

Industrial self-supplied withdrawals refer to water used for industrial purposes in such industries as pharmaceutical, chemical and allied products, food processing, and petroleum refining. Water for industrial uses at facilities requiring 10,000 gal/d or more of water as part of industrial processes is obtained from self-supplied ground-water withdrawals (100 percent). Industrial facilities that are typically supplied from public-supply water facilities were not included in this report.

The withdrawal data included in this report are limited to industrial self-supplied ground-water withdrawals and were provided by the PRDNER Permits and Water Franchise Division and from individual industries. In Puerto Rico, most of the self-supplied industries are located along the north coast of the island and can be grouped in the North American Industry Classification System Code (NAICS) code number 325412 (U.S. Bureau of Census, 2005). The NAICS code 325412 refers to chemical pharmaceutical preparation manufacturing.

Crop-Irrigation Water Use

Crop-irrigation water use is defined as water applied to the land to assist in the growing of crops, nursery plants, and pastures. Water applied to golf courses and parks was not included in this category. Surface-water withdrawals for crop-irrigation purposes were estimated for agricultural areas served by irrigation districts of the PREPA. There are four government-operated Irrigation Districts in Puerto Rico: the Guayama and Juana Díaz Irrigation Districts in the south; the Valle de Lajas Irrigation District, in the southwest, and the Isabela Irrigation District in northwestern Puerto Rico (fig. 3).

The Guayama Irrigation District (figs.2, 3) withdraws water from the Lago Patillas, Lago Carite, and the Lago Melania reservoirs, the Río Guamaní, and intrabasin transfer of water from Lago Carite to the Río Guamaní. These sources transfer to agricultural lands in the municipios of Patillas, Arroyo, Guayama, and Salinas. In 2005, water conveyed by the Guayama Irrigation District was also the source of public-supply water to three PRASA filtration plants in the municipios of Guayama, Cayey and Patillas. The Guayama filtration plant is supplied from the Patillas irrigation canal; the Cayey Farallón filtration plant from Lago Carite; and, the Patillas filtration plant

from Lago Patillas. In 2005, about 78 percent of the withdrawals from Lago Patillas and Canal de Patillas were for public-supply water use (Puerto Rico Electric and Power Authority, written comm., 2006).

The Juana Díaz Irrigation District (figs.2, 3) withdraws water exclusively from the Lago Guayabal reservoir in the municipio of Villalba and conveys the water to agricultural lands in the municipio of Juana Díaz, Santa Isabel, and the part of Salinas to the west of Río Nigua. In 2005, water conveyed by the Juana Díaz Irrigation District was also the source of public-supply water to two PRASA filtration plants in the municipios of Juana Díaz and Villalba: the Juana Díaz filtration plant and the Villalba, La Julita filtration plant. In 2005, about 20 percent of the withdrawals from irrigation canals of the Juana Díaz Irrigation District were for public-supply water use (Puerto Rico Electric and Power Authority, written comm., 2006).

The Valle de Lajas Irrigation District (figs.2, 3) withdraws water exclusively from the Lago Loco reservoir of the municipio of Yauco and conveys the water to agricultural lands in the municipios of Cabo Rojo, Guánica, Lajas, Sabana Grande, and Yauco. Diversion from Lago Loco to the Valle de Lajas Irrigation District provided the surface water withdrawn by the PRASA to filtration plants



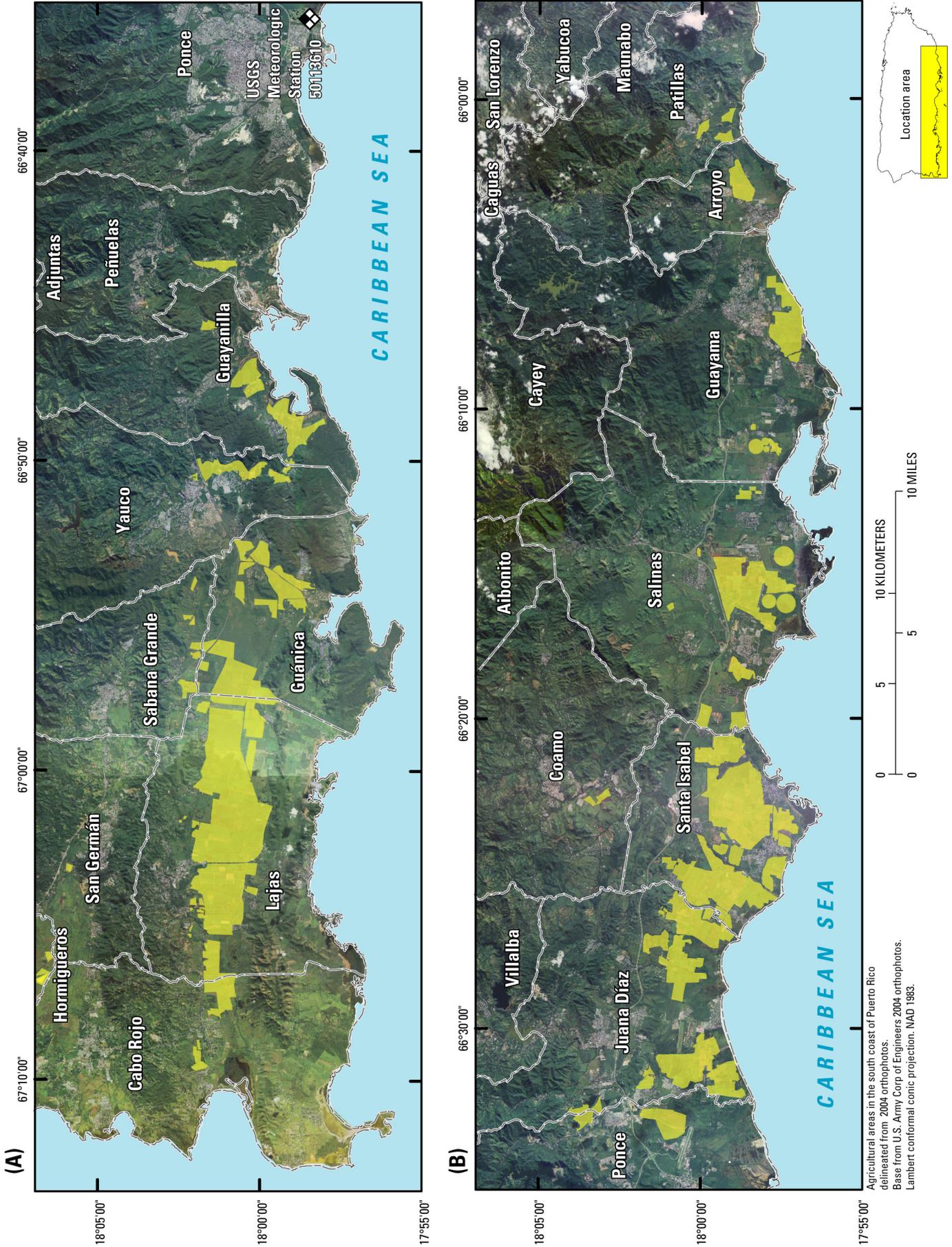


Figure 6.— Location of agricultural fields in the south coast of Puerto Rico, (A) from Cabo Rojo to mid Ponce and (B) from mid Ponce to Yabucoa.

in the municipios of Sabana Grande (Maginas filtration plant), Lajas (Lajas filtration plant) and Cabo Rojo (Betances filtration plant). Public-supply water withdrawals from the Valle de Lajas Irrigation Canal represents about 56 percent of the total withdrawals from the Lago Loco reservoir to the Valle de Lajas Irrigation District. (Puerto Rico Electric and Power Authority, written comm., 2006).

The Isabela Irrigation District withdraws water exclusively from Lago Guajataca reservoir in the municipio of Quebradillas and conveys the water to agricultural lands in the municipios of Aguadilla, Isabela, and Moca. About 95 percent of the water conveyed by the Isabela Irrigation District was the source of water at the Isabela, Aguadilla and Ramey PRASA filtration plants. These public-supply water filtration plants serve the population of the municipios of Isabela, Aguadilla, Aguada, Moca, and Rincón (Puerto Rico Electric and Power Authority, written comm., 2006).

Surface-water irrigation withdrawals at Irrigation Districts were provided by the PREPA. Estimates of ground-water withdrawals for crop irrigation within Irrigation Districts were estimated

by comparing water application rates based on the electric consumption of irrigation wells located at farms in Santa Isabel in 2005 and at Salinas during 2002 as documented by Rodríguez (2006). Aerial photos taken in 2004 by the U.S. Army Corps of Engineers (U.S. Army Corps of Engineers, 2004) were used to delineate acreage irrigated by municipio within the PREPA Irrigation Districts (fig. 6).

A crop irrigation water-use estimate also was aggregated for the eight principal ground-water provinces of the island: North Coast Province, South Coast Province, West Coast Province, East Coast Province, Lajas Valley, Interior Province, Isla de Vieques and Culebra and Isla de Mona (fig. 4).

The number of acres that were irrigated were obtained from the delineation of acreage of land cultivated in municipios within the Irrigation Districts. The 1998 and 2002 Census of Agriculture (U.S. Department of Agriculture, 2003) were used to obtain an estimate of the acreage that was irrigated in 2005 in municipios outside the Irrigation District limits. Irrigated farmland was reported to the Census in “cuerdas” which was multiplied by 0.89 to convert to acreage.



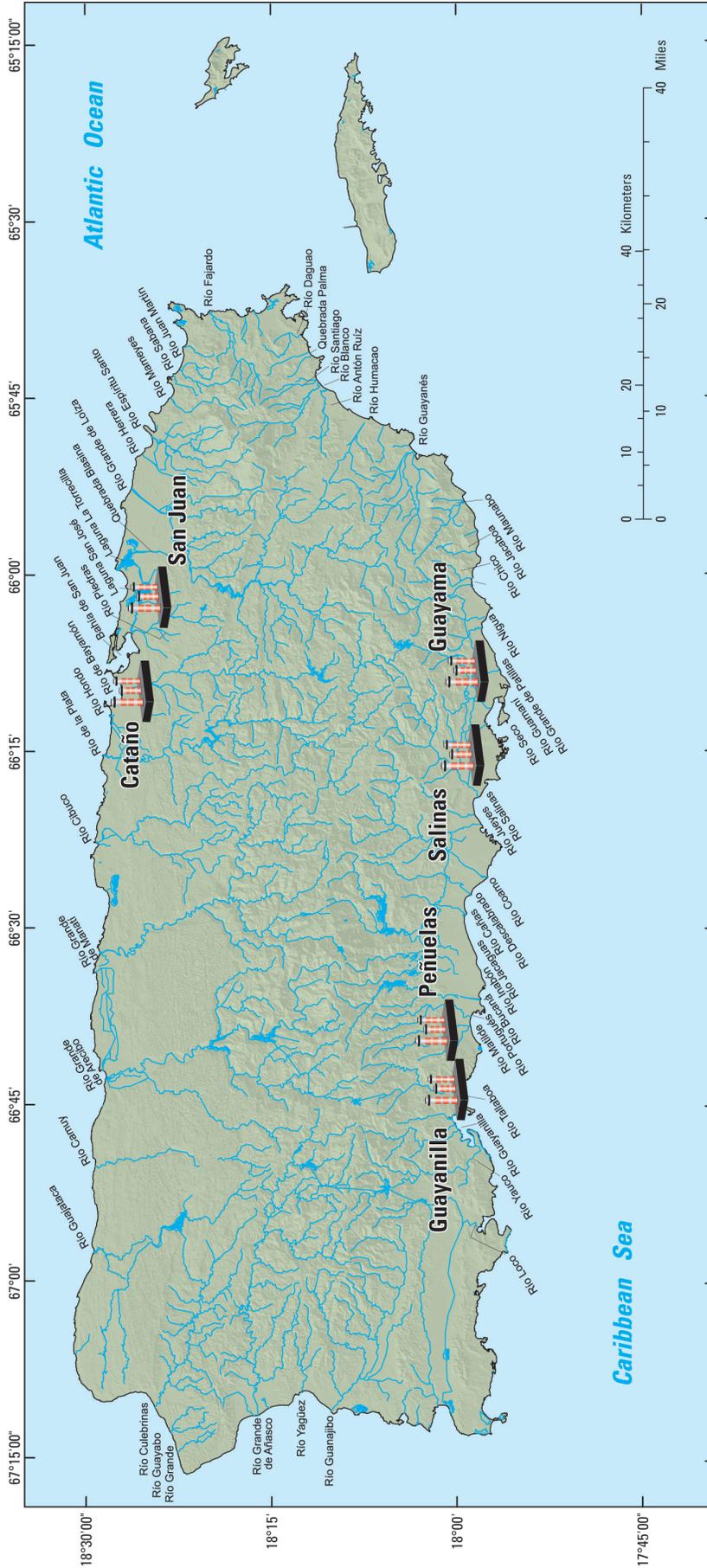


Figure 7.— Location of active thermoelectric power plants in Puerto Rico, 2005.

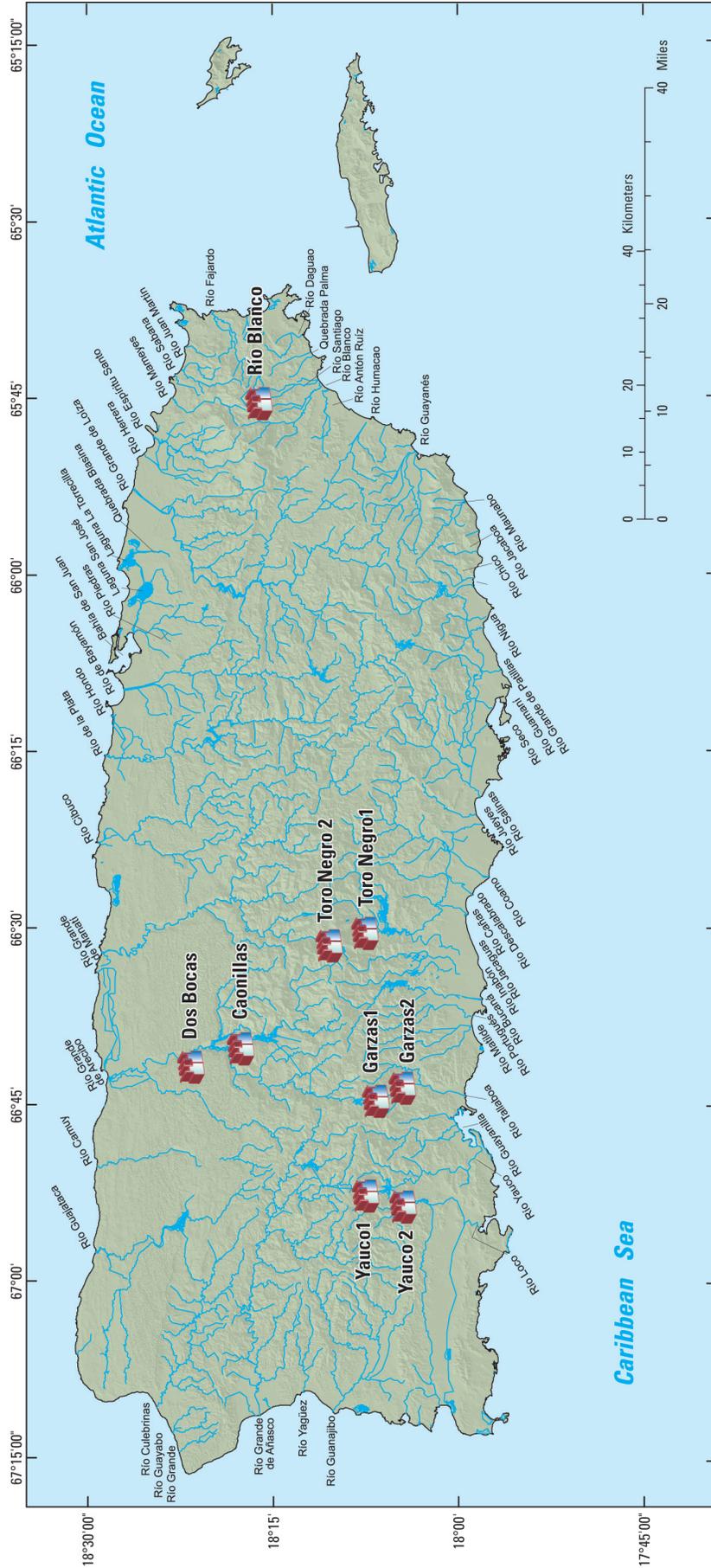


Figure 8.— Location of active hydroelectric power plants in Puerto Rico, 2005.

Table 1. Estimated public-supply water withdrawals by source and service areas, 2005.

[Location of areas shown in figure 1; Mgal/d, million gallons per day; PRASA, Puerto Rico Aqueduct and Sewer Authority]

Service Area Number	Areas	Withdrawals, in Mgal/d						
		PRASA Surface Water	PRASA Ground Water	Total PRASA	non-PRASA Surface Water	non-PRASA Ground Water	Total non-PRASA	
	Puerto Rico	553.57	92.99	646.56	2.72	3.16	5.88	652.44
1	Metropolitan area: Toa Alta, Toa Baja, San Juan, Trujillo Alto, Río Grande, Bayamón, Cataño, Guaynabo, Carolina, Loíza, Canóvanas, Caguas area - (Barrio San Antonio, Barrio Río Cañas)	209.73	0.78	210.51	0.04	0.00	0.04	210.55
2	Caguas, Gurabo area (Barrio Navarro)	10.30	0.14	10.44	0.11	0.33	0.44	10.88
3	Juncos, Gurabo area- Barrio Hato Nuevo and Mamey)	4.95	0.83	5.78	0.00	0.00	0.00	5.78
4	Gurabo	2.00	1.25	3.25	0.00	0.02	0.02	3.27
5	Dorado, Vega Alta	0.00	8.51	8.51	0.00	0.00	0.00	8.51
6	Manatí, Vega Baja	1.90	6.31	8.21	0.00	0.00	0.00	8.21
7	Barceloneta	0.00	3.70	3.70	0.00	0.00	0.00	3.70
8	Florida	0.00	1.17	1.17	0.00	0.00	0.00	1.17
9	Arecibo	91.90	11.47	103.37	0.00	0.02	0.02	103.39
10	Camuy, Hatillo	4.84	1.25	6.09	0.00	0.00	0.00	6.09
11	Isabela	28.67	0.00	28.67	0.00	0.00	0.00	28.67
12	Quebradillas	4.56	0.22	4.78	0.00	0.00	0.00	4.78
13	Aguadilla, Moca, Aguada, Rincón	5.98	3.09	9.07	0.00	0.20	0.20	9.27
14	Mayagüez, Añasco, Cabo Rojo area (Barrio Guanajibo), Hormigueros area (Barrio Guanajibo)	21.27	1.57	22.84	0.00	0.10	0.10	22.94
15	Cabo Rojo, Hormigueros area (Barrio Benavente)	0.00	4.83	4.83	0.00	0.00	0.00	4.83
16	Hormigueros	0.00	0.85	0.85	0.00	0.00	0.00	0.85
17	Lajas, San Germán	1.50	2.12	3.62	0.12	0.00	0.12	3.74
18	Guánica, Yauco	10.78	5.51	16.29	0.13	0.20	0.33	16.62
19	Guayanilla	0.26	2.53	2.79	0.01	0.00	0.01	2.80
20	Maricao, Sabana Grande	2.62	0.03	2.65	0.02	0.00	0.02	2.67
21	Las Marias	1.40	0.00	1.40	0.01	0.00	0.01	1.41
22	San Sebastián	4.34	0.14	4.48	0.00	0.04	0.04	4.52

Table 1. Estimated public-supply water withdrawals by source and service areas, 2005.—Continued

[Location of areas shown in figure 1; Mgal/d, million gallons per day; PRASA, Puerto Rico Aqueduct and Sewer Authority]

Service Area Number	Areas	Withdrawals, in Mgal/d						
		PRASA Surface Water	PRASA Ground Water	Total PRASA	non-PRASA Surface Water	non-PRASA Ground Water	Total non-PRASA	
23	Lares	2.86	0.00	2.86	0.01	0.06	0.07	2.93
24	Utua	4.04	0.14	4.18	0.14	0.02	0.16	4.34
25	Adjuntas	2.10	0.05	2.15	0.04	0.11	0.15	2.30
26	Peñuelas	2.32	0.00	2.32	0.19	0.04	0.23	2.55
27	Ponce	6.65	6.30	12.95	0.13	0.06	0.19	13.14
28	Juana Díaz	1.38	4.45	5.83	0.03	0.01	0.04	5.87
29	Villalba	21.09	0.11	21.20	0.19	0.01	0.20	21.40
30	Jayuya	2.12	0.00	2.12	0.23	0.00	0.23	2.35
31	Ciales	3.10	0.00	3.10	0.01	0.02	0.03	3.13
32	Morovis	3.87	0.25	4.12	0.00	0.00	0.00	4.12
33	Orocovis	3.34	0.00	3.34	0.12	0.19	0.31	3.65
34	Coamo, Santa Isabel	0.99	8.36	9.35	0.02	0.05	0.07	9.42
35	Barranquitas, Naranjito, Corozal	6.10	2.12	8.22	0.05	0.71	0.76	8.98
36	Comerio	2.05	0.30	2.35	0.14	0.02	0.16	2.51
37	Aibonito	3.30	1.28	4.58	0.04	0.01	0.05	4.63
38	Salinas	0.00	4.43	4.43	0.00	0.00	0.00	4.43
39	Aguas Buenas, Cidra	22.66	0.52	23.18	0.05	0.38	0.43	23.61
40	Cayey	8.88	0.35	9.23	0.03	0.03	0.06	9.29
41	Guayama, Arroyo, Patillas	10.48	3.59	14.07	0.26	0.04	0.30	14.37
42	Humacao, Las Piedras, Naguabo, Vieques, Culebra	19.55	0.32	19.87	0.27	0.05	0.32	20.19
43	Maunabo	0.09	1.55	1.64	0.02	0.00	0.02	1.66
44	Yabucoa	1.99	2.57	4.56	0.29	0.24	0.53	5.09
45	San Lorenzo	7.73	0.00	7.73	0.02	0.20	0.22	7.95
46	Luquillo, Fajardo, Ceiba	9.88	0.00	9.88	0.00	0.00	0.00	9.88

Table 2. Estimated public-supply water deliveries, population served, and per capita deliveries by service areas, 2005.

[Location of areas are shown in figure 1. Mgal/d, million gallons per day; gal/d-p, gallons per day per person;

Service Area Number	Areas	2005 Census Population	Population served by PRASA Systems	Population served by non-PRASA Systems	Total population served	PRASA Delivery, in Mgal/d	Per Capita Delivery in gal/d-p
	Puerto Rico	3,912,054	3,794,840	86,492	3,881,332	646.55	167
	Metropolitan area: Toa Alta, Toa Baja, San Juan, Trujillo Alto, Río Grande, Bayamón, Cataño, Guaynabo, Carolina, Loíza, Canóvanas, { part Caguas } - Barrio San Antonio, Barrio Río Cañas)	1,371,520	1,369,520	556	1,370,076	285.30	208
2	Caguas, Gurabo area (Barrio Navarro)	133,552	125,261	6,391	131,652	15.44	117
3	Juncos, Gurabo area- (Barrio Hato Nuevo and Mamey)	45,755	45,669	0	45,669	5.78	127
4	Gurabo	29,112	28,817	295	29,112	3.25	112
5	Dorado, Vega Alta	75,002	75,002	0	75,002	16.14	215
6	Manatí, Vega Baja	112,660	112,660	0	112,660	15.67	139
7	Barceloneta	22,829	22,829	0	22,829	4.56	200
8	Florida	14,678	14,678	0	14,678	1.17	80
9	Arecibo	101,920	101,346	350	101,696	22.18	218
10	Camuy, Hatillo	80,132	80,132	0	80,132	6.09	76
11	Isabela	46,824	46,824	0	46,824	5.32	114
12	Quebradillas	27,316	27,316	0	27,316	3.66	134
13	Aguadilla, Moca, Aguada, Rincón	170,271	166,585	2,876	169,461	32.42	191
14	Mayagüez, Añasco, Cabo Rojo area (Barrio Guanajibo), Hormigueros area (Barrio Guanajibo)	129,580	127,789	1,424	129,213	22.84	177
15	Cabo Rojo, Hormigueros area (Barrio Benavente)	47,660	47,634	0	47,634	6.83	143
16	Hormigueros	16,187	16,187	0	16,187	0.85	53
17	Lajas, San Germán	64,953	62,810	1,700	64,510	7.62	118
18	Guánica, Yauco	70,408	64,306	4,862	69,168	8.29	120

Table 2. Estimated public-supply water deliveries, population served, and per capita deliveries by service areas, 2005.—Continued

[Location of areas are shown in figure 1. Mgal/d, million gallons per day; gal/d-p, gallons per day per person;

Service Area Number	Areas	2005 Census Population	Population served by PRASA Systems	Population served by non-PRASA Systems	Total population served	PRASA Delivery, in Mgal/d	Per Capita Delivery in gal/d-p
19	Guayanilla	23,552	23,247	120	23,367	2.79	119
20	Maricao, Sabana Grande	33,643	33,347	250	33,597	4.65	138
21	Las Marías	11,854	11,728	100	11,828	1.40	118
22	San Sebastián	46,684	45,874	644	46,518	5.60	120
23	Lares	36,868	35,625	1,004	36,629	2.86	78
24	Utüado	34,972	31,868	2,413	34,281	4.18	122
25	Adjuntas	18,566	15,837	2,157	17,994	2.15	119
26	Peñuelas	28,692	24,555	3,290	27,845	2.32	83
27	Ponce	182,387	178,739	2,862	181,601	31.64	174
28	Juana Díaz	52,409	51,123	526	51,649	5.83	113
29	Villalba	29,637	26,136	2,887	29,023	2.51	86
30	Jayuya	18,010	13,672	3,434	17,106	2.12	124
31	Ciales.	20,378	19,718	560	20,278	3.10	153
32	Morovis..	32,012	30,807	0	30,807	4.12	134
33	Orocovis	24,648	19,222	4,640	23,862	3.34	140
34	Coamo, Santa Isabel.	61,575	60,213	1,048	61,261	9.35	153
35	Barranquitas, Naranjito, Corozal.	98,322	83,451	11,072	94,523	8.22	87
36	Comerio	19,524	16,638	2,349	18,987	2.35	124
37	Aibonito	26,942	25,996	650	26,646	4.58	172
38	Salinas	31,969	31,228	0	31,228	4.43	142
39	Aguas Buenas, Cidra	77,109	69,014	6,367	75,381	8.62	114
40	Cayey	47,279	45,999	860	46,859	9.23	197
41	Guayama, Arroyo, Patillas.	84,180	78,706	4386	83,092	14.07	169
42	Humacao, Las Piedras, Naguabo, Vieques, Culebra	133,766	127,322	4,798	132,120	19.87	150

Table 2. Estimated public-supply water deliveries, population served, and per capita deliveries by service areas, 2005.—Continued

[Location of areas are shown in figure 1. Mgal/d, million gallons per day; gal/d-p, gallons per day per person;

Service Area Number	Areas	2005 Census Population	Population served by PRASA Systems	Population served by non-PRASA Systems	Total population served	PRASA Delivery, in Mgal/d	Per Capita Delivery in gal/d-p
43	Maunabo.	12,776	12,367	325	12,692	1.64	129
44	Yabucoa	40,237	29,857	7,833	37,690	4.56	121
45	San Lorenzo	43,566	39,438	3,303	42,741	7.73	181
46	Luquillo, Fajardo, Ceiba	80,138	77,748	160	77,908	9.88	127

Thermoelectric Power Water Use

The thermoelectric-power category includes water that is used to generate electricity by using fossil fuel. In Puerto Rico, 100 percent of saline water withdrawals is made up entirely of seawater used for once-through cooling purposes. When freshwater is used at thermoelectric powerplants it is self-supplied or is delivered by a water supplier through a distribution system and is used mostly for boiler feed and domestic use within the facility. In 2005, Puerto Rico had six active thermoelectric powerplants, four operated by the PREPA and two by private enterprises (fig. 7). The estimates of water withdrawals by thermoelectric power plants were provided by the PREPA, the Franchise and Permit Division of the PRDNER, and by the private facilities.

Hydroelectric Power Instream Water Use

Water used for hydroelectric-power generation is classified as instream use and refers to water that is used to generate electricity at power plants, by using turbine generators that are driven by falling water. During 2005, there were nine active hydroelectric powerplants throughout Puerto Rico (fig. 8).

Water Use by Category and Source of Water

Water-use data are divided into offstream and instream uses. Offstream use is defined as water withdrawn or diverted from ground- or surface-water sources and conveyed to the place of use. Offstream water-use categories considered in this report are: public-supply water withdrawals and deliveries, domestic self-supplied ground-water use, industrial self-supplied ground-water withdrawals, crop irrigation water use, and thermoelectric-power freshwater use. An estimated 712 Mgal/d was withdrawn for offstream freshwater uses throughout Puerto Rico during 2005. The largest offstream use was for public-supply water purposes, which accounted for 652 Mgal/d (92 percent) of the total withdrawals. The San Juan metropolitan service area (service area 1 in fig. 1) accounted for 32 percent of the total public-supply water withdrawals in Puerto Rico. About 45.2 Mgal/d (6.3 percent) of all offstream freshwater withdrawals was used for crop-irrigation purposes. Fresh ground-water withdrawals for domestic self-supplied water use were estimated to be 2.1 Mgal/d, and industrial self-supplied ground-water use was estimated to be 9.4 Mgal/d in 2005.



Table 3. Estimated domestic use, population served by Puerto Rico Aqueduct and Sewer Authority systems, and domestic per capita use by service areas, 2005.

[Location of areas are shown in figure 1; Mgal/d, million gallons per day; gal/d-p, gallons per day per person; PRASA, Puerto Rico Aqueduct and Sewer Authority]

Service Area Number	Areas	Domestic use, in Mgal/d	Population served by PRASA Systems	Domestic Per Capita Use in gal/d-p
	Puerto Rico	346.78	3,794,840	91
1	Metropolitan area: Toa Alta, Toa Baja, San Juan, Trujillo Alto, Río Grande, Bayamón, Cataño, Guaynabo, Carolina, Loíza, Canóvanas, Caguas area - (Barrio San Antonio, Barrio Río Cañas)	139.32	1,369,520	102
2	Caguas, Gurabo area (Barrio Navarro)	9.93	125,261	79
3	Juncos, Gurabo area-Barrio Hato Nuevo and Mamey)	3.42	45,669	75
4	Gurabo	3.15	28,817	109
5	Dorado, Vega Alta	10.07	75,002	134
6	Manatí, Vega Baja	10.83	112,660	96
7	Barceloneta	2.98	22,829	131
8	Florida	0.84	14,678	57
9	Arecibo	13.63	101,346	134
10	Camuy, Hatillo	4.19	80,132	52
11	Isabela	3.55	46,824	76
12	Quebradillas	2.55	27,316	93
13	Aguadilla, Moca, Aguada, Rincón	9.58	166,585	58
14	Mayaguez, Añasco, Cabo Rojo area (Barrio Guanajibo), Hormigueros area (Barrio Guanajibo)	8.49	127,789	66
15	Cabo Rojo, Hormigueros area (Barrio Benavente)	4.87	47,634	102
16	Hormigueros	0.69	16,187	43
17	Lajas, San German	5.02	62,810	80
18	Guanica, Yauco	5.12	64,306	80
19	Guayanilla	1.92	23,247	83
20	Maricao, Sabana Grande	3.19	33,347	96
21	Las Marias	0.95	11,728	81
22	San Sebastián	3.83	45,874	83
23	Lares	2.00	35,625	56
24	Utua	2.64	31,868	83
25	Adjuntas	1.21	15,837	76
26	Peñuelas	1.39	24,555	57
27	Ponce	18.26	178,739	102

Table 3. Estimated domestic use, population served by Puerto Rico Aqueduct and Sewer Authority systems, and domestic per capita use by service areas, 2005.—Continued

[Location of areas are shown in figure 1; Mgal/d, million gallons per day; gal/d-p, gallons per day per person; PRASA, Puerto Rico Aqueduct and Sewer Authority]

Service Area Number	Areas	Domestic use, in Mgal/d	Population served by PRASA Systems	Domestic Per Capita Use in gal/d-p
28	Juana Diaz	4.06	51,123	79
29	Villalba	1.51	26,136	58
30	Jayuya	0.92	13,672	67
31	Ciales.	2.12	19,718	108
32	Morovis	2.86	30,807	93
33	Orocovis	1.84	19,222	96
34	Coamo, Santa Isabel	5.72	60,213	95
35	Barranquitas, Naranjito, Corozal	4.94	83,451	59
36	Comerio	1.41	16,638	85
37	Aibonito	2.64	25,996	102
38	Salinas	3.03	31,228	97
39	Aguas Buenas, Cidra	5.53	69,014	80
40	Cayey	6.32	45,999	137
41	Guayama, Arroyo, Patillas	4.69	78,706	60
42	Humacao, Las Piedras, Naguabo, Vieques, Culebra	9.93	127,322	78
43	Maunabo	1.06	12,367	86
44	Yabucoa	2.32	29,857	78
45	San Lorenzo	5.25	39,438	133
46	Luquillo, Fajardo, Ceiba	7.01	77,748	90

Table 4. Estimated domestic self-supplied use and population served by service areas, 2005.

[Location of areas are shown in figure 1; Mga/d, million gallons per day]

Service Area Number	Areas	Estimated self-supplied population	Total self-supplied withdrawals, in Mgal/d
	Puerto Rico	30,722	2.10
1	Metropolitan area: Toa Alta, Toa Baja, San Juan, Trujillo Alto, Río Grande, Bayamón, Cataño, Guaynabo, Carolina, Loíza, Canóvanas, Caguas area - (Barrio San Antonio, Barrio Río Cañas)	1,444	0.09
2	Caguas, Gurabo area (Barrio. Navarro)	1,900	0.13
3	Juncos, Gurabo area- Barrio Hato Nuevo and Mamey)	86	0.01
4	Gurabo	0	0.00
5	Dorado, Vega Alta	0	0.00
6	Manati, Vega Baja	0	0.00
7	Barceloneta	0	0.00
8	Florida	0	0.00
9	Arecibo	224	0.02
10	Camuy, Hatillo	0	0.00
11	Isabela	0	0.00
12	Quebradillas	0	0.00
13	Aguadilla, Moca, Aguada, Rincón	810	0.05
14	Mayaguez, Añasco, Cabo Rojo area (Barrio Guanajibo), Hormigueros area (Barrio Guanajibo)	367	0.03
15	Cabo Rojo, Hormigueros area (Barrio Benavente)	26	0.00
16	Hormigueros	0	0.00
17	Lajas, San German	443	0.03
18	Guanica, Yauco	1,240	0.09
19	Guayanilla	185	0.01
20	Maricao, Sabana Grande	46	0.00
21	Las Marias	26	0.00
22	San Sebastián	166	0.01
23	Lares	239	0.02
24	Utua	691	0.05
25	Adjuntas	572	0.04
26	Peñuelas	847	0.06
27	Ponce	786	0.05
28	Juana Diaz	760	0.05
29	Villalba	614	0.04
30	Jayuya	904	0.06
31	Ciales	100	0.01

Table 4. Estimated domestic self-supplied use and population served by service areas, 2005.—Continued

[Location of areas are shown in figure 1; Mga/d, million gallons per day]

Service Area Number	Areas	Estimated self-supplied population	Total self-supplied withdrawals, in Mgal/d
	Puerto Rico	30,722	2.10
32	Morovis	1205	0.08
33	Orocovis	786	0.05
34	Coamo, Santa Isabel	314	0.02
35	Barranquitas, Naranjito, Corozal	3,799	0.26
36	Comerio	537	0.04
37	Aibonito	296	0.02
38	Salinas	741	0.05
39	Aguas Buenas, Cidra	1,728	0.12
40	Cayey..	420	0.03
41	Guayama, Arroyo, Patillas	1,088	0.08
42	Humacao, Las Piedras, Naguabo, Vieques, Culebra	1,646	0.11
43	Maunabo	84	0.01
44	Yabucoa	2,547	0.17
45	San Lorenzo	825	0.06
46	Luquillo, Fajardo, Ceiba	2,230	0.15

Table 5. Public-supply ground-water withdrawals and domestic self-supplied use by ground-water provinces, 2005.

[Location of geographic areas in figure 4; Mgal/d, million gallons per day]

Ground-water Province	Geographic Areas 1/	Withdrawal and Use, in Mgal/d		
		Public-supply water systems Withdrawal	Domestic Self-supplied Use	Total, in Mgal/d
	Puerto Rico	96.15	2.11	98.26
North Coast Province	1A, B and C	34.00	0.24	34.24
South Coast Province	2D	27.12	0.24	27.36
South Coast Province	2E	8.28	0.16	8.44
West Coast Province	3F, G, H and I	5.49	0.06	5.55
East Coast Province..	4J, K, L and M	4.54	0.36	4.90
Lajas Valley	5	6.98	0.03	7.01
Interior Province	6	6.60	0.77	7.37
Interior Province	N and O	3.14	0.24	3.38
Vieques and Culebra Islands	7Q and P	0.00	0.01	0.01

1/ Numbers and letters correspond to those shown on figure 4.

Table 6. Industrial self-supplied ground-water withdrawals by municipio, 2005

[Location of municipios is shown in figure 2; Mgal/d, million gallons per day]

Municipio	Ground-water withdrawals, in Mgal/d
Puerto Rico	9.41
Aibonito	0.24
Arecibo	0.41
Barceloneta	4.33
Bayamón	0.40
Caguas	0.10
Cayey	0.31
Cidra	0.31
Guayama	0.42
Gurabo	0.04
Humacao	0.16
Juncos	0.04
Las Piedras	0.06
Manatí	1.01
Maricao	0.07
Peñuelas	0.05
Ponce	0.25
San Juan	0.08
San Lorenzo	0.01
Toa Baja	0.07
Vega Alta	0.05
Vega Baja	0.13
Yabucoa	0.87

Table 7. Estimated acres irrigated and irrigation water use by Irrigation District, 2005.

[[Location of irrigation districts are shown in figure 3. Cells highlighted in green are agricultural areas in the south coast of Puerto Rico delineated from 2004 orthophotos, base from U.S. Army Corps of Engineers, 2004

Aquifer System	Municipio	Estimated acres irrigated	Application rates in feet/year	Irrigation water use by source in acre-feet/year			Irrigation water use by source in million gallons per day		
				SW	GW	Total	SW	GW	Total
Puerto Rico				16968	23704	40672	15.15	19.83	34.98
	Arroyo	511	1.04	0	531	531	0.00	0.47	0.47
	Guayama	1707	1.04	347	1428	1775	0.31	1.28	1.59
	Patillas	315	1.04	381	0	381	0.34	0.00	0.34
Total		2533		728	1959	2687	0.65	1.75	2.40
	Juana Díaz	5258	1.43	2184	5335	7519	1.95	4.76	6.71
	Salinas.	3840	1.04	2822	2669	5491	2.52	1.05	3.57
	Santa Isabel	8121	1.43	3382	8231	11613	3.02	7.35	10.37
Total		17219		8389	16235	24624	7.49	13.16	20.65
	Aguadilla	1171	0.88	45	986	1031	0.04	0.88	0.92
	Isabela	433	0.88	123	258	381	0.11	0.23	0.34
	Moca	40	0.88	0	35	35	0.00	0.03	0.03
Total		1644		168	1279	1447	0.15	1.14	1.29
	Cabo Rojo	795	0.88	190	509	699	0.17	0.45	0.62
	Guánica	3278	1.43	482	4206	4688	0.43	3.76	4.19
	Lajas	10337	0.88	6003	3093	9096	5.36	2.76	8.12
	Sabana Grande	355	0.88	1008	0	1008	0.90	0.00	0.90
	Yauco	796	1.43	0	1138	1138	0.00	1.02	1.02
Total		15561		7683	4231	16629	6.86	3.78	14.85

Table 8. Estimated acres irrigated and irrigation water use by ground-water provinces, 2005.

[Location of ground-water provinces and aquifer systems are shown in figure 4. Cells highlighted in green are agricultural areas in the south coast of Puerto Rico delineated from 2004 orthophotos, base from U.S. Army Corps of Engineers, 2004.]

Ground-water Provinces	Aquifer System	Municipio	Estimated acres irrigated	Application rates in feet/year	Irrigation water use by source					
					in acre-feet/year		in million gallons per day			
				SW	GW	Total	SW	GW	Total	
Puerto Rico			54466.5		16971	33638	50608	15.15	30.01	45.16
South Coast Province	South Coastal Alluvial Plain	Arroyo	511	1.04	0	531	531	0.00	0.47	0.47
		Guayama	1707	1.04	347	1428	1775	0.31	1.28	1.59
		Juana Díaz	5258	1.43	2184	5335	7519	1.95	4.76	6.71
		Patillas	315	1.04	381	0	381	0.34	0.00	0.34
		Ponce	883	0.44	0	389	389	0.00	0.35	0.35
		Salinas	3840	1.04	2822	1171	3994	2.52	1.05	3.57
		Santa Isabel	8121	1.43	3382	8231	11613	3.02	7.35	10.37
Total			20635		9117	17085	26202	8.14	15.26	23.40
North Coast Province	North Coast Limestone	Aguadilla	1171	0.88	45	0	45	0.04	0.00	0.04
		Arecibo	2286	0.44	0	1006	1006	0.00	0.90	0.90
		Barceloneta	0	0.44	0	0	0	0.00	0.00	0.00
		Bayamón	53	0.44	0	23	23	0.00	0.02	0.02
		Camuy	1352	0.44	0	595	595	0.00	0.53	0.53
		Canóvanas	4.5	0.44	0	2	2	0.00	0.00	0.00
		Carolina	37	0.44	0	16	16	0.00	0.01	0.01
		Cataño	0	0.44	0	0	0	0.00	0.00	0.00
		Dorado	528	0.44	0	232	232	0.00	0.21	0.21
		Florida	0	0.44	0	0	0	0.00	0.00	0.00
		Hatillo	2461	0.44	0	1083	1083	0.00	0.97	0.97
		Isabela	433	0.88	123	258	381	0.11	0.23	0.34
		Manatí	891	0.44	0	392	392	0.00	0.35	0.35
		Moca	40	0.88	3	32	35	0.00	0.03	0.03
		Morovis	174	0.44	0	77	77	0.00	0.07	0.07

Table 8. Estimated acres irrigated and irrigation water use by ground-water provinces, 2005.—Continued

[Location of ground-water provinces and aquifer systems are shown in figure 4. Cells highlighted in green are agricultural areas in the south coast of Puerto Rico delineated from 2004 orthophotos, base from U.S. Army Corps of Engineers, 2004.]

Ground-water Provinces	Aquifer System	Municipio	Estimated acres irrigated	Application rates in feet/year	Irrigation water use by source in million gallons per day					
					SW	GW	Total			
	Quebradillas		125	0.44	0	55	55	0.00	0.05	0.05
	Toa Baja		592	0.44	0	260	260	0.00	0.23	0.23
	Vega Alta		151	0.44	0	66	66	0.00	0.06	0.06
	Vega Baja		137	0.44	0	60	60	0.00	0.05	0.05
Total			10436		171	4158	4329	0.15	3.71	3.86
East Coast Province	Fajardo area	Ceiba	0	0.44	0	0	0	0.00	0.00	0.00
	Naguabo-Humacao area	Fajardo	294	0.44	0	129	129	0.00	0.12	0.12
	Yabucoa Valley	Humacao	98	0.44	0	43	43	0.00	0.04	0.04
	Maunabo Valley	Maunabo	78	0.44	0	34	34	0.00	0.03	0.03
		Naguabo	200	0.44	0	88	88	0.00	0.08	0.08
		Yabucoa	7	0.44	0	3	3	0.00	0.00	0.00
Total			677		0	298	298	0.00	0.27	0.27
West Coast Province	Río Guanajibo Valley	Aguada	123	0.44	0	54	54	0.00	0.05	0.05
	Río Yagüez Valley	Añasco	61	0.44	0	27	27	0.00	0.02	0.02
	Río Grande de Añasco Valley	Cabo Rojo	795	0.88	190	509	700	0.17	0.45	0.62
	Río Culebrinas Valley	Hormigueros	178	0.44	0	78	78	0.00	0.07	0.07
		Mayagüez	213	0.44	0	94	94	0.00	0.08	0.08
		Rincón	57	0.44	0	25	25	0.00	0.02	0.02
		San Germán	33	0.44	0	15	15	0.00	0.01	0.01
Total			1460		190	802	992	0.17	0.70	0.87

Table 8. Estimated acres irrigated and irrigation water use by ground-water provinces, 2005.—Continued

[Location of ground-water provinces and aquifer systems are shown in figure 4. Cells highlighted in green are agricultural areas in the south coast of Puerto Rico delineated from 2004 orthophotos, base from U.S. Army Corps of Engineers, 2004.]

Ground-water Provinces	Aquifer System	Municipio	Estimated acres irrigated	Application rates in feet/year	Irrigation water use by source in acre-feet/year			Irrigation water use by source in million gallons per day		
					SW	GW	Total	SW	GW	Total
South Coast Province	Tallaboa, Guayamilla, Yauco and Guánica Valleys	Guánica	3278	1.43	482	4206	4688	0.43	3.76	4.19
		Guayamilla.	1610	0.44	0	708	708	0.00	0.63	0.63
		Peñuelas	232	0.44	0	102	102	0.00	0.09	0.09
		Yauco	796	1.43	0	1138	1138	0.00	1.02	1.02
Total			5916		482	6155	6636	0.43	5.50	5.93
Lajas Valley	Lajas Valley	Lajas	10337	0.88	6003	3093	9097	5.36	2.76	8.12
		Sabana Grande	355	0.88	1008	0	1008	0.90	0.00	0.90
Total			10692		7011	3093	10105	6.26	2.76	9.02
Interior Province	Interior	Adjuntas	225	0.44	0	99	99	0.00	0.09	0.09
	Caguas-Juncos Valleys	Aguas Buenas	85	0.44	0	37	37	0.00	0.03	0.03
	Cayey Valley	Aibonito	24	0.44	0	11	11	0.00	0.01	0.01
		Barranquitas	93	0.44	0	41	41	0.00	0.04	0.04
		Caguas	86	0.44	0	38	38	0.00	0.03	0.03
		Cayey	45	0.44	0	20	20	0.00	0.02	0.02
		Ciales	46	0.44	0	20	20	0.00	0.02	0.02
		Cidra.	44	0.44	0	19	19	0.00	0.02	0.02
		Coamo	124	0.44	0	55	55	0.00	0.05	0.05
		Comerio	12	0.44	0	5	5	0.00	0.00	0.00
		Corozal	198	0.44	0	87	87	0.00	0.08	0.08
		Guaynabo	537	0.44	0	236	236	0.00	0.21	0.21
		Gurabo	469	0.44	0	206	206	0.00	0.18	0.18
		Jayuya	211	0.44	0	93	93	0.00	0.08	0.08
		Juncos	364	0.44	0	160	160	0.00	0.14	0.14
		Lares	106	0.44	0	47	47	0.00	0.04	0.04

Table 8. Estimated acres irrigated and irrigation water use by ground-water provinces, 2005.—Continued

[Location of ground-water provinces and aquifer systems are shown in figure 4. Cells highlighted in green are agricultural areas in the south coast of Puerto Rico delineated from 2004 orthophotos, base from U.S. Army Corps of Engineers, 2004.]

Ground-water Provinces	Aquifer System	Municipio	Estimated acres irrigated	Application rates in feet/year	Irrigation water use by source				
					in acre-feet/year	in million gallons per day	Total		
				SW	GW	SW	GW	Total	
		Las Mariás	61	0.44	0	27	0.00	0.02	0.02
		Las Piedras	146	0.44	0	64	0.00	0.06	0.06
		Loíza	127	0.44	0	56	0.00	0.05	0.05
		Luquillo	0	0.44	0	0	0.00	0.00	0.00
		Maricao	65	0.44	0	29	0.00	0.03	0.03
		Naranjito	36	0.44	0	16	0.00	0.01	0.01
		Orocovis	241	0.44	0	106	0.00	0.09	0.09
		Río Grande	13	0.44	0	6	0.00	0.01	0.01
		San Juan	8	0.44	0	4	0.00	0.00	0.00
		San Lorenzo	357	0.44	0	157	0.00	0.14	0.14
		San Sebastián	688	0.44	0	303	0.00	0.27	0.27
		Toa Alta	17	0.44	0	7	0.00	0.01	0.01
		Trujillo Alto	12	0.44	0	5	0.00	0.00	0.00
		Utado	60	0.44	0	26	0.00	0.02	0.02
		Villalba	151	0.44	0	66	0.00	0.06	0.06
Total			4651		0	2046	0.00	1.81	1.81
Isla de Vieques	Vieques and Culebra	Culebra	0	0.44	0	0	0.00	0.00	0.00
		Vieques	0	0.44	0	0	0.00	0.00	0.00
Total			0		0	0	0.00	0.00	0.00

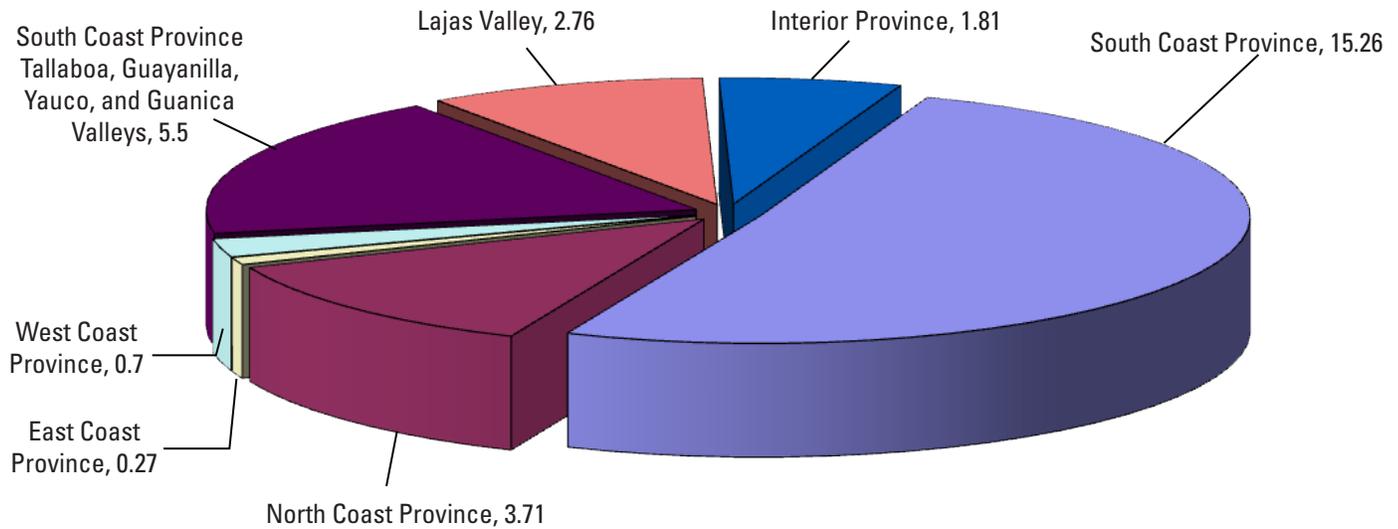


Figure 9. Estimated irrigation withdrawals in million gallons per day by ground water provinces, 2005.

Instream use is defined as water that is used, but not withdrawn, from a surface-water source for such purposes as hydroelectric power generation or saline withdrawals in thermoelectric plants. An estimated 2,855 Mgal/d was used for instream uses throughout Puerto Rico during 2005 for hydroelectric and thermoelectric-power generation.

Public-Supply Water Withdrawals and Deliveries

During 2005, public-supply water distributed by the PRASA was provided by 135 surface-water facilities and 291 wells. Surface-water from PRASA and non-PRASA systems were estimated at 556.3 Mgal/d (553.57 Mgal/d came from PRASA and 2.72 Mgal/d from non-PRASA systems), while 96.2 Mgal/d were provided by ground-water sources (92.99 Mgal/d from PRASA and 3.16 Mgal/d from non-PRASA systems) (table 1). Of the total population in 2005 (3,912,054 inhabitants), about 97 percent (3,794,840 people) were estimated to be served by a public-supply water system belonging to the PRASA. Non-PRASA system served 2.21 percent (86,492 people) (table 2) and withdrew 2.7 and 3.2 Mgal/d from surface-water and ground-water sources, respectively. The metropolitan service area was aggregated in this report, as the municipios of Toa Alta, Toa Baja, San Juan, Trujillo Alto, Río Grande, Bayamón, Cataño, Guaynabo, Carolina, Loíza, Canóvanas, and Caguas areas

(Barrio San Antonio and Barrio Río Cañas). Within this area, it is estimated that about 1,370,076 people are served by a highly interconnected water-distribution system supplied from sources within the geographic area. Withdrawals within this service area were estimated at 210.6 Mgal/d (table 1). The delivery by the North Coast Aqueduct system to the metropolitan service area was estimated to be 65 Mgal/d out of 285 Mgal/d. The largest public-supply water withdrawal was 105 Mgal/d by the Sergio Cuevas facility at Trujillo Alto. This facility withdraws water from the Lago Loíza reservoir at Trujillo Alto and principally provides water to the municipios for the eastern half of the metropolitan service area.



Table 9. Self-supplied withdrawals and deliveries from public-supply water by public and private thermoelectric power plants by municipio, 2005.

[Location of municipios is shown in figure 2; Mgal/d, million gallons per day; gWh, giga-watt hours]

Municipio	Self-supplied withdrawals (Mgal/d) by source and type					Deliveries from public supply (Mgal/d)	Total withdrawals and deliveries fresh and saline water (Mgal/d)	Power generated (gWh)	
	GW		SW		Fresh				Saline
	Fresh		Fresh						
Puerto Rico [freshwater]	1.39		1.42			2.33	2293.20	21,333	
Puerto Rico [saline water]					2288.06				
Cataño	0.00				530.34	1.10	531.44	3,366	
Guayama ^{2/}	0.20		0.86		689.16	0.00	0.20	3,063	
Guayanilla ^{1/}	0.55		0.56		7.46	0.00	690.57	5,237	
Peñuelas ^{2/}	0.00		0.64		523.50	0.00	8.02	3,120	
Salinas	0.64				537.60	0.00	524.14	4,310	
San Juan	0.00					1.23	538.83	2,237	

1/ Includes desalinated water from Peñuelas thermoelectric plant.

2/ Private facility.

Table 10. Water use and power generated by hydroelectric power plants by municipio, 2005.

[Location of municipios is shown in figure 2; gWh, giga-watt hours]

Municipio	Facility Name	Instream water use		Power generation, (gWh)
		Million gallons per day	acre-feet per year	
Puerto Rico		568.02	576575	140.39
Arecibo	Dos Bocas	415.30	465,127	58.96
Naguabo	Rio Blanco	0.80	840	0.85
Orocovis	Toro Negro II	7.29	8,168	4.52
Peñuelas	Garzas I	29.07	32,558	10.80
	Garzas II	9.85	11,028	3.66
Utuado	Caonillas I	0.62	693	0.30
Villalba	Toro Negro I	11.70	13,101	14.00
Yauco	Yauco I	40.23	45,060	30.40
	Yauco II	53.16	59,536	16.90

Table 11. Total water use estimates for offstream and instream categories, 2005.

[Mgal/d; million gallons per day]

Water Use Category	Total Withdrawals, in Mgal/d
Puerto Rico	3568.00
Offstream Use	711.92
Public-supply water use	
PRASA Withdrawal	646.56
Non_PRASA Withdrawal	5.88
Domestic Self-Supplied Water Use	2.10
Industrial Self-Supplied water Use	9.41
Crop Irrigation	45.16
Thermoelectric Power	
Freshwater withdrawals	2.81
Instream Use	2856.08
Hydroelectric Power	568.02
Saline withdrawals thermoelectric power	2,288.06

Table 12. Total water withdrawals by water-use categories, 2005

[Mgal/d; million gallons per day]

Water use category	Withdrawals, in Mgal/d	
	Freshwater	Saline water
Puerto Rico	711.92	2,288.06
Public supply	652.44	
Domestic	2.10	
Industrial	9.41	
Crop Irrigation	45.16	
Thermoelectric power	2.81	2,288.06

In addition to providing water for domestic use, public suppliers also deliver water to commercial, industrial, thermoelectric power, and other public facilities (the use of water by government facilitates such as schools, hospitals, public offices, and for fire hydrants). Public-supply water by the non-PRASA systems is used for domestic purposes by community-operated water systems (water systems that serve a rural or suburban housing area). Non-PRASA systems are considered public-water suppliers, because they provide piped water for human consumption and have at least 15 connections or regularly serve at least 25 people (U.S. Environmental Protection Agency, 1974).

Public-Supply Water Domestic Use

In 2005, public-supply domestic use in Puerto Rico was estimated at 347 Mgal/d, or about 54 percent of the total PRASA deliveries from surface-and ground-water sources. Also, the domestic per capita use was estimated at 91 gallons per day (gal/d) per person. Municipios included in the metropolitan service area (service area 1 in fig. 1) accounted for 40 percent of the total domestic delivery, providing about 102 gal/d per person for domestic use in the connecting service area during 2005 (table 3).

Domestic Self-Supplied Water Use

In 2005, domestic self-supplied water use was estimated at 2.1 Mgal/d. A total of 30,722 people or about 0.75 of 1 percent of the population in Puerto Rico rely on private wells or springs for their household water needs. Self-supplied domestic water use was derived by multiplying an assumed per capita use rate of 68 gal/d per person, based on 250 gal per household with 3.02 persons per household (table 4).

The importance of the aquifers in Puerto Rico, as sources of water for public-supply water needs and as the source for self-supplied domestic users, is indicated by the distribution of withdrawals given in table 5. The ground-water geographic province areas for Puerto Rico are shown in figure 4.

Industrial Self-Supplied Withdrawals

In 2005, industrial self-supplied ground-water withdrawal was estimated at 9.41 Mgal/d (table 6). All of the industrial users obtain water from ground-water wells. The municipios of Barceloneta and Manatí had the largest industrial ground-water withdrawals during 2005. The NAICS 325412, which corresponds to pharmaceutical products manufacturing, accounted for 62 percent of the industrial self-supplied ground-water withdrawals on the island. Yabucoa had substantial industrial activity related to the refining of petroleum products, which uses about 9 percent of the total industrial self-supplied withdrawals.

Crop-Irrigation Water Use

Surface-water withdrawals for irrigation use during calendar year 2005 were primarily from the four major irrigation systems operated by the PREPA: the Guayama and Juana Díaz Irrigation Districts on the south coast; the Valle de Lajas Irrigation District in the southwest, and the Isabela Irrigation District in northwest Puerto Rico (fig. 3). In 2005, these surface-water irrigation systems provided about 15.2 Mgal/d (table 7).

Ground-water provinces provided about 30 Mgal/d to irrigation water use in Puerto Rico. The South Coast Province provided about 20.8 Mgal/d, which includes about 14.9 Mgal/d from the South Coastal Alluvial Plain and 5.5 Mgal/d from the Tallaboa, Guayanilla, Yauco, and Guánica valleys aquifer systems, and about 0.35 Mgal/d from an independent Irrigation District at Ponce. The remaining 9.2 Mgal/d was provided by the North Coast, East Coast, West Coast and Interior Provinces, and the Lajas Valley (table 8, fig. 9).

During 2005, the estimated irrigation withdrawals in Puerto Rico averaged about 45.2 Mgal/d or 50,608 acre-feet per year (acre-ft/yr) for an estimate of 54,466 acres of irrigated land. Surface water accounted for about 15.2 Mgal/d and ground-water accounted for 30.0 Mgal/d of the total withdrawals.

Thermoelectric Power Water Use

In 2005, Puerto Rico had four thermoelectric powerplants operated by PREPA: in Cataño, San Juan, Guayanilla, and Salinas. In addition, there were two non-PREPA thermoelectric facilities located in Guayama and Peñuelas (fig. 7). Seawater used for cooling was estimated at 2,288 Mgal/d; the PRASA delivered

an estimated total of about 2.3 Mgal/d of freshwater to the San Juan and Cataño power plants (table 9). Total ground-water withdrawals by the Salinas and Guayanilla powerplants were 1.2 Mgal/d. The non-PREPA plant located in Guayama withdrew 0.20 Mgal/d from ground-water wells. The four PREPA and two non-PREPA thermoelectric plants generated 21,333 gigawatt-hour (gWh) of electricity during 2005 (table 9). The non-PREPA powerplant located in Peñuelas used about 7.5 Mgal/d of saline water (seawater) for cooling and 1.42 Mgal/d was withdrawn from desalination of which 0.56 Mgal/d was used in the Peñuelas power plant and 0.86 Mgal/d was delivered to the PREPA Guayanilla power plant.

Hydroelectric Power Instream Water Use

In 2005, Puerto Rico had nine active hydroelectric powerplants located in Arecibo (Dos Bocas), Naguabo (Río Blanco), Orocovis (Toro Negro II), Peñuelas (Garzas I and II), Utuado (Caonillas I), Villalba (Toro Negro I), and Yauco (Yauco I and II) (fig. 8). These power plants generated 140 gWh of electricity in 2005 with an average instream freshwater use of about 568 Mgal/d. In 2005, about 42 percent of all hydroelectric power in the island was generated by the Dos Bocas dam (59 gWh) (table 10).



Total Water Use

Total water use in Puerto Rico in 2005 was estimated for: public-supply water withdrawals and deliveries, domestic self-supplied water use, industrial self-supplied withdrawal, crop-irrigation water use, thermoelectric-power freshwater use, and hydroelectric power. Public-supply water delivered for domestic use also was estimated. Total offstream freshwater withdrawals in 2005 were estimated at about 712 Mgal/d, and instream water withdrawals were estimated at 2,856 Mgal/d. Saline water withdrawals used for cooling at thermoelectric plants were estimated at 2,288 Mgal/d and freshwater withdrawals from island streams used for hydroelectric power were about 560 Mgal/d (table 11).

Total withdrawals by category are listed in table 12. In 2005, the largest total water withdrawal was for thermoelectric power, of which 99 percent (2,288 Mgal/d) was saline (seawater). Public-supply water use accounted for the largest freshwater withdrawal (652 Mgal/d), followed by crop irrigation at 45.2 Mgal/d.

Summary

Puerto Rico is divided into 78 municipios. Water-use data for 2005 were aggregated by 46 service areas for the public-supply water withdrawals and deliveries and for domestic self-supplied; by ground-water provinces for crop irrigation, and by municipios for the rest of the categories. The data were compiled for major offstream categories: public-supply water withdrawals and deliveries, domestic and industrial self-supplied water use, crop-irrigation water use, and thermoelectric-power freshwater use. One water-use category also considered was: power-generation instream water use (thermoelectric saline withdrawals and hydroelectric power).

During 2005, public-supply water withdrawals and deliveries from surface- and ground-water sources constituted the major freshwater use category and were estimated at 652 Mgal/d. The population served by public-supply facilities operated by the Puerto Rico Aqueduct and Sewer Authority was estimated to be 97 percent of the total population for Puerto Rico in 2005 (about 3,794,840 inhabitants). Non-PRASA public-supply water withdrawals were estimated at 5.9 Mgal/d to serve a population of about 86,492. Public-supply domestic use in Puerto Rico was estimated at 347 Mgal/d, about 54 percent of the total PRASA deliveries from surface- and ground-water sources. Water withdrawals by domestic self-supplied users were estimated at 2.1 Mgal/d by a population of about 30,722. Ground-water withdrawals by industrial users were estimated at 9.4 Mgal/d.

Crop-irrigation withdrawals from surface- and ground-water sources were estimated at 45.2 Mgal/d, of which 15.1 Mgal/d were in areas supplied by the public irrigation network operated by the PREPA. Ground-water withdrawals from the island's two major aquifers were about 24.5 Mgal/d; 20.8 from the South Coast Province (South Coastal Alluvial Plain, including the Ponce independent Irrigation District and Tallaboa, Guayanilla, Yauco and Guánica valleys aquifer systems) and 3.7 Mgal/d from North Coast Province (North Coast Limestone).

In 2005, Puerto Rico had four thermoelectric powerplants that used large amounts of seawater for cooling. The instream saline withdrawals totaled 2,288 Mgal/d. Freshwater use at thermoelectric powerplants consisted of 2.3 Mgal/d from the PRASA to the San Juan and Cataño plants and 1.40 Mgal/d from local aquifers at the Guayama, Guayanilla and Salinas powerplants, and additional 7.46 Mgal/d from saline water at the non-PREPA facility in Peñuelas. The nine active hydroelectric powerplants located throughout Puerto Rico had an instream freshwater use of 568 Mgal/d in 2005.

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