

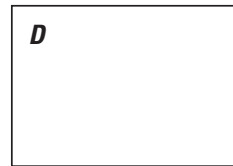
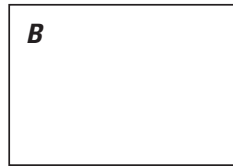
Prepared in cooperation with the Puerto Rico Aqueduct and Sewer Authority, Puerto Rico Department of Natural and Environmental Resources, and Puerto Rico Environmental Quality Board

Estimated Water Use in Puerto Rico, 2010



Open-File Report 2014–1117





Cover. From top to bottom: *A*, example of consumptive use, photograph by Wanda L. Molina, January 30, 2009; *B*, cotton crops in the south coast of Puerto Rico, photograph by Marcos Quiñones, April 13, 2012; *C*, example of surface-water intake located in southeastern Puerto Rico, photograph by Jessie Juarbe, September 13, 2013; *D*, example of household water use, photograph by Wanda L. Molina, January, 2009; *E*, example of plumbing configuration used by domestic wells in Puerto Rico, photograph by Jessie Juarbe, July 18, 2011. Background image: farm irrigated by a sprinkler system in the south coast of Puerto Rico, photograph by Marcos Quiñones, February 24, 2014.

Estimated Water Use in Puerto Rico, 2010

By Wanda L. Molina-Rivera

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Puerto Rico Aqueduct and Sewer Authority,
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Open-File Report 2014–1117

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

U.S. Department of the Interior

SALLY JEWELL, Secretary

U.S. Geological Survey

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Contents

Acknowledgments.....	vi
Abstract	1
Introduction.....	1
Purpose and Scope	1
Data-Compilation Procedures	3
Public-Supply Water Withdrawals, Deliveries and Population Served.....	3
Domestic Deliveries from Public-Supply Water	3
Domestic Self-Supplied Water Use	4
Industrial Self-Supplied Withdrawals	4
Crop-Irrigation Water Use.....	4
Thermoelectric-Power Water Use.....	6
Hydroelectric-Power Instream Water Use.....	6
Water Use by Category and Source of Water	6
Public-Supply Water Withdrawals and Deliveries.....	6
Public-Supply Water Domestic Use	20
Domestic Self-Supplied Water Use	20
Industrial Self-Supplied Withdrawals	20
Crop-Irrigation Water Use.....	21
Thermoelectric-Power Water Use.....	21
Hydroelectric-Power Instream Water Use.....	21
Total Water Use.....	21
Summary.....	34
References Cited.....	34

Figures

1. Location of municipios in Puerto Rico.....	2
2. Location of the Puerto Rico Electric Power Authority Irrigation Districts in Puerto Rico, 2010. See figure 1 for the names of the municipios	5
3. Location of major irrigated agricultural areas in Puerto Rico, from Rincón to mid Quebradillas, from Cabo Rojo to mid Juana Diaz and from mid Juana Diaz to Humacao.....	7
4. Location of thermoelectric powerplants in Puerto Rico, 2010	8
5. Location of hydroelectric powerplants in Puerto Rico, 2010.....	9
6. Population served by public-supply water systems by municipios in Puerto Rico, 2010	16
7. Public-supply water deliveries by municipios in Puerto Rico, 2010.....	17
8. Water deliveries among the North Coast Aqueduct interconnections in Puerto Rico, 2010	18
9. Location of municipios interconnected to the North Coast Aqueduct and public-supply water deliveries, in million gallons per day, 2010	19
10. Domestic water use per capita coefficients by municipios in Puerto Rico, 2010	28

Tables

1. Estimated population served and public-supply water withdrawals in Puerto Rico by source and municipio, 2010	10
2. Estimated deliveries from public-supply water systems to domestic use, population served and domestic per capita use in Puerto Rico by source and municipio, 2010	22
3. Estimated domestic self-supplied withdrawals from groundwater sources, population served and domestic per capita use in Puerto Rico by municipio, 2010.....	29
4. Industrial self-supplied withdrawals from groundwater sources in Puerto Rico by municipio, 2010.....	29
5. Estimated irrigation water use, cultivated and irrigated acres and irrigation methods in Puerto Rico by source and municipio, 2010.....	30
6. Withdrawals and deliveries from public-supply water by public thermoelectric power plants in Puerto Rico by source and municipio, 2010.....	31
7. Water use and power generated by hydroelectric power plants in Puerto Rico by municipio, 2010.....	31
8. Summary of total water use in Puerto Rico, 2010.....	31
9. Total freshwater withdrawals in Puerto Rico by offstream water-use categories and municipios, 2010.....	32

Appendix Table (Excel file available for download at <http://pubs.usgs.gov/of/2014/1117/>)

A1. Estimated public-supply water deliveries, population served and per capita deliveries in Puerto Rico by ward and municipio, 2010	Separate Excel file
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Conversion Factors

Inch/Pound to SI

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)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$^{\circ}\text{F}=(1.8\times^{\circ}\text{C})+32$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$^{\circ}\text{C}=(^{\circ}\text{F}-32)/1.8$$

Vertical coordinate information is referenced to local mean sea level.

Horizontal coordinate information is referenced to the Puerto Rico Datum, 1940 adjustment.

Abbreviations

gWh	gigawatt-hour
NCA	North Coast Aqueduct
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
PRLA	Puerto Rico Land Authority
USGS	U. S. Geological Survey

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The authors gratefully acknowledge the following Commonwealth agencies for their cooperation in making the water-use data available: the Puerto Rico Aqueduct and Sewer Authority regional and area offices, Permit and Franchise Division of Puerto Rico Department of Natural and Environmental Resources, the Puerto Rico Environmental Quality Board, the Puerto Rico Electric Power Authority, the Puerto Rico Department of Health, and the Puerto Rico Land Authority.

Estimated Water Use in Puerto Rico, 2010

By Wanda L. Molina-Rivera

Abstract

Water-use data were aggregated for the 78 municipios of the Commonwealth of Puerto Rico for 2010. Five major offstream categories were considered: public-supply water withdrawals and deliveries, domestic and industrial self-supplied water use, crop-irrigation water use, and thermoelectric-power freshwater use. One instream water-use category also was compiled: power-generation instream water use (thermoelectric saline withdrawals and hydroelectric power). Freshwater withdrawals for offstream use from surface-water [606 million gallons per day (Mgal/d)] and groundwater (118 Mgal/d) sources in Puerto Rico were estimated at 724 million gallons per day. The largest amount of freshwater withdrawn was by public-supply water facilities estimated at 677 Mgal/d. Public-supply domestic water use was estimated at 206 Mgal/d. Fresh groundwater withdrawals by domestic self-supplied users were estimated at 2.41 Mgal/d. Industrial self-supplied withdrawals were estimated at 4.30 Mgal/d. Withdrawals for crop irrigation purposes were estimated at 38.2 Mgal/d, or approximately 5 percent of all offstream freshwater withdrawals. Instream freshwater withdrawals by hydroelectric facilities were estimated at 556 Mgal/d and saline instream surface-water withdrawals for cooling purposes by thermoelectric-power facilities was estimated at 2,262 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 has 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-use data reports by "municipios" were published for 1980–82 (Torres and Avilés, 1986), 1986–87 (Molina and Dopazo, 1995), for 1988–89

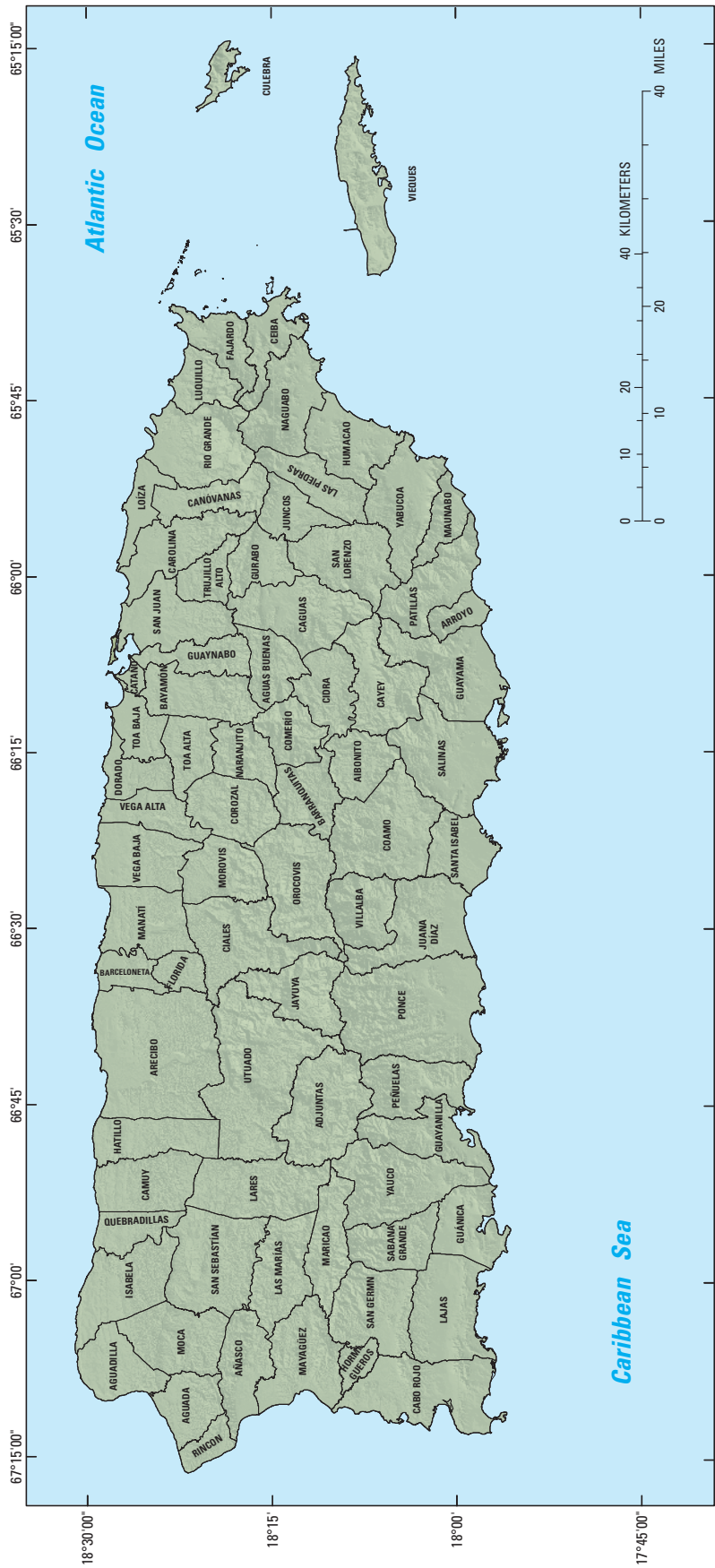
(Dopazo and Molina, 1995), for 1995, 2000 (Molina, 1998, 2005) and for 2005 (Molina and Gómez, 2008). Water-resources planners and managers must have information regarding the amount of water used, and where and how it is used, to adequately assess many of the critical water problems facing Puerto Rico.

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). A compilation of water-use data for major use categories is an important requirement to assist water-resources managers and planners in Puerto Rico.

Purpose and Scope

The purpose of this report is to document water-use data estimates in Puerto Rico for 2010. Estimated water use was determined for the following categories: (1) surface-water and groundwater withdrawals and their deliveries by public-supply facilities, (2) domestic use from public-supply water and self-supplied (3) groundwater withdrawals by industrial self-supplied users, (4) surface-water and groundwater withdrawals for crop irrigation, and (5) groundwater 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 powerplants.

Estimated water use was aggregated by municipios and sources of water for most of the water-use categories presented in this report. Public-supply water deliveries were categorized by ward ("barrios"), estimating the population served by individual public-supply water system. The location and geographic distribution of the 78 municipios of Puerto Rico are shown in figure 1.



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

Figure 1. Location of municipios in Puerto Rico.

Data-Compilation Procedures

Water-use data for major offstream categories were compiled for: public-supply water (surface-water and ground-water facilities) by municipios and by wards; domestic and industrial self-supplied use; crop irrigation, thermoelectric and hydroelectric-power water-use categories by source of water and 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, Deliveries and Population Served

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 (U.S. Environmental Protection Agency, 2012). Data documenting freshwater withdrawals from PRASA surface-water facilities and wells, by municipio, during 2010 were obtained from the PRASA (2010). Data documenting withdrawals from non-PRASA systems were obtained from the PRDOH (2010). Public-supply water withdrawals were compiled at a municipal level in which the withdrawals take place, although the water subsequently may be distributed and used elsewhere. Public-supply water withdrawal data were aggregated for the 78 municipios of Puerto Rico (fig. 1) and by sources of water and were sub-divided as PRASA or non-PRASA systems. The non-PRASA systems refer to community water systems that supply water to the same population year-round (U.S. Environmental Protection Agency, 2012).

Public-supply water deliveries were aggregated by wards based on the population served by the public-supply water system (PRASA and non-PRASA) in the area. Public-supply water deliveries were estimated for wards that are served as follow: exclusively from water treatment plants, exclusively from groundwater wells and for surface-water systems that are augmented by groundwater.

The population served refers to the resident population within a municipio receiving water from a public-supply water system on a year-round basis and excludes seasonal residents. In this report, the population served was estimated by the individual public-supply water system in the municipio where the delivery of water took place, which is not necessarily the municipio where the withdrawal took place. The combined total of all users of public-supply water served by the PRASA, non-PRASA, and domestic self-supplied users was considered in this report to equal the 2010 total population estimate obtained by the U.S. Census Bureau (2011). Public-supply water per capita use was obtained by dividing the average daily total public-supply water use by the population served.

Domestic Deliveries from Public-Supply Water

Domestic delivery represents water distributed by a public-supply facility to residential customers for domestic purposes, both indoor (drinking, washing, flushing) and outdoor (lawn watering, car washing, replenishing swimming pools). Public-supply domestic water delivery data were estimated from a report prepared by PRASA (Puerto Rico Aqueduct and Sewer Authority, 2009–2010, “PRASA Water Distribution Systems Assessment Fact Sheet”). Domestic water deliveries data for PRASA and non-PRASA systems were estimated applying a domestic per capita use coefficient to the population served. The aforementioned PRASA reports, prepared by each public-supply water system, contain summarized information on residential average consumption in gallons per day for 2010.

A domestic per capita use coefficient was calculated for each public-supply water system in Puerto Rico. Residential use varies from household to household; however households served by the same public-supply water system often have a common pattern of use affected by factors such as water cost rates, water conservation patterns, customer affluence, climate and topography. As a result, a public-supply domestic per capita water use coefficient can be determined for a specific system. Therefore, the coefficient for one system may or may not be valid for all systems within Puerto Rico.



Example of consumptive use, photograph by Wanda L. Molina, January 30, 2009.

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. Self-supplied domestic withdrawals were estimated by multiplying the self-supplied population by a public-supply water domestic per capita use coefficient. The self-supplied population is calculated by subtracting total resident population served by public-supply water systems in a municipio from the total 2010 Census of Population (U.S. Census Bureau, 2010) in the municipio.

In 2000, in the United States, the water source for about 98 percent of self-supplied domestic withdrawals was groundwater (Hutson and others, 2004). In Puerto Rico, it is assumed that the domestic self-supplied withdrawals come mainly from groundwater sources.

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. The withdrawal data estimates included are limited to industrial self-supplied groundwater 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, 2012). The NAICS code 325412 refers to pharmaceutical preparation manufacturing where self-supplied industrial withdrawals were greatest due to the need of large amounts of water for fabricating and processing.

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 four irrigation districts managed by the PREPA. The four irrigation districts are 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. 2).

The Guayama Irrigation District (fig. 2) withdraws water from the Lago Patillas and the Lago Melania reservoirs, the Río Guamaní, and from an intrabasin transfer of water from Lago Carite to the Río Guamaní. These streams and lakes transfer water to agricultural lands in the municipios of Arroyo, Guayama, Patillas and Salinas (fig. 1). In 2010, water conveyed

by the Guayama Irrigation District was also the source of public-supply water to three PRASA water treatment plants (WTP) that delivered water to the municipios of Arroyo, Guayama, Maunabo, Patillas and Salinas (fig. 1). The Guayama Urbano WTP is supplied from the Patillas irrigation canal; the Farallón WTP from Lago Carite; and, the Patillas Urbano WTP from Lago Patillas. Also, the Guayama Irrigation District delivered fresh surface water to a private thermoelectric company in the area, not included in this report.

The Juana Díaz Irrigation District (fig. 2) withdraws water exclusively from the Lago Guayabal reservoir in the municipio of Villalba and conveys the water to agricultural lands in the municipios of Juana Díaz, Santa Isabel, and the part of Salinas (fig. 1) to the west of Río Nigua. In 2010, water conveyed by the Juana Díaz Irrigation District was also the source of public-supply water for two PRASA WTPs in the municipios of Villalba (fig. 1), these are as follow: the Villalba WTP at Río Jacaguas and the La Julita WTP at Lago Guineo.

The Valle de Lajas Irrigation District (fig. 2) withdraws water from the Lago Loco and Lago Luchetti reservoirs of the municipio of Yauco and conveys the water to agricultural lands in the municipios of Cabo Rojo, Guánica, Lajas, Sabana Grande, and Yauco (fig. 1). Water diversion from Lago Loco and Lago Luchetti to the Valle de Lajas Irrigation District provided the surface water withdrawn by the PRASA to WTPs in the municipios of Sabana Grande, Lajas, and Cabo Rojo (fig. 1), these WTPs are as follow: Máginas WTP, Lajas WTP and Betances WTP.

The Isabela Irrigation District (fig. 2) withdraws water exclusively from Lago Guajataca reservoir, which is located in the municipios of Isabela and San Sebastián. The irrigation district conveys the water to agricultural lands in the municipios of Aguadilla, Isabela, and Moca (fig. 1). Diversion from Lago Guajataca, which is conveyed through the Canal de Moca and the Canal de Aguadilla, provided the surface water withdrawn by Aguadilla Nueva and Ramey PRASA WTPs. These public-supply water treatment plants serve the population of the municipios of Aguada, Aguadilla, Moca and Rincón (fig. 1).

Estimates of surface-water irrigation delivered to farms at irrigation districts were provided monthly by the PREPA. To assist in the objective of accurately measuring irrigation canal withdrawals, the following USGS streamflow stations were operated during 2010: USGS station 50093053 Canal de Patillas at Forebay; USGS station 50095000 Canal de Guamaní Oeste; USGS station 50039995 Lago Carite; USGS station 50111310 West Forebay at Lago Guayabal; USGS station 50111305 East Forebay at Lago Guayabal; and USGS station 50011000 Canal de Diversion Lago Guajataca. Streamflow data for Puerto Rico are available from the USGS Caribbean Water Science Center Web site at <http://wdr.water.usgs.gov/>.

Groundwater withdrawals for crop-irrigation purposes were estimated in the municipios along the irrigation districts and also at Coamo, Guayanilla, Maunabo, Peñuelas, Ponce and Yabucoa. Groundwater withdrawals were estimated as the difference of the total irrigation water use and the amount of surface water diverted from irrigation canals to the municipio.

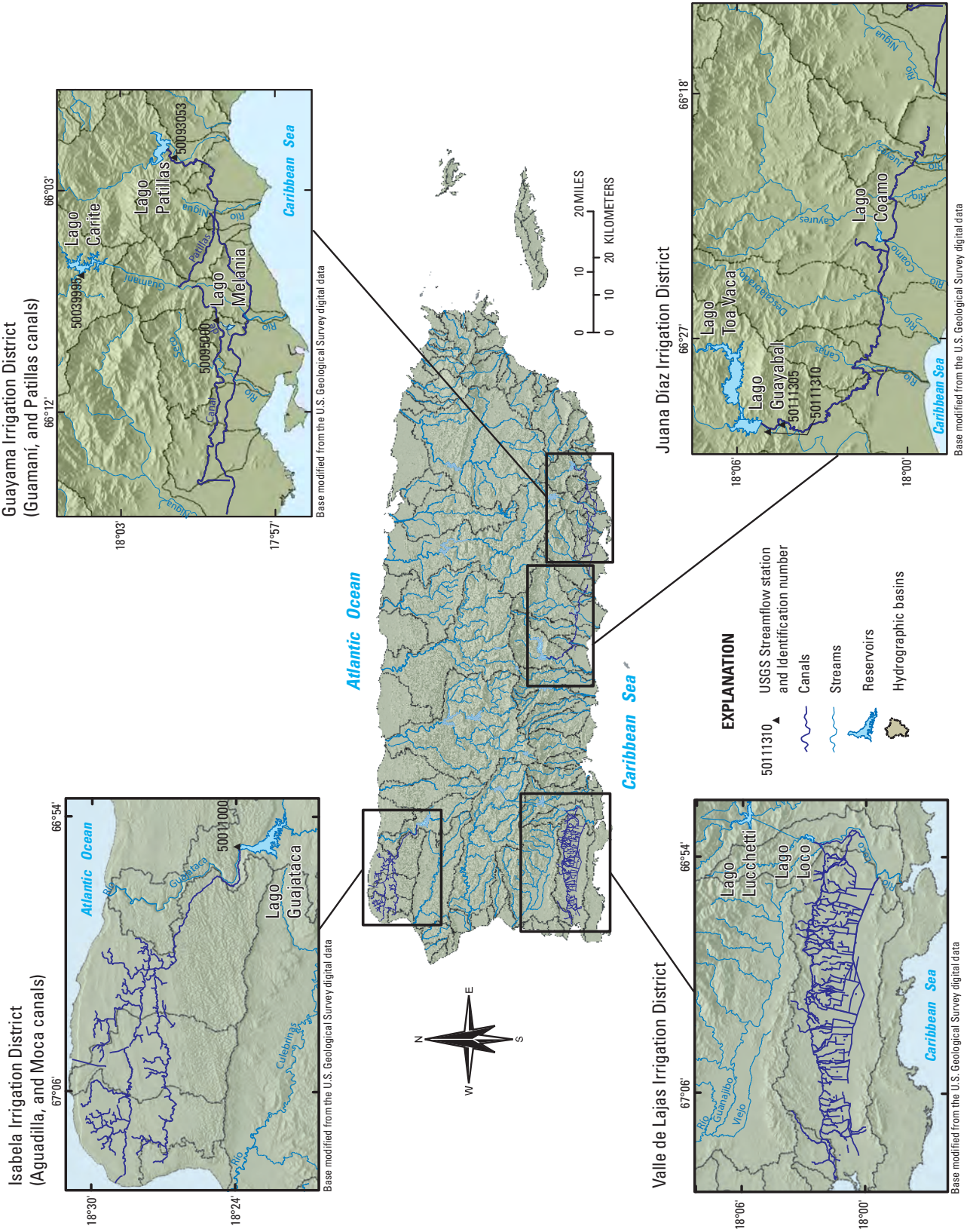


Figure 2. Location of the Puerto Rico Electric Power Authority Irrigation Districts in Puerto Rico, 2010. See figure 1 for the names of the municipalities.

Irrigation application rates were estimated by adjusting the 2005 application rates (Molina and Gómez, 2008) based on the changes in rainfall in the two climatic divisions of Puerto Rico where most of the agricultural lands are located. The two climatic divisions used were the south coast and north coast. The percent differences in annual rainfall from 2005 to 2010 were +9.2 percent in the south coast and +6.9 percent in the north coast (U.S. Department of Commerce, 2010). The application rates were multiplied by the irrigated acres at each municipio to determine the total irrigation water use. Groundwater withdrawals for irrigation were estimated as the difference of the total irrigation water used and the applied surface water reported.

The number of acres that were irrigated were obtained from the delineation of acreage of land cultivated in municipios within the irrigation districts, using aerial imagery collected in 2010 by the Puerto Rico Planning Board, 2010 (fig. 3).



Cotton crops in south coast of Puerto Rico, photograph by Marcos Quiñones, April 13, 2012.

Thermoelectric-Power Water Use

The thermoelectric-power category includes water that is used to generate electricity by using fossil fuel. In Puerto Rico, all of the saline water withdrawals are 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 2010, Puerto Rico had six active thermoelectric powerplants, four operated by the PREPA (fig. 4) and two by private companies that were not included in this report. The estimates of water withdrawals by public thermoelectric power plants were provided by the PREPA and the Franchise and Permit Division of the PRDNER.

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 powerplants, by using turbine generators that are driven by falling water. During 2010, there were nine active hydroelectric powerplants throughout Puerto Rico (fig. 5).

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 surface-water or groundwater sources and conveyed to the place of use. Offstream water-use categories considered in this report are as follows: public-supply water withdrawals, domestic and industrial self-supplied groundwater withdrawals, crop irrigation water use, and thermoelectric-power freshwater use. Offstream freshwater was estimated at 724 million gallons per day (Mgal/d) in Puerto Rico during 2010. The largest offstream use was for public-supply water withdrawals, which accounted for 677 Mgal/d (93 percent) of the total withdrawals; 38.2 Mgal/d (5 percent) of all offstream freshwater withdrawals was used for crop-irrigation purposes. Fresh groundwater withdrawals for domestic self-supplied water use were estimated to be 2.41 Mgal/d, and industrial self-supplied groundwater use was estimated to be 4.30 Mgal/d. Freshwater withdrawals for thermoelectric powerplants accounted for 1.67 Mgal/d in 2010.

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 2,817 Mgal/d was used under the category of instream use throughout Puerto Rico during 2010 for hydroelectric and thermoelectric-power generation.

Public-Supply Water Withdrawals and Deliveries

During 2010, public-supply water distributed by the PRASA was provided by 127 active public water treatment plants and 246 public-supply wells. Non-PRASA accounted for 108 surface-water facilities and 140 domestic wells serving communities with 15 or more connections. PRASA and non-PRASA systems withdrew 677 Mgal/d (590 Mgal/d from surface-water and 87 Mgal/d from groundwater facilities) (table 1) and delivered 663 Mgal/d (656 Mgal/d from PRASA and 7 Mgal/d from non-PRASA systems) (appendix 1). Of the total population in Puerto Rico for 2010 (3,725,789 thousand residents), 96 percent (3,586,165 thousand residents) were estimated to be served by a public-supply water system belonging to the PRASA. The non-PRASA systems served approximately 3 percent of the population (101,627 thousand residents) (table 1), and 1 percent of the population (37,997 thousand residents) was served by domestic self-supplied wells.

Public-supply water deliveries to the municipio of San Juan were estimated as 83.8 Mgal/d exclusively from surface-water facilities serving a population of 395,326 thousand residents (figs. 6 and 7). The PRASA metropolitan area systems also include the following municipios: Aguas Buenas, Bayamón, Caguas, Canóvanas, Carolina, Guaynabo, Gurabo, Juncos, Loíza, Naranjito Toa Alta, Toa Baja, and Trujillo Alto. Figure 7 also shows a distribution of the public-supply water deliveries among Puerto Rico.

The North Coast Aqueduct (NCA), commonly referred to as the “Superaqueduct”, a major public-supply facility, which entered into operation about September 2000, transfers water from the Río Grande de Arecibo Basin to the San Juan Metropolitan area through seven interconnections along the distribution system:

Miraflores, Sabana Hoyos, Barceloneta, Manatí, Vega Baja, Vega Alta/Dorado, and Bayamón. Water deliveries among the NCA interconnections are shown in figure 8. In 2010, the NCA delivered 101 Mgal/d to the 17 municipios shown on figure 9.

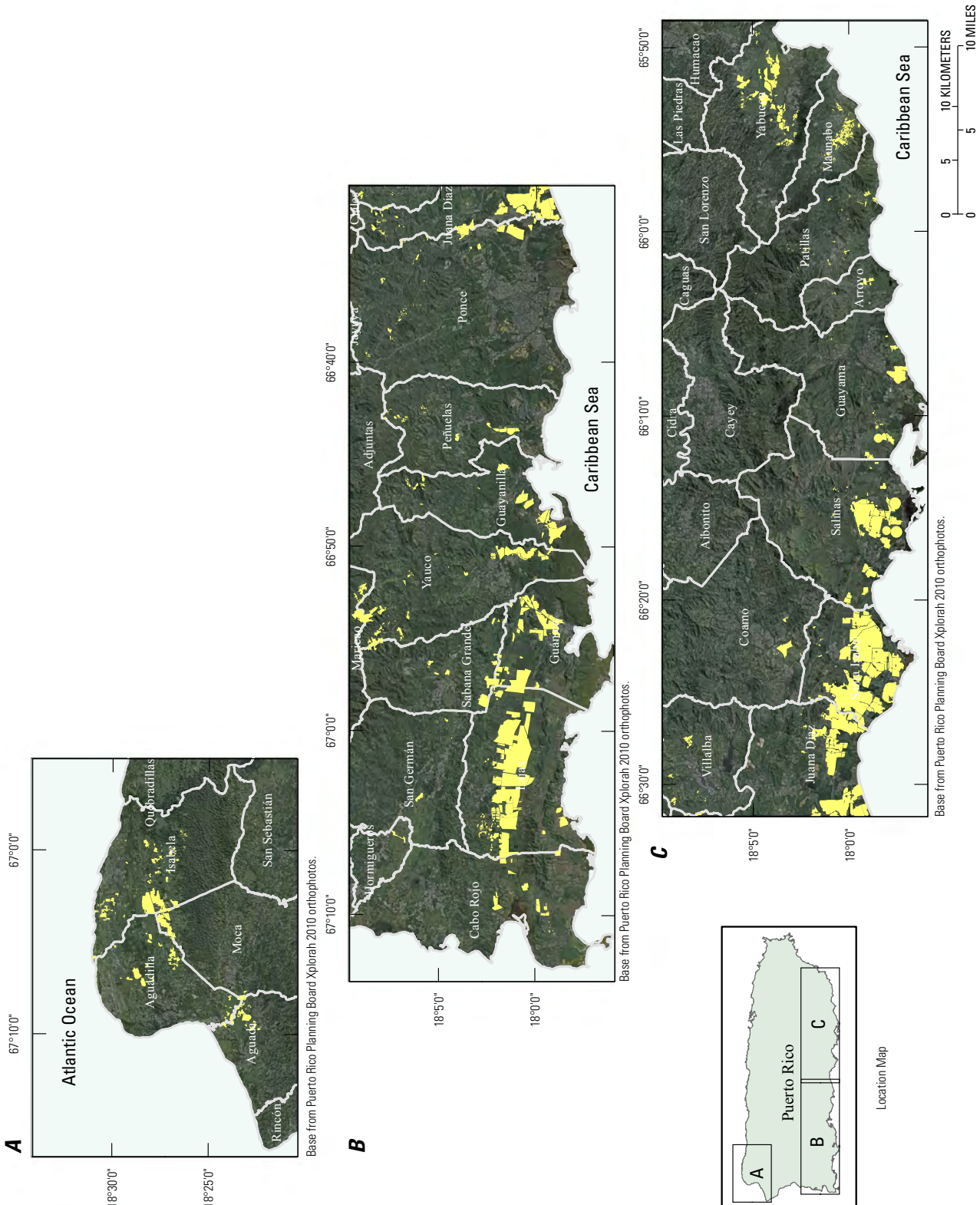


Figure 3. Location of major irrigated agricultural areas in Puerto Rico, (A), from Rincón to mid Quebradillas, (B), from Cabo Rojo to mid Juana Diaz, and, (C), from mid Juana Diaz to Humacao.

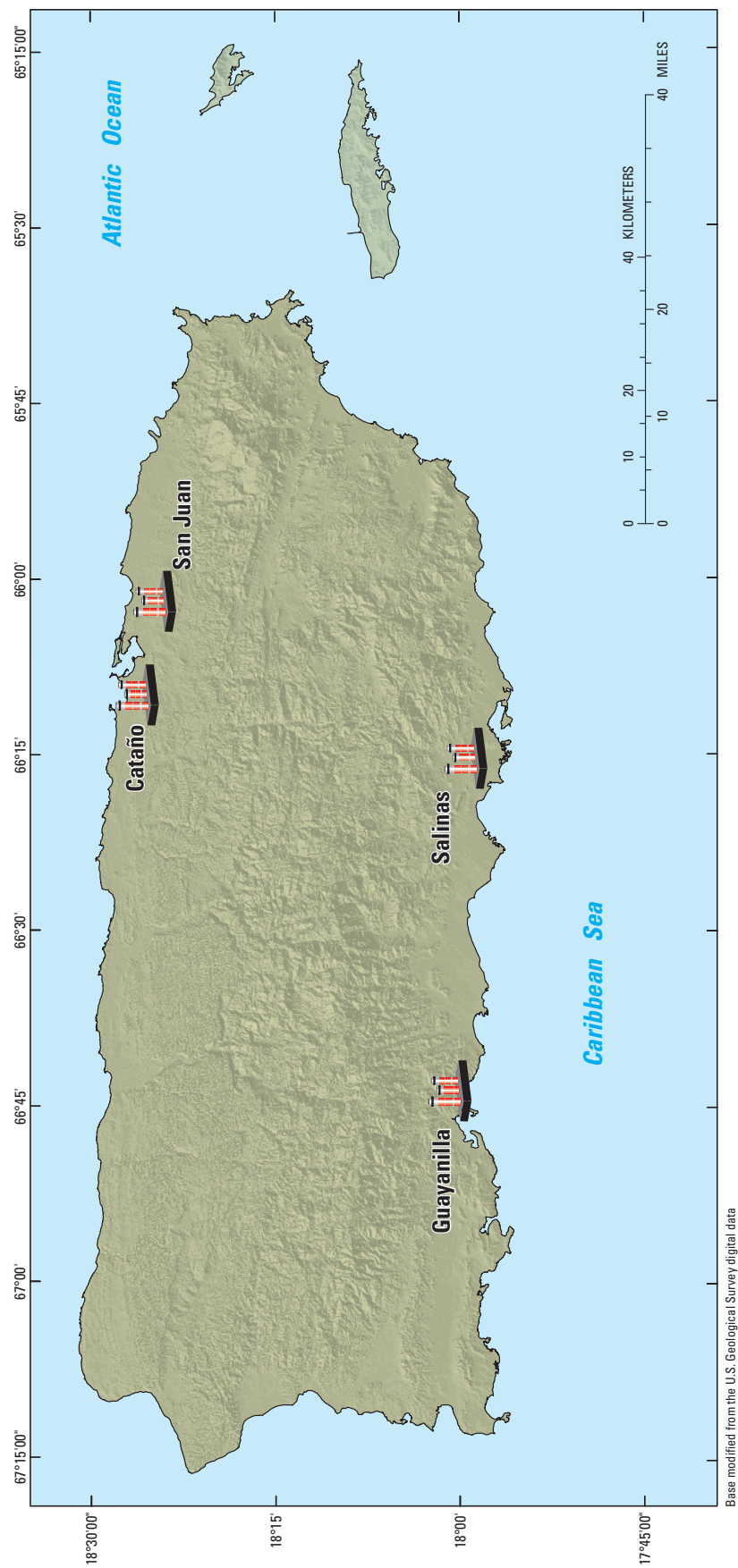


Figure 4. Location of thermoelectric powerplants in Puerto Rico, 2010.

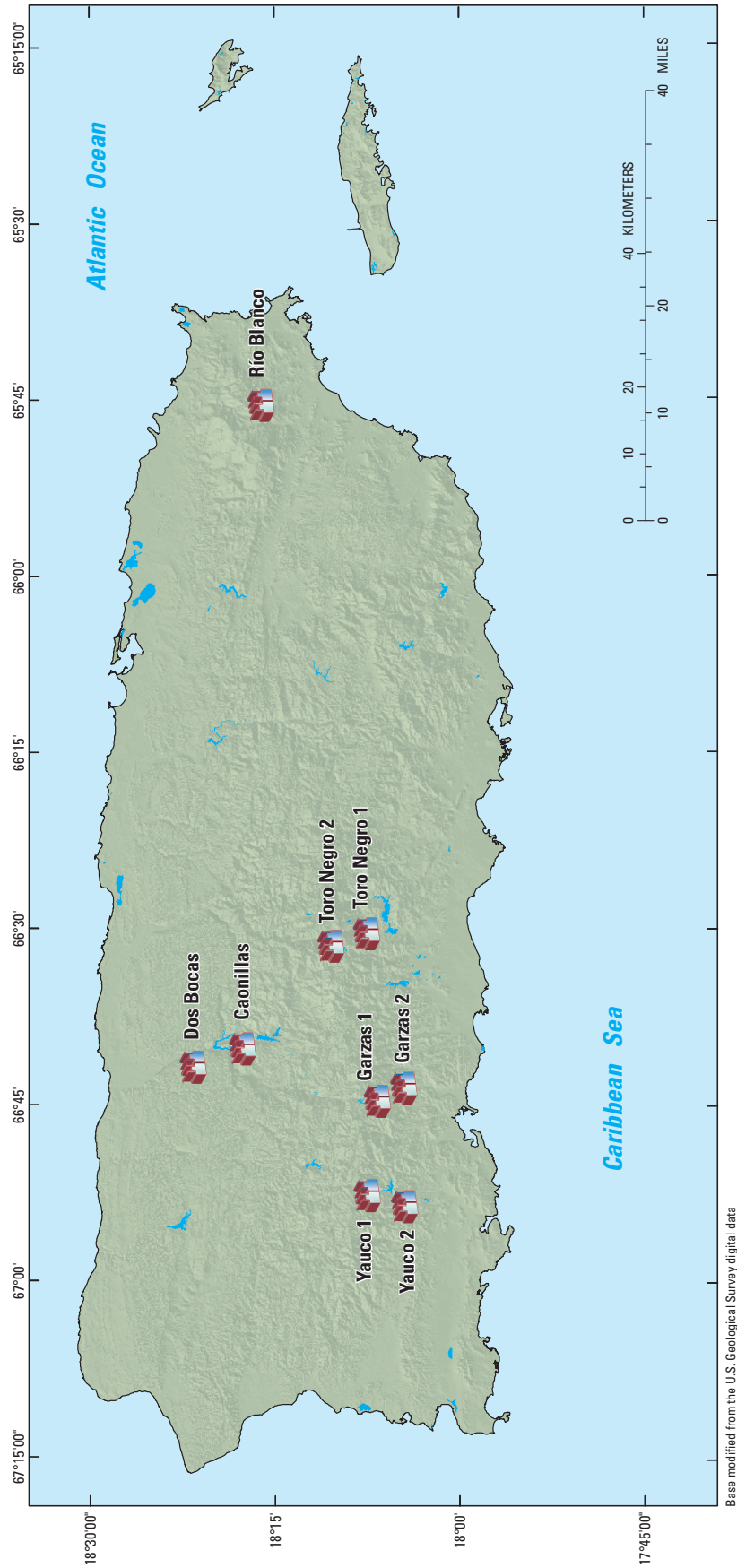


Figure 5. Location of hydroelectric powerplants in Puerto Rico, 2010.

Table 1. Estimated population served and public-supply water withdrawals in Puerto Rico by source and municipio, 2010.

[Source: U.S. Geological Survey, Caribbean Water Science Center; withdrawals are accounted in the municipios where the intakes are located; PRASA, Puerto Rico Aqueduct and Sewer Authority; sw, surface water; gw, groundwater; Mgal/d, million gallons per day; some municipios are served exclusively from surface-water systems, exclusively from groundwater wells, and for surface-water systems that are augmented by groundwater]

Municipio	2010 Census of population, in thousands	PRASA					
		Population served by GW, in thousands	Population served by SW, in thousands	Total popula- tion served, in thousands	Groundwater withdrawals, in Mgal/d	Surface water withdrawals, in Mgal/d	Total withdrawals, in Mgal/d
Puerto Rico	3,725.789	296.188	3,289.977	3,586.165	83.00	587.17	670.17
Adjuntas	19.483	1.222	16.011	17.233	0.07	1.01	1.08
Aguada	41.959	0.000	38.319	38.319	0.81	0.00	0.81
Aguadilla	60.949	0.000	58.915	58.915	0.00	27.79	27.79
Aguas Buenas	28.659	0.000	23.179	23.179	0.28	21.07	21.35
Aibonito	25.900	0.302	20.879	21.181	0.70	2.98	3.68
Añasco	29.261	0.000	27.341	27.341	0.43	2.19	2.62
Arecibo	96.440	8.553	83.296	91.849	14.92	103.64	118.56
Arroyo	19.575	14.821	4.754	19.575	1.76	0.00	1.76
Barceloneta	24.816	6.424	18.392	24.816	1.68	0.00	1.68
Barranquitas	30.318	0.000	23.833	23.833	1.04	2.20	3.24
Bayamón	208.116	0.000	208.116	208.116	0.00	0.19	0.19
Cabo Rojo	50.917	0.000	50.917	50.917	4.40	1.81	6.21
Caguas	142.893	0.000	133.394	133.394	0.05	9.01	9.06
Camuy	35.159	2.162	32.997	35.159	0.46	1.54	2.00
Canóvanas	47.648	0.000	47.648	47.648	0.00	6.78	6.78
Carolina	176.762	0.000	175.937	175.937	0.00	0.00	0.00
Cataño	28.140	0.000	28.140	28.140	0.00	0.00	0.00
Cayey	48.119	0.278	47.121	47.399	0.00	2.42	2.42
Ceiba	13.631	0.000	13.631	13.631	0.00	0.00	0.00
Ciales	18.782	0.743	17.651	18.394	0.00	2.57	2.57
Cidra	43.480	0.000	37.435	37.435	0.14	5.69	5.83
Coamo	40.512	28.558	10.414	38.972	0.09	0.84	0.93
Comerio	20.778	0.000	18.277	18.277	0.43	2.95	3.38
Corozal	37.142	0.000	31.009	31.009	0.00	3.62	3.62
Culebra	1.818	0.000	1.818	1.818	0.00	0.00	0.00
Dorado	38.165	15.178	22.987	38.165	3.89	0.00	3.89
Fajardo	36.993	0.000	36.833	36.833	0.00	12.12	12.12
Florida	12.680	8.454	4.226	12.680	2.20	0.00	2.20
Guánica	19.427	19.427	0.000	19.427	3.21	0.00	3.21
Guayama	45.362	4.775	40.312	45.087	0.99	12.74	13.73
Guayanilla	21.581	18.190	3.271	21.461	2.49	0.22	2.71
Guaynabo	97.924	0.000	95.133	95.133	0.00	8.03	8.03
Gurabo	45.369	0.000	43.211	43.211	0.00	2.97	2.97
Hatillo	41.953	2.132	39.821	41.953	0.57	3.02	3.59
Hormigueros	17.250	2.845	14.405	17.250	0.85	0.00	0.85
Humacao	58.466	0.000	58.466	58.466	0.00	5.43	5.43
Isabela	45.631	0.000	45.631	45.631	0.00	6.98	6.98
Jayuya	16.642	0.000	13.208	13.208	0.00	2.37	2.37
Juana Diaz	50.747	22.734	27.180	49.914	5.57	0.00	5.57
Juncos	40.290	0.000	40.290	40.290	0.13	1.56	1.69
Lajas	25.753	3.624	22.129	25.753	0.22	3.06	3.28

Table 1. Estimated population served and public-supply water withdrawals in Puerto Rico by source and municipio, 2010.—
Continued

[Source: U.S. Geological Survey, Caribbean Water Science Center; withdrawals are accounted in the municipios where the intakes are located; PRASA, Puerto Rico Aqueduct and Sewer Authority; sw, surface water; gw, groundwater; Mgal/d, million gallons per day; some municipios are served exclusively from surface-water systems, exclusively from groundwater wells, and for surface-water systems that are augmented by groundwater]

Municipio	2010 Census of population, in thousands	PRASA					
		Population served by GW, in thousands	Population served by SW, in thousands	Total popula- tion served, in thousands	Groundwater withdrawals, in Mgal/d	Surface water withdrawals, in Mgal/d	Total withdrawals, in Mgal/d
Puerto Rico	3,725.789	296.188	3,289.977	3,586.165	83.00	587.17	670.17
Lares	30.753	0.000	29.825	29.825	0.00	3.57	3.57
Las Marias	9.881	0.186	9.595	9.781	0.00	1.45	1.45
Las Piedras	38.675	0.000	35.757	35.757	0.00	1.95	1.95
Loiza	30.060	0.000	29.976	29.976	0.00	0.00	0.00
Luquillo	20.068	0.000	20.068	20.068	0.00	2.76	2.76
Manatí	44.113	3.752	40.361	44.113	4.39	0.00	4.39
Maricao	6.276	0.000	6.176	6.176	0.00	1.62	1.62
Maunabo	12.225	0.000	11.897	11.897	1.27	0.31	1.58
Mayagüez	89.080	1.687	83.858	85.545	1.16	23.55	24.71
Moca	40.109	4.076	29.671	33.747	1.40	0.00	1.40
Morovis	32.610	4.350	28.260	32.610	0.32	3.30	3.62
Naguabo	26.720	0.000	22.676	22.676	0.00	17.97	17.97
Naranjito	30.402	0.000	23.240	23.240	0.00	1.30	1.30
Orocovis	23.423	0.000	19.121	19.121	0.00	4.23	4.23
Patillas	19.277	2.929	12.682	15.611	0.76	2.54	3.30
Peñuelas	24.282	1.222	20.024	21.246	0.39	2.54	2.93
Ponce	166.327	7.772	155.064	162.836	3.34	1.14	4.48
Quebradillas	25.919	5.027	20.892	25.919	0.18	3.68	3.86
Rincón	15.200	0.000	11.404	11.404	1.63	0.00	1.63
Río Grande	54.304	0.000	54.044	54.044	0.00	13.96	13.96
Sabana Grande	25.265	3.366	21.899	25.265	0.25	2.84	3.09
Salinas	31.078	25.139	4.439	29.578	3.89	0.00	3.89
San Germán	35.527	5.509	27.132	32.641	1.46	1.13	2.59
San Juan	395.326	0.000	395.326	395.326	0.00	0.00	0.00
San Lorenzo	41.058	0.000	37.754	37.754	0.00	5.80	5.80
San Sebastián	42.430	2.772	38.669	41.441	0.14	4.64	4.78
Santa Isabel	23.274	23.274	0.000	23.274	6.92	0.00	6.92
Toa Alta	74.066	0.000	74.066	74.066	0.00	81.51	81.51
Toa Baja	89.609	0.000	89.609	89.609	0.00	1.97	1.97
Trujillo Alto	74.842	0.000	74.842	74.842	0.00	103.33	103.33
Utua	33.149	0.000	30.717	30.717	0.00	3.96	3.96
Vega Alta	39.951	1.863	38.088	39.951	1.56	0.00	1.56
Vega Baja	59.662	12.085	47.577	59.662	4.39	1.71	6.10
Vieques	9.301	0.000	9.301	9.301	0.00	0.00	0.00
Villalba	26.073	2.980	20.130	23.110	0.25	32.71	32.96
Yabucoa	37.941	10.904	16.155	27.059	1.13	2.41	3.54
Yauco	42.043	16.873	23.155	40.028	0.79	2.49	3.28

Table 1. Estimated population served and public-supply water withdrawals in Puerto Rico by source and municipio, 2010.—
Continued

[Source: U.S. Geological Survey, Caribbean Water Science Center; withdrawals are accounted in the municipios where the intakes are located; PRASA, Puerto Rico Aqueduct and Sewer Authority; sw, surface water; gw, groundwater; Mgal/d, million gallons per day; some municipios are served exclusively from surface-water systems, exclusively from groundwater wells, and for surface-water systems that are augmented by groundwater]

Municipio	2010 Census of population, in thousands	NON-PRASA					
		Population served by GW, in thousands	Population served by SW, in thousands	Total popula- tion served, in thousands	Groundwater withdrawals, in Mgal/d	Surface water withdrawals, in Mgal/d	Total withdrawals, in Mgal/d
Puerto Rico	3,725.789	64.153	37.474	101.627	4.32	2.72	7.04
Adjuntas	19.483	1.974	0.276	2.250	0.05	0.02	0.07
Aguada	41.959	3.640	0.000	3.640	0.27	0.00	0.27
Aguadilla	60.949	0.165	0.000	0.165	0.01	0.00	0.01
Aguas Buenas	28.659	5.480	0.000	5.480	0.43	0.00	0.43
Aibonito	25.900	0.542	0.314	0.856	0.07	0.02	0.09
Añasco	29.261	1.920	0.000	1.920	0.12	0.00	0.12
Arecibo	96.440	0.350	0.000	0.350	0.02	0.00	0.02
Arroyo	19.575	0.000	0.000	0.000	0.00	0.00	0.00
Barceloneta	24.816	0.000	0.000	0.000	0.00	0.00	0.00
Barranquitas	30.318	3.472	3.013	6.485	0.31	0.27	0.58
Bayamón	208.116	0.000	0.000	0.000	0.00	0.00	0.00
Cabo Rojo	50.917	0.000	0.000	0.000	0.00	0.00	0.00
Caguas	142.893	8.586	0.913	9.499	0.56	0.06	0.62
Camuy	35.159	0.000	0.000	0.000	0.00	0.00	0.00
Canóvanas	47.648	0.000	0.000	0.000	0.00	0.00	0.00
Carolina	176.762	0.800	0.025	0.825	0.06	0.00	0.06
Cataño	28.140	0.000	0.000	0.000	0.00	0.00	0.00
Cayey	48.119	0.348	0.372	0.720	0.01	0.02	0.03
Ceiba	13.631	0.000	0.000	0.000	0.00	0.00	0.00
Ciales	18.782	0.340	0.048	0.388	0.02	0.00	0.02
Cidra	43.480	0.994	0.000	0.994	0.04	0.00	0.04
Coamo	40.512	1.368	0.172	1.540	0.06	0.01	0.07
Comerio	20.778	2.276	0.155	2.431	0.12	0.01	0.13
Corozal	37.142	1.927	1.320	3.247	0.13	0.09	0.22
Culebra	1.818	0.000	0.000	0.000	0.00	0.00	0.00
Dorado	38.165	0.000	0.000	0.000	0.00	0.00	0.00
Fajardo	36.993	0.000	0.160	0.160	0.00	0.00	0.00
Florida	12.680	0.000	0.000	0.000	0.00	0.00	0.00
Guánica	19.427	0.000	0.000	0.000	0.00	0.00	0.00
Guayama	45.362	0.000	0.275	0.275	0.00	0.02	0.02
Guayanilla	21.581	0.000	0.120	0.120	0.00	0.01	0.01
Guaynabo	97.924	0.000	0.000	0.000	0.00	0.00	0.00
Gurabo	45.369	0.000	0.080	0.080	0.00	0.01	0.01
Hatillo	41.953	0.000	0.000	0.000	0.00	0.00	0.00
Hormigueros	17.250	0.000	0.000	0.000	0.00	0.00	0.00
Humacao	58.466	0.000	0.000	0.000	0.00	0.00	0.00
Isabela	45.631	0.000	0.000	0.000	0.00	0.00	0.00
Jayuya	16.642	0.000	3.434	3.434	0.00	0.23	0.23
Juana Diaz	50.747	0.000	0.833	0.833	0.00	0.05	0.05
Juncos	40.290	0.000	0.000	0.000	0.00	0.00	0.00
Lajas	25.753	0.000	0.000	0.000	0.00	0.00	0.00

Table 1. Estimated population served and public-supply water withdrawals in Puerto Rico by source and municipio, 2010—Continued

[Source: U.S. Geological Survey, Caribbean Water Science Center; withdrawals are accounted in the municipios where the intakes are located; PRASA, Puerto Rico Aqueduct and Sewer Authority; sw, surface water; gw, groundwater; Mgal/d, million gallons per day; some municipios are served exclusively from surface-water systems, exclusively from groundwater wells, and for surface-water systems that are augmented by groundwater]

Municipio	2010 Census of population, in thousands	NON-PRASA					
		Population served by GW, in thousands	Population served by SW, in thousands	Total popula- tion served, in thousands	Groundwater withdrawals, in Mgal/d	Surface water withdrawals, in Mgal/d	Total withdrawals, in Mgal/d
Puerto Rico	3,725.789	64.153	37.474	101.627	4.32	2.72	7.04
Lares	30.753	0.788	0.140	0.928	0.05	0.01	0.06
Las Marias	9.881	0.000	0.100	0.100	0.00	0.01	0.01
Las Piedras	38.675	2.008	0.910	2.918	0.12	0.05	0.17
Loiza	30.060	0.000	0.084	0.084	0.00	0.00	0.00
Luquillo	20.068	0.000	0.000	0.000	0.00	0.00	0.00
Manatí	44.113	0.000	0.000	0.000	0.00	0.00	0.00
Maricao	6.276	0.000	0.100	0.100	0.00	0.00	0.00
Maunabo	12.225	0.000	0.328	0.328	0.00	0.02	0.02
Mayagüez	89.080	0.000	0.000	0.000	0.00	0.00	0.00
Moca	40.109	0.000	0.000	0.000	0.00	0.00	0.00
Morovis	32.610	0.000	0.000	0.000	0.00	0.00	0.00
Naguabo	26.720	0.000	4.044	4.044	0.00	0.40	0.40
Naranjito	30.402	7.010	0.152	7.162	0.51	0.01	0.52
Orocovis	23.423	3.292	1.010	4.302	0.21	0.06	0.27
Patillas	19.277	0.843	2.823	3.666	0.05	0.17	0.22
Peñuelas	24.282	0.382	2.654	3.036	0.03	0.08	0.11
Ponce	166.327	2.336	1.155	3.491	0.13	0.07	0.20
Quebradillas	25.919	0.000	0.000	0.000	0.00	0.00	0.00
Rincón	15.200	0.000	0.000	0.000	0.00	0.00	0.00
Rio Grande	54.304	0.000	0.260	0.260	0.00	0.02	0.02
Sabana Grande	25.265	0.000	0.000	0.000	0.00	0.00	0.00
Salinas	31.078	1.500	0.000	1.500	0.10	0.00	0.10
San Germán	35.527	0.156	1.380	1.536	0.01	0.12	0.13
San Juan	395.326	0.000	0.000	0.000	0.00	0.00	0.00
San Lorenzo	41.058	2.856	0.448	3.304	0.18	0.03	0.21
San Sebastián	42.430	0.989	0.000	0.989	0.04	0.00	0.04
Santa Isabel	23.274	0.000	0.000	0.000	0.00	0.00	0.00
Toa Alta	74.066	0.000	0.000	0.000	0.00	0.00	0.00
Toa Baja	89.609	0.000	0.000	0.000	0.00	0.00	0.00
Trujillo Alto	74.842	0.000	0.000	0.000	0.00	0.00	0.00
Utua	33.149	0.285	2.042	2.327	0.02	0.12	0.14
Vega Alta	39.951	0.000	0.000	0.000	0.00	0.00	0.00
Vega Baja	59.662	0.000	0.000	0.000	0.00	0.00	0.00
Vieques	9.301	0.000	0.000	0.000	0.00	0.00	0.00
Villalba	26.073	0.100	2.863	2.963	0.01	0.20	0.21
Yabucoa	37.941	7.286	3.596	10.882	0.57	0.39	0.96
Yauco	42.043	0.140	1.875	2.015	0.01	0.14	0.15

Table 1. Estimated population served and public-supply water withdrawals in Puerto Rico by source and municipio, 2010.—Continued

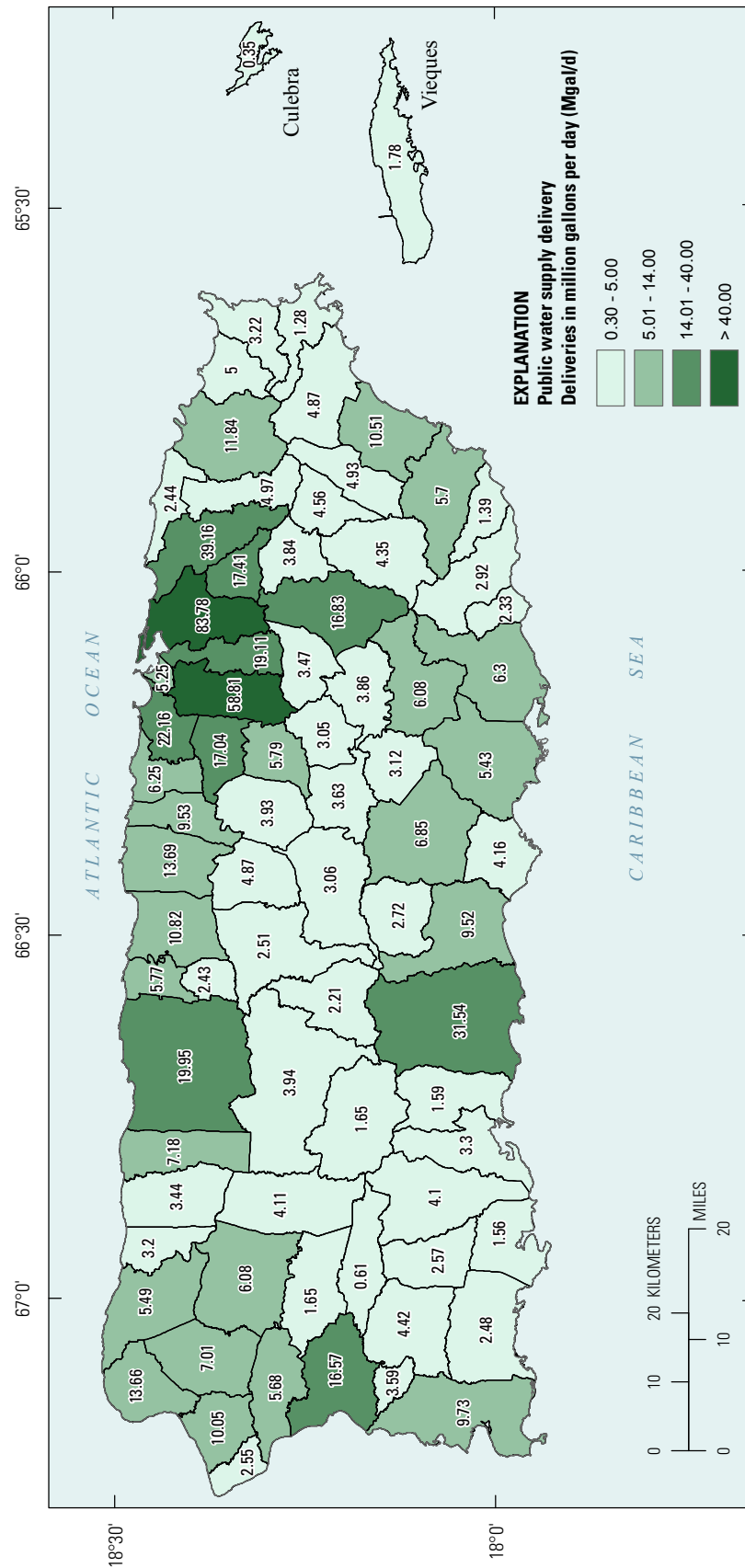
[Source: U.S. Geological Survey, Caribbean Water Science Center; withdrawals are accounted in the municipios where the intakes are located; PRASA, Puerto Rico Aqueduct and Sewer Authority; sw, surface water; gw, groundwater; Mgal/d, million gallons per day; some municipios are served exclusively from surface-water systems, exclusively from groundwater wells, and for surface-water systems that are augmented by groundwater]

Municipio	2010 Census of population, in thousands	TOTAL POPULATION SERVED			TOTAL WITHDRAWALS		
		Population served by GW, in thousands	Population served by SW, in thousands	Total Popula- tion served, in thousands	Groundwater withdrawals in Mgal/d	Surface-water withdrawals in Mgal/d	Total withdrawals, in Mgal/d
Puerto Rico	3,725.789	360.341	3,327.451	3,687.792	87.32	589.89	677.21
Adjuntas	19.483	3.196	16.287	19.483	0.12	1.03	1.15
Aguada	41.959	3.640	38.319	41.959	1.08	0.00	1.08
Aguadilla	60.949	0.165	58.915	59.080	0.01	27.79	27.80
Aguas Buenas	28.659	5.480	23.179	28.659	0.71	21.07	21.78
Aibonito	25.900	0.844	21.193	22.037	0.77	3.00	3.77
Añasco	29.261	1.920	27.341	29.261	0.55	2.19	2.74
Arecibo	96.440	8.903	83.296	92.199	14.94	103.64	118.58
Arroyo	19.575	14.821	4.754	19.575	1.76	0.00	1.76
Barceloneta	24.816	6.424	18.392	24.816	1.68	0.00	1.68
Barranquitas	30.318	3.472	26.846	30.318	1.35	2.47	3.82
Bayamón	208.116	0.000	208.116	208.116	0.00	0.19	0.19
Cabo Rojo	50.917	0.000	50.917	50.917	4.40	1.81	6.21
Caguas	142.893	8.586	134.307	142.893	0.61	9.07	9.68
Camuy	35.159	2.162	32.997	35.159	0.46	1.54	2.00
Canóvanas	47.648	0.000	47.648	47.648	0.00	6.78	6.78
Carolina	176.762	0.800	175.962	176.762	0.06	0.00	0.06
Cataño	28.140	0.000	28.140	28.140	0.00	0.00	0.00
Cayey	48.119	0.626	47.493	48.119	0.01	2.44	2.45
Ceiba	13.631	0.000	13.631	13.631	0.00	0.00	0.00
Ciales	18.782	1.083	17.699	18.782	0.02	2.57	2.59
Cidra	43.480	0.994	37.435	38.429	0.18	5.69	5.87
Coamo	40.512	29.926	10.586	40.512	0.15	0.85	1.00
Comerio	20.778	2.276	18.432	20.708	0.55	2.96	3.51
Corozal	37.142	1.927	32.329	34.256	0.13	3.71	3.84
Culebra	1.818	0.000	1.818	1.818	0.00	0.00	0.00
Dorado	38.165	15.178	22.987	38.165	3.89	0.00	3.89
Fajardo	36.993	0.000	36.993	36.993	0.00	12.12	12.12
Florida	12.680	8.454	4.226	12.680	2.20	0.00	2.20
Guánica	19.427	19.427	0.000	19.427	3.21	0.00	3.21
Guayama	45.362	4.775	40.587	45.362	0.99	12.76	13.75
Guayanilla	21.581	18.190	3.391	21.581	2.49	0.23	2.72
Guaynabo	97.924	0.000	95.133	95.133	0.00	8.03	8.03
Gurabo	45.369	0.000	43.291	43.291	0.00	2.98	2.98
Hatillo	41.953	2.132	39.821	41.953	0.57	3.02	3.59
Hormigueros	17.250	2.845	14.405	17.250	0.85	0.00	0.85
Humacao	58.466	0.000	58.466	58.466	0.00	5.43	5.43
Isabela	45.631	0.000	45.631	45.631	0.00	6.98	6.98
Jayuya	16.642	0.000	16.642	16.642	0.00	2.60	2.60
Juana Diaz	50.747	22.734	28.013	50.747	5.57	0.05	5.62
Juncos	40.290	0.000	40.290	40.290	0.13	1.56	1.69
Lajas	25.753	3.624	22.129	25.753	0.22	3.06	3.28

Table 1. Estimated population served and public-supply water withdrawals in Puerto Rico by source and municipio, 2010.—
Continued

[Source: U.S. Geological Survey, Caribbean Water Science Center; withdrawals are accounted in the municipios where the intakes are located; PRASA, Puerto Rico Aqueduct and Sewer Authority; sw, surface water; gw, groundwater; Mgal/d, million gallons per day; some municipios are served exclusively from surface-water systems, exclusively from groundwater wells, and for surface-water systems that are augmented by groundwater]

Municipio	2010 Census of population, in thousands	TOTAL POPULATION SERVED			TOTAL WITHDRAWALS		
		Population served by GW, in thousands	Population served by SW, in thousands	Total Popula- tion served, in thousands	Groundwater withdrawals in Mgal/d	Surface-water withdrawals in Mgal/d	Total withdrawals, in Mgal/d
Puerto Rico	3,725.789	360.341	3,327.451	3,687.792	87.32	589.89	677.21
Lares	30.753	0.788	29.965	30.753	0.05	3.58	3.63
Las Marias	9.881	0.186	9.695	9.881	0.00	1.46	1.46
Las Piedras	38.675	2.008	36.667	38.675	0.12	2.00	2.12
Loiza	30.060	0.000	30.060	30.060	0.00	0.00	0.00
Luquillo	20.068	0.000	20.068	20.068	0.00	2.76	2.76
Manatí	44.113	3.752	40.361	44.113	4.39	0.00	4.39
Maricao	6.276	0.000	6.276	6.276	0.00	1.62	1.62
Maunabo	12.225	0.000	12.225	12.225	1.27	0.33	1.60
Mayagüez	89.080	1.687	83.858	85.545	1.16	23.55	24.71
Moca	40.109	4.076	29.671	33.747	1.40	0.00	1.40
Morovis	32.610	4.350	28.260	32.610	0.32	3.30	3.62
Naguabo	26.720	0.000	26.720	26.720	0.00	18.37	18.37
Naranjito	30.402	7.010	23.392	30.402	0.51	1.31	1.82
Orocovis	23.423	3.292	20.131	23.423	0.21	4.29	4.50
Patillas	19.277	3.772	15.505	19.277	0.81	2.71	3.52
Peñuelas	24.282	1.604	22.678	24.282	0.42	2.62	3.04
Ponce	166.327	10.108	156.219	166.327	3.47	1.21	4.68
Quebradillas	25.919	5.027	20.892	25.919	0.18	3.68	3.86
Rincón	15.200	0.000	11.404	11.404	1.63	0.00	1.63
Río Grande	54.304	0.000	54.304	54.304	0.00	13.98	13.98
Sabana Grande	25.265	3.366	21.899	25.265	0.25	2.84	3.09
Salinas	31.078	26.639	4.439	31.078	3.99	0.00	3.99
San Germán	35.527	5.665	28.512	34.177	1.47	1.25	2.72
San Juan	395.326	0.000	395.326	395.326	0.00	0.00	0.00
San Lorenzo	41.058	2.856	38.202	41.058	0.18	5.83	6.01
San Sebastián	42.430	3.761	38.669	42.430	0.18	4.64	4.82
Santa Isabel	23.274	23.274	0.000	23.274	6.92	0.00	6.92
Toa Alta	74.066	0.000	74.066	74.066	0.00	81.51	81.51
Toa Baja	89.609	0.000	89.609	89.609	0.00	1.97	1.97
Trujillo Alto	74.842	0.000	74.842	74.842	0.00	103.33	103.33
Utua	33.149	0.285	32.759	33.044	0.02	4.08	4.10
Vega Alta	39.951	1.863	38.088	39.951	1.56	0.00	1.56
Vega Baja	59.662	12.085	47.577	59.662	4.39	1.71	6.10
Vieques	9.301	0.000	9.301	9.301	0.00	0.00	0.00
Villalba	26.073	3.080	22.993	26.073	0.26	32.91	33.17
Yabucoa	37.941	18.190	19.751	37.941	1.70	2.80	4.50
Yauco	42.043	17.013	25.030	42.043	0.80	2.63	3.43



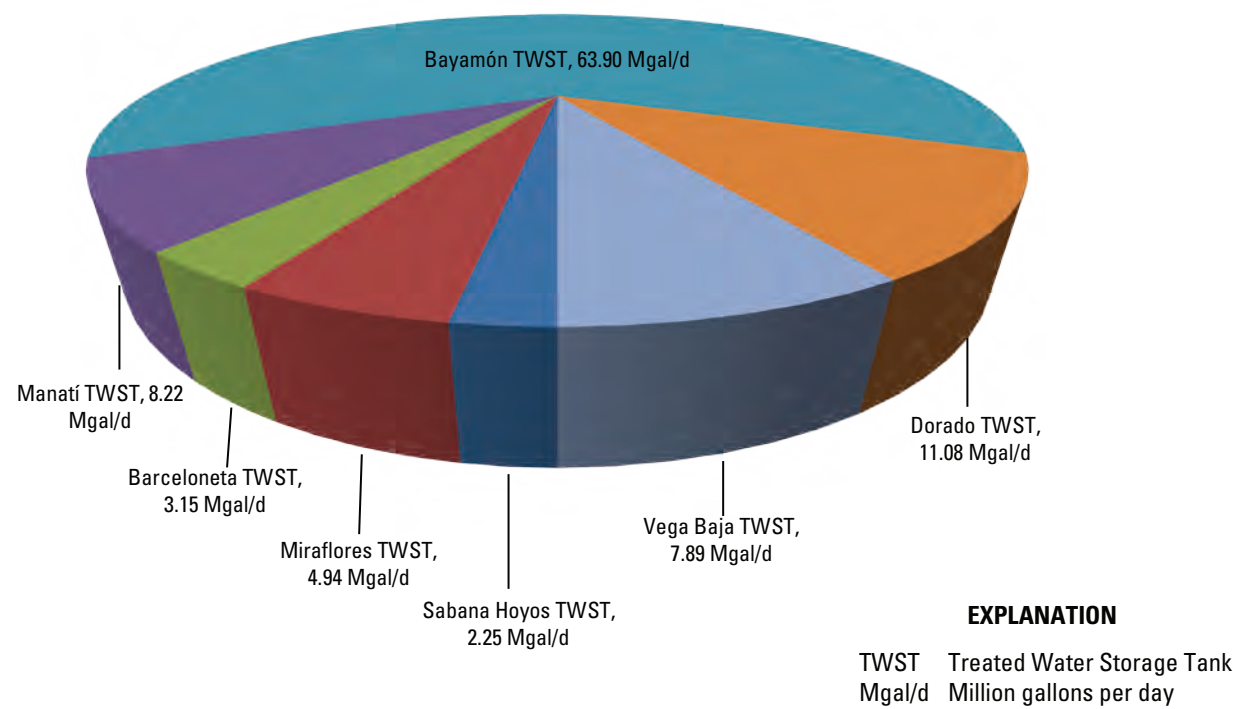
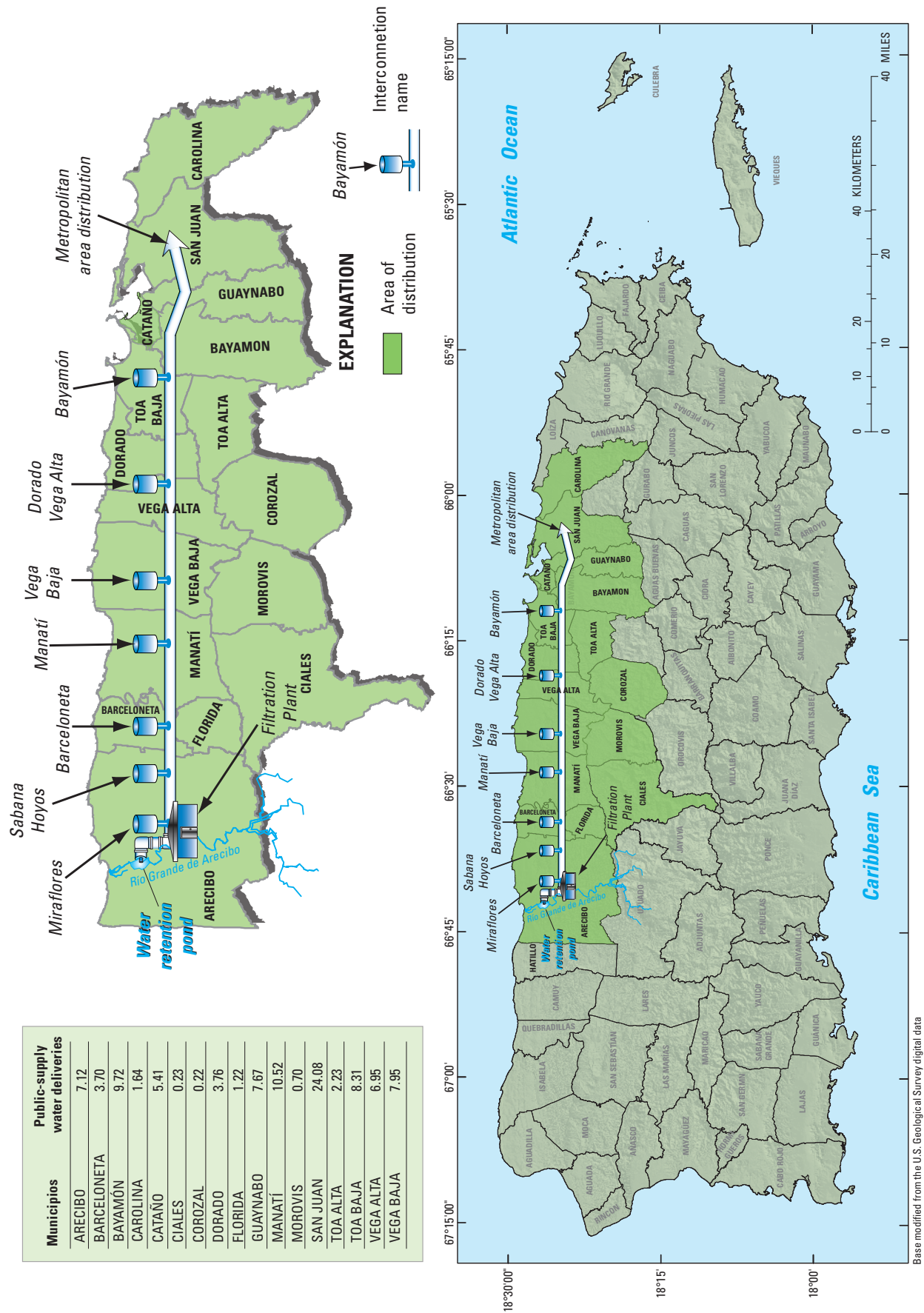


Figure 8. Water deliveries among the North Coast Aqueduct interconnections in Puerto Rico.





Example of surface-water intake located in southeastern Puerto Rico, photograph by Jessie Juarbe, September 13, 2013.

Public-supply water deliveries include 206 Mgal/d of water for domestic use, and 457 Mgal/d of water for commercial, industrial, thermoelectric power, and public facilities (the use of water by government facilities 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 that supply water to the same population year-round (water systems that usually serve rural areas). Non-PRASA systems are considered public-water suppliers, because they provide piped water for human consumption and have at least 15 service connections or regularly serve an average of at least 25 people at least 60 days per year (U.S. Environmental Protection Agency, 2012).

Public-Supply Water Domestic Use

In 2010, domestic use delivered by public-supply water system in Puerto Rico was estimated at 206 Mgal/d, (PRASA and non-PRASA systems). The PRASA system delivered 198 Mgal/d or about 30 percent of the total PRASA deliveries from surface-water and groundwater sources. The remaining was delivered from non-PRASA systems. The domestic per capita use for Puerto Rico was estimated at 56 gallons per day (gal/d) per person in 2010 (table 2). Domestic per capita use varies from municipio to municipio (fig. 10); however, households served by the same public-supply water system often have a common pattern of use affected by factors such as customer affluence, climate, and topography among other factors. About 50 percent of the 78 municipios in Puerto Rico had a domestic per capita use coefficient fluctuating between 53 and 60 gal/d per person during 2010 (fig. 10).

Economic constraint indicators such as water rate cost increases, reduction in the Puerto Rico's resident population, the implementation of low-flow fixtures and domestic conservation programs are some factors affecting the reduction of domestic per capita use in Puerto Rico during 2010. The U.S. Census Bureau indicated that Puerto Rico's resident population decreased 2 percent from the population counted a decade earlier (U.S. Census Bureau, 2010), which may affect the domestic per capita use reduction by about 40 percent; from 91 gal/d per person in 2005 to 56 gal/d per person in 2010.



Example of household water use, photograph by Wanda L. Molina, January, 2009.

Domestic Self-Supplied Water Use

In 2010, domestic self-supplied water use was estimated at 2.41 Mgal/d. About 38 thousand residents or about 1 percent of the population in Puerto Rico relies on private wells or springs for their household water needs. Self-supplied domestic water use was derived by multiplying the domestic self-supplied population by the domestic per capita use coefficient determined for the municipio, which are presented in table 3 as domestic per capita use in gallons per day per person.

The importance of groundwater resources in Puerto Rico, for public-supply water needs and as the source for self-supplied domestic users, is indicated by the distribution of withdrawals given in table 3.



Example of plumbing configuration used by domestic wells in Puerto Rico, photograph by Jessie Juarbe, July 18, 2011.

Industrial Self-Supplied Withdrawals

In 2010, industrial self-supplied groundwater withdrawal was estimated at 4.30 Mgal/d. Water for industrial uses at facilities requiring relatively large amounts of water as part of industrial processes is obtained from self-supplied groundwater withdrawals. Industrial facilities requiring lesser

amounts of water that are typically supplied from public-supply water facilities were not included in this report. In 2010, the municipios with the largest industrial groundwater withdrawals were Arecibo, Manatí and Barceloneta. The NAICS 325412 (U.S. Census Bureau, 2012), which corresponds to pharmaceutical products manufacturing, accounted for 65 percent of the total industrial self-supplied groundwater withdrawals on Puerto Rico. Yabucoa had substantial industrial activity related to the refining of petroleum products, which uses about 9 percent of the total industrial self-supplied withdrawals. Industrial self-supplied withdrawals from groundwater sources in Puerto Rico by municipio in 2010 are presented in table 4.

Crop-Irrigation Water Use

During 2010, the estimated irrigation withdrawals and water deliveries to farms in Puerto Rico averaged 38.2 Mgal/d from an estimate of 40.2 thousand cultivated acres (table 5). Minor crops such as vegetables and fruits accounted for 18.3 thousand cultivated acres, followed by 14.2 thousand acres cultivated for coffee and plantains. Cultivated acres for pineapples accounted for 7.72 thousand in Lajas Valley. About 33 thousand acres were irrigated using low-volume micro-irrigation systems; whereas the remaining 7.72 thousand acres used sprinkler irrigation systems, primarily for pineapple crops in Lajas Valley (table 5).

Crop-irrigation water use during calendar year 2010 was primarily withdrawn from groundwater sources. Groundwater aquifers provided 22.4 Mgal/d out of 38.2 Mgal/d for irrigation water use in Puerto Rico. Most of the groundwater withdrawals (19.4 Mgal/d) were from aquifers located in the south coast, from Arroyo to Lajas Valley. The remaining 3.01 Mgal/d were withdrawn from aquifers located in the north, east and west coasts of Puerto Rico.

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 northwestern Puerto Rico delivered 15.7 Mgal/d of surface water for irrigation in 2010 (table 5).



Farm irrigated by a sprinkler system in the south coast of Puerto Rico, photograph by Marcos Quiñones, February 24, 2014.

Thermoelectric-Power Water Use

In 2010, Puerto Rico had four thermoelectric powerplants operated by PREPA and located in Cataño, Guayanilla, Salinas and San Juan (fig. 4). In addition, there were two non-PREPA thermoelectric facilities located in Guayama and Peñuelas. Water use data for non-PREPA thermoelectric facilities were not included in this report.

Seawater used for cooling was estimated at 2,262 Mgal/d; the PRASA delivered an estimated total of 1.77 Mgal/d of freshwater to the Cataño and San Juan powerplants. Total groundwater withdrawals by the powerplants located in Guayanilla and Salinas were 1.15 Mgal/d. The PREPA plant located in Guayanilla received 0.52 Mgal/d of freshwater produced by a desalination plant in a non-PREPA thermoelectric facility located in the area. The four PREPA thermoelectric plants generated 13,545 gigawatt-hour (gWh) of electricity during 2010 (table 6).

Hydroelectric-Power Instream Water Use

In 2010, Puerto Rico had nine active hydroelectric powerplants located in Arecibo (Dos Bocas), Naguabo (Rio Blanco) Orocovis (Toro Negro 2), Peñuelas (Rio Garzas 1 and 2), Utuado (Caonillas 1), Villalba (Toro Negro 1), and Yauco (Yauco 1 and 2) (fig. 5). These powerplants generated 159 gWh of electricity in 2010 with a total-instream freshwater use of about 556 Mgal/d (622,179 acre-feet per year). In 2010, about 32 percent of all hydroelectric power in Puerto Rico was generated by the Dos Bocas powerplant (51gWh) (table 7).

Total Water Use

Total water use in Puerto Rico in 2010 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 and population served also were estimated. Total offstream freshwater withdrawals in 2010 were estimated at about 724 Mgal/d and instream water withdrawals were estimated at 2,818 Mgal/d. Instream water withdrawals included the saline water withdrawals used for cooling at thermoelectric plants (2,262 Mgal/d) and freshwater withdrawals from the island's streams used for hydroelectric power (556 Mgal/d) (table 8).

Total freshwater withdrawals by offstream water-use categories accounted for 724 Mgal/d and are listed in table 9. Public-supply water use accounted for the largest freshwater withdrawal (677 Mgal/d), followed by crop irrigation with 38.2 Mgal/d.

Table 2. Estimated deliveries from public- supply water systems to domestic use, population served and domestic per capita use in Puerto Rico by source and municipio, 2010.

[Source: U.S. Geological Survey, Caribbean Water Science Center; PRASA, Puerto Rico Aqueduct and Sewer Authority; sw, surface water; gw, groundwater; Mgal/d, million gallons per day; gal/d-p, gallons per day per person]

Municipio	PRASA				
	Delivery from SW, in Mgal/d	Delivery from GW, in Mgal/d	Total deliveries , in Mgal/d	Total population served, in thousands	Domestic per capita use, in gal/d-p
Puerto Rico	183.06	15.25	198.31	3,586.165	55.30
Adjuntas	0.78	0.06	0.84	17.233	48.74
Aguada	2.07	0.00	2.07	38.319	54.02
Aguadilla	3.18	0.00	3.18	58.915	53.98
Aguas Buenas	1.32	0.00	1.32	23.179	56.95
Aibonito	1.11	0.02	1.13	21.181	53.35
Añasco	1.52	0.00	1.52	27.341	55.59
Arecibo	4.54	0.46	5.00	91.849	54.44
Arroyo	0.24	0.73	0.97	19.575	49.55
Barceloneta	0.97	0.32	1.29	24.816	51.98
Barranquitas	1.19	0.00	1.19	23.833	49.93
Bayamón	12.19	0.00	12.19	208.116	58.57
Cabo Rojo	2.84	0.00	2.84	50.917	55.78
Caguas	7.62	0.00	7.62	133.394	57.12
Camuy	1.77	0.12	1.89	35.159	53.76
Canóvanas	2.47	0.00	2.47	47.648	51.84
Carolina	10.71	0.00	10.71	175.937	60.87
Cataño	1.72	0.00	1.72	28.140	61.12
Cayey	2.55	0.01	2.56	47.399	54.01
Ceiba	0.75	0.00	0.75	13.631	55.02
Ciales	0.88	0.04	0.92	18.394	50.02
Cidra	2.08	0.00	2.08	37.435	55.56
Coamo	0.52	1.42	1.94	38.972	49.78
Comerio	0.93	0.00	0.93	18.277	50.88
Corozal	1.59	0.00	1.59	31.009	51.28
Culebra	0.10	0.00	0.10	1.818	55.01
Dorado	1.25	0.85	2.10	38.165	55.02
Fajardo	2.03	0.00	2.03	36.833	55.11
Florida	0.23	0.44	0.67	12.680	52.84
Guánica	0.00	0.99	0.99	19.427	50.96
Guayama	2.08	0.24	2.32	45.087	51.46
Guayanilla	0.16	0.92	1.08	21.461	50.32
Guaynabo	5.94	0.00	5.94	95.133	62.44
Gurabo	2.37	0.00	2.37	43.211	54.85
Hatillo	2.15	0.11	2.26	41.953	53.87
Hormigueros	0.80	0.17	0.97	17.250	56.23
Humacao	3.13	0.00	3.13	58.466	53.54
Isabela	2.41	0.00	2.41	45.631	52.81
Jayuya	0.64	0.00	0.64	13.208	48.46
Juana Díaz	1.35	1.20	2.55	49.914	51.09
Juncos	2.15	0.00	2.15	40.290	53.36
Lajas	1.19	0.19	1.38	25.753	53.59

Table 2. Estimated deliveries from public- supply water systems to domestic use, population served and domestic per capita use in Puerto Rico by source and municipio, 2010.—Continued

[Source: U.S. Geological Survey, Caribbean Water Science Center; PRASA, Puerto Rico Aqueduct and Sewer Authority; sw, surface water; gw, groundwater; Mgal/d, million gallons per day; gal/d-p, gallons per day per person]

Municipio	PRASA				
	Delivery from SW, in Mgal/d	Delivery from GW, in Mgal/d	Total deliveries , in Mgal/d	Total population served, in thousands	Domestic per capita use, in gal/d-p
Puerto Rico	183.06	15.25	198.31	3,586.165	55.30
Lares	1.48	0.00	1.48	29.825	49.62
Las Marías	0.47	0.01	0.48	9.781	49.07
Las Piedras	1.93	0.00	1.93	35.757	53.98
Loíza	1.50	0.00	1.50	29.976	50.04
Luquillo	1.06	0.00	1.06	20.068	52.82
Manatí	2.16	0.20	2.36	44.113	53.50
Maricao	0.30	0.00	0.30	6.176	48.58
Maunabo	0.60	0.00	0.60	11.897	50.43
Mayagüez	4.65	0.09	4.74	85.545	55.41
Moca	1.60	0.21	1.81	33.747	53.63
Morovis	1.42	0.22	1.64	32.610	50.29
Naguabo	1.21	0.00	1.21	22.676	53.36
Naranjito	1.27	0.00	1.27	23.240	54.65
Orocovis	0.93	0.00	0.93	19.121	48.64
Patillas	0.64	0.15	0.79	15.611	50.61
Peñuelas	0.90	0.06	0.96	21.246	45.18
Ponce	7.91	0.41	8.32	162.836	51.09
Quebradillas	1.12	0.27	1.39	25.919	53.63
Rincón	0.62	0.00	0.62	11.404	54.37
Rio Grande	2.81	0.00	2.81	54.044	51.99
Sabana Grande	1.17	0.17	1.34	25.265	53.04
Salinas	0.23	1.28	1.51	29.578	51.05
San Germán	1.46	0.30	1.76	32.641	53.92
San Juan	24.32	0.00	24.32	395.326	61.52
San Lorenzo	1.98	0.00	1.98	37.754	52.44
San Sebastián	2.03	0.14	2.17	41.441	52.36
Santa Isabel	0.00	1.16	1.16	23.274	49.84
Toa Alta	4.26	0.00	4.26	74.066	57.52
Toa Baja	5.30	0.00	5.30	89.609	59.15
Trujillo Alto	4.61	0.00	4.61	74.842	61.60
Utua	1.52	0.00	1.52	30.717	49.48
Vega Alta	2.05	0.10	2.15	39.951	53.82
Vega Baja	2.55	0.64	3.19	59.662	53.47
Vieques	0.50	0.00	0.50	9.301	53.76
Villalba	0.96	0.14	1.10	23.110	47.60
Yabucoa	0.83	0.55	1.38	27.059	51.00
Yauco	1.19	0.86	2.05	40.028	51.21

Table 2. Estimated deliveries from public- supply water systems to domestic use, population served and domestic per capita use in Puerto Rico by source and municipio, 2010.—Continued

[Source: U.S. Geological Survey, Caribbean Water Science Center; PRASA, Puerto Rico Aqueduct and Sewer Authority; sw, surface water; gw, groundwater; Mgal/d, million gallons per day; gal/d-p, gallons per day per person]

Municipio	NON-PRASA				
	Delivery from SW, in Mgal/d	Delivery from GW, in Mgal/d	Total deliveries , in Mgal/d	Total population served, in thousands	Domestic per capita use, in gal/d-p
Puerto Rico	2.73	4.32	7.25	101.627	69.37
Adjuntas	0.02	0.05	0.07	2.250	31.11
Aguada	0.00	0.27	0.27	3.640	74.18
Aguadilla	0.00	0.01	0.01	0.165	60.61
Aguas Buenas	0.00	0.43	0.43	5.480	78.47
Aibonito	0.02	0.07	0.09	0.856	105.14
Añasco	0.00	0.12	0.12	1.920	62.50
Arecibo	0.00	0.02	0.02	0.350	57.14
Arroyo	0.00	0.00	0.00	0.000	0.00
Barceloneta	0.00	0.00	0.00	0.000	0.00
Barranquitas	0.27	0.31	0.58	6.485	89.44
Bayamón	0.00	0.00	0.00	0.000	0.00
Cabo Rojo	0.00	0.00	0.00	0.000	0.00
Caguas	0.06	0.56	0.62	9.499	65.27
Camuy	0.00	0.00	0.00	0.000	0.00
Canóvanas	0.00	0.00	0.00	0.000	0.00
Carolina	0.00	0.06	0.06	0.825	72.73
Cataño	0.00	0.00	0.00	0.000	0.00
Cayey	0.02	0.01	0.03	0.720	41.67
Ceiba	0.00	0.00	0.00	0.000	0.00
Ciales	0.00	0.02	0.02	0.388	51.55
Cidra	0.00	0.04	0.04	0.994	40.24
Coamo	0.01	0.06	0.07	1.540	45.45
Comerio	0.01	0.12	0.13	2.431	53.48
Corozal	0.09	0.13	0.22	3.247	67.75
Culebra	0.00	0.00	0.00	0.000	0.00
Dorado	0.00	0.00	0.00	0.000	0.00
Fajardo	0.01	0.00	0.01	0.160	62.50
Florida	0.00	0.00	0.00	0.000	0.00
Guánica	0.00	0.00	0.00	0.000	0.00
Guayama	0.02	0.00	0.02	0.275	72.73
Guayanilla	0.01	0.00	0.01	0.120	83.33
Guaynabo	0.00	0.00	0.00	0.000	0.00
Gurabo	0.01	0.00	0.01	0.080	125.00
Hatillo	0.00	0.00	0.00	0.000	0.00
Hormigueros	0.00	0.00	0.00	0.000	0.00
Humacao	0.00	0.00	0.00	0.000	0.00
Isabela	0.00	0.00	0.00	0.000	0.00
Jayuya	0.23	0.00	0.23	3.434	66.98
Juana Díaz	0.05	0.00	0.05	0.833	60.02
Juncos	0.00	0.00	0.00	0.000	0.00
Lajas	0.00	0.00	0.00	0.000	0.00

Table 2. Estimated deliveries from public- supply water systems to domestic use, population served and domestic per capita use in Puerto Rico by source and municipio, 2010.—Continued

[Source: U.S. Geological Survey, Caribbean Water Science Center; PRASA, Puerto Rico Aqueduct and Sewer Authority; sw, surface water; gw, groundwater; Mgal/d, million gallons per day; gal/d-p, gallons per day per person]

Municipio	NON-PRASA				
	Delivery from SW, in Mgal/d	Delivery from GW, in Mgal/d	Total deliveries , in Mgal/d	Total population served, in thousands	Domestic per capita use, in gal/d-p
Puerto Rico	2.72	4.32	7.04	101.627	69.27
Lares	0.01	0.05	0.06	0.928	64.66
Las Marías	0.01	0.00	0.01	0.100	100.00
Las Piedras	0.05	0.12	0.17	2.918	58.26
Loíza	0.00	0.00	0.00	0.084	0.00
Luquillo	0.00	0.00	0.00	0.000	0.00
Manatí	0.00	0.00	0.00	0.000	0.00
Maricao	0.00	0.00	0.00	0.100	0.00
Maunabo	0.02	0.00	0.02	0.328	60.98
Mayagüez	0.00	0.00	0.00	0.000	0.00
Moca	0.00	0.00	0.00	0.000	0.00
Morovis	0.00	0.00	0.00	0.000	0.00
Naguabo	0.40	0.00	0.40	4.044	98.91
Naranjito	0.01	0.51	0.52	7.162	72.61
Orocovis	0.06	0.21	0.27	4.302	62.76
Patillas	0.17	0.05	0.22	3.666	60.01
Peñuelas	0.08	0.03	0.11	3.036	36.23
Ponce	0.07	0.13	0.20	3.491	57.29
Quebradillas	0.00	0.00	0.00	0.000	0.00
Rincón	0.00	0.00	0.00	0.000	0.00
Rio Grande	0.02	0.00	0.02	0.260	76.92
Sabana Grande	0.00	0.00	0.00	0.000	0.00
Salinas	0.00	0.10	0.10	1.500	66.67
San Germán	0.12	0.01	0.13	1.536	84.64
San Juan	0.00	0.00	0.00	0.000	0.00
San Lorenzo	0.03	0.18	0.21	3.304	63.56
San Sebastián	0.00	0.04	0.04	0.989	40.44
Santa Isabel	0.00	0.00	0.00	0.000	0.00
Toa Alta	0.00	0.00	0.00	0.000	0.00
Toa Baja	0.00	0.00	0.00	0.000	0.00
Trujillo Alto	0.00	0.00	0.00	0.000	0.00
Utuado	0.12	0.02	0.14	2.327	60.16
Vega Alta	0.00	0.00	0.00	0.000	0.00
Vega Baja	0.00	0.00	0.00	0.000	0.00
Vieques	0.00	0.00	0.00	0.000	0.00
Villalba	0.20	0.01	0.21	2.963	70.87
Yabucoa	0.39	0.57	0.96	10.882	88.22
Yauco	0.14	0.01	0.15	2.015	74.44

Table 2. Estimated deliveries from public- supply water systems to domestic use, population served and domestic per capita use in Puerto Rico by source and municipio, 2010.—Continued

[Source: U.S. Geological Survey, Caribbean Water Science Center; PRASA, Puerto Rico Aqueduct and Sewer Authority; sw, surface water; gw, groundwater; Mgal/d, million gallons per day; gal/d-p, gallons per day per person]

Municipio	TOTAL				
	Delivery from SW, in Mgal/d	Delivery from GW, in Mgal/d	Total deliveries , in Mgal/d	Total population served, in thousands	Domestic per capita use, in gal/d-p
Puerto Rico	185.79	19.57	205.77	3,687.792	55.80
Adjuntas	0.80	0.11	0.91	19.483	46.71
Aguada	2.07	0.27	2.34	41.959	55.77
Aguadilla	3.18	0.01	3.19	59.080	53.99
Aguas Buenas	1.32	0.43	1.75	28.659	61.06
Aibonito	1.13	0.09	1.22	22.037	55.36
Añasco	1.52	0.12	1.64	29.261	56.05
Arecibo	4.54	0.48	5.02	92.199	54.45
Arroyo	0.24	0.73	0.97	19.575	49.55
Barceloneta	0.97	0.32	1.29	24.816	51.98
Barranquitas	1.46	0.31	1.77	30.318	58.38
Bayamón	12.19	0.00	12.19	208.116	58.57
Cabo Rojo	2.84	0.00	2.84	50.917	55.78
Caguas	7.68	0.56	8.24	142.893	57.67
Camuy	1.77	0.12	1.89	35.159	53.76
Canóvanas	2.47	0.00	2.47	47.648	51.84
Carolina	10.71	0.06	10.77	176.762	60.93
Cataño	1.72	0.00	1.72	28.140	61.12
Cayey	2.57	0.02	2.59	48.119	53.82
Ceiba	0.75	0.00	0.75	13.631	55.02
Ciales	0.88	0.06	0.94	18.782	50.05
Cidra	2.08	0.04	2.12	38.429	55.17
Coamo	0.53	1.48	2.01	40.512	49.61
Comerio	0.94	0.12	1.06	20.708	51.19
Corozal	1.68	0.13	1.81	34.256	52.84
Culebra	0.10	0.00	0.10	1.818	55.01
Dorado	1.25	0.85	2.10	38.165	55.02
Fajardo	2.04	0.00	2.04	36.993	55.15
Florida	0.23	0.44	0.67	12.680	52.84
Guánica	0.00	0.99	0.99	19.427	50.96
Guayama	2.10	0.24	2.34	45.362	51.59
Guayanilla	0.17	0.92	1.09	21.581	50.51
Guaynabo	5.94	0.00	5.94	95.133	62.44
Gurabo	2.38	0.00	2.38	43.291	54.98
Hatillo	2.15	0.11	2.26	41.953	53.87
Hormigueros	0.80	0.17	0.97	17.250	56.23
Humacao	3.13	0.00	3.13	58.466	53.54
Isabela	2.41	0.00	2.41	45.631	52.81
Jayuya	0.87	0.00	0.87	16.642	52.28
Juana Díaz	1.40	1.20	2.60	50.747	51.23
Juncos	2.15	0.00	2.15	40.290	53.36
Lajas	1.19	0.19	1.38	25.753	53.59

Table 2. Estimated deliveries from public- supply water systems to domestic use, population served and domestic per capita use in Puerto Rico by source and municipio, 2010.—Continued

[Source: U.S. Geological Survey, Caribbean Water Science Center; PRASA, Puerto Rico Aqueduct and Sewer Authority; sw, surface water; gw, groundwater; Mgal/d, million gallons per day; gal/d-p, gallons per day per person]

Municipio	TOTAL				
	Delivery from SW, in Mgal/d	Delivery from GW, in Mgal/d	Total deliveries , in Mgal/d	Total population served, in thousands	Domestic per capita use, in gal/d-p
Puerto Rico	185.78	19.57	205.77	3,687.792	55.80
Lares	1.49	0.05	1.54	30.753	50.08
Las Marías	0.48	0.01	0.49	9.881	49.59
Las Piedras	1.98	0.12	2.10	38.675	54.30
Loíza	1.50	0.00	1.50	30.060	49.90
Luquillo	1.06	0.00	1.06	20.068	52.82
Manatí	2.16	0.20	2.36	44.113	53.50
Maricao	0.30	0.00	0.30	6.276	47.80
Maunabo	0.62	0.00	0.62	12.225	50.72
Mayagüez	4.65	0.09	4.74	85.545	55.41
Moca	1.60	0.21	1.81	33.747	53.63
Morovis	1.42	0.22	1.64	32.610	50.29
Naguabo	1.61	0.00	1.61	26.720	60.25
Naranjito	1.28	0.51	1.79	30.402	58.88
Orocovis	0.99	0.21	1.20	23.423	51.23
Patillas	0.81	0.20	1.01	19.277	52.39
Peñuelas	0.98	0.09	1.07	24.282	44.07
Ponce	7.98	0.54	8.52	166.327	51.22
Quebradillas	1.12	0.27	1.39	25.919	53.63
Rincón	0.62	0.00	0.62	11.404	54.37
Rio Grande	2.83	0.00	2.83	54.304	52.11
Sabana Grande	1.17	0.17	1.34	25.265	53.04
Salinas	0.23	1.38	2.03	31.078	65.32
San Germán	1.58	0.31	1.89	34.177	55.30
San Juan	24.32	0.00	24.32	395.326	61.52
San Lorenzo	2.01	0.18	2.19	41.058	53.34
San Sebastián	2.03	0.18	2.21	42.430	52.09
Santa Isabel	0.00	1.16	1.16	23.274	49.84
Toa Alta	4.26	0.00	4.26	74.066	57.52
Toa Baja	5.30	0.00	5.30	89.609	59.15
Trujillo Alto	4.61	0.00	4.61	74.842	61.60
Utuado	1.64	0.02	1.66	33.044	50.24
Vega Alta	2.05	0.10	2.15	39.951	53.82
Vega Baja	2.55	0.64	3.19	59.662	53.47
Vieques	0.50	0.00	0.50	9.301	53.76
Villalba	1.16	0.15	1.31	26.073	50.24
Yabucoa	1.22	1.12	2.34	37.941	61.67
Yauco	1.33	0.87	2.20	42.043	52.33

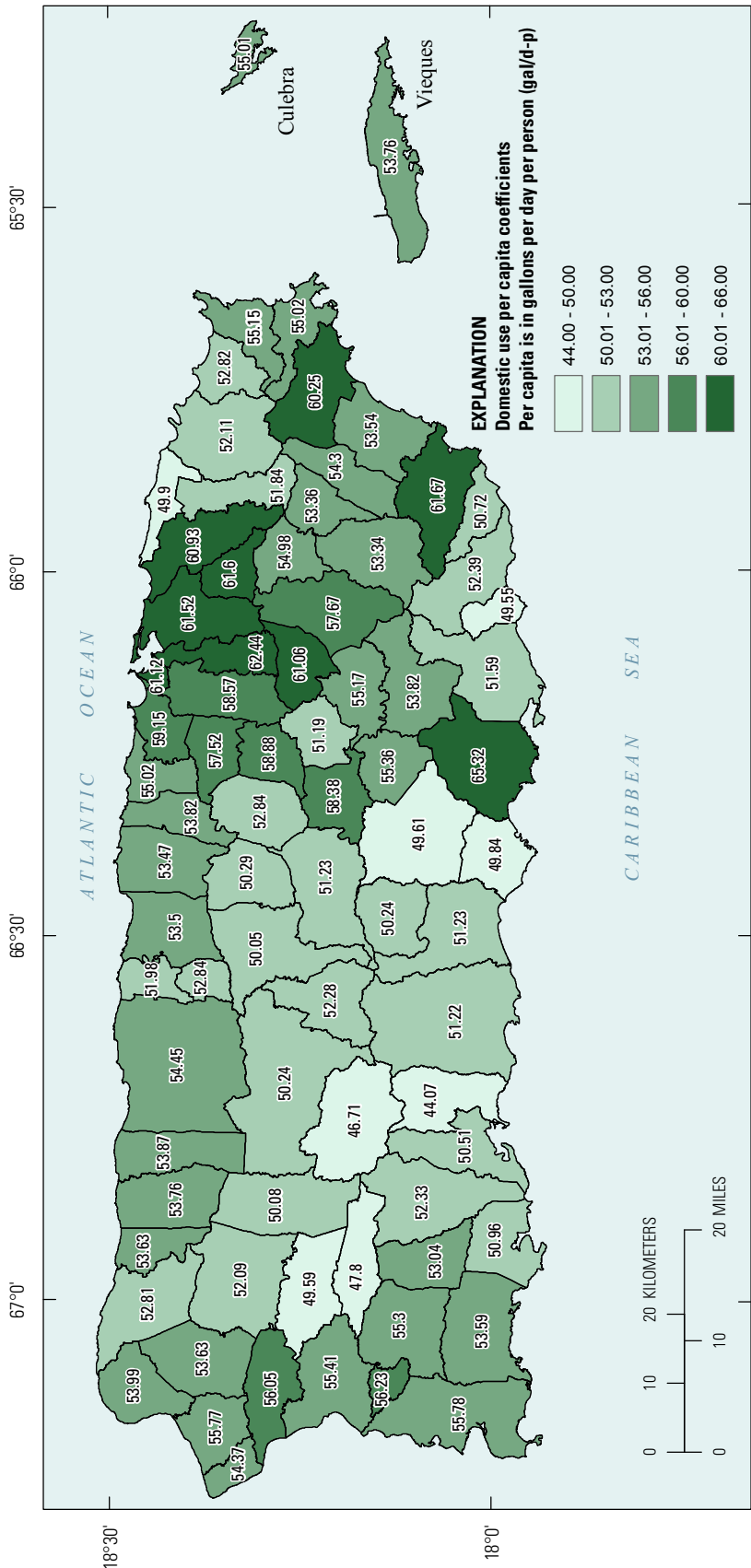


Figure 10. Domestic water use per capita coefficients by municipios in Puerto Rico, 2010.

Table 3. Estimated domestic self-supplied withdrawals from groundwater sources, population served and domestic per capita use in Puerto Rico by municipio, 2010.

[Source: U.S. Geological Survey, Caribbean Water Science Center; Mgal/d, million gallons per day; gal/d-p, gallons per day per person]

Municipio	Withdrawals, in Mgal/d	Population served, in thousands	Domestic per capita use , in gal/d-p
Puerto Rico	2.41	37.927	63.54
Aguadilla	0.12	1.869	64.21
Aibonito	0.27	3.863	69.89
Arecibo	0.28	4.241	66.02
Cidra	0.23	5.051	45.54
Corozal	0.20	2.886	69.30
Guaynabo	0.19	2.791	68.08
Gurabo	0.14	2.078	67.37
Mayagüez	0.20	3.535	56.58
Moca	0.40	6.362	62.87
Rincón	0.25	3.796	65.86
San Germán	0.12	1.350	88.89
Utado	0.01	0.105	95.24

Table 4. Industrial self-supplied withdrawals from groundwater sources in Puerto Rico by municipio, 2010.

[Source: U.S. Geological Survey, Caribbean Water Science Center; all values in million gallons per day]

Municipio	Withdrawals
Puerto Rico	4.30
Aguada	0.00
Aguadilla	0.02
Aibonito	0.23
Añasco	0.00
Arecibo	0.84
Barceloneta	0.46
Bayamón	0.20
Caguas	0.03
Carolina	0.04
Cayey	0.35
Cidra	0.08
Fajardo	0.08
Guayama	0.40
Humacao	0.04
Jayuya	0.03
Juncos	0.00
Las Piedras	0.10
Manatí	0.49
Maricao	0.05
Peñuelas	0.04
Salinas	0.01
San Juan	0.07
San Lorenzo	0.01
Toa Baja	0.28
Vega Baja	0.08
Yabucoa	0.37

Table 5. Estimated irrigation water use, cultivated and irrigated acres and irrigation methods in Puerto Rico by source and municipio, 2010.

[Source: U.S. Geological Survey, Caribbean Water Science Center; Mgal/d, million gallons per day; cultivated and irrigated acres in thousands; sw, surface water; gw, groundwater; mi, micro-irrigation; N/A, not applicable]

Municipio	Irrigation water use, in Mgal/d			Cultivated acres	Type of crop	Irrigation methods	
	SW	GW	Total			Sprinkler	MI
Puerto Rico	15.73	22.42	38.15	40.24		7.72	32.52
Aguadilla	0.04	0.47	0.51	0.69	Plantains	N/A	0.69
Arroyo	0.06	0.04	0.10	0.11	Coffee and plantains	N/A	0.11
Cabo Rojo	0.18	0.30	0.48	0.62	Vegetables	N/A	0.62
Coamo	0.00	0.11	0.11	0.28	Coffee, plantains	N/A	0.28
Guánica	0.53	2.25	2.78	2.39	Plantains	N/A	2.39
Guayama	0.90	0.23	1.13	0.97	Plantains	N/A	0.97
Guayanilla	0.00	0.49	0.49	1.38	Coffee	N/A	1.38
Isabela	0.10	0.98	1.08	1.48	Plantains	N/A	1.48
Juana Diaz	2.04	4.30	6.34	5.46	Pumpkins, watermelon, tomatoes, peppers, gherkins, peas, corn, potatoes, plantains, hay, soy	N/A	5.46
Lajas	3.48	3.00	6.48	7.72	Pineapples	7.72	0.00
Maunabo	0.00	0.24	0.24	0.63	Plantains	N/A	0.63
Moca	0.00	0.34	0.34	0.47	Coffee, plantains	N/A	0.47
Patillas	0.11	0.06	0.17	0.19	Plantains	N/A	0.19
Peñuelas	0.00	0.14	0.14	0.40	Coffee	N/A	0.40
Ponce	0.00	0.35	0.35	0.99	Coffee	N/A	0.99
Sabana Grande	0.86	0.00	0.86	1.02	Coffee	N/A	1.02
Salinas	4.29	0.36	4.65	4.00	Pumpkins, watermelon, tomatoes, peppers, gherkins, peas, corn, potatoes	N/A	4.00
Santa Isabel	3.15	6.38	9.53	8.21	Pumpkins, watermelon, tomatoes, peppers, gherkins, peas, corn, potatoes, mangoes	N/A	8.21
Yabucoa	0.00	0.68	0.68	1.77	Plantains	N/A	1.77
Yauco	0.00	1.70	1.70	1.46	Coffee, plantains	N/A	1.46

Table 6. Withdrawals and deliveries from public-supply water by public thermoelectric power plants in Puerto Rico by source and municipio, 2010.

[Source: U.S. Geological Survey, Caribbean Water Science Center; Mgal/d, million gallons per day; gWh, giga-watt hours]

Municipio	Facility name	Source of saline water	Fresh groundwater withdrawals, in Mgal/d	Fresh surface water withdrawals, in Mgal/d	Saline surface water withdrawals, in Mgal/d	Public-supply water deliveries, in Mgal/d	Withdrawals and deliveries, in Mgal/d	Power generation, in gWh
Puerto Rico			1.15	0.52	2,262.02	1.77	2,265.46	13,545.13
Cataño	Palo Seco	Ensenada Boca Vieja	0.00	0.00	604.71	0.66	605.37	3,783.20
Guayanilla	Costa Sur	Guayanilla Bay	0.39	0.52	590.01	0.00	590.92	2,100.07
Salinas	Aguirre	Jobos Bay	0.76	0.00	563.68	0.00	564.44	4,794.94
San Juan	San Juan	San Juan Bay	0.00	0.00	503.62	1.11	504.73	2,866.92

Table 7. Water use and power generated by hydroelectric power plants in Puerto Rico by municipio, 2010.

[Source: U.S. Geological Survey, Caribbean Water Science Center]

Municipio	Facility name	Instream water use		Power generation, in gWh
		Million gallons per day	acre-feet per year	
Puerto Rico		555.53	622,179	158.94
Arecibo	Dos Bocas	340.33	381,166	51.43
Naguabo	Río Blanco	2.87	3,219	3.24
Orocovis	Toro Negro 2	1.22	1,369	0.75
Peñuelas	Garzas 1	8.95	10,028	11.23
	Garzas 2	2.50	2,795	0.80
Utua	Caonillas 1	104.93	117,524	49.57
Villalba	Toro Negro 1	7.87	8,816	9.07
Yauco	Yauco 1	32.96	36,910	19.92
	Yauco 2	53.89	60,353	12.93

Table 8. Summary of total water use in Puerto Rico, 2010.

[Source: U.S. Geological Survey, Caribbean Water Science Center; Mgal/d, million gallons per day; gal/d, gallon per day]

2010 Census of population, in thousands	3,725.789
Population served by public-supply water systems, in thousands	3,687.792
Public-supply water withdrawals, in Mgal/d	677.21
Public-supply water deliveries, in Mgal/d	662.58
Public-supply per capita delivery, in gal/d per person	179.67
Domestic use from public-supply water systems, in Mgal/d	205.77
Domestic per capita use, in gal/d per person	55.80
Domestic self-supplied, in Mgal/d	2.41
Industrial self-supplied, in Mgal/d	4.30
Crop irrigation, in Mgal/d	38.16
Thermoelectric freshwater, in Mgal/d	1.67
Total offstream freshwater withdrawals, in Mgal/d	723.75
Surface water	606.14
Groundwater	117.61
Total instream water withdrawals, in Mgal/d	2,817.55
Saline surface water	2,262.02
Fresh surface water	555.53

Table 9. Total freshwater withdrawals in Puerto Rico by offstream water-use categories and municipios, 2010.

[Source: U.S. Geological Survey, Caribbean Water Science Center; all values in million gallons per day; N/A, not applicable]

Municipio	Public-supply water	Freshwater Withdrawals				Total water use
		Domestic self-supplied	Industrial self-supplied	Thermoelectric freshwater	Crop irrigation	
Puerto Rico	677.21	2.41	4.30	1.67	38.16	723.75
Adjuntas	1.15	N/A	N/A	N/A	N/A	1.15
Aguada	1.08	N/A	N/A	N/A	N/A	1.08
Aguadilla	27.80	0.12	0.02	N/A	0.51	28.45
Aguas Buenas	21.78	N/A	N/A	N/A	N/A	21.78
Aibonito	3.77	0.27	0.23	N/A	N/A	4.27
Añasco	2.74	N/A	N/A	N/A	N/A	2.74
Arecibo	118.58	0.28	0.84	N/A	N/A	119.70
Arroyo	1.76	N/A	N/A	N/A	0.10	1.86
Barceloneta	1.68	N/A	0.46	N/A	N/A	2.14
Barranquitas	3.82	N/A	N/A	N/A	N/A	3.82
Bayamón	0.19	N/A	0.20	N/A	N/A	0.39
Cabo Rojo	6.21	N/A	N/A	N/A	0.48	6.69
Caguas	9.68	N/A	0.03	N/A	N/A	9.71
Camuy	2.00	N/A	N/A	N/A	N/A	2.00
Canóvanas	6.78	N/A	N/A	N/A	N/A	6.78
Carolina	0.06	N/A	0.04	N/A	N/A	0.10
Cataño	0.00	N/A	N/A	N/A	N/A	0.00
Cayey	2.45	N/A	0.35	N/A	N/A	2.80
Ceiba	0.00	N/A	N/A	N/A	N/A	0.00
Ciales	2.59	N/A	N/A	N/A	N/A	2.59
Cidra	5.87	0.23	0.08	N/A	N/A	6.18
Coamo	1.00	N/A	N/A	N/A	0.11	1.11
Comerio	3.51	N/A	N/A	N/A	N/A	3.51
Corozal	3.84	0.20	N/A	N/A	N/A	4.04
Culebra	0.00	N/A	N/A	N/A	N/A	0.00
Dorado	3.89	N/A	N/A	N/A	N/A	3.89
Fajardo	12.12	N/A	0.08	N/A	N/A	12.20
Florida	2.20	N/A	N/A	N/A	N/A	2.20
Guánica	3.21	N/A	N/A	N/A	2.78	5.99
Guayama	13.75	N/A	0.40	N/A	1.13	15.28
Guayanilla	2.72	N/A	N/A	0.91	0.49	4.12
Guaynabo	8.03	0.19	N/A	N/A	N/A	8.22
Gurabo	2.98	0.14	N/A	N/A	N/A	3.12
Hatillo	3.59	N/A	N/A	N/A	N/A	3.59
Hormigueros	0.85	N/A	N/A	N/A	N/A	0.85
Humacao	5.43	N/A	0.04	N/A	N/A	5.47
Isabela	6.98	N/A	N/A	N/A	1.08	8.06
Jayuya	2.60	N/A	0.03	N/A	N/A	2.63
Juana Díaz	5.62	N/A	N/A	N/A	6.34	11.96
Juncos	1.69	N/A	N/A	N/A	N/A	1.69
Lajas	3.28	N/A	N/A	N/A	6.48	9.76
Lares	3.63	N/A	N/A	N/A	N/A	3.63
Las Marias	1.46	N/A	N/A	N/A	N/A	1.46
Las Piedras	2.12	N/A	0.10	N/A	N/A	2.22

Table 9. Total freshwater withdrawals in Puerto Rico by offstream water-use categories and municipios, 2010.—Continued

[Source: U.S. Geological Survey, Caribbean Water Science Center; all values in million gallons per day; N/A, not applicable]

Municipio	Public-supply water	Freshwater Withdrawals				Total water use
		Domestic self-supplied	Industrial self-supplied	Thermoelectric freshwater	Crop irrigation	
Puerto Rico	677.21	2.41	4.30	1.67	38.16	723.75
Loiza	0.00	N/A	N/A	N/A	N/A	0.00
Luquillo	2.76	N/A	N/A	N/A	N/A	2.76
Manatí	4.39	N/A	0.49	N/A	N/A	4.88
Maricao	1.62	N/A	0.05	N/A	N/A	1.67
Maunabo	1.60	N/A	N/A	N/A	0.24	1.84
Mayagüez	24.71	0.20	N/A	N/A	N/A	24.91
Moca	1.40	0.40	N/A	N/A	0.34	2.14
Morovis	3.62	N/A	N/A	N/A	N/A	3.62
Naguabo	18.37	N/A	N/A	N/A	N/A	18.37
Naranjito	1.82	N/A	N/A	N/A	N/A	1.82
Orocovis	4.50	N/A	N/A	N/A	N/A	4.50
Patillas	3.52	N/A	N/A	N/A	0.17	3.69
Peñuelas	3.04	N/A	0.04	N/A	0.14	3.22
Ponce	4.68	N/A	N/A	N/A	0.35	5.03
Quebradillas	3.86	N/A	N/A	N/A	N/A	3.86
Rincón	1.63	0.25	N/A	N/A	N/A	1.88
Río Grande	13.98	N/A	N/A	N/A	N/A	13.98
Sabana Grande	3.09	N/A	N/A	N/A	0.86	3.95
Salinas	3.99	N/A	0.01	0.76	4.65	9.41
San Germán	2.72	0.12	N/A	N/A	N/A	2.84
San Juan	0.00	N/A	0.07	N/A	N/A	0.07
San Lorenzo	6.01	N/A	0.01	N/A	N/A	6.02
San Sebastián	4.82	N/A	N/A	N/A	N/A	4.82
Santa Isabel	6.92	N/A	N/A	N/A	9.53	16.45
Toa Alta	81.51	N/A	N/A	N/A	N/A	81.51
Toa Baja	1.97	N/A	0.28	N/A	N/A	2.25
Trujillo Alto	103.33	N/A	N/A	N/A	N/A	103.33
Utua	4.10	0.01	N/A	N/A	N/A	4.11
Vega Alta	1.56	N/A	N/A	N/A	N/A	1.56
Vega Baja	6.10	N/A	0.08	N/A	N/A	6.18
Vieques	0.00	N/A	N/A	N/A	N/A	0.00
Villalba	33.17	N/A	N/A	N/A	N/A	33.17
Yabucoa	4.50	N/A	0.37	N/A	0.68	5.55
Yauco	3.43	N/A	N/A	N/A	1.70	5.13

Summary

Water-use data for 2010 were aggregated by 78 municipios for public-supply water withdrawals and deliveries, domestic and industrial self-supplied, crop irrigation, and thermoelectric and hydroelectric power water use. Public-supply water withdrawals were compiled for the municipio in which the withdrawals take place; and the public-supply water deliveries were aggregated by wards based in the population served by the public-supply water system. The data were compiled for five 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 instream water-use category also was compiled: power-generation instream water use (thermoelectric saline withdrawals and hydroelectric power).

During 2010, public-supply water withdrawals from surface-water and groundwater sources constituted the major freshwater use category and were estimated at 677 million gallons per day (Mgal/d). The population served by public-supply water facilities operated by the Puerto Rico Aqueduct and Sewer Authority (PRASA) was estimated to be 96 percent of the total resident population for Puerto Rico in 2010 (about 3,586 thousand residents). Non-PRASA public-supply water withdrawals were estimated at 7.1 Mgal/d to serve a population of about 102 thousand residents. Public-supply domestic water use in Puerto Rico was estimated at 206 Mgal/d, with about 30 percent of the total PRASA deliveries from surface-water and groundwater sources. Water withdrawals by domestic self-supplied users were estimated at 2.41 Mgal/d by a population of about 38 thousand people. Groundwater withdrawals by industrial users were estimated at 4.30 Mgal/d.

Crop-irrigation withdrawals from surface-water and groundwater sources were estimated at 38.2 Mgal/d, of which 15.7 Mgal/d of surface water were in areas supplied by the public irrigation systems operated by the Puerto Rico Electric Power Authority. Groundwater withdrawals from Puerto Rico's major aquifers for irrigation purposes were about 22 Mgal/d. Micro-irrigation was the predominant irrigation method (32.5 thousand of acres) to supply artificially the water requirements of 40.2 thousand cultivated acres.

In 2010, Puerto Rico had four thermoelectric powerplants that used large amounts of saline (seawater) for cooling. The instream saline withdrawals totaled 2,262 Mgal/d and produced 13,545 gWh of electricity in 2010. Freshwater use at thermoelectric powerplants consisted of 1.77 Mgal/d delivered from the PRASA to the plants located in Cataño and San Juan and 1.15 Mgal/d from local aquifers at the Guayanilla and Salinas powerplants.

The nine active hydroelectric powerplants located throughout Puerto Rico had an instream freshwater use of 556 Mgal/d in 2010 and combined they generated 159 gWh of electricity.

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