

Source, Use, and Disposition of Freshwater in Puerto Rico, 2010

Introduction

Water diverted from streams and pumped from wells constitutes the main source of water for the 78 municipios of the Commonwealth of Puerto Rico (fig. 1). A better understanding of water-use patterns is needed, particularly regarding the amount of water used, where and how this water is used and disposed, and how human activities affect water resources. Agricultural practices, indoor and outdoor household uses, industrial uses, and commercial and mining withdrawals affect reservoirs, streams, and aquifers. Accurate and accessible water information for Puerto Rico is critical to ensure that water managers have the ability to protect and conserve this essential natural resource.

From 2000 to 2010, the population of Puerto Rico decreased 2.6 percent, from 3.8 to 3.7 million residents (U.S. Census Bureau, 2011), and this decrease in population reduced the demand for freshwater. Factors that contributed to a reduction in domestic per capita water use in Puerto Rico include water-rate cost increases, the implementation of low-flow fixtures, and domestic conservation programs. Almost 99 percent of the residents in Puerto Rico were served by public-supply water systems in 2010. Public-supply water is provided by the Puerto Rico Aqueduct and Sewer Authority (PRASA) and by

non-PRASA systems. Non-PRASA systems include community-operated water systems (water systems that serve rural or suburban housing areas).

Sources of Water

Water-use data and concepts presented in this fact sheet refer only to offstream uses. Offstream use is the freshwater diverted or withdrawn from a surface-water or groundwater source and conveyed to the place of use. Offstream use is sometimes referred to as withdrawal use.

In 2010, a total of 733.16 million gallons per day (Mgal/d) of freshwater was withdrawn and delivered in Puerto Rico to satisfy the demand of approximately 3.7 million residents (U.S. Census Bureau, 2011). Puerto Rico has two principal natural sources of freshwater: groundwater and surface water.

Groundwater sources provided about 124.60 Mgal/d (GW in box A, fig. 2), or 17 percent, of the total freshwater withdrawn; 87.32 Mgal/d (PS subtotal in box A1, fig. 2) were withdrawn by public-supply water systems, and 37.28 Mgal/d (self-supplied withdrawals subtotal in box 1, fig. 2) were withdrawn by self-supplied groundwater systems during 2010.



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

Figure 1. Location of municipios in Puerto Rico.

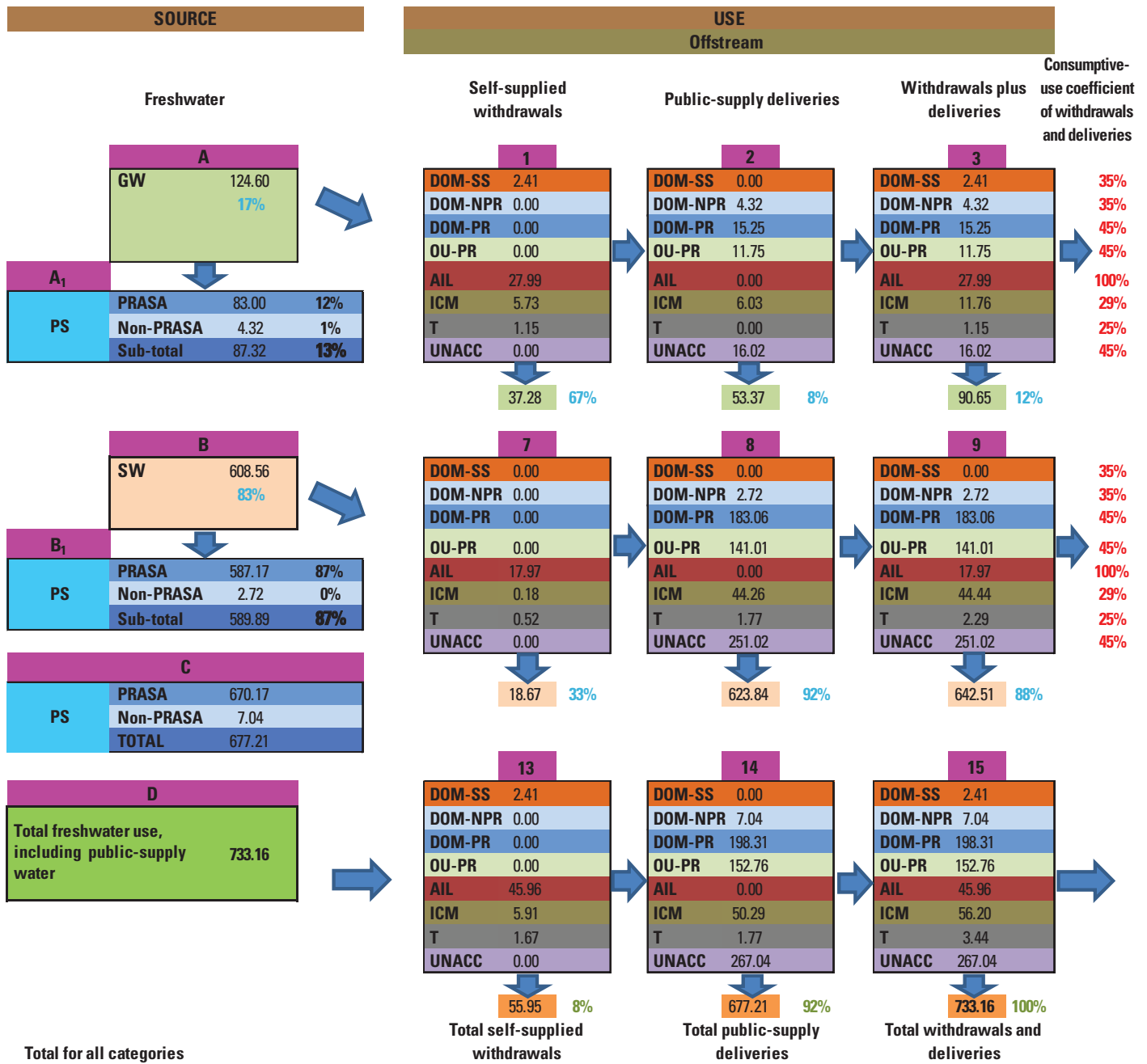


Figure 2. Source, use, and disposition of freshwater in Puerto Rico, 2010. [All values are in million gallons per day unless otherwise noted; GW, groundwater; SW, surface water; PS, public supply; PRASA, Puerto Rico Aqueduct and Sewer Authority; %, percent]

DISPOSITION

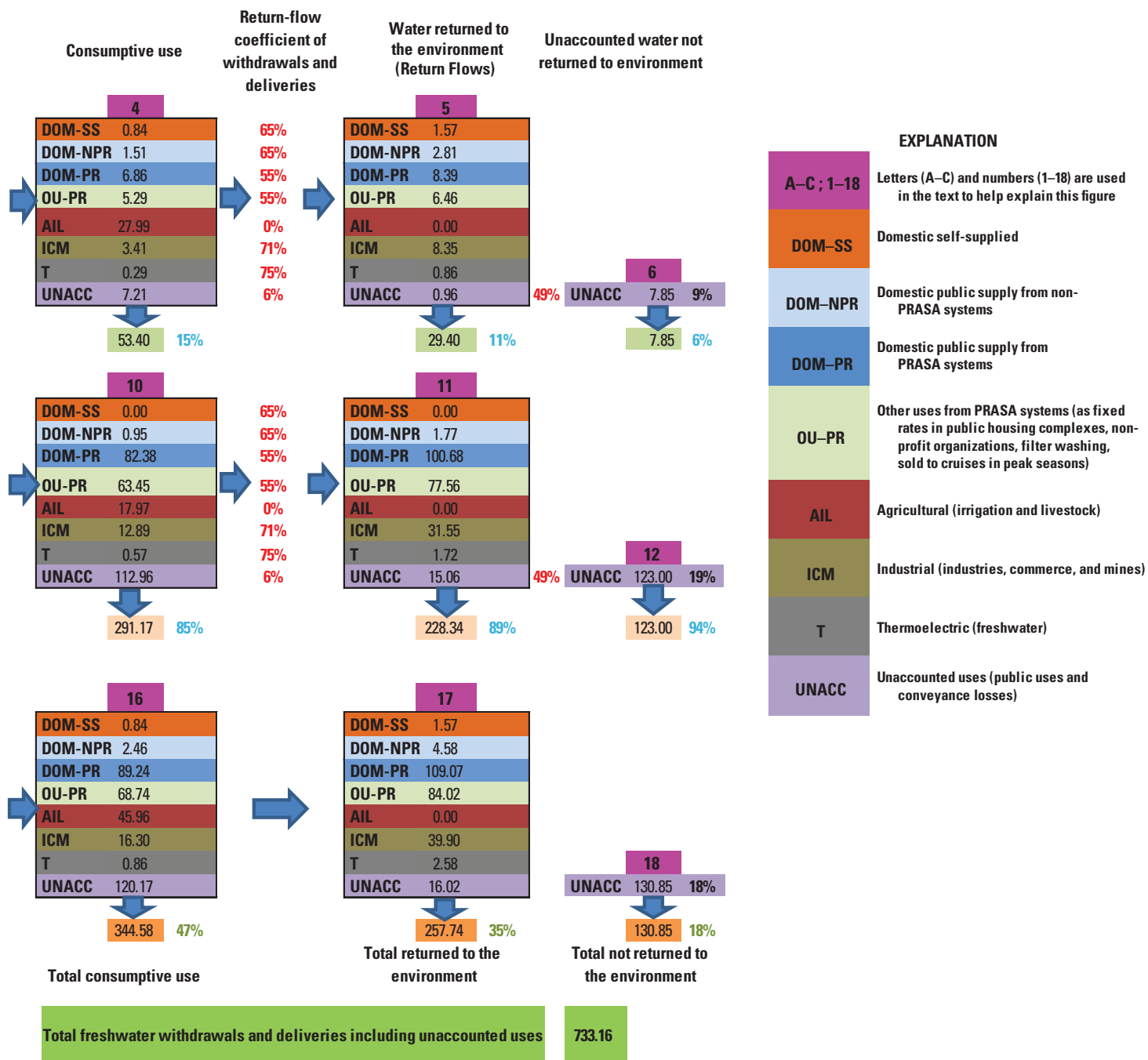


Figure 2.—Continued

Surface-water sources provided about 608.56 Mgal/d (SW in box B, fig. 2), or 83 percent, of the total freshwater withdrawn during 2010. Surface water supplied about 589.89 Mgal/d (PS subtotal in box B₁, fig. 2), or 87 percent, of total public-supply water withdrawals; the remaining 18.67 Mgal/d were self-supplied withdrawals (self-supplied withdrawals subtotal in box 7, fig. 2).

Use of Water

Four major water-use categories account for most of the offstream uses in Puerto Rico:

1. Domestic use: self-supplied withdrawals and PRASA and non-PRASA public-supply water deliveries represented as DOM-SS, DOM-PR, and DOM-NPR, respectively, in figure 2;
2. Agricultural use: irrigation and livestock represented as AIL in figure 2;
3. Industrial use: industries, commerce, and mines, represented as ICM in figure 2; and
4. Thermoelectric-power use represented as T in figure 2.

Other uses of water from PRASA systems were also considered during this analysis and are represented as OU-PR in figure 2. Other uses of water from PRASA include fixed amounts of water delivered to public housing complexes, water delivered to non-profit organizations, water used during filter backwashing, and water sold to cruise ships during the tourist season. Public-supply water delivered for other uses accounted for 152.76 Mgal/d (OU-PR in box 14, fig. 2), of which 11.75 Mgal/d were delivered from groundwater sources (OU-PR in box 2, fig. 2) and 141.01 Mgal/d were delivered from surface-water sources (OU-PR in box 8, fig. 2).

Domestic Use (Self-Supplied Withdrawals and PRASA and Non-PRASA Public-Supply Deliveries)

Domestic use includes water used for indoor and outdoor household purposes, such as drinking, preparing food, bathing, washing clothes and dishes, flushing toilets, cleaning vehicles, and maintaining lawns and gardens. The domestic use category combines the amount of water that is delivered from public-supply water systems (PRASA and non-PRASA) with water that is withdrawn by self-supplied systems.

During 2010, groundwater was the only source of domestic self-supplied withdrawals for 37,997 residents, and the withdrawals were estimated to be 2.41 Mgal/d (DOM-SS in box 13, fig. 2). The PRASA delivered 198.31 Mgal/d (DOM-PR in box 14, fig. 2) for domestic use to serve a population of 3.7 million residents. Of this 198.31 Mgal/d, groundwater sources provided 15.25 Mgal/d (DOM-PR in box 2, fig. 2), and surface water provided 183.06 Mgal/d (DOM-PR in box 8, fig. 2). On this basis, the PRASA domestic per capita use was estimated at 55 gallons per day (gal/d). The non-PRASA systems provided 7.04 Mgal/d (DOM-NPR in box 14, fig. 2) to serve a population of 101,627 residents. Groundwater and surface-water sources for non-PRASA systems were estimated to be 4.32 Mgal/d (DOM-NPR in box 2, fig. 2) and 2.72 Mgal/d (DOM-NPR in box 8, fig. 2), respectively. The average domestic per capita use for the non-PRASA systems was estimated as 69 gal/d.

Agricultural Use (Irrigation and Livestock)

Agricultural use includes the water applied for irrigation purposes and used for livestock practices. The estimated total quantity of water withdrawn for agricultural use (irrigation and livestock) during 2010 was 45.96 Mgal/d (AIL in box 13, fig. 2). Groundwater sources provided 22.42 Mgal/d for irrigation and 5.57 Mgal/d for livestock, for a total of 27.99 Mgal/d (AIL in box 1, fig. 2), mostly from the South Coastal Alluvial Plain aquifer system. Surface-water sources provided 15.73 Mgal/d for irrigation and 2.24 Mgal/d for livestock to total 17.97 Mgal/d (AIL in box 7, fig. 2). Groundwater and surface water from self-supplied sources satisfied the water requirements of 6.88 million animals, including poultry, in Puerto Rico during 2010 (U.S. Department of Agriculture, 2007).

All of the surface water withdrawn was provided by public irrigation districts that are operated by the Puerto Rico Electric and Power Authority and located near the south and northwest coasts of the island. All reported irrigation withdrawals are identified as self-supplied even though they were diverted from a public irrigation district.

Industrial (Combined Industrial, Commercial, and Mining) Use

The withdrawals for industrial, commercial, and mining facilities were combined into one category. Industrial use includes water used for manufacturing processes, such as fabrication, processing, washing, and cooling. Commercial use includes water used by hotels, restaurants, office buildings, commercial facilities, and civilian and military installations. Mining use includes water used for the extraction of sand and gravel.

Total use in this combined category during 2010 was estimated to be 56.20 Mgal/d (ICM in box 15, fig. 2). Self-supplied withdrawals accounted for 5.91 Mgal/d (ICM in box 13, fig. 2). The remaining 50.29 Mgal/d (ICM in box 14, fig. 2) were delivered from public-supply water systems.

Thermoelectric-Power Water Use

The thermoelectric-power category includes water used in the generation of electric power with fossil fuels. The largest amount of water used by thermoelectric power facilities was from seawater sources, but that amount of water was not included in this report about freshwater uses. Freshwater withdrawals accounted for 3.44 Mgal/d (T in box 15, fig. 2), of which self-supplied withdrawals accounted for 1.67 Mgal/d (T in box 13, fig. 2), and the remaining 1.77 Mgal/d (T in box 14, fig. 2) was from public-supply water systems.

Unaccounted Use (Public-Water Use and Conveyance Losses)

The unaccounted water use combines public-water use and conveyance losses. Public-water use includes water for non-individual consumption activities such as firefighting, street washing, and recreational activities at municipal parks. Conveyance loss includes water that is lost while in transit from a pipe or canal system due to leakage or evaporation. Water that is lost due to groundwater leakage and (or) percolation to an aquifer can become subsequently available and can be considered a return flow. An apparent loss is the term used for water that is delivered to customers but not metered. This loss is attributed to unmetered systems, errors in water accounting, and unauthorized use of water.

In 2010, public-water use and conveyance losses accounted for 267.04 Mgal/d (UNACC in box 15, fig. 2). Groundwater was the source for 16.02 Mgal/d (UNACC in box 3, fig. 2), and surface water was the source for 251.02 Mgal/d (UNACC in box 9, fig. 2); 120.17 Mgal/d (UNACC in box 16, fig. 2) were consumed and were not returned to the environment. Water returned to the environment totaled 16.02 Mgal/d (UNACC in box 17, fig. 2). The remaining 130.85 Mgal/d (UNACC in box 18, fig. 2) were lost or removed from the environment and were unavailable for subsequent use.

Disposition of Water

For this report, disposition refers to the destination of water consumed (consumptive use) or returned to the environment (return flows). A consumptive-use coefficient is defined as the percentage of water removed from the immediate environment by evaporation, transpiration, incorporation into crops, or consumption by humans or livestock. Consumptive-use coefficients were calculated by applying the following equation:

$$\text{Consumptive-use coefficient in percent} = \left(\frac{\text{Water consumed}}{\text{Water withdrawn and delivered}} \right) \times 100.$$

Table 1 contains the estimated consumptive-use and return-flow coefficients for Puerto Rico by category during 2010. The consumptive-use coefficient for domestic public-supply water supplied by PRASA (domestic public supply in table 1) was estimated to be 45 percent, which is greater than that for domestic public-supply water from non-PRASA (35 percent) and greater than that for domestic self-supplied water (35 percent). This difference occurs because water from PRASA domestic deliveries generally includes outdoor uses, resulting in a higher consumptive-use rate.

Table 1. Estimated consumptive-use and return-flow coefficients, in percent, for Puerto Rico, 2010.

[Source: U.S. Geological Survey Caribbean Florida Water Science Center; PRASA, Puerto Rico Aqueduct and Sewer Authority]

Water-use categories	Consumptive-use coefficient (percent)	Return-flow coefficient (percent)
Domestic self-supplied	35	65
Domestic public supply (Non-PRASA)	35	65
Domestic public supply (PRASA)	45	55
Other uses (PRASA)	45	55
Agricultural (irrigation and livestock)	100	0
Industrial (industries, commerce, and mines)	29	71
Thermoelectric (fresh-water)	25	75
Unaccounted uses (public uses and conveyance losses)	45	6

The consumptive-use coefficient for agricultural use (irrigation and livestock) was 100 percent (table 1). Puerto Rico has one of the highest estimated mean evapotranspiration rates in the United States (45 inches per year) (Hanson, 1991); therefore, all of the water withdrawn for agricultural activities in Puerto Rico was considered to be consumed (100 percent) and return flows were estimated to be 0 Mgal/d.

Calculating consumptive uses in Puerto Rico is challenging because information on return flows and conveyance losses is difficult to obtain. There are not published supporting data for the estimated consumptive-use coefficients in Puerto Rico; however, the estimated consumptive-use coefficients used in this fact sheet are in the range of values presented by Shafer and Runkle (2007) in a comprehensive investigation of consumptive-use coefficients reported in the literature for the Great Lakes Basin and climatically similar areas.

A return-flow coefficient (table 1) was estimated for each category of water that is not consumptively used and is returned to the environment. Return-flow coefficients were calculated by applying the following equation:

$$\text{Return-flow coefficient in percent} = \left(\frac{\text{Water returned}}{\text{Water withdrawn and delivered}} \right) \times 100.$$

Summary

In Puerto Rico, groundwater and surface-water sources accounted for 733.16 Mgal/d in 2010. Groundwater sources provided 124.60 Mgal/d, or 17 percent, and surface water provided 608.56 Mgal/d, or 83 percent, of the total water withdrawals. Self-supplied withdrawals were estimated as 55.95 Mgal/d, and public-supply deliveries totaled 677.21 Mgal/d. Total consumptive use was estimated as 344.58 Mgal/d; 53.40 Mgal/d were used from groundwater sources and 291.17 Mgal/d from surface-water sources. The consumptive use for each category of use was estimated by applying a consumptive-use coefficient. The consumptive-use coefficients varied from 100 percent for agricultural water use (irrigation and livestock) to 25 percent for freshwater used by thermoelectric-power plants. Return flows totaled 257.74 Mgal/d, and the remaining 130.85 Mgal/d were lost or removed from the environment and were unavailable for subsequent use.

Puerto Rico Water-Use Facts for 2010

- Offstream uses totaled 733.16 Mgal/d.
- Surface water provided 608.56 Mgal/d, or 83 percent, and groundwater provided 124.60 Mgal/d, or 17 percent, of the total offstream water used in Puerto Rico.
- Public-supply water systems distributed water to almost 99 percent of the residents in Puerto Rico.
- About 677 Mgal/d of water were delivered for public-supply water uses.

- Domestic water use accounted for 30 percent (7.04 Mgal/d for non-PRASA systems and 198.31 Mgal/d from PRASA systems) of the total water distributed for public-supply uses.
- The daily average domestic per capita use for the PRASA systems was estimated as 55 gallons.
- The daily average domestic per capita for the non-PRASA systems was estimated as 69 gallons.
- About 45 percent of the water produced for domestic use by PRASA public-supply water systems was mostly consumed through outdoor activities.
- Agricultural water use was estimated to be 45.96 Mgal/d, and 61 percent of this water was obtained from aquifers. All of the water used for agricultural purposes (irrigation and livestock) is assumed to be consumed.
- Unaccounted use (public-water use and conveyance losses) accounted for 267.04 Mgal/d, mostly from public-supply deliveries.
- Consumptive uses were estimated as 344.58 Mgal/d, return flows were estimated as 257.74 Mgal/d, and 130.85 Mgal/d were lost or removed from the environment and were unavailable for subsequent use.
- The mean annual evapotranspiration rate for Puerto Rico was estimated to be 45 inches per year, which is one of the highest evapotranspiration rates in the United States.

Additional information and water-use facts are available in U.S. Geological Survey Open-File Report 2014–1117, Estimated water use in Puerto Rico, 2010, by W.L. Molina-Rivera (<http://dx.doi.org/10.3133/ofr20141117>).

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