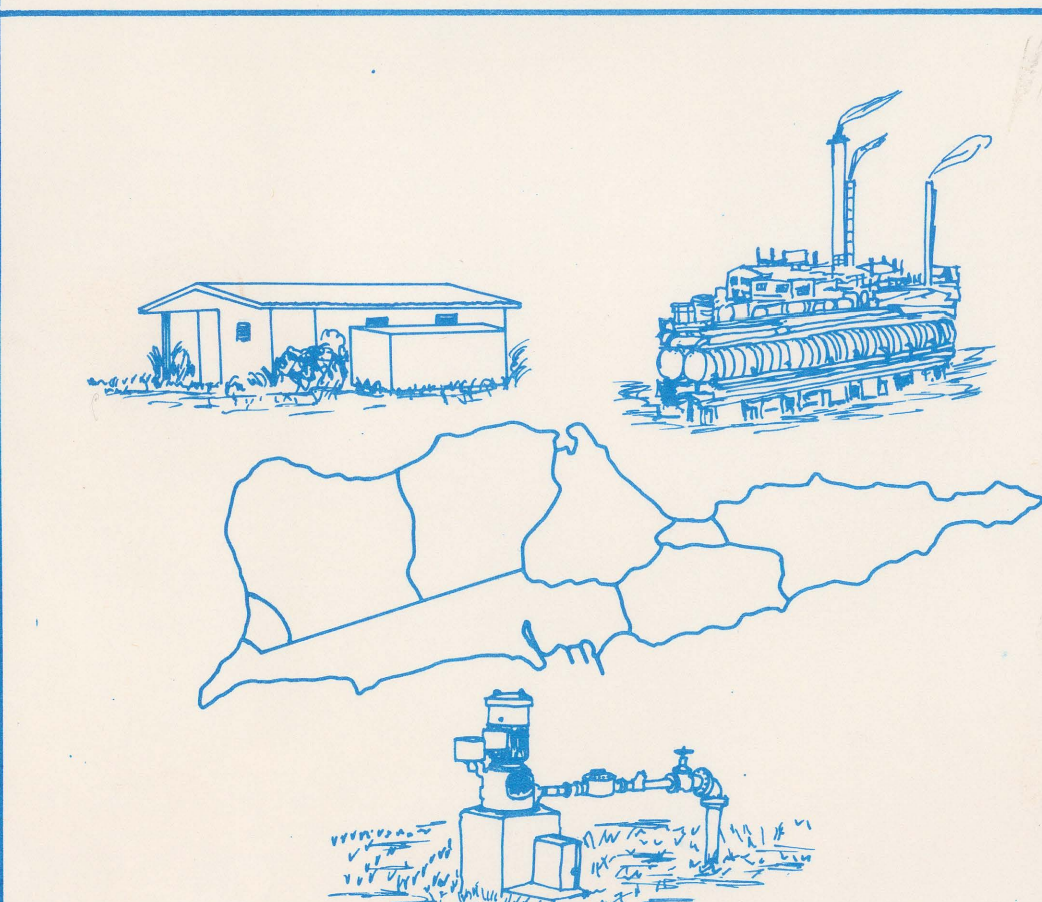


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ESTIMATED WATER USE IN ST. CROIX, U.S. VIRGIN ISLANDS, OCTOBER 1983 - SEPTEMBER 1985

By
Heriberto Torres-Sierra



Prepared in cooperation with the
CARIBBEAN RESEARCH INSTITUTE
COLLEGE OF THE VIRGIN ISLANDS
ST. THOMAS, U.S. VIRGIN ISLANDS

1987

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INTRODUCTION

St. Croix is the largest of the U.S. Virgin Islands, with a land area of 82 square miles. The island is located about 60 miles east-southeast of Puerto Rico and about 40 miles south of St. Thomas and St. John (fig. 1). St. Croix has experienced a dramatic increase in its population over the last 25 years, growing from about 15,000 inhabitants in 1960 to

about 54,000 in 1985 (personal communication, U.S. Virgin Islands Planning Office). Tourism development has also resulted in a large transient population with demands for services and facilities. The population and economic growth of St. Croix has resulted in a significant increase in the demand and supply of water (fig. 2).

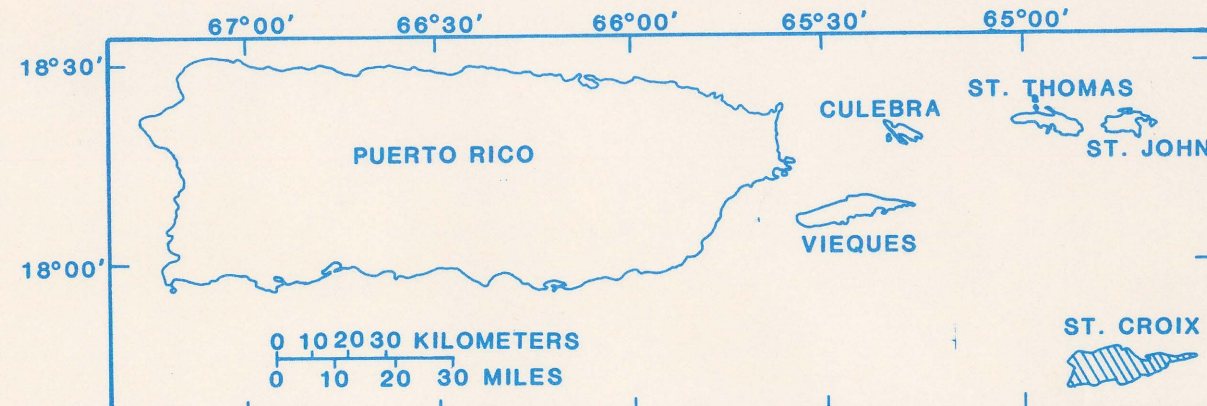


Figure 1. Location of the U.S. Virgin Islands.

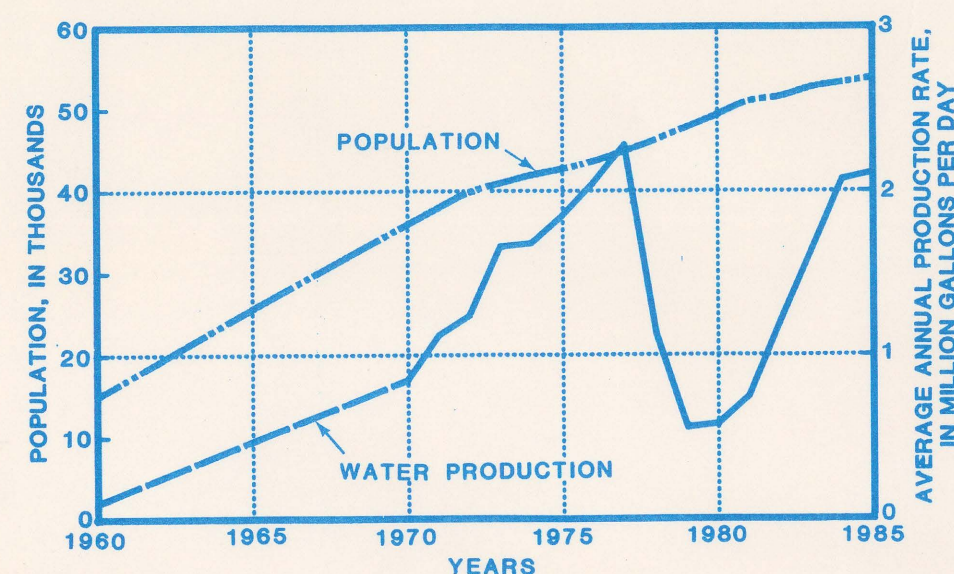


Figure 2. Water production and population trends in St. Croix. (Source: Virgin Islands Office of Policy, Planning, and Research.)

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

INTRODUCTION (Continued)

Water is not an abundant resource in St. Croix. Rainfall islandwide averages about 45 inches per year, most of which occurs during the rainy months from September to November (U.S. Geological Survey, 1984). Investigations conducted by Jordan (1975) show that as much as 90-95 percent of the precipitation is evapotranspired or runs off to the ocean. Rainfall catchments and cisterns are used extensively to collect and store water for domestic uses. There are no perennial streams in St. Croix, with most of the creeks and guts flowing only during intense rainstorms. Ground water is generally limited to the Kingshill

WATER SOURCES

Water in St. Croix is obtained principally from the sea, with smaller amounts from aquifers and rainfall catchments. The total water used during 1985 averaged about 72.4 million gallons per day (Mgal/d). Seawater use averaged about 70.6 Mgal/d. Ground water pumpage averaged 1.29 Mgal/d, while rainfall catchment systems collected about 0.49 Mgal/d (fig. 3).

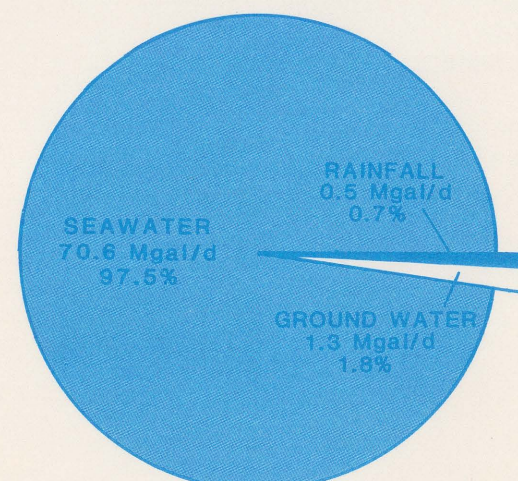


Figure 3. Water sources in St. Croix.

WATER USES

The principal uses of water in St. Croix include thermoelectric power generation, desalination for domestic supply, public water supply, public waste-water treatment, and domestic, commercial, and industrial self-supplied (fig. 4). Seawater is used for cooling at thermoelectric power generating plants and for freshwater production for public supply at desalination plants (figs. 5a and 5b). The power and desalination plants are operated by the Virgin Islands Water and Power Authority (WAPA). Several industries and hotels also use seawater to produce freshwater

(fig. 5c). Seawater is also used for fire emergencies and flushing of toilets in Christiansted and Frederiksted.

Ground water is used mainly by domestic, commercial, and industrial self-supplied users, which are not connected to the public water supply system (figs. 5d and 5e). The V.I. Department of Public Works (VIDPW) uses ground water to supplement desalinated water in the public supply system.

Rainwater is used by individual homeowners, commercial, and industrial facilities.

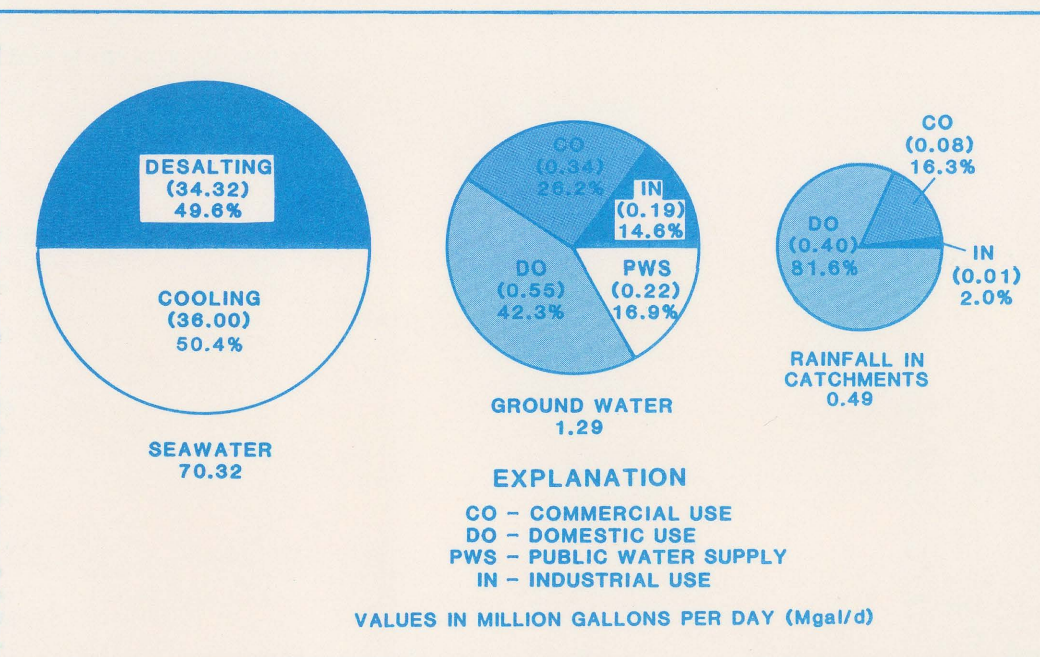


Figure 4. Estimated water use by source and major use category in St. Croix during 1985.



Figure 5c. Industrial self-supplied.

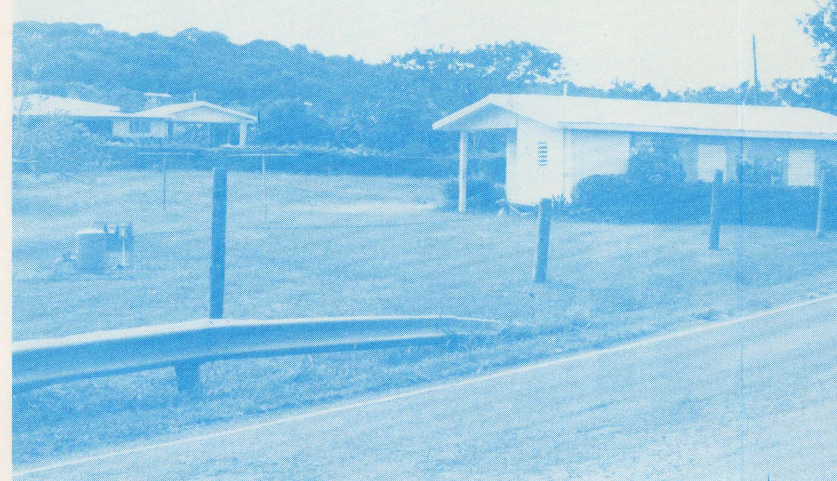


Figure 5d. Domestic self-supplied.



Figure 5e. Commercial self-supplied.

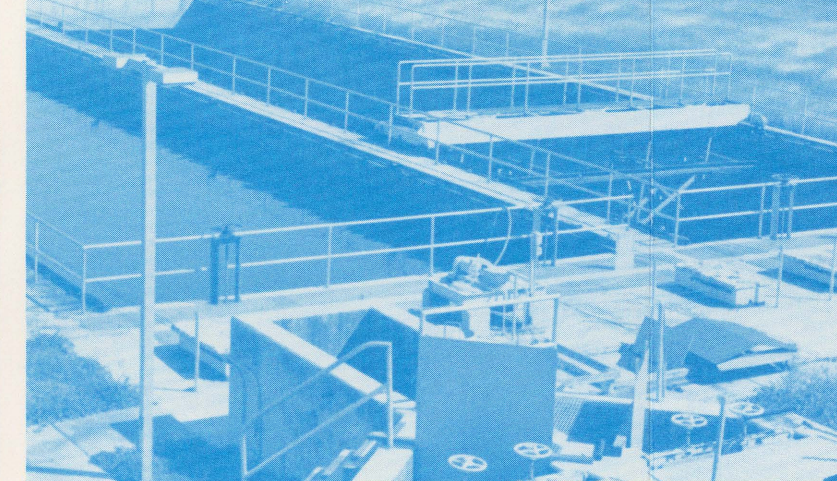


Figure 5f. Public waste-water treatment.



Figure 5a. Thermoelectric power generation.



Figure 5b. Domestic withdrawals from public water supply.

Public-Water Supply

The public-water supply system in St. Croix serves about 30,000 people (60 percent of the population), mostly in the urban areas of Christiansted and Frederiksted and along Centerline road (fig. 6). The desalination plants that feed freshwater to the system are located in Christiansted, where the water is pumped toward Frederiksted. Ground water is pumped into the distribution system halfway between the two towns. The distribution system covers about 14 square miles and operates under a combination of gravity and pumped pressure zones, (CH2M Hill Southeast, 1983).

The public water supply system in St. Croix provided about 2.11 Mgal/d during the study period or about 70 gallons per day per person. About 90 percent of the water (1.9 Mgal/d) was from the desalination plants operated by

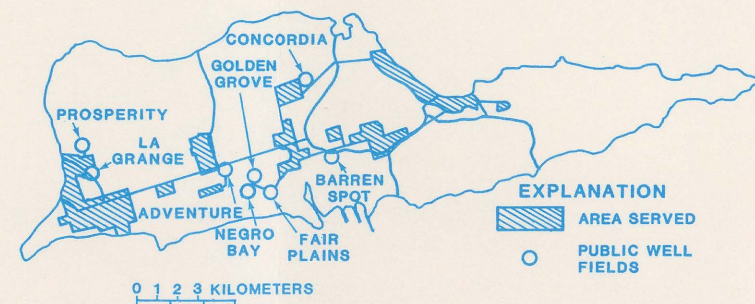


Figure 6. Area served by the freshwater distribution system and location of public supply well fields.

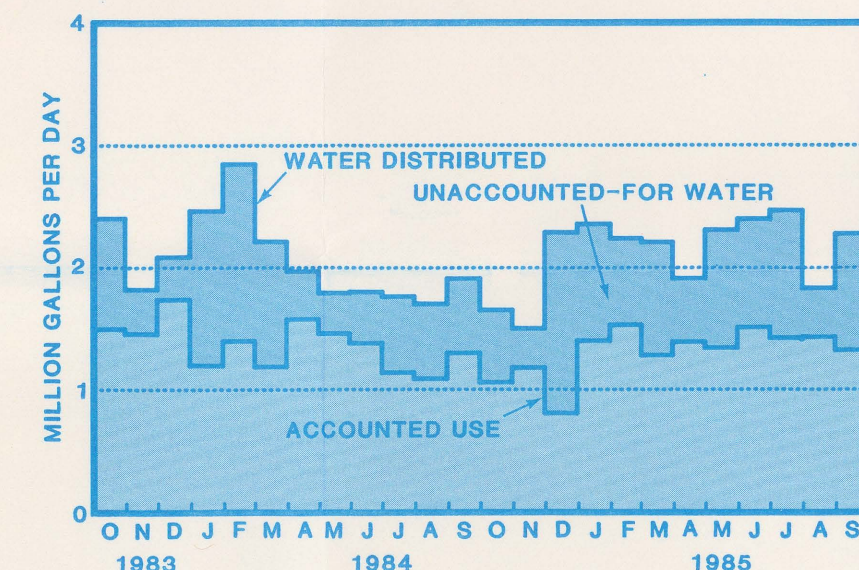


Figure 7. Comparison of the quantity of water distributed and accounted use by the Virgin Islands Department of Public Works.

WAPA. Ground water from the VIDPW well fields provided the remaining 0.21 Mgal/d. Production and delivery records show that only about 66 percent (1.4 Mgal/d) of the water produced is accounted for (fig. 7). Most of the water losses, about 0.72 Mgal/d (equivalent to 500 gallons per minute), are due to leaks in the distribution system and unauthorized connections.

There are two public seawater supply systems in St. Croix, one in Christiansted and the other in Frederiksted. Presently the system in Frederiksted is shut down (Peebles and others, 1979). Water pumped to the Christiansted system average 0.27 Mgal/d (Black, Crow, and Eidsness, Inc., 1976). The system is used for fire protection and for flushing of toilets at some of the Virgin Islands Housing Authority's projects.

Thermoelectric Power Generation

Thermoelectric power generation by WAPA in St. Croix during the study period required about 36 Mgal/d of seawater. The water was used for cooling of condensers. The

thermoelectric plants used about 0.06 Mgal/d of freshwater as boiler feed. Freshwater for this purpose was obtained from the desalination plants.

Industrial Self-Supplied

Petroleum refining and rum production are the principal industries in St. Croix that supply their own water. The petroleum refinery used about 14 Mgal/d of seawater for cooling and desalination purposes. Freshwater production at the refinery was about

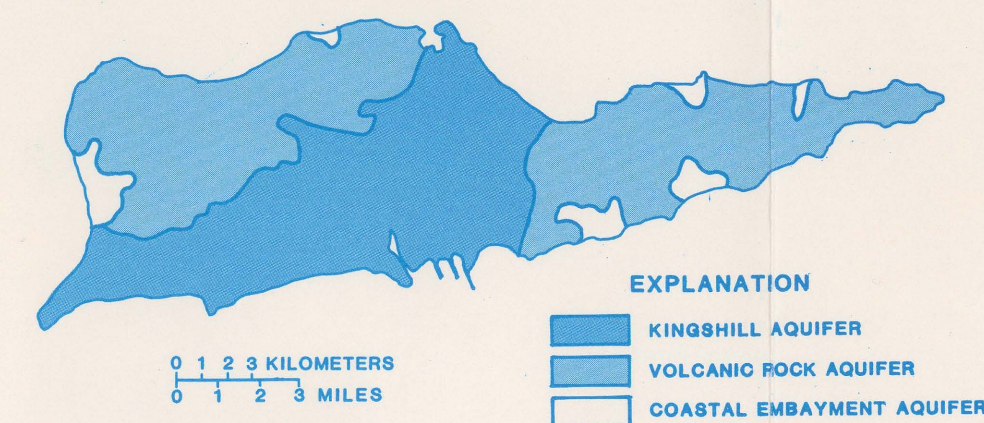
1.5 Mgal/d. The refinery also used about 0.15 Mgal/d of brackish ground water in processing crude oil. Rum distilleries used about 0.04 Mgal/d of ground water and 0.01 Mgal/d of rainwater collected in cisterns.

Domestic Self-Supplied

About 24,000 people in St. Croix supply their own water needs from ground water, rainwater collected from rooftops, or purchases from private water haulers. Estimated water use for this category was about 0.95 Mgal/d, or a per capita usage of about 40 gallons per day.

Ground water withdrawals for domestic self-supplied use was estimated at about 0.50 Mgal/d (58 percent of total use). Of this amount, 0.45

Mgal/d was obtained from private supply wells (Virgin Islands Department of Conservation and Cultural Affairs, personal communication, 1985). The remaining 0.05 Mgal/d was pumped by commercial water haulers. Several of these wells were visited during the study period as a quality assurance measure. Ground water for domestic use is available in nearly all parts of the island. The principal aquifers and their characteristics are shown in fig. 8.



Aquifer name and description	Aquifer thickness in 1980 (feet)	Well characteristics		Remarks
		Depth (feet)	Yield (gallons per minute)	
Kingshill aquifer: A complex of sand and lignitic limestone, marl, calcareous sandstone, and sand and gravel. Alluvium blankets west of aquifer along the coast and within drainage basins. Unconfined.	0.1	100-150	20-40	Mineralized solids vary considerably with depth, generally 1,500 to 3,000 mg/l, but exceed 20,000 mg/l in some wells.
Coastal embayment aquifer: Weathered rock, overlain by alluvium and beach deposits. Generally unconfined; unconfined conditions may exist within surficial deposits.	0.1	50-100	15-25	Water generally contains more than 2,000 mg/l dissolved solids; used to supply recreational water and desalination plants.
Volcanic rock aquifer: Weathered or fractured rock. Recharge is uncertain.	0.3	100-150	5-10	Wells commonly yield water with excessive concentrations of iron and manganese.

Figure 8. Principal aquifers and well characteristics in St. Croix.

Acknowledgments

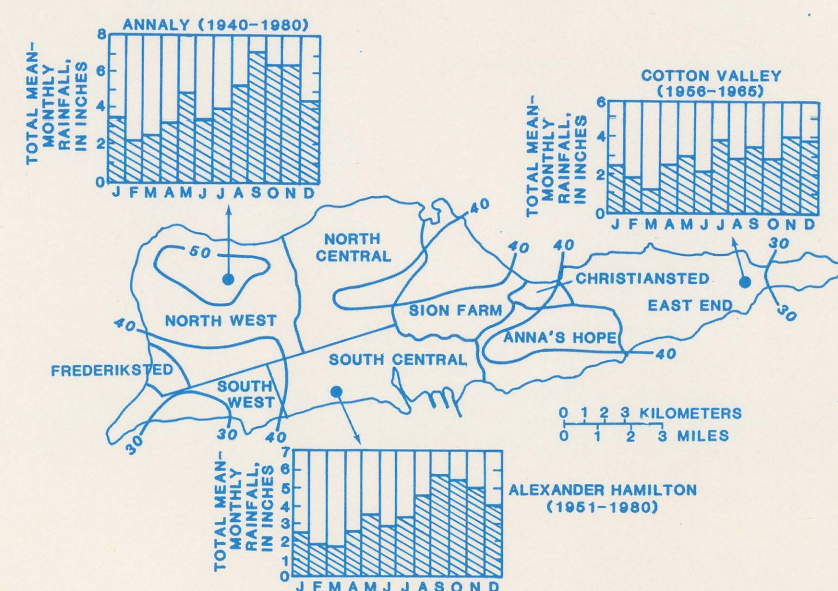
The author would like to acknowledge the following Virgin Islands Government Agencies and private industry employees for their cooperation: The Virgin Islands Public Works Department - Mr. Endel Hansen and Mr. Frederik Van Putten, The Virgin Islands Water and Power Authority - Mr. Adelbert Nico and Eng. Gregory Willocks, The Virgin Islands Planning Office - Mrs. Vena M. Springer, Bear Oil Virgin Islands Corporation - Eng. Barry L. Sans, and Cruzan Rum Inc. - Mr. Donald C. Neithropp.

The author also thanks the commercial water haulers and the managers and maintenance engineers of the St. Croix hotels and condominiums for their cooperation.

Domestic Self-supplied (Continued)

About 0.40 Mgal/d of the domestic self-supplied water was supplied from rainfall. Cisterns to store roof runoff are an important source of water supply for most private rural homes. The quantity of rainwater collected in a cistern is a function of the amount of rainfall, roof area and configuration, wind velocity, and weather conditions (Jordan and Cosner, 1973). Estimates of monthly rainfall recovery and cistern yield were made considering the following factors: 1) number of non-served housing units in each district, 2) roof area of 1,000

square feet per housing unit, 3) monthly rainfall in each district from October 1983 to September 1984, 4) a recovery of 70 percent of total rainfall (Jordan and Cosner, 1973). The estimates indicated that in areas with average rainfall of 50 inches per year (North West district) cisterns can supply about 50 percent of the total water needs. In areas of lower rainfall (East End district), with an average rainfall of about 35 inches per year) only 30 percent of the water needs can be obtained from rainfall (fig. 9).



PLANNING DISTRICT	NUMBER HOUSING UNITS	MONTHLY RAINFALL RECOVERY IN MILLION GALLONS PER DAY												WATER YEAR TOTAL (Mgal/d)	ANNUAL AVERAGE (Mgal/d)	YIELD (Gal/d)
		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT			
ELON PARK	1659	0.05	0.17	0.04	0.07	0.06	0.02	0.03	0.04	0.16	0.06	0.14	0.06	0.86	0.07	44
CHRISTIANSTED	318	0.01	0.04	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.18	0.01	44
FREDERIKSTED	18	0.03	0.09	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.06	0.04	0.46	0.04	44
SOUTH WEST	864	0.07	0.10	0.05	0.05	0.04	0.02	0.02	0.03	0.05	0.05	0.06	0.09	0.81	0.05	50
SOUTH CENTRAL	1034	0.01	0.14	0.09	0.09	0.04	0.01	0.02	0.05	0.05	0.07	0.08	0.14	0.87	0.07	50
NORTH CENTRAL	1450	0.02	0.13	0.04	0.04	0.05	0.01	0.01	0.03	0.05	0.10	0.05	0.10	0.63	0.05	45
ADNA'S HOPE	1148	0.01	0.10	0.08	0.08	0.02	0.02	0.04	0.08	0.10	0.08	0.13	0.05	0.87	0.07	54
NORTH WEST	1343	0.01	0.08	0.04	0.03	0.02	0.01	0.01	0.01	0.02	0.05	0.02	0.05	0.34	0.03	44
EAST END	949	0.01	0.08	0.04	0.03	0.02	0.01	0.01	0.01	0.02	0.05	0.02	0.05	0.34	0.03	44
TOTAL	8507	0.25	0.85	0.37	0.37	0.30	0.11	0.16	0.25	0.33	0.70	0.38	0.73	4.78	0.39	44

NOTE: --- VALUES LESS THAN 0.01 Mgal/d.

Figure 9. Monthly rainfall recovery and average annual yield by planning district in St. Croix during October 1983 to September 1984.

Commercial Self-Supplied

The principal commercial self-supplied users in St. Croix are hotels, with about 1.27 Mgal/d of the total self-supplied use of 1.42 Mgal/d. The hotels used about 1.0 Mgal/d of seawater as feedwater for small desalination plants, producing about 0.1 Mgal/d of freshwater. Other sources of water for the hotels include 0.19 Mgal/d from ground water (water haulers provide about 0.04 Mgal/d), and 0.08 Mgal/d from rainfall. Other commercial facilities (airport, laundries, gasoline stations) use about 0.15 Mgal/d of ground water.

SUMMARY

Seawater, ground water, and rainwater collected from residential rooftops are the main sources of water in St. Croix. Seawater use was about 70.6 Mgal/d, mostly for cooling at thermoelectric power plants (36 Mgal/d) and as feedwater for desalination plants (34.3 Mgal/d). The seawater distribution system supplied about 0.27 Mgal/d for fire protection and for flushing of toilets (fig. 10).

Ground-water use averaged 1.29 Mgal/d, mostly by self-supplied establishments and individual homes. Rainwater collected from rooftops provided about 0.49 Mgal/d to private homes, hotels, and industries.

Freshwater production from the desalination plants averaged 3.5 Mgal/d in 1985, with production about equally split between WAPA and self-supplied industries. Only about 66 percent of the water produced by WAPA is accounted for.

Discharges from the local waste-water treatment plant were about 0.70 Mgal/d.

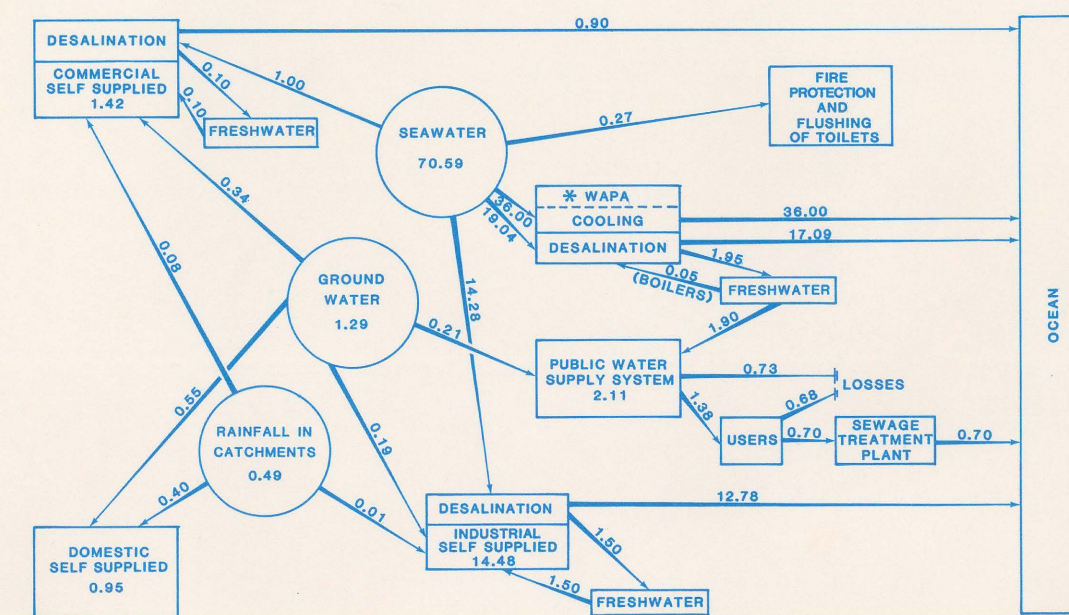


Figure 10. Water use in St. Croix during 1985.

WATER RESOURCES DIVISION
OPEN-FILE DATA REPORT 86-537

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CONVERSION TABLE

The following factors may be used to convert inch-pound units of measurement in this report to International System (SI) units.		
Multiply inch-pound unit by	Length	To obtain SI unit
inches (in.)	25.4	millimeters (mm)
miles (mi.)	1.609	kilometers (km)
Area		
square feet (ft ²)	0.0929	square meters (m ²)
square miles (mi ²)	2.590	square kilometers (km ²)
Volume		
gallons (gal)	3.785	liters (L)
Flow		
gallons per minute (gal/min)	0.06309	liters per second (L/s)
gallons per day (gal/d)	3.785	liters per day (L/d)
million gallons per day (Mgal/d)	0.04381	cubic meters per day (m ³ /d)

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