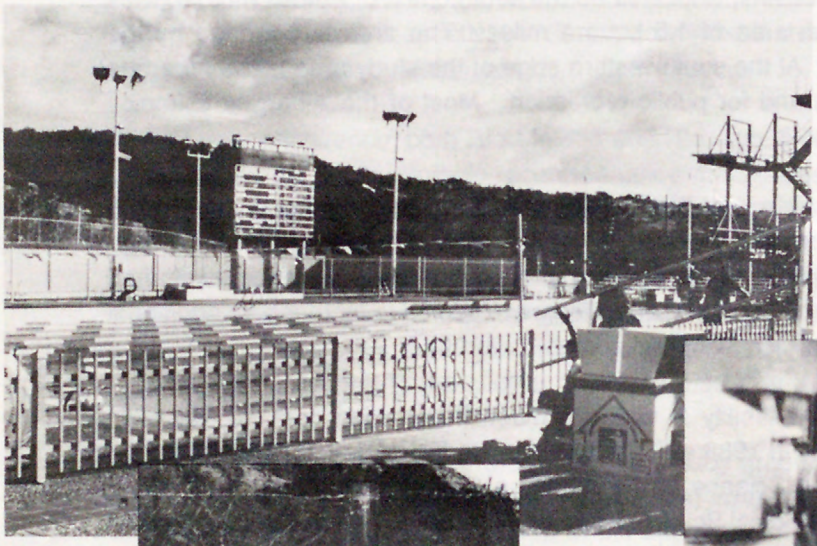
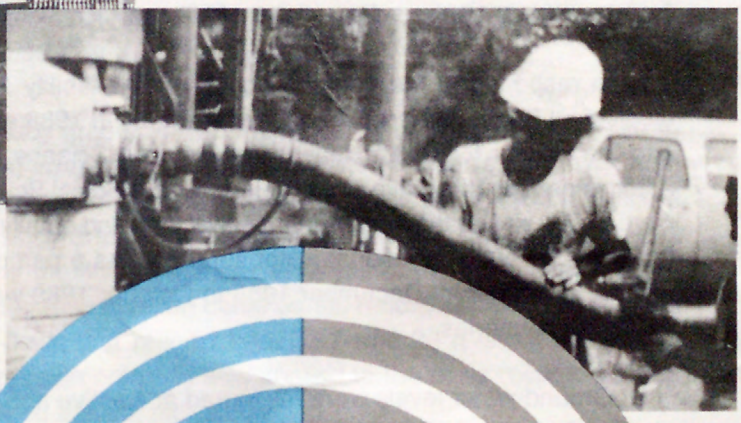
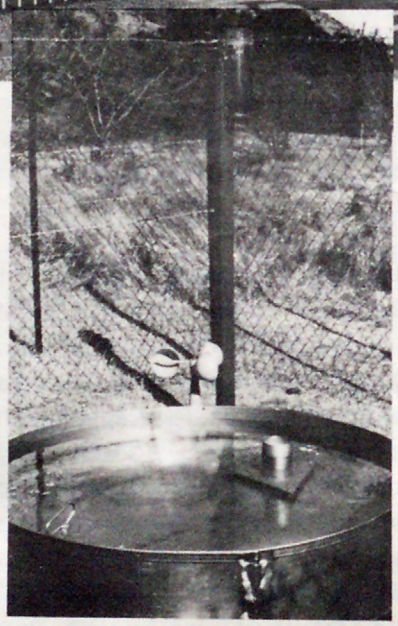
ELEVATION OF WATER TABLE AND HYDROLOGIC CONDITIONS IN THE RIO LAPA TO RIO MAJADA AREA, PUERTO RICO, FOR DECEMBER 1988, AND APRIL, JULY, AND OCTOBER 1989.







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ELEVATION OF THE WATER TABLE AND HYDROLOGIC CONDITIONS IN THE RIO LAPA TO RIO MAJADA AREA, PUERTO RICO, FOR DECEMBER 1988, AND APRIL, JULY, AND OCTOBER 1989.

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An increasing demand for water and a limited supply of both ground water and surface water are common problems on the south coast of Puerto Rico. The variability in rainfall throughout the year reduces the streamflow and lowers the water table during the dry season. The study area (fig. 1), which is part of the Río Majada and Río Lapa inter-mountain basins, is located on the south coast of Puerto Rico, 5 miles north-northeast of Salinas, and comprises an area of 1.5 square miles. The area is bounded by the alluvium-bedrock contact of the valley edges. At the southwestern edge of the study area is the Albergue Olímpico -a facility used for training athletes and for public recreation. Most of the Albergue Olímpico facility is not in the study area, but adjacent to it.

Ground-water withdrawals in the alluvial valleys of Río Majada and Río Lapa were increased in 1986 to meet the water-supply needs of the Albergue Olímpico. Prior to 1986, the average ground-water withdrawal rate in these valleys was 0.13 Mgal/d (million gallons per day), but by 1989, withdrawals had increased to 0.29 Mgal/d. Water-supply demands at the new facility are expected to increase an additional 0.10 Mgal/d by 1995 (J. Cruz-Vález, Albergue Olímpico, oral commun., 1990).

In response to the concern about the availability of water to meet the growing demand, the U.S. Geological Survey initiated a cooperative study in 1988 with the Puerto Rico Environmental Quality Board and the Center for Sport Health and Exercise Science of the Albergue Olímpico, the latter of which is administered by the University of Puerto Rico Medical Science Campus. The objectives of the investigation were to: (1) define the occurrence, availability, and quality of water resources, and (2) describe alternatives for development of additional water supplies. As a part of the overall investigation, hydrologic conditions for four periods from December 1988 to October 1989 were inventoried. This report presents the results of those inventories.

Ground-water levels were measured at 4 active and 5 abandoned or unused production wells and 12 observation wells in December 1988, and in April, July, and October 1989 (table 1 and fig. 1). These data were used to construct water-table maps for wet, dry, and intermediate hydrologic conditions. Water-level measurements were referenced to mean sea level. Stream-discharge measurements were made concurrent with the ground-water level measurements at seven sites along Río Majada, Río Lapa, and the Río Majada diversion canal. Flowing segments of the streams were also delineated. Additional data collected in the area included continuous measurements of stage at Río Majada and Río Lapa, from which discharges were estimated (sites 1 and 2), continuous ground-water level recording at five selected test wells (sites 9, 19, 21, 22, and 30), and rainfall and pan evaporation measurements at site 31 (fig. 1). The rainfall, pan evaporation, discharge, and water-level data collected at the monitoring sites are shown in figure 2.

Rainfall in the study area ranged from 0.06 to 7.57 in/mo (inches per month) and totaled 16.51 inches during the eleven months in which rainfall data were collected (February to December 1989). However, rainfall in the headwaters of the two streams ranged from 0.50 to 14.9 in/mo and totaled 50.3 inches in 1989 (Eloy Colón-Dieppa, U.S. National Oceanic and Atmospheric Administration, Weather Bureau, oral commun., 1990). Rainfall in the headwaters of the streams was about 35 percent less than the average annual rainfall of 77.2 inches for 1951 to 1980 and about 3 times higher than rainfall in the study area

during 1989 (U.S. National Oceanic and Atmospheric Administration, 1982). Pan evaporation in the study area ranged from 4.70 to 8.15 in/mo and totaled 70.1 inches for February to December 1989, more than 4 times the rainfall. The 30-day moving average shown in figure 2 indicates the trends in measured rainfall and pan evaporation.

Streamflow varied seasonally in response to rainfall in the Río Lapa and Río Majada basins (fig. 2). The streams had poorly sustained flows during 1989. Base-flow recession occurred from January to August and the lowest flows occurred during July and August. Mean monthly flows ranged from 0.62 to 30.1 ft^3/s (cubic feet per second) for Río Majada and 0.46 to 29.1 ft^3/s for Río Lapa during 1989. During January 1989, Río Majada and Río Lapa had average flows of 2.95 and 1.14 ft^3/s, respectively. The flow recession for both streams was about 0.01 ft^3/s per day for January to August 1989. Streamflow increased during September and October as a result of increased rainfall in the study area and in the headwaters. Average streamflows during the wet season (September and October) were 16.5 and 21.5 ft^3/s for Río Majada and Río Lapa, respectively. Streamflow in both streams decreased in November and December 1989 due to decreased rainfall.

At their confluence, both Río Majada and Río Lapa were dry in 1989, except during September and October. During the hydrologic reconnaissance measurements, no flow was observed at site 5 on Río Majada from April to August, or at site 7 on Río Lapa from January to August.

Flow out of the study area occurred during the high flows of September and October 1989 (fig. 2). Measured flow at the lower reach of Río Majada (site 6) was 2.20 ft^3/s on October 11, 1989. The incoming streamflow to the study area was 7.42 ft^3/s on the same day, indicating a net loss from the streams to evapotranspiration and to the alluvial aquifer of 5.22 ft^3/s.

The volume of water diverted outside the study area from Río Majada at the diversion canal (site 4) was estimated to be at least 58,800 ft^3/d (0.68 ft^3/s) from January to August 1989. This diversion amounted to about 40 percent of the streamflow in the upper Río Majada and resulted in a reduction in the amount of water available to recharge the aquifer in the study area. This estimate is based on the power curve-fit correlation (Riggs, 1968, p. 10) of instantaneous monthly flow measurements from Río Majada gaging station (site 1) with monthly flow rates measured at the diversion canal partial-record station (site 4). The correlation was constrained to measured base-flows that ranged from 0.47 to 2.26 ft^3/s. A correlation coefficient (r) of 0.84 was determined and the equation obtained was applied to the flows recorded at the Río Majada gaging station between the constrained values, inclusively.

Ground water generally flows west in the upper Río Majada Valley, south in the Río Lapa Valley, and southwest in the lower Río Majada Valley. In general, the slope of the water table reflects the slope of the land surface (fig. 3a, b, c, d). The average hydraulic gradient in the aquifer is 50 ft/mi (feet per mile) and varied from 37 to 42 ft/mi in the upper Río Majada Valley, from 46 to 52 ft/mi in the lower Río Majada Valley, and from 50 to 70 ft/mi at the Río Lapa Valley during the period of data collection. Water levels at observation wells declined at an average rate of 0.03 ft/d from January to August 1989 in the upper and lower part of the Río Majada Valley and declined by 0.05 ft/d for the same period in the Río Lapa Valley (fig. 2). However, ground-water levels rose during the period of high streamflow in September and October 1989. Ground-water levels rose by as much as 11 feet in the upper part of the Río Majada Valley, 12 feet in the lower part, and 22 feet in the Río Lapa Valley.

REFERENCES

Riggs, H.C., 1968, Some statistical tools in hydrology: Techniques of Water-Resources Investigations of the U.S. Geological Survey, book 4, chapter A1, 40 p.

U.S. National Oceanic and Atmospheric Administration, 1982, Monthly normals of temperature, precipitation, and heating and cooling degree days 1951-80, Puerto Rico, 12 p.

Table 1.--*Data collection sites*

[---, indicates data not available or does not apply to a particular station]

Site number (figure 1)	Site identification	Site name	Elevation (feet above sea level)	Depth (feet below surface)	Screen (feet below surface)	Casing diameter (inches)	Well status	Discharge (gallons per minute)
1	50100450	Río Majada at La Plena	426.51	---	---	---	---	---
2	50100200	Río Lapa near Rabo del Buey	395.25	---	---	---	---	---
3	180211066125500	RMS-B Río Majada	---	---	---	---	---	---
4	180211066130000	Diversion Canal	---	---	---	---	---	---
5	50100700	RMS-F	---	---	---	---	---	---
6	180108066153300	RMS-I	---	---	---	---	---	---
7	180218066143500	RLS-E	---	---	---	---	---	---
8	180059066151900	Santini 1	157.44	68	40 - 68	12	Active	100
9	180104066152300	RM-10	164.13	37	27 - 37	4	Observation	---
10	180123066151800	RM-11	181.81	42	37 - 42	2	Observation	---
11	180126066151400	Asphalt 3	189.37	100	---	18	Abandoned	---
12	180127066151600	Asphalt 4	191.64	50	0 - 50	8	Abandoned	---
13	180128066151500	Asphalt 2	189.56	100	0 - 100	8	Abandoned	---
14	180129066151600	Asphalt 1	190.77	105	0 - 105	18	Active	60
15	180132066153700	RL-3	185.51	59	54 - 59	2	Observation	---
16	180132066153701	RL-4	185.51	34	29 - 34	2	Observation	---
17	180159066132900	RM-8	315.00	55	45 - 55	2	Observation	---
18	180159066133402	RM-4	292.88	40	28 - 33	2	Observation	---
19	180201066133300	RM-7	298.17	50	40 - 50	2	Observation	---
20	180203066134500	Unknown-1	285.55	---	---	8	Abandoned	---
21	180206066135500	RM-5	276.35	34	24 - 34	4	Observation	---
22	180209066135400	RM-9	277.52	34	24 - 34	2	Observation	---
23	180210066135300	RM-6	282.34	28	18 - 28	4	Observation	---
24	180213066141900	Ceiba	258.01	---	---	10	Unused	---
25	180217066141600	Albergue Olímpico 2	262.66	70	0 - 70	10	Unused	---
26	180217066141900	Albergue Olímpico 3	254.82	52	12 - 52	10	Active	250
27	180217066142100	Albergue Olímpico 1	252.48	50	0 - 50	10	Active	300
28	180219066142200	Godreau 4	255.19	43	0 - 43	8	Abandoned	---
29	180227066144500	RL-1	263.20	48	43 - 48	2	Observation	---
30	180227066144501	RL-2	263.20	26	22 - 27	2	Observation	---
31	180210066135700	RM-PERS	275.00	---	---	---	Observation	---