Reconnaissance of Ground-Water Quality in the Manatí Quadrangle, Puerto Rico, August-November 1992

By Carlos E. Conde-Costas and Gilberto A. Rodríguez-Rodríguez

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CONVERSION FACTORS, ABBREVIATED WATER-QUALITY UNITS, AND ACRONYMS

Multiply	By	To obtain
foot	0.3048	meter
mile	1.609	kilometer
square miles	2.59	square kilometer

Temperatures can be converted from degrees Celsius (°C) to degrees Fahrenheit (°F) by the formula:

$$°F = 1.8 \times °C + 32$$

Abbreviated water-quality units used in report:

mg/L	milligram per liter
µg/L	micrograms per liter
µS/cm	microsiemens per centimeter at 25 degrees Celsius

Acronyms used in report:

MRL	Minimum reporting level
USGS	U.S. Geological Survey

Reconnaissance of Ground-Water Quality in the Manatí Quadrangle, Puerto Rico, August-November 1992

By Carlos E. Conde-Costas *and* Gilberto A. Rodríguez-Rodríguez

ABSTRACT

A synoptic water-quality survey was conducted in the Manatí quadrangle area of Puerto Rico between August 25 and November 12, 1992. Water samples were collected at 31 sites, consisting of 29 wells, one spring, and one creek. Water-quality properties determined for these samples included: field determinations for temperature, specific conductance, pH, and alkalinity, and laboratory analyses for dissolved constituents (cations, anions, and silica), nutrients (nitrite, nitrate plus nitrite, ammonia, phosphorous, and ortho-phosphorus), total organic carbon, trace metals; organochlorine insecticides and related compounds, organophosphorus insecticides, volatile organic compounds, semivolatile compounds (base, neutral, and acid methylene chloride extractable), and selected stable isotopes (oxygen-18, deuterium, nitrogen-15, and sulfur-34).

INTRODUCTION

The Manatí quadrangle area lies within the north coast limestone region (Monroe, 1980), which includes about 700 square miles of northern Puerto Rico and extends eastward from Rincón in the western part of the island to Loíza, a distance of about 85 miles (fig. 1). Three hydrogeologic units are present in the Manatí quadrangle: an upper aquifer contained in the Aymamón and Aguada Limestones of early Miocene age (fig. 2); a middle confining unit consisting of the upper member of the Cibao Formation of early Miocene age; and a lower aquifer in the Lares Limestone of Oligocene age (Rodríguez-Martínez, 1995).

The upper aquifer is the principal source of water supply in the study area. Ground water in the upper aquifer is mostly unconfined and exists as a lense of freshwater floating above a wedge of saline water and thinning toward the coast. The freshwater part of the aquifer is thickest within the Aguada Limestone where it could be as much as 300 feet thick. Within the Aymamón Limestone the thickness of the freshwater column ranges from less than 200 feet to zero at the coast. Ground-water withdrawals in the study area are

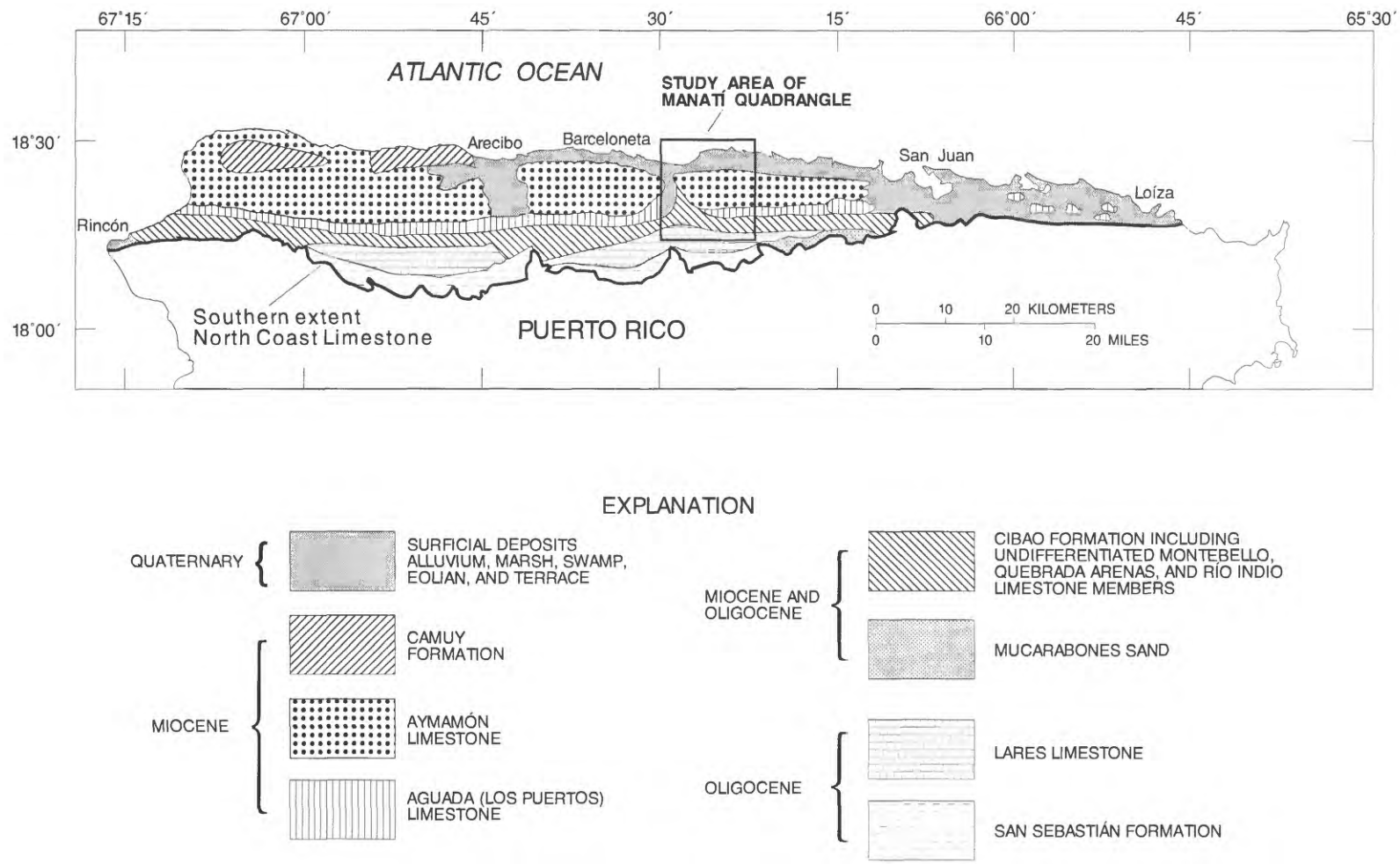

Figure 1. Generalized geologic map of the north coast limestone region of Puerto Rico.

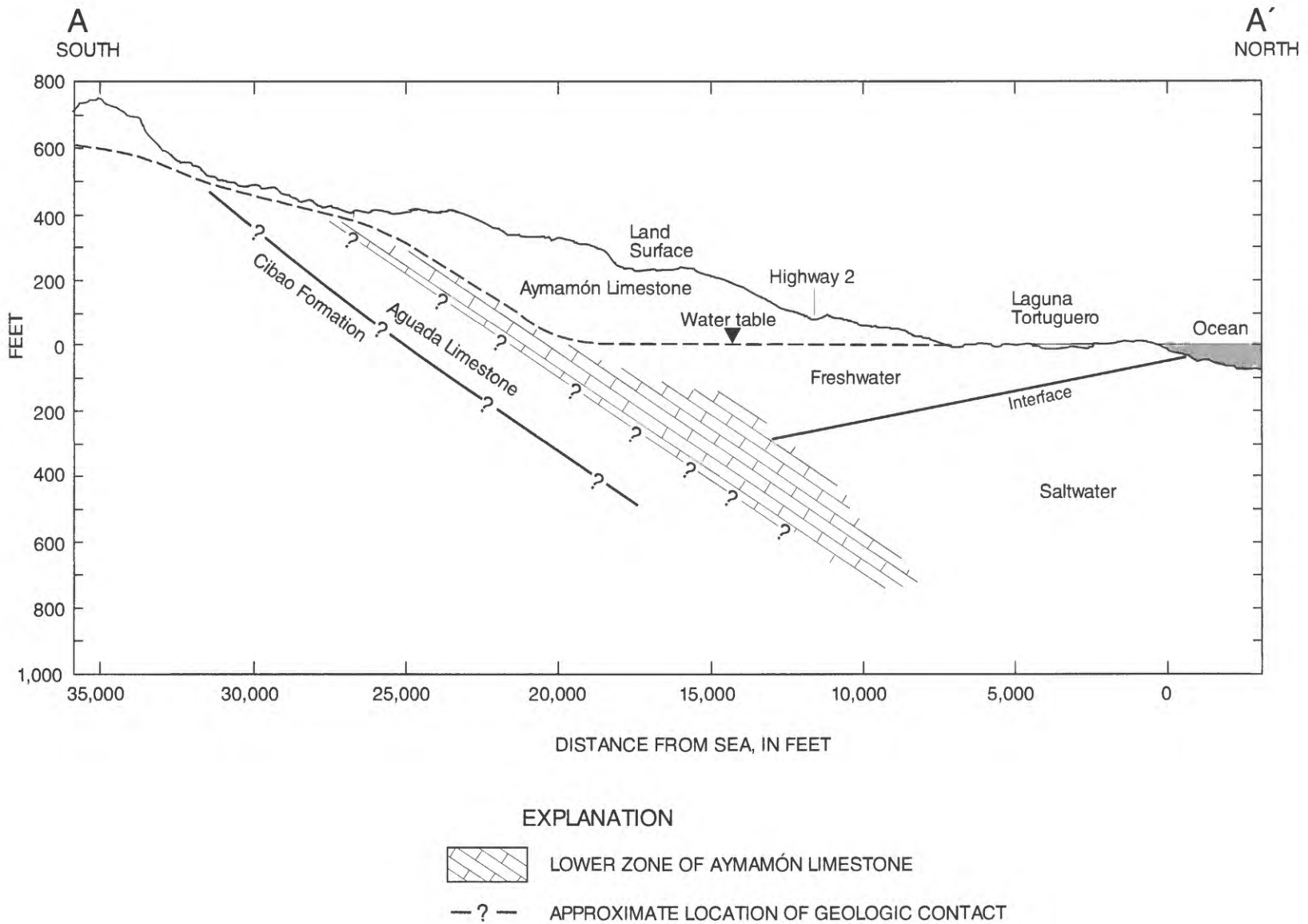

Figure 2. Generalized hydrogeologic cross section of the Manatí quadrangle, Puerto Rico (adapted from Bennett and Giusti, 1972).

mostly limited to areas north of latitude 18°25'00" N, where the Aymamón Limestone and Aguada Limestone become saturated and constitute the upper aquifer. South of this latitude only a few shallow wells exist and these are probably screened in the Quebrada Arenas Limestone member of the Cibao Formation.

The Manatí area has been subjected to extensive agricultural, industrial, and urban development. In order to provide baseline data related to water-quality conditions in the area, the U.S. Geological Survey, in cooperation with the Puerto Rico Environmental Quality Board, the Puerto Rico Aqueduct and Sewer Authority, the Puerto Rico Department of Natural and Environmental Resources and other agencies of the Commonwealth of Puerto Rico, conducted a synoptic ground-water quality survey from August 25 to November 12, 1992.

Purpose and Scope

The purpose of the synoptic water-quality survey was to obtain data on the quality of ground water within the Manatí quadrangle, Puerto Rico. The water-quality survey covers primarily an area of approximately 20 square miles of the upper aquifer (area north of latitude 18°25' N). However, the study area includes areas where wells tap the Quebrada Arenas Limestone, the Lares Limestone or the alluvial valley at inland parts of the quadrangle. The results from this survey are expected to be of use to water resources managers and planners, and to hydrologists for future reference and studies.

Water samples collected at 31 sites (29 wells, one spring, and one creek) were analyzed for temperature, specific conductance, pH, alkalinity (as calcium carbonate, $CaCO_3$), dissolved constituents (cations, anions, and silica), nutrients (nitrite, nitrate plus nitrite, ammonia, phosphorous and ortho-phosphorus), total organic carbon, trace metals, organochlorine insecticides and related compounds, organophosphorus insecticides, volatile organic chemicals, semivolatile compounds (base, neutral and acid methylene chloride extractable) and selected stable isotopes (oxygen-18, deuterium, nitrogen-15 and sulfur-34). Sampling sites, well characteristics and water-quality properties and constituents analyzed in the laboratory are listed in table 1.

Methods and Procedures

Water samples were collected at 31 sites, including 19 active public-water supply wells, six intermittently pumping wells (one industrial, three agricultural, and two livestock use wells), four unused wells (one flowing artesian well and three wells equipped with turbine pumps), one spring, and one small losing stream that recharges the aquifer south of latitude 18°25'00" N (fig. 3). Water samples collected from wells were obtained at or near the well-head and prior to chlorination. Intermittently pumped wells and unused wells were sampled within a period which did not exceed 30 minutes after the pump was turned-on. Pumping time constraints imposed either by the well owner or by on-site discharge facilities limited the sampling period.

Detailed information on the procedures and methods used for on-site measurements, collecting, treating, shipping samples, and laboratory analyses are given in the following U.S. Geological Survey publications "Techniques of Water-Resources Investigations of the U.S. Geological Survey" Book 1, Chap. D2 and; Book 5, Chap. A1 and A3. Field measurements for

Table 1. Description of selected surface- and ground-water sampling sites in the Manatí quadrangle, Puerto Rico, and parameters selected for laboratory analyses

[--, no data available; U, unused; UA, unused artesian; PS, public supply; SW, surface water; DO, domestic; AG, agricultural; LV, livestock; IN, industrial; SP, spring; A/C, anions and cations; NUT, nutrients; TM, trace metals; PST, organochlorine and organophosphorus insecticides; VOC, volatile organic compounds; SVOC, semi-volatile organic compounds: ISO. stable isotopes: Y, sample was collected; N, no sample was collected]

Map number	Latitude/ longitude	Municipality	Well name or site name	Type	Depth of well (feet)	Depth to water (feet)	Samples collected for analyses						
							A/C	NUT	TM	PST	VOC	SVOC	ISO
1	182630662740	Manatí	Atenas	PS	240	150	Y	Y	Y	Y	Y	Y	Y
2	182613663414	Vega Baja	Alturas	PS	--	220	Y	Y	Y	Y	Y	Y	Y
3	182328662529	Vega Baja	Beauchamp	AG	--	35	Y	Y	Y	Y	Y	Y	Y
4	182751662937	Manatí	Boquillas	PS	132	41	Y	Y	Y	Y	Y	Y	Y
5	182320662552	Vega Baja	Cátala	LV	150	--	Y	Y	Y	Y	Y	N	Y
6	182540662754	Manatí	Coto Sur #1	PS	300	233	Y	Y	Y	Y	N	N	Y
7	182552662647	Manatí	Coto Sur #2	U	390	260	N	Y	N	Y	Y	N	Y
8	182554662749	Manatí	Coto Sur #3	U	215	240	N	Y	N	Y	Y	N	Y
9	182546662712	Manatí	Coto Sur #5	PS	500	267	Y	Y	Y	Y	Y	Y	Y
10	182542662736	Manatí	Coto Sur #6	PS	475	244	Y	Y	Y	Y	Y	Y	Y
11	182546662730	Manatí	Coto Sur WH	AG	--	258	Y	Y	Y	Y	Y	Y	Y
12	182617662902	Manatí	Cordova Dávila	PS	200	92	Y	Y	Y	Y	Y	Y	Y
13	182705662952	Manatí	Cruz Rosa Rivas	PS	--	118	Y	Y	Y	Y	Y	Y	Y
14	182701662902	Manatí	Jacinto Cubano	LV	--	--	Y	Y	Y	Y	Y	Y	Y
15	182530662854	Manatí	Escalfullery	PS	400	225	N	Y	N	N	Y	N	N
16	182646662359	Vega Baja	Vega Baja #4	PS	--	76	Y	Y	Y	Y	Y	N	Y
17	182638662722	Manatí	Marista	U	--	--	N	Y	N	Y	Y	Y	Y
18	182412662949	Manatí	Monserrate Sur	LV	180	29	Y	N	Y	Y	N	Y	Y
19	182514662901	Manatí	Mónaco	PS	500	250	N	Y	N	Y	Y	N	Y
20	182735662343	Vega Baja	NC-9	UA	1,540	10	Y	Y	Y	N	Y	Y	Y
21	182657662506	Vega Baja	Ojo de Agua	SP	--	--	N	N	N	Y	N	Y	Y
22	182604662925	Manatí	Manatí 3	PS	200	63	Y	Y	Y	Y	Y	N	Y
23	182553662429	Vega Baja	Pugnado #1	PS	150	--	Y	Y	Y	Y	Y	Y	Y
24	182545662438	Vega Baja	Pugnado #2	PS	340	242	Y	Y	Y	Y	Y	Y	Y
25	182615662735	Manatí	Procter & Gamble	IN	240	174	Y	Y	Y	Y	Y	Y	Y
26	182305662659	Manatí	Quebrada	SW	--	--	N	Y	N	Y	Y	Y	Y
27	182714662924	Manatí	Rabanos	PS	160	112	Y	Y	Y	N	Y	Y	Y
28	182316662737	Manaíi	Río Arriba #2	PS	300	38	Y	Y	Y	Y	Y	N	Y
29	182312662749	Manatí	Río Arriba #3	PS	220	55	Y	Y	Y	Y	Y	N	Y
30	182651662416	Vega Baja	Vega Baja #2	PS	120	76	Y	Y	Y	Y	Y	Y	Y
31	182644662405	Vega Baja	Vega Baja #3	PS	140	--	Y	Y	Y	Y	Y	Y	Y

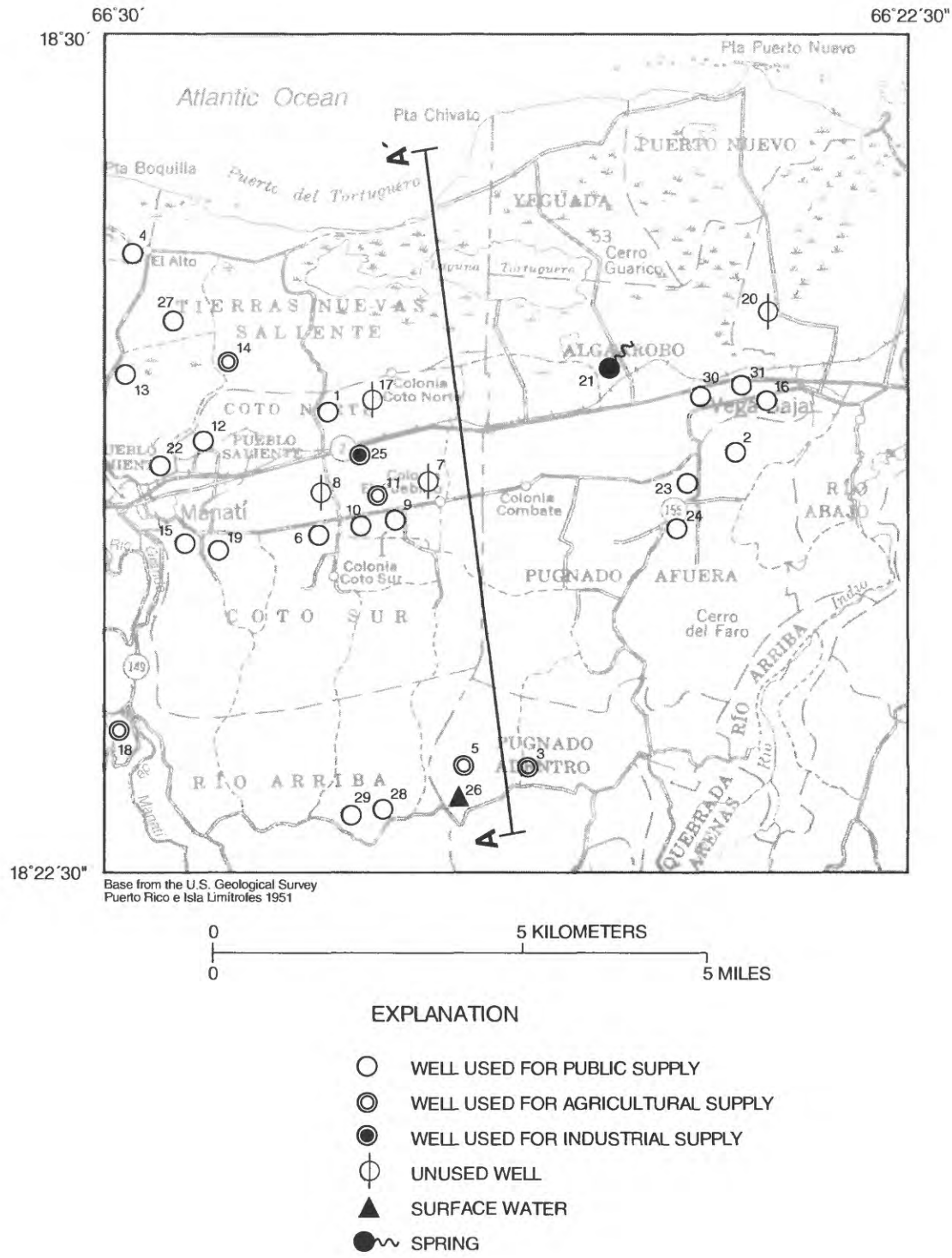

Figure 3. Location of sampling sites in the Manatí quadrangle, Puerto Rico.

temperature, specific conductance, and pH were determined during pumping at the nearest discharge tap from the well head. Samples for the analyses of alkalinity, the common constituents, nutrients, trace metals, and stable isotopes were withdrawn from a churn splitter (a container commonly used to obtain representative sub-samples) filled at the point of sampling. Samples for the analyses of insecticides, organic compounds (volatile and semivolatile) and total organic carbon were collected directly into sample containers at the well-discharge points. Sample treatment and preservation was conducted on-site following standard USGS procedures. The samples were shipped to and analyzed at the U.S. Geological Survey Central Laboratory in Arvada, Colorado. Analytical results indicated as "dissolved" or "filtered sample" correspond to samples filtered through a 0.45 micron filter.

RESULTS

Analytical results of the field and laboratory measurements of selected physical properties, major ions, nutrients, and total organic carbon are summarized in table 2. Analytical results for laboratory measurements of trace metals are summarized in table 3. Pesticides and organic compounds analyzed at selected wells are summarized in table 4, and analytical results are presented in table 5. Stable isotope analytical results are summarized in table 6.

Table 2. Major ions, nutrients, total organic carbon, and physical properties at selected surface- and ground-water sampling sites in the Manatí quadrangle, Puerto Rico

[SC, specific conductance; µS/cm, microsiemens per centimeter; pH, whole water field determinations; Temp, water temperature; °C, degrees Celsius; mg/L; milligrams per liter; Ca, calcium; Mg, magnesium; Na, sodium; K, potassium; HCO_3, bicarbonate, field end-point titration whole water sample; --, no data available; (a), artesian; (b), spring; (c) surface-water sample; all analytical results are for filtered water samples except alkalinity and TOC]

Map number	Well name or site name	Date	Time	SC (µS/cm)	pH (units)	Temp (°C)	Hard-ness (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	HCO_3 (mg/L)
1	Atenas	09/25/92	1200	1,020	7.0	26.0	290	95	12	98	2.7	270
2	Alturas	09/16/92	1200	900	7.1	25.5	320	110	9.8	59	3.5	290
3	Beauchamp	09/29/92	1400	625	6.5	25.5	290	100	9.7	13	2.3	390
4	Boquillas	09/17/92	1045	900	7.2	26.5	310	94	18	55	2.7	280
5	Cátala	10/02/92	1500	700	6.8	27.0	330	120	7.0	13	1.5	410
6	Coto Sur #1	11/05/92	1300	550	6.5	25.0	260	99	4.1	11	--	280
7	Coto Sur #2	11/12/92	1300	490	6.6	26.0	--	--	--	--	--	260
8	Coto Sur #3	11/12/92	1145	569	6.9	25.5	--	--	--	--	--	290
9	Coto Sur #5	09/14/92	1100	975	7.1	26.0	310	93	19	61	1.1	270
10	Coto Sur #6	09/15/92	1030	2,500	7.0	25.0	480	120	44	270	4.8	280
11	Coto Sur WH	09/18/92	1500	600	6.6	25.0	290	110	3.5	10	0 .7	260
12	Cordova Dávila	09/25/92	1000	810	6.9	25.5	310	96	16	48	2.4	330
13	Cruz Rosa Rivas	09/21/92	1230	870	6.9	26.5	320	98	17	53	2.2	300
14	Jacinto Cubano	09/30/92	1415	980	7.0	26.0	350	120	12	47	3.6	310
15	Escalfullery	10/06/92	1500	600	6.6	25.0	--	--	--	--	--	--
16	Vega Baja #4	09/14/92	1300	810	7.1	26.0	310	110	8.8	43	2.2	330
17	Marista	10/08/92	1330	575	6.8	26.0	--	--	--	--	--	--
18	Monserrate Sur	11/06/92	1200	450	7.2	27.0	200	65	8.5	13	1.5	260
19	Mónaco	10/06/92	1500	650	7.0	25.0	--	--	--	--	--	--
20	NC-9 (a)	09/18/92	0915	4,050	7.3	27.0	600	83	94	670	33	310
21	Ojo de Agua (b)	11/05/92	1530	1,000	6.5	25.5	--	--	--	--	--	--
22	Manatí #3	09/24/92	1230	860	7.0	27.0	300	96	15	42	1.9	330
23	Pugnado #1	09/10/92	1100	1,620	7.2	26.0	400	130	19	140	3.4	280
24	Pugnado #2	08/25/92	1100	760	6.5	25.0	280	100	7.9	35	1.3	280
25	Procter & Gamble	09/24/92	1030	820	7.5	25.5	280	88	14	40	2.3	270
26	Quebrada (c)	11/06/92	1330	650	7.4	25.0	--	--	--	--	--	370
27	Rabanos	09/18/92	0900	990	7.1	26.0	330	100	19	74	2.5	300
28	Río Arriba #2	10/01/92	1500	800	6.5	25.5	370	140	4.3	16	1.3	430
29	Río Arriba #3	10/01/92	1200	750	6.5	25.5	350	130	5.0	16	1.7	410
30	Vega Baja #2	09/15/92	0830	1,260	7.1	25.5	370	120	17	100	2.9	320
31	Vega Baja #3	09/15/92	1130	700	6.7	25.5	280	100	8.4	39	1.7	290

Table 2. Major ions, nutrients, total organic carbon, and physical properties at selected surface and ground-water sampling sites in the Manatí quadrangle, Puerto Rico--Continued

[Alk, alkalinity; mg/L; milligrams per liter; $CaCO_3$; calcium carbonate; Cl, chloride; F, fluoride; Br, bromide; SiO_2, silica; DS, dissolved solids sum of constituents; NO_2, nitrite as N; NO_2+NO_3, nitrite plus nitrate as N; NH_4, ammonia as N; P, phosphorus; o-P, orthophosphate; TOC, total organic carbon; --, no data available; <, less than; (a), artesian; (b), spring; (c) surface water sample; all analytical results are for filtered water samples except alkalinity and TOC]

Map number	Well name or site name	Alk (mg/L (as $CaCO_3$))	SO_4 (mg/L)	Cl (mg/L)	F (mg/L)	Br (mg/L)	SiO_2 (mg/L)	DS (mg/L)	NO_2 (mg/L)	NO_2+NO_3 (mg/L)	NH_4 (mg/L)	P (mg/L)	o-P (mg/L)	TOC (mg/L)
1	Atenas	220	29	180	<.10	0.63	7.8	563	<.010	6.5	0.020	0.020	0.020	0.7
2	Alturas	240	26	120	<.10	.40	7.0	481	<.010	3.8	.020	.010	.010	.5
3	Beauchamp	320	8.4	21	.20	.08	14	360	<.010	.40	.020	.020	<.010	.3
4	Boquillas	230	22	120	<.10	.44	19	472	<.010	3.8	.020	.030	.020	.7
5	Cátala	340	23	25	.10	.11	11	403	<.010	1.2	.010	.020	<.010	.8
6	Coto Sur #1	230	3	17	<.10	--	6.9	--	<.010	12	.020	.010	<.010	.5
7	Coto Sur #2	210	--	--	--	--	--	--	<.010	14	.010	<.010	<.010	--
8	Coto Sur #3	240	--	--	--	--	--	--	<.010	7.5	.020	<.010	<.010	--
9	Coto Sur #5	220	15	160	<.10	.36	6.7	488	--	--	--	--	--	.2
10	Coto Sur #6	230	--	--	--	--	--	--	--	--	--	--	--	.3
11	Coto Sur WH	210	8.6	16	<.10	.07	6.7	301	<.010	18	.010	.010	.010	.6
12	Cordova Dávila	270	15	83	<.10	.32	8.3	437	<.010	6.1	.030	.020	.020	.5
13	Cruz Rosa Rivas	250	24	120	<.10	.46	20	484	<.010	2.7	.070	.040	.030	.3
14	Jacinto Cubano	260	22	110	<.10	.37	11	488	<.010	11	.030	.020	.010	.4
15	Escalfullery	--	--	--	--	--	--	--	<.010	5.7	.400	.020	.010	--
16	Vega Baja #4	270	22	94	<.10	.35	8.4	450	--	--	--	--	--	.4
17	Marista	--		--	--	--	--	--	<.010	6.9	.020	.020	.010	.3
18	Monserrate Sur	210	11	13	.20	.07	18	258	--	--	--	--	--	--
19	Mónaco	--	--	--	--	--	--	--	<.010	6.2	<.010	<.010	<.010	.9
20	NC-9 (a)	260	180	1,200	.40	--	13	2,420	<.010	0.08	.10	<.010	<.010	.5
21	Ojo de Agua (b)	--	--	--	--	--	--	--	--	--	--	--	--	--
22	Manatí #3	270	22	84	<.10	.30	17	445	<.010	5.2	.050	.020	.020	.4
23	Pugnado #1	230	43	330	<.10	.14	6.9	814	<.010	4.0	.030	<.010	<.010	.4
24	Pugnado #2	230	10	92	<.10	.29	6.7	398	<.010	7.0	.030	<.010	<.010	2.6
25	Procter & Gamble	220	11	80	.10	.28	6.5	383	<.010	9.2	.050	.010	<.010	.3
26	Quebrada (c)	300	--	--	--	--	--	--	.010	.4	.160	.030	.020	8.7
27	Rabanos	250	27	160	<.10	.59	17	551	<.010	3.6	<.010	.030	.030	.5
28	Río Arriba #2	350	37	36	.10	.15	11	458	<.010	1.5	.010	<.010	<.010	.7
29	Río Arriba #3	340	32	33	.10	.14	10	431	<.010	2.3	<.010	<.010	<.010	1.2
30	Vega Baja #2	260	35	240	<.10	.74	8.2	681	--	--	--	--	--	.4
31	Vega Baja #3	240	20	82	<.10	.30	6.5	400	--	--	--	--	--	.5

Table 3. Concentrations of dissolved trace metals at selected ground-water sampling sites in the Manatí quadrangle, Puerto Rico

[All concentrations are in micrograms per liter.. Ba, barium; Be, beryllium; Cd, cadmium; Cr, chromium; Co, cobalt; Cu, copper; Fe, iron; Pb, lead; Li, lithium; Mn, manganese; Mo, molybdenum; Ni, nickel; Ag, silver; Sr, strontium; V, vanadium; Zn, zinc; < less than; (a) artesian]

Map number	Well name or site name	Ba	Be	Cd	Cr	Co	Cu	Fe	Pb	Li	Mn	Mo	Ni	Ag	Sr	V	Zn
1	Atenas	15	<.5	<1	<5	<3	<10	5	<10	<4	4	<10	<10	<1	99	<6	19
2	Alturas	19	<.5	<1	<5	<3	<10	<3	<10	<4	2	<10	<10	<1	160	<6	6
3	Beauchamp	33	<.5	<1	6	<3	<10	31	10	4	4	10	<10	<1	900	8	19
4	Boquillas	22	<.5	<1	5	<3	<10	<3	<10	<4	2	<10	<10	<1	510	<6	10
5	Cátala	38	<.5	<1	<5	<3	<10	7	<10	6	2	<10	<10	<1	550	7	8
6	Coto Sur #1	11	<.5	1	<5	<3	<10	<3	<10	<4	1	<10	<10	<1	55	<6	7
9	Coto Sur #5	24	<.5	<1	<5	<3	<10	6	<10	4	2	<10	<10	<1	170	<6	6
10	Coto Sur #6	48	<.5	<1	<5	<3	<10	17	<10	4	4	<10	<10	<1	300	<6	14
11	Coto Sur WH	9	<.5	<1	<5	<3	<10	6	<10	4	3	<10	<10	<1	45	6	11
12	Cordova Dávila	16	<.5	<1	6	<3	<10	5	<10	<4	3	<10	<10	<1	150	<6	3
13	Cruz Rosa Rivas	24	<.5	<1	<5	<3	<10	6	10	<4	2	<10	<10	<1	610	6	6
14	Jacinto Cubano	19	<.5	<1	<5	<3	10	6	<10	5	8	<10	<10	<1	110	<6	30
16	Vega Baja #4	38	<.5	<1	<5	<3	<10	<3	<10	<4	<1	<10	<10	<1	180	<6	5
18	Monserrate Sur	30	<.5	<1	<5	<3	<10	7	<10	7	21	<10	<10	<1	730	<6	15
20	NC-9 (a)	43	<2	<3	<20	<9	<30	1,200	<30	15	34	<30	<30	<3	3,900	<18	15
22	Manatí #3	29	<.5	<1	<5	<3	<10	6	<10	<4	5	<10	<10	<1	260	<6	5
23	Pugnado #1	19	<.5	<1	<5	<3	<10	13	10	7	2	<10	<10	<1	190	<6	10
24	Pugnado #2	10	<.5	<1	<5	<3	<10	6	<10	6	4	<10	<10	<1	72	<6	10
25	Procter & Gamble	11	<.5	<1	<5	<3	<10	6	<10	<4	5	<10	<10	<1	98	<6	7
27	Rabanos	21	<.5	<1	<5	<3	<10	6	<10	<4	1	<10	<10	<1	360	<6	4
28	Río Arriba #2	37	.5	1	5	3	40	4	10	6	2	10	10	1	370	6	13
29	Río Arriba #3	36	<.5	<1	<5	<3	<10	<3	<10	5	1	<10	<10	<1	410	<6	6
30	Vega Baja #2	28	<.5	<1	<5	<3	<10	<3	<10	4	<1	<10	<10	<1	230	<6	<3
31	Vega Baja #3	15	<2	<3	<5	<3	<10	<3	<10	<4	<1	<10	<10	<1	120	<6	4

Table 4. Organic compounds analyzed in water samples collected at selected sampling sites in the Manatí quadrangle, Puerto Rico

[All concentrations are in micrograms per liter, except where indicated and as total constituents. MRL, minimum reporting level.]

I. Organochlorine pesticides and related compounds

Compound	MRL	Compound	MRL
Aldrin	0.01	Fonofos	0.01
Chlordane	.01	Gross PCB's	.01
Chlorpyrifor	.01	Gross PCN's	.10
DDD	.01	Heptachlor	.01
DDE	.01	Heptachlor Epoxide	.01
DDT	.01	Lindane	.01
DEF	.01	Methoxychlor	.01
Di-Systone	.01	Mirex	.01
Dieldrin	.01	Perthane	.10
Endosulfan	.01	Phorate	.01
Endrin	.01	Toxaphene	1.00

II. Organophosphorus pesticides

Compound	MRL	Compound	MRL
Diazinon	.01	Methyl Parathion	.01
Ethion	.01	Parathion	.01
Melathion	.01	Trithion	.01

III. Volatile organic chemicals (VOCs)

Compound	MRL	Compound	MRL
1,1,1,2-Tetrachloroethane	3	1,2-Dichlorobenzene	3
1,1,1,-Trichloroethane	3	1,2-Dichloroethane	3
1,1,2,2-Tetrachloroethane	3	1,2-Dichloropropane	3
1,1,2-Trichloroethane	3	1,2-Transdichloroethene	3
1,1-Dichloroethane	3	1,3,5-Trimethylbenzene	3
1,1-Dichloroethylene	3	1,3-Dichlorobenzene	3
1,1-Dichloropropene	3	1,3-Dichloropropane	3
1,2,3-Trichlorobenzene	3	1,4-Chlorotoluene	3
1,2,3-Trichloropropane	3	1,4-Dichlorobenzene	3
1,2,4-Trichlorobenzene	3	2,2-Dichloropropane	3
1,2,4-Trimethylbenzene	3	2-Chloroethylvinylether	3

Table 4. Organic compounds analyzed in water samples collected at selected sampling sites in the Manatí quadrangle, Puerto Rico--Continued

III. Volatile organic chemicals (VOCs)--Continued			
Compound	**MRL**	**Compound**	**MRL**
1,2-Chlorotoluene	3	Acrolein	20
1,2-Dibromoethane	3	Acrylonitrile	20
Benzene	3	Methylchloride	3
Bromobenzene	3	Methylene chloride	3
Bromochloromethane	3	Methyltertbutylether	3
Bromoform	3	N-Butylbenzene	3
Carbontetrachloride	3	N-propylbenzene	3
Chlorobenzene	3	Naphthalene	3
Chlorodibromomethane	3	P-isopropyltoluene	3
Chloroethane	3	Sec-butylbenzene	3
Chloroform	3	Styrene	3
Cis-1,2-dichloroethene	3	Tert-butylbenzene	3
Cis-1,3-dichloropropene	3	Tetrachloroethylene	3
Dibromochloropropane	3	Toluene	3
Dibromomethane	3	Trans-1,3-dichloropropene	3
Dichlorobromomethane	3	Trichloroethylene	3
Dichlorodifluoromethane	3	Trichlorofluoromethane	3
Ethylbenzene	3	Trichlorotrifluoroethane	3
Hexachlorobutadiene	3	Vinyl chloride	1
Isopropylbenzene	3	Xylenes,total ortho, meta,	
Methylbromide	3	and para	3

IV. Semivolatile organic chemicals			
Compound	**MRL**	**Compound**	**MRL**
1,2,4-Trichlorobenzene	5	2-Chlorophenol	5
1,2,5,6-Dibenzanthracene	10	2-Nitrophenol	5
1,2-Dichlorobenzene	5	3,3-Dichlorobenzidine	20
1,2-Diphenylhydrazine	5	2-Methyl-4,6-dinitrophenol	30
1,3-Dichlorobenzene	5	4-Bromophenylphenylether	5
1,4-Dichlorobenzene	5	4-Chlorophenylphenylether	5

Table 4. Organic compounds analyzed in water samples collected at selected sampling sites in the Manatí quadrangle, Puerto Rico--Continued

IV. Semivolatile organic chemicals--Continued			
Compound	**MRL**	**Compound**	**MRL**
2,4,6-Trichlorophenol	20	4-Nitrophenol	30
2,4-Dichlorophenol	5	Acenaphthene	5
2,4-Dimethylphenol	5	Acenaphthylene	5
2,4-Dinitrophenol	20	Anthracene	5
2,4-Dinitrotoluene	5	Benzidine	40
2,6-Dinitrotoluene	5	Benzo (a) pyrene	10
2-Chloronaphthalene	5	Benzo (b) fluoranthene	10
Benzo (k) fluoranthene	10	Fluorene	5
Benzo (a) anthracene	10	Hexachlorobenzene	5
Benzo (g,h,i) perylene	10	Hexachlorobutadeine	5
Bis (2-chloroethoxy) methane	5	Hexachlorocyclopentadeine	5
Bis (2-chloroethyl) ether	5	Hexachloroethane	5
Bis (2-chloroisopropyl) ether	5	Indeno (1,2,3-cd) pyene	10
Bis (2-ethylhexyl) phthalate	5	Isophorone	5
Butyl benzyl phthalate	5	N-Nitrosodi-n-propylamine	5
4-Chloro-3-methylphenol	30	N-Nitrosodiphenylamine	5
Chrysene	10	Naphthalene	5
Di-n-butyl phthalate	5	Nitrobenzene	5
Di-n-octyl phthalate	10	Pentachlorophenol	30
Diethyl phthalate	5	Phenantherene	5
Dimethyl phthalate	5	Phenol	5
Fluoranthene	5	Pyrene	5

Table 5. Pesticides and organic compounds detected in water from selected wells in the Manatí quadrangle, Puerto Rico

[All concentration are in micrograms per liter]

Well number	Compound	Concentration
1	Dieldrin	0.20
	DDD	0.01
2	Dieldrin	0.01
	Heptachlor epoxide	0.01
4	Dieldrin	0.01
	Heptachlor epoxide	0.01
6	Lindane	0.01
	Toxaphene	1.00
	Heptachlor epoxide	0.02
7	Dieldrin	0.12
8	Dieldrin	0.07
	1,2,3,-Trichloropropane	3.20
9	Dieldrin	0.06
10	Dieldrin	0.04
11	Dieldrin	0.24
	Toxaphene	6.00
12	Dieldrin	0.01
	Heptachlor epoxide	0.01
13	Dieldrin	0.01
	Heptachlor epoxide	0.01
17	Dieldrin	0.01
18	Diazinon	0.01
19	Dieldrin	0.01
23	Dieldrin	0.06
24	Diazinon	0.01
25	Dieldrin	0.12
	Toxaphene	1.00

Table 6. Stable isotope analyses at selected ground-water sampling sites in the Manatí quadrangle, Puerto Rico

[O-18, oxygen-18; H-2 deuterium; N-15, nitrogen-15; S-34, sulfur-34; O-18 and H-2 in parts per mil relative to Vienna Standard Mean Ocean Water (VSMOW); N-15 in parts per mil relative to air; S-34 in sulfate, aqueous in parts per mil relative to Canyon Diablo Troilite (CDT); (a), artesian; (b), spring; (c), surface-water sample]

Map number	Well name or site name	O-18	H-2	N-15	S-34
1	Atenas	-2.60	-8.5	4.5	20.0
2	Alturas	-2.60	-9.5	8.2	13.1
3	Beauchamp	-2.50	-7.0	7.0	--
4	Boquillas	-2.60	-8.5	11.6	13.7
5	Cátala	-2.45	-7.0	10.0	2.4
6	Coto Sur #1	-2.55	-8.0	3.8	--
7	Coto Sur #2	-2.58	-7.7	3.4	--
8	Coto Sur #3	-2.88	-11.1	3.8	16.3
9	Coto Sur #5	-2.65	-9.0	3.4	15.4
10	Coto Sur #6	-2.50	-7.0	3.1	19.2
11	Coto Sur WH	-2.45	-8.0	2.5	11.5
12	Cordova Dávila	-2.45	-7.5	8.1	17.4
13	Cruz Rosa Rivas	-2.65	-8.5	11.9	13.5
14	Jacinto Cubano	-2.55	-9.5	10.9	16.6
16	Vega Baja #4	-2.50	-9.0	8.9	11.3
17	Marista	--	--	5.4	19.1
18	Monserrate Sur	-2.70	-9.5	9.5	3.9
19	Mónaco	-2.55	-8.5	6.0	7
20	NC-9 (a)	-1.50	-1.0	--	19.6
21	Ojo de Agua (b)	-2.40	-7.5	8.8	13.4
22	Manatí #3	-2.60	-8.0	12.7	16.1
23	Pugnado #1	-2.55	-9.5	--	17.6
24	Pugnado #2	--	--	--	14.1
25	Procter & Gamble	-2.50	-7.5	3.8	18.5
26	Quebrada (c)	-2.40	-6.5	7.2	21.9
27	Rabanos	-2.65	-8.0	12.0	17.2
28	Río Arriba #2	-2.55	-10.0	14.3	2.5
29	Río Arriba #3	-2.50	-7.5	13.4	--
30	Vega Baja #2	-2.50	-8.5	7.2	16.5
31	Vega Baja #3	-2.55	-8.0	7.6	11.9

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