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A STUDY OF COASTAL WATER QUALITY IN THE VICINITY OF SAN JUAN, PUERTO RICO, JANUARY 13-31, 1971

Environmental Protection Agency
Athens, Georgia

February 1971

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Southeast Water Laboratory
Technical Services Program
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I

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INTRODUCTION

A water quality investigation in the coastal environs of the greater San Juan, Puerto Rico, area was conducted during the period January 13-31, 1971. This investigation was conducted by the Technical Services Program, Southeast Region, Environmental Protection Agency in cooperation with Puerto Rico's:

- Environmental Quality Board,
- Department of Health, and
- Department of Public Works.

The use of personnel, facilities, and equipment from these three Commonwealth agencies made the study possible. The Environmental Quality Board participated in the complete study from the planning phase through sampling and laboratory analysis.

The primary purpose of the study was to document the extent of water pollution in the San Juan area with particular reference to violations of Puerto Rico's Coastal Water Quality Standards. Pollution problems have been reported for many years by various agencies and individuals.

San Juan Bay, Martin Peña Canal, and San Jose Lagoon are classified for industrial use in the Standards. Water quality criteria for this classification include:

- a minimum dissolved oxygen (DO) concentration of 4.5 mg/l,
- a maximum temperature of 93°F or no more than 4°F above ambient, and
- a pH between 6.8 and 8.5.

The Condado Lagoon and the oceanfront beaches in the San Juan area are classified for swimming and other water contact recreation. Criteria in this case include:

- a minimum dissolved oxygen of 5.0 mg/l
- a median total coliform limit (see Bacteriological discussion for detail).

Both use classifications prohibit floating solids, settleable solids, oils, and sludge deposits which are readily visible and attributable to waste discharges.

SUMMARY OF WATER QUALITY STANDARDS VIOLATIONS

DISSOLVED OXYGEN

1) Analyses of samples taken in upper San Juan Bay showed DO violations:

   - in 41% of all samples taken,
   - in 58% of samples taken between 4:00 a.m. and 10:00 a.m., and
   - in 67% of samples taken near the bottom of the navigational channel (adjacent to regular sampling stations).

2) In the lower bay, water quality was much better, but DO violations still occurred:

   - in 25% of samples taken near the bottom of the San Antonio Channel, and
   - in 36% of all samples taken and in 80% of samples taken between 4:00 a.m. and 10:00 a.m. at Station LB-8 (near Cataño).

3) One-fourth of the samples from Condado Lagoon had DO concentrations less than 5.0 mg/l.

4) Martin Peña Canal and San Jose Lagoon samples showed DO concentrations varying from supersaturation (up to 30 mg/l in San Jose Lagoon) to zero. Zero DO's occurred regularly at depths greater than seven feet in the lagoon, and on cloudy days DO approached zero at the surface. Anaerobic conditions in Martin Pena Canal are the rule rather than the exception.

pH

1) The pH was greater than 8.5 in 63% of the samples from San Jose Lagoon.
2) It was also greater than 8.5 in samples from Martin Peña Canal.

TEMPERATURE

1) Cooling water discharges from the Palo Seco thermal power plant caused temperatures to exceed 93°F at the mouth of the Bayamon River.

BACTERIA (See BACTERIOLOGICAL discussion)

1) Numerous violations in Condado Lagoon and at certain oceanfront beaches.

OILS AND SOLIDS

1) Oily discharge entering Condado Lagoon from Miramar side on January 13, 1971.
2) An oil slick 15 feet by 200 feet observed in San Juan Bay near the Army Terminal on January 13, 1971. Also floating and settleable solids and a brown film over half the upper bay on same date.
3) January 18, 1971--an oil slick, tons of floating debris, and a brown scum extending from Puerto Nuevo Channel to Point Cataño in upper San Juan Bay.

4) January 19, 1971--visible floating solids and a brown film over half the upper bay. Gas bubbles from decomposing sludge deposits observed in the vicinity of the Puerto Neuvo sewage treatment plant outfall.

5) Sludge deposits at least 12 feet thick were found throughout upper San Juan Bay.

RECOMMENDATIONS

As mentioned previously, the primary purpose of the study reported here was to document violations of Puerto Rico's Coastal Water Quality Standards in the San Juan area. The violations were numerous and the causes equally numerous:

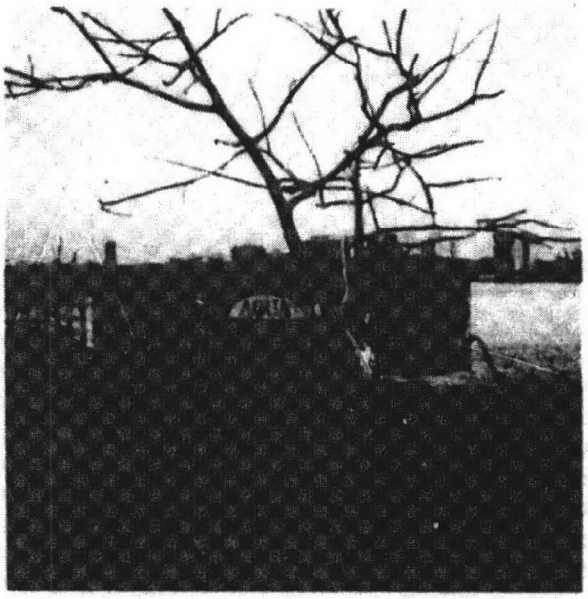
- untreated municipal waste discharges from unsewered areas
- untreated municipal waste discharges from sewered areas
- inadequately treated waste discharges from waste treatment plants
- untreated industrial waste discharges
- wastes from vessels and watercraft
- solid waste disposal practices which allow floating material to enter coastal waters
- broken and overloaded sewers
- clandestine sanitary connections to storm sewers
- erosion caused by poor construction practices.

Rather than being a noisome example of poor waste handling practices, the San Juan coastal waters can and should be upgraded to the esthetically pleasing and useful resource that they are capable of being. To list all the measures required to attain upgrading is a more comprehensive endeavor than is intended in this study. A program for water quality management throughout Puerto Rico is being developed at this time by the San Juan office of the Environmental Protection Agency.

The recommendation of this study is that all the water quality data contained herein be used by regulatory agencies to add impetus and a sense of urgency to an exemplary water quality control program for San Juan. This impetus should take the form of enforcement if necessary.

January 13, 1971
An Oil Slick 15'x200' in the
Vicinity of the Army Terminal Area

January 22, 1971
Oil in the Mosquito Control Canal
75' Before Mixing in San Juan Bay



January 1971
Operational Site of EPA Mobile Lab
Southeast Shore of Condado Lagoon
Adjacent to Power Company

SURVEY METHODS

Coastal water sampling stations were established in:

- San Juan Bay,
- Martin Peña Canal,
- San Jose Lagoon,
- Condado Lagoon, and
- the oceanfront beach areas from Old San Juan to Balneario Isla Verde.

A description of sampling stations in the first three areas is found in Table I. Stations in Condado Lagoon and along the beaches were established primarily for bacteriological studies and are described in a later section. Figure 1 (rear of report) shows the study area and location of all sampling stations.

Coastal water stations were sampled from January 13-22, 1971. In San Juan Bay, Martin Peña Canal, and San Jose Lagoon, samples were taken near surface and bottom and analyzed for temperature, DO and pH. Multiple samples were taken during the day to show diurnal DO, temperature, and pH variation. Some samples were taken in these areas for total plankton determinations and total organic carbon analyses.

At the Condado Lagoon and beachfront stations, surface samples were taken and examined for total and fecal coliform density and in some cases for the presence of Salmonella.

Most water samples were analyzed in a mobile laboratory stationed on the banks of the Condado Lagoon. Some samples were returned for analysis to the Southeast Water Laboratory in Athens, Georgia.

On January 20, sediment core samples were taken at selected stations in upper San Juan Bay, frozen and shipped to the Southeast Water Laboratory. There, analyses for chemical oxygen demand, total organic nitrogen, and total phosphorus were made.

Tidal variations during sampling periods in San Juan Bay were determined from tide tables and are shown in Figure 2.

TABLE I

SAMPLING STATIONS - SAN JUAN BAY,
SAN JOSE LAGOON, AND MARTIN PEÑA CANAL

San Juan Bay (Upper Bay)

UB-2 Near the mouth of Martin Peña Canal, 75' southwest of Channel Marker 6 (5 ft. depth).

UB-3 At the mid-point of a triangle formed by stations UB-4, UB-11, UB-10 (12 ft. depth).

UB-4 Midway between Graving Dock Channel Marker 3 and the shoreline adjacent to the U.S. Navy docking area (16 ft. depth).

UB-5 Channel Marker 13 adjacent to Deep Draft Anchorage Basin across from Isla Grande Airport (30 ft. depth).

UB-6 Adjacent to Army Terminal Channel Marker 2 across from Point Cataño (15 ft. depth).

UB-7 Adjacent to Army Terminal Channel Marker 5 (8 ft. depth).

UB-8 Midway between Army Terminal Channel Marker 6 and the shoreline (8 ft. depth).

UB-9 Adjacent to Army Terminal Turning Basin Marker 9 (6 ft. depth).

UB-10 Adjacent to Puerto Neuvo Channel Marker 3 (5 ft. depth).

UB-11 Adjacent to Puerto Neuvo Channel Marker 5 (5 ft. depth).

San Juan Bay (Lower Bay)

LB-1 Midway between Highway 26 bridge and Sea/Land dock at midpoint of San Antonio Channel (35 ft. depth).

LB-2 San Antonio Channel, midway on a line of sight from Pier #5 and a 25 ft. flashing red tower on Isla Grande (32 ft. depth).

LB-3 Midway between Channel Marker 11 and the shoreline of La Puntilla Point (20 ft. depth).

LB-4 50 yards offshore from the Governor's Palace (7 ft. depth).

LB-5 Adjacent to Anegado Channel Marker 8 (15 ft. depth).

LB-6 300 yards out from the mouth of the Bayamón River (6 ft. depth).

LB-8 75 yards north of a privately-maintained marker just offshore from Cataño (10 ft. depth).

LB-9 At the 25 ft. quick-flashing white beacon platform midway between the Cataño ferry landing and La Puntilla Point (15 ft. depth).

San Jose Lagoon and Martin Peña Canal

SJ-1 200 yards upstream from Suarez Canal (12 ft. depth).

SJ-2 250 yards upstream from recently cut canal through mangrove area on east end of San Jose Lagoon (3 ft. depth).

SJ-3 The center of the east end of San Jose Lagoon (4.5 ft. depth).

SJ-4 Directly across from Isla Guachinango, 50 ft. from the northeast shoreline (15 ft. depth).

SJ-5 Near the mouth of Martin Peña Canal adjacent to Isla Guachinango (5 ft. depth).

SJ-6 At mouth of Los Corozos section of Lagoon (6 ft. depth).

SJ-7 Upper northwest corner of Los Corozos section (4.5 ft. depth).

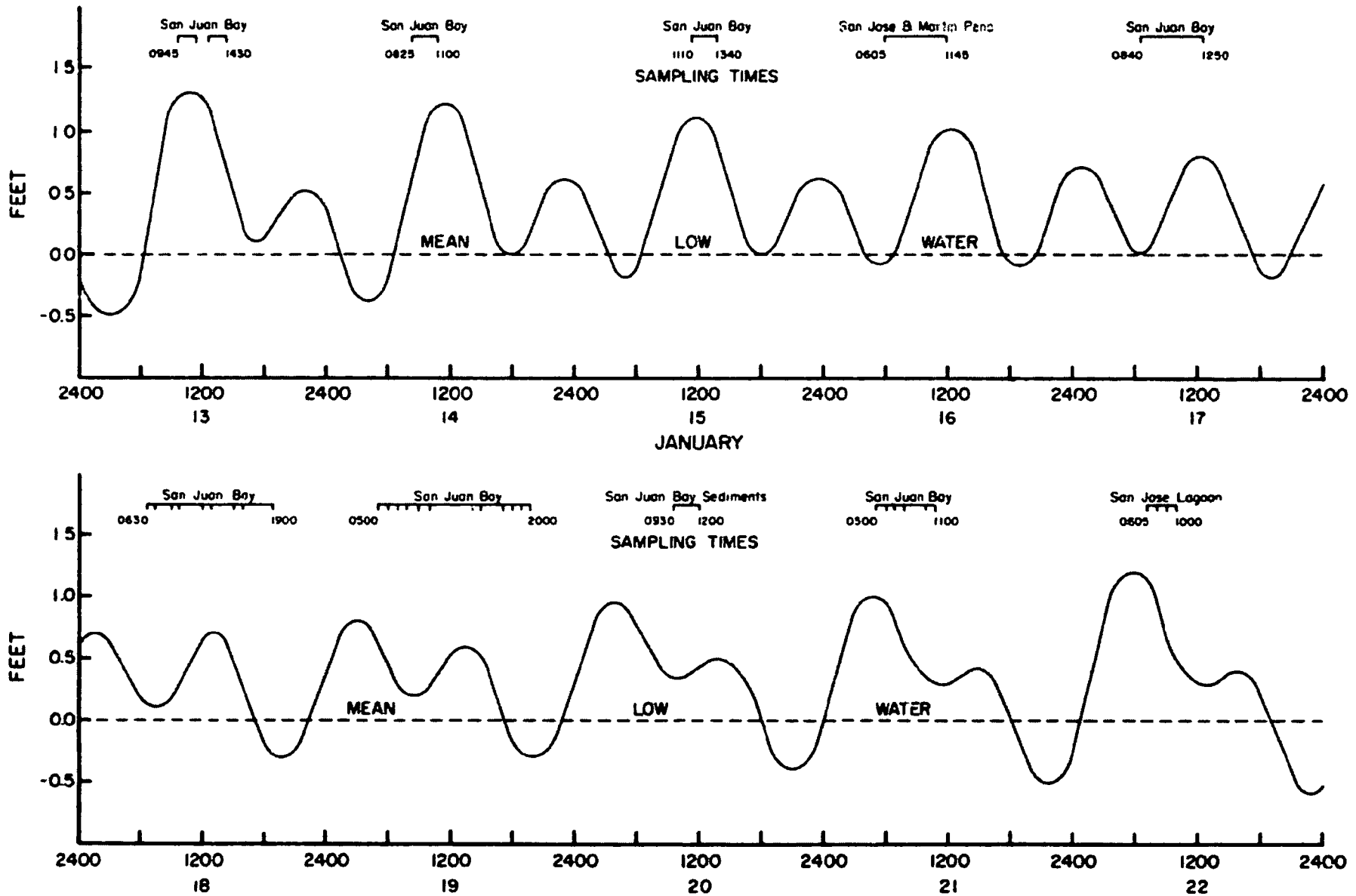
SJ-8 Adjacent to junction of canals draining from the airport and the Los Angeles residential district (8 ft. depth).

MP-1 Ponce de Leon bridge over Martin Peña Canal (2.5 ft. depth).

MP-2 Barbosa Drive bridge over Martin Peña Canal (2.5 ft. depth).

FIGURE 2

TIDAL CYCLES AND SAMPLING SCHEDULE
SAN JUAN BAY & COASTAL WATERS
JANUARY 13-22, 1971



WASTE SOURCES

Because of the large number of separate waste dischargers — municipal, Federal, Commonwealth, and industrial — in the San Juan region, no attempt was made to sample each waste source during this survey. An inventory is being made and effluents sampled under the direction of the Environmental Protection Agency's Planning Office in San Juan. To date, the inventory has identified 75 industries with separate waste discharges. Most of these have little or no treatment prior to discharge. In addition to industry, there are numerous outfalls from urban areas discharging untreated waste at various points around the shoreline or into the tributaries of San Juan Bay. The large Puerto Nuevo primary sewage treatment plant serves much of the San Juan area. This plant is overloaded and is a major contributor to pollution of upper San Juan Bay.

The major waste sources in the area include but are not limited to:

- raw or inadequately treated wastes from municipal sewerage and sewage treatment systems,
- Corona brewery,
- Caribbean Gulf Corporation,
- Bacardi Corporation (discharge to ocean),
- Old San Juan Distilling (discharge to ocean),
- Federal facilities, and
- vessels docked in the bay.

STUDY RESULTS

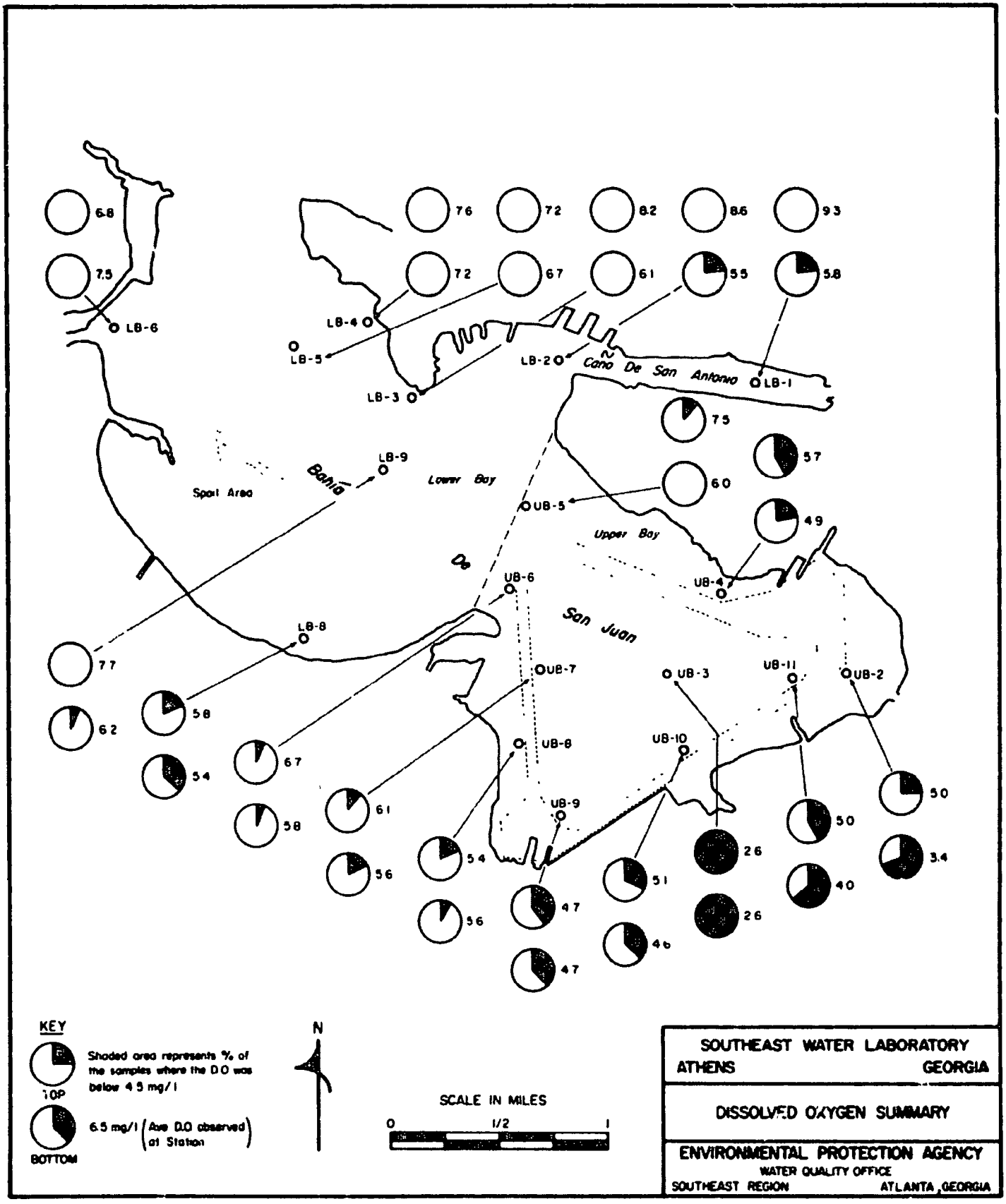
CHEMICAL AND PHYSICAL DATA

Dissolved oxygen, temperature, and pH data are summarized in Tables II through IV. Total organic carbon concentrations in San Juan Bay are listed in Table V.

Generally, all the data collected showed degraded water quality in upper San Juan Bay, Martin Peña Canal, and San Jose Lagoon. Septic conditions were common in these areas. The lower bay quality was generally satisfactory, although DO concentrations less than 4.5 mg/l were found at Station LB-8 near Cataño and in bottom water samples from the San Antonio Channel. Limited sampling in Condado Lagoon revealed two violations of the 5.0 mg/l DO criteria for this water body (Table IV). Figures 3 and 4 clearly indicate the DO levels throughout the study area. Supersaturated oxygen levels in San Jose Lagoon during daylight hours were indicative of extensive algal growth. Coupled with occasional rapid DO decreases during the night and following overcast conditions, the lagoon is a likely candidate for fish kills at any time.

Little variation in pH was observed within the bay (8.0 to 8.3 range). In San Jose Lagoon and Martin Peña Canal, however, the 8.5 upper limit in the Standards was exceeded on numerous occasions (9.4 maximum). The cause of high pH in these two areas was overenrichment of the waters from nutrients in waste discharges and urban runoff. The nutrients stimulate algal growth which in turn affect pH levels as well as cause color problems and nuisance conditions.

FIGURE 3

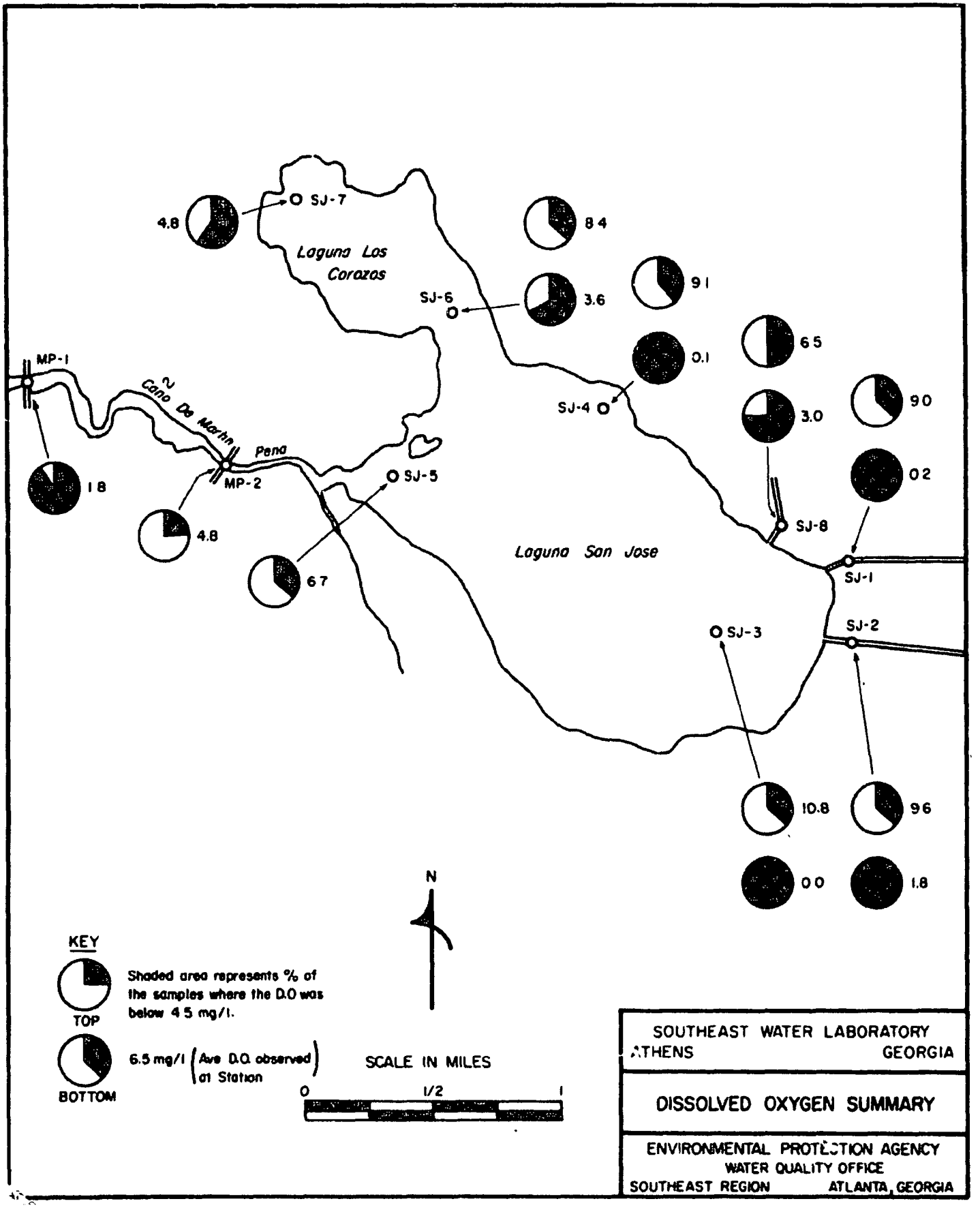


SOUTHEAST WATER LABORATORY
ATHENS GEORGIA

DISSOLVED OXYGEN SUMMARY

ENVIRONMENTAL PROTECTION AGENCY
WATER QUALITY OFFICE
SOUTHEAST REGION ATLANTA, GEORGIA

FIGURE 4



SOUTHEAST WATER LABORATORY
ATHENS GEORGIA

DISSOLVED OXYGEN SUMMARY

ENVIRONMENTAL PROTECTION AGENCY
WATER QUALITY OFFICE
SOUTHEAST REGION ATLANTA, GEORGIA

Temperature in the bay was generally in the 25 to 28°C (77 to 82°F) range. Highest values were found in the upper bay near the thermal power plant (85°F) and the Puerto Nuevo outfall (84°F). Cooling waters from the Palo Seco plant enters the Bayamón River and causes temperatures to exceed 95°F (a Standards violation) at the mouth of the river. The Standards requirement of no more than 4°F above ambient was exceeded near the outlet of the San Juan thermal power plant in the Army Terminal area.

Wastes from the Gulf Caribbean refinery are discharged into the mosquito control canal which enters San Juan Bay near Cataño (see Figure 1). Zero dissolved oxygen conditions were found at the mouth of the canal. Large quantities of oil also enter the bay from the canal.

Numerous violations of the oil and solids provisions of the Water Quality Standards were observed throughout the study area.

Total organic carbon (TOC) concentrations are indicative of the magnitude of pollution from sanitary and organic industrial waste sources. The data in Table V showed highest TOC concentrations in the bay at Stations UB-2 and UB-11, both located near large sources of municipal (Puerto Nuevo outfall and Martin Peña Canal) and industrial waste (Corona Brewery). In the lower bay, the cleansing effect of tidal exchange reduced TOC concentrations closer to background levels. The generally higher values in the upper bay, while not alarming, are a clear indication that waste inputs are not dissipated rapidly.

Weather during the month of January should permit optimum water quality conditions to prevail. The large percentage of Standards violations was unexpected.

TABLE II

SUMMARY OF CHEMICAL AND PHYSICAL DATA
REGULAR SAMPLING STATIONS

Station		Dissolved Oxygen (mg/l)		Temperature (°C)		pH
		Top	Bottom	Top	Bottom	
			San Juan Bay			
UB-2	Maximum	8.5	5.3	29	28.5	8.3
	Minimum	1.3	0.0	25.5	26	8.2
	Mean	5.0	3.4	27.2	27.2	8.2
	No. of observations	19	16			
	% Violations, all samples	26	69			
	% Violations, 0400-1000 hrs.	50	100			
UB-3	Maximum	3.1	2.8	27	27.5	
	Minimum	1.6	2.4	26	27	
	Mean	2.6	2.6	26.5	27.3	
	No. of observations	3	3	3	3	
	% Violations, all samples	100	100			
	% Violations, 0400-1000 hrs.	100	100			
UB-4	Maximum	12.7	6.0	29	28.5	8.1
	Minimum	1.8	3.3	26	26.0	8.0
	Mean	5.7	4.9	27.3	27.0	8.0
	No. of observations	19	18			
	% Violations, all samples	42	22			
	% Violations, 0400-1000 hrs.	75	25			
UB-5	Maximum	11.9	7.3	28.5	27.5	8.2
	Minimum	3.6	5.0	26.0	26.0	8.2
	Mean	7.5	6.0	27.1	26.6	8.2
	No. of observations	19	19			
	% Violations, all samples	11	0			
	% Violations, 0400-1000 hrs.	22	0			

TABLE II (cont'd)

SUMMARY OF CHEMICAL AND PHYSICAL DATA
REGULAR SAMPLING STATIONS

Station		Dissolved Oxygen (mg/l)		Temperature (°C)		pH
		Top	Bottom	Top	Bottom	
UB-6	Maximum	14.3	7.1	29	28.5	8.2
	Minimum	3.8	4.4	26.5	26	8.2
	Mean	6.7	5.8	27.6	27.2	8.2
	No. of observations	19	18			
	% Violations, all samples	5	6			
	% Violations, 0400-1000 hrs.	12	0			
UB-7	Maximum	12.7	10.4	29	29	8.2
	Minimum	3.6	3.7	26	27	8.1
	Mean	6.1	5.6	27.8	27.8	8.2
	No. of observations	19	17			
	% Violations, all samples	11	18			
	% Violations, 0400-1000 hrs.	0	14			
UB-8	Maximum	7.5	9.0	29.5	29	8.2
	Minimum	3.6	4.4	27.0	27	7.9
	Mean	5.4	5.6	28.1	28.2	8.0
	No. of observations	16	12			
	% Violations, all samples	19	8			
	% Violations, 0400-1000 hrs.	0	0			
UB-9	Maximum	5.7	5.8	29	29	8.1
	Minimum	3.5	3.3	26	26	8.0
	Mean	4.7	4.7	28	28.1	8.1
	No. of observations	20	16			
	% Violations, all samples	40	38			
	% Violations, 0400-1000 hrs.	56	80			

TABLE II (cont'd)

SUMMARY OF CHEMICAL AND PHYSICAL DATA
REGULAR SAMPLING STATIONS

Station		Dissolved Oxygen (mg/l)		Temperature (°C)		pH
		Top	Bottom	Top	Bottom	
UB-10	Maximum	9.4	8.2	29	29	8.3
	Minimum	1.6	1.7	26	26	8.0
	Mean	5.1	4.6	27.5	27.6	8.2
	No. of observations	19	15			
	% Violations, all samples	32	40			
	% Violations, 0400-1000 hrs.	71	80			
UB-11	Maximum	10.3	6.6	29.5	28	8.1
	Minimum	0.9	2.3	26.0	26.5	8.1
	Mean	5.0	4.0	27.3	27.4	8.1
	No. of observations	19	14			
	% Violations, all samples	42	64			
	% Violations, 0400-1000 hrs.	86	100			
LB-1	Maximum	12.9	8.0	29	28	8.0
	Minimum	6.4	3.3	26	25.5	8.0
	Mean	9.3	5.8	27.3	26.6	8.0
	No. of observations	17	17			
	% Violations, all samples	0	24			
	% Violations, 0400-1000 hrs.	0	25			
LB-2	Maximum	12.2	6.9	28	27	8.2
	Minimum	6.3	4.1	26	26	8.1
	Mean	8.6	5.5	27	26.6	8.2
	No. of observations	17	17			
	% Violations, all samples	0	24			
	% Violations, 0400-1000 hrs.	0	25			

TABLE II (cont'd)

SUMMARY OF CHEMICAL AND PHYSICAL DATA
REGULAR SAMPLING STATIONS

Station		Dissolved Oxygen (mg/l)		Temperature (°C)		pH
		Top	Bottom	Top	Bottom	
LB-3	Maximum	13.0	8.2	28	28	8.2
	Minimum	5.5	4.7	26	26	8.2
	Mean	8.2	6.1	27.2	26.9	8.2
	No. of observations	17	15			
	% Violations, all samples	0	0			
	% Violations, 0400-1000 hrs.	0	0			
LB-4	Maximum	9.8	9.0	27.5	27.5	8.3
	Minimum	6.5	5.7	26.0	26.5	8.3
	Mean	7.6	7.2	27.0	27	8.3
	No. of observations	10	9			
	% Violations, all samples	0	0			
	% Violations, 0400-1000 hrs.	0	0			
LB-5	Maximum	8.3	8.1	27.5	28	
	Minimum	6.5	5.5	26.5	26.5	
	Mean	7.2	6.7	27.1	26.9	
	No. of observations	6	6			
	% Violations, all samples	0	0			
	% Violations, 0400-1000 hrs.	0	0			
LB-6	Maximum	7.1	7.5	31	27	
	Minimum	6.5	7.5	27.5	27	
	Mean	6.8	7.5	29.3	27	
	No. of observations	2	1			
	% Violations, all samples	0	0			
	% Violations, 0400-1000 hrs.	0	0			

TABLE II (cont'd)

SUMMARY OF CHEMICAL AND PHYSICAL DATA
REGULAR SAMPLING STATIONS

Station		Dissolved Oxygen (mg/l)		Temperature (°C)		pH
		Top	Bottom	Top	Bottom	
LB-8	Maximum	8.7	7.7	29.	28.5	8.2
	Minimum	3.5	3.4	26	26	8.1
	Mean	5.8	5.4	27.2	27.2	8.2
	No. of observations	16	14			
	% Violations, all samples	19	36			
	% Violations, 0400-1000 hrs.	33	80			
LB-9	Maximum	11.8	7.8	28	28	8.2
	Minimum	5.7	2.0	26	26	8.1
	Mean	7.7	6.2	27.2	27.1	8.2
	No. of observations	17	17			
	% Violations, all samples	0	6			
	% Violations, 0400-1000 hrs.	0	0			
		San Jose and Las Corozos Lagoons				
SJ-1	Maximum	22.4	1.1	28	26.5	8.6
	Minimum	1.2	0.0	24	25	8.3
	Mean	9.0	0.2	25.3	26	8.4
	No. of observations	11	11			
	% Violations, all samples	36	100			
	% Violations, 0400-1000 hrs.	50	100			
SJ-2	Maximum	28.3	1.8	29	9.1	
	Minimum	2.0	1.8	23	8.2	
	Mean	9.6	1.8	25.4	8.6	
	No. of observations	11	1.8			
	% Violations, all samples	36	100			
	% Violations, 0400-1000 hrs.	50	100			

TABLE II (cont'd)

SUMMARY OF CHEMICAL AND PHYSICAL DATA
REGULAR SAMPLING STATIONS

Station		Dissolved Oxygen (mg/l)		Temperature (°C)		pH
		Top	Bottom	Top	Bottom	
SJ-3	Maximum	30.6	0.0	29		9.4
	Minimum	1.6	0.0	24		8.9
	Mean	10.8	0.0	25.5		9.1
	No. of observations	11	1			
	% Violations, all samples	36	100			
	% Violations, 0400-1000 hrs.	50	100			
SJ-4	Maximum	16.7	0.7	27	27	8.4
	Minimum	1.1	0.0	24	26	8.1
	Mean	9.1	0.1	25.4	26.6	8.3
	No. of observations	11	10			
	% Violations, all samples	36	100			
	% Violations, 0400-1000 hrs.	50	100			
SJ-5	Maximum	13.8		28		8.8
	Minimum	0.4		24		8.4
	Mean	6.7		25.5		8.6
	No. of observations	11				
	% Violations, all samples	36				
	% Violations, 0400-1000 hrs.	50				
SJ-6	Maximum	16.8	8.9	27.5	27	9.0
	Minimum	0.6	0.0	24	24	8.8
	Mean	8.4	3.6	25.5	25.5	8.9
	No. of observations	11	9			
	% Violations, all samples	36	67			
	% Violations, 0400-1000 hrs.	50	75			

TABLE II (cont'd)

SUMMARY OF CHEMICAL AND PHYSICAL DATA
REGULAR SAMPLING STATIONS

Station		Dissolved Oxygen (mg/l)		Temperature (°C)		pH
		Top	Bottom	Top	Bottom	
SJ-7	Maximum	11.8		28		8.4
	Minimum	0.0		23.5		7.8
	Mean	4.8		25.8		8.1
	No. of observations	11				
	% Violations, all samples	55				
	% Violations, 0400-1000 hrs.	62				
SJ-8	Maximum	18.9	12.2	27	26.5	8.5
	Minimum	0.0	0.0	24	24.5	8.4
	Mean	6.5	3.0	25	25.0	8.4
	No. of observations	8	8			
	% Violations, all samples	50	75			
	% Violations, 0400-1000 hrs.	67	67			
			Martin Peña Canal			
MPC-1	Maximum	5.8		28.5		8.8
	Minimum	0.1		25		7.2
	Mean	1.8		27		7.9
	No. of observations	21				
	% Violations, all samples	90				
	% Violations, 0400-1000 hrs.	88				
MPC-2	Maximum	6.3		28		9.0
	Minimum	1.3		25		7.6
	Mean	4.8		26.6		8.3
	No. of observations	21				
	% Violations, all samples	24				
	% Violations, 0400-1000 hrs.	12				

TABLE III

DISSOLVED OXYGEN AND TEMPERATURE DATA
SAN JUAN BAY NAVIGATIONAL CHANNEL*

Navigational Channel Near Station	January Date	Time	DO (mg/l)	Temperature (°C)
UB-4	19	0724	3.9	26
	19	1725	4.8	27
	21	0722	4.2	27
UB-7	19	0753	3.5	26
	19	1750	5.4	27
	21	0755	4.4	27
UB-9	19	0743	4.2	26
	19	1745	3.7	27
	21	0747	4.7	26.5
UB-10	19	0738	2.7	26.5
	19	1740	4.9	27.0
UB-11	21	0733	3.6	26.5

*All samples taken near channel bottom.

TABLE IV

CHEMICAL AND PHYSICAL DATA
CONDADO LAGOON AND SAN JUAN BAY TRIBUTARIES

Station or Location	January Date	Time	Dissolved Oxygen (mg/l)		Temperature (°C)		pH	
			Top	Bottom	Top	Bottom	Top	Bottom
Mosquito Control Canal Above Salinity Barrier	22	0820	0.0	0.0	27	26.5	7.1	7.1
	22	1501	0.6		25.5		7.0	
Mouth of Bayamón River	22	0845	5.6	5.7	32	34	7.7	7.8
	22	1410	5.9	5.2	35	35.5	7.7	7.8
Condado Lagoon								
C-1	22	1123	5.6		25		8.0	
C-2	22	1130	5.4		25		8.1	
C-3	22	1131	4.1		25		7.9	
C-4	22	1134	4.4		25		8.0	
C-5	22	1125	5.1		25		8.1	
C-6	22	1119	5.6		25		8.1	
C-7	22	1116	7.3		26		8.1	
C-8	22	[illegible]	5.8		25		8.0	

TABLE V

TOTAL ORGANIC CARBON CONCENTRATIONS
SAN JUAN BAY

Station*	Jan. 18, 1971	Jan. 19, 1971
	(mg/l)	(mg/l)
LB-1	4	3
LB-2	4	4
LB-3	-	5
LB-4	-	6
LB-5	-	5
LB-8	4	6
LB-9	4	4
UB-2	5	12
UB-4	5	7
UB-5	3	6
UB-6	3	7
UB-7	4	5
UB-8	3	3
UB-9	3	4
UB-10	5	4
UB-11	5	8

*Surface samples.

BACTERIOLOGICAL STUDY

As part of the January 1971 survey, a study was conducted to determine the bacterial quality of recreational waters in the greater San Juan area. Violations of the standards applying to these waters were documented. These waters are now being used extensively for water contact recreation.

The three-part bacterial criterion applying to Puerto Rico's recreational waters require a monthly median total coliform concentration not to exceed 1000/100 ml, or not to exceed 1000/100 ml in more than 20 percent of the samples examined in any month, or not over 2400/100 ml on any given day.

Bacterial quality was determined at 17 beach-front sites and eight sites within Condado Lagoon (Figure 1, Table VI). Total and fecal coliform concentrations were determined at each site, and one qualitative examination for the presence of Salmonellae was made at each site. The sampling sites were sampled a maximum of six and a minimum of four times during the study.

Condado Lagoon

Examination of the data in Tables VII through X shows numerous violations of the water quality standards. Some of the counts indicate extremely severe fecal contamination. Of the areas studied, Condado Lagoon had the most serious bacterial pollution. The total coliform concentrations at each of the sampling sites exceeded the bacterial standard (Table VII, Figure 5). The pathogen Salmonella heidelberg was also identified. Fecal coliform levels in Condado Lagoon, which are more indicative of wastes from man and animal, are shown in Table VIII

TABLE VI

BACTERIOLOGICAL SAMPLING STATION LOCATIONS

A. Beach Stations

B1 - West end of U.S. Naval Reserve Officers Beach

B2 - Beach located at the Piscina Olimpica, adjacent to a storm sewer

B3 - Pier adjacent to Caribe Hilton Hotel Beach

B4 - Balneario Condado Beach

B5 - Small park next to El Mirador Condominium on Ashford Avenue

B6 - Beach at the Hotel La Concha

B7 - Beach at the Atlantic Beach Hotel

B8 - Beach adjacent to Sheraton Hotel, next to large storm sewer east of hotel

B9 - Adjacent to large storm sewer behind the Condado del Mar Condominium

B10 - Adjacent to large storm sewer east of Casino de Puerto Rico

B11 - West end of Barbosa Park Beach

B12 - East end of Barbosa Park Beach

B13 - Beach behind the Park Boulevard Condominium

B14 - Beach of the El San Juan Hotel

B15 - Beach 100 yards east of Holiday Inn

B16 - West end of Isla Verde Public Beach

B17 - East end of Isla Verde Public Beach

TABLE VI (cont'd)

BACTERIOLOGICAL SAMPLING STATION LOCATIONS

B. Condado Lagoon Stations

C-1 - Approximately 50 feet from Flamboyan Hotel Beach

C-2 - Approximately 50 feet from boat dock just west of Barranquitas Street

C-3 - Near the end of a concrete jetty in the vicinity of Delcasse Avenue

C-4 - Approximately 50 feet from eastern end of the lagoon along the Avenue Baldorioty De Castro

C-5 - Approximately 30 feet west of boat launching ramp near the Baldorioty De Castro Statue

C-6 - Approximately 50 feet from shore on a line with Ensenada Street

C-7 - Easternmost bridge separating Condado Lagoon and Caño de San Antonio

C-8 - Center of lagoon directly out from Baldorioty De Castro Statue

and Figure 5.[1/]

Most of the bacterial pollution sources are located along the southern and eastern shores of the lagoon. Numerous sewers were observed discharging fecal material. The most obviously contaminated effluents were west of the Baldorioty De Castro Statue along the southern shore of the lagoon.

Violations of water quality standards other than excessive coliform concentrations were observed. Large quantities of floating and settleable solids were discharged from sewers. On January 13, 1971, oil was observed flowing from a sewer located on the southern shore of the lagoon on a line with Calle Madrid. Most of the nearshore area of the lagoon had considerable debris, both floating and submerged. Some evidence of garbage was noted in the proximity of the Baldorioty De Castro Statue. Rats were numerous along the shore.

Beach Areas

Bacterial water quality at the 17 beachfront stations was generally good (Table IX, Figure 6). Four areas sampled did have standards violations, however. These were located:

- Just east of the Puerto Rico Sheraton Hotel (Station B8)
- Behind the Condado Del Mar Condominium (Station B9)
- East of the Casino de Puerto Rico in the vicinity of Kings Court (Station B10)
- Behind the El San Juan Hotel (Station B14).

1/No standards for fecal coliform concentrations have been adopted for Puerto Rican waters. Counts higher than 200/100 ml are generally considered cause for concern.

The first three sites had the most severe bacterial quality problems and all were adjacent to large storm sewers which receive some sanitary wastes. The reason for the occasional high total coliform concentrations at the El San Juan Beach was not apparent.

Fecal coliform concentrations for beach stations are shown in Table X and Figure 6. Concentrations in excess of 200/100 ml were common at the four sites previously mentioned.

TABLE VII

TOTAL COLIFORM CONCENTRATIONS* IN
CONDADO LAGOON

Station	1/17/71	1/18/71	1/19/71	1/20/71	1/21/71	1/22/71	Median
C1	-	330,000	13,000	92,000	2,300	2,300	13,000
C2	-	230,000	54,000	35,000	490	3,300	35,000
C3	79,000	2,300,000	2,300,000	490,000	790,000	>240,000	640,000
C4	2,000	4,000	790	790	>240,000	4,900	3,000
C5	220,000	330,000	130,000	8,000	1,300,000	5,000	180,000
C6	2,300,000	790,000	1,300,000	130,000	11,000,000	5,400,000	1,800,000
C7	<2,000	9,000	4,900	3,500	1,300	3,500	3,500
C8	-	2,000	230	2,200	700	7,000	2,000

* MPN/100 ml

- No analysis

TABLE VIII

FECAL COLIFORM CONCENTRATIONS* IN
CONDADO LAGOON

Station	1/17/71	1/18/71	1/19/71	1/20/71	1/21/71	1/22/71	Median
C1	-	5,000	4,900	7,900	790	790	5,000
C2	-	33,000	1,400	7,900	490	3,300	3,300
C3	-	490,000	490,000	70,000	330,000	>240,000	330,000
C4	-	<2,000	130	3[illegible]0	>240,000	3,300	2,000
C5	-	130,000	49,000	8,000	1,300,000	2,000	49,000
C6	-	490,000	490,000	130,000	7,900,000	490,000	490,000
C7	-	2,000	790	3,500	790	790	790
C8	-	2,000	80	940	700	1,300	940

* MPN/100 ml

- No analysis

FIGURE 5

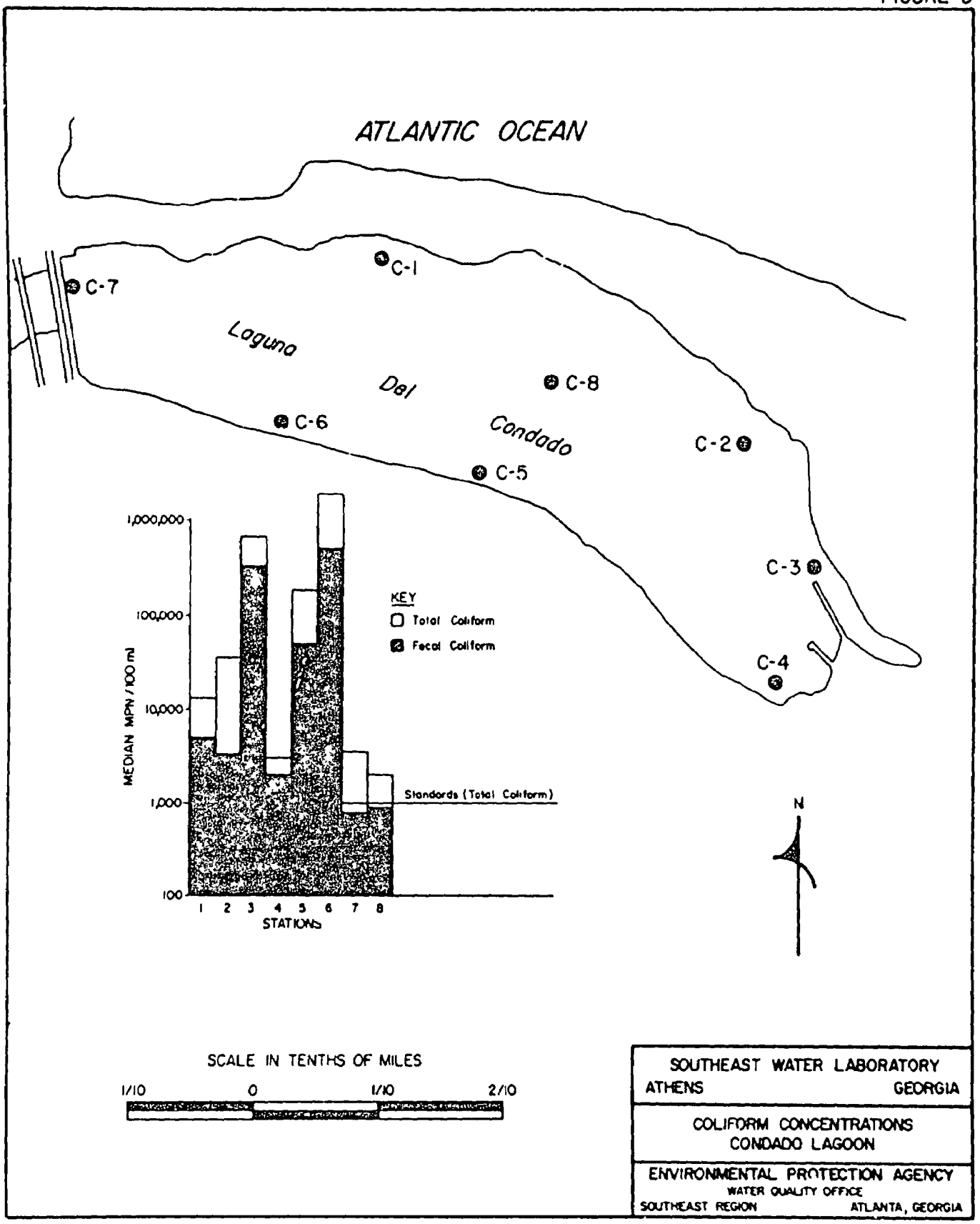

ATLANTIC OCEAN
C-1
C-7
Laguna
Del
C-8
C-6
Condado
C-2
C-5
C-3
C-4
1,000,000
100,000
10,000
1,000
100
MEDIAN MPN / 100 ml
KEY
Total Coliform
Fecal Coliform
Standards (Total Coliform)
1 2 3 4 5 6 7 8
STATIONS
N
SCALE IN TENTHS OF MILES
1/10 0 1/10 2/10
SOUTHEAST WATER LABORATORY
ATHENS GEORGIA
COLIFORM CONCENTRATIONS
CONDADO LAGOON
ENVIRONMENTAL PROTECTION AGENCY
WATER QUALITY OFFICE
SOUTHEAST REGION ATLANTA, GEORGIA

TABLE IX

TOTAL COLIFORM CONCENTRATIONS* AT
BEACHFRONT STATIONS

Station	1/17/71	1/18/71	1/19/71	1/20/71	1/21/71	1/22/71	Median
B1	80	490	170	130	1,300	330	250
B2	130	130	80	79	2,200	230	130
B3	<20	<20	80	330	33	50	42
B4	490	-	<20	23	280	<20	23
B5	230	70	80	23	330	50	75
B6	330	-	230	23	230	330	230
B7	260	-	230	790	330	170	260
B8	>240,000	-	700,000	230,000	170,000	70,000	240,000
B9	92,000	1,300,000	2,000	23,000	2,000	70,000	47,000
B10	35,000	2,300	7,000	27,000	70,000	33,000	30,000
B11	790	490	50	330	9,200	130	410
B12	790	490	80	33	490	33	290
B13	<20	790	20	23	130	17	22
B14	50	-	3,300	790	5,400	460	790
B15	110	-	20	7	>24,000	130	110
B16	20	-	230	79	330	46	79
B17	40	-	<20	13	130	49	40

* MPN/100 ml

- No analysis

TABLE X

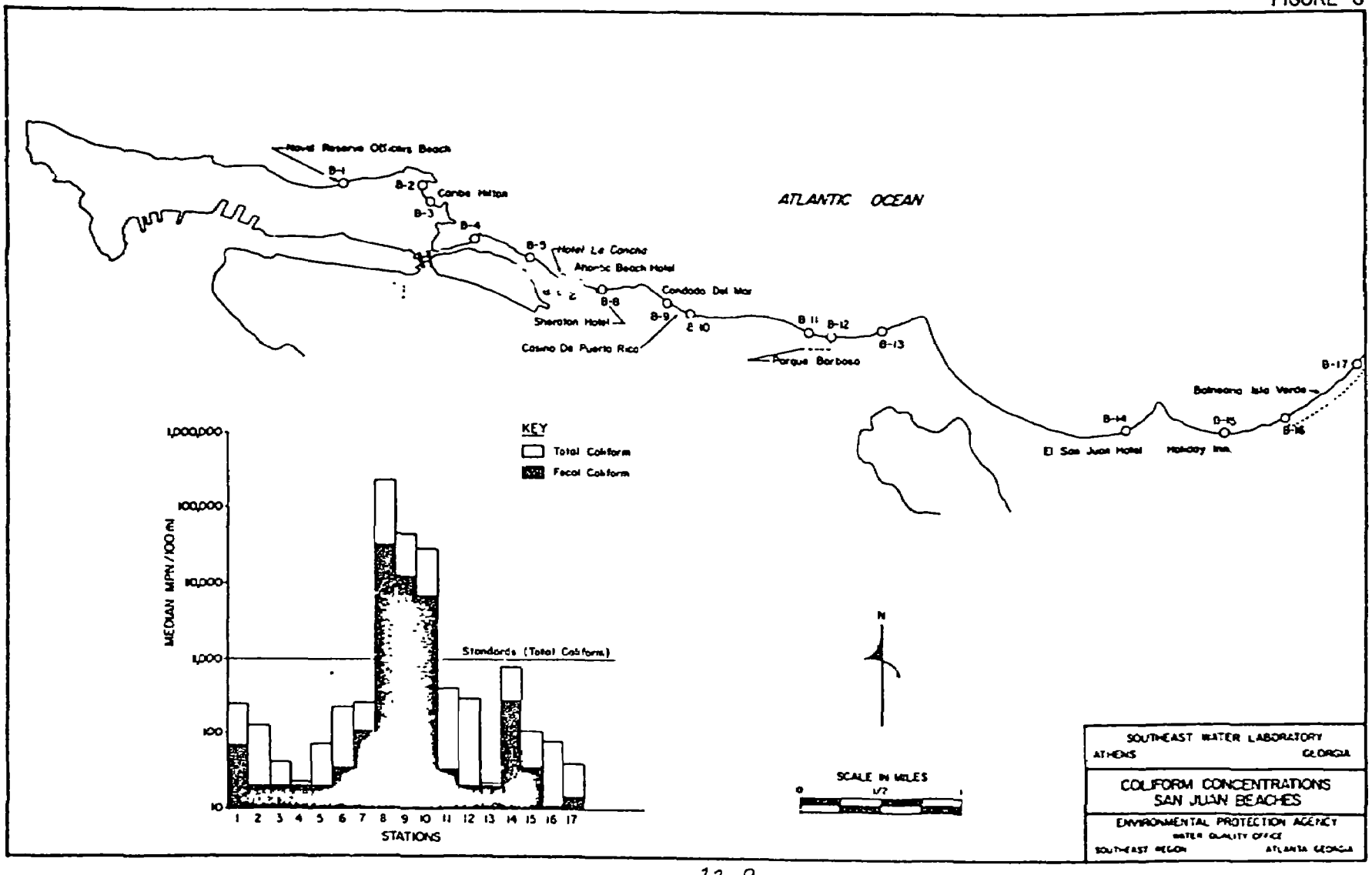
FECAL COLIFORM CONCENTRATIONS* AT
BEACHFRONT STATIONS

Station	1/17/71	1/18/71	1/19/71	1/20/71	1/21/71	1/22/71	Median
B1	-	70	20	2	790	80	70
B2	-	<20	20	22	79	20	20
B3	-	<20	50	310	5	20	20
B4	-	-	<20	8	170	<20	20
B5	-	20	20	23	70	20	20
B6	-	-	50	2	130	<20	35
B7	-	-	50	490	170	<20	110
B8	-	-	330,000	33,000	33,000	33,000	33,000
B9	-	790,000	<2,000	13,000	2,000	13,000	13,000
B10	-	2,300	7,000	4,000	9,000	13,000	7,000
B11	-	490	20	34	2,400	8	34
B12	-	490	20	7	490	5	20
B13	-	220	20	8	27	2	20
B14	-	-	490	330	230	230	280
B15	-	-	<20	2	5,400	49	35
B16	-	-	<20	<2	33	<2	11
B17	-	-	<20	8	23	<2	14

* MPN/100 ml

- No analysis

FIGURE 6


Hotel Reserve Officers Beach
B-1
B-2
Caribe Hilton
B-3
B-4
B-5
Hotel La Concha
Atlantic Beach Hotel
Condado Del Mar
B-8
B-9
B 10
B 11
B-12
B-13
Sheraton Hotel
Casino De Puerto Rico
Parque Barbosa
B-17
Balneario Isla Verde
B-14
B-15
B-16
El San Juan Hotel
Holiday Inn
ATLANTIC OCEAN
KEY
Total Coliform
Fecal Coliform
MEDIAN MPN/100 ml
1,000,000
100,000
10,000
1,000
100
10
Standards (Total Coliform)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
STATIONS
N
SCALE IN MILES
0
1/2
1
SOUTHEAST WATER LABORATORY
ATHENS
GEORGIA
COLIFORM CONCENTRATIONS
SAN JUAN BEACHES
ENVIRONMENTAL PROTECTION AGENCY
WATER QUALITY OFFICE
SOUTHEAST REGION
ATLANTA GEORGIA

SEDIMENT CHARACTERISTICS

The Corps of Engineers and the Puerto Rico Port Authority made several core borings in San Juan Bay in the early 1960's. The borings were taken as part of the plan for channel improvement. The description of the borings indicates that thick deposits (over 35 feet in some locations) of organic clay and silt covered much of the inner, or upper, bay area. Adjacent to the Puerto Nuevo channel and especially near the mouth of Martin Peña Canal, the organic deposits were more silt than clay. Closer to the mouth of San Juan Bay, the organic clay cover yielded to sand and sandy-shell deposits.

The channel which was constructed in the Puerto Nuevo area shortly after the borings were taken has been filling rapidly with solids since construction. Most of the settleable matter entering the channel comes from the silt-laden flow of the Rio Piedras, but a sizeable fraction originates from the discharge of municipal and industrial wastes at the upper end of the bay. A maintenance dredging project will be underway soon to restore the channel to its original depth.

During the January 1971 water quality study, additional cores were extracted from bottom deposits at seven of the Upper Bay Stations (see Table XI). These cores were examined for physical appearance, odor, and chemical characteristics. Most of the bottom samples were black, malodorous and resembled some type of organic sludge. A limited attempt at determining the thickness of the organic deposit showed that it was at least 12 feet thick at many points. Corps of Engineers data are more reliable thickness indicators.

While not as rich in organic nitrogen (as N), total phosphorus (as P), and organic carbon (as C), as some sediments found in polluted areas of the continental United States, the sediments were nevertheless quite high in these nutrient constituents. The carbon to nitrogen ratio was generally less than 15:1, and this is highly indicative of a sanitary or municipal waste origin.

Many raw or insufficiently treated waste sources contribute to the problem of solids buildup in upper San Juan Bay. Not the least of these contributors are the Puerto Nuevo sewage treatment plant, the Corona brewery, raw municipal waste discharges along Martin Peña Canal, and the U.S. Navy facilities. Untreated wastes from military and merchant ships pour into the upper bay in the Puerto Nuevo, Army Terminal, and Navy Base areas.

The large amounts of nutrients found in San Juan Bay bottom sediments contribute to accelerated eutrophication of bay waters. The eutrophication problem manifests itself primarily in the form of excessively high and low dissolved oxygen levels and overabundant algal growth.

TABLE XI

SEDIMENT ANALYSES, SAN JUAN BAY

Sta. No.*	Date Sampled	COD (mg/kg)	% Organic Carbon**	Organic Nitrogen (mg/kg)	Total Phosphorus (mg/kg)	Appearance	Core Length (ft)
UB-2-B	1-20-71	47,329	1.77	5,438	395	Black Sludge	4
UB-2-T	1-20-71	42,596	1.60	3,500	495	Black Sludge	4
UB-2-M	1-20-71	43,985	1.65	4,256	650	Black Sludge	4
UB-4-M	1-20-71	90,285	3.38	6,033	545	Black Sludge	4
UB-4-T	1-20-71	63,276	2.37	5,279	480	Black Sludge	4
UB-4-B	1-20-71	58,646	2.20	6,195	310	Black Sludge	4
UB-7-T	1-20-71	48,152	1.80	2,909	365	Dark Grey and Black	1 1/2
UB-7-B	1-20-71	152,433	5.71	6,176	250	Sludge Mixture With Some Shell	1 1/2
UB-8-T	1-20-71	10,496	0.39	4,200	320	Grey Mud and Mixture of Shell	2 1/2
UB-8-B	1-20-71	18,983	0.71	7,000	300	Grey Mud and Mixture of Shell	2 1/2
UB-10-T	1-20-71	46,300	1.73	2,653	305	Black Sludge	3
UB-10-M	1-20-71	30,249	1.13	747	255	Black Sludge	3
UB-11-T	1-20-71	55,560	2.08	5,997	715	Black Sludge	4
UB-11-M	1-20-71	75,932	2.84	3,920	815	Black Sludge	4
UB-11-B	1-20-71	68,524	2.57	3,582	550	Black Sludge	4

TABLE XI (cont'd)

SEDIMENT ANALYSES, SAN JUAN BAY

Sta. No.*	Date Sampled	COD (mg/kg)	% Organic Carbon**	Organic Nitrogen (mg/kg)	Total Phosphorus (mg/kg)	Appearance	Core Length (ft)
UB-3-T	1-20-71	65,848	2.47	4,527	640	Black Sludge	3 1/2
UB-3-M	1-20-71	97,230	3.64	2,217	635	Black Sludge	3 1/2
UB-3-B	1-20-71	57,244	2.14	2,217	375	Black Sludge	3 1/2

NOTE: All analyses on dry weight basis

* T, M, and B signify top, middle or bottom segments of the sediment core.

** By calculation from COD.

PLANKTON

Total phytoplankton counts (Table XII) in San Juan coastal waters showed that algal levels in:

- San Juan Bay were above average for marine conditions -- average 640/ml, maximum 1159/ml;
- San Jose Lagoon were extremely high -- average 17,400/ml, maximum 31,980/ml.

The dense algal population in San Jose Lagoon caused:

- Oxygen supersaturation near the surface on sunny days.
- Nuisance problems -- matting at the shoreline.

High DO values in San Jose Lagoon were accompanied by anoxic conditions at all times in waters overlying the Lagoon bottom. At night and on cloudy days, the entire water column approached anoxic conditions as a result of the excessive artificial enrichment which produced abnormal biotic response.

Algae play a vital role in a balanced aquatic environment. When nutrients from waste discharges enter receiving waters, the effect on such waters can be overenrichment, or accelerated eutrophication. This is happening to a highly damaging extent in San Jose Lagoon but to a lesser degree in San Juan Bay. The algal population in the bay is sufficient, however, to cause supersaturation of DO in almost all San Juan Bay in late afternoon. Nocturnal biotic activity decreases DO levels over a major portion of the upper bay to below 4.5 mg/l. There is no dominant subgroup of phytoplankton in San Juan Bay. Tidal action conveys significant numbers of plankton into the bay from San Jose Lagoon.

At times San Jose Lagoon is completely colored green from plankton. Greater than 50 percent of the plankton found were pigmented flagellates (these along with blue-greens are frequently encountered in waters affected by organic wastes). Some blue-green algae were also found in San Jose Lagoon, and these are probably responsible for reports of odors. A heavy algal bloom was present during the week of 17 January. The northeast shore of the lagoon was matted with an extensive accumulation of algae. Although no odor was present, the water quality damage was obvious.

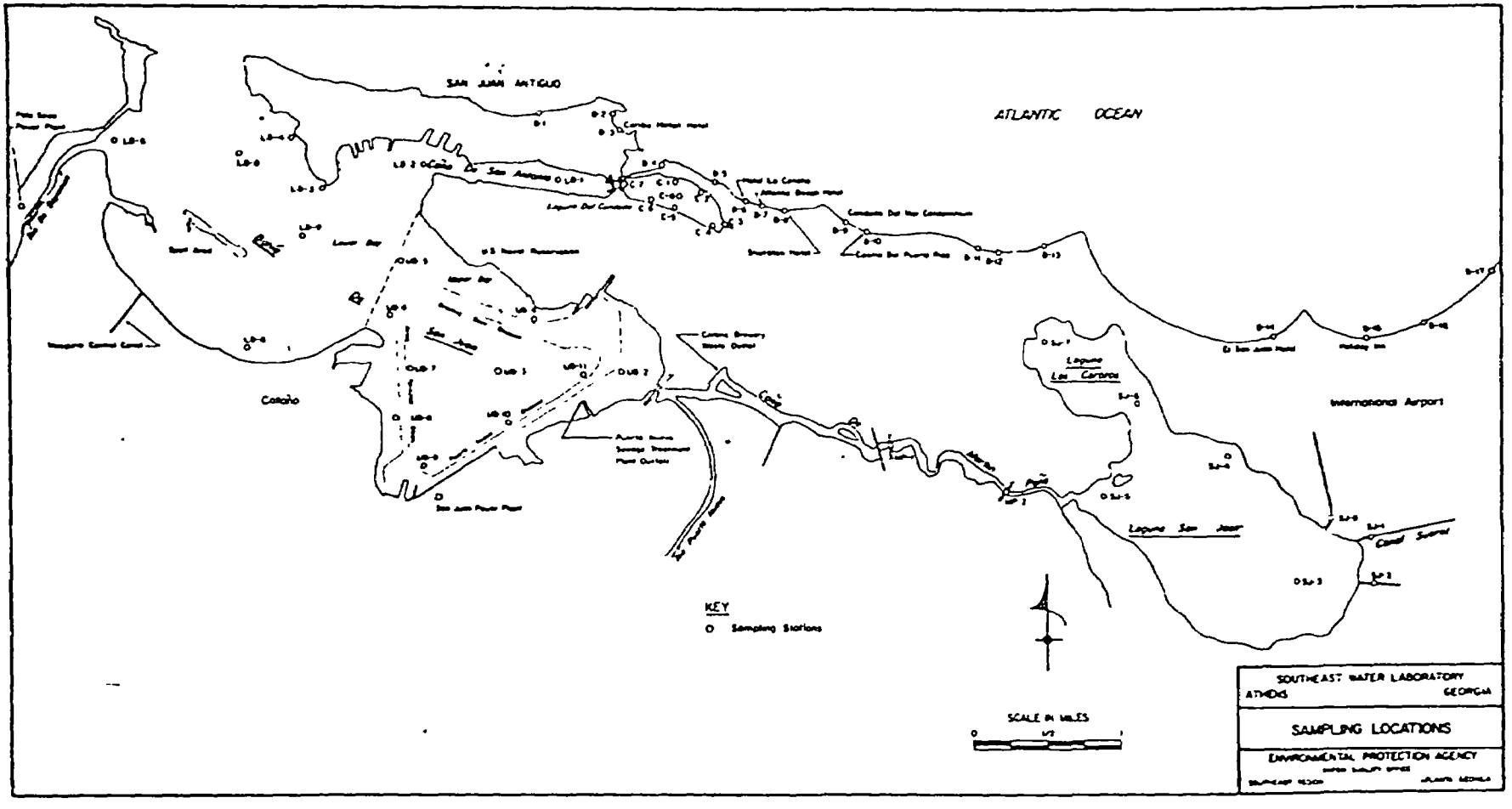
The biological and chemical characteristics of San Jose Lagoon, coupled with its physical appearance, indicate that the water body is little more than a waste stabilization pond. Fluctuations in oxygen levels from zero to 30.6 mg/l make the lagoon a likely candidate for fish kills at any time. The tremendous recreational potential of San Jose Lagoon for the San Juan area will never be realized while it remains in its present condition.

TABLE XII

PLANKTON DATA

SAMPLE LOCATION Station No.	Depth	PLANKTON (number per milliliter) TOTAL PLANKTON	BLUE GREEN Coccoid	BLUE GREEN Filamentous	GREEN Coccoid	GREEN Filamentous	FLAGELLATES (pigmented) Green	FLAGELLATES (pigmented) Other	DIATOMS Centric	DIATOMS Pennate	INERT DIATOM SHELLS Centric	INERT DIATOM SHELLS Pennate
San Juan Bay												
UB-2	Surf	368	0	0	26	0	105	0	211	26	26	105
UB-4	Surf	368	0	0	0	0	184	0	158	26	53	0
UB-5	Surf	711	0	0	26	53	132	0	474	26	26	79
UB-10	Surf	421	0	0	0	0	237	26	105	53	0	0
UB-11	Surf	790	0	0	26	0	421	0	290	53	26	26
LB-1	Surf	658	0	0	105	0	158	0	342	53	132	0
LB-9	Surf	1,159	0	0	132	0	105	0	790	132	158	0
San Jose Lagoon												
Near Boat Ramp	Surf	14,106	0	26	1,079	26	10,949	0	2,000	26	26	26
SJ-1	Surf	6,133	0	26	290	0	1,553	0	4,211	53	316	26
SJ-8	Surf	31,980	0	368	2,922	0	17,161	0	11,239	290	158	184

FIGURE 1


SAN JUAN ANTIGUO
ATLANTIC OCEAN
Condado
Laguna
Las Cabras
International Airport
Laguna San Juan
KEY
Sampling Stations
SCALE IN MILES
SOUTHEAST WATER LABORATORY
ATHENS GEORGIA
SAMPLING LOCATIONS
ENVIRONMENTAL PROTECTION AGENCY