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Characterization of Stormwater Discharges at the Guanajibo Industrial Park, Mayagüez, Puerto Rico, 1997-98

By José M. Rodríguez

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CONVERSION FACTORS, ABBREVIATED WATER-QUALITY UNITS, AND ACRONYMS

Multiply	By	To obtain
millimeter (mm)	0.03937	inch
meter (m)	3.281	foot
square meter (m^2)	10.76	square foot
cubic meter (m^3)	35.31	cubic foot
liter per second (L/s)	0.03531	cubic foot per second

Abbreviated water-quality units used in this report:

mg/L	milligram per liter
g	gram
mg/m^2	milligram per square meter
µS/cm	microsiemens per centimeter

Acronyms

BOD	Biochemical oxygen demand
COD	Chemical oxygen demand
GIP	Guanajibo Industrial Park
NPDES	National Pollutant Discharge Elimination System
PRIDCO	Puerto Rico Industrial Development Company
SIC	Standard Industrial Classification
TKN	Total Kjeldahl nitrogen
TOC	Total organic carbon
TP	Total phosphorus
TSS	Total suspended solids
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

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Abstract

Stormwater discharges from the Guanajibo Industrial Park, Mayagüez, Puerto Rico, were investigated from May 1997 to May 1998 by measuring the flow rate and collecting samples at three outfalls. The drainage area for each outfall was delineated. Flow rate measurements were used to calculate the volume of the stormwater discharges. The collected samples were analyzed to determine the quality of the discharges. Constituent loads and loads per area were estimated for each drainage area. The studied drainage subareas covered approximately 55 percent of the total area of the Guanajibo Industrial Park. Industrial groups represented in the study areas include manufacturers apparel, electronics, and food products.

The concentrations of oil and grease (less than 1 to 6 milligrams per liter), and total phosphorous (0.22 to 0.82 milligram per liter) from all the samples collected were less than the U.S. Environmental Protection Agency stormwater benchmark concentrations. Concentrations of biochemical oxygen demand (3.4 to 44 milligrams per liter), chemical oxygen demand (15.1 to 122 milligrams per liter) nitrate plus nitrite as nitrogen (0.06 to 1.6 milligrams per liter) and total suspended solids (50 to 456 milligrams per liter) exceeded benchmark concentrations at one or more of the studied drainage areas. Maximum concentrations for oil and grease, biochemical oxygen demand, and chemical oxygen demand were detected at an area where industrial groups that manufacture apparel and food products are represented. Maximum concentrations of total suspended solids, nitrate plus nitrite, and total phosphorous were detected at an area where apparel products manufacturing was the sole industrial activity.

INTRODUCTION

Studies conducted on a nationwide scale have demonstrated that runoff from urban and industrial areas can be a significant source of surface-water pollution (U.S. Environmental Protection Agency, 1983). Data obtained during these studies indicate that urban and industrial runoff may contain some pollutants in concentrations comparable to, and in some cases greater than, concentrations in effluents from wastewater secondary-treatment plants. Recent investigations at selected industrial parks in Puerto Rico (Rodríguez, 1998) detected the presence of elevated constituent concentrations indicative of waste in stormwater discharges in some of the studied areas.

The Federal Water Pollution Control Act, as amended in 1987 [section 402(p)], requires the U.S. Environmental Protection Agency (USEPA) to establish regulations under the National Pollutant Discharge Elimination System (NPDES) to control the quality of the stormwater discharges associated with industrial activities. The regulations require the owners or operators of facilities discharging stormwater associated with industrial activities to apply for a permit for those discharges and implement measures to minimize the contact of potential pollutants with the stormwater.

From May 1997 to May 1998, the U.S. Geological Survey (USGS), in cooperation with the Puerto Rico Industrial Development Company (PRIDCO), conducted a study to characterize the stormwater discharges at the Guanajibo Industrial Park (GIP) in the city of Mayagüez, which is located in western Puerto Rico (fig. 1). The GIP is one of over 200 industrial areas located in Puerto Rico in which PRIDCO is the owner of most of the industrial lots.

This report presents the data collected at three drainage subareas of the GIP. Stormwater runoff was characterized at each of the drainage subareas during at least two storm events. Data collected include drainage subarea characteristics; rainfall; stormwater discharge flow rates, volumes, and quality. These data were collected following methods required for a NPDES stormwater permit.The information collected during this study will improve the understanding of the stormwater discharges and indicate areas with constituent concentrations that exceeded recommended levels.

DESCRIPTION OF THE STUDY AREA AND SITE DRAINAGE

The GIP is located south of the urban center of the city of Mayagüez, western Puerto Rico. The principal hydrologic surface features related to the GIP are the Río Hondo and a wetland area northwest of the GIP (fig. 1). The Río Hondo and the wetland area receive the stormwater discharges from the GIP. The Río Hondo flows southwest and discharges into the Río Guanajibo. Two drainage channels convey part of the stormwater runoff produced at the park and eventually discharge into the wetland area. These drainage channels, which originate at the northwest boundary of the GIP have intermittent flow.

The GIP occupies an area of approximately 370,000 m^2, part of which is divided into three drainage subareas in which stormwater is conveyed by storm sewer (fig. 2). Subareas GIP 1, GIP 2, and GIP 3 were selected for stormwater characterization based on the feasibility of collecting stormwater flow and quality data.The feasibility of collecting the stormwater data depends on the site characteristics which include accessibility, safety, and proper conditions for equipment installation and operation.

Selected information was collected about the type of industrial activity conducted by each building tenant at the studied subareas of the GIP. The types of industrial activities were classified using the Standard Industrial Classification (SIC) (U.S. Executive Office of the President, 1987). Depending on the level of detail the SIC can use a 2- to 4-digit classification system, in which the first two digits show the major group, the third shows the industry group, and the fourth shows the industry code. In this report the 2-digit classification is used.

A total of 28 industrial lots were occupied at the GIP during the time of the study (table 1). Sampled areas included sections of 28 occupied lots. The principal industrial group at the GIP, classified under SIC 23 (apparel products), occupies 20 of the 28 lots included in the studied subareas. Other industrial groups represented at the GIP include SIC 20 (food and related products), SIC 34 (fabricated metal products), SIC 36 (electronic and other electrical equipment), and SIC 38 (measuring instruments).

GIP 1 covers about 70,500 m^2 (table 2) and includes sections of 9 industrial lots (fig. 2). Industrial groups represented at GIP 1 include SIC 23, 34, 36, and 38. Approximately 44,700 m^2 of GIP 1 is covered by pavement and buildings (table 2). The stormwater flow pattern in GIP 1 is mainly from the individual lots to the street (fig. 2). At the street, the stormwater flows toward storm drains located along the street. The storm sewer discharge eventually flows into the Río Hondo.

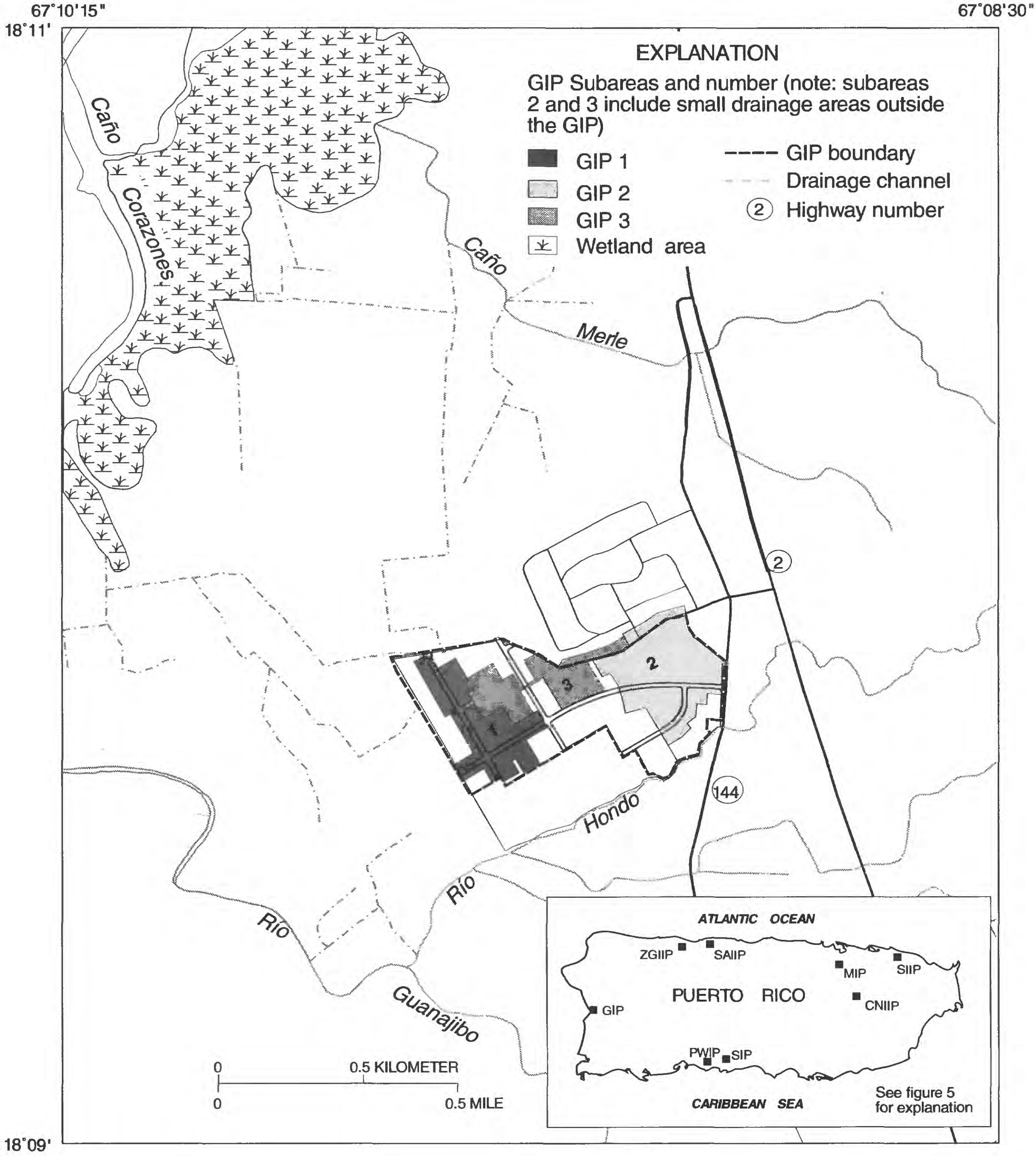

Figure 1. Location of the Guanajibo Industrial Park (GIP), Mayagüez, Puerto Rico.

Table 1. Industrial activities within selected drainage areas of the Guanajibo Industrial Park, Mayagüez, Puerto Rico

[SIC, Standard Industrial Classification]

Subarea	Lot number	SIC	Major group
1	17	38	Measuring instruments
1 and 3	47	34	Fabricated metal products
1 and 3	48	23	Apparel and other finished products
1	53	23	Apparel and other finished products
1	54, 55, 56	--	Unoccupied
1	57, 58	--	Unoccupied
1	59	36	Electronic and other electrical equipment
1	60	38	Measuring instruments
1	69	36	Electronic and other electrical equipment
1	70	36	Electronic and other electrical equipment
1	71	--	Non industrial
1	72	--	Non Industrial
1	73	--	Unoccupied
1	74	--	Unoccupied
1	75	--	Unoccupied
1	76	23	Apparel and other finished products
2	1	--	Non industrial
2	2	--	Non industrial
2	3	23	Apparel and other finished product
2	4	23	Apparel and other finished product
2	5	23	Apparel and other finished product
2	27, 29	20	Food and related products
2	31	23	Apparel and other finished product
2	32	23	Apparel and other finished product
2	33	23	Apparel and other finished product
2	34	--	Unoccupied
2	35	23	Apparel and other finished product
2	36, 37	23	Apparel and other finished product
2	38	23	Apparel and other finished product
2	39	23	Apparel and other finished product
2	40	23	Apparel and other finished products
3	41	23	Apparel and other finished products
3	42	23	Apparel and other finished products
3	43	23	Apparel and other finished products
3	44	23	Apparel and other finished products
3	45	--	Non industrial
3	49	--	Non industrial
3	50	--	Unoccupied
3	51	23	Apparel and other finished products

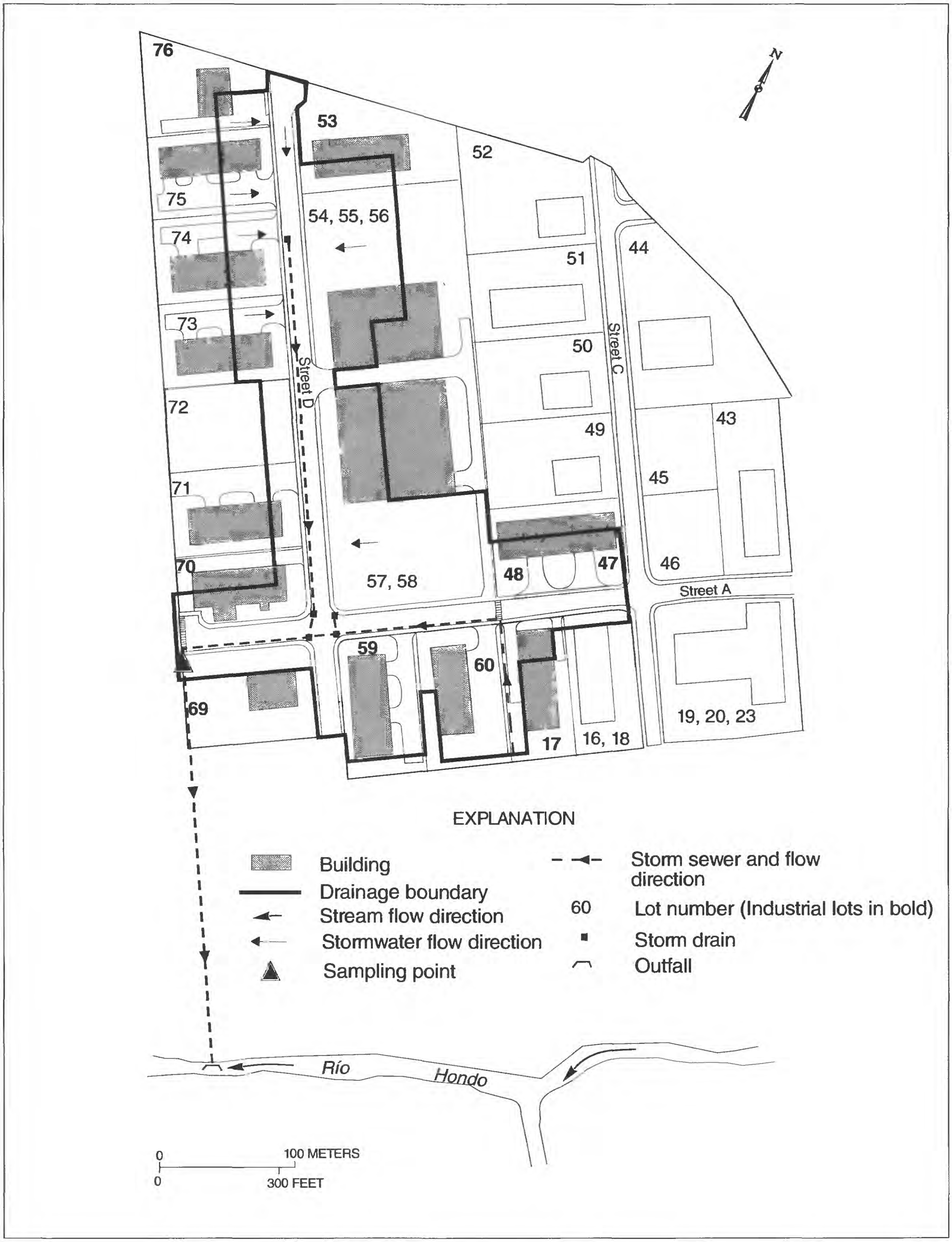

Figure 2. Site drainage for GIP 1.

Table 2. Estimated area covered by impervious surfaces and drainage area for selected subareas in the Guanajibo Industrial Park, Mayagüez, Puerto Rico
[m^2, square meters]

Subarea	Outfall location (Latitude-Longitude)	Area of impervious surface (m^2)	Drainage area (m^2)	Receiving water body
GIP 1	18°09'31"N. - 67°09'25"W.	44,700	70,500	Río Hondo
GIP 2	18°09'41"N. - 67°09'04"W.	54,000	[1]102,000	Río Hondo
GIP 3	18°09'28"N. - 67°09'31"W.	28,000	[2]48,000	Wetland area

[1] This area includes approximately 9,200 m^2 external to the GIP.
[2] This area includes approximately 7,500 m^2 external to the GIP.

GIP 2 covers approximately 102,000 m^2 (table 2) and contains sections of 14 industrial lots (fig. 3). Industrial groups represented at GIP 2 are SIC 23 and 20. Approximately 54,000 m^2 of GIP 2 are covered by pavement and buildings (table 2). The stormwater flow pattern in GIP 2 is mainly from the individual lots to the streets (fig. 3). Upon reaching the street, the stormwater flows into the stormwater sewer system. In addition to the stormwater runoff produced at GIP 2 contribution occurs from outside the industrial park (fig. 1). A storm drain located north of lot 36-37 conveys the stormwater from a section of the residential area (about 9 percent of the drainage subarea) north of the industrial park and discharges to the GIP 2 storm sewer (table 2). As in GIP 1, the stormwater from GIP 2 flows into the Río Hondo.

GIP 3 (fig. 4) covers approximately 48,000 m^2 (table 2) and contains sections of 7 industrial lots. All the industrial activity at GIP 3 is grouped under SIC 23. Approximately 28,000 m^2 is covered by pavement and buildings. Stormwater flows away from the street in the individual lots, where it is conveyed by storm drains (lots 41, 42, and 43) and a concrete channel. As in GIP 2, contribution of stormwater occurs from outside the park to GIP 3. A storm drain located north of lot 42 conveys the stormwater from a section of the residential area (about 16 percent of the drainage subarea) north of the park and discharges to the GIP 3 storm sewer. The outfall for the stormwater sewer system that drains GIP 3 discharges to a drainage channel that eventually flows into a wetland area northwest of the industrial park.

METHODS OF DATA COLLECTION AND ANALYSIS

Stormwater discharge characteristics were studied at three outfalls that drain different subareas of the GIP. Data collection at each outfall consisted of rainfall volume, flow rate, and quality of stormwater discharge. The data were collected for each drainage subarea with a continuous recording raingage, and a pressure transducer which was integrated with an automatic water sampler. The data-collection instruments were installed as near as possible to the outfalls of the storm sewer.

At GIP 1 and GIP 2 the pressure transducer and the intake of the sampler were placed at the bottom of the pipe of the corresponding section of the storm sewer system. At these subareas the automatic sampler and the raingage were installed above street level. At GIP 3 the pressure transducer and sampler intake were placed at the bottom of a concrete channel.

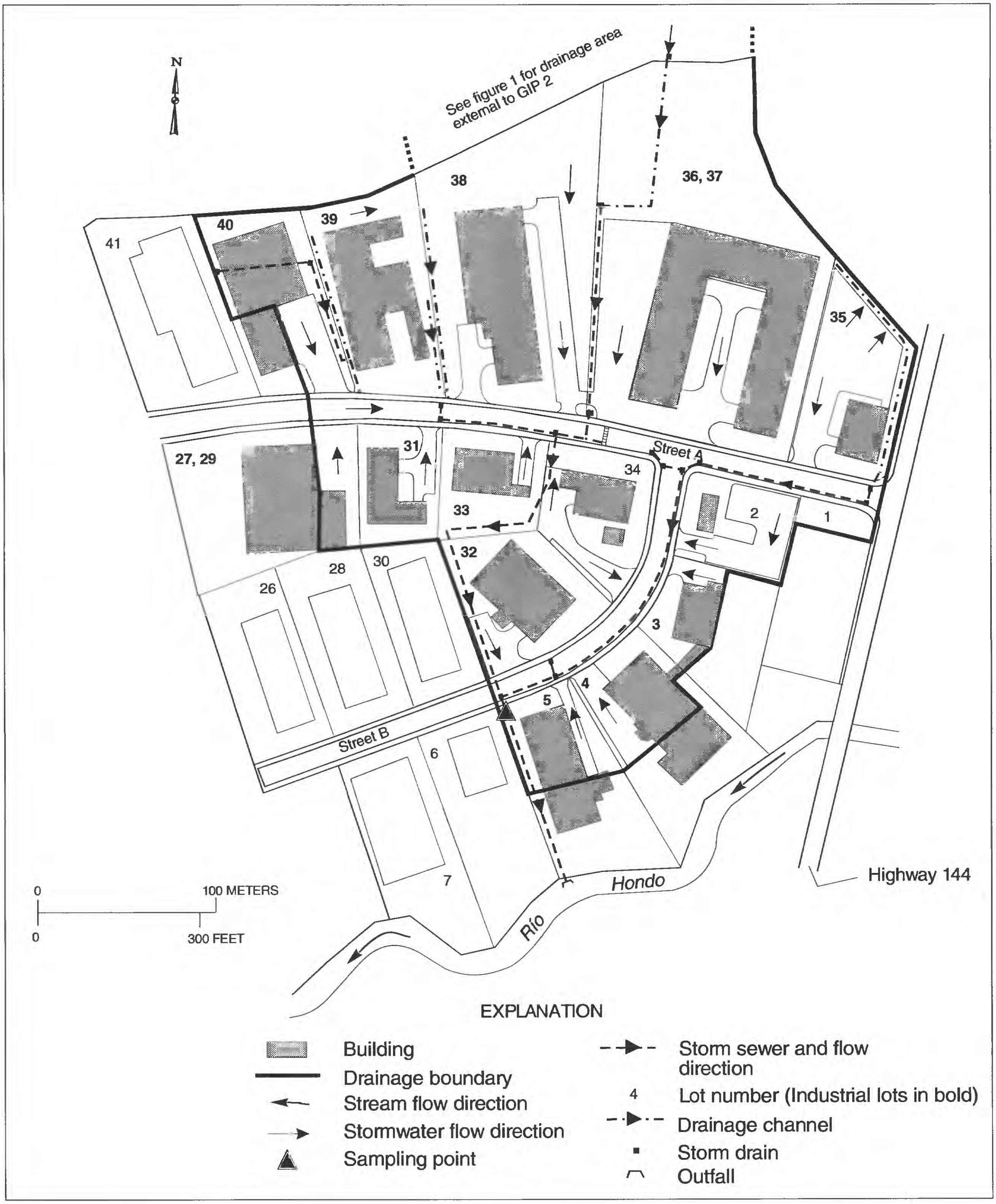

Figure 3. Site drainage for GIP 2.

Figure 4. Site drainage for GIP 3.

The pressure transducer measures the height of the water surface in the storm sewer pipe. The height of the water surface and the configuration of the storm sewer pipe or channel is then used to calculate the flow rate. At each of the sampling points, the pressure transducer was calibrated according to manufacturer instructions and programmed to record measurements every 5 minutes. The flow rate data were used to determine the stormwater runoff volumes during individual storm events and to determine the required sample volumes during the preparation of the flow-weighted composite samples.

Continuous rainfall data were collected with a tipping-bucket raingage. The raingage was connected to an automatic sampler. The automatic sampler was programmed to begin collecting stormwater samples when the required amount of rainfall, 2.54 mm or 0.1 inch, had accumulated. Each studied storm event was preceded by at least 72 hours in which no storm event of a magnitude greater than 2.54 mm or 0.1 inch of rainfall had occurred.

Two types of stormwater samples were collected during each of the studied storm events: grab and discrete-grab samples. Each grab sample was collected during the first 30 minutes of the storm runoff. Each discrete-grab sample was collected every 20 minutes throughout the storm runoff for a maximum period of 3 hours. The discrete-grab samples were used to prepare a flow-weighted composite sample from which an average constituent concentration for the storm event was determined.

The flow-weighted composite sample was prepared by using aliquots of the discrete-grab samples combined in proportion to flow. The required volume from each discrete-grab sample to prepare the composite was calculated using the following formula (U.S. Environmental Protection Agency, 1991):

$$V_n = \frac{V_{max} \cdot Q_n}{Q_{max}},$$

where

V_n is the volume required from discrete-grab sample *n* to prepare the composite,

V_{max} is the volume of sample collected at the highest flow rate,

Q_n is the flow rate associated with sample *n*, and

Q_{max} is the highest flow rate at which a sample was collected.

Processed samples were sent for analysis to the USGS National Water Quality Laboratory at Arvada, Colorado. Biochemical oxygen demand (BOD) analyses were performed at a local laboratory to meet the maximum holding time requirement of 24 hours for this analysis.

CHARACTERISTICS OF STORM EVENTS

Characteristics of selected storm events studied during this investigation are presented in table 3. The information presented includes the dates of the storm events, duration of each storm, the duration of each sampling period, the total rainfall, the duration of the dry period preceding each event, the maximum flow rate, and the total runoff volume.

The duration of the sampling period extends from the time the grab sample was collected to the time the last discrete-grab sample was collected. The discrete-grab samples were collected during the entire runoff event.

The total runoff volumes presented in table 3 were estimated by multiplying each of the discharge measurements by the time interval that represents the part of the sampling-period duration associated with the measurement (5 minutes), and then adding all such partial volumes (U.S. Environmental Protection Agency, 1991).

Data collected at the GIP during seven storm events indicated that stormwater maximum flow rates ranged from about 62 to 478 L/s in the three subareas. Total runoff volumes ranged from about 26 to 598 m^3 for all three subareas.

Table 3. Characteristics of the studied storm events at the Guanajibo Industrial Park, Mayagüez, Puerto Rico

Subarea	Date of storm event	Duration of storm, in minutes	Duration of sampling period, in minutes	Total rainfall, in millimeters	Duration of the dry period preceding the event, in hours	Maximum flow rate, in liters per second	Total runoff volume, in cubic meters
GIP 1	05-21-97	60	90	18.8	432	134	172
GIP 1	06-17-97	30	60	28.4	503	478	598
GIP 2	09-03-97	15	140	18.3	93	312	295
GIP 2	10-08-97	80	130	25.4	243	88	227
GIP 2	05-06-98	50	130	24.4	72	180	347
GIP 3	11-11-97	60	105	19.3	438	176	390
GIP 3	11-19-97	15	60	7.62	165	62	26

QUALITY OF STORMWATER DISCHARGES

A total of 14 stormwater samples were collected at the sampling points near the outfalls that drain the subareas. As mentioned previously, grab and flow-weighted composite samples were analyzed for each storm event characterized. Each sample was analyzed for BOD, chemical oxygen demand (COD), total organic carbon (TOC), total suspended solids (TSS), total Kjeldahl nitrogen (TKN, also known as ammonia plus organic nitrogen), nitrate plus nitrite dissolved as nitrogen, total phosphorous (TP), and pH. In addition to these constituents the grab samples were analyzed for oil and grease. The results of the laboratory analyses are presented in table 4.

The concentration for each analyzed constituent or property (except TKN and TOC) from samples collected at each subarea were compared to benchmark concentrations established by the USEPA. The benchmark concentrations (table 5) are values above which the USEPA has determined that a stormwater discharge could potentially impair or contribute to impairing water quality or affect human health from ingestion of water or fish (U.S. Environmental Protection Agency, 1995). For industries under a stormwater permit, these values are a goal to achieve by the implementation of pollution-prevention measures. The comparison of the concentrations with the benchmark values could be used as an indicator of meeting stormwater quality targets if the industries were under a permit.

Oil and grease concentrations at the three GIP subareas ranged from less than 1 to 6 mg/L. No concentration exceeded the benchmark concentration for oil and grease (15 mg/L). BOD concentrations ranged from 3.4 to 44 mg/L; the concentration in one sample, at GIP 2, exceeded the benchmark concentration (30 mg/L). COD concentrations for the samples collected ranged from 15.1 to 122 mg/L; the concentration in one sample, at GIP 2, exceeded the benchmark concentration (120 mg/L). Concentrations of TOC in samples collected from the three studied subareas ranged from 6.7 to 47 mg/L. TSS concentrations ranged from 50 to 456 mg/L; concentrations in 9 of the 14 samples that were collected exceeded the benchmark concentration (100 mg/L). Composite sample concentrations of TSS exceeded the benchmark concentration at GIP 2.

Table 4. Physical and chemical characteristics of stormwater discharges from the Guanajibo Industrial Park, Mayagüez, Puerto Rico

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; n/a, not applicable; --, no data]

Subarea	Date	Sample type	Specific conductance (µS/cm)	pH (standard units)	Oil and grease (mg/L)	Biochemical oxygen demand (mg/L)	Chemical oxygen demand (mg/L)	Total organic carbon (mg/L)	Total suspended solids (mg/L)	Ammonia plus organic nitrogen (mg/L as N)	Nitrate plus nitrite, dissolved (mg/L as N)	Total phosphorus (mg/L)
GIP 1	05-21-97	Grab	115	7.5	4	10	95.7	27	194	1.6	0.42	0.40
GIP 1	05-21-97	Composite	104	7.7	n/a	6.3	49.6	15	60	1.2	.42	.22
GIP 1	06-17-97	Grab	123	7.3	5	9.5	105	29	133	2.0	.31	.41
GIP 1	06-17-97	Composite	70.5	7.4	n/a	5.7	59.9	19	90	1.2	.20	.34
GIP 2	09-03-97	Grab	116	7.4	2	9.6	51	15	170	1.2	.38	.59
GIP 2	09-03-97	Composite	97.6	7.3	n/a	8.7	40	11	152	0.98	.35	.67
GIP 2	10-08-97	Grab	192	7.1	6	44	122	24	412	--	.06	--
GIP 2	10-08-97	Composite	191	7.2	n/a	6.9	36	12	112	--	.50	--
GIP 2	05-06-98	Grab	226	7.2	6	25	39.9	47	117	4.4	.43	.76
GIP 2	05-06-98	Composite	85.3	7.3	n/a	7.2	37.3	12	83	.73	.38	.23
GIP 3	11-11-97	Grab	153	8.1	<1	3.6	25.6	10	372	1.4	.36	.69
GIP 3	11-11-97	Composite	75.4	7.5	n/a	3.4	15.1	6.7	50	.72	.44	.27
GIP 3	11-19-97	Grab	123	8.1	<1	9.4	31.8	9.3	456	1.3	.45	.82
GIP 3	11-19-97	Composite	105	7.3	n/a	3.8	30.2	11	50	.93	1.6	.40

Table 5. Stormwater benchmark concentrations determined by the U.S. Environmental Protection Agency (1995)

[mg/L, milligrams per liter]

Constituent or property	Benchmark concentration (mg/L)
Oil and grease	15
Biochemical oxygen demand (BOD)	30
Chemical oxygen demand (COD)	120
Suspended solids, total (TSS)	100
Nitrate plus nitrite, dissolved as nitrogen	0.68
Phosphorous, total	2.0

The TKN concentrations ranged from 0.72 to 4.4 mg/L. The nitrate plus nitrite dissolved as nitrogen concentration ranged from 0.06 to 1.6 mg/L. The concentration of nitrate plus nitrite in one sample, from GIP 3, exceeded the benchmark concentration (0.68 mg/L). Concentrations of TP, which ranged from 0.22 to 0.82 mg/L, were below the benchmark concentration (2.0 mg/L).

Selected constituent concentrations in grab samples collected at the three subareas of the GIP are compared in figure 5 to the values for other industrial parks previously studied by the USGS (Rodríguez, 1998). Mean concentrations of COD and TOC were below the mean concentration of all the previously studied parks.

Potential pollutants from activities conducted by industries under SIC 20, 23, 34, 36, and 38 include BOD, COD, oil and grease, TSS, and TKN (U.S. Environmental Protection Agency, 1995). Maximum concentrations of BOD, COD, TKN, oil and grease, and TOC were detected at GIP 2 where industries of SIC 23 and SIC 20 are represented. Maximum concentrations of TSS, nitrate plus nitrite dissolved as nitrogen, and phosphorus were detected at GIP 3 where industries of SIC 23 and SIC 34 are represented.

Loads and loads per area calculated for each constituent are presented in tables 5 and 6. To calculate the load of each constituent present in a grab sample, each concentration was multiplied by the flow volume at the time of the sample collection. The loads of the selected constituents detected in the composite sample were calculated by multiplying each constituent concentration by the total volume of discharge during the sampling period. Loads and loads per area were not calculated for concentration below the minimum detection limit.

The loads calculated for grab samples for oil and grease ranged from 17.8 to 178 g; BOD, 74.3 to 475 g; COD, 119 to 3,750 g; TOC, 115 to 1,035 g; and TSS, 348 to 9,830 g. Loads values calculated for grab samples for TKN ranged from 13.1 to 70 g; nitrate plus nitrite dissolved as nitrogen, 0.37 to 18.8 g; and TP, 2.26 to 29.2 g. Loads for composite samples for BOD ranged from 98.8 to 3,410 g; COD, 785 to 35,800 g; TOC, 286 to 11,400 g; and TSS, 1,300 to 53,800 g. Loads values calculated for composite samples for TKN ranged from 24.2 to 718 g; nitrate plus nitrite dissolved as nitrogen, 42.6 to 172 g; and TP, 10.1 to 203 g.

Table 6. Load of selected water-quality constituents and properties of stormwater discharges from selected drainage subareas at the Guanajibo Industrial Park, Mayagüez, Puerto Rico

[GIP, Guanajibo Industrial Park; comp, composite; n/a, not applicable; --, no data; nd, not determined]

Subarea	Date	Sample type	Oil and grease (grams)	Biochemical oxygen demand (grams)	Chemical oxygen demand (grams)	Total organic carbon (grams)	Total suspended solids (grams)	Ammonia plus organic nitrogen (grams)	Nitrate plus nitrite as nitrogen (grams)	Total phosphorus (grams)
GIP 1	05-21-97	Grab	124	310	2,970	838	6,020	48.7	13	12.4
		Comp	n/a	1,080	8,530	2,580	10,300	198	72.2	37.8
GIP 1	06-17-97	Grab	178	339	3,750	1,035	4,740	70	11.1	14.6
		Comp	n/a	3,410	35,800	11,400	53,800	718	120	203
GIP 2	09-03-97	Grab	98.9	475	2,520	742	8,410	58.4	18.8	29.2
		Comp	n/a	2,570	11,800	3,240	44,800	289	103	198
GIP 2	10-08-97	Grab	36.7	269	732	147	2,520	--	0.37	--
		Comp	n/a	1,570	8,170	2,720	25,400	--	114	--
GIP 2	05-06-98	Grab	17.8	74.3	119	140	348	13.1	1.28	2.26
		Comp	n/a	2,500	12,900	4,160	28,800	253	132	79.8
GIP 3	11-11-97	Grab	nd	95.1	677	264	9,830	35.7	9.25	18.2
		Comp	n/a	1,330	5,890	2,610	19,500	277	172	105
GIP 3	11-19-97	Grab	nd	116	392	115	5,620	16	5.67	10.1
		Comp	n/a	98.8	785	286	1,300	24.2	42.6	10.1

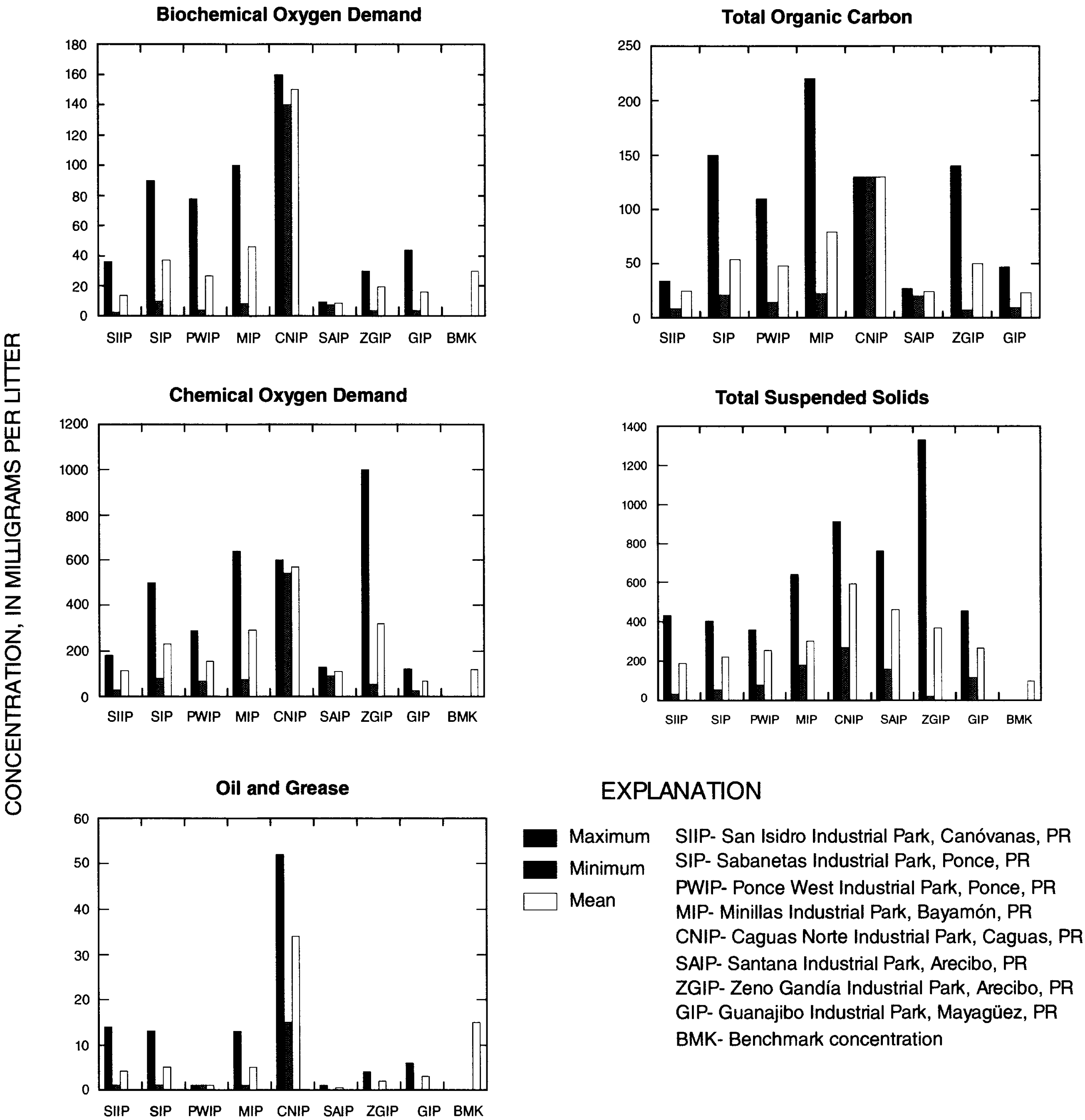

Figure 5. Selected mean constituents concentrations in grab samples collected at the GIP and other previously studied industrial parks.

The load per area values for grab samples calculated for oil and grease ranged from 0.17 to 2.52 mg/m^2; BOD, 0.73 to 4.81 mg/m^2; COD, 1.17 to 53.1 mg/m^2; TOC, 1.37 to 14.7 mg/m^2; and TSS, 3.41to 205 mg/m^2 (table 7). Loads per area from grab samples computed for TKN ranged from 0.13 to 0.99 mg/m^2; nitrate plus nitrite dissolved as nitrogen, 0.003 to 0.19 mg/m^2; and TP, 0.022 to 0.38 mg/m^2. The load per area for composite samples for BOD ranged from 2.06 to 48.4 mg/m^2; COD, 16.4 to 508 mg/m^2; TOC, 5.96 to 161 mg/m^2; and TSS, 27.1 to 763 mg/m^2. Loads per area values calculated for composite samples for TKN ranged from 0.50 to 10.2 mg/m^2; nitrate plus nitrite dissolved as nitrogen, 0.89 to 3.58 mg/m^2; and TP, 0.21 to 288 mg/m^2.

SUMMARY

The Guanajibo Industrial Park (GIP) is located in the municipality of Mayagüez in western Puerto Rico. The GIP covers about 370,000 m^2 of which 203,800 m^2 was included in three studied drainage areas. Approximately between 52 to 63 percent of the subareas is covered by impervious surfaces.

Five industrial groups were represented at the studied drainage subareas of the GIP. These industries were distributed throughout 28 industrial lots. The main type of activity at the studied subareas is classified under SIC 23, which groups manufacturers of apparel products.

During seven storm events measured in this study, stormwater discharge maximum flow rates ranged from about to 62 to 478 L/s in the three studied subareas. Stormwater discharge volumes for all three subareas ranged from about 26 to 598 m^3.

The analyses of the stormwater samples collected from the three studied subareas of the GIP, indicated that concentrations for oil and grease ranged from less than 1 to 6 mg/L. BOD concentrations ranged from 3.4 to 44 mg/L and concentrations of COD ranged from 15.1 to 122 mg/L. Concentrations of TOC and TSS ranged from 6.7 to 47 mg/L and 50 to 456 mg/L, respectively. Values for pH ranged from 7.1 to 8.1 units. The maximum concentrations of TKN, nitrate plus nitrite dissolved as nitrogen, and TP were 4.4, 1.6, and 0.82 mg/L, respectively.

BOD, COD, and nitrate plus nitrite dissolved as nitrogen concentrations exceeded the USEPA benchmark concentrations at one of the studied subareas. TSS benchmark concentrations were exceeded in 9 of the 14 samples collected.The benchmark concentrations are values above which USEPA has determined that a stormwater discharge could potentially impair or contribute to impairing water quality or affect human health from ingestion of water or fish.

Maximum concentrations of oil and grease, BOD, COD, TOC, and TKN were detected at subarea GIP 2, where industrial groups SIC 23 (apparel products) and SIC 20 (food products) are represented. Maximum concentrations of TSS, nitrate plus nitrite dissolved as nitrogen, and TP were detected at GIP 3, where industrial group SIC 23 and SIC 34 (fabricated metal products) are represented.

Table 7. Load per area of selected water-quality constituents and properties of stormwater discharges from selected drainage subareas at the Guanajibo Industrial Park, Mayagüez, Puerto Rico

[GIP, Guanajibo Industrial Park; n/a, not applicable; --, no data; nd, not determined; all units in milligrams per square meter]

Subarea	Date	Sample type	Oil and grease	Biochemical oxygen demand	Chemical oxygen demand	Total organic carbon	Total suspended solids	Ammonia plus organic nitrogen	Nitrate plus nitrite	Total phosphorus
GIP 1	05-21-97	Grab	1.76	4.40	42.1	11.9	85.4	0.69	0.18	0.176
		Composite	n/a	15.4	121	36.6	146	2.81	1.02	.54
GIP 1	06-17-97	Grab	2.52	4.81	53.1	14.7	67.2	.99	.16	.21
		Composite	n/a	48.4	508	161	763	10.2	1.70	2.88
GIP 2	09-17-97	Grab	0.97	4.66	24.7	7.27	82.4	.57	.18	.29
		Composite	n/a	25.2	116	31.8	439	2.83	1.01	1.94
GIP 2	10-08-97	Grab	.36	2.64	7.18	1.44	24.7	--	.003	--
		Composite	n/a	15.4	80.1	26.7	249	--	1.12	--
GIP 2	05-06-98	Grab	.17	0.73	1.17	1.37	3.41	.13	.012	.022
		Composite	n/a	24.5	126	40.8	282	2.48	1.29	.782
GIP 3	11-11-97	Grab	nd	1.98	14.1	5.50	205	.74	.19	.38
		Composite	n/a	27.6	123	54.4	406	5.77	3.58	2.19
GIP 3	11-19-97	Grab	nd	2.41	8.17	2.40	117	.33	.12	.21
		Comp	n/a	2.06	16.4	5.96	27.1	.50	.89	.21

REFERENCES

Rodríguez, J.M., 1998, Characterization of stormwater discharges from selected industrial parks in Puerto Rico, 1995-96: U.S. Geological Survey Water-Resources Investigations Report 98-4045, 46 p.

U.S. Environmental Protection Agency, 1983, Results of the nationwide urban runoff program: U.S. Environmental Protection Agency Final Report, 4 volumes.

U.S. Environmental Protection Agency, 1991, Guidance manual for the preparation of NPDES permit applications for stormwater discharges associated with industrial activity: Office of Wastewater Enforcement and Compliance, EPA-505/8-91-002.

U.S. Environmental Protection Agency, 1995, Final NPDES storm water multi sector general permits for industrial activities: Federal Register, v. 60, n. 189, p. 50,826.

U.S. Executive Office of the President, 1987, Standard industrial classification manual: Office of Management and Budget, p. 703.