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Characterization of Stormwater Discharges from Las Flores Industrial Park, Río Grande, Puerto Rico, 1998-99

Prepared in cooperation with the

PUERTO RICO INDUSTRIAL DEVELOPMENT COMPANY

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CONVERSION FACTORS, 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	microsiemen per centimeter

Acronyms used in this report

LFIP	Las Flores Industrial Park
PRIDCO	Puerto Rico Industrial Development Company
SIC	Standard Industrial Classification
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

Characterization of Stormwater Discharges from Las Flores Industrial Park, Río Grande, Puerto Rico, 1998-99

By **José M. Rodríguez**

Abstract

Stormwater discharges from Las Flores Industrial Park, Río Grande, Puerto Rico, were characterized from June 1998 to July 1999 by measuring the flow rate at two outfalls, delineating the drainage areas for each outfall, and calculating the volume of the stormwater discharges. Stormwater-discharge samples were collected and 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 46 percent of the total area of the Las Flores Industrial Park. Industrial groups represented in the study areas include manufacturers of textile, electronics, paper, fabricated metal, plastic, and chemical products.

The concentrations of oil and grease (1 to 6 milligrams per liter), biochemical oxygen demand (4.7 to 16 milligrams per liter), total organic carbon (5.8 to 36 milligrams per liter), total suspended solids (28 to 100 milligrams per liter), and total phosphorous (0.11 to 0.78 milligrams per liter) from all the samples collected were less than the U.S. Environmental Protection Agency stormwater benchmark concentrations. Concentrations of chemical oxygen demand (15.8 to 157 milligrams per liter) and nitrate and nitrite (0.06 to 1.75 milligrams per liter) exceeded benchmark concentrations at one of the studied drainage areas. Total Kjeldahl nitrogen concentrations (1.00 to 3.20 milligrams per liter) exceeded the benchmark concentrations at the two studied drainage areas. Maximum concentrations for oil and grease, biochemical oxygen demand, chemical oxygen demand, total organic carbon, total Kjeldahl nitrogen, nitrate plus nitrite, and total phosphorous were detected in an area where electronics, plastics, and chemical products are currently manufactured. The maximum concentration of total suspended solids was detected at an area where textile, paper, plastic, chemical, and fabricated metal products are manufactured.

Sumario

Las descargas de escorrentía del Parque Industrial Las Flores en Río Grande, Puerto Rico, se caracterizaron de junio de 1998 a julio de 1999 midiendo el caudal en dos puntos de salida del alcantarillado pluvial, delineando las áreas de drenaje de cada punto de salida y calculando el volumen de la escorrentía. Se recogieron muestras de escorrentía y se analizaron para determinar la calidad de las descargas. Para cada área de drenaje se estimaron las cargas de constituyentes y cargas de constituyentes por área. Las subáreas de drenaje estudiadas cubrieron un 46 por ciento del área total del Parque Industrial Las Flores. Entre las industrias representadas en las áreas de estudio se encuentran fabricantes de productos textiles, productos electrónicos, productos de papel, productos de metal, productos plásticos y productos químicos.

Las concentraciones de aceite y grasa (de 1 a 6 miligramos por litro), demanda bioquímica de oxígeno (de 4.7 a 16 miligramos por litro), carbono orgánico total (de 5.8 a 36 miligramos por litro), total de sólidos suspendidos (de 28 a 100 miligramos por litro) y total de fósforo (de 0.11 a

0.78 miligramos por litro) de todas las muestras recogidas eran menores que las concentraciones de referencia en escorrentías establecidas por la Agencia de Protección Ambiental de los Estados Unidos. Las concentraciones de demanda química de oxígeno (de 15.8 a 157 miligramos por litro), y nitrato y nitrito (de 0.06 a 1.75 miligramos por litro) excedieron las concentraciones de referencia en una de las áreas de drenaje estudiadas. Las concentraciones totales de nitrógeno Kjeldahl (de 1.00 a 3.20) excedieron las concentraciones de referencia en las dos áreas de drenaje estudiadas. Las concentraciones máximas de aceite y grasa, demanda bioquímica de oxígeno, demanda química de oxígeno, total de nitrógeno Kjeldahl, nitrato más nitrito y total de fósforo se detectaron en un área donde se fabrican productos electrónicos, plásticos y químicos. La concentración máxima de total de sólidos suspendidos se detectó en un área donde se fabrican productos textiles, de papel, plásticos, químicos y de metal.

INTRODUCTION

Studies conducted on a nationwide scale in the United States have demonstrated that runoff from urban and industrial areas can be a substantial source of surface-water pollution (U.S. Environmental Protection Agency, 1983). Data collected during these studies indicate that urban and industrial runoff may contain some pollutants in quantities comparable to, and in some cases greater than, effluents from secondary-treatment wastewater plants and may be a major detriment to water quality. Recent investigations at selected industrial areas in Puerto Rico (Rodríguez, 1998, 1999) detected elevated water-quality constituents or properties including biochemical oxygen demand, chemical oxygen demand, total organic carbon, and total suspended solids.

In 1998, the U.S. Geological Survey (USGS) began a study in cooperation with the Puerto Rico Industrial Development Company (PRIDCO) to characterize the stormwater discharges at Las Flores Industrial Park (LFIP) in the municipality of Río Grande, which is located in northeastern Puerto Rico (fig. 1). PRIDCO is a public organization that promotes industrial expansion in Puerto Rico. The LFIP is one of over 200 industrial areas located in Puerto Rico in which PRIDCO is the principal owner.

This report presents data collected at two drainage subareas of the LFIP. Stormwater runoff was characterized at each of the drainage subareas for two storm events. Data collected include drainage subarea characteristics, rainfall, stormwater discharge, discharge volumes, and water quality. The information collected during this study will improve the understanding of the stormwater discharges and identify areas with constituent concentrations that exceeded benchmark levels.

DESCRIPTION OF THE STUDY AREA AND SITE DRAINAGE CHARACTERISTICS

The LFIP is located south of the urban center of the town of Río Grande in northeastern Puerto Rico. The principal hydrographic surface features in the study area are two unnamed creeks located east of the LFIP (fig. 1). One creek is intermittent and flows into the other unnamed creek, which discharges into the Río Grande. The Río Grande is a tributary of the Río Espíritu Santo.

The LFIP occupies an area of approximately 261,000 square meters (m^2). Two drainage areas within the LFIP, where stormwater is conveyed by a storm drainage system, were designated as LFIP 1 and LFIP 2 (fig. 1). Subareas LFIP 1 and LFIP 2 were selected for stormwater characterization based on the feasibility to collect stormwater-flow and quality data. The feasibility to collect the stormwater data depends on 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 within the studied subareas of the LFIP. 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 was used.

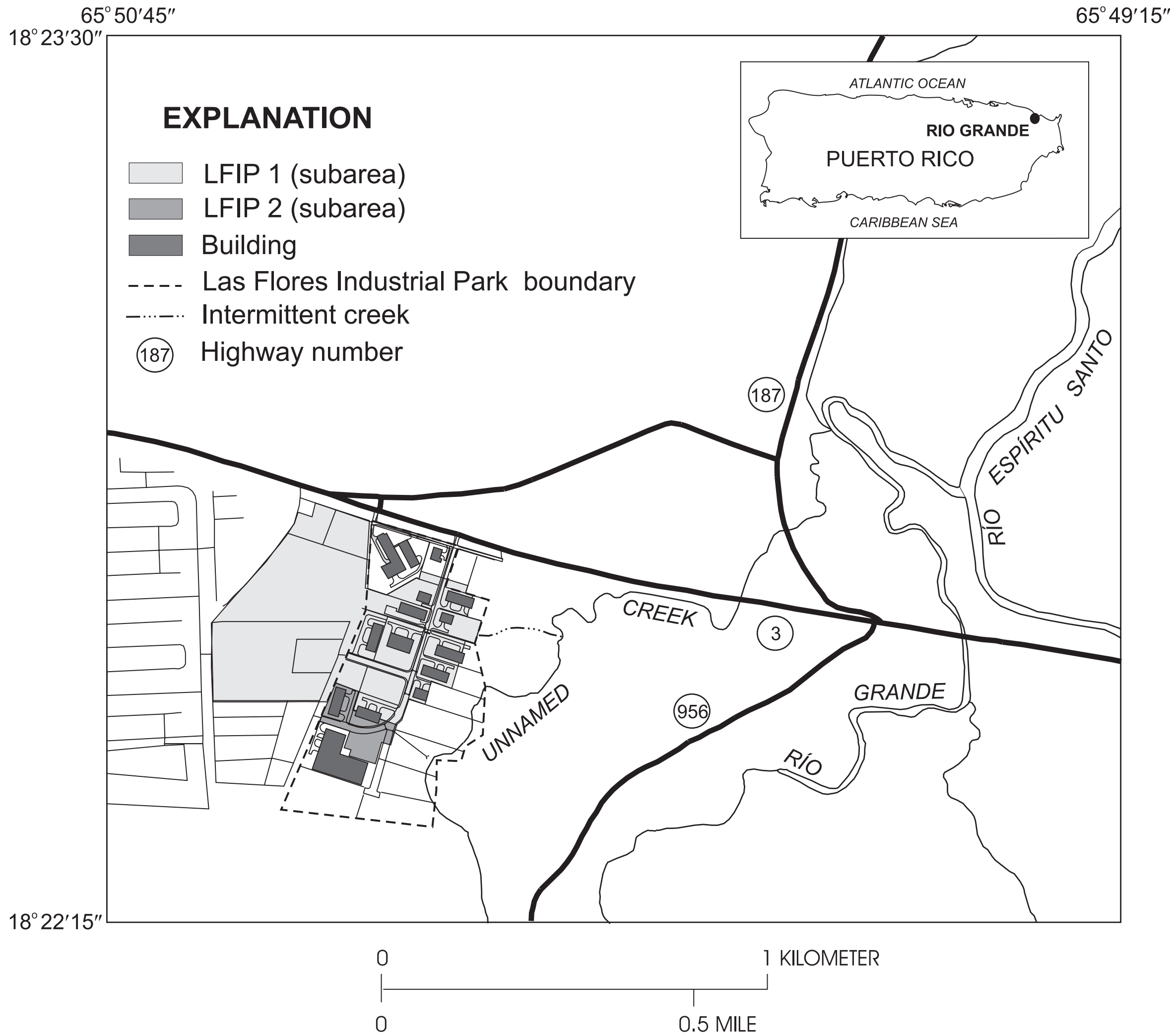

Figure 1. Location of Las Flores Industrial Park, Río Grande, Puerto Rico.

A total of 10 industrial lots were occupied at LFIP during the time of the study (table 1). Sampled areas included sections of nine occupied lots. Industrial groups represented at LFIP include manufacturers of textile products (SIC 23), paper products (SIC 26), chemical products (SIC 28), plastic products (SIC 30), fabricated metal products (SIC 34), and electronic products (SIC 36).

LFIP 1 covers about 248,000 m^2 (table 2), which includes 96,000 m^2 from the industrial park and 152,000 m^2 external to the industrial park (fig. 1). LFIP 1 includes sections of eight occupied industrial lots (fig. 2). Industrial groups represented at LFIP 1 include SIC 23, 26, 28, 30, and 34 (table 1). The stormwater flow pattern in LFIP 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 an intermittent creek. As mentioned above, a substantial portion of the stormwater runoff at LFIP 1 comes from outside the industrial park (fig. 1). A storm sewer pipe located at the boundary between lots 9 and 10 (fig. 2), conveys the stormwater from a section of a residential area (about 61 percent of the drainage subarea) west of the industrial park into the LFIP 1 storm sewer, which eventually flows into an intermittent creek.

LFIP 2 covers approximately 23,000 m^2 (table 2) and contains sections of three occupied industrial lots (fig. 2). Industrial groups represented at LFIP 2 are SIC 28, 30, and 36 (table 1). The stormwater flow pattern in LFIP 2 is mainly from the individual lots to the street (fig. 2). Upon reaching the street, stormwater flows into the storm drains along the street, which discharge into an unnamed creek.

Table 1. Industrial activities within selected drainage areas of Las Flores Industrial Park, Río Grande, Puerto Rico

[SIC, Standard Industrial Classification; --, not applicable]

Subarea	Lot number[1]	SIC	Major group
1	3	26	Paper products
1	6	26	Paper products
1	7	--	Unoccupied
1	8	--	Non industrial
1	9	--	Unoccupied
1	10-1	34	Fabricated metal products
1	10-2	--	Unoccupied
1	11	26	Paper products
1	12	30	Plastic products
1	13	23	Textile products
1	14	28	Chemical products
1	15	--	Unoccupied
1	16	30	Plastic products
2	14	28	Chemical products
2	16	30	Plastic products
2	19	36	Electronic products

[1] Lots shown in figure 2.

Table 2. Estimated drainage area for selected subareas in Las Flores Industrial Park, Río Grande, Puerto Rico

[LFIP, Las Flores Industrial Park; m^2, square meters]

Subarea	Outfall location (latitude-longitude)[1]	Drainage area (m^2)	Receiving water body
LFIP 1	18°22’39” - 65°50’20”	[2]248,000	Intermittent unnamed creek
LFIP 2	18°22’31” - 65°50’19”	23,000	Unnamed creek

[1] Coordinates are referenced to North American Datum 27.
[2] This area includes approximately 152,000 m^2 external to LFIP.

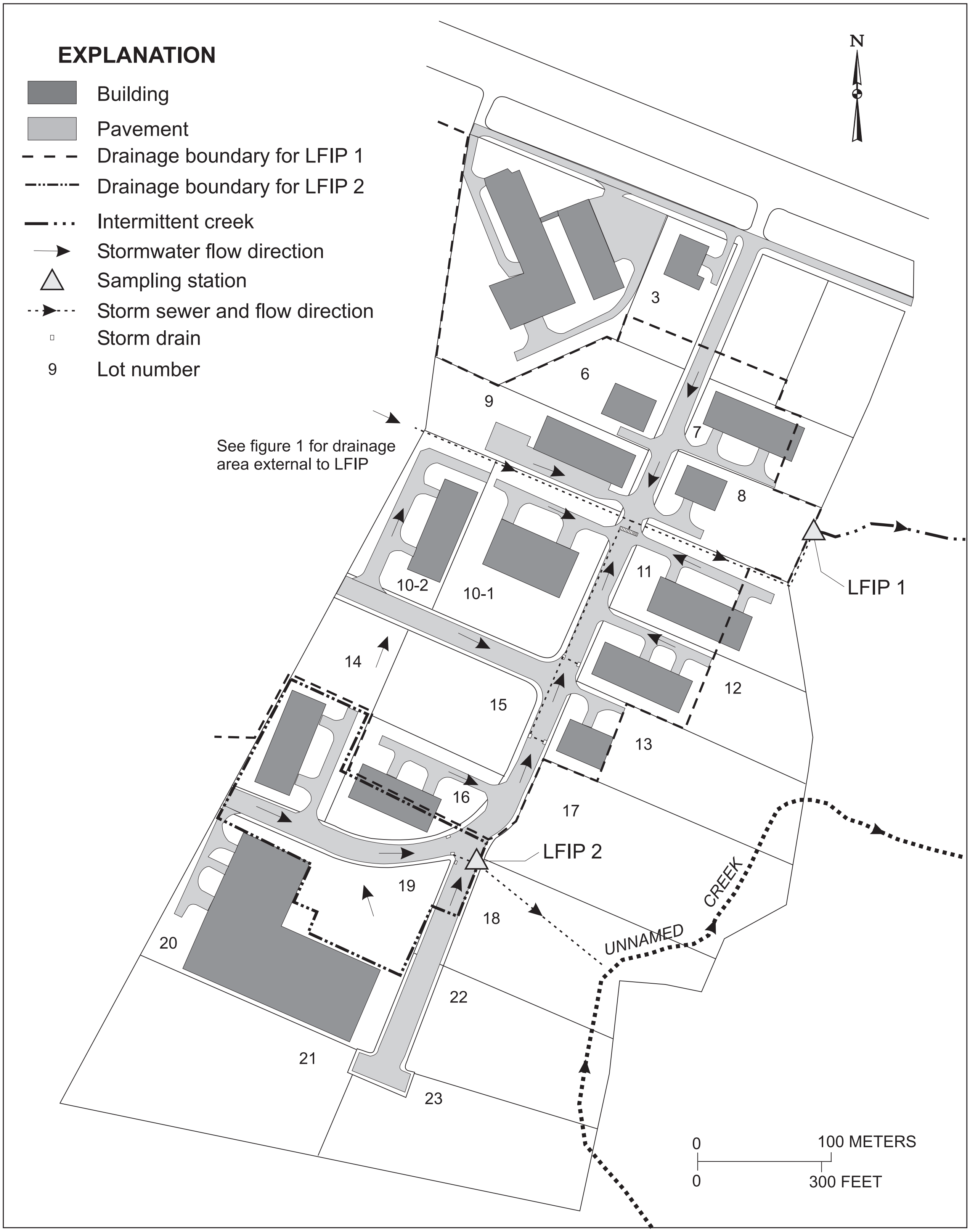

Figure 2. Site drainage for LFIP 1 and LFIP 2 and location of sampling sites.

METHODS OF DATA COLLECTION AND ANALYSIS

Stormwater-discharge data collected at each outfall consisted of rainfall volume, flow rate, and quality of stormwater discharge. The data were collected in each drainage subarea with a continuous recording raingage and a pressure transducer that was integrated with an automatic water sampler. The data-collection instruments were installed as near as possible to the outfalls of the storm drainage system.

At each sampling site, the pressure transducer and the intake of the sampler were placed at the bottom of the pipe of the corresponding section of the storm drainage system. The automatic sampler and the raingage were installed above street level.

The pressure transducer measured the height of the water surface in the storm sewer pipe. The height of the water surface and the geometry and slope of the storm sewer pipe are then used to calculate the flow rate using the Manning equation. At each of the sampling points, the pressure transducer was calibrated according to the manufacturer's instructions and a data logger was 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 automatic surface-water samplers at both LFIP 1 and LFIP 2. The automatic sampler was programmed to begin collecting stormwater samples when the required amount of rainfall, 2.54 millimeters (mm) or 0.1 inch, had been recorded by the raingage. Each 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 storm events, grab and composite samples. Grab samples were collected during the first 30 minutes of the storm-runoff event. Composite sample aliquots were collected every 20 minutes throughout the storm runoff, for a maximum period of 3 hours. The aliquots 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 using aliquots combined in proportion to flow. The aliquot volume required to prepare the composite was calculated using the following formula (U.S. Environmental Protection Agency, 1992):

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

where

V_n is the volume required from aliquot 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 is collected.

A total of eight stormwater samples from four storm events were collected at the sampling points near the subarea outfalls. The grab and flow-weighted composite samples were analyzed for biochemical oxygen demand, chemical oxygen demand, total organic carbon, total suspended solids, total Kjeldahl nitrogen (also known as ammonia plus organic nitrogen), nitrate plus nitrite dissolved as nitrogen, total phosphorous, and pH. Only grab samples were analyzed for oil and grease. The analyzed chemical constituents and properties, which are common pollutants in urban runoff, are widely used for screening stormwater-discharge quality.

Processed stormwater-runoff samples were sent for analysis to the USGS National Water Quality Laboratory at Denver, Colorado. Biochemical oxygen demand analyses were performed at a local laboratory to stay within the maximum holding time requirement of 24 hours.

The concentration of each analyzed constituent or property from samples collected at each subarea was compared to benchmark concentrations established by U.S. Environmental Protection Agency (USEPA, 1999). The benchmark stormwater discharge concentrations are values USEPA has determined could potentially impair or contribute to impairing water quality or affect human health from ingestion of water or fish (USEPA, 1995, 1999). For industries operating under a stormwater permit, these values are a goal to be achieved by the implementation of pollution prevention measures. Comparing constituent concentrations with benchmark values can be used as an indicator of whether industries operating under a permit are meeting stormwater quality targets.

STORM EVENT CHARACTERISTICS

Characteristics of selected storm events sampled during this investigation are presented in table 3. The information presented includes dates of storm events, duration of each storm, the duration of each sampling period, the total rainfall during the storm event, duration of the dry period preceding each event, maximum flow rate, flow rate during the collection of the grab sample, total runoff volumes, and ratio of runoff to rainfall.

The total runoff volumes presented in table 3 were estimated by multiplying each of the flow-rate 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 (USEPA, 1992). Data collected at the LFIP during four storm events indicated that maximum stormwater-flow rates (fig. 3) ranged from about 34.0 to 504 liters per second (L/s) in the two subareas. Total runoff volumes ranged from about 30.0 to 1,500 cubic meters (m^3) for the two subareas.

QUALITY OF STORMWATER DISCHARGES

The results of the laboratory analyses are presented in table 4 and benchmark concentrations (USEPA, 1999) are presented in table 5.

Oil and grease concentrations at two subareas of the LFIP ranged from 1 to 6 mg/L; no concentration exceeded the benchmark concentration for oil and grease (15 mg/L). Biochemical oxygen demand concentrations ranged from 4.7 to 16 mg/L; no concentration exceeded the benchmark concentration for biochemical oxygen demand (30 mg/L). Chemical oxygen demand concentrations for the samples collected ranged from 15.8 to 157 mg/L; one sample at LFIP 2 exceeded the benchmark concentration (120 mg/L). Concentrations of total organic carbon, which ranged from 5.8 to 36 mg/L, were below the benchmark concentration for the constituent (50 mg/L). Total suspended solids concentrations ranged from 28 to 100 mg/L; no concentrations exceeded the benchmark concentration for total suspended solids (100 mg/L).

Table 3. Characteristics of the sampled storm events at Las Flores Industrial Park, Río Grande, Puerto Rico

[LFIP, Las Flores Industrial Park]

Subarea	Date of storm event	Duration of storm (minutes)	Duration of sampling period (minutes)	Total rainfall (milli-meters)	Duration of the dry period preceding the event, (hours)	Maximum flow rate, (liters per second)	Flow rate during grab sample collection (liters per second)	Total runoff volume, (cubic meters)	Ratio of runoff to rainfall (percent)
LFIP 1	06-09-98	60	140	7.11	96	163	94.9	210	11.9
LFIP 1	08-24-98	95	100	8.13	73	504	314	1,500	74.4
LFIP 2	06-04-99	30	45	5.59	109	34.0	20.7	30.0	23.3
LFIP 2	07-01-99	60	55	18.5	259	388	12.5	287	67.5

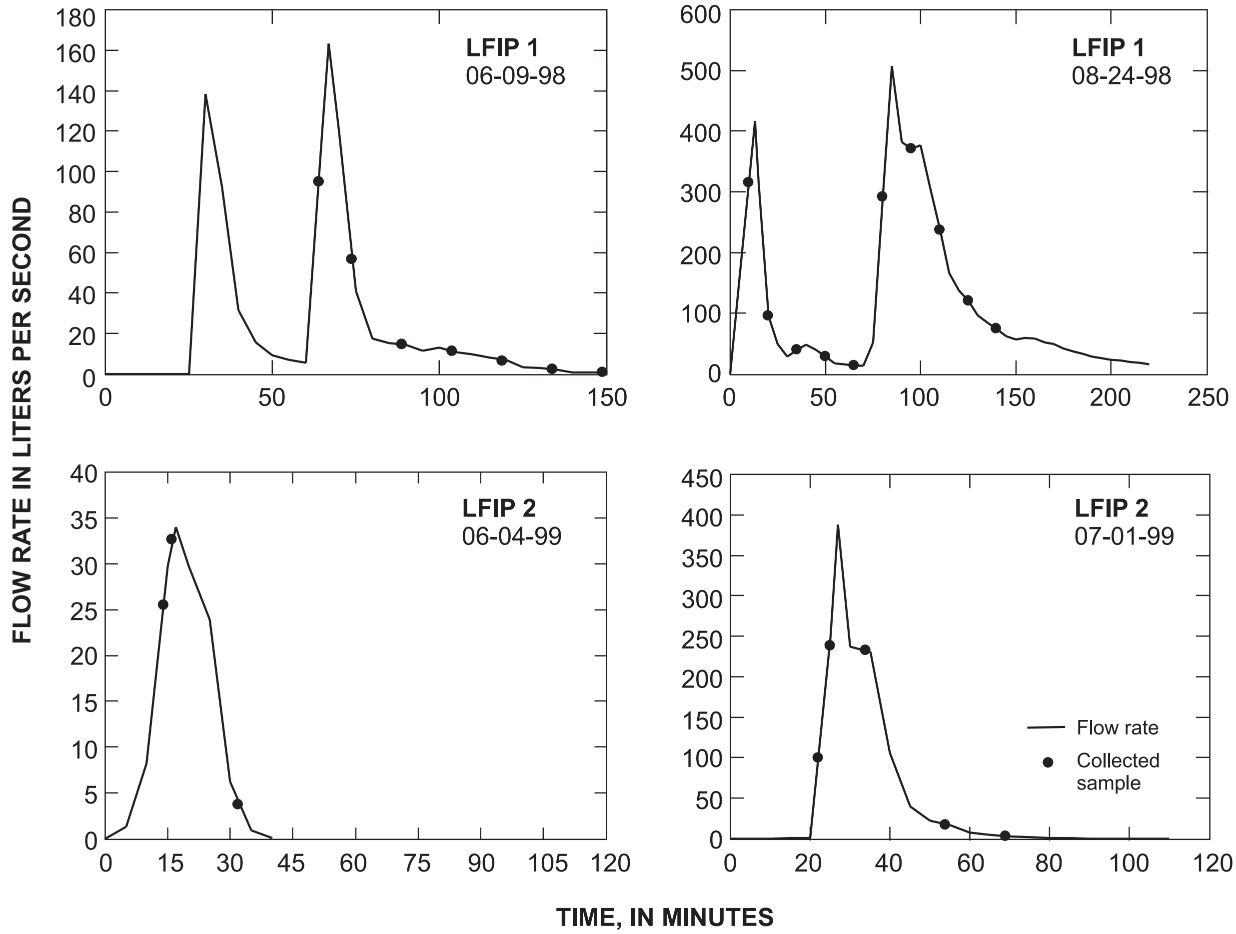

Figure 3. Stormwater discharge at LFIP 1 and LFIP 2 sampling stations.

The total Kjeldahl nitrogen concentrations ranged from 1.00 to 3.20 mg/L; one sample collected at LFIP 1 and two samples collected at LFIP 2 exceeded the benchmark value for the constituent (1.5 mg/L). The nitrate plus nitrite concentration ranged from 0.06 to 1.75 mg/L; two samples from LFIP 2 exceeded the benchmark concentration (0.68 mg/L). Concentrations of total phosphorous ranged from 0.11 to 0.78 mg/L; no concentration exceeded the benchmark concentration (2.0 mg/L).

Higher concentrations of constituents commonly occur in samples collected during the first flush of runoff compared to concentrations of aliquots collected throughout the storm event and composited in one sample. When the intensity of the rainfall is low or the dry period preceding the storm event is short, the difference in concentrations between the first flush and the composite sample may be less pronounced. Also, the difference in concentrations may be less pronounced between the first flush and the composite if a second period of intense rain occurs, which may produce an additional spike of constituent concentrations during the runoff event.

For samples collected at LFIP 1, concentrations of most constituents were similar between the grab (collected during the first flush) and the composite sample, or higher in the composite. Biochemical oxygen demand and total suspended solids were the only constituents that had higher concentrations in the grab sample for both of the sampled events. Both storm events sampled at LFIP 1 produced two peak flows during the runoff event (fig. 3). The occurrence of a second peak flow, which may have moved material not completely flushed by the initial runoff, may have been the cause of less pronounced difference between the grab and composite concentrations.

Table 4. Physical and chemical characteristics of stormwater discharges from Las Flores Industrial Park, Río Grande, Puerto Rico

[LFIP, Las Flores Industrial Park; µS/cm, microsiemen per centimeter at 25 degrees Celsius; mg/L, milligram per liter; n/a, not applicable; N, nitrogen]

Subarea	Date	Sample type	Specific con-ductance (µS/cm)	pH (standard units)	Oil and grease (mg/L)	Bio-chemical oxygen demand (mg/L)	Chemical oxygen demand (mg/L)	Total organic carbon (mg/L)	Total suspended solids (mg/L)	Total Kjeldahl nitrogen (mg/L as N)	Nitrate plus nitrite (mg/L as N)	Total phos-phorous (mg/L)
LFIP 1	06-09-98	Grab	125	7.5	4	14	22.8	17	100	1.51	0.24	0.28
LFIP 1	06-09-98	Composite	191	7.4	n/a	6.9	33.3	17	60	1.08	.43	.28
LFIP 1	08-24-98	Grab	115	7.5	1	6.8	16.0	13	39	1.00	.06	.25
LFIP 1	08-24-98	Composite	126	7.4	n/a	4.9	15.8	14	28	1.07	.08	.28
LFIP 2	06-04-99	Grab	472	7.3	6	16	157	36	35	3.20	1.00	.78
LFIP 2	06-04-99	Composite	335	7.4	n/a	12	112	33	47	1.44	1.75	.14
LFIP 2	07-01-99	Grab	179	7.5	4	4.7	56	8.6	70	1.30	.09	.11
LFIP 2	07-01-99	Composite	163	7.7	n/a	5.5	40	5.8	39	2.10	.10	.21

Table 5. Stormwater benchmark concentrations determined by the U.S. Environmental Protection Agency (1999)

[mg/L, milligram per liter]

Constituent or property	Benchmark concentration (mg/L)
Oil and grease	15
Biochemical oxygen demand	30
Chemical oxygen demand	120
Total organic carbon	50
Suspended solids, total	100
Total Kjeldahl nitrogen	1.5
Nitrate plus nitrite dissolved as nitrogen	0.68
Phosphorous, total	2.0

At LFIP 2, the sample collected during the storm on June 4, 1999, showed a relatively pronounced difference between the grab and composite concentrations for biochemical oxygen demand, chemical oxygen demand, total Kjeldahl nitrogen, and total phosphorous (table 4). This storm event produced runoff with a single peak flow, during which the grab sample was collected (fig. 3). The storm of July 1, 1999, also produced runoff with a single peak flow, however, the grab sample was collected during a period of low rainfall intensity. Less difference was recorded in grab and composite concentrations in this event (table 4).

Potential pollutants from activities conducted by industries classified as SIC 23, 26, 28, 30, 34, 36, and 38 include biochemical oxygen demand, chemical oxygen demand, oil and grease, total suspended solids, nitrate plus nitrite, organics, and metals (USEPA, 1995). The maximum concentration of total suspended solids was detected at LFIP 1, where industries of SIC 23, 26, 28, 30, and 34 are represented. Maximum concentrations of biochemical oxygen demand, chemical oxygen demand, oil and grease, total organic carbon, total Kjeldahl nitrogen, nitrate plus nitrite, and total phosphorous were detected at LFIP 2, where industries of SIC 28, 30, and 36 are represented.

Loads and loads per area calculated for each constituent in the composite samples from LFIP 1 and LFIP 2 are presented in tables 6 and 7, respectively.

The loads of the selected constituents were calculated by multiplying each constituent concentration (from the composite sample) by the total volume of discharge during the sampling period. Load per area for each constituent was calculated by dividing the load by the drainage area of the respective sampled sector. The loads and loads per area calculated for samples collected at LFIP 1 include an unknown fraction contributed by the residential area adjacent to the industrial park.

The loads calculated for composite samples for biochemical oxygen demand ranged from 360 to 7,350 grams (g); chemical oxygen demand, 3,360 to 23,700 g; total organic carbon, 990 to 21,000 g; and total suspended solids, 1,410 to 42,000 g. Loads values calculated for composite samples for total Kjeldahl nitrogen ranged from 43.2 to 1,600 g; nitrate plus nitrite as N, 28.7 to 120 g; and total phosphorous, 4.20 to 420 g (table 6).

The loads per area for composite samples for biochemical oxygen demand ranged from 5.85 to 68.7 milligrams per square meter (mg/m^2); chemical oxygen demand, 28.2 to 500 mg/m^2; total organic carbon, 14.4 to 84.5 mg/m^2; and total suspended solids, 50.9 to 487 mg/m^2. Loads per area values calculated for composite samples for total Kjeldahl nitrogen ranged from 0.915 to 26.2 mg/m^2; nitrate plus nitrite as N, 0.364 to 2.28 mg/m^2; and total phosphorous, 0.183 to 2.62 mg/m^2 (table 7).

Table 6. Load of selected water-quality constituents and properties of stormwater discharges from selected drainage subareas at Las Flores Industrial Park, Río Grande, Puerto Rico

[LFIP, Las Flores Industrial Park; n/a, not applicable; all units in grams]

Subarea	Date	Sample type	Oil and grease	Bio-chemical oxygen demand	Chemical oxygen demand	Total organic carbon	Total suspended solids	Total Kjeldahl nitrogen, as N	Nitrate plus nitrite, as N	Total phos-phorous
LFIP 1	06-09-98	Composite	n/a	1,450	7,000	3,570	12,600	227	90.4	58.9
LFIP 1	08-24-98	Composite	n/a	7,350	23,700	21,000	42,000	1,600	120	420
LFIP 2	06-04-99	Composite	n/a	360	3,360	990	1,410	43.2	52.5	4.20
LFIP 2	07-01-99	Composite	n/a	1,580	11,500	1,670	11,200	603	28.7	60.3

Table 7. Load per area of selected water-quality constituents and properties of stormwater discharges from selected drainage subareas at Las Flores Industrial Park, Río Grande, Puerto Rico

[LFIP, Las Flores Industrial Park; n/a, not applicable; all units in milligrams per square meter]

Subarea	Date	Sample type	Oil and grease	Bio-chemical oxygen demand	Chemical oxygen demand	Total organic carbon	Total suspended solids	Total Kjeldahl nitrogen	Nitrate plus nitrite	Total phos-phorus
LFIP 1	06-09-98	Composite	n/a	5.85	28.2	14.4	50.9	0.915	0.364	0.237
LFIP 1	08-24-98	Composite	n/a	29.6	95.6	84.5	169	6.64	.483	1.69
LFIP 2	06-04-99	Composite	n/a	15.7	146	43.1	61.3	1.88	2.28	.183
LFIP 2	07-01-99	Composite	n/a	68.7	500	72.4	487	26.2	1.25	2.62

Selected constituent concentrations in grab samples collected at the two subareas of LFIP are compared in figure 4 to the values for other industrial parks previously studied by USGS (Rodríguez, 1998, 1999). Mean concentrations of chemical oxygen demand, total organic carbon, and total suspended solids at the LFIP were below the mean concentrations for samples collected at all the previously studied industrial parks. Biochemical oxygen demand mean concentrations for samples collected at LFIP were below the mean concentrations for samples collected at all the previously studied industrial parks, except for the Santana Industrial Park, which was an undeveloped industrial park.

SUMMARY

The Las Flores Industrial Park (LFIP) is located in the municipality of Río Grande in northeastern Puerto Rico. The LFIP covers about 261,000 m^2, of which approximately 119,000 m^2 is within the two studied drainage areas.

Six industrial groups were represented at the studied drainage subareas of LFIP. These industries were distributed throughout nine industrial lots.

During the four storm events measured in this study, peak stormwater-flow rate ranged from about 34.0 to 504 L/s in the two studied subareas (fig. 3). Stormwater-discharge volumes for the two subareas ranged from about 30.0 to 1,500 m^3.

Analyses of the stormwater samples collected from the two studied subareas of the LFIP indicate that concentrations for oil and grease ranged from 1 to 6 mg/L. Biochemical oxygen demand concentrations ranged from 4.7 to 16 mg/L and concentrations of chemical oxygen demand ranged from 15.8 to 157 mg/L. Concentrations of total organic carbon and total suspended solids ranged from 5.8 to 36 mg/L and 28 to 100 mg/L, respectively. The maximum concentrations of total Kjeldahl nitrogen, nitrate plus nitrite dissolved as nitrogen, and total phosphorous were 3.20, 1.75 and 0.78 mg/L, respectively (table 4).

Chemical oxygen demand and nitrate plus nitrite concentrations exceeded the USEPA benchmark concentrations at LFIP 2. Total Kjeldahl nitrogen concentrations exceeded benchmark concentrations at LFIP 1 and LFIP 2. Maximum recorded concentrations of total suspended solids were detected at LFIP 1, where manufacturers of textile products (SIC 23), paper products (SIC 26), chemical products (SIC 28), fabricated metal products (SIC 34), and plastic products (SIC 30) are located. Maximum recorded concentrations of oil and grease, biochemical oxygen demand, chemical oxygen demand, total organic carbon, total Kjeldahl nitrogen, nitrate plus nitrite as nitrogen, and total phosphorous were detected at subarea LFIP 2, where manufacturers of chemical products (SIC 28), plastic products (SIC 30), and electronic products (SIC 36) are located. Comparison with other industrial parks in Puerto Rico indicate that stormwater runoff from studied areas of the LFIP contains relatively low concentrations of potentially harmful chemical constituents (fig. 4).

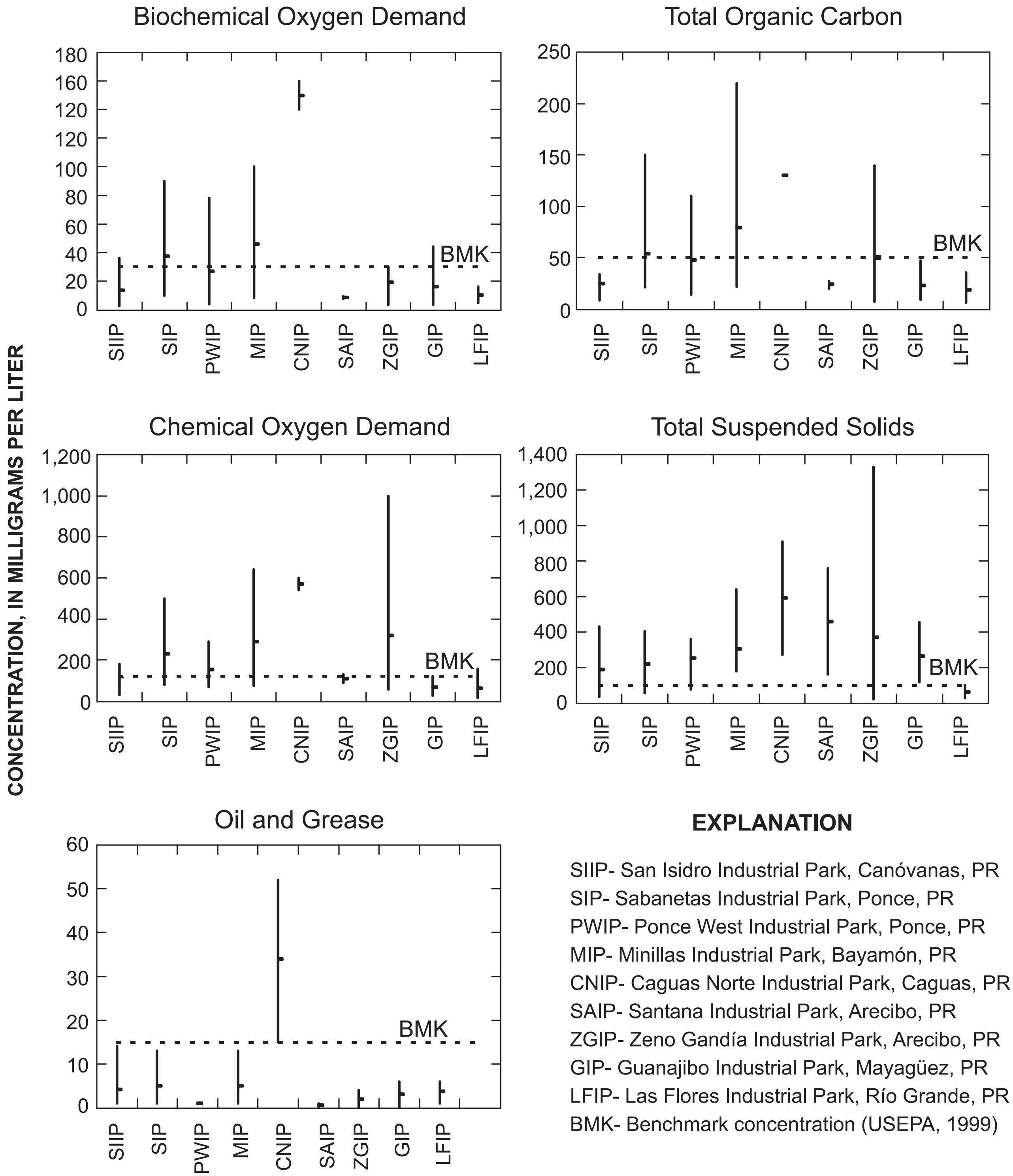

Figure 4. Range and mean concentration of selected constituents in grab samples collected at LFIP and other previously studied industrial parks.

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