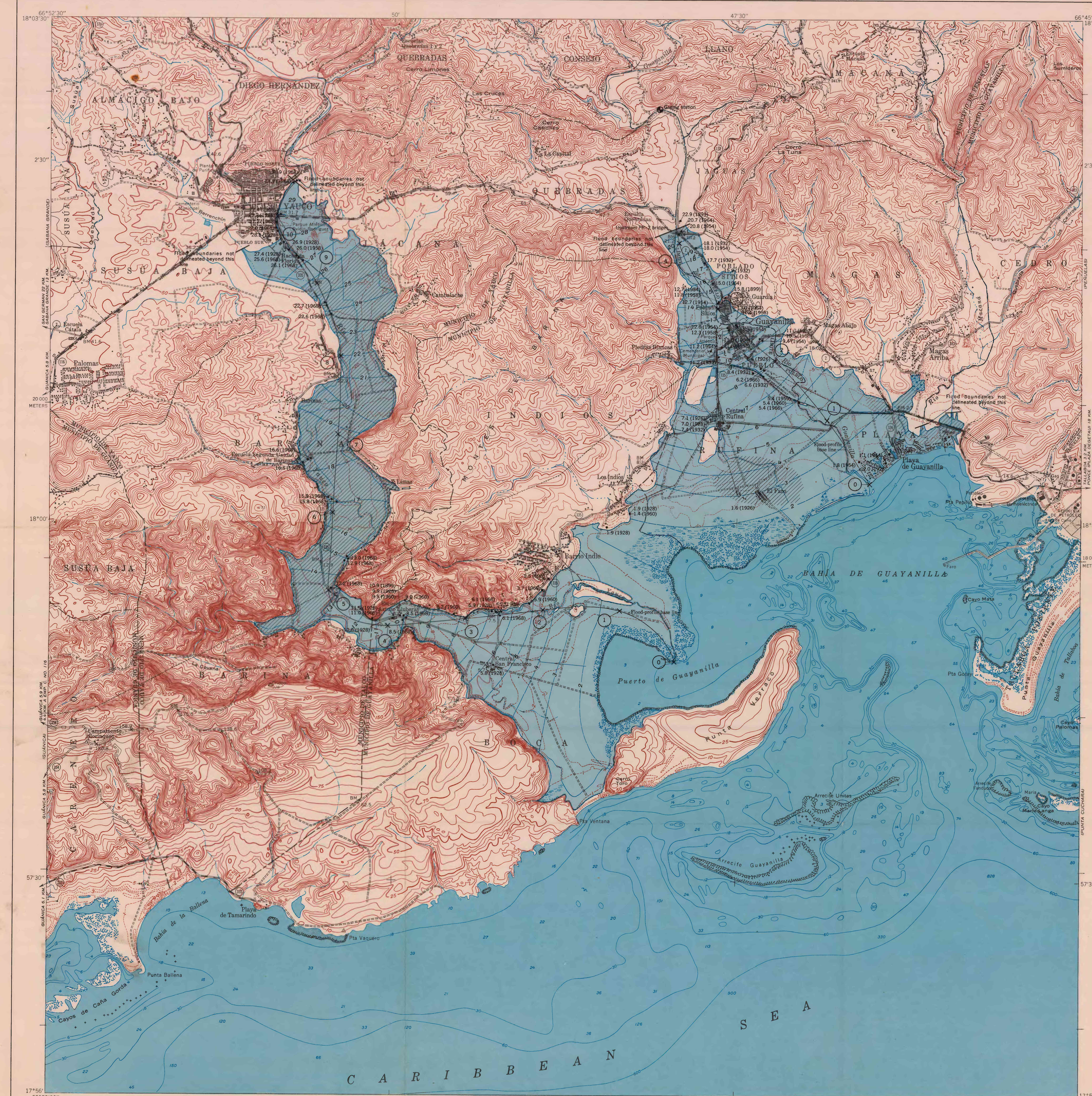
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
COMMONWEALTH OF PUERTO RICO
DEPARTMENT OF PUBLIC WORKS

HYDROLOGIC INVESTIGATIONS
ATLAS HA-414



Base from U.S. Geological Survey, Punta Verraco and Yauco, 1958

2,000 meter grid based on Puerto Rico coordinate system

SCALE 1:20 000

CONTOUR INTERVAL 5 AND 10 METERS
DASHED LINES REPRESENT 5-METER CONTOURS
DOTTED LINES REPRESENT 1-METER CONTOURS
DATUM IS MEAN SEA LEVEL
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS MEAN LOW WATER
SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER
THE MEAN RANGE OF TIDE IS APPROXIMATELY 0.2 METERS

EXPLANATION

Flood of September 13, 1928, patterned where estimated

Boundary of 1928 flood, dashed where estimated

Kilometers upstream from mouth measured along profile base line

Estimated water-surface contour for 1928 flood; contour interval 1 meter. Water-surface contour not determined below elevation of 2 meters. Datum is mean sea level

Floodmark elevation, in meters above mean sea level, and year of flood — 1.9 (1928)

FLOODS IN THE GUAYANILLA-YAUCO AREA, PUERTO RICO

By
Fred K. Fields
1971

FLOODS IN THE GUAYANILLA-YAUCO AREA, PUERTO RICO

This report is a compilation of data pertaining to floods in Ríos Guayanilla and Yauco and is based principally upon information obtained from residents in the study area. This information is a useful tool in making land-use and development decisions.

The Guayanilla and Yauco basins lie in the southwestern part of Puerto Rico. The streams flow southward from the rugged Cordillera Central and empty into Bahía de Guayanilla. The lower basins are devoted principally to the production of sugarcane and are subject to destructive floods. Details pertaining to basin features, flood frequency, flood profiles, and inundated areas are discussed by individual basins. All elevations given are in meters above mean sea level.

RÍO GUAYANILLA BASIN

The Río Guayanilla basin is the easterly basin of the study area shown in the location sketch, figure 1. It has a drainage area of 18.5 square miles at the U.S. Geological Survey gaging station 2.4 kilometers north of Guayanilla, and 20.8 square miles at the upstream Highway PR-2 bridge (of three Highway PR-2 bridges across Río Guayanilla). The total drainage area of the basin is about 31 square miles.

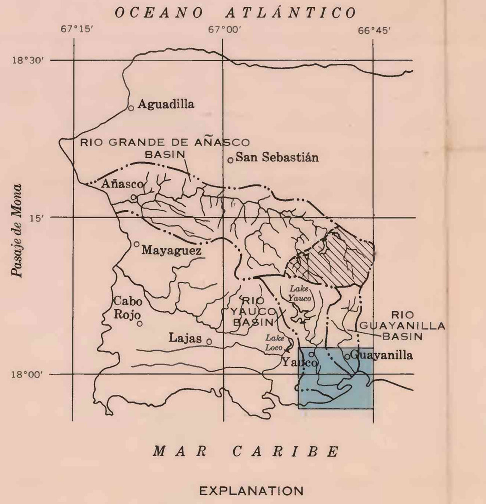


FIGURE 1.—*Location of Río Guayanilla and Río Yauco drainage basins.*

The lower flood plain is an alluvial fan and most of the city of Guayanilla is on the flood plain. Four highway bridges span Río Guayanilla in the study area. The abandoned railroad embankment that crosses the flood plain downstream from Guayanilla is an important feature that affects floodwater movement. The embankment profile is shown in figure 2. Río Guayanilla is diverted at three places for irrigation. However, no dams exist that would reduce the magnitude of floodflow.

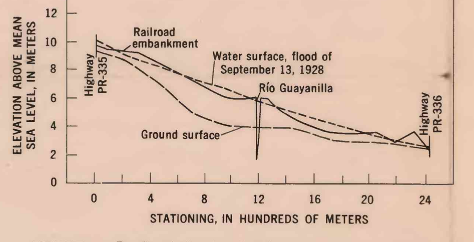


FIGURE 2.—*Profile of abandoned railroad embankment between Highways PR-335 and PR-336.*

Flood history.—The earliest floods documented in this basin occurred in 1876 and 1886. Stages of these floods, cited in highway damage reports, could not be recovered. The flood of August 8, 1899, is the greatest known flood. Since the 1899 event, major floods occurred in 1926, 1928, 1932, and 1954. Small floods, being less destructive and less spectacular, usually are soon forgotten. However, flood elevations were recovered for the lesser floods that occurred in 1955, 1958, 1960, 1963, and 1966. A tabulation of flood stages and estimated discharges at the upstream Highway PR-2 bridge (of three Highway PR-2 bridges in Guayanilla) is given below. The bridge is shown in figure 3.

Date	Elevation above mean sea level (meters)	Peak discharge (cubic feet per second)
August 8, 1899	22.0	39,000
September 13, 1928	20.9	23,000
September 21, 1932	21.3	28,000
October 13, 1954	20.5	18,000
May 6, 1958	19.4	6,400
September 14, 1961	18.5	2,800

FIGURE 3.—*Upstream Highway PR-2 bridge spanning Río Guayanilla. The 1954 flood reached the low beam of this bridge. The top of the bridge railing is about the same elevation as the crest of the 1899 flood.*

The 1926 flood stage was not established at the upstream Highway PR-2 bridge. Flood elevations farther downstream indicate the magnitude of the flood was slightly less than that of the 1928 flood. Stage and corresponding discharge at this site permit the development of the stage-discharge relation shown in figure 4.

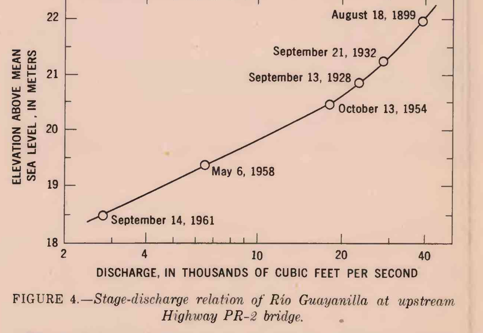


FIGURE 4.—*Stage-discharge relation of Río Guayanilla at upstream Highway PR-2 bridge.*

Flood frequency.—Historical floodmark elevations were used in conjunction with discharge records collected at the Río Guayanilla near Guayanilla gaging station, unadjusted for the intervening 2.3 square miles of drainage area, to establish a flood-frequency relation at the upstream Highway PR-2 bridge. The general relation of recurrence interval to river stage and discharge is shown in figure 5. Stage and discharge for selected recurrence intervals are tabulated below.

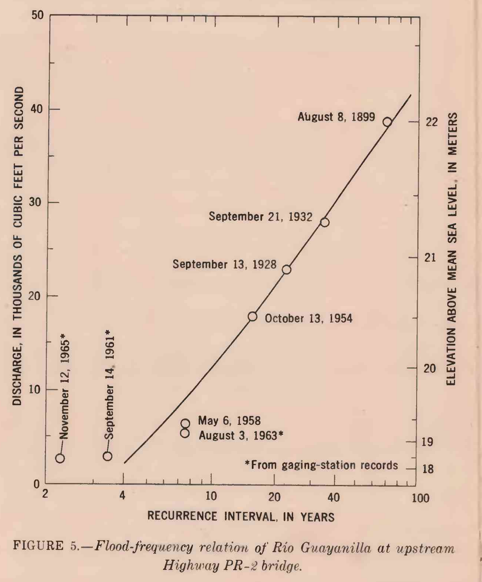


FIGURE 5.—*Flood-frequency relation of Río Guayanilla at upstream Highway PR-2 bridge.*

Recurrence interval (years)	Elevation above mean sea level (meters)	Peak discharge (cubic feet per second)
5	19.0	4,500
10	20.0	13,000
20	20.7	21,000
30	21.2	27,000
50	21.7	34,000

There is no means of predicting the date a flood of a given magnitude will occur. If a long-enough record of floods is available, however, the average recurrence interval of such a flood and the probability of its occurrence in any year can be computed. The recurrence interval, or frequency, of a flood of specific magnitude is the average length of time during which that flood has been equaled or exceeded. For floods greater than the 10-year flood, the reciprocal of the recurrence interval is virtually the probability of occurrence in a year; thus a 20-year flood will have a 5-percent chance of occurring in a year, and a 50-year flood will have a 2-percent chance.

At the upstream bridge on Highway PR-2, a flood elevation of 20.0 meters has an indicated 10-year recurrence interval. However, the 20.0 meter elevation was exceeded 3 times during the 7-year period 1926–32. It thus is emphasized that recurrence intervals are average figures—the *average* number of years in which floods of a specific magnitude have been equaled or exceeded.

Flood profiles.—Flood elevations referenced to the arbitrary base line shown on the topographic map are shown in figure 6. The 1932 and 1954 flood profiles are well defined above an elevation of 8 meters. The 1928 flood profile is poorly defined and has been drawn on the basis of the shape of the other flood profiles. The 1928 and 1954 profiles are estimated in the reach from 0.4 to 1.8 kilometers above the stream mouth.

Inundated area.—The area inundated by the 1928 flood has been delineated on the large topographic map. The area inundated by the 1932 and 1954 floods at Guayanilla is shown in figure 7. The 1928 flood was selected to be shown on the large map because it is known to have intermingled with Río Yauco and to have been consistent with the Río Yauco inundation area of 1928. The inundated area in the vicinity of El Faro and along Río Macaná is undefined and has been estimated. The effect of the abandoned railroad embankment upon the height of the water could not be defined from the available floodmarks.

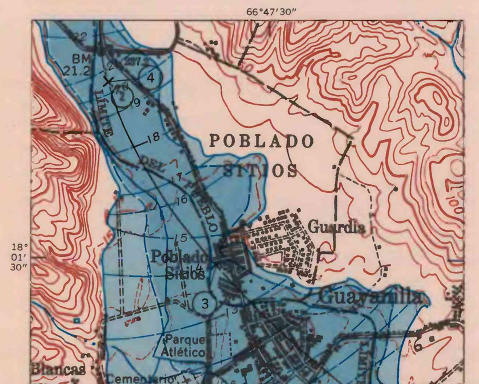


FIGURE 7.—*Area inundated in the vicinity of Guayanilla by the floods of September 27, 1932, and October 13, 1954.*

The flood boundaries delineated on the topographic maps provide a record of historic facts that reflect channel and flood-plain conditions existing at the time of each flood. No attempt was made to appraise the effect of later changes in the channel or flood plain. The Río Guayanilla channel was dredged in 1948, 1952, and 1965, and increasing urbanization may have changed runoff characteristics.

Highway PR-2 will be relocated upstream from the present (1968) upstream bridge. The inundation pattern of future floods may be affected by this relocation, by the possible relocation and improvement of the stream channel, by the removal of the railroad embankment, and by other cultural changes.

RÍO YAUCO BASIN

The Río Yauco basin is the westerly basin shown in the location sketch, figure 1. The drainage area of the basin at Escuela Arturo Lluberas, 1.3 kilometers northwest of Central San Francisco, is 45.5 square miles. The total drainage area of the basin is about 48 square miles. These areas include that part of the basin upstream from Antonio Lucchetti Dam.

Reservoirs partly regulate streamflow within this basin. A schematic diagram of the interconnected reservoir system is shown in figure 8. Lagos Yahuecas, Guayo, Toro, and Prieto, the four reservoirs in the headwaters of Río Grande de Añasco, have a combined storage capacity of about 20,000 acre-feet. These reservoirs, constructed during 1955 and 1956, divert flow from 39 square miles of the Río Grande de Añasco basin to Lago Yauco (above Antonio Lucchetti Dam) on Río Yauco. Lago Yauco also collects flow from 17.3 square miles of the Río Yauco basin, and it has a storage capacity of 16,500 acre-feet. Water from Lago Yauco then is conveyed to Lago Loco for power generation and for distribution to Valle de Lajas for irrigation.

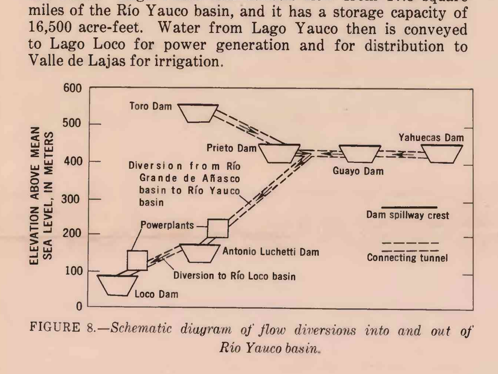


FIGURE 8.—*Schematic diagram of flow diversions into and out of Río Yauco basin.*

One major flood, in 1960, has been experienced at Yauco since the construction of Antonio Lucchetti Dam in 1953. The numerous irrigation diversions on Río Yauco from Yauco to Escuela Arturo Lluberas have minor influence on flood discharge. Six highway bridges and one foot bridge span Río Yauco in the study area.

Flood history.—The earliest flood known on Río Yauco was in 1867 during Hurricane San Narciso, when the highway bridge at Yauco was destroyed. No data were recovered to indicate the magnitude of this flood. The greatest known flood to occur in the basin was on August 1899. Other major floods occurred in 1926, 1928, and 1960. A tabulation of stage and approximate discharge of historical floods at Escuela Arturo Lluberas is shown below:

Date	Elevation above mean sea level (meters)	Peak discharge (cubic feet per second)
August 8, 1899	10.9	42,000
September 13, 1928	9.9	18,000
September 18, 1960	9.5	10,000
November 11, 1961	8.8	2,900
April 28, 1962	8.4	1,800
September 27, 1963	8.9	3,300
July 21, 1968	8.6	2,200

Flood stages after 1926 were collected at the Highway PR-335 bridge about 50 meters east of the school. These elevations have been transferred upstream to the school as a common point on the basis of the indicated water-surface slope.

Flood stage and discharge define the relation shown in figure 9.

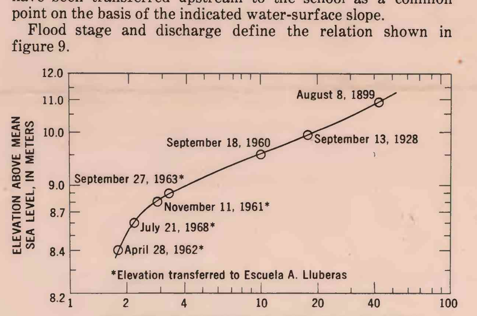


FIGURE 9.—*Flood stage-discharge relation of Río Yauco at Escuela Arturo Lluberas.*

Flood frequency.—Sufficient data are not available to define a flood-frequency relation for Río Yauco. The 1899 flood is estimated to have a recurrence interval of about 70 years and the 1928 flood a recurrence interval of about 35 years. The scattered flood discharge information relating to floods after the construction of Antonio Lucchetti Dam is not sufficient to define the present (1967) flood-frequency relation.

Flood profiles.—The 1928 and 1968 flood elevations, referenced to the arbitrary base line on the topographic map, are shown in figure 10. The 1928 water-surface profile between the elevation range of 13 to 26 meters is not defined by floodmarks, but it has been estimated. An average value of high-water marks was used near the elevation of 28 meters. Although several residents along the reach from 5 to 9 kilometers upstream from the mouth recalled the 1928 flood, the west edge of the valley has been changed, mainly by road construction, and old landmarks have been erased. One resident recalled that the flood reached Escuela Segunda Unidad de Barinas, but could point out no definite elevation of the flood. The profile has a probable accuracy of ±0.5 meter at elevations above 12 meters.

The flood of July 21, 1968, was not a major event, but its profile provides a basis for estimating the 1928 flood profile. Río Yauco is confined at low discharge by small levees downstream from about kilometer 2.5. The 1968 profile below this point is not applicable for comparison with the 1928 flood and is not shown.

Inundated area.—The area inundated by Río Yauco during the 1928 flood is shown on the topographic map. The delineated boundary reflects the channel and flood-plain conditions at the time of the 1928 flood. No attempt was made to ascertain the effect of later changes in the channel and flood plain, or in runoff characteristics.

Apparently only the buildings along Río Yauco in the vicinity of Highway PR-2 and at the southeastern tip of the city were affected by the flood. Water may have backed up some distance in Quebrada Berrenchín along the west and south edge of Yauco, but the extent could not be determined.

Housing has been expanding onto the flood plain of Río Yauco on the basis of unproven confidence that Lago Yauco has eliminated major floods. Lago Yauco may reduce the frequency of flooding, but it will not eliminate floods, particularly at times when it may be at full capacity. A service road recently has been constructed across the lower flood plain of Río Yauco, which crosses Río Yauco at base-line station 2.05 and extends to Punta Verraco. This and other changes along the channel and in the flood plain may well affect the inundation pattern of future floods.

HIGH-WATER MARK INFORMATION

The inundated areas have been delineated on the basis of flood-stage information furnished by residents. Field surveys were conducted to determine the elevation of the flood stages.

WATER-SURFACE ELEVATIONS

The estimated water-surface contours of the September 13, 1928, flood for both basins and of the 1932 and 1954 floods at Guayanilla are shown on the topographic maps.

DEPTH OF FLOODING

Depth of flooding at any point may be estimated by subtracting the ground elevation from the water-surface elevation. Each is shown by contours on the map. Intermediate estimates of depth may be determined by interpolation.

COOPERATION AND ACKNOWLEDGMENT

This report was prepared as part of the floods investigation authorized by a cooperative agreement between the Department of Public Works, Commonwealth of Puerto Rico, and the United States Geological Survey. Many of the flood data were provided by the Department of Public Works. Historical flood information was made available by the general archives of the Instituto de Cultura Puertorriqueña and by many residents of the study area.

ADDITIONAL INFORMATION

Additional information relating to floods on Río Guayanilla and Río Yauco can be obtained from the U.S. Geological Survey, San Juan, Puerto Rico, or from the Area de Prevención de Inundaciones, Departamento de Obras Públicas, Santurce, Puerto Rico.

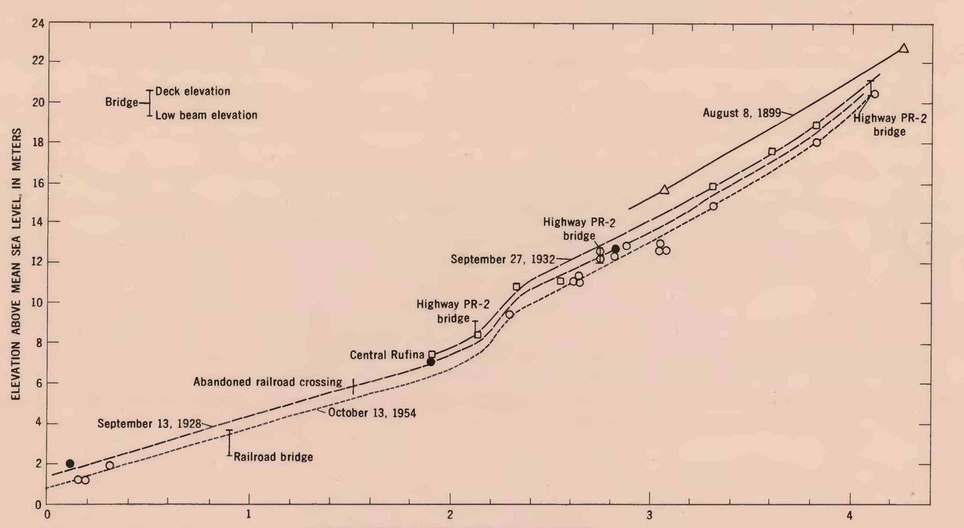


FIGURE 6.—*Flood profiles, Río Guayanilla.*

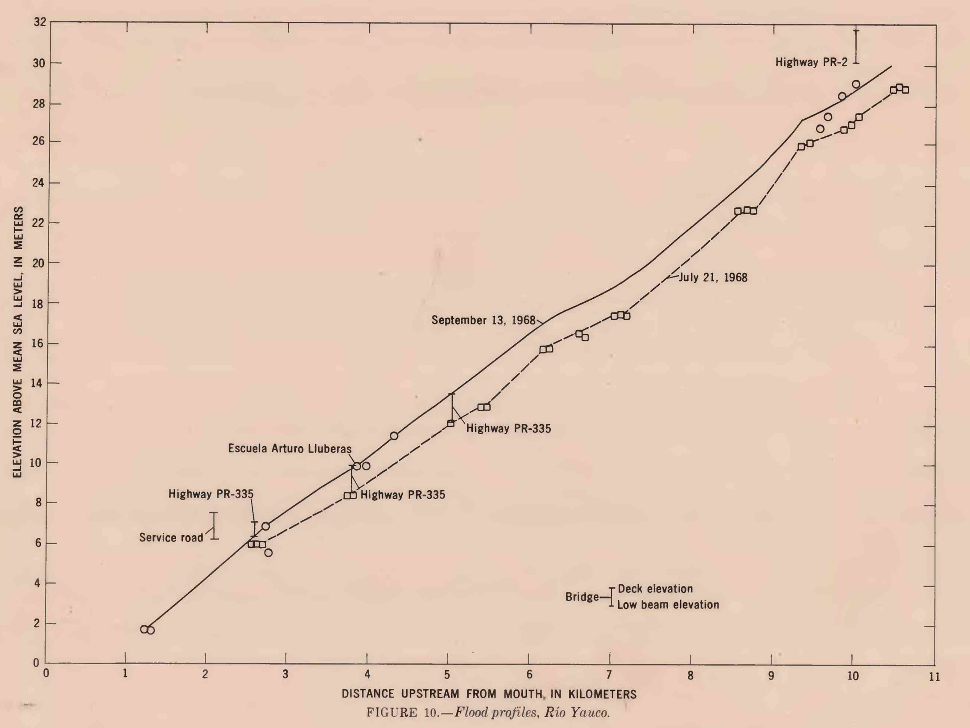


FIGURE 10.—*Flood profiles, Río Yauco.*

For sale by U.S. Geological Survey, price $1.00