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Flood-Inundation Maps for Río de la Plata in and Near Comerío, Puerto Rico, 2025

Scientific Investigations Report 2025–5094

U.S. Department of the Interior
U.S. Geological Survey

Cover. View looking west (upstream) along the Río de la Plata at the Puerto Rico Route 774 bridge in Comerío, Puerto Rico. Photograph by Keviān Pérez Valentín, University of Puerto Rico, February 3, 2025; used with permission.

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By Chad J. Ostheimer and Legna M. Torres-Garcia

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The content of this report is originally modified from Whitehead and Ostheimer (2009). The data, discussion, and other sections are updated serially as different study areas are investigated with the techniques described in this report (Ostheimer, 2012, 2013; Ostheimer and Huitger, 2019; Ostheimer and Whitehead, 2024; Whitehead, 2011, 2015, 2019; Whitehead and Ostheimer, 2014, 2015, 2024).

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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Datums

Vertical coordinate information is referenced to (1) stage, the height above an arbitrary datum established at a streamgage, and (2) elevation, the height above the Puerto Rico Vertical Datum of 2002 (PRVD 02).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Abbreviations

AEP	annual exceedance probability
DEM	digital elevation model
FEMA	Federal Emergency Management Agency
HEC–RAS	Hydrologic Engineering Center’s River Analysis System
lidar	light detection and ranging
NWS	National Weather Service
RAS	River Analysis System
RMSE	root mean square error
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey

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Abstract

Digital flood-inundation maps for a 3.1-mile reach of Río de la Plata in and near Comerío, Puerto Rico, were created by the U.S. Geological Survey (USGS). Water-surface profiles were computed for the stream reach by using a one-dimensional steady-state step-backwater model. The model was calibrated to the current (2025) stage-streamflow relation (rating curve 11.0) for the USGS streamgage 50043800, Río de la Plata at Comerío, Puerto Rico. The resulting hydraulic model was then used to compute 16 water-surface profiles for water levels (flood stages) ranging from 10.00 to 40.00 feet at the streamgage and ranging from "action stage" to above "major flood stage" as reported by the National Weather Service. The 40.00-foot stage was selected because it exceeds the peak stage of 34.86 ft recorded during Hurricane Maria at the USGS streamgage 50043800, Río de Plata at Comerío, Puerto Rico. The simulated water-surface profiles were then used in combination with a digital elevation model derived from light detection and ranging data to map the inundated areas associated with each flood profile.

The flood-inundation maps and the supporting hydraulic model produced by this study can be used by emergency managers and local officials to assess flood mitigation strategies and to define flood hazard areas to help protect life and property, to coordinate flood response activities such as evacuations and road closures, and to aid post-flood recovery efforts.

Introduction

Comerío is a municipality in the central-eastern region of Puerto Rico (fig. 1) and consists of nine barrios (neighborhoods): Cedrito, Cejas, Pueblo, Doña Elena, Naranjo, Palomas, Piñas, Río Hondo, and Vega Redonda (Hinojosa and others, 2021). The downtown area of Comerío is in Barrio Pueblo, and it comprises schools, administration offices, local businesses, and emergency response teams (Hinojosa and others, 2021). Comerío is the 58th largest municipality in Puerto Rico by total area, with a population of 18,883 (U.S. Census Bureau, 2020). One of the most notable geographical features of Comerío is the Río de la Plata, the longest river in Puerto Rico, which flows along Cayey, Guayama, Cidra, Aibonito, Barranquitas, Comerío, Naranjito, Bayamón, Toa Alta, Toa Baja, and Dorado municipalities (Picó and others, 1969) (fig. 1). Most of the town of Comerío is on the alluvial plain of Río de la Plata (Rodríguez-Martínez and others, 2001).

Río de la Plata plays a critical role in the region's history and economy. It has been a vital water source for agriculture and has influenced the development of the surrounding communities (Rodríguez-Martínez and others, 2001). Río de la Plata presents challenges to emergency managers due to flood risks, especially during heavy rainfall or natural disasters like hurricanes. Comerío is particularly vulnerable to riverine flooding. Since 1989, 13 flooding events have approached or exceeded the 10-percent annual exceedance probability (AEP) flood (U.S. Geological Survey [USGS], 2025d; Federal Emergency Management Agency [FEMA], 2009) at the USGS streamgage 50043800, Río de la Plata at Comerío, Puerto Rico (fig. 2) (hereafter referred to as the "Comerío streamgage"). The 13 flooding events happened in water years 1989, 1992, 1996, 1998, 2000, 2004, 2005, 2006, 2010, 2011, 2017, 2022, and 2024. A water year is defined as the period between October 1 of one year and September 30th of the next.

In September 2017, storm damages from Hurricane María totaled $90 billion in Puerto Rico and the U.S. Virgin Islands, making it the most destructive hurricane in modern Puerto Rican history (Pasch and others, 2023). The 2017 flood event was near a 1-percent AEP flood and had a peak of record stage of 34.86 feet. In Comerío, the storm produced 17.50 inches of rain (most of which fell in about 24 hours), causing major flooding and mudslides linked to the Río de la Plata (Pasch and others, 2023). The flooding damaged homes and infrastructure and affected the alluvial valley, including Toa Baja, where hundreds of families had to be rescued from rooftops.

In another example, during January 5–6, 1992, a cold front combined with an upper-level trough caused severe flooding near the Río de la Plata (Torres-Sierra, 1996). This event resulted in over $150 million in damages, with a peak stage of 29.22 ft and peak discharge of 127,000 ft^3/s (the peak of record discharge; USGS, 2025d) at the Comerío streamgage. The Highway 173 bridge (no longer in existence), originally located approximately 0.15 mile downstream from the PR-774 bridge (fig. 2) in Comerío, was washed away. As evidenced by the events of 1992 and Hurricane María in 2017, the topography of the area and its proximity to Río de la Plata pose a significant risk of riverine flooding in Comerío in the event of future natural disasters, particularly those with heavy precipitation and flash flooding (Hinojosa and others, 2021). The 1992 flood event, and yet another in 1996, exceeded the 1-percent AEP flood (FEMA, 2009).

In 2024, the USGS, with funding from Title VII of Division N in the Consolidated Appropriations Act, 2023 (Public Law 117–328) (Library of Congress, 2023; USGS, 2023), led a project to produce a library of flood-inundation maps in and near Comerío, Puerto Rico. Emergency managers near Comerío, Puerto Rico (fig. 2), rely on several information sources to make decisions on how to best alert the public and mitigate flood damages. One source is the FEMA (2009) flood insurance study for the Commonwealth of Puerto Rico and municipalities. A second source of information is the data on current and historical water level and streamflow (including annual peak flow) from the Comerío streamgage (tables 1 and 2; fig. 1; USGS, 2025d). A third source of flood-related information is the National Weather Service's (NWS) National Water Prediction Service, which displays stage data from the Comerío streamgage (the NWS identifies the streamgage with the code COMP4, fig. 2) and, in the future, could issue forecasts of stages (NWS, 2025b). This report and the associated library of flood-inundation maps provide an additional resource that emergency managers in and near Comerío, Puerto Rico can use to make decisions on how best to alert the public and mitigate flood damages.

Enhancing Flood-Risk Awareness

Information about the current stage at a USGS streamgage is useful for residents nearby, but it is of limited use to residents upstream or downstream because the water-surface elevation is not constant along the stream reach. Knowing the stage at a streamgage does little to inform nearby residents and officials about the depth and area of flooding. Flood depth estimates from stage increase in uncertainty as the distance from the streamgage increases. One way to address these informational gaps is to produce a library of flood-inundation maps that are referenced to stages at the streamgages. By referring to the appropriate map, emergency responders can better understand the severity of flooding (depth of water and area), identify roads that are or could soon be flooded, and make plans to notify or evacuate residents that could be in harm's way. In addition, the ability to visualize the potential area of flooding on a map can motivate residents to take precautions and heed warnings that they previously may have disregarded (Kuser Olsen and others, 2018).

Study Area

The study area includes a 3.1-mile (mi) reach of Río de la Plata that borders the community of Comerío, Puerto Rico (fig. 2). The limits of the hydraulic analyses of Río de la Plata are upstream from Río Arroyata (about 2.0 mi downstream from the Comerío streamgage) at the downstream end, and 0.7 mi below Río Hondo (about 1.1 mi upstream from the Comerío streamgage) at the upstream end. The contributing drainage area of the river at the Comerío streamgage is 117 square miles (mi^2) (table 1). The Comerío streamgage was established in December 1988 (table 2). The area closest to the Comerío streamgage is primarily urban, but about 0.6 mi upstream, the land becomes mostly forested and undeveloped, and about 1.1 mi downstream, the land is a mix of suburban and undeveloped area.

Previous Studies

The flood insurance study for the Commonwealth of Puerto Rico and municipalities was published in November 2009 (FEMA, 2009). For Río de la Plata, the study re-delineates the areas prone to large floods corresponding to 10-, 2-, 1-, and 0.2-percent AEP floods from work that originated in 1979. Selected AEPs for the Comerío streamgage location (FEMA, 2009) are shown in table 3.

The detailed flooding analyses for Río de la Plata in the 2009 flood insurance study include and extend beyond the upstream and downstream limits of the flood-inundation mapping study reach. While the FEMA (2009) work provides flood-profile information for four flooding events (the 10-, 2-, 1-, and 0.2-percent AEP floods), the flood-inundation mapping work expands the available flood-profile information for the Comerío area by including 16 water-surface profiles with current (as of 2025) stream and structure information.

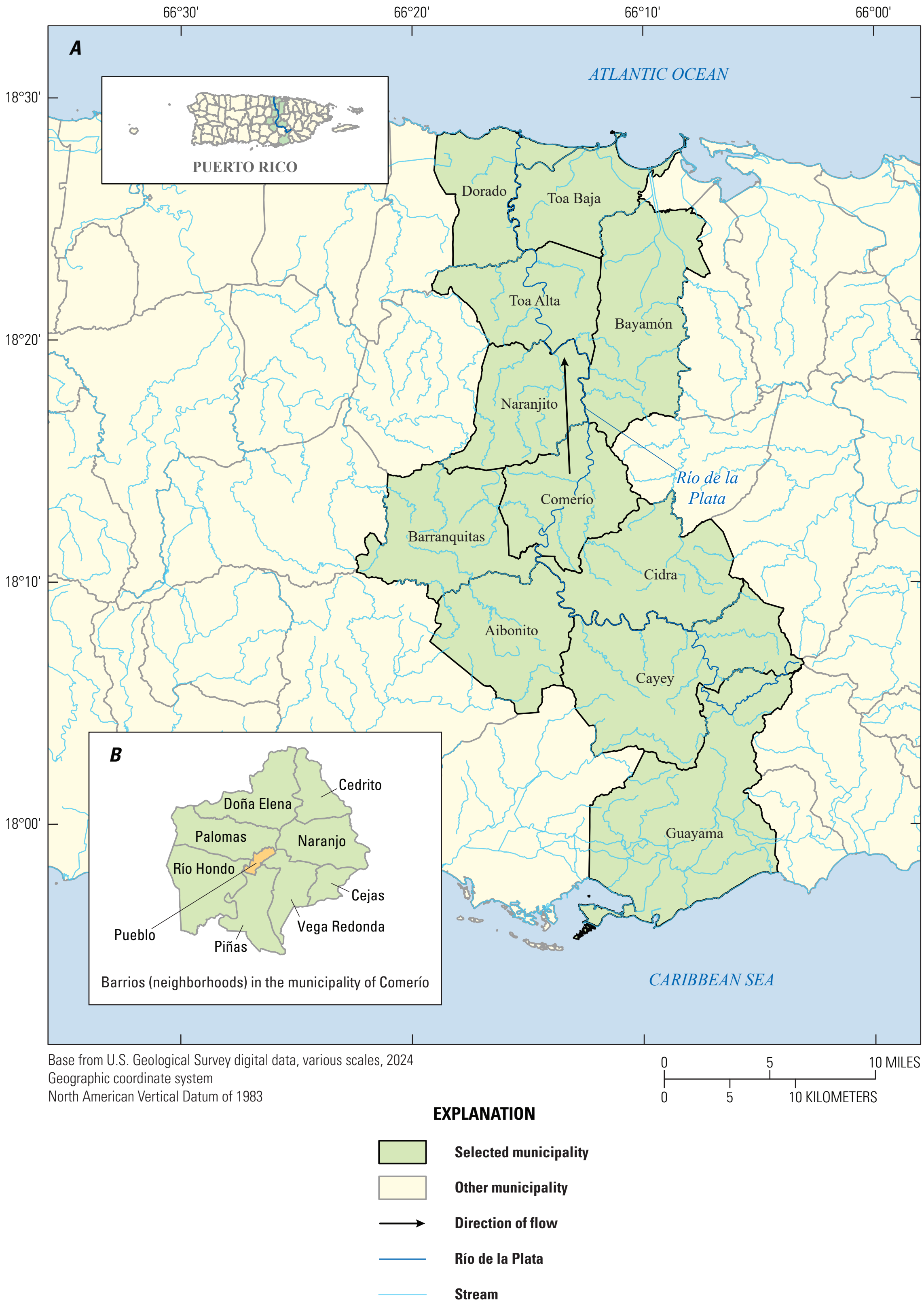

Figure 1. Map showing (*A*) the municipalities along Río de la Plata and selected tributaries and (*B*) the barrios (neighborhoods) of the municipality of Comerío.

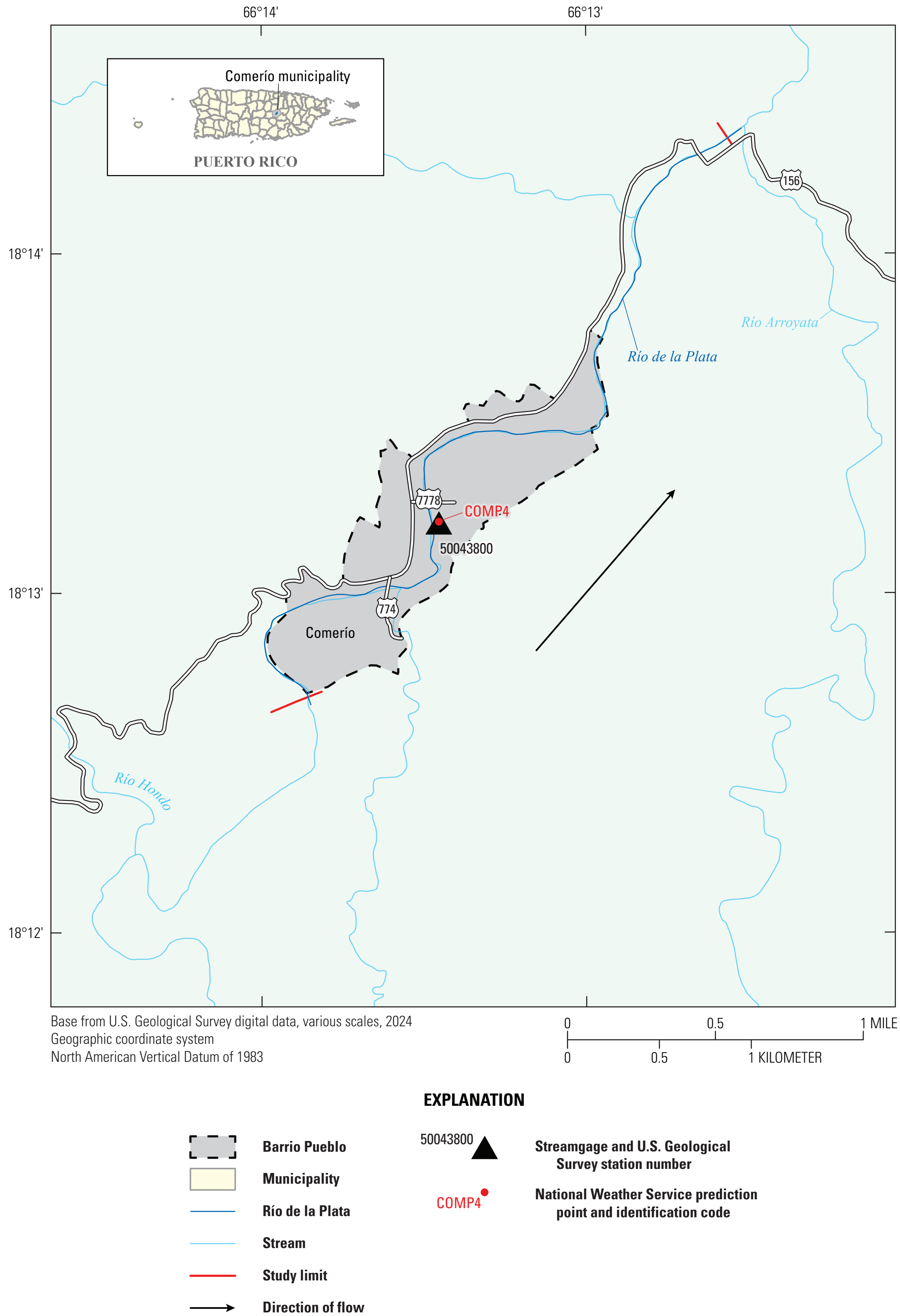

Figure 2. Map showing the study area along Río de la Plata, including selected roads and tributaries, and the location of the U.S. Geological Survey streamgage 50043800, Río de la Plata at Comerío, Puerto Rico.

Table 1. Summary of information for the U.S. Geological Survey streamgage near Comerío, Puerto Rico.

[Streamgage data from USGS (2025f). Horizontal coordinates are in the North American Datum of 1983. Streamgage location is shown in figure 2. P.R., Puerto Rico]

Station name	Station number	Drainage area (square miles)	Latitude	Longitude
Río de la Plata at Comerío, P.R.	50043800	117	18°13′12.61″	−66°13′27.23″

Table 2. Maximum stage record for the U.S. Geological Survey streamgage near Comerío, Puerto Rico.

[Streamgage data from USGS (2025d). Streamgage location is shown in figure 2. PRVD 02, Puerto Rico Vertical Datum of 2002. P.R., Puerto Rico]

Streamgage number and name	Streamflow record	Maximum stage			
		Streamgage height (feet)	Maximum stage elevation (feet above PRVD 02)	Streamflow (cubic feet per second)	Date
50043800, Río de la Plata at Comerío, P.R.	December 1988–2025	34.86	651.25	95,100[1]	September 20, 2017

[1]The peak of record discharge is 127,000 cubic feet per second and occurred on January 5, 1992, at a stage of 29.22 feet.

Table 3. Peak streamflows for selected annual exceedance probabilities for the U.S. Geological Survey streamgage 50043800, Río de la Plata at Comerío, Puerto Rico.

[Data from Federal Emergency Management Agency, 2009. USGS, U.S. Geological Survey; mi^2, square mile; ft^3/s, cubic foot per second; P.R., Puerto Rico]

USGS streamgage number and name	Drainage area (mi^2)	Estimated streamflows (ft^3/s) for indicated annual exceedance probabilities (percent)			
		10	2	1	0.2
50043800, Río de la Plata at Comerío, P.R.[1]	117	32,136	75,044	99,941	184,872

[1]This location is referred to in the Federal Emergency Management Agency Flood Insurance Study as "At Passarrel and Pina bridge."

Methods

The current (2025) stage-streamflow relation (rating number 11.0; USGS, 2025e) at the Comerío streamgage was used to input streamflows in the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center's River Analysis System (HEC–RAS) version 6.3.1 (USACE, 2025). The HEC–RAS software was used to develop 16 water-surface profiles, corresponding to stages from 10.00 to 40.00 feet (ft) in 2-ft increments (table 4).

The 10.00-ft stage corresponds approximately to bankfull conditions at the Comerío streamgage location; "bankfull" is defined by the NWS as the "action stage" or "the stage which, when reached by a rising stream, represents the level where the NWS or a partner/user needs to take some type

Table 4. Minimum and maximum target water-surface stages and National Weather Service-designated stages for U.S. Geological Survey streamgage 50043800, Río de la Plata at Comerío, Puerto Rico.

[All data are shown in feet. P.R., Puerto Rico]

Streamgage name	Minimum stage included in this report	Maximum stage included in this report	Action stage	Major flood stage
50043800, Río de la Plata at Comerío, P.R.	10.00	40.00	10.00	18.00

of mitigation action in preparation for possible significant hydrologic activity" (NWS, 2025a). The 40.00-ft stage was chosen because it exceeds the peak-of-record stage of 34.86 ft from Hurricane Maria recorded at the Comerío streamgage, (table 2; USGS, 2025d) and, it surpasses the "major flood stage" (18.00 ft) as defined by NWS. The NWS defines major flooding as "a general term including extensive inundation and property damage" and notes that it is "usually characterized by the evacuation of people and livestock and the closure of both primary and secondary roads" (NWS, 2025a). In addition, a stage of 40.00 ft is associated with a discharge of 128,000 cubic feet per second (ft^3/s) from the stage-streamflow relation, meaning the highest mapped stage will exceed the peak-of-record discharge of 127,000 ft^3/s.

Standard Procedures for Creating a Flood Map

The USGS has standardized procedures for creating flood-inundation maps for flood-prone communities to ensure that the methods used and products produced are consistent (USGS, 2025c). Tasks specific to development of the flood maps included (1) collecting topographic, bathymetric, and geometric data for selected cross sections and structures (such as bridges or culverts) along the study reach, (2) estimating energy-loss factors (roughness coefficients) in the stream channel and floodplain, (3) determining streamflows for each stage to be modeled, (4) computing and calibrating water-surface profiles using HEC–RAS (USACE, undated), (5) producing estimated flood-inundation maps for selected stages by using RAS Mapper (a feature within HEC–RAS; USACE, undated) and a geographic information system, and (6) preparing maps as shapefile polygons that depict the area of flood inundation and as depth grids that provide the depth of floodwaters, available through a USGS flood inundation mapping application. These methods follow procedures described in Bales and others (2007) and Whitehead and Ostheimer (2009). Techniques that were modified significantly from previously documented methods to accommodate local hydrologic conditions or availability of data are described in detail in this report.

Topographic Data

The topographic data used in this study are referenced vertically to the Puerto Rico Vertical Datum of 2002 (PRVD 02) and horizontally to the North American Datum of 1983 (NAD 83). Cross-section elevation data were obtained from a digital elevation model (DEM) that was derived from lidar data collected from July 2018 to August 2018 for the USGS (USGS, 2020) as a part of the USGS 3D Elevation Program (USGS, 2025a). The DEM is USGS Quality Level 2 (USGS, 2025a) with a cell size of 1.0 meter (m) (3.28 ft), a nominal pulse spacing of 0.71 m (2.33 ft), and a vertical root mean square error (RMSE) of 27 cm (0.89 ft). Lidar is a technology consisting of a global positioning system, an inertial navigation system, and a laser scanner (typically mounted in a small aircraft) that "transmits brief pulses of light to the ground surface. Those pulses are reflected or scattered back and their travel time is used to calculate the distance between the laser scanner and the ground" (USGS, 2025g).

The RAS Mapper feature within HEC–RAS was used to extract station and elevation data from the DEM at 176 cross sections (table 5) for use in HEC–RAS. The DEM-derived cross sections were co-located with the field-surveyed cross sections where possible. In those cases, DEM-based elevations were combined with the survey elevations to form composite cross sections. In-channel elevations and dimensions for DEM-derived cross sections that did not have field-surveyed elevations were estimated by interpolating between the closest field-surveyed cross sections as a function of distance along the hydraulic baseline.

Table 5. Survey characteristics and hydraulic parameters used to create the Río de la Plata hydraulic model.

[ft/ft, foot per foot slope]

Study reach length (miles)	Total number of cross sections	Number of surveyed cross sections	Number of hydraulic structures	Downstream hydraulic model boundary condition	Base Manning's roughness coefficient (*n*)			
					Main channel		Overbanks	
					Lowest value	Highest value	Lowest value	Highest value
3.1	176	30	3	Normal depth slope[1], of 0.00547 ft/ft	0.067	0.076	0.075	0.08

[1]Normal depth is the depth when the streamflow is uniform, steady, one-dimensional, and is not affected by downstream obstructions. Flow is considered uniform if the energy line, water surface, and channel bottom all are parallel (Chow, 1959). The slope used to compute the normal depth of flow for all stages was based on the minimum channel slope between two field-surveyed cross sections near the downstream end of the modeled reach.

Bathymetric and Structure Data

Channel cross sections were surveyed to collect data on elevations and dimensions below the water surface that are not provided by conventional light detection and ranging (lidar). Structures that could affect water-surface elevations during floods along the streams were also surveyed.

The USGS used a differential global positioning system and differential-leveling (hereafter referred to as "conventional") surveys for this study. Differential global positioning system surveys were completed using Level III real-time network surveying techniques (Rydlund and Densmore, 2012) and were used to establish an elevation control network at selected locations along the study reach. Elevations determined by using the differential global positioning system at six benchmark locations (table 6) had a vertical RMSE of 0.12 ft when compared with National Geodetic Survey published elevations (National Oceanic and Atmospheric Administration, 2025).

The USGS used the elevation control network to complete conventional surveys at each structure to obtain its geometry. All conventional surveys were done to third-order accuracy criteria in both horizontal and vertical directions (Federal Geodetic Control Committee, 1984). USGS field crews surveyed a total of three hydraulic structures (table 5) along Río de la Plata during three periods: March 2018, August 2024, and February 2025. Bathymetric data for 30 cross sections were also obtained by the USGS using conventional surveys to ensure that no reach length between surveyed cross sections was greater than 1 mi. The maximum distance between all cross sections (both conventionally surveyed and DEM-derived) was 181 ft, and the average distance was 95 ft.

Energy-Loss Factors

Hydraulic analyses require the estimation of energy losses that result from frictional resistance between the streamflow and the channel. The amount of frictional resistance may be quantified by the Manning's roughness coefficient ("*n*" value). Initial (precalibration) *n* values were selected based on field observations and high-resolution aerial photographs (Esri, Maxar, Earthstar Geographics, and the GIS Community, 2009). As a part of the calibration process, the initial *n* values were adjusted until the differences between computed and observed water-surface elevations at the Comerío streamgage for stage 10.00 ft were minimized for the lower modeled discharges. Frictional resistance of obstructions, such as rocks and vegetation, are diminished as the depth of streamflow over the obstructions increases. The use of flow roughness factors allows the model to linearly vary (reduce) the stream roughness coefficients with increasing streamflow. The (base) *n* values were then modified by using flow roughness factors (table 7).

For Río de la Plata, the final base *n* values ranged from 0.067 to 0.076 for the main channel and from 0.075 to 0.080 for the overbank (floodplain) areas (table 5). By use of the flow roughness factors (table 7), the base *n* values for the stage 40.00 ft (with an associated streamflow of 128,000 ft^3/s—estimated from a post-Maria step-backwater analysis done by the USGS Puerto Rico office) were reduced to 0.051 to 0.058 for the main channel and from 0.057 to 0.061 for the overbank (floodplain) areas. As noted in the "Study Area" section, the floodplains near the Comerío streamgage are primarily urban, changing to suburban, forested, and undeveloped areas in the lower and upper ends of the study reach. The stream channel throughout the study reach is mainly composed of exposed bedrock, large rocks, sand, and gravel; tall sawgrass, bamboo, and underbrush grow along the streambanks.

Table 6. Comparisons of published National Geodetic Survey benchmark coordinates and elevations to those surveyed by the U.S. Geological Survey.

[All data are shown in feet. State Plane Coordinate System (Puerto Rico, Virgin Islands). NGS, National Geodetic Survey; NAD 83, North American Datum of 1983; PRVD 02, Puerto Rico Vertical Datum of 2002; USGS, U.S. Geological Survey; n/a, not applicable]

NGS benchmark name	Permanent identifier[1]	Published NGS			Surveyed by USGS			Deltas		
		Northing (NAD 83)	Easting (NAD 83)	Elevation (PRVD 02)	Northing (NAD 83)	Easting (NAD 83)	Elevation (PRVD 02)	Northing (NAD 83)	Easting (NAD 83)	Elevation (PRVD 02)
G 1023 2010	DO1405	n/a	n/a	289.58	n/a	n/a	289.53	n/a	n/a	−0.05
H 1023 2010	DO1406	n/a	n/a	264.62	n/a	n/a	264.47	n/a	n/a	−0.15
K 1023 2010	DO1408	n/a	n/a	216.13	n/a	n/a	216.00	n/a	n/a	−0.13
D 1016 2008	DO1108	n/a	n/a	174.54	n/a	n/a	174.63	n/a	n/a	0.09
E 1016 2008	DO1109	n/a	n/a	202.21	n/a	n/a	202.21	n/a	n/a	0.00
B 1016 2008	DO1106	n/a	n/a	261.28	n/a	n/a	261.46	n/a	n/a	0.18

[1]Permanent identifier refers to the designation given to the benchmark by the National Geodetic Survey (National Oceanic and Atmospheric Administration, 2025).

Table 7. Streamflow roughness factors used in the Río de la Plata hydraulic model.

[ft, foot]

Streamflow (cubic feet per second)	Stage (ft)	Flow roughness factor
2,700	10	1.00
14,500	16	0.92
49,000	26	0.85
78,500	32	0.78
102,000	36	0.76
128,000	40	0.76

Hydrologic Data

The study reach includes the Comerío streamgage (fig. 2; tables 1 and 2). The stage is measured every 15 minutes, transmitted hourly by a satellite radio in the streamgage, and made available on the internet through the USGS National Water Information System (USGS, 2025f). Stage data recorded at the Comerío streamgage are referenced to a local datum but can be converted to water-surface elevations referenced to PRVD 02 by adding 616.39 ft. Vertical datum surveys for the Comerío streamgage were completed in March 2018 by using Level II static surveying techniques (Rydlund and Densmore, 2012) and have a vertical accuracy of 0.31 ft. Continuous records of streamflow are computed from a stage-streamflow relation, which has been developed for the streamgages, and are also available through the USGS National Water Information System website (USGS, 2025e).

For the modeled profiles, the streamflows used in the model simulations (table 8) were obtained from the current stage-streamflow relation (rating curve 11.0) for the Comerío streamgage. The changes in drainage area (table 9) between the Comerío streamgage and the top and bottom ends of the reach are 2.6 percent and 5.1 percent, respectively; therefore, the discharges for each modeled profile were kept constant throughout the study reach.

Table 8. Selected stages and associated streamflows for respective stage-streamflow relations for the U.S. Geological Survey streamgage 50043800, Río de la Plata at Comerío, Puerto Rico.

[ft, foot; ft^3/s, cubic foot per second; PRVD 02, Puerto Rico Vertical Datum of 2002]

Stage[1] (ft)	Elevation (ft, PRVD 02)	Streamflow (ft^3/s)
10	626.39	2,700
12	628.39	5,790
14	630.39	9,940
16	632.39	14,500
18	634.39	19,900
20	636.39	26,000
22	638.39	32,800
24	640.39	40,500
26	642.39	49,000
28	644.39	58,100
30	646.39	67,900
32	648.39	78,500
34	650.39	89,800
36	652.39	102,000
38	654.39	115,000
40	656.39	128,000

[1]Flood profiles are 2-foot increments of stage, referenced to the gage datum of the streamgage 50043800—Río del La Plata at Comerío, Puerto Rico.

Table 9. Drainage areas and percentages for selected locations on Río de la Plata.

[mi², square mile; USGS, U.S. Geological Survey; P.R., Puerto Rico]

Location	River station[1]	Drainage area (mi²)	Percentage of drainage area compared to Comerío streamgage location
Bottom of the study reach (approximately 530 feet downstream from the downstream side of the Puerto Rico Route 156 bridge—just above the confluence with Río Arroyata)	307	123	105.1
At USGS streamgage 50043800, Río de la Plata at Comerío, P.R.	11,028	117	100.0
Top of the reach (0.7 mile below the confluence with Río Hondo)	16,861	114	97.4

[1]River station numbers are referenced (in feet) above the hydraulic baseline used in the hydraulic model. For this study, the hydraulic baseline is approximately 530 feet downstream from the downstream side of the Puerto Rico Route 156 bridge.

Hydraulic Model

The water-surface profiles used to produce the 16 flood-inundation maps in this study were computed by using HEC–RAS version 6.3.1 (USACE, 2025). HEC–RAS is a one- or two-dimensional step-backwater model used to simulate water-surface profiles with steady-state (gradually varied) or unsteady-state flow computation options. The HEC–RAS analysis for this study was completed by use of the one-dimensional, steady-state flow computation option. A subcritical (tranquil) flow regime was assumed for the simulations.

Inputs to HEC–RAS were the flow regime, boundary conditions, and streamflow values. Starting water-surface elevations were set on the basis of a normal-depth slope of 0.00547 ft/ft (table 5). This normal-depth slope was found by computing the minimum channel slope between the two most downstream field-surveyed cross sections. Normal depth is defined as the depth when the streamflow is uniform, steady, one-dimensional, and unaffected by downstream obstructions. Streamflow is considered uniform if the energy line, water surface, and channel bottom are all parallel (Chow, 1959).

Development of Water-Surface Profiles

The hydraulic model was calibrated so that the simulated water-surface elevation at the Comerío streamgage matched the target water-surface elevations predicted by the stage-streamflow rating for a given streamflow. The calibrated hydraulic model was used to generate water-surface profiles for 16 stages at 2-ft intervals from 10.00 to 40.00 ft as referenced to the local datum of the Comerío streamgage. These stages correspond to elevations from 626.39 ft to 656.39 ft PRVD 02, respectively. The modeled and target water-surface elevations at the Comerío streamgage are listed in table 10. The RMSE of the differences between the modeled and target water-surface elevations for stages from 10.00 ft to 40.00 ft is 0.16 ft; minimum and maximum differences were −0.50 ft and 0.20 ft, respectively.

Development of Flood-Inundation Maps

Flood-inundation maps for the 16 water-surface profiles were created by using geographic information system software to combine the water-surface profiles and DEM data. Estimated flood-inundation boundaries and depth grids were developed for each simulated water-surface profile with RAS Mapper—a feature within HEC–RAS (USACE, undated) that allows the preparation of geometric data for import into HEC–RAS and the processing of simulation results exported from HEC–RAS. Shapefile polygons and depth grids of the inundated areas for each water-surface profile were manually edited with geographic information system software to ensure a hydraulically reasonable transition of the flood boundaries among modeled cross sections.

Any inundated areas that were detached from the main channel were examined to identify subsurface connections with Río de la Plata, such as culverts or similar engineering structures under roadways. Where such connections existed, the mapped inundated areas were retained in their respective flood maps; otherwise, the erroneously delineated parts of the flood area were deleted. The flood-inundation areas were overlain on high-resolution, georeferenced aerial photographs (Esri, Maxar, Earthstar Geographics, and the GIS Community, 2009) of the study area. One example of a profile (stage 40.00 ft) overlain on orthorectified imagery is illustrated in figure 3. Bridge surfaces are shown as not inundated up to the lowest flood stage that completely inundates one or both road approaches to the bridge. Estimates of water depths can be determined with the interactive mapping application (USGS, 2025b) described in the following section, "Data Dissemination."

Table 10. Calibration of model to target water-surface elevations at the U.S. Geological Survey streamgage 50043800, Río de la Plata at Comerío, Puerto Rico.

[ft, foot; PRVD 02, Puerto Rico Vertical Datum of 2002]

Stage of water-surface profile (ft)	Water-surface elevation (ft above PRVD 02)		Difference (ft)
	Target	Modeled	
10	626.40	625.89	−0.50
12	628.40	628.18	−0.21
14	630.40	630.59	0.20
16	632.40	632.57	0.18
18	634.40	634.52	0.13
20	636.40	636.44	0.05
22	638.40	638.37	−0.02
24	640.40	640.40	0.01
26	642.40	642.42	0.03
28	644.40	644.42	0.03
30	646.40	646.33	−0.06
32	648.40	648.25	−0.14
34	650.40	650.48	0.09
36	652.40	652.48	0.09
38	654.40	654.44	0.05
40	656.40	656.33	−0.06

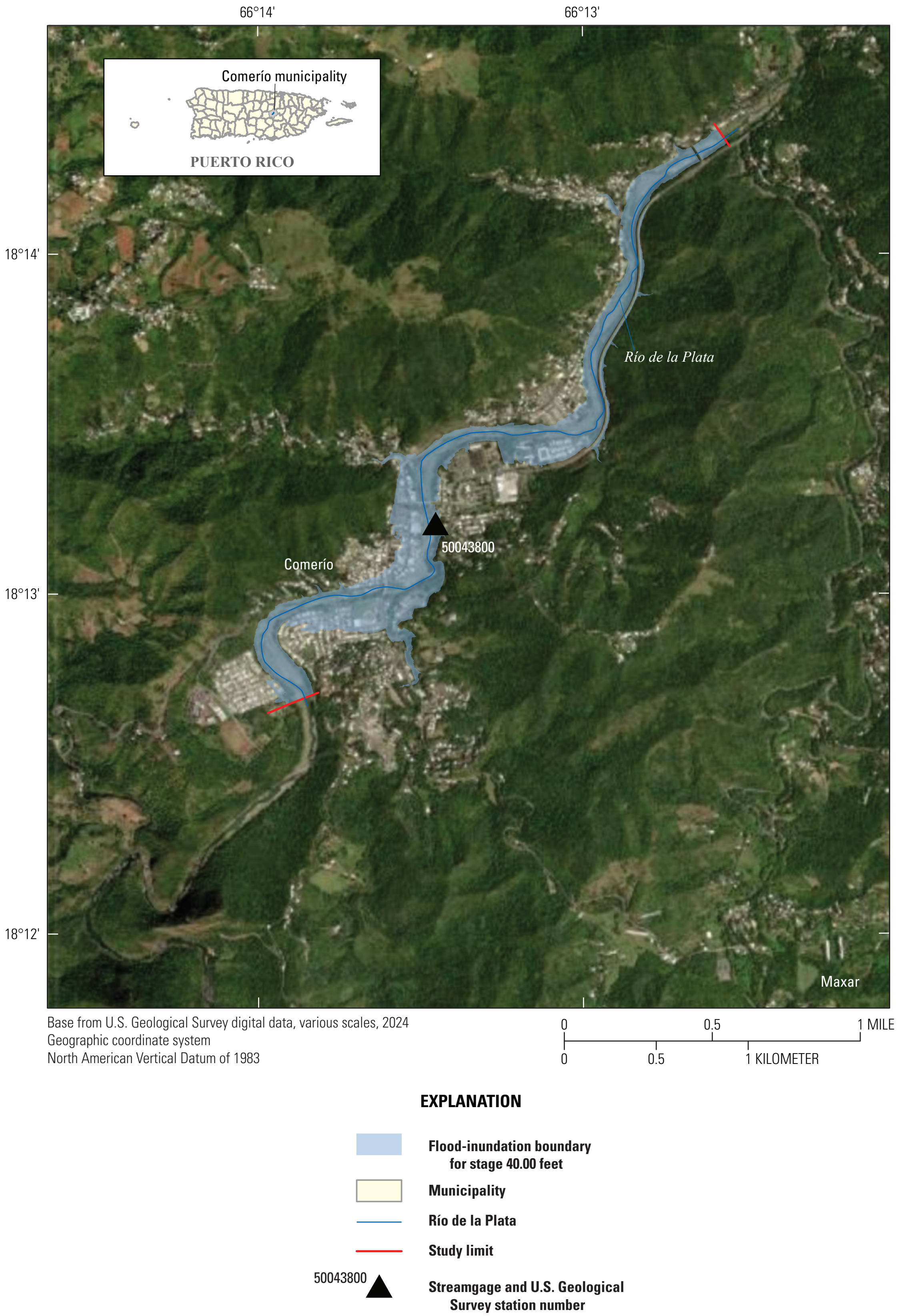

Figure 3. Map showing the floodplain boundary for stage 40.00 feet at the U.S. Geological Survey streamgage 50043800, Río de la Plata at Comerío, Puerto Rico, overlain on orthorectified imagery.

Data Dissemination

All data used in the creation of the flood-inundation boundaries are available in a companion USGS data release (Ostheimer, 2025). The data release includes flood inundation polygons and depth grids for each 2-ft increment of stage and the HEC–RAS model containing all input and output files involved with the hydraulic simulation.

The USGS Flood Inundation Mapper website (https://fim.wim.usgs.gov/fim/) (USGS, 2025b) was established to make USGS flood-inundation study information available to the public. The website is a mapping application that has collections of maps that provide detailed information on flood areas and depths for modeled sites. The website makes readily available to the public customized flood-inundation maps for the Comerío streamgage, along with the current stage and streamflow, as well as forecasted stage. A link is provided on the website to connect users to the USGS National Water Information System (USGS, 2025e), the source of the current and historical water level and streamflow information. A second link connects to the NWS National Water Prediction Service site (NWS, 2025b), where users could obtain additional information on forecasted peak stages if the NWS adds forecasting at the Comerío streamgage site in the future. The estimated flood-inundation maps have sufficient detail to allow for accurate preparation and decision-making by emergency response teams. Depending on the flood magnitude, roadways are shown as shaded (inundated and likely impassable) or not shaded (dry and passable) to facilitate emergency planning. Buildings are shaded where ground surfaces near the building are inundated (this should not be interpreted to mean that the structure is completely submerged). In these instances, the water depth (as indicated in the mapping application by clicking on an inundated area) near the building is an estimate of the water level inside the structure, if no flood-proofing measures have been implemented.

Uncertainties and Limitations of Flood-Inundation Maps

Although the flood-inundation maps represent the boundaries of floods with a distinct area, some uncertainty is associated with these maps. The flood boundaries shown were estimated on the basis of water stages and streamflows at selected the USGS streamgage. Water-surface elevations along the stream reach were estimated by steady-state hydraulic modeling, assuming unobstructed flow, and used streamflows and hydrologic conditions anticipated at the USGS streamgages. The hydraulic model reflects the land-cover and land-use characteristics and any bridge, dam, levee, or other hydraulic structures existing as of February 2025. Unique meteorological factors (such as timing and distribution of precipitation) may cause actual streamflows along the modeled reach to be different from those assumed during a flood, which may lead to deviations from the water-surface elevations and inundation boundaries shown here and in the datasets. Additional areas may be flooded because of unanticipated conditions such as changes in the streambed elevation or roughness, backwater into major tributaries along a main stem river, or backwater from localized debris or ice jams. The accuracy of the floodwater area portrayed on these maps will vary with the accuracy of the DEM used to simulate the land surface.

If this series of flood-inundation maps will be used in conjunction with NWS river forecasts, there may be additional uncertainties. The NWS uses forecast models to estimate the quantity and timing of water flowing through selected stream reaches in the United States. These forecast models (1) estimate the amount of runoff generated by precipitation and snowmelt, (2) simulate the movement of floodwater as it proceeds downstream, and (3) predict the flow and stage (and water-surface elevation) for the stream at a given location (National Water Prediction Service forecast point) throughout the forecast period (every 6 hours for the upcoming 3 to 5 days in many locations). For more information on National Water Prediction Service forecasts, please see https://water.noaa.gov.

At the Comerío streamgage, floodplain boundaries for flows above 13,000 ft^3/s have greater uncertainty than the boundaries associated with lower flows because no direct streamflow measurements have been made above 13,000 ft^3/s (stage 15.39 ft). The current rating curve (11.0) for the Comerío streamgage extends to 133,000 ft^3/s (stage 40.74 ft), and the highest modeled discharge is 127,000 ft^3/s (stage 40.00 ft). Although the model is expected to produce reasonable results for the full range of project discharge estimates, results for flows above 13,000 ft^3/s could not be verified with stage-discharge data available as of May 2025.

Summary

The U.S. Geological Survey (USGS) developed a series of 16 digital flood-inundation maps for a 3.1-mile reach of Río de la Plata in and near Comerío, Puerto Rico. The maps were calibrated to the USGS streamgage 50043800, Río de la Plata at Comerío, Puerto Rico. The U.S. Army Corps of Engineers' Hydrologic Engineering Center's River Analysis System (HEC–RAS) and RAS Mapper programs were used to compute water-surface profiles and to delineate estimated flood-inundation areas and depths of flooding in 2-foot (ft) increments for stages from 10.00 ft to 40.00 ft. The 40.00-ft stage exceeds the stage of 34.86 ft from Hurricane Maria recorded at the USGS streamgage 50043800, Río de la Plata at Comerío, Puerto Rico. The HEC–RAS hydraulic model was calibrated to the current stage-streamflow relation (rating curve 11.0) at the Comerío streamgage. The model was used to compute 16 water-surface profiles for flood stages from

"action stage" to above "major flood stage," as reported by the National Weather Service. The computed water-surface profiles were then used in combination with a digital elevation model, derived from light detection and ranging (lidar) data, to delineate estimated flood-inundation areas and flood depth grids. The flood maps are available through a mapping application that can be accessed on the USGS Flood Inundation Mapper website (https://fim.wim.usgs.gov/fim/).

The maps on this interactive mapping application can give users an indication of depth of water at any point in the study area by using the mouse cursor to click within the shaded areas. These maps, in conjunction with the real-time stage data from the USGS streamgages and (potentially available in the future) forecasted flood stage data from the National Weather Service's National Water Prediction Service, can help emergency planners and the public make more informed decisions about flood risk.

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