

Levee Analysis and Mapping Plan Portugués and Bucaná Rivers Project

Municipality of Ponce, Puerto Rico

May 2020



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Acronyms

44 CFR 65.10	Title 44, Chapter 1, Section 65.10 of the Code of Federal Regulations
BFE	Base Flood Elevation
CERC	Community Engagement and Risk Communication
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
HEC-HMS	Hydrologic Engineering Center Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center River Analysis System
LAMP	Levee Analysis and Mapping Procedures
LLPT	Local Levee Partnership Team
LOMR	Letter of Map Revision
NFIP	National Flood Insurance Program
NLD	National Levee Database
NOAA	National Oceanic and Atmospheric Administration
SCS	Soil Conservation Service
SFHA	Special Flood Hazard Area
STARR II	Strategic Alliance for Risk Reduction
USACE	U.S. Army Corps of Engineers

Definitions

The terms below have been used in this document. Additional terms are provided in FEMA's *Guidance for Flood Risk Analysis and Mapping, Levees* (February 2019) in the Glossary. This guidance document is available from the FEMA Library at https://www.fema.gov/media-library-data/1556726741363-2334a11b0de5b35a1e3210353c06148f/Levee_Guidance_Feb_2019.pdf.

Base Flood Elevation (BFE)** – Elevation of a flood having a 1-percent chance of being equaled or exceeded in any given year. Also referred to as the elevation of the 100-year flood. This elevation is the basis for the insurance and floodplain management requirements of the NFIP.

Levee Reach Analysis and Mapping Procedures* – Levee Analysis and Mapping Procedures include Sound Reach, Freeboard Deficient, Overtopping Analysis, Structural-Based Inundation, and Natural Valley. Details on these approaches can be found in FEMA's *Guidance for Flood Risk Analysis and Mapping, Levees* (February 2019).

Leveed Area – A spatial feature in the [National Levee Database](#) defined by the lands from which floodwater is excluded by the levee system.

Levee Reach* – A portion of a levee system (usually a length of a levee) that may be considered for analysis purposes to have approximately uniform representative properties.

Levee System* – A flood hazard-reduction system that consists of one or more levee segments/reaches and other features, such as floodwalls and pump stations, which are interconnected and necessary to ensure exclusion of the design flood from the associated hydraulically independent levee-impacted area, and which are constructed and operated in accordance with sound engineering practices.

Local Levee Partnership Team (LLPT)* – A workgroup that is facilitated by FEMA when a levee system will be analyzed by levee analysis and mapping procedures for non-accredited levees. The primary function of this group is to share information/data and identify options based on stakeholder roles and knowledge.

National Levee Database (NLD)* – The NLD, developed by the United States Army Corps of Engineers (USACE) in cooperation with FEMA, is a dynamic, searchable inventory of information for all levee systems in the Nation. The database contains information to facilitate and link activities, such as flood risk communication, levee system evaluation for the NFIP, levee system inspections, floodplain management, and risk assessments. The NLD continues to be a dynamic database with ongoing efforts to add levee data from Federal agencies, States, and Tribes.

Non-Accredited Levee System* – A levee system that does not meet the requirements in the NFIP regulations at Title 44, Chapter 1, Section 65.10 of the Code of Federal Regulations (44 CFR 65.10), Mapping of Areas Protected by Levee Systems, and is not shown on a FIRM as reducing the base flood hazards.

Zone A** – The Special Flood Hazard Area (except coastal V Zones) shown on a community's Flood Insurance Rate Map where no base flood elevation is provided.

Zone D** – Area of undetermined but possible flood hazard.

*Term description from FEMA's *Guidance for Flood Risk Analysis and Mapping, Levees* (February 2019).

**Term description from FEMA's Floodplain Glossary (https://www.fema.gov/pdf/floodplain/nfip_sg_appendix_d.pdf).

Executive Summary

The Federal Emergency Management Agency's (FEMA's) Flood Insurance Study (FIS) report and Flood Insurance Rate Map (FIRM) for the Municipality of Ponce, Puerto Rico show the Upper Bucaná Debris Basin and Bayagán North Levee Systems, which are part of the Portugués and Bucaná Rivers Project, as reducing the hazard from the 1-percent-annual-chance flood. The Bucaná East, Portugués and Bucaná, Portugués West, and Portugués North Tieback Levee Systems, which are also part of the Portugués and Bucaná Rivers Project, are not shown as providing a reduced hazard from the 1-percent-annual-chance flood. For the levee systems that do show reduced flood risk, to maintain this depiction of flood risk on the future FIRM, certified data must be provided to FEMA to show that the levee systems meet the minimum requirements of Title 44, Chapter 1, Section 65.10 of the Code of Federal Regulations (44 CFR 65.10), and FEMA must deem the data complete. As of the date of this levee plan, FEMA has received no data in support of 44 CFR 65.10; therefore, the levee systems would be considered non-accredited in a future remapping effort.

FEMA's guidance was revised in 2013 to incorporate new Levee Analysis and Mapping Procedures for non-accredited levees. This guidance provides a suite of flexible procedures to perform flood hazard analysis and mapping for non-accredited levee systems (see Section 1 of this report). FEMA Region II has initiated a Levee Discovery project to apply the Levee Analysis and Mapping Procedures (see Section 2) to the Bucaná East, Portugués and Bucaná, Portugués West, Upper Bucaná Debris Basin, Bayagán North, and Portugués North Tieback Levee Systems.

In June 2019, FEMA Region II partnered with stakeholders representing Puerto Rico's Municipality of Ponce to form a collaborative Local Levee Partnership Team (LLPT) and worked to determine potential Levee Analysis and Mapping Procedures that would apply to the Bucaná East, Portugués and Bucaná, Portugués West, Upper Bucaná Debris Basin, Bayagán North, and Portugués North Tieback Levee Systems (see Sections 3 and 4 respectively). The process involved collecting and evaluating available data, creating and evaluating an initial data analysis (see Section 5), and detailed discussions on mapping needs.

This levee plan summarizes the information gained through the extensive coordination and collaboration of the LLPT and through the initial data analysis. This plan also outlines potential reach analysis procedures and options for future mapping of the flood hazards within the areas affected by the Bucaná East, Portugués and Bucaná, Portugués West, Upper Bucaná Debris Basin, Bayagán North, and Portugués North Tieback Levee Systems in the Municipality of Ponce (see Section 6).

Representatives of the Municipality of Ponce expressed interest in pursuing accreditation of the Bucaná East, Portugués and Bucaná, Portugués West, Upper Bucaná Debris Basin, Bayagán North, and Portugués North Tieback Levee Systems to show the levee systems on a future FIRM as reducing flood risk. Risk mapping for accredited levee systems would reflect the interior drainage flooding on the landward side of the levee systems. If the levee systems are considered non-accredited, future FIRMs would depict much of the leveed area as a Zone AE Special Flood Hazard Area (SFHA).

1 Introduction

FEMA; its Production and Technical Services provider, Strategic Alliance for Risk Reduction II (STARR II); and its Community Engagement and Risk Communication (CERC) provider, Resilience Action Partners, initiated the Levee Analysis and Mapping Procedures process for non-accredited levees in the Municipality of Ponce. In addition to leveraging recent technological advances in data collection methods and hydrologic and hydraulic modeling, this process also:

- Leverages local knowledge and data, with proactive stakeholder engagement in LLPTs;
- Aligns available resources for engineering analyses and mapping commensurate with the level of risk in leveed areas; and
- Considers the unique characteristics of each levee system from an engineering perspective.

The levee systems in the Municipality of Ponce are not all currently accredited. FEMA is using the Levee Analysis and Mapping Procedures process to develop more refined flood hazard mapping in areas landward of the levees. Updated regulatory flood hazard mapping is not anticipated in this community for a number of years, so this effort is intended to provide a more realistic representation of levee-related flood hazards in the Municipality of Ponce for community officials and emergency managers to use in development and preparedness planning.

The Levee Analysis and Mapping Procedures process is conducted in four phases:

- **Phase 0: Flood Structure Identification and Review:** Levee systems are identified and verified as being constructed, operated, and maintained as flood risk reduction structures. An LLPT is established during this phase.
- **Phase 1: Analysis and Mapping Plan Preparation:** LLPT meetings are held periodically to review available data and documentation. Discussions assist in the preparation of an Analysis and Mapping Plan based on the available information.
- **Phase 2: Analysis Preparation and Results Review (if applicable):** Analysis is performed by FEMA and shared with the LLPT to validate results against available data and documentation. Results are compared to effective FISs to update the Levee Analysis and Mapping Plan, if necessary. Draft maps prepared at this stage may be used as best available data for floodplain management.
- **Phase 3: FIRM Update, Due Process and Effective FIRM Issuance:** FIRM panels are updated with Phase 2 results. Communities and FEMA follow all National Flood Insurance Program (NFIP) regulatory due process procedures, and updated FIRM panels are adopted as the regulatory basis for local floodplain management.

This levee plan is the result of the collaboration between FEMA, representatives from Puerto Rico including the Puerto Rico Department of Natural and Environmental Resources and the Puerto Rico Emergency Management Agency, the U.S. Army Corps of Engineers (USACE), and other stakeholders. The plan summarizes the stakeholder coordination, initial data analysis, and options to depict the flood hazard associated with the levee system on a future FIRM.

The Bucaná East, Portugués and Bucaná, Portugués West, Upper Bucaná Debris Basin, Bayagán North, and Portugués North Tieback Levee Systems in Ponce would be considered non-accredited in

a future remapping effort unless information is provided to support the accreditation of the levee system. FEMA is using the Levee Analysis and Mapping Procedures for non-accredited levees process to develop more refined flood hazard mapping in the levee-impacted areas.

2 Levee System Description

2.1 Flood Damage Reduction Project in the Municipality of Ponce

The Bucaná East, Portugués and Bucaná, Portugués West, Upper Bucaná Debris Basin, Bayagán North, and Portugués North Tieback Levee Systems were designed and constructed by the USACE as part of the Portugués and Bucaná Rivers Project to reduce flood risk within the Municipality of Ponce. Upon completion in 2013, the project was turned over to the local sponsor, the Puerto Rico Department of Natural and Environmental Resources. The Bucaná East Levee System extends along the left banks of the Bucaná and Cerrillos Rivers, from the mouth of the Bucaná River to 1,250 meters (4,100 feet) downstream of PR-5139. The Portugués and Bucaná Levee System begins just upstream of PR-504, along the left bank of the Chiquito River, then follows the left bank of the Portugués River and the right bank of the Bucaná River, and terminates along the right bank of Bayagán River, just upstream of Avenue Principal. The Portugués West Levee System extends from the mouth of the right bank of the Bucaná River to 1,100 meters (3,600 feet) upstream of PR-10, along the right bank of the Portugués River. The Upper Bucaná Debris Basin Levee System consists of two smaller tieback segments along the right bank of the Cerrillos River before the confluence with the Bayagán River. The Bayagán North Levee System extends from 50 meters (160 feet) to 320 meters (1,050 feet) upstream of Avenue Principal along the left bank of the Bayagán River. The Portugués North Tieback Levee system extends from PR-504 along the right bank of the Chiquito River to the left bank of the Portugués River, 1,000 meters (3,280 feet) upstream of its confluence with the Chiquito River. These systems are shown in Figures 1, 2, 3, 4, 5, and 6. Surveyed elevation data from the USACE National Levee Database (NLD) was available to inform the analysis of the Bucaná East, Portugués and Bucaná, Portugués West, Upper Bucaná Debris Basin, Bayagán North, and Portugués North Tieback Levee Systems. Survey locations containing elevation data are presented as survey points in Figure 1 through Figure 6.

The Bucaná East Levee System extends for 9.54 kilometers (5.93 miles). The Portugués and Bucaná Levee System extends for 12.4 kilometers (7.73 miles). The Portugués West Levee System extends for 8.06 kilometers (5.01 miles). The Upper Bucaná Debris Basin Levee System extends for 0.50 kilometers (0.31 miles). The Bayagán North Levee System extends for 0.27 kilometers (0.17 miles). The Portugués North Tieback Levee System extends for 1.3 kilometers (0.83 miles). All levee systems are of earthen construction and currently “inactive” in the USACE Rehabilitation Program; if damaged by flood these levee systems will be unable to receive assistance from USACE to restore these levee systems to their previous conditions.



Figure 1: Bucaná East Levee System Location

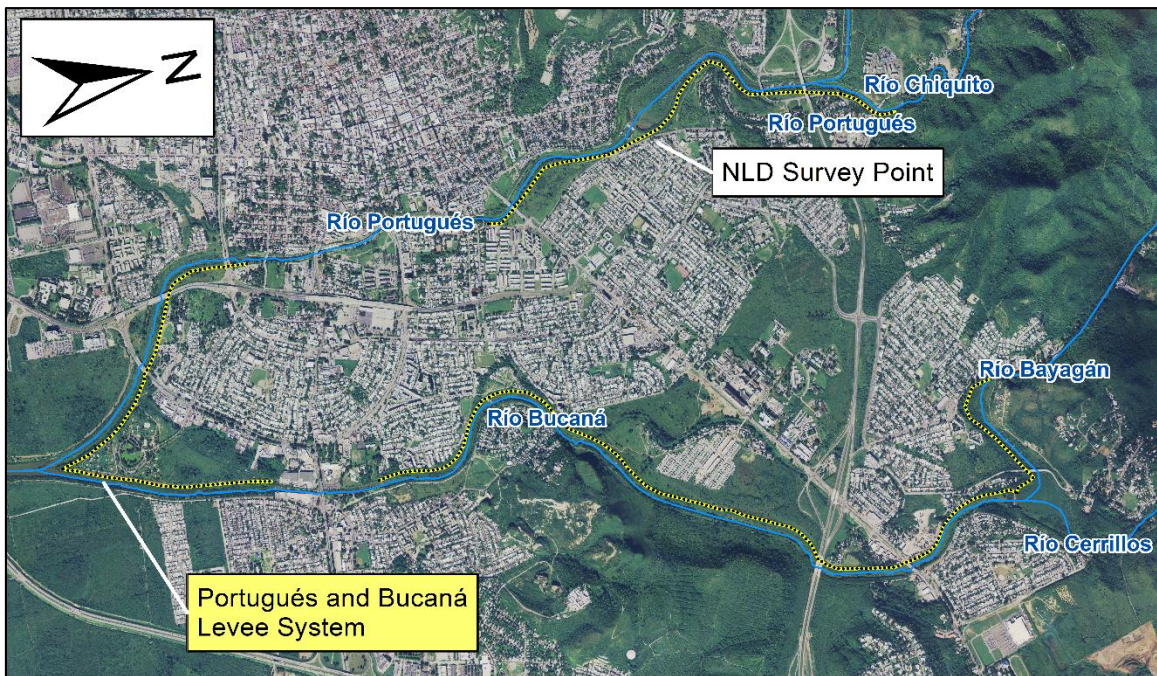


Figure 2: Portugués and Bucaná Levee System Location

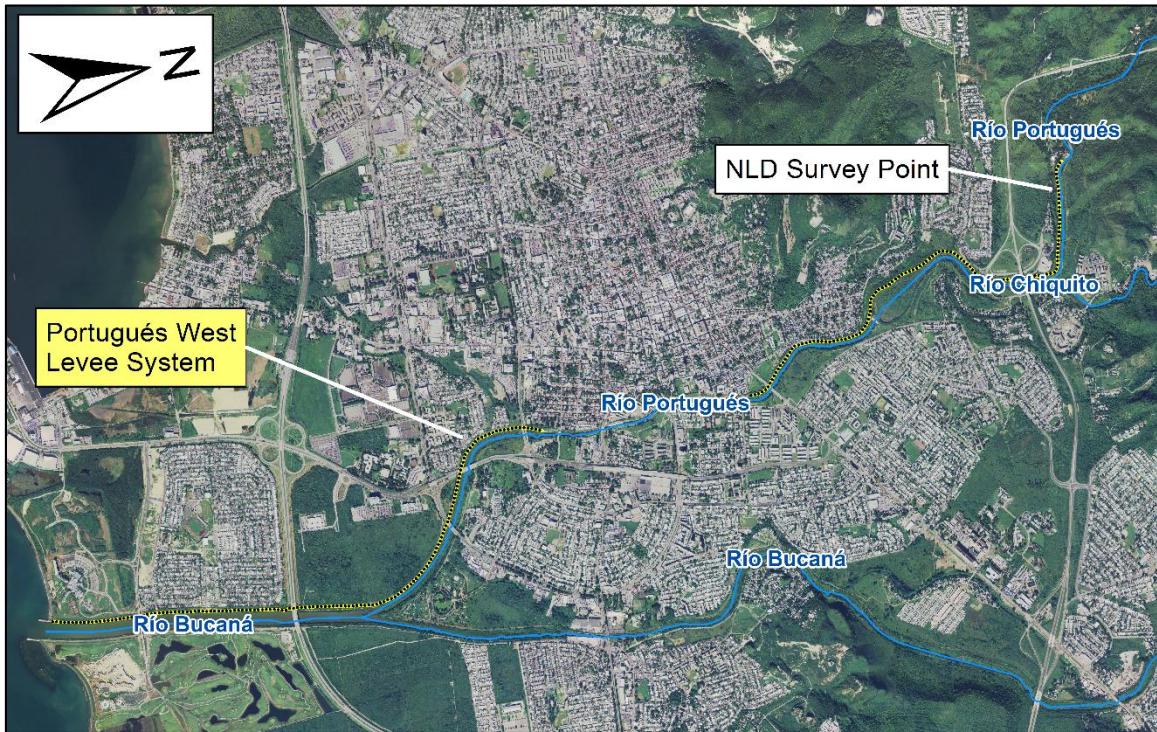


Figure 3: Portugués West Levee System Location

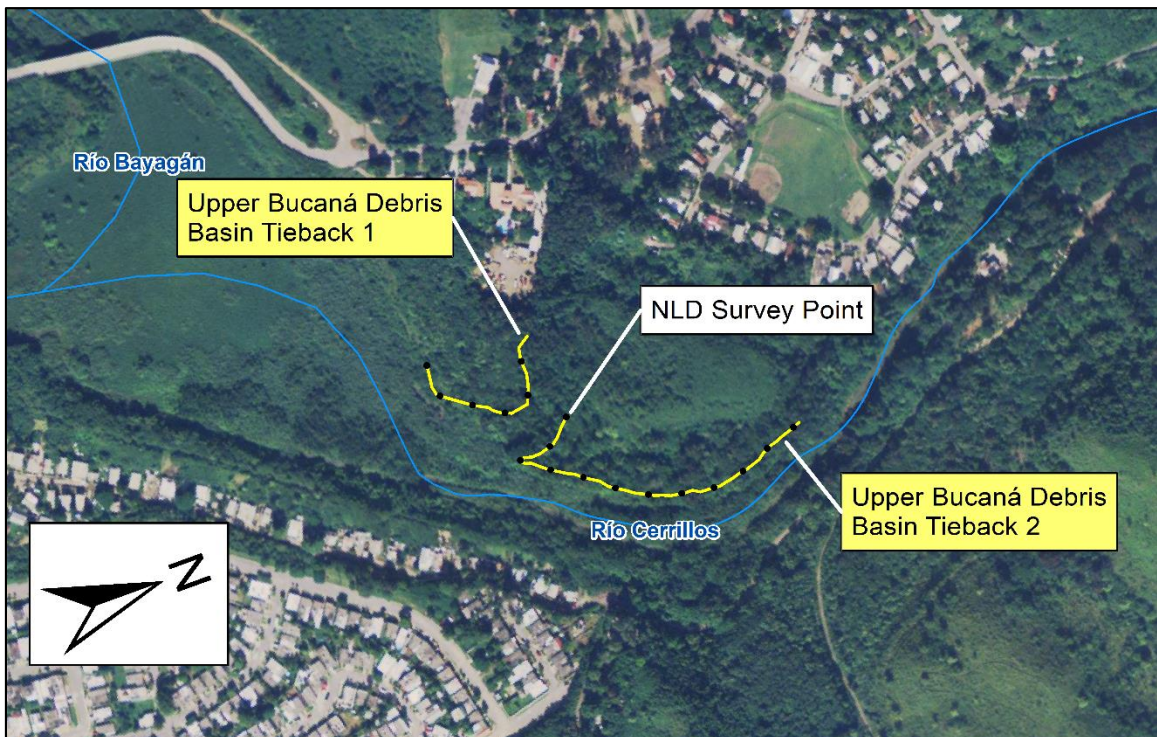


Figure 4: Upper Bucaná Debris Basin Levee System Location

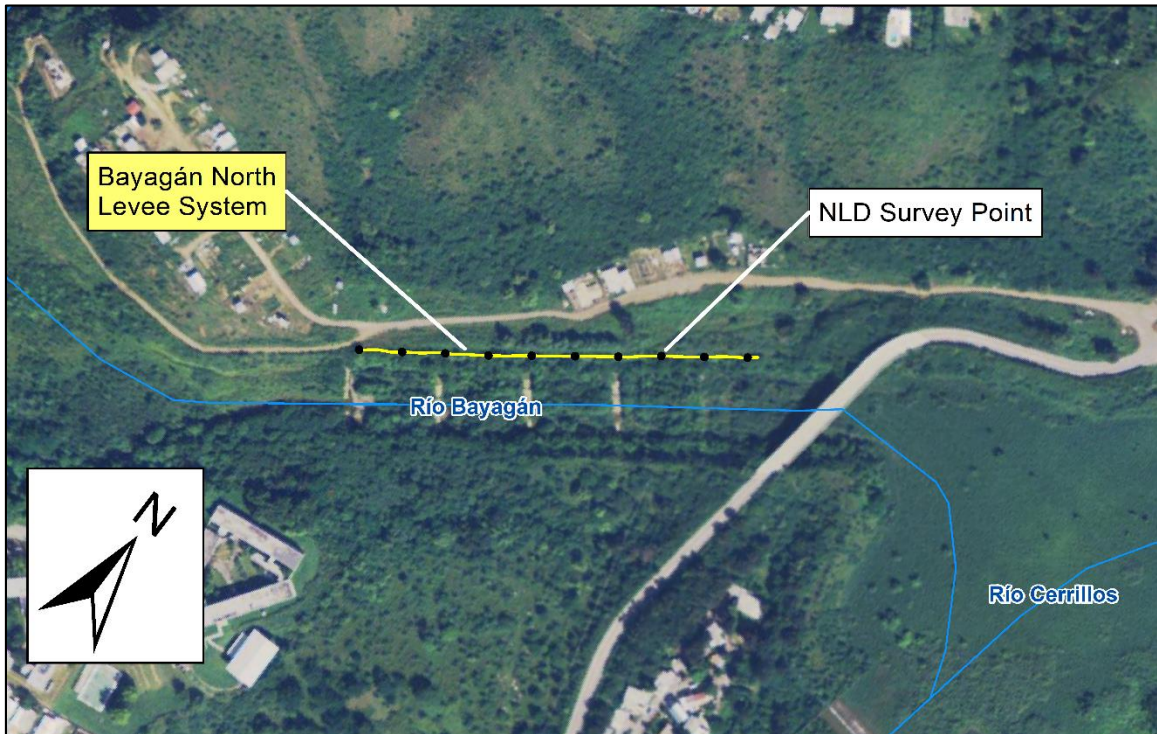


Figure 5: Bayagán North Levee System Location

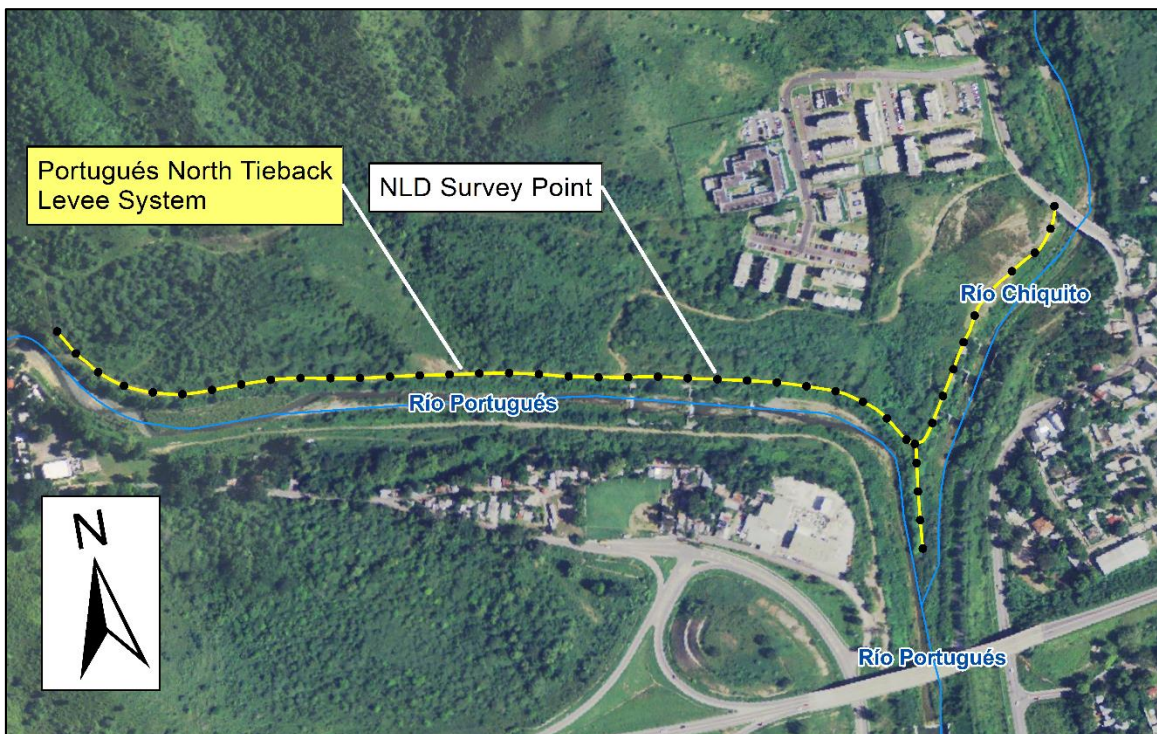


Figure 6: Portugués North Tieback Levee System

2.2 Community NFIP and FIRM History

Table 1 and Table 2 summarize the communities' NFIP and FIRM history.

Table 1. Summary of Project Area

County	Community	Participating in the NFIP?	Estimated Number of Potentially Impacted Structures in Levee-impacted Area ¹
Municipality of Ponce	Municipality of Ponce	Yes	25,600

Table 2. Community Map History

Community Name	Initial Identification	Flood Hazard Boundary Map Revision Date(s)	FIRM Effective Date	FIRM Revision Date(s)
Municipality of Ponce	August 1, 1978	July 19, 1982 August 3, 1992 June 2, 1999	April 19, 2005	November 18, 2009

On the effective FIRM for the Municipality of Ponce, the Upper Bucaná Debris Basin and Bayagán North Levee Systems are shown as reducing the hazard of the 1-percent-annual-chance flood. The Bucaná East, Portugués and Bucaná, Portugués West, and Portugués North Tieback Levee Systems are not shown on the effective FIRM as providing flood hazard reduction for the 1-percent-annual-chance flood.

2.3 Levee Analysis and Mapping Procedures Process Tasks

The Levee Analysis and Mapping Procedures (LAMP) process is divided into seven distinct tasks: LLPT Compilation, Field Reconnaissance, Initial Outreach, Initial Levee Analysis, Flood Risk Outreach, Complete Levee Analysis and Mapping Procedures, and Produce/Issue Preliminary Products (see Table 3).

¹ See Table 5 for additional information regarding potentially impacted structures.

Table 3. Project Tasks

Task	Details	Tentative Start/ End Dates*
LLPT Compilation (Phase 0)	Identification and outreach to individuals to serve on the LLPT.	4/1/2019 – 5/31/2019
Field Reconnaissance (Phase 1)	LLPT to determine levee reaches to study and potential analysis of those reaches. Perform field reconnaissance of these reaches.	6/3/2019- 6/7/2019
Initial Outreach (Phase 1)	LLPT convenes and discusses known flooding history and knowledge about the levees to be studied.	6/7/2019
Perform Initial Levee Analysis and develop Levee Analysis and Mapping Procedures (Phase 1)	FEMA to collaborate with the LLPT to develop analysis based on Field Reconnaissance findings and Levee Analysis and Mapping Plan.	2/1/2019 - 7/31/2019
Flood Risk Outreach (Phase 2)	FEMA presents initial Levee Analysis results to LLPT for their assessment. LLPT to work at local level to disseminate findings that could impact local communities. Determine expectations and delivery of LAMP Plan.	10/30/2019
Complete Levee Analysis and Mapping Procedures; Finalize LAMP mapping (Phase 2)	FEMA to complete detailed analysis based on chosen approach, develop mapping, and finalize Levee Analysis and Mapping Procedures; develop final analysis and mapping. Delivery of LAMP Plan is done at this time.	TBD
Produce / Issue Preliminary Products (Phase 3)	FEMA to develop Preliminary Products (including FIRM database) from revised analysis above and issue if that is the direction from FEMA and LLPT.	TBD

*All schedules are tentative and will be adjusted at the pace of the LLPT.

3 Local Levee Partnership Team

The LLPT was formed to provide FEMA with data and input, in addition to feedback on the procedures to be used for analyzing and mapping the levee reach, based on local levee conditions. The stakeholders who participated in the LLPT for this project are listed in Table 4.

Table 4. LLPT Participants

LLPT Member	Contact Information
Luis R. López	Municipality of Ponce 787.460.2027, luis.lopez@ponce.pr.gov
Edgar Seda	Municipality of Ponce 787.259.2210, edgar.seda@ponce.pr.gov
Juan Sánchez	Municipality of Ponce

LLPT Member	Contact Information
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Matt Kroneberger	Resilience Action Partners 212.237.6373, matt.kroneberger@ogilvy.com

4 Stakeholder Engagement

4.1 LLPT Meeting 1

A FEMA-led project team engaged stakeholders for the Bucaná East, Portugués and Bucaná, Portugués West, Upper Bucaná Debris Basin, Bayagán North, and Portugués North Tieback Levee Systems at the first LLPT Meeting on June 7, 2019, held at the Ponce Servicios Building. The intent of the meeting was to establish contact, explain the Levee Analysis and Mapping Procedures process, and discuss the application of these procedures to the Bucaná East, Portugués and Bucaná, Portugués West, Upper Bucaná Debris Basin, Bayagán North, and Portugués North Tieback Levee Systems.

At the initial LLPT meeting (LLPT 1), representatives from FEMA provided an overview to the invited communities, answered questions concerning FEMA products, terminology, and procedures, and provided a timeline for the Levee Analysis and Mapping Procedures projects. FEMA explained in detail the five procedures outlined in the Levee Analysis and Mapping Procedures Final Approach Document and the major distinctions between Levee Analysis and Mapping Procedures and earlier levee analyses. FEMA and its contractors led a discussion about how each procedure applied to the levees.

Representatives from local stakeholders provided additional background on the affected levees and discussed USACE involvement in the construction and the current condition of the levee system. (See Appendix A for minutes for the LLPT 1.)

4.2 LLPT Meeting 2

At the next LLPT Meeting, held on October 30, 2019, participants reviewed the initial data analysis and discussed outcomes from the data collection process. During the meeting, the FEMA project team discussed the results of the initial data analysis for the Natural Valley and Structural-Based Inundation procedures. The results of the Levee Analysis and Mapping Procedures led to a discussion about de-accrediting the levee system and concerns about overgrowth of vegetation on the levee systems. Levee ownership and maintenance for the Bucaná East, Portugués and Bucaná, Portugués West, Upper Bucaná Debris Basin, Bayagán North, and Portugués North Tieback Levee Systems was also covered, to ensure the levee continues to reduce the community's flood hazards.

Appendix B provides additional details on LLPT Meeting 2, and Appendices C through F provide information from the data collection.

4.3 LLPT Meeting 3

LLPT Meeting 3 was held on June 9, 2020 to review the draft Levee Analysis and Mapping Procedures Plan with the LLPT before finalizing it.

5 Initial Data Analysis

STARR II developed an initial data analysis to approximate the inundation area of the 1-percent-annual-chance flood for each relevant Levee Analysis and Mapping Procedures approach. This informed the discussions in LLPT Meeting 2 and the touchpoint call prior to LLPT Meeting 3. Details

of the initial data analysis and application of reach analysis procedures are provided below. Appendix F provides supporting data.

5.1 Hydrologic Analysis

The 1-percent-annual-chance flow events for Ríos Bucaná, Portugués, Cerrillos, Bayagán, and Chiquito were calculated as part of the initial data analysis. To analyze the flow event, a USACE Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) rainfall-runoff model was developed for Ríos Bucaná, Portugués, Cerrillos, Bayagán, and Chiquito. National Oceanic and Atmospheric Administration (NOAA) Atlas 14-point precipitation frequency estimates were used to estimate the 24-hour, 1-percent-annual-chance rainfall depth for the Bucaná, Portugués, Cerrillos, Bayagán, and Chiquito watersheds, and frequency temporal distribution was used to define the 24-hour rain event. The Soil Conservation Service (SCS) Curve Number was used to estimate hydrologic losses, and a unit hydrograph procedure was applied to develop sub-basin hydrographs. The Muskingum-Cunge method was used for channel routing. Hydrographs at significant points of interest were extracted and used in the hydraulic model.

5.2 Reach Analysis

Topographic data (Proprietary 0.5-meter Light Detection and Ranging, 2019) and levee crest survey data from USACE National Levee Database (NLD), along with design documents, were reviewed to define the levee systems and establish reach boundaries for the initial data analysis. A levee reach is any continuous section of a levee system to which a single reach analysis procedure (Section 5.2 through 5.5) may be applied. For the initial data analysis, each levee system was considered a single reach.

Based on the review of the available levee crest data, no levee system appears to meet minimum freeboard requirements of 44 CFR 65.10, as shown in levee profile exhibit in Appendix C.

5.3 Natural Valley Procedure

The Natural Valley Procedure was modeled by developing geometry to represent the natural topography as if the levee was never built. The resulting floodplain is a representation of the natural extent of the floodplain, assuming no flood hazard reduction is provided by the levee system. An unsteady two-dimensional (2-D) flow simulation provide better depth/velocity information than a one-dimensional (1-D) steady flow analysis. Therefore, USACE Hydrologic Engineering Center River Analysis System (HEC-RAS) 5.0.7 software, which has 2-D flow analysis capability, was selected. A 2D HEC-RAS model was developed for the natural valley procedure. The 1-percent-annual-chance Natural Valley floodplain reflecting the levee-lowered scenario was developed using the HEC-RAS model of the floodplain in Ponce.

5.4 Structural-Based Inundation Procedure

For the Structural-Based Inundation Procedure, hypothetical breach analyses were completed at 12 independent locations along the levee reaches. Each breach was analyzed individually using HEC-RAS 5.0.7 (2-D, unsteady flow). The breach analyses were performed at four locations along the Portugués and Bucaná Levee System; at two locations along the Portugués Upper West, Portugués

North Tieback, and Bucaná East Levee Systems; and at one location on the Bayagán North and Upper Bucaná Debris Basin Levee Systems. The breach widths ranged from 140 feet to 400 feet. The breach locations were developed for analysis purposes only and are not intended to indicate historic or future breach development. All 1-percent-annual-chance inundation breach areas were composited to develop the final visual depiction of the Structural-Based Inundation Procedure results. Breach locations developed for this model are presented in Figure 7.

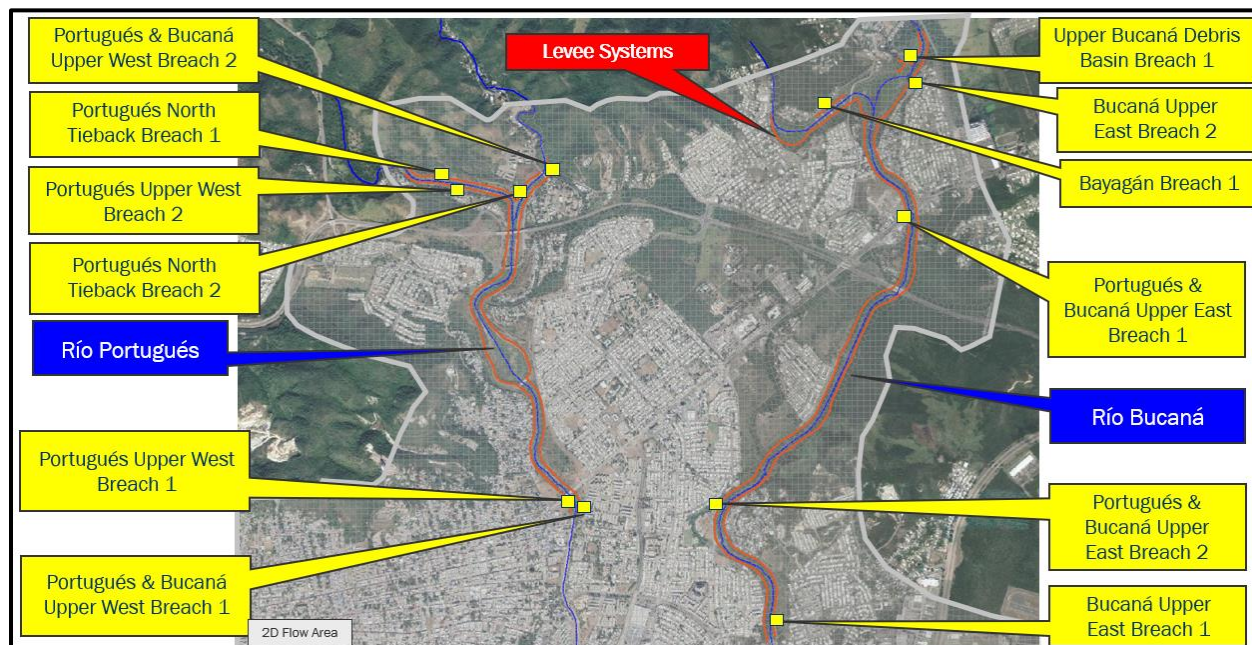


Figure 7: Breach Location Map

5.5 Freeboard Deficient Procedures

A Freeboard Deficient Reach is described as a reach that does not have enough freeboard to meet the freeboard standard outlined in 44 CFR 65.10. In the case of the Bucaná East, Portugués and Bucaná, Portugués West, Upper Bucaná Debris Basin, Bayagán North, and Portugués North Tieback Levee Systems, the currently available data does not show that the Freeboard Deficient Reach Procedure applies. Appendix C includes the levee profile exhibit.

5.6 Overtopping Procedure

An Overtopping Reach is described as a reach where the 1-percent-annual-chance flood event is above the levee crest and where it can be demonstrated that this event will not cause structural failure of the overtopped levee reach. In the case of the Bucaná East, Portugués and Bucaná, Portugués West, Upper Bucaná Debris Basin, Bayagán North, and Portugués North Tieback Levee Systems, the currently available data does not show that the Overtopping Reach Procedure applies.

5.7 Sound Reach Procedure

A Sound Reach is described as a reach that has been designed, constructed, and maintained to withstand the hazards posed by a 1-percent-annual-chance flood, in accordance with the standards in

44 CFR 65.10 of the NFIP regulations, but is part of a levee system that has not been accredited. In the case of the Bucaná East, Portugués and Bucaná, Portugués West, Upper Bucaná Debris Basin, Bayagán North, and Portugués North Tieback Levee Systems, the currently available data does not show that the Sound Reach Procedure applies.

5.8 Review of Initial Data Analyses

The effective FIRMs show the landside portion of the Portugués North Tieback, Bayagán North, and Bucaná Upper Debris Basin Levee Systems as unshaded Zone X. Landside portions of the Portugués West and Portugués & Bucaná Systems are mapped as unshaded Zone X, Zone AE, and Zone AO. Landside portions of the Bucaná East Levee System are mapped as unshaded Zone X and Zone AE.

The results of the Natural Valley procedure identify the potential flood risk if the levee systems were not providing flood hazard reduction during the base flood event. As described in Section 5.2 of this report, the inundation map represents the composite result of independent Natural Valley Procedures. Figure 8 illustrates the approximate inundation area for the 1-percent-annual-chance flood, using the Natural Valley Procedure within the levee-impacted areas. Figure 9 shows the approximate depth grid using the Natural Valley Procedure within the levee-impacted areas.

It should be noted that the development of the unsteady 2-D HEC-RAS hydraulic model to evaluate the reach analysis procedures was not informed by the model applied for the effective mapping analysis. Appendix F (DVD) provides additional information regarding the methodology used in the initial data analyses.

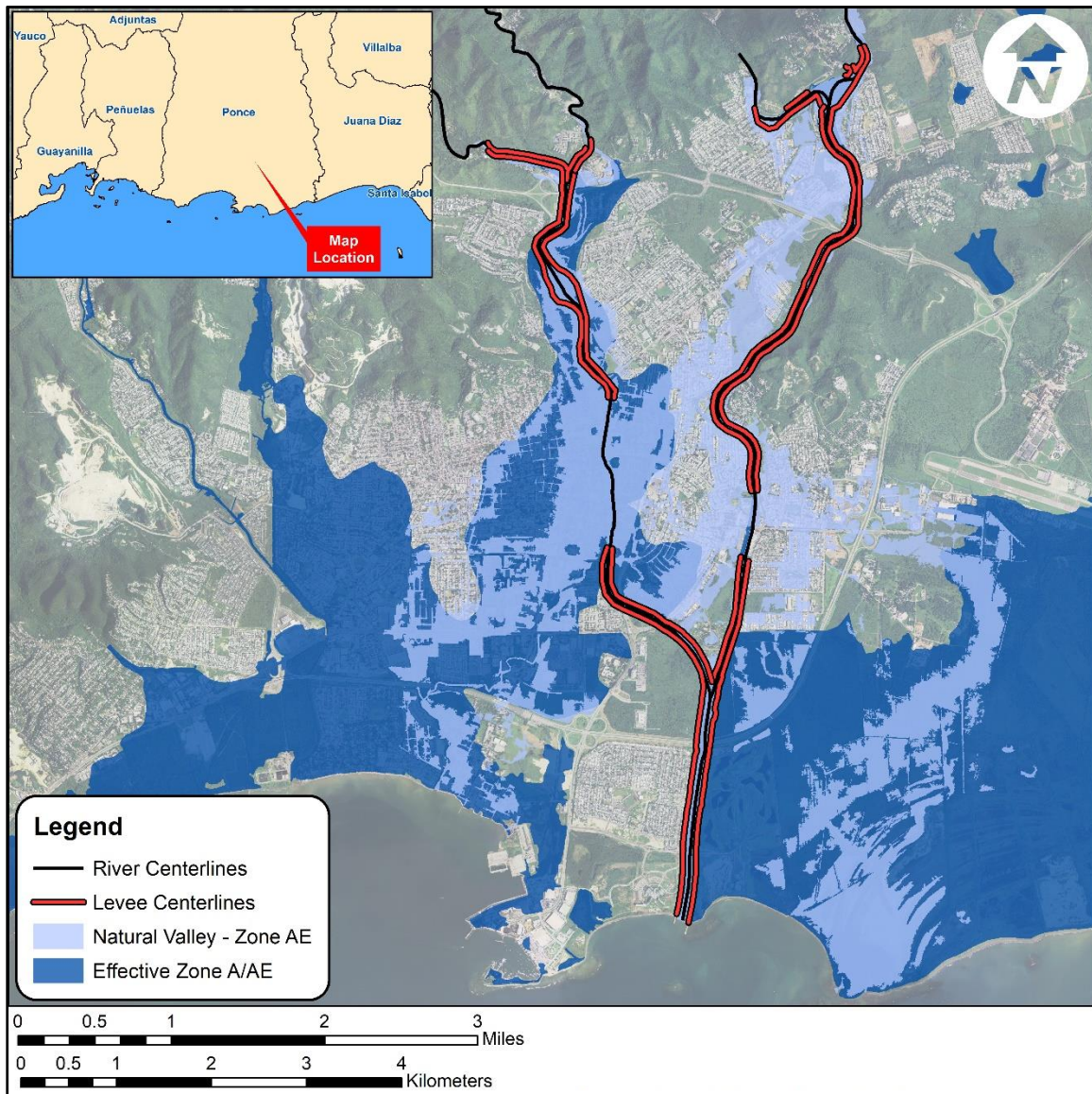


Figure 8: Natural Valley Procedure

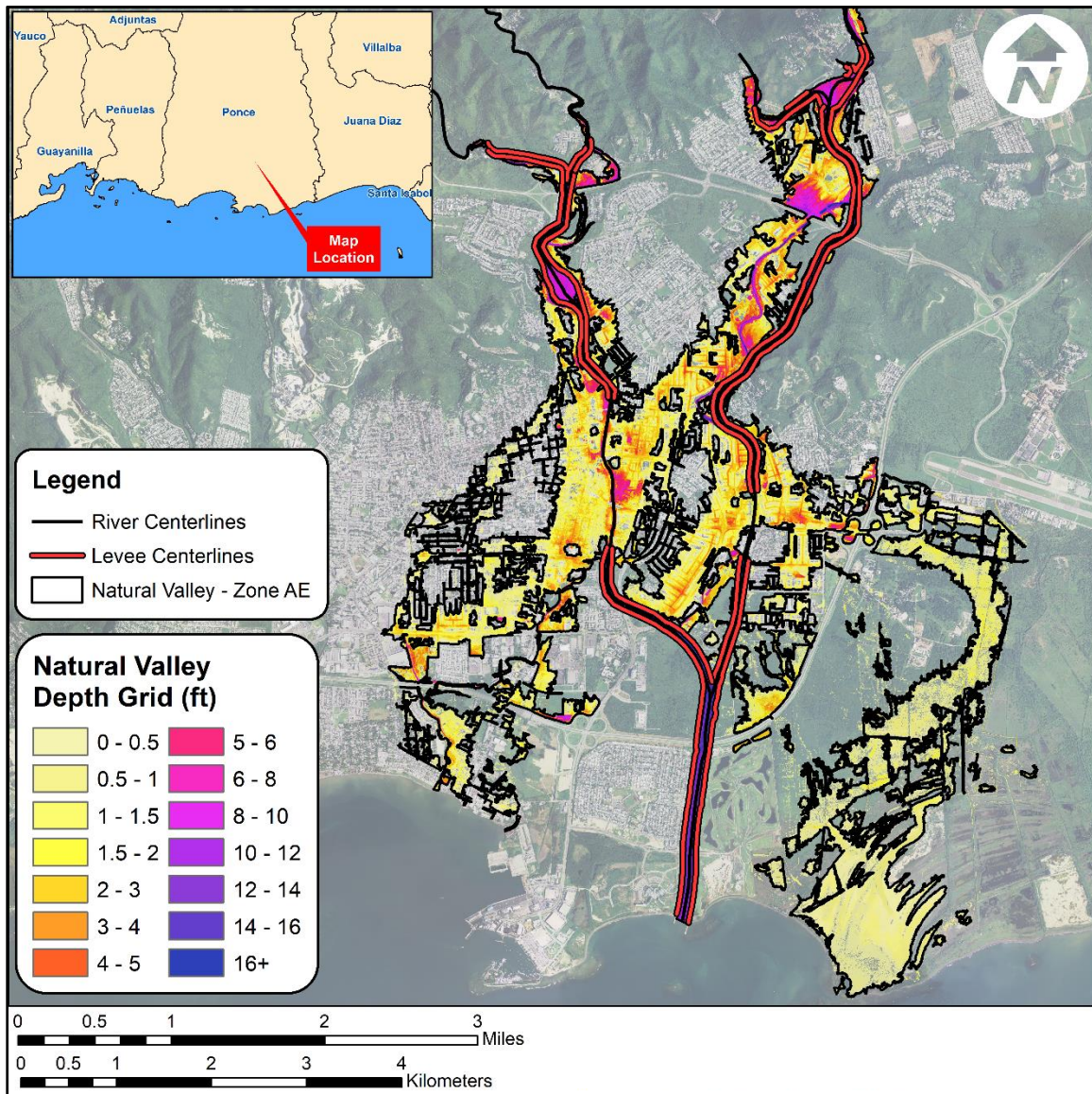


Figure 9: Natural Valley Procedure Flood Depth Grid

The composite results of the Structural-Based Inundation Procedure, shown in Figure 10 and Figure 11, yield an inundation area in the levee-impacted areas similar to that of the Natural Valley Procedure. The Structural-Based Inundation Procedure yielded a slightly decreased inundation area than the Natural Valley Procedure. Since there have been no historical breaches in any of the studied levee systems in the Portugués and Bucaná Rivers Project the Natural Valley Procedure would be used to map the levee flood hazard if incomplete or no additional data is provided for the levee systems.

Community officials and emergency managers can use the results of the Structural-Based Inundation Procedure to inform emergency action planning and outreach to residents living and working within the levee-impacted area. The Structural-Based Inundation Procedure is an important reminder that if

a breach of a levee system occurs, areas along or near a breach are potentially at increased risk to higher velocity flow and inundation, which could happen with little or no warning.

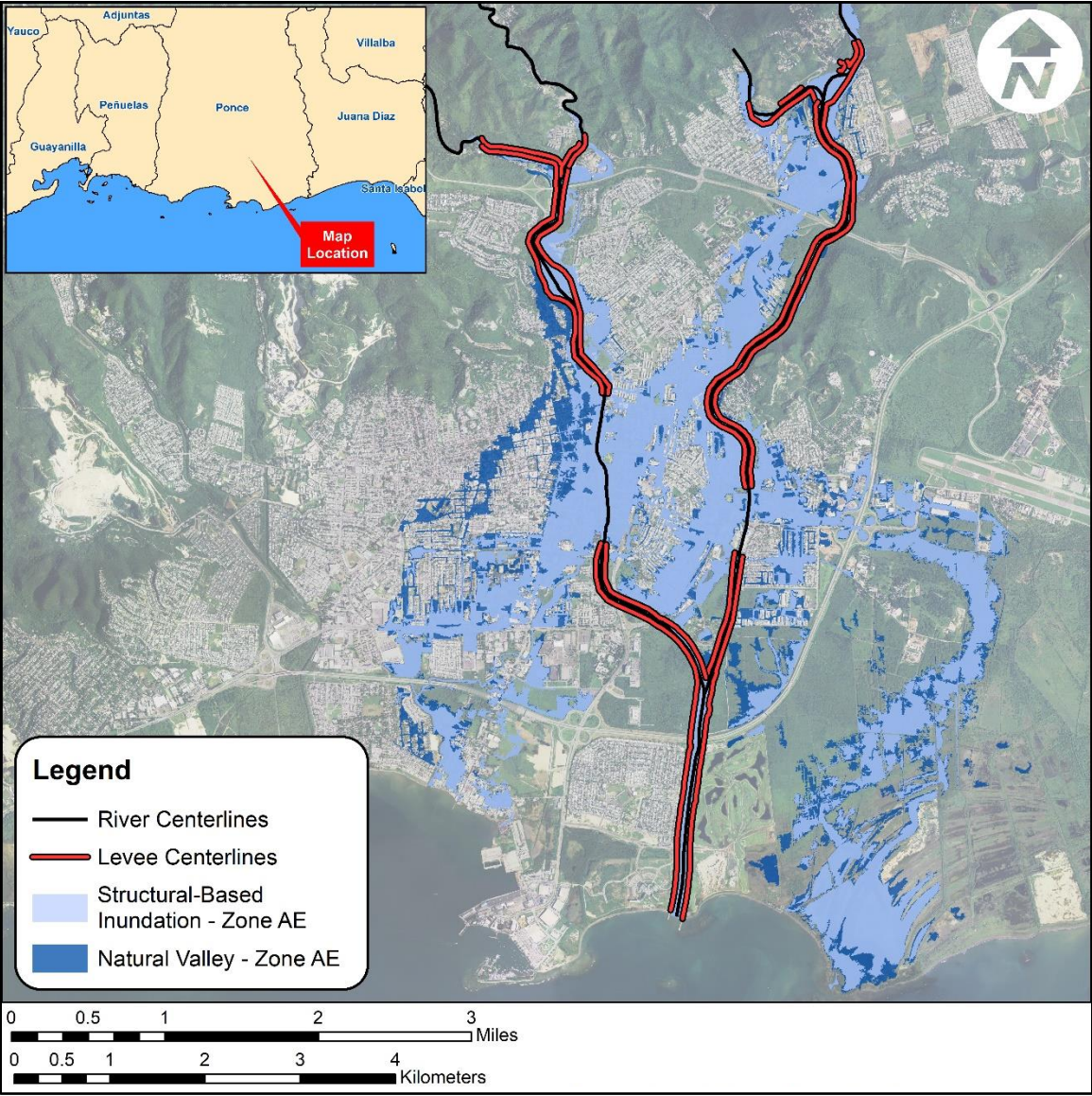


Figure 10: Structural-Based Inundation Procedure

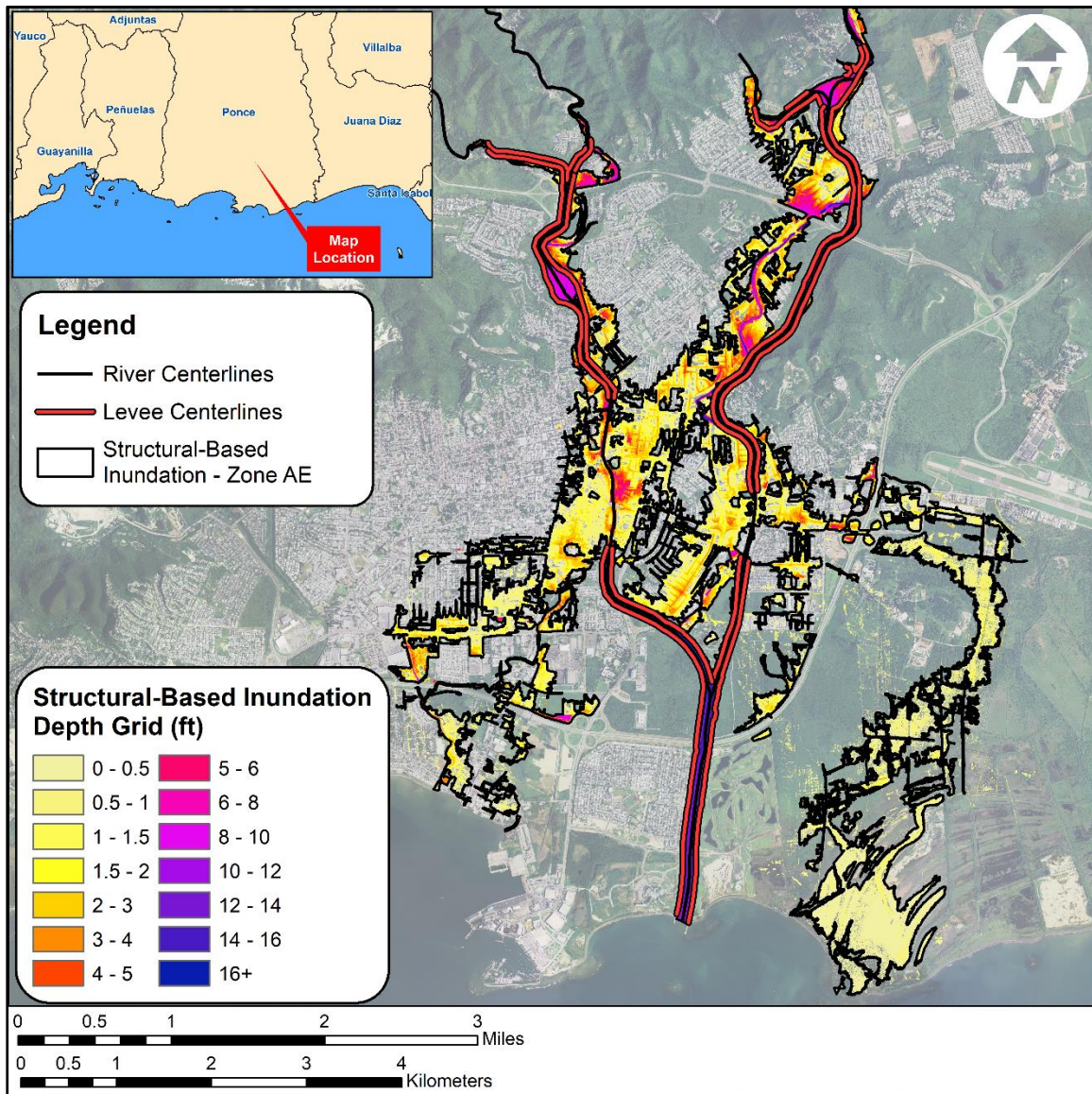


Figure 11: Structural-Based Inundation Procedure Flood Depth Grid

Table 5 includes a summary of the results obtained from the Initial Data Analysis.

Table 5. Results from the Initial Data Analysis

Reach	Approximate Length of Levee Segment	Comments: Natural Valley Procedure ³ (Figure 3)	Comments: Structural-Based Inundation Procedure ⁵ (Figure 5)
		<i>Approximate # Structures⁷ Impacted by Zone AE: Over 10,000</i>	<i>Approximate # Structures Impacted by Zone AE: Over 10,000</i>
Bucaná East	9.5 km (5.9 mi)	Results from updated hydraulic model (2D). Estimates potential inundation/levee-impacted area if not mapped as reducing flood hazard.	Inundation extents slightly smaller than the Natural Valley Procedure for the 1-percent-annual-chance flood. May be utilized for emergency planning.
Portugués West	8.1 km (5.0 mi)	Results from updated hydraulic model (2D). Estimates potential inundation/levee-impacted area if not mapped as reducing flood hazard.	Inundation extents slightly smaller than the Natural Valley Procedure for the 1-percent-annual-chance flood. May be utilized for emergency planning.
Portugués and Bucaná	12.4 km (7.7 mi)	Results from updated hydraulic model (2D). Estimates potential inundation/levee-impacted area if not mapped as reducing flood hazard.	Inundation extents slightly smaller than the Natural Valley Procedure for the 1-percent-annual-chance flood. May be utilized for emergency planning.
Portugués North Tieback	1,300 m (4,400 ft)	Results from updated hydraulic model (2D). Estimates potential inundation/levee-impacted area if not mapped as reducing flood hazard.	Inundation extents similar to the Natural Valley Procedure for the 1-percent-annual-chance flood. May be utilized for emergency planning.
Bayagán North	270 m (900 ft)	Results from updated hydraulic model (2D). Estimates potential inundation/levee-impacted area if not mapped as reducing flood hazard.	Inundation extents similar to the Natural Valley Procedure for the 1-percent-annual-chance flood. May be utilized for emergency planning.
Upper Bucaná Debris Basin	500 m (1,600 ft)	Results from updated hydraulic model (2D). Estimates potential inundation/levee-impacted area if not mapped as reducing flood hazard.	Inundation extents similar to the Natural Valley Procedure for the 1-percent-annual-chance flood. May be utilized for emergency planning.

³ Depicts levee reach as not reducing flood hazard. No additional data required to support future analysis or mapping.

⁴ Hypothetical levee breach analysis. No additional data required to support future analysis or mapping.

⁵ All minimum requirements of 44 CFR§65.10 are met. Certified data compliant with 44 CFR§65.10 required to support future analysis or mapping.

⁶ 44 CFR§65.10 data can be submitted at any time for any hydraulically independent levee system.

⁷ Approximate number of structures impacted estimated from aerial imagery.

6 Path Forward

6.1 Levee Analysis and Mapping Procedures

Currently, the Upper Bucaná Debris Basin and Bayagán North Levee Systems are shown as reducing the hazard from the 1-percent-annual-chance flood. The Bucaná East, Portugués and Bucaná, Portugués West, and Portugués North Tieback Levee Systems are not shown as providing a reduced hazard from the 1 percent-annual-chance flood. As FEMA has received no data in support of the 44 CFR 65.10 requirements for any of the levee systems in the levee project, all of the levee systems would be considered non-accredited in a future remapping effort.

FEMA engaged representatives from Puerto Rico throughout the process of applying the Levee Analysis and Mapping Procedures for non-accredited levees to help identify potential options to evaluate the flood hazard for the levee-impacted areas. The community is considering moving forward with levee certification and the accreditation process, to have the future FIRM map a reduced flood hazard due to the levee systems.

If the community can provide data compliant with 44 CFR 65.10 for the Bucaná East, Portugués and Bucaná, Portugués West, Upper Bucaná Debris Basin, Bayagán North, and/or Portugués North Tieback Levee Systems, the flood hazard of the associated levee-impacted areas could be shown as shaded Zone X, with areas of interior drainage zoned as Special Flood Hazard Areas (SFHAs). If 44 CFR 65.10 – compliant data can be provided for a hydraulically independent levee reach, the leveed area's flood hazard can be shown as a composite of Zone AE and shaded Zone X, areas of interior drainage shown as SFHAs. If the community does not provide data compliant with 44 CFR 65.10, the effective FIRMs dated November 18, 2009, could be revised to show the updated flood risk using the Natural Valley Procedure, once the FEMA Regional Office incorporates updates into future mapping studies.

FEMA anticipates updating the flood hazard maps in the future and would inform the community before it initiates any update project. If levee data compliant with 44 CFR 65.10 is provided prior to the Letter of Final Determination for the countywide mapping project, it could be incorporated into the final countywide mapping. However, data in support of 44 CFR 65.10 may be submitted through the Letter of Map Revision (LOMR) process to update the FIRM at any time. FEMA recommends that the community coordinate with FEMA Region II in advance of any submittal, to keep the Region apprised of the levee status. For reference, Appendix D includes FEMA's Levee Accreditation Checklist.

7 References

FEMA, Flood Insurance Study, Commonwealth of Puerto Rico and Municipalities, November 2009.

FEMA: Guidance for Flood Risk Analysis and Mapping, Levees, February 2019

FEMA: Non-Accredited Levee Analysis and Mapping Guidance, September 2013

USACE, National Levee Database (<https://levees.sec.usace.army.mil/#/>), 2019.

Appendix A

Stakeholder Engagement - LLPT Meeting 1 Information

Appendix B

Stakeholder Engagement - LLPT Meeting 2 Information

Appendix C

Freeboard Profile Comparison

Appendix D

Levee Accreditation Checklist

Appendix E Collected Data

(Full Appendix Provided on DVD)

Appendix F

Initial Data Analysis

(Full Appendix Provided on DVD)