Levee Analysis and Mapping Plan

Union County LAMP Project
Rahway, New Jersey

March 2016

FEMA

RiskMAP
Increasing Resilience Together

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Acronyms

CFR	Code of Federal Regulations
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
GIS	Geographic Information System
LAMP	Levee Analysis and Mapping Procedures
LiDAR	Light Detection And Ranging
LLPT	Local Levee Partnership Team
MIP	Mapping Information Platform
MLI	Mid-term Levee Inventory
NAVD88	North American Vertical Datum of 1988
NLD	National Levee Database
NYC	New York City
RAMPP	Risk Assessment, Mapping, and Planning Partners
USACE	United States Army Corps of Engineers
USGS	U.S. Geological Survey

1. Background

This is the Non-Accredited Levee Analysis and Mapping Plan for the Rahway Levee system in Union County, New Jersey. The Rahway Levee Analysis and Mapping Procedures (LAMP) project of Union County is based on the document “Operating Guidance 12-13 Non-Accredited Levee Analysis and Mapping Guidance” (FEMA 2013). The LAMP process is an improved mapping approach that replaced the old “without levee” approach for flood mapping of areas behind a non-accredited levee. Part of this process includes the creation of a Local Levee Partnership Team (LLPT) made up of representatives from FEMA, the mapping contractor, and local stakeholders. The LLPT provides input to be used during the flood mapping process.

Union County, located in central New Jersey, has a land area of 105 square miles, of which approximately 2.55 square miles is covered with water. Union County is bordered by Essex County to the northeast, Richmond County, NY and Hudson County to the east, Middlesex County to the south and Morris and Somerset Counties to the west, as illustrated in Figure 1.

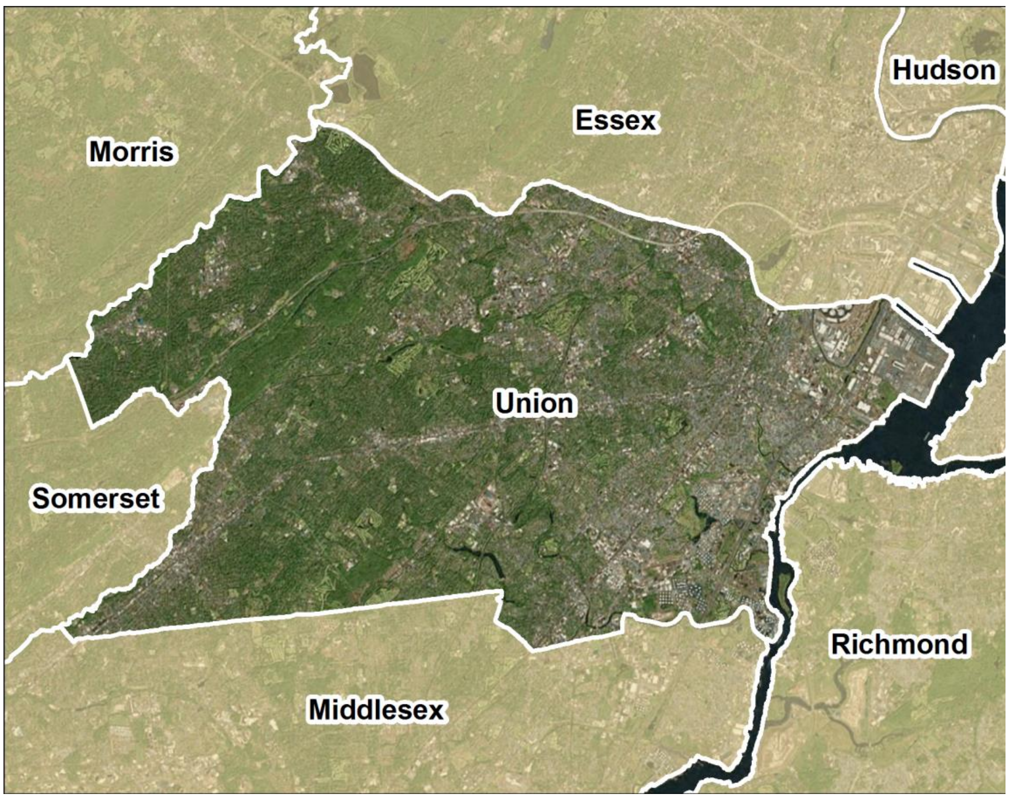

Figure 1. Union County location map

The current effective Flood Insurance Study (FIS) and Flood Insurance Rate Maps (FIRMs) for Union County covers the entire county. The effective FIRMs show the 1-percent-annual-chance floodplain confined to the South Bank river channel south of Hazelwood Avenue but exceeds the banks of the Rahway River north of Hazelwood Avenue. Based on this floodplain mapping and available documentation in the current effective FIS, the levee is non-accredited. The preliminary FIS and FIRM were prepared under the Risk MAP program and were issued on February 3, 2015. The preliminary FIRMs applied seclusion to the levee area, and therefore show identical mapping as the effective FIRMs in the seclusion area. It should be noted that the current effective map was completed prior to the new LAMP process development and also prior to the newer coastal analysis and coastal flood hazards now part of the levee analysis.

The Federal Emergency Management Agency (FEMA) requires that all non-accredited levees be evaluated as part of the LAMP process. For this project, all non-accredited levees in Rahway, New Jersey listed in the Mid-term Levee Inventory (MLI) and National Levee Database (NLD) will be evaluated. This study focuses on the Rahway Levee as delineated in the NLD.

2. Levee Description

The Rahway Levee is in the City of Rahway along the right bank (descending) of the Rahway River and the left bank of the South Branch Rahway River (descending), spanning a combined distance of approximately 5,000 feet. The northern limit of the levee ties into the Monroe Street Bridge, and the southern limit of the levee ties in to high ground near the intersection of Regina Avenue and Mill Street. A map illustrating the location of the Rahway Levee is provided in Figure 2.

The levee system borders commercial and residential properties along the Rahway River and South Branch Rahway River. Portions of this area are being redeveloped, and the community is interested in learning how the updated flood study will affect future floodplain management requirements. The Rahway Levee was designed to protect the area against the largest riverine flood of record, which occurred in October 1903 and the highest recorded storm tide, which was recorded during Hurricane Donna in September 1960. The design included 3 feet of freeboard above the combined flood elevation at that time (USACE 1966). Figure 3 shows a typical view of the levee along the Rahway River, looking south from Monroe Street. Figure 4 shows a view of the levee along the South Branch Rahway River, looking south toward Hazelwood Avenue with a view of the pumping station and one end of the floodwall. The section of levee shown in Figure 4 had sustained damage and was repaired within the last year. Additional photographs are provided in the Field Reconnaissance Report under Appendix D.

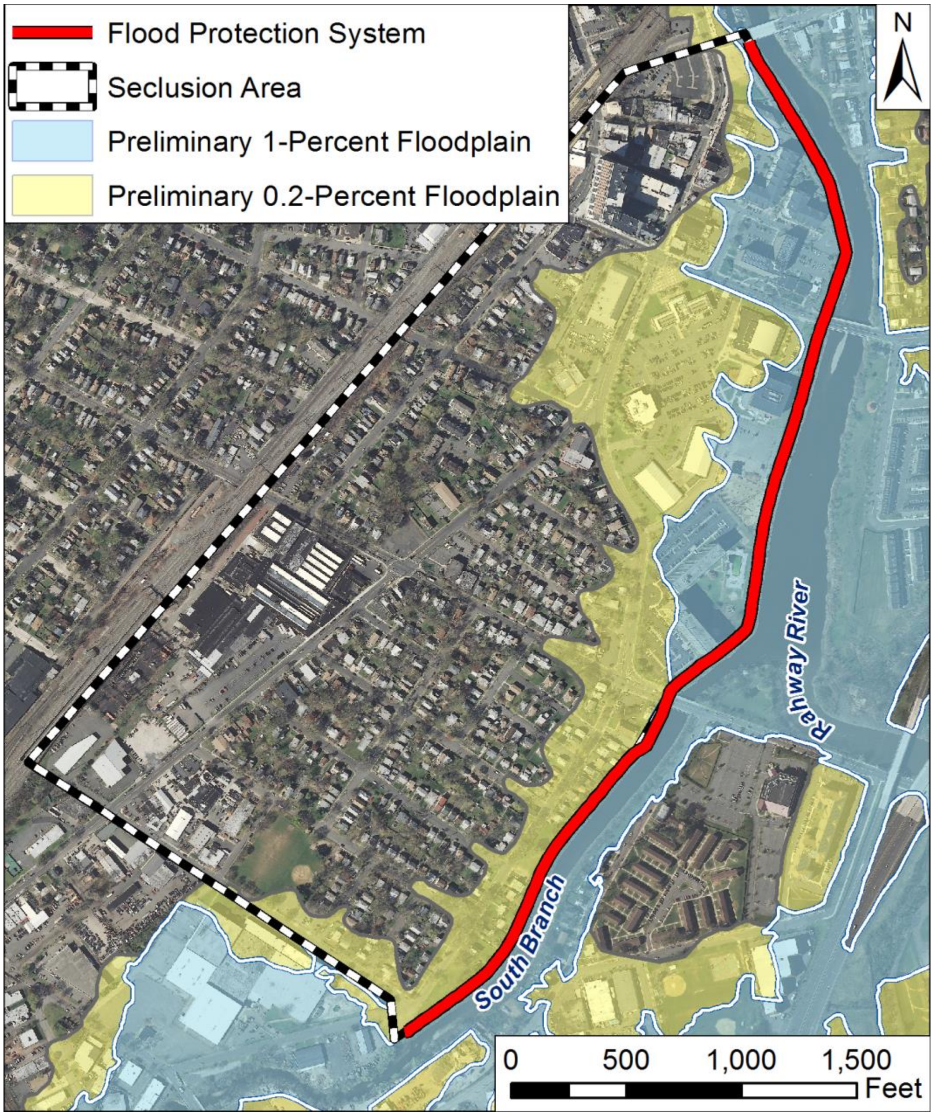

Figure 2. Rahway, New Jersey Levee system with seclusion applied to preliminary floodplains

According to the latest available survey from the U.S. Army Corps of Engineers (USACE), the levee crest height varies between 10.36 and 13.66 feet above the North American Vertical Datum of 1988 (NAVD88). Based on this survey, some sections of the levee are lower than the 1-percent-annual-chance-coastal Stillwater and some sections of the levee have 1 to 2 feet of freeboard above the 1-percent-annual-chance coastal stillwater elevation. During Hurricane Sandy, the levee was overtopped in places, producing flooding landward of the levee. Discussions with the community indicated that the levee was re-leveled in the past year to an elevation of 12.7 feet NAVD88. However, an as-built survey of the new elevations is not available at this time. Updated information should be used during a future LAMP Phase 2 analysis.

Figure 3. Rahway Levee looking south from Monroe Street

Figure 4. Rahway Levee looking south toward Hazelwood Avenue

3. Mapping History

The date of the effective FIRM is September 20, 2006. Table 1 indicates the FIRM history of the City of Rahway affected by the Rahway Levee system. In the current preliminary FIRM, seclusion mapping was applied to the Rahway Levee impacted area; therefore, the identified Special Flood Hazard Area (i.e., area with a 1-percent-annual-chance of flooding) in the preliminary FIRM is identical to the effective FIRM in that area. Downstream of the seclusion area, the preliminary study demonstrated higher coastal flood elevations than the effective study; consequently, the preliminary FIRMs typically show a more expansive floodplain than the effective FIRMs. The effective riverine flood elevation is higher than the coastal flood elevation upstream of the seclusion area; consequently, the preliminary and effective FIRMs show similar floodplains.

Table 1. FIRM History of City of Rahway

County	Community	Product	Effective FIRM Dates
Union County	County-wide	FIRM	September 20, 2006
Union County	City of Rahway	FIRM	December 20, 2002
Union County	City of Rahway	FIRM	August 2, 1982
Union County	City of Rahway	FIS	February 2, 1982
Union County	City of Rahway	FIRM	September 5, 1976
Union County	City of Rahway	FIRM	July 1, 1974
Union County	City of Rahway	FIRM	December 23, 1971

4. Levee Project Overview

As part of the LAMP process, FEMA and its contractor, (in this case) Risk Assessment, Mapping, and Planning Partners (RAMPP), work with a Local Levee Partnership Team (LLPT) to understand the operation of the levee system(s) and gather information to assist in the selection of the appropriate LAMP approach to determine the identified flood risk in the seclusion area. This process is divided into three distinct tasks as shown in Table 2.

Table 2. LAMP Project Tasks

Task	Details	Start Date - End Date
Field Reconnaissance	Representatives from RAMPP conducted site visits on June 21, 2015 and February 15, 2016.	6/21/2015 - 2/15/16
Hydrologic and Hydraulic Data Development	LLPT provided input for the hydrologic and hydraulic analysis based on Field Reconnaissance findings.	10/9/2014 - 3/30/2016
Flood Risk Outreach	LLPT is assessing results of the Field Reconnaissance, and Hydrologic and Hydraulic Data Development. LLPT will work at the local level to disseminate findings that could affect local stakeholders.	10/9/2014 - 3/30/2016

5. Stakeholder Engagement and Data Collection

The FEMA-led LAMP Phase 1 project team engaged the affected community and levee owners/operators in order to tailor a modeling and mapping approach for the levee system that meets the needs of the community and recognizes the available data and documentation, as well as the history of the levee system. The project team initiated a series of meetings, e-mails, and telephone calls with stakeholders to gain a better understanding of the levee system. Table 3 lists the stakeholders contacted during this process and their roles. Contact information for the project team is provided in Appendix A.

Table 3. Stakeholder Contacts

Stakeholder Contacted	Role
James Housten Rahway	LLPT
Cindy Solomon Rahway	LLPT
Encer Shaffer USACE	Stakeholder
Joseph Ruggeri New Jersey Department of Environmental Protection	Stakeholder

Details on meetings and telephone calls conducted during the Stakeholder Coordination and Data Collection process are summarized in Section 5.1 through 5.4 and documented in further detail in Appendix C.

5.1 Handshake / Stakeholder Coordination and Data Collection Meeting

FEMA held a Handshake/ Stakeholder Coordination and Data Collection Meeting on October 9, 2014 at the Hamilton Stage, Piano Room located at 360 Hamilton Street, Rahway, New Jersey.

The overarching objectives of the Handshake / Stakeholder Coordination and Data Collection Meeting were to introduce stakeholders to each other and discuss areas of flood risk, available data, and the FEMA process for analyzing and mapping flood hazards landward of non-accredited levee systems. Detailed lists of attendees, and meeting minutes are included in Appendix C.

5.2 Data Collection

During the Stakeholder Coordination and Data Collection process, FEMA requested all available data and documentation associated with the levee system.

Table 4 summarizes the data and documentation collected during the Stakeholder Coordination and Data Collection process. The data are included in Appendix D.

Table 4. Data Sources for the Levee System

Data Type	Data Description	Provided By	Date Obtained
Inspection Report	Inspection report conducted by USACE in August 2013.	Community	November 2014
Operation and Maintenance Manual	1966 USACE Operations and Maintenance Manual for Rahway River and South Branch, Rahway River	Community	November 2014
USACE As-Built Survey	1964 USACE as-built plans of levee, Note: It is recommended that the community provide an updated profile prior to the Phase 2 analysis.	Community	November 2014
Levee Breach Elevations	Breach elevations collected after Hurricane Sandy	Community	November 2014
Hurricane Flood Elevations	High water mark data collected after Hurricane Irene and Hurricane Sandy	Community	November 2014
Levee Survey	Undated USACE survey of levee and floodwall crest elevations	FEMA	January 2016
Topography	2014 light detection and ranging (LiDAR) data collected by U.S. Geological Survey (USGS)	RAMPP/FEMA	November 2015
Tide Gage Data	Gage record from NOAA's Bergen Point West Reach tide gage	RAMPP	November 2015

Table 5 outlines the unique identifiers associated with this project across the various project tracking systems.

Table 5. Project Tracking and Identification Information

Project Tracking Method	Project Identifier
Project and Purchase ID	Not assigned
MIP Case Number	14-02-2530S
LAMP Study Project Tracker (LAMP_ID)	R2NJ3
Levee Database Segment ID(s)	MLI: 1204000399, 1204000400, 1204000401 NLD: 4505000027
FIRM Panel(s) and Effective Date	34039C0044G – September 20, 2006

5.3 Local Levee Partnership Team

Based on the discussion during the Handshake / Stakeholder Coordination and Data Collection Meeting, two stakeholders were identified as members of an LLPT, as shown in Table 6. The primary function of the LLPT is to provide feedback and, if necessary, provide additional information or documentation.

Table 6. Local Levee Partnership Team Participants

Participant	Title	Contact Information	Meetings Attended	Agreed to Participate in the LLPT?
James Housten	City Engineer Rahway	1 City Hall Plaza Rahway, NJ jhousten@bohlereng.com (732) 827-2176	October 9, 2014: Kick-off LAMP Meeting (in person) October 27, 2014: Kick-off Follow-up (webinar) March 5, 2015: LLPT1 (in person) February 8, 2016: Preparation for LLPT2 (webinar) February 16, 2014: LLPT2 (in person)	Y
Cindy Solomon	City Planner Rahway	1 City Hall Plaza Rahway, NJ csolomon@cityofrahway.com (732) 827-2193	October 9, 2014: Kick-off LAMP Meeting (in person) October 27, 2014: Kick-off Follow-up (webinar) March 5, 2015: LLPT1 (in person) February 16, 2014: LLPT2 (in person)	Y

5.4 Local Levee Partnership Team Meetings

In addition to the Handshake / Stakeholder Coordination and Data Collection Meeting, two additional meetings were held during the Phase 1 Study, LLPT Meetings 1 and 2.

The first LLPT meeting was held on March 5th, 2015 at Rahway City Hall. The meeting objectives were to review the LAMP study process and discuss the analyses planned for the Phase 1 study. A summary of topics discussed during the first LLPT meeting held on October 9, 2014 is provided below; full meeting minutes are provided in Appendix C.

- Overview and objectives of the LAMP process.
- Identification of potential LLPT members.
- The community's goal to understand what level of protection the levee provides.
- Timing of the preliminary FIS and timing of the LAMP study.
- Planned re-leveling of the levee scheduled for spring 2015.

A second LLPT meeting convened on February 16th, 2016 at Rahway City Hall to review the results of Phase 1 and to develop a plan for the Phase 2 study. More details on the Phase 1 study results and plan for Phase 2 are provided in Sections 6 and 7, respectively. A summary of topics discussed during the second LLPT meeting held on February 16, 2016 is provided below; full meeting minutes are provided in Appendix C.

- Past levee performance during major storms including Tropical Storm Irene and Superstorm Sandy.
- The requirements for certification and accreditation of a levee based on elevation, geotechnical characteristics, closure structures, operation and maintenance, etc.
- A comparison of coastal and riverine flood hazards revealed coastal flooding yields higher flood elevations within the levee impacted area. Consequently, coastal flooding was utilized for the Phase 1 analysis.

- The requirements of the LAMP process as an alternative to accreditation, including the mapping of Zone D and the insurance implications.
- The current New Jersey Department of Environmental Protection building requirements based on Advisory Base Flood Elevations and how those might change through the lifecycle of the preliminary FEMA study.
- The status of the New York City (NYC) appeal (discussed in Section 8) and how potential changes to coastal surge might affect the Rahway Levee accreditation and/or the LAMP process.
- Two potential paths forward for the Phase 2 analysis (both are based on the assumption that the community will provide required 44 CFR 65.10 data): a LAMP freeboard deficient analysis if the surge resulting from the NYC appeal is within 2 feet of the levee crest, or an accreditation analysis if the surge resulting from the NYC appeal is more than 2 feet below the levee crest.

6. Initial Data Analysis

The initial analysis, also called first pass analysis, used the information and data provided by stakeholders and the LLPT to produce approximate flooding scenarios associated protection system vulnerabilities. The information gained from the first pass modeling, along with other data, provides FEMA and the LLPT a better perspective on the appropriate path forward in the LAMP process. The first pass analysis focused on three scenarios:

- Natural Valley analysis, which represents the natural floodplain in the absence of flood protection structures.
- Overtopping analysis, which assumes the levee maintains its current condition during a 1-percent-annual-chance event, including overtopped areas where breaches could occur, as defined by the USACE survey.
- Freeboard Deficient approach, which assumes the levee crest elevation is less than 2 feet above the 1-percent-annual-chance stillwater elevation. In this scenario, the Natural Valley floodplain is represented as Zone D and interior drainage greater than 1 foot as Special Flood Hazard Area.

For the first pass analysis, the effective riverine flood elevations were compared to the coastal flood elevations available from the preliminary FEMA study to determine the dominant flood hazard. Comparison demonstrated that the coastal flood elevations were significantly higher in the study area; therefore, the flooding scenarios discussed in Sections 6.1 through 6.3 are based on coastal flooding.

6.1 Natural Valley

The Natural Valley represents the floodplain assuming the absence of any flood protection structures (levees), and is the spatial extent of Zone D derived from the LAMP process. The Natural Valley flood extents were developed by extrapolating the preliminary FEMA 1-percent-annual-chance stillwater elevations across the study area, while removing any influence of protection structures. The stillwater elevation varies between 11.7 and 11.9 feet NAVD88 in the study area. The resulting Natural Valley floodplain contains approximately 120 structures and covers 61 acres. The flood depths across the study domain resulting from the Natural Valley are shown in Figure 5.

6.2 Overtopping

For the Phase 1 LAMP study, the sections of levee vulnerable to inundation were identified by comparing the USACE survey data to the stillwater elevation from the Natural Valley scenario. A depiction of this comparison is provided in Figure 6. A total of 48 top-of-levee survey points represented in the USACE survey are inundated by the 1-percent-annual-chance stillwater, which equates to roughly 1,300 linear feet of the levee being overtopped. As illustrated in Figure 6, these inundated points are typically clustered together, and were therefore combined into six reaches or levee segments for the Overtopping analysis. It is important to note that the levee was not designed for overtopping and therefore this scenario does not represent breaches that could develop at the overtopped locations. The Overtopping scenario described in this section was developed to understand the flooding dynamics of the system and should not be used beyond Phase I of the LAMP study.

For each of the six reaches, an average elevation was computed based on the USACE survey in order to calculate a time varying flow rate over the inundated levee using the broad crested weir equation (Pullen et al. 2007):

$$q_{overflow}(t) = 0.6\sqrt{g\left|-R_C^3\right|}$$

Where:

$q_{overflow}$ = time varying surge overflow rate [m^2/s]

g = gravitational acceleration, 9.81 [m/s^2]

$-R_c$ = overflow depth = time varying surge elevation – averaged levee crest elevation [meters]

The time varying surge elevation was represented by a simplified hydrograph, developed based on historic extra-tropical storms recorded at the National Oceanic and Atmospheric Administration's Bergen West Point Reach gage and scaled to the 1-percent-annual-chance stillwater level. An example of the time varying surge plotted with the levee crest elevation and resulting surge overflow rate is provided in Figure 7.

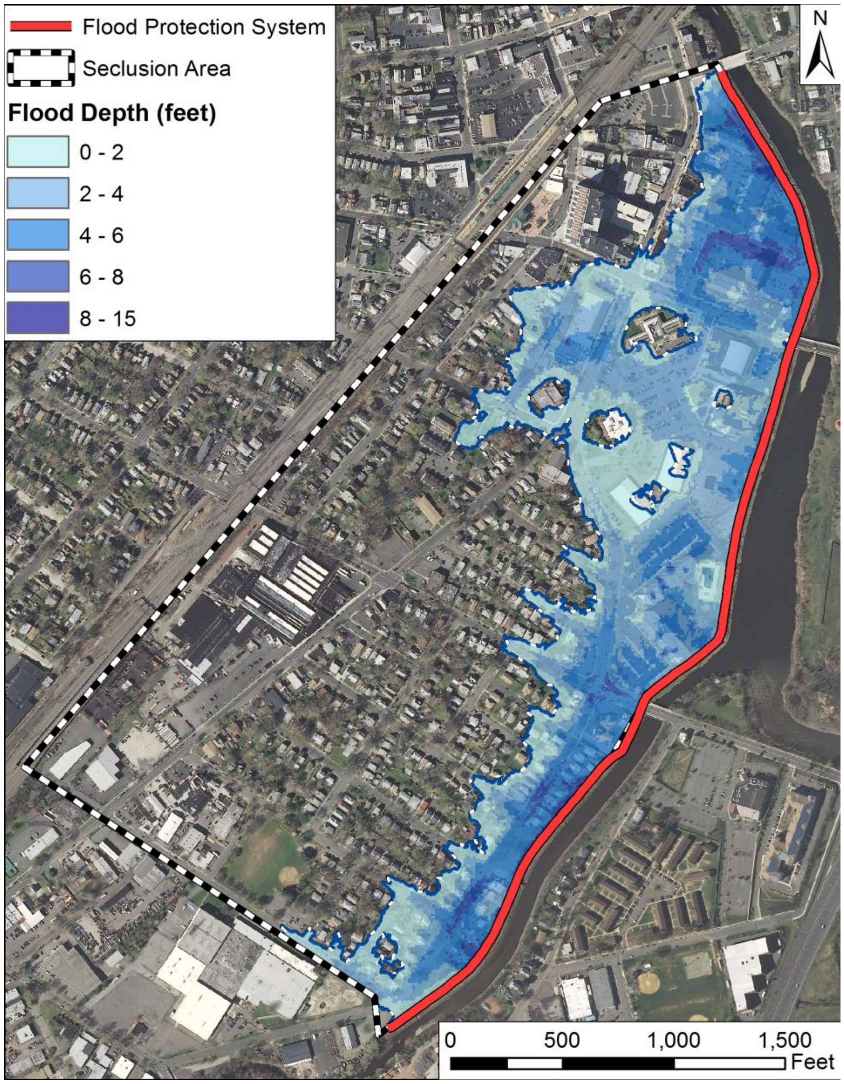

Figure 5. Natural Valley scenario flood depth

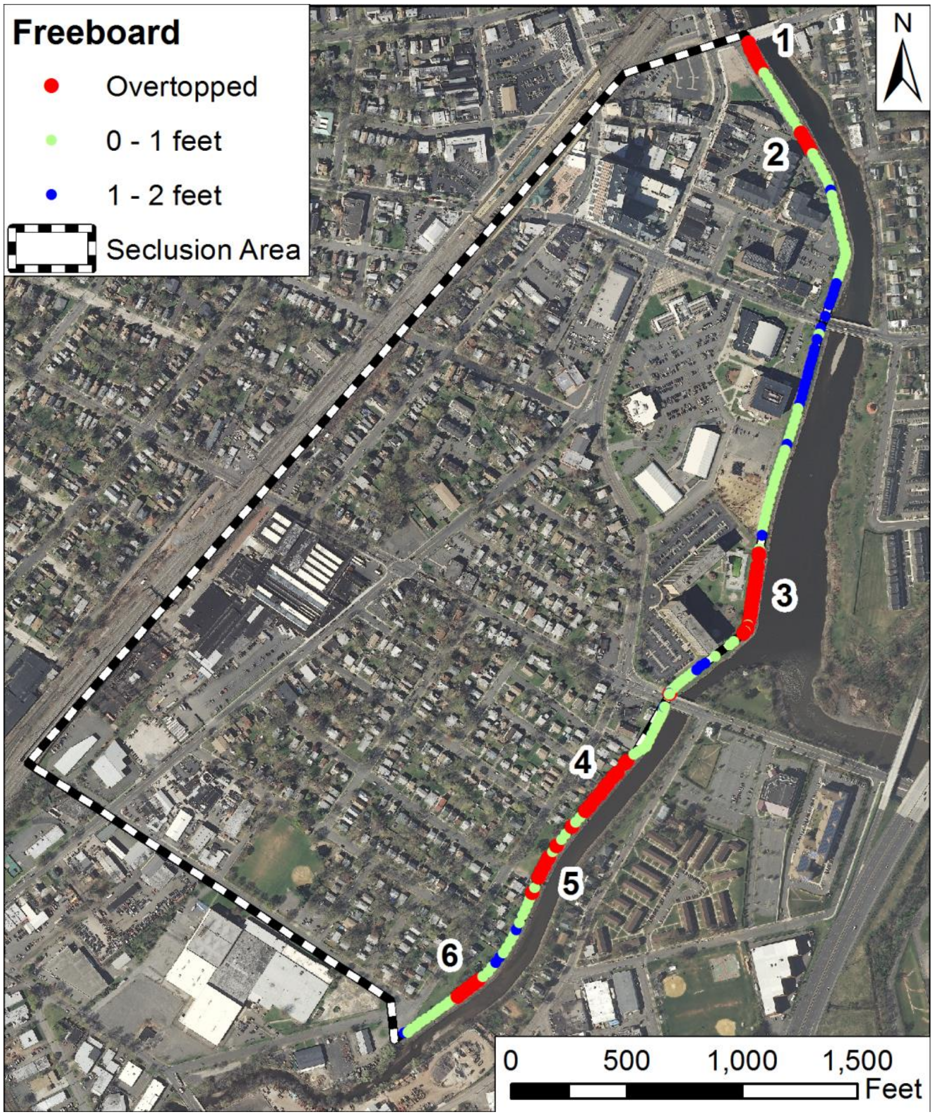

Figure 6. Comparison of surveyed levee crest elevation to the local stillwater elevation

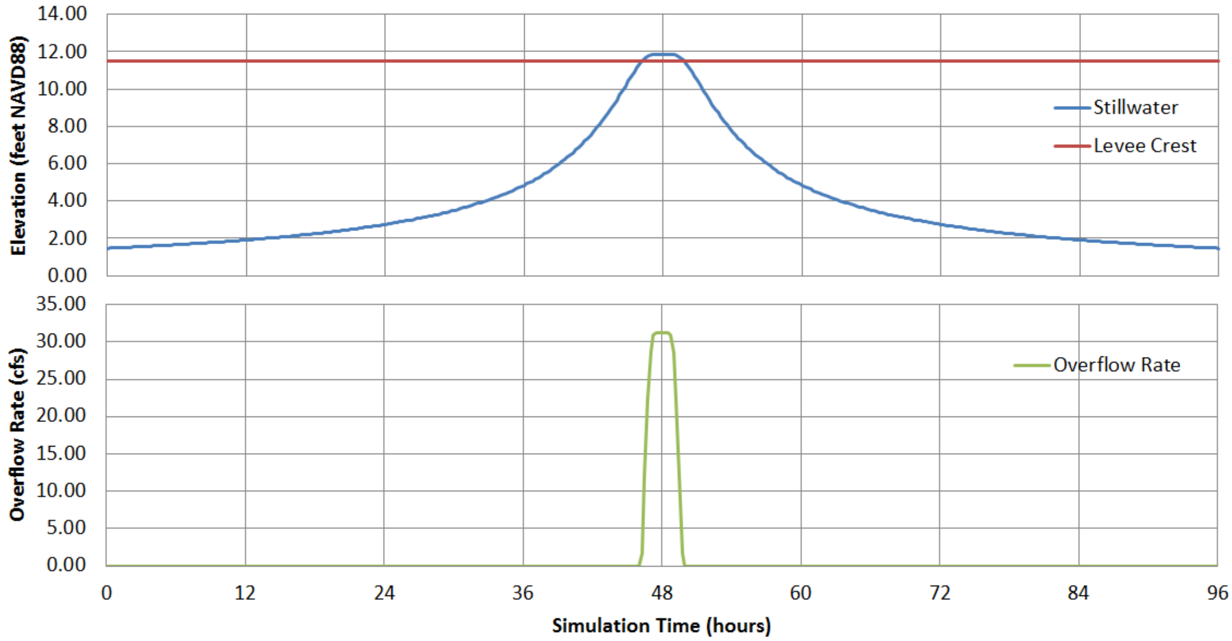

Figure 7. Example surge hydrograph and overtopping flow rate per linear foot of overtopped levee

The two-dimensional flood routing software, FLO-2D, was used to determine the maximum extent and depth of flooding caused by inundation of these levee reaches. The FLO-2D model was developed with a regular grid with a cell size of 30 feet by 30 feet. The seaward boundary of the model was defined by the extent of the levee; the inland boundary was defined by the railroad line running through the city. Using the FLO-2D software, the 2014 USGS LiDAR was resampled to the 30-foot resolution. The levee crest was also developed based on the LiDAR information. The USACE survey was not available at the time the FLO-2D model was developed; consequently, it was not incorporated into the model topography. However, the USACE survey data was used in the weir overtopping equation described above.

The model also incorporates land use data by assigning spatially varying roughness factors, including a very smooth factor for streets. Assigning streets a low roughness and ensuring their continuity in the model grid facilitates flood routing via the streets, simulating realistic flood behavior. Non-street areas, such as developed city blocks, are assigned a higher roughness factor. Also in developed areas, buildings are represented in the model as obstructions to flow and surface flood storage reduction factors.

Results from the production runs were processed in a Geographic Information System (GIS) to generate high-resolution floodplain boundaries and maximum flood depth grids. These spatial data sets and maps do not provide any regulatory information and are not intended to represent an expectation of how future regulatory data may appear or be developed. Rather, they are intended to provide information on the possible impacts from overtopping of the selected levee segments. The model can also provide some information related to depth of flooding, velocities, and direction of flow. Modeling files and data can be found in Appendix E, Initial Data Analysis.

The flooding produced by the Overtopping scenario is depicted in Figure 8. The resulting stillwater elevation varied between 12 and 14 feet NAVD88. The floodplain produced was approximately 65 acres and affected 140 structures. The higher stillwater elevation and larger floodplain produced by the Overtopping scenario compared to the Natural Valley is a result of flow trapped behind the levee and not draining into the river.

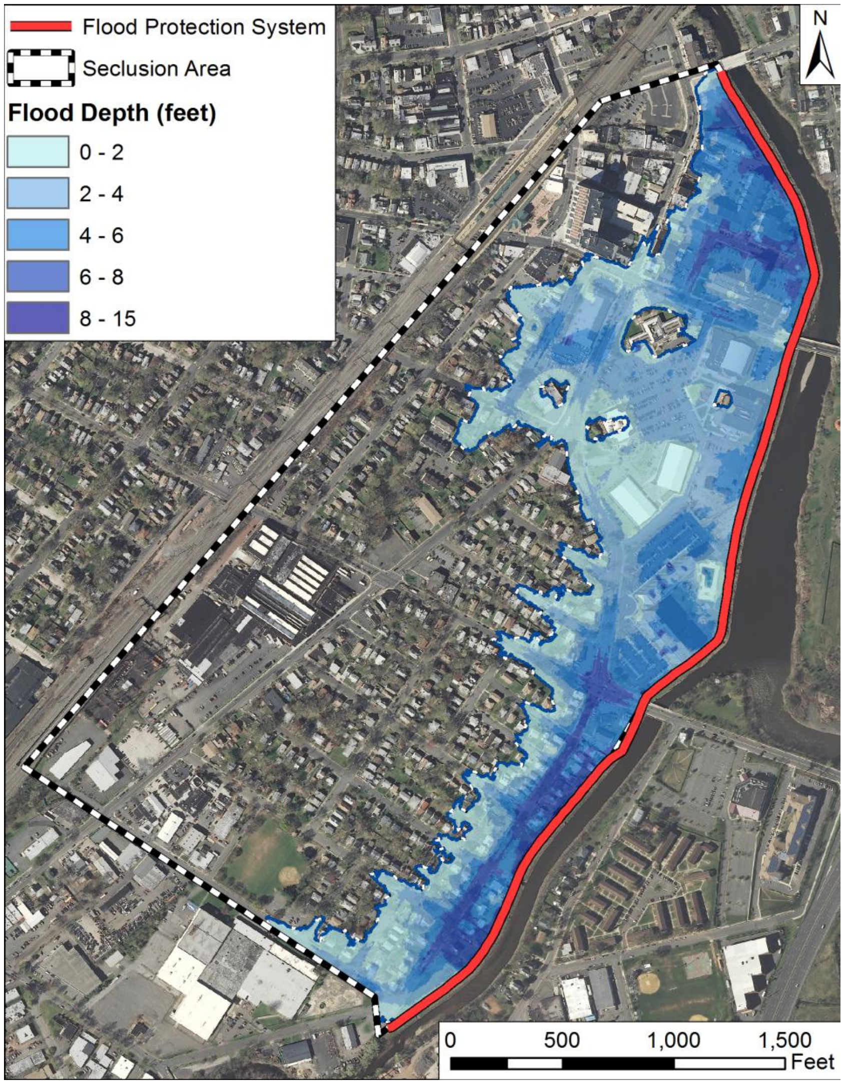

Figure 8. Overtopping scenario flood depth

6.3 Freeboard Deficient

Discussion with the community at the second LLPT meeting indicated the levee was re-leveled to an elevation of 12.7 feet NAVD88 and is therefore higher than the 1-percent-annual-chance flood elevation. However, a certified as-built survey of the new elevations was not available at the time of the Phase 1 LAMP study. If the community is able to provide the as-built survey along with all other 44 CFR 65.10 requirements, the levee could be treated as Freeboard Deficient, which means the Natural Valley scenario described in Section 6.1 would be represented as a Zone D, as depicted in Figure 9. More details on the path to a Freeboard Deficient analysis are discussed in Section 7.

Figure 9. Freeboard Deficient mapping

7. Path Forward

The next steps in the LAMP process include continued coordination with the LLPT and stakeholders, while refining the technical approach based on feedback and the intended course of action by the communities. Depending on the community's ability to generate or obtain all of the engineering documentation (44 CFR 65.10 data) required for certain LAMP technical approaches, the path forward may change. The following sections describe the path forward that was discussed at the final Phase 1 LLPT meeting based on currently available data and information.

7.1 Potential Reach Approaches

At the time of this study, NYC had submitted an appeal of the surge modeling used in the Region II preliminary FIS. This appeal may have implications for the City of Rahway and its levee. The appeal has the potential to lower the coastal surge elevations throughout coastal

New York and New Jersey. Consequently, the outcome of the appeal will govern the study approach recommended for a future LAMP Phase 2 study.

At the final Phase 1 LLPT meeting, the community explained that the levee had been re-leveled to an elevation of 12.7 feet NAVD88.[1] The preliminary FIS shows the coastal surge varies between 11.7 and 11.9 feet NAVD88. Based on these data, the levee does not meet the freeboard requirements for accreditation, and the Phase 2 analysis should treat the levee as freeboard deficient.[2] If the NYC appeal reduces the coastal surge by 1.2 feet or more, the Phase 2 analysis could proceed with levee accreditation. A graphical representation of these potential analyses is provided in Figure 10.

The primary difference between the two approaches is whether the land side of the levee will include a Zone D, similar to the floodplain depicted in Figure 9 or a Shaded Zone X. Both approaches should include a joint probability distribution analysis to show the SFHA for the interior precipitation/drainage associated with the 1-percent-annual-chance coastal storm surge. The corresponding interior drainage analysis should consider including the worst case scenario with inoperative pump stations and closed tide gates during a 1-percent-annual-chance storm surge event.

However, if the community is unable to meet any of the non-elevation certification requirements the flood hazards behind the levee will need to be mapped using the LAMP Natural Valley Procedure.

[1] The community will need to provide an as-built survey of the levee demonstrating its new elevation of 12.7 feet for it to be considered in the Phase 2 analysis.

[2] The freeboard deficient or accreditation analyses are contingent on the community meeting all other requirements documented in 44 CFR 65.10.

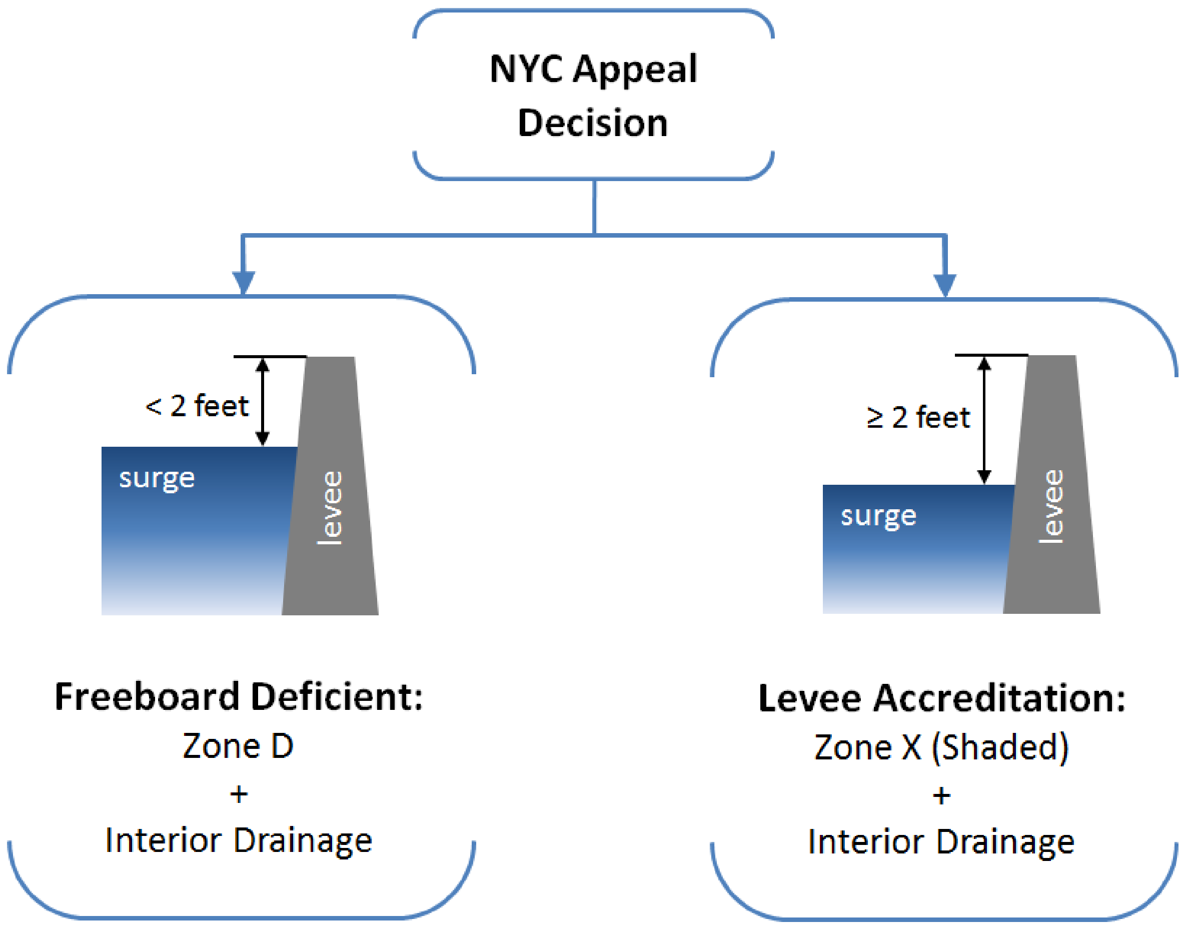

Figure 10. Diagram illustrating potential paths of Phase 2 LAMP coastal analysis, depending on the outcome of the NYC appeal

7.2 Model Refinements

The model refinements needed for the Phase 2 analysis are dependent on which study path is chosen. If the levee is found to be freeboard deficient following the resolution of the NYC appeal, the Zone D should be re-evaluated using the best available topography and the revised surge elevations. The study team will also need to develop an interior drainage analysis for Phase 2 based on the capacity of the pumping stations and the 1-percent-annual-chance interior precipitation. If the levee is found to meet freeboard requirements, only the interior drainage analysis will be necessary.

If the community is unable to meet any of the non-elevation certification requirements, the Phase 2 study team should analyze and map the 1-percent-annual chance flood hazards resulting from the flood control system's deficiency missing requirement. For example, at the time of the Phase 1 study, the community had not acquired the funding to repair their sluice gates. If those gates remain damaged at the time of the Phase 2 study, the study team should analyze the amount of water expected to infiltrate the gates during a 1-percent-annual-chance event.

7.3 Schedule

Discussion with the community during the second LLPT meeting indicated the community and FEMA would prefer to wait for the resolution of the NYC appeal before moving forward with the LAMP Phase 2 analysis. A timeline for resolution of the NYC appeal is currently unknown. Once the appeal is resolved, FEMA will need to plan and allot funding for the Phase 2 analysis.

8. References

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9. Appendix – Associated Files

The appendices are stored digitally under their respective folders on the digital storage device that accompanies this report.

Appendix A – Project Team Contact Information

Appendix B – Stakeholder Engagement Interviews

Appendix C – Stakeholder Engagement Meeting Data

Appendix D – Collected Data

Appendix E – Initial Data Analysis

Appendix F – Exhibits for Rahway Levee