Levee Analysis and Mapping Plan

Bayshore LAMP Project of Monmouth County

Monmouth County, New Jersey

March 2016

FEMA

RiskMAP

Increasing Resilience Together

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Acronyms

2D	Two-dimensional
CFR	Code of Federal Regulations
FCCE	Flood Control and Coastal Emergency
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
LAMP	Levee Analysis and Mapping Procedures
LiDAR	Light Detection and Ranging
LLPT	Local Levee Partnership Team
MLI	Mid-term Levee Inventory - FEMA
NLD	National Levee Database - USACE
SWEL	total stillwater elevation (surge stillwater plus wave setup)
USACE	U.S. Army Corps of Engineers
USGS	United States Geological Survey
WRDA	Water Resources Development Act of 2007

Executive Summary

The Bayshore Levee Analysis and Mapping Procedures Project of Monmouth County was funded under Contract Number HSFEHQ-09-D-0369, Task Order Number HSFE02-11-J-003, Change Request Number R2-11-03-004.

The Federal Emergency Management Agency's (FEMA's) guidance was revised in 2013 to a new Levee Analysis and Mapping Procedure (LAMP), which provides a suite of flexible procedures to perform flood hazard analysis and mapping. Under the new guidance, FEMA's coastal analysis and mapping for Monmouth County, New Jersey must be revised to reasonably account for the hazard reduction impacts of non-accredited levees.

From 2014 to 2016, FEMA Region II worked closely with stakeholders in Monmouth County as a collaborative Local Levee Partnership Team (LLPT) to determine potential LAMP approaches for all levee reaches in the County. The process involved collection and group evaluation of available data, creation and evaluation of first pass LAMP analysis and mapping, and detailed discussions on mapping needs. This project included three meetings with the community on October 7, 2014, February 5, 2015 and December 9, 2015. These meetings with the community leaders and Local Levee Partnership Team (LLPT) included a tour of the affected levees for collection of data and information.

The extensive coordination with the LLPT is supplemented by the data produced during the first pass LAMP analysis. These pieces allow for the development of this document: a LAMP Plan to outline the potential reach procedures and highlight outstanding data and information needed to complete the remainder of the LAMP Process in Phases 2 and 3. This LAMP Plan does not dictate a single procedure that must be applied for each reach, but sets the foundation for a dynamic plan that FEMA and the stakeholders will use to move into Phase 2.

1. Levee System Analysis Project Description

This Levee Analysis and Mapping Plan for the non-accredited Keansburg and Keansburg East Levees located in Monmouth County, New Jersey was developed as part of a pilot study conducted to evaluate the Federal Emergency Management Agency's (FEMA's) Levee Analysis and Mapping Procedures (LAMP). Because the levees impact a number of towns along the Bayshore in addition to Keansburg, the project was named Bayshore LAMP project of Monmouth County. The Bayshore LAMP project of Monmouth County is based on the Operating Guidance 12-13: Non-Accredited Levee Analysis and Mapping Guidance (FEMA 2013).

1.1 Project Background

Monmouth County, located in coastal central New Jersey, has a total area of 665 square miles, of which approximately 196.53 acres are covered with water. Monmouth County is within the New York Metropolitan Statistical Area (MSA) and is the northernmost county along the Jersey Shore. Monmouth County is bordered by Middlesex County to the northwest, Mercer and Burlington Counties to the west, and Ocean County to the south.

The current effective Flood Insurance Study (FIS) for Monmouth County is in the modernized county-wide format. The Flood Insurance Rate Map (FIRM) for Monmouth County is a raster format. The preliminary FIS and FIRM were prepared under the Risk MAP program and were issued on January 31, 2014 and January 30, 2015, respectively. The current FIRMs do not show the Keansburg levees as being accredited or providing any protection, and the September 25, 2009 preliminary FIRM shows the Keansburg and Keansburg East Levees under the "without-levee" scenario for the Base Flood Elevations. On the previous effective FIRM (May 16, 1983), the dunes were incorrectly labeled as a "Levee" – thus resulting in an incorrect representation of the flood hazard in this area. The 1983 previous effective FIRM showed Zone V (equivalent to the current Zone VE standard) seaward of the dune line, Zone C (equivalent to the current unshaded Zone X standard) immediately landward of the dune, and an area of Zone A (equivalent to the current Zone AE standard) due to the 1-percent-annual-chance flood of the Waackaack Creek.

FEMA requires that all non-accredited levees be evaluated as part of the LAMP process. As a part of this process, all non-accredited levees listed in the Mid-term Levee Inventory (MLI) and National Levee Database (NLD) are evaluated for consideration for the LAMP process in this county. The Keansburg and Keansburg East Levees are listed in the NLD together as the Raritan Bay & Sandy Hook Bay, Keansburg system.

At the Handshake / Stakeholder Coordination and Data Collection Meeting (refer to Section 2), all communities agreed that both levees identified in the MLI, Keansburg and Keansburg East, were originally designed as levees for flood protection. This discussion was documented in the meeting minutes included in Appendix C.

1.1 Levee Description

The Keansburg Levee (also known as the Thornes Creek Levee) is located along the west side of the Borough of Keansburg and the east side of the Borough of Union Beach. The Keansburg East Levee (also known as the Pews Creek Levee) is located in the Township of Middletown and runs along Pews Creek. Both levee systems tie into a coastal Primary Frontal Dune (PFD) along the Raritan Bay, as shown in Figure 1. A PFD is defined by Title 44 of the Code of Federal Regulations (CFR) Chapter 1, Part 59.1 as "a continuous or nearly continuous mound or ridge of sand with relatively steep seaward and landward slopes immediately landward and adjacent to the beach and subject to erosion and overtopping from high tides and waves during major coastal storms."

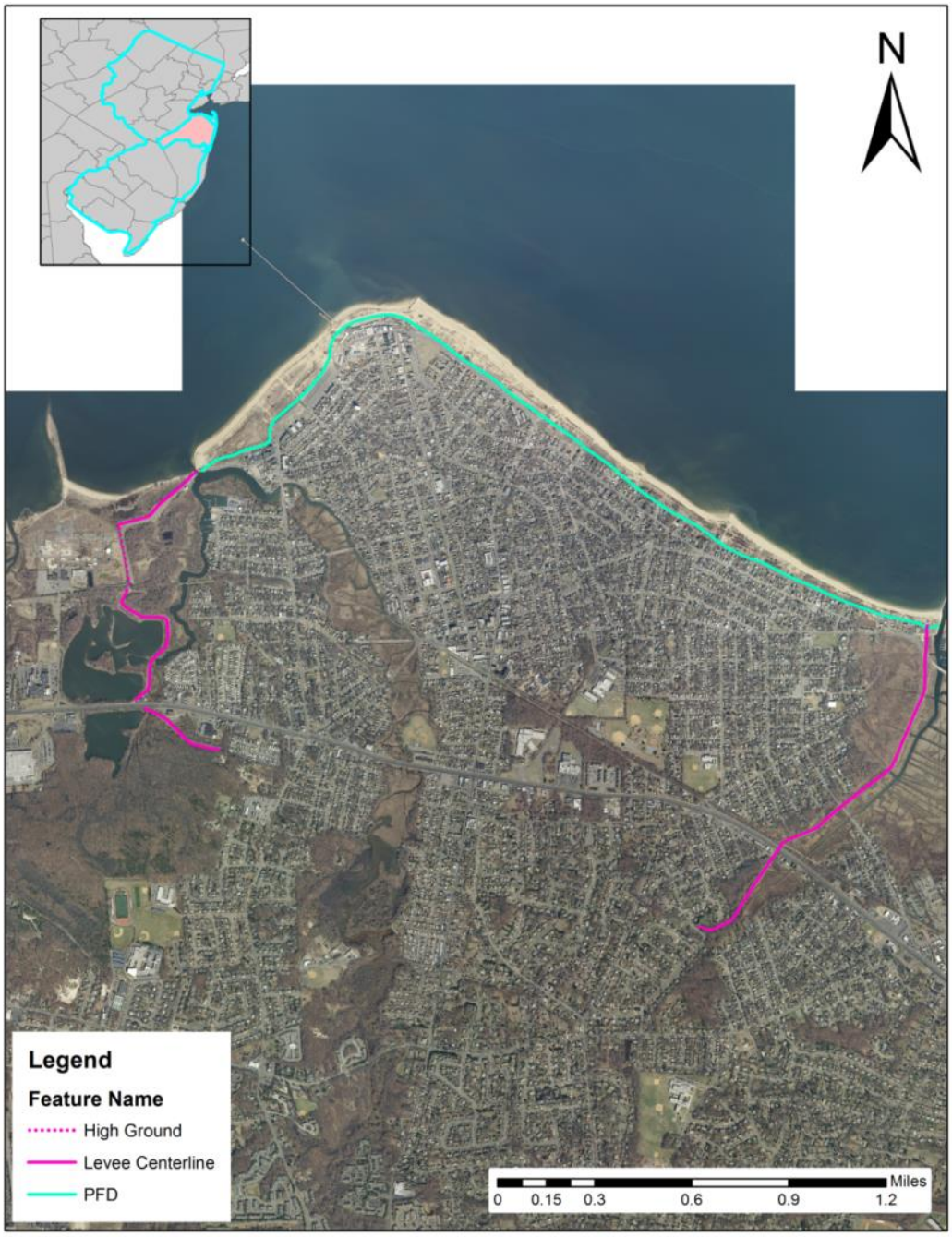

Figure 1: Bayshore LAMP Project of Monmouth County levee locator map

The levee system primarily protects commercial and residential properties along the Raritan bay between Thornes Creek and Pews Creek in the Townships of Middletown and Hazlet, and the Borough of Keansburg. The current effective FIRMs and preliminary FIRMs show the "without-levee" scenario because the levees were reported as non-accredited and do not meet the standards described in Title 44 of the CFR Chapter 1 Part 65.10. Because the levees were not accredited and the area was recently studied, Monmouth County was selected as one of the national pilot projects.

The Keansburg and Keansburg East Levees were designed to provide flood protection using a design storm based on the flood of 1950 caused by an extra-tropical event. Figure 2 shows the Keansburg East Levee (looking north). Figure 3 Shows the Keansburg Levee as it ties into the flood control gate and pumping station, next to the PFD. Additional photographs are provided in the Field Reconnaissance folder in Appendix D. Both levees' heights vary, with some sections of negative freeboard and the majority of both levees' crests 1 to 3 feet above the 1-percent-annual-chance total stillwater elevation (SWEL). During Superstorm Sandy in October 2013, the levees were not overtopped, but were damaged in some places.

Figure 2: Keansburg East Levee looking north

Figure 3: Keansburg Levee near pumping station and flood gate

1.2 Mapping History

The date of the current effective FIRM is September 25, 2009. Table 1 shows the FIRM history for Monmouth County communities. The Zone AE shown on the effective map is similar to the one on preliminary FIRMs. Historical FIRMs are included in Appendix F.

Table 1: Summary of Communities

County	Community	Product	Effective FIRM Date
Monmouth County	Borough of Keansburg	FIRM	September 25, 2009
			May 16, 1983
	Borough of Union Beach	FIRM	September 25, 2009
			August 15, 1992
			March 2, 1983
			May 15, 1980
	Township of Hazlet	FIRM	September 25, 2009
			December 1, 1982
	Township of Middletown	FIRM	September 25, 2009
			July 15, 1992
			February 15, 1984

A countywide study for Monmouth County was initiated in 2006 during FEMA's Map Mod program. As a part of the countywide study, Medina Consultants, P.C., under Contract No. EMN-2003-CO-0005, performed a detailed study of the Keansburg Levee area. The effective map dated September 25, 2009 shows the entire landward side of the levee as Zone AE (Appendix F). The levee continued to be shown as not providing protection, with a floodplain that extended

beyond the landward toe of the levee. The dune section of the flood protection system was found to be damaged and unable to provide protection during a 1-percent-annual-chance event.

1.3 Levee Project Overview

The Bayshore LAMP Project of Monmouth County was selected as one of 25 national projects to pilot FEMA's new levee analysis and mapping procedure. During this procedure, FEMA works with a Local Levee Partnership Team (LLPT) to understand the operation of the levee systems and identify information to assist in the selection of the appropriate LAMP approach to determine the flood risk in the levee impacted areas. This process is divided into three distinct tasks as shown in Table 2.

Table 2: LAMP Phase 1 Project Tasks

Task	Details	*Start - End Dates
Field Reconnaissance	Performed on February 5, 2015. Representatives from FEMA, Keansburg, Union Beach, Middletown, and other key stakeholders attended.	9/4/2014 – 3/15/2015
Hydrologic and Hydraulic Data Development	LLPT conducted hydrologic and hydraulic analysis based on field reconnaissance findings.	1/16/2015 – 11/15/2015
Flood Risk Outreach	LLPT assessed results of the Field Reconnaissance, and Hydrologic and Hydraulic Data Development. LLPT to work at the local level to disseminate findings that could impact local communities.	9/4/2014 – 1/15/2016

2. Stakeholder Engagement and Data Collection

A FEMA-led Project Team engaged stakeholder communities and levee owners/operators during the Handshake / Stakeholder Coordination and Data Collection process. Contact information for the Project Team is provided in Appendix A. The purpose of this initial engagement was to discuss the levee analysis and mapping process, and also collect initial community/levee-related data, information, and documentation to help streamline and facilitate future coordination meetings. Table 3 lists the stakeholders contacted during this process.

Table 3: Summary of Stakeholder Contact

Stakeholder Contacted	Role	Date Contacted
Robert Burlew *Union Beach*	LLPT	Initial email 8/25/2014
Raymond B. OHare *Keansburg*	LLPT	Initial email 8/25/2014
Edward P. Striedl *Keansburg*	LLPT	Initial email 8/25/2014
Fran Mullan *Keansburg*	LLPT	Initial email 8/25/2014

Stakeholder Contacted	Role	Date Contacted
Jenifer Thalhauser *U.S. Army Corps of Engineers*	Stakeholder	Initial email 8/25/2014
Joseph Ruggeri *New Jersey Department of Environmental Protection*	Stakeholder	Initial email 8/25/2014
Mr. Mercantante *Middletown*	Stakeholder	Initial email 8/25/2014
Dennis Pino *Hazlet*	Stakeholder	Initial email 8/25/2014
Jo Schloeder *Director of Public Policy for Congressman Chris Smith*	Stakeholder	Initial email 8/25/2014
Janice Fuller District Director for Congressman Pallone	Stakeholder	Initial email 8/25/2014

The Project Team initiated a series of meetings, emails, and telephone calls with stakeholders to gain a better understanding of the levee system. This allowed FEMA to tailor a modeling and mapping approach for the levee system that meets the needs of the community, and uses available data, information, and documentation, as well as the history of the levee system. Details on meetings and telephone calls conducted during the Stakeholder Coordination and Data Collection process are provided in Appendix B.

2.1 Data Collection

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

Table 4 provides a summary of the data, information, 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 (indicate certified/not certified)	Source	Date Obtained
As-built information on Keansburg Primary Frontal Dune	Profiles of the Primary Frontal Dunes – certified	New York District, USACE	December 10, 2014
Beach Erosion and Hurricane Project	Raritan Bay and Sandy Hook Bay beach and erosion project for the Keansburg Area General Plan	New York District, USACE	January 15, 2015
As-built information on Keansburg Levees	Public Law 84-99 project: Rehabilitation of hurricane shore protection for Raritan Bay and Sandy Hook Bay (Keansburg, East Keansburg, and Laurence Harbor, NJ); involved repair of hard features damaged by Superstorm Sandy - certified	New York District, USACE	January 15, 2015
Beach Fill Renourishment	Keansburg, East Keansburg and Laurence Harbor, NJ Draft Reevaluation Report – Beach Fill Renourishment (Section 506 of WRDA 1996) -	New York District, USACE	January 15, 2015

Report	certified		
Operation and Maintenance Manual	Operations and Maintenance Manual for Raritan Bay and Sandy Hook Bay, New Jersey	New York District, USACE	January 15, 2015
Survey data	Undated. Crest of levee and top of floodwall survey data in GIS shapefile format – not certified	New York District, USACE	September 1, 2015
As-built information on Keansburg Levee	FCCE Hurricane Sandy, Sandy Rehab, Raritan Bay & Sandy Hook Bay, Keansburg Hard Features, Keansburg Levee Plan View As-Built – certified	New York District, USACE	December 1, 2015
Hydraulic Model	Coastal flood study showing the preliminary regulatory 1-percent-annual-chance stillwater elevation	FEMA	1/31/2014
Topographic Data	2014 Digital elevation model derived from LiDAR	USGS	August 12, 2015

USACE = U.S. Army Corps of Engineers; WRDA = Water Resources Development Act of 2007; FCCE = Flood Control and Coastal Emergency; LiDAR = Light Detection and Ranging; GIS = geographical information system; FEMA = Federal Emergency Management Agency; USGS = United States Geological Survey

Additionally, Table 5 outlines the unique identifiers associated with this project across the various project tracking systems. The systems listed below effectively track the entire lifecycle of LAMP studies.

Table 5: Project Tracking and Identification Information

Project Tracking Method	Project Identifier
P4 Project and Purchase ID	Not assigned
Mapping Information Platform Case Number	14-02-2536S – REG - Keansburg (Non-Accredited Levee Analysis) - FY11 - Monmouth_NJ
LAMP Study Project Tracker (LAMP_ID)	R2NJ
Levee Database Segment IDs	12010056, 12010058, 120100059 – Keansburg Levee 12010057 – Keansburg Levee East
FIRM Panels and Effective Date	34025C0029G – September 25, 2009 34025C0034G – September 25, 2009 34025C0037G – September 25, 2009 34025C0042G – September 25, 2009 34025C0055G – September 25, 2009 34025C0061G – September 25, 2009

2.2 Stakeholder Coordination and Data Collection Meeting

Following the stakeholder engagement process, FEMA held a meeting on February 5, 2014 at the Middletown Arts Center located at 36 Church Street, Middletown, 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 information, and the FEMA process for analyzing and mapping flood hazards landward of non-accredited levee systems. Detailed lists of attendees, agendas, and meeting minutes are included in Appendix C.

Based on the discussion during this meeting, several stakeholders were identified as potential members of an LLPT, as shown in Table 6. The primary function of the LLPT is to provide feedback and, if necessary, additional data, information, or documentation.

Table 6: Potential Local Levee Partnership Team Participants

LLPT Member	Contact Information	Agreed to Participate in the LLPT?
Robert Burlew Floodplain Manager Construction Official Zoning Officer Union Beach	732-526-8687	Y
Raymond B. OHare Borough Manager Keansburg	732-787-0215 ext. 201	Y
Edward P. Striedl Floodplain Administrator Keansburg	732-787-0215 ext.228	Y
Fran Mullan Borough Engineer Keansburg	732-787-0215	Y

3. Initial Data Analysis

The initial analysis, also called first pass analysis, was designed to generate a number of approximate flooding scenarios associated with possible weak points in the protection system. Input information and data were provided by stakeholders and the LLPT. 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 two-dimensional (2D) flood routing software FLO-2D was used during the first pass analysis to determine the spatial extent of the floodplain and maximum depth of water throughout the model domain for each flooding scenario. Six potential flood sources were selected based on survey data, field reconnaissance, damage reports, and LiDAR topographic data. They are summarized in Table 7, and graphically represented in relation to the first pass model domain in Figure 4. Details on the model inflows, including calculations and data, can be found in Appendix E – Initial Data Analysis\1_Inflow_Computations.

Table 7: Summary of First Pass Analysis Flood Sources

Flood Source	Description of use in analyses
Navigation Gate	Floodwater entered domain through navigation gate while SWEL was lower than 4 feet NAVD88
Thornes Creek Levee Natural Low Point	Floodwater entered domain while SWEL was higher than local ground elevation
Thornes Creek Floodwall	Section of floodwall removed, floodwater entered domain while SWEL was higher than local ground elevation without floodwall
Pews Creek Floodwall	Section of floodwall removed, floodwater entered domain while SWEL was higher than local ground elevation without floodwall
Breach at Pews Creek	Simulated catastrophic breach of 150-foot-long damaged section of

Levee	levee, floodwater entered domain while SWEL was higher than local ground elevation in absence of levee
Dune Overtopping	Along entire dune line, overtopping due to wave runup on A) FEMA 540-rule eroded dunes, and B) 2012 post-Sandy LiDAR dunes

NAVD88 = North American Vertical Datum of 1988; SWEL = stillwater elevation; LiDAR =Light Detection and Ranging

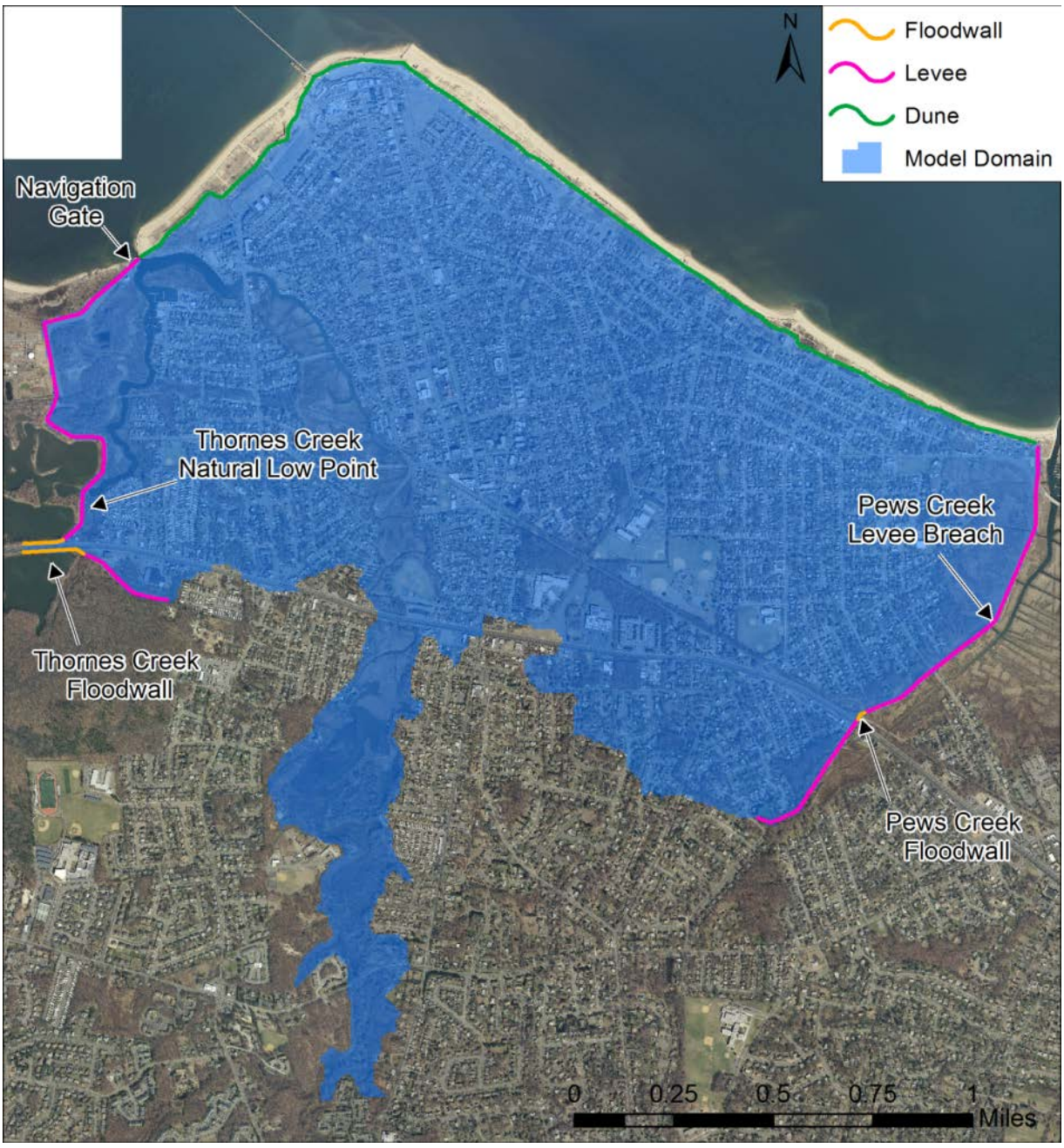

Figure 4: Model domain and locations of flood sources

Seven unique model runs were executed using FLO-2D modeling, each with different combinations of the inflows described in Table 7. Table 8 describes the configuration of inflows in each of those seven runs. The base model, upon which each of those inflow configurations

was executed, consists of a 50-foot-resolution grid covering the domain bounded by the beach dunes to the north, Pews Creek Levee to the east, Thornes Creek Levee to the west, and the 15-foot ground elevation contour to the south. The model domain is represented by the blue translucent polygon in Figure 4. Ground elevations were assigned to the 50-foot grid by interpolating 2014 U.S. Geological Survey (USGS) LiDAR data supplemented by levee crest elevations and top of floodwall elevations derived from an undated USACE survey. Since the model domain boundary sits at the approximate location of the dune crest along its northern boundary, the elevations along that boundary are controlled by the eroded dune calculated according to FEMA standard 540-rule methodology for all production runs except Run 6. The 2012 post-Sandy LiDAR supplied the dune elevations for Run 6. Details on topography and dune erosion modeling can be found in Appendix E – Initial Data Analysis\2_FLO-2D_Setup.

Table 8: Configuration of inflows in Each Model Production Run

Production Run No.	Navigation Gate	Thornes Natural Low Point	Removal of Thornes Floodwall	Removal of Pews Floodwall	Breach at Pews Creek Levee	Dune Overtopping
1	Closes at 4 feet	X				
2	Closes at 4 feet	X	X			
3	Closes at 4 feet	X		X		
4	Closes at 4 feet	X	X	X		
5	Closes at 4 feet	X			X	
6	Closes at 4 feet	X				Superstorm Sandy-Induced Erosion
7	Always closed					FEMA Standard Erosion

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. Buildings are represented in the model as obstructions to flow and surface flood storage reduction factors. Additional details on model setup can be found in Appendix E – Initial Data Analysis\2_FLO-2D_Setup.

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 maximum flood depth grids are not the greatest depth of flooding that could result, but instead depict the maximum depth of flooding according to the modeled conditions. These spatial data sets and maps do not contain any regulatory information and are not intended to represent an expectation of how future regulatory data will appear; rather, they are intended to provide information on the impacts from failure or compromise of the selected potential flood sources. The output from the first pass modeling will be used to inform future LAMP approaches and can

also be used to plan mitigation and emergency management activities. Modeling files and data can be found in Appendix E – Initial Data Analysis\3_FLO-2D_Runs.

The floodplains resulting from the production runs range from 0.38 square mile for Run 1 to 2.27 square miles for Run 7 and the Natural Valley. Figures showing the SWEL and depth grids resulting from each production run can be found in Appendix E – Initial Data Analysis\4_Mapping.

3.1 Natural Valley Modeling

The Natural Valley modeling represents the floodplain in the absence of any flood protection structures, and defines the spatial extent of Zone D derived from the LAMP process. The Natural Valley flooding was developed by extrapolating the preliminary FEMA 1-percent-annual-chance SWEL across the study domain, and removing any influence of protection structures. The Natural Valley floodplain contains approximately 5,605 structures and covers 2.27 square miles. Figure 5 shows that the SWEL of the Natural Valley scenario has a very tight range, from approximately 10.8 to 12 feet North American Vertical Datum of 1988 (NAVD88). The flood depth across the study domain resulting from the Natural Valley is shown in Figure 6.

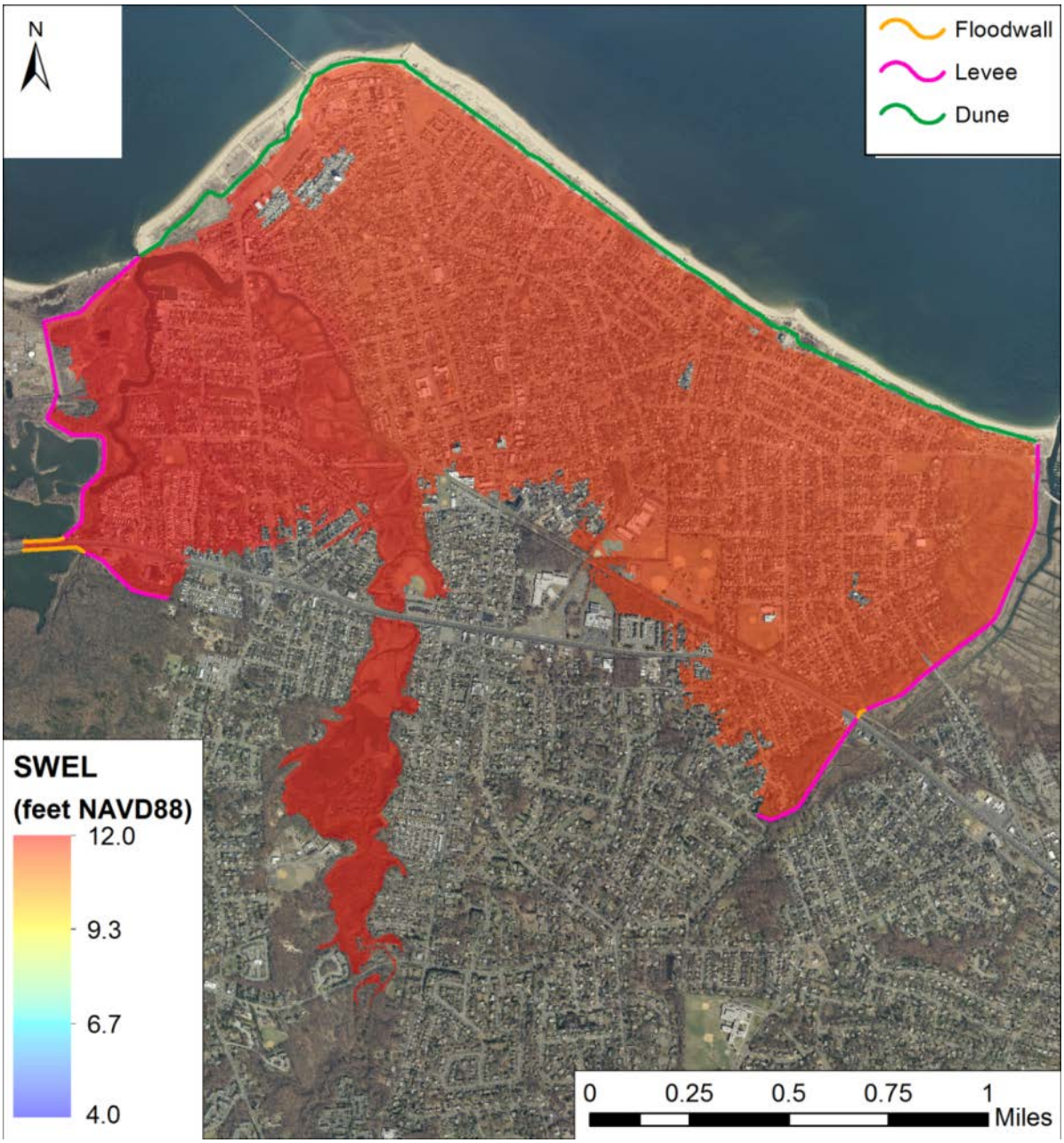

Figure 5: Natural Valley stillwater elevation [Imagery: NJOIT, 2013]

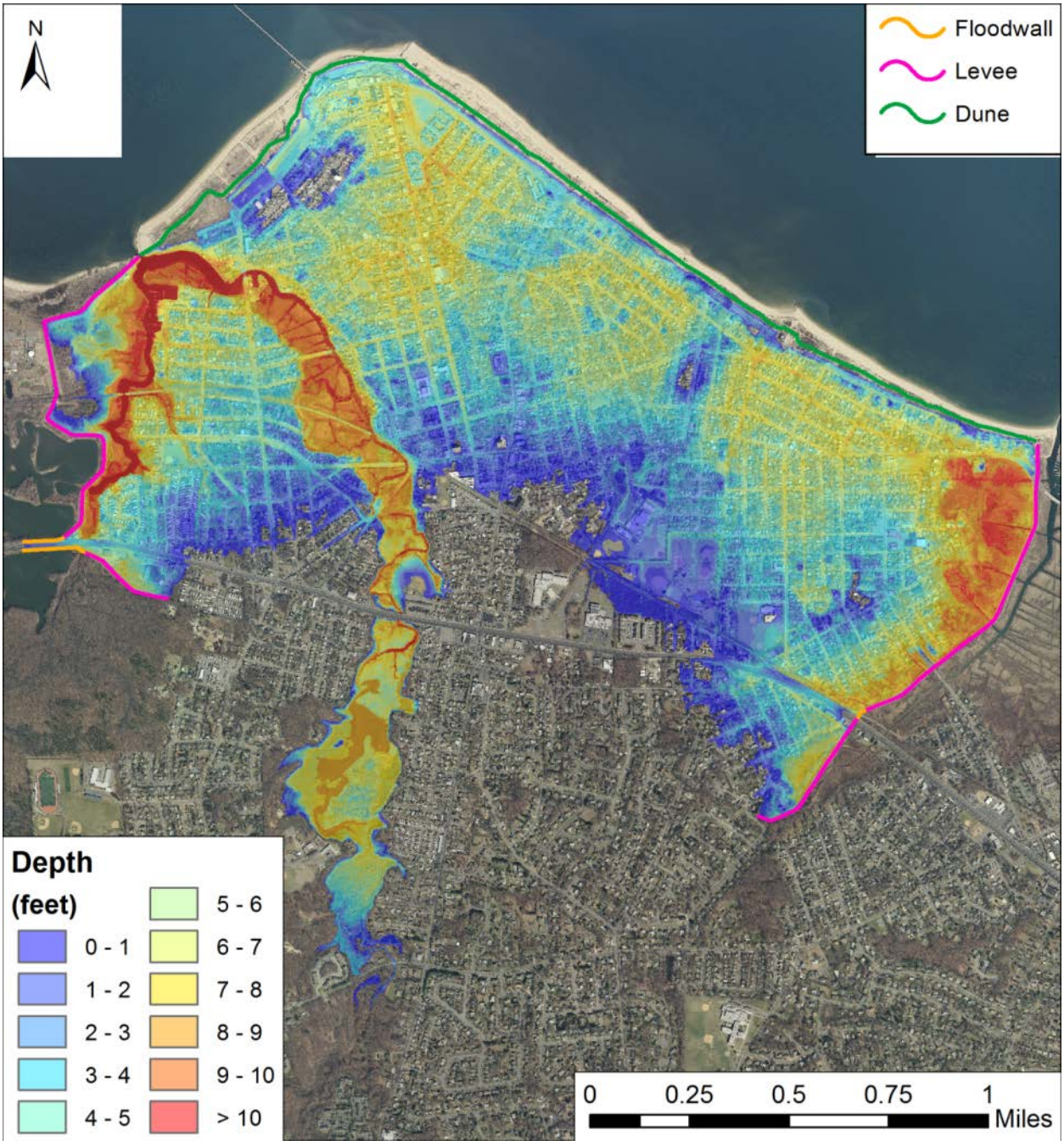

Figure 6: Flood depth resulting from Natural Valley [Imagery: NJOIT, 2013]

4. Local Levee Partnership Team

An LLPT was formed to provide data and input to FEMA. The LLPT also offered guidance on the creation of levee reaches and the procedures to be used for analyzing and mapping the reaches based on local levee conditions. The stakeholders that participated in the LLPT for this project are listed in Table 9. Additional information on the LLPT participants and the meetings held with the LLPT members is provided in Appendix C.

Table 9: Local Levee Partnership Team Participants

Participant	Title	Contact Information	Meetings Attended
Robert Burlew	Floodplain Manager Construction Official Zoning Officer Union Beach	Adult School at 1205 Florence Ave Union Beach, NJ 07735 732-526-8687	October 7, 2014: Kickoff LAMP Meeting (In person) February 5, 2015: Meeting and Field Visit (in person) December 2015: Meeting (in person)
Raymond B. OHare	Borough Manager Keansburg	29 Church Street, Keansburg NJ 07734 732-787-0215 ext. 201	October 7, 2014: Kickoff LAMP Meeting (In person) February 5, 2015: Meeting and Field Visit (in person)
Edward P. Striedl	Floodplain Administrator Keansburg	29 Church Street Keansburg, NJ 07734 732-787-0215 ext. 208	October 7, 2014: Kickoff LAMP Meeting (In person) February 5, 2015: Meeting and Field Visit (in person) December 2015: Meeting (in person)
Fran Mullan	Borough Engineer Keansburg	29 Church Street Keansburg, NJ 07734 732-787-0215	October 7, 2014: Kickoff LAMP Meeting (In person) February 5, 2015: Meeting and Field Visit (in person)

Issues discussed during the first LLPT meeting held on October 7, 2014 included:

- What level of protection does the PFD provide as part of the entire levee system?
- Why is flooding shown on the FIRMs when Superstorm Sandy did not affect these structures on the eastern portion of the levee system? Middletown had one community that has never flooded, and the pump has worked perfectly in the past, but the maps are not reflecting that. The people living in the community should benefit on their insurance for this.
- Communities want to protect homes in a cost-efficient manner. The sea level is rising and taking out more land. Communities want to better protect the homes behind the flood control system. This can be a long-term goal, and we want to do more than protect for just the 100-year flood.
- Community officials want the opportunity to provide municipal input and make sure the best available data and assumptions are being used and accurately reflect real life experiences. Communities want to understand the information being used and the expected results, initial potential consequences—both practical and financial, and the roles each stakeholder plays before the results are finalized,
- The community is concerned that people build according to mapped flooding, but then the maps change later, similar to the recent history of Louisiana building development.

People are walking away from their homes in the Bayshore area, which is bad for the communities.

Issues discussed during the first LLPT meeting held on February 5, 2015 include:

- Stakeholders want to know the cost implications to the residents and the municipality. If they built to the 1960s levels, how do they get to higher levels of protection? Discussion on the levees being built to 1960s standards took place.
- Concerns that the PFD does not meet FEMA's 540 rule as discussed in 44 CFR Sections 59.1 and 65.11.

Items discussed during the final LLPT meeting held on December 9, 2015 include:

- The results of the Phase 1 first pass analysis were presented to the LLPT and community stakeholders, and discussed during a pre-meeting conference call and again at the meeting. The analysis methods and results can be found in Appendix E of this document.
- The community expressed concern about the timeline and uncertainty of the LAMP project, and that the outcome may include higher insurance premiums for some residents.
- The group discussed alternative approaches to long-term solutions to the stakeholders' concerns, including the pursuit of a legislative change and the prospect of the USACE conducting a detailed risk-based analysis levee study.
- FEMA provided the stakeholders with information on the requirements for Sound Reach, Freeboard Deficient, and Overtopping classification of the levees during LAMP Phase 2, which include a stamped engineering analysis showing that the structures will withstand the 1-percent-annual-chance event.
- The dunes were discussed with regard to erosion analysis techniques approved by FEMA, and potential alternative approaches. The first pass analyses underscored the importance of the dunes as a line of defense against the base flood and revealed that an alternate erosion analysis could significantly change the base flood calculations within the study area.

5. Path Forward

The next steps in the LAMP process are to continue coordinating with the LLPT and stakeholders while refining the technical approach according to community feedback and the intended course of action. Depending on the stakeholders' ability to generate or obtain all of the engineering documentation required for certain LAMP technical approaches, the path forward may change. The following sections describe the procedures discussed at the final Phase 1 LLPT meeting based on currently available data and information.

5.1 Potential Reach Approaches

Two sources of detailed topographic data describing the elevation of the flood protection system were received during Phase 1: an undated USACE survey and as-built drawings of a repaired

segment of the Pews Creek Levee. The spatial coverage of these two sources is shown graphically in Figure 7 below. The as-built drawings showing that the Pews Creek Levee damage has been repaired potentially eliminates the “Breach at Pews Creek Levee” flood source used in Production Run 5 of the first pass analysis.

The dune crest survey portion of the original USACE survey data is excluded from this discussion because the LAMP-specific approaches discussed below apply only to levees and floodwalls. However, the dunes are an integral part of the flood protection system and their consideration is critical in the determination of the base flood hazard in this area.

Figure 7: Top of levee/top of floodwall data coverage

Figure 8 shows potential classifications of various levee reaches and floodwalls based on a comparison of the surveyed crest elevation against the local 1-percent-annual-chance stillwater elevation produced during the preliminary FIS. However, these classifications are based solely on elevation requirements and do not account for the additional documentation required for the flood protection system to qualify for the Freeboard Deficient, and Overtopping classifications, including operations and maintenance plans, inspection reports, and certification that the structures meet structural design requirements. Note that FEMA has received an operation and maintenance plan for the flood protection system (USACE, 1976).

Figure 8: Reach classification based on freeboard requirements; note that final reach classification is dependent on additional documentation

5.2 Model Refinements

The FLO-2D model generated during Phase 1 was designed to be expanded and supplemented as additional data and information become available in Phase 2. While the Phase 1 model was used to show the impacts of particular flood sources and vulnerabilities of the flood protection system, refinements should be made prior to the production of FIRMs. Refining the FLO-2D model could involve the following:

- Include riverine flow data for Thornes Creek, Pews Creek, and Waackaack Creek
- Include rainfall data in the study area
- Produce alternate dune erosion modeling, if allowable
- Include pumping system
- Develop a higher resolution grid

5.3 Schedule

The schedule is dependent on the availability of additional data from the community. For the tentative project path, please refer to Figure 9. This schedule does not include Phase 2 activities.

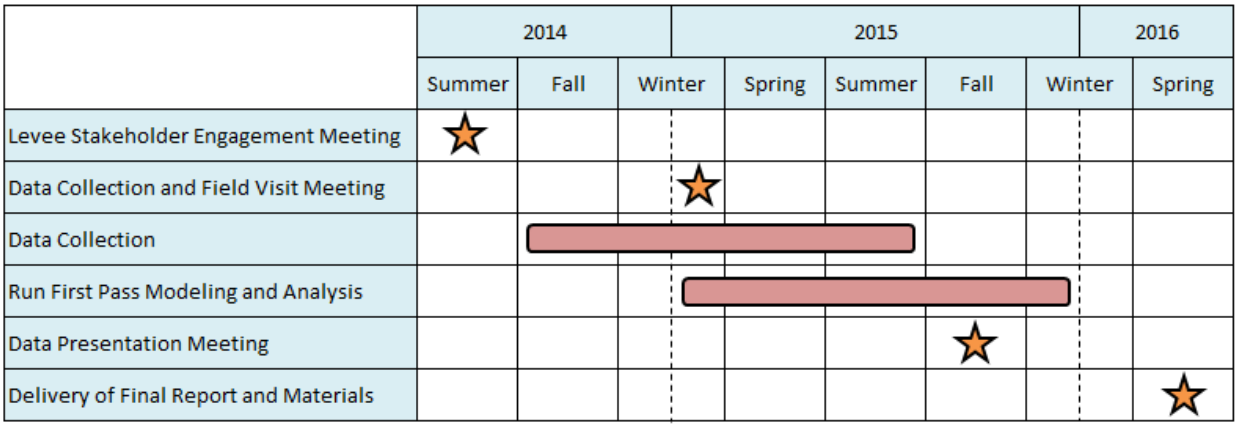

Figure 9: Bayshore LAMP Project Schedule

6. References

Department of the Army, New York District, Corps of Engineers. Raritan Bay and Sandy Hook Bay New Jersey Beach Erosion and Hurricane Project, Keansburg Section: Operation and Maintenance Manual. July, 1976. New York, New York.

Federal Emergency Management Agency (FEMA), 2014. Preliminary Flood Insurance Study, Monmouth County, New Jersey.

FEMA, 2013. Operating Guidance 12-13: Non-Accredited Levee Analysis and Mapping Guidance.

NJ Office of Information Technology (NJOIT), Office of Geographic Information Systems (May 8, 2013). New Jersey 2012-2013 High Resolution Orthophotography. Trenton, NJ.

7. 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

- Community Stakeholder Contact Information
- Meeting Invitations and Notification
- Meeting Agenda
- Meeting Notes
- Meeting Presentation

Appendix D – Collected Data

- Historical Data
- As-built drawings
- Field Reconnaissance Photos

Appendix E – Initial Data Analysis

- 1_Inflow_Computations
- 2_FLO-2D_Setup
- 3_FLO-2D_Runs
- 4_Mapping

Appendix F – Exhibits for Keansburg and Keansburg East Levee

- Effective FIRMS
- Meeting Exhibits
- Preliminary FIRMS
- Received information