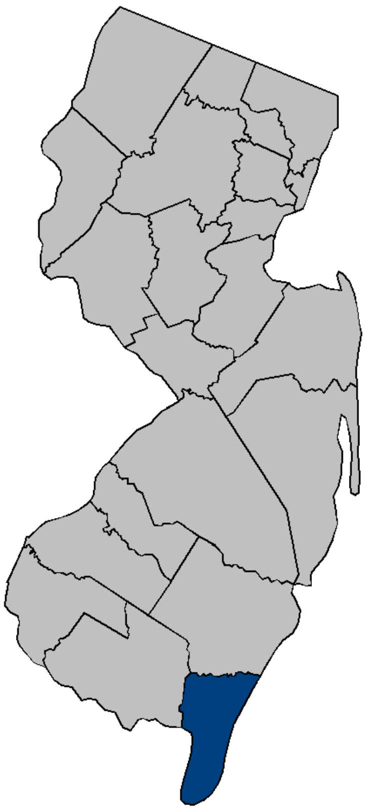
FLOOD INSURANCE STUDY

FEDERAL EMERGENCY MANAGEMENT AGENCY

VOLUME 1 OF 1



CAPE MAY COUNTY, NEW JERSEY (All Jurisdictions)

COMMUNITY NAME	COMMUNITY NUMBER
AVALON, BOROUGH OF	**345279**
CAPE MAY, CITY OF	**345288**
CAPE MAY POINT, BOROUGH OF	**345289**
DENNIS, TOWNSHIP OF	**340552**
LOWER, TOWNSHIP OF	**340153**
MIDDLE, TOWNSHIP OF	**340154**
NORTH WILDWOOD, CITY OF	**345308**
OCEAN CITY, CITY OF	**345310**
SEA ISLE CITY, CITY OF	**345318**
STONE HARBOR, BOROUGH OF	**345323**
UPPER, TOWNSHIP OF	**340159**
WEST CAPE MAY, BOROUGH OF	**340160**
WEST WILDWOOD, BOROUGH OF	**345328**
WILDWOOD, CITY OF	**345329**
WILDWOOD CREST, BOROUGH OF	**345330**
WOODBINE, BOROUGH OF	**340164**

U.S. DEPARTMENT OF HOMELAND SECURITY

FEMA

Preliminary: **June 30, 2014**

FLOOD INSURANCE STUDY NUMBER
34009CV000A
Version Number 1.0.0.0

NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for floodplain management and flood insurance purposes. This Flood Insurance Study (FIS) may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

The Federal Emergency Management Agency (FEMA) may revise or republish part or all of this FIS report at any time. In addition, FEMA may be revise part of this FIS report by the Letter of Map Revision process, which does not involve republication or redistribution of the FIS report. Therefore, users should consult with community officials and check the Community Map Repository to obtain the most current FIS report components.

Selected Flood Insurance Rate Map panels for this community contain information that was previously shown separately on the corresponding Flood Boundary and Floodway Map panels (e.g., floodways and cross sections). In addition, former flood hazard zone designations have been changed as follows:

Old Zone	New Zone
A1 through A30	AE
V1 through V30	VE
B	X
C	X

Initial Countywide FIS Effective Date:

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FLOOD INSURANCE STUDY
CAPE MAY COUNTY, NEW JERSEY (ALL JURISDICTIONS)

1.0 INTRODUCTION

1.1 Purpose of Study

This countywide Flood Insurance Study (FIS) investigates the existence and severity of flood hazards in, or revises and updates previous FISs/Flood Insurance Rate Maps (FIRMs) for the geographic area of Cape May County, New Jersey, including the Boroughs of Avalon, Cape May Point, Stone Harbor, West Cape May, West Wildwood, Wildwood Crest, and Woodbine; the Cities of Cape May City, North Wildwood, Ocean City, Sea Isle City, and Wildwood; and the Townships of Dennis, Lower, Middle, and Upper; (hereinafter referred to collectively as Cape May County)

This FIS aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This FIS has developed flood risk data for various areas of the county that will be used to establish actuarial flood insurance rates. This information will also be used by Cape May County officials to update existing floodplain regulations as part of the Regular Phase of the National Flood Insurance Program (NFIP), and will also be used by local and regional planners to further promote sound land use and floodplain development. Minimum floodplain management requirements for participation in the NFIP are found in Title 44 of the Code of Federal Regulations (CFR), Section 60.3.

In some States or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the State (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this FIS are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

This FIS was prepared to include all jurisdictions within Cape May County into a countywide format. Information on the authority and acknowledgments for each jurisdiction included in this countywide FIS, as compiled from their previously printed FIS reports, is shown below.

Cape May Point, Borough of:	The coastal storm surge and wave height analysis was prepared by Dewberry & Davis under agreement with the Federal Emergency Management Agency (FEMA). That work was completed in March 1994.

Lower, Township of:	The coastal storm surge and wave height analysis was prepared by Tippetts-Abbett-McCarthy-Stratton and the New Jersey Department of Environmental Protection (NJDEP), Division of Water Resources, Bureau of Floodplain Management, for FEMA, under Contract No. S-90022. That work was completed in December 1980.
North Wildwood, City of:	For the original July 1982 FIS, the coastal storm surge and wave height analysis was prepared by Century Engineering, Inc. For the February 16, 1996, revision, the analysis was prepared by the U.S. Army Corps of Engineers (USACE), Philadelphia District, for FEMA, under Inter-Agency Agreement No. EMW-92—E-3839, Project Order No. 5, Amendemnt No. A. That work was completed in February 1994.
Ocean City, City of:	The wave height analyses for the FIS were prepared by Dewberry & Davis for FEMA, under Contract No. EMW-C-0543. That work was completed in November 1983.
Upper, Township of:	The wave height analysis for the FIS was prepared by Dewberry & Davis for FEMA, under Contract No. EMW-C-0543. That work was completed in March 1983.
West Cape May, Borough of:	The coastal storm surge and wave height analysis for the FIS was prepared by Tippetts-Abbett-McCarthy-Stratton and the NJDEP, Division of Water Resources, Bureau of Floodplain Management, for FEMA, under Contract No. S-90022. That work was completed in December 1980.
Wildwood, City of:	For the July 1982 FIS, the analysis was prepared by Century Engineering, Inc., for FEMA. For the February 16, 1996, revision, the analysis was prepared by the USACE, Philadelphia District, for FEMA, under Inter-Agency Agreement No. EMW-92-E-3839, Project Order No. 5, Amendment No. A. That work was completed in February 1994.

Wildwood Crest, Borough of:	For the original July 1982 FIS, the analysis was prepared by Century Engineering, Inc., for FEMA. For the February 16, 1996, revision, the analysis was prepared by the USACE, Philadelphia District, for FEMA, under Inter-Agency Agreement No. EMW-92-E-3839, Project Order No. 5, Amendment No. A. That work was completed in February 1994.

The authority and acknowledgements for the FIS Wave Height Analysis for the Boroughs of Avalon and Stone Harbor and the Cities of Cape May and Sea Isle City were taken from "Phase I General Design Memorandum Cape May Inlet to Lower Township" (USACE 1980). There are no previous FISs for the Boroughs of West Wildwood and Woodbine and the Townships of Dennis and Middle.

For the [*date*] countywide FIS, updated coastal storm surge and wave height analysis has been performed for the entirety of the Cape May County shoreline. Flood hazard areas previously assessed by approximate methods were reanalyzed throughout the county, with results mapped using the updated topographic data provided to FEMA by the U.S. Geological Survey (USGS) and the NJDEP. This work was performed for FEMA by Risk Assessment, Mapping, and Planning Partners (RAMPP), a joint venture of Dewberry & Davis LLC, URS Group Inc., and ESP Associates. This work was completed in September 2013.

Base map information for this FIRM was developed from high-resolution orthophotography provided by the State of New Jersey. This information was derived from digital orthophotos produced at a scale of 1:2,400 with a 1-foot pixel resolution from photography dated 2012.

The projection used for the production of this FIRM is the New Jersey State Plane (FIPS 2900). The horizontal datum was North American Datum of 1983, GRS80 spheroid. Differences in the datum, spheroid, projection, or State Plane zones used in the production of FIRMs for adjacent counties may result in slight positional differences in map features at the county boundaries. These differences do not affect the accuracy of information shown on the FIRM.

1.3 Coordination

Consultation Coordination Officer's (CCO) meetings may be held for each jurisdiction in this countywide FIS. An initial CCO meeting is typically held with representatives of FEMA, the community, and the study contractor to explain the nature and purpose of an FIS, and to identify the streams to be studied by detailed methods. A final CCO meeting is typically held with representatives of FEMA, the community, and the study contractor to review the study results.

The dates of the initial and final CCO meetings held for jurisdictions within Cape May County are shown in Table 1, "Initial and Final CCO Meetings."

TABLE 1 – INITIAL AND FINAL CCO MEETINGS

Community	Initial CCO Date	Final CCO Date
Borough of Avalon	*	*
City of Cape May	*	*
Borough of Cape May Point	May 3, 1994[1]	*
Township of Dennis	*	*
Township of Lower	October 14, 1977	March 24, 1982
Township of Middle	*	*
City of North Wildwood	April 29, 1994[1]	July 26, 1994
City of Ocean City	*	April 5, 1983
City of Sea Isle City	*	*
Borough of Stone Harbor	*	*
Township of Upper	*	April 5, 1983
Borough of West Cape May	October 14, 1977	February 19, 1982
Borough of West Wildwood	*	*
City of Wildwood	April 29, 1994[1]	July 26, 1994
Borough of Wildwood Crest	April 29, 1994[1]	July 26, 1994
Borough of Woodbine	*	*

*Data not available
[1]Notified by letter

Initial CCO meetings for the [*date*] FIS were held on September 29, 2010, with representatives of the NJDEP, FEMA, RAMPP, and local officials. Flood Risk Review Meetings were held on November 13, 2013.

2.0 AREA STUDIED

2.1 Scope of Study

This FIS covers the geographic area of Cape May County, New Jersey.

All or portions of the Atlantic Ocean and Delaware Bay were studied by detailed methods. The areas studied were selected with priority given to all known flood hazard areas and areas of projected development and proposed construction. Coastal flooding including its wave action from the Atlantic Ocean and Delaware Bay was studied by detailed methods; which includes updated coastal storm surge and wave height analysis.

All or portions of numerous flooding sources (riverine and lacustrine) in the county were studied by approximate methods. Approximate analyses were used to study those areas having a low development potential or minimal flood hazards, or where resources were unavailable to conduct more refined and detailed analyses. For this revision, all areas of approximate riverine flood hazard analyses were updated using topography and the flood frequency estimation techniques developed by the USGS. Approximate lacustrine flood hazard analyses were prepared using rainfall runoff modeling conducted for this countywide project, as well as other analyses conducted.

The scope and methods of study were proposed to, and agreed upon by the NJDEP, FEMA, and the communities of Cape May County.

2.2 Community Description

Cape May County is located in the southeastern portion of the State of New Jersey. It is bordered on the north by Atlantic County and to the west by Cumberland County.

According to the 2010 U.S. Census, the population for Cape May County was 97,265 and the land area was 251.43 square miles (U.S. Census Bureau, 2010).

The climate of Cape May County is influenced by its location on Delaware Bay and the Atlantic Ocean. The mean annual temperature is approximately 55 degrees Fahrenheit (°F), with extremes varying from -12°F to 105°F. The average annual precipitation is approximately 46 inches and is evenly distributed throughout the year.

2.3 Principal Flood Problems

The history of flooding within Cape May County indicates that major floods can occur during any season of the year, particularly in the late summer and fall, when high tides are generated in Delaware Bay and along the Atlantic coastline. Flooding occurs from tropical storms, extratropical cyclones and, to a lesser extent, severe thunderstorm activity. Most serious tidal flooding problems are attributed to hurricanes, which occur during the late summer and early autumn. In addition to heavy precipitation, hurricanes produce high tides and strong waves, which can result in severe damage to coastal areas. Although extratropical cyclones, referred to as northeasters, can develop at almost any time of the year, they are more likely to occur during the winter and spring. Thunderstorms are a common occurrence during the summer months.

<u>September 14, 1944</u>

The Great Atlantic Hurricane of 1944 struck the entire shoreline of New Jersey with wind velocities ranging from 90 mph at Atlantic City to over 100 mph in New York City. During the passage of this storm, many communities reported extremely high tides.

November 25, 1950

The Great Appalachian Storm of November 1950 caused severe flood occurred on Thanksgiving Day. This strong northeaster struck the entire shoreline of New Jersey with gale force winds and more than 3 inches of rainfall.

March 6-8, 1962

This northeaster, also known as The Ash Wednesday Storm, was one of the most memorable storms to strike the shoreline in recent years. This storm struck the entire coastline of New Jersey with gale force winds, extremely high tides and heavy precipitation in the form of wet snow. Generating winds of 70 mph, this northeaster remained in the study area for 60 hours. The unusually long duration coincided with five successive high spring tides. Along the river front, many docks were under water for several days. Severe flooding conditions, not only in the study area but along the entire coastline of New Jersey, resulted from the high storm water, waves and gale force winds.

August 26-28, 1971

A heavy frontal storm in combination with Tropical Storm Doria produced the greatest flooding in the area. This storm caused the President to declare New Jersey a National Disaster Area. An extensive high water mark survey was conducted jointly by the State of New Jersey and the USGS following Doria. These data are on file with the Division of Water Resources.

The August 1971 flood resulted from heavy antecedent rainfall in the morning and afternoon of August 27 followed by precipitation associated with the passage of Tropical Storm Doria across New Jersey in the evening of August 27 and early-morning hours of August 28. On August 26-28, 1971, intense thunderstorm activity followed by the passage of Tropical Storm Doria brought heavy precipitation to south-central, central, and northeast New Jersey for 32 hours. Total storm rainfall amounts during a 32-hour period ranged from about 3 to over 11 inches across New Jersey. Storm runoff increased rapidly to peak flows greater than previously experienced prior to August 1971 recorded at 47 stream gaging stations in New Jersey.

A breach in the dune located on the property of YARA Engineering has resulted in frequent flooding of the area extending north from Mt. Vernon Avenue through Sunset Boulevard (FEMA, Township of Lower, 1982).

September 22, 1992

Tropical Storm Danielle dropped light rain fall across much of New Jersey. The southwest portion of the state experienced over 3 inches of rain. The storm washed out miles of beaches along the coastline.

December 11, 1992

A northeaster struck the New Jersey shoreline with winds reaching 90 miles per hour.

September 16, 1999, August 28, 2011 and October 29, 2012

Special consideration was given to storms which caused damages to the area in recent years, including Hurricane Floyd in 1999, Hurricane Irene in 2011, and Hurricane Sandy in 2012 (FEMA, 2013).

Hurricane Floyd originally made landfall in Cape Fear, North Carolina as a Category 2 hurricane on September 16, 1999. The storm crossed over North Carolina and southeastern Virginia, before briefly entered the western Atlantic Ocean. The storm reached New Jersey on September 17, 1999 and the recorded storm tide at Cape May was 4.1 feet (NAVD88). Record breaking flooding was recorded throughout the State of New Jersey. The Raritan River basin experienced record floods of up to 4.5 ft. higher than any previous record flood crest. The areas of Bound Brook and Manville were especially hit hard. A Federal Emergency Declaration was issued on September 17, 1999. Overall damage estimates for Hurricane Floyd, in the State of New Jersey are estimated around $250 million and damages in Cape May County are estimated at $492,000.

Having earlier been downgraded to an extra-tropical storm, Hurricane Irene came ashore in Little Egg Inlet in Southern New Jersey; on August 28, 2011. In anticipation of the storm Governor Chris Christy declared a state of emergency of August 25th, with President Obama reaffirming the declaration on August 27th. Mandatory evacuations were ordered throughout all of Cape May County. Wind Speeds were recorded at 75 mph and rain totals reached over 10 inches in many parts of the state. The recorded storm tide in Cape May was 5.5 feet (NAVD88). Overall damage estimates, for the State of New Jersey, came to over $1 billion; with over 200,000 homes and buildings being damaged.

Hurricane Sandy came ashore as an immense tropical storm in Brigantine, New Jersey, on October 29, 2012. Sandy dropped heavy rain on the area; almost a foot in some areas. Wind gusts were recorded at 90 mph. A full moon made the high tides 20 percent higher than normal and amplified the storm surge. The New Jersey shore suffered the most damage. Some barrier island communities suffered severe “wash over” including the creation of two temporary inlets. Cape May County had moderate damage in coastal areas but not nearly as bad as areas further north. The recorded storm tide at Cape May was 5.8 feet (NAVD88). NOAA’s gage #8534720 at Atlantic City, NJ; the high water mark (which is considered as a stillwater elevation without waves) was 6.3 ft. NAVD88 at 10:24 PM on October 29, 2012 and NOAA’s gage #8531680 at Sandy Hook, NJ; the high water mark (which is considered as a stillwater elevation without waves) was 10.4 ft NAVD88 at 7:36 PM on October 29, 2012. Seaside communities were damaged and destroyed up and down the coastline. Initial reports suggest that well over 24,000 homes and businesses were damaged or destroyed by the storm.

Governor Chris Christy declared a state of emergency on October 31. Hurricane Sandy is estimated to cost the State of New Jersey over $36 billion.

Low-lying areas of the county are subject to inundation by high tides from Delaware Bay and the Atlantic Ocean.

2.4 Flood Protection Measures

Shore protection measures in the form of seawalls, stone revetments, bulkheads, jetties, and groins have been employed to prevent abnormally high tides from flooding and eroding the county's developed shoreline areas.

In the Borough of Avalon, the northern portion of the community is protected by a series of bulkheads, revetments, groins, and jetties that span from the Townsend Inlet to the vicinity of 16th Street. For the community overall, especially south of 37th Street, the extensive dune system, consisting of primary and secondary dunes and thicket, serves as a protective barrier against the transmission of waves inland. The primary dunes, which are anchored by beach grass and lie closest to the shoreline, cannot be considered stable in nature. The secondary dunes further inland, are considered more stable as a consequence of their large spatial extent, the dissipation of wave energy attributable to the primary dunes or man-made structures, and the erosion protection afforded by the existence of vegetation.

The City of Cape May beachfront area is protected by a timber bulkhead (mostly on the southwestern end) and a stone seawall spanning most of the central beachfront and the western extremity.

In the Township of Lower, these structures are most effective along the Delaware Bay shoreline and effectively protect the township from wave attack. The Lower Township Planning Board is aware of the necessity to properly regulate development in areas prone to flooding and has employed ordinance controls to minimize potential damage to life and property.

In the City of North Wildwood, a stone and concrete seawall/revetment spans the shoreline along Hereford Inlet. Little to no beach exists to buffer the seawall from wave attack. The seawall's height is insufficient to prevent wave overwash during runup, and may even allow the propagation of waves. The seawall's condition is suspect. It is, therefore, an ineffective barrier to wave attack during the 1-percent annual-chance storm. The timber bulkhead between 13th Street and 17th Street, and the boardwalk beginning south of 16th Street and continuing the length of North Wildwood, are also inadequate wave barriers during a 1-percent annual chance storm.

The City of Sea Isle City's beachfront area is protected by a series of dune formations in conjunction with a seawall, which contributes to the dissipation of wave energy. The fairly dense structural development, especially in the central and southern portions of the city, also impedes wave action.

The Borough of Stone Harbor's beachfront is protected by a continuous system of timber bulkheads, which spans from 80th Street south to the proposed location of 127th Street. Revetment has also been constructed from 80th Street to 114th Street.

In the Borough of West Cape May, the USACE developed a protection of the beach at South Cape May, which lies south of the borough. The plan included the construction and maintenance of groins, the establishment of a berm on the beach, and the periodic nourishment of the dune and beaches. This plan has been executed and the dune and sandy beach are formed to protect the beach.

In the Borough of Wildwood Crest, the bulkhead between Rambler Road and the corporate limit was found to be effective in protecting against wave action, although its height was considered to be inadequate to protect from overwash and spray.

A number of man-made structures commonly called agricultural or salt-hay levees have been identified in this county. The inventory of these structures is detailed in a report (South Jersey Levee Inventory, 2010) developed by the United States Department of Agriculture (USDA), National Resource Conservation Service (NRCS) for the New Jersey Department of Environmental Protection (NJDEP).

However, these structures were studied and found to not provide protection from the 1-percent annual chance flood. There is a potential that these structures may increase local flood hazard due to higher velocity flows during a large flood event as they overtop, and may lead to increased time of inundation by retaining flood waters for an extended period. Local conditions should be assessed for this potential for increased flood hazard and appropriate mitigation measures are recommended.

More information on the non-levee structures located in this county may be found in the "South Jersey Levee Inventory" published in November, 2010 by the NRCS and the NJDEP, Bureau of Dam Safety and Flood Control.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the county, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this FIS. Flood events of a magnitude which are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long-term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (1-percent chance of annual exceedence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the county at the time of completion of this FIS. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Riverine Hydrologic Analyses

There are no detailed riverine flooding sources studied within the county.

3.2 Riverine Hydraulic Analyses

***Approximate* (A) "A Zones":** This category is assigned where "unnumbered" A Zones are shown on the effective maps, but the anticipated level of development does not warrant the collection of field survey; or where communities have requested an approximate study where there was currently no study at all. The desktop analysis approach to be applied to approximate studies is defined in Appendix C, Section 4.3 of FEMA's *Guidelines and Specifications for Flood Hazard Mapping Partners*. The level of effort includes orthophoto collection, Light Detection and Ranging (LiDAR) and stream breakline collection, use of engineering drawing plans and Department of Transportation studies (where appropriate and available), nomination of flow rates, and the development of Hydrologic Engineering Centers - River Analysis System hydraulic models.

The hydraulic analyses for this FIS were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if channel conveyance areas and hydraulic structures remain unobstructed, operate properly, and do not fail.

There are no detailed riverine flooding sources studied within the county.

3.3 Coastal Analysis

Prior to the [*date*] countywide FIS, some of the jurisdictions within Cape May County had a previously printed FIS report. Note that these analyses are now superseded by the revised coastal hydrodynamic analysis discussed in this section.

For the [*date*] countywide FIS, the FEMA Region II office initiated a study in 2009 to update the coastal storm surge elevations within the States of New York and New Jersey, including the Atlantic Ocean, Barnegat Bay, Raritan Bay, Jamaica Bay, Long Island Sound, and their tributaries. The study replaces outdated coastal analyses, as well as previously published storm surge stillwater elevations for all FIS Reports in the study area, including Cape May County, New Jersey, and serves as the basis for updated FIRMs. The coastal study for the New Jersey Atlantic Ocean coast and New York City coast was conducted for FEMA by RAMPP under contract HSFEHQ-09-D-0369 task order HSFE02-09-J-0001.

The regional storm surge modeling system includes the Advanced Circulation Model for Oceanic, Coastal, and Estuarine Waters (ADCIRC) for simulation of 2-dimensional hydrodynamics. ADCIRC was dynamically coupled to the unstructured numerical wave model Simulating WAves Nearshore (unSWAN) to calculate the contribution of waves to total storm surge (RAMPP, 2013). The resulting model system is typically referred to as SWAN+ADCIRC. A seamless modeling grid was developed to support the storm surge modeling efforts. The modeling system validation consisted of a comprehensive tidal calibration, followed by a validation using carefully reconstructed wind and pressure fields for six major flood events affecting the region: the 1938 hurricane, the Great Atlantic Hurricane of 1944, Hurricane Donna, Hurricane Gloria, and two extra-tropical storms from 1984 and 1992. Model skill was assessed by a quantitative comparison of model output to wind, wave, water level, and high-water mark observations. The model was then used to simulate 30 historical extra-tropical storms and 159 synthetic hurricanes to create a synthetic water elevation record from which the 10-, 2-, 1-, and 0.2-percent-annual-chance of exceedence elevations were determined.

Wave setup is the increase in mean water level above the still water level due to momentum transfer to the water column by waves that are breaking or otherwise dissipating their energy (Dean et al., 2005). For the New York and New Jersey surge study, wave setup was determined directly from the SWAN+ADCIRC model. The total stillwater elevation (SWEL), which includes wave setup, was then used for the erosion and overland wave modeling.

For the western coast of Cape May County, starting north of the Intracoastal Waterway on the Delaware Bay, the storm surge study conducted for FEMA Region III was used to supplement the data. Similar to the study in FEMA Region II, a coastal flooding analysis was performed to establish the frequency peak elevation relationships for this portion of Cape May County. The end-to-end storm surge modeling system in Region III again made use of the coupled surge and wave model SWAN+ADCIRC (USACE, 2012). A seamless modeling grid was developed to support the storm surge modeling efforts. The modeling system validation consisted of a comprehensive tidal calibration followed by a validation using carefully reconstructed wind and pressure fields from three major flood events for the Region III domain: Hurricane Isabel, Hurricane Ernesto, and extratropical storm Ida. Model skill was accessed by a quantitative comparison of model output to wind, wave, water level, and high-water mark observations. The Region III model for the western coast of Cape May county was developed in close coordination with the Region II model for the Atlantic Coast, and the model results compared well in overlapping areas.

3.4 Wave Height Analysis

Coastal flooding in the county affects the Boroughs of Avalon, Cape May Point, Stone Harbor, West Wildwood, Wildwood Crest; the Cities of Cape May, North Wildwood, Ocean City, Sea Isle City, Wildwood; and the Townships of Dennis, Lower, Middle, and Upper. Along the Atlantic Ocean and Delaware Bay, most of the shoreline is sandy with a variable height sand dune and characterized by high-density residential areas. The northern portion of Cape May County's coastline on the Delaware Bay is characterized by low-lying marsh land. The bay sides of the barrier islands are a mix of low lying marsh, armored shoreline, and residential areas. The inland shoreline is primarily low-lying with a mix of residential areas and marsh.

The tidal surge in the Atlantic Ocean and Delaware Bay affects approximately 70 miles of Cape May County coastline, and that entire length was modeled for overland wave hazards. The fetch length across the backbays varies from approximately 0.5 to 3 miles.

The coastal analysis for this revision involved transect layout, field reconnaissance, erosion analysis, and overland wave modeling, including wave height and wave run-up analysis.

Transects represent the locations where the overland wave height analysis was modeled and are placed with consideration given to topography, land use, shoreline features and orientation, and the available fetch distance. Each transect was placed to capture the dominant wave direction; typically perpendicular to the shoreline and extended inland to a point where coastal flooding ceased. Along each transect, wave heights were computed considering the combined effects of changes in ground elevation, obstructions, and wind contributions. Transects were placed along the shoreline at all sources of primary flooding in Cape May County, as illustrated on the FIRMs. Transects also represent locations visited during field reconnaissance to assist in parameterizing obstructions and observing shore protection features.

Starting wave conditions (offshore) were derived from the two-dimensional SWAN+ADCIRC model developed for the Atlantic Coast and Delaware Bay. Wave heights were then computed across transects defined for coastal areas within Cape May County.

Erosion was modeled at transects where a dune was identified; this included most of the Cape May County shoreline along the Atlantic Ocean, and the southern portion of the coastline along the Delaware Bay. A review of the geology and shoreline type in Cape May County supported using FEMA's standard erosion methodology for primary frontal dunes, referred to as the "540 rule" (FEMA, 2007a). This methodology first evaluates the dune's cross-sectional profile to determine whether the dune has a reservoir of material that is greater or less than 540 square feet. If the reservoir is greater than 540 square feet, the "retreat" erosion method is employed and approximately 540 square feet of the dune is eroded using a standardized eroded profile, as specified in FEMA's Atlantic Ocean and Gulf of Mexico Coastal Guidelines Update (2007a). If the reservoir is less than 540 square feet, the "remove" erosion method is employed and the dune is removed for subsequent analysis, again using a standard eroded profile. The storm surge study provided the return period SWELs required for erosion analysis. Each cross-shore transect was analyzed for erosion, when applicable.

The methodology for analyzing the effects of wave heights associated with coastal storm surge flooding is described in a report prepared by the National Academy of Sciences (NAS) entitled Methodology for Calculating Wave Action Effects

Associated with Storm Surges (NAS, 1977). This method is based on three major concepts. First, depth-limited waves in shallow water reach a maximum breaking height that is equal to 0.78 times the stillwater depth. The wave crest is 70 percent of the total wave height above the stillwater level. The second major concept is that wave height may be diminished by dissipation of energy due to the presence of obstructions, such as sand dunes, dikes and seawalls, buildings, and vegetation. The amount of energy dissipation is a function of the physical characteristics of the obstruction and is determined by procedures prescribed in the NAS Report. The third major concept is that wave height can be regenerated in open fetch areas due to the transfer of wind energy to the water. This added energy is related to fetch length and depth.

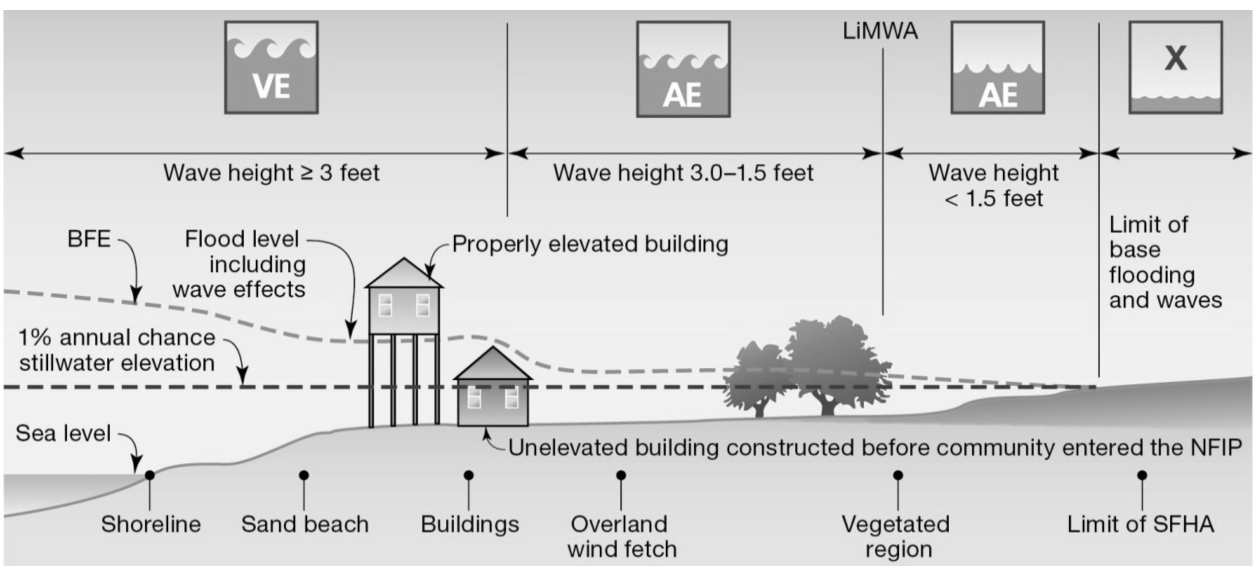
Simulations of inland wave propagation were conducted using FEMA's Wave Height Analysis for Flood Insurance Studies (WHAFIS) model Version 4.0 (FEMA, 2007b). WHAFIS is a 1-dimensional model and was applied to each transect in the study area. The model uses the total stillwater and starting wave information extracted from the coupled wave and storm surge model. In Table 2, "Transect Data," the 10-, 2-, 1-, and 0.2-percent-annual-chance SWELs for each transect are provided, along with the starting wave height and period. Coordinates in Table 2 are shown to indicate the starting location of the transects at the shoreline. The starting wave conditions are selected from an offshore location and is further detailed in the study Technical Support Data Notebook (TSDN). Simulations of wave transformations were then conducted with WHAFIS accounting for the storm-induced erosion and overland features of each transect. The model outputs the combined flood elevation from the total SWEL and wave height along each cross-shore transect to establish Base Flood Elevations (BFEs) and flood zones from the shoreline to points inland within the study area. Wave heights were calculated to the nearest 0.1 foot, and BFEs were determined at whole-foot increments along the transects.

Wave runup is defined as the maximum vertical extent of wave uprush on a beach or structure. FEMA's Atlantic Ocean and Gulf of Mexico Coastal Guidelines Update (2007a) require the 2-percent wave runup level be computed for the coastal feature being evaluated (cliff, coastal bluff, dune, or structure). The 2-percent runup level is the elevation exceeded by 2-percent of incoming waves affecting the shoreline during the 1-percent-annual-chance flood event. Each transect defined within the study area was evaluated for the applicability of wave runup, and if necessary, the appropriate runup methodology was selected and applied to each transect. Runup elevations were then compared to the WHAFIS results to determine the dominant process affecting BFEs and associated flood hazard levels. Based on wave runup rates, wave overtopping was computed following the FEMA Guidelines and Specifications.

Controlling wave heights, which are used to determine BFEs for the one-percent annual chance event and are output from the WHAFIS model, range from 2.9 to 7.4 feet at the shoreline. The dune along the coast serves to reduce wave height transmitted inland, but the large areas of low-lying marshes that are inundated by the tidal surge allow regeneration of the waves as they proceed inland. In general, the relatively shallow depth of water in the marshes, along with the energy dissipating effects of vegetation, allows only minor wave regeneration.

Between transects, elevations were interpolated using topographic maps, land-use and land cover data, and engineering judgment to determine the aerial extent of flooding. The results of the overland wave height and runup calculations are accurate until local topography, vegetation, or cultural development within the community undergoes major changes. The transect data table, Table 2**,** provides the 10-, 2-, 1- and 0.2-percent-annual-chance SWELs and the starting wave conditions for each transect.

Areas of coastline subject to significant wave attack are referred to as coastal high hazard areas. The USACE has established the 3-foot breaking wave as the criterion for identifying the limit of coastal high hazard areas (USACE, 1975). The 3-foot wave has been determined as the minimum size wave capable of causing major damage to conventional wood frame or brick veneer structures. The one exception to the 3-foot wave criteria is where a primary frontal dune exists. The limit of the coastal high hazard area then becomes the landward toe of the primary frontal dune, or where a 3-foot or greater breaking wave exists, whichever is most landward. The coastal high hazard zone is depicted on the FIRMs as Zone VE, where the delineated flood hazard includes wave heights equal to or greater than 3 feet. Zone AE is depicted on the FIRMs where the delineated flood hazard includes wave heights less than 3 feet. A depiction of how Zones VE and AE are mapped is shown in Figure 1, "Transect Schematic."



<u>FIGURE 1 – TRANSECT SCHEMATIC</u>

Post-storm field visits and laboratory tests have confirmed that wave heights as small as 1.5 feet can cause significant damage to structures when designed without consideration of the coastal hazards. Additional flood hazards associated with coastal waves include floating debris, high velocity flow, erosion, and scour, which can cause damage to Zone AE-type construction in these coastal areas. To help community officials and property owners recognize this increased potential for damage from wave action in the AE Zone, FEMA issued guidance in Procedure Memorandum 50 (December 2008) on identifying and mapping the 1.5-foot wave height line, referred to as the Limit of Moderate Wave Action (LiMWA). While FEMA does not impose floodplain management requirements based on the LiMWA, it is provided to help communicate the higher risk that exists in those areas. Consequently, it is important to be aware of the area between this inland limit and the Zone VE boundary as it still poses a high risk, though not as high of a risk as Zone VE (see Figure 1, "Transect Schematic").

Figure 2, "Transect Location Map," shows the location of each transect. Along each transect, wave envelopes were computed considering the combined effects of changes in ground elevation, vegetation, and physical features. Between transects, elevations were interpolated using topographic maps, land-use and land-cover data, and engineering judgment to determine the aerial extent of flooding. The results of the calculations are accurate until local topography, vegetation, or cultural development within the community undergoes major changes.

Qualifying bench marks within a given jurisdiction that are cataloged by the National Geodetic Survey (NGS) and entered into the National Spatial Reference System (NSRS) as First or Second Order Vertical and have a vertical stability classification of A, B, or C are shown and labeled on the FIRM with their 6-character NSRS Permanent Identifier.

Bench marks cataloged by the NGS and entered into the NSRS vary widely in vertical stability classification. NSRS vertical stability classifications are as follows:

- Stability A: Monuments of the most reliable nature, expected to hold position/elevation well (e.g., mounted in bedrock)
- Stability B: Monuments which generally hold their position/elevation well (e.g., concrete bridge abutment)
- Stability C: Monuments which may be affected by surface ground movements (e.g., concrete monument below frost line)
- Stability D: Mark of questionable or unknown vertical stability (e.g., concrete monument above frost line, or steel witness post)

In addition to NSRS bench marks, the FIRM may also show vertical control monuments established by a local jurisdiction. These monuments will be shown on the FIRM with the appropriate designations. Local monuments will only be placed on the FIRM if the community has requested that they be included, and if the monuments meet the aforementioned NSRS inclusion criteria.

To obtain current elevation, description, and/or location information for bench marks shown on the FIRM for this jurisdiction, please contact the Information

Services Branch of the NGS at (301) 713-3242, or visit their Web site at www.ngs.noaa.gov. It is important to note that temporary vertical monuments are often established during the preparation of a flood hazard analysis for the purpose of establishing local vertical control. Although these monuments are not shown on the FIRM, they may be found in the Technical Support Data Notebook associated with this FIS and FIRM. Interested individuals may contact FEMA to access this data.

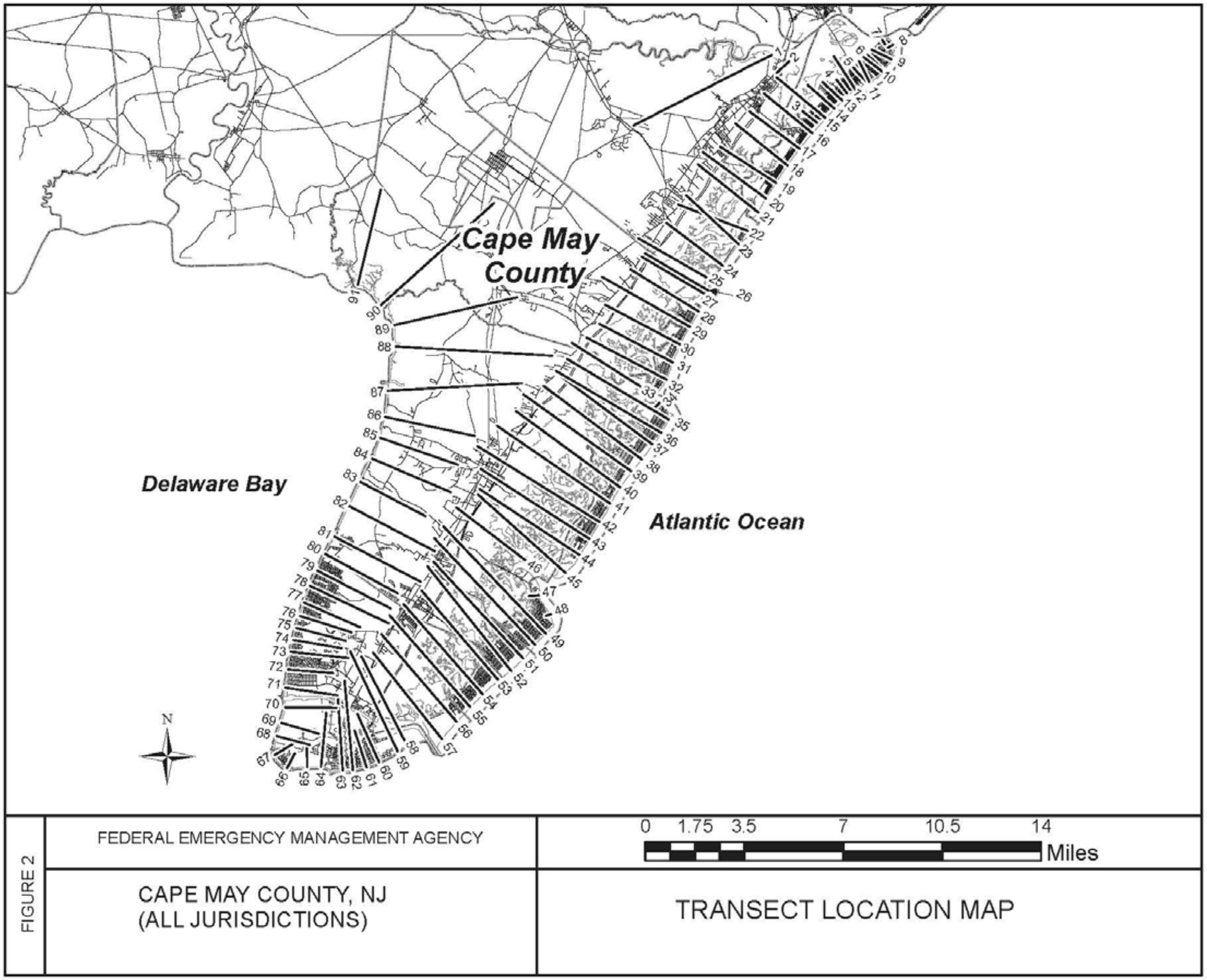


FIGURE 2 – TRANSECT LOCATION MAP

TABLE 2 – TRANSECT DATA TABLE

Flood Source	Transect		Starting Wave Conditions for the 1% Annual Chance		Starting Stillwater Elevations[1](ft NAVD88) Range of Stillwater Elevations[2](ft NAVD88)			
	Number	Coordinates	Significant Wave Height	Peak Wave Period	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Great Egg Harbor Bay	1	N 39.290532 W 74.632879	2.87	2.49	6.2 5.8 - 6.2	7.7 7.4 - 7.7	8.3 8 - 8.3	9.7 9.1 - 9.7
Great Egg Harbor Bay	2	N 39.287179 W 74.621201	3.24	2.82	6.2 6.2 - 6.5	7.8 7.7 - 8.1	8.4 8.3 - 8.7	9.8 9.7 - 10.2
Peck Bay	3	N 39.261319 W 74.613606	2.11	2.63	6.4 6.0 - 6.4	8.0 7.7 – 8.0	8.6 8.3 - 8.6	10.1 9.7 - 13.4
Great Egg Harbor Bay	4	N 39.276911 W 74.590560	2.39	2.52	6.2 6.0 - 6.3	7.8 7.6 - 8.8	8.4 8.2 - 9.1	10.0 9.8 - 13.1
Great Egg Harbor Bay	5	N 39.283128 W 74.579443	1.81	2.39	6.2 5.8 - 7.2	7.9 7.7 - 7.9	8.5 8.2 - 8.5	10.3 10.0 - 12.8
Great Egg Harbor Bay	6	N 39.289319 W 74.569707	2.59	2.39	6.2 5.9 - 6.8	7.9 7.7 - 8.5	8.6 8.4 - 9.3	10.5 10.4 - 12.8
Great Egg Harbor Bay	7	N 39.296637 W 74.559875	2.89	9.25	6.2 5.9 - 6.7	8.0 7.7 – 8.0	8.7 8.3 - 8.7	10.7 10.2 - 10.7
Atlantic Ocean	8	N 39.294206 W 74.552435	5.30	14.64	6.4	8.2 8.0 - 8.5	9 8.4 - 9.1	11.1 10.3 - 11.3
Atlantic Ocean	9	N 39.286550 W 74.554030	7.41	13.56	6.4 5.7 - 6.4	8.5 7.7 - 8.5	9.5 8.4 - 9.5	12.9 10.4 - 12.9
Atlantic Ocean	10	N 39.280094 W 74.559858	11.18	12.22	6.5 5.7 - 6.5	8.5 7.7 - 8.5	9.4 8.3 - 9.4	12.8 10.3 - 12.8
Atlantic Ocean	11	N 39.275262 W 74.568949	10.89	12.28	6.4 6.0 - 6.4	8.5 7.7 - 8.5	9.4 8.4 - 9.4	12.8 10.3 - 12.8
Atlantic Ocean	12	N 39.271463 W 74.578267	10.75	12.36	6.4 5.9 - 6.4	8.5 7.6 - 8.5	9.4 8.2 - 9.4	12.8 9.9 - 12.9
Atlantic Ocean	13	N 39.266038 W 74.586854	11.10	12.39	6.6 5.7 - 6.7	8.6 7.5 - 8.7	9.5 8.2 - 9.6	12.9 9.6 - 13.1
Atlantic Ocean	14	N 39.261988 W 74.592273	11.17	12.39	6.6 4.6 - 7	8.6 7.5 - 8.8	9.5 8.1 - 9.7	12.9 9.5 - 13.2

[1]Stillwater elevations include the contribution from wave setup.

[2]For transects with a constant stillwater elevation, only one number is provided to represent both the starting value and the range.

TABLE 2 – TRANSECT DATA TABLE - continued

Flood Source	Transect		Starting Wave Conditions for the 1% Annual Chance		Starting Stillwater Elevations[1] (ft NAVD88) Range of Stillwater Elevations[2] (ft NAVD88)			
	Number	Coordinates	Significant Wave Height	Peak Wave Period	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Atlantic Ocean	15	N 39.257298 W 74.598203	11.56	12.16	6.5 6.0 - 6.6	8.6 7.6 - 8.6	9.5 8.2 - 9.6	12.9 9.7 - 13.3
Atlantic Ocean	16	N 39.249839 W 74.607177	11.78	11.79	6.6 6.1 - 7.1	8.6 7.7 - 8.9	9.5 8.3 - 10	12.9 9.8 - 13.3
Atlantic Ocean	17	N 39.242077 W 74.615922	12.04	11.74	6.5 5.9 - 6.6	8.5 7.7 - 8.6	9.4 8.3 - 9.5	12.8 9.8 - 12.9
Atlantic Ocean	18	N 39.233653 W 74.624227	12.25	12.53	6.5 6.0 - 6.5	8.5 7.7 - 8.5	9.4 8.3 - 9.4	12.8 9.8 - 12.8
Atlantic Ocean	19	N 39.224925 W 74.632136	12.25	12.49	6.5 5.8 - 7.2	8.5 7.7 - 8.5	9.4 8.4 - 9.4	12.8 9.8 - 12.8
Atlantic Ocean	20	N 39.217119 W 74.638952	12.16	12.29	6.6 1.7 - 6.9	8.6 7.7 - 8.6	9.5 8.4 - 9.5	12.8 10.1 - 12.8
Atlantic Ocean	21	N 39.209873 W 74.644377	12.05	13.04	6.5 2.3 - 7.8	8.5 7.3 - 8.8	9.4 8.4 - 9.7	12.5 10.2 - 12.7
Atlantic Ocean	22	N 39.200432 W 74.651025	11.38	12.61	6.7 5.0 - 7.3	8.7 7.8 - 8.7	9.5 8.5 - 9.5	12.6 10.3 - 12.6
Atlantic Ocean	23	N 39.193779 W 74.657589	11.30	12.36	6.6 6.1 - 8.2	8.6 8.0 - 8.6	9.5 8.7 - 9.5	12.7 10.5 - 12.7
Atlantic Ocean	24	N 39.183056 W 74.668396	11.84	12.52	6.6 6.3 - 6.6	8.6 8.0 - 8.6	9.5 8.6 - 9.5	12.6 10.1 - 12.6
Atlantic Ocean	25	N 39.175203 W 74.675104	12.31	12.46	6.7 6.4 - 7.2	8.6 8.1 - 8.6	9.5 8.6 - 9.5	12.6 10.0 - 12.6
Atlantic Ocean	26	N 39.170445 W 74.678448	11.77	12.23	6.7 6.5 - 6.7	8.6 8.2 - 8.6	9.5 8.8 - 9.5	12.6 10.3 - 12.6
Atlantic Ocean	27	N 39.168411 W 74.679792	11.98	12.29	6.7 6.4 - 6.7	8.6 8.2 - 8.6	9.5 8.8 - 9.5	12.6 10.3 - 12.6
Atlantic Ocean	28	N 39.160069 W 74.685169	10.53	12.00	6.6 6.5 - 7.4	8.5 8.3 - 8.6	9.4 8.9 - 9.4	12.5 10.4 - 12.5
Atlantic Ocean	29	N 39.152150 W 74.691211	11.30	12.28	6.6 6.0 - 7.3	8.6 7.8 - 8.6	9.4 8.5 - 9.4	12.5 10.1 - 12.5
Atlantic Ocean	30	N 39.143290 W 74.697807	11.53	12.41	6.7 5.5 - 7.3	8.6 7.7 - 8.6	9.5 8.3 - 9.5	12.6 9.8 - 12.6
Atlantic Ocean	31	N 39.134320 W 74.703056	11.70	12.30	6.7 5.2 - 7.3	8.6 7.8 - 8.6	9.4 8.3 - 9.4	12.5 9.6 - 12.5
Atlantic Ocean	32	N 39.125557 W 74.707471	10.28	12.75	6.6 5.7 - 7.2	8.6 7.7 - 8.6	9.4 8.3 - 9.4	12.4 9.9 - 12.4

[1]Stillwater elevations include the contribution from wave setup.

[2]For transects with a constant stillwater elevation, only one number is provided to represent both the starting value and the range.

TABLE 2 – TRANSECT DATA TABLE - continued

Flood Source	Transect		Starting Wave Conditions for the 1% Annual Chance		Starting Stillwater Elevations[1] (ft NAVD88) Range of Stillwater Elevations[2] (ft NAVD88)			
	Number	Coordinates	Significant Wave Height	Peak Wave Period	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Intracoastal Waterway	33	N 39.120479 W 74.721435	2.73	6.58	6.3 6.2 - 7.3	8.1 7.8 - 8.3	8.8 8.7 – 9.0	10.6 10.2 - 10.7
Atlantic Ocean	34	N 39.113737 W 74.712414	5.88	11.00	6.5 5.1 - 6.5	8.2 7.8 - 8.2	9.0 8.4 - 9	11.2 10 - 11.2
Atlantic Ocean	35	N 39.105007 W 74.706657	10.01	12.87	6.5 5.6 - 6.5	8.4 7.7 - 8.4	9.3 8.4 - 9.3	12.0 9.9 – 12.0
Atlantic Ocean	36	N 39.098274 W 74.711759	10.48	13.01	6.5 5.8 - 7.2	8.4 7.3 - 8.6	9.2 8.3 - 9.4	12.0 9.8 - 12.1
Atlantic Ocean	37	N 39.092219 W 74.717624	11.76	12.44	6.5 5 - 7.1	8.4 7.3 - 8.4	9.2 8.3 - 9.2	12.0 9.7 - 12.3
Atlantic Ocean	38	N 39.084966 W 74.725178	11.72	12.12	6.4 5.5 - 7.4	8.3 7.6 - 9.8	9.1 8.2 - 9.7	11.9 9.9 - 16.4
Atlantic Ocean	39	N 39.078778 W 74.731654	11.30	12.25	6.4 5.7 - 6.5	8.3 7.3 - 8.8	9.1 8.1 - 9.8	11.9 9.7 - 12.6
Atlantic Ocean	40	N 39.070762 W 74.739830	11.52	12.40	6.5 5.4 - 7.2	8.4 7.4 - 8.5	9.2 8.1 - 9.3	12.0 9.7 - 12.2
Atlantic Ocean	41	N 39.062590 W 74.746335	12.55	12.48	6.6 2.3 - 7.3	8.5 7.1 - 8.5	9.2 8.1 - 9.3	12.1 9.5 - 12.2
Atlantic Ocean	42	N 39.053152 W 74.753522	12.82	12.45	6.5 5.8 - 7.3	8.4 7.5 - 8.4	9.2 8.2 - 9.2	12.1 9.5 - 12.1
Atlantic Ocean	43	N 39.044690 W 74.760575	12.76	12.39	6.6 5.7 - 6.8	8.4 7.5 - 8.4	9.2 8.1 - 9.2	12.1 9.6 - 12.1
Atlantic Ocean	44	N 39.036715 W 74.767478	12.12	13.01	6.6 4.9 - 6.9	8.4 7.2 - 8.5	9.2 8.1 - 9.3	12.1 9.6 - 12.2
Atlantic Ocean	45	N 39.027683 W 74.777048	7.21	13.61	6.5 6.1 - 7.2	8.3 7.8 - 8.3	9.1 8.6 - 9.1	11.6 10.2 - 11.6
Grassy Sound Channel	46	N 39.034533 W 74.803068	2.72	2.52	6.3 6.1 - 7.3	8.1 7.9 - 8.3	8.8 8.8 – 9.0	10.6 10.4 - 10.8
Atlantic Ocean	47	N 39.016614 W 74.794122	4.16	14.70	6.6 5.9 - 6.6	8.4 7.4 - 8.4	9.2 8.2 - 9.2	11.9 9.7 - 11.9
Atlantic Ocean	48	N 39.006725 W 74.787193	6.06	13.62	6.6 6.4 - 6.7	8.4 8 - 8.5	9.1 8.7 - 9.3	11.8 10.9 - 12
Atlantic Ocean	49	N 38.996845 W 74.790953	7.78	13.75	6.3 5.7 - 7.9	8.1 7.7 - 8.4	8.9 8.4 - 9.1	11.8 9.8 - 11.9

[1]Stillwater elevations include the contribution from wave setup.

[2]For transects with a constant stillwater elevation, only one number is provided to represent both the starting value and the range.

TABLE 2 – TRANSECT DATA TABLE - continued

Flood Source	Transect		Starting Wave Conditions for the 1% Annual Chance		Starting Stillwater Elevations[1] (ft NAVD88) Range of Stillwater Elevations[2] (ft NAVD88)			
	Number	Coordinates	Significant Wave Height	Peak Wave Period	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Atlantic Ocean	50	N 38.991221 W 74.798163	9.30	13.30	6.3 5.8 - 7.3	8.1 7.7 - 8.9	8.9 8.3 - 9.8	11.8 9.8 - 12.4
Atlantic Ocean	51	N 38.984349 W 74.806213	11.81	13.35	6.2 5.8 - 7.2	8.1 7.8 - 9.2	8.9 8.4 - 10.2	11.7 9.8 - 12.9
Atlantic Ocean	52	N 38.978315 W 74.814347	11.65	13.27	6.1 5.0 - 8.1	7.9 7.7 – 9.0	8.6 8.3 - 9.9	11.5 9.8 - 12.4
Atlantic Ocean	53	N 38.973435 W 74.822708	11.82	13.37	6.2 5.4 - 7.1	7.9 6.8 - 9.1	8.6 7.7 – 10.0	11.5 9.2 - 12.7
Atlantic Ocean	54	N 38.966463 W 74.833312	12.15	12.67	6.2 5.5 - 6.9	8.0 6.8 - 9.1	8.7 7.7 - 10.2	11.6 9.3 - 12.9
Atlantic Ocean	55	N 38.960130 W 74.841650	12.37	12.41	6.2 5.4 - 6.7	8.0 6.8 - 9.1	8.7 7.7 - 10.1	11.6 9.2 - 12.8
Atlantic Ocean	56	N 38.952678 W 74.850977	13.00	12.00	6.2 2.7 - 6.2	8.0 7.1 – 8.0	8.7 7.6 - 8.7	11.5 8.8 - 12.1
Atlantic Ocean	57	N 38.943989 W 74.860897	12.17	12.20	6.3 4.5 - 6.3	8.0 7.0 - 8.1	8.8 7.7 - 8.8	11.4 9.0 - 11.5
Atlantic Ocean	58	N 38.941412 W 74.883776	9.98	13.28	6.1 5.8 - 6.2	7.8 7.0- 7.8.0	8.5 7.8 - 8.5	11.3 9.2 - 11.3
Atlantic Ocean	59	N 38.938349 W 74.889912	10.10	12.92	6 5.8 - 7.2	7.7 6.9 - 7.7	8.4 7.7 - 8.4	11.1 9 - 11.1
Atlantic Ocean	60	N 38.933080 W 74.902288	10.78	12.71	5.8 3.7 - 6.3	7.7 7.2 - 7.8	8.5 8.0 - 8.5	11.0 9.6 - 11.1
Atlantic Ocean	61	N 38.930518 W 74.910757	9.65	13.18	6.0 5.9 - 6.3	7.6 7.2 - 7.7	8.3 8.0 - 8.4	10.7 9.7 - 10.8
Atlantic Ocean	62	N 38.929185 W 74.919659	10.58	12.66	6.0 5.2 - 6.3	7.6 7.3 - 7.6	8.3 8.0 - 8.3	10.5 9.5 - 10.5
Atlantic Ocean	63	N 38.929183 W 74.926473	9.76	12.70	6.0 2.1 - 6.4	7.5 6.8 - 7.6	8.2 7.4 - 8.3	10.4 8.8 - 10.5
Atlantic Ocean	64	N 38.931336 W 74.940576	8.24	13.10	5.9 1.4 - 6.3	7.5 6.7 - 7.7	8.1 7.2 - 8.4	10.2 8.1 - 10.6
Atlantic Ocean	65	N 38.931264 W 74.949562	7.31	12.51	5.9 2.2 - 6.3	7.5 6.7 - 7.5	8.1 7.2 - 8.1	10.0 8.1 - 10.1
Atlantic Ocean	66	N 38.930979 W 74.962964	7.08	11.07	5.8 5.7 - 5.9	7.2 7.2 - 7.6	7.8 7.8 - 8.3	9.1 9.1 - 10.1
Atlantic Ocean	67	N 38.937849 W 74.970966	7.00	10.60	5.8	7.3	7.8 7.8 - 7.9	9.2 9.2 - 9.3

[1]Stillwater elevations include the contribution from wave setup.

[2]For transects with a constant stillwater elevation, only one number is provided to represent both the starting value and the range.

<u>TABLE 2 – TRANSECT DATA TABLE</u> - continued

Flood Source	Transect		Starting Wave Conditions for the 1% Annual Chance		Starting Stillwater Elevations[1] (ft NAVD88) Range of Stillwater Elevations[2] (ft NAVD88)			
	Number	Coordinates	Significant Wave Height	Peak Wave Period	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Delaware Bay	68	N 38.947538 W 74.969295	6.07	10.12	5.8	7.3 6.7 - 7.3	7.9 7.3 - 7.9	9.3 8.3 - 9.3
Delaware Bay	69	N 38.954350 W 74.966222	5.28	10.24	5.8 3.8 - 5.8	7.3 6.7 - 7.3	7.8 7.2 - 7.8	9.3 8.3 - 9.3
Delaware Bay	70	N 38.962243 W 74.963181	5.20	9.81	5.8 5.8 - 6.2	7.3 7.0 - 7.3	7.8 7.3 - 7.8	9.3 8.9 - 9.3
Delaware Bay	71	N 38.972163 W 74.962897	4.65	12.57	5.8 5.5 - 5.8	6.9 6.9 - 7.3	7.4 7.3 - 7.4	9.0 8.9 - 9.4
Delaware Bay	72	N 38.981450 W 74.960627	4.56	12.68	5.8	6.8	7.4	9.0
Delaware Bay	73	N 38.990575 W 74.958755	4.79	11.12	5.8 5.8 - 5.9	7.1 6.9 - 7.1	7.4 7.4 - 7.5	9.1
Delaware Bay	74	N 38.996701 W 74.957157	4.67	11.06	5.8 5.8 - 5.9	7.1 6.9 - 7.1	7.5	9.2 9.1 - 9.2
Delaware Bay	75	N 39.002808 W 74.954793	4.45	11.02	5.9	6.9	7.5	9.2 9.1 - 9.2
Delaware Bay	76	N 39.008966 W 74.952436	4.62	11.10	5.9	7.1 7.0 - 7.1	7.5	9.2
Delaware Bay	77	N 39.015639 W 74.949296	4.12	10.92	5.9	7.0	7.6	9.3 9.2 - 9.3
Delaware Bay	78	N 39.024145 W 74.945081	3.95	10.58	5.9	6.9 6.9 – 7.0	7.6	9.3 9.1 - 9.3
Delaware Bay	79	N 39.032113 W 74.940428	3.94	10.38	5.9	7.0	7.6	9 9 - 9.1
Delaware Bay	80	N 39.040315 W 74.934755	3.32	10.23	5.9	7.0 6.9 – 7.0	7.6	9.2 9.1 - 9.5
Delaware Bay	81	N 39.049084 W 74.928512	3.21	8.28	5.9	7.0 6.9 – 7.0	7.7 7.5 - 7.7	9.5 9.5 - 9.7
Delaware Bay	82	N 39.064546 W 74.918351	2.84	3.06	5.9 5.7 - 5.9	7.0 6.8 – 7.0	7.7 7.5 - 7.7	9.9 9.7 - 9.9
Delaware Bay	83	N 39.076777 W 74.910532	2.63	2.99	5.8 5.7 - 5.8	6.9 6.8 - 6.9	7.6 5.7 - 7.6	10.1 9.9 - 10.1
Delaware Bay	84	N 39.088722 W 74.902456	2.57	2.88	5.9 5.6 - 5.9	7.1 6.9 - 7.1	7.8 5.7 - 7.8	10.6 10.5 - 10.6
Delaware Bay	85	N 39.099194 W 74.897018	3.16	3.18	6.0	7.2 7.1 - 7.2	8.0 6.7 – 8.0	11.0 10.0– 11.0

[1]Stillwater elevations include the contribution from wave setup.

[2]For transects with a constant stillwater elevation, only one number is provided to represent both the starting value and the range.

TABLE 2 – TRANSECT DATA TABLE - continued

Flood Source	Transect		Starting Wave Conditions for the 1% Annual Chance		Starting Stillwater Elevations[1] (ft NAVD88) Range of Stillwater Elevations[2] (ft NAVD88)			
	Number	Coordinates	Significant Wave Height	Peak Wave Period	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Delaware Bay	86	N 39.109906 W 74.893218	2.89	2.90	6.0 4.3 - 6.1	7.2 5.4 - 7.2	8.1 6.7 - 8.1	11.3 9.5 - 11.3
Delaware Bay	87	N 39.123302 W 74.891255	3.22	3.09	6.0 4.2 - 6.1	7.2 5.5 - 7.2	8.1 7.2 - 8.1	11.5 10.3 - 11.6
Delaware Bay	88	N 39.145913 W 74.884943	2.98	3.29	6.1 4.2 - 6.1	7.3 5.5 - 7.3	8.4 5.7 - 8.4	12.1 8.1 - 12.1
Delaware Bay	89	N 39.156730 W 74.885767	2.72	3.46	5.8 2.1 - 5.8	7.0 3.7 – 7.0	8.1 5.6 - 8.1	11.9 8.1 - 11.9
Delaware Bay	90	N 39.167159 W 74.894263	3.41	3.46	5.3 3.0 - 5.3	6.5 3.7 - 6.5	8.1 5.9 - 8.1	11.7 8.4 - 11.7
Delaware Bay	91	N 39.177909 W 74.909261	3.78	4.45	5.5 5.1 - 5.5	6.7 6.2 - 6.7	8.3 8.3 - 8.7	11.9 11.9 - 12.0

[1]Stillwater elevations include the contribution from wave setup.
[2]For transects with a constant stillwater elevation, only one number is provided to represent both the starting value and the range.

3.5 Vertical Datum

All FISs and FIRMs are referenced to a specific vertical datum. The vertical datum provides a starting point against which flood, ground, and structure elevations can be referenced and compared. Until recently, the standard vertical datum in use for newly created or revised FISs and FIRMs was the National Geodetic Vertical Datum of 1929 (NGVD29). With the finalization of the North American Vertical Datum of 1988 (NAVD88), many FIS reports and FIRMs are being prepared using NAVD88 as the referenced vertical datum.

All flood elevations shown in this FIS report and on the FIRM are referenced to NAVD88. Structure and ground elevations in the community must, therefore, be referenced to NAVD88. It is important to note that adjacent communities may be referenced to NGVD29. This may result in differences in BFEs across the corporate limits between the communities.

Prior versions of individual community FIS reports and FIRMs were referenced to NGVD29. When a datum conversion is effected for an FIS report and FIRM, the Flood Profiles, BFEs, and Elevation Reference Marks reflect the new datum values. To compare structure and ground elevations to 1-percent-annual-chance flood elevations shown in the FIS and on the FIRM, the subject structure and ground elevations must be referenced to the new datum values.

As noted above, the elevations shown in the [*date*] FIS report and on the FIRM for Cape May County are referenced to NAVD88. Ground, structure, and flood elevations may be compared and/or referenced to NGVD29 by applying a standard conversion factor. The conversion factor to NGVD29 is +1.275. The conversion between the datums may be expressed as an equation:

NAVD88 = NGVD29 - 1.275 foot

The BFEs shown on the FIRM represent whole-foot rounded values. For example, a BFE of 102.4 will appear as 102 on the FIRM and 102.6 will appear as 103. Therefore, users that wish to convert the elevations in this FIS to NGVD29 should apply the stated conversion factor(s) to elevations shown on the Flood Profiles and supporting data tables in the FIS report, which are shown at a minimum to the nearest 0.1 foot.

For more information on NAVD88, see Converting the National Flood Insurance Program to the North American Vertical Datum of 1988, FEMA Publication FIA-20/June 1992, or contact the Spatial Reference System Division, National Geodetic Survey, NOAA, Silver Spring Metro Center, 1315 East-West Highway, Silver Spring, Maryland 20910 (Internet address http://www.ngs.noaa.gov).

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound floodplain management programs. To assist in this endeavor, each FIS provides 1-percent-annual-chance floodplain data, which may include a combination of the following: 10-, 2-, 1-, and 0.2-percent-annual-chance flood elevations; delineations of the 1- and 0.2-percent-annual-chance floodplains; and 1-percent-annual-chance floodway. This information is presented on the FIRM and in many components of the FIS, including Flood Profiles, Floodway Data tables, and Summary of Stillwater Elevation tables. Users should reference the data presented in the FIS as well as additional information that may be available at the local community map repository before making flood elevation and/or floodplain boundary determinations.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1-percent annual chance flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2-percent-annual-chance flood is employed to indicate additional areas of flood risk in the county. For the streams studied in detail, the 1- and 0.2-percent-annual-chance floodplain boundaries have been delineated using the flood elevations determined at each cross section.

For the [*date*] countywide FIS, LiDAR data were provided in classified American Society of Photogrammetry and Remote Sensing (ASPRS) LiDAR data exchange format (LAS) files for Cape May County. Data were uploaded into Environmental Systems Research Institute, Inc. (ESRI) file geodatabases (FGDBs) as multi-point feature classes with elevation attributes based on Class 2 bare earth points. An

ESRI Terrain dataset was generated and spatially constrained to the data extent for the county.

The 1- and 0.2-percent-annual-chance floodplain boundaries are shown on the FIRM (Exhibit 2). On this map, the 1-percent-annual-chance floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones A, AE, V and VE), and the 0.2-percent-annual-chance floodplain boundary corresponds to the boundary of areas of moderate flood hazards. In cases where the 1- and 0.2-percent-annual-chance floodplain boundaries are close together, only the 1-percent-annual-chance floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

In areas where a wave height analysis were performed for the AE and VE zones were divided into whole-foot elevation zones based on the average wave crest elevation in that zone. Where the map scale did not permit delineating zones at 1 foot intervals, larger increments were used.

For the streams studied by approximate methods, only the 1-percent-annual-chance floodplain boundary is shown on the FIRM (Exhibit 2).

4.2 Floodways

Encroachment on floodplains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the NFIP, a floodway is used as a tool to assist local communities in this aspect of floodplain management. Under this concept, the area of the 1-percent-annual-chance floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the 1-percent-annual-chance flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced. Floodways are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway studies. However, the State of New Jersey had established criteria limiting the increase in flood heights to 0.2 foot.

No floodways have been computed for this FIS.

Encroachment into areas subject to inundation by floodwaters having hazardous velocities aggravates the risk of flood damage and heightens potential flood hazards by further increasing velocities.

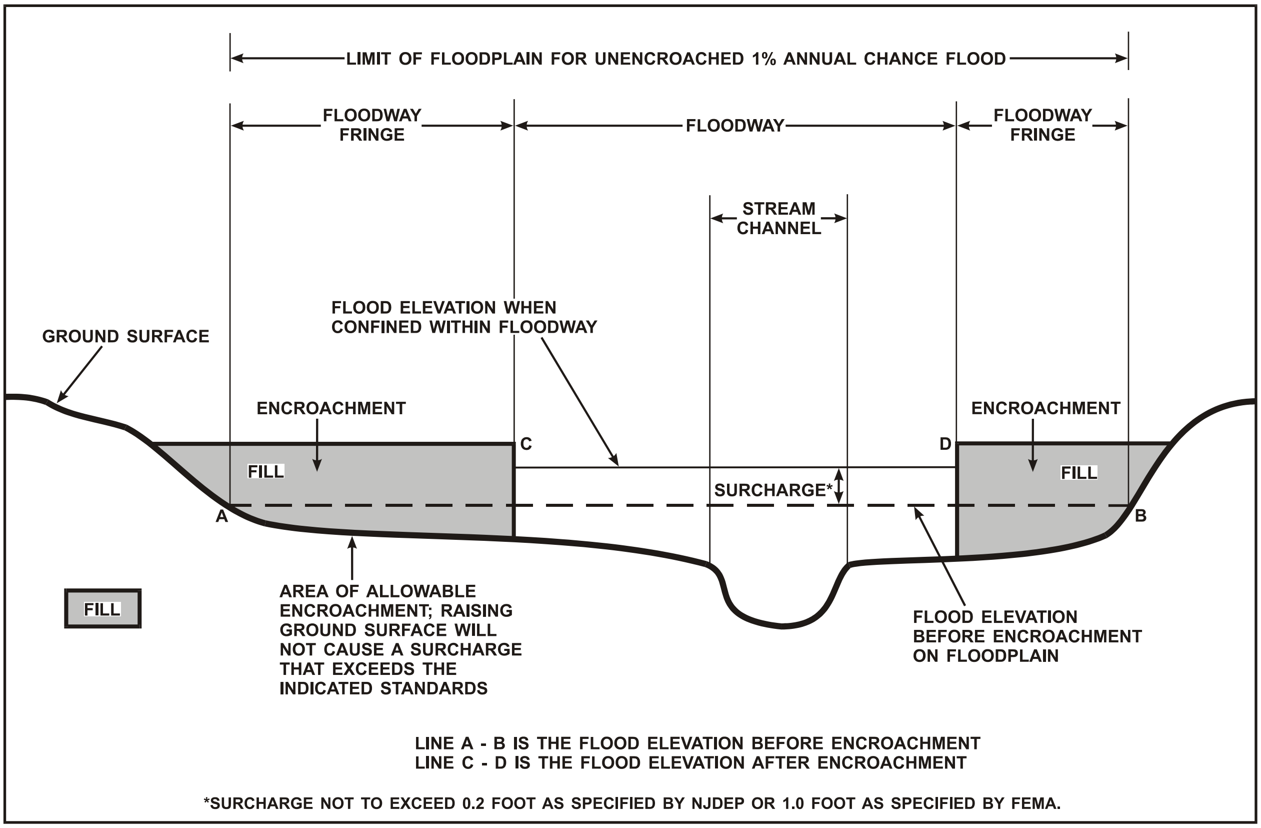


FIGURE 3 – FLOODWAY SCHEMATIC

The area between the floodway and 1-percent-annual-chance floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the water-surface elevation of the 1-percent-annual-chance flood by more than 0.2 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 3.

5.0 INSURANCE APPLICATIONS

For flood insurance rating purposes, flood insurance zone designations are assigned to a community based on the results of the engineering analyses. The zones are as follows:

Zone A

Zone A is the flood insurance rate zone that corresponds to the 1-percent-annual-chance floodplains that are determined in the FIS by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no BFEs or depths are shown within this zone.

Zone AE

Zone AE is the flood insurance rate zone that corresponds to the 1-percent-annual-chance floodplains that are determined in the FIS by detailed methods. In most instances, whole-foot BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AH

Zone AH is the flood insurance rate zone that corresponds to the areas of 1-percent-annual-chance shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. Whole-foot BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AO

Zone AO is the flood insurance rate zone that corresponds to the areas of 1-percent-annual-chance shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. Average whole-foot depths derived from the detailed hydraulic analyses are shown within this zone.

Zone AR

Zone AR is an area of special flood hazard formerly protected from the 1-percent-annual-chance flood event by a flood-control system that was subsequently deaccredited. Zone AR indicates that the former flood-control system is being restored to provide protection from the 1-percent-annual-chance or greater flood event.

Zone A99

Zone A99 is the flood insurance rate zone that corresponds to areas of the 1-percent-annual-chance floodplain that will be protected by a Federal flood protection system where construction has reached specified statutory milestones. No BFEs or depths are shown within this zone.

Zone V

Zone V is the flood insurance rate zone that corresponds to the 1-percent-annual-chance coastal floodplains that have additional hazards associated with storm-induced waves. Because detailed coastal analyses have not been performed for such areas, no BFEs are shown within this zone.

Zone VE

Zone VE is the flood insurance rate zone that corresponds to the 1-percent-annual-chance coastal floodplains that have additional hazards associated with storm-induced velocity wave action. Whole-foot BFEs derived from the detailed coastal hydraulic analyses are shown at selected intervals within this zone.

Zone X

Zone X (shaded) is the flood insurance rate zone that corresponds to areas within the 0.2-percent-annual-chance floodplain, and areas of 1-percent-annual-chance flooding where average depths are less than 1 foot; areas of 1-percent-annual-chance flooding where the contributing drainage area is less than 1 square mile; and areas protected from the 1-percent-annual-chance flood by levees. No BFEs or depths are shown within this zone. Zone X (unshaded) are the areas outside the 1 and the 0.2-percent-annual-chance floodplain. No BFEs or depths are shown within these zones.

Zone D

Zone D is the flood insurance rate zone that corresponds to unstudied areas where flood hazards are undetermined, but possible.

6.0 FLOOD INSURANCE RATE MAP

The FIRM is designed for flood insurance and floodplain management applications.

For flood insurance applications, the map designates flood insurance rate zones as described in Section 5.0, and in the 1-percent-annual-chance floodplains that were studied by detailed methods, shows selected whole-foot BFEs or average depths. Insurance agents use the zones and BFEs in conjunction with information on structures and their contents to assign premium rates for flood insurance policies.

For floodplain management applications, the map shows by tints, screens, and symbols, the 1- and 0.2-percent-annual-chance floodplains. Floodways and the locations of selected cross sections used in the hydraulic analyses and floodway computations are shown where applicable.

The current FIRM presents flooding information for the entire geographic area of Cape May County. Previously, separate Flood Hazard Boundary Maps (FHBMs) and/or FIRMs were prepared for each incorporated community in the county with identified flood hazard areas. Historical map dates relating to the pre-countywide FIRMs for each community are presented in Table 3, "Community Map History."

7.0 OTHER STUDIES

Information pertaining to revised and unrevised flood hazards for each jurisdiction within Cape May County has been incorporated into this FIS. Therefore, this FIS supersedes all previously printed FIS Reports, FHBMs, Flood Boundary and Floodway Maps, and FIRMs for each incorporated area within Cape May County.

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISIONS DATE	FIRM EFFECTIVE DATE	FIRM REVISIONS DATE
Avalon, Borough of	April 17, 1970	None	December 31, 1970	July 1, 1974 October 31, 1975 February 2, 1983
Cape May City, City of	August 7, 1970	None	February 26, 1971	July 1, 1974 February 13, 1976 January 6, 1983 October 16, 1984 July 15, 1992 April 16, 1993
Cape May Point, Borough of	July 1, 1970	None	December 31, 1970	July 1, 1974 February 13, 1976 January 6, 1983 December 5, 1995
Dennis, Township of	April 4, 1975	None	September 17, 1982	July 15, 1992
Lower, Township of	July 19, 1974	April 9, 1976	February 2, 1983	July 15, 1992
Middle, Township of	September 20, 1974	None	May 16, 1977	July 15, 1992
North Wildwood, City of	March 6, 1971	None	March 6, 1971	July 1, 1974 December 19, 1975 January 6, 1983 February 16, 1996 July 20, 1998

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CAPE MAY COUNTY, NJ
(ALL JURISDICTIONS)

COMMUNITY MAP HISTORY

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISIONS DATE	FIRM EFFECTIVE DATE	FIRM REVISIONS DATE
Ocean City, City of	April 17, 1970	None	April 17, 1970	July 1, 1974 December 26, 1975 September 5, 1984 July 15, 1992
Sea Isle City, City of	July 17, 1970	None	December 31, 1970	July 1, 1974 December 26, 1975 January 6, 1983
Stone Harbor, Borough of	January 8, 1971	None	January 8, 1971	July 1, 1974 November 14, 1975 February 2, 1983 April 17, 1985 July 15, 1992
Upper, Township of	December 6, 1974	None	December 10, 1976	June 1, 1984 July 15, 1992
West Cape May, Borough of	June 14, 1974	September 12, 1975	February 16, 1983	July 15, 1992
West Wildwood, Borough of	January 8, 1971	None	December 31, 1970	July 1, 1974 October 17, 1975
Wildwood, City of	June 5, 1970	None	December 31, 1970	July 1, 1974 December 19, 1975 January 6, 1983 February 16, 1996

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CAPE MAY COUNTY, NJ
(ALL JURISDICTIONS)

COMMUNITY MAP HISTORY

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISIONS DATE	FIRM EFFECTIVE DATE	FIRM REVISIONS DATE
Wildwood Crest, Borough of	February 26, 1971	None	February 26, 1971	July 1, 1974 December 26, 1975 January 6, 1983 February 16, 1996
Woodbine, Borough of	March 8, 1974	None	May 18, 1979	

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CAPE MAY COUNTY, NJ
(ALL JURISDICTIONS)

COMMUNITY MAP HISTORY

8.0 LOCATION OF DATA

Information concerning the pertinent data used in preparation of this FIS can be obtained by contacting FEMA, Federal Insurance and Mitigation Division, 26 Federal Plaza, Room 1337, New York, New York 10278.

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