

# FLOOD INSURANCE STUDY



## HUDSON COUNTY, NEW JERSEY (ALL JURISDICTIONS)

Hudson County



**COMMUNITY NAME**  
BAYONNE, CITY OF  
EAST NEWARK, BOROUGH OF  
GUTTENBERG, TOWN OF  
HARRISON, TOWN OF  
HOBOKEN, CITY OF  
JERSEY CITY, CITY OF  
KEARNY, TOWN OF  
NORTH BERGEN, TOWNSHIP OF  
SECAUCUS, TOWN OF  
UNION CITY, CITY OF  
WEEHAWKEN, TOWNSHIP OF  
WEST NEW YORK, TOWN OF

**COMMUNITY NUMBER**  
340218  
340219  
340220  
340221  
340222  
340223  
340224  
340225  
340226  
340058  
340228  
340229

AUGUST 16, 2006



Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER  
34017CV000A

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.

Part or all of this FIS may be revised and republished at any time. In addition, part of this FIS may be revised by the Letter of Map Revision process, which does not involve republication or redistribution of the FIS. It is, therefore, the responsibility of the user to consult with community officials and to check the community repository to obtain the most current FIS components.

Initial Countywide FIS Effective Date: August 16, 2006

Revised Countywide FIS Dates:

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FLOOD INSURANCE STUDY  
HUDSON COUNTY, NEW JERSEY (ALL JURISDICTIONS)

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study (FIS) investigates the existence and severity of flood hazards in or, revises and updates a previous FIS/Flood Insurance Rate Map (FIRM) for the geographic area of Hudson County, including the Towns of Guttenberg, Harrison, Kearny, Secaucus, and West New York; the Townships of North Bergen and Weehawken; the Borough of East Newark; and the Cities of Bayonne, Hoboken, Jersey City, and Union City (hereinafter referred to collectively as Hudson County). The City of Union City is non-floodprone. Please note that a portion of the Hackensack Meadowlands Commission also lies within Hudson County. This portion will be shown as an area not included. Flood hazard information for the Hackensack Meadowlands Commission is shown in its entirety on the FIS and FIRM for Bergen County (All Jurisdictions) (Reference ♦).

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 be used by Hudson County to update existing floodplain regulations as part of the Regular Phase of the National Flood Insurance Program (NFIP). The information 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 set forth in the Code of Regulations at 44 CFR, 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 the incorporated communities within Hudson County in a countywide FIS. 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:

Bayonne, City of:	the hydrologic and hydraulic analyses from the original February 15, 1983, FIS report were prepared by the New Jersey
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Department of Environmental Protection (NJDEP), Division of Water Resources, for the Federal Emergency Management Agency (FEMA), under Contract No. H-4623. That work was completed in January 1981. Part of the hydrologic and hydraulic analyses for that study was performed by Harris-Toups Associates under subcontract to the NJDEP.

East Newark, Borough of:

the hydrologic and hydraulic analyses from the September 1977 FIS report, were performed by the NJDEP, Division of Water Resources, Bureau of Floodplain Management, and Tippetts - Abbett - McCarthy - Stratton, Engineers and Architects for the Federal Insurance Administration (FIA), under contract No. 3855. That work was completed in November 1976.

Guttenberg, Town of:

the hydrologic and hydraulic analyses from the January 16, 1984, FIS report, were performed by Camp, Dresser and McKee, under subcontract to the New York State Department of Environmental Conservation (NYSDEC), during the FIS for the City of New York, dated May 16, 1983.

Harrison, Town of:

the hydrologic and hydraulic analyses from the September 1977 FIS, were performed by Tippetts - Abbett - McCarthy - Stratton, Engineers and Architects, for the FIA, under Contract Number H-3855. That work was completed in December 1976.

Hoboken, City of:

the hydrologic and hydraulic analyses from the May 17, 1982, FIS report, were prepared by the NJDEP, Division of Water Resources, for FEMA, under Contract No. H-4623. That work was completed in January 1981. Part of the hydrologic and hydraulic analyses for that study was performed by Harris-Toups Associates under subcontract to the NJDEP.

Jersey City, City of:

the hydrologic and hydraulic analyses from the September 1, 1983, FIS report, were prepared by the NJDEP, Division of Water

Resources, for FEMA, under Contract No. H-4623. That work was completed in January 1981. Part of the hydrologic and hydraulic analyses for that study was performed by Harris-Toups Associates under subcontract to the NJDEP.

Kearny, Town of:

the hydrologic and hydraulic analyses from the February 1977 FIS report, were performed by the NJDEP, and Tippetts-Abbett-McCarthy-Stratton, Engineers and Architects for the FIA, under contract No. 3855. That work was completed in December 1976.

North Bergen, Township of:

the hydrologic and hydraulic analyses from the March 30, 1982, FIS, were prepared by the NJDEP for FEMA, under Contract No. 4546. That work was completed in November 1979. Part of the hydrologic and hydraulic analyses for that study was conducted by URS/MSR Engineers under subcontract to the NJDEP. The 1982 wave height analysis for that study was prepared by Dewberry and Davis under contract No. EMW-C-0543.

Weehawken, Township of:

the hydrologic and hydraulic analyses from the November 1, 1983, FIS report, were performed by Camp, Dresser and McKee, under subcontract to the NYSDEC, for FEMA, during the FIS for the City of New York, dated May 16, 1983.

West New York, Town of:

the hydrologic and hydraulic analyses from the November 1, 1988, FIS report, were performed by Camp, Dresser and McKee, under subcontract to the NYSDEC, for FEMA, during the FIS for the City of New York, dated May 16, 1983.

The authority and acknowledgments for the Town of Secaucus and City of Union City is not available because no FIS report was ever published for the communities.

Base map information shown on this FIRM was provided in digital format by the State of New Jersey. The digital orthophotography was produced at a scale of 1"=200' from photography dated 2002. The digital FIRM was produced in New Jersey State Plane projection, FIPZONE 2900.

### 1.3 Coordination

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

The dates of the initial and final CCO meetings held for Hudson County and the incorporated communities within its boundaries are shown in Table 1, "CCO Meeting Dates for Precountywide FISs."

TABLE 1 - CCO MEETING DATES FOR PRECOUNTYWIDE FISs

<u>Community Name</u>	<u>Initial CCO Date</u>	<u>Final CCO Date</u>
City of Bayonne	February 15, 1978	October 5, 1982
Borough of East Newark	May 16, 1975	November 9, 1976
Town of Guttenberg	*	June 21, 1983
Town of Harrison	May 16, 1975	November 30, 1976
City of Hoboken	February 9, 1978	December 23, 1981
City of Jersey City	February 17, 1978	August 8, 1982
Town of Kearny	May 16, 1975	December 16, 1976
Township of North Bergen	May 1979	November 3, 1981
Township of Weehawken	*	June 21, 1983
Town of West New York	*	June 21, 1983

\*Data not available

For this revision, the communities were informed by letter dated August 26, 2005.

A final CCO meeting was held on December 21, 2005, and was attended by representatives of the City of Bayonne, Town of Harrison, Township of North Bergen, Town of Secaucus, NJDEP, Medina, Dewberry, and FEMA.

## 2.0 AREA STUDIED

### 2.1 Scope of Study

This FIS covers the incorporated areas of the geographic area of Hudson County, New Jersey.

The flooding in Hudson County is mainly attributed to tidal flooding from the following coastal and riverine sources: the Hudson River, Upper New York Bay, Kill Van Kull, the Hackensack River, and the Passaic River. Throughout Hudson County, these flooding sources were studied by detailed methods, based on the extent and validity of available existing hydrologic and hydraulic data. In

addition, flooding due to storm sewer overflow was also studied by detailed methods. The areas studied by detailed methods were selected with priority given to all known flood hazard areas and areas of projected development and proposed construction.

## 2.2 Community Description

Hudson County is located in northeastern New Jersey. Hudson County is comprised of 12 incorporated communities. The City of Bayonne is located in the southern portion of the county. The Town of Guttenberg and West New York, Townships of North Bergen, Weehawken, and Secaucus, and the City of Union City are located in the northern portion of the county. The City of Jersey City, Town of Kearny and Harrison, and the Borough of East Newark are located in the center of Hudson County.

Hudson County is bordered to the north by the Township of Lyndhurst, and the Boroughs of Carlstadt, Cliffside Park, East Rutherford, Edgewater, Fairview, North Arlington, Ridgefield, and Rutherford in Bergen County. To the west, the county is bordered by the Township of Belleville and City of Newark City in Essex County, as well as the City of Elizabeth City in Union County. To the east, the Hudson River is the dividing border between the City of New York, New York, and the Town of Guttenberg and West New York, Townships of North Bergen and Weehawken, City of Hoboken and the northern portion of the City of Jersey City; Upper Bay borders the southern portion of Jersey City. To the south, the county is bordered by the City of New York where Kill Van Kull is the dividing border.

According to the 2000 U.S. Census, the land area in Hudson County was 47 square miles and the estimated population of Hudson County was 608,975 in 2000.

The topography of Hudson County varies from gentle rolling hills to flat lowland areas. The climate of the county is characteristic of the Middle Atlantic seaboard. Vegetation consists of planted lawns, trees, and shrubbery and is typical of residential, commercial areas. The climate in Hudson County is variable, with the winters characterized by cold dry air masses which have their origin over sub-polar continental regions, and summers characterized by warm, humid air masses from sub-tropical regions, modified by their passage over land surfaces. During the spring and fall, maritime polar air masses become increasingly influential. The average annual rainfall is approximately 42.4 inches and snowfall averages about 30 inches per year. The average annual temperature is approximately 53 degrees Fahrenheit (°F), with the lowest average temperature (31.4°F) in January and the highest average temperature (76.4°F) in July (Haven and Emerson, Inc., 1979).

## 2.3 Principal Flood Problems

Flooding in Hudson County is caused primarily by tidal flooding, from such sources as the Upper New York Bay, New York Bay and Kill Van Kull. These sources in turn affect the riverine sources as the Hudson River, Hackensack River

and Passaic River. Throughout Hudson County, low-lying surface flooding and interior shallow ponding occurs as a result of heavy rainfall accompanied by high tides. Concave coastal areas are prone to flooding caused by high tides and wind driven currents. Interior flooding is primarily due to inadequate capacity of combined storm and sanitary sewers (Haven and Emerson, Inc., 1979; Malcolm Pirnie, Inc., 1979).

Flooding in the Township of Weehawken, and Towns of Guttenberg and West New York is caused primarily by tidal flooding of the Hudson River in the low-lying areas along the shore.

In the Cities of Bayonne, Jersey City, and Hoboken, the most severe flooding events were due to hurricanes. The flood of record for these cities occurred during Hurricane Donna on September 12, 1960. The water level at East Newark applicable to Newark Bay during September 12, 1960, flood reached 8.4 feet at high tide, a level of 5.5 feet above the normal high tide. The maximum storm surge of record in the Hackensack estuary occurred on November 25, 1950, when the water-surface elevation increased 9 feet above low tide, reaching an elevation of 6.5 feet. If this surge would have occurred at high tide, the resultant flood elevation would have reached 12 feet.

The Towns of Kearny and Harrison are subject to tidal flooding from the Passaic River. The flooded areas run adjacent to the Passaic River. Flooding usually occurs when the annual peak rainfall coincides with a high tide in the Passaic River. A maximum recorded tide level of 8.33 feet was measured on the Passaic River at East Newark on September 12, 1960; it had a 20-year recurrence interval. The flood of record for the Passaic River was in October 1903.

In the Township of North Bergen, flooding results from the tidal stages of Newark Bay which affect the Hackensack River and, in turn, Bellmans Creek, Cromakill Creek, and Penhorn Creek, which wind their way through the Hackensack estuary. Tidal elevation from the Hackensack River also affects the meadowlands district with the Township from North Bergen. The storm of record for the Hackensack River occurred on September 27, 1975. The U.S. Geological Survey (USGS) gage located at New Milford, New Jersey, recorded a flow of 4,300 cubic feet per second (cfs) with an associated gage height of 7.54 feet (USGS, 1970-1976). This flow has approximately a 25-year recurrence interval.

#### 2.4 Flood Protection Measures

Presently, there are no flood control measures that would alter flood hazards due to coastal flooding within Hudson County. Residents throughout the county depend on the usual warnings issued through the radio, television, and local newspapers for information concerning possible flood conditions. Flood warnings and predicted flood peaks are issued by the National Oceanic and Atmospheric Administration, Flood Forecasting Center, located at Trenton, New Jersey.

The U.S. Army Corps of Engineers (USACE) have planned a project for the Passaic River Basin that would provide flood protection for the Towns of

Harrison and Kearny and the Borough of East Newark. The planned project would consist of channel improvements, flood walls and levees, and flood impoundments. The project has not yet been authorized and is, therefore, not considered in this study.

The Hackensack Meadowlands Development Commission (HMDC), authorized by state statute in January 1969, has jurisdiction over development in the Hackensack Meadowlands District. In connection with New York District of the USACE, flood protection measures for the Hackensack River are being studied. Various plans for flood control have been presented by the USACE in their draft report and in their Environmental Impact Statement on the Hackensack River Basin (USACE, 1969; USACE, unpublished).

### 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 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for each flooding source studied in detail affecting the county.

For each community within Hudson County that has a previously printed FIS report, the hydrologic analyses described in those reports have been compiled and are summarized below.

##### Upper New York Bay And Kill Van Kull

The extent of coastal flooding due to hurricanes and northeasters is determined by three factors: 1) the nature of the storm with respect to intensity, duration, and path; 2) astronomic tide conditions at the time the storm surge wave reaches shore; and 3) the physical geometry and bathymetry to a particular area, which affect the timing and passage of the surge wave.

The Joint Probability Method (JPM) was used to determine stillwater elevations for specific recurrence intervals (Tetra Tech, Inc., 1981). The backbone of the JPM is a statistical analysis of historic storms to determine significant parameters.

JPM is a statistical analysis of historic storms to determine significant parameters. These assumptions are representative of the total distribution of possibly occurring events.

The JPM, as applied in this study, involved simulating a large number of synthetic storms over a mathematical representation of the geometry and bathymetry of the study site. Each storm is comprised of specific storm parameters selected from a range of possibly occurring values, each with an associated probability of occurrence. The values selected best represent the probability distribution of each parameter based on historic records of storms. A varying degree of coincidence of the astronomic tide with meteorologic storms was also included in the analyses.

Storm parameters used in the JPM for analyzing hurricanes consist of the storm frequency, direction of travel, forward velocity, radius to maximum winds, and central pressure depression. Based on a selection of storm parameters and their associated probabilities, 252 synthetic hurricanes were examined.

New York City and vicinity are equally affected by hurricanes and northeasters. Approximately one-half of the surges with a recurrence interval (return period) of 100 years are from northeasters. The problem of flooding produced by northeasters has never been studied in depth in the past. The large contribution of northeasters to the coastal flooding potential made a detailed analysis of northeasters necessary. A new methodology following the concept of the JPM was developed to statistically describe these storms.

From historical data, 13 storms were selected as representative of storms in the vicinity of New York City. Forty-two synthetic northeasters were examined and developed from the 13 observed storms. Parameters involved in the surge potential differ from those used to describe hurricanes and include a five degree latitude maximum pressure gradient, fetch length, duration, and stability condition based on the air-sea temperature. A complete summary of the development of the northeaster methodology is presented in Coastal Flooding Storm Surge Model (Tetra Tech, Inc., 1981).

Each storm surge was combined with five astronomic tides that cover the range of tides of each storm season. Hurricanes usually occur between the months of June and October, and northeasters from November through March. A statistical analysis based on peak daily tides for each of these periods was performed. Five peak values were selected from a cumulative probability curve for each season based on predicted high-water elevations from tide tables.

## Newark Bay

Tidal elevation-frequency relationships for Newark Bay were determined by analyzing the tidal gage records and historical high-water mark data for Upper New York Bay and Newark Bay. Tide gages are maintained at East Newark on the Passaic River by the USGS for the tide data applicable to Newark Bay, and at the Battery (Fort Hamilton), which has a longer period of record (since 1921), for Upper New York Bay.

A total of 563 northeasters occurring between 1926 and 1976 were analyzed and their peak storm surge elevations obtained and ranked by a disaggregation program for East Newark and the Battery. The highest storm tide recorded during this period was that of Hurricane Donna on September 12, 1960 with an elevation of 8.4 feet.

A correlation was established between maximum water-surface elevations at the Battery (Fort Hamilton) and at East Newark. This correlation may be used to transpose storm tides from the Battery to East Newark using the equation,  $H_{en} = 1.06 H_{fh}$ , where  $H_{en}$  is the maximum storm tide at East Newark and  $H_{fh}$  is the maximum storm tide at Fort Hamilton.

A summary of the tidal elevation frequency relationship for Upper New York Bay at the Battery, Newark Bay is shown in Table 2, "Summary of Elevations."

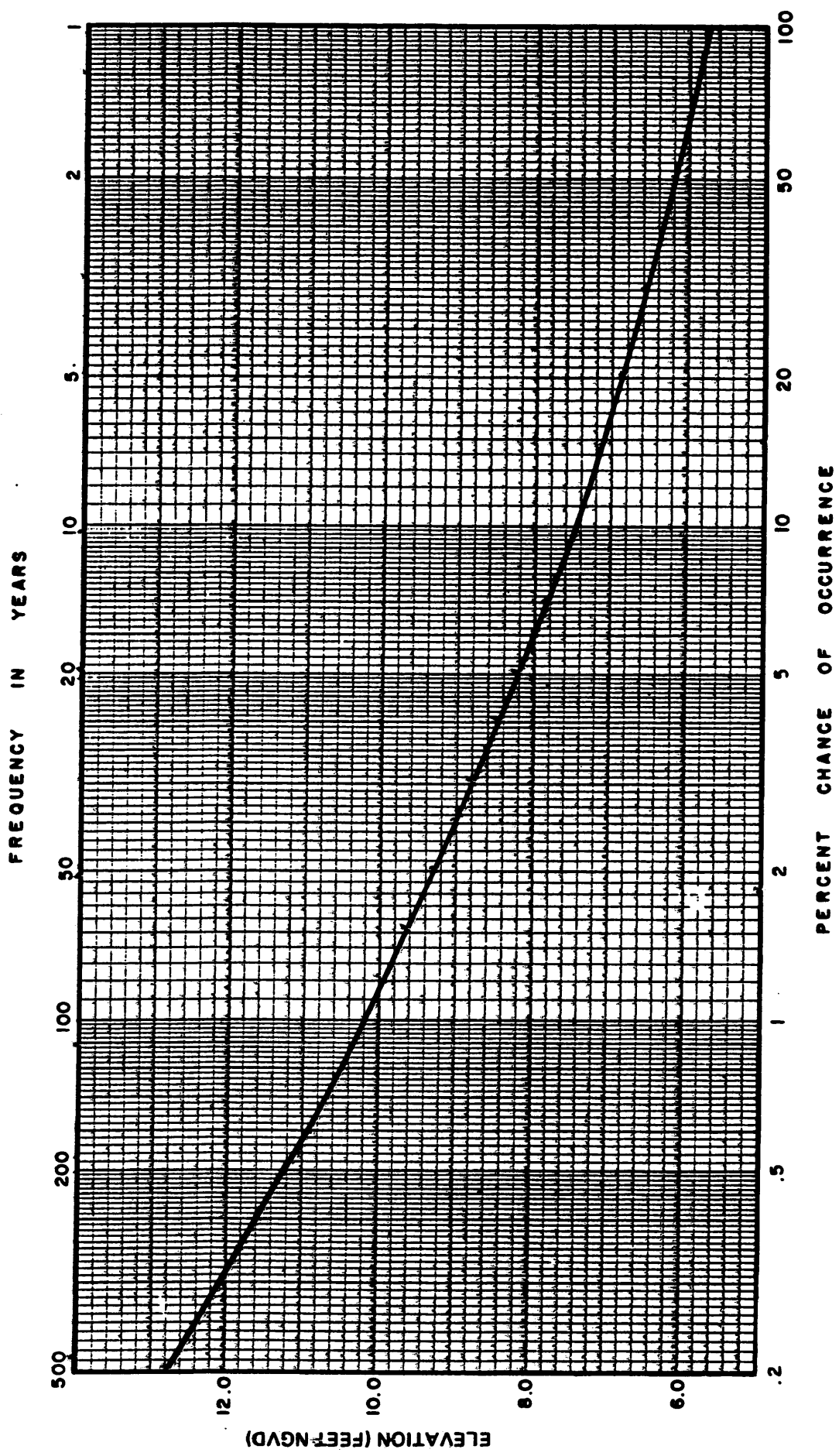
## Hudson River

The detailed analyses for the Hudson River were obtained from the FIS for the City of New York (FEMA, 1983). Water-surface elevations for the 10-, 2-, 1-, and 0.2- percent annual chance floods were taken from a point on the Hudson River closest to the Towns of West New York and Guttenberg and Township of Weehawken, as surface elevations change very gradually along the river.

Tidal-frequency relationships for the Hudson River bordering the Township of North Bergen were developed by FEMA using information from the West Side Highway Project to determine the stillwater surge elevations (Lawler et al., 1979). The stillwater surge elevation is the elevation of the water due solely to effects of the astronomical tides, storm surges, and wave set-up on the water surface. The inclusion of wave heights, which is the distance from the trough to the crest of the wave, increases the water-surface elevations. The height of a wave is dependent upon wind speed and its duration, depth of water, and length of fetch. The wave crest elevation is the sum of the stillwater elevation and the portion of the wave height above the stillwater elevation.

## Passaic River

Peak storm tide levels versus frequency of occurrence, in the Passaic River at East Newark, New Jersey, have been estimated by the USACE (USACE, 1976). The estimates were based on statistical analysis (Water Resources Council, 1967; USACE, 1962) of recorded tide levels at East Newark (1938-1974) and supplemented by recorded tide data at Fort Hamilton (1893-1974). The resultant tide frequency curve is shown in Figure 1, "Total Tide-Frequency Curve." For the purposes of this study, this frequency curve has not been converted from NGVD 29 to NAVD 88. See Section 3.3, "Vertical Datum," for further explanation.



**FIGURE 1**

**FEDERAL EMERGENCY MANAGEMENT AGENCY**  
 HUDSON COUNTY, NJ  
 (ALL JURISDICTIONS)

**TOTAL TIDE-FREQUENCY CURVE**  
**PASSAIC RIVER**

## Hackensack River

For the Hackensack River, the tidal-frequency data as developed for the FIS for the Hackensack Meadowlands District was adopted for this study (FEMA). The tide-frequency data as developed for the Hackensack River also pertains to Bellmans, Cromakill and Penhorn Creeks.

A summary of the tidal elevation frequency relationships is shown in Table 2, "Summary of Stillwater Elevations."

TABLE 2 - SUMMARY OF STILLWATER ELEVATIONS

<u>FLOODING SOURCE AND LOCATION</u>	<u>ELEVATION (feet NAVD 88)</u>			
	<u>10-PERCENT</u>	<u>2-PERCENT</u>	<u>1-PERCENT</u>	<u>0.2-PERCENT</u>
<b>UPPER NEW YORK BAY</b>				
At the confluence of the Hudson River	5.9	7.8	8.4	10.8
Eastern shoreline of the City of Bayonne	6.3	8.1	8.6	10.8
<b>NEWARK BAY</b>				
At the confluence of the Passaic River	6.3	8.3	8.9	9.9
Approximately 0.5 mile downstream of the Newark Bay Bridge	6.0	7.3	8.4	9.5
At Shooters Island	5.3	6.8	7.2	8.6
<b>KILL VAN KULL</b>				
At the confluence of the Upper New York Bay	6.3	8.1	8.6	10.8
Approximately 2.0 miles upstream of the Bayonne Bridge	5.8	7.4	9.9	9.8
Approximately 0.7 mile upstream of the Bayonne Bridge	5.3	6.8	7.2	8.6
At the confluence with Newark Bay	5.3	6.8	7.2	8.6
<b>HUDSON RIVER</b>				
Entire shoreline of West New York, Weehawken, and Guttenberg	6.3	7.8	8.6	10.7
Entire shoreline of North Bergen	6.1	7.7	8.3/11.1 <sup>1</sup>	9.9
<b>HACKENSACK RIVER</b>				
In the vicinity of Bellmans Creek	5.5	6.9	7.5	8.0
In the vicinity of Cromakill Creek	5.5	6.9	7.6	8.0
In the vicinity of Penhorn Creek	2.2	3.3	3.8	4.2

<sup>1</sup>Surge Stillwater Elevation/Maximum Wave Crest Elevation

<sup>2</sup>Surge Stillwater Elevation

### 3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals. Users should be aware that flood elevations shown on the FIRM represent rounded whole-foot elevations and may not exactly reflect the elevations shown on the tables in the FIS report. For construction and/or floodplain management purposes, users are encouraged to use the flood elevation data presented in this FIS in conjunction with the data shown on the FIRM.

For each community within Hudson County that has a previously printed FIS report, the hydraulic analyses described in those reports have been compiled and are summarized below.

Hydraulic analyses of the shoreline characteristics of the flooding sources studied in detail were carried out to provide estimate of the elevations of floods of the selected recurrence intervals along each of the shorelines. Consideration was given to the vulnerability of the shorelines of the Cities of Jersey City, Hoboken, and Bayonne to wave action during severe hurricanes and northeasters. However, the effects of wave action were found to be minimal.

Water-surface elevations for the eastern shores of Jersey City and Hoboken inundated by tidal flooding from Upper New York Bay were determined from data from data at the gaging station at the Battery, New York (TAMS, 1980). For the City of Bayonne, water-surface elevations for the eastern and southern shores inundated by tidal flooding from Upper New York Bay and Kill Van Kull, respectively, were determined using data from historic and synthetic hurricanes and northeasters which occurred in the vicinity of New York City (Tetra Tech, Inc., 1981). Water-surface elevations for the western shore of Bayonne and Jersey City inundated by tidal flooding from Newark Bay were determined from gage data at East Newark, New Jersey (TAMS, 1980).

Flood boundary determinations were also undertaken to delineate interior drainage flood hazard areas which flood due to tidal backwater and inadequate combined stormwater and sanitary sewer capacity. The methodology used to determine the elevation of these low-lying ponding areas consisted first of determining the capacity of the storm drainage collection system and developing an intensity-duration rainfall curve (Malcolm Pirnie, Inc., 1979; Barnett and Herenchak, Inc., 1962). The time of concentration at the local flooding point was then estimated and a simple inflow unit hydrograph was derived. After this, a stage-storage relationship for each ponding area was developed, and finally, a complete flood routing was produced to compute pond elevations based upon inflow, outflow, and ponding storage.

Analysis of hydraulic shoreline characteristics of the Hudson River were carried out to provide estimates of wave heights and corresponding wave crest elevations of floods of the selected recurrence intervals along its shoreline.

Areas of coastline subject to significant wave attack are referred to as coastal high hazard zones. The USACE has established the 3-foot breaking wave as the criterion for identifying the limit of coastal high hazard zones. 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. This criterion has been adopted by FEMA for the determination of V-zones.

The methodology for analyzing wave heights and corresponding wave crest elevations was developed by the National Academy of Sciences (NAS, 1977). The NAS methodology is based on three major concepts.

First, a storm surge on the open coast is accompanied by waves. The maximum height of these waves is related to the depth of water by the following equation:

$$H_b = 0.78d$$

where  $H_b$  is the crest to trough height of the maximum or breaking wave and  $d$  is the stillwater depth. The elevation of the crest of an unimpeded wave is determined using the equation:

$$Z_w = S^* + 0.7H^* = S^* + 0.55d$$

where  $Z_w$  is the wave crest elevation,  $S^*$  is the stillwater surge elevation at the site, and  $H^*$  is the wave height at the site. The 0.7 coefficient is the portion of the wave height which reaches above the stillwater surge elevation,  $H_b$  is the upper limit for  $H^*$ .

The second major concept is that the breaking wave height may be diminished by dissipation of energy by natural or man-made obstructions. The wave height transmitted past a given obstruction is determined by the following equation:

$$H_t = BH_i$$

where  $H_t$  is the transmitted wave height,  $H_i$  is the incident wave height and  $B$  is the transmission coefficient ranging from 0.0 to 1.0. The coefficient is a function of the physical characteristics of the obstruction. Equations have been developed by the NAS to determine  $B$  for vegetation, buildings, natural barriers such as dunes, and man-made barriers such as breakwaters and seawalls (NAS, 1977).

The third concept deals with unimpeded reaches between obstructions. New wave generation can result from wind action. This added energy is related to distance and mean depth over the unimpeded reach.

Within North Bergen, these concepts and equations were used to compute wave height and wave crest elevations associated with the 1-percent annual chance storm surge. Accurate topographic, land use, and land cover data are required for the wave height analysis. Maps of the study area at a scale of 1:2,400 with a contour interval of 5 feet were used for topographic data (Geod Aerial Survey, Inc., 1978). The land-use and land-cover data were obtained from aerial

photographs (stereoscopic coverage) of North Bergen. These photographs were taken in March of 1979 and are at a scale of 1:12,000 (Keystone Aerial Surveys, Inc., 1979).

Wave heights were computed along transects which were located perpendicular to the average mean shoreline. The transects were located with consideration given to the physical and cultural characteristics of the land so that they would closely represent conditions in their locality. Transects were spaced close together in areas of complex topography and dense development. In areas having more uniform characteristics, the transects were spaced at larger intervals. It was also necessary to locate transects in areas where unique flooding existed and in areas where computed wave heights varied significantly between adjacent transects. Figure 2, "Transect Location Map" illustrates the location of the transect in the community of North Bergen and Table 3, "Transect Descriptions" provides a physical description of the area along the shoreline represented by the transect.

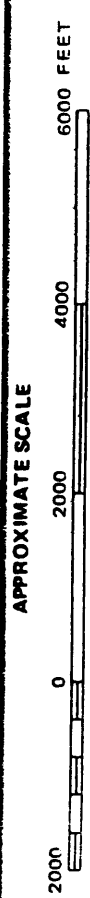
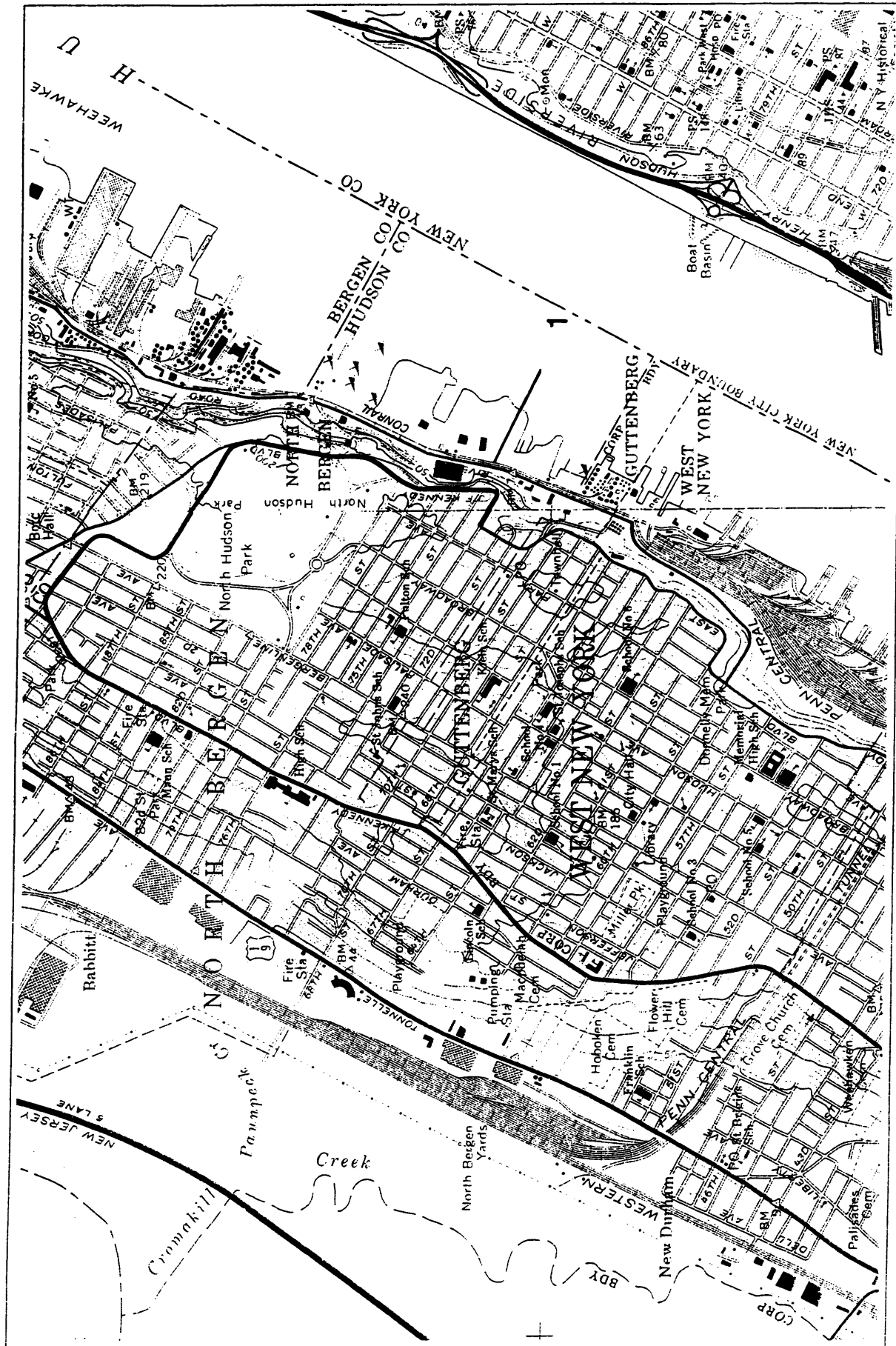
TABLE 3 - TRANSECT DESCRIPTIONS

<u>TRANSECT</u>	<u>LOCATION</u>	<u>ELEVATION (feet NAVD)</u>	
		<u>1-PERCENT STILLWATER</u>	<u>MAXIMUM 1-PERCENT WAVE CREST</u>
1	Shoreline of Hudson River	8.3	10.9

Along each transect, wave heights and wave crest elevations were computed considering the combined effects of changes in ground elevation, vegetation, and physical features. Wave heights were calculated to the nearest 0.1 foot, and wave crest elevations were determined at whole-foot increments along the transects. The calculations were carried inland along the transect until the wave crest elevation was permanently less than 0.5 foot above the stillwater surge elevation or the coastal flooding met another flooding source (i.e., riverine) with an equal water-surface elevation. The results of the calculations are accurate until local topography, vegetation, or cultural development of the community undergo any major changes.

No profiles were developed for either the Passaic River or the Hackensack River because flooding is tidal and elevations would be constant.

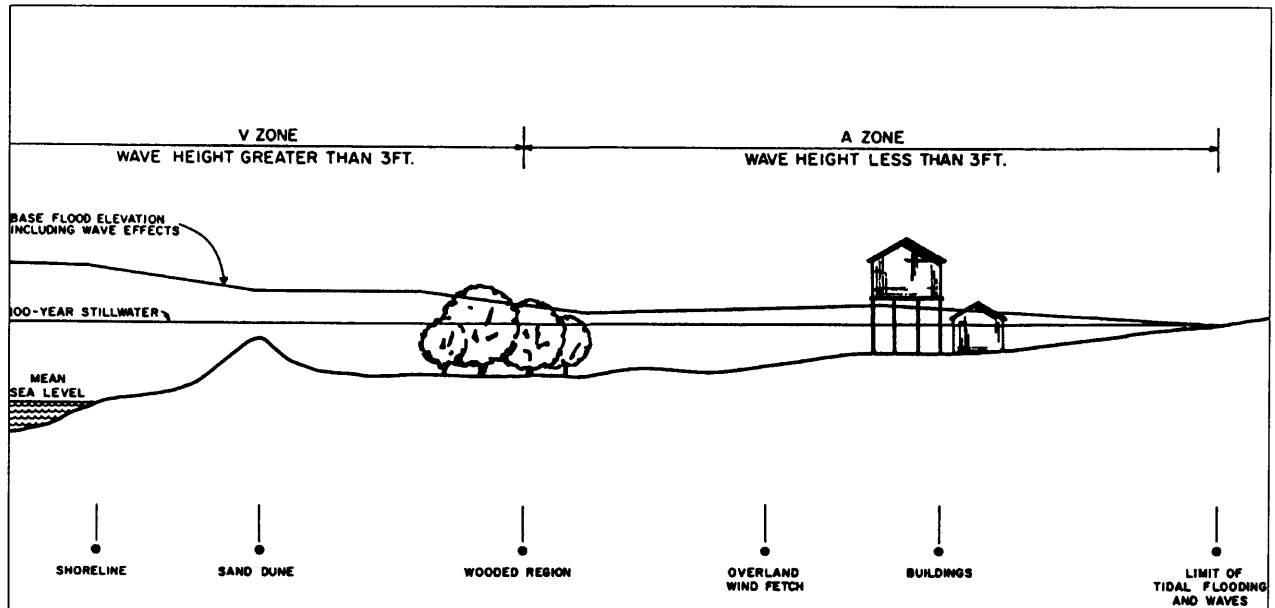
Figure 3 represents a sample transect that illustrates the relationship between the stillwater elevation, the wave crest elevation, the ground elevation profile, and the location of the A/V zone boundary.



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**TRANSECT LOCATION MAP**

**FIGURE 2**



**TRANSECT SCHEMATIC**

Figure 3

All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29). Elevation reference marks (ERMs) used in this study, and their descriptions, are shown on the FIRM. ERMs shown on the FIRM represent those used during the preparation of this and previous FISs. The elevations associated with each ERM were obtained and/or developed during FIS production to establish vertical control for determination of flood elevations and floodplain boundaries shown on the FIRM. Users should be aware that these ERM elevations may have changed since the publication of this FIS. To obtain up-to-date elevation information on National Geodetic Survey (NGS) ERMs shown on this map, please contact the Information Services Branch of the NGS at (301) 713-3242, or visit their website at [www.ngs.noaa.gov](http://www.ngs.noaa.gov). Map users should seek verification of non-NGS ERM monument elevations when using these elevations for construction or floodplain management purposes.

### 3.3 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 (NGVD 29). With the finalization of the North American Vertical Datum of 1988 (NAVD 88), many FIS reports and FIRMs are being prepared using NAVD 88 as the referenced vertical datum.

All flood elevations shown in this FIS report and on the FIRM are referenced to NAVD 88. Structure and ground elevations in the community must, therefore, be referenced to NAVD 88. It is important to note that adjacent communities may be

referenced to NGVD 29. This may result in differences in base flood elevations across the corporate limits between the communities.

Prior versions of the FIS report and FIRM were referenced to NGVD 29. When a datum conversion is effected for an FIS report and FIRM, the Flood Profiles, base flood elevations (BFEs) and ERMs 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 FIS report and on the FIRM for Hudson County are referenced to NAVD 88. Ground, structure, and flood elevations may be compared and/or referenced to NGVD 29 by applying a standard conversion factor. The conversion factor to NGVD 29 is +1.1. 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 NGVD 29 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 NAVD 88, see Converting the National Flood Insurance Program to the North American Vertical Datum of 1988, FEMA Publication FIA-20/June 1992, or contact the Vertical Network Branch, National Geodetic Survey, Coast and Geodetic Survey, National Oceanic and Atmospheric Administration, Rockville, 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 one 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 one 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 (100-year) flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2-percent annual chance (500-year) flood is employed to indicate additional areas of flood risk in the community.

For the Cities of Bayonne, Hoboken, and Jersey City, the 1- and 0.2-percent annual chance boundaries were delineated using topographic maps of the study area at a scale of 1:2,400 with a contour interval of 2 feet, superimposed on orthophotos prepared from aerial photographs. For the Towns of Guttenberg and West New York, and the Township of Weehawken, the 1- and 0.2-percent annual chance boundaries were delineated using topographic maps of the study area at a scale of 1:1,200, with a contour interval of 5 feet. For the Borough of East Newark, Towns of Harrison and Kearny, and the Township of North Bergen the 1- and 0.2-percent annual chance floods were delineated using topographic maps with a scale of 1:2,400 and contour intervals of 5 feet. In cases where the 1- and 0.2-percent annual chance flood boundaries are close together, only the 1-percent annual chance boundary has been shown.

#### 4.2 Floodways

Encroachment on flood plains, such as artificial fill, reduces the flood-carrying capacity and increases flood heights, thus increasing flood hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from flood plain development against the resulting increase in flood hazard. For purposes of the National Flood Insurance Program, the concept of a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the one percent annual chance flood is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus and adjacent flood plain areas, that must be kept free of encroachment in order that the one percent annual chance be carried without substantial increases in flood heights. Criteria adopted by the NFIP limit such increase to 1.0 foot, provided that hazardous velocities are not produced.

The area between the floodway and the boundary of the one percent annual chance flood is termed the floodway fringe. The floodway fringe thus encompasses the portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the one percent annual chance flood more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe are their significance to floodplain development are shown in Figure 4, "Floodway Schematic."

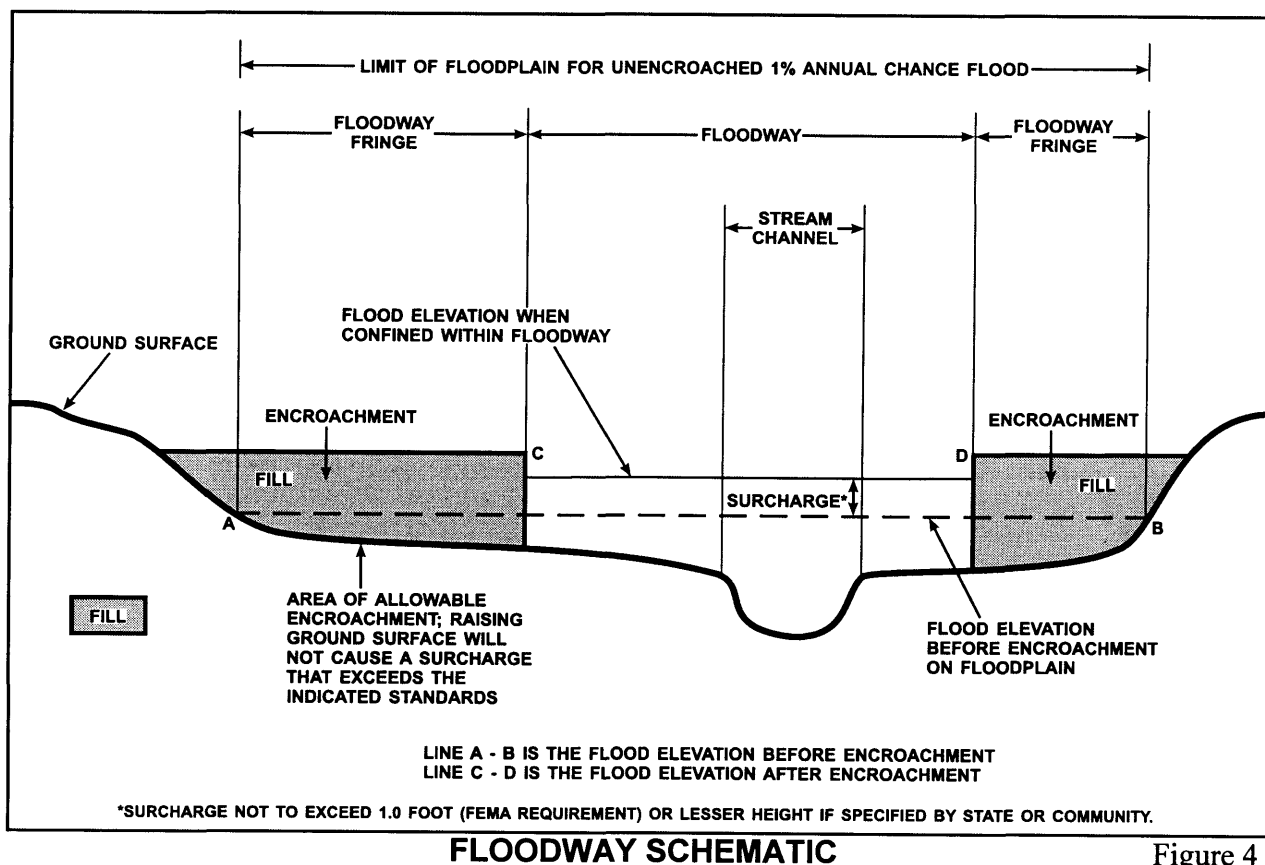


Figure 4

No floodways were calculated as part of this study.

## 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 one percent annual chance floodplains that are determined in the FIS by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no base flood elevations or depths are shown within this zone.

### Zone AE

Zone AE is the flood insurance rate zone that corresponds to the one percent annual chance floodplains that are determined in the FIS by detailed methods. In most instances, whole-foot base flood elevations 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 one percent annual chance shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. Whole-foot base flood elevations 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 one 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

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

### Zone A99

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

### Zone V

Zone V is the flood insurance rate zone that corresponds to the one percent annual chance coastal floodplains that have additional hazards associated with storm waves. Because approximate hydraulic analyses are performed for such areas, no base flood elevations are shown within this zone.

### Zone VE

Zone VE is the flood insurance rate zone that corresponds to the one percent annual chance coastal floodplains that have additional hazards associated with storm waves. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

### Zone X

Zone X is the flood insurance rate zone that corresponds to areas outside the 0.2 percent annual chance floodplain, areas within the 0.2 percent annual chance floodplain, and areas of one percent annual chance flooding where average depths are less than 1 foot, areas of one percent annual chance flooding where the contributing drainage area is less than 1 square mile, and areas protected from the

one percent annual chance flood by levees. No base flood elevations or depths are shown within this zone.

#### 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 one percent annual chance floodplains that were studied by detailed methods, shows selected whole-foot base flood elevations or average depths. Insurance agents use the zones and base flood elevations 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. On selected FIRM panels, 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 Hudson County. Previously, separate Flood Hazard Boundary Maps and/or FIRMs were prepared for each identified flood-prone incorporated community. This countywide FIRM also includes flood hazard information that was presented separately on Flood Boundary and Floodway Maps (FBFMs), where applicable. Historical data relating to the maps prepared for each community, up to and including this countywide FIS, are presented in Table 4, "Community Map History."

### 7.0 OTHER STUDIES

Information pertaining to revised and unrevised flood hazards for each jurisdiction within Hudson County has been compiled in this FIS. Therefore, this FIS supersedes all previously printed FIS reports, FIRMs, and or FBFMs for all of the incorporated jurisdictions within Hudson County.

FISs have been prepared for adjacent communities, and county jurisdictions were reviewed and are in agreement with this FIS. These include reports prepared by the City of Elizabeth City, New Jersey (FEMA, November 1, 1985), City of Newark City, New Jersey (FEMA, September 4, 1987), Bergen County and All Jurisdictions, New Jersey (FEMA, December 12, 1988), the City of New York, New York (FEMA, May 31, 2001).

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISIONS DATE	FIRM EFFECTIVE DATE	FIRM REVISIONS DATE
Bayonne, City of	May 17, 1974	September 17, 1976	August 15, 1983	August 16, 2006
East Newark, Borough of	June 28, 1974	June 11, 1976	September 30, 1977	August 16, 2006
Guttenberg, Town of	June 28, 1974	February 6, 1976	July 16, 1984	August 16, 2006
Harrison, Town of	June 28, 1974	None	September 30, 1977	August 16, 2006
Hoboken, City of	June 28, 1974	April 30, 1976	November 17, 1982	August 16, 2006
Jersey City, City of	July 25, 1975	August 13, 1976	March 1, 1984	August 16, 2006
Kearny, Town of	June 28, 1974	August 13, 1976	December 1, 1977	August 16, 2006
North Bergen, Township of	June 28, 1974	October 31, 1975 August 13, 1976	September 30, 1982	August 16, 2006
Secaucus, Town of	October 5, 1973	August 13, 1976	March 25, 1983	August 16, 2006
Weehawken, Township of	August 2, 1974	March 5, 1976	May 1, 1984	August 16, 2006
West New York, Town of	May 31, 1974	August 20, 1976	May 1, 1984	August 16, 2006

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**COMMUNITY MAP HISTORY**

**TABLE 7**

## 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 1351, New York, New York 10278.

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