FLOOD INSURANCE STUDY

FEDERAL EMERGENCY MANAGEMENT AGENCY

VOLUME 1 OF 1

CITY OF NEW YORK, NEW YORK

COMMUNITY NAME	COMMUNITY NUMBER
BRONX COUNTY	
KINGS COUNTY	
NEW YORK COUNTY	
QUEENS COUNTY	
RICHMOND COUNTY	

FEMA

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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 FIS Effective Date: May 16, 1983 (FIS report);
November 16, 1983 (Flood Insurance Rate Map)

Revised FIS Dates: February 15, 1991- To change zone designations and to add special flood hazard areas.

May 18, 1992- To add otherwise protected areas.

July 5, 1994- To add base flood elevations, to add special flood hazard areas and to change special flood hazard areas.

May 21, 2001- To reflect updated topographic information, to update map format and to change special flood hazard areas.

September 5, 2007- To reflect updated topographic information, to update map format and to change special flood hazard areas

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FLOOD INSURANCE STUDY
CITY OF NEW YORK,
BRONX, KINGS, NEW YORK, QUEENS, AND RICHMOND COUNTIES,
NEW YORK

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study (FIS) revises and updates a previous FIS/Flood Insurance Rate Map (FIRM) for the City of New York, which incorporates all of Bronx, Kings, New York, Queens, and Richmond counties, New York, this also includes Ellis Island and Liberty Island. This information will be used by the City of New York 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.

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.

For the original May 16, 1983, FIS and November 16, 1983, FIRM (hereinafter referred to as the 1983 FIS), the hydrologic and hydraulic analyses for Arthur Kill, the Atlantic Ocean, Bronx Kill, the Bronx River, the East River, the Harlem River, the Hudson River, the Hutchinson River, Jamaica Bay, Kill Van Kull, Long Island Sound, Lower Bay, Newark Bay, Raritan Bay, and Upper Bay were prepared by Camp, Dresser and McKee, Inc., under subcontract to the New York State Department of Environmental Conservation (NYSDEC) for the Federal Emergency Management Agency (FEMA), under Contract No. H-4784. That work was completed in December 1981.

For the February 15, 1991, revision, the hydrologic and hydraulic analyses for Ranger Creek were prepared by the New York City Department of City Planning for FEMA. That work was completed in May 1989.

For the July 5, 1994, revision, the hydrologic and hydraulic analyses for Sweet Brook, Colon Tributary, Eltingville Tributary, Arbutus Creek, Jansen Tributary, Denise Tributary, Lemon Creek, and Sandy Brook, were prepared by Leonard Jackson Associates for FEMA, under Contract No. 91-R-3373. That work was completed in June 1992.

For the May 21, 2001, revision, updated topographic information of wetlands within Richmond County only was prepared by the New York City Department of Environmental Protection (NYCDEP). This information was agreed upon with FEMA to be used for the revision.

For the September 5, 2007, revision, updated topographic information for the City of New York was provided by the City of New York Department of Information Technology and Telecommunication (DOITT) and used to redelineate all detailed flood hazard areas. Additionally, updated hydrologic and hydraulic analyses for the Bronx River, Arbutus Creek, Blue Heron Main, Blue Heron Tributary, Butler Manor, Colon Tributary, D Street Brook, Denise Tributary, Eltingville Tributary, Foresthill Road Brook, Jansen Tributary, Lemon Creek, Mill Creek, Mill Creek Tributary 1, Mill Creek Tributary 2, Mill Creek Tributary 3, Sandy Brook, Sweet Brook, and Richmond Creek were prepared by Leonard Jackson Associates for FEMA, under Contract No. EMN-2003-RP-001.

For the [*date*] revision, updated topographic information generated by LiDAR (Light Detection and Ranging) for the City of New York was collected and processed by Sanborn Map Company. The LiDAR data were collected from April 14 to May 1, 2010. The updated topographic information was used to redelineate all detailed flood hazard areas. New coastal analysis was performed for the coastal flood hazard areas.

Base map information shown on the FIRMs was provided by DOITT. This information was derived from digital orthophotography produced at a scale of 1:1,200 from photography dated April 2008.

The coordinate system used for the production of this FIRM is New York State Plane FIPSZONE 3104.

1.3 Coordination

The purpose of an initial Consultation Coordination Officer's (CCO) meeting is to discuss the scope of the FIS. A final CCO meeting is held to review the results of the study.

For the 1983 FIS, an initial CCO meeting was held on August 12, 1976, and a final CCO meeting was held on December 13, 1982. Both of these meetings were attended by representatives of the City of New York; Camp, Dresser and McKee, Inc.; and FEMA.

For the July 5, 1994, study, an initial CCO meeting was held on February 1990 and was attended by representatives of the City of New York, Leonard Jackson Associates, and FEMA.

For the May 21, 2001, revision, a Cooperating Technical Community (CTC) Agreement was made on July 8, 1999, between the Borough of Staten Island and FEMA.

For the September 5, 2007, revision, an initial CCO meeting was held on April 22, 2004, and was attended by representatives of the City of New York Department of Buildings, DOITT, City of New York Department of Planning, City of New York Office of Emergency Management, Leonard Jackson Associates, Dewberry, and FEMA.

For the [*date*] revision, New York City serves as a Cooperating Technical Partner with FEMA for this Flood Insurance Study and Flood Insurance Rate Map update. FEMA has worked closely with New York City throughout the development of this updated Flood Insurance Study. FEMA and NYC have met on a weekly basis to discuss technical, programmatic, and administrative matters related to this project. Additionally, FEMA presented detailed technical information on October 18, 2012 to many NYC Departments such as New York City Department of City Planning, the Mayor's Office of Long-Term Planning and Sustainability, Department of Buildings, and the Office of Emergency Management. Further, on June 26, 2013, FEMA and the New York State Department of Environmental Conservation met with the New York City Department of City Planning, the Mayor's Office of Long-Term Planning and Sustainability, Department of Buildings to discuss the regulatory aspects of administering the Flood Insurance Rate Maps and Flood Insurance Study update.

2.0 AREA STUDIED

2.1 Scope of Study

This FIS covers the incorporated area of the City of New York, Bronx, Kings, New York, Queens, and Richmond Counties, New York; this also includes Ellis Island and Liberty Island. Although Elis Island is largely part of Jersey City, New Jersey, the island will be shown on the Hudson County, NJ maps along with the City of New York maps.

For the 1983 FIS, the following streams were studied by detailed methods: the Bronx River, the Hutchinson River, the Atlantic Ocean, Raritan Bay, New York Bay (including the Upper Bay, Lower Bay, and the Narrows), Jamaica Bay, Long Island Sound, Little Neck Bay, the East River, the Harlem River, the Hudson River, Arthur Kill, Bronx Kill, and Kill Van Kull.

The February 15, 1991, FIS was prepared to map wetlands as 1-percent-annual-chance special flood hazard areas along Ranger Creek stream corridors in Richmond County on Staten Island.

For the July 5, 1994, FIS, the following streams were studied by detailed methods: Sweet Brook, from its confluence with the Richmond Creek swamplands to Delmar Avenue; Colon Tributary, from its confluence with Sweet Brook to Gifford's Lane; Eltingville Tributary, from its confluence with Sweet Brook to the Staten Island Railroad; Arbutus Creek, from the Hylan Boulevard to a point approximately 1,200 feet upstream of Amboy Road; Jansen Tributary, from its confluence with Arbutus Creek to a point near Kingdom Avenue; Denise Tributary, from its confluence with Arbutus Creek to a point near Hogan Avenue;

Lemon Creek, from a point approximately 500 feet upstream of Rossville Avenue to Amboy Road for a distance of approximately 1.5 miles; and Sandy Brook, from its confluence with Lemon Creek to a point approximately 500 feet downstream of Sharrotts Road.

For the May 21, 2001, FIS, some 1-percent-annual-chance Flood (Zone A) floodplains and a portion of the 1-Percent Annual Chance Flood (Zone AE) floodplain along Eltingville Tributary, from Katan Avenue to a point approximately 200 feet upstream of Wilson Avenue, within Richmond County on Staten Island, were removed and/or redelineated based on updated topographic information (NYCDEP, 1999). The revision also incorporated the following Letter of Map Revisions: 92-02-014P, dated December 24, 1992, to reflect the effects of two completed storm drain projects, to contain Springville Creek in the vicinity of the Heartland Condominiums II and 98-02-698P, dated May 2, 1999, to modify Special Flood Hazard Areas (SFHAs) near the intersection of Dewey Avenue and Greaves Avenue.

For the September 5, 2007 FIS, some 1-percent-annual-chance (Zone AE) and 500-year (Zone X shaded) floodplains were revised and/or redelineated based on updated topographic and base map information (NYC DOITT, 2004).

The September 5, 2007 FIS also incorporates the following Letter of Map Revision: 01-02-045P, dated July 3, 2002, to reflect the construction of a rip-rap revetment and slope protection along Prince's Bay.

As part of the September 5, 2007 FIS, updated analyses were included for the flooding sources shown in Table 1, "Detailed Flooding Sources."

TABLE 1: DETAILED FLOODING SOURCES

Amboy Road Wetland
Arbutus Creek
Blue Heron Main
Blue Heron Tributary
Bronx River
Butler Manor
Cleveland Avenue Wetland
Colon Tributary
D Street Brook
Denise Tributary
Eibs Pond
Eltingville Tributary
Forest Hill Road Brook
Hillside Avenue Wetland
Jacks Pond
Jansen Tributary
Lemon Creek
Mill Creek
Mill Creek Tributary 1
Mill Creek Tributary 2
Mill Creek Tributary 3
Richmond Creek
Sandy Brook
Stump Pond
Sweet Brook
Wolfe's Pond
Wood Duck Pond

Limits of detailed study are indicated on the Flood Profiles (Exhibit 1) and on the FIRM (Exhibit 2). 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.

Several streams were studied by approximate methods. Approximate analyses were used to study those areas having a low development potential or minimal flood hazards. The scope and methods of study were proposed to, and agreed upon by, FEMA and the City of New York.

For the [*date*] FIS, new analysis for coastal flood hazard areas for the entire shoreline of the City of New York was incorporated and all detailed flood hazard areas were redelineated based on updated topographic data.

2.2 Community Description

The City of New York is located in southeastern New York State and consists of Bronx County (Bronx Borough), Kings County (Brooklyn Borough), New York County (Manhattan Borough), Queens County (Queens Borough), and Richmond County (Staten Island Borough). The City of New York is bordered to the west and southwest in the State of New Jersey by Sandy Hook, the Towns of Middletown, Union Beach, Cliffwood, Cliffwood Beach, Lawrence Harbor, Sayreville, the City of South Amboy and the Boroughs of Keansburg and Keyport along the southern shore of Raritan Bay; the Cities of Perth Amboy, Linden, Elizabeth and Bayonne, the Township of Woodbridge, and the Borough of Carteret, located west of Staten Island; and the Cities of Jersey City and Hoboken, the Towns of West New York, and Guttenburg, the Townships of Weehawken, North Bergen, and Tenafly, on the west side of the Hudson River. In the State of New York, communities bordering the City of New York to the north include the Cities of Yonkers and Mount Vernon, the Villages of Pelham Manor, Pelham, and New Rochelle. The surface area of the City of New York is 412.3 square miles (27 percent is under water) with a land area of 303 square miles.

New York City originated in the spring of 1624 when 30 families arrived on Manhattan Island and constructed permanent dwellings on the southern shore, now known as the Battery. By 1700, the population had increased to 5,000. By that time, the docks along the coastline had been filled in with refuse and silt and paved over so that the docks could be extended. By 1800, the population of the city increased to 60,000. Staten Island had a population of 4,500. In 1834, Brooklyn became a city with a population of 24,000. By 1850, the population of New York City, still consisting only of Manhattan, had increased to 515,000. In 1898, greater New York originated the merger of Manhattan with Brooklyn, Staten Island, Queens, and the Bronx. The correct borough name for Richmond County is also Richmond. However, the borough is most commonly referred to as Staten Island, which is used throughout this study. Today, the City of New York is the largest city in the United States and one of the largest cities in the world. The 1980 population of the city was 7,035,348 (U.S. Department of Commerce, 1981). The 1990 population of the city was 7,322,564. The population of the city increased to 8,008,278 in the 2000 Census (U.S. Census, 2000). In the 2010 census, the population of the city increased to 8,175,133 (U.S. Census, 2010). The populations of the counties and boroughs in New York are shown in Table 2, “Population and Land Area of New York City.”

TABLE 2: POPULATION AND LAND AREA OF NEW YORK CITY

County	Borough	1990 Census Population	2000 Census Population	2010 Census Population	Land Area (sq. miles)
Bronx	Bronx	1,203,789	1,332,650	1,385,108	42
Kings	Brooklyn	2,300,664	2,465,326	2,504,700	71
New York	Manhattan	1,487,536	1,537,195	1,585,873	23
Queens	Queens	1,951,598	2,229,379	2,230,722	109
Richmond	Staten Island	378,977	443,728	468,730	58

The following brief history of the Rockaway Peninsula and Jamaica Bay will provide some insight as to the reason data regarding the city's coastline and water area should be referenced to a specific time period.

In 1835, Rockaway Point was located near the present east boundary of Jacob Riis Park. East Rockaway Inlet was located 20,000 feet east of its present position, near Long Beach, New York. South of Rockaway Point, a large shoal had formed which was to provide the material for extending this point nearly four miles to the east during the next 100 years. The shoreline generally receded between 1835 and 1878 while, at the same time, Rockaway Point extended two miles westward. Jacob Riis Park acquired its present shoreline during this period.

Between 1878 and 1927, the shoreline of the Rockaways advanced a small amount. Rockaway Point grew rapidly until 1902, but from 1902 to 1927, its westward expansion was only half its previous rate. From 1927 to 2007, the shoreline of the Rockaways has been stable. Nearly 12 million cubic yards of sand have been artificially placed east of Rockaway Point since that time.

Within Jamaica Bay, it has been estimated that 150 million cubic yards of material have been dredged. The most common use for dredged material has been for fill purposes in land reclamation projects. Originally, almost all of the area surrounding Jamaica Bay except the barrier beach to the south was marshland. Due to extensive filling, the shoreline around the bay is always changing.

Some of the larger projects in Jamaica Bay during this time were: Floyd Bennet Airfield at Barren Island; the development of the Mill Basin area by private developers; the construction of Canarsie pier; the completion of the Shore Parkway over low-lying marshland; the City of New York Department of Parks reclamation work in connection with the building of Spring Creek Park; the fill around Broad Channel and Rulers Bar Hassock for the construction of Cross Bay Boulevard in the 1920s; and the operations concerned with the development of John F. Kennedy Airport.

The excellent harbor facilities and location in respect to canal and railroad transportation systems have contributed to the growth of the City of New York. In addition to shoreline development associated with the city's commerce as a port, the high population density has caused development in areas subject to flooding.

Despite the proximity of the City of New York to the Atlantic Ocean and its numerous bays and rivers, the climate of the city is more continental than maritime. This is because the weather conditions affecting New York usually approach the city from the west. However, the maritime influence is not totally absent. During the summer, sea breezes moderate the heat, and during the winter, coastal storms accompanied by winds from the east may bring considerable amounts of rain or snow.

The mean annual temperature for the City of New York is 55.2 degrees Fahrenheit (°F). Subfreezing temperatures occur on an average of 92 days per year; however, subzero weather may occur only two days in every three winters. During an average summer, the temperature reaches the 90s on 7 days. Temperatures of 100°F or higher have occurred approximately 7 times since 1871.

Precipitation is moderate and is distributed evenly throughout the year. The normal annual precipitation is 46.2 inches; with approximately 25 inches occurring between April and October. A prolonged dry period may be expected approximately every two or three years, usually in September or October. Rainfall occurring between June and September is usually the result of thunderstorms and is brief and relatively intense. From October through April, rainfall is generally associated with widespread storms generating day-long precipitation. The average annual snowfall is approximately 28.6 inches and occurs on an average of approximately 35 days between November and April.

The City of New York consists of three physiographically different areas. Bronx and New York Counties are an eroded southern extension of the glaciated upland area that occupies a large part of New England. The northern half of Kings and Queens Counties and all but a one-mile wide strip on the southeastern shore of Richmond County consists of terminal moraine and the hilly till-covered area north of the terminal moraine. The remainder of these three counties is made up of glacial outwash plain.

The New York Bight is the geographic designation for the portion of the continental shelf bordered by the Atlantic Coastal Plain extending from Cape May, New Jersey, northeast to Montauk, Long Island. It is characterized by beaches, numerous shallow, irregular estuaries and bays, the most prominent of which is the estuary of the Hudson River. The Hudson River has drowned valley morphology. Sediment movement and deposition have resulted in significant changes in the shelf area nearest the bight.

Long Island Sound also has drowned valley morphology. The southern slope of the ground, near Long Island, is steep and smooth, reaching depths of over 140 feet.

New York Bay is divided into Upper New York Bay and Lower New York Bay by the Narrows. The Upper Bay is bounded by the Battery on the north and Fort Hamilton-Fort Wadsworth on the south. The Lower Bay is bounded by Fort Hamilton and Sandy Hook.

Raritan Bay is part of the system of interconnected bays and channels surrounding Staten Island and the northern coast of New Jersey. This system also includes Arthur Kill, Kill Van Kull, and Newark Bay.

The Bronx River extends 23 miles from its mouth at the East River to Kensico Reservoir. The Kensico Reservoir does not release flows to the river, but serves as a water supply for the City of New York. From the just downstream of the reservoir, the river flows through Westchester County. Within the City of New York, the Bronx River flows south from the Yonkers corporate limits through the center of the borough for approximately 8.7 miles to its mouth at the East River. The river once served as the border between the Cities of Yonkers and Mount Vernon; however, continued relocations of the river have altered this. Within the City of New York, a series of four dams cause a drop in elevation of approximately 40 feet. The dams limit backwater effects from reaching far upstream on the Bronx River. Within the city, the river drops a total of 60 feet before flowing into the East River between Hunts Point and Claron Point. The Bronx River has a drainage area of 56.4 miles at its mouth. Exclusion of the areas draining into four water supply reservoirs reduces the drainage area to 38.3 square miles. The average width of the drainage basin is 2.5 miles.

The Hutchinson River originates in New Rochelle and flows for approximately 11 miles to Long Island Sound. The Hutchinson River is tidally controlled for its entire length. Within the study area, the river has a drainage area of 5.8 square miles. Historical discharge data for the Hutchinson River is available from USGS gaging station No. 01301500 at Pelham, New York. As of May 1, 2013 funding was dropped for USGS monitoring network in the five boroughs of New York City. (USGS, September 24, 2013).

The Hudson River originates in the Adirondack Mountains. The river has a drainage area of 13,400 square miles, most of which lie in the northern and eastern parts of New York and in small portions of Vermont, Massachusetts, Connecticut, and New Jersey. The lower Hudson is an estuary with tidal effects propagating 150 miles upstream to the Green Island Dam at Troy, New York, and downstream from the confluence of the Mohawk River.

The East River and the Harlem River serve as a connection between the Hudson River, the Upper Bay and Long Island Sound.

Jamaica Bay is a semi-enclosed body of water, sheltered from the Atlantic Ocean by the Rockaway Peninsula. The Rockaway Inlet is a long, narrow channel between the peninsula and Brooklyn, and is the only connection between the bay and the ocean during the non-storm tidal cycles. Many islands make Jamaica Bay into a network of channels and marshy areas.

2.3 Principal Flood Problems

The City of New York is affected by flooding from local, fluvial, and coastal flooding. Local flooding refers to flooding of inland portions of the city from short-term, high-intensity rainfall in areas with poor drainage.

Fluvial flooding is caused by rivers and streams overflowing their banks. Most of the rivers within the City of New York are tidally influenced. This means that water levels in the rivers are controlled by the tidal conditions at the mouth of the river with little or no influence from the flow in the stream. Both fluvial and tidal flooding associated with waves occur within the study area; however, tidal flooding was found to be the primary cause of damage within the city.

Coastal flooding is caused by long and short wave surges that affect the shores of the open ocean, bays and tidally influenced rivers, streams, and inlets. The movement of coastal waters is influenced by the astronomic tide and meteorological forces such as northeasters and hurricanes. Hurricanes and northeasters have historically caused flooding in and around the study area. Inundation of low-lying coastal areas in the City of New York is primarily the result of storm surges, wave setup, and wave runup, which occur during hurricanes and northeasters.

The City of New York is built in a confined coastal location, which accounts for much of its natural protection against hurricanes. The strongest winds from a storm rarely reach New York since the New Jersey coast is on one side of the city and Long Island is on the other side. However, high storm surges can propagate within the New York Bight and cause severe flooding along the coastal portions of the city. Moreover, the cuplike topography of the area accounts for most of the dynamic effects, including resurgence, which cause the waters to oscillate to flood levels well after the storm has left the area.

Sections of Queens, Brooklyn, and Staten Island are exposed to direct ocean surges and waves. Coney Island and the Rockaway Peninsula are particularly vulnerable to wave damage. On Rockaway Peninsula and Jamaica Bay, the shoreline configuration has changed considerably over the past 50 years due to dredging and filling. These changes affect wave propagation, particularly in areas such as Rockaway Point at Rockaway Inlet, where the configuration of the point controls the direction of the incoming waves. Surge waves can also propagate through Long Island Sound. Consequently, a surge wave can propagate in the New York Bight, move into New York Bay through the Hudson River and enter the East River from the south.

Jamaica Bay is affected by astronomical tides, storm surges from the Atlantic Ocean off New York Bay, wind-generated wave setups within the bay, and rainfall runoff from other areas (American Society of Engineering, 1964). The outer shoreline of the Rockaway Peninsula is subject to tidal fluctuations from the Atlantic Ocean. The Rockaway Peninsula can be a surge barriers to Jamaica Bay during small storm surges; however, a storm surge can almost entirely overtop and inundate the peninsula during larger surge events.

The most severe flooding conditions result from the overtopping of the peninsula. The low-lying areas of Brooklyn and Southern Queens including Kennedy Airport are directly affected by flooding from Jamaica Bay.

The northern portion of Queens and the east Bronx are directly affected by surges originating in Long Island Sound. The east shore of City Island has a history of severe damage. In 1969, it was estimated that a recurrence of the 1938 hurricane, the storm of record, would produce $23 million damage of City Island alone.

Detailed descriptions of coastal flood damage in and around the City of New York caused by the November 1950, November 1953, September 1960, and March 1962 storms are presented in Study Overview (Camp, Dresser and McKee, 1983).

The storm of November 1950 caused millions of dollars worth of damage and required evacuation of many parts of New York. Damage as a result of the flood occurred in parts of Queens, Jamaica Bay, Brooklyn, Rockaway Point, and Staten Island. Tides inundated portions of Staten Island for up to one mile inland.

During this flood, Rockaway Point beaches were severely eroded and the protective dunes were leveled. Homes along the ocean and bay were inundated by one to two feet of water. Wave crest heights ranged to an estimated 25 feet along the Atlantic Ocean.

There was a tide recorded (8.6 feet at Fort Hamilton, Brooklyn, New York) that resulted from the hurricane of September 1960. The City of New York experienced damage estimated at close to $20,000,000.

As a result of the March 1962 storm, the City of New York experienced damages totaling approximately $17,000,000. Portions of Coney Island and Rockaway Beach were inundated by one to two feet of water.

Almost all of the largest storms through the April 1962 to November 1992 period were either small tropical storms by the time they got to the Northeast or they passed to the east of New York City and had very little impacts in New York City, such as Gloria in 1985 (Category 2) and Agnes in 1972 (Category 1).

On December 12, 1992, the city sustained the most significant flood damage since the March 1962 storm. A peak wind gust of 67 mph was recorded at LaGuardia Airport. Commerce and transportation all but ceased as roads and subway tunnels became flooded. Peak tidal elevations were recorded 8.04 feet NAVD 1988, at the Battery, in Manhattan and 11.27 feet NAVD 1988 at Willets Point, in Queens. Over 3000 homes, citywide, sustained storm related damage. Estimates of storm related damage topped 750 million dollars.

Having earlier been downgraded to a tropical storm, Irene came ashore in Brooklyn on August 28, 2011 during the astronomical high tide. Peak winds were recorded at 58 mph at JFK International Airport. A peak tidal elevation of approximately 9.5 feet NAVD 1988 was recorded at the Battery. Heavy rain swept through the city with 6.87 inches of rain being reported in Central Park. Fearing damage to infrastructure and possible public safety issues, the city shut down the subway system and evacuated thousands of residents in low-lying coastal areas; however, only minor flooding was reported. The storm continued

inland with extensive flood related damages to property and infrastructure, for areas upstate of the city, approximating 1.3 billion dollars.

Sandy came ashore as an immense extratropical storm in Brigantine, New Jersey, on October 29, 2012. Being north and east of the storm track the city sustained extensive damage to property and infrastructure in each of the 5 boroughs. The astronomical tides in the city at the time of landfall were at their highest level. A peak wind gust of 90 mph was recorded at Islip, in Long Island. At the entrance to New York Harbor, wave heights were recorded to 32.5 feet. Storm related tidal levels were approximately 11.28 feet NAVD 1988 at the Battery (NOAA NOS Hurricane Sandy Water Level & Meteorological Data Report, January 24, 2013) and 12.5 feet NAVD 1988 at Kings Point. General tidal inundation elevations were 9 to 12 feet NAVD 1988 in Manhattan, 10 to 13 feet NAVD 1988 in Staten Island, 9 to 12 feet NAVD 1988 in Brooklyn, and 10 to 11 feet NAVD 1988 in Queens and the Bronx. Emergency responses were hampered; especially in Queens, where high winds and storm surge prevented fire response which resulted in the loss of approximately 122 structures. Extensive coastal flooding occurred in Staten Island, affecting the communities of Oakland Beach, New Dorp and Midland. In Manhattan, inundation occurred in the vicinity of the Battery, East Village and areas along and below Canal Street. Public infrastructure, citywide, was severely affected with all modes of public transportation ceasing operations due to storm conditions. Seven major subway tunnels were flooded, disrupting service for up to several weeks. Several highway tunnels were also flooded as well as the World Trade Center site. Bridges and tunnels were closed. Extensive disruptions in electrical power occurred in Manhattan. Commerce was disrupted, on a nationwide basis, with a closure of the stock exchanges, lasting 2 days. Estimates of storm related damages, including the City of New York, exceed 42 billion dollars.

2.4 Flood Protection Measures

Numerous flood protection measures have been developed in the City of New York. Many portions of the city are subjected to the direct influence of the ocean and have had bulkheads constructed for the purpose of beach stabilization. Riprap and seawalls have been constructed to dissipate waves caused by tidal action. Much construction has been elevated or protected to prevent extensive flood damage. In order to comply with requirements allowing citizens to be eligible for the Flood Insurance Program, the City of New York calls for all new construction to be protected to a specified elevation. A summary of flood protection measures built up until 1983 for Staten Island, the Rockaway Peninsula, and Jamaica Bay is presented in Study Overview (Camp, Dresser and McKee, 1983). The Coastal Protection Section (Chapter 3) of the New York City "A Stronger, More Resilient, New York" comprehensive plan (New York City, 2013) states that there are no purpose-built coastal flood protection structures in New York City but act in this way by coincidence. The New York City comprehensive plan also contains a detailed description of the shorelines of New York City and the impacts of Hurricane Sandy, as well as proposed protection measures.

The City of New York has an intricate navigational system. While the purpose of the system is not to provide flood protection, the existence of well-maintained channels assures a relatively unrestricted flow of water throughout the area which could potentially result in water reaching areas that it should not.

The principal deep-water channels of the Port of New York include: Ambrose Channel, from the Atlantic Ocean into Lower New York Bay; Anchorage Channel, in Upper New York Bay; and the Hudson River Channel, up to 59th Street. These channels have a depth of 45 feet and a width of 2,000 feet. Buttermilk, Bay Ridge, and Red Hook Channels, the East River to the Brooklyn Navy Yard, and tributary channels all have depths of 40 feet. Kill Van Kull and Arthur Kill Channels, known as the New York and New Jersey Channels, respectively, have a separate entrance to the ocean by way of Bayside Channel and have depths of 35 feet. A recently authorized modification provides a new entrance channel replacing the eastern portion of the Bayside-Gedney Channel. The East River has been improved to a point 35 feet beyond the Navy Yard. Secondary channels such as Gowanus Creek, Newtown Creek, Coney Island Channel, Rockaway Inlet, Jamaica Bay, and the Harlem River have depths ranging from 15 to 30 feet.

Federal construction and maintenance costs now total more than $200 million since the first dredging and removal of rock obstructions at Hells Gate in the East River was undertaken by the U.S. Army Corps of Engineers (USACE) in 1853. The average annual commerce in the Port of New York between 1966 and 1975 was over 180 million tons. Commerce including waste material during 1975 was more than 177 million tons. While the port has naturally deep-water harbors and channels, extensive improvements have been made over the last 150 years. Some of the current active projects are listed below and detailed descriptions can be found in (USACE, 2013).

Bronx River Basin
Jamaica Bay
Flushing Bay and Creek (Ecosystem Restoration and Navigation)
Hudson Raritan Estuary—Gowanus Bay and Canal
Hudson Raritan Estuary—Overall Feasibility Study
Hudson River
New York City Watershed
Atlantic Coast of New York Monitoring Program
East River/ Queensbridge Seawall
East River South Border Island Channel
East Rockaway Inlet to Rockaway Inlet (Rockaway Beach)
Rikers Island
Rockaway Inlet to Norton Point (Coney Island)
South Shore of Staten Island
Arthur Kill Channel
Buttermilk Channel
New York and New Jersey Channels
Great Kills Harbor
New Harbor

Engineer School/Fort Totten
Gerritsen Creek
Plumb Beach
Orchard Beach

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equaled or exceeded once on the average during any 10-, 2-, 1-, and 0.2-percent-annual-chance Flood 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 community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

For the 1983 FIS, the City of New York separately examined the impact of fluvial flooding, coastal flooding caused by hurricane surges, and coastal flooding caused by northeasters. Since the causes of flooding are independent, the separate results were combined in a probabilistic sense. A wave height analysis was also performed to account for the inclusion of short-period, wave-induced waves. The extensive hydrologic and hydraulic analyses necessary to accomplish this study have been documented in a series of reports prepared for the New York State Department of Environmental Conservation (NYSDEC) (Camp, Dresser and McKee, 1983, 1979, 1982, April 1981, 1980, December 1981, November 1981, Total Stillwater Elevations; November 1981, Wave Crest Analysis).

3.1 Riverine Hydrologic Analyses

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

For the May 16, 1983, study, a log-Pearson Type III distribution of the annual peak flows was used to generate discharge-frequency relationships for the Bronx River (Water Resources Council, 1977; U.S. Department of the Interior, 1979). Discharge-frequency estimates were made for other points along the Bronx River by adjusting the discharge-frequency curve at the gaging station according to the ratios between corresponding drainage areas, main channel slopes, surface storage indexes, and indexes of manmade impervious cover. The procedure is

documented in a report prepared for the NYSDEC (Camp, Dresser and McKee, April 1981). A similar procedure was used to study New Jersey by the State of New Jersey Department of Environmental Protection (Stankowski, 1974).

From the FIS for Mount Vernon, Westchester County, New York, it was determined that flooding along portions of the Hutchinson River downstream of East Sanford Boulevard was completely tidally controlled; therefore, no fluvial analysis was performed (FEMA, 1978). The stage-frequency analysis for the Hutchinson River in the Bronx is, therefore, performed as part of the coastal analysis in for the May 16, 1983 study.

For the September 5, 2007, revision, the USACE HEC-1 Flood Hydrograph computer program was used to establish peak discharge and peak elevation-frequency relationships for all streams except Wood Duck Pond and Eibs Pond, where a stage elevation relationship was derived and analyzed.

For the [*date*] revision, no new riverine analysis was performed. The flood hazard boundaries were redelineated using updated topographic information. As of May 1, 2013 funding was dropped for the USGS monitoring network in the five boroughs of New York City (USGS, September 24, 2013).

A summary of the drainage area-peak discharge relationships for a portion of the streams studied by detailed methods is shown in Table 3, "Summary of Discharges."

TABLE 3: SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
ARBUTUS CREEK					
Confluence with Arbutus Lake	0.71	205	330	404	575
Upstream of Hylan Boulevard	0.59	293	414	484	650
Upstream of Arbutus Avenue	0.42	211	297	347	450
Upstream of Louise Street	0.37	187	263	307	410
At confluence with Jansen Tributary	0.30	151	212	248	320
Upstream of Amboy Road	0.23	117	165	193	260
BLUE HERON MAIN BRANCH					
Outflow from Lipsett Pond	0.50	193	239	345	440
Upstream of Hylan Boulevard	0.47	208	303	342	430
Upstream of confluence with Blue Heron Main Tributary	0.22	112	134	193	245
Upstream of Eylandt Street	0.17	92	131	155	195
Upstream of Tallman Street	0.10	50	72	85	110
BLUE HERON TRIBUTARY					
Upstream confluence with Blue Heron Main Branch	0.13	75	109	128	170
Upstream Barclay Avenue	0.08	47	70	82	110

TABLE 3: SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
BRONX RIVER					
At confluence with East River	38.3	2,312	3,486	4,097	5,798
At East Gun Hill Road	34.4	2,175	3,286	3,866	5,495
At East 238th Street (corporate limits)	31.4	2,065	3,125	3,680	5,250
At USGS gage	26.5	1,875	2,847	3,358	4,823
BUTLER MANOR					
Mouth to Raritan Bay	0.18	305	414	276	600
Approximately 1,000 feet upstream of Raritan Bay	0.18	172	228	257	315
Upstream of Richard Avenue	0.06	67	82	89	105
Downstream of Hylan Boulevard	0.05	50	60	62	70
Upstream of Hylan Boulevard	0.05	64	89	104	130
COLON TRIBUTARY					
Confluence with Sweet Brook	0.36	108	151	177	225
Approximately 1,530 feet Upstream of D Street	0.01	126	166	192	248
DENISE TRIBUTARY					
Confluence with Arbutus Creek	0.13	65	92	108	150
ELTINGVILLE TRIBUTARY					
Confluence with Sweet Brook	1.17	339	479	560	710
FORESTHILL ROAD BROOK					
Approximately 756 feet upstream of Foresthill Road	*	263	387	443	565
At the confluence with Richmond Creek	*	126	172	199	260
JANSEN TRIBUTARY					
Confluence with Arbutus Creek	0.05	25	35	41	57
LEMON CREEK					
Mouth to Princes Bay (Raritan Bay)	2.09	490	708	849	1,120
Upstream of Bayview Avenue	1.67	390	572	689	920
Upstream of S.I.R.T.	1.23	290	438	529	730
Upstream of Maguire Avenue	0.77	147	246	301	440
At Richmond Parkway	0.73	139	234	285	425

*Data not available

TABLE 3: SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
LEMON CREEK (cont'd)					
Upstream of Richmond Parkway/confluence with Sandy Bridge	0.50	100	171	209	315
Upstream of Detention Basin Outlet near Helene Court	0.38	86	153	189	285
Outlet from Prodzio Pond	0.16	37	63	78	115
Upstream of Rossville Avenue	0.09	27	40	47	62
MILL CREEK					
Upstream of Page Avenue – downstream limit of study	1.30	1,012	1,411	1,653	2,100
Upstream of lower S.I.R.T. crossing	0.61	533	742	863	1,080
Upstream of Upper S.I.R.T. crossing	0.59	516	718	835	1,050
Upstream of Boscombe Avenue (gage)	0.47	408	569	661	840
Upstream of Richmond Parkway	0.39	311	434	506	620
Upstream of West Shore Expressway	0.24	159	223	260	335
Upstream of Vereans Road West	0.12	69	97	114	150
MILL CREEK TRIBUTARY 1					
Confluence with Mill Creek	0.16	153	213	247	320
MILL CREEK TRIBUTARY 2					
Confluence with Mill Creek	0.42	368	513	597	760
MILL CREEK TRIBUTARY 3 (TO TRIBUTARY 2)					
Confluence with Mill Creek Tributary 2	0.15	164	228	265	340
RICHMOND CREEK					
Upstream of Arthur Kill Road	1.90	780	1,010	1,170	1,400
Upstream of Eleanor Street	1.00	335	440	515	620
Upstream of Rockland Avenue	0.50	150	200	230	280
SANDY BROOK					
At confluence with Lemon Creek	0.22	48	70	83	115
Upstream of Bloomingdale Road	0.13	33	48	57	78

TABLE 3: SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
SWEET BROOK					
Upstream of Arthur Kill Avenue	2.92	793	1,142	1,388	1,850
Upstream of Abingdon Avenue	2.23	602	875	1,070	1,500
Upstream of Ridgewood Road	2.09	567	826	1,011	1,380
Upstream of Genesee Avenue/ Richmond Avenue	2.06	558	814	997	1,360
Upstream of confluence with Eltingville Tributary	0.84	219	337	424	600
Upstream of Grantwood Avenue	0.65	178	278	352	640
Upstream of Arden Avenue	0.52	154	243	310	440
Upstream of Detroit Avenue	0.46	151	222	296	400
Upstream of Ionia Avenue	0.43	139	208	278	380
Upstream of Richmond Parkway	0.40	124	191	256	340
Upstream of Annadale Wedge Pond	0.30	88	145	194	280
Upstream of Sheldon Avenue	0.30	132	185	217	300
WOLFES POND					
Mouth at outlet to Raritan Bay (downstream study limit)	0.91	227	290	380	620
Downstream Wolfe's Pond	0.89	225	287	377	610
Upstream Wolfe's Pond	0.89	238	300	411	680
Downstream Hylan Boulevard	0.71	190	240	344	530

The stillwater elevations have been determined for the 10-, 2-, 1-, and 0.2-percent-annual-chance floods for the flooding sources studied by detailed methods and are summarized in Table 4, "Summary of Stillwater Elevations."

TABLE 4: SUMMARY OF STILLWATER ELEVATIONS

FLOODING SOURCE	ELEVATION (feet NAVD*) 1-Percent Annual Chance Flood
Amboy Road Wetland	49.17
Cleveland Avenue Wetland	56.88
Eibs Pond	86.30
Hillside Avenue Wetland	54.43
Jacks Pond	51.22
Stump Pond	270.10
Wood Duck Pond	52.77

*North American Vertical Datum of 1988

3.2 Riverine Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the source 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 Flood Profiles or in the Floodway Data 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 the July 5, 1994 study, below-water sections were obtained by field measurement. All bridges and culverts were field surveyed to obtain elevation data and structural geometry. Along certain portions of Sweet Brook and Lemon Creek, a profile base line is shown on the maps to represent channel distances as indicated on the flood profiles and floodway data tables.

Channel roughness factors (Manning's "n") used in the hydraulic computations for the streams studied by detailed methods were chosen by engineering judgment and based on field observations of the streams and floodplain areas (Barnes, 1967). For streams studied by detailed methods, the channel "n" value used was 0.015-0.035 and the overbank "n" values ranged from 0.04 to 0.12. An "n" value of 0.015 was used for concrete structures and 0.024 was used for corrugated metal pipes. A weighted average "n" value was used for bridges with steel decks, concrete abutments, and earthen bottoms. Non-effective flow areas were disregarded by using extremely high "n" values. The acceptability of all assumed hydraulic factors, cross sections, and hydraulic structure data was checked by calibrating computed flood profiles to known historic flood profiles.

For the May 21, 2001, revision, for streams studied by detailed methods, water-surface elevations of floods of selected recurrence intervals were computed through the use of the HEC-2 step-backwater computer program (USACE, 1990).

Several stream courses in the Borough of Staten Island have been enclosed in storm sewers. In some cases, these storm sewers were found to be unable to contain the 1-percent-annual-chance flood discharges. The capacity of these storm sewers was estimated using standard pipe flow methods and was subtracted from the estimated 1-percent-annual-chance discharge at the entrance. Based on the street network and the line of greatest slope, a profile baseline was estimated for the excess discharges and was incorporated into the HEC-2 program. The built environment and infrastructure system within the City of New York have altered the natural storm water system to the extent that it's more difficult to predict where smaller areas of overland flooding might occur.

For the September 5, 2007, revision, for streams studied by detailed methods, water-surface elevations of floods of selected recurrence intervals were computed through the use of HEC-RAS 3.1.3 (USACE, 3.1.3). Starting water-surface elevations for Blue Heron Main, Blue Heron Tributary, Butler Manor, D Street Brook, Denise Tributary, Foresthill Tributary, Jensen Tributary, Lemon Creek, Richmond Creek and Sandy Creek were obtained by utilizing normal depth.

Starting water-surface elevations for Arbutus Creek were obtained by utilizing critical depth. Starting water-surface elevations for the remaining revised streams were obtained from known water surface elevations as per studies conducted by the NYCDEP.

Flood profiles were drawn showing computed water-surface elevations to an accuracy of 0.5 foot for floods of the selected recurrence intervals. Locations of selected cross sections used in the hydraulic analyses are shown on the flood profiles (Exhibit 1). For stream segments for which a floodway is computed (Section 4.2), selected cross-section locations are also shown on the revised FIRM (Exhibit 2).

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

For *[date*] revision, no new riverine analysis was performed. The flood hazard boundaries were redelineated using updated topographic information. However, floodplain mapping and elevations for the riverine areas have been updated to reflect tie-in information from the updated coastal analysis

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.

3.3 Coastal Analyses

Coastal stillwater analysis was performed for the Harlem, Hudson, Hutchinson, and East Rivers, Arthur and Bronx Kills and Kill Van Kull, the Atlantic Ocean, Raritan Bay, New York Bay, Jamaica Bay, Long Island Sound, Little Neck Bay, and all the bays and inlets within these areas.

The City of New York and the New York Bight area are affected equally by hurricanes and northeasters. 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 the shore; and 3) the physical geometry and bathymetry of a particular area, which affects the timing and passage of the surge wave.

Bronx County is separated from New York County (Manhattan) by the Harlem River and from Queens by the East River. The county is also affected by flooding from Long Island Sound, Hudson River, and Eastchester Bay. High bluffs subject to erosion can be found along Long Island Sound. The shoreline is a mix of natural and developed areas and includes some unpopulated islands.

New York County (Manhattan) is an island. New York County is separated from Bronx County by the Harlem River and from Kings and Queens Counties by the East River. New York County is separated from New Jersey by the Hudson River. The shoreline in New York County is generally highly developed with many piers. There are some bluffs and other park areas on the upper west side of the island.

Richmond County (Staten Island) is an island and is separated from Long Island by the Narrows and from mainland New Jersey by the Arthur Kill and Kill Van Kull. Coastal flooding affects all shorelines of the island. A low primary frontal dune (PFD) is situated in Richmond County along the Franklin D. Roosevelt Boardwalk. Other sections of PFD are present in Fort Wadsworth, Cedar Grove, New Dorp Beach, Oakwood Beach and in Great Kills Park. These areas are subject to erosion. Erodible bluffs are present along the Raritan Bay in Richmond County. The rest of the shoreline is a mix of natural and developed areas

Kings County (Brooklyn) is located on Long Island and is separated from Richmond County and Hudson County, NJ by the Upper and Lower Bays and the Narrows. Kings County is separated from New York County by the East River. Kings and Queens Counties are separated by Newtown Creek at the northern Kings Boundary (across the East River from New York County). Jamaica Bay separates the barrier island portion of Queens from Kings Counties and Old Mill Creek separates the two counties just west of John F. Kennedy airport. A small primary frontal dune has been delineated in the Sea Gate area and a large beach-front area with a boardwalk runs along the Coney Island, Brighton Beach, and Manhattan Beach neighborhoods. Many areas of the shoreline also have erosion control structures such as bulkheads and groins. The rest of the shoreline is a mix of natural and developed areas with some areas with extensive pier networks.

Queens County is located on Long Island and is separated from Kings County by Newtown Creek (along the East River at the northern part of Kings County), by Old Mill Creek just west of John F. Kennedy airport, and by Jamaica Bay between the barrier island portion of Queens and the Kings mainland. Queens is separated from New York County by the East River and from Bronx by the East River and Long Island Sound. Queens shares a land boundary with Nassau County except for the Head of Bay division to the east of John F. Kennedy airport. Beaches and primary frontal dune areas can be found along the barrier island covering Breezy Point, and the Rockaway neighborhoods. There are several unpopulated islands in Jamaica Bay along with the populated Broad Channel Island. Queens is characterized by erodible bluffs on the North Shore or Long Island Sound shoreline. The rest of the shoreline is a mix of natural and developed areas

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, the Barnegat Bay, the Raritan Bay, the Jamaica Bay, the West end 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 all five New York City boroughs and serves as the basis for updated FIRMs.

The region wide 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 (FEMA, 2010). 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. Two of the more recent storm events Irene

and Sandy were not used in this study for validation. Both Irene and Sandy occurred during the study or after this storm surge study was completed. Irene was a major rainfall event and did not produce major coastal tidal flooding. The climatology of Sandy at this time is not well studied.

Model skill was assessed by quantitative comparison of model output to wind, wave, and high water mark observations. The model was then used to re-create 30 historical extra-tropical storms and 157 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 results in an increased water level at the shoreline due to the breaking of waves and transfer of momentum to the water column during hurricanes and severe storms. For the New York and New Jersey surge study, wave setup was determined directly from the coupled wave and storm surge model. The total stillwater elevation with wave setup was then used for the erosion and overland wave modeling.

The stillwater elevations for the 10-, 2-, 1-, and 0.2- percent annual chance floods determined for the primary sources of flooding in New York City including: Long Island Sound, East River, Hudson River, Raritan Bay, Jamaica Bay, and others are shown in Table 5, "Transect Data." The analyses reported herein reflect the stillwater elevations due to tidal and wind setup effects. If the elevation on the FIRM is higher than the elevation shown in this table, a wave height or wave runup component likely exists, in which case, the higher elevation should be used for construction and/or floodplain management purposes.

3.4 Wave Height Analyses

The wave height analysis was carried out to provide estimates of the elevations of floods of the selected recurrence intervals along the shoreline of the Atlantic Ocean, Raritan Bay, New York Bay, Jamaica Bay, Long Island Sound, Little Neck Bay, and the East River.

The destructiveness of coastal flooding due to high stillwater elevations may be increased by wind-induced waves which contribute to increased water levels and whose size and velocity may damage structures directly. 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.

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. 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. 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. 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. Transects were placed along the shoreline along all sources of primary flooding in each New York City county, as illustrated on the FIRMs and in the "Transect Location Map" provided in Figures 1-1 thru 1-5. Transects also represent locations visited during field reconnaissance to assist in parameterizing obstructions and observing shore protection features.

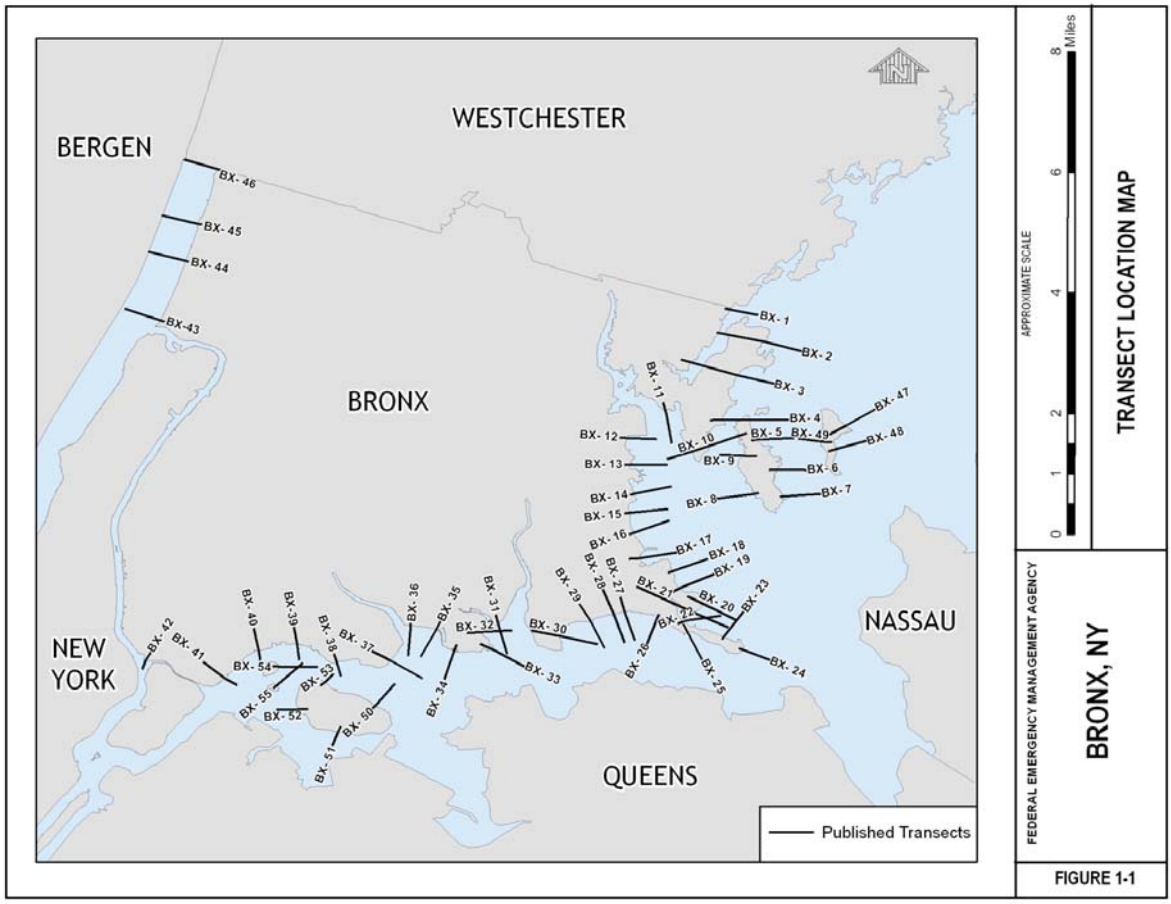

Figure 1-1: Bronx published and mapping transect location map

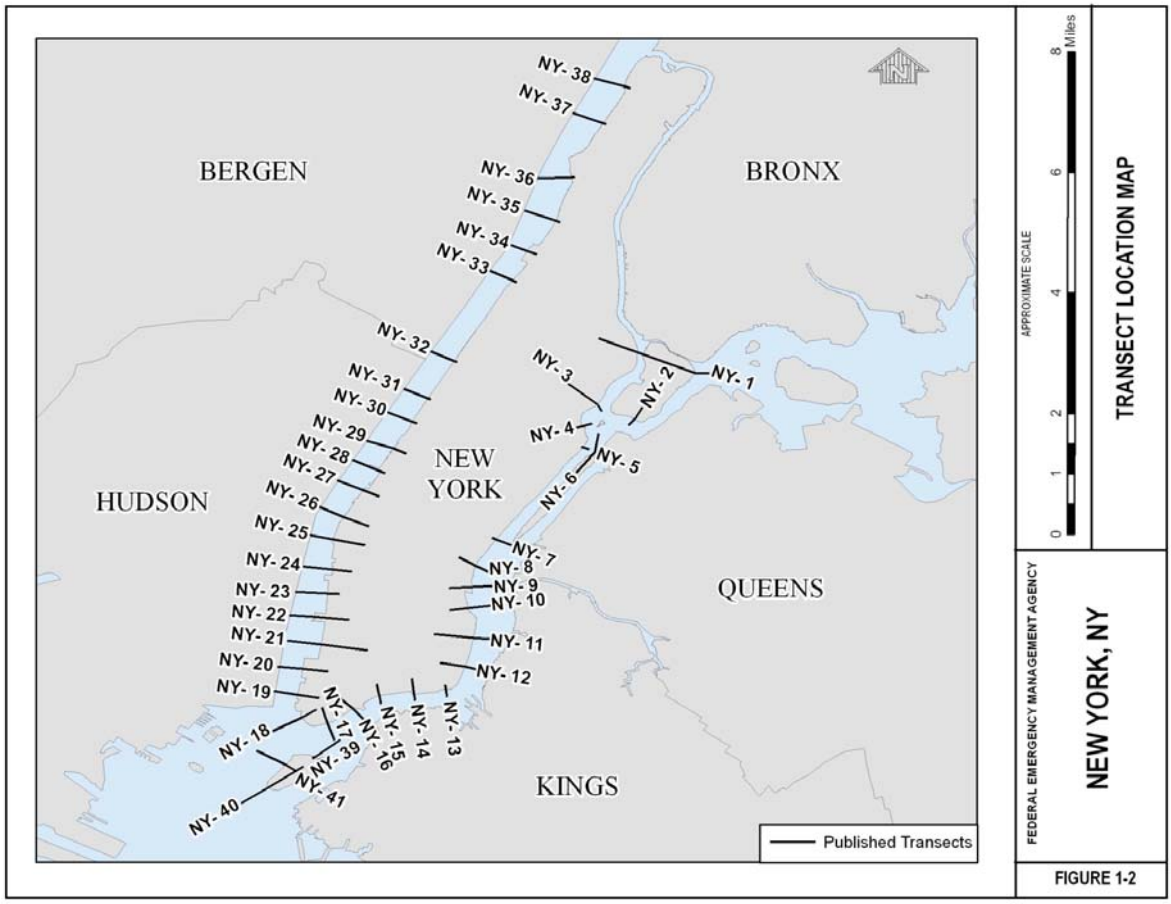

Figure 1-2: New York County published and mapping transect map

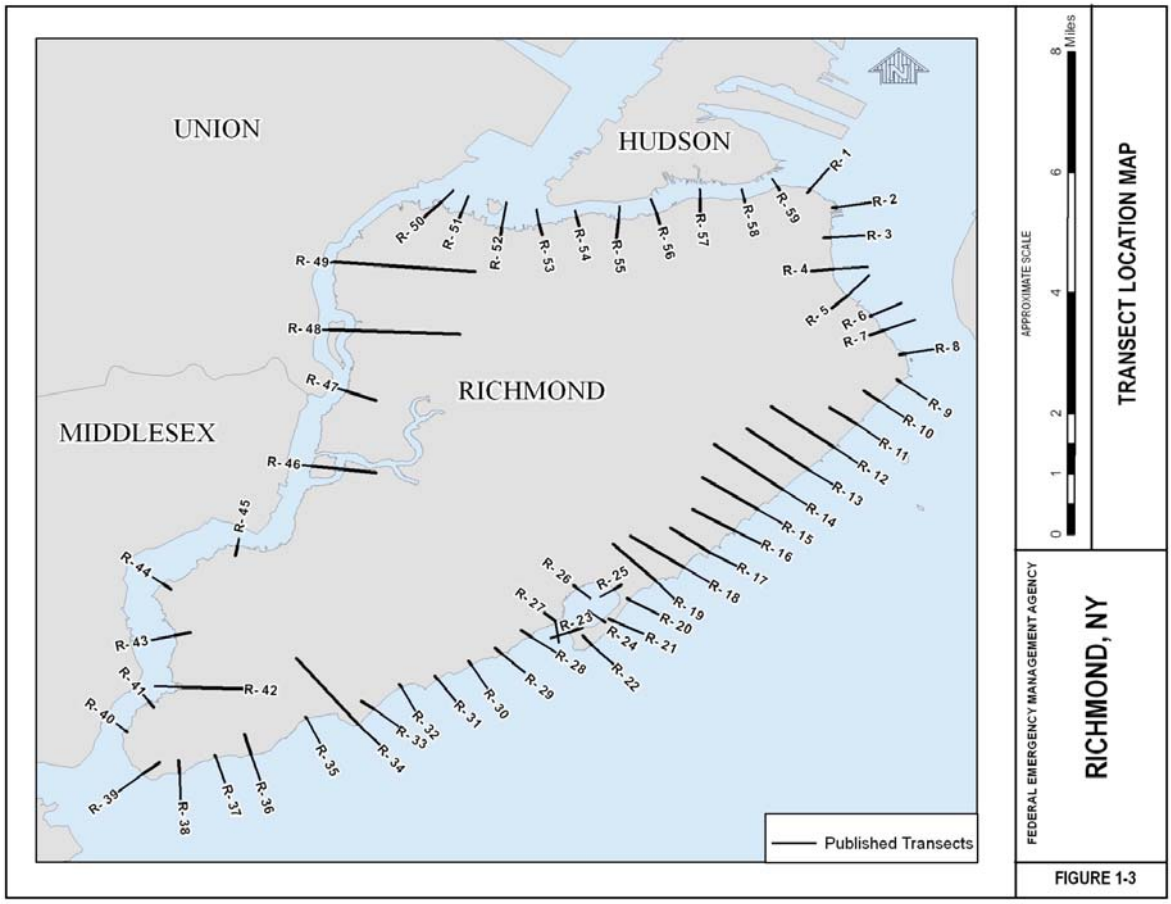

Figure 1-3: Richmond County published and mapping transect map

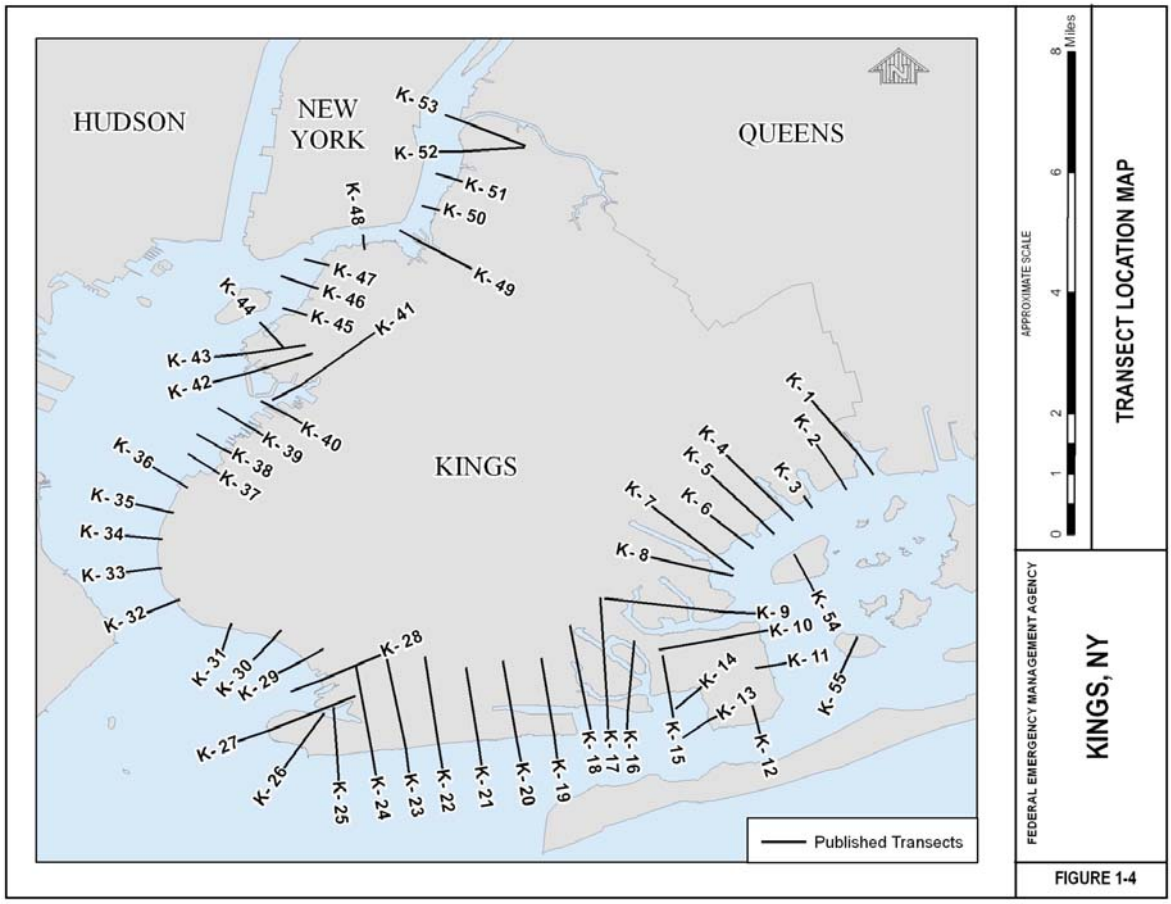

Figure 1-4: Kings County published and mapping transect map

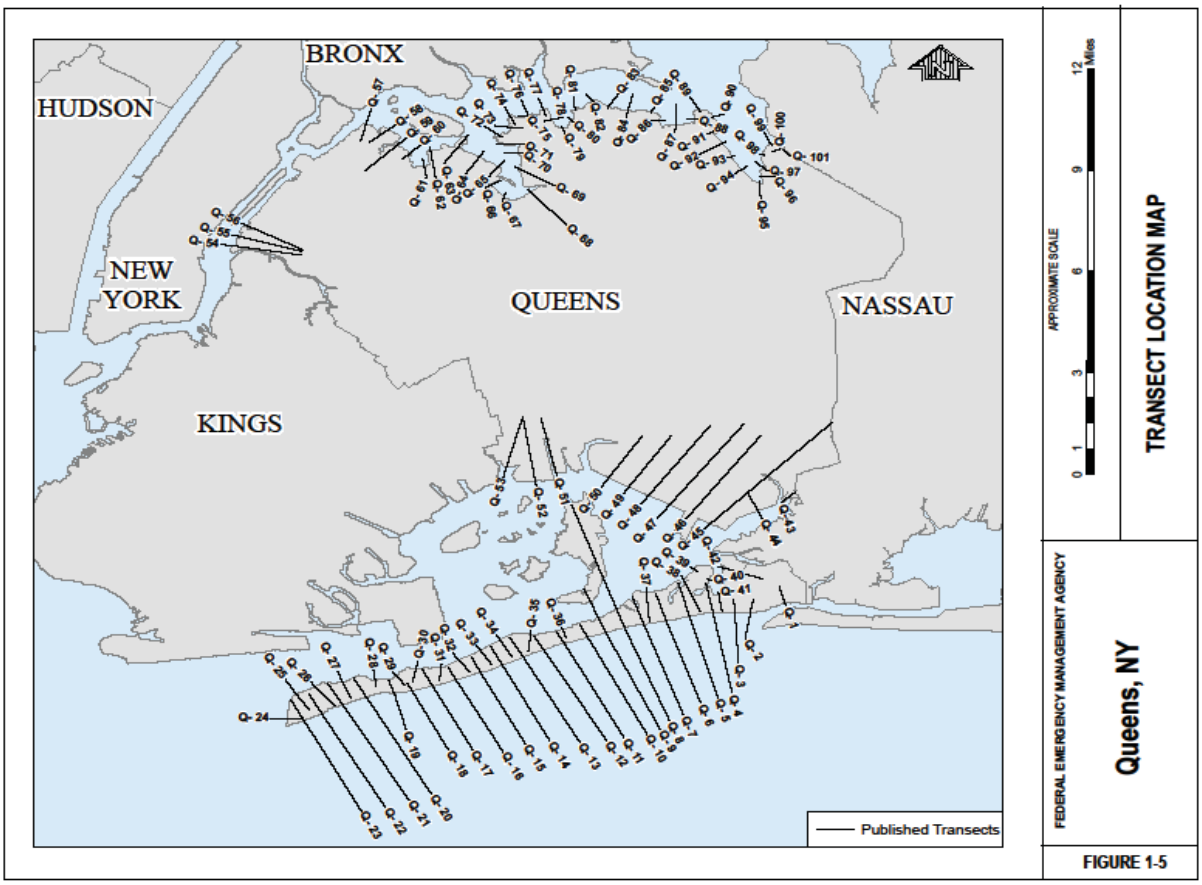

Figure 1-5: Queens County published and mapping transect map

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) (NAS, 1977). This method is based on three major concepts. First, depth-limited waves in shallow water reach maximum breaking height that is equal to 0.78 times the total stillwater depth. The wave crest is 70 percent of the total wave height above the total 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 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.

A review of the geology and shoreline type was made to determine the applicability of standard erosion methods, and FEMA's standard erosion methodology for coastal areas having primary frontal dunes, referred to as the "540 rule," was used (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 guidelines. If the reservoir is less than 540 square feet, the "remove" erosion method is employed where the dune is removed for subsequent analysis, again using a standard eroded profile. The storm surge study provided the return period stillwater elevations required for erosion analyses. Each cross-shore transect was analyzed for erosion, when applicable.

Simulations of inland wave propagation were conducted using FEMA's Wave Height Analysis for Flood Insurance Studies (WHAFIS) model Version 4.0 (FEMA, August 2007). WHAFIS is a one-dimensional model that 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 5, "Transect Data," the 10-, 2-, 1-, and 0.2-percent annual chance stillwater elevations for each transect are provided along with the starting wave height and period. Simulations of wave transformations were then conducted with WHAFIS taking into account the storm-induced erosion and overland features of each transect such as ground elevation, obstructions, and wind contributions. The model outputs the combined flood elevation from the total SWEL and wave height along each cross-shore transect allowing for the establishment of 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 2007 Guidelines and Specifications require the 2-percent wave runup level be computed for the coastal feature being evaluated (cliff,

coastal bluff, dune, or structure) (FEMA, February 2007). The 2-percent runup level is the highest 2 percent of wave runup 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 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 2007 Guidelines and Specifications.

Between transects, elevations were interpolated using topographic maps, land-use and land-cover data, and engineering judgment to determine the extent of coastal flood zones. 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.

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 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 three feet. Zone AE is depicted on the FIRMs where the delineated flood hazard includes wave heights less than three feet. A depiction of how the Zones VE and AE are mapped is shown in Figure 2.

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 constructed without consideration to 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 due to wave action in the AE zone, FEMA issued guidance in 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, the LiMWA is provided to help communicate the higher risk that exists in that area. 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 2, "Transect Schematic".

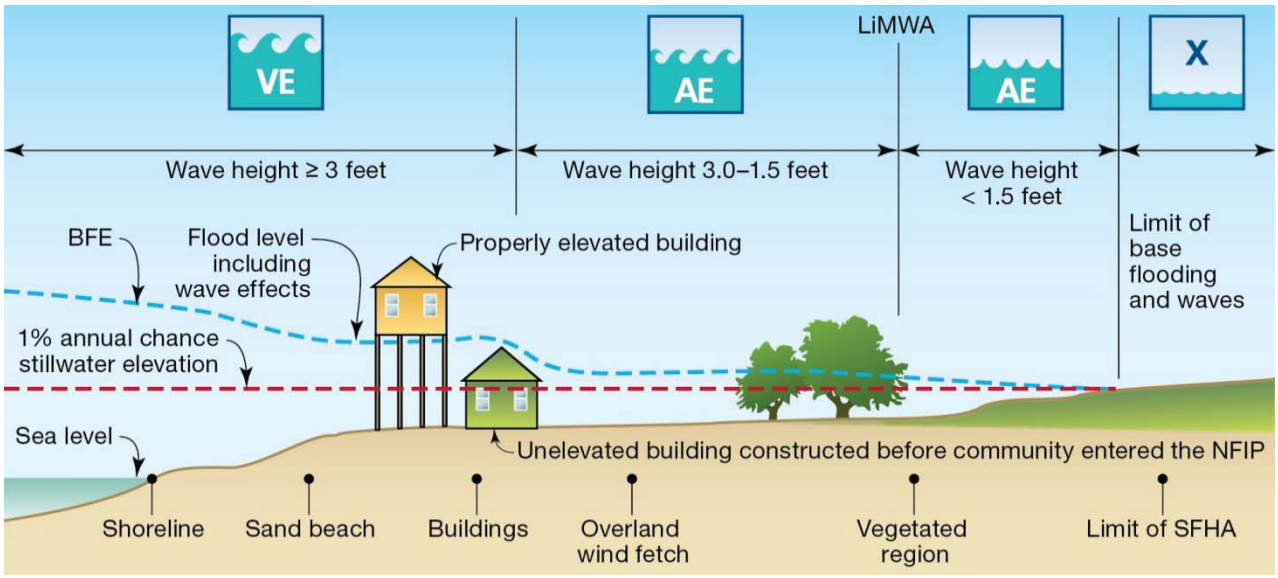

Figure 2: Transect Schematic

A description of the starting wave conditions and stillwater elevation input to the modeling for each transect is shown in Table 5, “Transect Data.”

TABLE 5: TRANSECT DATA

Flood Source	Transect	Starting Wave Conditions for the 1% Annual Chance			Starting Stillwater Elevations[1] (ft NAVD88) Range of Stillwater Elevations[2](ft NAVD88)			
		Coordinates	Significant Wave Height (ft)	Peak Wave Period (sec)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Bronx County, NY								
Long Island Sound	BX-1	N 40.882876 W 73.793188	3.08	4.36	9.7	11.9 11.9 - 12	12.9 12.8 - 12.9	14.9
Long Island Sound	BX-2	N 40.875510 W 73.785368	4.81	4.61	9.6 9.6 - 9.8	11.9 11.9 - 12.1	12.8 12.8 - 13	14.7 14.7 - 15
Long Island Sound	BX-3	N 40.867896 W 73.791576	5.04	5.29	9.6 9.5 - 9.8	11.9 11.9 - 12.2	12.8 12.8 - 13.2	14.6 14.6 - 15.2
Long Island Sound	BX-4	N 40.857657 W 73.788791	4.55	4.43	9.7 9.6 - 9.7	11.9 11.8 - 12	12.8 12.7 - 12.9	14.6 14.5 - 14.8
Long Island Sound	BX-5	N 40.853174 W 73.787539	4.08	4.03	9.7	12	12.8 12.8 - 12.9	14.7 14.6 - 14.7
Long Island Sound	BX-6	N 40.846334 W 73.782475	3.11	3.36	9.6	11.9 11.8 - 11.9	12.7 12.6 - 12.7	14.5
Long Island Sound	BX-7	N 40.840038 W 73.781424	3.83	3.50	9.6	11.9	12.8	14.6
Eastchester Bay	BX-8	N 40.840755 W 73.787536	2.63	3.02	9.6	11.9	12.8	14.6
Eastchester Bay	BX-9	N 40.849456 W 73.789833	2.26	3.11	9.6	11.9 11.8 - 11.9	12.8	14.6
Eastchester Bay	BX-10	N 40.850414 W 73.801881	2.79	2.98	9.7 9.6 - 9.7	12 11.8 - 12	12.9 12.6 - 12.9	14.7 14.5 - 14.7
Eastchester Bay	BX-11	N 40.859015 W 73.807876	2.50	2.92	9.7	12	12.9	14.8
Eastchester Bay	BX-12	N 40.853506 W 73.817070	2.59	2.91	9.7	12.1	13	15

[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 5: TRANSECT DATA - 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)			
		Coordinates	Significant Wave Height (ft)	Peak Wave Period (sec)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Eastchester Bay	BX-13	N 40.847353 W 73.816165	2.83	3.02	9.8	12.1	13 12.9 - 13	15 14.8 - 15
Eastchester Bay	BX-14	N 40.840772 W 73.815333	2.66	2.99	9.8	12.1	13	14.9
Eastchester Bay	BX-15	N 40.836330 W 73.816310	2.79	3.11	9.8	12.1	13	14.9
Eastchester Bay	BX-16	N 40.831840 W 73.815367	2.88	3.17	9.8	12.1	13	14.9
Eastchester Bay	BX-17	N 40.825977 W 73.814133	3.12	3.49	9.8	12 12 - 12.1	13.1	15
Eastchester Bay	BX-18	N 40.822950 W 73.806499	3.28	3.46	9.8	12	13	14.8
Eastchester Bay	BX-19	N 40.819079 W 73.804739	3.29	3.50	9.8	12	13 12.9 - 13	14.8 14.8 - 14.9
Long Island sound	BX-20	N 40.815456 W 73.799164	3.28	3.40	9.7 9.7 - 9.8	12.1 12 - 12.1	12.9 12.8 - 12.9	14.8 14.7 - 14.9
Long Island sound	BX-21	N 40.813471 W 73.801406	3.26	3.53	9.8 8.7 - 9.8	12.1 12 - 12.1	12.9 12.8 - 13.1	14.8 14.8 - 15
Long Island sound	BX-22	N 40.811723 W 73.803529	3.25	3.45	9.8	12	13 12.9 - 13	14.9 14.8 - 14.9
Long Island sound	BX-23	N 40.807911 W 73.794756	3.32	3.36	9.8	12	12.9	14.7
Long Island sound	BX-24	N 40.804938 W 73.790269	3.05	3.29	9.7	12 11.9 - 12	12.9 12.8 - 12.9	14.7 14.6 - 14.7
East River	BX-25	N 40.809133 W 73.803045	2.62	3.50	9.7 9.7 - 9.8	12	12.9 12.9 - 13.1	14.8 14.8 - 15
East River	BX-26	N 40.812835 W 73.809719	2.58	3.41	9.7	12	12.9	14.8

[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 5: TRANSECT DATA - 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)			
		Coordinates	Significant Wave Height (ft)	Peak Wave Period (sec)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
East River	BX-27	N 40.813721 W 73.817371	2.55	3.28	9.7 9.6 - 9.7	12 11.9 - 12	12.9 12.8 - 12.9	14.9 14.8 - 14.9
East River	BX-28	N 40.813192 W 73.819875	2.62	3.28	9.7 9.5 - 9.7	12 11.9 - 12	12.9 12.8 - 12.9	14.9
East River	BX-29	N 40.811760 W 73.825350	2.57	3.33	9.7	12.1 11.9 - 12.1	13 12.9 - 13	14.9 14.9 - 15.2
East River	BX-30	N 40.808182 W 73.832188	2.47	3.25	9.8 9.6 - 9.8	12.1 11.8 - 12.2	13 12.7 - 13.1	15 14.7 - 15
East River	BX-31	N 40.810697 W 73.846372	2.43	3.14	9.7	11.4 11.1 - 11.4	13 12.8 - 13	15 14.9 - 15
East River	BX-32	N 40.809094 W 73.850006	2.07	2.57	9.7	12.1 12 - 12.1	13 12.9 - 13.1	15.1
East River	BX-33	N 40.805165 W 73.847739	2.69	3.64	9.7	12 12 - 12.1	13 13 - 13.1	14.9 14.9 - 15.1
East River	BX-34	N 40.804769 W 73.856471	2.59	3.30	9.6	12.1	13	15 15 - 15.2
East River	BX-35	N 40.809620 W 73.860589	2.29	2.86	9.6	12.1	12.9	15 15 - 15.1
East River	BX-36	N 40.810482 W 73.866440	2.11	2.62	9.6	12.1	13.1	15.2
East River	BX-37	N 40.802478 W 73.871062	2.62	3.06	9.7	12.1 11.8 - 13.5	13.1 12.9 - 13.1	15.2 15.1 - 15.2
East River	BX-38	N 40.802234 W 73.883391	2.28	3.19	9.6 9.5 - 9.6	12 11.5 - 12	13 12.7 - 13	15.1 14.9 - 15.1
East River	BX-39	N 40.806363 W 73.892463	2.79	3.39	9.5	12 11.8 - 12	12.9 12.8 - 12.9	15.1 14.9 - 15.1
East River	BX-40	N 40.804857 W 73.901251	2.11	3.02	9.4 9.1 - 9.4	11.9 11.6 - 13.5	12.9 12.6 - 12.9	15.2 15 - 15.2

[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 5: TRANSECT DATA - 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)			
		Coordinates	Significant Wave Height (ft)	Peak Wave Period (sec)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
East River	BX-41	N 40.798453 W 73.908958	2.71	2.74	9.4	11.9 11.4 - 11.9	12.9 12.7 - 12.9	15.2 15.1 - 15.3
Harlem River	BX-42	N 40.802539 W 73.927213	1.80	2.43	7.9	10.4 10.1 - 10.7	11.4 11.2 - 11.4	13.8 13.5 - 13.8
Hudson River	BX-43	N 40.880389 W 73.923785	4.12	4.43	5.4	8	9.1	12.3 12.2 - 12.3
Hudson River	BX-44	N 40.894006 W 73.918004	4.05	4.51	5.4	7.8	9	12.1 12.1 - 12.2
Hudson River	BX-45	N 40.902509 W 73.915161	4.07	5.01	5.4	7.8	8.9	11.9
Hudson River	BX-46	N 40.915050 W 73.910557	3.51	4.58	5.3	7.7	8.9	11.8 11.7 - 11.8
Long Island sound	BX-47	N 40.856289 W 73.766650	5.93	4.23	9.6 9.5 - 9.6	11.8 11.6 - 11.8	12.6 12.5 - 12.8	14.4 14.2 - 14.9
Long Island sound	BX-48	N 40.851035 W 73.768842	4.59	3.87	9.6	11.7	12.6	14.4
Long Island sound	BX-49	N 40.852594 W 73.771758	3.89	4.25	9.6	11.8 11.8 - 11.9	12.6 12.6 - 12.7	14.3 14.2 - 14.6
East River	BX-50	N 40.792101 W 73.874565	2.50	2.95	9.7	12.2	13.2	15.4
East River	BX-51	N 40.786214 W 73.882983	2.58	2.74	9.4	11.9 11.7 - 11.9	12.8 12.7 - 12.8	15 14.9 - 15
East River	BX-52	N 40.791346 W 73.892419	2.87	3.17	9.4	11.9	12.9 12.8 - 12.9	15
East River	BX-53	N 40.797559 W 73.886136	2.40	3.37	9.5	12	13	15.1
East River	BX-54	N 40.801180 W 73.896639	2.99	4.01	9.6 9.6 - 9.8	12 11.9 - 12	13 12.8 - 13	15.2

[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 5: TRANSECT DATA - 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)			
		Coordinates	Significant Wave Height (ft)	Peak Wave Period (sec)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
East River	BX-55	N 40.796870 W 73.897179	2.83	3.47	9.5 9.4 - 9.5	11.9 11.8 - 11.9	12.9 12.8 - 12.9	15 14.9 - 15

[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 5: TRANSECT DATA - 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)			
		Coordinates	Significant Wave Height (ft)	Peak Wave Period (sec)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Kings County, NY								
Jamaica Bay	K-1	N 40.650180 W 73.857295	3.20	2.91	6.5	9 8.9 - 9.1	10.1 10.1 - 10.3	12.9 12.6 - 13.2
Jamaica Bay	K-2	N 40.642913 W 73.861579	3.19	2.91	6.5 6.5 - 6.6	9 8.8 - 9	10.1	12.8 12.7 - 13
Jamaica Bay	K-3	N 40.637659 W 73.870611	3.43	3.16	6.6	9	10.1	12.8 12.7 - 12.8
Jamaica Bay	K-4	N 40.635459 W 73.877340	3.34	3.08	6.6 6.5 - 6.7	9.5 9.5 - 9.8	10.2 10.1 - 10.3	12.9 12.7 - 13.1
Jamaica Bay	K-5	N 40.631760 W 73.882391	3.08	2.92	6.7	9.8	10.2 10 - 10.2	12.9 12.7 - 13.1
Jamaica Bay	K-6	N 40.627664 W 73.888337	3.21	3.00	6.7 6.6 - 6.7	9.8	10.3 10 - 10.3	13 12.9 - 13.1
Jamaica Bay	K-7	N 40.622933 W 73.894580	3.08	3.02	6.7	9.8	10.3 10.1 - 10.4	13 12.9 - 13.4
Jamaica Bay	K-8	N 40.618794 W 73.895780	3.08	3.06	6.7 6.7 - 6.8	9.8	10.3 10 - 10.3	13 12.8 - 13.4
Jamaica Bay	K-9	N 40.608044 W 73.892504	3.10	3.11	6.7 6.7 - 7.1	9.1 8.9 - 9.8	10.2 10.1 - 10.7	12.8 12.8 - 13.7
Jamaica Bay	K-10	N 40.602728 W 73.883254	3.03	3.12	6.6	9.1 8.8 - 9.1	10.1 9.9 - 10.2	12.7 12.4 - 13
Jamaica Bay	K-11	N 40.593793 W 73.880519	3.05	3.12	6.6	9	10	12.6 12.6 - 13.1
Jamaica Bay	K-12	N 40.578895 W 73.883644	3.89	4.57	6.6	8.9	9.9 9.7 - 9.9	12.5 12.4 - 12.8
Dead Horse Bay	K-13	N 40.579371 W 73.896649	4.46	4.03	6.6	8.9	10.1	12.9 12.8 - 12.9

[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 5: TRANSECT DATA - 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)			
		Coordinates	Significant Wave Height (ft)	Peak Wave Period (sec)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Dead Horse Bay	K-14	N 40.587565 W 73.899036	3.49	3.28	6.6	8.9	10.3	13.1
Dead Horse Bay	K-15	N 40.586948 W 73.906879	3.58	3.62	6.6	9.1 8.7 - 9.2	10.3 10 - 10.3	13.2 13.2 - 13.3
Raritan Bay	K-16	N 40.582036 W 73.917709	4.80	4.58	6.7 6.6 - 6.7	9.2 8.9 - 9.8	10.4 10.2 - 10.5	13.3 13.2 - 13.6
Raritan Bay	K-17	N 40.583425 W 73.923126	5.00	4.58	6.7 6.6 - 6.7	9.2 8.9 - 9.8	10.5 10.3 - 10.7	13.4 13.4 - 13.8
Raritan Bay	K-18	N 40.583473 W 73.928895	5.25	4.67	6.7	9.3 9 - 9.8	10.5 10.3 - 10.7	13.5 13.5 - 14.1
Raritan Bay	K-19	N 40.575543 W 73.937167	6.89	5.94	6.7	9.4 9.4 - 9.8	10.5 10.1 - 10.7	13.5 13.2 - 13.8
Raritan Bay	K-20	N 40.574959 W 73.947220	7.25	7.18	6.8	9.6 9.1 - 9.8	10.7 10.1 - 10.9	13.7 13.1 - 14.3
Raritan Bay	K-21	N 40.574173 W 73.957374	7.81	8.44	6.8	9.6 9.2 - 9.8	10.9 10.2 - 10.9	14 12.9 - 14.2
Raritan Bay	K-22	N 40.573203 W 73.967783	8.47	10.64	6.9	9.7 9 - 9.8	11 10 - 11	14.3 12.5 - 14.5
Raritan Bay	K-23	N 40.572069 W 73.976340	8.36	10.66	6.6 6.6 - 6.7	9.8 9.1 - 9.8	11.1 10 - 11.2	14.4 12.9 - 14.6
Raritan Bay	K-24	N 40.571304 W 73.985245	8.36	11.20	7 6.7 - 7	9.9 9.4 - 10	11.2 10 - 11.4	14.6 12.8 - 14.9
Raritan Bay	K-25	N 40.570384 W 73.994383	8.64	11.34	7 6.7 - 7	9.8 9.4 - 9.8	11.1 10.7 - 11.2	14.5 13.9 - 14.6
Raritan Bay	K-26	N 40.572728 W 74.004156	8.91	11.14	7 6.6 - 7	9.8 9.5 - 9.8	11.1 10.8 - 11.1	14.4 14.2 - 14.5
Raritan Bay	K-27	N 40.576794 W 74.012480	8.55	6.99	7	9.8 9.8 - 9.9	11.1 10.2 - 11.3	14.4 13.1 - 14.9

[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 5: TRANSECT DATA - 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)			
		Coordinates	Significant Wave Height (ft)	Peak Wave Period (sec)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Lower New York Bay	K-28	N 40.590029 W 73.998578	4.48	4.56	7 7 - 7.1	9.8	11.2 10.1 - 11.2	14.5 12.9 - 14.5
Lower New York Bay	K-29	N 40.595454 W 74.002996	4.73	5.34	7	9.9	11.2 11 - 11.3	14.6 14.5 - 14.6
Lower New York Bay	K-30	N 40.600945 W 74.011295	5.69	6.00	7	9.9	11.3	14.7 14.6 - 14.7
Lower New York Bay	K-31	N 40.603748 W 74.022831	6.03	5.96	7.1	10	11.4 11.2 - 11.4	14.8 14.8 - 15.1
Upper New York Bay	K-32	N 40.610985 W 74.036792	7.18	6.66	7.1	10	11.3 11.3 - 11.4	14.7
Upper New York Bay	K-33	N 40.619585 W 74.041365	7.20	7.43	7	9.9	11.3	14.6
Upper New York Bay	K-34	N 40.627366 W 74.041565	6.59	6.87	7	9.9	11.3	14.7
Upper New York Bay	K-35	N 40.634525 W 74.039003	6.25	5.98	7	10	11.4 11.3 - 11.4	14.8 14.6 - 14.8
Upper New York Bay	K-36	N 40.642177 W 74.036170	5.84	5.29	7	10	11.4 11 - 11.4	14.8 14.6 - 14.8
Upper New York Bay	K-37	N 40.645337 W 74.026905	4.92	4.45	7	9.9 9.8 - 9.9	11.4 11.3 - 11.4	14.8 14.7 - 14.8
Upper New York Bay	K-38	N 40.650947 W 74.024463	4.83	4.33	7	9.9	11.3 11.1 - 11.3	14.8 14.5 - 14.8
Upper New York Bay	K-39	N 40.657654 W 74.018838	4.45	4.10	6.9 6.8 - 6.9	9.9	11.3 11.2 - 11.3	14.8 14.6 - 14.8
Upper New York Bay	K-40	N 40.660150 W 74.007926	2.64	3.11	6.9	9.8 9.6 - 9.8	11.2 11 - 11.2	14.7 14.5 - 14.7
Upper New York Bay	K-41	N 40.667702 W 74.004180	2.71	2.44	6.9 6.6 - 6.9	9.8 9.5 - 9.8	11.3 10.3 - 11.3	14.8 13.8 - 14.8

[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 5: TRANSECT DATA - 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)			
		Coordinates	Significant Wave Height (ft)	Peak Wave Period (sec)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Upper New York Bay	K-42	N 40.670684 W 74.018672	4.30	4.12	7 6.8 - 7	9.9 9.7 - 9.9	11.4 10.7 - 11.4	14.9 14.4 - 14.9
Upper New York Bay	K-43	N 40.676241 W 74.017878	4.24	4.09	7	9.9 9.7 - 9.9	11.3 10.9 - 11.3	14.9 14.6 - 14.9
Upper New York Bay	K-44	N 40.683167 W 74.013571	3.15	4.24	6.8 6.7 - 7	9.9 9.7 - 9.9	11.3 11.1 - 11.3	14.9 14.7 - 14.9
East River	K-45	N 40.687110 W 74.005415	1.61	3.74	6.9	9.8 9.8 - 9.9	11.3 10.8 - 11.3	14.8 14.5 - 14.8
East River	K-46	N 40.693747 W 74.001117	3.35	3.17	6.8	9.8 9.7 - 9.8	11.2 11.1 - 11.2	14.8 14.7 - 14.8
East River	K-47	N 40.699626 W 73.997517	3.32	3.61	6.8	9.8 9.7 - 9.8	11.2 10.8 - 11.2	14.7 14.6 - 14.7
East River	K-48	N 40.705170 W 73.987400	2.66	2.67	6.8	9.7 9.5 - 9.7	11 10.9 - 11	14.3 14.1 - 14.3
East River	K-49	N 40.705888 W 73.973068	2.86	2.93	6.9 6.7 - 6.9	9.7 9.2 - 10.6	10.9 10.6 - 11	14 13.8 - 14.1
East River	K-50	N 40.714219 W 73.968382	3.08	3.31	6.9	9.6	10.9	13.9
East River	K-51	N 40.722032 W 73.962987	3.30	3.48	6.9	9.6 9.3 - 9.6	10.9 10.7 - 10.9	13.9 13.7 - 13.9
East River	K-52	N 40.729474 W 73.961207	3.14	3.21	7 7 - 7.1	9.7 9.6 - 9.7	10.9 10 - 10.9	13.9 12.8 - 13.9
East River	K-53	N 40.736815 W 73.960049	3.12	3.24	6.9	9.6	10.9 10.1 - 10.9	13.9 13 - 13.9
Jamaica Bay	K-54	N 40.616812 W 73.870376	2.93	3.03	6.6 6.5 - 6.6	9 8.9 - 9	10.1 10 - 10.1	12.7 12.6 - 12.7
Jamaica Bay	K-55	N 40.596268 W 73.859579	3.04	2.87	6.6 6.5 - 6.6	8.9 8.8 - 8.9	9.9 9.8 - 9.9	12.5 12 - 12.5

[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 5: TRANSECT DATA - 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)			
		Coordinates	Significant Wave Height (ft)	Peak Wave Period (sec)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
New York County, NY								
East River	NY-1	N 40.793831 W 73.913812	2.68	2.92	9.3 7.5 - 9.3	11.8 10.3 - 11.8	12.8 11.3 - 12.9	15.1 13.4 - 15.4
East River	NY-2	N 40.781691 W 73.929639	2.18	2.68	8.1 8.1 - 8.2	10.8 10.7 - 10.8	11.9 11.8 - 11.9	14.5 14.3 - 14.5
East River	NY-3	N 40.785609 W 73.939519	2.32	2.97	8.2 5.6 - 8.2	10.9 10.4 - 12.6	12 11.8 - 12	14.5 14.5 - 14.7
East River	NY-4	N 40.779837 W 73.943466	2.45	2.82	8.2	10.8	11.9 11.8 - 11.9	14.5 14.4 - 14.5
East River	NY-5	N 40.774289 W 73.943270	2.78	3.50	7.9	10.5	11.7	14.3
East River	NY-6	N 40.772969 W 73.940171	2.52	3.02	8.1 7.6 - 8.1	10.6 10.4 - 10.7	11.7 11 - 11.7	14.1 13.6 - 14.2
East River	NY-7	N 40.749979 W 73.966252	2.98	3.18	7.1	9.8	11	13.9
East River	NY-8	N 40.743089 W 73.971655	3.11	3.21	7	9.8	11 10.7 - 11	14 13.9 - 14
East River	NY-9	N 40.737477 W 73.972616	3.15	3.22	7 6.7 - 7	9.7	11 10.7 - 11	13.9 13.9 - 14.1
East River	NY-10	N 40.731894 W 73.973573	3.18	3.24	6.9	9.7	11 10.7 - 11	13.9
East River	NY-11	N 40.724087 W 73.972177	3.32	3.48	6.9 6.9 - 7.4	9.7 9.5 - 9.7	10.9 10.7 - 10.9	13.9 13.9 - 14
East River	NY-12	N 40.716408 W 73.974358	3.16	3.36	6.8 6.6 - 6.8	9.6 9.5 - 9.6	10.9 10.7 - 10.9	13.9 13.8 - 14.1
East River	NY-13	N 40.710420 W 73.979459	2.74	2.86	6.8	9.6	10.9 10.7 - 10.9	14 13.9 - 14

[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 5: TRANSECT DATA - 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)			
		Coordinates	Significant Wave Height (ft)	Peak Wave Period (sec)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
East River	NY-14	N 40.709185 W 73.987873	2.58	2.65	6.8 6.6 - 6.8	9.6	11 10.9 - 11	14.3 14.3 - 14.5
East River	NY-15	N 40.708799 W 73.997024	2.93	3.09	6.8 6.7 - 6.8	9.7	11.1 10.9 - 11.1	14.6
East River	NY-16	N 40.705313 W 74.003819	3.12	3.51	6.8 6.6 - 6.8	9.8 9.7 - 9.8	11.2 10.9 - 11.3	14.7 14.7 - 14.8
East River	NY-17	N 40.701590 W 74.010682	3.37	3.21	6.9 6.9 - 7.4	9.9	11.3 10.7 - 11.3	14.8 14.8 - 14.9
Upper New York Bay	NY-18	N 40.702983 W 74.017383	5.01	5.17	6.9	9.9	11.3 11 - 11.3	14.9 14.7 - 14.9
Hudson River	NY-19	N 40.709054 W 74.018613	5.02	5.81	6.9 6.9 - 7.3	9.8 9.1 - 9.8	11.3 10.5 - 11.3	14.8 14.3 - 15.1
Hudson River	NY-20	N 40.715891 W 74.017227	4.94	5.82	6.6	9.7	11.2 10.7 - 11.2	14.7 14.3 - 14.7
Hudson River	NY-21	N 40.722252 W 74.012398	4.71	5.27	6.7	9.7 9.6 - 9.7	11.1 10.1 - 11.1	14.6 14.4 - 14.6
Hudson River	NY-22	N 40.729533 W 74.014233	4.59	5.21	6.7 6.6 - 6.7	9.6	11 10.8 - 11	14.4 14.2 - 14.4
Hudson River	NY-23	N 40.735728 W 74.010684	4.56	5.01	6.6	9.4	11 10.8 - 11	14.4 14.3 - 14.4
Hudson River	NY-24	N 40.742069 W 74.009242	4.40	4.89	6.5	9.4	10.9 10.8 - 10.9	14.3 14.1 - 14.3
Hudson River	NY-25	N 40.750050 W 74.009229	4.44	5.20	6.4 6.4 - 6.6	9.3 9.1 - 9.3	10.7 10.4 - 10.7	14.1 13.9 - 14.1
Hudson River	NY-26	N 40.755928 W 74.006425	4.56	4.89	6.5 6.5 - 6.6	9.3	10.6 10 - 10.6	14 13.7 - 14
Hudson River	NY-27	N 40.763002 W 74.001275	4.36	4.68	6.6	9.3	10.7 10.4 - 10.7	14.2 13.8 - 14.2

[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 5: TRANSECT DATA - 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)			
		Coordinates	Significant Wave Height (ft)	Peak Wave Period (sec)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Hudson River	NY-28	N 40.767894 W 73.996609	2.66	4.43	6.4	9.2	10.6	14 13.8 - 14
Hudson River	NY-29	N 40.773962 W 73.993331	4.16	4.41	6.4	9.1	10.5 10.2 - 10.5	13.8 13.6 - 13.8
Hudson River	NY-30	N 40.781047 W 73.988345	4.59	5.17	6.2	9	10.4	13.7 13.4 - 13.7
Hudson River	NY-31	N 40.787199 W 73.984194	4.58	5.15	6.2	8.9	10.2	13.4 13.4 - 13.5
Hudson River	NY-32	N 40.797037 W 73.977270	3.88	4.85	6	8.8	10.2	13.6
Hudson River	NY-33	N 40.818234 W 73.961908	3.98	4.58	5.9	8.6 8.6 - 8.8	9.9 9.7 - 9.9	13.2 12.7 - 13.2
Hudson River	NY-34	N 40.826015 W 73.957987	3.79	4.47	5.9	8.5	9.7 9.6 - 9.7	12.9 12.6 - 12.9
Hudson River	NY-35	N 40.833945 W 73.950475	3.57	4.21	5.8	8.4	9.7	12.9 12.8 - 12.9
Hudson River	NY-36	N 40.845426 W 73.946225	3.37	3.93	5.8	8.4	9.6 9.6 - 9.7	12.8 12.6 - 12.8
Hudson River	NY-37	N 40.859698 W 73.937985	3.67	4.03	5.6	8.1	9.3	12.5
Hudson River	NY-38	N 40.869369 W 73.932182	3.84	3.93	5.5	8.1	9.4	12.6 12.2 - 12.6
East River	NY-39	N 40.692651 W 74.014019	3.35	3.21	6.9	9.8	11.3	14.8
Upper New York Bay	NY-40	N 40.684656 W 74.026236	5.45	5.23	6.9	9.9 9.8 - 9.9	11.3 10.9 - 11.3	14.9 14.8 - 14.9
Upper New York Bay	NY-41	N 40.690563 W 74.021778	5.56	5.44	6.9	9.8	11.2 10.8 - 11.2	14.8 14.6 - 14.8

[1]Stillwater elevations include the contribution from wave setup.
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TABLE 5: TRANSECT DATA - 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)			
		Coordinates	Significant Wave Height (ft)	Peak Wave Period (sec)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Queens County, NY								
Oyster Bay Inlet	Q-1	N 40.594669 W 73.745862	3.35	3.21	6.2	8.8 8.3 - 8.8	10.2 9.9 - 10.7	14 14 - 14.2
Atlantic Ocean	Q-2	N 40.591015 W 73.759443	16.60	12.67	6.6	9.4 8.3 - 9.7	10.8 9.4 - 10.8	15.1 12.5 - 15.4
Atlantic Ocean	Q-3	N 40.591317 W 73.765597	16.58	12.68	6.7 6.4 - 6.7	9.3 8 - 9.3	10.8 9 - 10.8	15 11.4 - 15
Atlantic Ocean	Q-4	N 40.590428 W 73.773961	16.58	12.65	6.7 6.3 - 6.7	9.5 8.3 - 9.6	11 9.3 - 11	15.4 11.7 - 16
Atlantic Ocean	Q-5	N 40.588977 W 73.783052	16.56	12.59	6.8 6.4 - 6.8	9.6 8 - 9.6	11.1 9.1 - 11.4	15.5 11.5 - 16.1
Atlantic Ocean	Q-6	N 40.587307 W 73.792161	16.47	12.51	6.9 6.5 - 7	9.7 8.3 - 9.8	11.2 9.2 - 11.2	15.4 11.5 - 15.4
Atlantic Ocean	Q-7	N 40.585476 W 73.800662	16.64	12.47	6.6 6.4 - 6.6	9.6 8.3 - 9.6	11.2 9.3 - 11.3	15.7 11.7 - 15.8
Atlantic Ocean	Q-8	N 40.584194 W 73.808180	16.61	12.41	6.8 6.1 - 6.8	9.6 8.2 - 9.6	11 9.2 - 11	15.3 11.7 - 15.3
Atlantic Ocean	Q-9	N 40.582866 W 73.815873	16.80	12.41	6.9 6.4 - 6.9	9.5 8.3 - 9.5	10.9 9.4 - 10.9	15.1 11.7 - 15.1
Atlantic Ocean	Q-10	N 40.580918 W 73.822877	16.77	12.35	6.8 6.6 - 6.8	9.5 8.4 - 9.5	10.9 9.5 - 10.9	15.1 11.8 - 15.1
Atlantic Ocean	Q-11	N 40.578178 W 73.831836	16.55	12.22	6.8	9.5 8.5 - 9.5	11.1 9.6 - 11.1	15.5 12 - 15.5
Atlantic Ocean	Q-12	N 40.575263 W 73.839673	16.41	12.13	6.9 6.5 - 6.9	9.7 8.6 - 9.7	11.2 9.7 - 11.3	15.4 12.2 - 15.8
Atlantic Ocean	Q-13	N 40.572588 W 73.847907	16.10	11.98	6.9 6.5 - 6.9	9.5 8.6 - 9.5	11.2 9.7 - 11.2	15.4 12.2 - 15.7

[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 5: TRANSECT DATA - 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)			
		Coordinates	Significant Wave Height (ft)	Peak Wave Period (sec)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Atlantic Ocean	Q-14	N 40.569530 W 73.856159	15.63	11.79	6.9 6.6 - 6.9	9.3 8.7 - 9.3	11.2 9.9 - 11.2	15.2 12.5 - 15.2
Atlantic Ocean	Q-15	N 40.566813 W 73.864874	15.52	11.80	6.9 6.6 - 6.9	9.7 8.8 - 9.7	11.1 9.9 - 11.1	15.1 12.4 - 15.1
Atlantic Ocean	Q-16	N 40.563836 W 73.874305	15.61	11.83	6.9	9.7 8.8 - 9.7	11.1 9.9 - 11.5	15.1 12.5 - 15.6
Atlantic Ocean	Q-17	N 40.560930 W 73.883202	15.43	11.99	6.9 6.6 - 6.9	9.6 8.6 - 9.6	11 9.8 - 11	14.9 12.5 - 14.9
Atlantic Ocean	Q-18	N 40.558587 W 73.891068	15.37	12.08	6.8	9.6 8.7 - 9.6	11 10 - 11	14.9 12.8 - 14.9
Atlantic Ocean	Q-19	N 40.557177 W 73.897973	16.30	11.79	6.9 6.7 - 6.9	9.4 8.9 - 9.4	11 10 - 11.1	14.9 12.8 - 15.5
Atlantic Ocean	Q-20	N 40.555047 W 73.908256	16.19	11.83	7.1 6.6 - 7.1	9.9 9.1 - 10	11.3 10.3 - 11.6	15.1 13.1 - 15.3
Atlantic Ocean	Q-21	N 40.551618 W 73.917206	16.58	11.72	7 6.5 - 7	9.8 9.1 - 10.1	11.2 10.4 - 11.5	14.9 13.2 - 15.3
Atlantic Ocean	Q-22	N 40.548471 W 73.925678	16.84	11.68	7 6.5 - 7.3	9.8 9.1 - 10	11.2 10.4 - 11.3	14.7 13.4 - 14.9
Atlantic Ocean	Q-23	N 40.545638 W 73.932721	17.12	11.62	7 6.6 - 7	9.7 8.9 - 9.8	11 10.1 - 11.1	14.3 13.1 - 14.7
Atlantic Ocean	Q-24	N 40.547566 W 73.940247	7.40	7.80	6.7 6.7 - 6.9	9.3 9.1 - 9.3	10.4 10.3 - 10.5	13.2 13.1 - 13.8
Rockaway Inlet	Q-25	N 40.557202 W 73.935954	4.60	4.05	6.8 6.6 - 6.8	9.3 9 - 9.5	10.5 10.2 - 10.8	13.4 13.4 - 14.3
Rockaway Inlet	Q-26	N 40.560125 W 73.928427	4.59	4.09	6.7 6.6 - 6.7	9.2 9 - 9.7	10.4 10.4 - 11.1	13.3 13.3 - 14.9
Rockaway Inlet	Q-27	N 40.562836 W 73.918331	4.81	4.29	6.7 6.6 - 6.7	9.2 9.2 - 9.7	10.4 10.4 - 11.2	13.2 13.2 - 15

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

TABLE 5: TRANSECT DATA - 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)			
		Coordinates	Significant Wave Height (ft)	Peak Wave Period (sec)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Rockaway Inlet	Q-28	N 40.562807 W 73.905540	4.04	3.99	6.7	9.1 8.9 - 9.1	10.2 10 - 10.2	12.9 12.8 - 13.5
Rockaway Inlet	Q-29	N 40.564806 W 73.897078	3.65	3.67	6.6	9.1 8.8 - 9.1	10.1 10 - 10.1	12.8 12.8 - 13
Rockaway Inlet	Q-30	N 40.568633 W 73.889579	3.90	4.35	6.6	8.9 8.7 - 8.9	10 9.8 - 10	12.6 12.4 - 12.7
Rockaway Inlet	Q-31	N 40.568614 W 73.879877	3.28	4.01	6.6	8.8 8.5 - 8.9	9.7 9.7 - 10.1	12.4 12.4 - 13.6
Jamaica Bay	Q-32	N 40.571129 W 73.872699	3.31	3.58	6.6	8.9 8.8 - 9.3	9.9 9.9 - 11.3	12.4 12.4 - 15.7
Jamaica Bay	Q-33	N 40.575222 W 73.864420	2.31	2.53	6.5 6.5 - 6.7	8.9 8.8 - 9	9.9 9.8 - 10.7	12.4 12.4 - 14.3
Jamaica Bay	Q-34	N 40.579347 W 73.856668	2.33	2.53	6.6 6.5 - 6.6	8.8 8.7 - 8.9	9.9 9.8 - 10.8	12.3 12.2 - 14.9
Jamaica Bay	Q-35	N 40.581586 W 73.845151	2.36	2.42	6.5 6.5 - 6.6	8.8 8.7 - 9	9.7 9.6 - 10.5	12.1 12.1 - 14.3
Jamaica Bay	Q-36	N 40.583782 W 73.832484	2.31	2.37	6.5	8.7 8.6 - 8.7	9.7 9.5 - 9.9	11.9 11.9 - 13.3
Jamaica Bay	Q-37	N 40.599213 W 73.799926	2.45	2.51	6.4 6.4 - 6.5	8.6 8.3 - 8.6	9.5 9.3 - 9.6	11.8 11.6 - 14
Jamaica Bay	Q-38	N 40.601870 W 73.784291	2.46	2.69	6.6 6.5 - 6.6	8.7 8.2 - 8.8	9.6 9.2 - 10	11.8 11.6 - 13.7
Jamaica Bay	Q-39	N 40.608130 W 73.780568	3.11	3.74	6.4	8.5	9.5	11.8
Jamaica Bay	Q-40	N 40.604180 W 73.775460	2.16	3.30	6.4	8.5	9.5	11.8
Jamaica Bay	Q-41	N 40.597957 W 73.771696	1.98	2.93	6.4 6.4 - 6.5	8.5 8.3 - 8.6	9.4 9.2 - 10.7	11.7 11.6 - 15

[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 5: TRANSECT DATA - 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)			
		Coordinates	Significant Wave Height (ft)	Peak Wave Period (sec)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Jamaica Bay	Q-42	N 40.608876 W 73.768933	2.47	3.19	6.4	8.5 8.4 - 8.6	9.5 9 - 9.5	11.8 11.4 - 11.8
Head of Bay	Q-43	N 40.636635 W 73.746686	2.96	2.90	6.3 6.2 - 6.3	8.5 8.2 - 8.6	9.4 8.7 - 9.4	11.9 11.1 - 11.9
Head of Bay	Q-44	N 40.632402 W 73.756471	3.12	3.04	6.3	8.5 8.5 - 8.6	9.5 8.7 - 9.5	11.8 10.4 - 11.8
Jamaica Bay	Q-45	N 40.626856 W 73.775550	3.39	3.88	6.3	8.5 7.8 - 8.7	9.5 8.7 - 9.5	11.9 10.4 - 11.9
Jamaica Bay	Q-46	N 40.630490 W 73.783438	3.13	3.35	6.4	8.6 8.6 - 8.7	9.7 9.3 - 9.7	12.1 8.9 - 12.1
Jamaica Bay	Q-47	N 40.634532 W 73.791294	3.77	3.45	6.4	8.7	9.7 9.5 - 9.7	12.2 10.4 - 12.2
Jamaica Bay	Q-48	N 40.638481 W 73.799361	4.07	3.74	6.4	8.7	9.7 9.4 - 9.7	12.2 9 - 12.2
Jamaica Bay	Q-49	N 40.641954 W 73.807004	4.13	3.79	6.4	8.7	9.7	12.3 11.1 - 12.4
Jamaica Bay	Q-50	N 40.645451 W 73.815218	3.80	3.48	6.4	8.7	9.8	12.3 11.3 - 12.3
Jamaica Bay	Q-51	N 40.648086 W 73.835104	3.00	3.03	6.4 6.4 - 6.6	8.8 8.4 - 8.9	9.9 9.6 - 10	12.5 12.1 - 12.7
Jamaica Bay	Q-52	N 40.644655 W 73.843198	3.45	3.00	6.4 6.4 - 6.5	8.9 8.6 - 9.6	10 9.7 - 10	12.6 12.2 - 12.8
Jamaica Bay	Q-53	N 40.650765 W 73.854350	2.70	2.74	6.5	9 9 - 9.6	10.1 9.7 - 10.1	12.9 12.6 - 13
East River	Q-54	N 40.741010 W 73.961831	3.12	3.26	7 6.7 - 7	9.7 8.9 - 9.7	11 10.3 - 11	14 13.4 - 14
East River	Q-55	N 40.744804 W 73.958734	2.92	3.17	7 7 - 7.1	9.8 8.9 - 9.8	11 10.1 - 11	14 12.8 - 14

[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 5: TRANSECT DATA - 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)			
		Coordinates	Significant Wave Height (ft)	Peak Wave Period (sec)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
East River	Q-56	N 40.749444 W 73.955923	2.73	3.15	7.1 7 - 7.1	9.8 9 - 9.9	11 9.8 - 11.2	14 12.2 - 14.2
East River	Q-57	N 40.790792 W 73.909040	2.64	2.77	9.2 9.1 - 9.2	11.7 11.4 - 12.1	12.7 12.4 - 12.7	14.9 14.6 - 14.9
East River	Q-58	N 40.788781 W 73.900060	2.89	3.17	9.4	11.8 11.8 - 12.6	12.7 12.7 - 12.8	15 15 - 15.3
East River	Q-59	N 40.783012 W 73.895900	2.85	3.00	9.4 9.3 - 9.4	11.9 11.6 - 12.6	12.9 12.7 - 12.9	15.1 15.1 - 15.3
East River	Q-60	N 40.779115 W 73.891502	2.77	2.74	9.5	11.9 11.9 - 12.3	12.9 12.8 - 12.9	15.1 15 - 15.1
Bowery Bay	Q-61	N 40.773964 W 73.886563	2.15	2.59	9.4 9.4 - 9.5	11.9 11.7 - 12.6	12.9 12.7 - 12.9	15 14.8 - 15
East River	Q-62	N 40.780091 W 73.884032	2.63	2.78	9.4	11.9 11.6 - 12.4	12.8 12.6 - 12.8	15 14.7 - 15
East River	Q-63	N 40.785453 W 73.870015	2.17	2.97	9.7 9 - 9.7	12.2 11.4 - 12.6	13.1 12.5 - 13.4	15.2 14.7 - 16
Flushing Bay	Q-64	N 40.776960 W 73.865277	2.14	2.75	9.7 9.6 - 9.8	12.1 12.1 - 12.6	13.1 12.8 - 13.4	15.2 15.1 - 15.7
Flushing Bay	Q-65	N 40.773346 W 73.857673	1.98	2.55	9.9 9.6 - 9.9	12 12 - 12.6	13 12.7 - 13.3	15 15 - 15.6
Flushing Bay	Q-66	N 40.765428 W 73.861606	1.99	2.43	9.8 9.7 - 9.8	12.2 12.2 - 12.6	13.1 12.9 - 13.1	15.1 15 - 15.1
Flushing Bay	Q-67	N 40.760713 W 73.855522	1.97	2.40	9.7	12.1 12.1 - 12.5	13 12.8 - 13	15 14.7 - 15
Flushing Bay	Q-68	N 40.762636 W 73.844918	1.88	2.31	9.7 9.4 - 9.7	12 11.5 - 12.6	12.9 12.2 - 12.9	14.9 13.2 - 14.9
Flushing Bay	Q-69	N 40.772603 W 73.849560	1.96	2.55	9.7	12 11 - 12.3	12.9 12.1 - 12.9	14.9 13.8 - 14.9

[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 5: TRANSECT DATA - 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)			
		Coordinates	Significant Wave Height (ft)	Peak Wave Period (sec)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Flushing Bay	Q-70	N 40.778912 W 73.849789	2.20	2.57	9.7	12 12 - 12.4	12.9 12.8 - 12.9	14.9 14.7 - 14.9
Flushing Bay	Q-71	N 40.782781 W 73.855419	2.11	2.57	9.6 9.6 - 9.7	12 11.8 - 12	13 12.7 - 13	15 14.8 - 15
East River	Q-72	N 40.786851 W 73.858353	2.41	3.05	9.7	12.2 11.8 - 12.2	13.2 12.9 - 13.2	15.4 15 - 15.4
East River	Q-73	N 40.789605 W 73.854575	2.33	3.00	9.7	12.3	13.3	15.7 15.7 - 15.8
East River	Q-74	N 40.794228 W 73.853197	2.48	3.37	9.6	12	13	15.1 15.1 - 15.8
East River	Q-75	N 40.794223 W 73.849052	1.92	2.74	9.6	12 12 - 12.1	12.9	14.9
East River	Q-76	N 40.795995 W 73.846778	2.54	3.48	9.7	12.1	13	15
East River	Q-77	N 40.796866 W 73.840234	2.72	3.58	9.6 9.6 - 9.7	11.8 11.8 - 11.9	12.8 12.7 - 12.9	14.7 14.7 - 15
East River	Q-78	N 40.792646 W 73.836711	1.89	2.48	9.7	12.1 12.1 - 12.4	13 12.9 - 13	15
East River	Q-79	N 40.788656 W 73.832370	1.73	2.37	9.7	12.1 11.9 - 12.1	13 12.8 - 13	15 14.9 - 15
East River	Q-80	N 40.792125 W 73.828807	1.81	2.62	9.7	12	12.9	14.9
East River	Q-81	N 40.796754 W 73.827758	2.68	3.44	9.7	12	12.9	14.9
East River	Q-82	N 40.800467 W 73.820914	2.60	3.41	9.6	11.9	12.8	14.7
East River	Q-83	N 40.798011 W 73.814756	2.77	3.61	9.7	12	12.9	14.8

[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 5: TRANSECT DATA - 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)			
		Coordinates	Significant Wave Height (ft)	Peak Wave Period (sec)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
East River	Q-84	N 40.796555 W 73.807127	2.76	3.60	9.7	11.9	12.8 12.7 - 12.8	14.7 14.6 - 14.7
East River	Q-85	N 40.795622 W 73.798051	2.97	3.84	9.7	12.1	12.9 12.9 - 13	14.8
Little Bay	Q-86	N 40.792174 W 73.794948	3.07	3.44	9.9 9.8 - 9.9	12.3 12.1 - 12.3	13.2 13.1 - 13.2	15.3 15.1 - 15.3
Little Bay	Q-87	N 40.790352 W 73.788610	3.32	3.58	9.8	12.1 11.9 - 12.2	12.9 12.8 - 12.9	14.8 14.7 - 14.8
Little Bay	Q-88	N 40.792818 W 73.780787	2.99	3.75	9.8	12	12.9	14.8
Little Neck Bay	Q-89	N 40.796678 W 73.779399	3.07	3.32	9.7 9.7 - 9.8	12	12.8 12.8 - 12.9	14.6
Little Neck Bay	Q-90	N 40.793805 W 73.774072	3.34	3.39	9.8	12	12.8 12.8 - 12.9	14.7
Little Neck Bay	Q-91	N 40.789138 W 73.771231	3.08	3.23	9.8	12 11.9 - 12.6	12.9 12.8 - 12.9	14.7 14.6 - 14.8
Little Neck Bay	Q-92	N 40.782543 W 73.771118	3.09	3.23	9.8	11.9 11.9 - 12.6	12.8 12.8 - 13	14.6 14.6 - 14.8
Little Neck Bay	Q-93	N 40.777313 W 73.767301	2.89	3.16	9.8	12	12.9	14.6
Little Neck Bay	Q-94	N 40.771976 W 73.763192	2.76	3.09	9.8	12 11.7 - 12	12.9 12.7 - 12.9	14.6 14.5 - 14.7
Little Neck Bay	Q-95	N 40.766360 W 73.756074	2.61	3.20	9.8 9.7 - 9.8	12 11.3 - 12.4	12.8 12.2 - 12.8	14.5 14 - 14.6
Little Neck Bay	Q-96	N 40.769218 W 73.754705	2.62	3.23	9.8	12 11.8 - 12	12.8 12.6 - 12.8	14.5 14.3 - 14.5
Little Neck Bay	Q-97	N 40.772355 W 73.753746	2.85	3.15	9.8	12 11.8 - 12	12.8 12.6 - 12.8	14.5 14.4 - 14.5

[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 5: TRANSECT DATA - 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)			
		Coordinates	Significant Wave Height (ft)	Peak Wave Period (sec)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Little Neck Bay	Q-98	N 40.778121 W 73.754360	2.89	3.16	9.6	11.9	12.7	14.5 14.4 - 14.5
Little Neck Bay	Q-99	N 40.782501 W 73.751333	2.45	2.95	9.7	12.4	12.7	14.3
Little Neck Bay	Q-100	N 40.780487 W 73.748058	2.16	3.20	9.7	11.9 11.7 - 11.9	12.7 12.5 - 12.7	14.5 14.3 - 14.5
Little Neck Bay	Q-101	N 40.780321 W 73.746834	2.15	3.16	9.7	11.9 11.7 - 12.4	12.7 12.5 - 12.7	14.4 14.2 - 14.4

[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 5: TRANSECT DATA - 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)			
		Coordinates	Significant Wave Height (ft)	Peak Wave Period (sec)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Richmond County, NY								
Lower New York Bay	R-1	N 40.647928 W 74.078417	5.51	4.67	7.1	10.1	11.5 11.2 - 11.5	14.9 14.8 - 14.9
Lower New York Bay	R-2	N 40.643297 W 74.071423	6.73	5.84	7.1	10	11.4	14.8 14.7 - 14.8
Lower New York Bay	R-3	N 40.635432 W 74.073159	6.89	6.01	7.1	10.1 9.8 - 10.1	11.5 11.3 - 11.5	14.9 14.9 - 15.1
Lower New York Bay	R-4	N 40.627468 W 74.072360	6.25	5.96	7.1	10.1 10 - 10.1	11.4 11.3 - 11.5	14.8 14.8 - 15
Lower New York Bay	R-5	N 40.620604 W 74.068853	6.25	6.12	7.1	10 9.9 - 10.4	11.4 11.4 - 11.5	14.8 14.8 - 14.9
Lower New York Bay	R-6	N 40.615459 W 74.062568	7.05	7.09	7.1	10	11.4	14.7
Lower New York Bay	R-7	N 40.611680 W 74.059456	7.19	7.02	7.1	9.9	11.3	14.6 14.5 - 14.6
Lower New York Bay	R-8	N 40.605653 W 74.053732	7.24	6.72	7	9.9 9.9 - 10.6	11.3	14.5 14.4 - 14.5
Lower New York Bay	R-9	N 40.598287 W 74.055109	6.90	5.68	7.1	10 9.9 - 10	11.4 11.2 - 11.4	14.7 14.7 - 14.8
Lower New York Bay	R-10	N 40.593355 W 74.060615	6.97	5.51	7.1	10.1 10.1 - 10.7	11.5 11.5 - 11.7	14.9 14.9 - 15.3
Lower New York Bay	R-11	N 40.587474 W 74.066428	7.22	5.86	7.2	10.1 9.9 - 10.3	11.5 11.5 - 11.8	15 15 - 15.5
Lower New York Bay	R-12	N 40.581523 W 74.072310	7.35	6.55	7.2	10.2 10 - 10.3	11.6 11.4 - 11.8	15.1 15.1 - 15.8
Lower New York Bay	R-13	N 40.575897 W 74.078931	8.19	6.31	7.3 7.2 - 7.3	10.3 9.7 - 10.5	11.7 11.1 - 11.8	15.2 15.2 - 16

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

TABLE 5: TRANSECT DATA - 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)			
		Coordinates	Significant Wave Height (ft)	Peak Wave Period (sec)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Lower New York Bay	R-14	N 40.570726 W 74.085542	8.01	5.49	7.3 7.2 - 7.3	10.3 9.7 - 10.5	11.7 11.2 - 11.9	15.2 15.2 - 16
Lower New York Bay	R-15	N 40.565630 W 74.092032	7.95	5.51	7.4 7.2 - 7.4	10.4 9.9 - 10.6	11.8 11.7 - 11.9	15.3 15.3 - 16
Raritan Bay	R-16	N 40.560017 W 74.097971	7.70	5.57	7.4	10.4 10.3 - 10.4	11.8 11.8 - 12	15.4 15.4 - 16
Raritan Bay	R-17	N 40.554569 W 74.104308	7.35	5.94	7.4 6.6 - 7.4	10.4 10.3 - 10.5	11.7 11.7 - 11.9	15.4 15.4 - 16
Raritan Bay	R-18	N 40.550606 W 74.110940	7.05	6.51	7.4	10.5 10.4 - 10.7	11.9 11.8 - 12	15.5 15.5 - 16.1
Raritan Bay	R-19	N 40.547211 W 74.118255	6.71	6.05	7.5 7.4 - 7.7	10.6 10.5 - 10.7	12 11.8 - 12.1	15.5 15.2 - 16.2
Raritan Bay	R-20	N 40.542278 W 74.124885	6.85	6.28	7.6	10.6	12.1	15.6
Raritan Bay	R-21	N 40.536754 W 74.128999	6.74	6.34	7.6	10.6	12.1 11.9 - 12.1	15.6 15.5 - 15.6
Raritan Bay	R-22	N 40.530708 W 74.134748	7.21	6.65	7.5 7.5 - 7.6	10.6	12 11.8 - 12	15.5 15.5 - 15.8
Raritan Bay	R-23	N 40.533872 W 74.140535	5.08	5.95	7.5	10.6	12.1 12 - 12.1	15.6
Great Kills Harbor	R-24	N 40.537078 W 74.132095	1.76	2.38	7.4	10.6	12	15.6
Great Kills Harbor	R-25	N 40.544967 W 74.128942	2.09	2.62	7.4	10.6	12	15.7 15.6 - 16
Great Kills Harbor	R-26	N 40.545236 W 74.138461	2.03	2.76	7.5 7.4 - 7.5	10.6 10.5 - 10.6	12.1 12 - 12.1	15.8
Raritan Bay	R-27	N 40.536842 W 74.144047	5.27	5.93	7.5 7.4 - 7.5	10.6	12.1 12.1 - 12.2	15.7 15.7 - 15.9

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

TABLE 5: TRANSECT DATA - 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)			
		Coordinates	Significant Wave Height (ft)	Peak Wave Period (sec)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Raritan Bay	R-28	N 40.532775 W 74.150388	6.36	6.83	7.6 0 - 0	10.7	12.1 12.1 - 12.2	15.7 15.7 - 16.1
Raritan Bay	R-29	N 40.528419 W 74.157873	6.37	6.15	7.7	10.8	12.3	15.8
Raritan Bay	R-30	N 40.525471 W 74.165748	7.30	6.44	7.8	10.9	12.3	15.8
Raritan Bay	R-31	N 40.521914 W 74.174300	7.42	6.08	7.8	10.9	12.4	15.9
Raritan Bay	R-32	N 40.519829 W 74.183611	7.53	6.08	7.8	11	12.4	16
Raritan Bay	R-33	N 40.514262 W 74.190726	7.53	5.93	7.8 7.7 - 7.8	11	12.4 12.3 - 12.4	16 16 - 16.6
Raritan Bay	R-34	N 40.510220 W 74.194769	6.10	4.72	7.9 7.7 - 7.9	11 10.9 - 11	12.4 12.3 - 12.7	16 15.8 - 16.5
Raritan Bay	R-35	N 40.511679 W 74.208054	4.87	4.43	7.9	11.1	12.5	16.1
Raritan Bay	R-36	N 40.502497 W 74.222385	6.65	5.49	8 6.9 - 8.1	11.2	12.7 12.5 - 12.7	16.2 16.1 - 16.3
Raritan Bay	R-37	N 40.501746 W 74.231526	6.17	5.27	8.1	11.3	12.8	16.3
Raritan Bay	R-38	N 40.497605 W 74.240883	6.05	5.46	8.1 7.9 - 8.7	11.3	12.8 12.8 - 13	16.4 16.4 - 16.7
Raritan Bay	R-39	N 40.497433 W 74.250294	4.71	4.75	8.2 6.8 - 8.3	11.4 11.3 - 11.4	12.9 12.8 - 12.9	16.4 16.4 - 16.6
Arthur Kill	R-40	N 40.508668 W 74.254714	1.47	2.17	8.2	11.4	12.8	16.2
Arthur Kill	R-41	N 40.516106 W 74.248753	3.15	3.67	8.2	11.3 11.2 - 11.3	12.7 12.6 - 12.7	16.1 16 - 16.1

[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 5: TRANSECT DATA - 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)			
		Coordinates	Significant Wave Height (ft)	Peak Wave Period (sec)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Arthur Kill	R-42	N 40.519839 W 74.240138	3.30	3.84	8.1 7.4 - 8.1	11.3	12.7 12.2 - 12.7	16.1 15.8 - 16.4
Arthur Kill	R-43	N 40.533052 W 74.242277	3.31	4.09	8	11.2	12.6 12.2 - 12.6	16.1 15.9 - 16.1
Arthur Kill	R-44	N 40.546489 W 74.245113	3.04	3.53	8	11.1 11 - 11.1	12.5 12.3 - 12.5	15.9 15.8 - 15.9
Arthur Kill	R-45	N 40.556223 W 74.225917	2.36	2.46	7.9 7.8 - 8.4	10.9 10.4 - 10.9	12.3 12 - 12.3	15.6 15.6 - 16.1
Arthur Kill	R-46	N 40.576712 W 74.206661	1.23	1.94	7.7 7.6 - 7.7	10.7 10.5 - 12	12 11.6 - 12	15.2 14.8 - 15.2
Arthur Kill	R-47	N 40.596065 W 74.198014	1.46	2.24	7.6 7.5 - 8.1	10.5 9.6 - 10.8	11.8 11.2 - 11.8	15 14.6 - 15
Arthur Kill/Pralls River	R-48	N 40.611746 W 74.202226	0.89	1.64	7.5 7.4 - 7.7	10.4 9.4 - 10.9	11.7 10.9 - 11.7	14.8 14.1 - 14.8
Arthur Kill	R-49	N 40.629270 W 74.200964	1.02	1.81	7.4 6.8 - 7.4	10.3 9.1 - 10.7	11.6 10.6 - 12.2	14.7 13.5 - 14.7
Newark Bay	R-50	N 40.644615 W 74.173481	2.29	3.06	7.1 7 - 7.2	9.8 9.4 - 10.1	11 10.8 - 11	13.9 13.5 - 14
Newark Bay	R-51	N 40.641895 W 74.168219	2.45	3.07	7.1	9.8 9.6 - 9.8	10.9 10.8 - 10.9	13.7
Newark Bay	R-52	N 40.637944 W 74.157896	3.35	3.82	7.1 7.1 - 7.5	9.7 9.6 - 9.7	10.9 10.5 - 10.9	13.7 13.5 - 13.7
Newark Bay	R-53	N 40.638943 W 74.148219	3.21	3.23	7 6.8 - 7	9.7 9.6 - 9.7	10.8 10.6 - 10.8	13.6 13.3 - 13.7
Kill Van Kull	R-54	N 40.640911 W 74.138589	1.71	2.50	7	9.6	10.8 10.6 - 10.8	13.6 13.3 - 13.6
Kill Van Kull	R-55	N 40.640142 W 74.127786	1.58	2.36	7.1 7 - 7.5	9.8	11 10.9 - 11	13.9 13.4 - 13.9

[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 5: TRANSECT DATA - 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)			
		Coordinates	Significant Wave Height (ft)	Peak Wave Period (sec)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Kill Van Kull	R-56	N 40.641811 W 74.117989	1.45	2.18	7.2 7.2 - 7.3	9.8	11.1 10.7 - 11.1	14 13.8 - 14
Kill Van Kull	R-57	N 40.645573 W 74.106734	1.43	2.40	7.1 6.9 - 7.1	9.9 9.2 - 10	11.1	14.1
Kill Van Kull	R-58	N 40.645431 W 74.095429	1.74	2.64	7.1 0 - 0	10	11.3	14.5
Kill Van Kull	R-59	N 40.648563 W 74.086878	3.66	3.46	7.1	10	11.3	14.6

[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 (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 Elevation Reference Marks (ERM) reflect the new datum values. To compare structure and ground elevations to 1-percent annual chance flood elevation shown in the FIS report and on the FIRM, the subject 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 New York City 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 feet, where:

$$\text{NGVD 29} = \text{NAVD 88} + 1.1 \text{ ft}$$

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 of 1988, 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 1-percent-annual-chance flood data, which may include a combination of the following: 10-, 2-, 1-, and 0.2-percent-annual-chance flood elevations; delineations of the 1-percent and 0.2-percent floodplains; and 1-percent 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 streams studied in detail, the 100- and 500-year floodplains have been delineated using the flood elevations determined at each cross section.

For the approximate analysis in the July 5, 1994, revision, the 1-percent-annual-chance floodplain boundaries were delineated using maps supplied by the city and topographic information from maps at a scale of 1:24,000 with a contour interval of 10 feet (USGS, 1975, et cetera). For the Borough of Staten Island, the boundaries were interpolated between cross sections using topographic maps at a scale of 1:960 with a contour interval of 2 feet (Aerial Data Reduction Associates, Inc., 1989).

For the approximate analysis on Staten Island in the May 21, 2001, revision, the 1-percent-annual-chance floodplain boundaries were delineated using topographic maps supplied by the NYCDEP, at a scale of 1:400, with a contour interval of 2 feet (NYCDEP, 1999).

For the September 5, 2007, revision, all unrevised, detailed study flood hazard boundaries were redelineated using topographic maps at a scale of 1:1,200, with a contour interval of 2 feet as well as a 3 meter digital elevation model (NYC DOITT). For the revised analyses of the Bronx River, D Street Brook, Forest Hill Road Tributary, Richmond Creek as well as Eibs Pond and Stump Pond, the 3 meter digital elevation model was used to delineate boundaries between hydraulic cross sections. The remaining revised analyses were delineated using topographic maps at a scale of 1:2,400, with a contour interval of 2 feet (NYCDEP).

For the [*date*] revision, all detailed study flood hazard boundaries were delineated using updated topographic information generated by LiDAR (Light Detection and Ranging) for the City of New York. The LiDAR data were collected and processed by Sanborn Map Company from April 14 to May 1, 2010.

The 1- and 0.2-percent-annual-chance floodplain boundaries are shown on the FIRM (Exhibit 2). On these maps, the 1-percent-annual-chance floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones A, AE, and VE), and the 0.2% 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.

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. The floodways in this study are presented to local agencies as a minimum standard that can be adopted directly or that can be used as a basis for additional floodway studies.

The floodways presented in this study were computed for certain stream segments on the basis of equal conveyance reduction from each side of the floodplain. Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations are tabulated for selected cross sections (Table 6). The computed floodways are shown on the revised FIRM (Exhibit 2). In cases where the floodway and 1-percent-annual-chance floodplain boundaries are either close together or collinear, only the floodway boundary is shown. Portions of the floodway for the Bronx River extend beyond the corporate limits. The 1-percent-annual-chance flood discharges for Colon Tributary are contained within the storm drain. Therefore, a floodway was not computed.

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. A listing of stream velocities at selected cross sections is provided in Table 6, "Floodway Data." To reduce the risk of property damage in areas where the stream velocities are high, the community may wish to restrict development in areas outside the floodway.

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Arbutus Creek								
A	350	414	*	*	*	*	*	*
B	1,100	254	1,140	0.4	11.9	7.4[2]	7.4	0.0
C	2,136	68	446	1.1	14.1	14.1	14.1	0.0
D	2,496	56	212	1.6	14.1	14.1	14.1	0.0
E	3,170	116	98	3.5	20.5	20.5	20.5	0.0
F	3,690	12	47	6.5	25.7	25.7	26.1	0.4
G	3,860	25	79	3.9	29.3	29.3	29.3	0.0
H	4,620	16	61	5.0	30.4	30.4	31.2	0.8
I	5,340	87	76	3.3	35.8	35.8	35.8	0.0
J	5,940	15	41	6.1	39.0	39.0	39.0	0.0
K	6,460	10	28	8.9	46.7	46.7	46.8	0.1
L	6,850	46	165	1.2	51.4	51.4	52.0	0.6
M	7,130	24	53	3.6	51.5	51.5	52.0	0.5
N	7,690	77	180	1.1	55.5	55.5	55.5	0.0

[1]Feet above confluence with Raritan Bay
[2]Elevation computed without consideration of backwater effects from Raritan Bay
*Cross section (A) Not Mapped; Superseded By New Coastal Analyses

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY (BRONX, KINGS, NEW YORK, QUEENS, AND RICHMOND COS.)

FLOODWAY DATA

ARBUTUS CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Blue Heron Main Branch								
A	900[1]	96	433	0.8	12.4	6.4[3]	7.3	0.9
B	1322[1]	80	669	0.5	16.0	16.0	16.0	0.0
C	1570[1]	10	38	9.0	16.0	15.9	16.2	0.3
D	2,050[1]	38	131	2.6	24.0	24.0	25.0	1.0
E	2,510[1]	55	62	5.5	30.6	30.6	30.7	0.1
F	3,000[1]	85	151	1.3	35.1	35.1	35.9	0.8
G	3,590[1]	22	30	6.7	41.1	41.1	41.1	0.0
H	3,900[1]	16	26	7.3	44.5	44.5	44.7	0.2
I	4,540[1]	32	130	1.5	46.7	46.7	46.7	0.0
J	5,030[1]	50	276	0.6	53.1	53.1	53.7	0.6
K	5,600[1]	10	13	6.6	62.2	62.2	62.2	0.0
L	6,200[1]	10	22	3.9	66.0	66.0	66.3	0.3
M	6,500[1]	140	593	0.1	68.4	68.4	68.5	0.1
Blue Heron Tributary								
A	490[2]	7	23	5.5	34.5	34.5	35.5	1.0
B	640[2]	30	16	3.4	39.2	39.2	39.2	0.0
C	1,320[2]	40	20	2.6	47.1	47.1	47.2	0.1
D	1,520[2]	204	903	0.1	48.5	48.5	48.7	0.2
E	2,020[2]	7	16	5.2	55.1	55.1	55.7	0.7
F	2,273[2]	15	15	5.6	63.9	63.9	63.9	0.0

[1]Feet above confluence with Raritan Bay
[2]Feet above confluence with Blue Heron Main Branch
[3]Elevation computed without consideration of backwater effects from Raritan Bay

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY (BRONX, KINGS, NEW YORK, QUEENS, AND RICHMOND COS.)

FLOODWAY DATA

BLUE HERON MAIN BRANCH – BLUE HERON TRIBUTARY

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Bronx River								
A	3,600	169	4,008	1.0	13.1	11.9[3]	12.9	1.0
B	6,900	160	3,166	1.3	13.1	11.9[3]	12.9	1.0
C	8,390	180	3,929	1.0	13.1	12.0[3]	13.0	1.0
D	9,300	310	4,389	0.9	13.1	12.0[3]	13.0	1.0
E	10,900	90	1,578	2.6	13.1	12.2[3]	13.2	1.0
F	12,200	138	2,353	1.7	13.1	12.4[3]	13.4	1.0
G	13,820	86	1,214	3.4	13.1	12.8[3]	13.8	1.0
H	14,970	75	763	5.4	13.3	13.3	14.3	1.0
I	16,040	94	768	5.3	27.6	27.6	28.2	0.6
J	18,430	203	1,890	2.2	28.8	28.8	29.2	0.4
K	19,600	99	776	5.3	29.5	29.5	29.8	0.3
L	21,850	89	472	8.7	40.0	40.0	40.3	0.3
M	23,390	110	648	6.3	52.6	52.6	52.6	0.0
N	25,000	117	776	5.3	55.2	55.2	55.3	0.1
O	27,320	82	572	7.2	56.5	56.5	56.8	0.3
P	28,720	63	700	5.9	60.0	60.0	60.2	0.2
Q	29,960	69	798	5.1	60.9	60.9	61.7	0.8
R	30,960	91	1,090	3.6	63.1	63.1	63.7	0.6
S	33,150	91	856	4.5	64.0	64.0	64.7	0.7
T	35,150	63	755	5.1	65.4	65.4	66.1	0.7
U	36,270	63	803	4.8	66.0	66.0	66.8	0.8
V	37,260	100	1,005	3.9	68.2	68.2	68.9	0.7
W	38,310	86	943	4.1	68.9	68.9	69.7	0.8
X	39,070	132	1,242	3.0	69.6	69.6	70.3	0.7
Y	40,180	92[2]	860	4.5	70.1	70.1	70.8	0.7
Z	41,310	91[2]	1,053	3.7	71.1	71.1	71.8	0.7

[1]Feet above confluence with the East River
[2]Width extends beyond county boundary
[3]Elevation computed without consideration of backwater effects from the East River

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY (BRONX, KINGS, NEW YORK, QUEENS, AND RICHMOND COS.)

FLOODWAY DATA

BRONX RIVER

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Bronx River (Continued)								
AA	42,440[1]	215	1,549	2.5	72.1	72.1	72.7	0.6
Butler Manor								
A	1,550[2]	152	387	0.3	12.6	8.8[5]	9.8	1.0
B	1,838[2]	13	17	5.3	12.6	9.7[5]	9.8	0.1
C	2,170[2]	11	25	2.4	13.7	13.7	14.2	0.5
D	2,440[2]	8	17	3.8	23.1	23.1	23.4	0.3
E	2,600[2]	20	15	4.1	25.4	25.4	25.4	0.0
F	2,935[2]	330	1,315	0.1	32.2	32.2	32.4	0.2
D Street Brook								
A	0[3]	154	69	2.8	95.4	95.4	95.4	0.0
B	356[3]	64	42	4.6	101.7	101.7	101.7	0.0
C	695[3]	20	28	6.8	111.4	111.4	111.4	0.0
D	990[3]	33	33	5.8	124.3	124.3	124.3	0.0
E	1,237[3]	27	31	6.1	137.3	137.3	137.3	0.0
F	1,532[3]	49	32	6.0	153.6	153.6	153.6	0.0
Denise Tributary								
A	460[4]	38	24	4.6	22.1	22.1	22.1	0.0
B	640[4]	40	95	1.1	26.4	26.4	26.7	0.3
C	880[4]	9	19	5.8	27.9	27.9	28.2	0.3
D	1,200[4]	6	19	5.8	32.6	32.6	33.4	0.8
E	1,530[4]	26	21	5.2	38.1	38.1	38.1	0.0
F	2,000[4]	23	28	3.9	50.0	50.0	50.0	0.0

[1]Feet above confluence with the East River
[2]Feet above confluence with Raritan Bay
[3]Feet above 'D" Street culvert
[4]Feet above confluence with Arbutus Creek
[5]Elevation computed without consideration of backwater effects from Raritan Bay

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY (BRONX, KINGS, NEW YORK, QUEENS, AND RICHMOND COS.)

FLOODWAY DATA

BUTLER MANOR – D STREET BROOK – DENISE TRIBUTARY

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Eltingville Tributary								
A	170[1]	20	58	9.7	37.2	34.4[4]	37.2	0.0
B	360[1]	18	86	6.5	38.5	38.5	38.7	0.2
Forest Hill Road Brook								
A	440[2]	30	106	5.2	10.9	3.9[5]	4.7	0.8
B	1,467[2]	44	144	3.1	10.9	4.9[5]	5.9	1.0
C	3,061[2]	26	77	2.6	12.5	12.5	12.5	0.0
D	3,344[2]	26	53	3.7	12.8	12.8	12.9	0.1
E	3,737[2]	24	31	6.5	23.8	23.8	23.8	0.0
F	4,010[2]	22	30	6.7	31.6	31.6	31.7	0.1
G	4,247[2]	30	45	4.5	38.3	38.3	38.8	0.5
H	4,462[2]	22	30	6.6	45.8	45.8	45.8	0.0
I	4,664[2]	21	30	6.8	50.6	50.6	50.8	0.2
J	5,040[2]	26	45	4.4	56.0	56.0	56.9	0.9
K	5,236[2]	33	36	5.6	56.9	56.9	57.7	0.8
L	5,615[2]	74	146	1.4	59.3	59.3	59.8	0.5
M	5,953[2]	71	69	2.9	61.4	61.4	61.7	0.3
N	6,232[2]	40	41	4.9	64.9	64.9	65.1	0.2
O	6,652[2]	20	29	6.9	72.5	72.5	72.6	0.1
Jansen Tributary								
A	340[3]	40	13	3.1	23.8	23.8	23.8	0.0
B	800[3]	48	24	1.7	28.8	28.8	28.8	0.0
C	1,080[3]	48	13	3.0	31.3	31.3	31.3	0.0
D	1,340[3]	44	13	3.1	39.9	39.9	39.9	0.0

[1]Feet above confluence with Sweet Brook
[2]Feet above confluence with Richmond Creek
[3]Feet above confluence with Arbutus Creek
[4]Elevation computed without consideration of backwater effects from Sweet Brook
[5]Elevation computed without consideration of backwater effects from Richmond Creek

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY (BRONX, KINGS, NEW YORK, QUEENS, AND RICHMOND COS.)

FLOODWAY DATA

ELTINGVILLE TRIBUTARY – FOREST HILL ROAD BROOK – JANSEN TRIBUTARY

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Lemon Creek								
A	7,135	118	866	0.6	16.3	16.3	16.3	0.0
B	7,700	53	351	1.5	16.3	16.3	16.3	0.0
C	7,975	130	585	0.9	16.4	16.4	16.5	0.1
D	8,350	42	68	7.8	16.4	16.4	16.4	0.0
E	8,480	37	79	6.7	17.7	17.7	17.7	0.0
F	8,680	42	77	6.8	20.2	20.2	20.2	0.0
G	9,150	30	75	4.0	26.0	26.0	26.2	0.2
H	9,600	26	75	4.0	29.3	29.3	30.0	0.7
I	9,920	11	31	9.6	33.2	33.2	33.2	0.0
J	10,520	25	38	5.5	38.5	38.5	38.5	0.0
K	11,280	56	146	1.4	41.5	41.5	42.3	0.8
L	11,830	38	44	4.7	44.6	44.6	44.6	0.0
M	12,730	75	68	3.1	50.7	50.7	50.7	0.0
N	13,650	58	70	3.0	56.5	56.5	56.5	0.0
O	14,130	35	50	3.8	58.7	58.7	59.0	0.3
P	14,630	21	40	4.7	62.6	62.6	62.6	0.0
Q	15,230	31	42	4.5	68.5	68.5	68.5	0.0
R	15,510	50	261	0.7	72.6	72.6	72.6	0.0
S	15,760	25	12	0.2	76.2	76.2	76.2	0.0
T	16,103	20	3	1.1	80.0	80.0	80.0	0.0
U	16,400	63	53	0.1	82.3	82.3	82.3	0.0
V	16,800	265	306	0.2	82.3	82.3	82.3	0.0
W	17,150	32	18	4.3	86.4	86.5	86.5	0.1
X	17,440	35	28	2.8	92.4	92.5	92.5	0.1
Y	17,650	50	149	0.3	98.3	98.3	98.3	0.0
Z	17,920	47	23	2.0	100.2	100.6	100.6	0.4

[1]Feet above confluence with Raritan Bay

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY (BRONX, KINGS, NEW YORK, QUEENS, AND RICHMOND COS.)

FLOODWAY DATA

LEMON CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Mill Creek								
A	1,775[1]	200	*	*	*	*	*	*
B	2,780[1]	254	*	*	*	*	*	*
C	3,815[1]	43	100	8.6	13.7	13.7	13.9	0.2
D	4,500[1]	107	189	4.4	21.2	21.2	21.4	0.2
E	5,240[1]	25	111	7.5	26.2	26.2	26.4	0.2
F	5,710[1]	49	503	1.3	34.7	34.7	34.9	0.2
G	6,350[1]	110	447	1.1	39.4	39.4	39.7	0.3
H	6,640[1]	41	126	2.1	40.2	40.2	40.5	0.3
I	6,965[1]	11	43	6.1	40.4	40.4	40.6	0.2
J	7,570[1]	18	21	5.5	50.1	50.1	50.1	0.0
K	8,215[1]	50	32	3.6	65.0	65.0	65.0	0.0
L	8,805[1]	90	36	3.1	76.3	76.3	76.3	0.0
Mill Creek Tributary 1								
A	370[2]	14	29	8.4	43.6	43.6	43.6	0.0
B	800[2]	20	45	5.5	48.7	48.7	48.7	0.0
C	1,260[2]	36	42	5.9	53.2	53.2	53.2	0.0
D	1,630[2]	35	40	6.2	59.2	59.2	59.2	0.0
Mill Creek Tributary 2								
A	450[2]	50	101	8.2	12.4	10.7[4]	10.7	0.0
B	1,450[2]	87	161	3.7	12.4	11.4[4]	11.9	0.5
Mill Creek Tributary 3								
A	300[3]	38	43	6.1	14.8	14.8	14.8	0.0
B	860[3]	40	78	3.4	21.2	21.2	21.2	0.0

[1]Feet above confluence with Arthur Kill
[2]Feet above confluence with Mill Creek
[3]Feet above confluence with Mill Creek Tributary 2
[4]Elevation computed without consideration of backwater effects from Mill Creek

**Cross sections (A and B) are Not Mapped; Superseded By New Coastal Analyses

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY (BRONX, KINGS, NEW YORK, QUEENS, AND RICHMOND COS.)

FLOODWAY DATA

MILL CREEK – MILL CREEK TRIBUTARY 1 – MILL CREEK TRIBUTARY 2 – MILL CREEK TRIBUTARY 3

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Richmond Creek								
A	14,999	99	348	3.4	10.9	4.7[2]	5.7	1.0
B	15,345	42	249	4.7	10.9	6.6[2]	7.6	1.0
C	15,887	121	762	1.5	11.5	11.5	12.4	0.9
D	16,246	160	238	4.9	12.5	12.5	12.5	0.0
E	16,600	97	538	2.2	13.5	13.5	13.5	0.0
F	17,669	37	156	7.5	15.6	15.6	16.2	0.6
G	18,227	231	937	1.3	18.1	18.1	19.1	1.0
H	19,019	47	139	8.4	21.4	21.4	21.7	0.3
I	19,526	47	242	4.8	25.4	25.4	26.4	1.0
J	20,060	28	111	10.5	29.8	29.8	30.8	1.0
K	20,534	41	159	7.4	36.7	36.7	37.4	0.7
L	20,822	52	148	7.9	41.9	41.9	42.4	0.5
M	21,212	25	102	11.5	49.6	49.6	49.8	0.2
N	21,746	50	76	6.8	60.0	60.0	60.0	0.0
O	22,138	12	51	10.0	75.4	75.4	75.5	0.1
P	22,743	25	58	8.8	90.6	90.6	90.6	0.0
Q	23,368	23	67	7.7	104.9	104.9	105.3	0.4
R	23,847	41	166	3.1	115.5	115.5	115.6	0.1
S	24,203	28	64	3.6	120.2	120.2	121.2	1.0
T	24,931	41	47	4.9	130.2	130.2	130.2	0.0
U	25,605	35	48	4.8	145.5	145.5	145.5	0.0
V	26,079	5	20	11.6	164.1	164.1	164.5	0.4
W	26,679	15	29	8.0	185.3	185.3	185.3	0.0
X	27,319	13	28	8.4	214.6	214.6	214.6	0.0
Y	28,065	12	26	8.7	244.4	244.4	244.4	0.0
Z	28,664	18	69	3.4	253.3	253.3	253.4	0.1

[1]Feet above confluence with Fresh Kills
[2]Elevation computed without consideration of backwater effects from Fresh Kills

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY (BRONX, KINGS, NEW YORK, QUEENS, AND RICHMOND COS.)

FLOODWAY DATA

RICHMOND CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Sandy Brook								
A	480[1]	12	24	3.5	38.1	38.1	38.1	0.0
B	850[1]	14	15	5.4	42.2	42.2	42.2	0.0
C	1,200[1]	12	18	4.6	47.7	47.7	47.8	0.1
D	1,600[1]	10	13	6.5	51.2	51.2	51.2	0.0
E	2,000[1]	63	45	1.8	56.9	56.9	57.0	0.1
F	2,400[1]	123	52	1.6	62.3	62.3	62.4	0.1
G	2,890[1]	14	11	5.1	68.3	68.3	68.3	0.0
H	3,220[1]	13	15	3.9	72.5	72.5	72.5	0.0
I	3,600[1]	10	10	5.6	80.2	80.2	80.2	0.0
Sweet Brook								
A	3,420[2]	25	96	11.1	14.0	14.0	14.0	0.0
B	3,690[2]	34	146	7.3	17.3	17.3	17.3	0.0
C	4,275[2]	68	131	6.9	28.1	28.1	28.2	0.1
D	4,865[2]	58	253	3.6	29.2	29.2	29.7	0.5
E	5,280[2]	75	586	1.7	29.6	29.6	30.5	0.9
F	5,715[2]	129	709	1.4	29.7	29.7	30.6	0.9
G	6,250[2]	50	292	3.5	30.5	30.5	31.1	0.6
H	6,760[2]	95	741	1.3	37.2	37.2	37.5	0.3
I	7,220[2]	90	523	0.8	37.3	37.3	37.5	0.2
J	8,100[2]	72	54	4.9	45.8	45.8	45.8	0.0
K	8,600[2]	50	47	5.6	50.8	50.8	50.9	0.1
L	9,450[2]	50	47	5.6	55.8	55.8	55.8	0.0
M	10,259[2]	55	43	5.1	64.0	64.0	64.0	0.0
N	10,455[2]	48	74	4.8	65.0	65.0	65.4	0.4
O	11,125[2]	21	69	5.1	70.1	70.1	70.7	0.6

[1]Feet above confluence with Lemon Creek
[2]Feet above confluence with Richmond Creek

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY (BRONX, KINGS, NEW YORK, QUEENS, AND RICHMOND COS.)

FLOODWAY DATA

SANDY BROOK – SWEET BROOK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Sweet Brook (continued)								
P	12,020[1]	28	63	5.6	75.2	75.2	75.4	0.2
Q	12,585[1]	49	251	1.2	80.5	80.5	80.8	0.3
R	12,870[1]	24	106	2.9	80.7	80.7	81.1	0.4
S	13,389[1]	55	368	0.2	81.0	81.0	81.8	0.8
T	13,775[1]	68	261	0.2	81.0	81.0	81.8	0.8
U	14,395[1]	94	498	0.1	81.0	81.0	81.8	0.8
V	14,795[1]	142	256	1.2	81.1	81.1	81.9	0.8
W	15,055[1]	42	83	3.6	82.2	82.2	83.1	0.9
X	15,340[1]	10	47	5.9	83.4	83.4	83.9	0.5
Y	15,945[1]	108	306	0.9	85.9	85.9	86.5	0.6
Z	16,220[1]	17	52	4.9	87.1	87.1	87.6	0.5
Wolfe's Pond								
A	1,220[2]	120	*	*	*	*	*	*
B	1,940[2]	610	*	*	*	*	*	*
C	2,610[2]	304	1,634	0.3	12.4	8.2[3]	8.9	0.7
D	3,950[2]	20	47	8.7	12.4	8.9[3]	8.9	0.0
E	4,400[2]	23	53	7.7	15.7	15.7	15.8	0.1
F	4,580[2]	40	153	2.7	17.4	17.4	17.6	0.2
G	4,930[2]	43	248	1.4	20.3	20.3	21.3	1.0

[1]Feet above confluence with Richmond Creek
[2]Feet above confluence with Raritan Bay
[3]Elevation computed without consideration of backwater effects from Raritan Bay
*Cross Sections (A-B) are Not Mapped; Superseded By New Coastal Analyses

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY (BRONX, KINGS, NEW YORK, QUEENS, AND RICHMOND COS.)

FLOODWAY DATA

SWEET BROOK – WOLFE'S POND

Near the mouths of streams studied in detail, floodway computations are made without regard to flood elevations on the receiving water body. Therefore, "Without Floodway" elevations presented in Table 6 for certain downstream cross sections of Arbutus Creek, Blue Heron Main Branch, Butler Manor, Mill Creek, Mill Creek Tributary 2, and Wolfe's Pond are lower than the regulatory flood elevations in that area, which must take into account the 1-percent-annual-chance flooding due to backwater from other sources.

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 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 3, "Floodway Schematic."

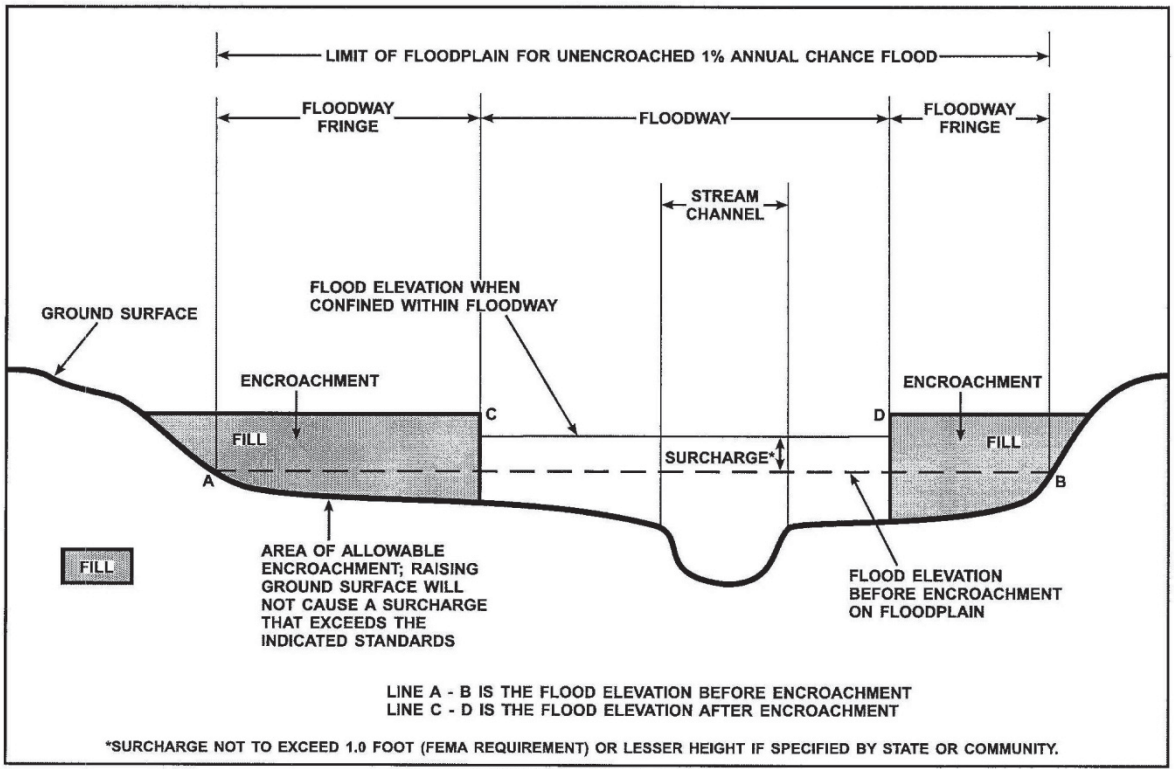

Figure 3: Floodway Schematic

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 base flood elevations 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 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 1-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 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 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 base flood elevations 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 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 1-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 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 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 1-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.

7.0 OTHER STUDIES

Due to its political and economic importance, and history of flood-related problems, the City of New York and surrounding areas have undergone numerous other hydrologic studies. A summary of these studies is provided in Study Overview (Camp, Dresser and McKee, 1983).

Because it is based on more up-to-date topographic information, this FIS supersedes the previously printed FIS for the City of New York (FEMA, 2007).

8.0 LOCATION OF DATA

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

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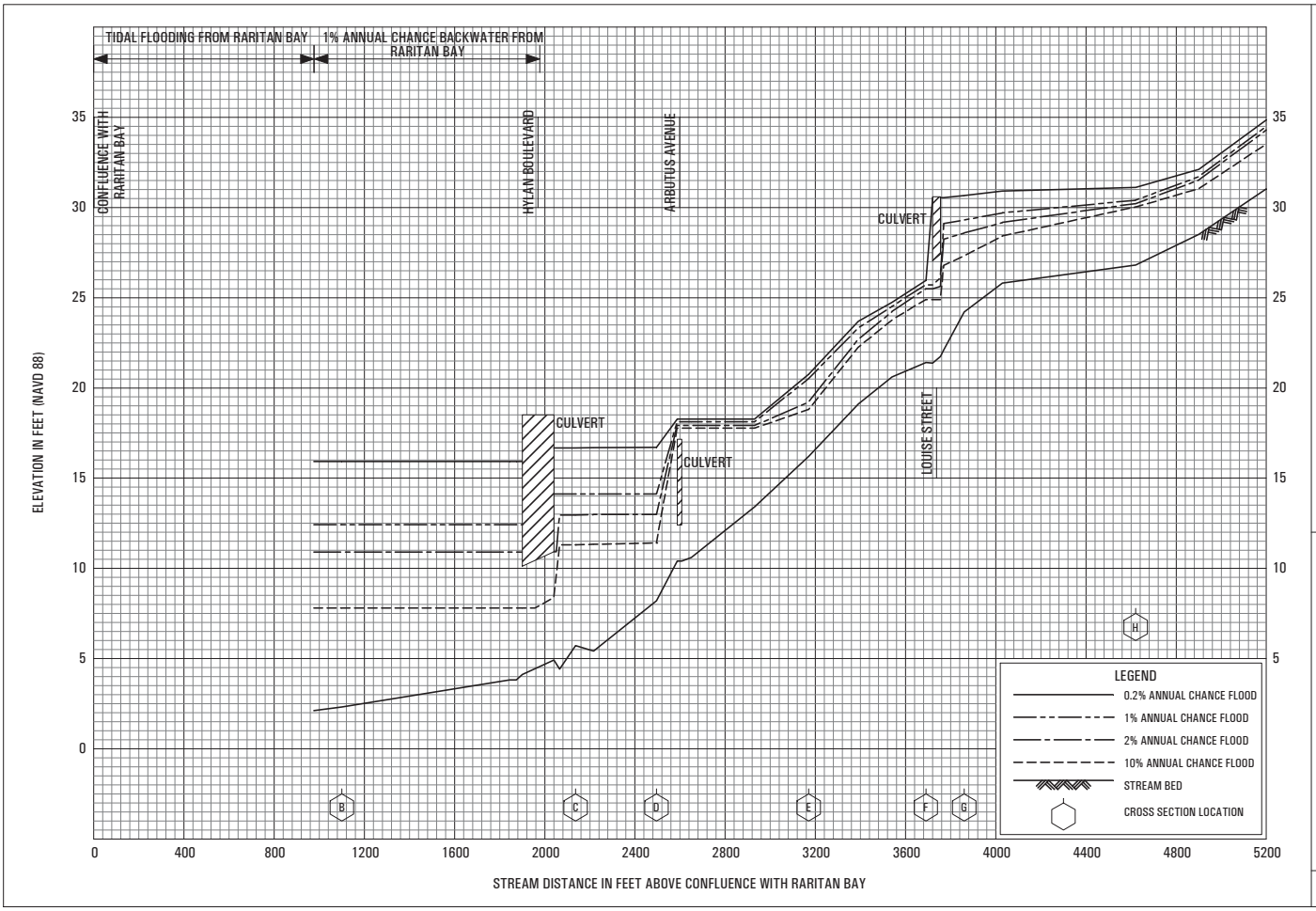


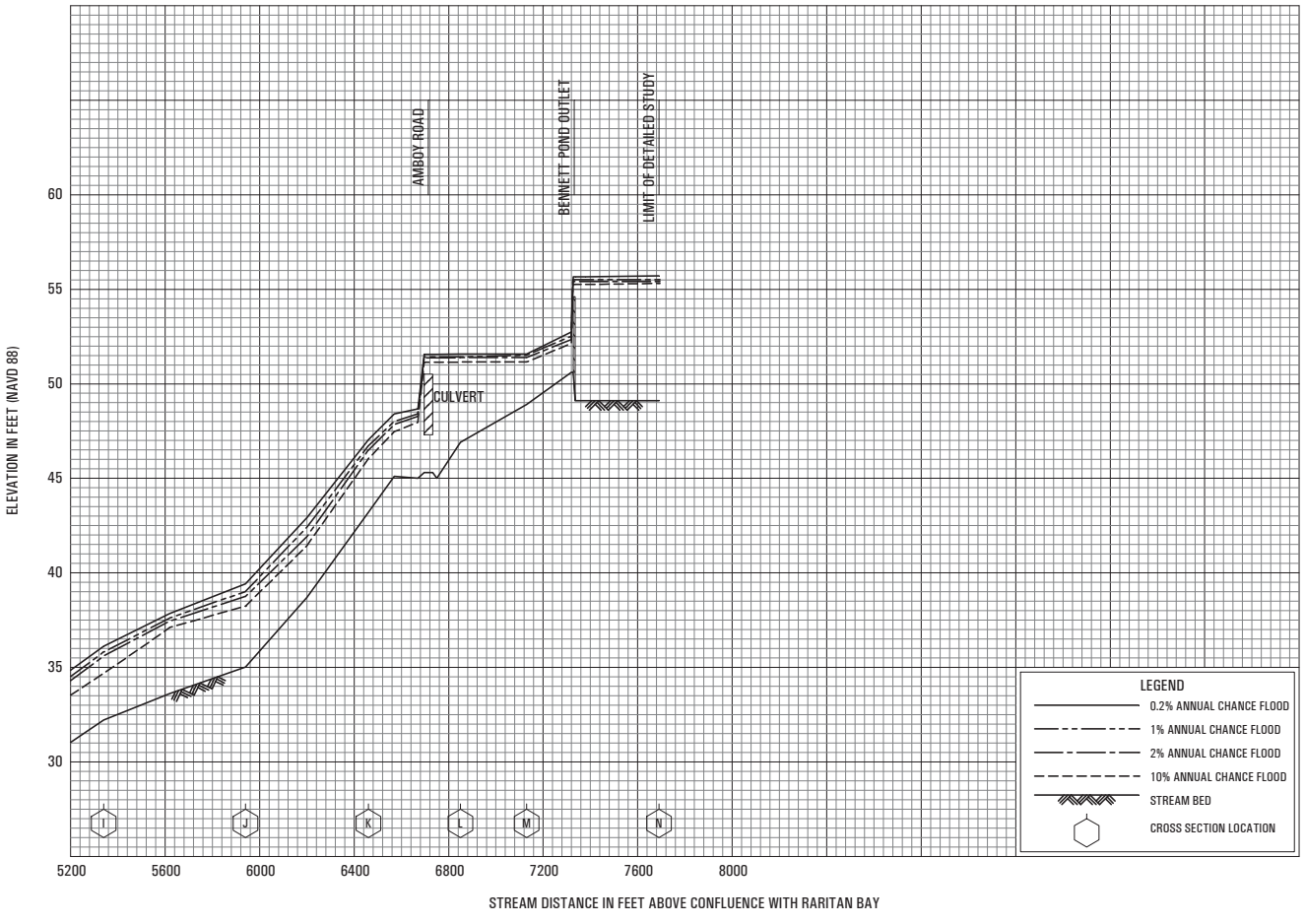
FLOOD PROFILES

ARBUTUS CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

01P



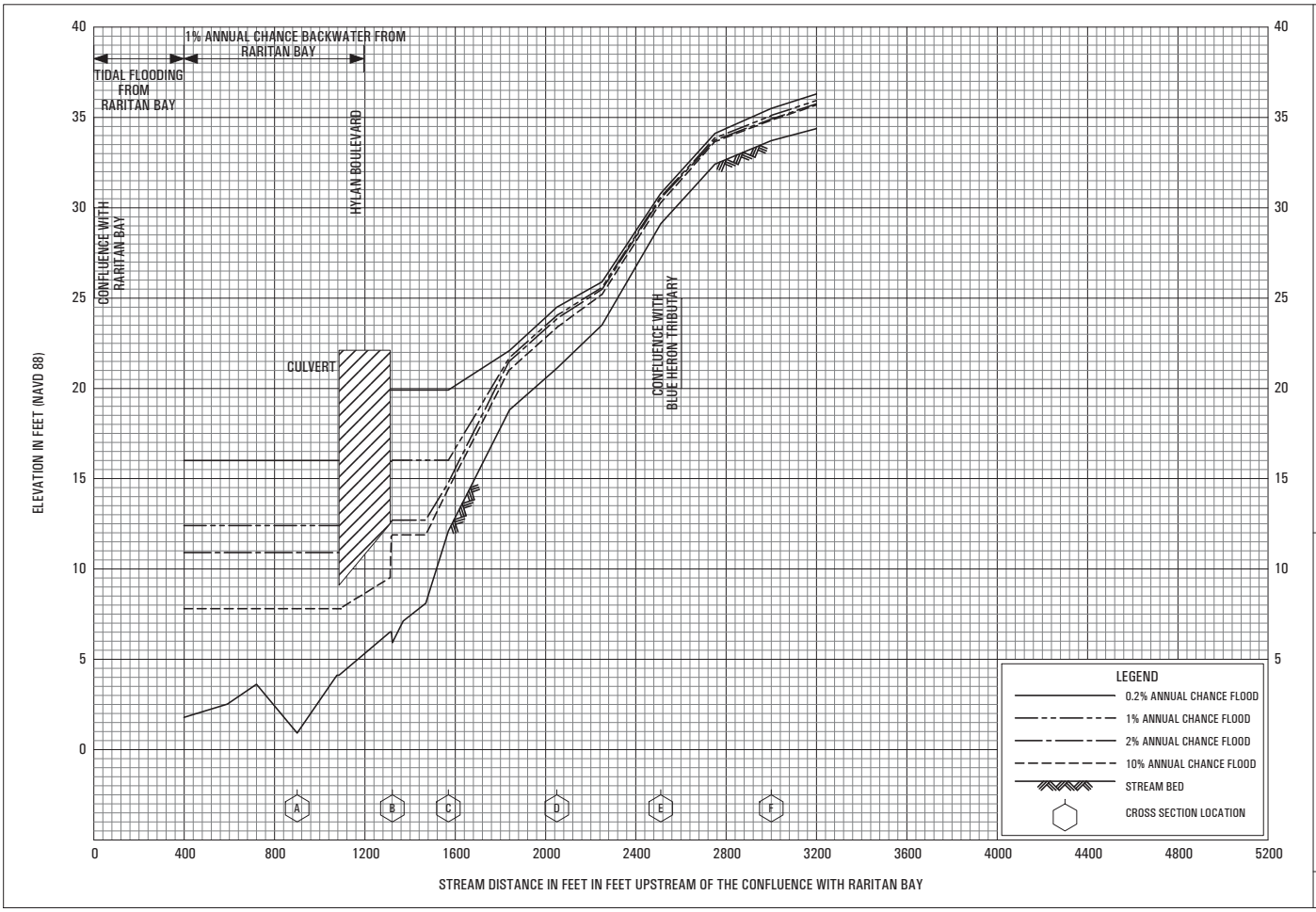
FLOOD PROFILES

ARBUTUS CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

02P



FLOOD PROFILES

BLUE HERON MAIN BRANCH

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

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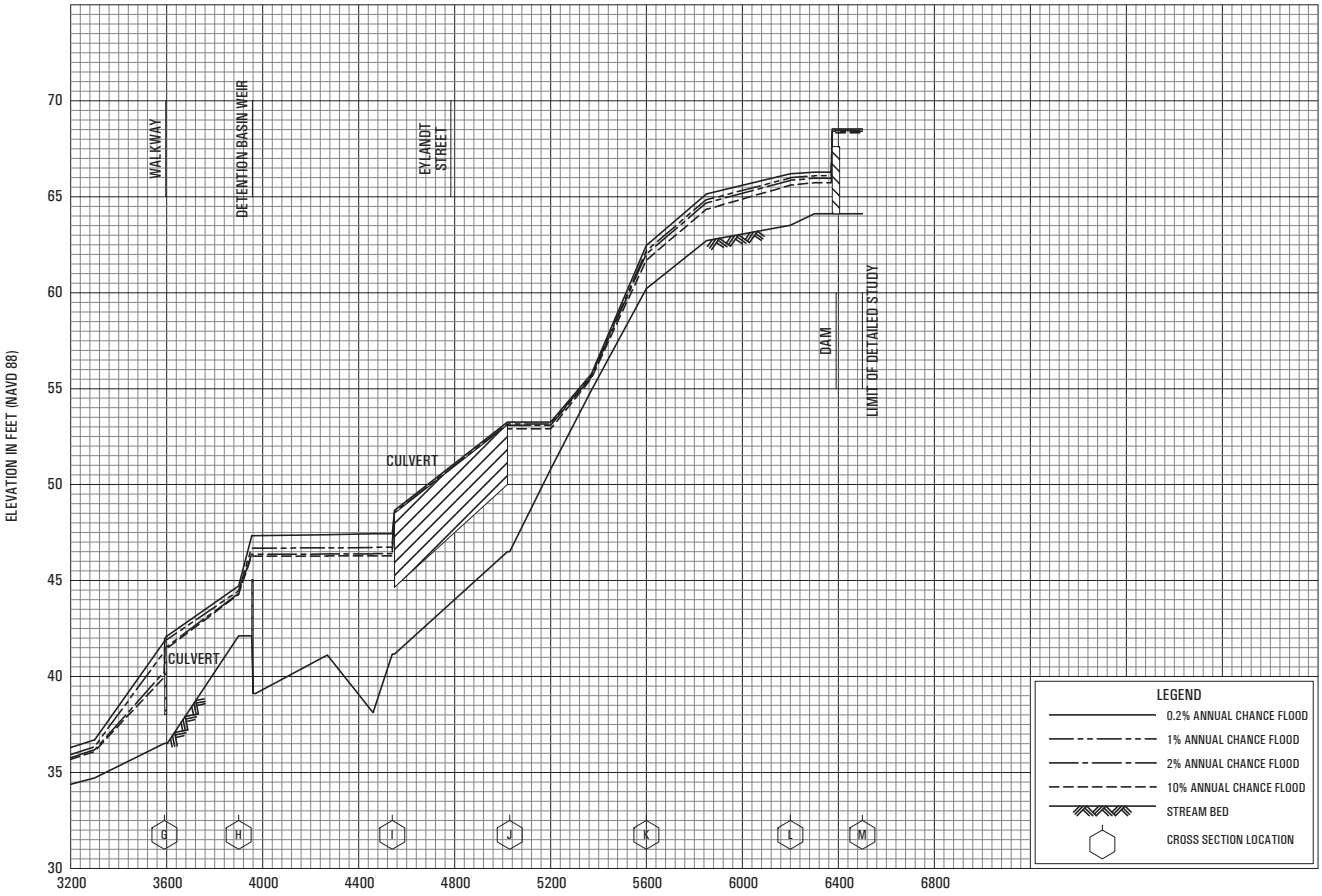


FLOOD PROFILES

BLUE HERON MAIN BRANCH

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

04P

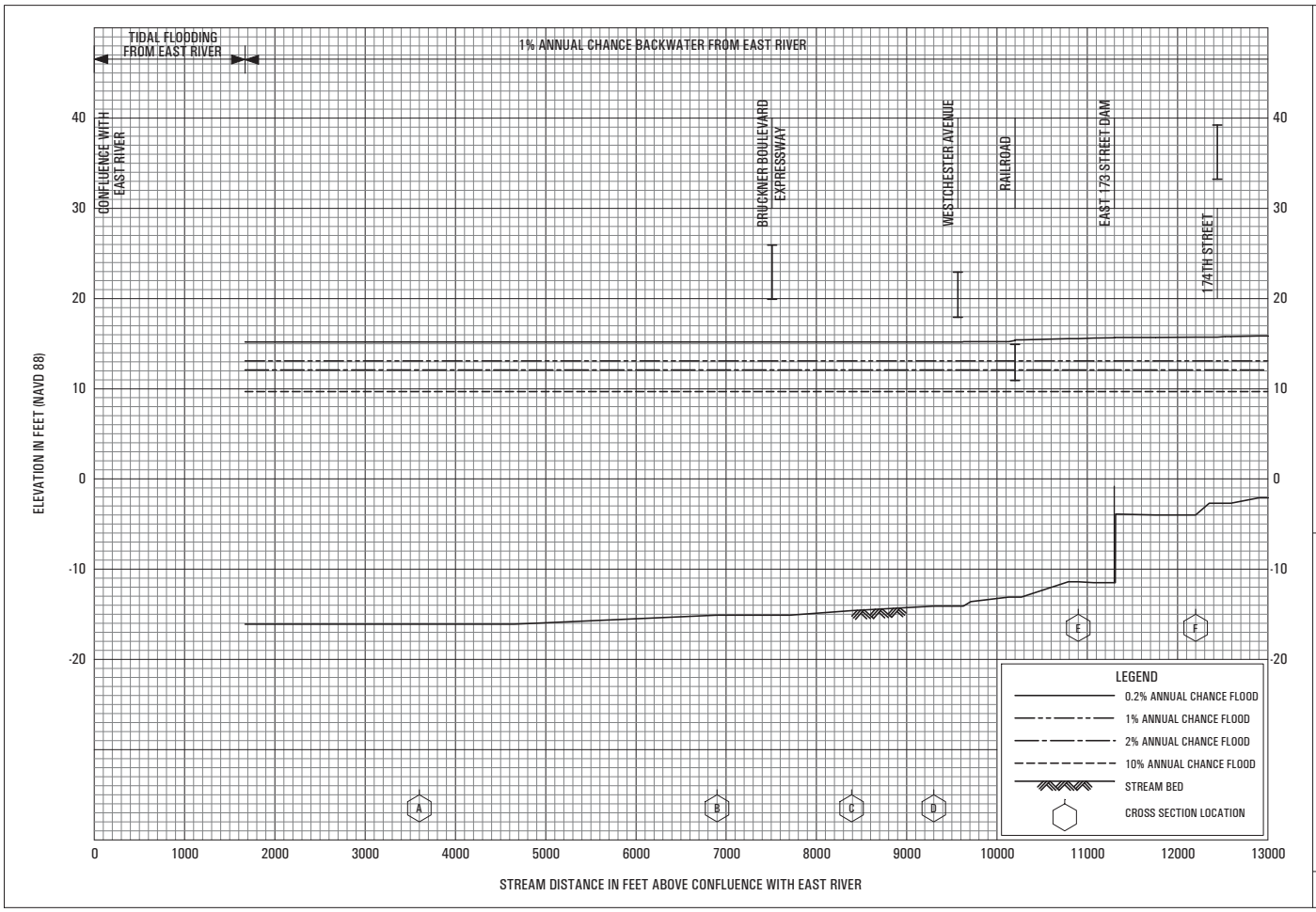
FLOOD PROFILES

BLUE HERON TRIBUTARY

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

05P



FLOOD PROFILES

BRONX RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

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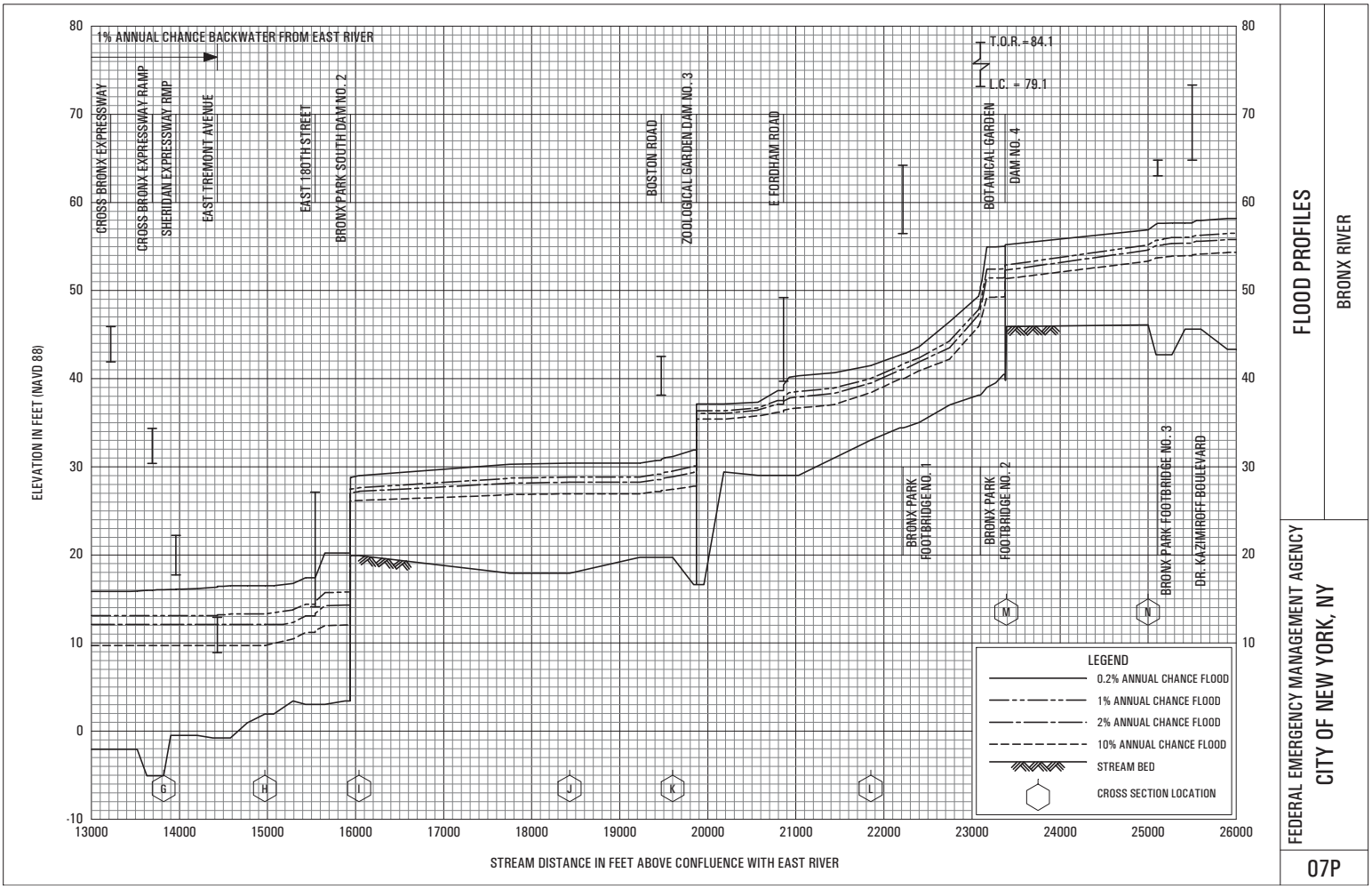


FLOOD PROFILES

BRONX RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

07P

FLOOD PROFILES

BRONX RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

08P

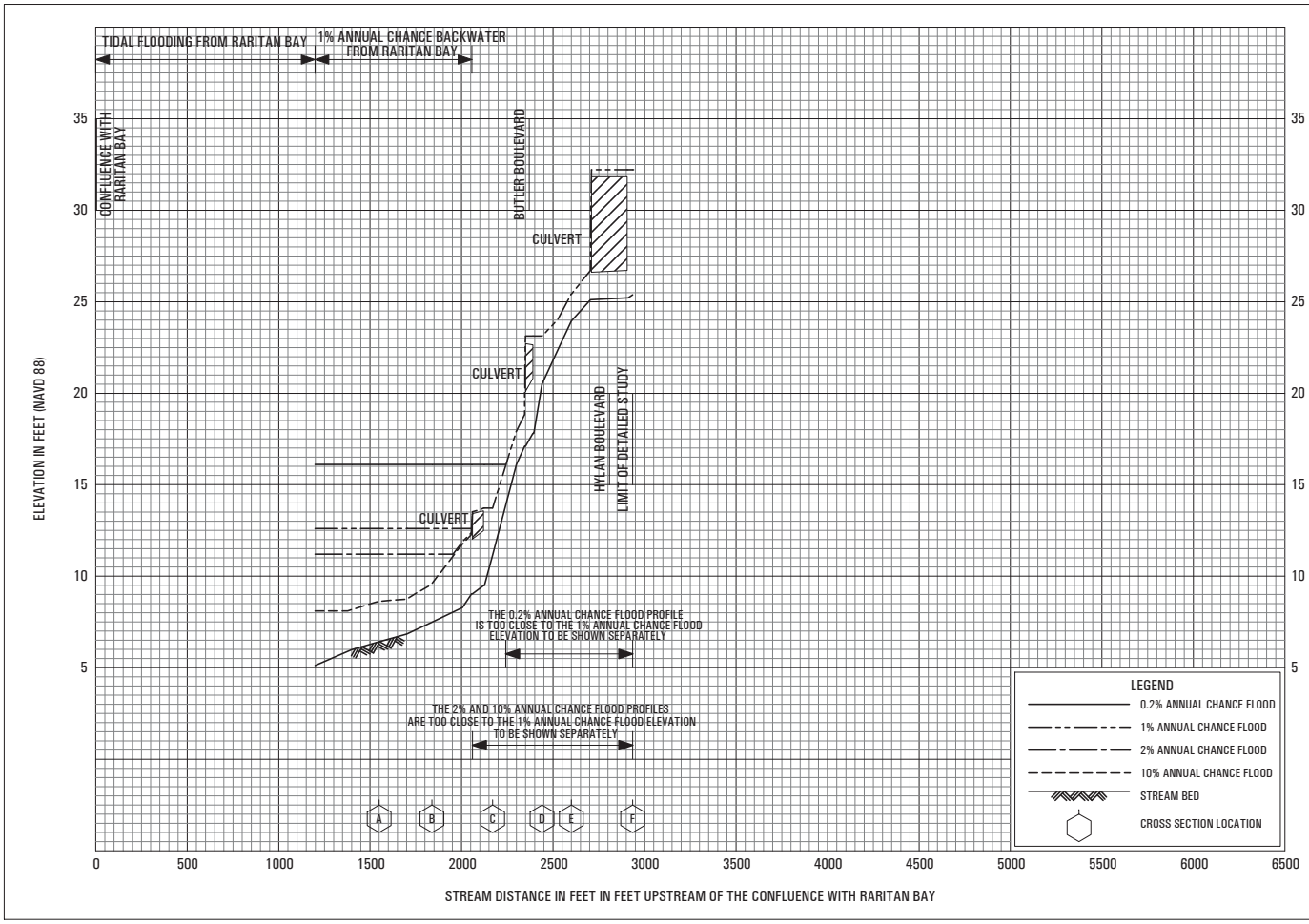
FLOOD PROFILES

BRONX RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

09P



FLOOD PROFILES

BUTLER MANOR

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

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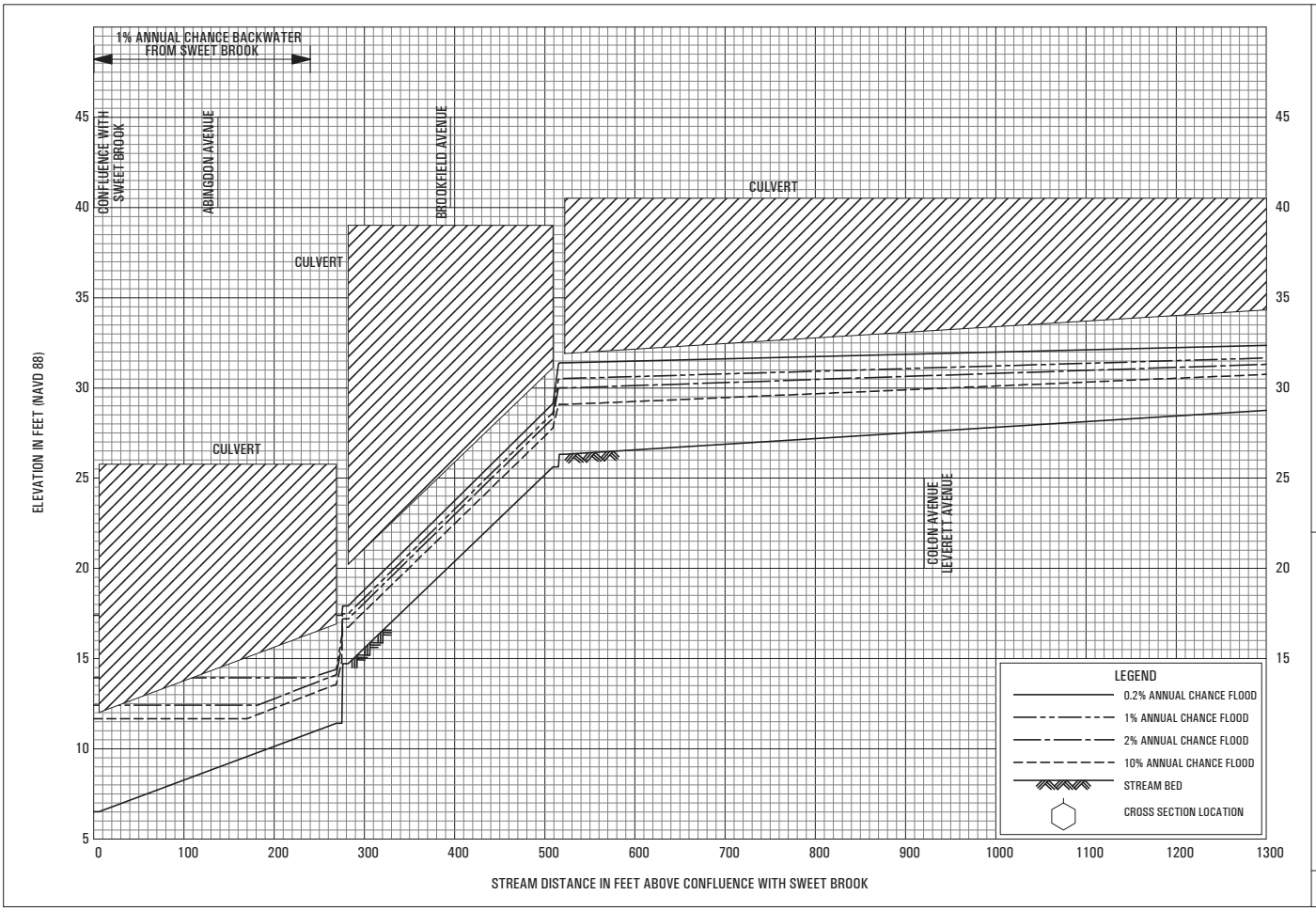


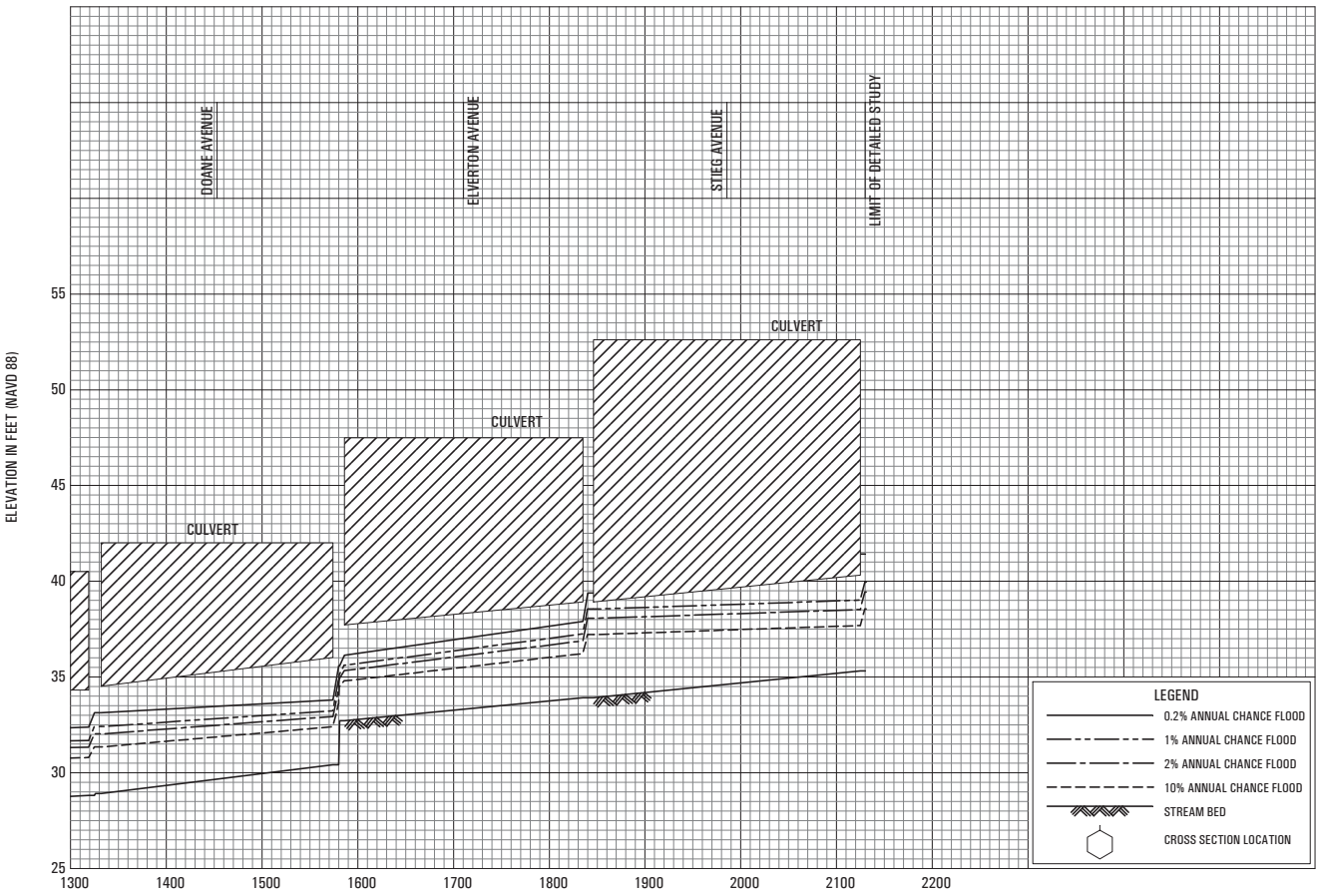
FLOOD PROFILES

COLON TRIBUTARY

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

11P



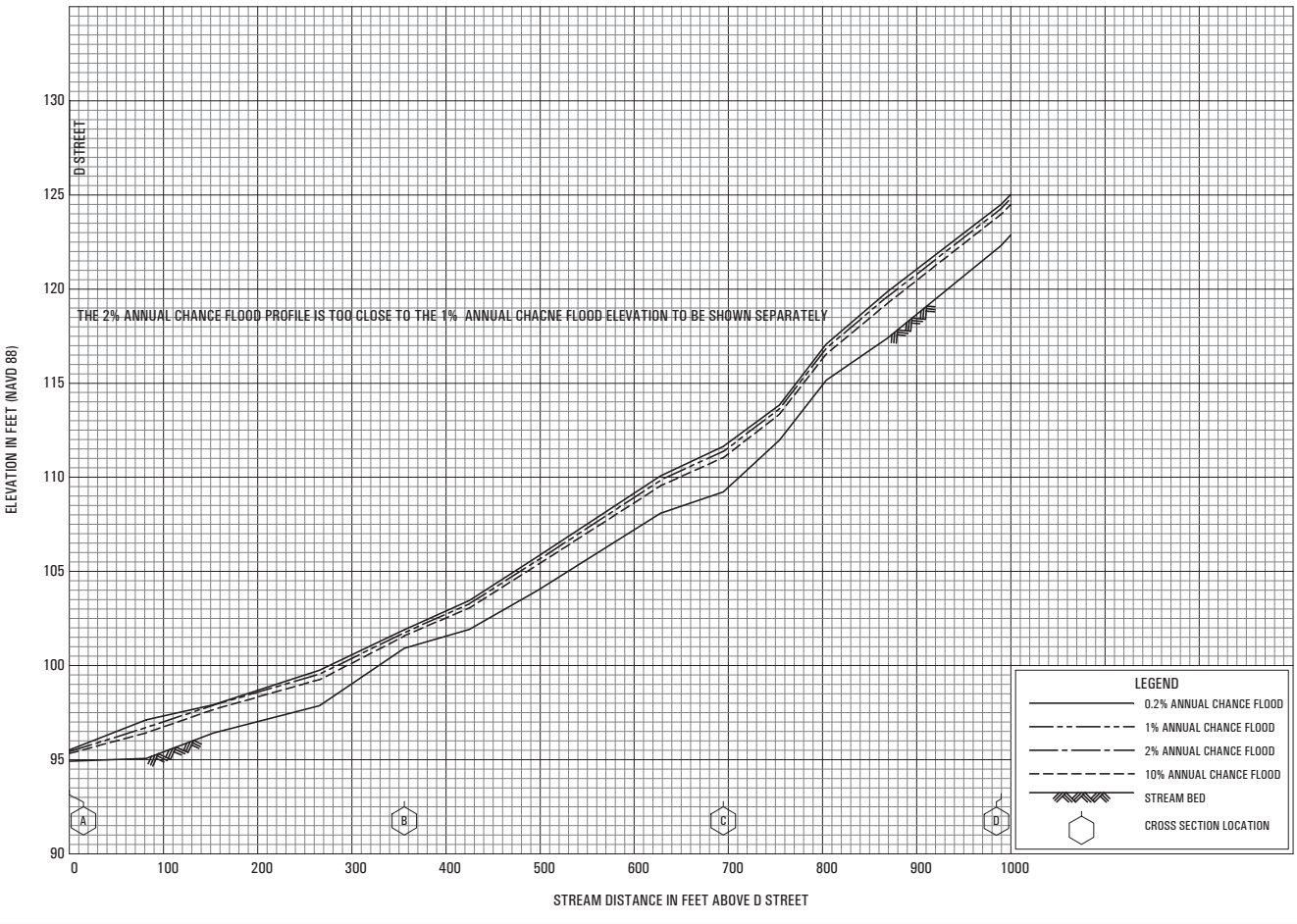
FLOOD PROFILES

COLON TRIBUTARY

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

12P



FLOOD PROFILES

D STREET BROOK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

13P

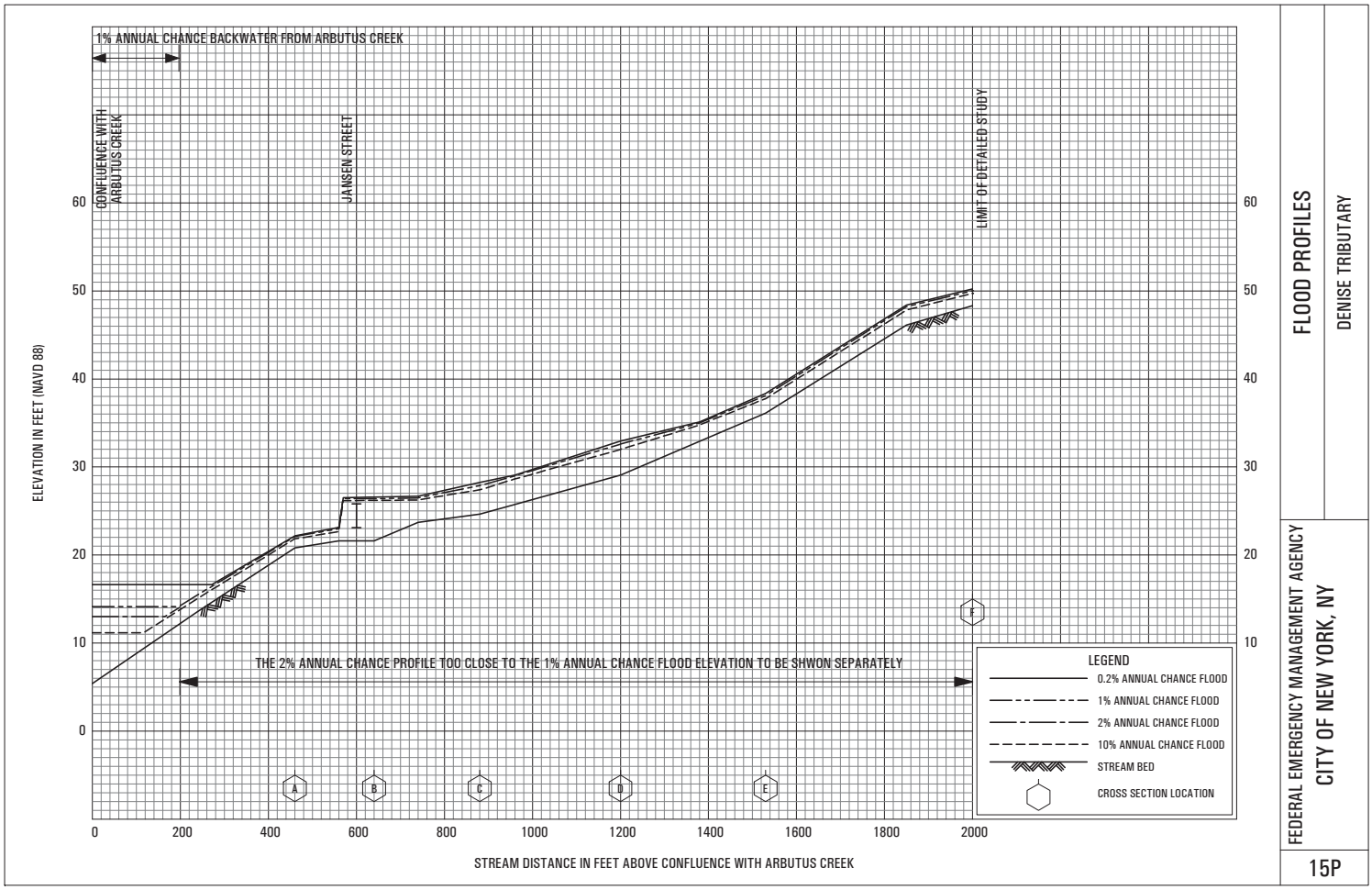
FLOOD PROFILES

D STREET BROOK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

14P



FLOOD PROFILES

DENISE TRIBUTARY

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

FLOOD PROFILES

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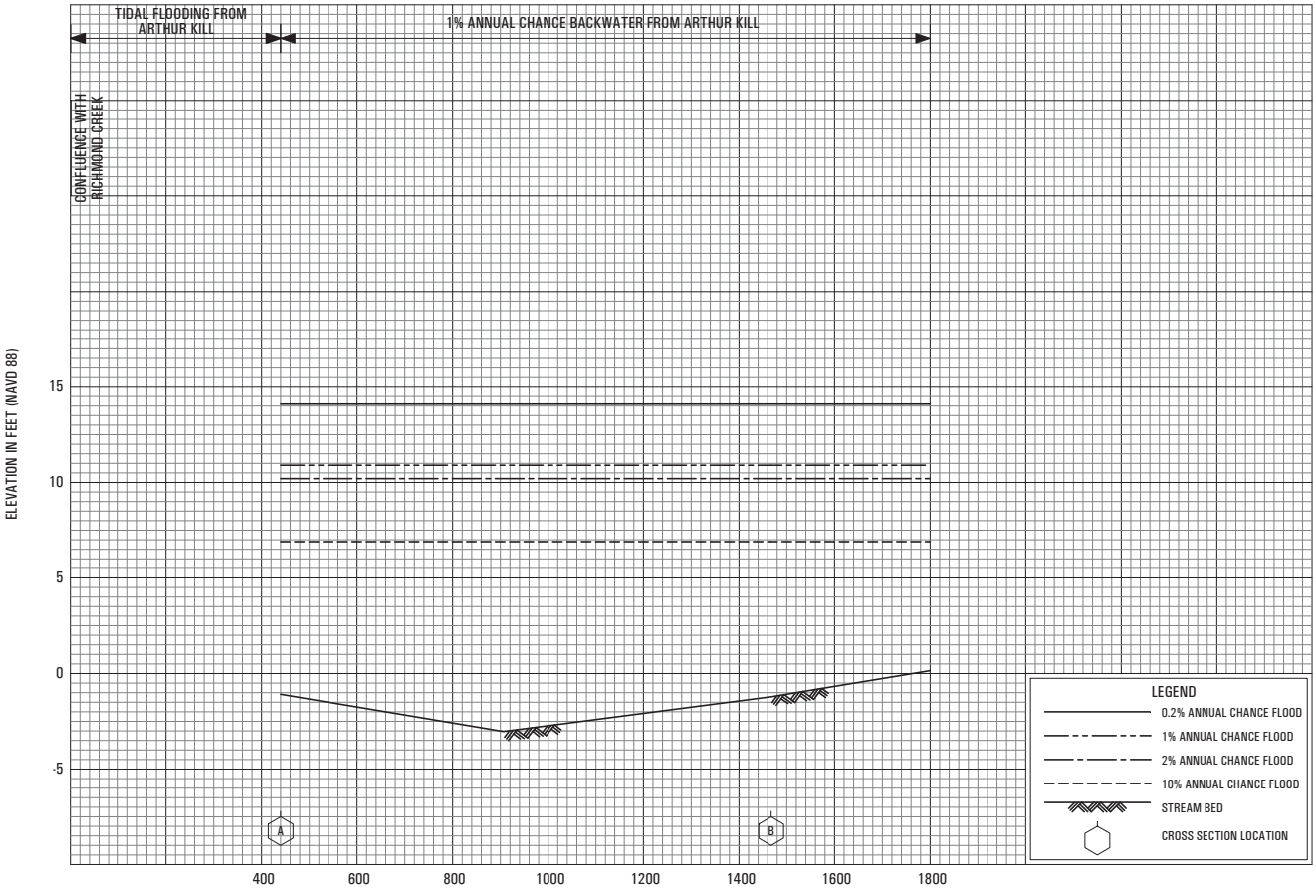
FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

16P

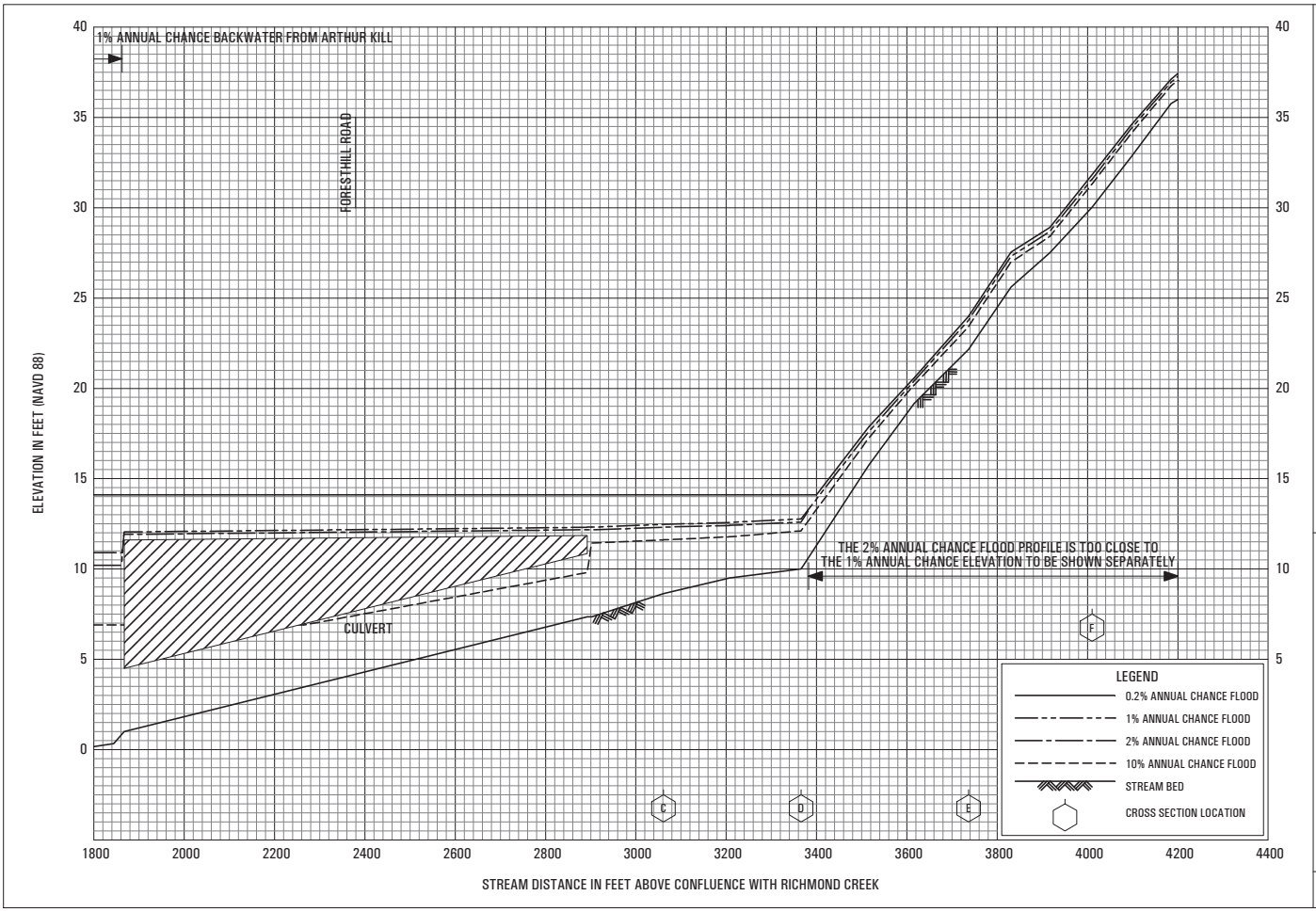


FLOOD PROFILES

FOREST HILL ROAD BROOK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY



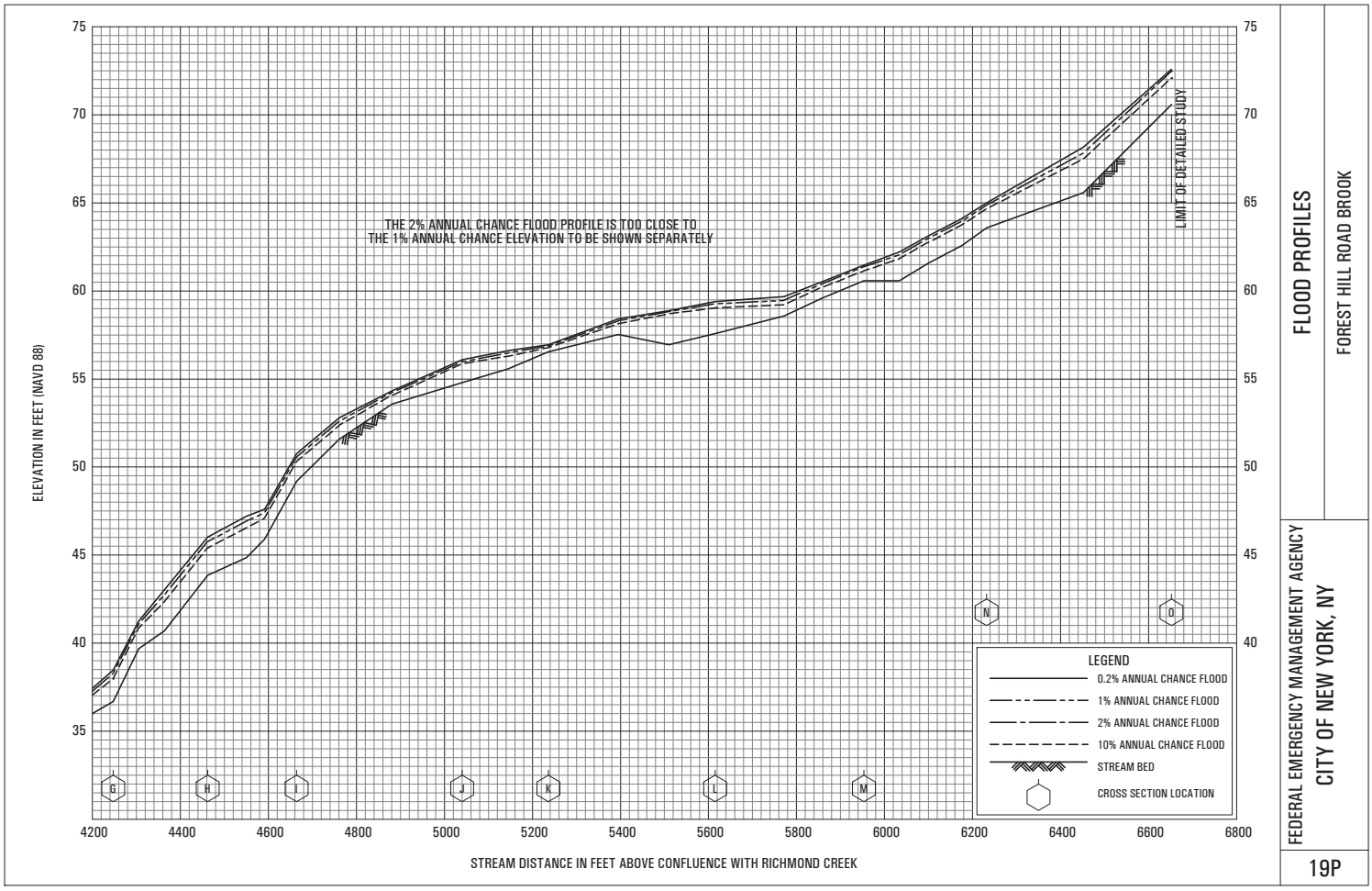
FLOOD PROFILES

FOREST HILL ROAD BROOK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

18P

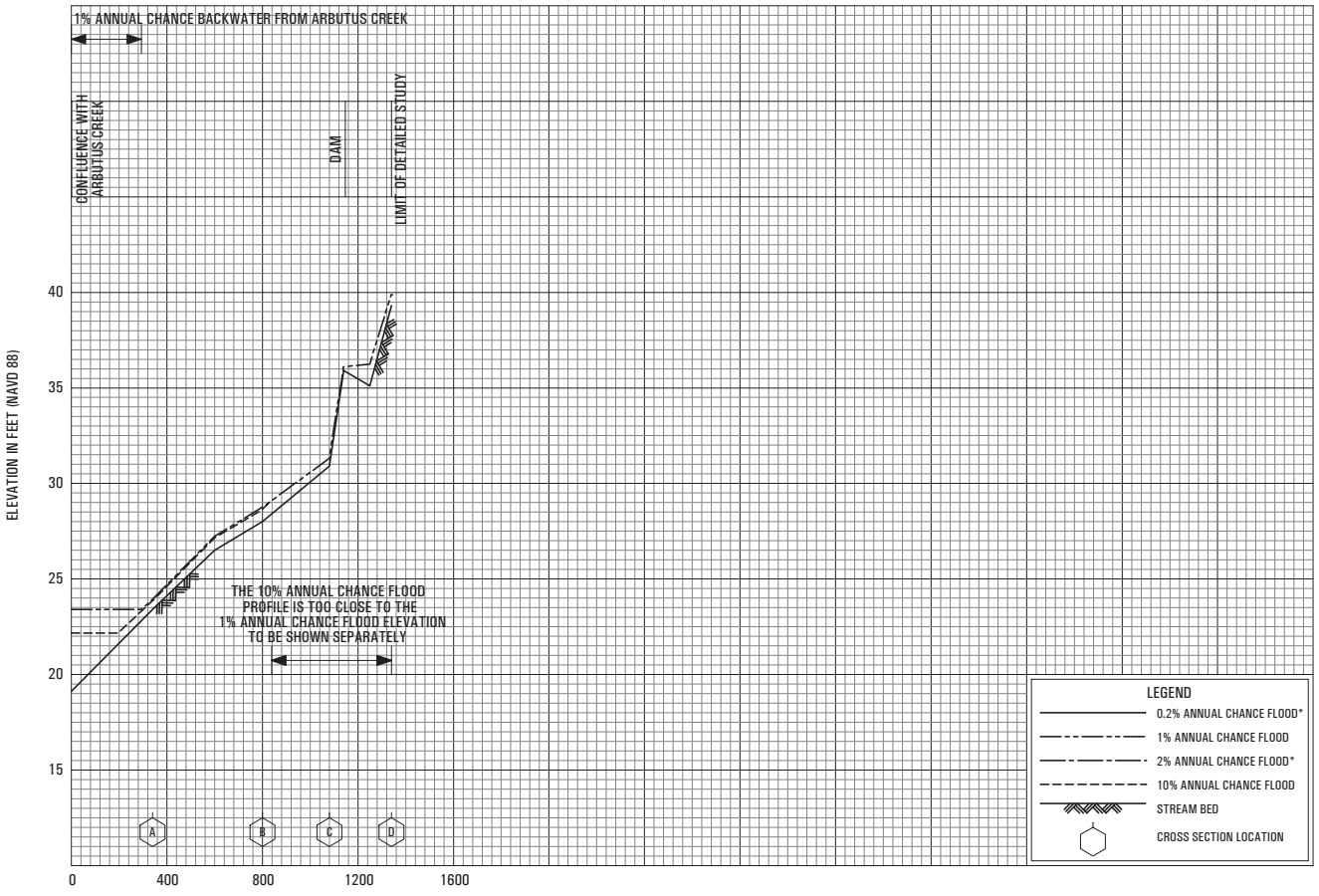


FLOOD PROFILES

FOREST HILL ROAD BROOK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY



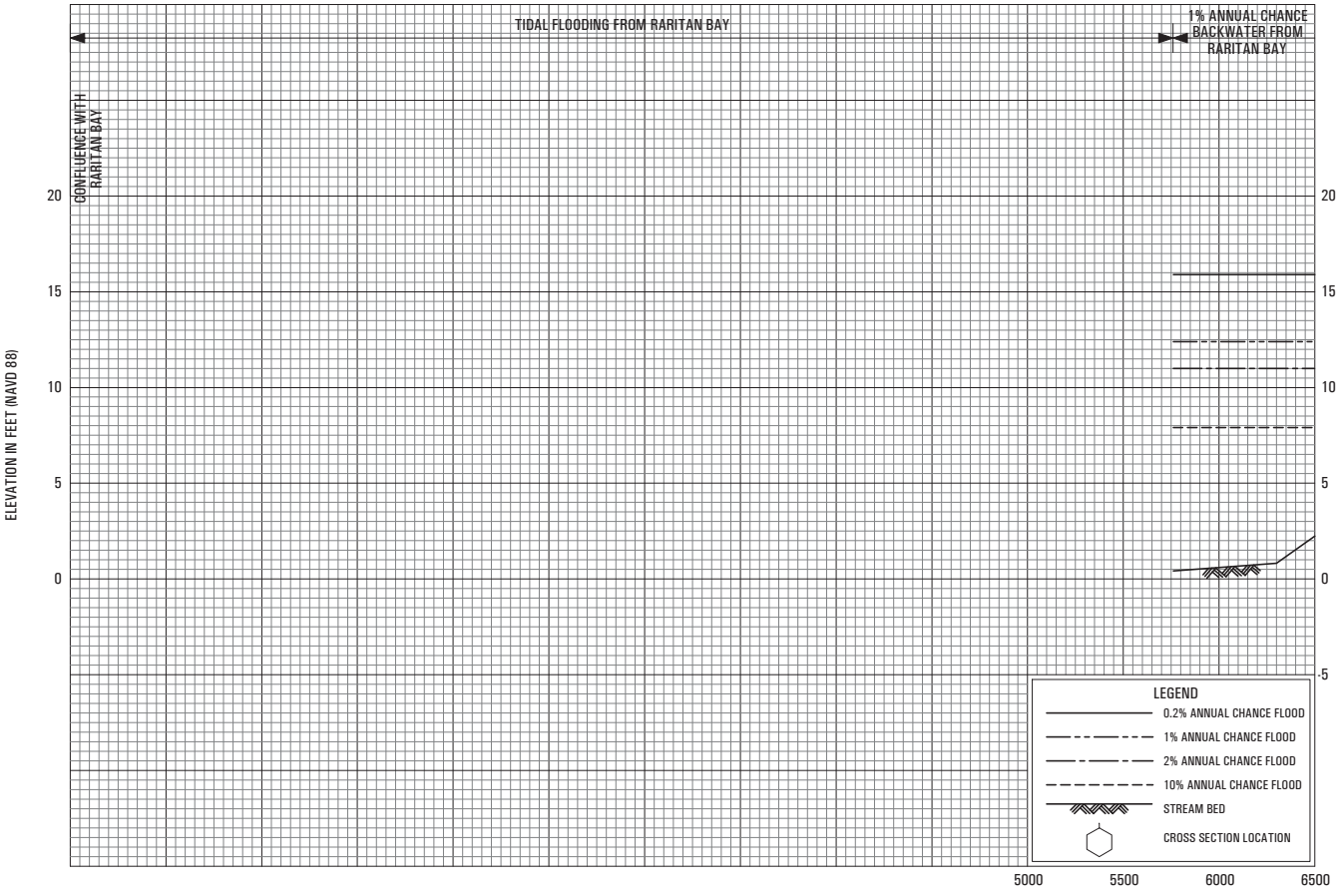
FLOOD PROFILES

JANSEN TRIBUTARY

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

20P

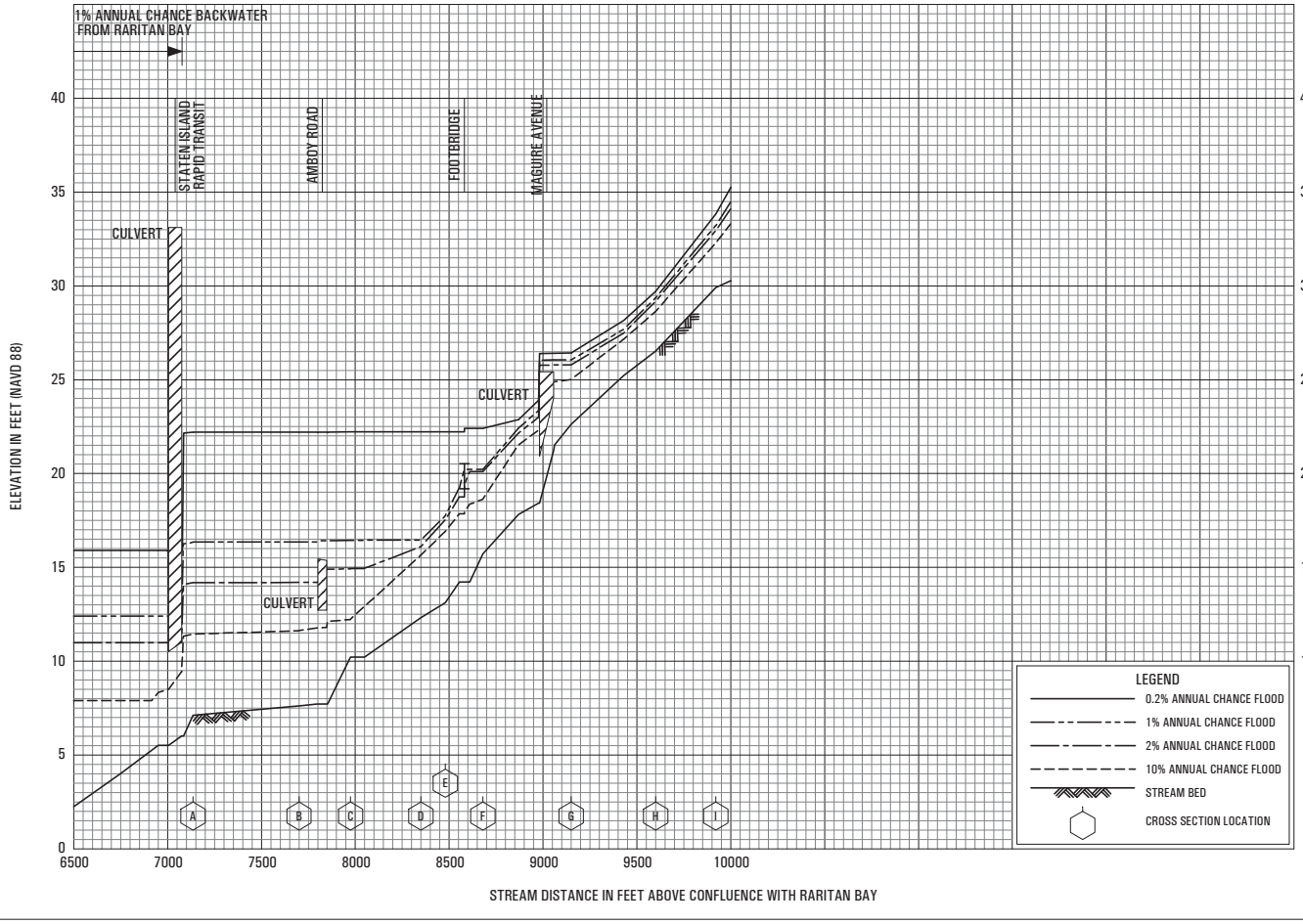


FLOOD PROFILES

LEMON CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY



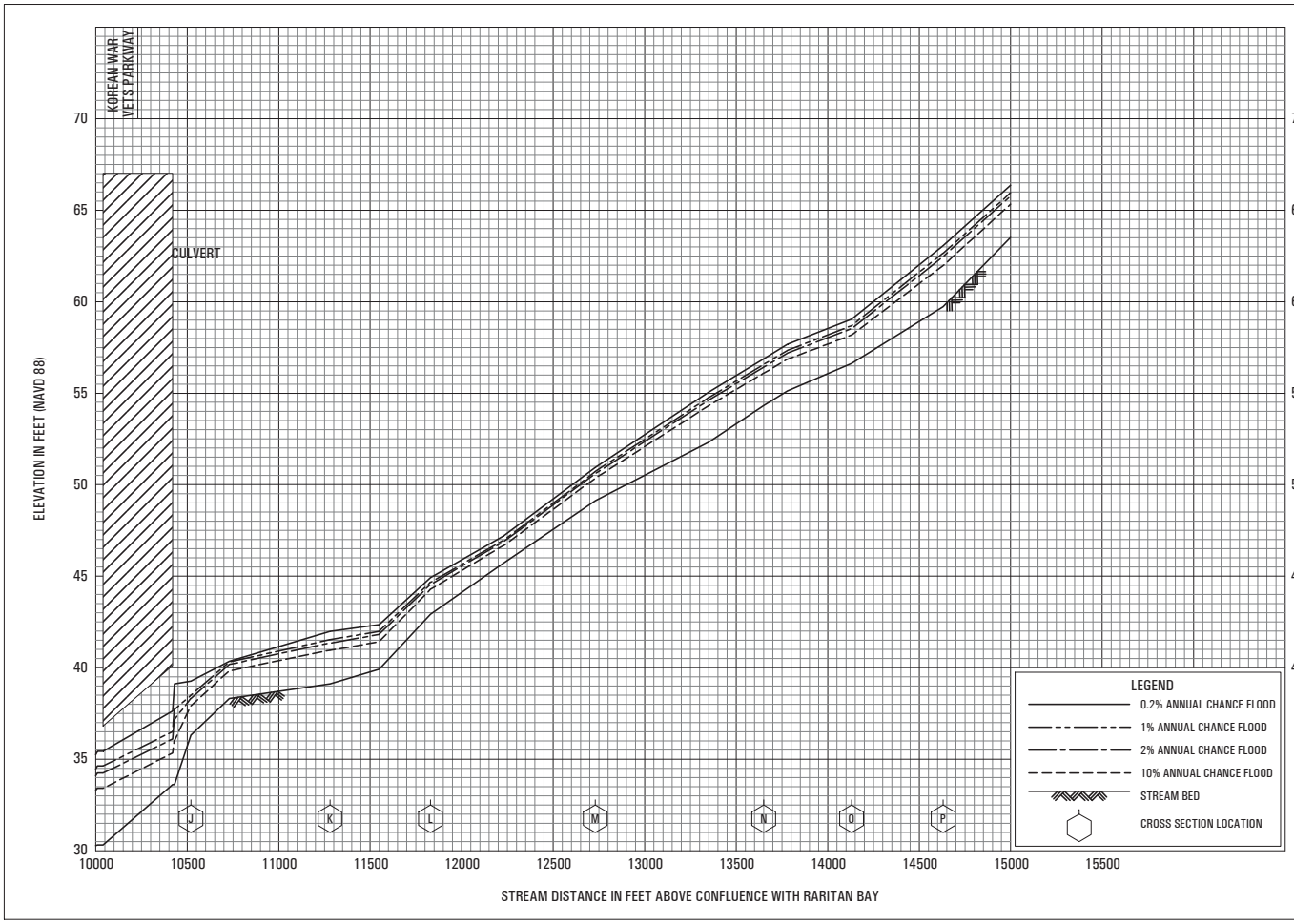
FLOOD PROFILES

LEMON CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

22P



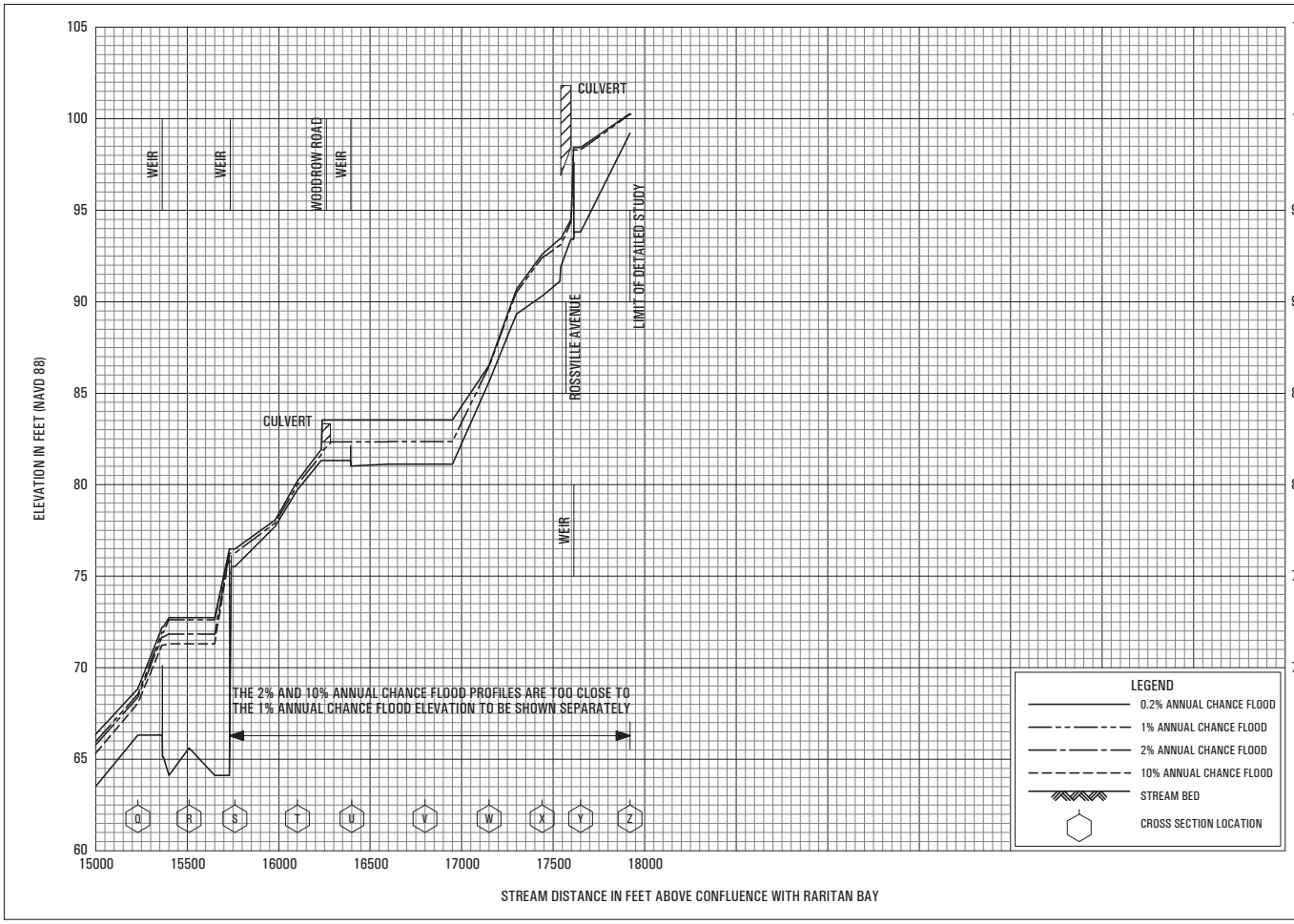
FLOOD PROFILES

LEMON CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

23P



FLOOD PROFILES

LEMON CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

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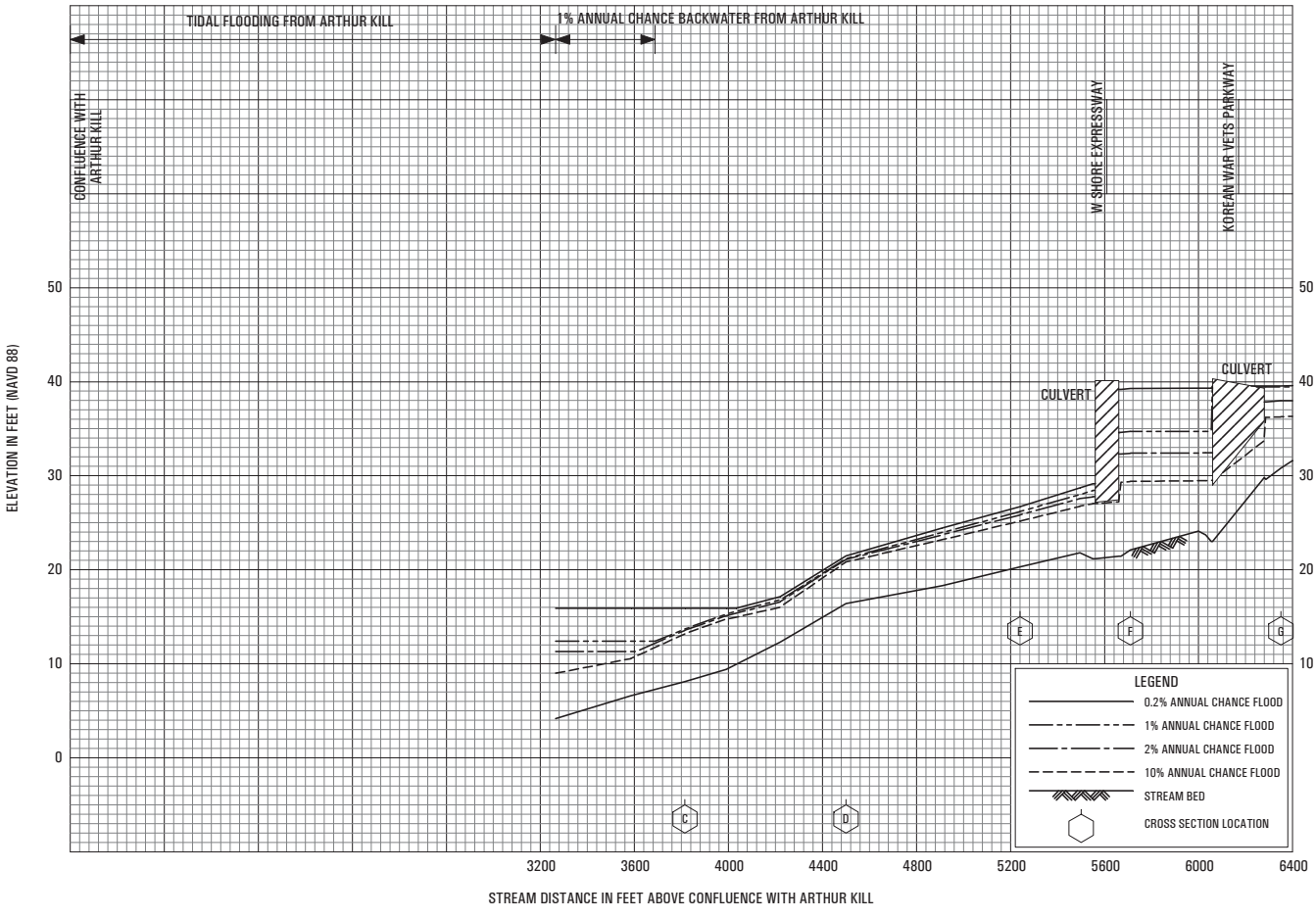


FLOOD PROFILES

MILL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

25P

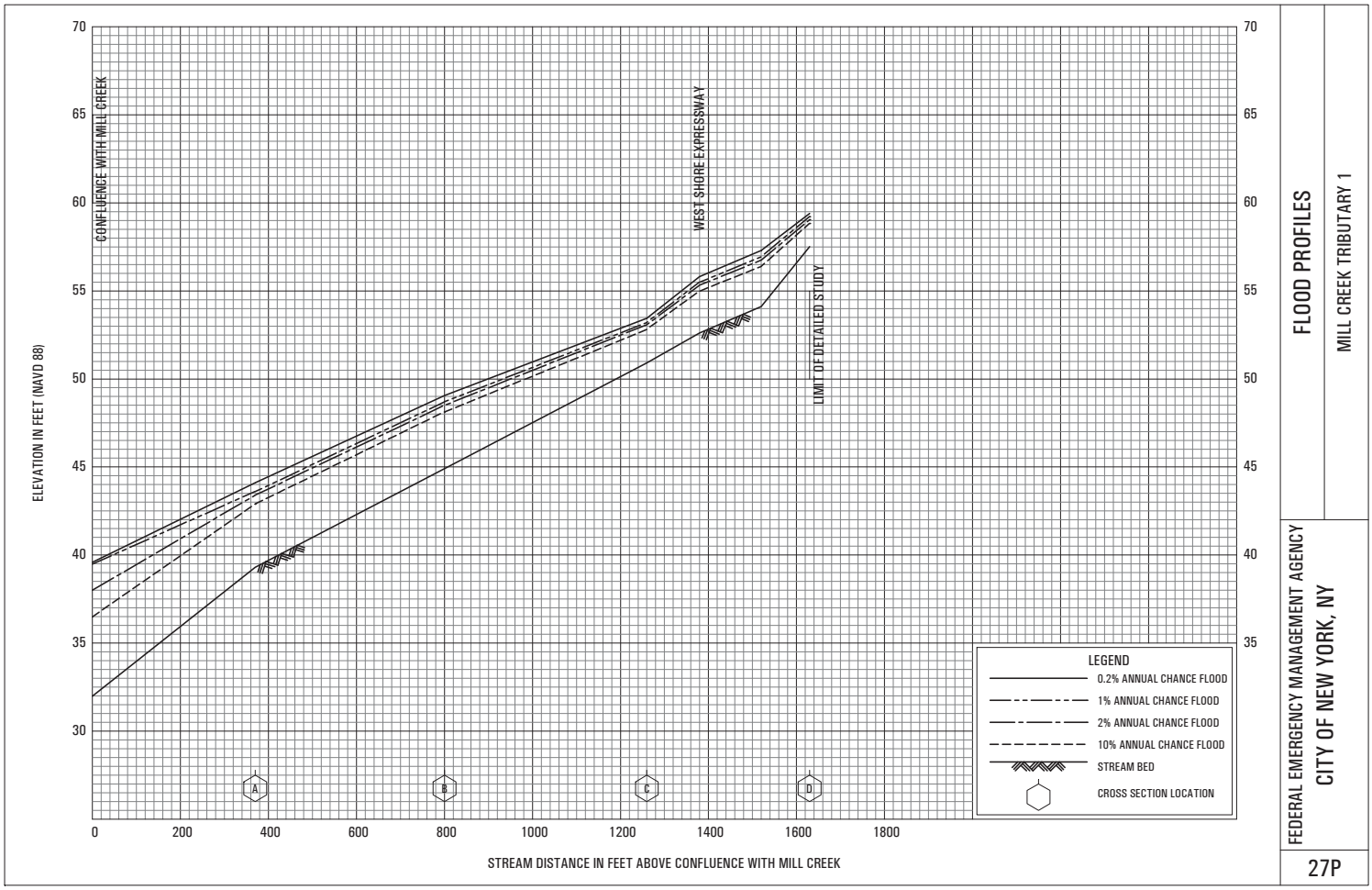
FLOOD PROFILES

MILL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

26P



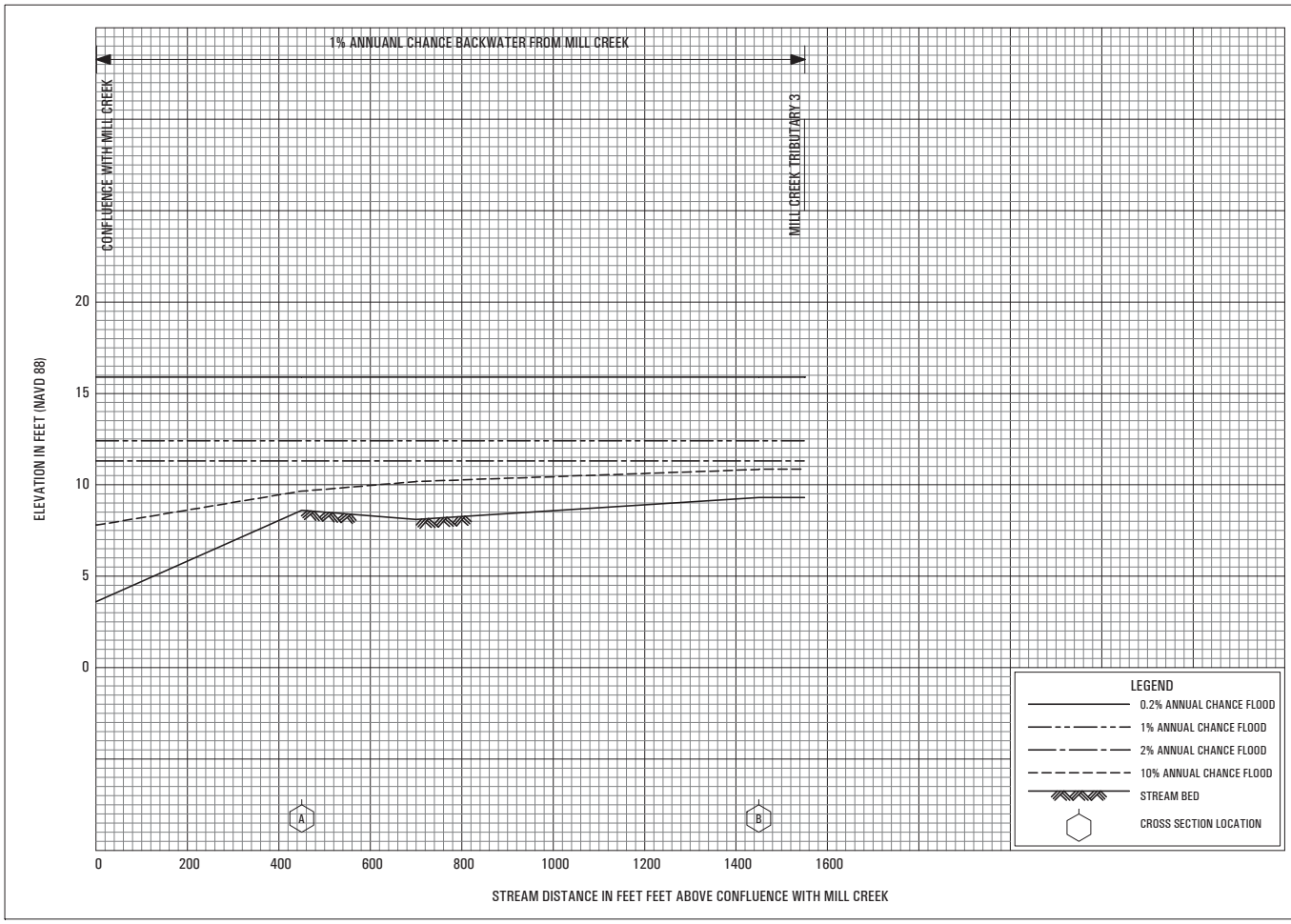
FLOOD PROFILES

MILL CREEK TRIBUTARY 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

27P



FLOOD PROFILES

MILL CREEK TRIBUTARY 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

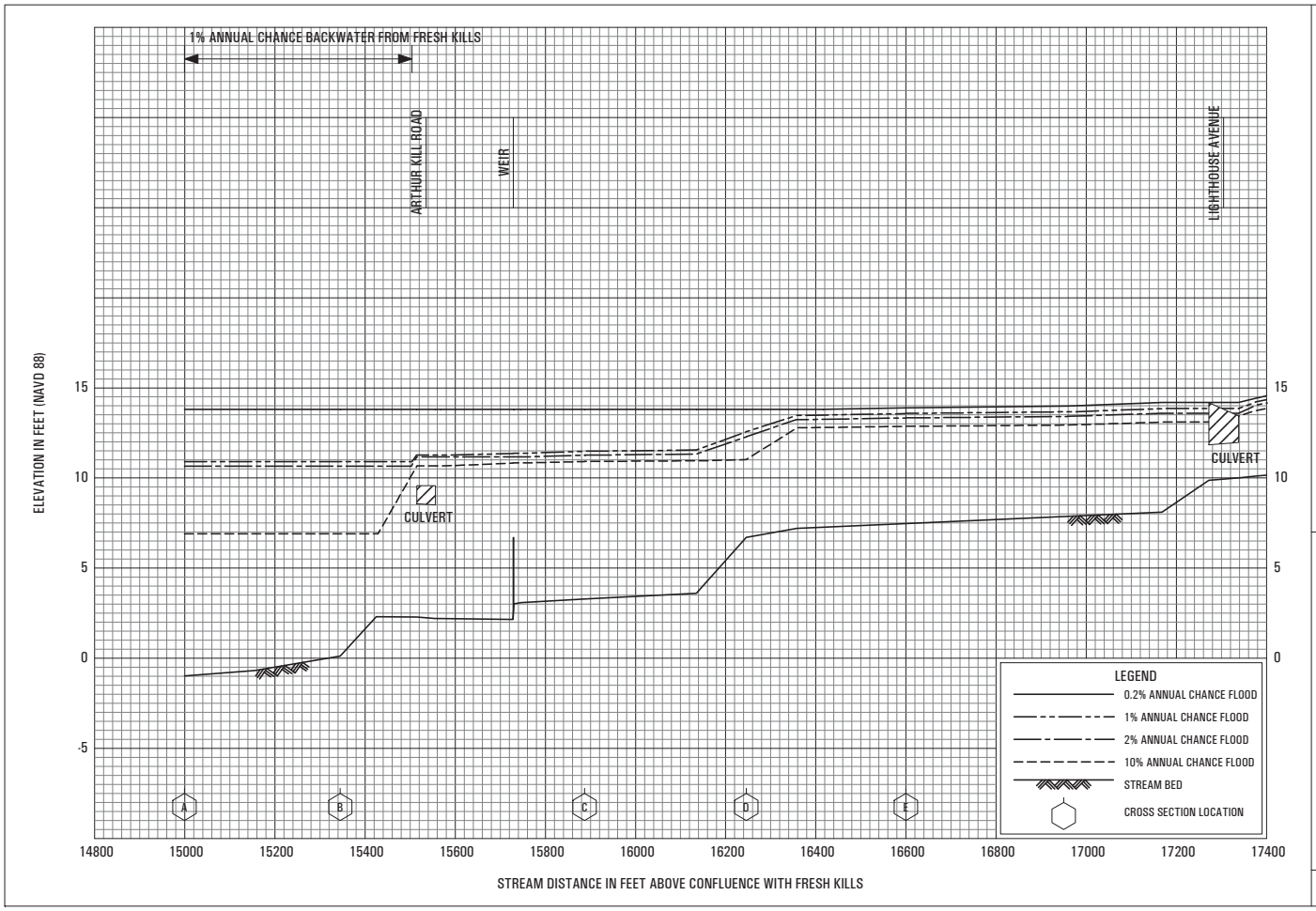
CITY OF NEW YORK, NY

FLOOD PROFILES

MILL CREEK TRIBUTARY 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

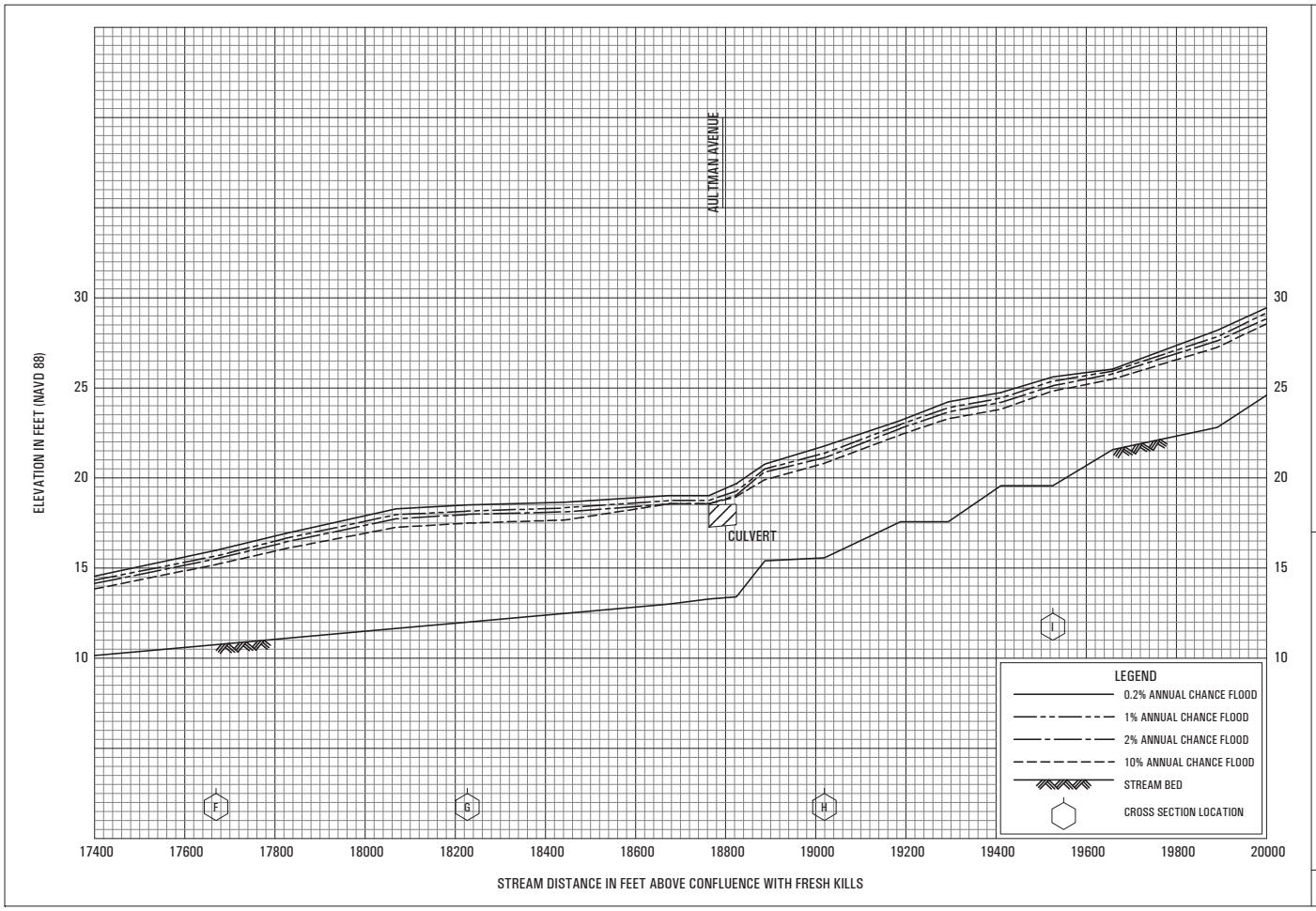


FLOOD PROFILES

RICHMOND CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

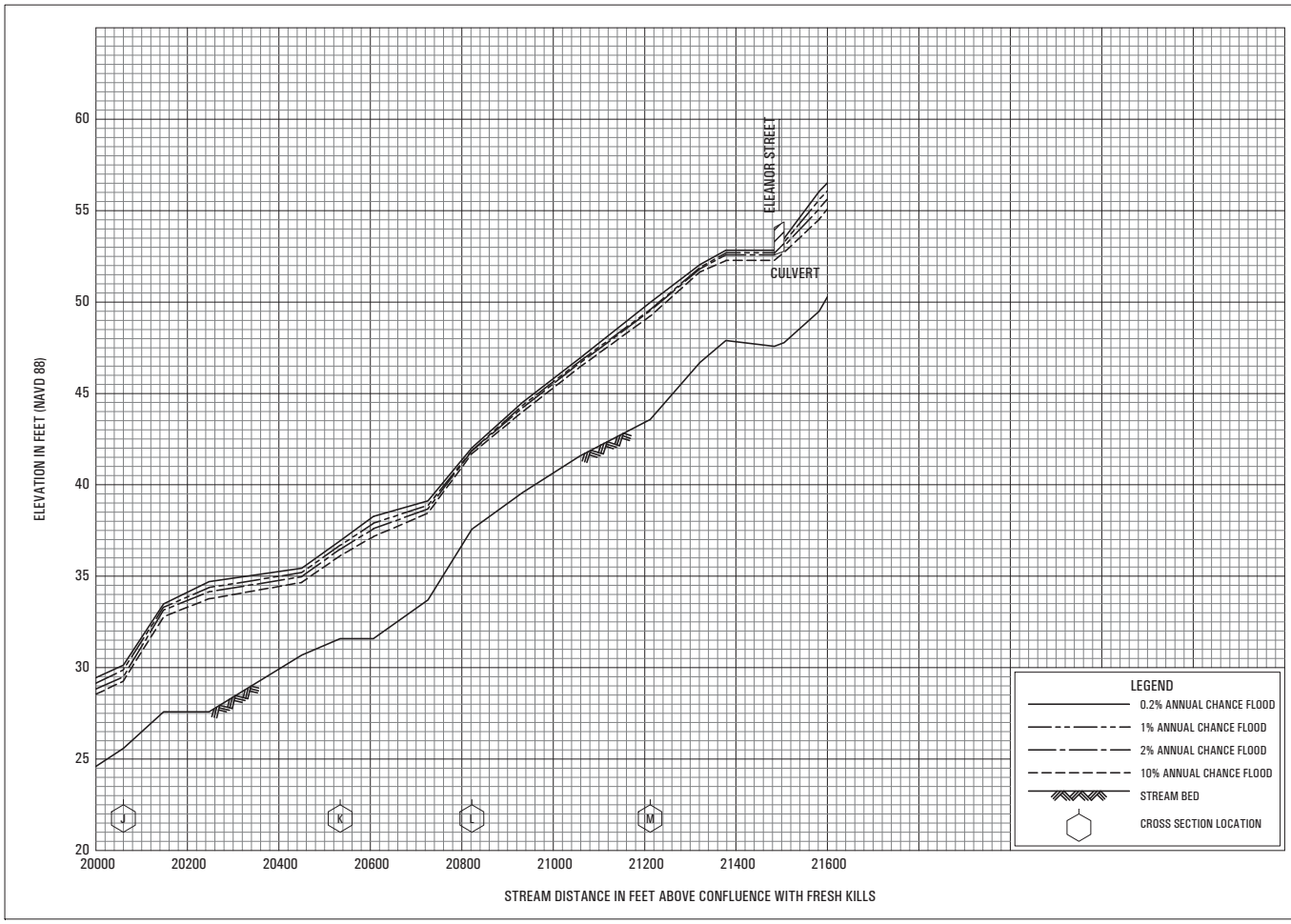


FLOOD PROFILES

RICHMOND CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

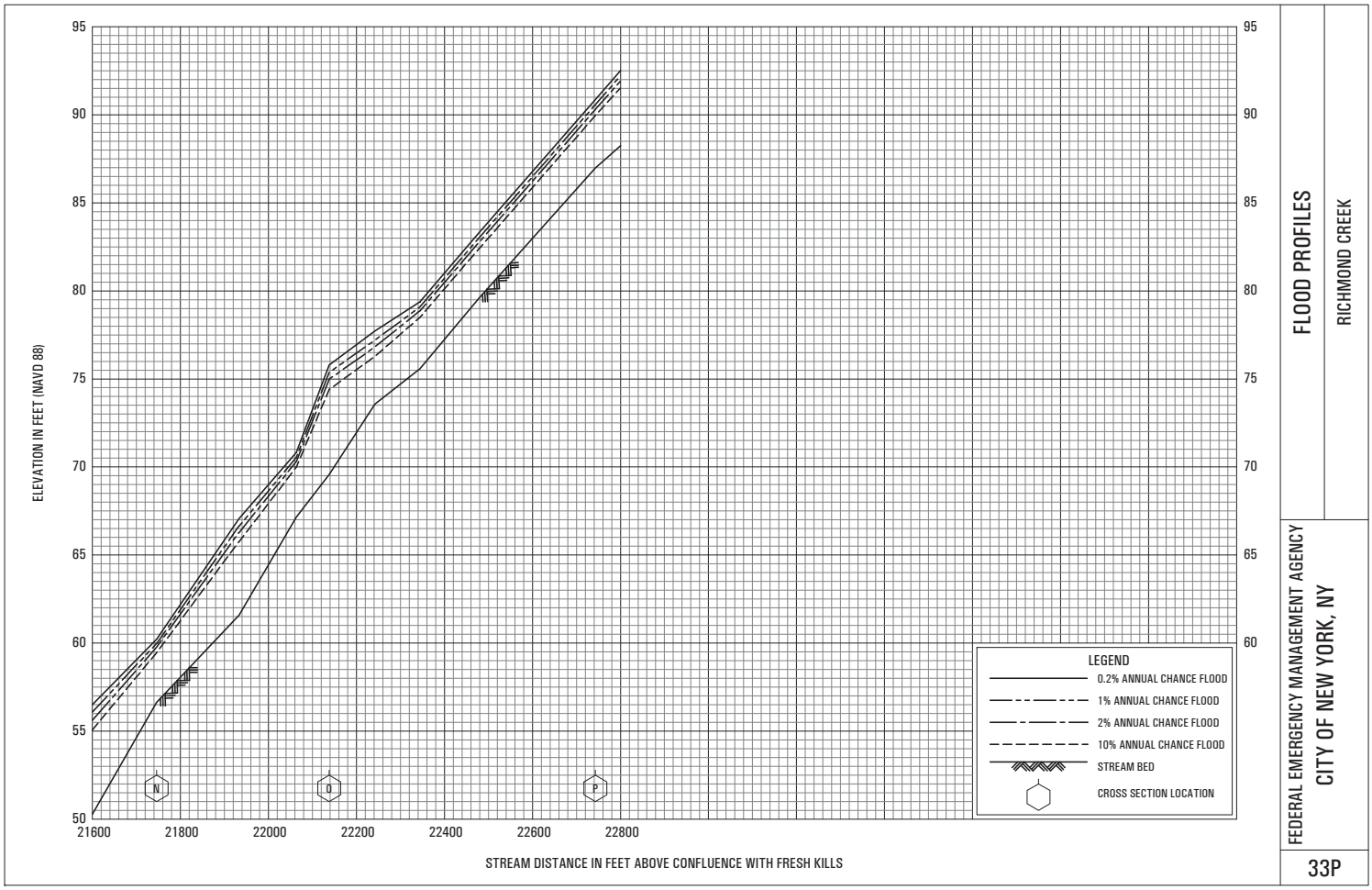


FLOOD PROFILES

RICHMOND CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY



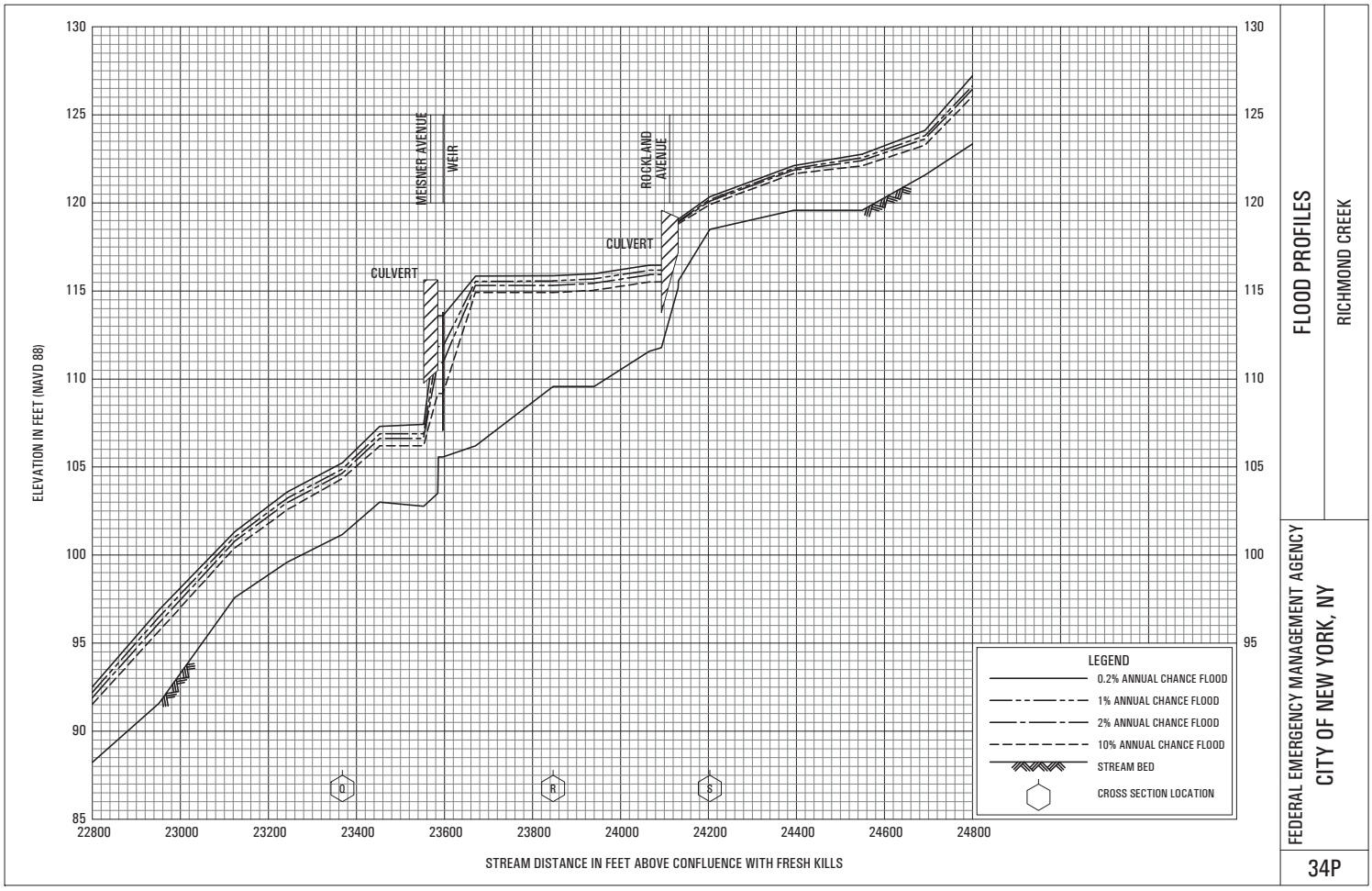
FLOOD PROFILES

RICHMOND CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

33P

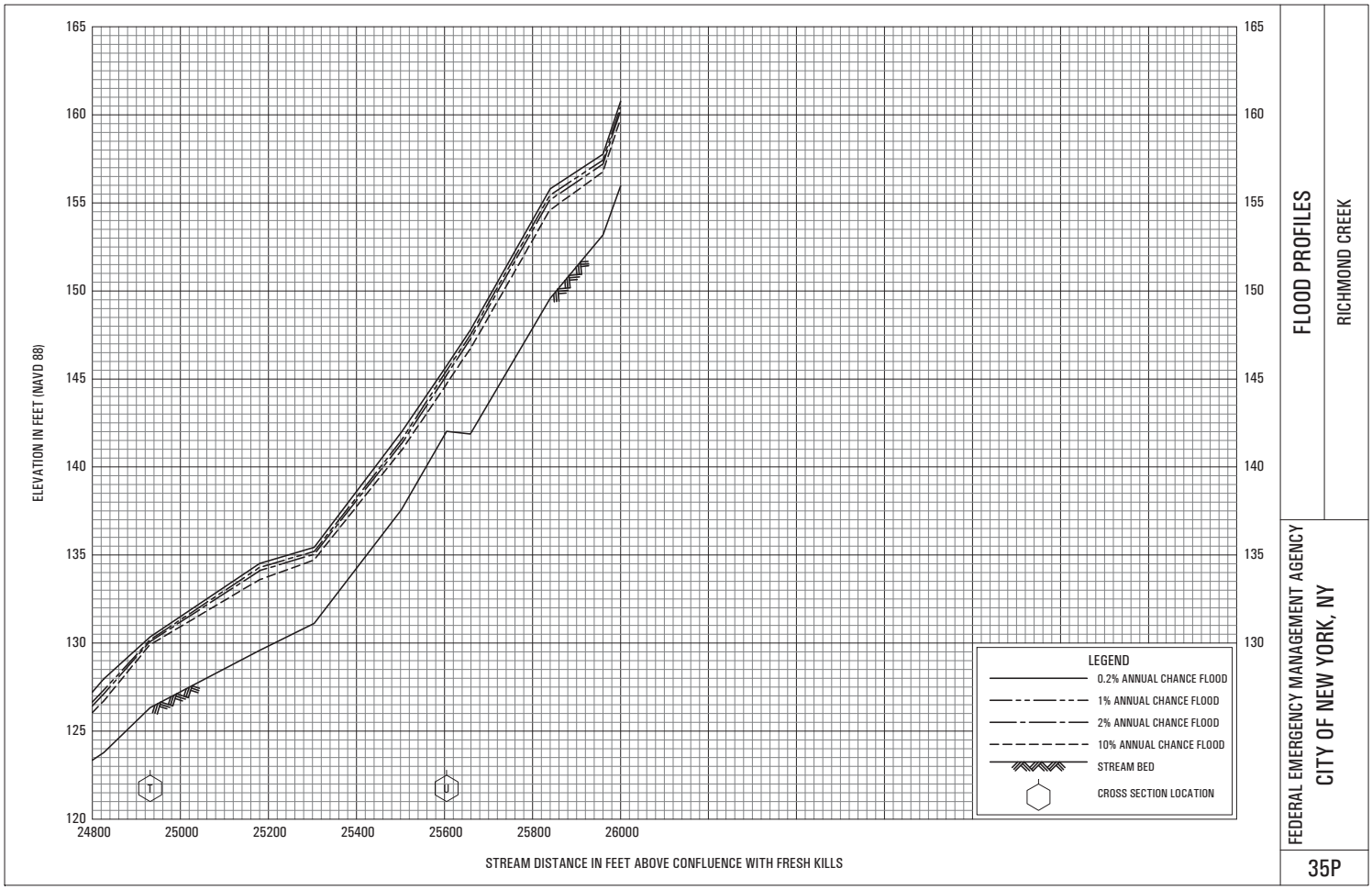


FLOOD PROFILES

RICHMOND CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY



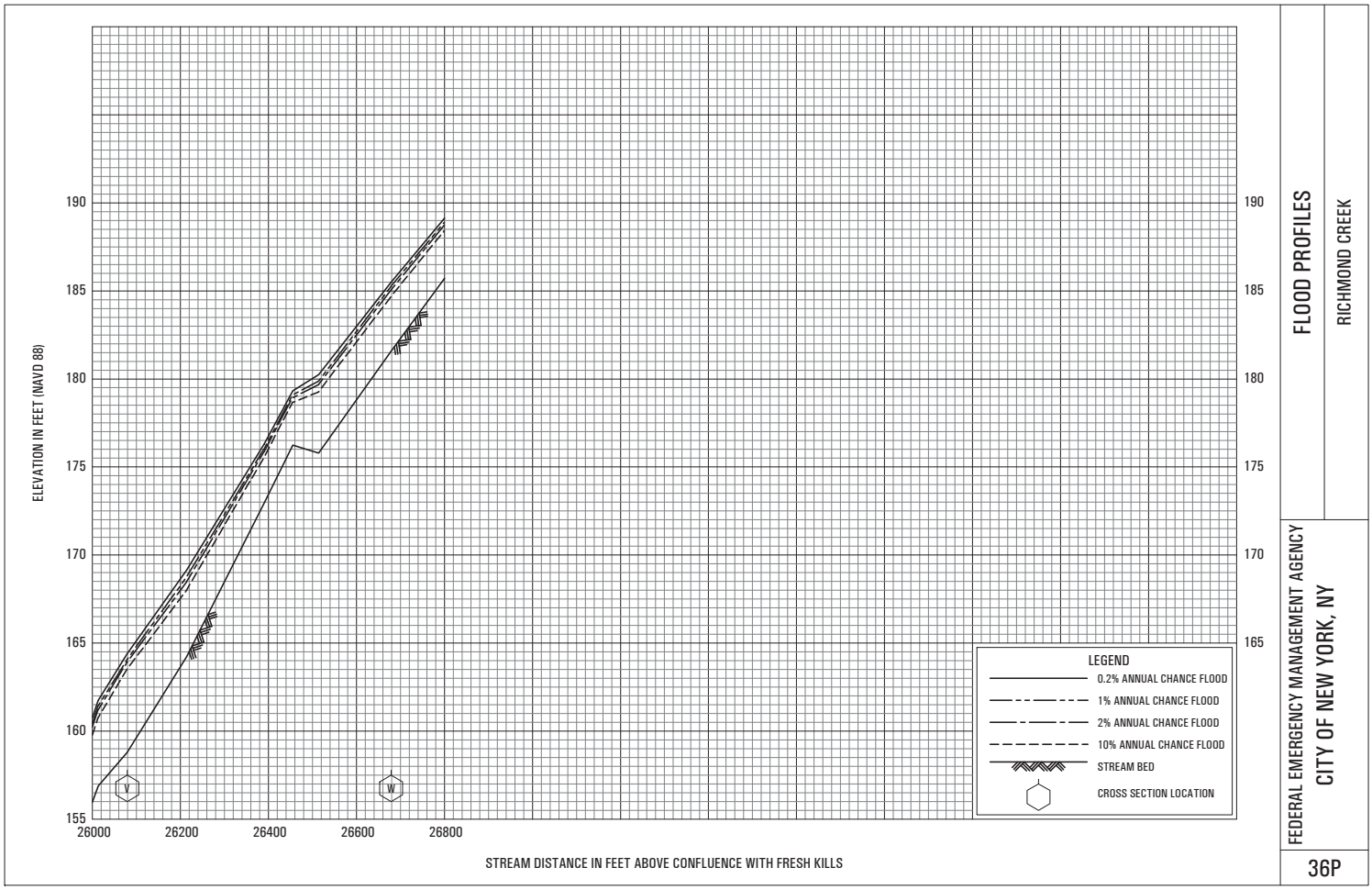
FLOOD PROFILES

RICHMOND CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

35P



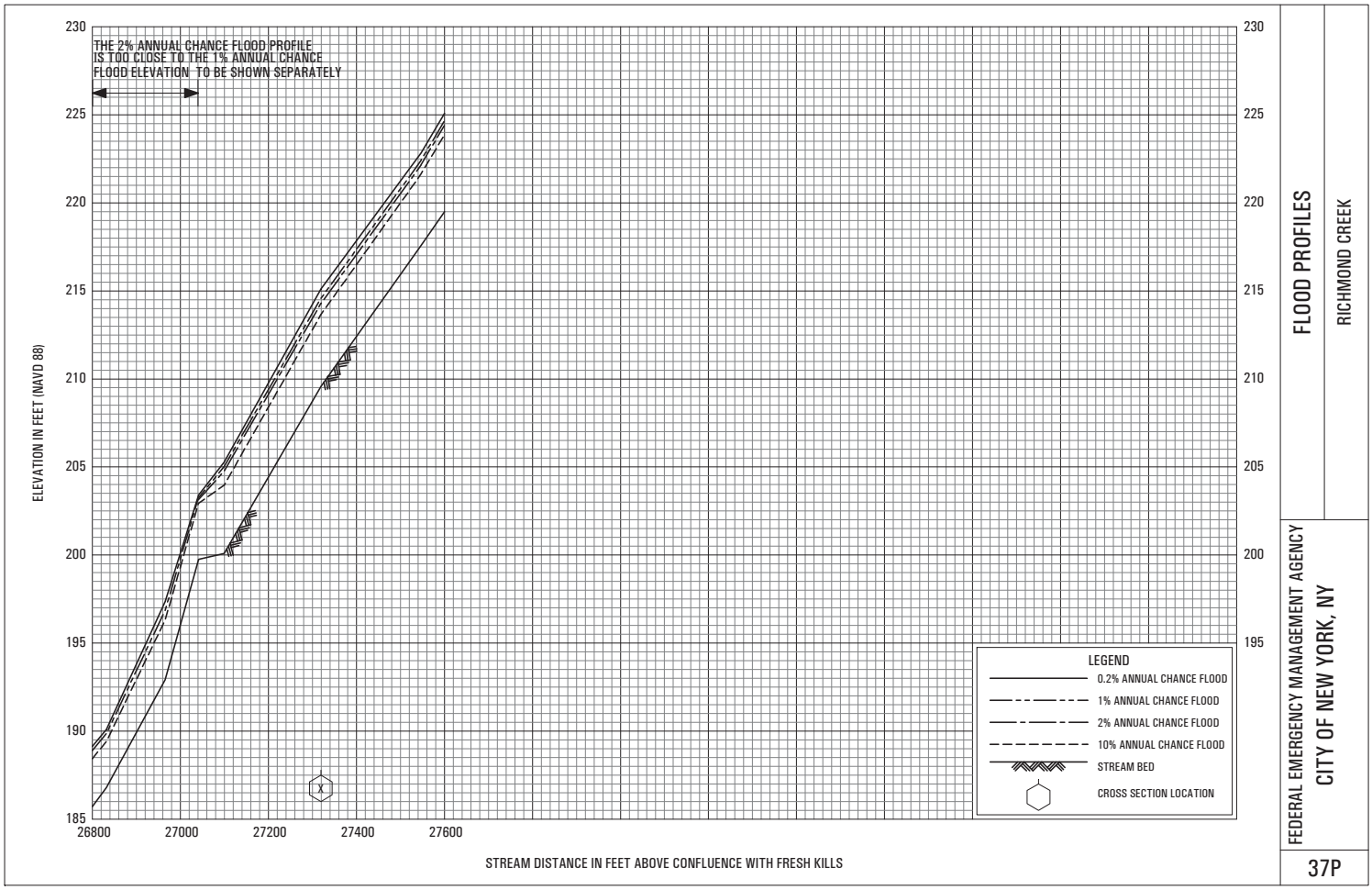
FLOOD PROFILES

RICHMOND CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

36P



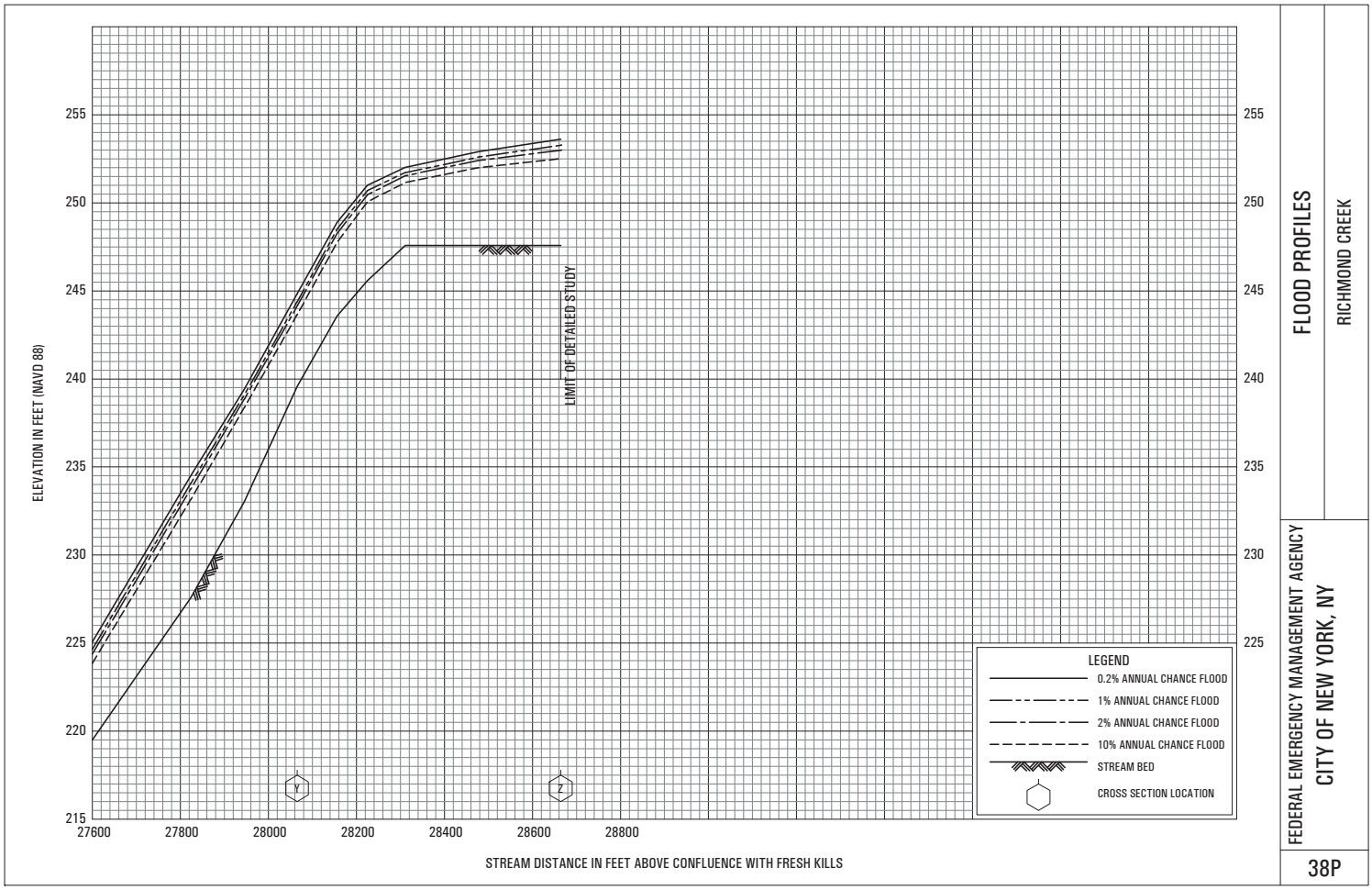
FLOOD PROFILES

RICHMOND CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

37P



FLOOD PROFILES

RICHMOND CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

38P

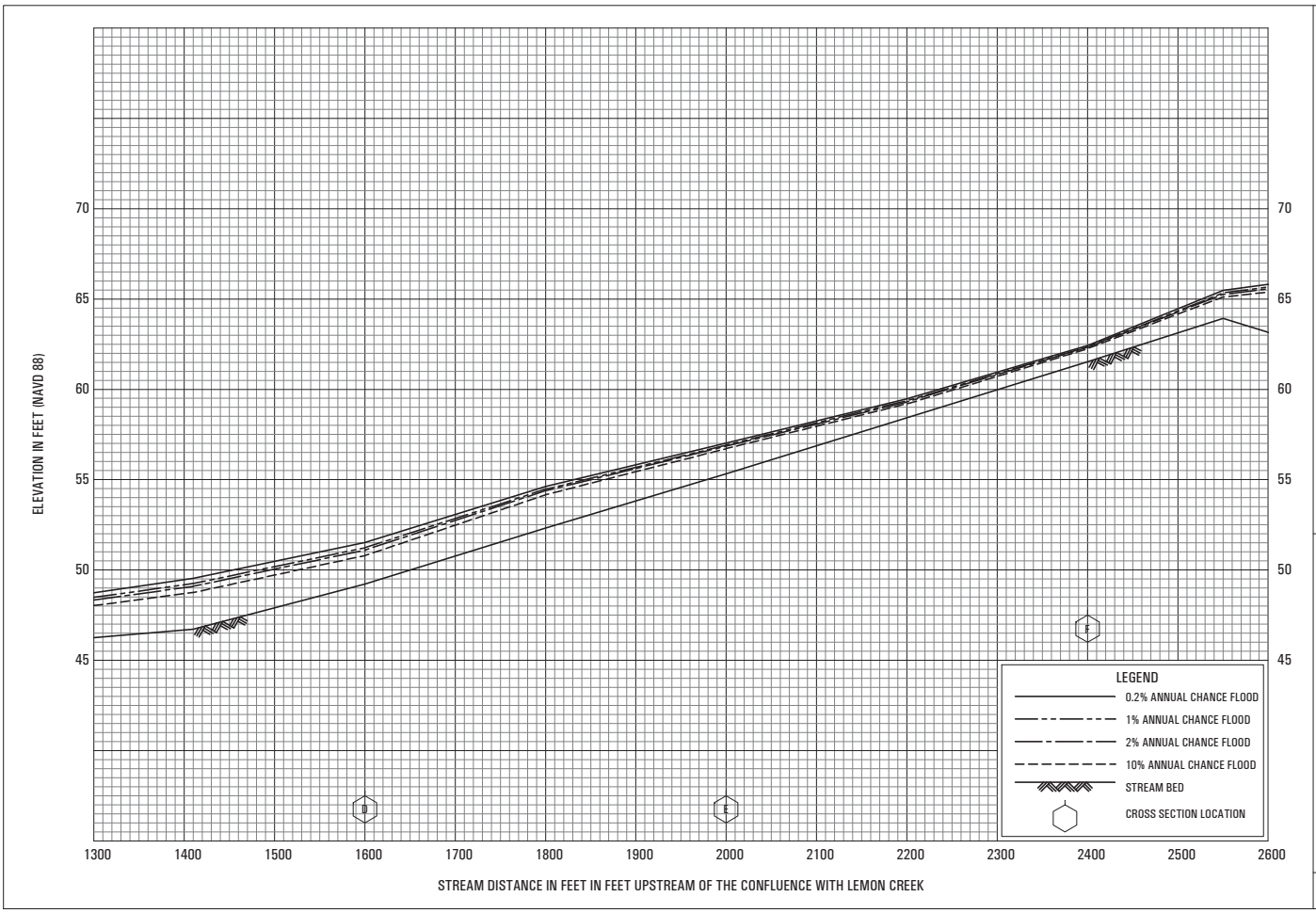
FLOOD PROFILES

SANDY BROOK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

39P



FLOOD PROFILES

SANDY BROOK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

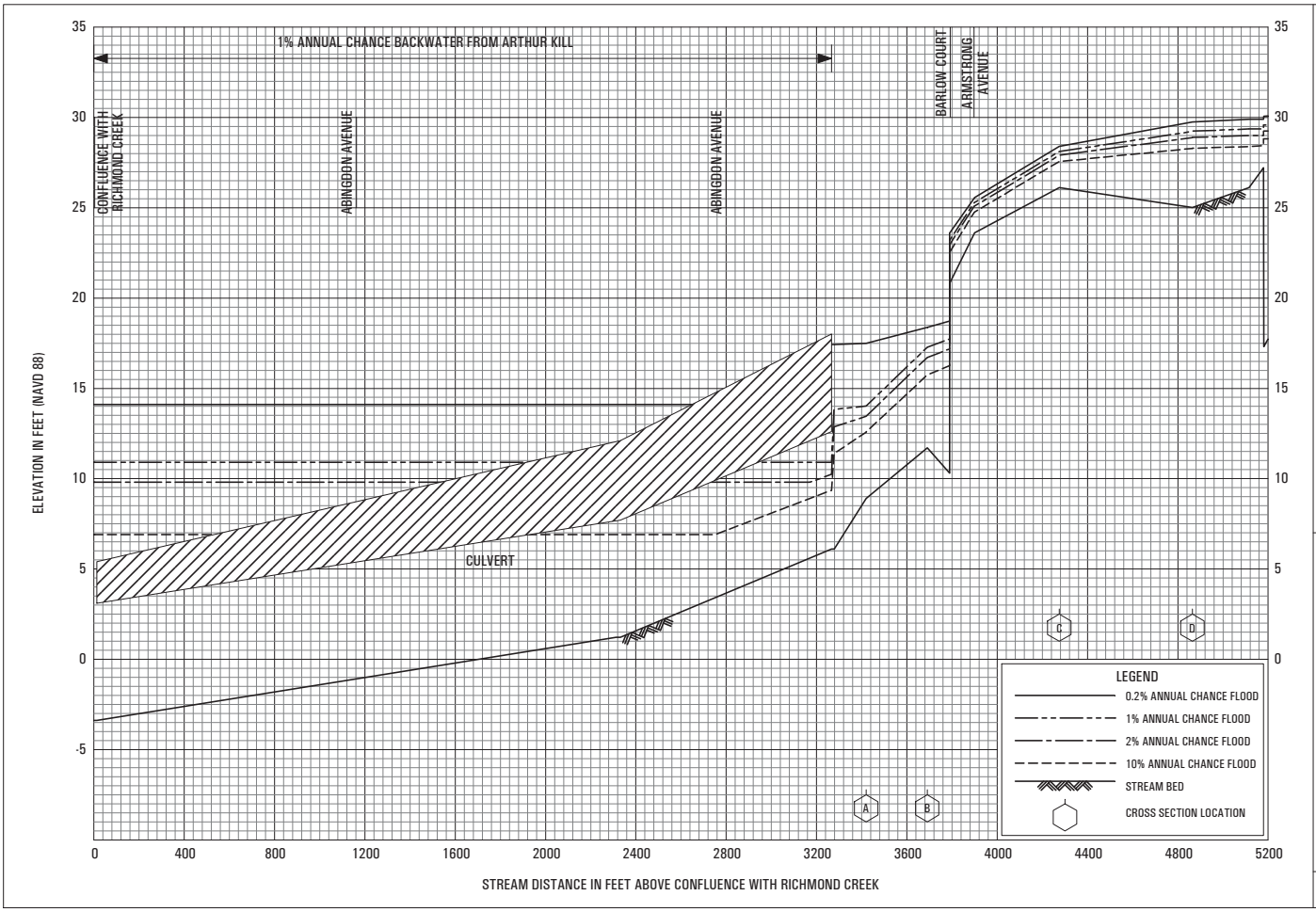
40P

FLOOD PROFILES

SANDY BROOK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY

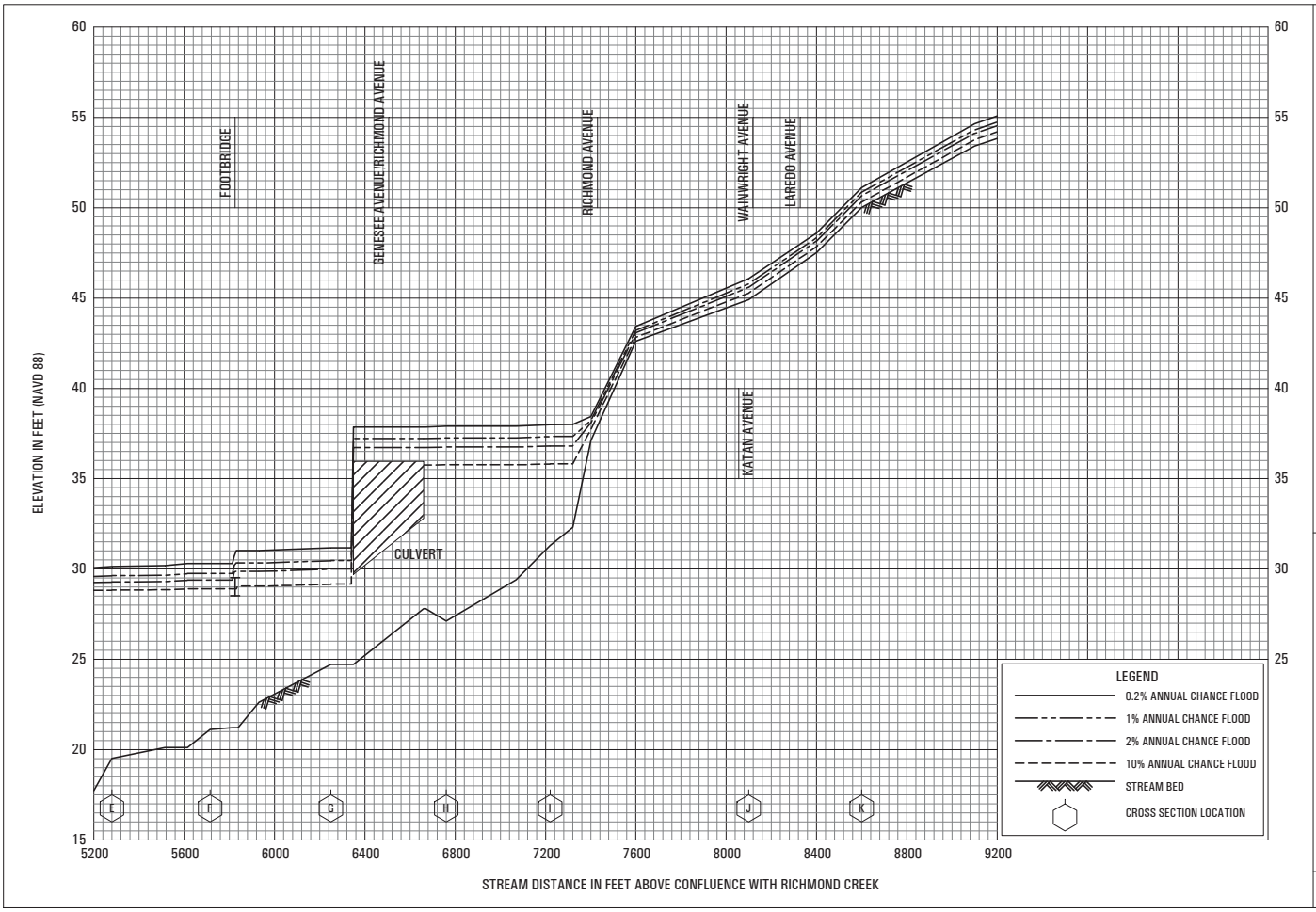


FLOOD PROFILES

SWEET BROOK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF NEW YORK, NY



FLOOD PROFILES

SWEET BROOK

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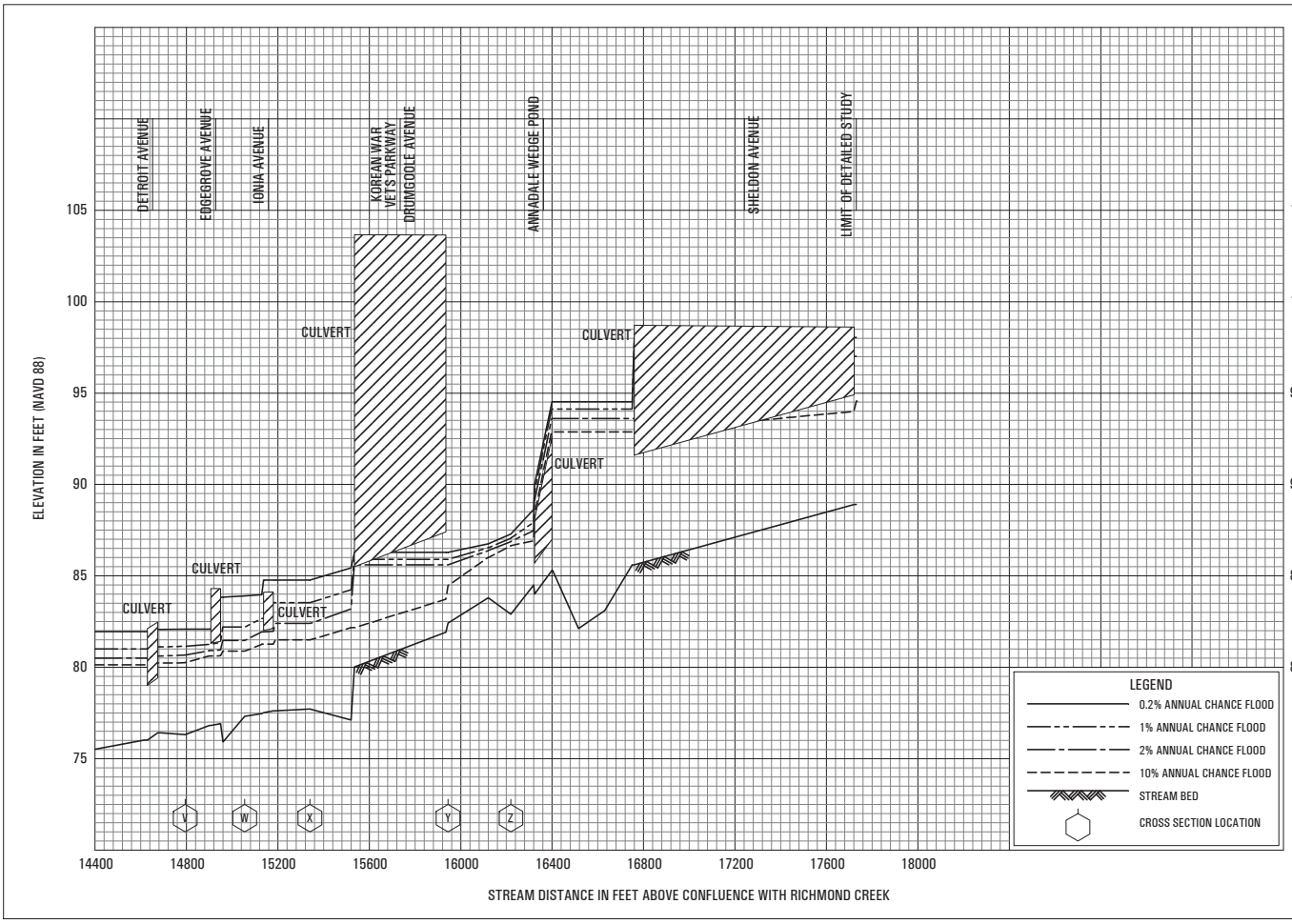
44P



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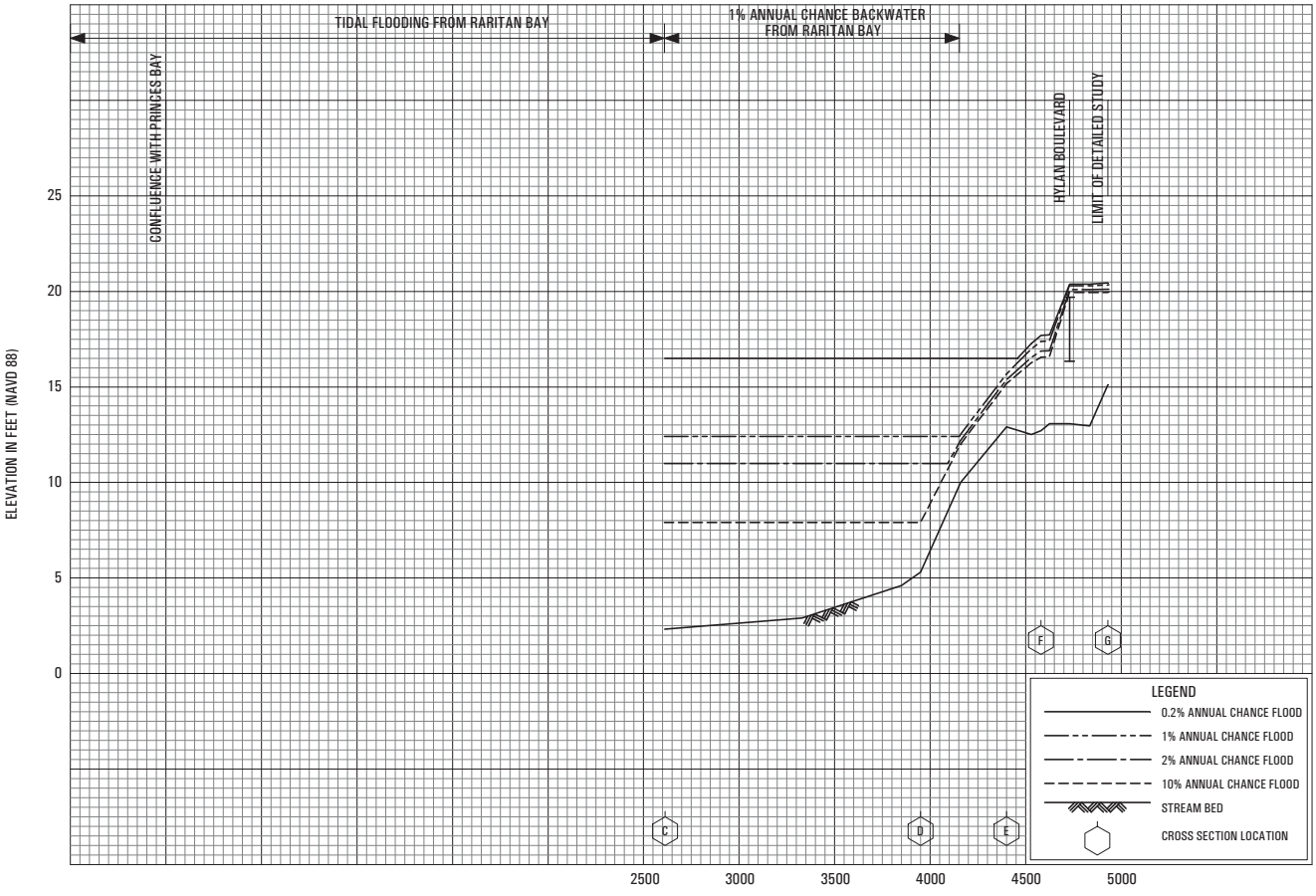
45P



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WOLFE'S POND

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46P