MAMARONECK & SHELDRAKE RIVERS
NEW YORK
FLOOD RISK MANAGEMENT

GENERAL REEVALUATION REPORT
FOR
THE VILLAGE OF MAMARONECK

DRAFT MAIN REPORT

US Army Corps of Engineers
New York District

JANUARY 2016

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EXECUTIVE SUMMARY

Introduction

A feasibility-level investigation has been conducted to analyze and formulate a Flood Risk Management (FRM) project for the Village of Mamaroneck, Westchester County, New York. A General Reevaluation Report (GRR) has been prepared to document the economic investigations, engineering analyses, and environmental considerations conducted to formulate a FRM project for the Village of Mamaroneck, which will reduce the damaging effects of severe storms to life and property. The GRR updates the studies performed for the 1977 Feasibility Report and the 1989 General Design Memorandum (1989 GDM) as well as identifies and affirms Federal interest in a solution for flooding in the Village of Mamaroneck.

The study to evaluate flood risk management measures along the Mamaroneck and Sheldrake Rivers in the Village of Mamaroneck, Westchester County, New York was authorized under resolutions adopted September 14, 1955 and November 14, 1955 by the United States Senate Committee on Public Works, and a resolution adopted June 13, 1956 by the United States House of Representatives Committee on Public Works. The Project proposed by the U.S. Army Corps of Engineers as a result of these studies under these resolutions was authorized for construction by Section 401(a) of the Water Resources Development Act of 1986 (Public Law 99-662, 99th Congress, 2nd Session) adopted November 17, 1986.

A severe flood risk persists in the Village of Mamaroneck based on the recurrence of flood events and the damages sustained. Approximately750 homes and businesses are located within the flood plain for the Mamaroneck and Sheldrake Rivers Basin within the Village of Mamaroneck and the Town of Harrison. The largest floods of record resulted from the storms of October 1955, June 1972, September 1975 and April 2007. In addition, there have been 19 significant flood events from July 1889 to present.

Extensive damages and loss of live have occurred during these major flood events. Damages within the Mamaroneck and Sheldrake Rivers Basin for the June 1972 and September 1975 floods alone amounted to approximately $18M and $92M, respectively, based on conditions of development at the time and October 2015 price levels. The flood waters from these storms inundated large areas of industrial, commercial and residential property at the Village of Mamaroneck. Further, during the September 1992 flood, one person drowned when the car he was traveling in was swept away in a flow of water. Additionally, during the April 2007 storm, a person died in a house fire because flood waters prohibited emergency vehicles from responding to the person's home to provide emergency and medical care.

Additionally, people have been continually evacuated from homes, businesses and vehicles during these damaging floods along both the Mamaroneck and Sheldrake Rivers. For example the April 2007 nor'easter flood, which was estimated to be a 100-year flood, damaged over 300 residential and 100 commercial structures and disrupted the lives of thousands of people through transportation delays and loss of income.

Recommendations

The plan recommended for construction is the National Economic Development Plan (NED Plan) which consists of channel modification work along the Mamaroneck and Sheldrake Rivers, with various channel widths, depths and lengths within the Village of Mamaroneck (Alternative 1Z).

The river will be realigned to the confluence to Mamaroneck Harbor with a 25 foot wide by 8 foot high, 350 foot long culvert that will be placed under the railroad station parking lot to alleviate the poor channel alignment. Trapezoidal channel improvements will consist of a natural bed channel with side slopes of one vertical on two and a half horizontal (1:2.5), and concrete retaining walls will be used where space is limited. Removal and replacement of existing retaining walls and utilities will be necessary along the length of the channel. Several small bridges will be removed and one bridge will be replaced. In addition to channel modification along both rivers, the NED Plan will have a nonstructural component along the Mamaroneck and Sheldrake rivers that include structure elevation, ringwall levees, and/or floodproofing.

Summary of the Recommended Plan – NED Plan, Alternative 1Z

Actions	**Alternative 1Z – NED Plan**
Bridge Removal	
Ward Avenue	**Remove**
Waverly Place	**Remove/replace**
Centre Avenue Footbridge	**Remove**
Footbridge #1 (near confluence)	**Remove**
Footbridge #2	**Remove**
Channel Work Length (ft)	
Harbor Heights	**No action**
Mamaroneck Upstream	**2,400 feet**
Mamaroneck Downstream	**2,400 feet**
Sheldrake	**3,470 feet**
Channel Width Size (ft)	
Harbor Heights	**No action**
Mamaroneck Upstream	**45**
Mamaroneck Downstream	**45**
Sheldrake	**33**
Channel Cut Depth (maximum) (ft)	
Harbor Heights	**No action**
Mamaroneck Upstream	**2.3**
Mamaroneck Downstream	**4.2**
Sheldrake	**3.4**
Walls (average height/length) (ft)	**8.5 ft / 4,360 feet**
Nonstructural	**9 structures**

NED Plan Costs and Benefits

The initial construction cost for the project proposed in this study will total **$69,702,577** at a Total Investment Cost of **$72,037,019.** The cost share analysis for this project is 65 percent Federal and 35 percent non-Federal. The non-Federal cost-share includes 100% of the cost of the estimated Lands, Easements, Right-of-Way, Relocations, and Disposal (LERRDs) requirements in accordance with Engineering Regulation, ER 1165-2-131, paragraph 12-c(5). The non-Federal partner is the New York State Department of Environmental Conservation (NYSDEC). The NYSDEC executed a sub-agreement with Westchester County as a cost-sharing partner. The Village of Mamaroneck is the local stakeholder. The Federal share of the project's total first cost is **$45,306,675** the non-Federal share is **$24,395,902.**

The Federal Government will design the project, prepare detailed plans/specifications and construct the project, exclusive of those items specifically required of the non-Federal partner. The non-Federal partner is responsible for all Lands, Easements, Right-of-ways, and Relocations (LERR) costs and all Operations and Maintenance (O&M) costs. The LERR costs are applicable to the non-Federal share of the initial project costs. For example, the approximate Total Project LERR Costs of **$13,104,090** borne by the non-Federal partner are applicable to the **$24,395,902** share of non-Federal Project Costs.

Cost Apportionment

Federal Project Cost (65%)	**$45,306,675**
Non-Federal Project Cost (35%)	**$24,395,902**
Lands & Damages	$4,913,531
Relocations	$8,190,559
5% Cash Requirement	$3,485,130
Cash or In-Kind Service balance	$7,806,682
Total Project Cost (100%) ***Does not include O&M and IDC**	**$69,702,577**

Financial Analysis

The FY 2016 project cost as noted above is $69,702,577. Total investment costs are $72,037,019. Annual costs are approximately $2,866,566 and annual benefits are $3,102,900 with a BCR of approximately 1.1 which yields annual net benefits of about $236,300 for the NED plan.

NED Plan Economic Summary

	NED Plan
Total Annual Net Benefits	$3,102,900
Total Annual Costs	$2,866,600
Net Benefits	$236,300
BCR	**1.1**

Originally, on November 17, 1986, a plan for flood risk management in the Village of Mamaroneck was authorized for construction in Section 401(a) of the Water Resources Development Act (WRDA) (PL 99-662, 99th Congress, 2nd Session) at a total cost of $68,500,000 ($156,500,000 at FY15 price level). The 2015 GRR NED plan is approximately half the total investment cost of the plan authorized in WRDA 1986, thereby saving the federal government, non-federal partners and the local taxpayer appreciable funds for project implementation.

Non-Federal Responsibility

The non-Federal sponsor will be responsible for the operation, maintenance, replacement, repair and rehabilitation (OMRR&R) of the project upon construction completion. Additionally, the NED Plan will have a defined area and specific locations of improvement within the Mamaroneck River and Sheldrake River channels. Consideration of future work after plan construction that is proposed on or near the Mamaroneck River and Sheldrake River, must comply with the intent, goals and objectives of the Plan.

Modification to structures by others (such as bridges) that currently exist within the project alignment must be submitted for approval to USACE to ensure that the functionality of the project is not compromised. Further, the functionality of the project due to modifications may affect the non-federal sponsor's ability to submit a request to FEMA for revisions to the Floodplain Maps for the study area.

Environmental Analysis

The GRR report includes an environmental analysis conducted under the National Environmental Policy Act and documented within an Environmental Impact Statement (EIS). A summary of the resources and activities analyzed within the EIS to minimize impacts are provided below. A complete discussion of resources and potential impacts can be found in Appendix B (Environmental Impact Statement).

Topography and Geology

- Current applicable USACE design criteria will be met, taking into account site conditions, physical constraints, and design flood requirements.
- Excavated material will be handled, removed, utilized, and/or disposed of in accordance with applicable construction standards and regulations.
- USACE will coordinate with local authorities and make public announcements to help ensure public safety, acquire a Dig Safe permit to locate and identify utilities, and properly handle and dispose of waste material.
- Proposed improvements will be designed and built to meet USACE and other applicable codes and standards, including seismic standards.
- OSHA guidelines and standard construction practices (e.g., shoring-up of channel slopes) will be followed during construction.
- Monitoring equipment will be used, as necessary, to ensure construction activities that cause ground vibrations do not exceed state and Federal thresholds to avoid damages to nearby structures. Pre-construction inspections of buildings may be required as part of the efforts to monitor effects of vibrations.

HTRW

- There should be no impacts to HTRW for most of the project area. The ITT Sealectro site, a State Superfund site, is located along a portion of the Sheldrake River. The soil in this area will have solvents. Prior to construction in this area, NYSDEC Environmental Remediation staff will be contacted and testing to determine VOC levels will be conducted. Any soil removal that may be required will be removed and disposed of at an acceptable facility.

Land Use, Cover, and Zoning

- Most of the construction activity will occur within the existing channel, which will help minimize impacts to adjacent land uses. Temporary workspaces along the top of the channel will generally be limited to a 15 ft (4.5 m) clearance from the channel bank edge along portions of the Project area.
- Channel construction (and related impacts) will not be concentrated in any one location for extended periods of time; construction will be moved from area to area as it progresses.
- Disturbed areas will be restored and their use returned to pre-construction land uses and habitat.

Water Resources

- Standard industry BMPs to protect water quality and wetlands during in-stream work will be implemented to reduce the potential for impacts during construction.
- An ESCP and site-specific SWPPP will be developed and implemented in accordance with the SPDES General Permit for Storm water Discharges from Construction Activity. Upon completion, a Notice of Termination will be filed to verify that BMPs were implemented and that disturbed areas were restored and stabilized.
- Water quality and water resources protection measures will be implemented in accordance with local, county, NYSDEC permitting requirements and regulations, CWA Sections 401 and 404, RHA Section 10, Article 15, and Village Code Chapter 192-5.
- Project area will be restored to pre-construction conditions: temporary workspaces will be stabilized and revegetated by planting trees and shrubs in forested wetlands, native trees and shrubs will be planted, and native wetlands seed mix applied to exposed soils to maximize the rate of revegetation and reduce the likelihood that invasive species will take over disturbed areas.
- In-stream activities will be avoided from 1 June through 1 September

Vegetation

- Impacts to vegetation will be mitigated by avoidance and minimization, where possible, and replaced by restoring riparian areas to pre-construction conditions. Following construction activities temporary workspaces will be stabilized and revegetated as recommended by the Village of Mamaroneck Department of Public Works and Tree Committee by planting trees where mature trees were removed, the top layer of soil will be removed and replaced with clean topsoil that is seeded with a native upland or wetland seed mix in order to maximize the rate of revegetation and reduce the likelihood that invasive species will take over disturbed areas, and native trees and shrubs will be planted in areas where mature trees and shrubs were removed during construction.

Fish and Wildlife

- Standard industry BMPs to protect water quality during in-stream work and activities that will disturb or remove soils will be implemented in accordance with NYSDEC and USACE CWA permitting requirements.
- Streamside wildlife habitat that is removed or disturbed will be revegetated using native plant species, with immediate results expected for grasses and other herbaceous species and long-term restoration needed for establishment of larger shrub and tree species.
- No tree cutting will occur from 1 April to 1 August. If trees greater than three inches density breast height (dbh) will be removed from 1 January through 31 March, a survey for breeding raptors will be conducted.
- No in-stream work will be conducted from 1 June through 1 September.

Cultural Resources

- Adverse effects to the Ward Avenue Bridge, Metro-North Railroad Bridge, and the stone retaining walls thematic district.
- Mitigation, at a minimum, will include consideration of incorporation of these elements into the NED Plan and the documentation of these resources
- A Memorandum of Agreement (MOA) will be prepared and consultation with the NYSHPO, interested parties and federally-recognized Tribes will further determine other appropriate measures.

Coastal Zone Management

- Mitigation measures required based on the determination issued by NYSDOS includes implementation of standard industry BMPs to protect water quality during construction of the NED Plan (e.g., development of a SWPPP and ESCP).
- See impact mitigation and minimization measures for Water Resources, Vegetation, Fish and Wildlife, Aesthetics and Scenic Resources, and Recreation.

Aesthetic and Scenic Resources

- Measures that could be implemented to reduce the short-term effects of construction activities include: adhering to the Project's ESCP to minimize the transport of suspended solids downstream, and erecting temporary fences in Columbus Park to screen the construction staging area.
- Various measures will be implemented to reduce the Project's long-term adverse visual impacts and restore the Project area to pre-construction conditions including: riparian habitat restoration activities such as riverbank shaping, tree replanting, and revegetation; and the use of riprap and other more "natural" looking channel modifications where possible.

Recreation

- USACE will ensure that there are safe and effective pedestrian routes encircling Columbus Park following the removal of two pedestrian footbridges.
- Upon Project completion, parks and surrounding areas will be restored to pre-construction conditions and access to other riverine areas and affected parks will be restored.
- Additional specific measures that could be implemented to reduce the limited short-term effects of construction activities include: adhering to the Project's ESCP to minimize the transport of suspended solids downstream, restricting construction primarily to normal weekday business hours in residential areas, erecting temporary fences and other physical barriers around construction areas, temporarily reducing vehicular speed limits, and hanging signage that informs people of the Project's purpose, duration, and expected outcomes.
- USACE will work with the Village of Mamaroneck to determine if there are opportunities to improve public access to the rivers in the Project area during post-construction restoration by establishing riverwalk areas.

Transportation

- No mitigation measures will be required, but USACE is currently evaluating additional measures to be implemented for construction activities to further minimize these already limited effects. Traffic control and operations strategies may include measures like preparing a Construction Traffic Management Plan, establishing detours and alternate routes when/where needed, or temporarily reducing speed limits.

Air Quality

- Construction will be performed in full compliance with the Clean Air Act and with the current NYSDEC Chapter III-Air Quality Regulations requirements, with compliant practices and/or products. No mitigation measures will be required outside of the local applicable air pollution control regulations.

Noise

- USACE is currently evaluating additional noise risk management measures to be implemented for construction activities to further minimize already limited effects.
- In accordance with the local noise ordinance, sounds generated from heavy equipment will be required to close down after 6:00 p.m. from Monday through Saturday, and on Sundays and holidays
- Special variances to the local noise ordinance may be obtained; however, additional noise reduction measures (e.g., enclosure of construction power units and generator sets, use of noise barriers) could be required.

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ABBREVIATIONS AND ACRONYMS

%	*Percent*
01:02.5	*One Vertical On Two-And-A-Half Horizontal*
1:03	*One Vertical On Three Horizontal*
§	*Section*
°C	*Degrees Celsius*
°F	*Degrees Fahrenheit*
$\mu g/m^3$	*Micrograms Per Cubic Meter*
a.m.	*Between Midnight And Noon*
AAD	*Average Annual Damages*
AADT	*Average Annual Daily Traffic*
ac	*Acre(S)*
ACHP	*Advisory Council On Historic Preservation*
AMSL	*Above Mean Sea Level*
ANSI	*American National Standards Institute*
APE	*Area Of Potential Effect*
AQCR	*Air-Quality Control Region*
ASA	*Assistant Secretary Of The Army*
BCR	*Benefit To Cost Ratio*
BERH	*Board Of Engineers For Rivers And Harbors*
BMPs	*Best Management Practices*
CAA	*Clean Air Act*
CEQ	*Council On Environmental Quality*
CERCLA	*Comprehensive Environmental Response, Compensation, And Liability Act*
CFR	*Codes Of Federal Regulations*
cfs	*Cubic Feet Per Second*
cm	*Centimeter(S)*
CMP	*Coastal Management Program*
cms	*Cubic Meters Per Second*
CO	*Carbon Monoxide*
CO_2	*Carbon Dioxide*
CS	*Coastal Shoals*
CSRA	*Cost And Schedule Risk Analysis*
CW	*Civil Works*
CWA	*Clean Water Act*
CWBS	*Cost Work Breakdown Structure*

dB	*Decibel(S)*
dBA	*A-Weighted Decibel(S)*
DDT	*Dichlorodiphenyltrichloroethane*
DEIS	*Draft Environmental Impact Statement*
District	*United States Army Corps Of Engineers, New York District*
DNL	*Day-Night Sound Level*
DO	*Dissolved Oxygen*
EAD	*Equivalent Annual Damages*
EC	*Engineer Circular*
EFH	*Essential Fish Habitat*
EGM	*Economic Guidance Memorandum*
EIS	*Environmental Impact Statement*
EJ	*Environmental Justice*
EQ	*Engineering Quality*
ER	*Engineering Regulation*
ESCP	*Erosion And Sediment Control Plan*
FEMA	*Federal Emergency Management Agency*
FR	*Feasibility Report*
FRM	*Flood Risk Management*
ft	*Foot/Feet*
FY	*Fiscal Year*
GDM	*General Design Memorandum*
GHG	*Greenhouse Gas*
GIS	*Geographic Information Systems*
GMSL	*Global Mean Sea Level*
GRR	*General Re-Evaluation Report*
ha	*Hectare(S)*
HEC	*Hydrologic Engineering Center*
HEC FDA	*Hydrologic Engineering Center Flood Damage Reduction Analysis*
HEC FIA	*Hydrologic Engineering Center Flood Impact Analysis*
HEC-RAS	*Hydraulic Engineering Center, River Analysis System*
HQUSACE	*Headquarters U.S. Army Corps Of Engineers*
HTRW	*Hazardous, Toxic And Radioactive Wastes*
I	*Interstate*
IBI	*Index Of Biological Integrity*
IM	*Intertidal Marsh*
in	*Inch(Es)*
IPCC	*Intergovernmental Panel On Climate Change*
km	*Kilometer(S)*
km^2	*Square Kilometers*

L_{eq}	*Equivalent Sound Level*
LER	*Lands, Easements, And Rights-Of Way*
LERRDS	*Lands, Easements, Right-Of-Way, Relocations, And Disposal*
LGA	*La Guardia Airport*
LISS	*Long Island Sound Study*
LOP	*Level-Of-Protection*
LOS	*Level Of Service*
LZ	*Littoral Zone*
m	*Meter(S)*
MBTA	*Migratory Bird Treaty Act*
mi	*Mile(S)*
mi^2	*Square Miles*
MLW	*Mean Low Water*
MOA	*Memo Of Understanding*
MSC	*Major Subordinate Command*
MSFCMA	*Magnuson-Stevens Fishery Conservation And Management Act*
MTA	*Metropolitan Transportation Authority*
n.d.	*No Date*
NAAQS	*National Ambient Air Quality Standards*
NAVD	*North American Vertical Datum*
NED	*National Economic Development*
NEPA	*National Environmental Policy Act*
NEPA	*National Environmental Policy Act*
NERO	*Northeast Regional Office*
NFIP	*National Flood Insurance Program*
NJIS	*New Jersey Impairment Score*
NO_2	*Nitrogen Dioxide*
NOAA	*National Oceanic And Atmospheric Administration*
NO_x	*Oxides Of Nitrogen*
NRC	*National Research Council*
NRHP	*National Register Of Historic Places*
NYCPCC	*New York City Of Panel Of Climate Change*
NYDOS	*New York Department Of State*
NYSDEC	*New York State Department Of Environmental Conservation*
NYSDOH	*New York State Department Of Health*
NYSDOS	*New York Department Of State*
NYSECL	*New York State Environmental Conservation Law*
NYSHPO	*New York State Historic Preservation Office*
NYSM	*New York State Museum*

O_3	*Ozone*
OASA(CW)	*Office Of Assistant Secretary Of The Army For Civil Works*
OMRRR	*Operations, Maintenance, Replacement, Repair And Rehabilitation*
OPRHP	*Office Of Parks, Recreation And Historic Preservation*
OSE	*Other Social Effects*
OSHA	*Occupational Safety And Health Administration*
OST	*On Screen Take-Off*
p.m.	*Between Noon And Midnight*
PCB	*Polychlorinated Biphenyls*
PCBS	*Polychlorinated Biphenyls*
PDT	*Project Delivery Team*
PEM	*Palustrine Emergent (Wetland Type)*
PFO	*Palustrine Forested (Wetland Type)*
PGA	*Peak Ground Acceleration*
PL	*Public Law*
PM_{10}	*Particulate Matter Less Than 10 Microns In Diameter*
$PM_{2.5}$	*Particulate Matter Less Than 2.5 Microns In Diameter*
PPA	*Project Partnership Agreement*
ppb	*Parts Per Billion*
ppm	*Parts Per Million*
Project	*Mamaroneck And Sheldrake Flood Risk Management Project*
PSS	*Palustrine Scrub-Shrub (Wetland Type)*
RBP	*Rapid Bioassessment Protocol*
RED	*Regional Economic Development*
RHA	*River And Harbors Act*
SAV	*Submerged Aquatic Vegetation*
SC	*Saline Surface Waters*
SFHA	*Special Flood Hazard Area*
SIP	*State Implementation Plan*
SLC	*Sea Level Change*
SLR	*Sea Level Rise*
SO_2	*Sulfur Dioxide*
SO_x	*Oxides Of Sulfur*
SPF	*Standard Protection Flood*
spp.	*Two Or More Species*
SWPPP	*Stormwater Pollution Prevention Plan*
TSP	*Tentatively Selected Plan*
U.S.	*United States*
USACE	*United States Army Corps Of Engineers*

USC	*United States Code*
USEPA	*United States Environmental Protection Agency*
USFWS	*United States Fish And Wildlife Service*
USGS	*United States Geological Survey*
V/C	*Volume To Capacity Ratio*
VE	*Value Engineering*
VE Zone	*Velocity Zone*
VLM	*Vertical Land Movement*
VOC	*Volatile Organic Compounds*
vpd	*Vehicles Per Day*
vph	*Vehicles Per Hour*
WAC	*Watershed Advisory Committee*
WC	*Westchester County*
WCJWW	*Westchester County Joint Water Works*
WJWW	*Westchester Joint Water Works*
WPA	*Works Progress Administration*
WRDA	*Water Resources And Development Act*
WSEL	*Water Surface Elevation*

1. INTRODUCTION & AUTHORITY

The Federal government authorized the United States Army Corps of Engineers to study water resource problems and potential solutions along the Mamaroneck and Sheldrake rivers in the Village of Mamaroneck, Westchester County, New York under resolutions adopted September 14, 1955 and November 14, 1955 by the United States Senate Committee on Public Works, and a resolution adopted June 13, 1956 by the United States House of Representatives Committee on Public Works (USACE New York District 2011a). Following the disastrous floods of June 1972 and September 1975, local interests requested Federal assistance.

In April 1976, the Chief of Engineers, granted approval for the preparation of an interim report for the Mamaroneck and Sheldrake Rivers under the Westchester County Streams Survey Investigation. The USACE conducted a feasibility study and completed the *Feasibility Report for Flood Control, Mamaroneck and Sheldrake Rivers Basin and Byram River Basin* in October 1977 (USACE New York District 1977). The recommended plan for the Mamaroneck and Sheldrake Rivers Basin was determined to be economically favorable. This plan was authorized for construction on November 17, 1986 in Section 401(a) of the Water Resources Development Act (WRDA) (PL 99-662, 99th Congress, 2nd Session), as follows:

> *The project for flood control, Mamaroneck and Sheldrake River Basins, New York and Connecticut, and Byram River Basin, New York and Connecticut: Report of the Chief of Engineers, dated April 4, 1979, at a total cost of $68,500,000, with an estimated first Federal cost of $51,400,000 and an estimated first non-Federal cost of $17,100,000. Such project shall include flood protection for the Town of Mamaroneck as recommended in the report of the Division Engineer, North Atlantic Division, dated March 28, 1978.*[1]

A General Design Memorandum (1989 GDM) was completed in 1989 that would have provided for modifying approximately 10,400 feet (ft) of river channel, constructing about 7,200 ft of retaining walls, replacing six bridges, and removing one bridge on the Mamaroneck River (USACE New York District 1989a). On the Sheldrake River, modifications would have included a diversion tunnel 3,550 ft in length from its inlet at Fenimore Road to the west basin of Mamaroneck Harbor, channel modification along approximately 4,200 ft and a retaining wall for a length of approximately 900 ft. However, this project was not constructed due to concerns related to costs and concerns of the non-Federal partner and other local interested parties and therefore did not advance any further.

However, interest in the project was renewed following several flood events, particularly two events in the spring of 2007. In May 2007, a Presidential Disaster Declaration (Federal Emergency Management Agency [FEMA]-1692-DR, New York) was issued for most of the Lower Hudson Valley as well as other affected counties in the state, including Westchester County, in response to severe flooding resulting from the April 15–16 Nor'easter. Subsequent to the issuance of the disaster declaration, on May 25, 2007, the "U.S. Troop Readiness, Veterans' Care, Katrina Recovery, and Iraq Accountability Appropriations Act,

[1] It is noted that the Village of Mamaroneck project was one of three independent plans authorized under WRDA 1986. The other authorized projects were the Sheldrake River in the Town of Mamaroneck, New York, and the Byram River in the area of Greenwich, Connecticut and Port Chester, New York. These latter two projects are not addressed in this Report.

2007" was signed into law by the President as PL 110-28. Title V, Chapter 3, pages 51–53 of PL 110-28 states "For an additional amount for 'Investigations' for flood damage reduction studies to address flooding associated with disasters covered by Presidential Disaster Declaration FEMA-1692-DR, $8,165,000, to remain available until expended."

On March 1, 2010, a Design Agreement for the project was executed between New York State Department of Environmental Conservation (NYSDEC) and the Department of the Army to cost-share this General Reevaluation Report to determine a technically feasible, environmentally acceptable and economically justified solution to the flood risk that plagues the study area from flood damage based on National Economic Development (NED) plan criteria.

1.1 Study Purpose

The purpose of this reevaluation study is to reformulate the project and investigate alternatives for a flood risk management solution much like what would be performed in a Feasibility Study. A Reevaluation Justification Report, dated February 2008 was approved by the Major Subordinate Command (MSC) in June of 2008.This study is being developed in accordance with ER 1105-2-100 §4.1 (b) dated 22 April 2000 which states that, post-authorization change reports are required when conditions of economics, engineering, or environment have changed in the project area. In the approximately 26 years that have passed since completion of the 1989 GDM for this project, changes are evident. A new Feasibility Study is not warranted, as the project remains authorized in accordance with Section 401(a) of the Water Resources and Development Act (WRDA) of 1986 (P.L. 99-662).

This re-evaluation study is being conducted in accordance with the Assistant Secretary of the Army (ASA) Civil Works (CW) guidance dated 18 August 2004 and in accordance with the executed Design Agreement, dated 3 May 2010. The cost of the re-evaluation study and pre-Project Partnership Agreement (PPA) engineering and design activities is being cost-shared by the non-Federal partner, the NYSDEC with funds contributed by Westchester County, NY. Upon approval of the GRR, a Project Partnership Agreement (PPA) will be executed with the non-Federal Partner for construction activities.

Changes in existing conditions as recorded in the 1989 GDM versus current conditions warranted further investigation and led to potential changes to the authorized plan.

Additionally, twenty-six years of flood history have accumulated in the Mamaroneck River Basin since the completion of the 1989 GDM hydrology (through water year 1982). Large flood-producing storms, such as Tropical Storm Floyd (mid-September 1999) and the April 2007 "tax day" nor'easter have occurred. The latter storm produced the new flood of record in the basin, surpassing the prior flood of record of September 1975 by 44.6 % in terms of gaged peak discharge. Four other floods occurred for which claims were made by the Village of Mamaroneck residents to the FEMA National Flood Insurance Program (NFIP). An updated gaged peak discharge vs. frequency analysis has shown significant increases in the smaller specific-frequency hypothetical peak flows, ranging from a 31.7 % increase for the one year peak flow to a 4.3 % increase for the 25 year peak flow. This would indicate that flood damages may be experienced more often and would impact the current economic analysis and benefits. New hydrologic data, i.e. rainfall data and frequency distribution curves have been developed in order to more accurately define the flood plain and identify areas in need of flood risk management efforts. In addition, the changes in construction techniques may have a positive impact on the overall cost of the project.

Major changes that have occurred since 1986 project authorization are changes to the USACE Principles and Guidelines, engineering requirements, environmental compliance and plan formulation guidance, which will have a significant impact on the economic analysis for this reevaluation. As per EC 1105-2-409 § 4.c.3, any alternative plan may be selected and recommended for implementation if it has, on balance, net beneficial effects after considering all plan effects, beneficial and adverse, in the four Principles and Guidelines evaluation accounts: National Economic Development, Environmental Quality, Regional Economic Development, and Other Social Effects. In accordance with ER 1105-2-100 § 2-3 (d)(3), dated 22 April 2000, the following four accounts are defined as (a) The national economic development account displays changes in the economic value of the national output of goods and services; (b) The environmental quality account displays non-monetary effects on ecological, cultural, and aesthetic resources including the positive and adverse effects of ecosystem restoration plans; (c) The regional economic development (RED) account displays changes in the distribution of regional economic activity (e.g., income and employment); (d) The other social effects (OSE) account displays plan effects on social aspects such as community impacts, health and safety, displacement, energy conservation and others.

During and after the April 2007 nor'easter and subsequent flooding, the Village of Mamaroneck was significantly impacted. In addition to the devastation the residents and owners of flood-damaged property experienced, people who were not directly affected by the flood were also impacted. There were considerable transportation delays as a result of flooded roadways (including I-95), one death occurred during the flood, and residents and businesses not directly flooded were closed for more than four days after the flood event because of damaged electric transmission lines from flooding. There was no power to a significant portion of the Village, especially the downtown area of the Village as a result of the floods. These RED and OSE benefits, in combination with physical damages, income losses and emergency costs (as defined in ER 1105-2-100, Appendix E, and paragraph E-19 (b)(3)a-c) will generate significant benefit streams for the reevaluation, leading to a project that is economically justified.

1.2 Study Scope

This report focuses on the flood risk management problems in the Mamaroneck and Sheldrake Rivers Basin within the Village of Mamaroneck. It offers a recommendation on the cooperative actions that should be taken by the Federal government and the non-Federal partner of the project. The recommendation is based on the following considerations, all of which are documented in this report.

a. Identification of the flood risk management problems;
b. Relationship of flood risk management problems to the environmental and socioeconomic needs and desires of the people living and working in the study area;
c. Refinement of solutions in the 1977 Feasibility Report for protecting the flood prone areas and reducing flood risk and re-examining the National Economic Development (NED) plan in the 1989 GDM;
d. Determination of the costs and benefits as well as the environmental, social and economic impacts associated with implementing these measures;
e. Selection of the plan that would greatly reduce the flood risk in the Village of Mamaroneck consistent with Federal and local planning objectives;
f. Provision for protection to emergency response and other critical lifeline facilities impacting the general health and welfare of the region, as well as facilities of public congregation such as schools, municipal buildings, etc.; and
g. Identification of the shared responsibilities of the Federal government and non-Federal partner.

h. The feasibility of flood risk management measures in the Basin will be examined by:

- Re-defining the problems, needs and opportunities for improvements associated with periodic flooding from storms within the Mamaroneck and Sheldrake Rivers Basin, New York;
- Re-evaluating the technical, economic, environmental, and institutional feasibility for Federal interest in addressing flooding issues; identifying and re-evaluating potential solutions to flooding issues;
- Resolving any significant concerns and issues related to biological, ecological, and cultural resources and Hazardous, Toxic and Radioactive Waste (HTRW); and
- Determining if there is local support for implementation of the GRR tentatively selected plan.

1.3 Non-Federal Partner & Local Stakeholders

The non-Federal partner for this Study is the NYSDEC, with the Westchester County Department of Planning serving as the local cost-sharing partners for the General Reevaluation Study. Other municipalities involved in the development of this study include the Town and Village of Mamaroneck. Other agencies involved in the coordination of this study include the New York Department of State (NYDOS), New York State Historic Preservation Office (NYSHPO), United States Geologic Society (USGS), NYSDEC, the Federal Emergency Management Administration (FEMA), the New York State Emergency Management Administration, the Federal Railroad Authority, as well as the U.S. Fish and Wildlife Service (USFWS).

1.4 Study Area

The Mamaroneck and Sheldrake Rivers watershed is approximately 24 square miles in area, and is located along the northwestern coast of Long Island Sound within the New York City metropolitan area (Figure 1). The Mamaroneck and Sheldrake Rivers Basin lies entirely within Westchester County, New York and contains portions of the Village and Town of Mamaroneck, the City of White Plains, the Village and Town of Harrison, Village of Larchmont, the City of Rye, North Castle, and the Village of Scarsdale.

Specifically, the study area is defined by the flood damage areas located in the Village of Mamaroneck and the Town of Harrison. On the Mamaroneck River, the damage area extends from below Tompkins Avenue upstream to the Westchester County Joint Water Works Dam. On the Sheldrake River damages occur from the confluence with the Mamaroneck River upstream to the Village line at the New England Thruway (I-95) Bridge.

1.5 Report Organization

This document has been organized in a manner consistent with USACE requirements for feasibility reports. The main report summarizes the results of feasibility studies, and the technical appendices present the details of the technical investigations conducted during this Study.

- Section 1 of this report introduces the study and provides the authority under which the study is being conducted.
- Section 2 of this report provides a summary of Federal and local participation in previous studies or projects within the bounds of the study area.
- Section 3 of this report reviews the existing site conditions pertinent to quantifying the “without” project consequences.

- Section 4 of this report provides the “future without project” conditions
- Section 5 identifies the flood risk management problems, opportunities and constraints within the study area.
- Section 6 provides an overview of the step-by-step process leading up to the identification of the Tentatively Selected Plan (TSP).
- Section 7 describes the components of the NED Plan.
- Section 8 refines the NED Plan.
- Section 9 provides a review of improved conditions and project impacts
- Section 10 reviews the project costs and cost-share
- Section 11 provides plan implementation items
- Section 12 provides public involvement history and path forward
- Section 13 provides the recommendation for plan implementation by the District Engineer.
- Section 14 lists the sources referenced throughout the report.

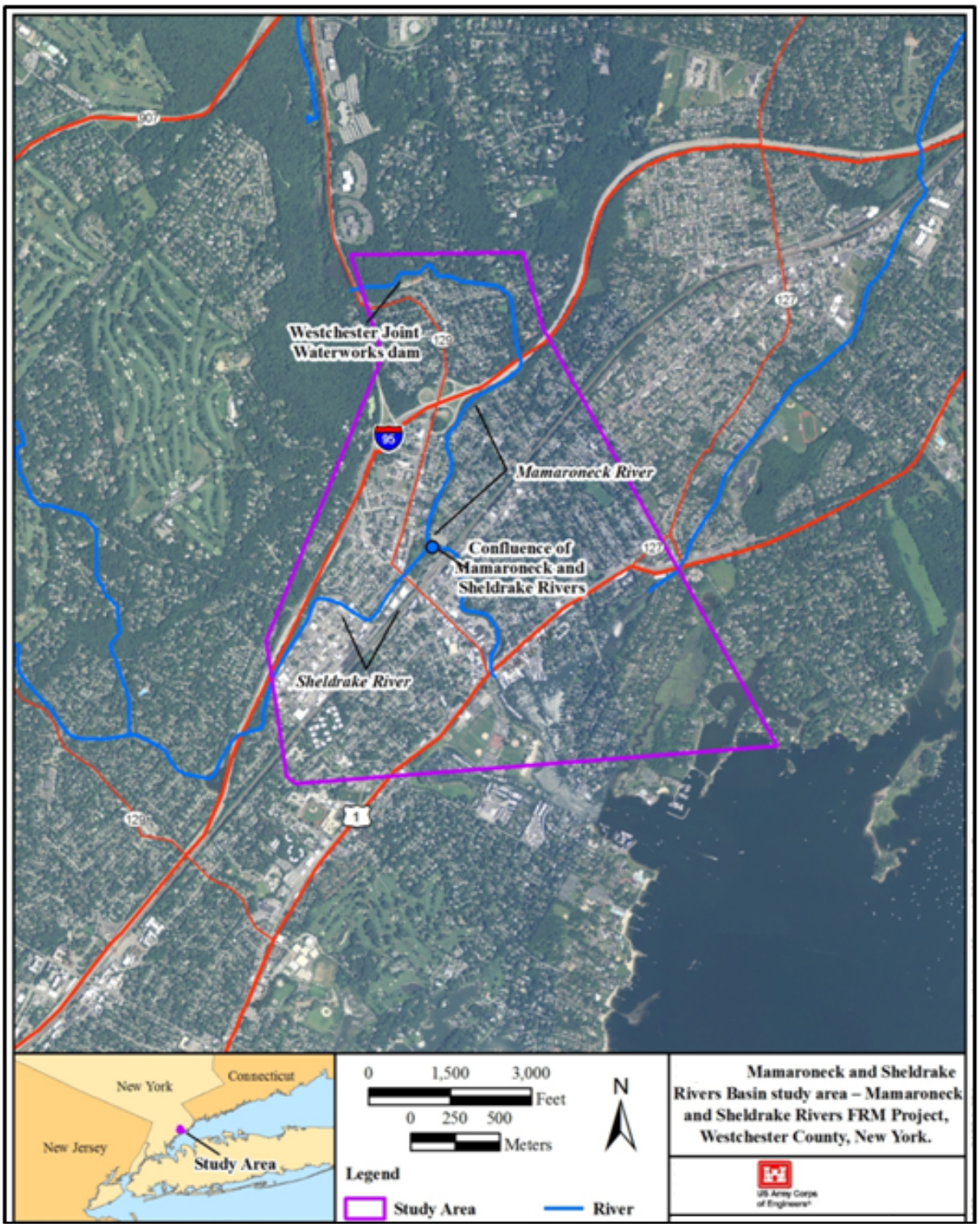

Figure 1 - Mamaroneck & Sheldrake Rivers Basin Study Area

2. PRIOR STUDIES AND PROJECTS

2.1 Prior Studies

The Feasibility Study, completed in October 1977, recommended a plan (National Economic Development Plan or NED plan) of protection on the Mamaroneck and Sheldrake Rivers at the Village and Town of Mamaroneck consisting of channel modifications, levees, retaining walls and a diversion tunnel. This plan consisted of the total diversion of the Sheldrake River at Fenimore Road that would reduce the flood risk in the worst damage area, near the confluence of the Mamaroneck and Sheldrake Rivers. Additionally, the recommended plan included a reduction in channel width on the Mamaroneck River from 70 feet to 60 feet and a deeper bottom cut. Furthermore, the recommended plan included the construction of levees for 300 feet along the Sheldrake River near the Thruway. As authorized, this project had an estimated cost of $68.5 Million (approximately $156 Million in 2015 dollars). The project recommended in the feasibility report was authorized for construction by Section 401(a) of WRDA 1986.

The General Design Memorandum was completed in 1989, with the detailed design providing for modifying approximately 10,400 feet of river channel, constructing about 7,200 feet of retaining walls, replacing six bridges, and the removal of one bridge on the Mamaroneck River. On the Sheldrake River, modifications include a diversion tunnel 3,550 feet in length from its inlet at Fenimore Road to the west basin of Mamaroneck Harbor, channel modification along approximately 4,200 feet, and a retaining wall for approximately 900 feet (Figure 2). The 1989 GDM documented the plan as providing approximately a 200-year level of protection along the Mamaroneck River and the lower Sheldrake River and a Standard Protection Flood (SPF) level along the middle of the Sheldrake River. The developed project in the 1989 GDM had an estimated first cost of $67.1 Million (approximately $156 Million in 2015 dollars)

Previous reports on all or part of the Mamaroneck and Sheldrake River Basins are described below. Several of the reports investigated flood control improvements along the same reaches of the Mamaroneck and Sheldrake Rivers which are considered in this report. All of these reports were reviewed as part of this study. Please refer to Appendix A for a chronology of events that also includes a synopsis of prior studies and reports.

2.2 Prior Studies and Reports

A *Preliminary Examination Report on the Mamaroneck and Sheldrake Rivers and Bridges in the Village and Town of Mamaroneck and Town of Harrison* was completed by the New York District on August 14, 1942. This report was marginally favorable and recommended further study in the form of a survey report. However, the Survey Report, which was subsequently completed and submitted to Congress on December 9, 1948, was unfavorable.

A *Survey Report for Streams in Westchester County* completed by the New York District in May 1968 considered local protection works at the Village of Mamaroneck consisting of channel modifications with walls and levees along the Mamaroneck and Sheldrake Rivers. The study was favorable; however, the Board of Engineers for Rivers and Harbors returned the report to the District for reconsideration. Restudy indicated the considered project was not economically feasible.

A reconnaissance report was completed in April 1973 that considered channel improvements along the Sheldrake River in the Town of Mamaroneck consisting of a reinforced concrete flume. The report was

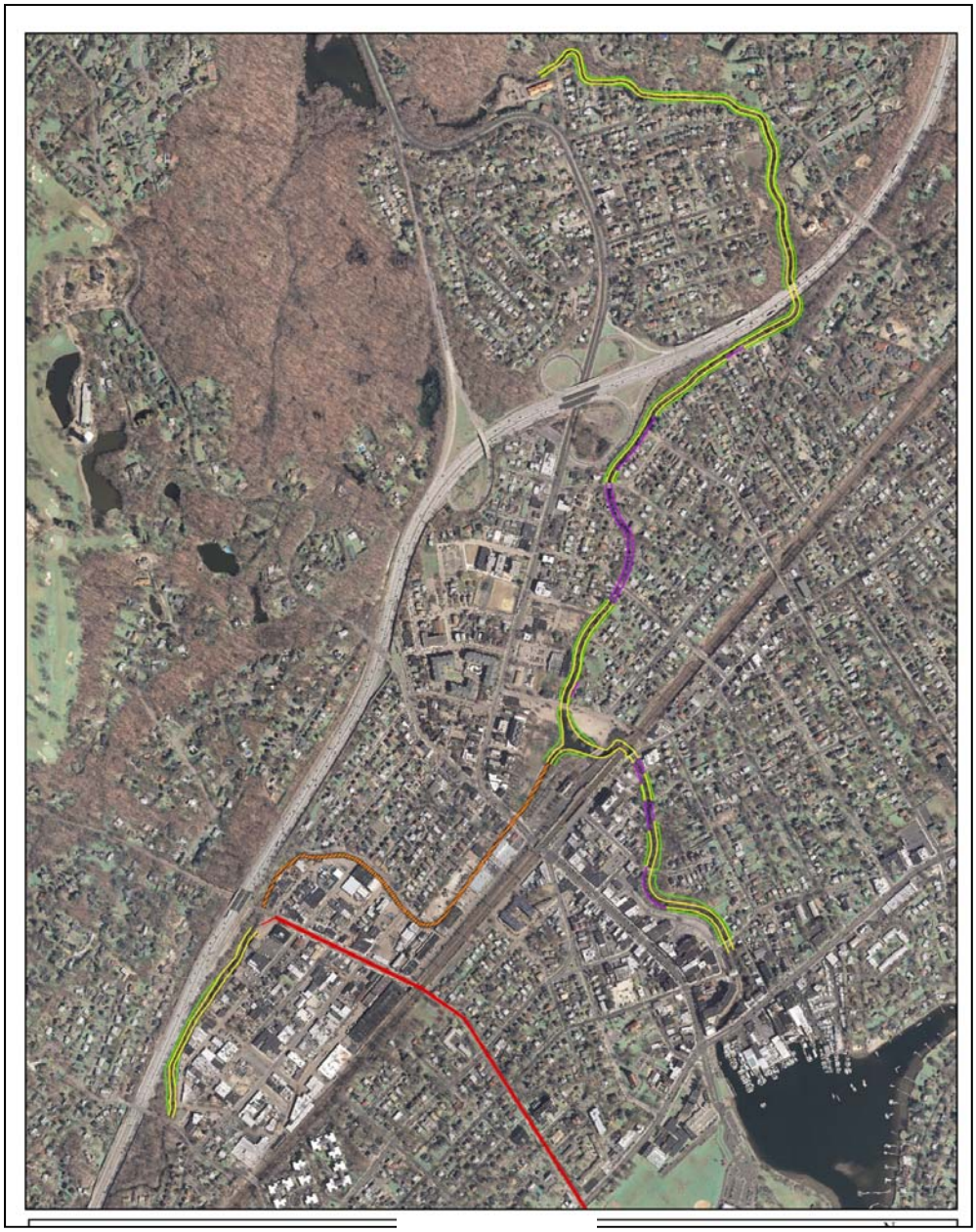

Figure 2 - Plan of Improvement based on the 1989 GDM for Mamaroneck and Sheldrake Rivers Basin.

favorable, however, the cost apportioned to Federal interests was in excess of the small project authority limitation, and further study was recommended under the Westchester County Streams Survey authority.

Following the disastrous floods of June 1972 and September 1975, local interests again requested Federal assistance. On April 22, 1976, the Chief of Engineers granted approval for the preparation of an interim report for the Mamaroneck and Sheldrake Rivers under the Westchester County Streams Survey Investigation. The feasibility report recommended a combination of channel widening and deepening, retaining walls, stream realignment, bridge replacement and enlargement, levees, and a diversion tunnel. The recommended plan for Mamaroneck and Sheldrake was economically favorable, and the project was

recommended for further development along with flood risk management projects for the Town of Mamaroneck and for the Byram River.

The Board of Engineers for Rivers and Harbors (BERH) transmitted the Feasibility Report to the Chief of Engineers on July 12, 1978. He supported the plans for the Village of Mamaroneck and for the Byram River but the Board recommended deletion of the plan for the Town of Mamaroneck due to Corps policy which deemed the problem area as local drainage and therefore a local responsibility.

The General Design Memorandum (GDM) was completed for the Mamaroneck and Sheldrake Rivers Basin (Village of Mamaroneck) project in 1989. However, this project was not constructed due to concerns relating to costs, separable element justification and concerns of the non-Federal partners and other local interested parties.

2.3 Other Corps of Engineers Reports

Navigation Survey Report for the East Basin of Mamaroneck Harbor at the lower estuary of the Mamaroneck River was developed. This report resulted in the authorized Federal navigation project. The first phase of the project completed 1933 was for an entrance channel and anchorage area in the east basin of the Mamaroneck Harbor to 10 feet below mean low water. In 1939 the project was extended to the west basin including an entrance channel and an anchorage area to a depth of six (6) feet. An additional six (6) foot deep anchorage area was completed for the East Basin in 1966.

An *Interim Survey Report on Hurricane Study of Westchester County, New York along Long Island Sound*, was submitted to Congress on November 29, 1967. This report recommended that no improvements designed to protect the shoreline areas of Westchester County, New York along Long Island Sound against tidal inundation be authorized at that time. Additionally, Part Two, Chapter XXXIX (unpublished) of the report *Land and Water Resources of the New England - New York Region*, (Senate Document No. 14, 85th Congress, 1st Session), prepared by the New England-New York Inter-Agency Committee, includes a brief history of hurricane occurrences in this region, a description of the hurricane problem, and a general discussion of methods of reducing damages.

2.4 Reports by other agencies

A report on flood conditions on the streams in Westchester County, including the Mamaroneck and Sheldrake Rivers, was submitted to the Westchester County Board of Supervisors on Storm Water Control on November 27, 1945. Major flood relief measures considered in this report included: (a) channel improvements along the Mamaroneck and Sheldrake Rivers in the Village of Mamaroneck, (b) the diversion of flood flows from the Mamaroneck and Sheldrake Rivers in the Village of Mamaroneck, and (c) flood detention along the Mamaroneck River at the Westchester County Joint Water Works (WCJWW) Reservoir, along the Sheldrake River at Larchmont Reservoir #2 and on the East Branch of the Sheldrake River. This report recommended that a project consisting of channel improvement in the Village of Mamaroneck in combination with upstream flood detention be adopted to control floods along the Mamaroneck and Sheldrake Rivers.

A Reconnaissance Report, entitled *Mamaroneck and Sheldrake River Basins - Analyses of Flood Control studies*, was prepared by Dolph Rotfeld Associates and submitted to the Westchester County Department of Planning in April 1968. This report recommended (subject to further detailed studies) the use of the WCJWW Reservoir, Silver Lake, Larchmont Reservoir, Forest Lake and Spring Lake as flood control facilities in the Mamaroneck and Sheldrake River Basins.

A May 27, 1983 report entitled *Washingtonville Flood Control Project* was prepared by Clarke and Rapuano Inc., consulting engineers to the Village of Mamaroneck. The report recommended a series of staged channel modifications and bridge alterations to reduce flooding along the lower Mamaroneck and lower Sheldrake Rivers. The recommendations were aimed at providing some immediate flood reduction at a much reduced cost when compared to the Federal plan, and was also viewed by the Village as a possible non-Federal contribution toward the larger plan recommended in the USACE's Feasibility Report.

No locally constructed project has been implemented as a result of these reports and investigations.

2.5 Existing Projects

No flood risk management projects exist in the Village of Mamaroneck or in the study area.

2.6 Improvements by Other Federal Agencies

No flood risk management improvements have been constructed by other Federal agencies within the study basin. However, the Village of Mamaroneck has on two (2) occasions received Federal funds for implementing locally-conceived flood management improvements on the Mamaroneck and Sheldrake Rivers. In 1933, using Federal work relief funds, the Village cleared the channels of these streams within its corporate limits. In 1937, using Works Progress Administration (WPA) funds, the channel of the Mamaroneck River was widened to 30 feet and masonry walls were constructed from North Barry Avenue to Jefferson Avenue, a distance of approximately 2,400 feet. The WPA also funded the construction of Hillside Avenue Bridge. Only the middle 1,000 feet of this project centered on Hillside Avenue remained during the period that the 1977 Feasibility Study was being developed, the upper reach having been replaced by a channel relocation required for the construction of the New England Thruway and the lower reach, by channel work done by the Village in 1953 and 1954.

2.7 Improvements by Non-Federal Agencies

Numerous improvements for flood risk management, including considerable channel rectification, have been made throughout the basin. In 1953-1954 the Village of Mamaroneck straightened the Mamaroneck River between Nostrand and Jefferson Avenues and deepened it between Halstead Avenue and a point downstream of the U.S.G.S gaging station weir. The 1977 Feasibility Study noted that this straightening and deepening of the Mamaroneck River resulted in lower stages than would otherwise have prevailed during the substantial floods which have occurred since the completion of this referenced work.

In connection with the construction of the New England Thruway in the early 1950's, the Mamaroneck River channel was improved within the reach of stream extending from the vicinity of the south end of First Street to the Town of Harrison boundary line for a total of 1,800 feet. Wider channels on better alignments were provided and the old low, short-span bridge at North Barry Avenue was replaced with a higher, longer triple-span structure on a new alignment several hundred feet downstream of the old bridge. Also, in connection with the construction of the Thruway, two reaches of channel of the Sheldrake River totaling nearly 3,000 feet in length within the reach of stream extending from the vicinity of Larchmont Gardens Lake to a point 600 feet below Fenimore Road were replaced with wider reaches on better alignments. Additionally, old, low, short-span bridges at Rockland Avenue and Fenimore Road were replaced with higher, longer twin-span structures.

3. EXISTING CONDITIONS

3.1 Physical Setting

The Mamaroneck and Sheldrake Rivers Basin is located entirely in Westchester County and contains portions of the Village and Town of Mamaroneck, the City of White Plains, the Village and Town of Harrison, Village of Larchmont, the City of Rye, North Castle, and the Village of Scarsdale, New York (Appendix D) . The combined watershed of the Mamaroneck and Sheldrake Rivers has a total drainage area of approximately 24 square miles. Delineation of the 500-year floodplain in the Mamaroneck and Sheldrake Rivers Basin indicates the majority of the structures within the floodplain are located in the Village of Mamaroneck.

The Mamaroneck and Sheldrake Rivers Basin is heavily urbanized and developed. The lower reaches of the Mamaroneck and Sheldrake rivers within the Village of Mamaroneck study area consist of low-, medium- and high-density residential neighborhoods as well as varied commercial (retail and office) and light industrial properties. As with most urban rivers, extensive development in the basin, right up to the riverbanks, has resulted in changes in the hydrologic regime and morphology of the rivers. The existing channel side slopes are moderate, ranging from one vertical to one horizontal (1:1), to one vertical to three horizontal (1:3), and the river channel bottom has a moderate slope, approximately 12 ft per mile (USACE New York District 2011a).

The Mamaroneck River is a natural stream with perennial flow that runs from north to south within the study area. The Mamaroneck River enters the northern portion of the study area southeast of the dam at WCJWW. The river continues east and then south under several road crossings and pedestrian bridges before it empties into the East Basin of Mamaroneck Harbor. The river has moderate meander and is confined by rock retaining walls for much of its length. Within the study area, the Mamaroneck River ranges in width from 30 to 50 ft (water and bank), and in depth from approximately 20 inches (in.) to more than 36 in. in pools. The majority of the Mamaroneck River riparian corridor has been reduced to narrow bands of mature trees and shrubs on either side of the river; the overbank area downstream of the confluence is more vegetated and contains a large amount of loose rocks. The only remaining significant cluster of trees is immediately downstream of the WCJWW dam on the northern bank of the river. Works Project Administration-era and other retaining walls have been constructed along most of the Mamaroneck River, further decreasing the riparian habitat. Invasive plant species have developed along the riverbanks (USACE New York District 2012a).

The Sheldrake River is a natural, perennial stream that flows northeast within the study area. The Sheldrake River enters the southwest portion of the study area at the I-95 underpass. The river continues northeast under several road crossings and pedestrian bridges before it empties into the Mamaroneck River at Columbus Park. The river has moderate meander and is confined by rock retaining walls for much of its length. Within the study area, the Sheldrake River ranges in width from 20 to 40 ft (water and bank), and in depth from approximately 10 in. to more than 36. in pools. A few trees remain along the banks but no large mature trees remain. The river has been confined with hardened shores along most of its length in the Village. Invasive plant species have developed along the riverbanks (USACE New York District 2012a). Downstream of the confluence, the overbank areas are highly vegetated with a large amount of loose rocks.

3.2 Socioeconomics

3.2.1 Accessibility

The Mamaroneck and Sheldrake Rivers watershed is located along the northwestern coast of Long Island Sound within the New York City metropolitan area. The Basin lies entirely within Westchester County, New York and contains portions of the Village and Town of Mamaroneck, the Cities of New Rochelle and White Plains, the Towns of Harrison and North Castle, and the Village of Scarsdale.

The project area is comprised of river bank and adjacent properties which include public areas accessible in Columbus Park and private areas flanking residences and businesses. Public access to the river is limited to Columbus Park, which is adjacent to Metro North rail service. Various county and state roads, including I-95, provide access and emergency evacuation to and from the study area.

3.2.2 Population and Housing

The 2010 U.S. Census data indicates that the population of the Village of Mamaroneck is 18,929, the number of households is 6,998, the population density is 5,971.3 people per square mile, the median income for a household is $85,803, and there are 7,512 housing units (Table 1). The Census data also indicates that the population for the state of New York has increased by 2.1% since year 2000, and Westchester County increased by 2.78%, while the population of the Village of Mamaroneck increased nearly 1%. Because the Village of Mamaroneck is fully developed, future population increase is expected to be negligible. Table 1 compares the Village of Mamaroneck demographics to Westchester County and those of New York State.

Table 1: 2010 Demographics

	New York State	Westchester County	Village of Mamaroneck
Population (2010 census)	19,487,053	949,113	**18,929**
Population *	19,651,127	968,802	**19,237**
Area (mi^2)**	54,555	500	**6.7**
Density (ppl/sq-mi)	411.2	2,204.7	**5971.3**
Housing Units*	8,113,270	369,996	**7,693**
Median Value of Housing Units*	**$288,200**	**$518,400**	**$582,800**

**2013 American Community Survey Estimates*
***USGS, Total Area including water area*

3.3 Land Use

The structure inventory for the project area included 225 non-residential structures, 466 single family residential structures, and 12 apartment buildings. Development of the structure inventory is described in greater detail in the Economics Appendix (Appendix D).

3.3.1 Residential.

Residential uses account for the vast majority of the Village's land area. Residential characteristics vary from waterfront estates, suburban developments, apartment houses, townhouse complexes, condominiums, apartments above storefronts, and single- and two-family houses. Older residences were not constructed to minimize flood impacts. Recent housing developments which concentrate many dwellings within smaller footprints have been constructed that comply with flood elevation standards, but which are still threatened with service interruptions and damage to vehicles and utility services during flood events.

3.3.2 Commercial and Institutional.

The largest community and institutional uses within the Village include the water-treatment plant, the Village Hall, Mamaroneck Avenue School, and Mamaroneck High School. The traditional commercial and service core of Mamaroneck was centered along Mamaroneck Avenue between the Boston Post Road and Halstead Avenue. Recent growth has brought commercial uses, such as service and retail to the entire length of Mamaroneck Avenue and the Boston Post Road.

3.3.3 Industrial.

The industrial area of the Village is located in the northwest, bounded by the railway to the south, Fenimore Road to the west, the New England Thruway to the north and Rockland Avenue to the east. This area is located in the M-1 (Industrial) zoning district, and since 1968, residences have been a non-conforming use. Several residential uses remain interspersed among the industrial businesses.

3.3.4 Income and Economy

A summary of the income and economy in the project study area is presented in Table 2.

Table 2: 2010/2011 Income and Economy

	New York State	Westchester County	Village of Mamaroneck
Private Non-Farm Establishments	527,001	31,496	**795****
Private Non-Farm Employment	7,556,521	378,508	**7,902***
Total Number of Firms	1,956,733	120,727	**2,756**
Median Household Income*	$58,003	$81,946	**$85,803**
Persons Below Poverty (%)*	15.3	9.5	**7.4**
High School graduate or higher, % of persons over 25*	85.2	87.6	**87.9**
Bachelors Degree or higher, % of persons over 25*	**33.3**	**44.3**	**51.5**

**2013 American Community Survey Estimates*
***2012 US Census NAICS Business Pattern Data*

3.3.5 Recreation

The Study Area includes several recreational areas which are impacted by inundation during flood events, but the recreational impacts do not qualify as benefit sources for NED purposes.

Columbus Park, located at the confluence of the Mamaroneck and Sheldrake Rivers is a passive park with playground equipment, pedestrian paths and pedestrian bridges over the rivers. The park is adjacent to the train station and commercial areas. During flood events, the park is inaccessible and vehicles within the park are susceptible to damage.

Saxon Woods Park is a 700-acre property offering a variety of recreational facilities at the northernmost extent of the project area. According to Westchester County, the park contains an 18-hole golf course as well as a miniature golf course, the county's largest swimming pool, a children's aquatic playground and picnic areas. It is also the site of the county's only playground that is accessible to the disabled.

A trail system connects the southern section to the northern wooded part of the park, popular with hikers, cross country skiers and horseback riders. The entire system extends along the Hutchinson River Parkway to Twin Lakes Park and north to Maple Moor Golf Course and links to the Leatherstocking Trail and Colonial Greenway. No measures are proposed which will impact the recreational resources or accrue recreational benefits.

3.4 Existing Watershed Conditions

3.4.1 Physical Characteristics

The combined watershed of the Mamaroneck and Sheldrake Rivers has a total drainage area of approximately 24 square miles (Figure 3). The leaflike multi-stem watershed is roughly elliptical shaped, with a maximum length of nine miles in a north-south direction and a west to east width that varies from two to three miles. The terrain is gently rolling, lightly wooded in the upper portion and generally cleared in the lower valley. The ridges extend generally in a north-south direction. Ground elevations range from near sea level at the mouth of the Mamaroneck River to about 500 feet above mean sea level in the northwest corner of the basin.

The Mamaroneck River drains into Long Island Sound at the East Basin of Mamaroneck Harbor. The Mamaroneck Harbor consists of an inner harbor and an outer open harbor, connected by an inlet approximately 350 feet wide. This inner harbor is divided into two basins, East Basin and West Basin, by a projecting land area known as Harbor Island Park. Further, the Mamaroneck River rises downstream of Rye Lake in the northern section of Harrison at an elevation of 520 feet above mean sea level. The river flows generally south for a distance of about 11 miles to Mamaroneck Harbor. The average slope of the Mamaroneck River is approximately 10 feet per mile. The Sheldrake River rises in the northeast portion of Scarsdale at an elevation of 300 feet above mean sea level. The river flows generally south-southeast for a distance of about 7.0 miles and joins the Mamaroneck River at a point about 0.6 miles above its mouth. One major tributary, known as the East Branch, enters the Sheldrake River at a point 1.8 miles upstream of its junction with the Mamaroneck River. The average slope of the Sheldrake River is approximately 25 feet per mile. The average slope of the entire Mamaroneck and Sheldrake Basin is 12 feet per mile.

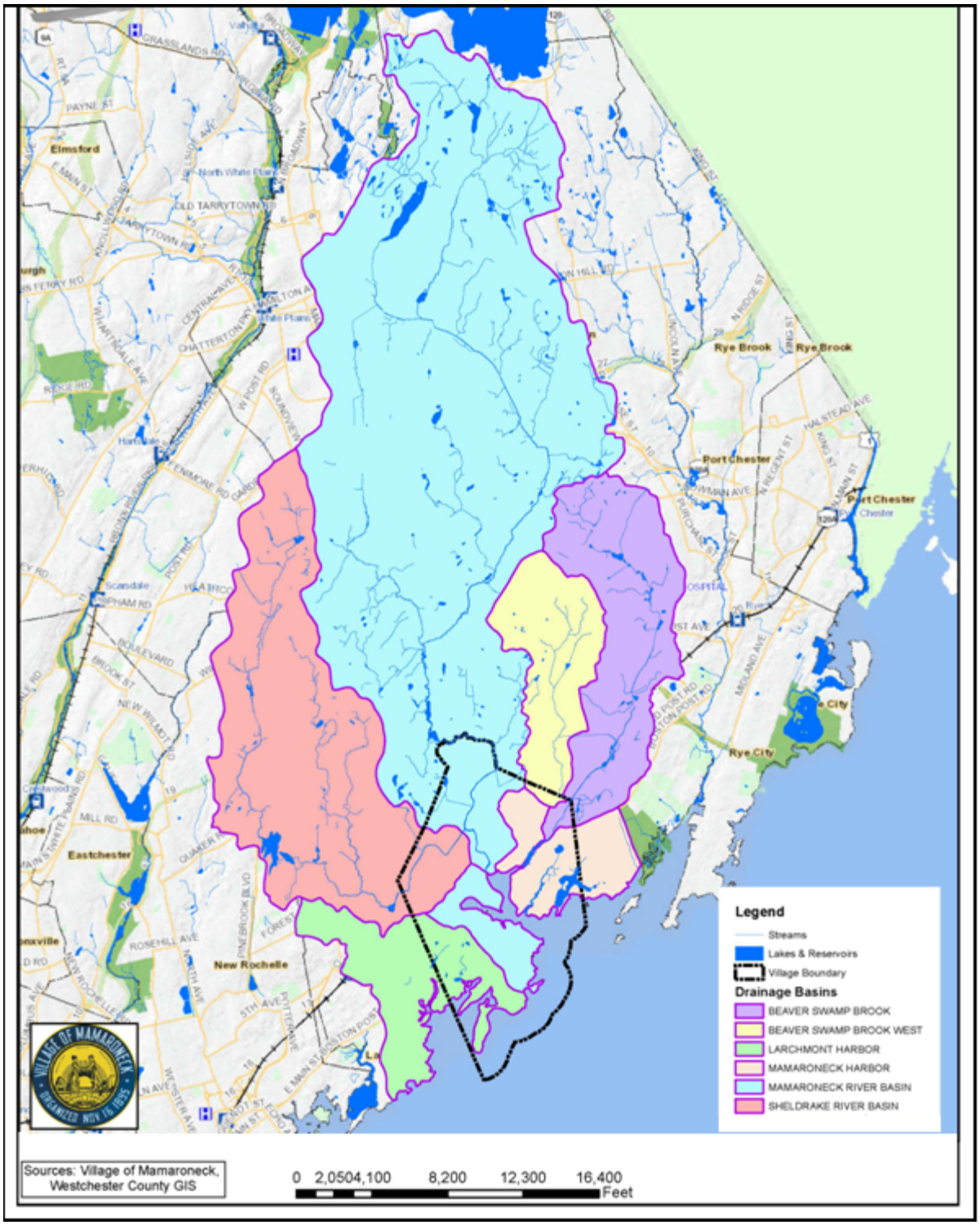

Figure 3 - Mamaroneck/Sheldrake Watershed Map

3.5 Physical Conditions

3.5.1 Geology

The geology of the Mamaroneck and Sheldrake Rivers Basin is composed of gneiss and mica-schist with intercalated beds of coarse-grained dolomitic marble and thin layers of sedimentary beds. These limestone beds were deposited horizontally, compacted, and set on edge. The limestone is relatively soft and has easily eroded as the waterways have carved out the valleys, marshes, and, lakes.

The lower courses of the Mamaroneck and Sheldrake Rivers flow over moderately thin alluvial deposits. Bedrock under the channels and along the valley slopes is of metamorphic origin ranging in age from pre-Cambrian to Ordovician. The alluvial deposits are variable in composition and are predominantly gravelly sand with some boulders and a minor amount of clay and silt. Along the Mamaroneck River channel, bedrock crops out at several localities and it is estimated that its maximum depth below the surface is about 40 feet. Lesser outcrops are observed along the Sheldrake River in its lower course (USACE 1977).

3.5.2 Topography

The topography of the Village of Mamaroneck is part of the coastal plain, with elevations ranging from a high of 120 ft above mean sea level (amsl) in the northern part of the Village to sea level in the south (USGS 1975 and Google Earth 2013). Low hills rise above the generally level to gently sloping plain. Some of these hills have steep slopes greater than 15%. There are extensive low-lying floodplains along the Mamaroneck and Sheldrake rivers and along the coast.

The upland portions of the study area range from approximately 5 to 50 ft at mean sea level (amsl), with generally level to moderately sloping ground. The Mamaroneck River portion of the study area begins in a valley between hills that exceed 100 ft amsl at approximately 45 ft amsl southeast of the WJWW dam (USGS 1975). The Sheldrake River portion of the study area starts at the I-95 underpass at approximately 30 ft amsl. The confluence of the two streams is at approximately 15 ft amsl. The Mamaroneck River drains into Long Island Sound at the East Basin of Mamaroneck Harbor .

Elevations in the upper Mamaroneck River watershed reach approximately 520 ft amsl in Harrison, New York. The upper portion of the Mamaroneck River watershed (upstream and northwest of the study area) includes gently rolling terrain with generally north-south trending ridges (USACE New York District 1989a). The upper portion of the watershed is characterized as lightly wooded. The lower reaches are generally cleared. The Sheldrake River begins in Scarsdale, New York at an elevation of approximately 300 ft amsl. Channel depth varies from 10 to 20 ft in the Mamaroneck River and from 5 to 15 ft in the Sheldrake River. The channel bottom has a moderate slope, approximately 12 ft per mile.

3.5.3 Surficial Geology:

The bedrock is generally overlain by unconsolidated glacial deposits. Hill slopes are covered with varying depths of glacial till (a mix of glacially-deposited clays, sands, rocks, and boulders). Lower-lying areas are typically overlain by stratified drift mixed with more recent alluvial deposits (USACE New York District 1989b, U.S. Department of the Interior 2013).

Previous surveys in the study area characterized the surficial material as moderately thin alluvial deposits that vary in composition and are predominantly gravelly sand with some boulders and minor amounts of clay and silt (USACE New York District 1989b). The *Geological and Soil Investigations* (USACE New York District 1989b) noted that there were occasional layers of silt are found interbedded with the sandy

soils. These layers were usually less than one (1) ft in thickness, except in the vicinity of the confluence of the Sheldrake River where the silt attained a depth of 12 ft and extended below the streambed level. The material in the streambed generally consisted of recent alluvial deposits of sand and gravel with occasional boulders and cobbles in the upstream section. There are bedrock outcrops in several areas along the channel and banks through the proposed alignment. The riverbanks from First Street to downstream of Hillside Avenue are lined with riprap protection and masonry walls.

The general soil profile along the Sheldrake River consists of sand and sand-gravel materials with varying amounts of silt, cobbles, and boulders. Generally, a silty sand and sand layer overlies a layer of sand-gravel material, which is found below the streambed level and above the bedrock. Gneissic bedrock, which is exposed at several areas adjacent to the channel, is generally close to the river bottom. The riverbanks downstream of Fenimore Road were composed of miscellaneous overbank fill and debris to a point in the vicinity of Center Avenue, and below this area the banks were composed of dry masonry walls.

3.5.4 Stream Channel Erosion and Streambed Scour

Lateral streambank erosion (channel widening) and/or streambed downcutting (scour) are typically associated with flood events and can impact slope stability and pose a hazard to nearby structures and utilities. Channel widening is defined as the erosion and subsequent recession of one or both streambanks that widens the channel without changing the channel location. Streambed scour is erosion of the streambed resulting in the development of deep pools and/or the systematic lowering of the channel floor elevation. Streambed scour also may result from the passage of debris flows and debris torrents. As described above, the Mamaroneck and Sheldrake rivers have an extensive history of flooding, as well as significant channel erosion and streambed scour.

3.6 Storms and Storm Types

The storms which occur over the northeastern states have their origins in or near the Pacific and the South Atlantic oceans and may be classified as: extratropical storms, which include thunderstorms, cyclonic (transcontinental) storms and tropical storms, which include the West Indies hurricanes. The extratropical storms, which, due to rapid convective circulation that occurs when a tropical marine air mass is lifted suddenly on contact with hills and mountainous terrain, cause heavy rains, usually in the summer and fall seasons. The thunderstorms, due to rapid convective circulation, usually in July, are limited in extent and cause local flooding on flashy streams. The cyclonic storms, containing transcontinental air mass movements with attendant highs and lows, usually occur in the winter or early spring and are potential flood producers over large areas because of their widespread extent. The West Indies hurricanes, of tropical origin, proceed northward along the coastal areas accompanied by extremely violent winds and torrential rains of several days duration. Other storm types also occur, including Nor'easters, such as the Tax Day Storm of April 2007 and the Ash Wednesday nor'easter of March 1962.

3.6.1 Floods of Record

Until the Tax Day Storm of April 2007, the most damaging flood of record resulted from the storms of 15-16 October 1955, 18-19 June 1972, and 26-27 September 1975. Other floods occurred in October 1877, September 1882, July 1889, October 1903, March 1936, July 1938, September 1938, July 1942, August 1942, September 1944, May 1946, March 1953, August 1955, August 1960, April 1961, Ash Wednesday nor'easter of March 1962, August 1971, September 1974, April 1983 and September 1999 (Tropical Storm Floyd). Flood damages for the June 1972, September 1975 and April 2007 floods are described in the following paragraphs.

3.6.2 June 1972 Flood

During the June 1972 flood, hundreds of residents, employees and school children were evacuated by boats and trucks as the Mamaroneck and Sheldrake Rivers overflowed their banks, inundating local streets and numerous homes and business establishments. Areas inundated in the Village of Mamaroneck from this flood include approximately 107 acres of industrial, commercial and residential property. Along the Mamaroneck River, the flood damage area was located on both banks between Ward Street and First Street. From First Street upstream to the New England Thruway damages were confined to the left bank and in the reach between Chestnut Avenue and the Joint Waterworks Dam; the Village flood damage area lies on the right bank. Along the Sheldrake River the flood damage area was on both banks between the confluence with the Mamaroneck River and Fenimore Road. Between Fenimore Road and the Village line the damage area lies on the right bank.

Also, as a result of this storm, 26 industrial structures, 33 commercial establishments, five public buildings and 207 dwellings were flooded. Columbus Park was completely submerged. The industrial park was inundated to a depth of two feet and many businesses were not able to resume production for a week or more. Hardest hit industrial areas were at the Sealectro Corporation Plant on Hoyt Street, where 60 employees were evacuated, and the Bordow Corporation, located at Mamaroneck and Jefferson Avenues, which had several feet of water in its buildings.

The main floors of many dwellings between Mamaroneck Avenue and the Mamaroneck River were flooded to a depth of one foot. Along Chestnut Avenue basements were flooded to a depth of five feet causing severe content damage. Several homes along Winfield Avenue suffered first floor flooding when the Winfield Avenue Bridge was overtopped.

3.6.3 September 1975 Flood

The flood of September 1975[2] produced stages in the Village of Mamaroneck of approximately 10.15 feet, 0.44 feet higher than those produced during the June 1972 flood. Total flood damages from the September 1975 flood in the Village of Mamaroneck are estimated at $92M (2015 prices). More than 65 percent of these damages were suffered by the industrial and commercial establishments of the village, particularly at the reach along the right bank of the lower Sheldrake River. This flood resulted in stages of up to three feet above the main floors of several of the industries in this reach. Again, the hardest-hit industrial plants along the Sheldrake River included Sealectro Corporation (manufacturer), and also Marval Industries (plastics), Elgene Chemicals, Westchester Light Company and Magnetic Media Corporation (electronics).

Additionally, several industries which were not seriously affected by past floods also suffered damages from the September 1975 flood, including Sockolof Brothers (wood products), Philips Offset Company and Schrier Brothers (paper). The residential areas of the Village were also severely flooded once again during this flood.

3.6.4 April 2007

The April 15-16 2007 nor'easter storm (the Tax Day storm) dropped about three to ten inches of rain on the watersheds within the New York District's civil works boundaries between the early morning of Sunday April 15th, 2007 and the early afternoon of Monday April 16th, 2007, resulting in new flood peaks of record at ten USGS gages in New Jersey, and, in New York, at the USGS gages Saw Mill River at

[2] The September 1975 flood was the flood of record prior to the April 2007 flood.
The 1977 Feasibility Report and the 1989 GDM refer to the September 1975 flood as the flood of record.

Yonkers and, most importantly for the present study, Mamaroneck River at Mamaroneck (Halstead Avenue) New York.

Unlike Tropical Storm Floyd, which broke the summer 1999 drought and fell on dry ground, the April 2007 nor'easter caused as much flooding as it did because it was preceded by the smaller March 1-2 and April 12-13 2007 storms, and, as such, and for other reasons of antecedent soil moisture conditions, fell on saturated ground.

The March 1-2 2007 storm also caused flooding within the Mamaroneck River basin, albeit far less than the flooding resulting from the April 15-16 2007 storm. Total basin rainfall for this storm was estimated at 3.18 inches using rain data from the Dobbs Ferry-Ardsley and Westchester County Airport rain gages. It was estimated to have caused a peak flow of 2680 cfs at the Mamaroneck gage.

A peak flow of 5,340 cfs on April 15, 2007 was estimated at the Mamaroneck gage by hydrologic modeling, and subsequently confirmed by hydraulic calibration to recorded high water marks on the Mamaroneck and Sheldrake Rivers. This is a 100 year flood peak on the current existing conditions peak discharge vs. frequency curve at the Halstead Avenue gage. Total rainfall over the study basin was estimated at 7.90 inches using data from the Westchester County Airport rain gage, and local observations of total storm rainfall at East White Plains and New Rochelle, New York. Damage estimates for the April 2007 storm are well over $50 million.

3.7 Damage Areas

The flood damage areas are located in the Village of Mamaroneck and the Town of Harrison. On the Mamaroneck River, the damage area extends from below Tompkins Avenue upstream to the WCJWW Dam. On the Sheldrake River damages occur from the confluence with the Mamaroneck River upstream to the Village line at the New England Thruway Bridge.

3.8 Climate

The climate of the Mamaroneck/Sheldrake Rivers basin is characteristic of the entire Middle Atlantic seaboard. Marked changes of weather are frequent, particularly during the spring and fall. The winters are moderate in temperature and snowfall. The summers are moderate with hot sultry weather with the potential for frequent thunderstorms. Rainfall is moderate and well distributed throughout the year. The average annual temperature is 52 degrees Fahrenheit at the Village of Mamaroneck, with extremes from 11 degrees Fahrenheit below zero to 105 degrees Fahrenheit above zero. Prevailing winds are from the northwest, with an annual average velocity of 10 miles per hour at Mamaroneck.

The average annual precipitation in the Mamaroneck and Sheldrake Rivers Basin is approximately 44.2 inches. The observed extreme annual values were 66.98 inches at the Bedford Hills, NY precipitation station in 1901, and 25.83 inches at the White Plains Maple Moor, NY precipitation station in 1965. The monthly extremes are 16.64 inches in October 1955, and a trace in November 1917, at the Bedford Hills, NY precipitation station. The distribution of precipitation throughout the year is fairly uniform, with higher amounts occurring during the summer months. The average annual snowfall recorded at Scarsdale, NY, is approximately 39 inches, with a water equivalent of four (4) inches.[3]

[3] Precipitation data provided from the 1989 GDM

3.9 Hydrology and Hydraulics

The complete discussion of the hydrology and hydraulics of the Mamaroneck and Sheldrake Rivers Basin can be found in Appendix C. A summary is presented below.

3.9.1 Hydrological Existing Conditions

While excessive rainfall does contribute to flooding, flooding events are caused by a number of variables, only one of which is rainfall. Conditions such as the amount of impervious cover in the watershed, the degree to which soils are already saturated at the time of the storm, whether there is snow on the ground or whether the ground is frozen, all play a role in flooding. For these reasons, a 100-year, 24-hour rainfall may not necessarily cause a 100-year flood. In addition, the 100-year rainfall event is calculated largely using regional data sources and predictive modeling programs and is presented as the total inches of rainfall in a variety of time periods such as 1-hour, 6-hour, 12-hour, 24-hour (the 24-hour period is often used as the default). The hydrologic analysis conducted for this study was based on observations at existing river gauges within the study area during storm events, providing a much higher data resolution and level of accuracy. This data was used to produce accurate peak flows to determine the level of protection and water surface elevation that the selected plan will provide for a 100-year flood event. While this may differ from methodologies used by other federal agencies, this yields more accurate results than similar analyses prepared using only rainfall data. The data and model used in this study may be used by non-federal partners for purposes such as submission of a request to FEMA for revisions to the Flood Insurance Rate Maps for the study area.

The hydrologic analysis for existing conditions included data gathered from peak discharge records, average discharge, storm types, and the storms of water years 1990 through 2010. The storms for water years 1990-2010 are of concern, because these storms occurred after the gage at Halstead Avenue (the Mamaroneck gage) was discontinued at the end of water year 1989, downstream of Halstead Avenue, the major calibration point of the hydrology of this study.

Analysis indicated that the seven most important storms of these water years are those of May 17 1990, April 16 1996, October 19 1996, September 15-15, 1999 (Tropical Storm Floyd), September 8 2004, October 7-16 2005, and the “Tax Day” 2007 nor’easter storm of April 15-16 2007. This last important storm resulted in the current largest historic flood to date in the Mamaroneck and Sheldrake Rivers Basin.

The hydrologic modeling procedure of the current effort is both a continuation and an update of the hydrologic modeling that was done for the 1989 GDM. The update included an uploading of the HEC-1 model used for the 1989 GDM to the current hydrologic computer program HEC-HMS. Other updates include percent impervious area values, storage-discharge data, flood frequency analysis of the USGS gage on the Mamaroneck River downstream of Halstead Avenue, and the hydraulic model was calibrated to high water marks for the largest historic flood.

The quality and accuracy of the hydrologic model from the 1989 GDM was verified by using it to reproduce two historic floods that had occurred since the completion of the hydrology of the 1989 GDM; those of July 1984 and May 1989. The April 15-16 2007 flood was also reproduced and confirmed by the hydraulic model’s calibration to its high water marks

The flood frequency analysis of the USGS gage on the Mamaroneck River downstream of Halstead Avenue had to be updated from the 1989 GDM. The methodology for this update is included in detail in Appendix C1-Hydrology. The result was a homogeneous sample of annual peak discharges, representing

current hydrologic conditions, from which an accurate and valid existing conditions peak discharge vs. frequency calculation was made.

The existing conditions peak discharge vs. frequency curve for water years 1938, and 1944 through 2010, for the long term USGS gage Mamaroneck River at Mamaroneck at Halsted Avenue was computed. The hydrologic model of the Mamaroneck and Sheldrake Rivers basin was calibrated to this peak discharge vs. frequency curve. This was performed to compute existing conditions specific-frequency hypothetical peak discharges throughout the basin, including the locations at which flood risk management measures are proposed.

Floods modeled included the historic April 2007 flood, and the hypothetical 1, 2, 5, 10, 25, 50, 100, 200, 250 and 500 year floods. The Standard Project Flood was also modeled. A comparison was made between the current existing conditions peak discharge vs. frequency curve at the Mamaroneck gage and the frequency curve in the 1989 GDM (Table 3). The differences between the two curves are documented and explained, as provided in Appendix C1 along with the reasons why the current frequency curve is an improvement over, and more accurate than, the frequency curve in the 1989 GDM.

Table 3: Comparison of Peak Discharges (1989 GDM vs. Current GRR)

Frequency	Peak Discharge from 1989 GDM (cfs)	Peak Discharge from current GRR (cfs)
1-year	1230	1620
2-year	1680	2140
5-year	2300	2870
10-year	3000	3370
25-year	3980	4150
50-year	4950	4740
100-year	6000	5350
200-year	7100	5990
250-year	7500	6200
500-year	9050	6860
SPF	9580	10130

3.9.2 Existing Conditions Hydraulics

The Mamaroneck and Sheldrake Flood Risk Management Project area is primarily within the Village of Mamaroneck in the County of Westchester, New York. The hydraulic study extends a distance of 2.5 miles from the mouth of Mamaroneck River upstream to the WCJWW Dam. The study also extends a distance of 1.0 mile along the Sheldrake River from its confluence with the Mamaroneck River upstream for to the I-95 Bridge. The hydraulic model limits are defined by flood damage areas located in the Village of Mamaroneck and the Town of Harrison, NY. Along the Mamaroneck River, the model area extends from below the Rt. 1 Bridge to above the WCJWW Dam. On the Sheldrake River, the model extends from the confluence with the Mamaroneck River to the Village boundary at the New England Thruway (I-95) Bridge.

3.9.3 Existing Channel

The project reach on the Mamaroneck River is 2.5 miles in length and contains several major bends. The channel side slopes are moderate and vary from five to 15 ft in height. The channel bottom has a moderate slope, averaging 12 ft per mile, and varies in width from 20 ft at the upstream end to 55 ft at the mouth. The mouth of the Mamaroneck River is a short steep reach subject to some tidal inundation (Tompkins Avenue Bridge). The upstream reaches are subject to fluvial inundation only. The Sheldrake is a major tributary of the Mamaroneck River with its confluence about 3,500 ft upstream of the mouth of the Mamaroneck River, as shown in Figure 4 and Figure 5.

The Sheldrake River is narrower than the Mamaroneck River with steeper side slopes. The Sheldrake River is not subject to tidal inundation because it discharges into the Mamaroneck River upstream of the tidal reach. The length of the Sheldrake River in the study area is about 1.0 mile.

3.9.4 Present Flooding Problems

Periodic storms have caused severe flooding along the Mamaroneck and Sheldrake Rivers. Floods are fluvial for Sheldrake River and most of Mamaroneck River. There is a possibility of tidal flooding along the downstream area of Mamaroneck River. Flooding along the Mamaroneck River is caused by low channel capacity; two 90 degree bends forming an “S” turn at the Railroad Station just downstream from the confluence between the Mamaroneck and Sheldrake Rivers (see Figure 4). Other constrictions at Tompkins, Valley Place and the Halstead Avenue Bridges are the cause for frequent inundations in the downstream reach of the Mamaroneck River and the confluence with Sheldrake River. Flooding along the Sheldrake River is due to a low channel capacity and the backwater effect from the Mamaroneck River.

The hydraulic analysis of the Mamaroneck and Sheldrake Rivers is based on a steady state numeric model using the Hydraulic Engineering Center, River Analysis System (HEC-RAS). The existing conditions HEC-RAS mode*l of the study area was divided* into three hydraulic reaches: Mamaroneck Upstream, Mamaroneck Downstream, and Sheldrake. A total of 176 channel cross-sections, 21 bridges, and two dam structures were surveyed and used in the HEC-RAS hydraulic model.

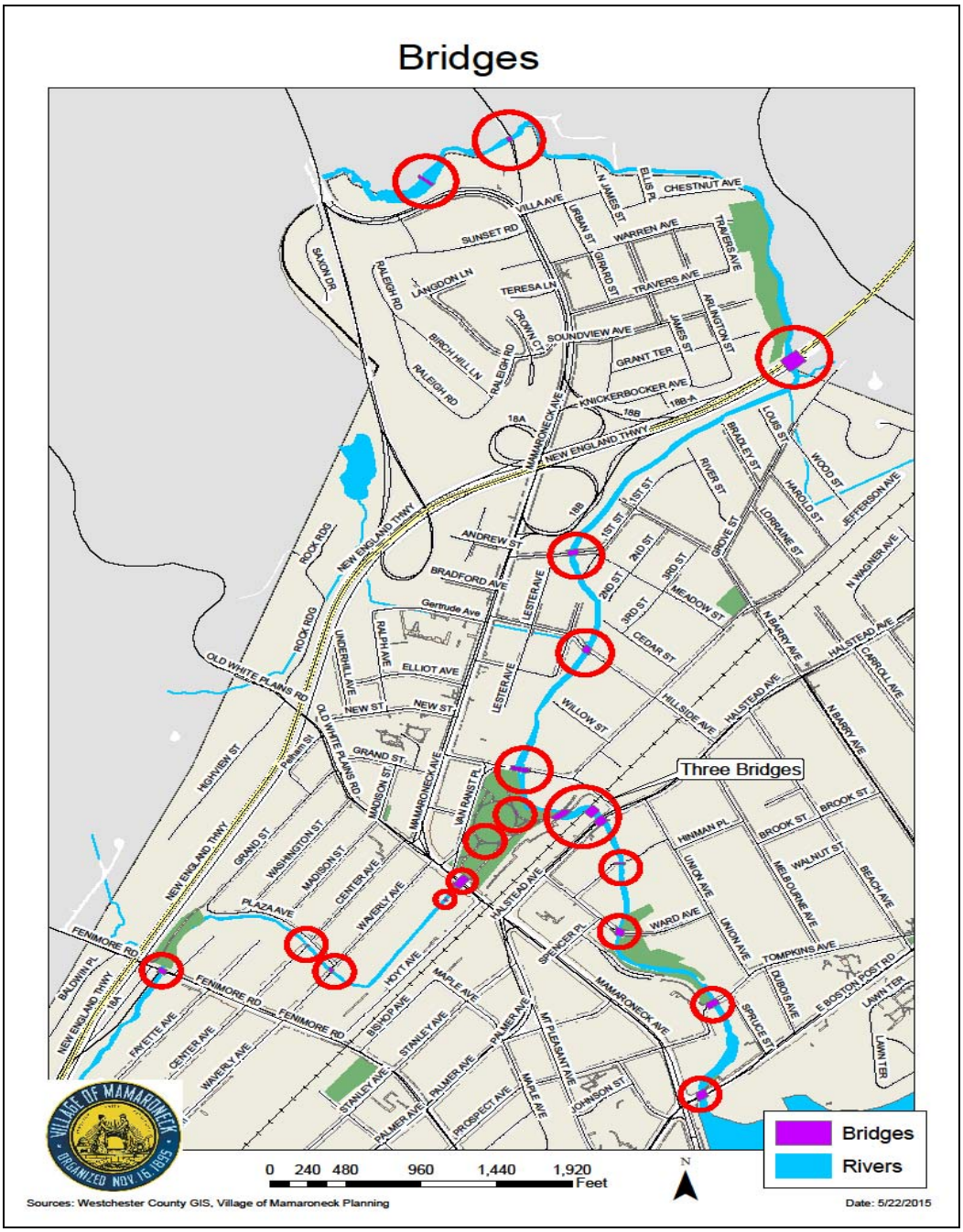

Figure 4 - Mamaroneck River - two 90 degree bends forming "S" shape

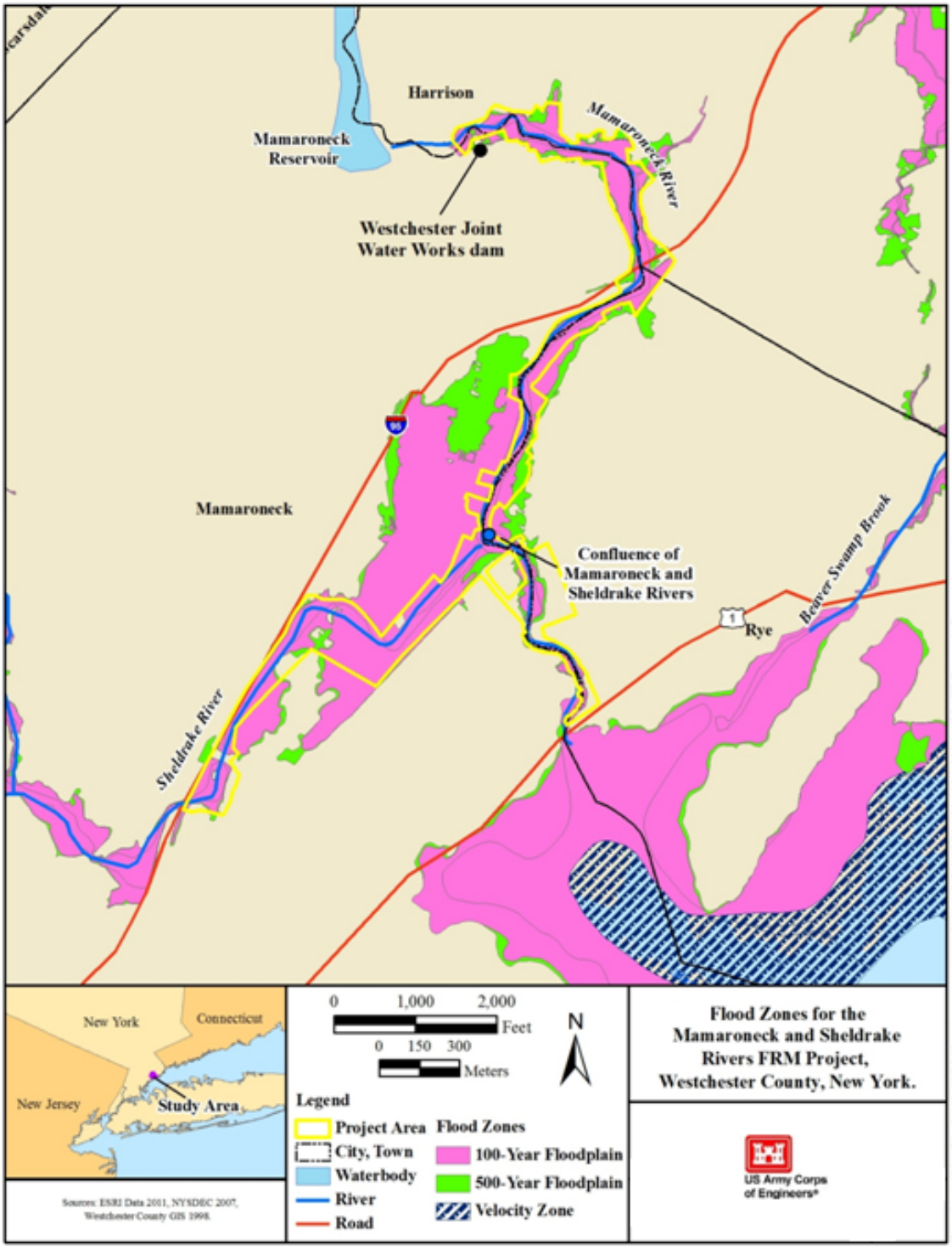

Figure 5 - Village of Mamaroneck– 100 and 500 year flood plain map.

The nor'easter storm of April 15 2007, roughly a 100-year event in this area, was used to calibrate the steady state HEC-RAS model. The calibrated HEC-RAS model of the Mamaroneck and Sheldrake Rivers was used to determine the WSEL for the 1, 2, 5, 10, 25, 50, 100, 250, and 500-year frequency events. Since the Mamaroneck River flows into Long Island Sound a Tidal-Fluvial correlation was performed to analyze the harbor elevations that may occur due to tide and surge during a typical fluvial event. Based on the Tidal-Fluvial correlation and hydraulic analysis, a weak correlation between the low frequency tidal and fluvial events was found. Also, the influence of high tides during fluvial events on the Mamaroneck River does not extend beyond Tompkins Avenue Bridge. The area just downstream of the confluence between the Mamaroneck and the Sheldrake River, which includes the Station Avenue Bridge, Metro North Railroad Bridge and the Halsted Avenue Bridge, is causing considerable losses and high water surface elevations. The small flow capacity of the channel bends through the bridges and the small size of the Halstead Avenue Bridge are key reasons for the frequent flooding in the Village of Mamaroneck.

3.9.5 Existing Channel Description

Based on the hydraulic analysis, the influence of high tides during fluvial events does not extend beyond the Tompkins Avenue Bridge. The existing conditions hydraulic profiles for the Mamaroneck River are shown in Figure 6 and Figure 7. Note that the reach of the Mamaroneck River downstream of the confluence is characterized by water surface elevation (WSEL) in a step-like pattern caused by the bridges and channel contraction. This pattern serves as an impediment to tide controlled floods in the lower reach of the Mamaroneck River, but also indicates that the bridges and channel contractions are causing upstream flooding. Flood "pools" upstream of Tompkins Avenue Bridge, Ward Avenue Bridge and Valley Place Bridge are caused by backwater due to the bridges small size openings and utility pipes under the low cords. Poorly designed wing walls and ineffective transitions from the channel to the constrictions of the bridges are also a cause for floods in this area. At the Valley Place Bridge, the upstream left side wing wall was constructed towards the center of the channel about 10ft upstream the face of the bridge, thereby obstructing the flow and causing a jump in WSEL of approximately 0.25 ft for the 100-year event. High velocities downstream of Tompkins Avenue Bridge exist due to a steep channel bed slope and channel bends; possible scouring is expected during low tides and significant fluvial events. The area just downstream the confluence between the Mamaroneck and the Sheldrake River, which includes the Station Avenue Bridge, Metro North Railroad Bridge and the Halsted Avenue Bridge, is causing considerable losses and high water surface elevations.

The small flow capacity of the channel bends through the bridges and the small size of the Halstead Avenue Bridge are key reasons for the frequent flooding in the Village of Mamaroneck. The constriction caused by these three bridges and the "S" shaped channel is causing the most extensive flood "pool" leading to significant flood damages and creating back water upstream of the confluence and into the Sheldrake River (Figure 8). The effect on the Sheldrake River extends upstream to the Rockland Avenue Bridge for large flood events. Floods in the upstream section of the Mamaroneck River are caused mostly by poor channel capacity, channel bends and thick vegetation in the overbanks. The Glendale Avenue and the Winfield Avenue Bridges obstructions also cause upstream flooding in this reach of the Mamaroneck River.

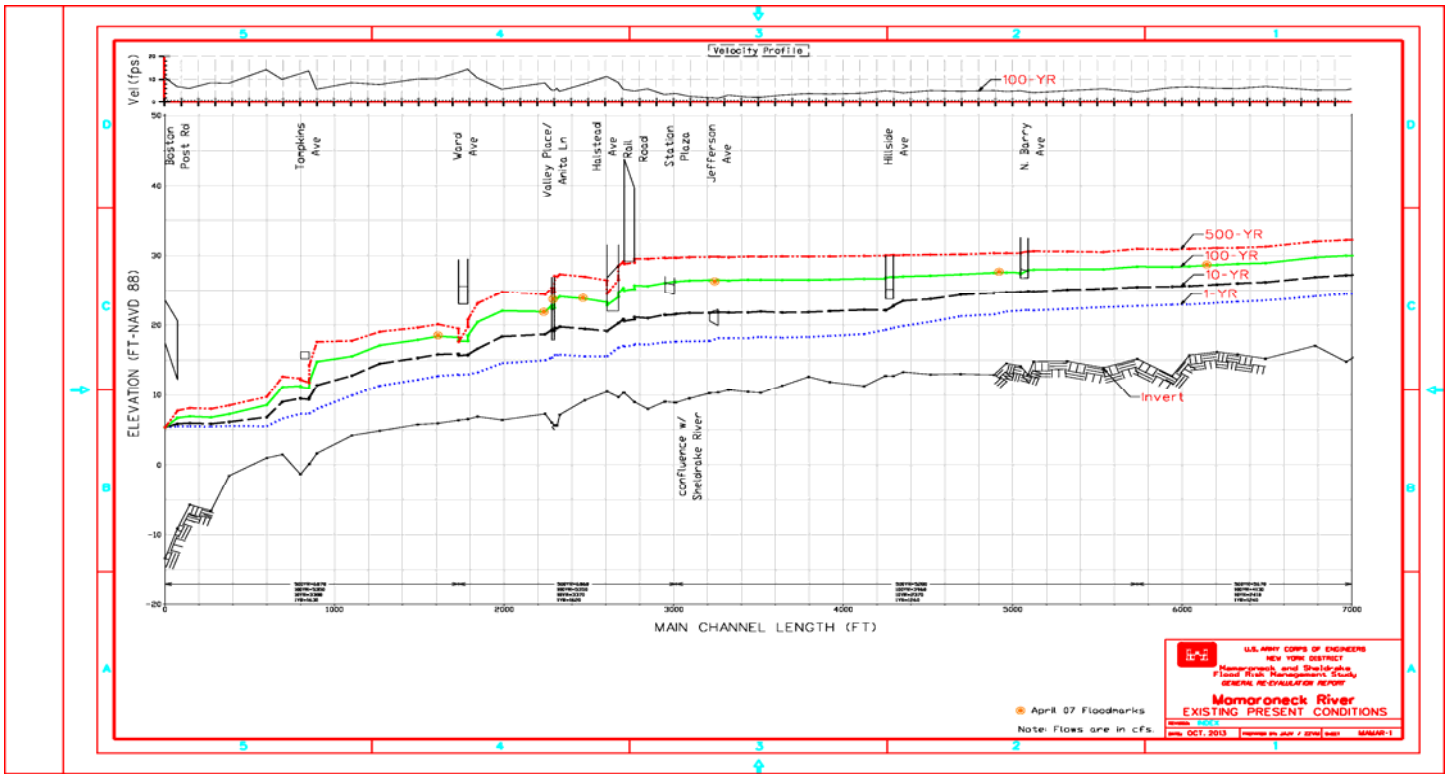

Figure 6 - Mamaroneck River existing conditions hypothetical event profiles - ExistingCond_Mamaroneck

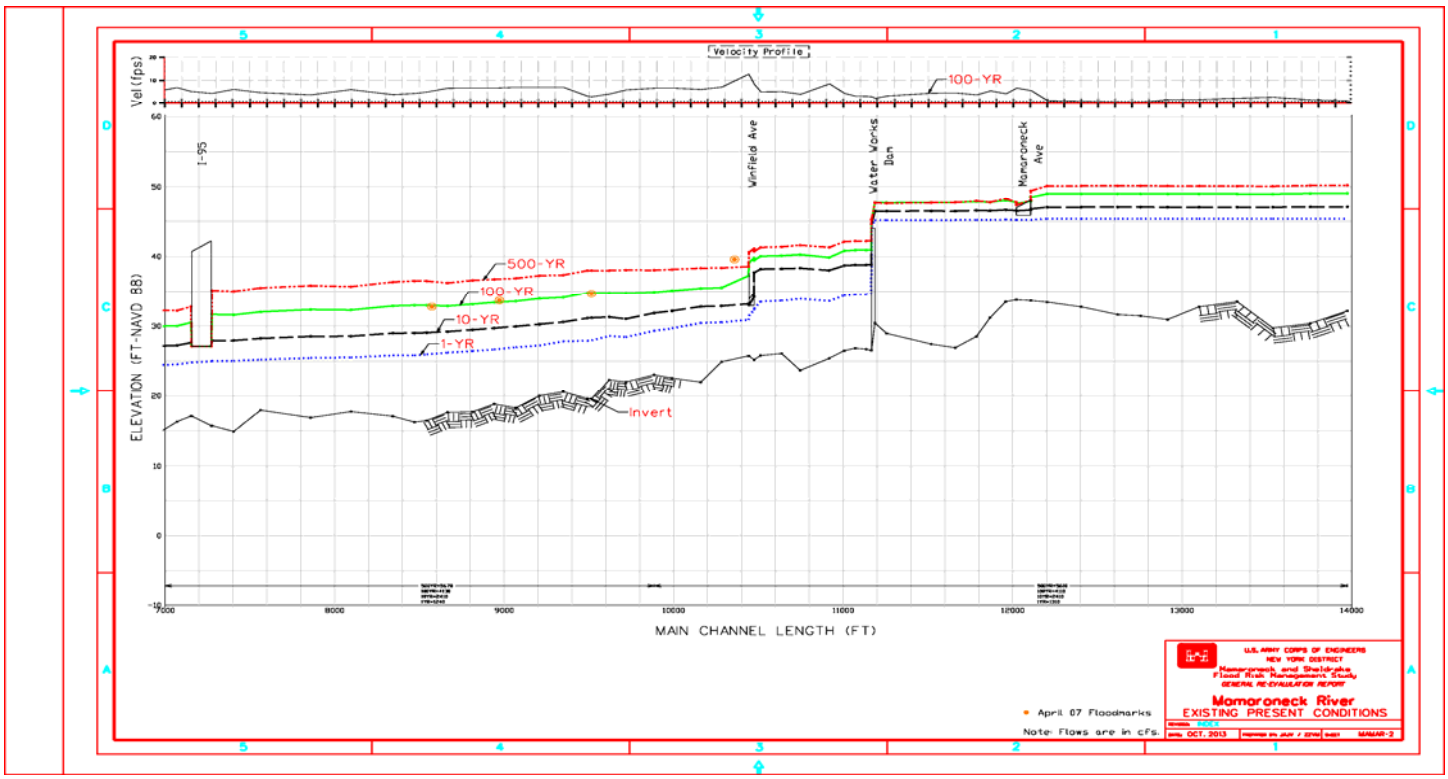

Figure 7 - Mamaroneck River existing conditions hypothetical event profiles- ExistingCond_Mamaroneck2

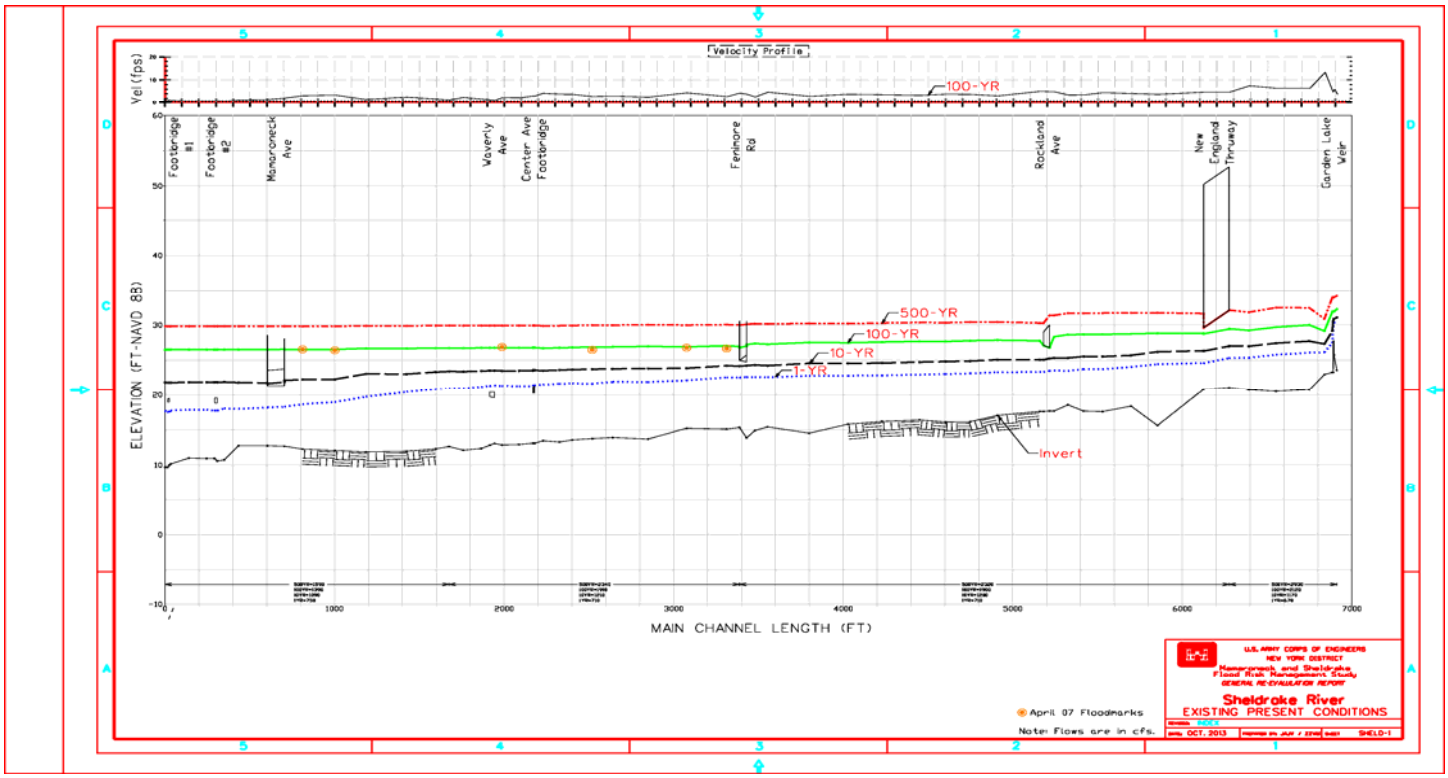

Figure 8 - Sheldrake River existing conditions hypothetical event profiles ExistingCond_Sheldrake

3.10 Land Use & Cover

Community planners have categorized the Village into 11 land use zones, including waterbodies (Figure 9; Village of Mamaroneck 2012b). The combined Mamaroneck-Sheldrake river system crosses nine of these land use categories, five of which are predominant within the study area. The 5 land use categories within the study area excluding *Waterbodies* are:

- ***Residential*** – Residential land use is the dominant land use in the study area and also accounts for the majority of the Village's land area. Residential use within the Village includes single-, two-, and multi-family residences, apartments, townhouse complexes, and condominiums in a mix of low-, medium- and high-density residential neighborhoods.
- ***Manufacturing/Industrial*** – The Sheldrake River flows along and through the Manufacturing/Industrial zone, which is located on the west side of the Village. This zone includes commercial and light manufacturing, auto-repair shops, wholesale and trucking operations, and warehouses, as well as a few residences. Much of this area lies within the 100-year floodplain.
- ***Commercial/Office – The*** Village has several concentrations of commercial retail and office space (along Mamaroneck Avenue, East and West Boston Post Road, and Halstead Avenue). The Mamaroneck River flows through or alongside a large portion of the central business district. Many of these businesses are in the floodplain.
- ***Transportation/Utilities-*** Both rivers run along the two major transportation corridors that cross the Village: I-95 and the Metro-North Railroad, operated by the Metropolitan Transportation Authority (MTA). I-95, also known as the "New England Thruway," is the major highway between New York City and Boston and is the busiest transportation corridor in the Northeast (Village of Mamaroneck 2012a). The New Haven Line (operated Metro-North Railroad) is a major commuter rail line that offers a 40-minute train ride to Midtown Manhattan and has a busy

station (i.e., Mamaroneck), which is located near the confluence and adjacent to the proposed staging area at Columbus Park. There are several parking areas along the Mamaroneck River near the train station and along Philips Park Road upstream from Tompkins Avenue. This line is known as the busiest commuter line in the nation. Access to the train station is cut-off during storm events.

- ***Open Space*** – There are several parks and open spaces within the study area. The largest, Columbus Park (6 acres), is located at the confluence of the two (2) rivers and is subject to extensive flooding during flood events.

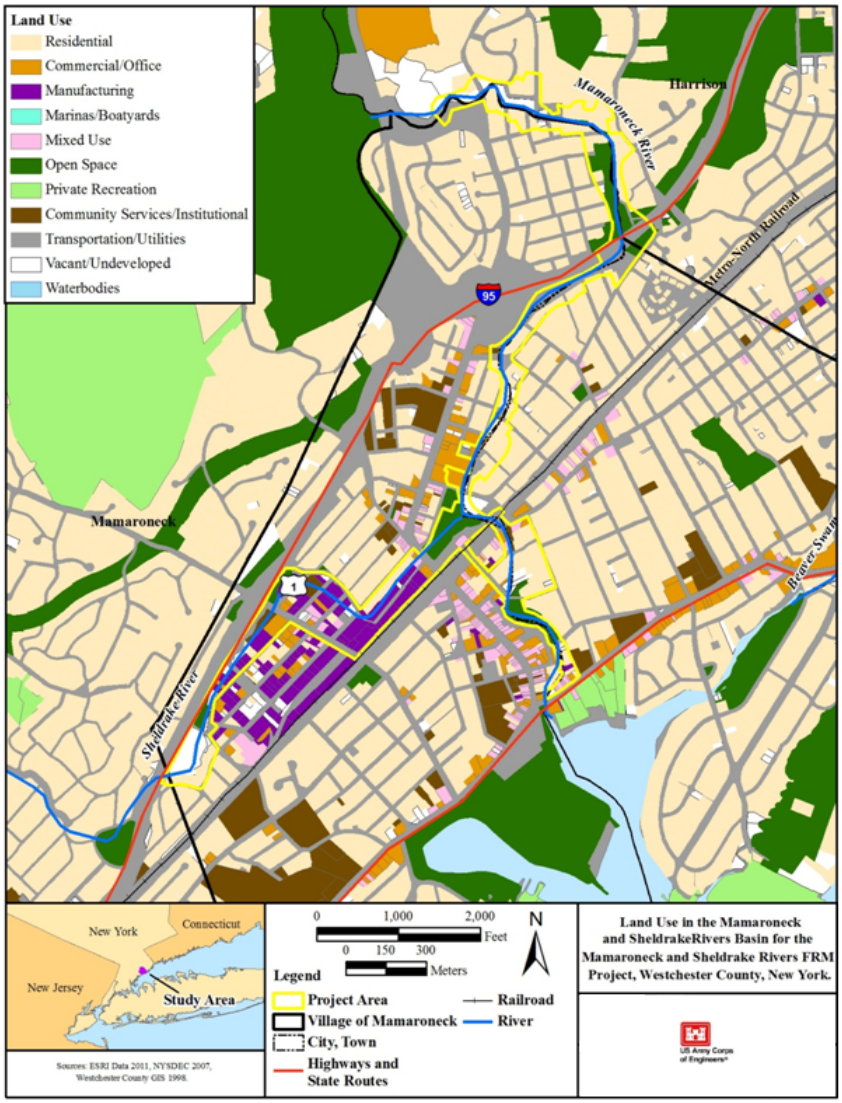

Figure 9 - Land Use in the Mamaroneck & Sheldrake Rivers Basin

3.10.1 Land Cover

The majority of the study area is developed land dominated by structures, roads, and other impermeable surfaces. Many structures, backyards, roads, and developed areas (e.g., parking or storage areas) are constructed or maintained up to the edge of the streambanks. The Mamaroneck and Sheldrake river

channels provide a narrow band of open water and undeveloped riparian areas that wind through the mostly developed residential and commercial areas. The Mamaroneck River riparian corridor can be summarized as a narrow, partially shrub- and tree-lined or open corridor generally 100–200 ft wide. The upper reaches of the Mamaroneck River upstream of I-95 are bordered by more extensive upland and floodplain forests and shrub dominated areas, which include larger stands of riparian forest. The lower reaches of the Mamaroneck are more commonly channelized and bordered by retaining walls.

The Sheldrake River is typically narrower and more constrained by surrounding development. The upper reaches are similarly shrub- and tree-lined, but the lower reaches are more commonly confined to retaining walls with limited riparian habitat and the riparian corridor is less than 50 ft wide. The two rivers are commonly used as physical dividing lines between land use zones. Current use of the channels does not conflict with any of these land uses.

3.11 Noise

The Noise Control Act of 1972 (PL 92-574) directs Federal agencies to comply with applicable Federal, state, and local noise control regulations. In 1974, the USEPA provided information suggesting that continuous and long-term noise levels in excess of DNL 65 dBA are normally unacceptable for noise-sensitive land uses such as residences, schools, churches, and hospitals. The Village of Mamaroneck maintains a noise ordinance that limits construction noise in residential areas to the hours of 8:00 a.m.–6:00 p.m. Monday–Saturday, whereas no construction noise is permitted on Sundays or major holidays (Village of Mamaroneck Noise Ordinance §254-3). The adjacent community of Harrison, limits construction noise to the hours of 7:30 a.m.–8:00 p.m. weekdays, and 10:00 a.m.–8:00 p.m. on weekends and holidays (Harrison Noise Ordinance §177-2.F).

3.12 Biological Resources

3.12.1 Water Classification

Water classification of the tidal portion of the Mamaroneck River (from the mouth extending upstream to East Boston Post Road in Mamaroneck) is classified as Class SC (saline surface waters). The water classification of the portion of Mamaroneck River upstream from East Boston Post Road and the Sheldrake River is Class C (fresh surface waters). Both of these classifications include a best usage of these waters for fishing, and waters that are suitable for fish, shellfish, and wildlife propagation and survival. Water quality of Class SC and C waters shall be suitable for primary and secondary contact recreation, although other factors may limit use for these purposes.

Mamaroneck Harbor is classified as Class SB (saline surface waters), which has a best usage definition of waters used for primary and secondary contact recreation and fishing. Class SB waters shall be suitable for fish, shellfish, and wildlife propagation and survival.

3.12.2 Water Quality

Approximately 53% of rivers and streams located within the Atlantic Ocean/Long Island Sound Watershed have been assessed for water quality by NYSDEC. This assessment included both the Mamaroneck and Sheldrake rivers. Results of the assessment determined that approximately 17% of surface waters within the watershed are of good water quality (fully support designated activities and uses), 13% have satisfactory water quality conditions (fully supports designated activities, but with minor impacts), and 30% have poor water quality (impaired waters that do not support designated activities and uses). The remaining 40% of surface waters of the watershed were not included in the assessment. The primary water quality issue within the watershed is low dissolved oxygen (DO), which can be detrimental to aerobic organisms. Discharge of treated wastewater into the watershed adds nutrients to the system,

which can contribute to the pathogen loads of fresh and saline waters located downstream of their location.

The *Waterbody Inventory for the Western Long Island Sound Watershed* identifies surface waters that do not meet their designated class standards for one or more uses, or are threatened due to poor water quality. The lower segment of the Mamaroneck River is listed on the New York State 2010 Section 303(d) List of Impaired Waters, with the tidal portion of the river (from the mouth upstream to Route 1) classified as impaired for aquatic life and recreation, and stressed for aesthetics. Aquatic life and recreation are impaired in this segment of the Mamaroneck River due to low DO levels and nutrient loads, as well as silt and sediment originating from urban stormwater runoff and other nonpoint sources. Periodic beach closures are associated with heavier rainstorms that can wash pollutants into Mamaroneck Harbor. A 2008 biological assessment of the Mamaroneck River (near Ward Avenue) determined this segment to have poor water quality and not fully supportive of aquatic life.

The Sheldrake River, from the mouth to Upper Larchmont Reservoir, including tributaries, is listed on the New York State 2010 Section 303(d) List of Impaired Waters and is impaired for fish consumption, aquatic life, and recreation. Fish consumption is impaired due to pesticide levels in contaminated sediment. Aquatic life and recreational uses are considered impaired by nutrients as well as silt and sediment loads associated with urban stormwater runoff and other nonpoint sources; however, water quality sampling has not fully documented these impairments. Although the 2008 biological assessment described above for the Mamaroneck River did not include the Sheldrake River, similar water quality impacts are likely associated with this waterbody.

Mamaroneck Harbor is listed on the New York State 2010 Section 303(d) List of Impaired Waters. The 2010 *Waterbody Inventory for the Western Long Island Sound Watershed* identified portions of Mamaroneck Harbor that are impaired for human uses (public bathing and recreation), with other portions identified as stressed for use by aquatic life, fish consumption, and aesthetics.

3.12.3 Wetlands

Relatively few riparian wetlands remain as a result of dense commercial and residential development within the watershed, including a rock retaining wall and riprap that lines much of the length of both the Mamaroneck and Sheldrake rivers. It is estimated that nearly 60% of wetlands that occurred within the Mamaroneck River Watershed have been destroyed (Westchester County 2001). The NYSDEC (1974) Tidal Wetlands Inventory Maps indicate tidal wetlands within the Project area boundary (Figure 10). These tidal wetlands are shown in small areas along the Project area boundary in the East and West basins of the Mamaroneck Harbor and are comprised of: Coastal Shoals, Bars and Mudflats (2010 SM); Littoral Zone (2020 LZ); and Intertidal Marsh (3000 IM). The NYSDEC (2011a) Freshwater Wetland Map does not indicate any wetlands within the Project area boundary. The U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory map indicates a single freshwater wetland within Columbus Park, which is classified as a freshwater pond located at the confluence of the Mamaroneck and Sheldrake rivers (Figure 11) (USFWS Long Island Field Office 2015). Additionally, there are tidal habitats along the East and West basins of the Mamaroneck Harbor classified as estuarine subtidal unconsolidated bottom, subtidal wetlands (E1UBL) (USFWS Division of Habitat and Resource Conservation 2008).

Although small tidal wetlands (i.e., salt marshes) occur to the west of the Project area along the west side of the West Basin of Mamaroneck Harbor, no tidal wetlands were documented within the Project area in the East or West Basin. As in the other sections of the Project area, a vertical seawall and development, including a marina, line the harbor.

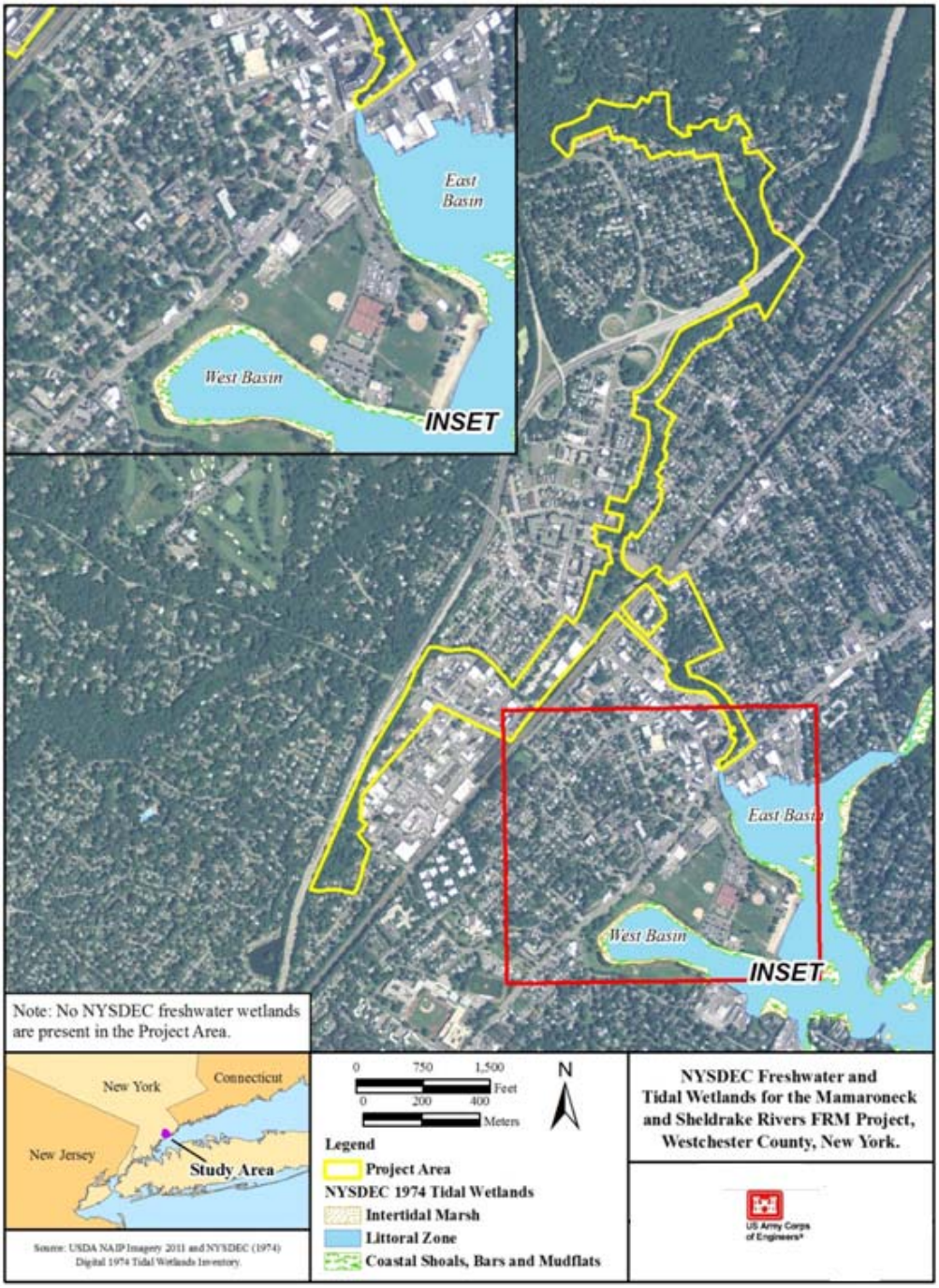

Figure 10 - NYSDEC Freshwater and Tidal Wetlands for the Mamaroneck and Sheldrake Rivers FRM Project, Westchester County, New York.

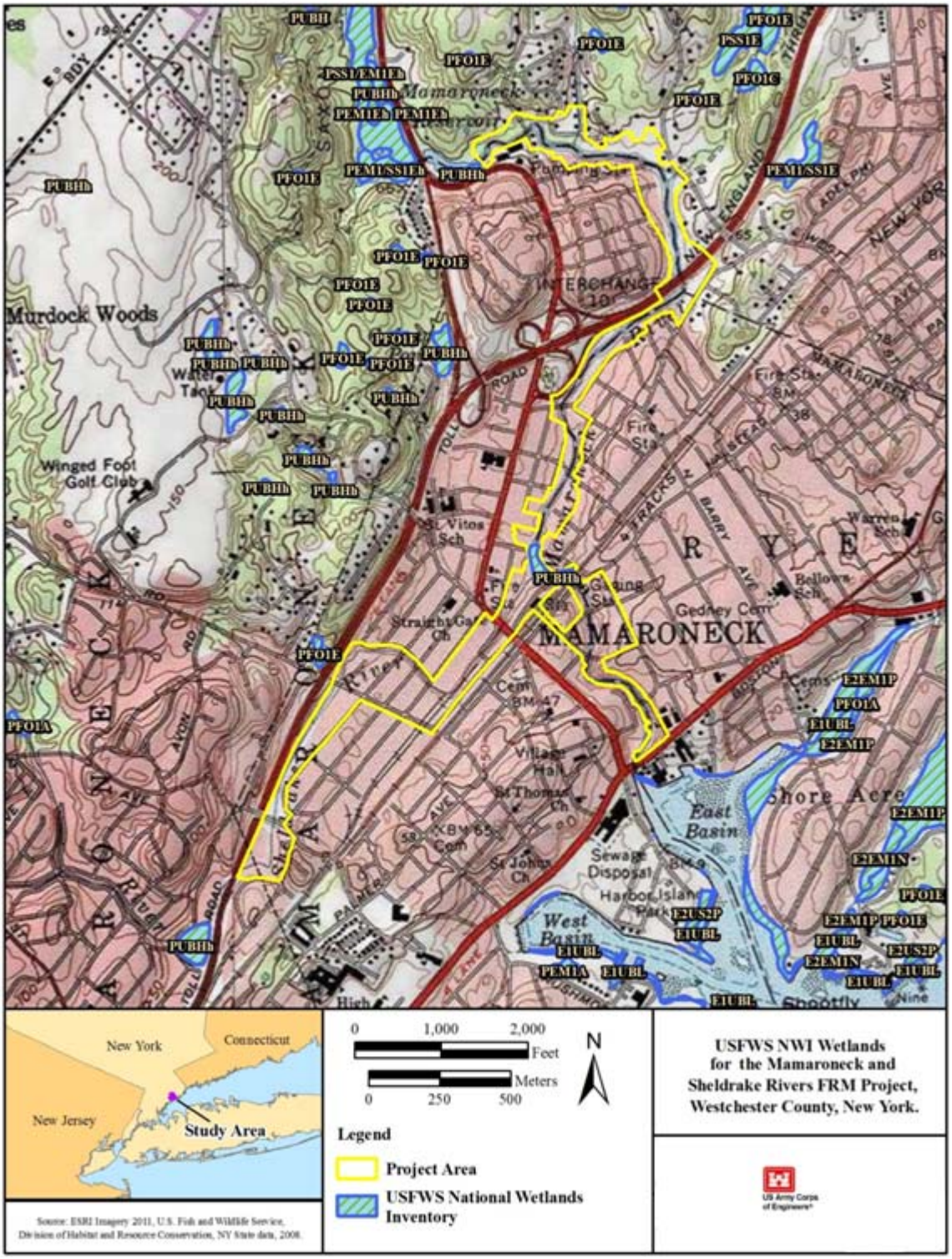

Figure 11 - USFWS NWI Wetlands for the Mamaroneck and Sheldrake Rivers FRM Project, Westchester County, New York.

3.13 Vegetation

3.13.1 Uplands

The majority of upland within the study area is commercial, residential, or transportation development. Vegetated uplands are mostly maintained lawns dominated by a variety of common native and nonnative grass species. Native vegetation is outcompeted by non-native species. A narrow band of vegetation lines the Mamaroneck and Sheldrake rivers. Larger swaths of upland and floodplain forests and shrub-dominated areas do occur in some sections, primarily in the north and west sections of the Project area as well as in the several of the Village's parks and natural areas. Common tree species that occur in upland forests include tulip poplar (*Liriodendron tulipifera*), Norway maple (*Acer platanoides*), American sycamore (*Platanus occidentalis*), red oak (*Quercus rubra*), silver maple (*Acer saccharinum*), black cherry (*Prunus serotina*), box elder (*Acer negundo*), American beech (*Fagus grandifolia*), and sugar maple (*Acer saccharum*). Common shrub and vine species include multiflora rose (*Rosa multiflora*), Asiatic bittersweet (*Celastris orbiculatus*), and Japanese honeysuckle (*Lonicera japonica*), and herbaceous species include garlic mustard (*Alliaria petiolata*), bittersweet nightshade (*Solanum dulcamara*), and violets (*Viola* species [spp.]). Japanese knotweed (*Polygonum cuspidatum*) was especially abundant throughout the Project area along the banks of both the Mamaroneck and Sheldrake rivers (USACE New York District 2012a).

A geographic information system analysis of mature trees located within the Project area footprint identified less than six non-contiguous, linear acres of mature.

3.13.2 Wetlands

Wetland communities are relatively uncommon within the Project area due in large part to development in the surrounding area as well as the rock retaining walls and riprap that line much of the Mamaroneck and Sheldrake rivers (Figure 12). However, seasonally-flooded forested wetlands are likely scattered throughout the Project area, particularly in the northern sections.

The PFO wetland found in the Project area is dominated by common wetland plant species such as red maple (*Acer rubrum*), green ash (*Fraxinus pensylvanica*), spicebush (*Lindera benzoin*), skunk cabbage (*Symplocarpus foetidus*), and sweet white violet (*Viola incognita*) (See Figure 12 USACE New York District 2012a). Several PSS/PEM wetland communities occur in small patches along both the Mamaroneck and Sheldrake rivers. Common species in the PSS communities include arrowwood (*Viburnum recognitum*), speckled alder (*Alnus incana* ssp. *rugosa*), dogwoods (*Cornus* spp.), green ash (*Fraxinus pensylvanicum*), willows (*Salix* spp.), spotted jewelweed (*Impatiens capensis*), sedges (*Carex* spp.), and yellowflag iris (*Iris pseudocorus*) (USACE New York District 2012a). Vegetation for the wetland in Columbus Park consists of Japanese knotweed (*Polygonum cuspidatum)*, garlic mustard (*Allliaria petiolata)*, multiflora rose (*Rosa multiflora)*, box elder (*Acer negundo)*, willow (*Salix babylonica)*, black locust (*Robinia pseudoacacia*) and Norway maple (*Acer platanoide.)*

A wetland delineation field survey was conducted in May 2011 (USACE New York District 2012a). During the field survey, a single, small (0.03 acre) palustrine forested (PFO) wetland (Wetland 002-W1) was identified and mapped within the northern part of the study area boundary in the Town of Harrison, across from Harbor Heights section of the Village (Figure 12). Small pockets of riparian areas consisting of possible palustrine scrub-shrub (PSS) and palustrine emergent (PEM) wetland were observed (based on visual identification) on parcels where access had not been granted and also within the stream channel

where sediment had accumulated along an existing retaining wall or section of riprap. These riparian areas were predominantly linear features located along the streambanks.

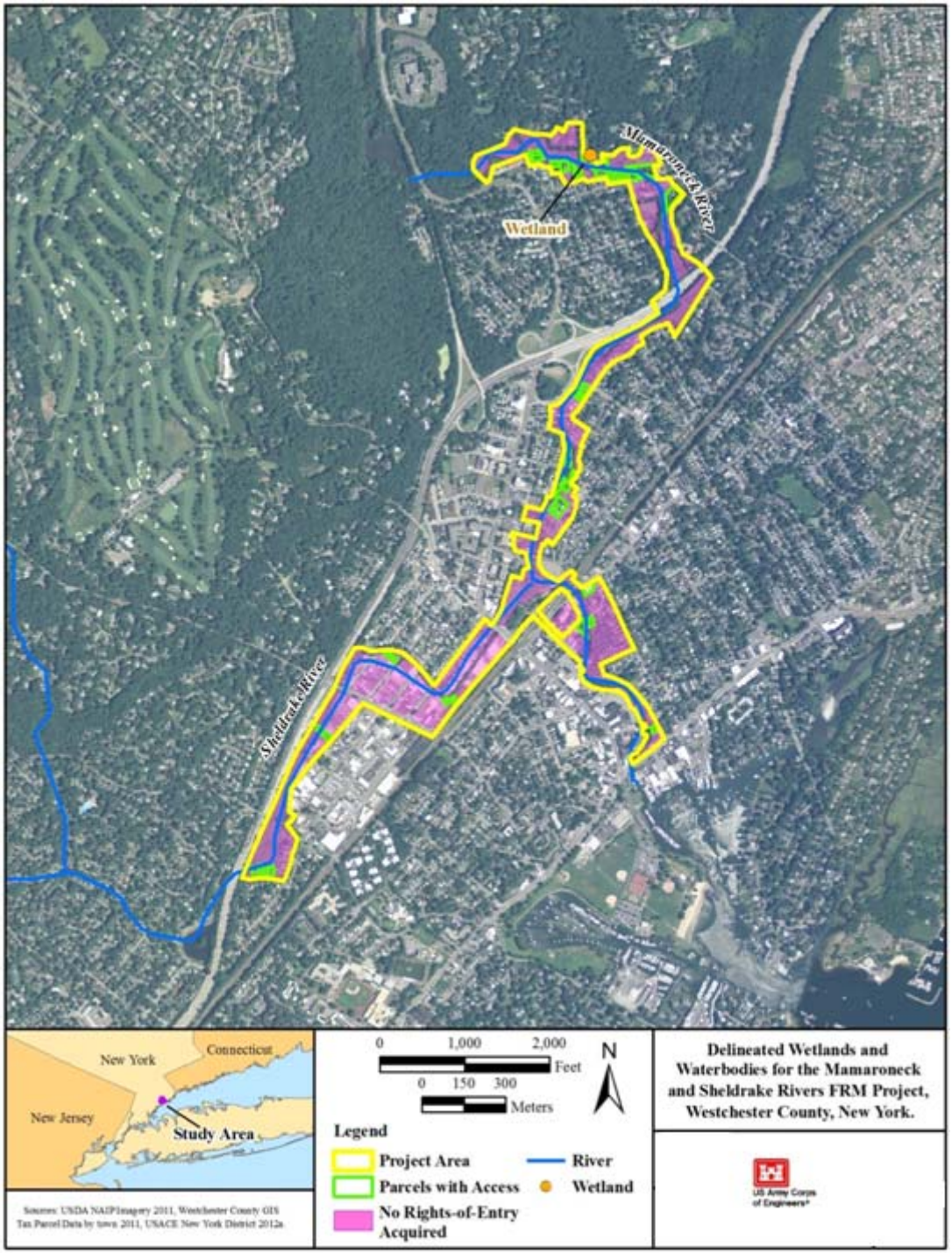

Figure 12 - Delineated Wetlands and Waterbodies for the Mamaroneck and Sheldrake Rivers FRM Project, Westchester County, New York.

3.14 Rare, Threatened, Endangered and Special Concern Species

Approximately 150 New York State special status species are known to or have the potential to occur in Westchester County (Young 2010; see Appendix A of the DEIS [Appendix B). Review of the Federal threatened and endangered species lists available for Westchester County did not identify any Federally listed plant species with the potential to occur in the study area (USFWS 2015). The study area also was analyzed using the NYSDEC Environmental Resource Mapper, which displays the location of all State listed species in New York (NYSDEC n.d.). This desktop review did not identify any known occurrences or observations of rare plants within the study area. Due to the highly developed nature of the study area, and the limited amount of quality, suitable habitat to support rare plant species, state or Federal rare, threatened, and endangered species are not likely to occur.

3.15 Fish and Wildlife

Historically, the western area of Long Island Sound was a prime area for shellfishing including clams (class Pelecypoda), oysters and mussels (class Bivalvia), and scallops (family Pectinidae). Oyster harvests plummeted in the 1990s due to a parasitic disease; however, the oyster population in Long Island Sound has shown signs of improvement as impacts from this disease have subsided (LISS 2010). Oyster populations were again impacted from substantial sedimentation within the Sound from Hurricane Irene in 2011 and Hurricane Sandy in 2012 (LISS 2012). Lobster populations in the Sound also have been subject to drastic declines; however, this species has not shown any recent signs of improvement (LISS 2010).

Shellfish harvesting for consumption purposes in Mamaroneck Harbor, just below the reach of the Mamaroneck River located in the Project area, is designated as uncertified for the taking of shellfish for use as food. Although neither the harbor nor lower Mamaroneck River include shellfishing as an appropriate use, other recreational uses are considered to be impacted based on pathogen monitoring in shellfish (NYSDEC 2010a).

Fish diversity in the Mamaroneck River Watershed is expected to be low due to poor water quality and insufficient flows that are not favorable to natural fish propagation, particularly for game fish species; insufficient base flow resulting in low flow conditions during portions of the year; relatively poor stream cover along sections of the river that are heavily populated/urbanized; and a high level of suspended sediments in the water column and sedimentation (Westchester County 2001 and USACE New York District 2011a).

Fifteen freshwater fish species that are likely to occur within the Mamaroneck River Watershed, upstream of I-95 include redbreast sunfish (*Lepomis auritus*), pumpkinseed, and minnows (family Cyprinidae), and the study area is reported to support a warmwater recreational fishery for common (white) suckers (*Catostomus commersonii*) and pumpkinseed (*Lepomis gibbous*) (USACE New York District 1989d).

A fish survey conducted within the study area of the Mamaroneck and Sheldrake rivers in 2011 identified American eel, (*Anguilla rostrata*) bluegill (*Lepomis macrochirus*), green sunfish (*L. cyanellus*), redbreast sunfish, pumpkinseed, brown bullhead (*Ameiurus nebulosus*), largemouth bass (*Micropterus salmoides*), tessellated darter (*Etheostoma olmstedi*), and white sucker (USACE New York District 2011e). The most abundant species collected within the Mamaroneck River just upstream from Columbus Park were American eel (approximately 49% of total catch), redbreast sunfish (approximately 34% of total catch), and white sucker (approximately 8% of total catch). The most abundant species collected within the Sheldrake River at Columbus Park were tessellated darter (approximately 46% of total catch), white

sucker (approximately 21% of total catch), American eel (approximately 16% of total catch), and pumpkinseed (approximately 12% of total catch).

Fish diversity would be expected to increase toward the outer harbor and Long Island Sound, as water quality is generally better in open water areas. The New York State Department of Health (NYSDOH) has issued precautionary health advisories recommending limited consumption of American eel, bluefish, striped bass, and weakfish (*Cynoscion regalis*) from Long Island Sound and tributary waters, including Mamaroneck Harbor, due to possible elevated levels of PCBs (NYSDEC 2010a). The most current advisories are available on the NYSDOH website (NYSDOH 2013a):

http://www.health.ny.gov/environmental/outdoors/fish/health_advisories/regional/.

Fish consumption in the section of the Mamaroneck River located upstream from Route 1 is considered stressed due to pesticides. Fish consumption in the Sheldrake River is considered impaired and the NYSDOH has issued a health advisory recommending American eel not be consumed, and for goldfish (*Carassius auratus*) to be consumed no more than once per month (NYSDEC 2010a and NYSDOH 2013b).

3.16 Benthic Resources

Benthic resources are described as the community of plants and animals that reside on or in the bottom sediments of oceans, streams, and wetlands. In general, water quality in the Mamaroneck River is considered to be poor and aquatic life is not fully supported in the river. A stream bioassessment of the Mamaroneck River conducted by NYSDEC in 2000 determined that macroinvertebrate communities are moderately impacted by poor water quality caused by urban stormwater runoff (USACE New York District 2011a).

A benthic macroinvertebrate survey conducted within the Mamaroneck and Sheldrake rivers in 2011 in support of the Project established existing conditions for benthic macroinvertebrate assemblages, and assessed the impacts to these species and their habitat resulting from the implementation of the proposed flood management measures (USACE New York District 2011e).

Based on the results and metrics analysis conducted for the benthic macroinvertebrates collected within the Mamaroneck and Sheldrake rivers, water quality was considered moderately impaired and the habitat was determined to be of “marginal” condition based on USEPA physical habitat assessment criteria (Barbour et al. 1999).

3.17 Reptiles and Amphibians

The Mamaroneck and Sheldrake rivers and adjacent riparian areas—where present—provide habitat for common amphibian and reptile species. Four species of herpetofauna were observed within the Project area during field surveys conducted in May 2011: eastern painted turtle (*Chrysemys picta*), red-eared slider (*Trachemys script elegans*), snapping turtle (*Chelydra serpentina*), and green frog (*Lithobates clamitans*) (field notes [in support of USACE New York District 2012a], May 24, 2011). Although all of these species were observed along the Sheldrake River, it is likely they occur within the Project area along the Mamaroneck River as well, particularly where vegetated buffers are present.

Records collected for the New York State Herp Atlas indicate that fourteen additional species of reptiles and amphibians occur in proximity to the Project area and can reasonably assumed to be present where

appropriate habitat exists. These species include, but are not limited to, northern redback salamander (*Plethodon cinereus*), Fowler's toad (*Bufo fowleri*), northern spring peeper (*Pseudacris crucifer*), pickerel frog (*Lithobates palustris*), eastern box turtle (*Terrapene carolina*), common garter snake (*Thamnophis sirtalis*), and eastern milk snake (*Lampropeltis triangulatum*).

3.18 Birds

Many common bird species that are typical of a suburban habitat have been recorded in the vicinity of the Project area. Nearby coastal wetlands and coastal bays provide habitat for shorebirds, waterfowl, and seabirds. Coastlines are typically used by passerines and raptors during migration. Nearby parks, coastal habitats, and protected (for conservation) coastal habitats can provide migratory stopover habitat. Examples of bird species observed within the study area are noted in Appendix B – EIS.

The USFWS Information for Planning and Conservation (IPaC) website identified 26 species of migratory birds that may be within the proposed project area utilizing the habitat year round for breeding or wintering purposes. These species include one state-endangered species, the short-eared owl (*Asio flammeus)* and five state-threatened species: upland sandpiper (*Bartramia longicauda)*; pied-billed grebe (*Podilymbus podiceps)*; least tern (*Sternula antillarum)*, least bittern (*Ixobrychus exilis)*; and the bald eagle (*Haliaeetus leucocephalus)*. Five are listed as a state species of special concern: American bittern (*Botaurus lentiginosus*); black skimmer (*Rynchops niger*), cerulean warbler (*Dendroica cerulean*); golden-winged warbler (*Vermivora chrysoptera*); and the seaside sparrow (*Ammodramus maritimus*) (USFWS 2015).

Nearly all migratory bird species that have the potential to occur in the study area are protected by the Migratory Bird Treaty Act (MBTA) (16 USC 703–712). Under the MBTA, Federal project proponents are required to comply with the provisions of the MBTA that do not allow intentional or unintentional take of migratory birds.

3.19 Mammals

Five species of mammals were observed within the study area during field surveys conducted in May 2011 (field notes [in support of USACE New York District 2012a], May 24, 2011). The species observed directly include eastern gray squirrels (*Sciurus carolinensis*), eastern chipmunks (*Tamias striatus*), muskrat (*Ondatra zibethicus)*, and eastern cottontail rabbit (*Sylvilagus floridanus*).

Additional mammalian species have been documented at the nearby Greenburgh Nature Center in southern Westchester County and also likely occur within the study area where suitable habitat exists. These species may include common species such as Virginia opossum (*Didelphis virginiana*), striped skunk (*Mephitis mephitis*), woodchuck (*Marmota monax*), house mouse (*Mus musculus*), white-footed mouse (*Peromyscus leucopus*), hoary bat (*Lasiurus cinereus*), and little brown bat (*Myotis lucifugus*) (Greenburgh Nature Center 2003).

3.20 Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA [PL 94-265]), as amended, is the primary law governing the conservation and management of fisheries in Federal waters of the United States. A formal EFH analysis of the study area has not been conducted; however, a review of EFH designations available on NOAA Fisheries Service's EFH-mapper website did not identify any EFH or Habitat Areas of Particular Concern within the study area (NOAA Fisheries Service Habitat Conservation Division n.d. a). However, the EFH summary for the area that includes Mamaroneck

Harbor identifies 16 fish species with designated EFH (NOAA Fisheries Service Habitat Conservation Division n.d. b).

3.21 Rare, Threatened, Endangered and Special Concern Species

In accordance with the Fish and Wildlife Coordination Act of 1973, as amended (87 Stat. 884; 16 U.S.C. 1531 *et seq*.) USFWS has prepared a draft Fish and Wildlife Coordination Act Report (FWCAR) for the Project (see Appendix C of the DEIS [Appendix B]). Review of the Federal threatened and endangered species lists available for Westchester County identified three Federally listed species that have the potential to occur in the county: the Federally endangered Indiana bat (*Myotis sodalis*) and the Federally threatened bog turtle (*Clemmys muhlenbergii*), and the northern long-eared bat (*Myotis septentrionalis*) (also known as northern myotis and eastern long-eared bat) (USFWS 2012). Two additional species with the potential to occur in Westchester County are New England cottontail (*Sylvilagus transitionalis*), a Federal candidate species for listing; and the bald eagle (*Haliaeetus leucocephalus*). Although the bald eagle has been Federally delisted, it is still protected by the Bald and Golden Eagle Protection Act (16 USC 668–668c) and the MBTA. Habitat to support New England cottontail, bald eagle, and bog turtle are not present in the study area. Although the study area may contain suitable roosting and foraging habitat for Indiana bat and northern long-eared bat (NYSDEC 2013f), the developed and urbanized nature of the Project area (e.g., high ambient light levels; lack of large, contiguous forested blocks) substantially lower the likelihood for Indiana bat and northern long-eared bat to be present.

A review of the study area using the NYSDEC Environmental Resource Mapper tool did not identify any state listed wildlife species (NYSDEC n.d.).

3.22 Cultural and Historic Resources

As an agency of the Federal government, the District has certain responsibilities regarding the identification and protection of cultural resources. The Federal statutes and regulations authorizing the Corps to undertake these responsibilities include Section 106 of the National Historic Preservation Act, as amended, and the Advisory Council on Historic Preservation Guidelines for the Protection of Cultural and Historic Properties (36 CFR Part 800). The District is required to identify historic properties with the Area of Potential Effect (APE) of proposed projects and determine if the proposed project will have an effect on those properties. The District must allow the relevant State Historic Preservation Office, Federally-recognized Tribe, the Advisory Council on Historic Preservation and the public an opportunity to comment on its determination of effect.

The current APE for this project will include the area of channel modification along the Mamaroneck and Sheldrake Rivers, as well as the proposed culvert for Columbus Park, and the non-structural project elements. The APE also included the alignments of proposed culvert underneath Columbus Park beginning at the confluence of the Sheldrake and Mamaroneck Rivers and ending at the at the confluence of the Sheldrake and Mamaroneck Rivers to the railroad bridge over the Mamaroneck River. The construction staging area will be located within Columbus Park, within the APE.

3.22.1 Previous Studies

Reported Archaeological Sites: According to the files of the New York State Office of Parks, Recreation and Historic Preservation (OPRHP) and the New York State Museum (NYSM), 34 archaeological sites have been reported within a two mile radius of the APE. These sites represent a range of sites from shell middens and camps to burial sites dating to all periods, including potential Paleoindian, Archaic and Woodlands periods.

Two archaeological sites, New York State Museum Sites (NYSM) 5227 and 7710, are located within the APE and consist of two pre-contact period camps. These sites were identified at the northern end of the APE between Winfield Avenue and I-95 by Parker in 1922. Testing in this area in 1977 did not encounter any further evidence of these sites (Scarpa 2012; Zukerman and Rothschild 1977).

The OPRHP and NYSM files identify seven historic period sites located with a two-mile radius of the APE. None of these sites are within the APE. Based on the documentary research and the previous identification of sites, the APE has sensitivity for the presence of both prehistoric and historic period sites. Based on the pedestrian surveys conducted as part of this project, most, if not all of the APE has undergone prior disturbance resulting from the development of the Village and the rechanneling of the rivers within the Village (Blair, Wheeler and Kirk 2011; Scarpa 2012).

State and National Register of Historic Places: There is one listed National Register of Historic Places (NRHP) property, the Mamaroneck Railroad Station at Station Plaza, within the current APE.

3.22.2 Historic Overview

During the 1930s, large-scale Works Progress Administration (WPA)-funded projects added a number of significant features to the Village. These included the construction of bridges over and retaining walls along the Mamaroneck River within the APE, the Harbor Island Beach, jetty and East Basin Walls, and the Village Garage on Fayette Avenue. The stone used in these projects were from the removal of the large rock outcroppings that were once in the Village. Development in the Village slowed by the 1950s, and more recently, consists of larger scale residential condominium and apartment complexes, that respond to the need for residences for people commuting to New York City (Blair, Wheeler and Kirk 2011).

3.22.3 Architectural Survey

As part of the current study, an architectural survey was conducted in April 2011 to identify cultural resources that had the potential to be eligible for the State and National Registers within or adjacent to the APE. This survey included a review of the OPRHP structure files and a field inspection of structures located within and adjacent to the project area. Anything that was built before 1962 (greater than 50 years) was evaluated using the National Register criteria for significance as a guideline (Blair, Wheeler and Kirk 2011). A total of 254 structures were identified within or adjacent to the APE dating to before 1962. Of these, a total of 30 structures and objects as well as the numerous stone retaining walls lining both sides of the river were identified to be potentially eligible for the National Register, pending further assessment. Included in this list is the Mamaroneck Railroad Station at Station Plaza, which was previously determined to be eligible. The survey also identified the presence of WPA retaining walls and other older retaining walls that are eligible for the National Register, as is the Ward Avenue Bridge, also constructed by the WPA.

3.22.4 Archaeological Survey

Based on the results of the research and pedestrian survey, in comparison with the 1977 field investigations, two areas were recommended for limited archaeological investigation: 1) along the left bank of the Mamaroneck River on either side of Glendale Road; and 2) along the Sheldrake River near the upper limit of the project area. These areas were not tested or had limited testing in 1977 and are likely undisturbed. The other areas along the APE were previously disturbed or subjected to sufficient testing in 1977. In 2012, a total of 21 shovel tests were excavated within the two areas. No archaeological remains were identified. (Blair, Wheeler and Kirk 2011; Scarpa 2012).

3.23 Coastal Zone Management

NOAA defines the coastal zone as the seaward boundary is the 3-nautical mile territorial sea for the project area. New York's coastal zone varies from region to region and incorporates the following conditions:

- The inland boundary is approximately 1,000 ft from the shoreline of the mainland.
- In urbanized and developed coastal locations the landward boundary is approximately 500 ft from the mainland's shoreline, or less than 500 ft where a roadway or railroad line runs parallel to the shoreline at a distance of under 500 ft and defines the boundary.
- In locations where major state-owned lands and facilities or electric power generating facilities abut the shoreline, the boundary extends inland to include them.
- In some areas, such as Long Island Sound and the Hudson River Valley, the boundary may extend inland up to 10,000 feet to encompass significant coastal resources, such as areas of exceptional scenic value, agricultural or recreational lands, and major tributaries and headlands (NOAA 2012).
- The Project area is entirely located within the New York-designated coastal zone management area that is associated with Long Island Sound (New York State Department of State [NYSDOS] Coastal Management Program [CMP] 1999). Pursuant to 15 CFR Part 930.34(b) of the Federal Coastal Zone Management Act, USACE New York District must evaluate the Preferred Alternatives and consult with the CMP to ensure that the Preferred Alternatives are consistent with the 44 NYSDOS CMP Coastal Policies and that neither would have undue adverse impacts on New York coastal zone resources (NYSDOS CMP 2001). The 44 New York State Coastal Policies are grouped together to address issues related to development, fish and wildlife resources, flooding and erosion hazards, general issues, public access, recreation, historic and scenic resources, agricultural lands, energy and ice management, and water and air resources in New York-designated coastal zone areas. To ensure that the Preferred Alternatives are consistent with NYSDOS' Coastal Policies and will have no undue adverse impacts on New York coastal zone resources, the District must coordinate and consult with the NYSDOS CMP and other agencies.

3.24 Recreation

The largest Village park within the Project area is Columbus Park (6 acres), which surrounds the Mamaroneck and Sheldrake rivers at their confluence. This popular park, which contains a playground, basketball courts, benches, walking paths and footbridges across the rivers, is unique because it offers one of the few areas along the Sheldrake River where development does not encroach up to the river's edge. Columbus Park experiences substantial flooding problems during high flow periods following storm events. There are also several other smaller parks found along the Mamaroneck and Sheldrake rivers within the study and project area. There is currently very limited public access to the Village of Mamaroneck's rivers. Much of the property abutting the Mamaroneck and Sheldrake rivers is privately owned (mostly residential) and is therefore unavailable for public open space and recreational use.

Although there are no designated wildlife refuges or preserves in the study area, the tidal wetlands in the East and West basins of the Mamaroneck Harbor provide opportunities for wildlife observation, particularly of resident and migratory wildfowl. There are no state or county parklands or recreational areas in the study area.

3.25 Transportation

Transportation in the Village of Mamaroneck mainly consists of road and street networks and pedestrian walkways. The Village is a suburban area with a well-traveled network of roadways throughout. I-95 is the major thoroughfare in the area, traveling northeast through Westchester County with Exit 18 at Mamaroneck Avenue. Secondary roadways within the area include Jefferson Avenue, Station Plaza, Hillside Avenue, Palmer Avenue, Halstead Avenue, and Ward Street. In addition to I-95, regional access is provided by Metro-North Railroad commuter rail service (the New Haven Line) that operates between New York City and New Haven, Connecticut with branches to Waterbury, Danbury, and New Canaan, Connecticut (MTA 2013 and Metro-North Railroad 2013a). State routes that provide access to the area include Mamaroneck Avenue and Old White Plains Road. Jefferson Avenue, Station Plaza, Hillside Avenue, Palmer Avenue, Halstead Avenue, and Ward Street provide direct access to the Project area; and Jefferson Avenue, Mamaroneck Avenue, and Van Ranst Place provide access to Columbus Park, which is the staging area under the Preferred Alternative. Due to the heavily urbanized and developed nature of the Mamaroneck and Sheldrake Rivers Basin, 2 in of rainfall in 24 hours or 4 inches in 48 hours can cause the rivers to flood, and residential roadways can retain as much as 3 ft of water for several days after heavy rains have subsided (USACE New York District 2011a).

3.25.1 Air, Rail, and Public Transportation

The closest airport is Westchester County Airport (HPN), which is 10 mi away and has 441 operations per day (AirNav 2013). The closest international airport is La Guardia (LGA), which is 15 mi away and has 726 operations per day (AirNav 2013). Other nearby airports includes Teterboro and Danbury municipal airports (TEB and DXR, respectively). The closest Amtrak station is 4 mi away in New Rochelle (Amtrak 2013). The public agencies that provide transit service to the Village of Mamaroneck are the Westchester County Bee-line bus system and MTA's Metro-North Railroad (Metro-North Railroad 2013a).

3.25.2 Parking

Curbside parking and parking lots are provided in both residential and commercial areas throughout the Village. Metro-North Railroad and the Village of Mamaroneck provide nine distinct parking areas near the Mamaroneck Station for commuters. LAZ Parking (the parking operator for Metro-North Railroad at the Mamaroneck Station) provides metered and permit parking and has a capacity of 254 spaces near the station building and platform on Station Plaza and Hoyt Avenue. Village of Mamaroneck metered parking has a capacity of 358 spaces in lots and/or along the street on Van Ranst Place, Jefferson Avenue, and Halstead Avenue (Metro-North Railroad 2013b). Parking fees can be paid daily or monthly by permit; both providers offer free weekend and holiday parking (Metro-North Railroad 2013b and 2013c).

3.26 Air Quality

The USEPA Region 2 and NYSDEC regulate air quality in New York. The Clean Air Act (CAA) (42 USC 7401-7671q), as amended, assigns the USEPA responsibility to establish the primary and secondary National Ambient Air Quality Standards (NAAQS) (40 CFR Part 50) that specify acceptable concentration levels of six criteria pollutants: particulate matter (measured as both particulate matter less than 10 microns in diameter [PM_{10}] and particulate matter less than 2.5 microns in diameter [$PM_{2.5}$]), sulfur dioxide (SO_2), carbon monoxide (CO), oxides of nitrogen (NO_X), ozone (O_3), and lead. Short-term NAAQS (1-, 8-, and 24-hour periods) have been established for pollutants contributing to acute health effects, while long-term NAAQS (annual averages) have been established for pollutants contributing to chronic health effects. Although each state has the authority to adopt standards stricter than those established under the Federal program, New York State has adopted slightly stricter standards for NO_x

(0.05 ppm) and 3-hour SO_2 (0.050 ppm), and has standards for total suspended particulates and non-methane hydrocarbons (NYSDEC 2013g).

Federal regulations designate Air Quality Control Regions (AQCRs) in violation of the NAAQS as *nonattainment* areas. Federal regulations designate AQCRs with levels below the NAAQS as *attainment* areas. *Maintenance* areas are AQCRs that have previously been designated as nonattainment and have been redesignated to attainment for a probationary period through implementation of maintenance plans. According to the severity of the pollution problem, O_3 and PM_{10} nonattainment areas can be categorized as marginal, moderate, serious, severe, or extreme.

Westchester County (and therefore all areas within the study and project areas) is within the New Jersey–New York–Connecticut Interstate AQCR (AQCR 43) (40 CFR 81.13). The USEPA has designated Westchester County as moderate nonattainment for the 8-hour O_3 NAAQS, nonattainment for the $PM_{2.5}$ NAAQS, and maintenance for the CO NAAQS (USEPA 2013a). In addition, it is located in the Ozone Transport Region, which includes twelve states and the District of Columbia. The USEPA monitors levels of criteria pollutants at representative sites in each region throughout New York State.

3.26.1 Greenhouse Gas and Climate Change

The average high temperature in Westchester County is 86 °Fahrenheit (°F) (30.0 °Celsius [°C]) in the hottest month of July, and the average low temperature is 20.1 °F (-6.6 °C) in the coldest month of January. Westchester County has an average annual precipitation of 46.5 in (118.1 cm). The wettest month of the year is September with an average rainfall of 4.4 in (11.2 cm) (Idcide 2013).

Greenhouse gases (GHGs) are components of the atmosphere that trap heat relatively near the surface of the earth, and therefore contribute to the greenhouse effect and climate change. Most GHGs occur naturally in the atmosphere, but increase in their concentration as a result of human activities such as the burning of fossil fuels. Global temperatures are expected to continue to rise as human activities continue to add carbon dioxide (CO_2), methane, nitrous oxide, and other greenhouse (or heat-trapping) gases to the atmosphere. Whether or not rainfall will increase or decrease remains difficult to project for specific regions (USEPA 2013c and Intergovernmental Panel on Climate Change [IPCC] 2007).

The CEQ recently released draft guidance on when and how Federal agencies should consider GHG emissions and climate change in NEPA analyses. The draft guidance includes a presumptive effects threshold of 27,563 tons per year (25,000 metric tons per year) of CO_2 equivalent emissions from a Federal action (CEQ 2010).

In considering project effects on GHG, the effect of vegetation removal, particularly of mature trees, and their replacement with younger, smaller trees, should also be addressed. Trees take carbon dioxide from the air and use it to grow roots, leaves, etc. Over its lifetime, a tree can remove several tons of carbon dioxide from the air. Trees also lower air temperature, transpire water and provide shade that can reduce energy use, indirectly reducing carbon dioxide emissions (McPherson 2007; Nowak et al 2002).

Maximum carbon dioxide reductions require a relatively stable population of trees, representing a mix of species, sizes and ages. Sequestration rates will level off with mature trees, although energy savings will continue. Trees that are larger at their maturity will sequester more carbon than smaller trees and faster-growing trees will sequester carbon sooner. In an urban setting, planting should include long-lived, low maintenance, moderate to fast growing species that are large at maturity but require minimal maintenance to increase survival and longevity.

As stated above (Section 3.5) within the project area, there are approximately less than six, non-contiguous acres of mature trees along the Sheldrake and Mamaroneck Rivers. These acres include a mix of native and non-native species. Concerned with the health and maintenance of its existing trees as well as expanding planting throughout, the Village of Mamaroneck established a Village Tree Committee to advise the Planning Board, Village Engineer, and Department of Public Works. The Village Tree Committee developed and administers a management plan for the Village trees, as well as reviews site plans and subdivisions to preserve trees or advise on proper tree plantings taken from a list of species of trees recommended as suitable for planting within the Village. The Village is currently replanting trees lost during Hurricane Sandy as well as continuing to replace and expand planting throughout the Village to maintain its neighborhoods' aesthetics as well as increase erosion control and carbon reduction

4. FUTURE WITHOUT-PROJECT CONDITIONS

4.1 Land Use & Development

The future without-project condition was determined by projecting conditions in the study area over a 50-year period of analysis. The period of analysis is determined to be from 2020, the year that construction is implemented and construction is complete for a period of 50 years. In the absence of Federal action, flooding problems associated with rainfall events in the study area are expected to continue. These problems may be exacerbated by increased damage potential in the floodplain of the Village of Mamaroneck within the Mamaroneck and Sheldrake Rivers Basin, based upon increases in the values of structures and contents, and by climate change, leading to an increase in intensity and frequency of storm events. It is expected, based on future land use projections in the study area, there will be limited additional development within the Basin in the future period of analysis..

Examining the land use patterns within the Mamaroneck and Sheldrake Rivers Basin, it is clear that this will continue to be a very urbanized watershed. Following the river from its headwaters in the Town of Harrison, to the mouth at the Village of Mamaroneck, most of the watershed has been developed and is characterized as residential, commercial or industrial development. Many of these have been constructed to the edge of the river banks. Within the State of New York, if applicants for new construction can show that their facilities will not increase the 100-year flood elevation, they are generally permitted to build flood proofed structures where the lowest floor including any basement, must be at or above the base flood elevation plus two feet beginning in 2007 Refer to Economics Appendix (Appendix D) of this report for additional future land use and development details for municipalities within the 24 square miles river basin.

However, in general, there is not expected to be any significant changes in the land use characterization within the Village of Mamaroneck over the 50 year period of analysis.

4.2 Future Without Project Hydrologic Conditions

Undeveloped areas of land within the basin, mostly parks and golf courses, were identified using available maps. Westchester County planning officials, and representatives of the Village of Mamaroneck, and other communities within the basin, were consulted about possible future development of the undeveloped land areas. The results included the development of six (6) golf courses within the watershed municipalities as the most likely future development. Increases from existing conditions peak discharges were small, 30 cfs at most, for several reasons:

1) Present conditions values of percent impervious area are already fairly high.
2) The estimated increases in the percent impervious values from present to future conditions are small, and
3) The infiltration loss parameters for most hypothetical floods are low, so that an increase in the percent of impervious area would have relatively little effect on computed peak flows of runoff.

Future values of sub-basin percent impervious area were estimated from this input, and input to the hydrologic model of the basin. The model was then run to compute future unimproved conditions peak discharges throughout the basin. Increases from existing conditions peak discharges were small, ranging from zero to 2.3 %.

4.3 Future Without Project Hydraulic Conditions

The hydraulic analysis of the Mamaroneck and Sheldrake Rivers is based on a steady state numeric model using the Hydrologic Engineering Center, River Analysis System (HEC-RAS). The technical approach of the numerical modeling involves two phases prior to providing the improvement alternatives. The first phase, the existing condition hydraulics, is described above and in greater detail in Appendix C. Phase two addresses the future without project conditions including an evaluation of future conditions considering the effect of the land use changes over the project life on the hydrologic and hydraulic characteristics of the Mamaroneck and Sheldrake River Basins. Future unimproved WSEL for the 1, 2, 5, 10, 25, 50, 100, 200, 250, and 500-year frequency floods were computed in the existing conditions hydraulic model. Because there was only a small increase in the flows between existing conditions and the future unimproved conditions, there is no increase in damages expected for the future unimproved conditions due to the change in flows. Since this project will not provide any protection from tidal or coastal surge type of events and because fluvial flooding in the existing channel is not impacted by the Sea Level Rise (SLR) there will be no change in the damage computations due to SLR.

4.4 Sea Level Change

Department of the Army Engineering Circular EC-1165-2-211 requires that each civil works project take into consideration the effects of potential sea level change (SLC) over the design life of the project. ER 1100-2-8162 requires the use of three scenarios, at a minimum, to estimate future sea levels. These scenarios are a low rate that shall be based on an extrapolation of the historical tide gauge rate and intermediate and high rates that include future acceleration of global mean sea level (GMSL). The effects of vertical land movement (VLM) must also be considered as a component of sea-level rise. The low rate of future sea-level rise is based upon the historic rate of SLR in the vicinity of the project area ("regional" sea-level rise). For our purposes, 43 years of data from the National Oceanic and Atmospheric Administration (NOAA) tide gauge # 8467150 at Bridgeport, Connecticut were used. These data indicate an upward trend of 2.56 mm/year (+/-0.10 in/yr) with a 95% confidence limit of +/- 0.58 mm/year (+/-0.02 in/yr).

In consideration of VLM, it is assumed that the regional mean sea level trend is equal to the global, or "eustatic," mean sea level trend, which has been determined by the International Panel on Climate Change (IPCC 2007a) to be 1.7 mm/year (+/-0.07 in/yr), +/- 0.5 mm/year (+/-0.02 in/yr). Removing the eustatic SLR component from the regional sea level rise will isolate the regional rate of VLM. The result obtained is 0.86 mm/year (0.03 in/yr), or a total of 0.12 ft of VLM subsidence over the 50-year design life of the project. The low, intermediate and high rates of future SLR (i.e.; Type I, II and III) are determined from the modified National Research Council (NRC -1987) eustatic sea-level change scenarios and the IPCC (2007).

SLR was computed for the period of 50 years from the beginning of the project (2015-2064) with an increment of every 5-years and accounting for the VLM. Changes in SLR and VLM can be seen in Table 4. The net change in SLR taking into account VLM subsidence over the 50-year period of analysis is 0.30, 0.7 and 2.06 ft for the low, intermediate and high rates modified National Rate Council (NRC) respectively. These results are in accordance with NYSDEC as projections based in IPCC were adopted by the New York City of Panel of Climate Change (NYCPCC).

Table 4: Estimates of Sea Level Change (SLC) and Vertical Land Movement (VLM) 50 year period of Analysis

Year	*SLR (ft)			VLM (ft)
	Type I	Type II	Type III	
2015	0.0	0.0	0.0	0.0
2020	0.05	0.08	0.16	-0.01
2025	0.09	0.14	0.31	-0.02
2030	0.13	0.21	0.49	-0.03
2035	0.17	0.29	0.68	-0.04
2040	0.21	0.37	0.88	-0.06
2045	0.25	0.46	1.11	-0.07
2050	0.29	0.55	1.36	-0.08
2055	0.33	0.64	1.62	-0.09
2060	0.37	0.74	1.91	-0.11
2065	0.42	0.82	2.18	-0.12

** Based on NRC -1987 and the IPCC (2007). Required by ER-1100-2-8162*

Higher downstream water levels resulting from future sea level change will not have an effect on the performance of this flood risk management project. The projected rise in sea level will only extend as far upstream as the Tompkins Avenue Bridge. The main damage areas are approximately 2,000 feet upstream and 10 feet higher than the Tompkins Ave area. The first significant damage elevations for this project are at about elevation 20 ft (NAVD 88) which is well above the elevation of any recent coastal storm. Sea level change is expected to have major impacts on direct coastal flooding and wind-wave erosion along the Mamaroneck Bay shoreline, including impacts to properties and critical infrastructure; however this project does not reduce the risk associated with coastal flooding, and is limited to river flow related events, and is not impacted by sea level rise projections.

4.5 Climate Change

The Mamaroneck River is located in the northeastern part of the country where "wet areas can be expected to get wetter." NOAA Technical Report NESDIS 142-1 states that the historic annual increase in precipitation is statistically significant. This report also states that there is a "substantial decadal-scale variability" associated with extreme precipitation. Therefore estimates of the 50 and 100 year events are very sensitive to the 10-30 year period of record used to compute these estimates. Finally the report states that there is great uncertainty associated with model simulation predictions of future precipitation increases. Preliminary results presented by Geoff Bonnin of the National Weather Service at a National Dam Safety Technical Seminar in Feb 2014 indicate that climate change appears to be impacting frequent events like the 1 year to 10 year return period but there is little to no significant impact on large major events like the 50 year and greater.

4.6 Risk & Uncertainty Analysis Unimproved Conditions

The uncertainty associated with the computed water surface elevations (WSELs) or stage was evaluated by conducting a sensitivity analysis. The goal or overall approach was to develop realistic upper and

lower bounds on the computed stage for a given discharge. The hydraulic characteristics considered in developing the upper and lower bounds were the Manning's n-value, debris jams at bridges, channel bed changes and changes in the Mamaroneck Harbor sea level, which is the downstream boundary condition in the HEC-RAS model. To account for the debris during a storm and to develop the upper uncertainty boundary, most bridge parapets were considered to be blocked.

In addition, select bridge low cords were lowered by a foot and all bridge pier sizes were increased by a foot to model debris accumulation. To account for the lack of debris and to develop the lower uncertainty boundary, selected bridge parapets that were blocked in the calibration or base model were opened and the expansion and contraction coefficients of all bridges were lowered by a maximum value of 0.1. A channel bed slope change analysis was based on an invert comparison between the cross-sections surveyed for the 1989 GDM and the cross-sections surveyed for this GRR. The comparison indicated that there was a small but general scouring trend for the Mamaroneck River. The results of the last 20 years were extrapolated 50 years into the future and only the future unimproved model was modified to reflect the scour and help develop the lower uncertainty boundary. Sediment did not appear to be an issue and was not included in the upper boundary computations. To help develop the degree of uncertainty related to the Mamaroneck Harbor boundary condition, different combinations of tide, surge and sea level rise were developed. This combination can be observed inTable 5. All future conditions were run with the maximum and minimum projected SLR. The minimum SLR was calculated using the regional trends at Bridgeport, Willets Point & Kings Point, and the highest SLR by using the NRC Type III curve.

Hydraulic runs that represented the lower and upper uncertainty stage were modeled at a range of tidal water surface elevations. As explained previously, high tides with additional storm surge values superimposed were used to develop the upper limit and best estimate model for existing conditions. Also as previously stated, low or mid tide elevations without superimposed storm surge values were used to develop the lower limit model for existing conditions. Future conditions were modeled by adding high and low sea level rise estimates to the upper and lower limit models respectively.

The WSELs and uncertainty information and a recommendation to use either the triangular or the log normal distribution for input into the HEC-FDA model were generated for use in the economic analysis.

Table 5: Downstream boundary conditions, Mamaroneck Harbor WSEL

	Downstream Boundary	Value			Elevation (NAVD 88)		
		Low	Mean	High	Low	Mean	High
Existing	Tide (NAVD 88)	-3.93	3.24	3.24	-2.93	5.34	7.01
	High Surge (April 07)	0.00	1.10	2.77			
	Sea Level Rise	0.00	0.00	0.00			
	Gage translation	1.00	1.00	1.00			
Future With and Without Project	Tide (NAVD 88)	-3.93	3.24	3.24	-2.51	6.16	9.19
	Surge	0.00	1.10	2.77			
	Sea Level Rise	0.42	0.82	2.18			
	Gage translation	1.00	1.00	1.00			

4.7 Opportunities

4.7.1 Description of the Problem

A severe flood risk is evident based on the recurrence of flood events and the damages sustained. Four hundred fifteen (415) repetitive FEMA Flood Insurance Claims in the Village of Mamaroneck have been recorded prior to the April 2007 nor'easter. Damages within the Mamaroneck and Sheldrake Rivers Basin for the June 18-19 1972 and September 26-27 1975 floods amounted to approximately $18M and $92M, respectively, based on conditions of development at the time and October 2015 price levels. The flood waters from these storms inundated large areas of industrial, commercial and residential property at the Village and Town of Mamaroneck. The April 2007 flood damaged over 300 residential and 100 commercial structures and disrupted the lives of thousands of people through transportation delays and loss of income.

Further, during the September 1992 flood, one person drowned when the car he was traveling in was swept away in a flow of water. Additionally, during the April 2007 storm, a person died in a house fire because flood waters prohibited emergency vehicles from responding to the person's home to provide emergency and medical care. People have been continually evacuated from homes, businesses and vehicles during these damaging floods along both the Mamaroneck and Sheldrake Rivers. No records appear to exist that indicate the number of people evacuated for each flood event or the length of time they were required to stay away from their homes, businesses or jobs. However, Red Cross estimates indicated that more than 200 people were evacuated in the Village of Mamaroneck during the September 1975 flood.

4.8 Causes of Flooding and Historic Storm Damage

4.8.1 Causes of Flooding

The Village of Mamaroneck experiences significant damage to life and property because of flooding from the Mamaroneck and Sheldrake Rivers caused by runoff during high intensity and volume precipitation from storm events that provides devastating flood conditions within a matter of hours. Primary causes of flooding include small bridge openings, poor channel flow capacity and channel constrictions/bends and high velocities due to steep channels.

Flooding in the Mamaroneck and Sheldrake Rivers occurs principally from runoff caused by precipitation of high intensity, great total, or prolonged duration, and has an adverse effect on the economy and the general well-being of the flood-prone areas. Flooding causes physical damage to property and loss of commercial, industrial and public activity, with consequent loss of business and wages. Vehicular traffic is also affected adversely with consequent loss to those who depend on this mode of transportation. In addition to the foregoing, recurring flooding represents a threat to health and safety of those who live or work in these areas.

4.8.2 Historic Storm Damage

Until the Tax Day Storm of April 2007, the most damaging flood of record resulted from the storms of 15-16 October 1955, 18-19 June 1972, and 26-27 September 1975. Other floods occurred in October 1877, September 1882, July 1889, October 1903, March 1936, July 1938, September 1938, July 1942, August 1942, September 1944, May 1946, March 1953, August 1955, August 1960, April 1961, Ash Wednesday nor'easter of March 1962, August 1971, September 1974, April 1983 and September 1999 (Tropical Storm Floyd).

During the June 1972 flood, hundreds of residents, employees and school children were evacuated by boats and trucks as the Mamaroneck and Sheldrake Rivers overflowed their banks, inundating local streets and numerous homes and business establishments. Areas inundated in the Village of Mamaroneck from this flood include approximately 107 acres of industrial, commercial and residential property. Along the Mamaroneck River, the flood damage area was located on both banks between Ward Street and First Street. From First Street upstream to the New England Thruway damages were confined to the left bank and in the reach between Chestnut Avenue and the Joint Waterworks Dam; the Village flood damage area lies on the right bank. Along the Sheldrake River the flood damage area was on both banks between the confluence with the Mamaroneck River and Fenimore Road. Between Fenimore Road and the Village line the damage area lies on the right bank.

During the June 1972 flood, 26 industrial structures, 33 commercial establishments, five (5) public buildings and 207 dwellings were flooded. Columbus Park was completely submerged. The industrial park was inundated to a depth of two feet and many businesses were not able to resume production for a week or more. Hardest hit industrial areas were at the Sealectro Corporation Plant on Hoyt Street, where 60 employees were evacuated, and the Bordow Corporation, located at Mamaroneck and Jefferson Avenues, which had several feet of water in its buildings. The main floors of many dwellings between Mamaroneck Avenue and the Mamaroneck River were flooded to a depth of one (1) foot. Along Chestnut Avenue basements were flooded to a depth of five (5) feet causing severe content damage. Several homes along Winfield Avenue suffered first floor flooding when the Winfield Avenue Bridge was overtopped.

If the Standard Project Flood (as identified in the 1977 Feasibility Study) were to occur along the Mamaroneck and Sheldrake Rivers in the Village of Mamaroneck, approximately 300 acres would be inundated up to depths in excess of 16 feet. The flood of September 1975[4] produced stages in the Village of Mamaroneck of approximately 10.15 feet, 0.44 feet higher than those produced during the June 1972 flood. Total flood damages from the September 1975 flood in the Village of Mamaroneck are estimated at $92M (October 2015 prices). More than 65 percent of these damages were suffered by the industrial and commercial establishments of the village, particularly at the reach along the right bank of the lower Sheldrake River. This flood resulted in stages of up to three (3) feet above the main floors of several of the industries in this reach. The residential areas of the Village were also severely flooded once again during this flood (Figure 13 through Figure 22).

The April 15-16 2007 nor'easter storm, described in greater detail in Section 3.6.4, dropped about three (3) to ten inches of rain on the watersheds within the New York District's civil works boundaries between the early morning of Sunday April 15th, 2007 and the early afternoon of Monday April 16th, 2007, resulting in new flood peaks of record at ten USGS gages in New Jersey, and, in New York, at the USGS gages Saw Mill River at Yonkers and, most importantly for the present study, Mamaroneck River at Mamaroneck (Halstead Avenue) New York. Unlike Tropical Storm Floyd, which broke the summer 1999 drought and fell on dry ground, the April 2007 nor'easter caused as much flooding as it did because it was preceded by the smaller March 1-2 and April 12-13 2007 storms, and, as such, and for other reasons of antecedent soil moisture conditions, fell on saturated ground.

The March 1-2 2007 storm also caused flooding within the Mamaroneck River basin, albeit far less than the flooding resulting from the April 15-16 2007 storm. Total basin rainfall for this storm was estimated at 3.18 inches using rain data from the Dobbs Ferry-Ardsley and Westchester County Airport rain gages.

[4] The September 1975 flood was the flood of record prior to the September 2004 and the April 2007 floods. The 1977 Feasibility Report and the 1989 GDM refer to the September 1975 flood as the flood of record.

It was estimated to have caused a peak flow of 2,680 cfs at the Mamaroneck gage. A peak flow of 5,340 cfs on April 15, 2007 was estimated at the Mamaroneck gage by hydrologic modeling, and subsequently confirmed by hydraulic calibration to recorded high water marks on the Mamaroneck and Sheldrake Rivers. This is a 100 year flood peak on the current existing conditions peak discharge vs. frequency curve at the Halstead Avenue gage. Total rainfall over the study basin was estimated at 7.90 inches using data from the Westchester County Airport rain gage, and local observations of total storm rainfall at East White Plains and New Rochelle, New York. Damage estimates for the April 2007 storm are well over $50 million.

Figure 13 - End of Winfield Avenue

Figure 14 - Church bldg corner of Ralph Ave and Elliot Ave

Figure 15 - River flooding harbor heights

Figure 16 - 2007 Flood Evacuations

Figure 17 - River flooding harbor heights

Figure 18 - Flooding from the Mamaroneck River at New Street

Figure 19 - 2007 Flood Evacuations

Figure 20 - Fenimore Avenue - 2007

Figure 21 - Mamaroneck Sheldrake confluence-Columbus Park

Figure 22 - Mamaroneck Harbor – April 2007 aftermath

4.9 Modeling of Storm Damage Conditions

4.9.1 General and Conditions

Economic benefits warrant reevaluation since changes in land use and development, and increases in the water flows in the area are evident. While newer buildings have been constructed above the 100-year floodplain, garages and utility spaces at ground level are subjected to flood damage from both the Mamaroneck and Sheldrake Rivers and area disruptions pose loss of economic activity in the area.

4.9.2 Benefit Types

Benefit analysis for a feasibility study include quantifiable benefits in the four accounts as put forth in ER 1105-2-100 and non dollar denominated impacts for the evaluation and comparison of alternatives as directed by WRDA and various guidance documents. The damages consist of primary tangible damages, including (1) physical damages to property, such as damages to buildings and other structures, and loss of contents, including furnishings, inventory and equipment and autos; (2) emergency costs, such as additional expenses due to evacuation and reoccupation, personnel and equipment expenses incurred in floodfighting; and (3) extra costs due to traffic interruptions and delays, and (4) advanced bridge replacement costs.

4.9.3 Physical damages to property

The study area is divided into study reaches for formulation purposes and to facilitate analysis of alternatives. Average annual damages to property and contents were calculated for each reach by combining water surface elevations with structure inventory data and damage functions specific to the type of structure. The Flood Damage Reduction Analysis (HEC-FDA) software developed by the US Army Corps of Engineers' Hydrologic Engineering Center (HEC) integrates hydrologic engineering and economic analysis to evaluate flood risk management plans. HEC-FDA combines hydrologic and economic data and computes expected annual damage (EAD) and equivalent annual damages, and implements the risk analysis procedures described in EM 1110-2-1619.

4.9.4 Emergency Costs

Emergency costs include expenses that result from a flood. Emergency costs include expenses for emergency evacuation, flood fighting, administrative costs of disaster relief, public clean up costs, and increased costs of police, fire, and military patrol. Emergency costs were derived from actual emergency costs incurred by the Village of Mamaroneck during significant flood events and interpreted for and applied to different frequency events.

4.9.5 Bridge Replacement

The plans of protection along the Mamaroneck and Sheldrake Rivers will require the replacement of several existing bridges. The bridges considered to be replaced in the alternatives included Ward Street, Halstead Avenue, Station Plaza and Hillside Bridge. The replacement of an existing bridge extends the life of the structure with a reduction of maintenance costs. These net reductions were considered as benefits accruing to the plans of protection.

4.9.6 Transportation disruptions

The transportation routes within the study area experience significant disruption in service during flood events. Major access routes which wind through the study area and larger routes which have access and exit ramps in the Village of Mamaroneck are inaccessible under flood conditions. Quantification of transportation disruptions is precise and comprehensive, and for this study area would not generate benefits which significantly affect the comparability of plans of improvement. Therefore, the study does

not include monetized transportation disruptions in the benefit calculation beyond the costs of emergency personnel responding to dangerous and inaccessible roadways. Those impacts are captured within the emergency costs.

4.9.7 Economic Reaches

Multiple reaches were established within the current study to capture the varying influences of hydrology and hydraulics within the model. The areas susceptible to flooding along the Mamaroneck and Sheldrake Rivers were divided into thirteen separate areas, or reaches, to facilitate the collection of flood damage data, and the calculation of flood damages to include the 500-year floodplain of each reach area. The reaches may be further subdivided into right and left bank segments as the data is assessed and input into HEC-FDA. In order to conduct economic benefit analyses for without-project and with-project alternative plans, the study area has been divided into three streams containing the 13 economic reaches; five along the Mamaroneck River downstream of its confluence with the Sheldrake River, four along the Sheldrake River, and four along the Mamaroneck River upstream of the confluence. The upstream and downstream limits of the reaches were selected to be consistent with the hydrologic/hydraulic modeling and were mostly located at the location of bridges considered for replacement and the inlet/outlet structures for alternatives featuring diversion tunnels, so that the effects of these measures could be modeled in detail. A summary of the economic reaches is presented inTable 6:

Table 6: Summary of Economic Reaches

Stream	Reach	Description
Mamaroneck Downstream	MD1	Harbor to Tompkins Ave Bridge
	MD2	Tompkins Ave Bridge to Ward Ave Bridge
	MD3	Ward Ave Bridge to Valley Place Bridge
	MD4	Valley Place Bridge to Halstead Ave Bridge
	MD5	Halstead Ave Bridge to confluence
Sheldrake	S1	Confluence to Mamaroneck Ave Bridge
	S2	Mamaroneck Ave Bridge to Fenimore Ave Bridge
	S3	Fenimore Ave Bridge to Rockland Ave Bridge
	S4	Rockland Ave Bridge to upstream of I-95 Bridge
Mamaroneck Upstream	MU1	Confluence to Hillside Ave Bridge
	MU2	Hillside Ave Bridge to I-95 Bridge
	MU3	I-95 Bridge to Winfield Ave Bridge
	MU4	Winfield Ave Bridge to Mamaroneck Reservoir Dam

Although each proposed reach has similar hydraulic characteristics which cause small differences in WSEL, small changes to the reach (e.g. bridge improvement or replacement) may produce high economic benefits or a big reduction in the flood pool. Therefore, reaches were defined to facilitate comparison of with and without project conditions which result from possible structural changes.

4.9.8 Inventory Methodology

A structure inventory for the project area was compiled in stages for use in the HEC FDA model. Initially populated from the FEMA 500 year floodplain data in a GIS format, staff conducted a 100% survey of

structures and generated a database confirming existing structures and their defining characteristics, and adding new developments to the inventory. Commercial, industrial, and residential properties were described by building type, number of stories, use, and condition for valuation purposes. Characteristics such as low opening, main floor elevation and building material were recorded to determine the percent damage to the structures resulting from inundation levels. Elevations and square footage were elicited from GIS resources and confirmed in the field at the time of inventory. Residential valuations were assigned in accordance with RS Means square foot costs for depreciated replacement value, adjusted for the current price level and regional price factors at the time of comparison. Commercial valuations were derived through Marshall Swift square foot costs which were also adjusted for regional differences in construction factors and for current price level.

4.9.9 Inundation Damage Functions

The computation of annual flood damages in this analysis is based on the application of depth-damage functions to the structures in the study area to compute damage incurred by structures and contents during flood events of different probability of occurrence. The primary source of depth-damage functions for this study were the generic depth-damage functions for residential structures developed by the U.S. Army Corps of Engineers and the damage functions for non-residential structures that were developed following an expert opinion elicitation exercise carried out by FEMA and USACE/Institute for Water Resources:

Based on the type, usage and size of each structure inventoried, damage was calculated relative to the main floor elevation of the structure. Using structure and ground elevation data, these depths vs. damage relationships were converted to corresponding stage (NAVD 1988) vs. damage relationships. Damages for individual structures at various stages were aggregated according to structure type (residential, apartment, commercial, etc.) and location (reach). Generalized Depth-Percent Damage functions were applied to structures for calculation of inundation damage.

4.10 Without-Project Damages Summary

Using HEC-FDA, Average Annual Damages (AAD) were calculated for the without-project base year and future condition, and Equivalent Annual Damages (EAD) were calculated for the 50-year period of analysis, using the 2012 fiscal year (FY) USACE project evaluation and federal plan formulation discount rate of 4.0%. A summary of equivalent annual damages for the without-project condition is presented inTable 7.

Table 7: Summary of Equivalent Annual Damages for the Without-Project Condition

Reach	Damage Categories						Reach Total
	Residential	Apartment	Commercial	Industrial	Public	Vehicles	
MD1	$20	$1,720	$1,820	$0	$0	$6,790	$10,350
MD2	$130	$0	$980	$0	$0	$0	$1,110
MD3	$12,770	$0	$230	$0	$0	$440	$13,440
MD4	$470	$0	$10,360	$0	$0	$20	$10,850
MD5	$70	$0	$0	$0	$0	$0	$70
Stream Total	*$13,460*	*$1,720*	*$13,390*	*$0*	*$0*	*$7,250*	*$35,820*
S1	$109,430	$7,470	$124,610	$0	$7,620	$28,830	$277,960

Reach	Damage Categories						Reach Total
	Residential	Apartment	Commercial	Industrial	Public	Vehicles	
S2	$590,530	$7,610	$660,520	$396,730	$0	$36,420	$1,691,810
S3	$9,580	$0	$48,880	$26,650	$0	$360	$85,470
S4	$3,870	$0	$0	$0	$0	$110	$3,980
Stream Total	*$713,410*	*$15,080*	*$834,010*	*$423,380*	*$7,620*	*$65,720*	*$2,059,220*
MU1	$268,200	$880	$236,390	$0	$104,020	$14,510	$624,000
MU2	$397,380	$0	$1,580	$0	$1,040	$22,720	$422,720
MU3	$256,730	$0	$0	$0	$0	$4,940	$261,670
MU4	$0	$0	$6,900	$0	$0	$0	$6,900
Stream Total	*$922,310*	*$880*	*$244,870*	*$0*	*$105,060*	*$42,170*	*$1,315,290*
Project Total	**$1,649,180**	**$17,680**	**$1,092,270**	**$423,380**	**$112,680**	**$115,140**	**$3,410,330**

Price level: FY2012, 4.0% Discount rate.

The cost and benefits of the initial screening process have not been updated to 2015 price levels or current discount rate, since the comparisons will not be affected by the updates. Subsequent comparisons of the revised alternatives are presented in current price level and discount rates to ensure that all impacts are evaluated in current terms.

Results of this analysis indicate that 60% of the without-project condition damages are being incurred by structures considered to be primarily flooded by the Sheldrake River, and 50% of the total damages are being incurred in just one reach (S2). While significant damages (almost 40% of the total) are being incurred by flooding on the Mamaroneck River upstream of the confluence, flooding on the Mamaroneck downstream of the confluence accounts for approximately 1% of the total damages.

4.11 Opportunities

4.11.1 Flood Risk Management

Because this is a flood risk management project, problems and opportunities are developed to address the Federal objective of NED. Goals, objectives, and constraints are developed to provide potential solutions to reduce flood risk and achieve the opportunities within the confines of legislative authority, policies, and other restrictions. Opportunities to solve problems in the study area include:

- Manage storm damage risk to residents, property, and infrastructure associated fluvial flood events.
- Support the resiliency of the community that without flood protection has negative safety and economic consequences to the region and to the nation.

Project opportunities were developed to comply with the Project authority and to respond to study area problems. The primary goal of the current study is to manage the flood risk from repetitive flooding caused by the Mamaroneck and Sheldrake rivers (USACE New York District 2011a).

5. PLAN FORMULATION, EVALUATION, COMPARISON, & TENTATIVE PLAN SELECTION

The Plan formulation, evaluation, comparison, tentative selection, and optimization efforts for this general reevaluation study were conducted between the study initiation and this Draft GRR. This section provides the formulation, evaluation, selection and comparison process that were completed for the identified alternatives to manage flood risk in the study area.

5.1 Plan Formulation and Evaluation Criteria

The formulation process used in this study is consistent with the national objectives as stated in the *Planning Guidance Notebook*. In flood risk management plans must contribute to the National Economic Development (NED) account consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders and other Federal planning requirements. Plans to address the needs in the study area must be formulated to provide a complete, effective, efficient, and acceptable plan of coastal storm risk management. These objectives impose general planning constraints within any study area.

- **Completeness** is defined as *"the extent to which a given alternative plan provides and accounts for all necessary investments of other actions to ensure the realization of the planned effects. This may require relating the plan to other types of public or private plans if the other plans are crucial to realization of the contributions of the objective."*
- **Effectiveness** is defined as *"the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities."*
- **Efficiency** is defined as *"the extent to which an alternative plan is the most cost effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment."*
- **Acceptability** is defined as *"the workability and viability of the alternative plan with respect to acceptance by State and local entities, and the public, and compatibility with existing laws, regulations, and public policies."*

This report was prepared in accordance with the provisions of ER 1110-2-1150 (as modified), and is based upon the plan of protection contained in the October 1977 feasibility document entitled *Feasibility Report For Flood Control, Mamaroneck and Sheldrake Rivers Basin (Village and Town of Mamaroneck New York) and Byram River Basin (Greenwich, Connecticut and Port Chester, New York)* and the 1989 General Design Memorandum.

Flood Risk Management measures that were examined in this reevaluation report include the "no action" alternative, non-structural measures, structural measures as well as a combination of the previous solutions. This included, but was not limited to; variations of the recommended plan's components: e.g. channel modification, diversion tunnel, levees and floodwalls. More specifically, the tunnel's alignment and desired level of protection was re-evaluated. Non-structural measures such as buyouts, floodproofing and preservation and/or creation of open space in the floodplain was also reconsidered in light of changes to existing conditions and changes to environmental policy.

However, since the Feasibility Report and 1989 GDM have already been completed, this GRR focuses on review of plans which were the most feasible, based on prior information and updated information where necessary. Therefore, preliminary alternatives were analyzed as listed below:

1. Authorized (1989 GDM) Plan (channel modification and diversion tunnel);
2. Channel modification only;
    i. Mamaroneck below confluence
    ii. Mamaroneck River only
    iii. Mamaroneck and Sheldrake Rivers
3. Channel modification with new tunnel alignment (along Mamaroneck Avenue or another route with an outlet into the East Basin of Mamaroneck Harbor);
4. Non-structural plan alone.
5. Non-structural plan in combination with any of the plans mentioned above.
6. No Action Plan.

This reevaluation report serves to document the re-evaluation of the recommended plan, (including any adjustments or variations of said plan) and provides a basis for a decision on construction authorization of the project (if needed) and serves as the decision document for execution of a Project Partnership Agreement.

The formulation of potential modifications and re-evaluation of the recommended plan is constrained by technical, environmental, economic, and social considerations. These constraints shall appropriately limit and screen proposed modifications to the recommended plan and serve to focus formulation efforts. During the re-evaluation, once existing conditions are reassessed and without project conditions established, the analysis proceeds to a "with project conditions" assessment. Plan formulation techniques were employed to guide the development, screening and selection of opportunities for improvement to the recommended plan, in accord with local interests' needs, while meeting planning objectives and within the aforementioned constraints. Formulation will seek to maintain the recommended plan's purposes of flood risk management, while employing environmentally sound solutions.

The direct benefit (NED) of flood risk management will be analyzed in accordance with ER 1105-2-100 § 2-3 (d)(3), dated April 22, 2000, as well benefits ascribed to the other accounts (OSE, RED, and EQ) as described in EC 1105-2-409 § 4.c.3.

5.2 USACE Planning Process

The USACE Planning Process consists of six (6) steps as follows:

1) The first step of the planning process defines study area problems and opportunities, as well as study constraints, goals, and objectives. Because this is a flood risk management study, problems and opportunities are developed to address the Federal objective of National Economic Development (NED). Goals, objectives, and constraints are developed to provide potential solutions to reduce flood risk and achieve the opportunities within the confines of legislative authority, policies, and other restrictions.
2) The second step in the planning process consists of the inventory and forecast of resources within the study area. This evaluation, or inventory step, accounts for the level or amount of a particular resource that currently exists within the study area, i.e., identification of existing conditions. This step also involves forecasting to predict what changes will occur to resources throughout the 50-year period of analysis, assuming no actions are taken to address the problems in the study area.

Comparison of the existing and forecast conditions of the study area measures the problems resulting from the change in resources over time. Study area problems are quantified based on this predicted change in resources. This second step also results in the delineation of opportunities that fully or partially address the problems in the study area. An opportunity is a resource, action, or policy that, if acted upon, may alter the conditions related to an identified problem.

3) The third step in the planning process is to generate alternative solutions. Alternative plans are formulated across a range of potential scales to demonstrate the relative effectiveness of various approaches at varying scales.
4) In the fourth step in the planning process, alternative plans are evaluated for their potential results in addressing the specific problems, needs, and objectives of the study. The evaluation will be conducted by assessing or measuring the differences between each with- and without-project condition and by appraising or weighting those differences. This difference is referred to as the benefits of the action alternative. Criteria to evaluate the alternative plans include all significant resources, outputs and plan effects. They also include contributions to the Federal objective, the study planning objectives, compliance with environmental protection requirements, the P&G's four evaluation criteria (completeness, effectiveness, efficiency and acceptability) and other criteria deemed significant by participating stakeholders. Evaluation of the beneficial and adverse effects of the alternatives will provide a basis to determine which plans should be considered further, dropped or reformulated.
5) In the fifth step of the planning process, plans (including the no action plan) are compared against each other, with emphasis on the outputs and effects that will have the most influence in the decision making process. Beneficial and adverse effects of each plan must be compared. These include monetary and non-monetary benefits and costs. Identification and documentation of tradeoffs will be required to support the final recommendation. The effects include those identified during the evaluation phase and any other significant effects identified in step 5. The output of the comparison step shall be a ranking of plans.
6) The sixth and final step in the planning process is the selection of the plan that best meets the study objectives and the four criteria in the Principles and Guidelines: completeness, effectiveness, efficiency, and acceptability.

Using the six-step planning process, a Tentatively Recommended Plan is identified.

5.3 Environmental Operating Principles

In 2002, the USACE reaffirmed its long-standing commitment to environmental conservation by formalizing a set of Environmental Operating Principles applicable to decision-making in all programs. The principles are consistent with NEPA; the Department of the Army's Environmental Strategy with its four pillars of prevention, compliance, restoration, and conservation; other environmental statutes and WRDA that govern USACE activities. The Environmental Operating Principles informed the plan formulation process and are integrated into all proposed program and project management processes.

5.4 Planning Objectives

Planning objectives were identified based on the needs and opportunities, as well as existing physical and environmental conditions in the project area:

Specific Objectives

- Manage the risk to life and property of future fluvial storm damages.
- Preserve the function of significant environmental resources.

- Goal: Manage the risk of fluvial flooding and associated damages to the Village of Mamaroneck

Community Resiliency

- ► Protecting major evacuation routes
- ► Protecting regional transportation sources
- ► Reducing regional workforce disruption

5.5 Planning Constraints

The formulation and evaluation of alternative plans are constrained by technical, environmental, economic, regional, social and institutional considerations. For plans analyzed in this study, the following constraints should be taken into account:

5.5.1 Planning Constraints Specific to the Study

Three planning constraints had to be considered when planning this study:

- Metro North Bridge – New Haven Railroad Bridge: There are 4 heavily utilized commuter tracks on the bridge. The cost to maintain service and replace the bridge would far out-weigh the benefits. Additionally, a duplicate bridge constructed with zero deflection and an exact bend radius would need to be erected to divert train traffic. Further, Station Plaza is listed on the National Register of Historic Places. Any modification to this bridge would not be approved by Metro North regardless of the high cost.
- New England Thruway – the cost for any improvement, modification, relocation, traffic maintenance, etc would largely outweigh any benefit that may be accrued.
- Lack of real estate or open space – the Village of Mamaroneck is highly urbanized and highly developed. There is little to no opportunity to preserve or create open space.

General, physical/technical, economical, environmental, regional/social and institutional considerations must also be taken into account during alternative screening:

5.5.2 General:

The plan must:

1. Meet the needs and concerns of the public within the study area;
2. Be flexible to accommodate changing economic, social and environmental patterns and changing technologies;
3. Integrate with and be complementary to other related programs in the study area;
4. Be able to be implemented with respect to financial and institutional capabilities and public consensus;
5. Comply with USACE environmental operating procedures.

5.5.3 Physical/Technical :

1. Plans shall represent sound, safe, and acceptable engineering solutions;
2. Plans shall minimize the footprint of structures when possible;
3. Plans shall be designed to be low-maintenance;
4. Plans should avoid and minimize impacts to environmental resources with the potential for enhancement;

5. Plans shall be sustainable, resilient and adaptable;
6. Plans shall take into consideration aesthetics and viewshed.
7. Plans shall be in compliance with USACE regulations;
8. Plans shall be realistic and state-of-the-art while not relying on future research or development;

5.5.4 Economic:

1. Plans must be efficient, make optimal use of resources, and not adversely affect other economic systems;
2. Average annual benefits must exceed the average annual costs.

5.5.5 Environmental:

1. Plans must avoid and minimize environmental impacts to the maximum degree practicable.

5.5.6 Regional and Social:

1. All reasonable opportunities for development within the project scope must be weighed, with consideration of state and local interests;
2. The needs of other regions must be considered, and one area cannot be favored to the detriment of another;
3. Plans must maintain existing cultural resources to the maximum degree possible and produce the least possible disturbance to the community.

5.5.7 Institutional:

1. Plans must be consistent with existing federal, state, and local laws;
2. Plans must be locally supported and signed by local authorities in the form of a Project Partnership Agreement and guarantee for all items of local cooperation including possible cost sharing;
3. The plan must be fair and find overall support in the region and state.

6. FORMULATION AND EVALUATION OF ALTERNATIVE PLANS

A variety of structural and nonstructural plans were evaluated to satisfy the study objectives and constraints. Formulation and evaluation of the alternative plans was conducted consistent with Federal water resources policies and practices. As required by ER 1105-2-100, alternative plans are evaluated by comparing conditions expected under with and without-project scenarios.

6.1.1 No-Action

The No-Action Alternative reflects the continuation of existing economic, social, and environmental conditions and trends within the affected area. Failure to provide the Mamaroneck and Sheldrake Rivers Basin study area with flood risk management measures could continue to contribute to the potential loss of life and physical, as well as environmental, damage to study area communities in the occurrence of significant flooding. Significant flooding can result in municipal infrastructure damage, loss of jobs, and closure of businesses.

6.1.2 Non-Structural

In accordance with the USACE National Nonstructural Flood Proofing Committee, nonstructural measures and flood proofing alternatives can be used to mitigate flood hazards and damages. Nonstructural measures typically provide protection to individual structures. Techniques may include:

a. Elevation: Elevation is the process of raising a structure so that the main living area (main floor) will be above design flood elevation.

b. Buy-Out or Acquisition: Buyout or acquisition results in the permanent removal or evacuation of the structure from the floodplain and is typically applied when other nonstructural measures are too costly. Following acquisition, the structure and associated property development is either demolished or relocated. Acquired lands are typically restored to a natural condition and used for recreation or other purposes that would not be jeopardized by the flood hazard.

c. Flood Warning System: Flood warning systems may be utilized to warn property owners of impending floods, and therefore allow time to evacuate and relocate property subject to flood damage. Currently, there is no Flood Warning System in place for the Mamaroneck and Sheldrake Rivers Basin, to warn residents of the area subject to flooding.

d. Floodproofing: Floodproofing is the process of making any combination of structural or nonstructural changes or adjustments incorporated in the design, construction, or alteration of individual buildings or properties in order to reduce flood damages. There are two categories of floodproofing: wet floodproofing and dry floodproofing.

Wet floodproofing refers to the protection of a building in a manner that allows floodwaters to enter and exit freely, in such a way that internal and external hydrostatic pressures are equalized. This equalization of pressures reduces the loads imposed on a structure and reduces the probability of structural damage or failure. Additionally, basement utilities subjected to flooding may be relocated to an above-grade utility room, where space permits, otherwise, the basement utilities may be surrounded by a watertight barrier.

Dry floodproofing is the process of protecting a building by sealing its exterior walls and by providing removable flood shields at structure openings to prevent the entry of floodwaters. Dry floodproofing is practical only for buildings with structurally sound walls and only where flood depths are low: no more than 2 to 3 feet for wood frame structures, or 3 to 4 feet for brick with masonry foundation walls.

e. Surface Periphery Floodwalls or Ringwalls: For structures that are too large to elevate (generally in excess of a 2,000 SF footprint), a concrete wall or levee (ringwall) may be considered around the structure's property, where space and aesthetics permit.

f. Rebuilding: If the estimated cost of any other nonstructural alternative exceeds the estimated cost to demolish a structure and rebuild an equivalent structure, rebuilding the structure above the design flood elevation may be an economically viable nonstructural alternative.

6.1.3 Structural

Structural alternatives typically consist of constructed barriers that protect areas of development, and may include levees, walls, and detention basins. Structural alternatives may also include increasing the size of existing floodwater conveyances, such as channel-widening and deepening, or diverting floodwaters through other channels, pipes, and culverts.

6.1.4 Diversions

An underground culvert may be used to divert river overflow from upstream of a developed area. Flood flows contained within the culvert would bypass the developed area and re-enter the river downstream. Under normal conditions, base flow would continue to flow within the river channel. An intake structure would allow flood flows to be diverted into the culvert. This type of alternative can also minimize environmental impacts to the stream by avoiding alterations within the river channel.

6.1.5 Channel Modifications

Channel modifications may be used to help protect communities against riverine flooding and stream blockages. Channel modifications can include dredging, deepening and widening, rechannel modification, dam modifications, and elevating or widening bridges. Channel modifications can be an effective means to reduce flooding, however, environmental impacts may be significant. Channel modifications are typically only cost effective for small to medium sized waterways..

6.1.6 Detention Basins

Detention basins may be used to reduce the peak flood flows by temporarily storing (detaining) floodwater, then releasing it at a substantially reduced flow to reduce peak flood flows. This reduces peak water surface elevations and helps to minimize flood damages downstream.

6.1.7 Levees/Floodwalls

Floodwalls and levees are intended to provide protection against flooding to homes, commercial buildings, municipal buildings, roadways, and bridges by prohibiting floodwaters from reaching these structures. While levees and floodwalls can provide a cost-effective means to prevent flooding of low-lying areas, interior drainage facilities are required to handle run-off trapped behind them to prevent interior residual flooding.

6.2 Screening of Initial Management Measures

The screening of flood risk management measures includes an assessment of the potential engineering, economic, environmental, public, financial, and institutional feasibility of implementing each measure.

Those measures that are not entirely screened out are carried forward for more detailed analysis as alternative plan components. Based on the physical layout of the study area, the flood hydrology, and the profiles of structures at risk, the following flood risk management measures were considered for application to flooding problems in the study area: These measures and the results of the initial screening are described below and in Table 8.

The Diversion Culvert Plan (i.e.: the Tunnel Plan): The "Tunnel" plan was the NED Plan identified during the 1977 Feasibility Study and was the authorized plan. Therefore in accordance with ER 1105-2-100, the Tunnel/NED plan cannot be eliminated for re-evaluation.

Levees & Floodwalls: preliminary screening activities eliminated levees and floodwalls due to the high land acquisition costs that would be incurred. Further, levees and floodwalls were not economically justified in the 1977 Feasibility Study and were also eliminated as an alternative. The GRR has been updated to clarify and expands the elimination of levees and floodwalls as a potential solution.

Floodwalls and levees would also result in socio-economic impacts due to the higher and wider levees which require substantial portions of residential, commercial and industrial property and the extensive raising of bridges and roadways which would severely disrupt the business community during construction. The high levees and floodwalls, which average approximately 7 and 11 feet in height along the Mamaroneck and Sheldrake Rivers as identified in the 1977 Feasibility Report, respectively, would also have an adverse aesthetic impact on the community.

Non-Structural Alternatives: no non-structural measure has been eliminated at this time. Further, non-structural measures will also be evaluated in combination with structural alternative measures. Specifically, the plan selection process will consider the following non-structural measures:

> Preservation and/or Creation of Open Space in the Floodplain: there is not an opportunity for preservation or creation of open space within the damage area of the Village. The Village is entirely urbanized and no open space is available nor did future land use investigations reveal and possibility of creation of open space.
>
> Detention: There are several upstream sites within the Mamaroneck and Sheldrake Rivers basin at which flood detention reservoirs are possible. These sites include two areas which are currently occupied, in part, by existing reservoirs which were formerly used for water supply purposes. These facilities, which were used until the 1970s as standby reserves to the supplies obtained from the New York City water supply system, are Larchmont Reservoir #2 along the Sheldrake River, and the Westchester Joint Water Works Reservoir on the Mamaroneck River. Additional sites exist along the Mamaroneck River at Maple Moor Golf Course, and at Silver Lake. However, the development of a flood storage reservoir at each of these sites is not particularly attractive because of excessive costs and/or limited regulation and effectiveness at the downstream areas. The development of flood detention at each of the possible sites is discussed in the following paragraphs.
>
> *Larchmont Reservoir #2*. Larchmont Reservoir #2 lies along the Sheldrake River, upstream of the damage areas in the Village of Mamaroneck, and upstream of the Sheldrake River's confluence with its East Branch. A flood control reservoir at this site would control a drainage area of 2.63 square miles, constituting 42.7 percent of the entire Sheldrake River watershed. Various schemes for flood risk management at this site were investigated, the most viable of

which considered the modification and utilization of the existing dam. As part of this plan, the dam's existing non-overflow section would be increased in elevation, the existing reservoir dewatered, and regulating works constructed. The resulting reservoir would reduce the 100-year discharges along the Sheldrake River at the damage area in the Town of Mamaroneck from Lansdowne Drive upstream to Bonnie Briar Lane by approximately 40 and 7 percent, respectively. However, this improved 100-year discharge is in excess of the bankfull capacity for this reach of stream, and local protection works would still be necessary at this area for protection against a 100-year storm, or greater.

Furthermore, the effect of the reservoir diminishes progressively at downstream areas, and would provide minimal benefits to the Village of Mamaroneck. The costs of modifying the existing dam, including regulating works, would be approximately 25 million dollars (1977 price level) alone, and combined with the costs of the upstream levees required around the reservoir, relocations and easements and local protection works in the Village of Mamaroneck, the plan would be highly cost prohibitive. Additionally, to increase the storage capacity for the reservoir at this site, a new dam would have to be constructed and more extensive levees constructed around the reservoir. Although such a detention reservoir would provide a higher level of protection at the Town of Mamaroneck, benefits to the areas below the Sheldrake River's confluence with the East Branch would be limited, and the resulting plan also highly cost prohibitive. No other practical reservoir sites exist in the Sheldrake River watershed.

Westchester County Joint Water Works Reservoir. The Westchester County Joint Water Works Reservoir lies on the Mamaroneck River, upstream of the damage areas in the Village of Mamaroneck. A flood control reservoir at this site would control a drainage area of 15.35 square miles, constituting 65 percent of the entire Mamaroneck River watershed. The existing dam at the site was investigated to determine its potential for flood risk management. This evaluation indicated that, even with significant modifications, the existing structure provided no significant reduction in the peak flows.

A number of alternatives were then considered which included a new dam at this site. The most viable of these schemes considered a new dam with a 200-foot long spillway, averaging 35 feet in height, and an 800-foot long earthen non-overflow section averaging 26 feet in height. Such a reservoir would reduce the 100-year flood discharges by approximately 50 and 25 percent, respectively, along the Mamaroneck River at its confluence with the Sheldrake River. However, the improved 100-year discharge is in excess of the bankfull capacity for the Mamaroneck River in the village, and local protection works would be necessary to protect against a 100-year or greater storm.

Furthermore, the cost of the structural works required to provide the flood storage discussed above, far exceeds the flood risk management benefits derived. In addition to the new dam and regulating works, several roads and highways would be raised substantial heights. For example, Mamaroneck Avenue would be raised to heights up to 21 feet, with the length of roadway affected in excess of 8,009 feet. Other roads to be raised would include Union Avenue, portions of the Hutchinson River Parkway, New England Thruway access ramp, and local streets lying from Winfield Avenue to Teresa Lane.

The real estate requirements for such a reservoir at this site would total more than 200 acres, while the total cost, including new dam, road relocations and raising, real estate and local

protection works would be in excess of $150 million dollars (1977 price level). Reservoir schemes which consider lower storage capacities would be less costly at the detention site itself; however, the associated cost of the local protection works that would be required downstream to provide at least a 100-year level of protection would escalate the overall cost and the resulting plan would be highly uneconomical.

Flood Detention at Maple Moor Golf Course. The utilization of the Maple Moor Golf Course and the surrounding area was considered as a possible flood storage site along the Mamaroneck River in response to requests by local interests. The Maple Moor Golf Course lies upstream of the Village of Mamaroneck and the Westchester Joint Water Works Reservoir. A flood risk management reservoir at this site would control a drainage area of 9.4 square miles, constituting 39.8 percent of the entire Mamaroneck River watershed. An analysis of possible reservoir schemes revealed that even if a reservoir at this site stored the total existing 100-year peak discharge, the incremental flows generated below the Maple Moor Golf Course from local runoff would far exceed bankfull capacity of the Mamaroneck River at downstream areas and severe flooding would still result in the Village of Mamaroneck during a 100-year event. Thus, for such a level of protection, or greater, extensive local protection works would be necessary in the village even if such a reservoir were constructed at Maple Moor. The construction of a reservoir at the Maple Moor site to provide substantial flood storage would affect the Hutchinson River Parkway, and Interchanges 22 and 23 of the Cross Westchester Expressway. The cost of such a dam and reservoir would far exceed the limited flood management benefits it would provide in the Village.

In addition to considering the Maple Moor site individually as a detention reservoir, further consideration was given to a system of storage reservoirs at the Maple Moor Golf Course and the Westchester Joint Water Works site to function in tandem. However, even with such a system, the incremental runoff flows generated below the Westchester Joint Water Works site for a 100-year or greater event would cause flooding at the Village of Mamaroneck. The flood risk management benefits which can be attributed to such a reservoir system clearly cannot support the excessive costs required for construction of the two dams and reservoirs, and downstream local protection works.

Flood Detention at Silver Lake. The use of Silver Lake along the Mamaroneck River was considered as a possible flood detention site in response to requests by local interests. However, a flood control reservoir at this site would control a drainage area of 1.1 square miles, constituting only 4.7 percent of the entire Mamaroneck River watershed. Even if the entire existing 100-year peak discharge at Silver Lake could be retained, the resulting 100-year flow for the Mamaroneck River in the Village would be reduced by less than 5 percent. Silver Lake site lies too far upstream from the damage areas in the Village to be effective for flood risk management purposes.

Table 8: Initial Screening of Measures for Flood Risk Management

Opportunity	Objective	Constraint	Retained for Further Study?
No Action (means that no additional federal actions would be taken to provide for coastal storm risk management)	• NA	• NA	• Yes, as per NEPA and ER 1105-2-100, the No Action alternative provides the base against which project benefits are measured.
Channel modification	Reduce risk to life and property by widening or deepening the channel to increase conveyance capacity of stream to reduce water surface elevations and flood damages throughout the basin during flood events.	• lack of available real estate	• Yes, only minimal real estate will be required for channelization, this measure will meet the planning objectives.
Diversion Culvert	Reduce risk to life and property by increasing conveyance capacity of the stream to reduce water surface elevations and flood damages throughout the study area during flood events.	• Costs for substantial amount of real estate interests may be high.	• Yes, this measure will meet the planning objectives to reduce flood impacts in the basin. Real estate interests could mostly be underground.
Levee / Floodwall	Reduce risk to life and property by reducing flood damages throughout the basin by protecting areas traditionally sustaining flood damages from overbank flooding.	• May not minimize impacts to historical/cultural resources to the maximum degree practicable. • May not minimize environmental impacts to the maximum degree	• No, land acquisition would be extremely high for the installation of floodwalls and levees. There is not the available space to construct levees

		practicable. • Substantial requirement for real estate interests	and floodwalls in the project area.
Creation of temporary detention basins	• Reduce risk to life and property by reducing water surface elevations and flood damages by temporarily detaining waters upstream of areas traditionally sustaining flood damages.	• May not minimize environmental impacts to the maximum degree practicable.	• Yes, reevaluation requested by non-Federal partner for further evaluation.
Floodproofing/Elevation of flood prone residences, businesses and public facilities subject to frequent flooding	• Reduce risk to life and property by moving the public out of flood damage • Minimize environmental impacts.	• may not effectively reduce the risk to life as floodplain will still be impacted by floodwaters thereby prohibiting the emergency vehicles access to residents or evacuations.	• Retained for further study. As per ER 1105-2-100, a non-structural flood risk management plan must be examined to compare against structural flood risk management plans.
Permanent evacuation/ Flood Warning of residences and businesses (buyouts)	• Reduce flood damages to properties. • Minimize environmental impacts and possibly create additional open space and floodplain area.	• Access routes would not remain open during flood event (New England Thruway) • Continued potential for loss of life and physical, as well as environmental, damage to study area communities in the occurrence of significant flooding.	• Retained for further study. As per ER 1105-2-100, a non-structural flood risk management plan must be examined to compare against structural flood risk management plans.

Opportunities with potential for addressing flood risk management that met USACE policy were developed into alternatives and are discussed in the following section.

6.3 Alternative Plan Formulation

Alternative plans are combinations of management measures that collectively meet study goals and objectives within the defined study constraints. Alternative plans are assembled and compared against one another using performance outputs and costs. Alternative plans and their component management measures will be assessed relative to the objective of National Economic Development (NED).

Preliminary costs, benefits, and impacts of each potential alternative were developed to determine which flood risk management plans should be considered for more detailed design and economic analysis.

6.3.1 Description of Alternative Plans

As discussed previously, the objective for the development of improvements is to prevent recurrent flooding in the project areas, along the Mamaroneck and Sheldrake Rivers. The following sections present a preliminary list of improvements to be considered in the feasibility study. As part of the GRR a set of alternatives have been considered, including the reevaluation of improvements proposed in the 1989 GDM, to evaluate the possible solution to the flooding problems in the Mamaroneck and Sheldrake River Basin.

To provide a basis for selection of the final plan and design, the District evaluated eight (8) alternatives for their potential results in addressing the specific problems, needs, and objectives of the Project. The evaluation assessed or measured the differences between each with- and without-project condition and appraised or weighted those differences. These differences are referred to as the benefits of the action alternative. Criteria to evaluate the alternative plans include all significant resources, outputs, and plan effects. They also include contributions to the Federal objective, the Project planning objectives, compliance with environmental protection requirements, four evaluation criteria (completeness, effectiveness, efficiency and acceptability) and other criteria deemed significant by participating stakeholders. Evaluation of the beneficial and adverse effects (including both monetary and nonmonetary benefits and costs) of the alternatives provided a basis for determining which plans should be considered further, eliminated or reformulated. As required by ER 1105-2-100, alternatives were evaluated by comparing conditions expected under with- and without-project scenarios. Alternatives (including the No Action alternative) were compared against each other, with emphasis on the outputs and effects that would have the most influence in the decision-making process. The identification and documentation of tradeoffs were used to support the final recommendation. The output of this comparison process resulted in the ranking of alternatives considered.

The nonstructural alternatives identified for the study area incorporate flood proofing measures and the raising of buildings within the floodplain. The existing floodplain zones would be maintained, with flood risks reduced through modifications of existing structures. Two nonstructural alternatives were identified. These nonstructural alternatives are generally reserved to reduce damages in frequently flooded properties (i.e., less than 25-year flood event) due to their associated high costs. Six structural alternatives were identified. As a contrast to the nonstructural alternatives, all of the structural alternatives identified for the study area would at least meet FRM requirements for a 100-year flood event.

6.3.2 Alternative #1 – Lower Mamaroneck River and Confluence Area

This plan includes channel deepening and widening along both the Mamaroneck and Sheldrake Rivers from a little above the confluence to the Tomkins Avenue Bridge (tidal limit) as seen in *Figure 23*. Five bridges will be removed and/or replaced including the two Columbus Park pedestrian bridges, Station Plaza, Halstead Avenue and Ward Avenue. Along the Mamaroneck River, channel work extends from the Tompkins Ave. Bridge to 400 ft above the Hillside Avenue Bridge, for an approximate length of 4,200 ft. Along the Sheldrake River, channel work extends from the confluence to 700 ft above the Mamaroneck Avenue Bridge, for an approximate length of 1,400 ft. The river will be significantly realigned at the confluence and below the Ward Ave Bridge. Trapezoidal channel improvements will consist of a natural bed channel with a 30 to 50 ft width and side slopes of one vertical on two and a half horizontal (1:2.5). Concrete retaining walls will be used where space is limited. The existing channel side slopes range from one vertical on one horizontal (1:1), to one vertical on three horizontal (1:3). The width of the existing channel varies from 30 to 50 ft for the Mamaroneck River and from 20 to 40 ft in the Sheldrake River. The channel bottom will be lowered from two (2) to four (4) ft. The channel bottom has a moderate slope, approximately 12 ft per mile. Columbus Park will be used as the staging area during construction.

Figure 23 - Alternative 1

6.3.3 Alternative #2 – Mamaroneck River and Confluence Area

This plan includes Alternative 1 and additional work along the Mamaroneck River up to the Winfield Avenue Bridge as seen in Figure 24. Six bridges will be removed and/or replaced including Hillside Avenue the two Columbus Park pedestrian bridges, Station Plaza, Halstead Avenue and Ward Avenue. Along the Mamaroneck River, channel work extends from the Tompkins Avenue Bridge to 270 ft above Winfield Avenue Bridge, for an approximate length of 6,700 ft. Along the Sheldrake River, channel work extends from the confluence to 750ft above the Mamaroneck Avenue Bridge, for an approximate length of 1,500ft. The river will be significantly realigned at the confluence and just below the Ward Avenue Bridge. Trapezoidal channel improvements will consist of a natural bed channel with side slopes of one vertical on two and a half horizontal (1:2.5), with retaining walls where space is limited. Articulated concrete mats block may be used throughout and just downstream of the Winfield Avenue Bridge due to the high stream velocities.

Figure 24 - Alternative 2

6.3.4 Alternative #3 – Mamaroneck and Sheldrake Rivers

This plan includes Alternative 2 with additional channel deepening along the Sheldrake River as seen in *Figure 25*. Eight (8) bridges will be removed and/or replaced including Centre Avenue, the two (2) Columbus Park pedestrian bridges, Hillside Avenue, Station Plaza, Halstead Avenue, Valley Place (Anita Lane Sewer Bridge); and Ward Avenue. Along the Mamaroneck River, channel work extends from Tompkins Avenue Bridge to 270 ft above Winfield Avenue Bridge, an approximate length of 6,700ft. The Sheldrake River channel work extends from the confluence to 450ft above the Rockland Avenue Bridge, for an approximate length of 6,700ft; a significant amount of retaining walls will be used for this alternative. The river will be significantly realigned throughout the confluence and just below the Ward Avenue Bridge. Trapezoidal channel modification will consist of a natural bed channel with side slopes of one vertical on two and a half horizontal (1:2.5), and concrete retaining walls will be used where space is limited. Articulated concrete mats will be used throughout and just downstream of Winfield Avenue Bridge due to the high stream velocities. A rectangular channel with concrete retaining walls and channel bottom is needed from the Railroad Bridge to the Halstead Avenue Bridge.

Figure 25 - Alternative 3

6.3.5 Alternative #4 – and Fenimore Road Tunnel (From the 1989 GDM)

The 1989 GDM river diversion and channel improvements plan consists of a tunnel system running beneath Fenimore Rd. from the Sheldrake River to the West Basin of Mamaroneck Harbor as seen in Figure *26*. This 16 ft wide by 16 ft high tunnel system which was approximately 4,010 ft in length, is comprised of an inlet structure, the tunnel works and the outlet structure. Channel work in the Mamaroneck River includes a trapezoidal channel modification consisting of a natural bed channel, 45 to 60 ft wide. Side slopes of one vertical on three horizontal (1:3) with concrete retaining walls where space is limited. Sheldrake improvements extend from the Mamaroneck Avenue. to I-95 with a trapezoidal channel with a natural bed channel 30 ft wide. The 1989 GDM improvements on the Mamaroneck and Sheldrake Rivers were expected to contain the 200-year frequency flood, or 0.5% exceedance probability event.

Figure 26 - Alternative 4

6.3.6 Alternative #5 – Ward Avenue Tunnel

Alternative #5 (Figure 27) would include channel works throughout the Mamaroneck and Sheldrake rivers. Along the Mamaroneck River, channel work would extend from Tompkins Avenue Bridge to 270 ft (82 m) above Winfield Avenue Bridge for approximately 6,700 ft . In the Sheldrake River, channel work would extend from the confluence to 450 ft above the Rockland Avenue Bridge for approximately 5,700 ft. Trapezoidal channel improvements would consist of a natural bed channel 30–50 ft wide along the Mamaroneck and 20–40 ft wide along the Sheldrake and vertical concrete walls in areas limited by structures and private properties. A diversion tunnel with an ogee spillway approximately 5.3 ft high and 40 ft long would be constructed just downstream of the confluence between the Mamaroneck and Sheldrake rivers. The diversion tunnel, of approximately 1,050 ft in length and 13 ft in diameter, would start at the confluence and run underneath the railroad and Ward Avenue, discharging back into the Mamaroneck River just downstream of a new Ward Avenue Bridge. Five bridges would be removed and replaced: Ward Avenue, Hillside Avenue, Center Avenue, and the two Columbus Park pedestrian bridges. The Ward Avenue Bridge would be relocated approximately 20 ft upstream of its current location to allow the proposed tunnel to discharge downstream of the bridge.

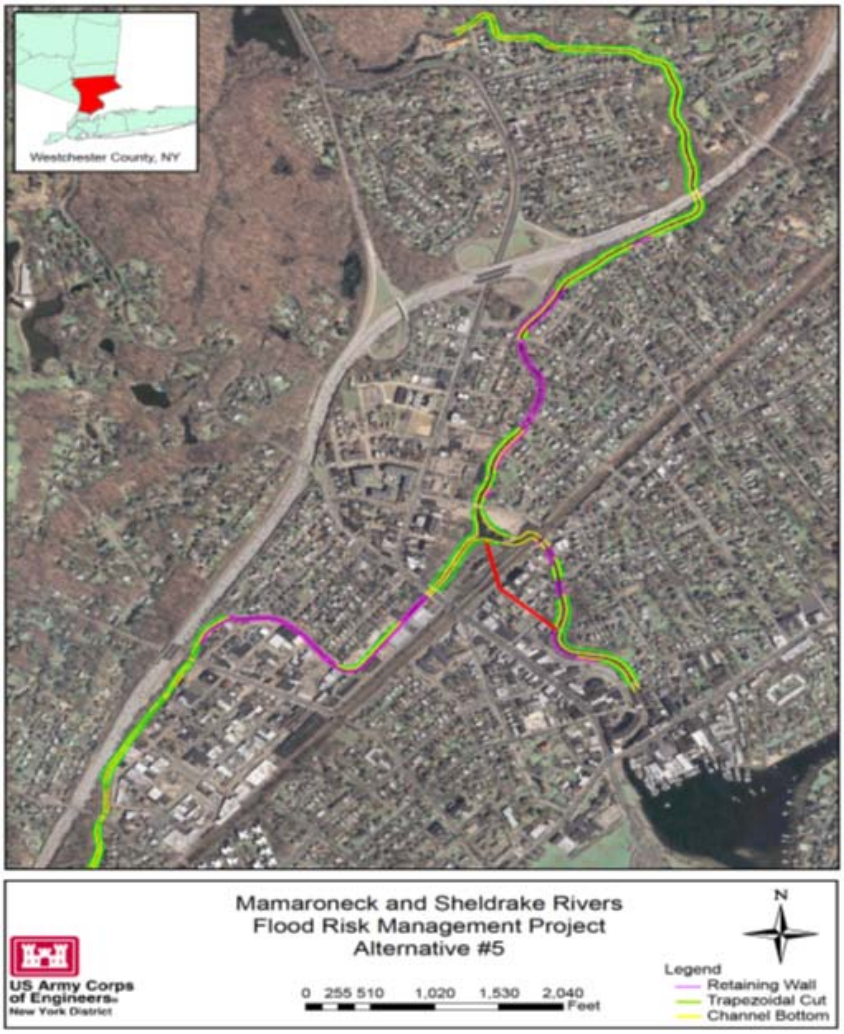

Figure 27 - Alternative 5

6.3.7 Alternative #6 – Nonstructural Alternative

Non-structural flood risk management techniques consist of measures such as relocation, acquisition, and/or flood proofing. Non-structural measures were identified and evaluated for structures in the Mamaroneck Sheldrake Area. Measures evaluated included raising buildings (elevation), wet flood proofing, dry flood proofing (sealants and closures), and ring walls/ring levees. Floodplains corresponding to a flood frequency of 2, 10, 100 years were evaluated without considering future sea level rise. The non-structural measures to be considered in the feasibility study of the Mamaroneck and Sheldrake River project includes flood warning, dry flood proof measures, wet flood proofing, raising buildings (elevation), acquisition or purchasing and removing low lying at risk structures (relocation). Two of the measures considered (i.e., flood proofing and raising buildings) maintain residential, commercial and industrial areas, reducing flood damages through modifications of the existing structures. A more invasive non-structural measure is buying and removing low lying high risk properties. These non-structural measures are generally used for the reduction of damages for frequently flooded properties events (i.e., 25 year event or below).

6.3.8 Level of Protection

A nonstructural component was formulated into specific alternative plans for evaluation. The village of Mamaroneck specifically requested that a 100-year level-of-protection (LOP) be evaluated; therefore one of the nonstructural plans was designed to withstand inundation for up to and including a 100-yr return period event (with 1 foot of "freeboard"). This alternative would protect most of the residential and nonresidential structures on the right bank and some of the residential and nonresidential structures on the left bank from a 100-year flood on Mamaroneck and Sheldrake Rivers.

Nonstructural Flood Proofing measures considered in this project were dry and wet flood proofing, elevation (aka. raise) and barriers (aka. ringwall).

Screening Level Results. Results of the screening levels analysis using the algorithms by structure type are shown on Table 9 for all three floodplains (100, 10, and 2-year). Table 9 identifies the number of residential and non-residential structures targeted for treatment in the 50%, 10% and the 1% annual chance of exceedance non-structural plans. Table 9 also identifies the number of structures identified for each of the different types of non-structural treatments. All structures will be treated to the 100 year (1% chance of exceedance event) level plus an additional foot of freeboard regardless of the size of the non-structural plan, therefore while the number of structures treated under each plan changes, the design water level of treatment for each structure does not vary by plan. Finally, the identification of structures and types of treatment is only a computer screened identification at this point; should a non-structural features be selected for implementation then a more detailed analysis of each structure and each treatment would have to be conducted. The home owners would also be consulted before final determination on any non-structural treatment was implemented.

Table 9: Structure and Treatment Type as identified in the Screening Process of the Non-Structural Alternatives for the 50% (2 yr.), 10% (10 yr.) and 1% (100 yr) events.

Nonstructural Flood Proofing Measure	50% (2-yr) Annual Exceedance			10% (10-yr) Annual Exceedance			1% (100-yr) Annual Exceedance		
	Residential	Non-Residential	Sub Total	Residential	Non-Residential	Sub Total	Residential	Non-Residential	Sub Total
Dry Flood proofing	0	2	2	0	4	4	9	19	28
Wet Flood proofing	7	0	7	29	0	29	100	1	101
Barriers	1	34	35	11	61	72	16	73	89
Raise	35	0	35	105	0	105	145	0	145
Total of Structures	43	36	79	145	65	210	270	93	363

6.3.9 Alternative 7: Combination Plan

This plan was originally intended to combine non-structural features with structural features. The non-federal sponsor requested that an additional alternative be analyzed (Alternative 8). Therefore, Alternative 7 was deleted from analysis.[5]

6.3.10 Alternative #8 – Reservoir and Bridge Plan

This alternative was proposed by NYSDEC and Westchester County (WC). It consists of a combination of detention areas, the realignment of the confluence and bridge removal and/or replacement. The plan was designed to limit the improvements or changes to public lands and thereby avoiding the Real Estate costs associated with purchasing private property. The two primary areas identified for possible detention were the Mamaroneck Reservoir and Sheldrake Lake/Larchmont Reservoir.

For the Mamaroneck Reservoir, the plan includes the removal of sediment accumulation near Mamaroneck Avenue Bridge, which is a major cause of ineffective or dead storage within Mamaroneck Reservoir. The new slope in this area is 0.0015ft/ft. In order to maximize storage, which would allow low flow to go through without filling Water Works Dam and Mamaroneck Reservoir, a new lower level outlet design is required.

For the existing Sheldrake Lake/Larchmont Reservoir, the plan includes dredging and sediment removal. This adds approximately 85.4 MGa of volume capacity approximately a 50% increase in the reservoir volume. The dam will require an additional 30in diameter pipe below the existing outlet and 5ft above the reservoir is lowest bottom elevation.

[5] A combination plan of structural/non-structural elements was eventually developed during the optimization of the TSP.

The last component of the alternative is bridge Modification and/or Removal. The Ward and Winfield Avenue Bridges were completely removed as well as the Glendale Avenue abutments (Road to No-where). The Halstead Avenue Valley Place (Anita Lane), Hillside Avenue and Jefferson Avenue Bridges were modified.

The confluence was re-aligned and Station Plaza Bridge was aligned with the Rail Road and Halstead Avenue Bridges.

This alternative was subdivided into five parts: Alternative 8A (a larger Mamaroneck Reservoir with modifications to the WCJWW Dam), Alternative 8B (a larger Sheldrake Lake/Larchmont Reservoir with modification to the dam), Alternative 8C (Bridge Modifications and/or Removal plan), Alternative 8D (Combination Plan), Alternative 8E (All Inclusive Plan). Refer to Appendix C2 for additional information regarding the details of Alternatives 8A, 8B, 8C, 8D and 8E.

6.4 Impacts of the Alternatives on the Hydrology

A total of eight alternatives (six structural, one non-structural, and one combination of structural and non-structural) were analyzed. They are explained in more detail in Appendix C2-Hydraulics. For most of the structural alternatives, "improved conditions" peak discharges were needed to re-run the RAS model for these alternatives. A summary of actions for the 8 alternatives is provided in Table 10.

All channel improvements proposed will result in loss of natural flood plain storage, and the flood peak reductions associated with it. That is, peak flows will increase downstream of proposed channel improvements, and will occur sooner, under improved conditions, as compared to existing conditions. The loss of downstream flood peak attenuation (reduction) is not linear with regard to loss of natural flood plain storage. That is, a 10 percent loss of storage does not necessarily result in a 10 percent increase in peak flow, under improved conditions, as compared to existing conditions.

The diversion tunnels proposed will result in a decrease in peak flows downstream. The diversion tunnel proposed at Fenimore Road for the Sheldrake River will bring the flood hydrographs of the Sheldrake River from Fenimore Road into the West Basin of Mamaroneck Harbor. These diverted flood hydrographs do not return to either the Mamaroneck or the Sheldrake River. The Ward Avenue diversion tunnel diverts flood hydrographs from the Mamaroneck River downstream of the Sheldrake River at station or cross section 3554.501. The diverted flood hydrographs re-enter the Mamaroneck River further downstream at station or cross section 2041.332.

Table 10: Summary of Actions for the Initial Eight Alternatives.

Actions	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 8e *
Bridge Removal / Replacement							
Ward Avenue	Remove/ replace	Remove/ replace	Remove /replace		Remove/ replace[1]		Remove
Station Plaza	Relocate	Relocate	Relocate				Relocate
Waverly Place	No action	Remove/ replace	No action		No action		No action

Actions	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 8e *
Halstead Avenue	Remove /replace	Remove/ replace	Remove/ replace				Modify
Hillside Avenue		Remove/ replace	Remove /replace		Remove /replace		Modify
Valley Place (Anita Lane)			Remove/ replace	No action		No action	Modify
Winfield Avenue	No action	No action	No action		No action		Remove
Jefferson Avenue			No action				Modify
Centre Avenue Footbridge			Remove/ replace		Remove/ replace		
Footbridge #1 (near confluence)	Remove/ replace	Remove/ replace	Remove/ replace		Remove/ replace		No action
Footbridge #2	Remove/ replace	Remove/ replace	Remove/ replace		Remove/ replace		
Tunnel/Culvert & Spillway Construction							
Tunnel length / diameter (ft)	390	390	390	4,010.00 / 16.00	1,050.00 / 13.00	No action	No action
Tunnel construction details				Beneath Fenimore Rd. from the Sheldrake River south to the West Basin of the Mamaroneck Harbor	Beneath the railroad and Ward Ave. from the confluence to the Mamaroneck River, downstream of new Ward Ave. Bridge	No action	No action
Ogee spillway construction details	No action	No action	No action	No action	From just downstream of the confluence between the two rivers	No action	No action
Channel Work Length (ft)							

Actions	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 8e *
Mamaroneck	4,200.00 (Tomkins Ave. Bridge to 400 ft above Hillside Ave. Bridge)	6,700.00 (Tomkins Ave. Bridge to 270 ft above Winfield Ave. Bridge)	6,700.00 (Tomkins Ave. Bridge to 270 ft above Winfield Ave. Bridge)	10,420	6,700.00 (Tomkins Ave. Bridge to 270 ft above Winfield Ave. Bridge)	No action	No action
Sheldrake	1,400.00 (confluence to 700 ft. above Mamaroneck Ave. Bridge)	1,500.00 (confluence to 750 ft. above Mamaroneck Ave. Bridge)	5,700.00 (confluence to 450 ft. above Rockland Ave. Bridge)	5,740 (Mamaroneck Avenue to I-95)	5,700.00 (confluence to 450 ft. above Rockland Ave.)	No action	No action
Channel Width Size (ft)							
Mamaroneck	30.00–50.00	30.00–50.00	30.00–50.00	45.00–60.00	30.00–50.00	No action	No action
Sheldrake	20.00–40.00	20.00–40.00	20.00–40.00	30.00	20.00–40.00	No action	No action
Channel Slope							
	1:2.5	1:2.5	1:2.5	1:3	1:2.5	No action	No action
Nonstructural	No action	No action	No action	No action	No action	363 structures evaluated for structure raising, wet/dry floodproofing, ringwalls/ring levees, etc.	No action

* Alternative #7 was conceived as a combination of structural and nonstructural alternatives. However, this plan has been omitted from this table due to the local partners' request to add Alternative 8 to the analysis. Alternative #8a would consist of enlarging Mamaroneck Reservoir with modifications to the WCJWW dam including removal of sediment accumulation near Mamaroneck Avenue Bridge. Alternative #8b would consist of enlarging the Sheldrake Lake/Larchmont Reservoir with modifications to the dam and would include dredging and sediment removal. Alternative #8d would be a combination plan; details for this alternative were not fully developed.

[1] Under Alternative #5 the Ward Avenue Bridge would be relocated approximately 20 ft upstream of its current location to allow the proposed tunnel to discharge downstream of the bridge.

[2] Under Alternative #8c the Station Plaza Bridge would be aligned with the railroad and Halsted Avenue bridges.

6.5 Detailed Alternative Analysis

A range of nonstructural and structural alternatives were considered and evaluated and presented in the previous section of this report. Evaluation consisted of four general tasks described below:

- forecast the most likely with-project condition expected under each alternative plan;
- compare each with-project condition to the without-project condition and document the differences between the two;
- characterize the beneficial and adverse effects by magnitude, location, timing and duration; and
- identify the plans that will be further considered in the planning process, based on a comparison of the adverse and beneficial effects and the evaluation criteria.

6.5.1 Project Performance and Risk Analysis

6.5.2 Alternative Analysis

Table 11 provides the detailed analysis of the alternatives presented in Section 6.4. A detailed cost analysis was conducted in developing the cost estimates for the alternative analysis. Additionally, the economic performance of all analyzed alternatives has been computed by HEC-FDA and summarized in Table 11. The results in Table 11 indicate that only Alternative 1 and 2 show positive annual net benefits. Alternative 1 maximizes the annual net benefits and therefore was identified as the Tentatively Selected Plan which was optimized in the next phase of this study.

Table 11: Summary of Damages, Benefits, and BCRs

Alternative	Stream/Benefit Source	Annual Flood Damages		Annual Benefits	Total Investment Cost	Total Annual cost	Net Excess Benefits	BCR
		Without Project	With Project					
Alt 1	Mamaroneck D/S	$35,820	$12,210	$23,610				
	Sheldrake	$2,059,220	$325,890	$1,733,330				
	Mamaroneck U/S	$1,315,290	$397,620	$917,670				
	Pre Base Year	N/A	N/A	$0				
	Bridge Replacement	N/A	N/A	$553,300				
	Emergency	$94,190	$30,320	$63,870				
	Total	*$3,410,330*	*$735,720*	*$3,291,780*	*$54,434,000*	*$2,724,300*	*$567,500*	***1.2***
Alt 2	Mamaroneck D/S	$35,820	$13,030	$22,790				
	Sheldrake	$2,059,220	$367,720	$1,691,500				
	Mamaroneck U/S	$1,315,290	$89,350	$1,225,940				
	Pre Base Year	N/A	N/A	$153,230				
	Bridge Replacement	N/A	N/A	$675,000				
	Emergency	$94,190	$22,980	$71,210				
	Total	*$3,410,330*	*$470,100*	*$3,839,670*	*$72,705,000*	*$3,625,400*	*$214,300*	***1.1***
Alt 3	Mamaroneck D/S	$35,820	$13,280	$22,540				
	Sheldrake	$2,059,220	$37,680	$2,021,540				
	Mamaroneck U/S	$1,315,290	$33,480	$1,281,810				
	Pre Base Year	N/A	N/A	$312,590				
	Bridge Replacement	N/A	N/A	$683,600				
	Emergency	$94,190	$12,330	$81,860				
	Total	*$3,410,330*	*$84,440*	*$4,403,940*	*$95,961,000*	*$4,772,100*	*-$368,200*	***0.9***
Alt 4	Mamaroneck D/S	$35,820	$8,030	$27,790				
	Sheldrake	$2,059,220	$12,700	$2,046,520				

Alternative	Stream/Benefit Source	Annual Flood Damages		Annual Benefits	Total Investment Cost	Total Annual cost	Net Excess Benefits	BCR
		Without Project	With Project					
Alt 4 (Cont.)	Mamaroneck U/S	$1,315,290	$56,340	$1,258,950				
	Pre Base Year	N/A	N/A	$478,330				
	Bridge Replacement	N/A	N/A	$684,800				
	Emergency	$94,190	$12,130	$82,060				
	Total	*$3,410,330*	*$77,070*	*$4,578,450*	*$154,481,000*	*$7,715,400*	*-$3,137,000*	***0.6***
Alt 5	Mamaroneck D/S	$35,820	$7,600	$28,220				
	Sheldrake	$2,059,220	$93,730	$1,965,490				
	Mamaroneck U/S	$1,315,290	$58,260	$1,257,030				
	Pre Base Year	N/A	N/A	$153,230				
	Bridge Replacement	N/A	N/A	$266,600				
	Emergency	$94,190	$14,410	$79,780				
	Total	*$3,410,330*	*$159,590*	*$3,750,350*	*$91,151,000*	*$4,529,300*	*-$779,000*	***0.8***
Alt 6	Mamaroneck D/S	$35,820	$18,690	$17,130				
Nonstructural	Sheldrake	$2,059,220	$442,440	$1,616,780				
	Mamaroneck U/S	$1,315,290	$243,510	$1,071,780				
	Total	*$3,410,330*	*$704,640*	*$2,705,690*	*$86,082,000*	*$4,007,100*	*-$1,301,400*	***0.7***
Alt 8	Mamaroneck D/S	$35,820	$8,220	$27,600				
	Sheldrake	$2,059,220	$583,740	$1,475,480				
	Mamaroneck U/S	$1,315,290	$544,070	$771,220				
	Pre Base Year	N/A	N/A	$68,340				
	Bridge Replacement	N/A	N/A	$530,100				
	Emergency	$94,190	$41,380	$52,810				
	Total	*$3,410,330*	*$1,136,030*	*$2,925,550*	*$79,178,000*	*$3,979,300*	*-$1,053,800*	***0.7***

Price level: FY 2012, 4.0% Discount rate

7. NATIONAL ECONOMIC DEVELOPMENT (NED) PLAN

Following evaluation of the initial array of alternatives, the Tentatively Selected Plan (TSP) was identified as Alternative 1. During consultation with the local partner, the project delivery team evaluated optimization of the plan to ensure the scale addressed the greatest possible portion of the study area. This optimization generated four scales of Alternative 1, Small (1S), Medium (1M), Large (1L), and Final (1F) identified as 1S, 1M, 1L, and 1F. These scales were developed to include increasing lengths of channel work.

7.1 Optimization of Alternative 1

The process of optimization is to determine the project size that would maximize net benefits. The plan exhibiting the highest net benefits is identified as the National Economic Development (NED) plan. The width, depth and extent of the initial Alternative 1 channel improvements were varied along with the number of bridge replacements to develop iterative plans of size. Variations of Alternative 1 were completed as noted below:

- The small alternative (Alt. 1S) would not include flood risk management features in Harbor Heights.
- The medium alternative (Alt. 1M) will have some channel work in the Harbor Heights area and the removal of Glendale Avenue.
- Alternative 1F is similar (albeit slightly smaller than Alt 1M) will have a non-structural component in the Harbor Heights area instead of channel work. Non-structural component includes proposed raisings or elevated structures in the Harbor Heights residential area. In Sheldrake River, there is a proposed barrier or ringwall around the commercial building located near Fenimore Road; while in Mamaroneck River.
- The large alternative (Alt. 1L) will have the same nonstructural component in both the Mamaroneck and Sheldrake Rivers for structures with estimated BCRs above one as Alt. 1F.

Table 12 through 15 provides the design details that were evaluated during the optimization of Alternative 1. Optimization consisted on successive variations of the widening, deepening and lengthening of channel sections along the Mamaroneck and Sheldrake Rivers, and bridge removal/modifications.

Table 12:Channel modification in Alternative #1 S

		Details
Mamaroneck Upstream	2,400	Channel deepening and widening, one on two and a half side slopes (1h: 2.5V). Channel bottom width from the confluence to Hillside Ave. 40ft (distance 1,050ft) and 30 ft from Hillside Ave. to just upstream of Barry Ext. (approx. distance 1,350ft), with a slope of 0.3%.
Mamaroneck Downstream	2,400	Channel deepening and widening, one on two and a half side slopes (1h: 2.5V). Channel bottom width 45ft from the confluence to just downstream of Tompkins Ave. bridge, slope 0.3%. Retaining wall and utilities removal and replacement will be necessary in certain locations.
Sheldrake	3,470	Channel deepening and widening, one on two and a half side slopes (1h: 2.5V) and rectangular channel where needed (upstream of Mamaroneck Ave. Bridge). Channel bottom width 20ft from the confluence to Mamaroneck Ave. Bridge and 30ft from Mamaroneck Ave. Bridge to Fenimore Ave. Bridge. Slope 1.0% from the confluence 390ft upstream and then 0.1% to Fenimore Rd. Utilities removal and replacement will be necessary in certain locations.

Table 13: Channel modification in Alternative #1 M

		Details
Mamaroneck Upstream	3,740	Channel deepening and widening, one on two and a half side slopes (1h: 2.5V). Channel bottom width variable; 25ft wide from 200ft upstream of the "road to nowhere" and 35ft wide for the next 650 downstream of "road to nowhere", slope variable 0.6% and 0.2% (approx. 1340ft). Upstream the confluence 45ft wide and 0.25% slope for approx. 2400ft. Retaining wall and utilities removal and replacement will be necessary in certain locations.
Mamaroneck Downstream	2,400	Channel deepening and widening, one on two and a half side slopes (1h: 2.5V). Channel bottom width 45ft from the confluence to just downstream of Tompkins Ave. bridge, slope 0.25%. Retaining wall and utilities removal and replacement will be necessary in certain locations.
Sheldrake	3,470	Channel deepening and widening, one on two and a half side slopes (1h: 2.5V) and rectangular channel where needed (upstream of Mamaroneck Ave. Bridge). Channel bottom width 20ft from the confluence to Mamaroneck Ave. Bridge, 33ft from Mamaroneck Ave. Bridge to 1,000ft downstream and 30 ft rectangular and semi trapezoidal to Fenimore Ave. Bridge. Slope 1.0% from the confluence 390ft upstream and then 0.1% to Fenimore Rd. Utilities removal and replacement will be necessary in certain locations.

Table 14: Channel modification in Alternative #1 L

		Details
Mamaroneck Upstream	2,400	Channel deepening and widening, one on two and a half side slopes (1h:2.5V), upstream the confluence 45ft and 0.25% slope for approx 2400ft. Retaining wall and utilities removal and replacement will be necessary in certain locations.
Mamaroneck Downstream	2,400	Channel deepening and widening, one on two and a half side slopes (1h: 2.5V). Channel bottom width 45ft from the confluence to just downstream of Tompkins Ave. bridge, slope 0.25%. Retaining wall and utilities removal and replacement will be necessary in certain locations. Retaining wall and utilities removal and replacement will be necessary in certain locations.
Sheldrake	3,470	Channel deepening and widening, one on two and a half side slopes (1h: 2.5V) and rectangular channel where needed (upstream of Mamaroneck Ave. Bridge). Channel bottom width 30ft from, slope 0.25%. Utilities removal and replacement will be necessary in certain locations.

Table 15: Channel modification in Alternative #1 F

		Details
Mamaroneck Upstream	2,400	Channel deepening and widening, one on two and a half side slopes (1h:2.5V). Channel bottom width from the confluence to Hillside Ave. 40ft (distance 1050ft) and 30 ft from Hillside Ave. to just upstream of Barry Ext. (approx. distance 1350ft), with a slope of 0.3%.
Mamaroneck Downstream	2,400	Channel deepening and widening, one on two and a half side slopes (1h:2.5V). Channel bottom width 45ft from the confluence to just downstream of Tompkins Ave. bridge, slope 0.3%.
Sheldrake	3,470	Channel deepening and widening, one on two and a half side slopes (1h:2.5V) and rectangular channel where needed (upstream of Mamaroneck Ave. Bridge). Channel bottom width 20ft from the confluence to Mamaroneck Ave. Bridge, 33ft from Mamaroneck Ave. Bridge to 1,000ft downstream and 25ft rectangular and semi trapezoidal channel to Fenimore Ave. Bridge. Slope 1.0% from the confluence 390ft upstream and then 0.1% to Fenimore Rd. Channel bottom width 30ft, slope 0.25%.

The benefits of each scale were initially compared to the costs. During this comparison, Alternative 1F was initially demonstrated to provide the highest net benefits. However, it should be noted that further analysis and comparison resulted in the identification of an alternate plan, Alternative 1Z that will be presented later in this report. The cost summary of these scales is presented in Table 16. The comparison of these costs and benefits are presented in Table 18. A summary of actions for each plan is provided in Table 18.

Table 16: Cost Summary of Scales of TSP Plan

ACCT#	CWBS FEATURE	Alt 1S	Alt 1M	Alt 1L	Alt 1F
02	RELOCATIONS	$663,151	$710,516	$670,234	$663,151
08	ROADS, RAILROADS AND BRIDGES	$11,450,852	$13,010,363	$29,184,434	$13,010,363
09	CHANNELS AND CANALS	$10,358,374	$12,796,645	$11,976,202	$10,358,374
11	LEVEES AND FLOODWALLS	$6,371,782	$7,254,497	$13,586,641	$6,371,782
12	FLOODWAY CONTROL & DIV STR				
16	ENVIRONMENTAL MITIGATION	$1,800,000	$2,280,000	$1,800,000	$1,800,000
	TOTAL CONSTRUCTION COST	$30,644,159	$36,052,021	$58,536,865	$33,523,024
01	LANDS & DAMAGES	$9,693,750	$11,787,500	$9,693,750	$9,693,750
30	ENGINEERING & DESIGN	$4,597,269	$5,408,562	$8,781,762	$5,029,159
31	CONSTRUCTION MANAGEMENT	$2,451,533	$2,884,162	$4,682,949	$2,681,842
	TOTAL FIRST COST	**$47,386,711**	**$56,132,245**	**$81,695,326**	**$50,927,775**
	IDC	$2,638,983	$3,126,022	$4,549,638	$2,836,182
	TOTAL INVESTMENT COST	**$50,025,694**	**$59,258,267**	**$86,244,964**	**$53,763,957**
	ANNUAL COST	$2,328,706	$2,758,484	$4,014,720	$2,502,723
	O&M	$153,300	$180,300	$292,700	$167,700
	MAJOR REHAB/REPLACEMENT	$0	$0	$0	$0
	TOTAL NED ANNUAL COST	**$2,482,006**	**$2,938,784**	**$4,307,420**	**$2,670,423**

FY 2012 Price Level, 4% Interest Rate

Table 17: Economic Summary Table of Alternative 1

Plan	Stream	Without Project Damages	With Project Damages	Annual Benefits	Total Investment Cost	Total Annual Cost	Net Excess Benefits	BCR
Alt 1S	Mamaroneck DS	$35,820	$7,750	$28,070				
	Sheldrake	$2,059,220	$339,810	$1,719,410				
	Mamaroneck US	$1,315,290	$420,980	$894,310				
	Pre Base Year	N/A	N/A					
	Bridge Replacement	N/A	N/A	$357,700				
	Emergency	$94,185	$31,225	$62,960				
	Total	*$3,410,330*	*$799,765*	*$3,050,350*	*$50,026,000*	*$2,482,000*	*$568,350*	*1.23*
Alt 1M	Mamaroneck DS	$35,820	$5,620	$30,200				
	Sheldrake	$2,059,220	$173,100	$1,886,120				
	Mamaroneck US	$1,315,290	$246,400	$1,068,890				
	Pre Base Year	N/A	N/A					
	Bridge Replacement	N/A	N/A	$357,700				
	Emergency	$94,185	$21,741	$72,444				
	Total	*$3,410,330*	*$446,861*	*$3,403,254*	*$59,258,000*	*$2,938,800*	*$465,454*	*1.16*
Alt 1L	Mamaroneck DS	$35,820	$5,670	$30,150				
	Sheldrake	$2,059,220	$203,110	$1,856,110				
	Mamaroneck US	$1,315,290	$121,220	$1,194,070				
	Pre Base Year	N/A	N/A					
	Bridge Replacement	N/A	N/A	$874,300				
	Emergency	$94,185	$19,114	$75,071				
	Total	*$3,410,330*	*$349,114*	*$4,000,301*	*$86,245,000*	*$4,307,400*	*(-307,099)*	*.92*
Alt 1F	Mamaroneck DS	$35,820	$5,870	$29,950				
	Sheldrake	$2,059,220	$254,180	$1,805,040				
	Mamaroneck US	$1,315,290	$272,660	$1,042,630				
	Pre Base Year	N/A	N/A					
	Bridge Replacement	N/A	N/A	$357,700				
	Emergency	$94,185	$24,712	$62,960				
	Total	*$3,410,330*	*$557,422*	*$3,298,279*	*$53,763,957*	*$2,670,423*	***$627,856***	*1.24*

FY 2012 Price Level, 4% Interest Rate – cost are prior to the Value Engineering study

Table 18: Summary Action per Alternative

Feature			Alternatives												Units
Bridge Name	**River/Reach**	**Hydraulic River Stationing**	**Alt. 1**		**Alt. 1S - Small**		**Alt. 1M - Medium**		**Alt. 1L - Large**		**Alt. 1F - Final**		**Alt. 1Z**		
Bridge Modification:															
Ward Ave.	Mamaroneck/DS	17+86	Remove/replace		No action		Remove		Remove		Remove		Remove		-
Halstead Ave.	Mamaroneck/DS	26+75	Remove/replace		No action		No action		Remove/replace		No action		No action		-
Station Plaza	Mamaroneck/DS	29+84	Remove/relocate		Remove/relocate		~~(Remove/relocate)~~ *		Remove/relocate		~~(Remove/relocate)~~ *		~~(Remove/relocate)~~ *		-
Footbridge #1 (near confluence)	Sheldrake/Sheldrake	00+25	Remove		Remove		Remove		Remove		Remove		Remove		-
Footbridge #2	Sheldrake/Sheldrake	03+07	Remove		Remove		Remove		Remove		Remove		Remove		-
Waverly Ave.	Sheldrake/Sheldrake	19+43	No action		Remove/replace		Remove/replace		Remove/replace		Remove/replace		Remove/replace		-
Centre Ave. Footbridge	Sheldrake/Sheldrake	21+71	Remove		Remove		Remove		Remove		Remove		Remove		-
Channel Work Length:															
Mamaroneck River at Harbor Heights		93+50 (midpoint)	N/A		N/A		1,340.00		N/A		N/A		N/A		ft
Mamaroneck River Upstream of Confluence		42+50 (midpoint)	1,800.00		2,400.00		2,400.00		2,400.00		2,400.00		2,400.00		ft
Mamaroneck River Downstream of Confluence		20+00 (midpoint)	2,400.00		2,400.00		2,400.00		2,400.00		2,400.00		2,400.00		ft
Sheldrake River		17+50 (midpoint)	1,400.00		3,470.00		3,470.00		3,470.00		3,470.00		3,470.00		ft
Channel Width Size:															
Mamaroneck River at Harbor Heights			N/A		N/A		25.00 - 35.00		N/A		N/A		N/A		ft
Mamaroneck River Upstream of Confluence			45		30.00 - 40.00		45		45		30.00 - 40.00		45		ft
Mamaroneck River Downstream of Confluence			45		45		45		45		45		45		ft
Sheldrake River			30		20.00 - 30.00		25.00 - 33.00		30		20.00 - 33.00		25.00 - 33.00		ft
Channel Cut Volume (Soil/Rock):			47,000.00	10,000.00	60,990.00	11,250.00	89,210.00	11,250.00	87,230.00	11,250.00	60,990.00	11,250.00	89,210.00	11,250.00	cyd
Walls (average height/Length):			8.5	4,955.00	8.4	4,085.00	8.5	4,360.00	8.7	7,210.00	8.4	4,085.00	8.5	4,360.00	ft
Non-Structural:															
Raise			No action		No action		No action		8 structures		8 structures		8 structures		-
Ringwall			No action		No action		No action		1 structure		1 structure		1 structure		-

***** Subsequent design change as a result of the Value Engineering Study resulted in the inclusion of a short diversion culvert instead of replacing the Station Plaza Bridge.

8. REFINEMENT & OPTIMIZATION OF THE NED PLAN

The plan that optimizes the annual net benefits is Alternative 1F, for details see Table 19. Alternative 1L shows negative annual net benefits and therefore is dropped from further analysis and consideration. However, Alternative 1M provides a higher level of flood risk management than Alternative1F and will be retained for further consideration. Because Alternative 1S includes no elements or features in the Harbor Heights area (Alternative 1F (including the non-structural solution in the Harbor Heights reach whereas Alternative 1M includes channelization in the Harbor Heights reach), any cost refinement applied to Alternative 1S would decrease the BCR, proportionately. Therefore, further cost refinement is applied to Alternative 1M and 1F only. Regardless, this cost refinement will be applied to Alternative 1S to ensure the appropriate identification of the NED Plan. Alternative 1M and Alternative 1F have been retained for further analysis.

8.1 Value Engineering Recommendations

The Value Engineering (VE) analysis is an internal review conducted by a VE team, exclusive of the Project Development Team, who seek, during their review to add additional value to the project by changing, modifying, or taking a different approach to the solutions proposed. The findings of this study were evaluated by the VE team after the TSP plan was developed.

The most significant recommendation by the team was to keep the Station Plaza Bridge as is and substitute the replacement of that bridge with an overflow diversion culvert under the commuter parking lot located on the left bank (north side) of the river. The culvert would start just downstream of the Jefferson Ave Bridge and discharge almost directly into the Rail Road Bridge opening.

A hydraulic and an economic analysis of the VE recommendation was performed and the diversion culvert should reduce construction cost by $3 to $5 million, without altering the water surface elevations or reducing the flood risk management benefits of both Alternative 1F and 1M.

The culvert will be about 390 feet long with a slope of 0.36 feet per 100 feet, 25 feet wide, 8 feet high, will be about 3 feet above the proposed bottom of the river and about 3.5 feet under the finish grade of the parking lot. Therefore, the culvert will be dry during normal flows but it will divert a portion of the Mamaroneck River flows for a one year event or greater. The channel from the Rail Road Bridge to the Jefferson Avenue Bridge will still be deepened to the same depths previously specified but the alignment of the river will remain as it currently is. While the two (2) 90-degree bends will remain, the impact of head losses will be reduced since a portion of the river will now flow “straight” through the culvert (Alternative 1F is shown in Figure 28 through *Figure 31* and Alternative 1M is shown in Figure 32 through *Figure 35*).

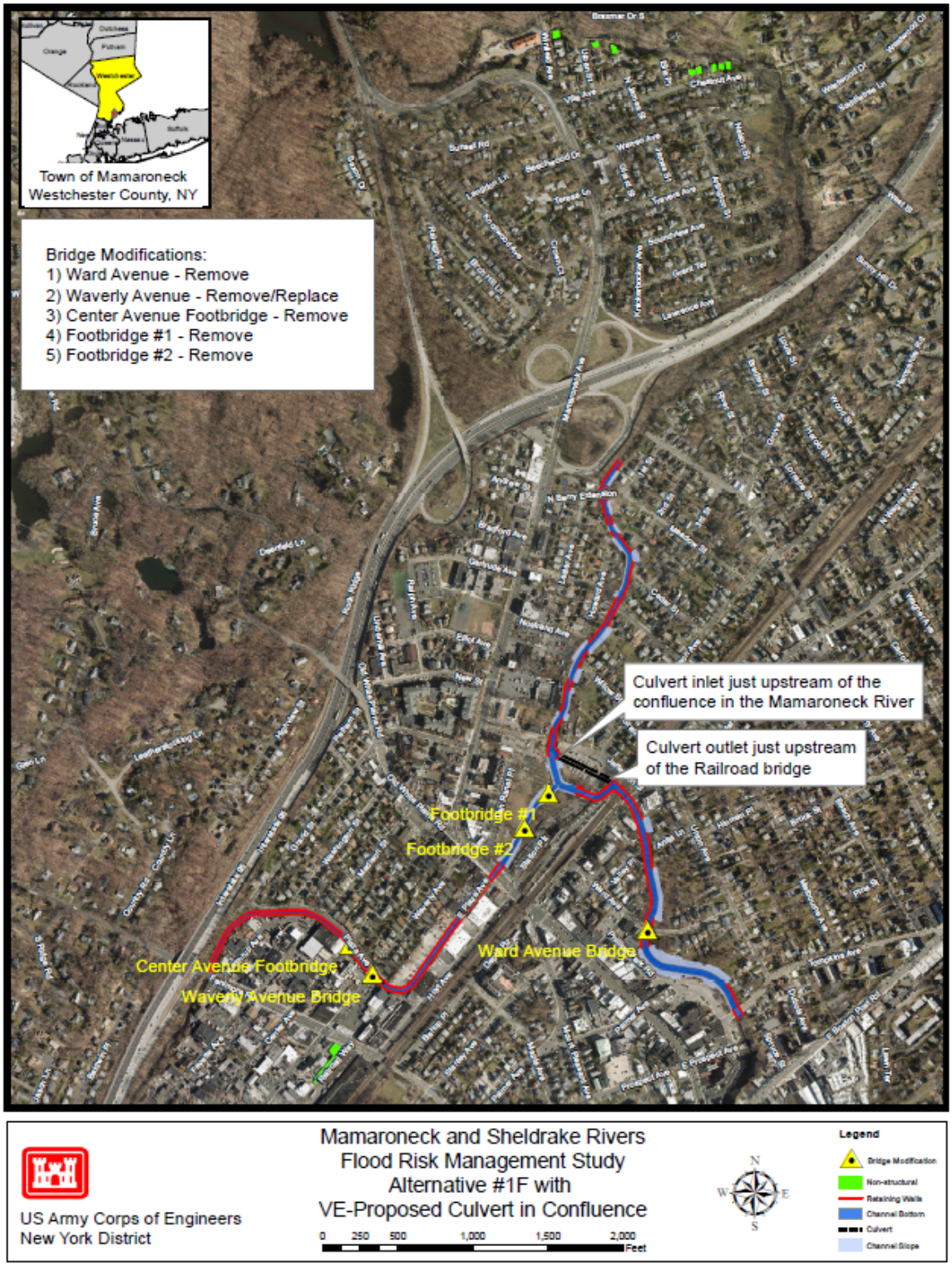

Figure 28 - Alternative 1F | with the VE proposed culvert in confluence plan view.

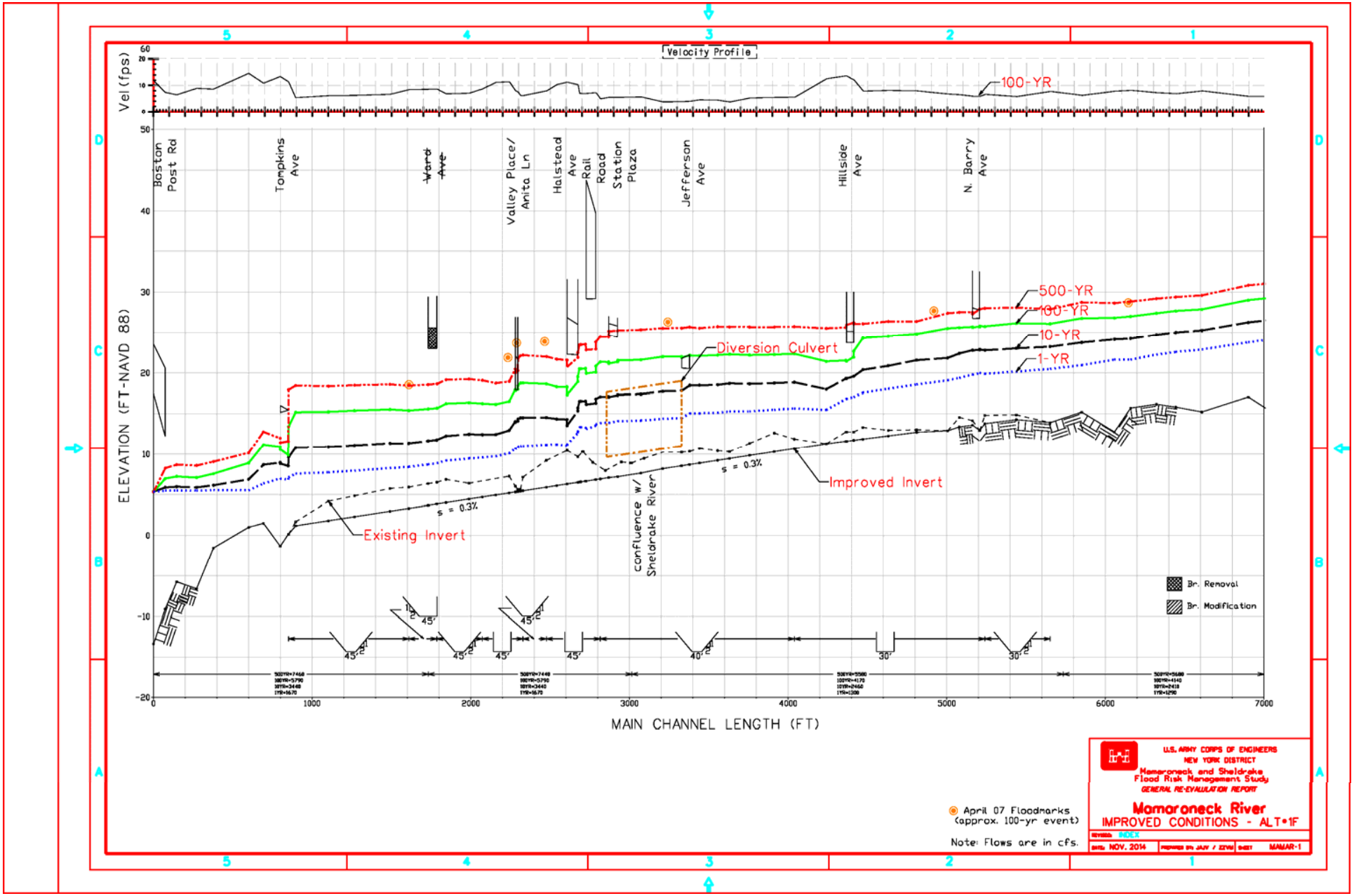

Figure 29 - Alternative 1F | Mamaroneck1 Profile

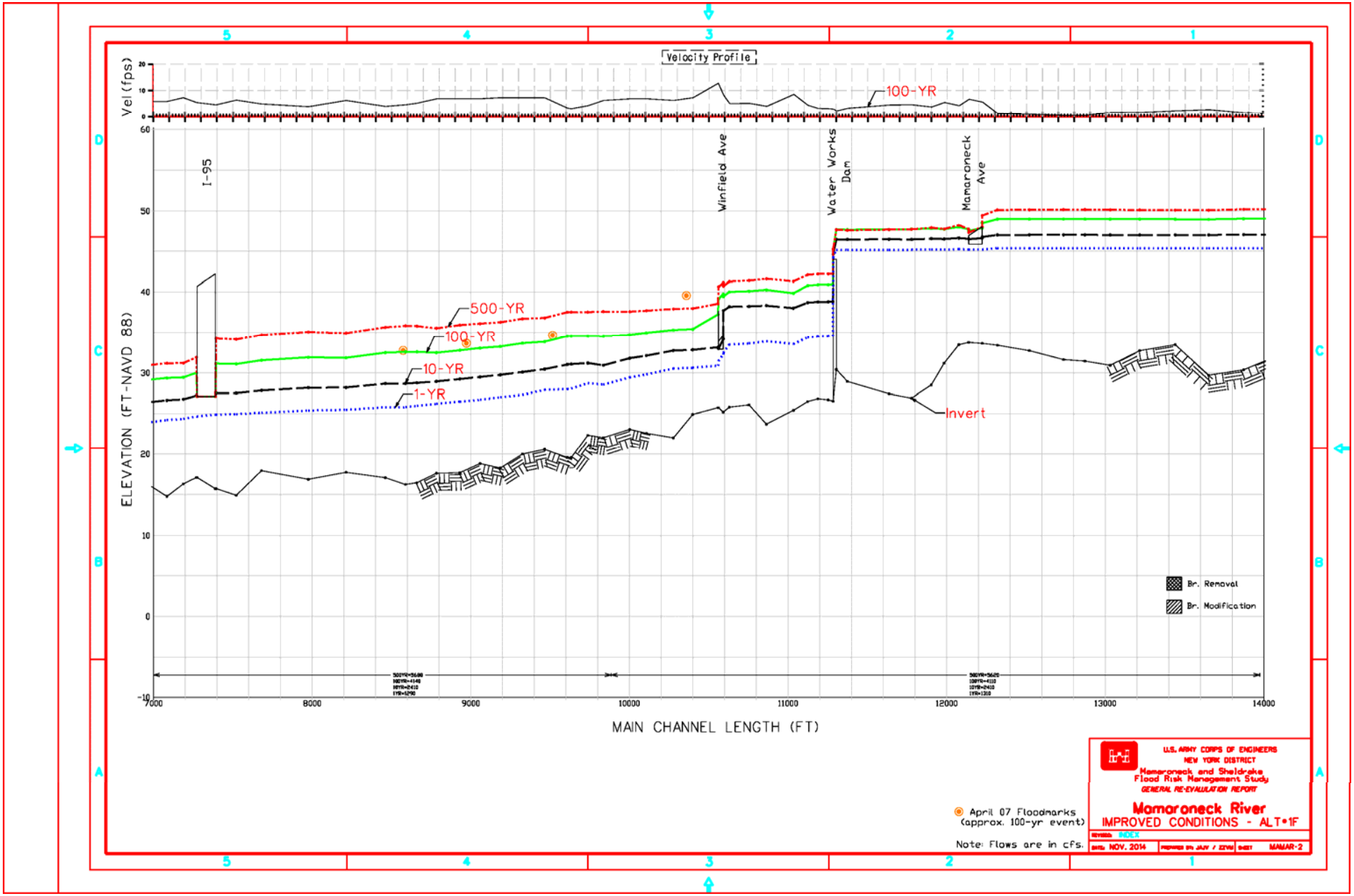

Figure 30 - Alternative 1F | Mamaroneck2 Profile

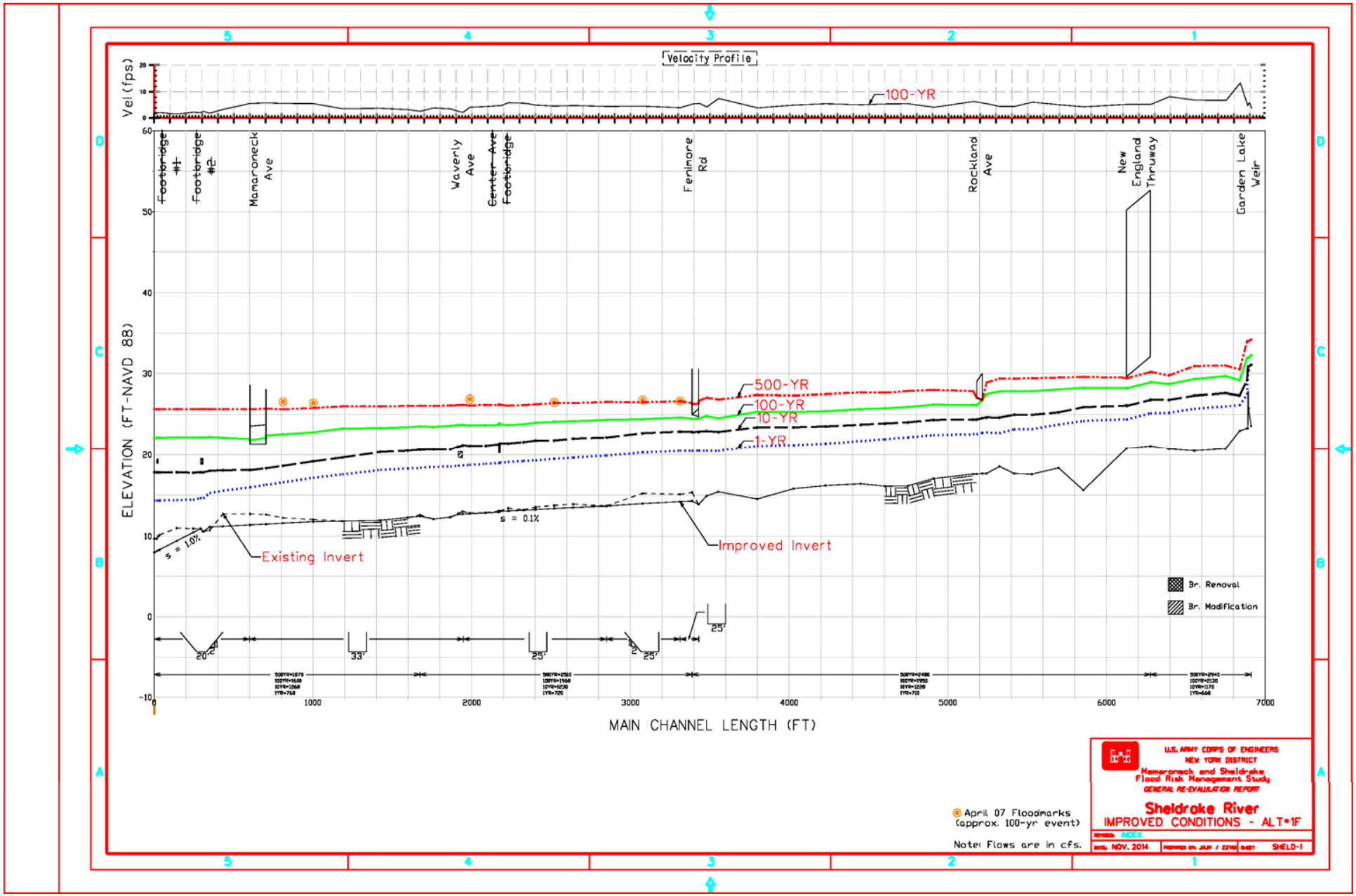

Figure 31 -Alternative 1F | Sheldrake Profile

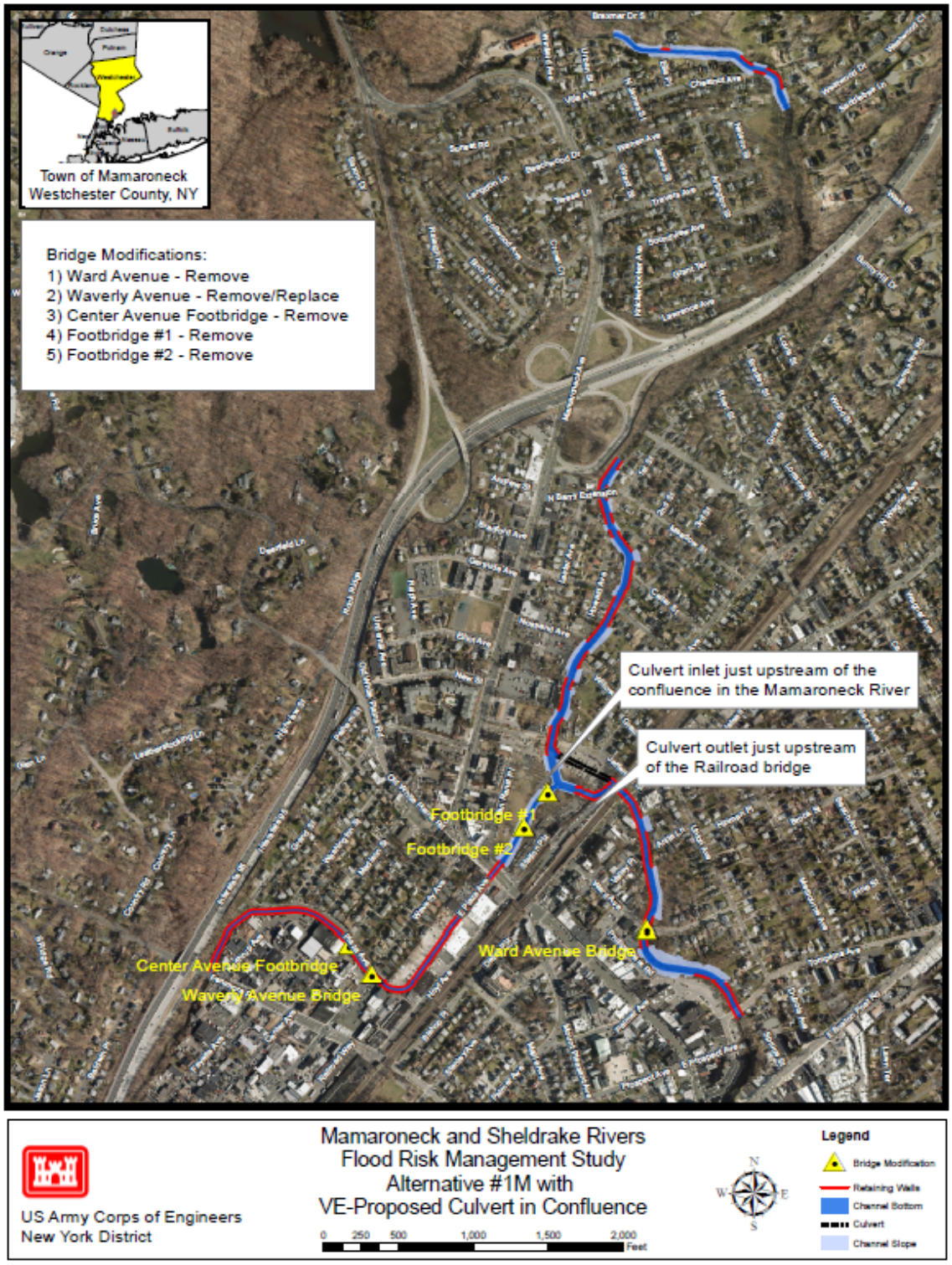

Figure 32 - Alternative 1M | Plan view with the VE proposed culvert in confluence

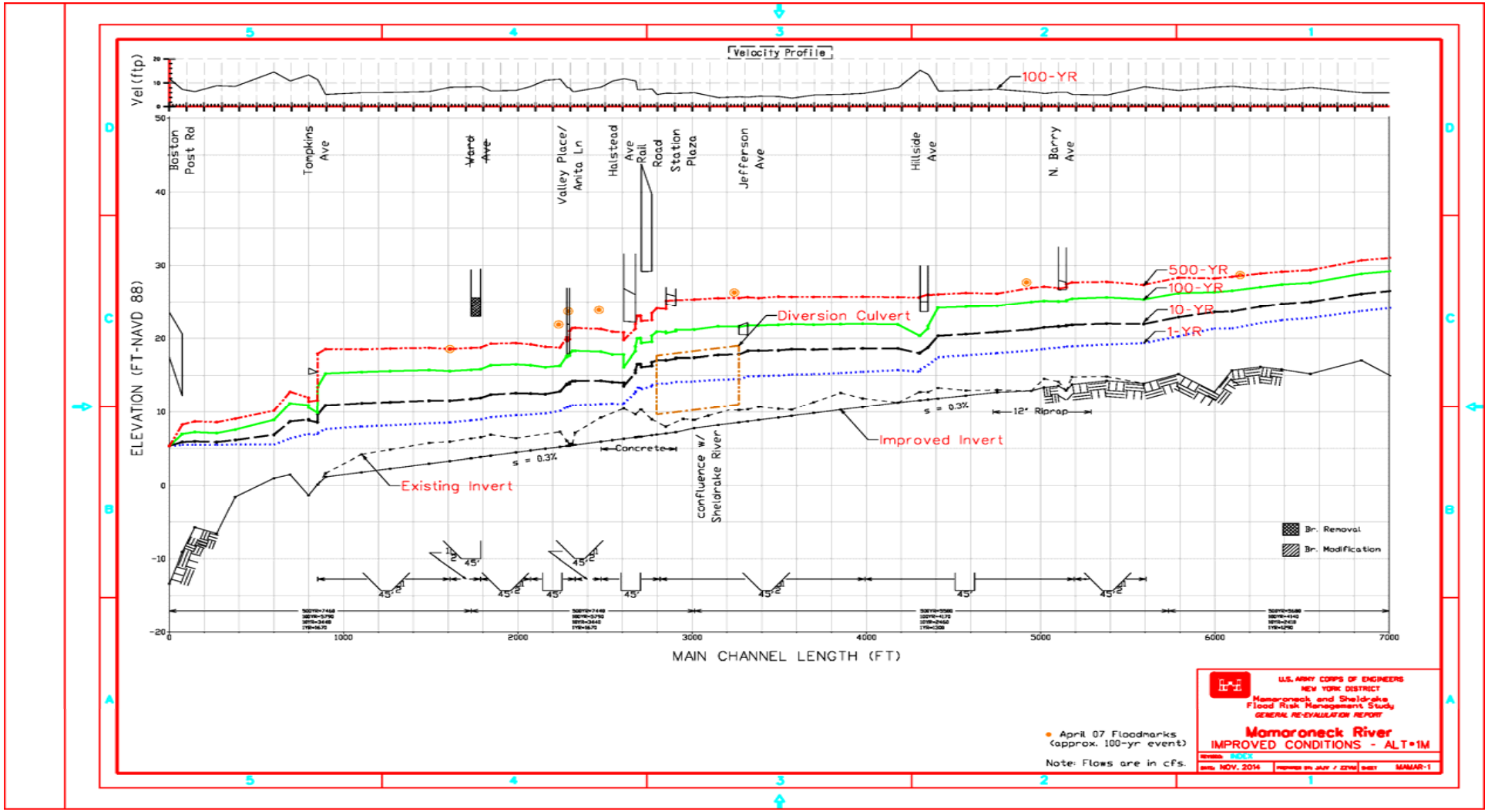

Figure 33 - Alternative 1M | Mamaroneck1 Profile

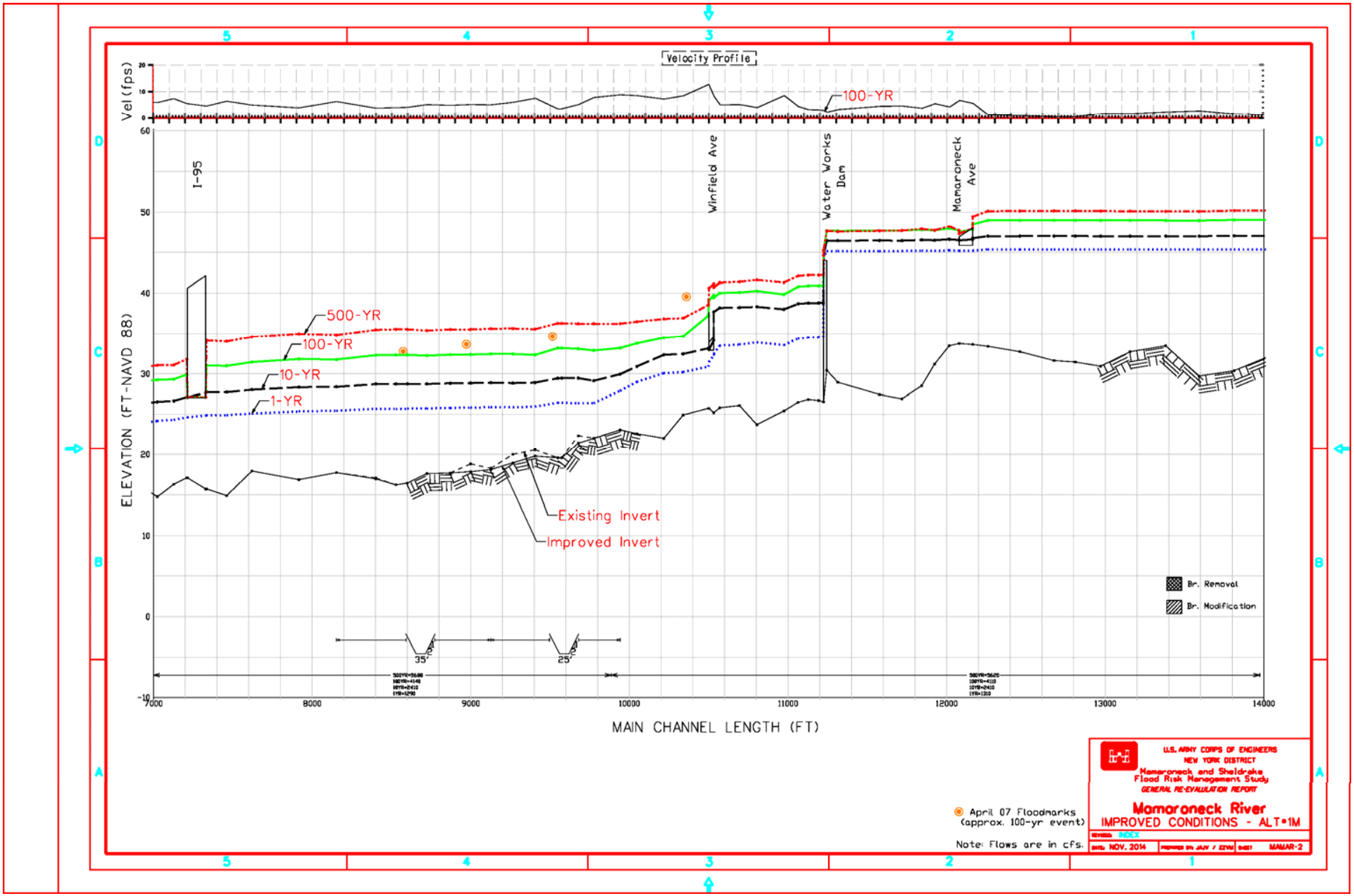

Figure 34 - Alternative 1M | Mamaroneck2 Profile

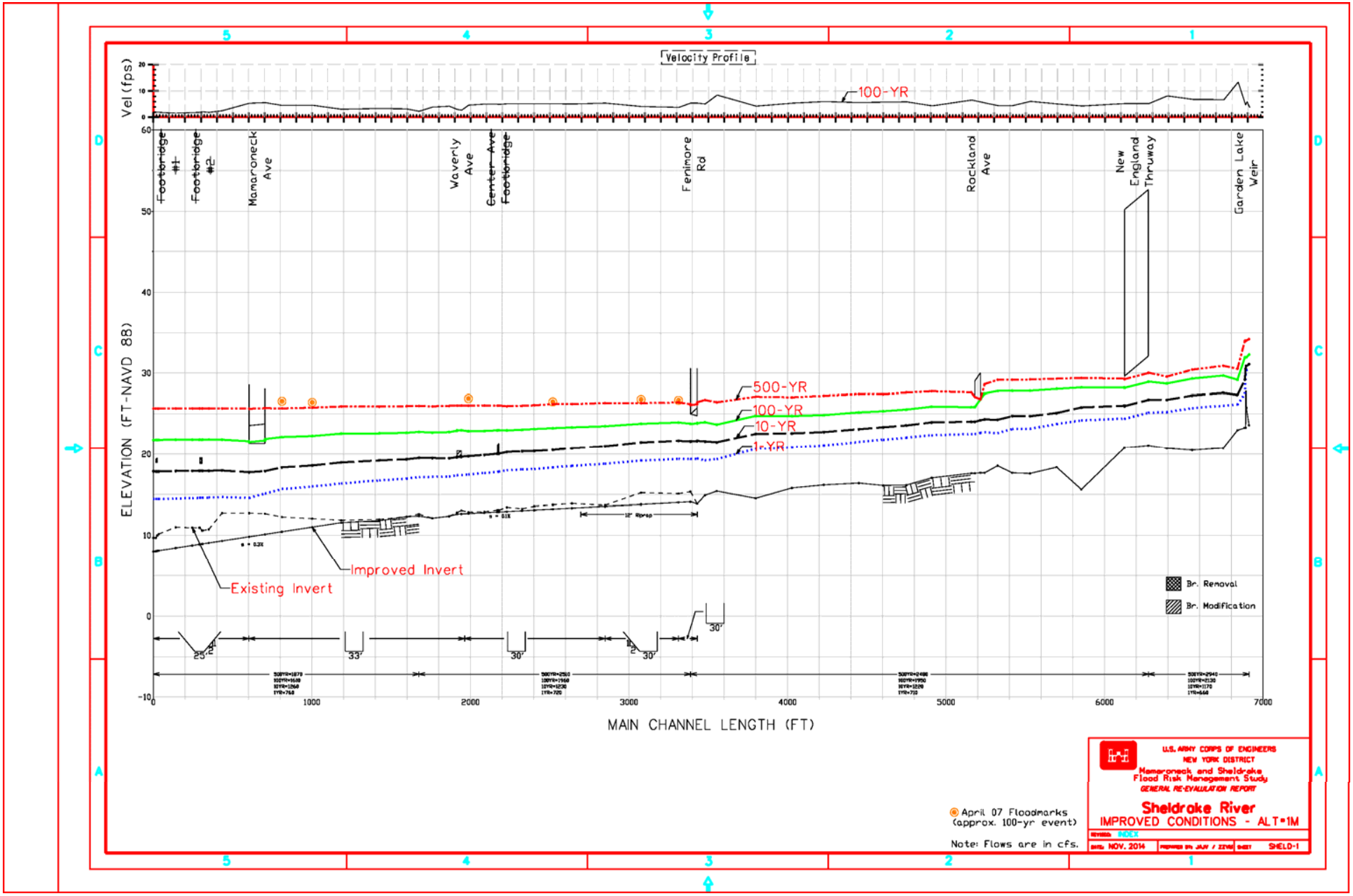

Figure 35 - Alternative 1M | Sheldrake Profile

8.2 Updated Cost and Benefit Summaries

As noted in Section 4 of the Economic Appendix, significant time has elapsed since the initial formulation and cost and benefit calculations. Therefore, prior to refining the design for Alternative 1F and Alternative 1M, the economics for the plans were updated (also the costs were updated to incorporate the Value Engineering design modifications results to Alternative 1F and 1M). The cost summary of the optimized alternatives and the benefits comparisons are presented in October 2014 price level, and at the FY15 discount rate of 3.375%.

The cost and benefit comparison changed in two ways. The structure inventory was updated to reflect the change in price level and the updated benefits are shown in the final benefit cost comparison table. Structures and content values were adjusted to the current price level with the changed with RSMeans indices, and the bridge benefits were adjusted with the CWBS Indices for Feature Code 08, Roads, Railroads and Bridges. Advanced wall replacement benefits were added to the benefit pool upon final assessment of the design team during the optimization phase. The hydrologic data generated to assess with and without project conditions assumes the stability of the floodwalls is maintained throughout the 50 year evaluation period. The final assessment of the engineering team, and the final cost estimates which resulted, reflect that the existing walls will not withstand the channel work required. The final plan requires replacement of the existing walls, and advanced wall replacement benefits are calculated as an avoided cost in the near future, since it was determined that the walls would need to be replaced in the without project condition in year 2020. This benefit is comparable to the advanced bridge replacement benefits. If a floodwall is replaced as the result of a flood control project, a benefit can be claimed to at least partially offset the cost of bridge replacement. Advanced wall replacement benefits are quantified for the period that the useful life of the floodwall is extended by the project.

Based on the economic update, Alternative 1F still provides the maximum annual net benefits with a BCR of 1.21. Alternative 1M was also economically justified with a BCR of 1.17 and indicates a higher level of protection . The comparison of these costs and benefits and project actions are presented in Table 19 and Table 20.

Table 19: Comparison of the Benefits and Costs of the 1F and 1M

Plan	Stream/Benefit Source	Flood Damages Without Project	Flood Damages With Project	Annual Benefits	Ratio	Updated Benefits	Total Investment Cost	Total Annual cost[2]	Net Excess Benefits	BCR
1M	Mamaroneck DS	$35,820	$5,620	$30,200	1.07	$32,222				
	Sheldrake	$2,059,220	$173,100	$1,886,120	1.07	$2,012,383				
	Mamaroneck US	$1,315,290	$246,400	$1,068,890	1.07	$1,140,445				
	Pre Base Year	N/A	N/A	$165,494	1.07	$176,573				
	Wall Replacement	N/A	N/A	$160,500	1.00	$160,500				
	Bridge Replacement	N/A	N/A	$119,900	1.06	$127,100				
	Emergency	$94,185	$21,741	$72,444	1.09	$78,891				
	Total	*$3,410,330*	*$446,861*	*$3,503,548*		*$3,728,114*	*$70,079,000*	*$3,181,000*	*547,100*	*1.17*
1F	Mamaroneck DS	$35,820	$5,870	$29,950	1.07	$31,955				
	Sheldrake	$2,059,220	$254,180	$1,805,040	1.07	$1,925,876				
	Mamaroneck US	$1,315,290	$272,660	$1,042,630	1.07	$1,112,427				
	Pre Base Year	N/A	N/A	$165,494	1.07	$176,573				
	Wall Replacement	N/A	N/A	$118,600	1.00	$118,600				
	Bridge Replacement	N/A	N/A	$119,900	1.06	$127,100				
	Emergency	$94,185	$24,712	$62,960	1.09	$68,563				
	Total	*$3,410,330*	*$557,422*	*$3,344,574*		*$3,561,093*	*$64,958,000*	*$2,951,000*	*610,100*	*1.21*

FY 2015 Price Level, 3.375% Interest Rate

Table 20: Summary of Actions for the Alternatives

Bridge Removal	Alternative 1F		Alternative 1M	
Ward Avenue	Remove		Remove	
Station Plaza	No action		No action	
Waverly Place	Remove/replace		Remove/replace	
Centre Avenue Footbridge	Remove		Remove	
Footbridge #1 (near confluence)	Remove		Remove	
Footbridge #2	Remove		Remove	
Road Removal				
Glendale Avenue (20-ft section)	No action		Remove	
Channel Work Length (ft)				
Harbor Heights	No action		1,340.00	
Mamaroneck Upstream	2,400.00		2,400.00	
Mamaroneck Downstream	2,400.00		2,400.00	
Sheldrake	3,470.00		3,470.00	
Channel Width Size (ft)				
Harbor Heights	No action		25.00–35.00	
Mamaroneck Upstream	30.00–40.00		45	
Mamaroneck Downstream	45		45	
Sheldrake	20.00–30.00		25.00–30.00	
Channel Cut Depth (maximum) (ft)				
Harbor Heights	No action		1.1	
Mamaroneck Upstream	2.3		2.3	
Mamaroneck Downstream	4.2		4.2	
Sheldrake	1.8		3.4	
Channel Slope				
Harbor Heights	No action		0.6%–0.2%	
Mamaroneck Upstream	0.30%		0.25%	
Mamaroneck Downstream	0.30%		0.25%	
Sheldrake	0.25%		0.25%	
Channel Cut Volume (soil/rock) (cubic yards)	60,990.00	11,250.00	89,210.00	11,250.00
Walls (average height/length) (ft)	8.4	4,085.00	8.5	4,360.00
Nonstructural	9 structures		No action	

8.3 NED Plan Identification

Upon presentation of the plan formulation and optimization tables with Benefit to Cost Ratios (B/C), Net Benefits and Local Cost Sharing Amounts, both the Non-Federal Partner (NYS DEC) and the Local Partners (County of Westchester and The Village of Mamaroneck) jointly requested that the Federal Government further analyze the level of protection that the Harbor Heights Reach was providing for Alternative 1M (channelization) and Alternative 1F (non-structural component). Based on this request, USACE also conducted an incremental economic analysis for the Harbor Heights reach.

As illustrated by Figure 36 and Figure 37, Alternative 1M provides more flood risk management than Alternative 1F based on the reduction in WSELs with the project. However, the channelization in the Harbor Heights reach (upstream Mamaroneck Reach) requires further evaluation and analysis (level of protection and incremental justification) to determine the applicability and justification of the Harbor Heights Reach.

The flood risk management solution for Alternative 1F in Harbor Heights is a non-structural feature that includes the elevation of approximately eight structures along the Mamaroneck River (during Plans and Specifications, additional structures may be identified for elevation whiles others identified for elevation may be wet or dry floodproofed). Alternately, the flood risk management solution proposed for Alternative 1M is channelization.

As indicated in the following figures that illustrate the reduction in WSEL and also residual risk for first floor damage for a modeled 1% probability of exceedance storm event, channelization in Harbor Heights for Alternative 1M only provides a 0.4 ft reduction in WSEL. Because Alternative 1F proposed to elevate structures out of the 100 year floodplain at a project cost of approximately $2.4M, a “level of protection” analysis was conducted for the channelization solution in Harbor Heights as the channelization cost estimate is over $6M. This also led to an incremental economic justification analysis for the non-structural solution versus the channelization solution for Alternative 1F and 1M, respectively.

It should be noted at this juncture that the remaining areas of Alternative 1F and 1M other than Harbor Heights represent almost identical flood risk management features with Alternative 1M providing slightly more flood risk management probability than Alternative 1F as noted in Figure 36 and Figure 37 with wider and/or deeper channel modification along the Sheldrake and Mamaroneck Rivers as noted in Table 20 above.

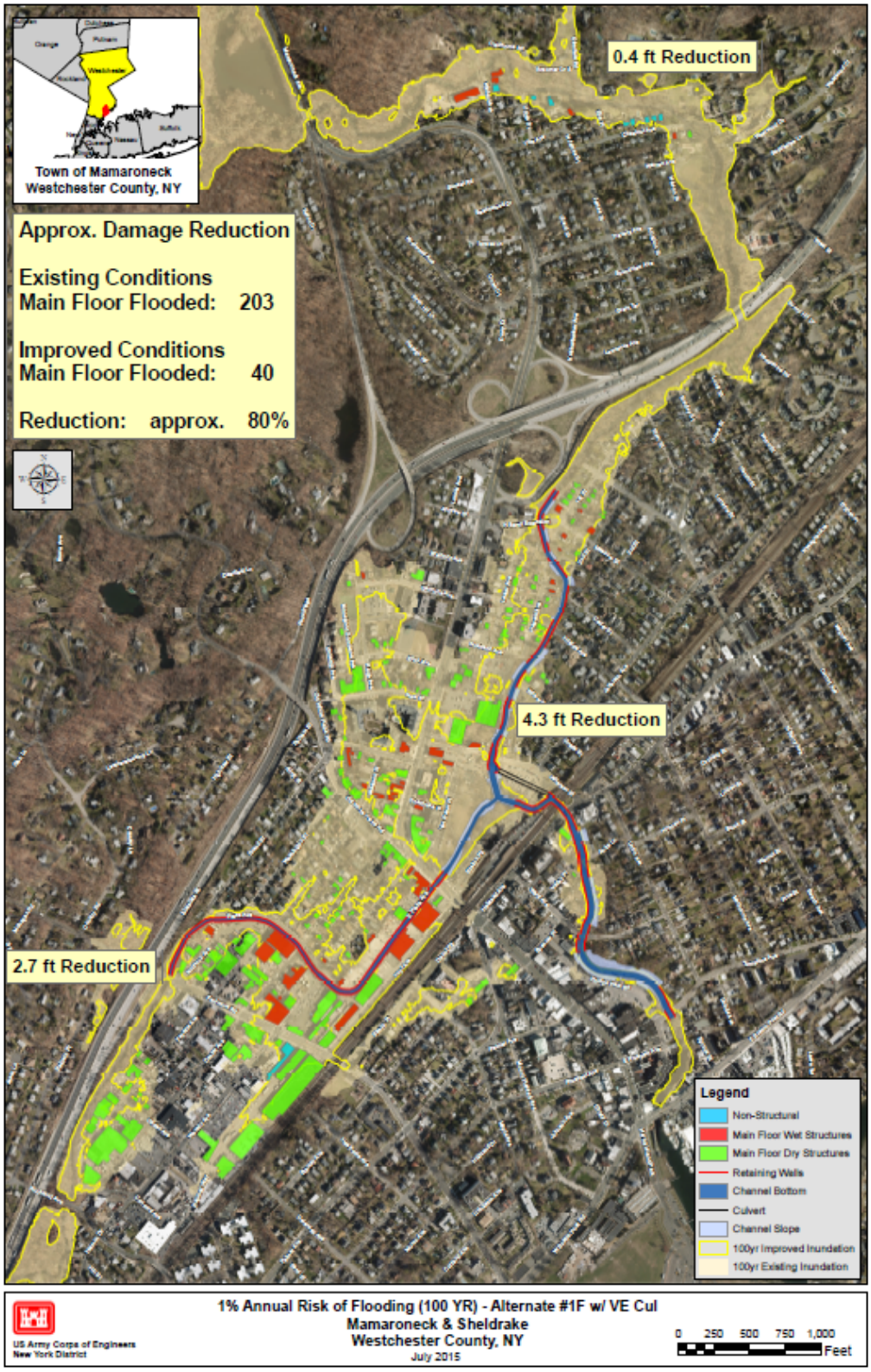

Figure 36: *Alternative 1F -1% Annual Probability of Exceedance Residual Risk*

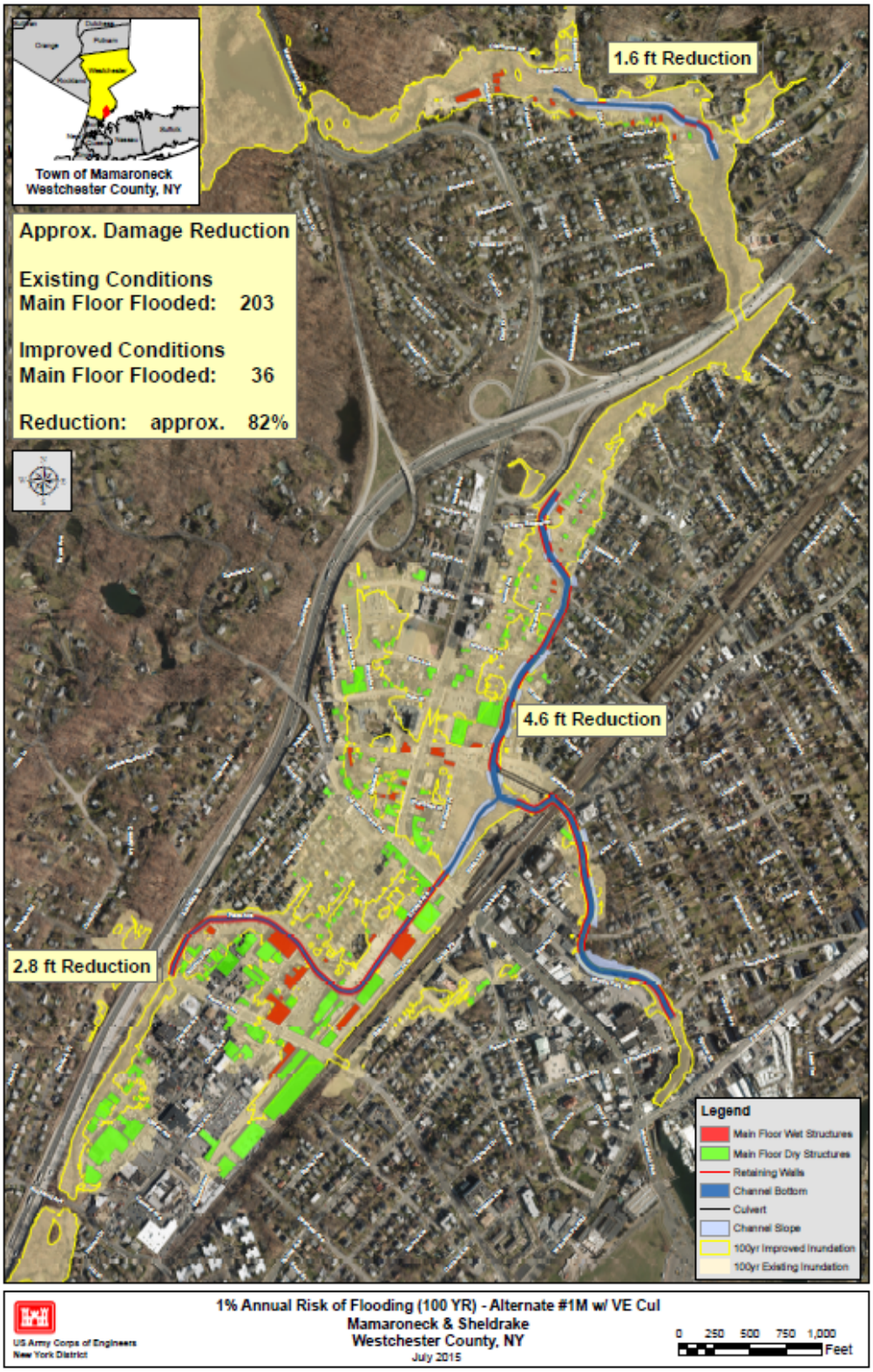

Figure 37: Alternative 1M -1% Annual Probability of Exceedance Residual Risk

8.3.1 NED Plan Level of Protection Analysis

As stated above, Alternative 1M and 1F were retained for further optimization analysis.

The following is the step by step analysis for the "level of protection" analysis (Table 21) for each reach for Alternative 1M and 1F and also the "incremental justification" analysis conducted on the Harbor Heights reach (Upper Mamaroneck) for each alternative.

STEP 1: LEVEL OF PROTECTION ANALYSIS

Table 21: ***Level of Protection Analysis (Alternative 1M & 1F)***

	Alt 1F	**Alt 1M**
Mamaroneck Reaches	Return Period in years*	Return Period in years*
Tompkins to Ward	50 yr.	50 yr
Ward to Valley	>200 yr	>200 yr
Valley to Halstead	>100 yr	>100 yr
Halstead to Confluence	65-85 yr	75-100 yr
Confluence to Hillside	30 yr	30 yr
Hillside to I-95	**15 yr**	**30 yr**
I 95 to Winfield (Harbor Heights)[1]	**100 yr (select structures)**	**5 yr**
Sheldrake Reaches		
Mouth to Mamaroneck Ave	50 yr	50 yr
Mamaroneck Ave to Fenimore[2]	**50 yr**	**65-95 yr**
Fenimore to Rockland[2]	**20 yr**	**40 yr**

1. Channelization determined to be not economically justified in Harbor Heights (see next section)
2. Due to development along Sheldrake, Alternative 1M & 1F will now be identical on the Sheldrake River

This "Level of Protection Analysis" indicates that the channel modification that is proposed in Alternative 1M, in the Harbor Heights reach of the Upper Mamaroneck River (1,340 feet) would only provide against a 20% annual average exceedance probability (equivalent to a "5 year level of protection") whereas the non-structural elevation of homes would be raised out of the 100-year flood plain. At the initiation of optimization of Alternative 1, it was not expected that a) channelization

would have such a minimal effect on water surface elevations and thus, level of protection output and b) resident participation would be receptive.

8.3.2 NED Plan Incremental Justification Analysis

Once it was determined that the level of protection in the Harbor Heights reach for channelization in Alternative 1M was only 20% annual exceedance probability, an incremental economic analysis was conducted for the Harbor Heights reach.

The total cost of channel modification in Alternative 1M for the Harbor Heights reach is approximately $6.4M with a total annual equivalent cost of approximately $322K and annual benefits of only $147K for a BCR of 0.46.

Noting that Harbor Heights channelization is not incremental justified (and therefore does not meet NED plan qualifications for federal interest), the non-structural feature for Harbor Heights as presented in Alternative 1F was incrementally analyzed. The total cost for the non-structural solution in Alternative 1F (currently the NED plan) for the Harbor Heights reach is approximately $2.4M with a total annual equivalent cost of approximately $114,100 and annual benefits of $154,700 for a BCR of 1.36.

Based on the above analysis, channel modification is not incrementally justified and only provides a 5 year "level of protection (Alternative 1M for the Harbor Heights reach). Therefore, a new Alternative 1 was developed during the optimization, Alternative 1Z. Alternative 1Z is the same as alternative 1M below the Harbor Heights reach. In the Harbor Heights reach (upper Mamaroneck) channel modification has been replaced with the non-structural elevation of structures.

Table 22 provides the updated cost and benefit analysis including Alternative 1Z comparison to Alternative 1M and 1F. Please note that alternative costs have been updated for Alternative 1F and 1M to include post-ATR refinements and preliminary CSRA contingencies. Based on this refined analysis and revision, Alternative 1Z is the updated NED Plan and the recommended plan for implementation. Alternative 1Z cost estimates are further refined in Section 10. Any cost refinements noted in Section 10 of this Report for Alternative 1Z would also apply to Alternative 1M and 1F equally and proportionally and therefore would not change the plan selection results.

Further, please also note that the cost of Alternative 1S would increase proportionately with Alternative 1M and 1F. However, Alternative 1S does not include the Harbor Heights reach at all. Therefore, Alternative 1S would not capture the benefits of the increase of annual net benefits (but would capture the cost increases noted in 1F and 1M) and therefore a total decrease in annual net benefits, Alternative 1S annual net benefits will change relative to Alternative 1F. Alternative 1F is identical to Alternative 1S with the exception of Harbor Heights. Alternative 1S does not include any flood works in Harbor Heights. Therefore, the Annual Net Benefits for Alternative 1S will always remain below those of Alternative 1F and therefore below Alternative 1Z, the NED Plan. Therefore, Alternative 1S was removed from further consideration.

Costs and benefits were refined for Alternative 1Z and are presented in Table 23.

Table 22: Comparison of the Benefits and Costs of the 1F, 1M and 1Z

Project Plan	Total Project Cost	Total First Cost	Real Estate Cost	Harbor Heights	O&M	IDC	Annual Cost	Annual Benefits	Net Benefits	BCR
Alt 1M Channelization in Harbor Heights Reach	$70,021,000	$67,778,000	$6M	$6,481,232	$311,846	$2,243,720	$3,2,30,159	$3,581,438	$351,279	1.11
Alt 1Z non-structural in Harbor Heights Reach Alt 1F & 1M HYBRID PLAN	$64,212,440	$62,265,040	$4.9M	$2,429,725	$270,663	$1,947,396	2,946,861	$3,403,704	$456,843	1.16
Alt 1F Non-structural in Harbor Heights Reach	$64,772,400	$62,825,000	$4.9M	$2,429,725	$270,663	$1,947,396	$2,970,200	$3,368,217	$398,019	1.13

Table 23: Updated Benefits and Costs of the NED – Alternative 1Z

Plan	Stream/Benefit Source	Flood Damages Without Project	Flood Damages With Project	Annual Benefits	Ratio	Updated Benefits	Total Investment Cost	Total Annual cost	Net Excess Benefits	BCR
1Z	Mamaroneck DS	$35,820	$5,620	$30,200	1.07	$32,222				
	Sheldrake	$2,059,220	$173,100	$1,886,120	1.07	$2,012,383				
	Mamaroneck US	$1,315,290	$246,400	$1,042,630	1.07	$1,147,914				
	Non-Structural			145,000	1.07	154,707				
	Wall Replacement	N/A	N/A	$118,600	1.00	$118,600				
	Bridge Replacement	N/A	N/A	$133,900	1.06	$142,497				
	Emergency			$62,960	1.09	$68,563				
	Total	*$3,410,330*	*$532,710*	*$3,306,380*		*$3,403,704*	*$71,893,100*	*$3,146,900*	*$256,800*	*1.1*

Post CSRA Cost Estimate and Updated Comparison of the Benefits and Costs of the NED- FY 2016 Price Level, 3.125% Interest Rate

8.4 Description of the NED Plan

Based on consideration of benefits from an assessment of damages avoided in accordance with economic and environmental USACE procedures, the NED Plan (Alternative #1 Z) was selected by the District. It involves channel modifications, retaining walls, bridge removal and replacement, a culvert under the railroad parking lot, and trapezoidal cuts along the Mamaroneck and Sheldrake rivers, as well as nonstructural measures potentially applied to a maximum of eight residences and one non-residential building. The NED Plan includes approximately 1.82 miles of channel work in the Mamaroneck and Sheldrake rivers. The average height of the new channel retaining walls will be 8.5 ft and the total combined length of new channel retaining walls in the entire Project area will be 4,360 ft.

Riprap and concrete was selected to protect the banks of the Mamaroneck and Sheldrake Rivers from erosion. This solution will stabilize the stream bank using techniques consistent with the requirements of the USACE, NYSDEC, Westchester County and the Village of Mamaroneck. The size and gradation of the riprap was determined following Corps of Engineers' procedures and methodology presented in EM 1110-2-1601, 1 July 1991, revised 30 June, 1994. Approximately 1,200 linear feet of riprap (i.e.; 13,000 square feet, 600 cubic yards) will be used for the Mamaroneck and Sheldrake Rivers. About 500 feet of riprap will be located roughly 200 feet both upstream and downstream of the N. Barry Ave Extension Bridge over the Mamaroneck River and 700 feet of riprap will be placed at the 90 degree turn in the Sheldrake River located downstream of the Fennimore Rd. Bridge. Also, due to high velocities and structural considerations along the Mamaroneck River from the Station Plaza Bridge to just downstream of the

Halstead Ave Bridge, 300 LF concrete will placed along the bottom of the stream prevent scour under and around the footings of these three bridges.

Channel work on the segment of the Mamaroneck River south of I-95 and upstream of the confluence with Sheldrake River will total approximately 2,400 ft, and channel work on the segment stretching from south of the confluence to just downstream of the Tompkins Avenue Bridge also will total approximately 2,400 ft. In both segments, the river channel will be deepened and widened to 1:2.5 side slopes, and the channel bottom will be widened to 45 ft with 0.25% slope. The removal and replacement of retaining walls and utilities will be necessary in certain locations including the removal/replace of the Ward Avenue Bridge.

Channel work on the Sheldrake River from Fenimore Road to the confluence in Columbus Park will total approximately 3,470 ft. The river channel will be deepened and widened to 33 feet wide and 3.4 ft cut with 0.25% slope. Rectangular channel modification will be executed, upstream of Mamaroneck Avenue Bridge. The removal and replacement of retaining walls and utilities will be necessary in certain locations including the removal/replacement of Waverly Avenue Bridge and the removal of the Center Avenue footbridge. Two footbridges in Columbus Park (footbridge #1, near the confluence, and footbridge #2, closer to the southern edge of the park across from Station Plaza) also will be removed and not replaced.

In addition to channel work along both rivers, the NED Plan will have a nonstructural component along the Mamaroneck and Sheldrake rivers. A total of nine (9) structures were selected based on a benefit-cost evaluation. Eight of these are residential properties in the Harbor Heights neighborhood just south of the Mamaroneck River, all of which are candidates for structure elevation, or raising). The ninth structure is a nonresidential property in the Village's industrial area along Fenimore Road and just south of the Sheldrake River, which is a candidate for the construction of a ringwall. All nonstructural actions are contingent upon owner approval and will adhere to construction standards outlined in Village Code Chapter 186-5 that apply to the improvement of structures located in areas of special flood hazard (Village of Mamaroneck 1987). It should be noted that during the design phase of this project, additional structures may be identified for elevation or wet/dry floodproofing.

Table 24 provides a summary of features for the NED Plan. Additionally, Figure 38 through Figure 41 provides features and profiles of the NED Plan, Alternative 1Z.

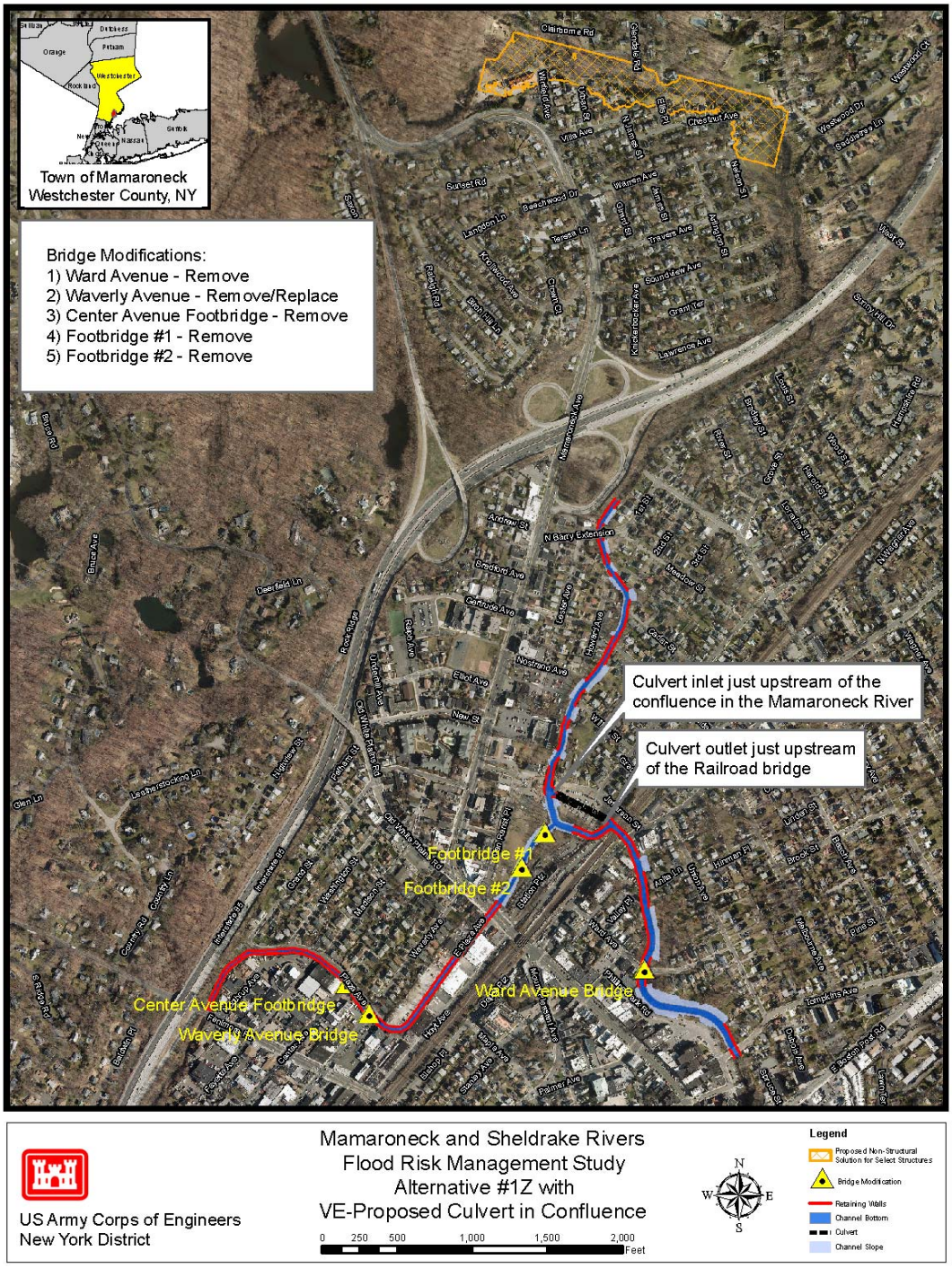

Figure 38: Alternative 1Z | Plan view of alternative 1Z with the VE proposed culvert in confluence

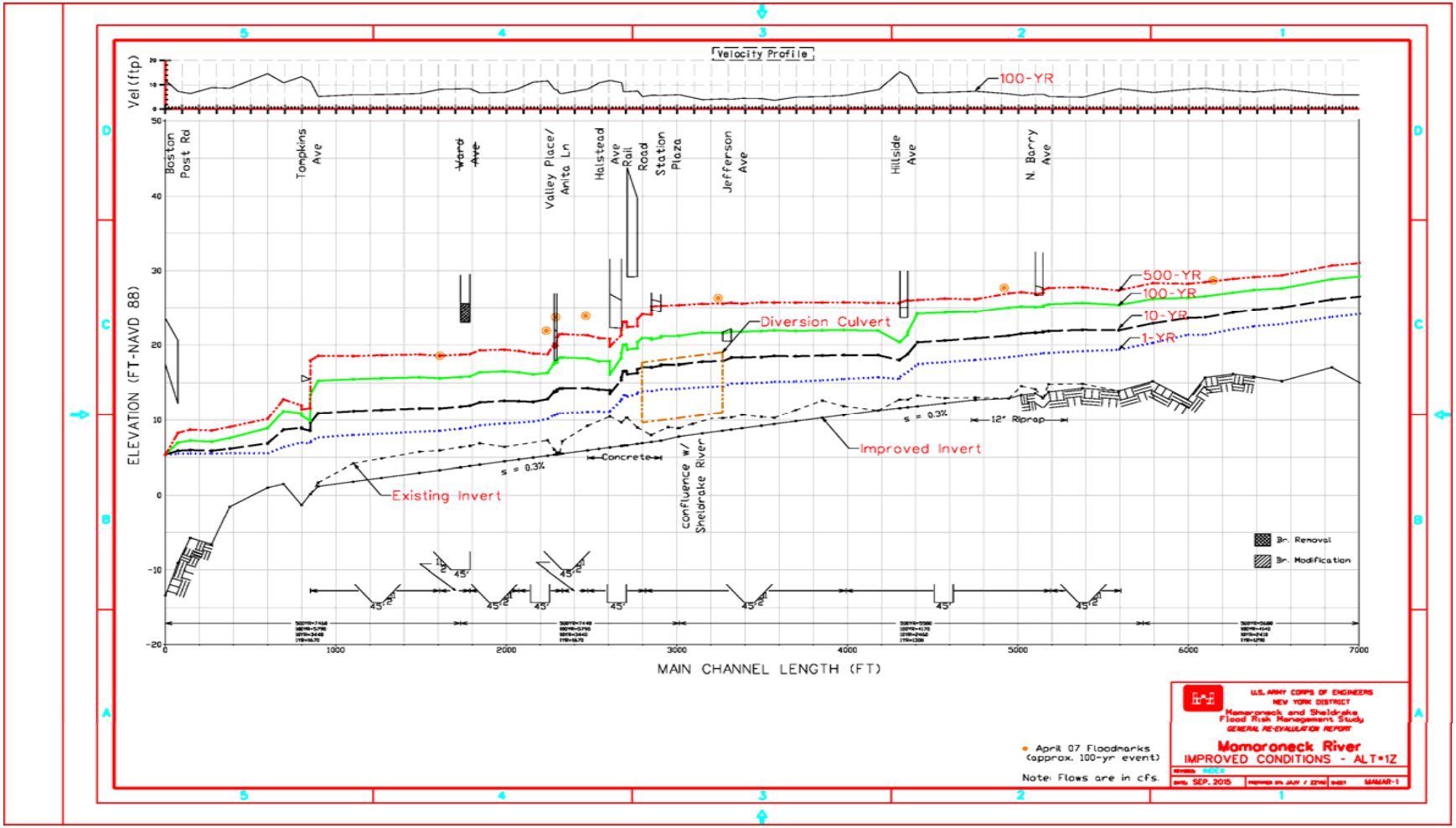

Figure 39: Alternative 1Z | Mamaroneck1 Profile

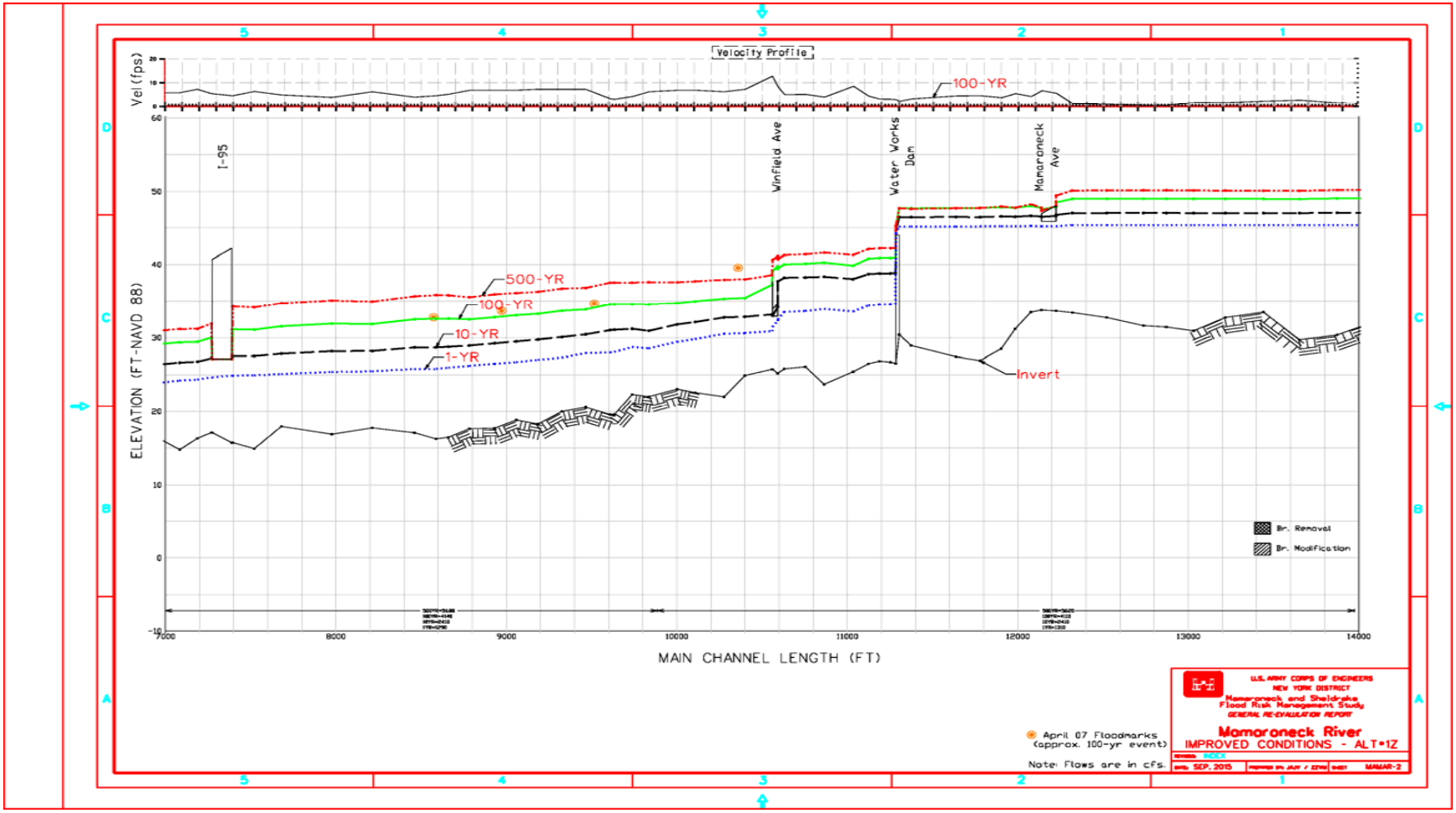

Figure 40: Alternative 1Z | Mamaroneck2 Profile

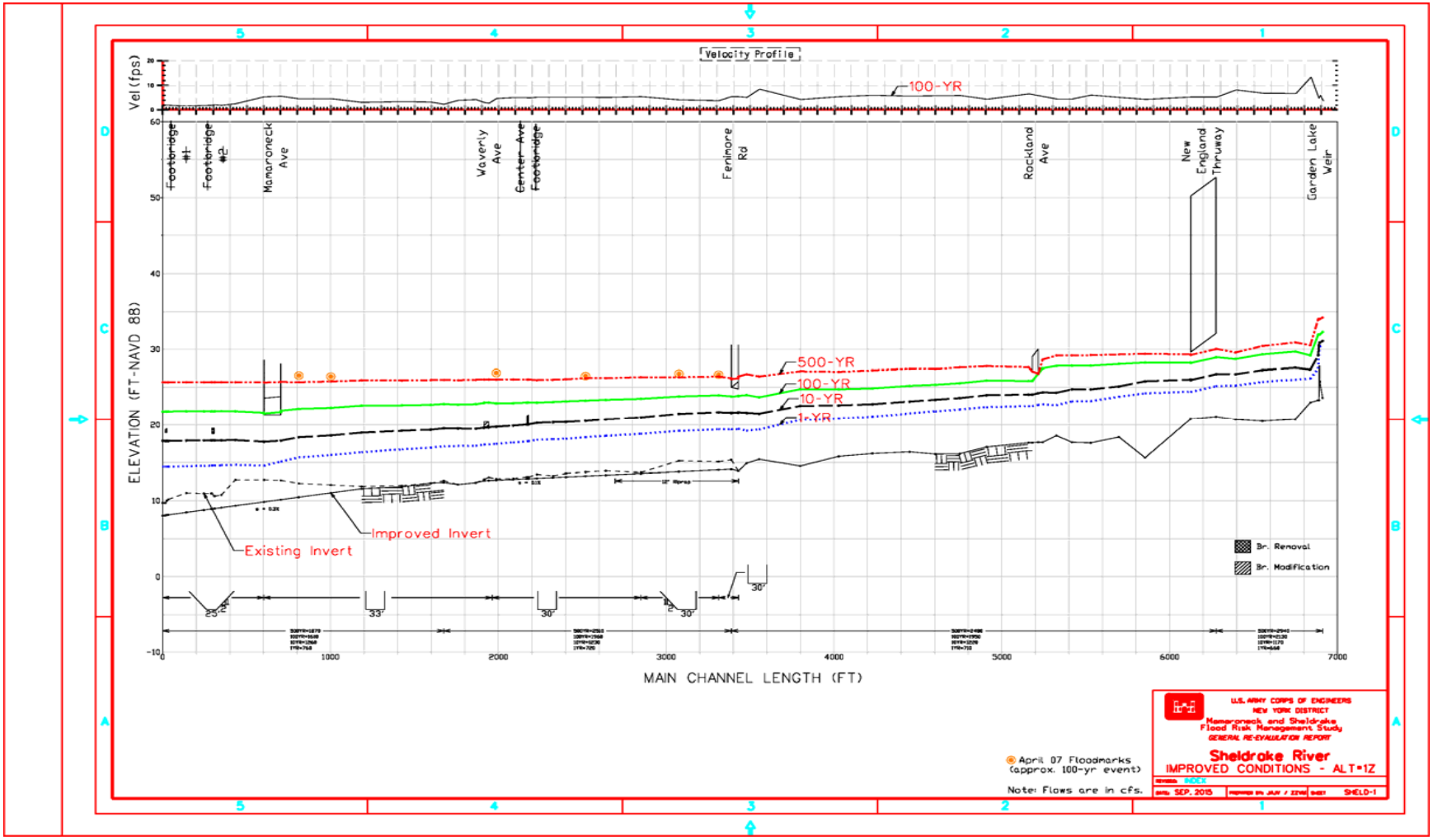

Figure 41: *Alternative 1Z | Sheldrake Profile*

Table 24: Summary of Actions for the NED Plan

Actions	Alternative 1Z – NED Plan
Bridge Removal	
Ward Avenue	**Remove**
Station Plaza	**No action**
Waverly Place	**Remove/replace**
Centre Avenue Footbridge	**Remove**
Footbridge #1 (near confluence)	**Remove**
Footbridge #2	**Remove**
Channel Work Length (ft)	
Harbor Heights	**No action**
Mamaroneck Upstream	**2,400.00**
Mamaroneck Downstream	**2,400.00**
Sheldrake	**3,470.00**
Channel Width Size (ft)	
Harbor Heights	**No action**
Mamaroneck Upstream	**45**
Mamaroneck Downstream	**45**
Sheldrake	**33**
Channel Cut Depth (maximum) (ft)	
Harbor Heights	**No action**
Mamaroneck Upstream	**2.3**
Mamaroneck Downstream	**4.2**
Sheldrake	**3.4**
Channel Slope	
Harbor Heights	**No action**
Mamaroneck Upstream	**0.25%**
Mamaroneck Downstream	**0.25%**
Sheldrake	**0.25%**
Riprap (12, 24, 36 inch)	**8,400 1,500 800**
Crushed stone base	**5,000**
Walls (average height/length) (ft)	**8.5 4,360**
Nonstructural	**9 structures**

8.5

8.6

8.7 Residual Risk

This study has been conducted in accordance with ER 1105-2-101, "Risk Analysis for Flood Damage Reduction Studies (USACE, January 3, 2006), which stipulates that the risk analysis for a flood protection project should quantify the performance of all alternatives and evaluate the residual risk, including the consequences of the project's capacity exceedance. In addition to the basic economic performance of a project, the guidance stipulates that the engineering performance of the project is to be reported in terms of 1)The annual exceedance probability; 2)the long-term risk of exceedance and; 3)the conditional non-exceedance probability.

As part of the continued coordination with the local partners and the public, the following concepts of flood risk management have been presented on several occasions.

- No Flood Risk Management project can eliminate the risk of flooding. Given a long enough period of time, all projects will experience an event exceeding design criteria.
- Flood Risk Management Projects can only reduce the frequency and/or severity of flood damages and can provide additional time to respond.
- Communication of accurate and timely information about the risk of living in a flood prone area is critical.
- Physical features are only a single component of a flood risk management approach. (insurance, zoning, Emergency Action Plans)
- Flood safety is a shared responsibility and a collaborative approach is required to effectively manage the risk of flooding and to save lives. (Corps, FEMA, State, County, Local Government Emergency Personnel & Residents)

In addition, "residual risk" inundation maps have been presented to both the local partners and the public as a means of illustrating both the amount of flood risk reduction and the amount of residual risk. Since this project consist of channel improvements there will be no significant change in the warning time and the depth of flooding will be reduced about 2.5 to 3.5 feet for almost all events regardless of whether the channel design capacity is exceeded of not (Figure 42).

The NED Plan would have reduced the April 15-16 2007 flood elevations by about four (4) feet in Columbus Park, four (4) feet along lower the Sheldrake, about three (3) feet at Barrie Avenue and tapering to no change in all other areas.

8.7.1 Residual Risk-Executive Order 11988

Executive Order 11988 requires federal agencies to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of flood plains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. In accomplishing this objective, action shall be taken to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by flood plains in carrying out its responsibilities for the following actions:

- acquiring, managing, and disposing of federal lands and facilities;
- providing federally-undertaken, financed, or assisted construction and improvements;
- water and related land resources planning, regulation, and licensing activities
- conducting federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulation, and licensing activities

Residual Risk in accordance with EO 11988 was conducted on the NED Plan. Such measures determined by residual flooding information such as rates of rise, depths and velocities, warning times and evacuation routes are included such as emergency action planning advice.

The Water Resources Council Floodplain Management Guidelines for implementation of EO 11988, as referenced in USACE ER 1165-2-26, requires an eight step process that agencies should carry out as part of their decision making on projects that have potential impacts to, or are within the floodplain. The eight steps and project-specific responses to them are summarized below. Recognizing the Federal government's commitment to ensure no inducement of development in the floodplain, pursuant to Executive Order 11988, this project will identify in the Project Partnership Agreement, the need for the local partner to develop a Floodplain Management Plan.

1. **Determine if a proposed action is in the base floodplain (that area which has a one percent of greater chance of flooding in any given year).** The proposed action is within the base floodplain. However, the project is designed to reduce damages to existing infrastructure located landward of the proposed project.

2. **If the action is in the base flood plain, identify and evaluate practicable alternatives to the action or to location of the action in the base flood plain.** This document presents an analysis of potential alternatives. Practicable measures and alternatives were formulated and evaluated against the Corps of Engineers guidance, including non-structural measures such as retreat, demolition and land acquisition.

3. **If the action must be in the flood plain, advise the general public in the affected area and obtain their views and comments.** There has been extensive coordination with pertinent Federal, State and local agencies. Once the draft report is released, public hearing will be scheduled in the study area during the public review period.

4. **Identify beneficial and adverse impacts due to the action and any expected losses of natural and beneficial flood plain values. Where actions proposed to be located outside the base flood plain will affect the base flood plain, impacts resulting from these actions should also be identified.** The anticipated impacts associated with the Selected Plan are summarized in this report. The project would not alter or impact the natural or beneficial flood plain values.

5. **If the action is likely to induce development in the base flood plain, determine if a practicable non-flood plain alternative for the development exists.** The project provides benefits solely for existing and previously approved development.

6. **As part of the planning process under the Principles and Guidelines, determine viable methods to minimize any adverse impacts of the action including any likely induced development for which there is no practicable alternative and methods to restore and preserve the natural and beneficial flood plain values. This should include reevaluation of the "no action" alternative.** There is no mitigation to be expected for the Selected Plan. The project would not induce development in the flood plain and the project will not impact the natural or beneficial flood plain values. This report summarizes the alternative identification, screening and selection process. The "no action" alternative was included in the plan formulation phase.

7. **If the final determination is made that no practicable alternative exists to locating the action in the flood plain, advise the general public in the affected area of the findings.** The Draft

GRR and Environmental Impact Statement will be provided for public review and a public hearing will be scheduled during the public review period. Each comment received will be addressed and, if appropriate, incorporated into the Final Report. A record of all comments received will also be included in the Pertinent Correspondence Appendix.

8. **Recommend the plan most responsive to the planning objectives established by the study and consistent with the requirements of the Executive Order.** The Recommended Plan is the most responsive to all of the study objectives and the most consistent with the executive order.

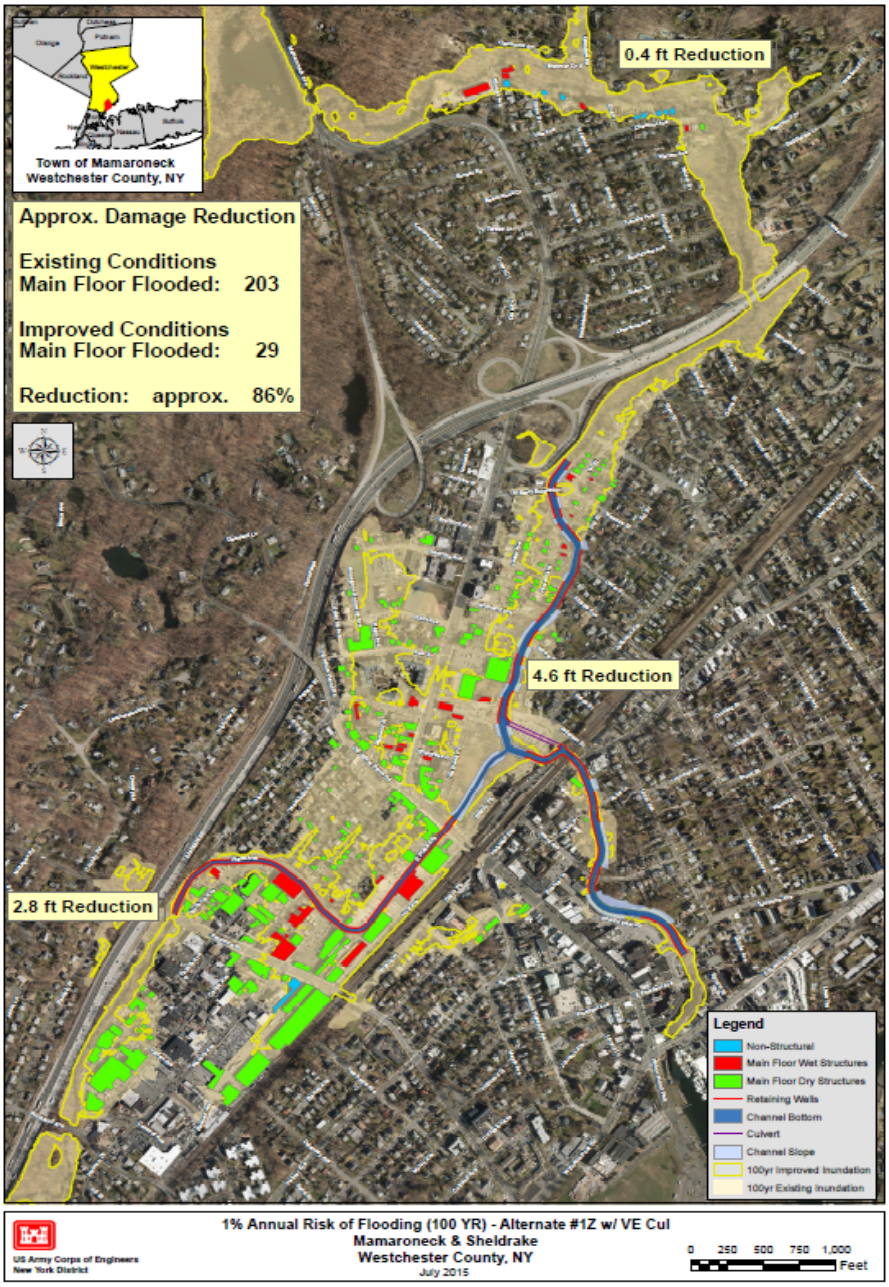

Figure 42 - Residual risk associated to Alternative 1Z at the 4% Annual Risk of Flooding (25-yr event)

The implementation of the NED Plan will not eliminate flooding or the potential for loss of life or damage to property. The NED Plan will reduce the risk of loss of life and damage to property by reducing the frequency of flooding from overbank flooding which may generate life safety risks in addition to those created by the depth of flooding alone.

The Village of Mamaroneck has an education and outreach program to increase flood evacuation awareness among the residents. To support this objective, the Village of Mamaroneck runs a Web site that provides a broad approach to communicating preparedness and evacuation information. The goal is to inform the public what evacuation procedures to adhere in the event of a storm event. The online mapping tool also shows the locations of the evacuation centers, which are the central nodes for a system of shelters strategically placed throughout the Village that would be put in use in the event that an evacuation order was in effect. In the event of a significant storm, official evacuation orders are sent through a wide range of networks including telephone to communicate the level of risk to the public.

Media broadcasts, e-mail, reverse 911 telephone calls, social media alerts, and other Emergency Alerts are all sent to notify residents at risk. Special attention is given to notify those who are homebound or need special assistance. Evacuation orders are issued by the Village Manager's office based upon the storm's predicted intensity and direction (bearing), in coordination with County and State emergency services. Evacuation decisions typically must occur before real-time/storm specific probabilistic storm forecasts are made available, usually when a Flood Watch is issued.

As part of the Mamaroneck & Sheldrake Flood Risk Management Study, the Village of Mamaroneck should conduct an analysis of the existing evacuation zones/routes within the study area upon plan implementation to ensure the appropriate level of evacuation safety.

8.7.2 Critical Infrastructure

The NED Plan provides a significant reduction in water surface elevations in the Mamaroneck and Sheldrake Rivers at and above the confluence to manage the risk of:

a) Rapid rate of rise of flood waters
b) Evacuation routes impassable
c) Schools and daycares within floodplain
d) Emergency access

Implementation of the NED Plan will reduce the risk associated with flood damages to life and property. Figure 43 and Figure 44 indicate the transportation infrastructure, schools, daycares, hospitals, fire stations and police station that are all vulnerable under the "without project condition".

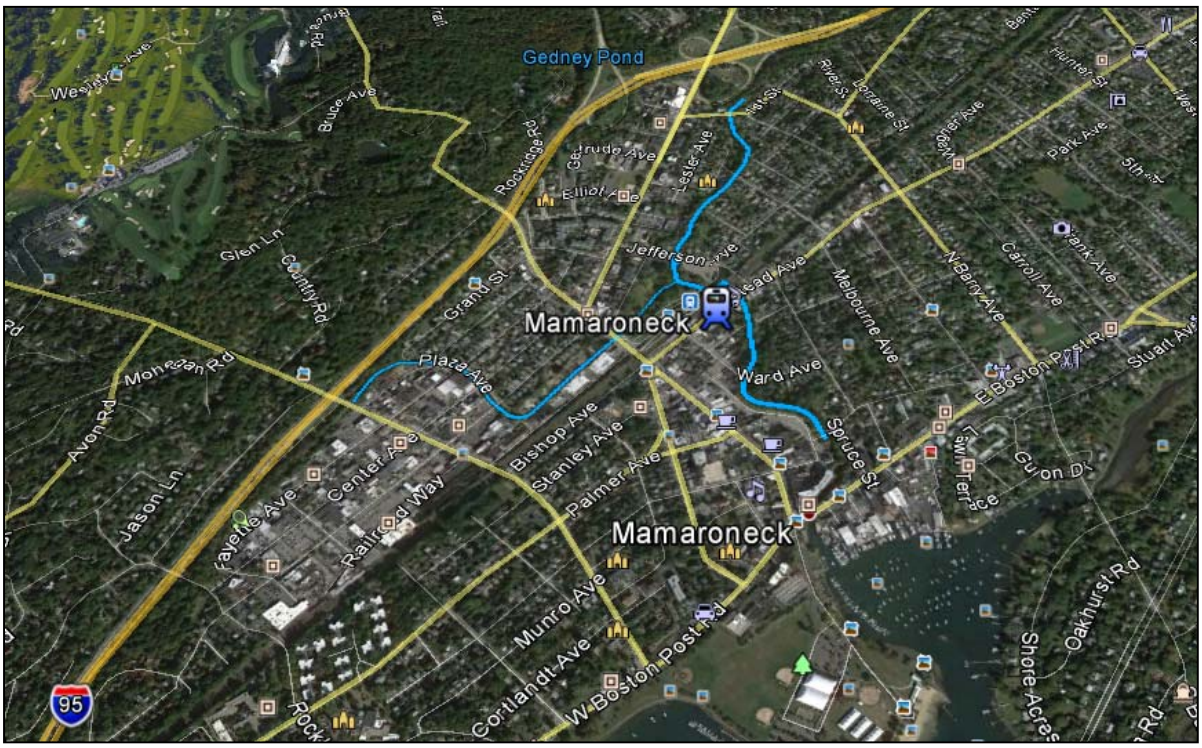

Figure 43: Transportation, Evacuation and Access – Village of Mamaroneck

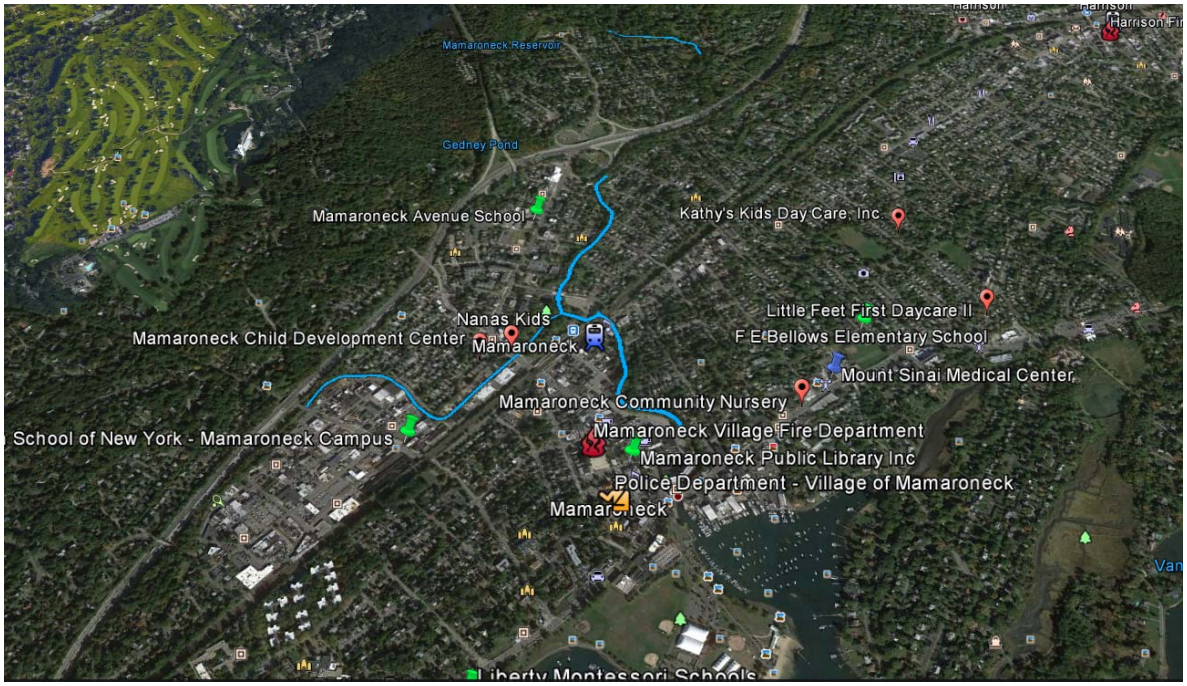

Figure 44: Vulnerable Infrastructure – Village of Mamaroneck

9. IMPROVED CONDITIONS & PLAN IMPACTS

9.1 Sedimentation

A rough sediment trend assessment was conducted. The soils and channel bottom for the project area above the railroad consists of silty sands. Below Halstead Avenue there are large cobbles and bedrock in the channel especially where the channel bottom gets steeper. There are small reservoirs upstream of the project area on both rivers which have been filling in and have historically been cleared of sediment. The local officials noted that shoals have formed under one bay of the North Barry Avenue Bridge on the inside of a bend. They noted that after the April 15-16 2007 storm they removed some sediment from under Fenimore Road, the Thruway, North Barry Avenue and the Anita Lane/Valley Place bridges. They also noted that the river banks in Columbus Park tend to erode. An invert comparison between the cross-sections surveyed for the 1989 GDM and the cross-sections surveyed for this GRR was made. The comparison indicated that there was a small but general scouring trend for the Mamaroneck River. Based on the information collected, this small trend seems reasonable. The results of the last 20 years were extrapolated 50 years into the future and the future unimproved model inverts were lowered to reflect the small erosion trend. Since the improved conditions will include channel and bank erosion protection, none of the improved conditions models were modified to include an erosion trend. It is anticipated that the reservoirs will continue to prevent some sediment from entering the project area. Large events will cause some bank and bottom erosion in or near the project area but much of that sediment will pass through the project area and be deposited in the harbor. Sediment transport is not expected to be a significant concern for this project.

9.1.1 Westchester County Joint Water Works Reservoir

Westchester County Joint Water Works Reservoir. The Westchester County Joint Water Works Reservoir lies on the Mamaroneck River, upstream of the damage areas in the Village of Mamaroneck. The Village of Mamaroneck is considering the decommissioning of the dam. Construction activities for the removal of the dam will include: 1) demolition of the existing dam and associated structures; 2) channel modifications above the dam; 3) removal of sediment from the existing reservoir; 4) restoration/armoring of the surrounding area; 5) flood control measures downstream from the dam; and 6) erosion control measures. The decommissioning of the existing dam was investigated to determine its potential for "with project" impacts. This evaluation indicated that, even with the removal of the dam and other modifications, the decommissioning of the existing structure provides no significant increase in the peak flows and water surface elevations and therefore will not cause adverse environmental impact to the selected plan. Table 25 details the impacts to WSE's on the "with project" condition based on the Village of Mamaroneck decommissioning the WCJWW dam.

Table 25: Decommissioning Impacts

Location	Change is WSEs / Chance of Exceedance (ft)		
	100% (1yr)	10% (10yr)	1% (100yr)
Upstream WWD	-8.5	-6.8	-5.6
Harbor Height	0.0	0.0	+0.1
Confluence	+.4	+.15	+.20

9.2 Erosion Protection and Bank Stabilization

Riprap and concrete was selected to protect the banks of the Mamaroneck and Sheldrake Rivers from erosion. This solution will stabilize the stream bank using techniques consistent with the requirements of the USACE, NYSDEC, Westchester County and the Village of Mamaroneck. The size and gradation of the

riprap was determined following Corps of Engineers' procedures and methodology presented in EM 1110-2-1601, 1 July 1991, revised 30 June, 1994. Approximately 1,200 linear feet of riprap (i.e.; 13,000 square feet, 600 cubic yards) will be used for the Mamaroneck and Sheldrake Rivers. About 500 feet of riprap will be located roughly 200 feet both upstream and downstream of the N. Barry Avenue Extension Bridge over the Mamaroneck River and 700 feet of riprap will be placed at the 90 degree turn in the Sheldrake River located downstream of the Fennimore Road Bridge. Also, due to high velocities and structural considerations along the Mamaroneck River from the Station Plaza Bridge to just downstream of the Halstead Avenue Bridge, 300 LF concrete will placed along the bottom of the stream prevent scour under and around the footings of these three bridges.

9.3 Environmental Consequences

The Environmental Consequences section in the EIS presents the potential adverse impacts and beneficial effects associated with implementing the Preferred Alternatives and the No Action alternative (Appendix B). For each resource subsection, impacts related to the NED Plan are comprehensively analyzed and presented. Lastly, expected outcomes of selecting the No Action alternative are summarized based on the assessment of environmental consequences of the Preferred Alternative. Table 26 provides a summary of the anticipated adverse impacts and/or beneficial effects for each resource area under the NED Plan and No Action alternative scenarios of the Project. This section also summarizes the impact minimization and mitigation measures that will be carried out if the NED Plan is implemented. Based on the results of the environmental consequences analysis and the proposed minimization and mitigation measures provided below, the Selected Plan is expected to result in an overall long-term benefit to natural resources and inhabitants of the study area due to the substantial reduction in flood risk that will be realized. Some short- and long-term minor and moderate adverse impacts will result from implementation of the NED Plan, but these are expected to be outweighed by the long-term beneficial effects the Project will provide. No significant adverse impacts are associated with the NED Plan.

9.3.1 Cumulative Effects

This section analyzes the cumulative effects of the NED Plan that would be expected from implementation of the NED Plan along with other actions in the study area. There are no other projects within the study area currently or in the immediate future. . A summary of the proposed mitigation measures, which include avoidance and minimization, is provided below (Table 26).

9.3.2 Topography and Geology

The NED Plan will result in short- and long-term minor adverse impacts—primarily associated with sedimentation, dust and waste generated by rock excavation, the clearing and grading of construction and staging sites, and other channel modifications. However, these impacts are expected to have negligible cumulative effects overall. Implementation of the NED Plan is expected to have long-term beneficial effects on stream channel erosion and streambed scour.

Monitoring equipment will be used, as necessary, to ensure construction activities that cause ground vibrations do not exceed state and Federal thresholds to avoid damages to nearby structures. Pre-construction inspections of buildings may be required as part of the efforts to monitor effects of vibrations.

9.3.3 Hazardous Toxic And Radioactive Waste

The ITT Sealectro Site is located along the Sheldrake River within the project area, where retaining walls will be constructed. Prior to construction, USACE will test soils for Volatile Organic Compounds (VOCs) and other Hazardous, Toxic, and Radioactive Waste (HTRW) and will contact the NYSDEC Remediation staff to determine if contaminated soils are to be disturbed. Soil removed as part of construction may require handling and disposal in accordance with NYSDEC standards. The NED Plan will have negligible cumulative effects on issues involving HTRW.

9.3.4 Land Use, Cover, and Zoning

Due to the relatively small foot print of the area required to construct the project, and because the modifications proposed by the project fit within the existing footprint of the existing waterbodies, the NED Plan will have negligible cumulative effects on land use, cover or zoning.

9.3.5 Water Resources

The NED Plan will not have an adverse effect on either of the wetlands located within the project area. No channel modification will be undertaken in the Harbor Heights area, where wetlands were identified during the course of this study. Also, freshwater pond at the confluence of the Sheldrake and Mamaroneck Rivers will have no significant adverse impacts. It will be protected during construction and the use of the area around Columbus Park as a construction staging area. In-stream activities will be avoided from 1 June through 1 September.. The NED Plan will have no significant adverse cumulative impacts on regional hydrogeology, groundwater resources, or tidal influences, and is expected to produce long-term benefits to water quality by decreasing storm-related erosion and sedimentation.

The NED Plan will result in short-term minor impacts to surface waters and water quality during excavation activities. These short term impacts may include an increase in turbidity, sedimentation, and erosion; water flow changes; an increase in downstream water temperatures; and mobilization of heavy metals, PCBs, and pesticides. An update to existing floodplain maps for the study area also will be required; however, this is considered a beneficial effect resulting from the reduction in flood risk within the study area that will result from the NED Plan.

The NED Plan will result in short-term minor and long-term minor and moderate adverse impacts to wetland resources. Short-term impacts include loss of vegetation during construction activities. Short-term impacts are expected to be minor due to the relatively low density of riparian areas within the Project area and the restoration of riparian areas to pre-construction conditions using native species.

9.3.6 Vegetation

The NED Plan will result in short-term minor and long-term moderate adverse impacts to upland and wetland vegetation within the Project area. Short-term impacts include trampling of vegetation within construction workspaces and conversion of forested uplands and wetlands to herbaceous communities. Short-term impacts will have negligible cumulative effects due to restoration of the impacted areas. In the long term, there will be an overall loss of riparian vegetation, including the removal of mature trees, where the new channel extends into existing riparian habitats and in construction workspaces. The loss of vegetation in a watershed with high density of development may have moderate cumulative impacts.

9.3.7 Fish and Wildlife

The NED Plan will result in short- and long term minor adverse impact on local populations of amphibians, reptiles birds and mammals. In the short-term construction of the NED plan may result in some mortality, displacement of individuals and disrupted bird nesting. The NED plan is not expected to impact rare, threatened, and/or endangered species that have the potential to occur in the project area. Due to the limited availability of roosting trees, there is a low likelihood that Indiana bat and northern long-eared bat occur in the project area. Tree cutting will be avoided from 1 April to 1 August. If trees greater than three inches density breast height (dbh) will be removed from 1 January through 31 March, a survey for breeding raptors will be conducted. No in-stream work will be conducted from 1 June through 1 September. These measures will minimize any project impact to fish and wildlife.

9.3.8 Socioeconomics

The Selected Plan will have no adverse cumulative impacts on the existing demographics, economy, housing, and Environmental Justice (EJ) communities in the study area. Increasing storm and flood

protection will reduce damage to property and infrastructure within the study area; thus implementation of the Selected Plan is expected to benefit the local economy and housing in the long term.

9.3.9 Cultural Resources

The cumulative effect of the removal or alteration of the National Register eligible or listed properties, the Ward Avenue Bridge, the Metro North Railroad Bridge and the stone retaining walls will have and adverse effect on historic properties. Floodproofing or other activities as part of the non-structural element also has the potential to affect resources that may be eligible for the National Register. As part of the on-going consultation, mitigation efforts will look to reduce these effects.

9.3.10 Coastal Zone Management

The NED Plan would result in short-term minor impacts to water resources, vegetation, fish and wildlife, aesthetics and scenic resources, and recreation, and long-term minor impacts to fish and wildlife resources. The NED Plan also would result in long-term minor and moderate impacts to water resources, vegetation, aesthetics and scenic resources, and recreation. The impacts to these resources will have negligible cumulative effects, with an overall net benefit provided by the NED Plan to development; fish and wildlife resources; flooding and erosion hazards; economic, social and environmental interests; historic and scenic resources; and water resources. No cumulative effects from hazardous wastes, air resources, or wetlands are expected from the NED Plan.

9.3.11 Aesthetics and Scenic Resources

The NED Plan will result in short-term minor adverse impacts to aesthetics and scenic resources, such as the presence of construction equipment and machinery in parks and neighborhoods and the muddying of water downstream of construction areas and potentially at the mouth of Mamaroneck River during construction, but these impacts will have negligible cumulative effects. In the long term, visual resources in the study area will be moderately adversely affected due to the removal of trees and other vegetation, as well as the utilization of concrete channels in some stream segments. However, the restoration of riparian areas to pre-construction conditions will reduce the cumulative effects to a minimal level.

Vegetation will be replanted using native plants and trees. No trees will be allowed in the newly constructed channel or on slide slopes; these areas will be re-vegetated with other types of vegetation. The District will work with the Village on a replanting plan and the Village's Tree Committee regarding replacement of trees. An additional long-term impact is the replacement, in some stream segments, of natural riverbed channels and old stone retaining walls with concrete retaining walls, which people generally find less visually appealing. The implementation of nonstructural measures, per the property owners' request, is expected to result in no impacts on the area's aesthetics and scenic resources.

9.3.12 Recreation

The NED Plan will result in short-term park closures and other construction-related disruptions to recreation, but these impacts will have negligible cumulative effects. In the long term, recreation in Columbus Park area may be adversely affected due to the removal of two footbridges, but the long-term benefits from river channel modifications that reduce flooding and future park damages will reduce these cumulative effects. The NED Plan is expected to benefit recreational resources and activities in the study area by reducing damages from repetitive flooding, particularly in Columbus Park at the confluence of the Mamaroneck and Sheldrake rivers.

9.3.13 Transportation

The NED Plan will result in short-term transportation impacts during construction. The removal and or replacement of the Ward Avenue and Waverly Place Bridges are expected to change travel patterns, but

long term effects are expected to be negligible. As a result, the traffic impacts will not contribute appreciably to cumulative effects, and therefore would be negligible.

9.3.14 Air Quality

Based on regulated air emissions calculations for the construction of the NED Plan, the project falls below de minimus levels for all constituents, which keeps the project in compliance with the Clean Air Act. Additional discussion and emissions calculations can be found in Appendix D of the DEIS (Appendix B).

Greenhouse Gases and Climate Change. There will be no ongoing sources of GHG emissions resulting from the NED Plan once the Project is completed. All construction activities combined will generate approximately 5,042 tons (4,574 metric tons) of CO_2, which will be below the CEQ threshold. These effects will be negligible.

There are less than six acres of mature trees within the project area, although not all of the trees may be removed nor is the acreage contiguous. The NED Plan avoids the removal of the mature trees that form the larger upland forest located upstream of I-95 across from the Harbor Heights section of the Village. Most vegetation, including trees will be replaced and all tree removal and replacement will involve consultation with the Village's Tree Committee. It is anticipated that minor, short-term impacts to carbon sequestration and temperature reduction will occur until the trees achieve a larger size. In the long-term, replanting even with younger trees may introduce a variety of ages and species that would maximize carbon reduction over time.

9.3.15 Noise

The NED Plan will introduce short-term incremental increases in the noise environment from construction and changes in traffic patterns. These changes will have negligible cumulative effects. Upon completion of the Project there will be no cumulative long-term impacts on the existing noise environment.

Table 26: Summary of Mitigation (Avoidance, Minimization, Compensation) Measures

Topography and Geology

- Current applicable USACE design criteria will be met, taking into account site conditions, physical constraints, and design flood requirements.
- Excavated material will be handled, removed, utilized, and/or disposed of in accordance with applicable construction standards and regulations.
- USACE will coordinate with local authorities and make public announcements to help ensure public safety, acquire a Dig Safe permit to locate and identify utilities, and properly handle and dispose of waste material.
- Proposed improvements will be designed and built to meet USACE and other applicable codes and standards, including seismic standards.
- OSHA guidelines and standard construction practices (e.g., shoring-up of channel slopes) will be followed during construction.
- Monitoring equipment will be used, as necessary, to ensure construction activities that cause ground vibrations do not exceed state and Federal thresholds to avoid damages to nearby structures. Pre-construction inspections of buildings may be required as part of the efforts to monitor effects of vibrations.

HTRW

- There should be no impacts to HTRW for most of the project area. The ITT Sealectro site, a State Superfund site, is located along a portion of the Sheldrake River. The soil in this area will have solvents. Prior to construction in this area, NYSDEC Environmental Remediation staff will be contacted and testing to determine VOC levels will be conducted. Any soil removal that may be required will be removed and disposed of at an acceptable facility.

Land Use, Cover, and Zoning

- Most of the construction activity will occur within the existing channel, which will help minimize impacts to adjacent land uses. Temporary workspaces along the top of the channel will generally be limited to a 15 ft (4.5 m) clearance from the channel bank edge along portions of the Project area.
- Channel construction (and related impacts) will not be concentrated in any one location for extended periods of time; construction will be moved from area to area as it progresses.
- Disturbed areas will be restored and their use returned to pre-construction land uses.

Water Resources

- Standard industry BMPs to protect water quality and wetlands during in-stream work will be implemented to reduce the potential for impacts during construction.
- An ESCP and site-specific SWPPP will be developed and implemented in accordance with the SPDES General Permit for Stormwater Discharges from Construction Activity. Upon completion, a Notice of Termination will be filed to verify that BMPs were implemented and that disturbed areas were restored and stabilized.
- Water quality and water resources protection measures will be implemented in accordance with local, county, NYSDEC permitting requirements and regulations, CWA Sections 401 and 404, RHA Section 10, Article 15, and Village Code Chapter 192-5.
- Project area will be restored to pre-construction conditions: temporary workspaces will be stabilized and revegetated by planting trees and shrubs in forested wetlands, native trees and shrubs will be planted, and native wetlands seed mix applied to exposed soils to maximize the rate of revegetation and reduce the likelihood that invasive species will take over disturbed areas.
- In-stream activities will be avoided from 1 June through 1 September

Vegetation

- Impacts to vegetation will be minimized and mitigated by restoring riparian areas to pre-construction conditions. Following construction activities temporary workspaces will be stabilized and revegetated as recommended by the Village of Mamaroneck Department of Public Works and Tree Committee by planting trees where mature trees were removed, the top layer of soil will be removed and replaced with clean topsoil that is seeded with a native upland or wetland seed mix in order to maximize the rate of revegetation and reduce the likelihood that invasive species will take over disturbed areas, and native trees and shrubs will be planted in areas where mature trees and shrubs were removed during construction.

Fish and Wildlife

- Standard industry BMPs to protect water quality during in-stream work and activities that will disturb or remove soils will be implemented in accordance with NYSDEC and USACE CWA permitting requirements.
- Streamside wildlife habitat that is removed or disturbed will be revegetated using native plant species, with immediate results expected for grasses and other herbaceous species and long-term restoration needed for establishment of larger shrub and tree species.
- No tree cutting will occur from 1 April to 1 August. If trees greater than three inches density breast height (dbh) will be removed from 1 January through 31 March, a survey for breeding raptors will be conducted.
- No in-stream work will be conducted from 1 June through 1 September.

Cultural Resources

- Adverse effects to the Ward Avenue Bridge and the stone retaining walls thematic district.
- Mitigation, at a minimum, will include documentation of these resources
- A Memorandum of Agreement (MOA) will be prepared and consultation with the NYSHPO, interested parties and federally-recognized Tribes will further determine other appropriate measures.

Coastal Zone Management

- Mitigation measures required based on the negative determination[6] issued by NYSDOS includes implementation of standard industry BMPs to protect water quality during construction of the NED Plan (e.g., development of a SWPPP and ESCP).
- See impact mitigation and minimization measures for Water Resources, Vegetation, Fish and Wildlife, Aesthetics and Scenic Resources, and Recreation.

Aesthetic and Scenic Resources

- Measures that could be implemented to reduce the short-term effects of construction activities include: adhering to the Project's ESCP to minimize the transport of suspended solids downstream, and erecting temporary fences in Columbus Park to screen the construction staging area.
- Various measures will be implemented to reduce the Project's long-term adverse visual impacts and restore the Project area to pre-construction conditions including: riparian habitat restoration activities such as riverbank shaping, tree replanting, and revegetation; and the use of riprap and other more "natural" looking channel modifications where possible.

[6] As a result of the negative determination, no significant adverse impacts on the coastal zone will be expected from the Proposed Action.

Recreation

- USACE will ensure that there are safe and effective pedestrian routes encircling Columbus Park following the removal of two pedestrian footbridges.
- Upon Project completion, parks and surrounding areas will be restored to pre-construction conditions and access to other riverine areas and affected parks will be restored.
- Additional specific measures that could be implemented to reduce the limited short-term effects of construction activities include: adhering to the Project's ESCP to minimize the transport of suspended solids downstream, restricting construction primarily to normal weekday business hours in residential areas, erecting temporary fences and other physical barriers around construction areas, temporarily reducing vehicular speed limits, and hanging signage that informs people of the Project's purpose, duration, and expected outcomes.
- USACE will work with the Village of Mamaroneck to determine if there are opportunities to improve public access to the rivers in the Project area during post-construction restoration by establishing riverwalk areas.

Transportation

- No mitigation measures will be required, but USACE is currently evaluating additional measures to be implemented for construction activities to further minimize these already limited effects. Traffic control and operations strategies may include measures like preparing a Construction Traffic Management Plan, establishing detours and alternate routes when/where needed, or temporarily reducing speed limits.

Air Quality

- Construction will be performed in full compliance with the Clean Air Act and the current NYSDEC Chapter III-Air Quality Regulations requirements, with compliant practices and/or products. No mitigation measures will be required outside of these and other applicable air pollution control regulations.

Noise

- No mitigation measures will be required, but USACE is currently evaluating additional noise risk management measures to be implemented for construction activities to further minimize these already limited effects.
- In accordance with the local noise ordinance, sounds generated from heavy equipment will be required to close down after 6:00 p.m. from Monday through Saturday, and on Sundays and holidays
- Special variances to the local noise ordinance may be obtained; however, additional noise reduction measures (e.g., enclosure of construction power units and generator sets, use of noise barriers) could be required.

10. PROJECT COSTS & COST SHARE

10.1 Project First Costs

For the detailed cost estimate, project quantities were developed using On Screen Take-Off (OST), Microsoft Excel calculations, and manual calculations, where applicable. The cost estimate was compiled using the Micro-Computer Aided Cost Estimating System, Second Generation (MII).

The detailed cost estimate for the NED Plan is based on combination of MII's 2012 English Cost Book, estimator-created site specific cost items, local subcontractor quotations, and local material suppliers' quotations. For the purposes of updating the Cost Book to present day pricing, a current, area-specific labor library was used to reflect market labor conditions. Major material costs were verified. For cost book material items that did not reflect current commodities pricing, vendor quotes were obtained and estimator judgment applied where warranted.

The specific components in the cost basis are outlined in the Cost Appendix (Appendix C). Cost contingencies were developed through a standard Cost and Schedule Risk Analysis (CSRA). The Project First Cost for the NED Plan is approximately $69.7M. Project First Costs for the NED plan by line item are presented in Table 27.

Table 27: Cost Summary of the NED Plan

ACCT#	CWBS FEATURE	NED- Plan 1Z
02	RELOCATIONS	8,190,559
08	ROADS, RAILROADS AND BRIDGES	1,066,947
09	CHANNELS AND CANALS	38,850,341
12	FLOODWAY CONTROL & DIVERSION STRUCTURE	2,975,887
19	BUILDINGS, GROUNDS & UTILITIES	
	TOTAL CONSTRUCTION COST	**$54,013,546**
01	LANDS & DAMAGES	4,913,531
30	ENGINEERING & DESIGN	7,010,400
31	CONSTRUCTION MANAGEMENT	3,765,100
	TOTAL FIRST COST	**69,702,577**
	INTEREST DURING CONSTRUCTION (IDC)	2,334,441
	TOTAL INVESTMENT COST	**$72,037,019**
	ANNUAL COST	$2,860,800
	O&M	$286,100
	TOTAL NED ANNUAL COST	**$3,146,900**

Oct 2015 Price Level, 3.125% Interest Rate

10.2 Operation and Maintenance Considerations of the NED Plan

Since this project consists of channel improvements and a culvert it is important that the hydraulic capacity of the channel and culvert be maintained over time. Access to the project must be maintained for inspection and maintenance purposes. The project and areas immediately upstream and downstream should be inspected annually. Channel improvements provide passive flood risk management assistance and do not require any operation. However, removal of debris, particularly from bridges during a storm, should be performed.

To maintain the hydraulic capacity of this project, shoals, debris, encroachments and heavy vegetation should be removed from the channel. Shoaling and debris accumulation can be expected after a significant flood especially under and around bridges, the inside of bends (North Barry Ave) and at the confluence of the Mamaroneck and Sheldrake Rivers. The channel cross-section should be maintained to the original design invert and bottom width as shown in the contract plans. The amount of sediment removal required should be slightly less than the historic volumes of sediment removed because the riprap and other erosion protection measures will reduce the amount of erosion experienced in the project area. Vegetation along the side slopes of the channel should be cut once a year in the late spring. There should be no woody vegetation on the low half of the slope. Small bushes and shrubs should only be permitted above mid-slope and trees should only be permitted at the top of slope. Vegetation along the access and maintenance paths should be cleared several times a year. Riprap erosion protection should be inspected and any broken or displaced stones should be repaired or replaced. Dumping of snow or grass clippings into the channel should not be permitted.

The culvert under the Station Plaza parking lot should be inspected yearly for cracks, movement and sediment accumulation. Large sized sediment or significant volumes of sediment should be removed. Channel retaining walls and the culvert should be inspected yearly for cracks and movement such as sliding, rotation and tilting. All vegetation should be removed from the walls and drainage openings. No improvements or changes shall be made over, under or through this project without prior determination by the District Engineer that the requested improvements or changes will not adversely affect the function of the improved channel and culvert. The O&M cost basis is outlined in the Cost Appendix, Appendix C.

10.3 Real Estate Requirements

The NED Plan, Alternative 1Z, requires a total of 14.3 acres in permanent easements due to channel improvements which impacts approximately 96 Parcels. Additionally, the NED requires acquisition of approximately 7.8 acres in Temporary Work Area Easements impacting a total of 83 parcels. This alternative impacts a total of 110 parcels, 88 privately-owned and 22 publicly-owned. Detailed discussion regarding the real estate requirements for the NED is outlined in the Real Estate Appendix, Appendix E. The NED real estate maps are included as Exhibit A.

10.3.1 Appraisal Information:

An appraisal cost estimate was prepared in November 2014 identifying the land values for this the NED Plan – Alternative 1Z. The land values for this plan are as follows in Table 28:

Table 28: Appraisal Cost Estimate for NED Plan

NED Plan	
Easement Type	**Value**
Channel Improvement Easements-----	$483,826
Temporary Work Area Easements----	$2, 655,602
Contingency (10%)----------	$313,943
Total NED Plan:	**$3,453,371**

Baseline Cost Estimates for Real Estate: The following Table 29 details the total 01-Lands and Damages costs for both the NED Plan: To avoid double accounting, a 20% contingency was only applied to the Incidental Cost because a contingency is already embedded in the Acquisition Costs through the appraisal cost estimate.

Table 29: Total 01-Lands and Damages Costs for NED Plan

Real Estate Cost	Total
Incidental Cost----------	$1,216,800
Acquisition Cost----------	$3,453,371
20 % Contingency (less Land Payments)----------	$243,360
Total Lands and Damages (01- Account)----------	**$4,913,531**

Facility and/or Utility Relocations There are existing sanitary sewer and water pipelines that will be required to be relocated for implementation of the selected alternative. The precise location of the pipelines and whether the owners have a compensable real property interest is still being determined. The Real Estate Plan will be updated accordingly upon the conclusion of the forgoing. The NED Plan requires the removal of three public bridges. These bridges will not be replaced. A fourth bridge, the Waverly Avenue Bridge will be removed and replaced. The following is the total 02-Relocation costs:

NED Plan	
Real Estate Cost	Total
Relocation Cost----------	$5,150,815
63 % Contingency----------	$3,039,744
Total Relocations (02- Account)----------	**$8,190,559**

11. PLAN IMPLEMENTATION

The completion of this GRR/EIS and Recommendation by the District Engineer are the first steps toward implementing the design and construction of the flood risk management Project along the Mamaroneck and Sheldrake Rivers in the Village of Mamaroneck, Westchester County, New York. Upon approval by USACE's North Atlantic Division, the project will be considered for design and construction upon Congressional authorization and appropriation.

11.1 Local Partners' Responsibilities

The non-Federal project partner, New York State Department of Environmental Conservation (NYSDEC), in cooperation with Westchester County and the Village of Mamaroneck, must comply with all applicable Federal laws and policies and other requirements, including but not limited to:

1. In coordination with the Federal Government, who shall provide 65% of the initial project cost,

    a. Provide all lands, easements, rights of way and relocations (LERR) determined by the Federal Government to be necessary for the initial construction and operation, and maintenance of this project.

    b. Provide all improvements required on lands, easements, and rights-of-way to enable the proper disposal of excavated material associated with the construction, operation, and maintenance of the project.

    c. Perform, or cause to be performed, any investigations for hazardous substances as are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law (PL) 96-510, as amended, 42 U.S.C. 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for the construction, operation, and maintenance of the Project. However, for lands that the Federal Government determines to be subject to the navigational servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-Federal project partner with prior specific written direction, in which case the non-Federal project partner shall perform such investigations in accordance with such written direction.

    d. Coordinate all necessary cleanup and response costs of any CERCLA-regulated materials located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be necessary for the construction, operation, or maintenance of the Project.

    e. Coordinate mitigation and data recovery activities associated with historic preservation, that are in excess of one percent of the total amount authorized to be appropriated for the project.

2. For so long as the project remains functioning, operate, maintain, repair, replace, and rehabilitate the completed project, or functional portion of the project, including mitigation features, at no cost to the Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and any specific directions prescribed by the Government in the Operations, Maintenance, Replacement, Repair and Rehabilitation (OMRR&R) manual and any subsequent amendments thereto.

3. Provide the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal project partner, now or hereafter, owns or controls for access to the Project for the purpose of inspection, and, if necessary after failure to perform by the non-Federal project partner, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the Project. No completion, operation, maintenance, repair, replacement, or rehabilitation by the Federal Government shall operate to relieve the non-Federal project partner of responsibility to meet the non-Federal project partner's obligations, or to preclude the Federal Government from pursuing any other remedy at law or equity to ensure faithful performance.

4. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, replacement, and rehabilitation of the Project and any Project-related betterments, except for damages due to the fault or negligence of the United States or its contractors.

5. Keep, and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the Project in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Codes of Federal regulations (CFR) Section 33.20.

6. As between the Federal Government and the non-Federal partner, the non-Federal project partner shall be considered the operator of the project for the purpose of CERCLA liability. To the maximum extent practicable, operate, maintain, repair, replace and rehabilitate the Project in a manner that will not cause liability to arise under CERCLA.

7. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1790, Public Law 91-646, as amended by Title IV of the Surface Transportation and Unifom1 Relocation Assistance Act of 1987 (Public Law 100-17),and the Unifom1 Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way, required for the construction, operation, and maintenance of the Project, including those necessary for relocations, borrow materials, and dredged or excavated material disposal, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act.

8. Comply with all applicable Federal and State laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense directive 5500.11 issued pursuant thereto, as well as Army regulation 600- 7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army."

9. Participate in and comply with applicable Federal flood plain management and flood insurance programs and comply with the requirements in Section 402 of the Water Resources Development Act of 1986, as amended.

10. Not less than once each year inform affected interests of the extent of protection afforded by the Project.

11. Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in preventing unwise future development in the flood plain

and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with the protection provided by the project.

12. Prevent obstructions of or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) which might hinder its operation and maintenance, or interfere with its proper function, such as any new development on project lands or the addition of facilities which would degrade the benefits of the project.

13. Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms.

14. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non- Federal project partner has entered into a written agreement to furnish its required cooperation for the project or separable element.

15. At least twice annually and after storm events, perform surveillance of the Line of Protection and determine any physical variances from the project design section and provide the results of such surveillance to the Federal Government.

11.2 Implementation Schedule

Release of this Draft Feasibility Report and Environmental Impact Statement has been approved by HQUSACE at the TSP Briefing held on 10 September 2015. Public release is scheduled for November 2015. Public review is scheduled to be completed within 45 days unless an extension is requested to extend the public review period. Public review will be conducted concurrently with MSC and HQUSACE review of the draft report. Please note that Agency Technical Review has been completed and Independent External Peer Review is ongoing. Once the public review is complete, the draft report will be revised to incorporate all comments received from the MSC, HQUSACE, the public and IEPR for the final report submittal.

Task	*Date*
Release Draft Report for Public Comment	*Jan 2016*
Public Meetings	*Feb 2016*
Public Review Complete	*Mar 2016*
Civil Works Review Board	*Dec 2016*
Chiefs Report Issued	*Apr 2017*

11.3 Financial Analysis

Typical cost share for Flood Risk Management projects is 65% Federal and 35% non-Federal. The District conducted a cost share analysis to determine the cost share ratio for the initial construction costs of the NED Plan. The Lands, Easements, Relocations, Right-of-Ways and Disposal (non-Federal responsibility) cost-share analysis was completed in accordance with ER 1165-2-161(12)(c)(5) that states:

> *Where the value of LERRD in a structural flood control project is greater than 45 percent of the total project cost, the LCA should be prepared to reflect that agreement has been reached on the most efficient and practical means for acquisition of the LERRD over 45 percent. If there is no Government acquisition, the District Commander should budget for the value of the LERRD exceeding 45 percent. The LCA should then provide a mechanism for the Government to reimburse the local*

partner this difference upon completion of construction. (See paragraph d. of ARTICLE II - OBLIGATIONS OF PARTIES and explanatory note in paragraph b.3. of Option II, ARTICLE VI - METHOD OF PAYMENT of the model Flood Control LCA, Appendix A).

The cost-share analysis concluded that the value of the LERRDs (that is a non-federal partner responsibility) is less than the 35% cost share required for federal construction projects (Table 30). The estimated federal cost for both the NED plan is 65% of the Project First Cost. The non-federal cost-share is 35% of the Project First Cost of the NED plan.

Table 30: Cost-Share Analysis

Cost Account	Account Description	NED
01	**LANDS & DAMAGES**	**$4,913,531**
02	**RELOCATIONS**	**$8,190,559**
Total LERRDs		**$13,104,090**

Table 31 displays the apportionment of cost sharing responsibilities between the Federal government and the non-Federal partners and the Total Project Costs (Fully Funded). The table includes costs associated with flood risk management features and environmental mitigation features. The total project costs are shared on a 65% basis by the Federal government and a 35% basis by the non-Federal partners. Cost share responsibilities do not include Interest During Construction (used for the annualization of project costs for economic purposes) and O&M costs. O&M is a 100% non-Federal responsibility and the calculation of which is used for the annualization of project costs for economic purposes). As indicated in Table 35, the Federal share of the project's total first cost is **$45,306,675** the non-Federal share is **$24,395,902.**

The Federal Government will design the project, prepare detailed plans/specifications and construct the project, exclusive of those items specifically required of the non-Federal partner. The non-Federal partner is responsible for all Lands, Easements, Right-of-ways, and Relocations (LERR) costs and all Operations and Maintenance (O&M) costs. The LERR costs are applicable to the non-Federal share of the initial project costs. For example, the approximate Total Project LERR Costs of **$13,104,090** borne by the non-Federal partner are applicable to the **$24,395,902** share of non-Federal Project Costs.

Table 31: Cost Apportionment

Federal Project Cost (65%)	**$45,306,675**
Non-Federal Project Cost (35%)	**$24,395,902**
Lands & Damages	**$4,913,531**
Relocations	**$8,190,559**
5% Cash Requirement	**$3,485,130**
Cash or In-Kind Service balance	**$7,806,682**
Total Project Cost (100%)	**$69,702,577**
***Does not include O&M and IDC**	

Financial Analysis

The FY 2016 project cost as noted above is $69,702,577. Total investment costs are $72,037,019. Annual costs are approximately $3,153,222 and annual benefits are $$3,102,900 with a BCR of approximately 1.1 which yields annual net benefits of about $236,300 for the NED plan.

TOTAL FIRST COST	**$69,702,577**
IDC	$2,334,441
TOTAL INVESTMENT COST	**$72,037,019**
ANNUAL COST	$2,860,800
O&M	$286,100
TOTAL NED ANNUAL COST	$3,146,900
Annual Net Benefits	$3,403,704
BCR	**1.1**

12. VIEWS OF NON-FEDERAL PARTNERS AND OTHER AGENCIES

The New York State Department of Environmental Conservation, Westchester County and the Village of Mamaroneck are fully supportive of the NED Plan. The flooding and damages within the Village of Mamaroneck have a long history. It is the concern of the above non-federal partner and local stakeholders that if this study is not approved and construction funds are not appropriated expeditiously, there may not be another opportunity to provide a comprehensive flood risk management to this area that has been repetitively plagued by floods over the past century. There is significant motivation to implement the recommended plan.

12.1 Areas of Concern

Flood risk management studies in highly urban area within the New York District boundaries have generally exhibited BCRs between 1.0 to 1.3. The reason for this relatively low benefit to cost ratio is the regional expense of construction costs and high contingency factors that are applied to the already high costs for projects in the region. However, the benefit categories are not afforded the same escalation or contingency factors that the costs are for this expensive region. The concern of the non-federal partners is that the BCR for the recommended plan relative to the rest of the nation for flood risk management projects will minimize the importance and need for the project. The residents and businesses in the Village of Mamaroneck have been continually subjected to flood damages that are swift and highly damaging to personal property, safety, business losses, emergency costs, transportation, recreation and the environmental.

12.2 Major Conclusions and Findings

In such a populous area, finding and implementing a feasible Flood Risk Management Plan solution is critical for ability for continued functionality and livelihood of the local residents. The implementation of the Selected Plan would be the difference between saving lives and businesses in the event of another storm event like the April 2007 nor'easter. A quantitative review of the economic analysis used for the Selected Plan finds that the basis for the implementation of the project is sound. The estimated Total Investment Cost to achieve these benefits is $72M.

Through the cycles of iterations involved in the planning process the project plan has grown in physical size, shape and monetary cost—all with the aim of producing a robust and resilient Flood Risk Management solution that provides a high level of Net Excess Benefits.

12.3 Public Involvement

The first public meetings were held during the NEPA scoping process during 2010 (June 22, 2010). Additional public meetings to present the Alternative Analysis and Tentative Selected Plan were held in 2014 (May 22, 2014). Public release of this draft Report and EIS is currently scheduled for January 2016 with public meetings expected to be held in the Village of Mamaroneck in February 2016.

13. RECOMMENDATIONS

Prefatory Statement

In making the following recommendations, I have given consideration to all significant aspects of this study as well as the overall public interest in flood risk management within the Village of Mamaroneck Study Area. The aspects considered include engineering feasibility, economic effects, environmental impacts, social concerns, and compatibility of the project with the policies, desires, and capabilities of the local government, State, Federal government, and other interested parties.

Recommendations

A number of alternatives have been examined as part of the ongoing general reevaluation and the National Economic Development Plan has been identified. That plan may be further refined during the design phase once this report has been approved and the project has been authorized. However, in accordance with the current analysis and the guidance outlined in ER 1105-2-100, the Mamaroneck & Sheldrake Rivers Project described in this report is acceptable to the non-Federal partner, agencies, and stakeholders as a Flood Risk Management Project for immediate implementation.

I make this recommendation based on findings that the NED Plan constitutes engineering feasibility, economic justification, and environmental acceptability. These recommendations are made with such further modifications thereof, as in the discretion of the ASA (CW) may be advisable, at total project first cost of $**69,702,577** (at October 2015 price levels) and a Total Investment cost of **$72,037,019** (based on an estimated pending midpoint of construction), provided that non-Federal interests comply with all the requirements substantially in accordance with the Project Partnership Agreement which will be executed upon approval of this report.

Disclaimer

The recommendations contained herein reflect the information available at this time and current Department policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of the national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to higher authority as proposals for authorization and/or implementation funding.

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