PASSAIC RIVER MAIN STEM
Flood Risk Management
New Jersey/New York

PRELIMINARY ALTERNATIVE REEVALUATION REPORT
Phase 1

United States Army Corps of Engineers
New York District
&
State of New Jersey
Department of Environmental Protection

September 2013

EXECUTIVE SUMMARY

Flooding has long been a problem in the 935-square mile Passaic River Basin, located in north-central New Jersey. Since 1900, at least twenty-six (26) lives have been lost and over $6 billion in losses have been reported. The most severe known flood, the "flood of record," occurred in 1903, with recorded damages of $2.44B in fiscal year 2012 dollars. In April 2007, the basin was struck by a nor'easter, which caused significant flooding, damage, and loss of life. This storm caused the evacuation of approximately 5,000 people and caused $792 million in damages (October 2012 price level (P.L.). In March 2010 and March 2011, the Passaic River Basin was struck by nor'easters which caused significant flooding and damages which together were estimated at over $1 billion. Soon after, in August 2011, Tropical Storms Irene and Lee brought another estimated $1 billion in damages to the area.

As a result of the April 2007 storm event, the New Jersey Department of Environmental Protection (NJDEP), as the non-Federal sponsor, requested that the United States Army Corps of Engineers (USACE) initiate the process for conducting a reevaluation of the Passaic River Basin and previously identified alternatives to manage the risk associated with the flooding within the Passaic River Basin.

In June 2012, USACE initiated the alternative reevaluation in accordance with Engineering Regulation 1105-2-100 (ER 1105-2-100) in the form of a General Reevaluation Report (GRR). The GRR is being conducted in two (2) phases, the Preliminary Alternative Reevaluation phase (Phase 1) and the Detailed Analysis phase (Phase 2). The combination of the Phase 1 report and the Phase 2 report will serve as the decision document for Congressional authorization of a project .

This report details the results of the Phase 1 alternative reevaluation. The submission of this Preliminary Alternative Reevaluation Report will provide NJDEP an opportunity to determine alternative(s) should proceed to the Detailed Analysis Phase. This reevaluation provides sufficient detail to allow the NJDEP to conduct public coordination by soliciting comments via a series of public meetings and make an appropriate decision for the path forward.

Prior to the study, it was assumed there have been significant changes in engineering requirements, land usage and river flow records that may affect how various alternatives would be analyzed today. Previously evaluated alternatives from the 1987 General Design Memorandum (1987 GDM) were updated to account for changes in engineering (*eg.* technology, design requirements, costs), economic and environmental factors and the frequency of flooding.

Results of this Phase 1 reevaluation of the changes in the frequency of flooding show that all flows provided by current gages located in all monitored municipalities that comprise the Basin, (with the exception of Chatham) are now greater than those predicted in the 1987 study. Predicted flows for the 100 year storm event have generally increased between 6% and 34% and some water surface elevations (WSELs) have increased up to 1.6 feet. The risk of larger flood events has increased while the smaller storm events have decreased based upon updated hydrology.

Reevaluation of alternatives included in this Phase 1 report that were analyzed in 1987 include Alternative 14A, Alternative 16A, the Newark Outlet Tunnel Alternative, and the 10 year floodplain non-structural alternative. Further, a new alternative that evaluates a plan called the Beatties/Two Dams Alternative was also included in this Phase 1 analysis.

Reevaluation of alternatives deemed to be economically justified in the 1987 GDM indicates that Alternative 14A, the Newark Outlet Tunnel Alternative and the 10 year floodplain non-structural plan all appear to be marginally economically. All benefits and costs were calculated at fiscal year 2013 price levels, 3.75% discount rate, and a 50-year period of analysis.

It should be noted that Alternative 14A has a 1% annual chance of flooding (a 100 year annual risk of flooding) for much of the plan with the exception of the non-structural measures in the Central Basin and therefore is a more comprehensive watershed solution than the Non-structural 10 year floodplain Alternative. The non-structural measures in Alternative 14a and the Non-Structural alternative have a greater than 10% annual chance of flooding (less than 10-year annual risk of flooding).

Although the Newark Outlet Tunnel Alternative was determined to be economically justified in this preliminary reevaluation, USACE is prohibited from expending any federal funds for the design or construction of this project. Congressional authority to further study the Newark Outlet Tunnel Alternative would be required. Analysis was conducted on this alternative for comparison purposes only, as required by ER 1105-2-100.

Preliminary analyses of Alternative 16A and the Beatties Dam/Two Bridges Alternative may have Benefit to Cost ratios (BCRs) that are below 1.0 for all iterations of ranges of costs and damages. These Alternatives may still be included in the Detailed Analyses Report (Phase 2) for more thorough evaluation if requested by NJDEP.

As a result of Hurricane Katrina, design requirement changes to hard structure features, such as “I” walls, have increased project costs and buyouts of frequently damaged structures have decreased the available benefits. Thus, benefits appear to have slightly underperformed the increase in cost of the implementation of any alternative. As a result of the post-Katrina changes related to costs and benefits, the BCRs appear to have only marginally decreased since the 1987 and 1995 studies.

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TABLE OF CONTENTS

FIGURE LIST

TABLE LIST

LIST OF APPENDICES

List of Acronyms

A/E .... Architect/Engineer
ACHP .... Advisory Council on Historic Preservation
ADR .... Alternative Dispute Resolution
AHA .... Activity Hazards Analysis
ANSI .... American National Standards Institute
AR .... Army Regulation
ASA-CW .... Assistant Secretary of the Army for Civil Works
ATR .... Agency Technical Review
BA .... Biological Assessment
BCOES........ Biddability, Constructability, Operability, Environmental and Sustainability Review
BCR .... Benefit to Cost Ratio
CAA .... Clean Air Act
CADD .... Computer Aided Design and Drawing
CENAN .... US Army Engineer District, New York
CEQ .... Council on Environmental Quality
CFR .... Code of Federal Regulations
CIP .... Construction in Progress
CP .... Conceptual Phase
CWBS .... Civil Works Breakdown Structure
CWT .... Civil Works Team
DDR .... Design Documentation Report
DEIS .... Draft Environmental Impact Statement
DQC .... District Quality Control
DQC .... District Quality Control
E&D .... Engineering and Design
EA .... Environmental Assessment
EC .... Engineer Circular
EDR .... Engineering Documentation Report
EFAR .... Engineers Federal Acquisition Regulation
EFH .... Essential Fish Habitat
EIS .... Environmental Impact Statement
EM .... Engineer Manual
EPA .... Environmental Protection Agency
EPR .... External Peer Review
ER .... Engineer Regulation
ERDC .... Engineering Research and Development Center
ESA .... Endangered Species Act
FAR .... Federal Acquisition Regulation
FCSA .... Feasibility Cost Sharing Agreement
FEIS .... Final Environmental Impact Statement
FONSI .... Finding of No Significant Impacts
FWCAR .... Fish &Wildlife Coordination Act Report
FY .... Fiscal Year
GDM .... General Design Memorandum

GDMP .... Geospatial Data Management Plan
GE .... General Expenses
GE .... Government Estimate
GIS .... Geographic Information System
GRR .... General Re-evaluation Report
H&H.. Hydraulics and Hydrology
HEC.. Hydraulic Engineering Center
HQ .... Headquarters
HTRW.. Hazardous, Toxic or Radioactive Waste
IDTC .... Indefinite Delivery Type Contract
IFB .... Invitation for Bids
IWR... Institute for Water Resources
LCPM... Life Cycle Project Management
LERR .... Lands, Easements, Rights-of-Way, and Relocations
MII .... Micro Computer Aided Cost Estimating System
MOA .... Memorandum of Agreement
MOU .... Memorandum of Understanding
NAD.. North Atlantic Division
NEC.. National Electric Code
NEPA .... National Environmental Protection Act
NFPA .... National Fire Prevention Association
NGO... Non-Governmental Organization
NHPA.. National Historic Preservation Act
NJDEP... State of New Jersey Department of Environmental Protection
NJHPO…………………………………… ....…….New Jersey Historic Preservation Office
NOAA .... National Ocean and Atmospheric Administration
NRHP .... National Register of Historic Places
O&M .... Operation & Maintenance
OBS .... Organizational Breakdown Structure
OSE .... Other Social Effects
OSHA... Occupational Safety and Health Act
P&S .... Plans and Specifications
PA .... Programmatic Agreement
PAC.. Post Authorization Change
PDT .... Project Delivery Team
PGL .... Planning Guidance Letter
PM .... Project Manager
PMBP .... Project Management Business Process
PMP .... Project Management Plan
PPA .... Project Partnership Agreement
PRB .... Project Review Board
QA/QC .... Quality Assurance/Quality Control
QCP .... Quality Control Plan
RAM .... Responsibility Assignment Matrix
RAP .... Resource Allocation Plan
RED.. Regional Economic Development

REP .... Real Estate Plan
ROD .... Record of Decision
ROE..Right-of-Entry
SACCR ....Schedule and Cost Change Request
SHPO ....State Historic Preservation Officer
TBD..To Be Determined
USACE ....United States Army Corps of Engineers
USFWS ....United States Fish & Wildlife Service
VE .... Value Engineering
WBS.. Work Breakdown Structure

1. INTRODUCTION & REPORT PURPOSE

Flooding has long been a problem in the 935-square mile Passaic River Basin in north central New Jersey. Since colonial times, floods have been documented as claiming lives and damaging property in this region. Since 1900, twenty-six (26) lives have been lost and over $6 billion in losses have been reported. The most severe known flood, the “flood of record,” occurred in 1903, with recorded damages of $2.44B in today’s dollars. More recent floods in 1968, 1971, 1972, 1973, two in 1975, 1984, 1992, 1999, and 2005 caused several billion more dollars in damages. In April 2007, Bergen, Essex, Hudson, Morris, Passaic, Somerset, Sussex and Union Counties, New Jersey and Orange and Rockland Counties, New York were struck by a nor’easter, which caused significant flooding, damage, and loss of life. This storm caused the evacuation of approximately 5,000 people and caused $792 million in damages (October 2012 price level (P.L.)). In March 2010 and March 2011, the Passaic River Basin was struck by nor’easters, which caused significant flooding and damages, which together were estimated at over $1 billion. Soon after, in August 2011, Tropical Storms Irene and Lee brought another estimated $1 billion in damages to the area.

With average annual equivalent flood damages estimated at approximately $251 million (October 2012 P.L.) not calculated to include the March 2010, March 2011, and August 2011 storm damages, the Passaic River Basin has been characterized as a major East Coast flood problem area; however, finding a comprehensive solution has been an unresolved challenge to the flooding problems in the Basin. U.S. Army Corps of Engineers (USACE) involvement in Passaic River Basin planning was first authorized in the Flood Control Act of 1936. Since then, reports recommending plans of action were issued in 1939, 1948, 1962, 1969, 1972, 1973, 1987 and 1995. None of these plans were implemented on the main stem of the Passaic River although there have been projects implemented on some of its tributaries.

Report Purpose

As a result of the April 2007 storm event, the Passaic River Basin Flood Task Force (“the Task Force”), comprised of multi-agency and stakeholder participants, which was reformed after the 2005 flood event, provided recommendations and documented the public interest for flood risk management measures in the Basin to the State of New Jersey through its agent, the Department of Environmental Protection (NJDEP). In a letter dated 13 January 2009, the NJDEP requested that USACE initiate a reevaluation of the Passaic River Main Stem Authorized Study (Appendix C). USACE’s North Atlantic Division (NAD) approved the Passaic Main Stem Reevaluation Study initiation request on 18 August 2009. Pursuant to USACE Guidance (Engineering Regulation 1105-2-100 §4.1 (b)), the New York District (“the District”) prepared a Passaic Main Stem Reevaluation Justification Letter Report. This report was approved by USACE NAD on 27 May 2010. Based on meetings with the NJDEP and in accordance with the January 2011 *Report to the Governor: Recommendations of the Passaic River Basin Flood Advisory Commission* (Appendix G), a Passaic River Main Stem Basin Reevaluation was initiated. The Preliminary Alternative Reevaluation Phase (Phase 1) Project Management Plan (PMP) was prepared and approved by USACE NAD. A Feasibility Cost-Sharing Agreement for the study was executed with NJDEP, the non-federal partner, on 13 June 2012.

This Phase I Report will be the completion of analyses that will determine whether there exists an economically justified locally preferred plan for the Passaic River Basin, and specifically, whether or not Alternative Plans 14A, 16A, Beatties Dam and Two Bridges and the non-structural Alternative, as formulated in the original feasibility report are still economically justified.

Goals & Objectives

The submission of this Preliminary Alternative Reevaluation Report (Phase 1) will provide the NJDEP an opportunity to determine alternative(s) to include for analyses in the Detailed Analyses Report (Phase 2). The Phase 1 analyses are based on conceptual costs and economics derived from updated Engineering and Environmental requirements with sufficient detail to allow the NJDEP to solicit input from the public and make an appropriate decision for those alternatives to be analyzed in the Phase 2 report.

Based on project delivery team meetings with participation of the NJDEP and in accordance with the January 2011 *Report to the Governor: Recommendations of the Passaic River Basin Flood Advisory Commission*, the following six Alternatives/Plans were reevaluated in this Phase 1 Report:

1. Alternative 14A – Levee/Floodwall/Nonstructural/Bridge & Dam Modification Alternative.

2. Alternative 16A–Levee/Floodwall/Nonstructural/ Channel Modification Alternative.

3. Dual Inlet – Newark Bay Tunnel Alternative (Newark Outlet Tunnel Alternative) – Authorized Plan – Passaic/Pompton River Dual Inlet Tunnel Diversion Alternative. In accordance with re-evaluation requirements, the authorized plan, must be reevaluated for comparison of alternate plans. This plan is being reevaluated for comparison purposes only.

4. Alternative #4 – Beatties Dam/Two Bridges improvements: Modifications to Beatties Dam, channel improvements upstream (including the Two Bridges Area) on both the Passaic and the Pompton were be evaluated.

5. Non-structural –As part of a complete alternatives analysis, The 10 year non-structural alternative from the 1987 GDM will be analyzed This measure will also be examined throughout the Passaic Basin in conjunction with the structural alternatives.

6. No Action Plan – as required by NEPA and other regulations, the No Action Plan (Future without Project Condition) will be identified and the impacts will be clearly discussed and analyzed.

The combination of this report (Phase 1) and the Phase 2 report will serve as the final decision document, called a General Reevaluation Report (GRR), required to make a recommendation for Congressional authorization for a comprehensive Flood Risk Management project for construction. Construction of the recommended plan would then be dependent upon Congressional Appropriations.

Upon concurrence between the NJDEP and USACE for the path forward the Phase 2 Project Management Plan (PMP) will be rescoped, accordingly. Combined with the Phase 1 Report, the Phase 2 Report will produce a GRR in accordance with ER 1105-2-100 as approved in the June 2012 PMP for this study.

The following section contains the basic assumptions and risks assumed for the Phase I Report to ensure that the appropriate level of effort is provided for Federal and NJDEP decision making purposes.

CRITICAL ASSUMPTIONS & CONSTRAINTS

The following are the critical assumptions that went into the development of the Preliminary Phase PMP and the schedule leading to the completion of this phase:

a. All funds appropriated in FY12 and projected FY13 Energy & Water Appropriations Bill will be available as scheduled.

b. Non-Federal funds will be available as scheduled.

c. It is assumed that NAD/HQUSACE is an active and cooperative participant on the vertical project delivery team (PDT) with the authority and capability to commit their resources, as scheduled. .

d. No work will begin until the Feasibility Cost-Sharing Agreement (FCSA) is signed.

e. Alternatives to be examined will be locally (*eg*. Passaic River Basin municipalities) acceptable.

f. The buyouts that receive any Federal Emergency Management Agency (FEMA) funding have deed restrictions that do not allow any type of flood risk management structure on those lands.

g. Specific Assumptions for the (Phase 1 Report for each USACE Technical Office (i.e. Division, Branch) or discipline are listed in subsections 1-13, as follows;

Engineering Assumptions

1. General

- The Costs presented are for six (6) alternatives identified for the Phase 1 Report . Changes to the alternatives will result in changes to the costs to accomplish this first phase.

- This report will not address the ownership of the Operation & Maintenance (O&M) responsibility for the features of each alternative.

Civil Resources Branch Assumptions

2. Survey and Mapping

- No processing or mining of the May 2005/2006 LIDAR data, provided to the District by NJDEP, will be conducted in this phase.
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- No new channel cross-sections or other surveys will be obtained, either to supplement the FEMA HEC-RAS model or to update the 1990s data in the Upper Passaic, Rockaway, and Whippany and Deepavaal Brook areas.

3. Existing Conditions Hydrology

- The existing conditions hydrology will be developed as would normally be done in any standard feasibility report. However, the rough FEMA HEC-HMS model and GeoHMS project file (used to generate the HMS basin file) as provided for the entire Passaic River Watershed by NJDEP will be used as the basis for the final model. It is assumed that only minor modifications to the physical parameters (i.e. measure area of sub-basin, up to date land use of the watershed, etc.) of the sub-basins within the Passaic River Watershed will be required. If major differences to the physical parameters are discovered, they will be reconciled in the Detailed Analysis Phase. The hydrologic model will only be calibrated for one event (Tropical Storm Irene).

4. Existing Conditions Hydraulics

- The updated flows from the detail hydrologic model will be run through a rough existing conditions hydraulic model (see bullet below) to determine qualitative and relative changes in water surface elevation as a result of the updated flows. The changes in water surface elevation (resulting from the updated flows) will be described in a general, relative and limited manner. These relative stage differences will be reevaluated economically to determine relative change in benefits.
- The 1990s UNET model will be converted to a HEC-RAS model. It is expected that the FEMA HEC-RAS model as provided by NJDEP will be available within 30 calendar days from the signing of the agreement. The converted 1990s UNET model data and the current FEMA HEC-RAS models will be combined to create a single unsteady flow model for the entire basin. Note that the FEMA HEC-RAS model does not include the upper Passaic, Rockaway, Whippany, and Deepavaal Brook basins, which would be augmented with the converted 1990s UNET data. The combined basin wide unsteady flow model would not be calibrated and would contain "mixed" geometric data from two different decades (the 1990s and the 2010s).

5. Existing Conditions Hydrodynamic Model

- No modeling will be done by the Corps for the tidal areas below Dundee Dam during this phase. If the FEMA hurricane/coastal modeling results are available for Newark Bay and the lower Passaic River before the Hydraulics & Hydrology (H&H) analyses for the Phase 1 report is complete then the impacts on the hurricane/coastal levees will be evaluated. The results of FEMA's current coastal stage frequency data will be compared to the stage frequency relations used in the previous studies and general relative differences will be economically reevaluated to approximate changes in benefits for the hurricane/coastal features.

- If results of the FEMA hurricane/coastal modeling are not available in a timely manner then evaluation of the hurricane/coastal features will be limited to approximating how development and other physical changes have impacted the design and costs.

(note: In accordance with P.L. 113-2, the tidal portion of the Passaic will be spun-off as a separate study. Tidal model data is being prepared under the above referenced Public Law that will include impacts sustained by Hurricane Sandy on October 29, 2012. This Phase 1 report includes both the fluvial and tidal reevaluation of alternatives)

6. Hydraulic Development of Alternatives to Manage Flood Risk

- A very rough unsteady flow model for the Beatties Dam & Two Bridges alternative will be developed. Since this plan is anticipated to be a hybrid combination of several plans previously studied, a new layout is needed. In addition, since the hydraulic conditions at the confluence of the Passaic and Pompton Rivers varies quite a bit during each event, an unsteady flow model will be used to evaluate this alternative.

- None of the hydraulic features of any alternatives will be resized or otherwise modified to address any changes in flow or frequency such that the general quantities computed in previous studies will not be changed.
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- Rough and approximate models of all the structural alternatives will be created to develop relative changes in water surface elevations for each alternative. The coding in these rough models will not change or alter the alignment or features of the alternatives from the previous reports. Levees will be coded as vertical barriers of infinite height and the channels will be coded as uniform trapezoidal excavations. The relative changes in stage will then be economically reevaluated to approximate changes in the benefits.

- Future conditions flows and stages will not be developed for this phase.

- Flood inundation mapping will not be developed for this phase.

- Risk and uncertainty will not be evaluated during this phase.

7. GIS & Mapping

- A large single page overall layout poster of each alternative (six including the "no action alternative) will be generated for PDT use and use at public meetings. Approximately six (6) large "expanded" single page posters at roughly 1"=500' scale will be developed for several key community areas for use at public meetings. A small number of GIS sheets (at roughly 1" = 1,000' scale) will be developed to help the team identify major changes since the previous studies were conducted.

8. Cost Estimating Assumptions

- The basis of the cost estimate for alternative 30E (tunnel) is the 1995 Draft GDM, Appendix I, Cost Engineering. This estimate will be updated to reflect changes to USACE or 'industry' standards or if there has been an improvement to construction technology.

- No detailed cost estimates are currently available for the other alternatives. The construction cost for the alternatives will be based on the best possible information available from historical project data, historical data of similarly constructed features and rough order of magnitude (ROM) quantities provided by the design team. ROM O&M cost will be developed for each alternative. Costs will be developed using historical data where possible.

- A cost and schedule risk analysis will not be performed in this (Phase 1 Report. Cost contingency for each alternative will be based on the level of detail of information available for each alternative and engineering judgment. First Cost and O&M costs will not be provided.

- Any additional work not mentioned above will result in the need for additional funding.

- The estimated costs for the Project Feature Accounts, (i.e. 01, 02, 06, 30 and 31 Accounts) will be provided by their respective office.

- No construction schedule will be developed for the Phase 1 Report.

9. Design Branch Assumptions

- A new topographic survey will not be included at this time. Lack of detailed survey may result in assumptions that yield inaccurate quantities and costs. Limited survey data may also bring uncertainty during developing the alternatives and the selected (Phase 1 Report.
- No additional soil borings, soil sampling or testing will be obtained. This is a significant cost item and will be included in the Pre- Engineering and Design (PED) Phase.
- Change or modification of existing transportation facilities such as highways and bridges have major impact to the public and will increase the project cost and schedule significantly. Current estimates assume that the related work is minimal.
- Electrical and mechanical engineering tasks will focus on the new facilities related to the development of the alternatives for the preliminary phase. Further works on existing electrical or mechanical facilities are not included in current PMP for the Phase 1 Report.

10. Plan Formulation

- No qualitative input of future without project conditions from New York District's Engineering Division will be provided in the Phase 1 Report. Plan Formulation will conduct a qualitative analysis of future without project conditions.

- Any alternative(s) plan may be selected and recommended for implementation if it has net beneficial effects after considering all plan effects, beneficial and adverse, based on the National Economic Development during the Phase 1 Report analyses. In accordance with ER

1105-2-100 § 2-3 (d)(3), dated 22 April 2000 and the Principles and Guidelines evaluation accounts, Environmental Quality, Regional Economic Development, and Other Social Effects will not be considered during the Preliminary Phase of the GRR but will be considered in the Phase 2 Report, accordingly.

- In terms of implementability of a comprehensive solution, there is currently a legislative prohibition on the use of funds for design and construction of the tunnel element. WRDA 2000, Section 327(i) states:

> *(i) RESTRICTION ON USE OF FUNDS.—The Secretary shall not obligate any funds to carry out design or construction of the tunnel element of the Passaic River flood risk management project, as authorized by section 101(a)(18)(A) of the Water Resources Development Act of 1990 (104 Stat. 4607).*

However, in order to analyze the project area in a manner which meets the requirement of ER 1105-2-100 and to conform to the WRDA restriction, the tunnel benefits and costs will be updated for comparison purposes and no funds will be spent on design.

- WRDA 1990 restricts the construction of levees in Bergen County. Specifically, Section 101(a)(18)(ii) states:

> *(ii) Design and construction.--The Secretary shall design and construct the project in accordance with the Newark Bay tunnel outlet alternative described in the Phase I General Design Memorandum of the District Engineer, dated December 1987. The main diversion tunnel shall be extended approximately 6 1/2 miles to outlet in Newark Bay, the 9 levee systems in Bergen, East Essex, and Passaic Counties which were associated with the eliminated Third River tunnel outlet shall be excluded from the project, and no dikes or levees shall be constructed along the Passaic River in Bergen County in connection with the project. With respect to the Newark Bay tunnel outlet project, all acquisition, use, condemnation, or requirement for parklands or properties in connection with the excluded 9 levee systems and the eliminated Third River tunnel outlet works, and any other acquisition, use or condemnation, or requirement for parkland or properties in Bergen County in connection with the project, is prohibited. The Secretary shall certify to the Committee on Public Works and Transportation of the House of Representatives and the Committee on Environment and Public Works of the Senate that no detrimental flood impact will accrue in Bergen County as a result of the project.*

Because of the WRDA 1990 prohibition above, alternatives 14A, 16A and 30E will need to be re-assessed in order to analyze the project area in a manner which meets the requirement of ER 1105-2-100 for comparison purposes.

11. Economics

- Survey and structural inventory tasks will be performed mainly using GIS and such tasks will require minimal in-field effort as a "standard structure" will be used throughout the basin (sub-assumption is that such GIS data is available). This will understate the fact that there are many commercial buildings in the project area with unique and not easily moveable contents.

- Compliance with Section 2033 of WRDA 2007 and Section 904 of WRDA 1986 will require no effort. Life safety will not be addressed in this document. Coordination with the vertical team will be required.

- Only 11 reaches per alternative will be utilized. Reaches were chosen based on the available structure inventory data for each river length reach. Only 11 are available for comparison in the Phase I Report. The scope of the project area is limited.

- The (Phase 1 Report entails performing flood risk analysis at a preliminary level for reaches in which there exist flood gages for which Engineering Division has stage damage functions. The analysis of reaches for which these functions exist will be approximated over reaches which will be damaged in the without-project condition for which no data in readily available. The Phase 2 Report will provide more detailed analysis, by reach, as necessary. The amount of analysis is limited to reaches for which known information already exists. This may not be a representative sample and may subsequently underestimate or overestimate benefits of particular alternatives over the basin. The maximum number of reaches for this exercise will be 10.

- HEC-FDA modeling will only be performed for a maximum of six (6) plans over a maximum of 11 reaches. The number of alternatives for which flood damage analysis is performed is limited.

- There will be no more than two kickoff meetings and ten public meetings.

12. Environmental Resources List of Assumptions

- The Phase 2 Report will not include the preparation of a National Environmental Policy Act (NEPA) document or NEPA-level analysis.. Formal NEPA scoping meetings will be held at the initiation of the Phase 2 Report compilation .

- The Phase 1 Report will not result in compliance with Section 106 of the National Historic Preservation Act, as amended.

- The goal of the environmental analysis for the (Phase 1 Report will be to coordinate with local, State and Federal environmental regulators and stakeholders to determine current issues and concerns as well as provide a limited conceptual update to the possible scope of potential adverse impacts and associated mitigation costs, as identified in the existing 1987 Environmental Impact Statement (EIS) and 1995 Supplemental Environmental Impact Statement (SEIS).

- Additional environmental issues, including the potential adverse effects to water quality ,wildlife habitat and wetlands , as identified in the 2011 Commission Report will not be specifically further analyzed as part of the (Phase 1 Report.

- Phase 1 Report mapping will be limited to the use of Google Earth and other on-line resources, as applicable, for the depiction of the location of alternatives and/or environmental resource areas, etc.

- The data in the 1987 EIS and the 1995 SEIS will be used to the extent practicable.

Fieldwork will consist only of limited site visits to verify existing environmental conditions.

13. Real estate assumptions, constraints, & risks

- All real estate costs for the (Phase 1 Report are being updated based on consumer price indexing from the 1995 Draft GDM and 1987 Feasibility Report

- The Real Estate Division, Appraisal Team, is not involved in the Phase 1 Report.

- There are several on-going buyout programs throughout the Basin that utilize local, state and federal funds but the current, ongoing buyouts will not be taken into account during the Phase 1 Report.

- Mapping will be conducted by the Environmental and Engineering GIS teams. No tax maps will be generated at this time.

- No physical site visit for the purpose of evaluating real estate requirements will be conducted during the Phase 1 Report.

- Gross Appraisal requirements will not be addressed in the (Phase 1 Report.

- No Rights-of-Entry will be needed in the Phase 1 Report.

- Gross Appraisal/valuation document requirements to provide a detailed estimate of all real estate costs to be associated with acquisition of real property interests for project's complexity and final alignment will be decided by the PDT Vertical Team. The Gross Appraisal will be prepared during the Phase 2 Report.

- Fluctuations in market conditions may affect real estate values and may increase or decrease the project's overall real estate costs.

- On-going, past, or future buyouts may affect Project real estate costs.

NOTE: 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. Buy-outs involve the acquisition of a property and its structures, either by purchase or by exercising the powers of eminent domain. 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 nor exacerbate the existing flood hazard.

2. AUTHORIZATION

Section 101(a) of the Water Resources Development Act (WRDA) of 1976 authorized a comprehensive look at the Passaic River Basin based on the Report of the Chief of Engineers dated February 18, 1976. Further, Section 101(a) (18) of the Water Resources Development Act of 1990, as amended in 1992, 1996, and 2000, authorized a project for construction, which *inter alia* recommended a diversion tunnel.

> *Section 101(a) (18) of WRDA 1990 states, in pertinent part:*
> *Passaic River Main Stem, New Jersey and New York. --(A) Flood control elements.*
> *(i) In general. --The project for flood control, Passaic River Main Stem, New Jersey and New York: Report of the Chief of Engineers, dated February 3, 1989, except that the main diversion tunnel shall be extended to include the outlet to Newark Bay, New Jersey, at a total cost of $1,200,000,000, with an estimated first Federal cost of $890,000,000 and an estimated first non –Federal cost of $310,000,000.*

No project has been constructed as a comprehensive solution to flooding in the Passaic River Basin. Flooding continues to be a major problem in the Passaic River Basin in New Jersey and New York (See Figure 1 for location map). There have been more than 15 Federal Disaster Declarations, six since 2005, resulting from Passaic River Basin flooding. Since the construction authorization in 1990, over $3.5 billion in losses have been reported. At today's price level (October 2012) the 1990 authorized project would have cost $2.1 billion. Additional Authorizations and Legislative History may be found in Appendix F.

3. PROJECT LOCATION

The upper section of the Passaic River Basin study area , known as the Highlands Area, consists of 500 square miles of the north-westerly portion of the Passaic River Basin. It is a mountainous and heavily wooded section of the Appalachian Mountain Province. This roughly rectangular area is about 13 miles wide and 38 miles long. It is characterized by a series of parallel ridges which are separated by steep-sided, narrow valleys in which flow the Ramapo, Wanaque, Pequannock, Rockaway and Whippany Rivers. This portion of the basin contains a large number of natural and artificial lake areas. Three streams, the Ramapo, Wanaque and Pequannock join to form the Pompton River, the major flood producing river within the Passaic River Basin. The elevation of the Highlands Area averages about 900 feet NGVD 29, and varies from about 1300 feet NGVD 29 at the western rim to 300 feet NGVD 29 in the valley at the eastern edge. The average stream slopes vary from 30 to 40 feet per mile. The delineation of the Highlands Area, with its corresponding major subwatersheds (Rockaway, Pequannock, Wanaque, and Ramapo), is shown in (Figure 1 and Table 1).

The Central Basin, containing 262 square miles, is a flat, oval-shaped depression about 9 miles wide and 30 miles long. This area lies between the foot of the easterly slope of the Highlands Area and the crescent-shaped Watchung Mountains to the south and east. Low-lying and marshy lands adjacent to the various streams form a floodplain that originally extended over 21,000 acres above Little Falls. The floodplain includes the Great Piece Meadows, Hatfield Swamp, Troy Meadows, Black Meadow along the Passaic River, as well as the Bog and Vly Meadows adjacent to the Pompton River.

The Passaic River flows through this floodplain from the southwest and meanders gently to the north and east until it passes out of the area through the existing gorge at Little Falls. The five major tributaries from the Highlands Area discharge into the Central Basin near Fairfield Township and at Two Bridges, the confluence of the Passaic and Pompton Rivers. The basin elevation averages 300 feet NGVD 29, varying from about 500 feet NGVD 29 along the rims of the basin to 160 feet NGVD 29 at the northeasterly end of the basin. The average stream slope varies from 19.5 feet per mile in the headwaters above Chatham to 1.4 feet per mile through the floodplain downstream of Chatham. The delineation of the Central Basin, with its corresponding major subwatersheds (Upper Passaic, Whippany, and Central Passaic), are shown in (Figure 3).

The Lower Valley, containing 173 square miles lies between Little Falls on the eastern edge of the Central Basin and Newark Bay. This roughly rectangular area, about 7 miles wide and 24 miles long, is heavily urbanized and densely populated. The valley has rolling sides and a comparatively flat, wide bottom which narrows down to about 0.75 mile below Dundee Dam. The average elevation of the area is about 250 feet NGVD 29, varying from 500 feet NGVD 29 along the westerly edge of the basin to sea level at the mouth of the Passaic River. The main stream slope averages 2.9 feet per mile with concentrated falls of 33 feet at Beattie's Dam above Little Falls, 63 feet at the Great Falls above Paterson and 17 feet at Dundee Dam above the City of Passaic. The major tributary in this area is the Saddle River which joins the Passaic River 15.5 miles above Newark Bay. The Saddle River has an average stream slope of 22 feet per mile. Smaller tributaries join the main stem of the Passaic at intervals below Two Bridges and are short and precipitous. These tributaries have stream slopes that vary from 45 to 194 feet per mile. The Passaic River upstream of Dundee Dam is subjected to tidal impacts from Newark Bay. The delineation of the Lower Valley Area, with its corresponding major subwatersheds (Lower Passaic and Saddle River), is shown in (Figure 2).

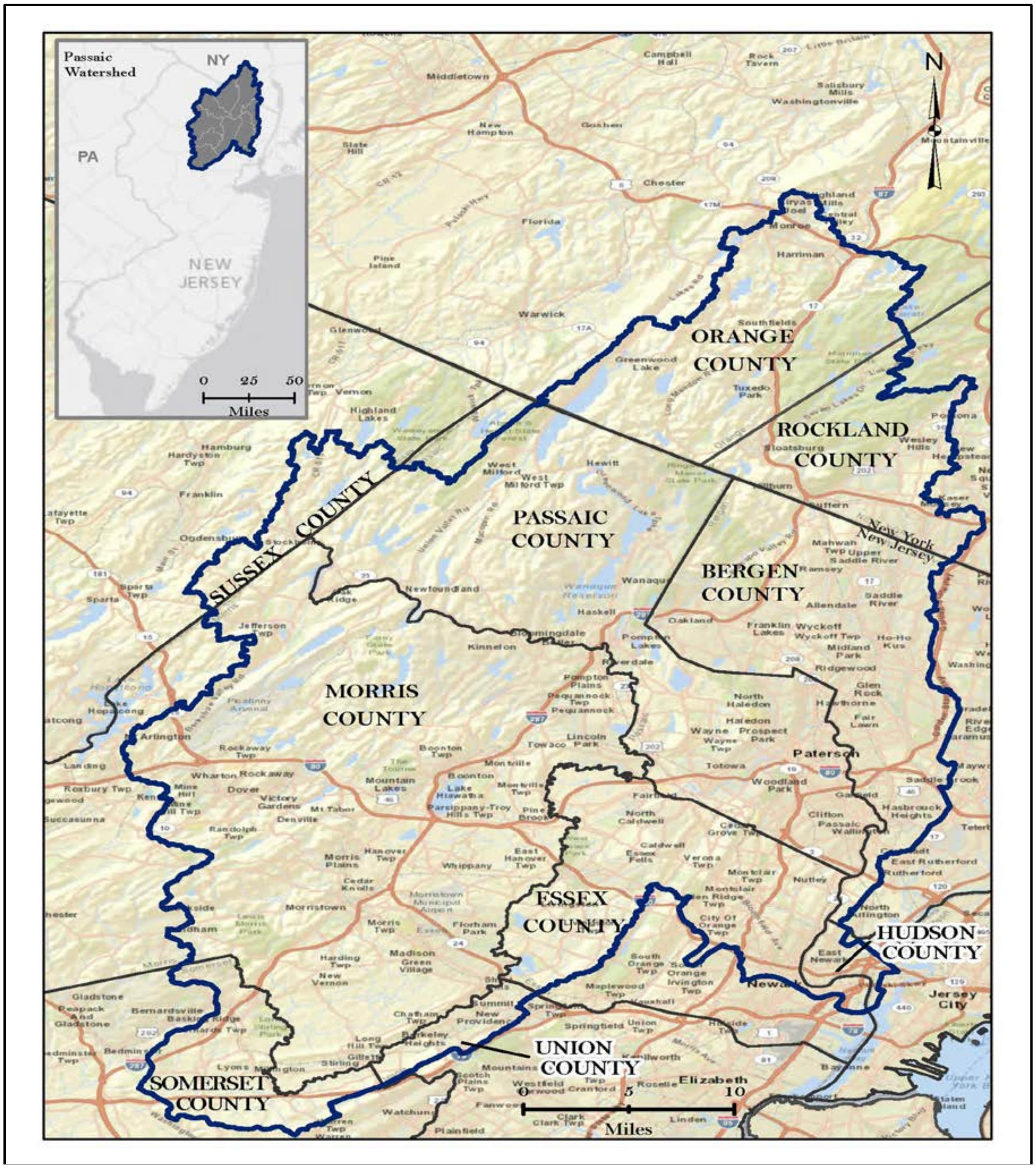


FIGURE 1: STUDY AREA – PASSAIC RIVER BASIN

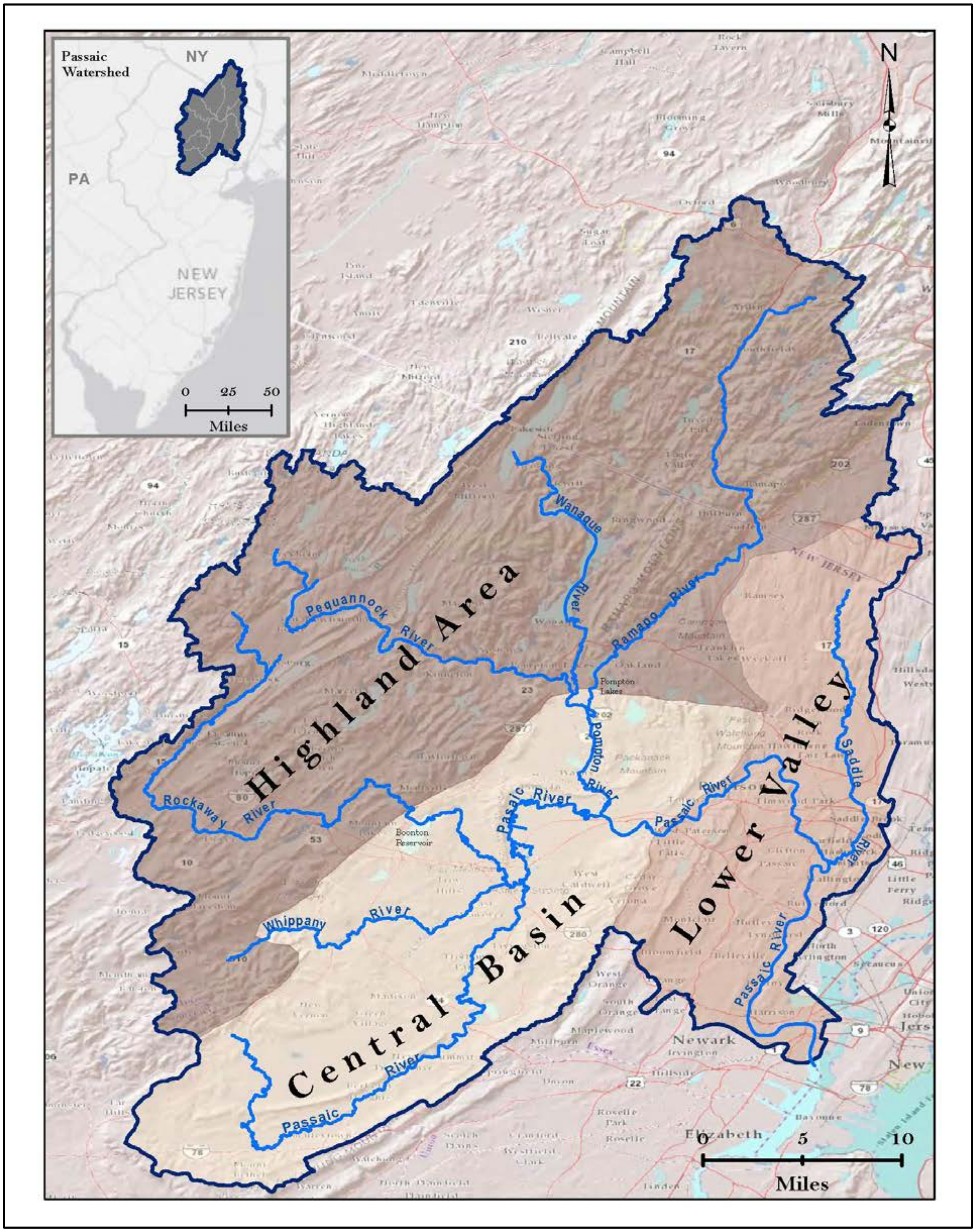


FIGURE 2: PASSAIC MAIN STEM TRIBUTARIES AND SUB-BASINS

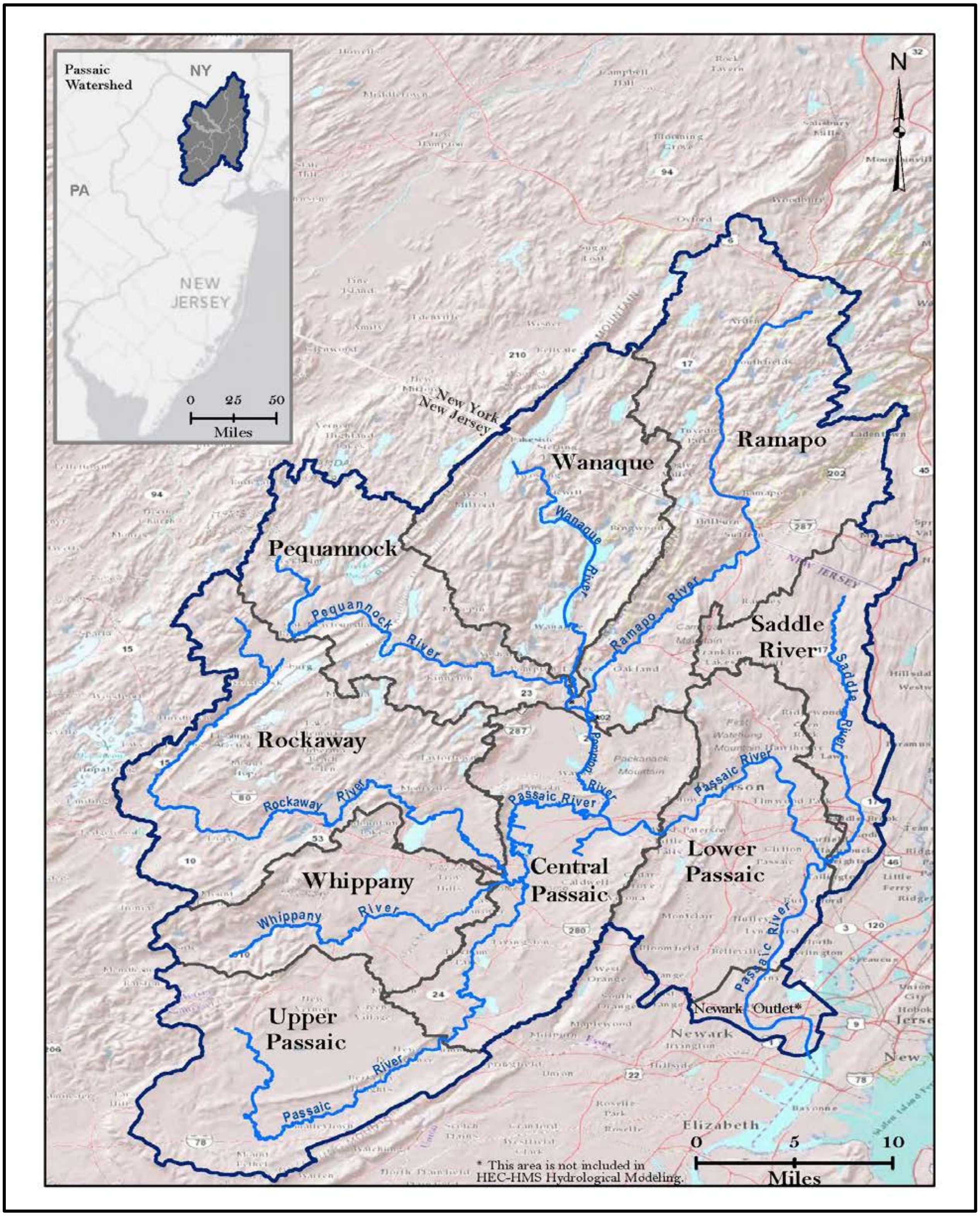


FIGURE 3: SUB-WATERSHED WITHIN THE PASSAIC RIVER WATERSHED

Each of the three topographic regions have different flood producing characteristics. The basins of the Highlands Area are the greatest flood producers in the Central Basin although they contain a large number of natural and artificial lakes and reservoirs. These impoundments, which tend to reduce the flood peaks to some extent, are used principally for water supply and recreational purposes. Although the flood peaks are somewhat reduced and slowed due to tributary lakes, reservoirs and valley storage between Pompton Lakes and the Passaic River at Two Bridges, the Pompton River peaks at Two Bridges from 24 to 48 hours earlier than the Passaic River peaks during basin-wide floods. This phenomenon has been recorded by the USGS stream flow gages for several historical flood events, including the April 1984 event. The southerly upland tributaries, namely the Whippany and Rockaway Rivers, are as precipitous as the northerly tributaries, but they join the Passaic River well upstream and hence are widely separated in time. This results in de-synchronization of their peaks when compared to the northerly upland tributaries. In addition, the Rockaway and Whippany are greatly affected by the large valley storage in their lower reaches, and therefore, contribute less to the flood peaks in the Central Basin and Lower Valley.

Flooding upstream of Two Bridges is aggravated by the restricted river section and control above Little Falls, which throttles the flow into the Lower Valley. This restriction can also create flow reversals of the Pompton River flood flows upstream into the Great Piece Meadows, (part of the Central Basin floodplain). Thus, the combined flow from the total watershed above Two Bridges (740.8 sq. mi.) raises the water level in the Meadows until it becomes equal to or greater than that at Two Bridges. As a result, during periods of high runoff, the floodplain in the Central Basin acts as a natural detention reservoir. This action significantly retards peak flood flows and reduces the flood intensities in the Lower Valley below Little Falls.

TABLE 1: PASSAIC MAIN STEM TRIBUTARIES

Stream	Location	Distance Above Mouth (Miles)	Drainage Area (Square Miles)	Length (Miles)	Slope (Feet/Miles)
Passaic River					
At mouth	Newark	0.0	935.0	87.6	7.9
At Dundee Dam	Clifton	17.4	809.9	70.2	8.9
At Beatties Dam	Little Falls	29.7	762.2	57.9	8.5
At Two Bridges	Lincoln Park	33.0	740.8	54.6	9.0
Pompton River	At mouth	0.0	378.1	44.8	21.0
Pequannock River	At mouth	0.0	192.6	30.8	35.2
Wanaque River	At mouth	0.0	180.1	25.0	33.0
Ramapo River	At Pompton Lakes	0.0	160.0	35.8	25.1
Rockaway River	At mouth	0.0	205.7	43.0	26.8

The Lower Valley is also subject to fluvial floods due to the short, flashy streams below Little Falls. These streams peak much earlier than the Upper Passaic River (Highlands) and the flood peaks are a result of high percents of runoff due to the extremely urbanized nature of the Lower Valley. Flood stages in the Passaic River downstream of Dundee Dam are also tidally influenced from Newark Bay. This area of the Passaic Basin is therefore vulnerable to both coastal Nor'easters and Hurricanes, which can raise water levels within Newark Bay and upstream on the Passaic River.

Three regions play different roles in producing floods. The rapidly flowing streams in the Highlands area are the greatest flood producers, the effects of which are suffered in the floodplains of flat and slower flowing streams in the Central Basin. In the basin-wide floods, the Pompton River peaks at Two Bridges one to two days sooner than the Passaic River. Flooding in the Central Basin upstream of Two Bridges is aggravated by very flat stream slopes of the Central Basin area and the restriction upstream of Little Falls. This promotes the storage of flood waters in those areas thus reducing the flood peaks in the Lower Valley. Flashy tributaries in the Lower Valley below Little Falls peak earlier than the Passaic because of the large runoff from their urbanized watersheds. Flood stages in the Lower Valley are also aggravated by high tides, nor'easters and hurricanes. Portions of the Lower Valley floodplain are also affected by coincident flows from the Hackensack River. However, the flooding impact of the Hackensack River is insignificant in comparison to damage caused by tidal events.

3.1 Passaic River Basin Municipalities

The Passaic Basin is a major center of economic activity in New Jersey. Occupying about 10.5% of the area of the state, the basin contains all or part of 117 municipalities in portions of eight (8) counties – Bergen, Essex, Hudson, Morris, Passaic, Somerset, Sussex, and Union. In New York State, the Passaic Basin includes some 15 municipalities in Orange and Rockland counties. Appendix E provides a list of all Passaic River Basin Municipalities in New Jersey & New York.

3.2 Passaic River Basin Congressional Districts

New Jersey is represented in the Senate by Hon. Frank Lautenberg (D) – deceased, and Hon. Robert Menendez (D). New York is represented in the Senate by Hon. Charles Schumer (D) and Hon. Kirsten Gillibrand (D). There are ten Congressional districts in the Basin, eight in New Jersey and two in New York. These are NJ-5, NJ-6, NJ-7, NJ-8, NJ-9, NJ-10, NJ-11, NJ-12, NY-17, and NY- 18.

3.3 Population and Income

The study area is a mixed urban/suburban area containing portions of Newark and Paterson, New Jersey's first and second largest cities, and forty smaller municipalities. Based on the 2010 U.S. Bureau of Census data, the municipalities contained (all or in part) within the study area have a combined population of 1,265,521, in comparison to a 1980 population of 1,234,280. This minor difference in overall population is the result of two contrasting trends: significant population growth in a number of suburban communities combined with a 16% decline in the overall population of Newark. Thus, while population levels for the overall area are relatively static, there have been substantial changes within individual communities.

Population density in the study area varies widely. With two exceptions, the communities in the Central Passaic and Pompton Basin have less than 2,700 residents per square mile. The more urbanized Lower Passaic basin communities range from 2,403 (East Rutherford) to 23,532 (East Newark) persons per square mile. As noted above, Newark experienced the greatest population decline (-16%) since 1980, while Montville in Morris County saw the greatest growth (51%) in the same period. Thirty-three communities saw at least a 1% increase in population, while nine saw some level of decrease. The state population of New Jersey has risen 19% from 1980 to 2010. The study area has one of the highest population densities in the northeast.

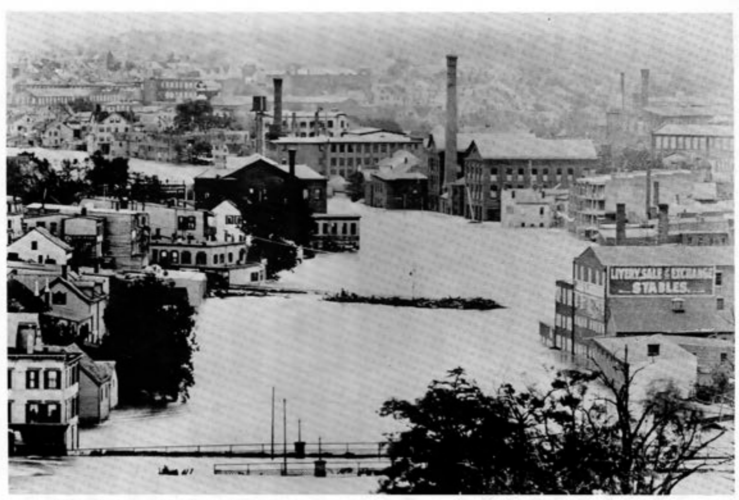
The median household income for the study area is $78,466, or 10.2% greater than the State median household income of $71,180. However, the mean household income for the State of New Jersey of $95,812 is significantly higher than the study area figure of $80,688.

4. HISTORY OF FLOODING IN THE AREA

Flooding has long been a problem in the Passaic River Basin. Since 1900, twenty-six (26) lives have been lost and over $6 billion in losses have been reported. The flood of record, a 100-year event, occurred in October 1903. The reported damages from that flood, a 100-year event, in October 2012 price level would amount to $2.44 billion in damages.

More recent floods in 1968, 1971, 1972, 1973, two in 1975, 1984, 1992, 1999, 2005, April 2007, March 2010, March 2011 and most recently Tropical Storm Irene/Lee in August/ September 2011 were sufficiently devastating to warrant Federal Disaster Declarations.[1] The flood of 1984 resulted in three deaths and caused $892 million in damages (P.L. 2012). Tropical Storm Floyd in September 1999 caused over $357 million in damages (P.L. 2012).

Tropical Storm Irene in August 2011 was the most destructive flood that the Passaic River Basin had experienced in over 100 years, with an estimated $1billion in damages. Prior to the August 2011 event, the most devastating event occurred in April 1984 insofar as reported damages. The flood of 1984 resulted in the loss of three lives and caused $892 million in damages (October 2012 dollars) sustained by approximately 6,400 properties. In that event, over 9,000 people were evacuated from their homes. The 1984 flood can be expected to be equaled or exceeded once every 25 to 50 years.



Passaic River flood of 1903 in Paterson, showing bridges awash. *Photo by G. K. Livitsanos, Passaic County Historical Collections*

FIGURE 4: FLOOD OF 1903

1 It may be that floods that occurred before this time were also severe enough that they would have warranted Federal Disaster Declarations, but there was no mechanism in place to effect them.. P.L. 100-707, "The Robert T. Stafford Act Disaster Relief and Emergency Assistance Act" or, familiarly, "The Stafford Act" which was signed into law on November 23, 1988 is an amended version of the Disaster Relief Act of 1974, P.L. 93-288. The history of "Emergency Disaster" Declarations predates this, but the earliest retrievable finding of this history dates only to the Eisenhower Administration (1953-1961).

FIGURE 5:
(A) FLOOD OF 1984 ($892M AT OCTOBER 2012 PRICE LEVEL) & (B) FLOOD OF 2007 CAUSED SIGNIFICANT FLOODING, DAMAGE, AND DEATHS.THIS STORM REQUIRED THE EVACUATION OF APPROXIMATELY 5,000 PEOPLE AND CAUSED $823 MILLION IN DAMAGE (P.L. 2012).

FIGURE 6:
TROPICAL STORM IRENE/STORM LEE - (A&B) PATERSON, NJ (MEL EVANS, ASSOCIATED PRESS) (C&D) FAIRFIELD, NJ (ANDREW MILLS, STAR LEDGER).

ADDITIONAL STORM EVENT PHOTOGRAPHS MAY BE FOUND IN APPENDIX A.

5. PASSAIC MAIN STEM STUDIES, REPORTS, AND PROJECTS

5.1 Prior Studies and Reports

The USACE involvement in Passaic River Basin planning was first authorized in the Flood Control Act of 1936. Since then, reports recommending plans of action were issued in 1939, 1948, 1962, 1969, 1972, 1973, 1987 and 1995.

- 1900 - 1940: 8 State Studies
- 1936 - 1973: Numerous Federal reports that would be considered for Final Feasibility Reports in current USACE terminology.
- 1976: New Basin Study Authorized -150 alternatives studied including buy-outs, flood plain regulations, channels, levees, floodwalls, reservoirs, tunnels, and multiple combinations. Also considered environmental impacts National Environmental Protection Act (NEPA) and Public Acceptance
- 1987 General Design Memorandum (GDM) and 1989 Chief's Report, USACE
- 1989 Beatties Dam Reconnaissance Report – No Federal Interest
- 1990 Construction Authorization (WRDA 1990, P.L. 101-640)
- September 1995 – Passaic River draft GDM (authorized project)
- September 1995 – Passaic River Buyout Study Report [BCR of 0.1 (100 year)]
- October 1995 – Passaic River Floodway Buyout Study Report[BCR of 0.2]
- WRDA 2000, Section 327(i) Restriction on use of funds
- February 2011 – Governor's Flood Advisory Commission Report

Appendix D provides a thorough summary of previous Reports related to the Passaic Main Stem (Federal and non-Federal) prior to construction authorization in 1990.

5.1.1 Passaic River Main Stem Feasibility Report

The December 1987 Passaic River Main Stem Feasibility Report recommended plan combined large underground diversion tunnels with levees, floodwalls, channel modifications and natural flood storage to provide flood risk management to major damage areas in the Pompton River Valley, the Central Passaic Basin and the Lower Passaic River. This plan would manage risk to flood-prone areas along the Passaic, Pompton, Pequannock, Wanaque, Ramapo, Rockaway and Whippany Rivers and Deepavaal and Pinch Brooks.

The major element of this flood risk management project was a dual inlet tunnel, with the key being the 13.5-mile long, 39-foot diameter main tunnel, which would carry floodwaters from an inlet at the upper Pompton River down to an outlet on the lower Passaic River. A 1.2-mile long, 22-foot diameter spur tunnel would convey Central Basin area floodwaters from an inlet just downstream of Two Bridges on the Passaic River to an underground connection with the main diversion tunnel. The two inlets would be located in Wayne Township while the outlet would rise on the west bank of the Passaic River at its confluence with the Third River in Clifton

(WRDA 1990 extended the outlet to Newark Bay)[2]. The diversion tunnels and associated surface works were designed to protect against a 100-year flood event.

The tunnels were to be entirely underground some 125 feet below the surface at the Pompton Inlet, about 130 feet below the Passaic Inlet, and would be approximately 155 feet below ground before coming to its outlet in Newark Bay. The intersection of the main and spur tunnels would be about 150 feet below ground level. At its deepest point, under the Watchung Mountains in the vicinity of the Little Falls-Clifton border, the main tunnel would be some 450 feet underground.

A total of 5.9 miles of channel modifications would be required to direct the flows into the inlets, and the diversion tunnels will be augmented by 26 levee/floodwall systems, comprising 23.7 miles of levee and 14.0 miles of floodwall. The levees and floodwalls would be situated along the Passaic River and tributaries throughout the damage areas. Except for a transition channel at the Passaic River confluence, no other structural remedies would be needed along the Pompton River, because the tunnel would divert the Pompton Valley flood flows.

In the Lower Valley, no works were proposed from Beatties Dam downstream to just above the Saddle River because the tunnel would divert most of the damaging flood flows away from this area. From just above the Saddle River down to Newark Bay, the plan calls for 14 levee/floodwall systems with about 11.2 miles of levee and 12.8 miles of floodwall. The levee/ floodwall systems between the Saddle River vicinity and the Second River are required to protect against the combined tidal and fluvial effects, including the tunnel discharges. These systems would provide protection against an l00-year flood. The tunnel diversion plan would increase flood risks downstream without the implementation of these additional flood risk management measures. From the Second River downstream to Newark Bay, intermittent levees and floodwalls are required to protect against flooding from tidal events. They would provide protection against a 500-year flood.

Upstream of the Pompton Inlet, 3.5 miles of levees, 0.7 miles of floodwalls, and 4.8 miles of channel modifications would be required to direct flood flows into the tunnel, and to protect upstream areas. The lower Pequannock, Wanaque and Ramapo Rivers would be deepened an average of 7, 6, and 4 feet, respectively. The Pompton Valley would be protected against a 100-year flood event. The Passaic River channel would be deepened for a distance of 0.8 miles from upstream of Two Bridges to the Route 46 crossing to divert flood flows into the spur tunnel's Passaic River inlet. A 0.3-mile transition channel would extend up the Pompton River from the confluence.

Along the Passaic River and its tributaries upstream of Two Bridges, levels of protection ranging from 100- to 500-year would be provided at intermittent locations by setback levees and floodwalls. These systems include about 9 miles of levees and 1/ 2 mile of floodwall. Each

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[2] The project authorized in WRDA 1990 was, in fact, not the National Economic Development (NED) plan recommended by the Corps. The recommended plan had the outlet at the Third River in Clifton. The authorization extended the tunnel to an outlet in Newark Bay and eliminated the levees and floodwalls in Bergen County. As a result, the authorized project has no direct analog in any Corps report. There was no further discussion of NED versus Locally Preferred Plan (LPP) because the WRDA 1990 legislation also directly specified cost-sharing for the project as authorized.

levee/floodwall system includes interior drainage facilities such as ponding areas and pumping stations which would handle the interior runoff generated behind the line of protection.

The preservation of up to 5,350 acres of natural storage areas in the Central Passaic Basin is also a major feature of the plan. The acquisition of these lands would ensure the future integrity of the design scale of the project by preventing increases in flood flows which might be caused by the loss of these areas to development. This acquisition, in conjunction with the 15,865 acres already protected under existing Federal and State programs, would preserve the flood storage and environmental characteristics of the Central Basin wetlands.

5.1.2 Draft Passaic River Flood Risk Management Project, General Design Memorandum and Supplemental 1 to the Environmental Impact Statement

The most recent USACE report, the draft Passaic River Flood Risk Management Project, General Design Memorandum (GDM), dated September 1995, recommended a plan of protection on the Passaic River Main Stem consisting of channel modifications, levees, retaining walls and tunnel diversion works. As authorized, this project had an estimated fully funded cost of $1.87 billion at the October 1994 price level (approximately $3.335 billion in 2012 dollars). This draft GDM recommended a revision to the authorized construction design from the Passaic River Main Stem Feasibility Report, December 1987. Revisions for the tunnel system included increasing the length and diameter of the main tunnel to 20.4 miles in length and 42 feet in diameter to discharge in Newark Bay at Kearny Point. Further revisions included a 1.3 mile, 23 foot diameter spur tunnel, modifying inlet and outlet structures, decreasing the length of river deepening for the Passaic and Lower Pompton Rivers, enlarging the bypass channel on the Pequannock River, increasing the length of deepening for the Wanaque River Channel and Ramapo River. Further modifications include 2,200 feet of levees and 2,910 feet of floodwalls at the Pequannock/Ramapo River. Additionally, the revised Plan relocates Pequannock and Great Piece Weir.

Additionally, revisions for the Central Basin protection include the shortening of the length of levee on the Passaic to 9,298 feet, replacing the downstream portion of Rockaway River levee with 521 feet of floodwall and decreasing the levee length along sections of the Rockaway River. The length of levee was shortened to 2,812 feet for Pinch Brook and an intervening flood wall was added and for Deepavaal Brook, the levee was eliminated and replaced by 7,660 feet of channel improvement by increasing the bottom and top width.

Revisions for the Tidal Area Protection included an increase in the total length at Kearney Point to 37,679 feet that includes 33,771 feet of floodwall and 3,908 feet of levee. On South First Street in Harrison, the project was lengthened to 7,450 feet to include 1,750 feet of levee and 5,700 feet of floodwall. At Lister/Turnpike/Doremus, three original separate systems, totaling 14,470 feet of levees and floodwalls were modified and combined into one continuous system 23,256 feet long. The system includes 5,599 feet of levee and 5,700 feet of floodwall.

Additional modifications also included land acquisition for the preservation of natural storage areas (5,350 acres) and fish and wildlife habitat mitigation at various localities that incorporate wetland hydrology at ponding sites, which resulted in the reduction of impacted wetlands from

905 acres to 94 acres. Remaining wetland impacts were addressed specifically by restoration of disturbed wetlands. Figure 7 illustrates the revised plan based on the 1995 draft GDM for the Passaic Main Stem River Basin.

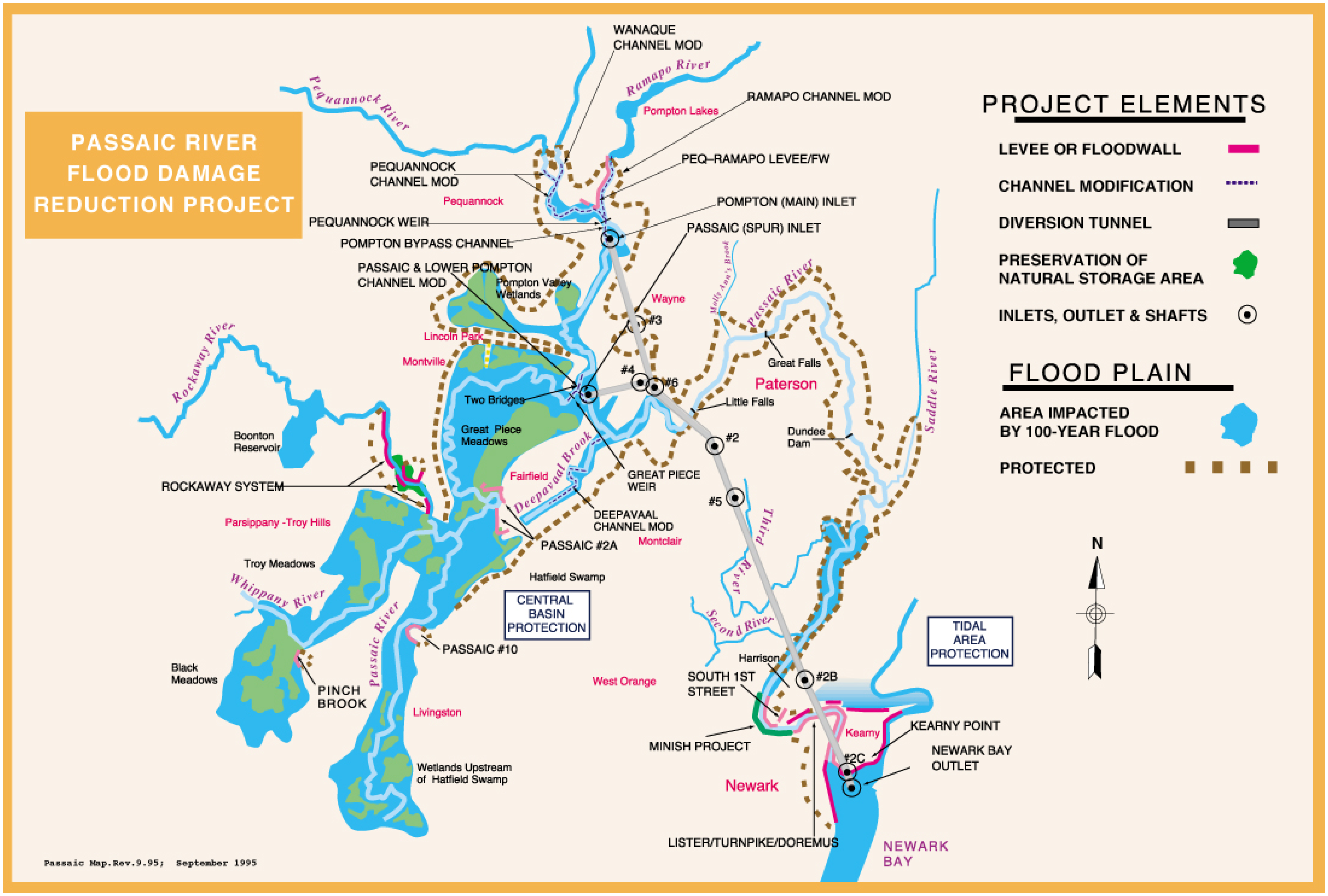

FIGURE 7: PLAN OF IMPROVEMENT BASED ON THE 1995 DRAFT GDM FOR THE PASSAIC MAIN STEM RIVER BASIN

5.2 ONGOING AND COMPLETED PROJECTS & STUDIES

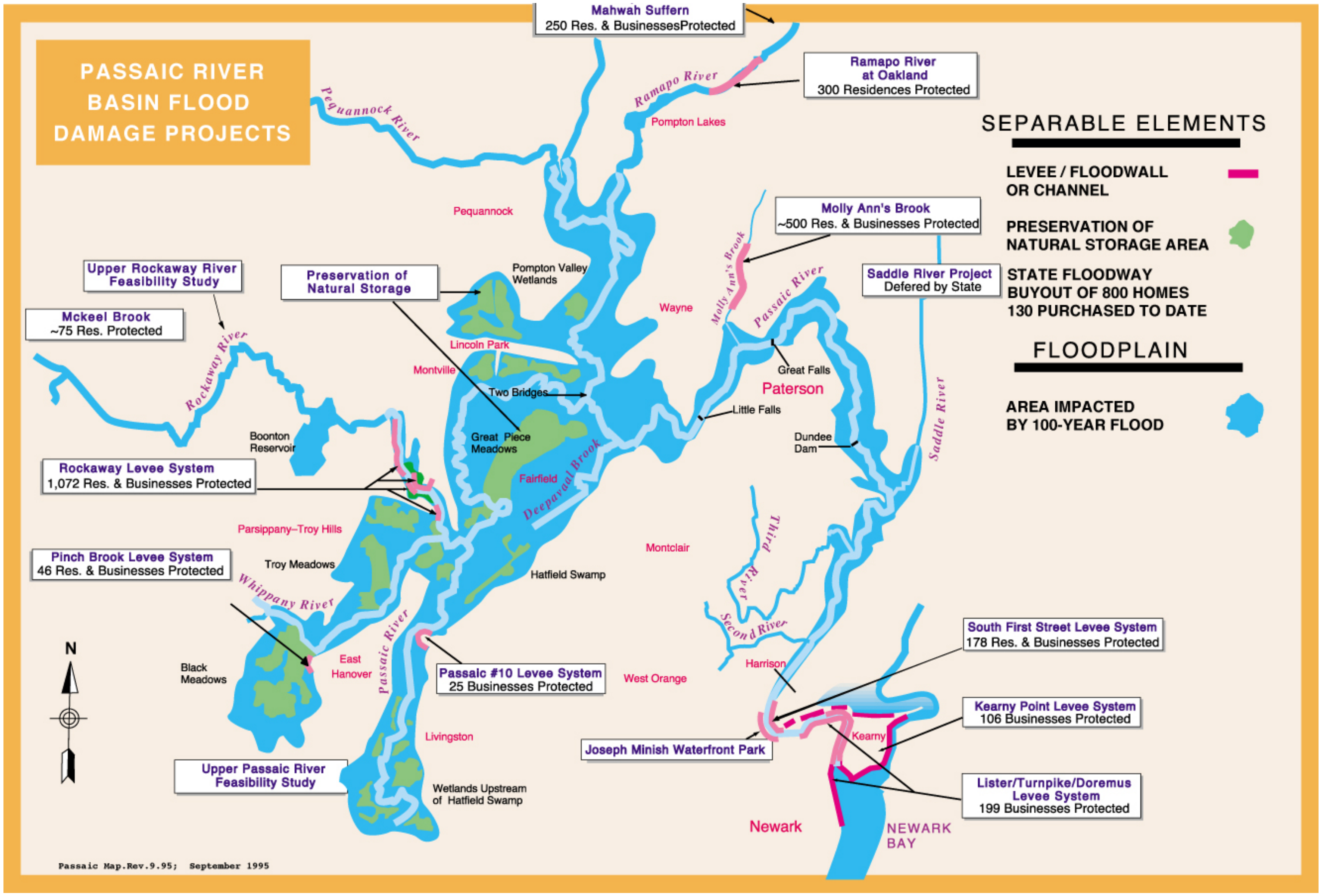

FIGURE 8: CURRENT PROJECTS CONDUCTED ON PASSAIC MAIN STEM

Figure 8, above, shows the locations of projects completed and ongoing studies in the Passaic River basin.

- Molly Ann's Brook – construction completed 2007
- Lower Saddle River – ongoing study
- Long Hill Township – study deferred
- Jackson Brook – no Federal interest
- Malapardis Brook – no Federal interest
- Ramapo River at Mahwah/Suffern – Study deferred
- Joseph Minish Waterfront Park – on going construction (P.L. 113-2 funding provided to complete construction)
- Floodway Buyout – Implementation guidance from HQ to proceed with 30 buyouts received 15 November 2012.
- Ramapo River at Oakland – construction completed 2007
- Preservation of Natural Storage Areas – authorized for the purchase of up to 5,350 acres: 3, 400 bought to date and project is ongoing
- McKeel Brook – construction complete 2004
- South First Street Floodwall at Harrison – ongoing evaluation
- Lower Passaic River Restoration Project[3] – ongoing study, conducted jointly with the US Environmental Protection Agency (USEPA)
- Newark Bay Superfund Study – ongoing study by USEPA

In addition, Congress authorized new studies on the Upper Rockaway River, Peckman River, and other small projects.[4]

6. ALTERNATIVE PLANS TO BE EVALUATED

Appendix G of ER 1105-2-100 dictates that post-authorization change reports are required when conditions of economics, engineering, or environment have sufficiently changed in the project area. In the 26 years that have passed since completion of the Feasibility Study for this project, changes in the Basin that could affect the project are evident. The rationale for re-evaluation was established in the *Passaic Main Stem Justification Report* approved on 27 March 2010. The major changes that have occurred are frequency of storm events, changes to the water flows, new state and federal statutory environmental designations and regulations, and new plan formulation guidance. These four elements have a significant impact on the economic, environmental and cost analysis for this reevaluation.

The formulation of potential alternatives and re-evaluation of the recommended plan is constrained by technical, environmental, economic, and social considerations. These constraints appropriately limit and screen the proposed modifications to the Phase 1 Report analyses and

[3] Because of the Superfund site designation within the Lower Passaic River, extensive communication with the USEPA will be required for the screening of alternatives and the consideration of environmental and project cost/construction impacts.

[4] Please note that since authorized, the Upper Rockaway River flood risk management study was deferred at the request of the non-Federal partner, NJDEP, due to local sponsor support issues.

serve to focus formulation efforts.

At a minimum, the potential Flood Risk Management measures that may be examined in the reevaluation report include channel modification, levees, floodwalls, detention, diversion, as well as non-structural measures and the “no action” alternative. Solutions may include, but will not be limited to, variations of the recommended plan’s structural components including channel work, diversion tunnel(s), levees and floodwalls. Non-structural measures such as flood proofing, buyouts and preservation and/or creation of open space in the floodplain will also be reconsidered in light of changes to existing conditions and changes to environmental policy.

Based on project delivery team meetings with participation of the NJDEP and in accordance with the January 2011 *Report to the Governor: Recommendations of the Passaic River Basin Flood Advisory Commission*, the following items have been reevaluated in this Phase 1 Report.

1. Alternative 14A – Levee/Floodwall/Nonstructural/Bridge & Dam Modification Alternative (Figure 20). Plan 14a is a Levee and Non-structural plan with the levees being distributed throughout the upper and lower areas of the basin and the non-structural being limited to the middle part of the basin.

2. Alternative 16A–Levee/Floodwall/Nonstructural/ Channel Modification Alternative (Figure 21). Alternative 16a is a Channel, Levee and Non-structural plan with many features in common with Alternative 14a. The main difference between Alts 16a and 14a is that in Alt 16a all the levees from North Arlington in the lower Valley to Little Falls have been replaced with channel modification. The levees in the upper and tidal/coastal areas of the basin are the same as are the non-structural measures in the middle part of the basin are also the same.

3. Dual Inlet – Newark Bay Tunnel Alternative (Newark Outlet Tunnel Alternative) – Authorized Plan – Passaic/Pompton River Dual Inlet Tunnel Diversion Alternative. In accordance with re-evaluation requirements, the authorized plan, must be reevaluated for comparison of alternate plans. This plan is being reevaluated for comparison purposes only. This plan is identical to the plan developed in the 1995 Phase 2 GDM. See Figure 22. Please note that this plan is currently mistakenly referred to as Alternative 30E. However, Alternative 30E in the 1987 Phase 1 Feasibility Report has an outlet at Third River and includes many levees in Bergen County. The Dual Inlet Tunnel with an outlet in Newark Bay is not truly Alternative 30e as it does not include levees in Bergen County and the outlet is 1,850 feet off shore of Kearney Point in Newark Bay.

4. Alternative #4 – Beatties Dam/Two Bridges improvements: Modifications to Beatties Dam, channel improvements upstream (including the Two Bridges Area) on both the Passaic and the Pompton were be evaluated. This plan is the only plan in this reevaluation that has not been studied before. The 1976 Corps report recommended a reservoir in the Great Piece Meadows with a diversion tunnel from the Upper Pompton River into the Great Pier Meadows. Plans to remove, lower or modify Beatties Dam have been studied and presented many times including a Corps of Engineers Reconnaissance from 1989. This new plan however, combines both concepts and uses the Great Piece Meadows as a reservoir and modifies Beatties Dam along with

some channel deepening and widening. This plan does not protect as extensive an area as the other plans but should cost considerably less.

5. Non-structural –As part of a complete alternatives analysis, The 10 year non-structural alternative from the 1987 GDM will be analyzed This measure will also be examined throughout the Passaic Basin in conjunction with the structural alternatives.

6. No Action Plan – as required by NEPA and other regulations, the No Action Plan (Future without Project Condition) will be identified and the impacts will be clearly discussed and analyzed.

These above alternatives were determined to be reevaluated in the "Preliminary Alternative Reevaluation Phase" report based on the analysis of the 1987 Feasibility Report. Alternative 14A and Alternative 16A indicated a BCR close to or above unity. Although the "Beatties Dam/Two Bridges" alternative was not analyzed in the 1987 Feasibility Report, this "junction" has indicated that it may be economically feasible because of the significant increase in water surface elevations reported by recent hydrologic modeling by the State. Because these alternatives were also considered to be technically feasible and environmentally justified, these 3 alternatives were also selected in coordination with the non-Federal sponsor and public participation.

The "Non-Structural" Alternative and the "No Action Plan" Alternative are required to be reevaluated in accordance with Planning Guidance regulations of ER 1105-2-100. Additionally, the previously authorized plan would have provided for the 100-year annual risk of flooding on the Passaic River and a 500-year annual risk of flooding for the tidal area/floodwall systems.

In terms of implementability of a comprehensive solution, there is currently legislative language restricting the use of funds for design or construction of the tunnel element. WRDA 2000, Section 327(i) states:

> *(i) RESTRICTION ON USE OF FUNDS.—The Secretary shall not obligate any funds to carry out design or construction of the tunnel element of the Passaic River flood risk management project, as authorized by section 101(a)(18)(A) of the Water Resources Development Act of 1990 (104 Stat. 4607).*

While this restriction is in place, the study must meet the requirement of ER 1105-2-100. Any locally preferred plan must be compared to the NED plan – which prior USACE studies have designated as the tunnel alternative (Newark Outlet Tunnel Alternative). The tunnel alternative will be part of the reevaluation study for comparison purposes only, but neither the design nor construction of the tunnel will be further developed unless the law restricting use of funds is repealed.

Based on the preliminary analysis of hydrology, economics, and environmental considerations documented in the Preliminary Alternative Reevaluation Phase Report scope in the 13 June 2012 PMP, as well as non-Federal sponsor input and public, we expect to proceed with a Detailed Analysis Phase, which will include one or more alternative as determined by this analysis, the

NJDEP and local support. Ultimately, the final GRR will detail the optimal plan among the six alternatives for flood risk management in the Passaic River Basin, based on NED plan criteria. The reevaluation report will serve to document the re-evaluation of the recommended plan, (including any adjustments or variations of said plan) and provide a basis for a decision on construction authorization of the project (if needed) and serve as the decision document for execution of a Project Partnership Agreement.

Table 2 provides a simple price level update for alternatives evaluated in the 1987 GDM to the October 2012 price level for reference during this analysis. The purpose of this report is to apply realistic hydrologic and economic modeling based on current costs and existing conditions.

TABLE 2:
COMPARISON OF PASSAIC RIVER BASIN PLANS FROM 1987 FEASIBILITY REPORT

Plan	BCR 1987	Cost October 1987	Escalated Cost October 2012 (Price level update only)	Structures Protected/Acquired
10 Year Floodplain Buyout	0.8	$587M	$1.3B	~7,400
Floodway Buyout[5]	0.1	$200M	$295	~800
100 Year Authorized Tunnel Diversion Plan (Newark Outlet Tunnel Alternative)	1.1	$995M	$2.1B	over 14,000
Levees, Floodwalls, Nonstructural Measures, some Bridge and Dam Modifications (14A)	1.06	$395	$876M	10 to 100 year annual risk of flooding
Levees, Floodwalls, Nonstructural Measures and Channel Modification, some Bridge and Dam Modifications (16A)	1.1	$452	$1B	10 to 100 year annual risk of flooding

5 The Floodway Buyout is currently authorized as a separate study and structure buyouts within the floodplain are on-going. These buyouts have been taken into consideration in the damage calculations for with project and future without project conditions.

Prior to the study, it was assumed there have been significant advances in engineering technology, and specifically tunnel-boring technology, since 1995 that may affect how those alternatives would be ranked today. Changes in existing conditions as recorded in the 1995 GDM versus current conditions warrant further investigation and lead to potential changes to the recommended plan, such as increased upstream development in the past 17 years which may have led to increased runoff into the Passaic River and its tributaries. This could indicate that flood damages may be experienced more often and would impact the economic analysis and benefits. To examine this possibility, new hydrologic data are being developed in the "Preliminary Alternative Reevaluation Phase" report in order to more accurately define the peak discharges and therefore increase in damages. In addition, the changes in construction techniques may have an impact on the overall cost of the project. These changes are being evaluated in the reevaluation's Preliminary Alternative Reevaluation Phase that is currently on-going.

7. EXISTING CONDITIONS IN THE PASSAIC RIVER BASIN

The Passaic River Basin is home to more than 2.5 million people (2010 Census) and includes more than 20,000 homes, businesses, and public buildings over 100 municipalities. Major economic activities and land uses in the basin are related to residential, commercial and industrial development. There are 117 communities whose boundaries are partially or entirely within the floodplain. Numerous highways and railroads traverse the area. Communities in the eastern portion of the basin are older with high density multi-family housing and a large industrial base. Such is the case in cities as Newark, Kearny, Harrison, Passaic and Paterson. Near the mouth of the Passaic River there are many port-related activities devoted to the transfer of goods and materials, disruption of which results in large and costly damages.

The 100-year floodplain (FEMA) covers almost 60 square-miles (40,000 acres) of the 935 square-mile basin and approximately half of the floodplain is fully developed. Indeed, in 2012, the Passaic River floodplain is one of the most densely developed floodplains in the nation. There are approximately 50,000 people currently living in the 100-year floodplain, many of whom have been subjected to significant repetitive flooding.

The severity of the flood risk may be best illustrated not only by the amount of damages in dollars but also in the number of repetitive flood insurance claims. Data was collected from National Flood Insurance Program website (http://www.fema.gov/national-flood-insurance-program) for the period 1 January 1978 through 31 December 2009, then again from 1 January 2010 through 31 July 2012 as to include claims made during the 2010 and 2011 storms. These claims indicate that Passaic County had the most claims at 13,442 followed by Morris, Bergen and Essex Counties with 8,521, 6,537, and 4,352 claims, respectively. The total number of claims in New Jersey for the Passaic River Basin for the period 1 January 1978 through 31 December 2009 is approximately 20,079 and 13,586 claims in the period of 1 January 2010 through 31 July 2012 period. New York's Orange and Rockland Counties only reported 370 for the period from 1 January 1978 through 31 December 2009 and 1,437 claims for the period of 31 December 2009 through 31 July 2012.

The importance of this data illustrates that there has been a dramatic increase in the number of claims in the last 2.5 years alone. The average number of claims for the period between 1978-

2009 (31 years) is approximately 660 per year. However, the average number of claims for the period between 2010 and 2012 (2.5 years) is over 6,000 claims per year. The time period between from 1 January 2010 through 31 July 2012 (2.5 years) account for approximately 43.5% of the total claims within the Passaic Basin in New Jersey and New York since 1978.

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FIGURE 9:
WHILE FLOODING HAS LONG BEEN A PROBLEM IN THE BASIN, THE APRIL 2007 NOR'EASTER AND SUBSEQUENT FLOODING IN MARCH 2010, MARCH 2011 AND AUGUST 2011 WERE PARTICULARLY SEVERE FOR THEREGION.DAMAGES FROM TROPICAL STORM IRENE/ LEE IN AUGUST/SEPTEMBER 2011.

A. HYDROLOGY & HYDRAULICS - EXISTING CONDITIONS

Since Passaic River flooding has been studied many times over the last 100 years and because public support and political factors have historically had a significant impact on the progression of this project, it was determined that a new approach to the first phase of this study might be appropriate. It should also be noted that various and multiple local interests have historically expressed both strong support and opposition to many of the proposed flood risk management features. Many of these local interests are in opposition with each other. A sample of the project features that are likely to receive considerable opposition are: a tunnel, channel excavation, high levees and floodwalls, extensive non-structural measures, large operable gates and a new dam and reservoir. Given these political and local concerns, the objective of this phase of the study is to provide the NJDEP with the following: a rough update of how conditions have changed; a discussion of what flood risk management measures are available; which measures are likely to be economically justified; what the rough total and local cost of each measure might be and the pros and cons of each alternative.

Hydrology

While utilizing existing Federal Emergency Management Agency (FEMA) hydrologic models (HEC-HMS & RAS) data, the hydrologic efforts in this study were some of the most complete and extensive of all the elements of this study. The conclusion of the updated Hydrology analysis provides revisions to the peak discharges within the select plans to reflect any changes that have occurred since 1995.

Storm Events

Descriptions of the storms of water years 1984-1998, Tropical Storm Floyd (September 15-16 1999), notable storms of water years 2000 through 2006, the April 15-17 2007 nor'easter storm, notable storms of water years 2008 through 2010, and Tropical Storm Irene (August 2011) and Lee (September 2011) and their impact on the watersheds of the USACE New York District in general, and the Passaic River basin in particular, are provided in the Hydrology Report in the Engineering Appendix H. They can be considered an extension and continuation of paragraphs 13.1 through 13.14, Past Storms: Hydrology & Hydraulics, of the September 1995 Passaic River GDM, which describe the storms of September 20-24 1882 through March and April 1984. The paragraphs on the storms of March and April 1984 are restated from the 1995 Passaic River GDM because of the importance of these storms to the Passaic River Basin.

Storms of March and April 1984:

The storm of 28 – 30 March 1984 was a northeaster of extra-tropical origin. It brought with it a major tidal surge (March 29th) and significant precipitation in the form of rain, sleet and snow. The maximum know accumulation of such precipitation (water equivalent basis) in the Passaic Basin was 3.87 inches (Little Falls). There was no snow on the ground at the onset of the storm.

The storm of 4 – 5 April 1984 was of extra-tropical nature arising out of a large, low pressure system moving out of the Ohio Valley. It entered New Jersey on the 4th where it intensified towards dawn of the 5th with gale force winds and near record rainfalls (there was no snowfall). Storm totals at the Little Falls, Charlotteburg, and Wanaque gages were respectively, 5.34, 6.10, and 4.15 inches. Maximum 3-hour accumulation at the Little Falls and Charlotteburg gages were, respectively 1.30 and 1.40 inches. Sub 24-hour data is unavailable for Wanaque due to the hourly gage malfunctioning.

Total precipitation for the two storms, extending over a 10-day period and including rain and the water equivalent of sleet and snow, exceeded 9 inches at Little Falls, 8 inches at Mahwah and 7 inches at Charlotteburg, Oak Ridge and Canistear Reservoirs and at Greenwood Lake. For the Passaic Basin, as a whole, the total was probably close to 7 inches. Snow on the ground at the start of the second storm was apparently minimal because at those few sites where observations were made, no more than traces were reported for the preceding day (3 April).

The flood of April 1984 resulted, in part, from high antecedent flows due to the precipitation in late March. At a number of gaging stations in the northern and western subareas of the Passaic Basin with 40 or more years of record, the flood peaks were the highest or second highest record at that time. Estimated frequencies of the flood peaks ranged from approximately 25 years at

Little Falls to approximately 50 years at Pompton Plains, which exceeded the frequency of the storm that caused it.

Storm of 15-16 April 2007

The 15-16 April 2007 nor'easter dropped between three and ten inches of rain on the watersheds within the Passaic River Basin between the early morning of Sunday, 15 April 2007 and the early afternoon of Monday, 16 April, 2007, resulting in new flood peaks of record at ten USGS gages in New Jersey. This storm caused the significant flooding in the Raritan and Passaic River basins, and the was the largest flood event in the Raritan basin since Tropical Storm Floyd, in September 1999.

The approximate time distribution of the total rainfall of the 15-16 April 2007 nor'easter over the watersheds of the New York District was an average of 7 to 7 ½ inches between about 2 a.m. on Sunday, 15 April to 2 p.m. on Monday, 16 April 2007, with most within the 24 hours beginning at 2 a.m. on Sunday the 15th. Greatest hourly amounts were from 0.6 to 0.8 inches at about 2 p.m. on Sunday, 15 April 2007.

The storm of 15-16 April 2007 produced the water year 2007 annual peak flow at the following four key USGS stream gages: Passaic River near Chatham, at Pine Brook, Pompton River at Pompton Plains, and Passaic River at Little Falls.

Storm of 11-14 March 2010

Four days of rain, heaviest on the 13th, culminated in major flooding in the Passaic Basin and flooding throughout New Jersey. Four day storm totals averaged around 2.5 to 6 inches with the highest amounts in the Passaic Basin. It was the largest flood event in the Passaic Basin since April of 1984. Periods of rain started during the morning of the 12th and fell at its heaviest on the 13th. The heaviest rain fell during the morning in the southern third of the state, afternoon in the central part of the state and in the afternoon into the evening in the northern third of the state. Periods of lighter rain persisted into the 14th and 15th which slowed the recession of streams and rivers in the area.

Total rainfall amounts received across Bergen County ranged from 2.90 inches in Teterboro to 4.10 inches in Oakland. Total rainfall amounts received across Passaic County averaged to 3.15 inches, 3.17 inches in Wayne and 3.13 inches in Hawthorne.

The storm of 11-14 March 2010 produced the water year 2010 annual peak flow at the following four key USGS stream gages: Passaic River near Chatham, at Pine Brook, Pompton River at Pompton Plains, and Passaic River at Little Falls.

Storm of 27-28 August 2011 (Tropical Storm Irene)

Tropical Storm Irene made its second United States landfall near Little Egg Inlet, NJ, 10 miles east-south-east of Atlantic City, at 5:35 a.m. Eastern Daylight Time (EDT), Sunday, 28 August 2011 as a hurricane, with maximum sustained winds of 75 mph. At 9:00 a.m. EDT, Irene was over New York City and had weakened to a Tropical Storm. Tropical Storm Irene produced between three and thirteen inches of rain on the watersheds within the New York District's civil works boundaries in northern New Jersey and southern New York in about a 16 hour period between about 4 p.m. Saturday, 27 August 2011 and about 8 a.m. Sunday, 28 August 2011, resulting in new flood peaks of record at fifteen USGS gages in New Jersey at Federally built flood control projects and current study sites.

In New Jersey, 39 of the 94 USGS gages with greater than or equal to 20 years of record had record high peaks due to Irene. Thirty-three of these gages experienced peaks equal to or greater than the 100-year recurrence interval (< 1.0% annual exceedance probability). Irene also resulted in new flood peaks of record at the USGS gages Ramapo River at Suffern and Mahwah River near Suffern NY.

The approximate time distribution of the total rainfall of Tropical Storm Irene over the watersheds of the New York District was an average of 5 to 10 inches between about 4 p.m. on Saturday, 27 August to 8 a.m. on Sunday, 28 August 2011. Greatest hourly amounts were between 1 to 2 inches occurring between 1:00 and 2:00 a.m. on Sunday, 28 August, 2011. Tropical Storm Irene rainfall total for the Rahway River basin was approximately 10 inches. Total Irene rainfall over the Passaic and Raritan River basins was approximately 8 inches.

In New Jersey, 39 of the 94 USGS gages with greater than or equal to 20 years of record had record high peaks due to Irene. Thirty-three of these gages experienced peaks equal to or greater than the 100-year recurrence interval (< 1.0% annual exceedance probability). Irene also resulted in new flood peaks of record at the USGS gages Ramapo River at Suffern and Mahwah River near Suffern NY.

The approximate time distribution of the total rainfall of Tropical Storm Irene over the watersheds of the New York District was an average of 5 to 10 inches between about 4 p.m. on Saturday, 27 August to 8 a.m. on Sunday, 28 August 2011. Greatest hourly amounts were from 1 to 2 inches from about 1 to 2 a.m. on Sunday, 28 August 2011. Total Irene rainfall over the Passaic and Raritan River basins was about 8 inches.

Unlike Tropical Storm Floyd, which broke the summer 1999 drought and fell on dry ground, Tropical Storm Irene caused significant flooding because it was preceded by one of the wettest months of August on record, which saturated the ground.

August 2011 was the wettest month on record in New Jersey since record keeping began in 1895. On average, 16.64 inches fell statewide. This is 12.43 inches greater than the 1981 to 2010 monthly average of 4.21 inches and 4.66 inches more than the second wettest month on record, October 2005. Irene produced the water year 2011 annual peak flow at the following four key USGS stream gages: Passaic River near Chatham, at Pine Brook, Pompton River at Pompton Plains, and Passaic River at Little Falls

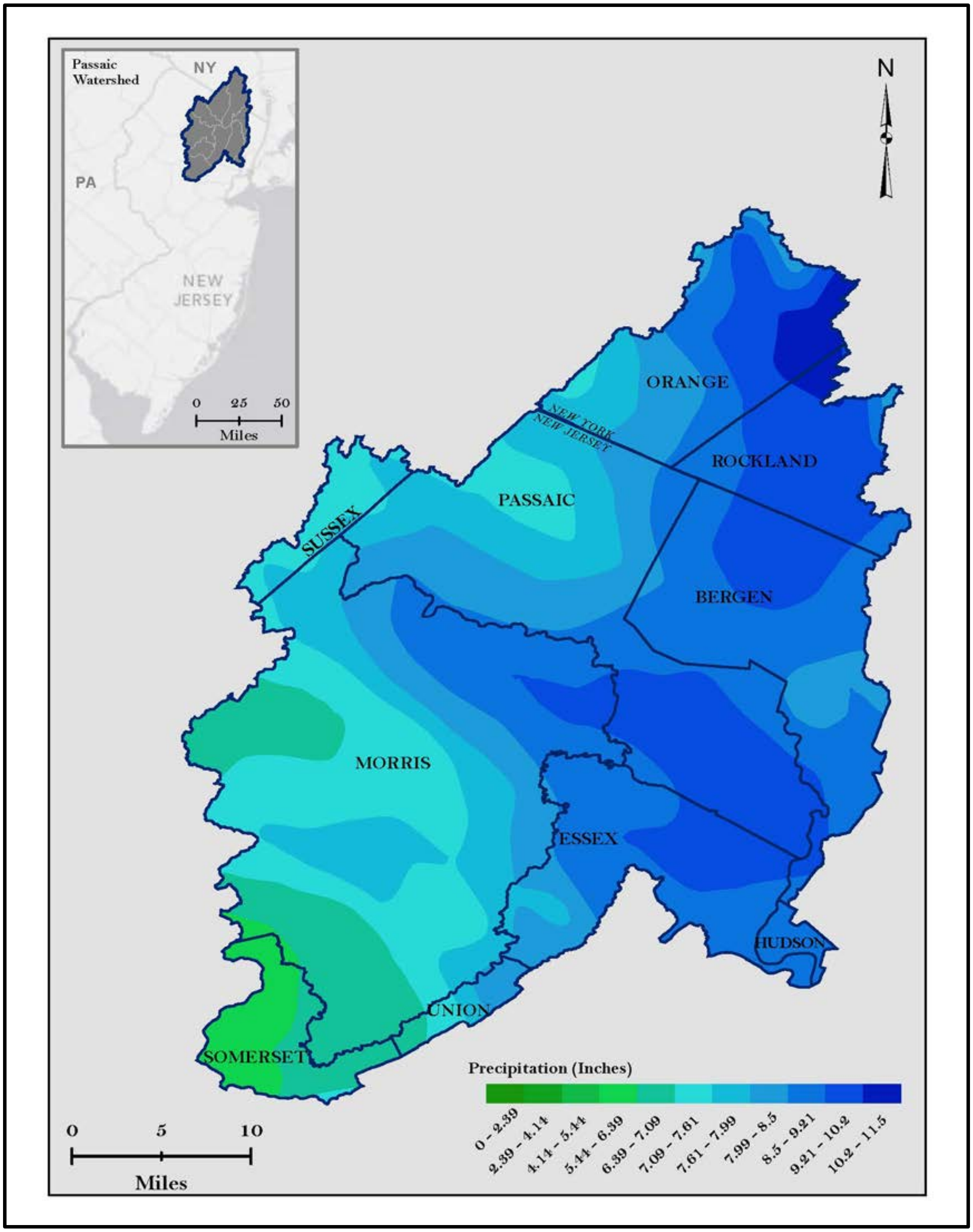


FIGURE 10:
TOTAL RAINFALL DISTRIBUTION WITHIN THE PASSAIC RIVER WATERSHED (TROPICAL STORM IRENE: AUGUST 27 TO 28, 2011)

Storm of 5-6 September 2011 (Tropical Storm Lee)

The remnants of Tropical Storm Lee that interacted with a stalled frontal boundary produced several days with periods of heavy rain across New Jersey from September 5th into the 8th.

Event precipitation totals averaged 3 to 8 inches, with lesser amounts in Atlantic, Cape May and eastern Ocean Counties. The heavy rain caused renewed flooding mainly to the west and northwest of the New Jersey Turnpike corridor with mainly moderate flooding along the main stem of the Delaware River with moderate to major flooding in the Passaic and Raritan Basins.

Showers and thunderstorms from that approaching cold front arrived during the evening and overnight on the 5th and set off the first round of flash flooding rains in Northwest New Jersey. The front then stalled just south of Delmarva on the 6th. A relative lull in the rain then occurred during the morning of the 6th. As the front started to back north into New Jersey as a warm front later in the day on the 6th, more bands of heavier rain returned that afternoon and particularly that evening. A blocking weather pattern then moved the frontal boundary little from the morning of the 7th into the morning of the 8th over New Jersey. Most of the precipitation on the 7th remained west of the state. Heavier rain formed north of the stalled frontal boundary in central and northern New Jersey during the evening of the 7th. A band of showers and thunderstorms with heavier rain then moved across the state during the first half of the day on the 8th. The frontal boundary started to drift offshore on the 8th and little if any Lee related precipitation fell in the state after that morning.

Hydrology Analysis: overview

Existing FEMA HEC-HMS models of the Passaic River watersheds were provided by NJDEP as a means to accomplish the hydrologic analysis required for the subject study. A separate model was furnished for each of the following watersheds: Upper Passaic, Whippany River, Rockaway River, Pompton River (which consist of Ramapo, Pequannock and Wanaque subwatersheds), Central Passaic, Lower Passaic and Saddle River. The current analysis updated input parameters as necessary and calibrated the models to observed flood hydrographs at the many relevant USGS stream gages within each watershed for the August 27 – September 5 2011 (Tropical Cyclone Irene) storm and flood only.

Peak discharge vs. frequency relations for nineteen relevant Passaic River Basin USGS stream gages were developed using the flood frequency analysis option of computer program HEC-SSP (Statistical Software Package) to determine the annual series relations, and several utility programs to determine the partial duration relations. The annual series and partial duration relations were then merged graphically for each USGS stream gage analyzed, to form existing conditions peak discharge vs. frequency relations. The specific frequency hypothetical storm and flood HEC-HMS models of the Passaic River basin were then created. Nine frequencies were modeled.

They were then calibrated to these existing conditions peak discharge vs. frequency relations. These HEC-HMS models used, as their driving input, appropriate hypothetical point precipitation values, obtained from on-line NOAA Atlas 14. The calibration was performed by a trial and error adjustment of initial abstraction (precipitation loss); NRCS curve numbers, and routing parameters within the HEC-HMS models.

For the historic & existing conditions, the upstream boundary locations of the unsteady flow HEC-RAS model were identified as points where the HEC-HMS hydrologic model would have to generate discharge hydrograph for input into the HEC-RAS model. The HEC-HMS model also generated many runoff hydrographs at many locations that were used within the unsteady HEC-RAS model as point inflow and uniform or lateral inflow. Note that there was no need for the hydrologic HEC-HMS model to compute improved conditions flow since those flow changes are captured in the HEC-RAS unsteady model.

For calibrating to Tropical Storm Irene flood hydrograph, both the HEC-HMS model and the unsteady HEC-RAS model computed flow hydrographs at three USGS gages locations (Pompton River at Pompton Plains, Passaic River at Pine Brook, and at Little Falls) which both models had in common. It should be noted that the results of these computed discharge hydrographs within the hydrology section of this report are from HEC-HMS and they will differ a small amount from the discharge hydrographs shown in the hydraulics section, which are based on the unsteady HEC-RAS model results. Also, the HMS model is fully calibrated to the Tropical Storm Irene flood hydrograph, while the unsteady HEC-RAS is only partially calibrated at these three gage locations.

Conclusion of Analysis

A comparison of existing conditions peak flows, as presented in the Passaic River 1995 GDM and this 2013 Preliminary Alternative Reevaluation Report, is shown in Tables 16 (a) & (b) in the Engineering Hydrology Appendix H. The additional years of data used to develop the new peak discharge-frequency curve moved the curve up or down depending on the new data specific to each gage. Hydrologic models were calibrated to the updated peak discharge-frequency curves and generated the values shown in tables as Preliminary Alternative Reevaluation Report existing conditions. Therefore, both increases and decreases in peak discharges are dependent on the additional years of record at the stream gages and are a normal variation associated with hydrologic analysis. Figures 76 and 77 in the Engineering Hydrology Appendix shows the shift in the peak discharge vs. frequency curves, comparing the 1995 GDM results vs. the 2013 Preliminary Alternative Reevaluation Report results, for the Chatham and Pompton Plains gages.

TABLE 3: EXISTING CONDITIONS PEAK FLOWS

USGS Gage Number	Gage Location	Existing Conditions Peak Flows (cfs)											
		2-Year			5-Year			10-Year			25-Year		
		1995 GDM	2013 Phase 1	Change (%)	1995 GDM	2013 Phase 1	Change (%)	1995 GDM	2013 Phase 1	Change (%)	1995 GDM	2013 Phase 1	Change (%)
01379500	Passaic R at Chatham[6]	1,480	1,420	-4.1	1,980	1,940	-2.0	2,450	2,320	-5.3	3,020	2,830	-6.3
01380500	Rockaway R above Boonton Res7.	2,420	1,940	-19.8	3,780	3,420	-9.5	4,590	4,850	5.7	5,970	7,130	19.4
01381500	Whippany R at Morristown	1,220	1,220	0.0	1,560	1,640	5.1	1,880	1,930	2.7	2,200	2,320	5.5
01388000	Ramapo R at Pompton Lakes8	4,300	3,860	-10.2	6,610	6,780	2.6	8,780	9,340	6.4	12,950	13,400	3.5
01388500	Pompton R at Pompton Plains9	7,260	6,780	-6.6	11,650	12,180	4.5	14,720	16,360	11.1	20,160	22,690	12.5
01389500	Passaic R at Little Falls	7,790	7,800	0.1	11,560	11,900	2.9	14,350	15,260	6.3	18,450	20,400	10.6
01391500	Saddle R at Lodi	1,850	2,520	36.2	2,700	3,200	18.5	3,650	3,750	2.7	4,670	4,700	0.6

6 For the Chatham gage, it did not experience the same magnitude of peak flooding as the other gages within the Passaic Watershed (i.e. Tropical Storm Irene) over the past 17 years (1995-2012) of additional data. Therefore, the flows for each return period for the Chatham gage were less than the recorded values noted in the 1995 GDM.

7 For Boonton Reservoir, the 2 year and the 5 year event peak discharge, with 17 years of additional data, was less than the 1995 GDM. The reason for which is that the partial duration analyses at this gage were different during the Phase 1 reevaluation than the 1995 GDM.

8 For Ramapo River at Pompton Lakes, the 2 year event peak discharge, with 17 years of additional data, was less than the 1995 GDM. The reason for which is that the partial duration analyses at this gage were different during the Phase 1 reevaluation than the 1995 GDM.

9 For Ramapo River at Pompton Plains, the 2 year event peak discharge, with 17 years of additional data, was less than the 1995 GDM. The reason for which is that the partial duration analyses at this gage were different during the Phase 1 reevaluation than the 1995 GDM.

USGS Gage Number	Gage Location	Existing Conditions Peak Flows (cfs)								
		50-Year			100-Year			500-Year		
		1995 GDM	2013 Phase 1	Change (%)	1995 GDM	2013 Phase 1	Change (%)	1995 GDM	2013 Phase 1	Change (%)
01379500	Passaic R at Chatham10	3,420	3,260	-4.7	4,020	3,700	-8.0	4,970	4,840	-2.6
01380500	Rockaway R above Boonton Res.	7,060	9,300	31.7	8,670	11,590	33.7	12,130	18,660	53.8
01381500	Whippany R at Morristown	2,530	2,650	4.7	2,820	2,980	5.7	3,640	3,850	5.8
01388000	Ramapo R at Pompton Lakes	15,450	17,120	10.8	19,350	21,500	11.1	31,700	34,820	9.8
01388500	Pompton R at Pompton Plains	24,050	28,610	19.0	29,730	35,270	18.6	42,040	55,050	30.9
01389500	Passaic R at Little Falls	21,990	24,920	13.3	26,050	29,960	15.0	36,280	44,270	22.0
01391500	Saddle R at Lodi	5,270	5,770	9.5	6,430	7,060	9.8	8,760	10,800	23.3

B. HYDRAULICS

Hydraulic Model

Given the highly varying flow conditions experienced by the Passaic River and its tributaries, such as the Rockaway and Pompton Rivers, at major confluences and the large natural storage areas in the Central Basin, such as the Great Piece Meadows and the tidal/coastal influences in the lower reaches of the river, an unsteady hydraulic flow model was best suited to analyze the basin as previously noted. During the Phase 2 GDM in 1995 a HEC-1 basin wide hydrologic model was used to generate to both the interior runoff hydrographs and the boundary flow hydrographs for the smaller UNET study area hydraulic model. For this report, a basin wide HEC-HMS hydrologic model is being used to generate both interior runoff and boundary condition flow hydrographs for a smaller HEC-RAS hydraulic study area model. The HEC-HMS model of the basin includes the Highlands and the Central & Lower Basin while the HEC-RAS model of the study area includes most of the Central & Lower Basin but does not include the Highlands, see Figure 11.

10 For the Chatham gage, it did not experience the same magnitude of peak flooding as the other gages within the Passaic Watershed (i.e. Tropical Storm Irene) over the past 17 years (1995-2012) of additional data. Therefore, the flows for each return period for the Chatham gage were less than the recorded values noted in the 1995 GDM.

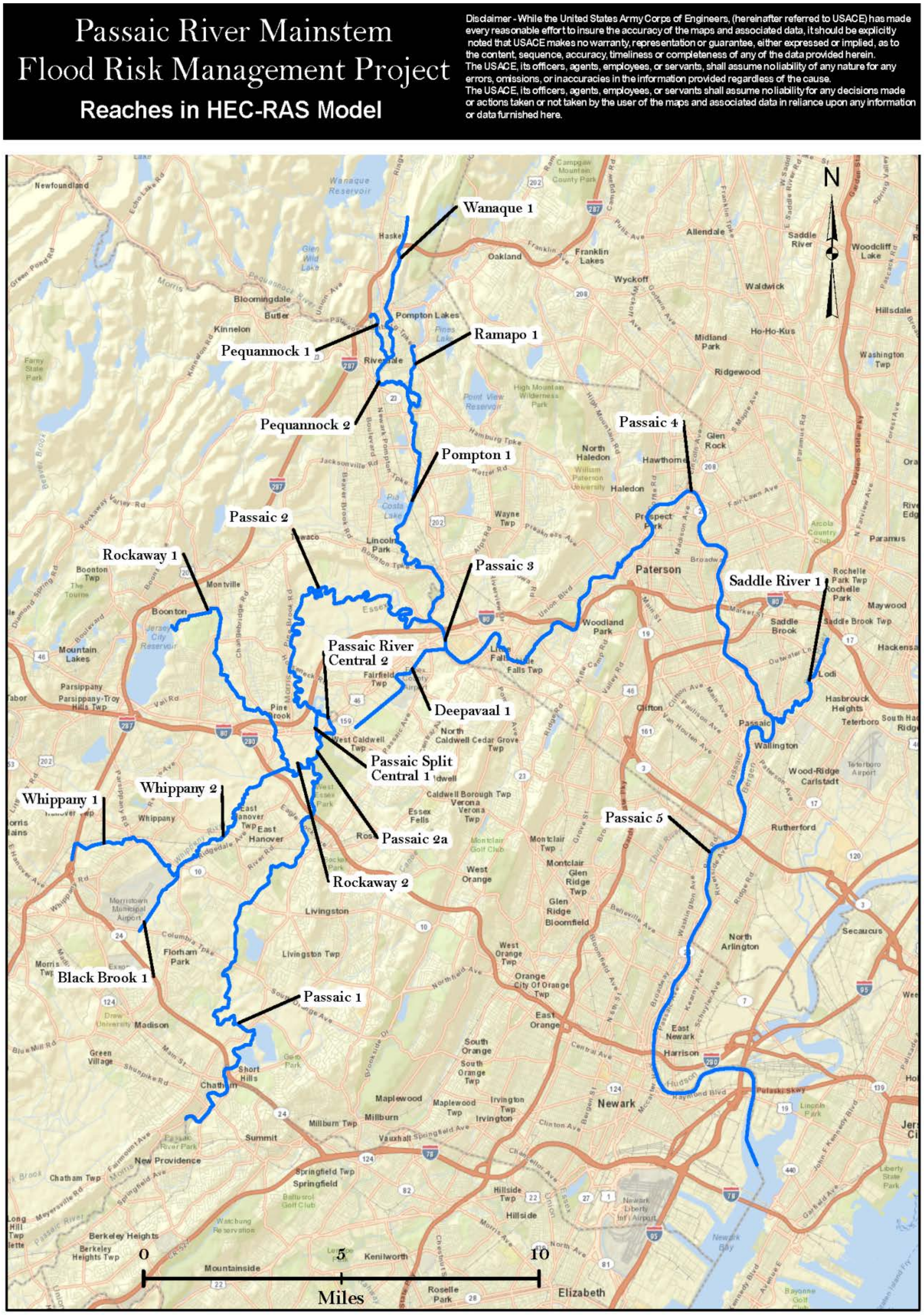


FIGURE 11: HYDRAULIC REACHES

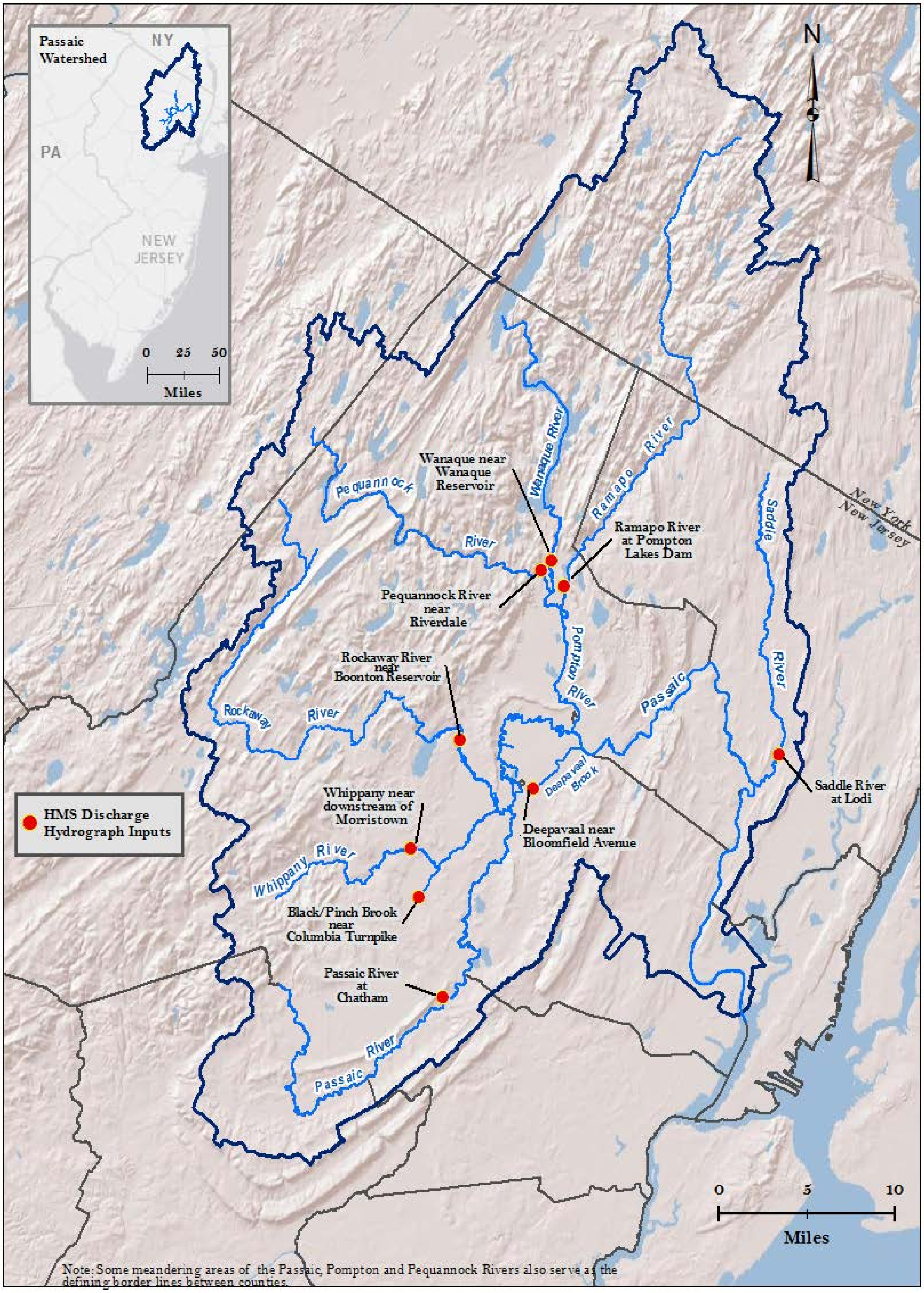


FIGURE 12: LIMITS AND DATA SOURCES -HEC-RAS MODEL

A HEC-RAS unsteady flow model was developed to determine estimated water surface elevations (WSEL) for several rivers in the Passaic River Basin. To maximize the use of available data various current FEMA flood insurance HEC- RAS models, a USACE HEC-RAS model and the UNET model from the USACE 1995 Phase 2 GDM were combined to create a single basin wide HEC-RAS model.

Dr. Michael Gee of the Hydrologic Engineering Center (HEC) converted the original 1995 UNET model into a new HEC-RAS model to which many portions were removed and replaced with newer models. The total basin wide model includes ten rivers (and brooks) for a total length of about 95 miles. The FEMA storm surge model which was to be used to set the downstream "tidal" boundary condition has not yet been provided and was not used as originally anticipated. The tidal (or coastal) boundary condition was set using the observed WSEL at Newark, NJ for Tropical Storm Irene (Aug & Sep 2011). FEMA model cross-sections are often further apart than an USACE model and too widely spaced to accurately model and design improved features such as levees and floodwalls, which could become an issue as the study progresses. Figure 11 shows the names of each reach in the HEC-RAS model. Figure 12 shows the limits and data sources for various portions of the HEC-RAS model.

Model Calibration and Performance Check

Since this basin wide model represents many rivers and was obtained from multiple sources, the range of Manning's "n" values and other model features is fairly diverse and differed throughout the model. The hydraulic model was not fully calibrated at this phase, to a series of flood marks as would normally be done. The model was however, reviewed, checked and adjusted especially to reasonably match flow and stage hydrographs at the four USGS gage locations that were within the limits of the model. Future work will include calibrating the model to a full set of flood marks. The HEC-RAS model's reproduction of the observed gage hydrographs for Tropical Strom Irene (Aug. & Sep. 2011), can be seen in Figures 13-16 below.

Only stage information was available for the Two Bridges gage which was replicated. The Pine Brook gage is located at a point where there are two branches to the Passaic River and priority was given to matching the stage because that is what the gage actually measures and was assumed to be more accurate. It should be noted that peak flows from the Pompton River actually flow upstream along the Passaic River into the Great Piece Meadows in the area of Two Bridges. This flow reversal is well known and was replicated in the model and can be seen in Figures 15 & 17. There was difficulty matching both the stage and flow at the Pompton Plains gage and the flow was matched instead because that better represented downstream flooding conditions.

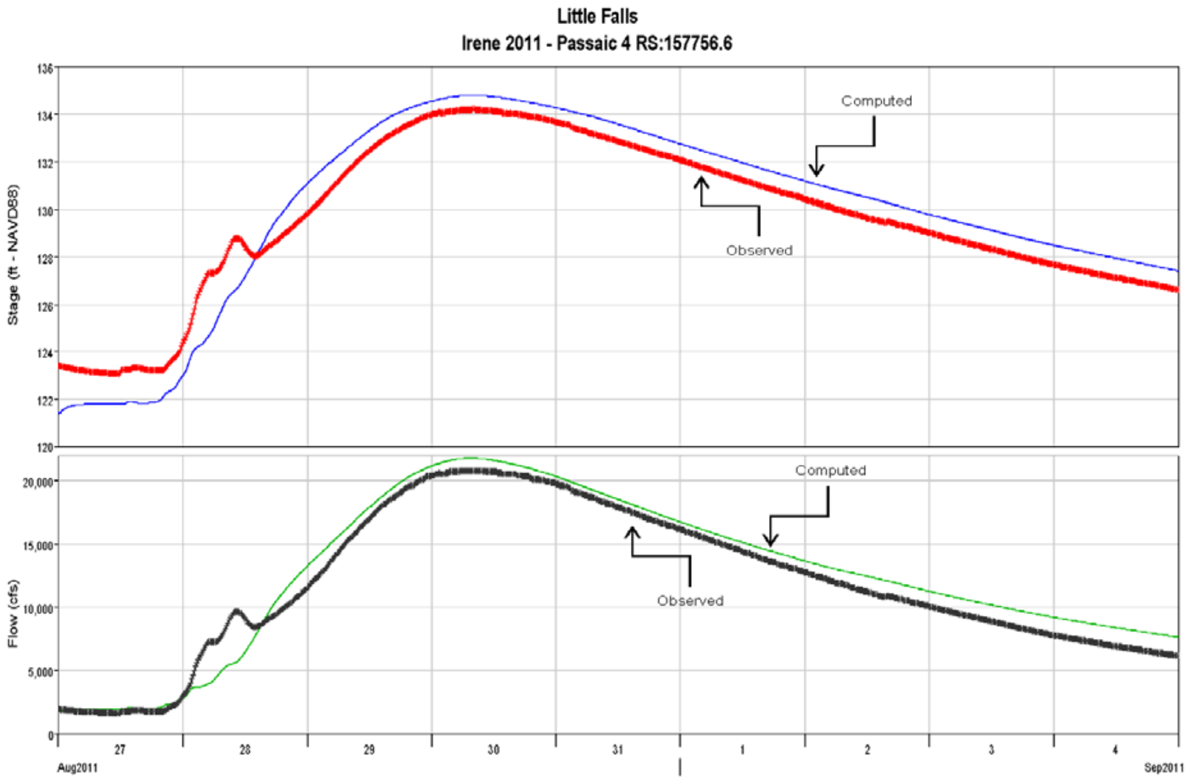


FIGURE 13: FLOW & STAGE HYDROGRAPHS - TS IRENE @ LITTLE FALLS

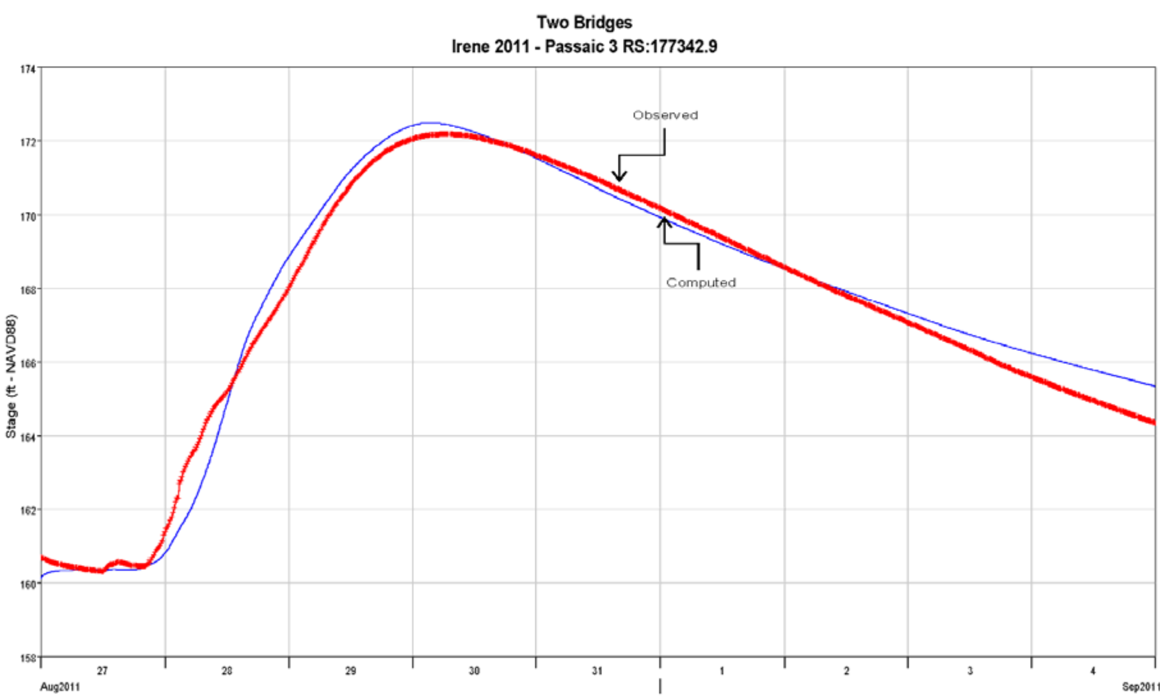


FIGURE 14: FLOW & STAGE HYDROGRAPHS - TS IRENE @ TWO BRIDGES

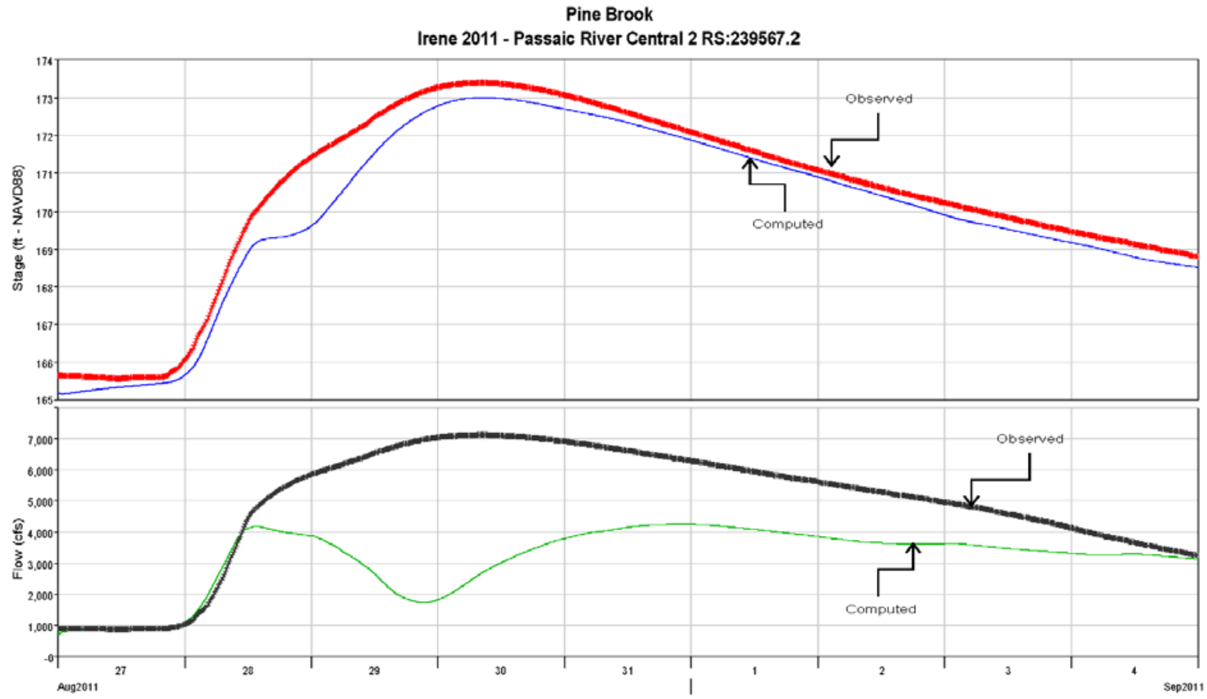


FIGURE 15: FLOW & STAGE HYDROGRAPHS - TS IRENE @ PINE BROOK

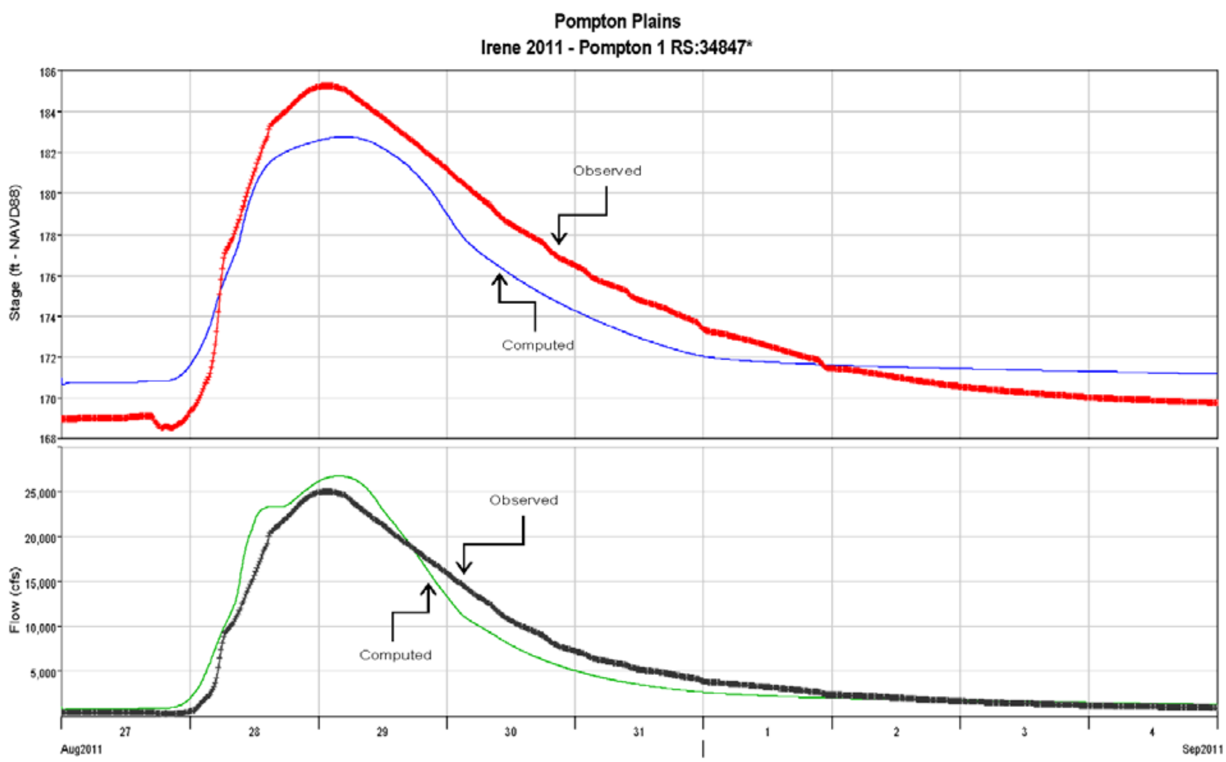


FIGURE 16: FLOW & STAGE HYDROGRAPHS - TS IRENE @ POMPTON PLAINS

Model Hypothetical Production Runs

The downstream boundary condition in Newark Bay for all hypothetical events was set as the observed water surface elevations for Tropical Storm Irene as recorded at the USGS gage in Newark Bay at the Passaic Valley Sewer Commission facility. This event was selected as a boundary condition for all the hypothetical events because it was a very recent event and represented a rare storm with both significant rainfall and storm surge. Several previous studies have indicated that there is little correlation between large rainfall amounts and high storm surge in this area. However, Tropical Storm Irene is a real life example of how a large storm caused both coastal and rainfall flooding and provides a very realistic condition to use for modeling purposes.

Other inflow boundary conditions were obtained from the HEC-HMS model results. These results were used for both internal and external boundary conditions, which were inserted into the HEC-RAS model using HEC-DSS. The upstream inflow boundary conditions were at the following locations: Passaic River at Chatham, Saddle River at Lodi, Deepalvaal near Bloomfield Ave, Ramapo River at Pompton Lakes Dam, Wanaque near Wanaque Reservoir, Pequannock River near Riverdale, Rockaway River near Boonton Reservoir, Whippany River downstream Morristown and Black/Pinch Brook near Columbia Turnpike.

Assumptions Made & Risks Taken During Phase 1

Previous studies and reports were used to determine what items would not be likely to have a significant impact on the results and decisions related to this study. Assumptions, risks and items are listed below:

- The hydraulic model was not fully calibrated to a series of known flood marks.
- A coincidence analysis of the tidal and fluvial interaction was not conducted. Previous studies have indicated that the correlation between the tide and peak river flows is weak. The expected coastal or tidal elevations were not updated because the results of FEMA's coastal surge model were not received. The tidal/coastal elevations have no impact on the majority of the study reaches. Only one sample economic reach is being used in the tidal/coastal areas. The use of observed coastal elevations from Tropical Storm Irene (Aug – Sep 2011) is assumed to be adequate.
- Future conditions were not developed and are assumed to be similar to the present condition.
- A formal H&H sensitivity, risk and uncertainty analysis was not conducted. The continuous years of record at each stream gage was assumed to be the equivalent period of record for HEC-FDA purposes. Since this was an unsteady flow analysis using stage frequency curves, both the flow and stage uncertainties is addressed in HEC-FDA with the use of a period of record and no other specific data is required to address stage uncertainty.
- Sedimentation and erosion was not addressed or analyzed and is assumed to be included in the high cost contingency.

General Results and Findings

The computed water surface elevations (WSEL) can be seen on the profiles in the Hydraulic Appendix, Plates 1-125. These profiles are the results of the unsteady HEC-RAS run and both the peak elevations and the peak flow are shown (it should be noted that the peak elevation and peak flow do not occur at the same time). The fact that the Pompton River peaks before the Passaic River (at their Two Bridges confluence) and then proceeds to flow up the Passaic River channel into the Great Piece Meadows is well known and an important flow reversal to capture in the model.

The incorporation of 17 years of additional rainfall data (which included several significant events) since the 1995 GDM has generally increased the flow estimates for all the hypothetical storms. This increase in flow has resulted in a general lowering in the annual risk of flooding for the project features as designed in the previous reports. The 100 year flows have increased 7% to 23%, the stages have increased 0.3 to 1.3 feet and the annual risk of flooding dropped from 100 year to about a 50 or 60 year. Tables 4-5 below illustrate some of these changes at the two gages located within the HEC-RAS model that are centered in high damage areas. It should be noted that these result are from the HEC-RAS runs and they differ a small amount from the results shown in the Hydrology Section which are based on the HEC-HMS model results.

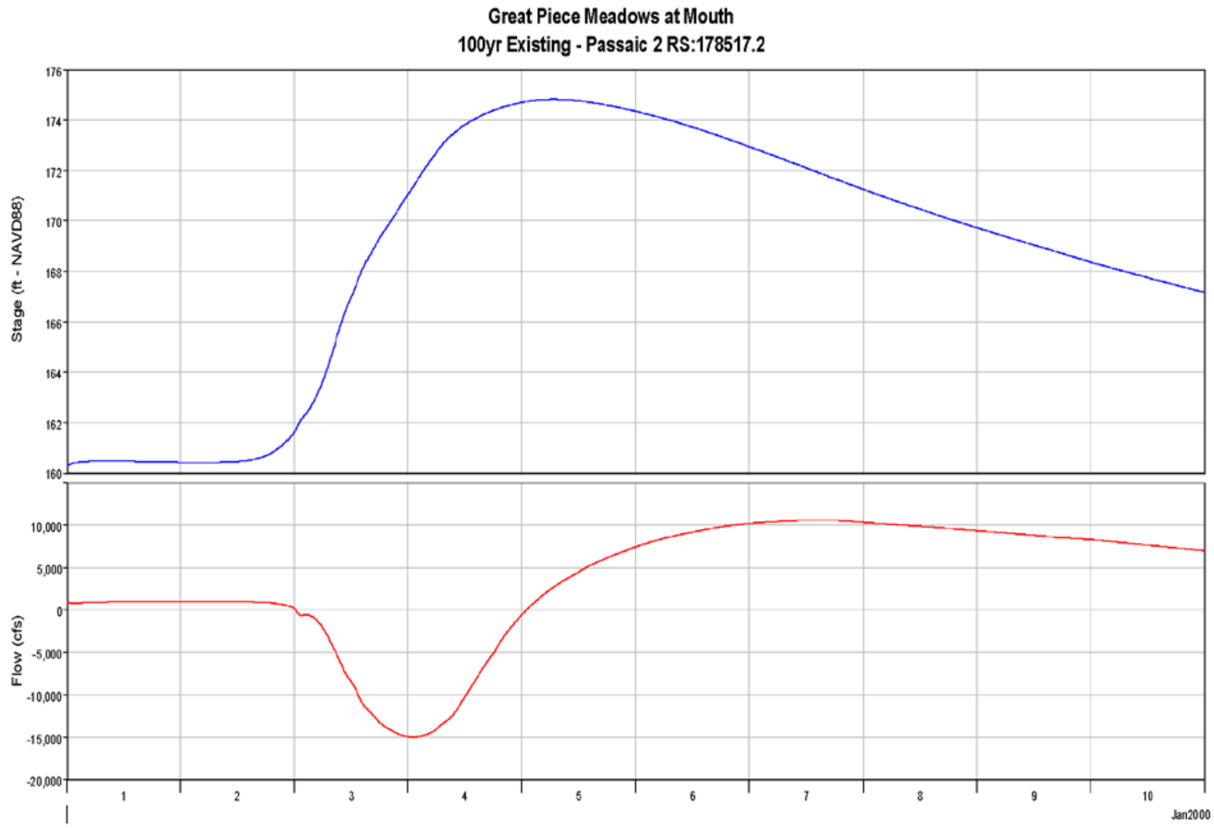


FIGURE 17: FLOW & STAGE HYDROGRAPHS - TS IRENE @ GREAT PIECE MEADOWS 1% EVENT

TABLE 4: WSELS AND FLOW COMPARISON AT LITTLE FALLS

Return Period[11]	1995 Report Flow (cfs)	2013 Report Flow (cfs)	1995 Report Elevation (ft-NAVD88)	2013 Report Elevation (ft-NAVD88)	Difference (feet)
10 year	14,350	14,900	162.0	163.6	1.6
100 year	26,050	28,040	164.8	166.1	1.3
500 year	36,280	40,600	166.8	167.9	1.1

TABLE 5: WSELS AND FLOW COMPARISON AT POMPTON PLAINS

Return Period	1995Report Flow (cfs)	2013Report Flow (cfs)	1995 Report Elevation (ft-NAVD88)	2013 Report Elevation (ft-NAVD88)	Difference (feet)
10 year	14,720	17,250	180.9	179.5	-1.4 *
100 year	29,730	38,821	184.2	184.5	0.3
500 year	42,040	59,118	186.1	187.1	1.0

*See "Model Calibration" on page 7 of the H&H Appendix H for additional analysis explanation.

The return periods and annual exceedance values of the water surface elevations (WSEL) at the tidal/reaches were not specifically addressed, especially since the FEMA coastal model results are still not available. Nevertheless, the model study results and observations during Tropical Storm Irene indicate that storm surges impact WSELs up to but not above Dundee Dam.

The computed water surface elevations (WSEL) were supplied to the economic members of the design team.

C. ENVIRONMENTAL EXISTING CONDITIONS

Feasibility level reports, such as a General Re-evaluation Report (GRR), must include National Environmental Policy Act (NEPA) documentation and Decision, and consultation and compliance with Federal, state and local environmental agencies laws and regulations, as well as public review by interested parties and stakeholders (NEPA 1969, as amended). In addition, to comply with NEPA, analysis of all relevant data which is either readily available or reasonably attainable is required to complete the NEPA analysis. The environmental documentation for the Phase 1 Report broadly discusses the environmental resources as identified in the previous Passaic Main Stem reports. This phase of the study does not include any NEPA analyses, documentation or Decisions. The Phase I Report includes a review of historical and current natural resource data to identify existing conditions as it relates to the Alternatives.

Environmental Resources

11 Return Period is defined as an estimate of the likelihood of an event, such as flood or a river discharge flow to occur. It is a statistical measurement typically based on historic data denoting the average recurrence interval over an extended period of time.

Existing environmental resources in the study area were identified based on a review of the two prior feasibility phase documents USACE produced in 1987 and 1995. The 1987 report focused on the existing conditions of the Basin and the 1995 report focused on the potential environmental effects upon implementation of the selected plan. A desktop literature search since 1995 was also conducted to identify changes to the environmental conditions.

The environmental documentation for this Phase I Report, broadly and generally discusses the environmental resources as identified in the previous reports regarding the four Alternatives, 14A, 16A, Newark Outlet Tunnel Alternative, and Two Bridges Beatties Dam (minus the No Action and the nonstructural Alternative, which has not yet been identified) , with a minimal update based on a desktop literature review . The update to the environmental section for this report will be to identify the applicable data from the 1987 Feasibility Report (USACE 1987) and 1995 General Design Memorandum (USACE 1995) reports as may be relevant to the current study of the Passaic River Basin and to identify other sources of available data and data gaps with which to update the existing conditions for this report. This update is not intended to initiate or complete any rigorous technical analyses or NEPA compliance and documentation, including formal consultation with federal and state regulatory agencies..

The first environmental review component entailed reviewing reports prepared in 1987 and 1995 to view the structural alignments currently proposed for Alternatives 14A, 16A, Newark Outlet Tunnel Alternative, and Two Bridges Beatties Dam, and then determine what environmental resources may be impacted by those alignments, particularly any resources not previously identified. Literature searches were also conducted to identify any research that has been conducted by others since the 1995 Report. . The District did not conduct an environmental review for the non-structural alternative, as the design elements of that alternative are not identified.

The basic footprint of each of the four alternatives reviewed and their respective structural elements were overlain onto Google Earth maps of the Passaic River Basin. From there, it was possible to identify where the structures were and the types of environmental resources adjacent to or potentially affected by each structural alternative. Assessments of the alternatives were limited to desk-top topographical views available on Google Earth, and other desk-top applications, with no field-based “ground-truthing” of those environmental features undertaken. .

Applicable environmental data from the 1987 and 1995 Reports are summarized below.

1987 Feasibility Report

Water Quality and Resources - Lower Valley

Water quality in the Passaic River basin is poor and often does not meet water quality standards. The river is tidal up to the Dundee Dam and estuarine up to the Belleville Ave Bridge in Belleville, approximately 9 miles. The tidal portion of the Passaic River is classified as FW2-NT/SE2 (fresh water-non trout/saline estuarine waters) from Dundee Dam to the confluence of the Second River where it becomes SE3 (saline estuarine waters) to its mouth at Newark Bay.

Fish were sampled in the tidal segment of the Passaic River from Newark Bay to Dundee Dam during 1981. Of special note are anadromous fish, which utilize this river, albeit in small numbers. The low population is likely due to the limited amount of habitats, because of the relatively short reach of the river which-is free flowing, and because of the high amount of pollutants. The species found in 1981 included: Alewife (*Alosa pseudoharengus*), Blueback Herring (*Alosa aestivalis*), American Shad (*Alosa sapidissima*), Striped Bass (*Morone saxatilis*), and White Perch (*Morone Americana*). Additionally, in a survey conducted from 1971 to 1973 Rainbow Smelt (*Osmerus mordax*) were also captured. In the Passaic River, the most numerous adult anadromous species collected were Alewife, followed by White Perch, Blueback Herring, and Striped Bass. Blueback Herring were the most widely distributed species, found at six locations, while White Perch was found at five locations, Alewife at four locations and Striped Bass at two locations.

Benthic samples were only taken in the lower portion of the tidal reach during 1971 to 1973. The species diversity was limited; with only eight species recovered during transect sampling. Oligochaete worms were the most numerous type (class) with 3 taxa observed.

Water Quality and Resources -Central Basin

The Central Valley portion of the Passaic River is classified as FW2-TP(C1) (fresh water-trout production) from the source to, but not including, Osborn Pond near Basking Ridge, NJ and FW2-NT to Dundee Lake Dam. The water quality of the Central Passaic Basin is considered poor. In general, the fishable and swimmable goals are not met due to low dissolved oxygen (DO} and high Biochemical Oxygen Demand (BOD}, nutrients, ammonia, and fecal coliform levels. The relatively higher quality water of the Pompton River improves the water quality of the main stem at the confluence, but the reach downstream of the confluence is degraded by intervening point sources.

Fish were sampled at five sites (two in 1976, three in 1980) in the reach between South Orange Avenue Bridge on Route 510 in Livingston and Two Bridges. Analysis of the sampling results indicated that this reach of the Passaic River was severely stressed. Only ten species were observed, of which only nine were collected. The range was from eight species at Route 10, East Hanover to four species at Two bridges. Including the two additional species observed (Yellow Bullhead [*Ameiurus natalis]* and Brown Bullhead [*A. nebulosus]*) at Two Bridges, the average site yielded six species. This indicated poor species diversity. Further sampling revealed a lack of higher predators. Of the ten species observed, American Carp, White Sucker (*Catostomus commersonii*) and Golden Shiner (*Notemigonus crysoleucas*) were found at each sample site. American Carp dominated the catches by both number and total weight. Additionally, goldfish (*Carassius* spp.) and Spotted Shiner (*Notropis hudsonius*) were found at four of the five sites. Panfish were collected at only two sites and observed at another.

Benthic invertebrates were also sampled in 1980. Results indicate poor diversity, with only two families present; Diptera and Lumbriculida.

Water Quality and Resources Highlands Area

The Wanaque, Pequannock, Ramapo, and Rockaway Rivers are mostly contained within the Highlands area. The Pequannock River has the highest water quality and is a stocked trout fishery. The water qualities of these rivers were generally considered good to excellent and in compliance with water quality standards. Water quality tended to degrade the closer it was to the mainstem of the Passaic River. The rivers were classification ranged from FW1-TP to FW2-NT depending on the specific area.

These rivers contain balanced warmwater and coldwater fisheries. Fishes observed included: Tessalated Darter (*Etheostoma olmstedi*), Fallfish (*Semotilus corporalis*), White Sucker, Rockbass (*Ambloplites rupestris*), Redbreast Sunfish (*Lepomis auritus*), Bluegill (*Lepomis macrochirus*), Pumpkinseed (*Lepomis gibbosus)*, Smallmouth Bass (*Micropterus dolomieu*), Largemouth Bass (*M. salmoides*), Brown Trout (*Salmo trutta*), Yellow Bullhead, Common Shiner (*Luxilus cornutus*), and Creek Chub (*Semotilus atromaculatus*). Benthic macroinvertebrates were broad in diversity and normally include dipteran larvae, mayfly nymphs, stonefly nymphs, caddisfly larvae, beetle larvae, amphipods, polycepods, and gastropods.

Wildlife Resources - Lower Valley

The general lack of large undisturbed or undeveloped tracts of terrestrial habitat in the lower basin limits the composition of the wildlife to human-tolerant species found in urban settings. Native wildlife such as the raccoon (*Procyon lotor*), eastern gray squirrel (*Sciurus carolinensis*), eastern cottontail rabbit (*Sylvilagus floridanus*), and opossum (*Didelphis virginiana*) still exist, but population numbers are very low, with human-tolerant species present in disproportionately high numbers. Avian species consist mainly of common varieties such as European Starling (*Sturnus vulgaris*),Common Grackle (*Quiscalus quiscula*), House Sparrow (*Passer domesticus*), Northern Cardinal (*Cardinalis cardinalis*), American Crow (*Corvus brachyrhynchos*), doves (*Columbidae* spp.), and Blue Jay (*Cyanocitta cristata*).

Species which require more seclusion and special habitats, such as some warblers, tanagers and most raptors, have been eliminated, although American Kestrels (*Falco sparverius*) still occasionally inhabit the area. Large mammals such as the White-tailed Deer (*Odocoileus virginianus*), which requires multiple cover types, large quantities of food and freedom from human harassment, have been extirpated from the study area. Urban encroachment into the floodplains has severely affected both amphibians and reptiles. Loss of ground cover has destroyed the moist microclimate amphibians need to survive. Food loss for both amphibians and reptiles through habitat destruction has further reduced their populations.

Wildlife Resources - Central Basin

The Central Basin contains the majority of the wetlands that occur within the study area. Wildlife observed within the Central Basin had the greatest abundance and diversity within the wetlands. The Central Basin discrete wetlands vary functionally as wildlife refuges because of variations in their vegetation types, their relative sizes, fluctuations in water levels, impacts caused by development, soils, and ambient wildlife population levels. Although it is difficult to integrate these variables to rank the overall productivity of these wetlands, it can be inferred, based on species numbers found during the 1979 field surveys , that the 2,390- acre Troy Meadows wetland is the most significant wetland from a wildlife habitat perspective. It had the greatest numbers of overall species sighted ((ex. reptile, bird, and mammal) , the most endangered and threatened faunal species and the highest habitat suitability indices (using the Habitat Evaluation Procedure's criteria) of all the wetlands analyzed. It also had the least fluctuation in flood water levels, the greatest percentage of open wetlands with shrubby or herbaceous habitats, and standing water was found over larger areas and for greater lengths of time than in the other Central Basin wetlands (USDOI 1979).

Great Piece Meadows, covering 4,125 acres, 4,005 acres of which are wetland (the largest wetland), had the second highest species total in the 1979 survey (USDOI 1979). Extreme fluctuations in flooding levels may be responsible for the reduced wildlife resource occurrence, therefore, lowering its productivity (USDOI 1979). Hatfield Swamp, covering 1,775 acres, ranked third in productivity. It has additional value owing to its location between Great Piece and Troy Meadows. Hatfield swamp is a critical migration and dispersal link.

Within the study project area, there are nine significant wetlands: Black Meadows, Bog and Vly Meadows, Great Piece Meadows, Hatfield Swamp, Troy Meadows, Canoe Brook wetlands, Hatfield swamp-South, and the Pequannock-Ramapo confluence wetlands. Long Meadow is the smallest wetland, of approximately 200 acres. It is the most vulnerable to development and has been greatly diminished and fragmented. The report noted that while Long Meadow had a high potential for development; it has not been developed.

Wildlife Resources - Highlands Area

Wildlife resources within the Highlands Area were not discussed in the 1987 Feasibility Report.

Vegetation - Lower Valley

Since most of the land in the Lower Passaic River Basin is urban, most of the vegetation that exists is classified as upland cover types of an urban nature. Only a small amount of native natural vegetation remains in the lower basin. Wetlands, once commonly found in the floodplains, are now almost all gone, having been filled and developed. The extremely dense development in the lower basin of the Passaic River has diminished and degraded its environmentally sensitive areas.

Vegetation diversity is mostly found in the parks and includes; American sycamore (*Platanus occidentalis*), sugar maple (*Acer saccharum*), Norway maple (*Acer platanoides*), silver maple (*Acer saccharinum*), sweet gum (*Liquidambar styraciflua*), white ash (*Fraxinus americana*), yellow poplar (*Liriodendron tulipifera*), dogwood (*Cornus* spp.), American birch (*Betula* spp.), red oak (*Quercus rubra*), black oak (*Quercus velutina*), pin oak (*Quercus palustris*), white oak (*Quercus alba*), hickories (*Carya* spp.), Norway spruce (*Picea abies*), Allegheny blackberry (*Rubus allegheniensis*), arrowwood (*Cornus* spp.), touch-me-not (*Impatiens* spp.), staghorn sumac (*Rhus typhina*), poison ivy (*Toxicodendron radicans*), common elderberry (*Sambucus canadensis*), and various ferns (*Pteridophyta*), grasses and sedges.

The portions of the potential project area consisting of wetland cover types are small and isolated, although all three types of palustrine wetlands are found: emergent (28 acres), scrub/shrub (20 acres), and forested wetlands (36 acres). Emergent wetlands occur in the Kearny area near the mouth of the Passaic River, as well as in small pockets at the river's edge in upstream parks. Scrub-shrub wetlands include red maple saplings, gray birch, pin oak, and silky dogwood. Shrub-scrub ground cover includes poison ivy, Virginia creeper, and wild rose. The palustrine forested wetland area within this basin typically includes in its overstory mature red maples; willows; pin, red, and white oaks; river birch and slippery elm. Understory species such as hazelnut, ironwood, and dogwoods will occur. Ground cover in palustrine wetlands typically includes ferns, mosses, and vines.

Ninety-seven acres of estuarine and 34 acres of riverine wetlands are found along the Passaic River in the Lower Valley. Estuarine flats and adjacent emergent grasses exist below the Second River. Riverine tidal flats are found from the Second River to the Dundee Dam. The zone of emergent grasses at the water's edge represents potential areas of food sources and cover for larval fish, which could include anadromous fish.

Vegetation- Central Basin

Within the Central Basin are many of the wetlands found within the Passaic River Basin: Great Piece, Troy, Black, Long, and Bog and Vly Meadows, Great Swamp National Wildlife Refuge, Hatfield Swamp, and Canoe Brook Wetlands. Typical vegetation found in the wetlands include: reed grass (*Phragmites australis*), reed canary grass (*Phalaris arundinacea*) cattails (*Typha spp.*), river bulrush (*Scirpus fluviatilis*), goldenrod (*Solidago spp.*), smartweed (*Polygonum spp.*), multiflora rose (*Rosa multiflora*), blackberry (*Rubus spp.*) poison ivy (*Rhus radicans*), jewelweed. (*Impatiens biflora*), and clear weed (*Pilea pumila*), as well as scrub-shrub communities, mixed hardwood and oak tree communities.

Vegetation - Highlands Area

The 1987 Feasibility study specifically did not discuss vegetation within the Highlands Area. The Pequannock and Ramapo Confluence Wetlands as well as the Bog and Vly Meadows are actually within the Highlands Area however they were discussed within the Central Basin with the other wetlands. Vegetation in the Highlands would be similar to that of the Central Basin.

Threatened and Endangered Species

A literature and herbaria search was conducted to determine the existence of Federally designated or nominated endangered or threatened plant species in the Passaic River Basin. No designated nominated species were discovered. Similarly, no New Jersey rare or endangered plants were found in the study area. With the exception of potential incidental occurrences associated with the migratory patterns of the Bald Eagle (*Haliaeetus leucocephalus*) and Peregrine Falcon (*Falco* peregrines), there are no Federally designated endangered or threatened animal species known to inhabit the Passaic River Basin.

During surveys for the 1987 report at least seven of New Jersey's endangered species occurred in the Passaic River Basin. They included the Blue-spotted Salamander (*Ambystoma laterale*), Tremblay's Salamander (*A. laterale-jeffersonianum*), Bog Turtle (*Glyptemys muhlenbergii*), Pied-billed Grebe (*Podilymbus podiceps*), Cooper's Hawk (*Accipiter cooperii*), Northern Harrier (*Circus cyaneus*) and the short-billed marsh wren (*Cistothorus stellaus*), Wood Turtle (*Glyptemys insculpta*), Osprey (*Pandion haliaetus*), Great Blue Heron (*Ardea herodias*), Red-shouldered Hawk (*Buteo lineatus*), Barred Owl (*Strix vari*a), Bobolink (*Dolichonyx oryzivorus*) and Savannah Sparrow (*Passerculus sandwichensis*). Five of these State-endangered species were found in the Central Basin during 1979 field surveys.

One species, the American Shad (*Alosa sapidissima)*, classified by the State of New Jersey as threatened, is found in the Lower Valley.

1995 General Design Memorandum

Congressional authorization of the recommended Passaic River Project extended the project's tunnel outlet from an upriver terminus to Newark Bay. As a result, the 1995 GDM included a Supplemental EIS. The 1995 report focused on mitigation measures as the engineering designs were further refined. Scoping meetings were held in 1993 to gain public input in the identification of environmental issues resulting from the relocation of the tunnel outlet to Newark Bay and other plan modifications to the recommended plan. Additional data was gathered when necessary particularly in the Newark Bay due to the change in the tunnel outlet. The 1995 Supplemental EIS indicated the Federally listed endangered Indiana bat (*Myotis sodalis*) is known to occur in the Passaic River Basin. In February 1993, an Indiana bat hibernacula was identified in Morris County by USFWS and New Jersey Department Fish Game and Wildlife personnel. Indiana bat hibernates in caves and abandoned mine shafts from October to April, depending on climate conditions. In the summer of 1995, post lactating female Indiana bats were discovered within the Passaic River Basin, confirming the presence of breeding Indiana bats in the area.

Current Existing Conditions

A literature search for data since the 1995 GDM yielded results mostly from work the USEPA, USACE and Cooperating Parties Group (CPG) have conducted along the lower 17-miles of the Passaic River as part of the Lower Passaic River Superfund Investigation and Restoration Project. Extensive data collection efforts have occurred to inventory and assess existing conditions of fish, benthic invertebrate and avian communities and habitat during 1995, 1999, 2000 and 2003 through 2012. The NJDEP has also conducted benthic and fish surveys within the Passaic River Basin. Those publications are listed in the literature cited section. The Passaic River Coalition and Great Swamp Watershed Association had no new data pertinent to this study.

In general, the quality of the Passaic River and its resources has improved since the heavily polluted times of the 1960's. However, the biological communities within the Lower Basin (lower 17 miles of the river) are still considered highly degraded and unacceptably impacted by contamination in the river. Review of more recent data collected from 1995 through 2012 illustrated an increase in species diversity for fish (~ 27 species), birds (~40 species) and benthic invertebrate communities as compared to surveys conducted in 1987 and 1995. Detailed information will be presented in the Phase 2 Report.

There is a strong public desire to access the water for recreation in the water or just on the banks. Some projects have addressed that desire to be closer to the water such as: Joseph G. Minish Passaic River Waterfront Park and Historic Area, Riverbank Park in Newark, and Passaic Riverside County Park in Bergen County which includes a boat dock. In addition, the Lower Passaic River & Saddle River Alliance Canoe and Kayak Trail Action Plan outlines recreational access points planned from Pompton River (RM32) to the confluence with Newark Bay and up the Hackensack River (Lower Passaic River & Saddle River Alliance, 2007).

Cultural Resources

As an agency of the Federal Government, USACE has certain responsibilities concerning the protection and preservation of historic properties. The federal statutes regarding these responsibilities include Section 106 of the National Historic Preservation Act of 1966, as amended, Executive Order 11593, and the Advisory Council on Historic Preservation Procedures for the Protection of Historic and Cultural Properties (36 CFR Part 800). Section 106 requires Federal agencies to take into account the effect of any undertaking on any historic property included on, or eligible for inclusion on, the National Register of Historic Places (NRHP). The work undertaken for this phase was not intended to result in the completion of the Section 106 process in accordance with the National Historic Preservation Act, as amended nor satisfy a complete review or consideration of effect under the National Environmental Policy Act. The objective of this phase of study was to review the data gathered as part of the previous Passaic Main Stem and other studies conducted within the Passaic Basin, to update the potential for the identification of historic properties with the study area as part of this study's existing conditions.

Cultural resources work in conjunction with the preparation of this phase was limited in scope . The first study component entailed reviewing reports prepared under the 1987 and 1995 General Design Memoranda to determine if any areas then surveyed lie within the alignments now proposed for Alternatives 14A, 16A, Newark Outlet Tunnel Alternative and Two Bridges/Beatties Dam and then to determine within those locations, what, if any resources, were previously identified. This work also serves to highlight areas that were not previously subject to a survey. Research included a review of other USACE studies in the Passaic River Basin and an examination of existing digital databases held by the New Jersey Historic Preservation Office (NJHPO). Little of the archaeological data held by the New Jersey State Museum has presently been considered for the Passaic Main Stem study as a data sharing agreement has yet to be signed. This will be included as part of the next phase. No detailed research into primary material such as historic maps or deeds was undertaken nor were published works on county and local histories consulted at this time. Work on the Newark Outlet Tunnel Alternative was particularly cursory as there is currently legislative language restricting the use of funds for design or construction of the tunnel element. No work was undertaken at this time for the non-structural alternative as no specific structures have been proposed for this treatment.

The gathered data was entered into the project's Geographic Information System (GIS) to provide a preliminary sensitivity assessment. Maps depicting known historic resources within the study area were created. Basic footprints of project alternatives were also overlain on Google Earth maps to assist in the assessment of potential impact areas. Site assessments, when conducted, were limited to views available on Google Earth as no fieldwork was undertaken.

Previous Studies under 1987 and 1995 GDMs

During the previous feasibility and GDM phases of the Passaic River study, cultural resource surveys were conducted that identified a number of resources eligible for inclusion in the NRHP and areas sensitive for archaeological resources, which were not tested at that time. In general, with regard to cultural resources, it is recommended that proposed project plans be modified to avoid or minimize any impacts to eligible resources. As avoidance may not always be possible and as large tracts of land within the GDM study had not yet then been surveyed, a Programmatic Memorandum of Agreement (PMOA) was developed and signed in 1993 by the Corps, the NJHPO, the Advisory Council on Historic Preservation and interested parties. Interested parties to the agreement included the New Jersey State Archaeologist, Passaic County Historian, Newark City Historian, Pompton Lakes Historical Commission, Wayne Township Historical Commission, Canal Society of New Jersey, Archaeological Society of New Jersey and the Roebling Chapter of the Society for Industrial. The PMOA outlined the course of study the Corps would follow as the project went forward in identifying cultural resources, evaluating their NRHP eligibility, determining effects and mitigating for impacts. Although out of date, sections of the PMOA will be useful for the current work.

The 1987 Feasibility Study report proved to be almost devoid of cultural resources information and provided no useful data. Historic resources were clearly not a focus of study at that time and were deferred to the future.

The 1995 study focused largely on the Newark Outlet Tunnel Alternative. Although, not a focus of the current study, the Newark Outlet Tunnel Alternative proposed plan however includes sections of levees, floodwalls, and channel modifications some of which overlap with Alternatives 14A, 16A and Beatties Dam/Two Bridges. Selected pieces of the levees and floodwalls proposed under Newark Outlet Tunnel Alternative was subjected to cultural resources surveys and therefore provide useful data for the current Preliminary Alternative Reevaluation plan effort. Most of the then proposed levee and floodwall alignments, however, were not surveyed.

Identified Historic Properties (1995)

At the confluence of the Passaic and Pompton Rivers, in the vicinity of Two Bridges, are three Native American sites: Sites 28-Ex-23, 28-Mr-156, and 28-Mr-157. The Passaic/Pompton confluence area also contains locations where geomorphic analysis and fieldwork indicated that unidentified archaeological sites may be present. Most of the confluence area has a high to moderate potential for Native American site preservation (Rutgers University Center for Public Archaeology [RUCPA] and Historic Conservation and Interpretation [HCI] 1995; Hartwick, Mueller and Cavallo 1995). Historic period properties identified in the Two Bridges area were the Two Bridges Road Bridge, Truss Bridge, the Budd/Campbell House, Ryerson House Site, Van Ness/Dormus House Site, and the Dey/Post House Sites. Research and testing was advised at these historic house sites. It was also noted that the entire parcel north of the Passaic River on either side of Two Bridges Road lying between the Pompton River confluence and the northward bend in Two Bridges Road should be subject to additional research and archaeological testing (RUCPA and HCI 1995; Bzdak and Howson 1995).

As an element of the Tunnel Alternative, the Passaic Levee #10 was tested for archaeological resources and a NRHP-eligible Native American archaeological site was discovered within the bounds of the proposed levee. The site, designated Site 28-Ex-78, is located on a terrace which projects westward into the wetlands adjoining the Passaic River (Perazio and Joire 1993; Cavallo, Ashley and Rakos 1994).

Other Corps Cultural Resources Studies for the Passaic River and Tributaries

There are over a dozen individual on-going or completed Corps studies in the Passaic River Basin most, if not all, have associated cultural resource studies. These works include Lower Saddle River, Long Hill Township, Jackson Brook, Malapardis Creek, Ramapo River at Mahwah/Suffern, Joseph Minish Waterfront Park, Floodway Buyout, Ramapo River at Oakland, McKeel Brook, South First Street Floodwall at Harrison, Lower Passaic River Restoration Project, Hudson Raritan Estuary Ecosystem Restoration, Upper Rockaway River, Upper Passaic River, Peckman River, Goffle Brook, and other small studies/projects. To date there are almost 30 reports prepared for the Corps within the Passaic River Basin. Several of these studies are directly within or adjacent to the Passaic Main Stem Area of Potential Effect (APE) including the Joseph Minish Waterfront Park in Newark, the South First Street Floodwall in Harrison and the Lower Saddle River in Wallington and Garfield. The other Corps studies provide useful background material.

Perhaps the study most relevant to the current work is the cultural resources sensitivity study of the entire Passaic River Basin prepared for the Corps by the New Jersey State Museum (Williams, Rutsch and Flinn 1978). The overall goals of the sensitivity study were: 1) to compile a record of known archaeological resources; and 2) to predict the nature and significance of sites which may exist in the study area. Based upon physiographic, archaeological and historical data the potential for prehistoric and historic occupation of the three zones of the Passaic River Basin (Highlands, Central Basin and Lower Valley) was analyzed. For both prehistoric and historic periods, the Central Basin and the Lower Valley (downstream of Little Falls) zones were predicted to have the highest potential for occupation, with more limited potential indicated for the Highlands zone.

At the time of this analysis prehistoric archaeological research in the Passaic River Basin had been biased toward plowed fields along watercourses and against more inaccessible and vegetation-covered upland and swamp sections. Historic sites then recorded were overwhelmingly those with at least some above-ground features intact. As the authors indicate, the predicted relative potential for prehistoric and historic utilization of the three zones must be considered only suggestive given the biases manifest in the available data. The data allowed an assessment of areas with high probability for existence of archaeological sites (i.e., prehistoric sites at rivers' confluences and historic mill sites at waterfalls) but the data were not useful for identifying areas likely not to contain archaeological sites. For example, it is suggested that certain kinds of terrain such as steep slopes have a low probability of human occupation, but there is a lack of archaeological survey data to empirically demonstrate an absence of sites in sampled areas of such terrain.

In the Lower Valley zone many prehistoric and historic archaeological sites have undoubtedly been destroyed by more recent urban and industrial development. Others have been buried beneath alluvial deposits and/or landfill. Isolated prehistoric sites may still exist in this zone in relatively undisturbed pockets of the landscape, such as parks and residential estates. Any sites which remain are extremely valuable as they offer our only empirical evidence for prehistoric occupation of the Lower Valley.

The Central Basin zone which includes the Great Piece Meadows, Hatfield Swamp and the confluence of the Whippany, Rockaway and Pompton Rivers with the Passaic combines high potential for Native American and historic occupation. While some destruction has likely occurred, much of the area is less affected by development than is the Lower Valley zone. A coincidence of prehistoric and historic sites can be expected to occur in the vicinity of stream confluences and along the higher ground crossing or along the fringes of marshes.

This 1978 cultural resources sensitivity assessment was followed up by the Corps in 1983 with a rudimentary GIS based predictive model study for the Central and Lower Passaic River Basin (Bodie and Klein 1983). Acknowledging there were issues with the methodology used to develop their models, the report notes that 10% of their study area is highly sensitive for prehistoric as well historic resources and overall 90% of the study area was determined to be at least moderately sensitive. The authors state that very little, if any, of the study area can be legitimately eliminated from further survey on the basis of having no cultural resources present. The recommendations note that Native American sites may be found in areas considered “disturbed” such as areas containing fill and such areas should be tested. Also recommended is that deep testing occur in areas with thick alluvial deposits and in poorly drained areas.

The Corps’ Lower Saddle River study identified three NRHP-eligible properties at the river’s confluence with the Passaic River and within the proposed alignments of the Passaic Main Stem features (MAAR Associates 1991). The Hamersley Manufacturing Co., Garfield/Hemming Manufacturing Co. and Zabriskie’s Dock, a log wharf along the right bank of the Saddle River but adjacent to the Passaic, which may extend along the Passaic shoreline. This location was also the site of an 18^{th} century community that included mills, dams and docks.

The studies associated with the Joseph Minish Waterfront Park project identified several NRHP-eligible or listed resources including the New Jersey Railroad & Transportation Company/The Hudson & Manhattan Passaic River Bridge Sites and the Morris Canal Lock 18E. These resources were addressed in a Memorandum, of Agreement (MOA) signed by the Corps. Should impacts from the Passaic Main Stem be anticipated to resources that were not mitigated during the park’s construction the existing MOA will provide useful guidance. The South First Street Floodwall study identified several historic resources in Harrison including the Guyon Factory wall and the Otis Elevator Building (Panamerican Consultants, Inc. 2004). Recent redevelopment of the Harrison waterfront might have destroyed these resources.

The Hudson-Raritan Estuary (HRE) Ecosystem Restoration Feasibility Study, on-going by the Corps, recently produced a draft Programmatic Environmental Impact Statement (PEIS) which includes a GIS database of all resources documented by the NJHPO within the HRE study area, some of which overlaps with the Passaic River Main Stem Study. This work included digitizing the archaeological site data held by the New Jersey State Museum. A number of archaeological sites are present along proposed Passaic Main Stem alignments.

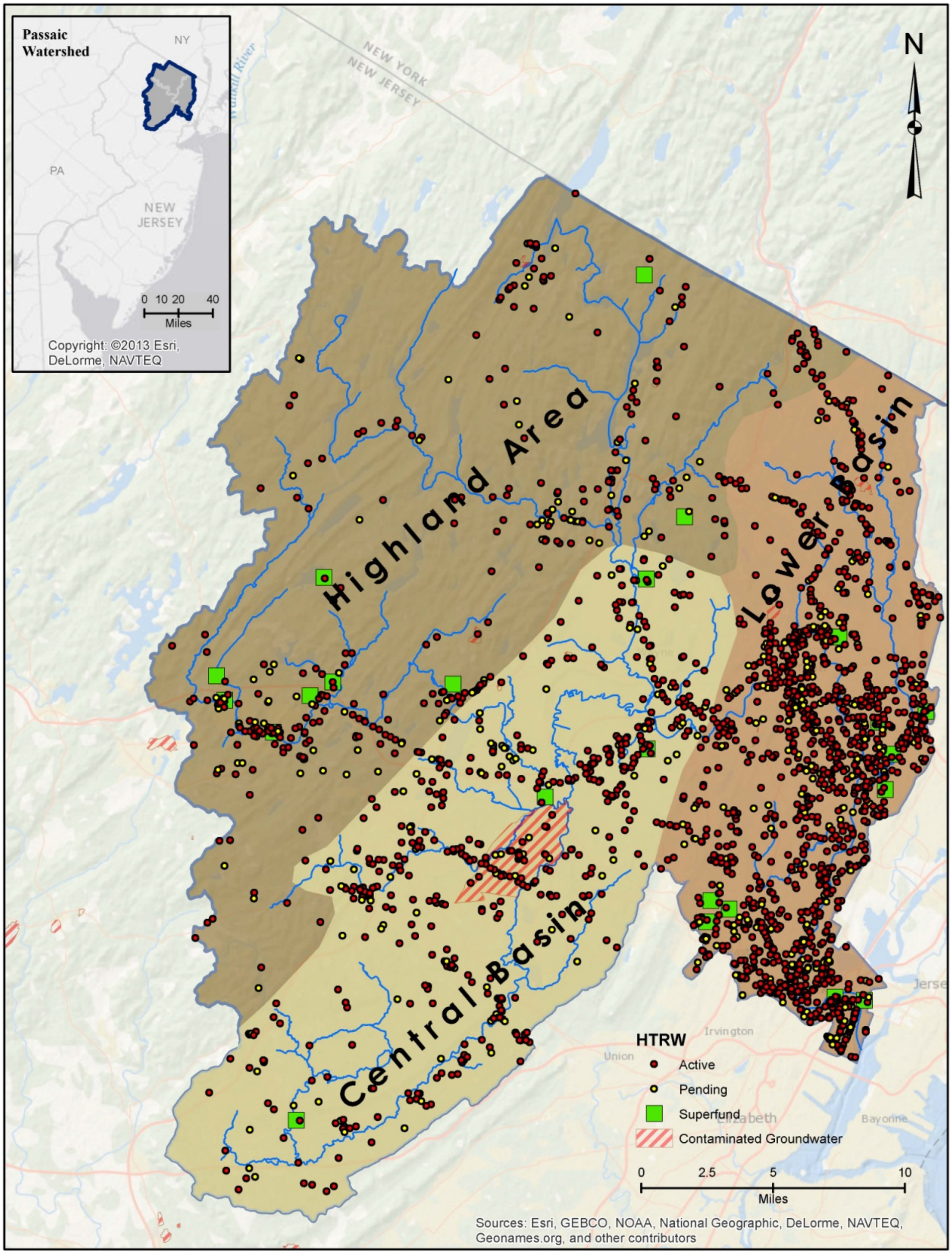
Other Resources

Alanson Skinner and Max Schrabisch conducted surveys of New Jersey's Native American sites in the early 20th century mainly through interviews with farmers about finds in their plowed fields and with collectors. They recorded numerous sites along the Passaic and its tributaries although some of the site location data is vague and it is likely many sites have been destroyed by development. The Indian Sites Survey directed by Dorothy Cross under the auspices of by the Works Progress Administration, built on these earlier surveys and identified dozens of Native American sites in the vicinity of proposed Passaic Main Stem alternatives. The work was particularly focused in areas that had not been urbanized so the preponderance of sites identified within the Passaic study area are in the Central Basin near the Great Piece Meadows at the confluence of Passaic and Pompton Rivers.

A unique resource and one likely to be a challenge should Alternative 16A channel modifications go forward, are the stone fish weirs in the Passaic River. These fish weirs are considered to be of Native American construction and are believed to have been used seasonally in the entrapment and harvesting of anadromous fish. At least eleven such features were identified in the Passaic River by Skinner and Schrabisch. Two weirs clearly remain in the Paterson-Fairlawn vicinity and have been subjected to further research and limited field studies (Lutins and DeCondo 1999). The remains of other fish weir sites may be present along the river.

Significant resources along the Passaic include numerous sites in the City of Paterson. A stretch of the city along the Passaic River has become the Paterson Great Falls National Historical Park. Much of the area near the Great Falls has been designated a National Natural Landmark, National Historic Landmark and Historic Civil Engineering Landmark. Within the Great Falls of Paterson/Society for Useful Manufactures Historic District are many contributing resources both archaeological remains and extant structures. Of particular concern for work along the river banks are the intakes and outfalls of the historic raceways that powered the mills. The resources in Paterson will present interesting challenges as the project proceeds.

As per recent NJHPO database search the proposed alternatives intersect several linear listed or eligible historic districts (US Routes 1 & 9, Pulaski Skyway, and several railroad alignments). It is anticipated that there will be no impacts to these districts as the work generally will not directly affect the resources and visual impacts will be minimal. Proposed plans also intersect, in more than one location, with the linear Morris Canal Historic District requiring that effects to the district be evaluated. Individually eligible or listed resources include many bridges over the Passaic. Of the three bridges currently proposed for direct modification the Eighth St-Locust Avenue Bridge has been determined eligible for the NRHP. The eligibility of the other bridges is not known at this time. The Dundee Canal Historic District sits on the bank of the Passaic and impacts to it will need to be assessed. The Little Falls Hydroelectric Facility and Little Falls Water Treatment Plant were determined eligible for the NRHP in 1984. Beatties Dam is within the historic district and is a contributing element. The dam itself may be individually eligible although it has been altered over time. The Little Falls Water Treatment Plant was also determined eligible. Other significant resources line the banks of the Passaic.



Hazardous, Toxic and Radioactive Wastes

The purpose of this section is to review the potential Hazardous, Toxic and Radioactive Waste (HTRW) concerns identified in the 1987 and 1995 reports and to review the current databases to determine if these issues are still extant in the Basin as well as identify other issues that have developed since 1995 to provide an initial indication of potential effects and update cost estimates. No fieldwork has been conducted at this phase of the analysis.

In accordance with Corps guidance, the local sponsor is responsible for the management and costs associated with any remedial actions associated with CERCLA contamination at sites affected by project construction.

The Passaic River Basin, particularly from Little Falls and Paterson's Great Falls, downstream to the confluence of the Passaic with Newark Bay (29 miles) has been the location of industrialization since the late 18^{th} century. Industry was founded along this stretch of the river because of the water power from the Great Falls. Throughout the 19^{th} and early 20^{th} centuries, it became an industrial center, with manufacturing complexes, textile mills, and refineries. Two hundred years of industry and population growth has made a tremendous impact within the Basin. This manufacturing legacy is now represented by numerous contaminated sites throughout the study area, the majority of which are concentrated in the Lower Basin. Contaminated sites within the Basin range from gasoline stations, machine shops, textile manufacturing, dye houses, heavy manufacturing/assembly, auto repair shops, dry cleaners and home-owners heating oil tanks leaking into the groundwater. Other sites include sites on the National Priority List (NPL), Comprehensive Environmental Response and Liability Act (CERCLA) or Superfund sites and NJDEP Known Contaminated Sites (KCS).

1987 GDM and EIS

The EIS identified 50 NPL and CERCLA Information System (CERCLIS) sites within the 100-year floodplain. It noted most were outside areas of construction, eliminating 42 areas because they were beyond the limits of the areas anticipated to be impacted by the construction of the tunnel alternative. The remaining eight, all within the Lower Basin, were targeted for close coordination with the USEPA and NJDEP and special construction planning (Table 6). The remediation of two of the sites, Sherwin-Williams and Benjamin Moore have been completed, but noted a concern existed regarding the potential residual contamination (USACE 1987 EIS 72-73).

TABLE 6: EIGHT SITES IDENTIFIED IN THE 1987 EIS (USACE 1987: TABLE 11)

Site Name	City
GAESS Environmental Services	Passaic
Diamond Shamrock (Occidental Chemical)	Newark
Sherwin-Williams	Newark
Benjamin Moore	Newark

Conrail Meadows Yard	Kearny
S&W Waste	Kearny
Modern Transportation	Kearny
BASF Wyandotte (Badische)	Kearny

The Diamond Alkali Superfund Site listed on the National Priority List (NPL) was identified in Newark in 1984. A remediation plan for containing the contaminated materials at the site had been selected. The plan consisted of the demolition of the standing buildings, capping the rubble with an impermeable cover, and the construction of a slurry wall that would girdle the site along with a riverside floodwall built to the Corps' specification to protect the site against flooding. It was anticipated that the remediation of the dioxin contamination at this site would be completed prior to construction. The EIS also noted the presence of dioxin-contaminated sediments in the river, relating to the Diamond Alkali site. It anticipated that the NJDEP would remediate the dioxin contamination at this location prior to the construction of the proposed project alternative (USACE 1987 EIS-74).

The sites and data presented in the report was limited to CERCLA and NPL sites. There was no identification of other types of sites present within the Highlands, Central and Lower Basins. Impacts were limited to the elements related to the flood tunnel and its various features primarily within the Lower Basin.

1995 GDM and Supplement to the EIS

Investigations for HTRW at this phase involved field investigations at the tunnel inlet and outlet locations, one proposed levee location and several proposed shaft locations, in addition to a records and database search of the proposed project area. These investigations identified project features, including tunnel shafts and the outlet, that have the potential to encounter contaminated material. In general, the report noted that there were numerous sites within the 100-year floodplain and tunnel alignment. As part of the authorized plan, non-regulated and non-hazardous contaminated excavated soil would be reused on-site in accordance with NJDEP. Hazardous soils would be managed in accordance with NJDEP regulations (USACE 1995:SEIS-19).

The supplement also provided a risk analysis on the potential for occupational exposure to contaminated soil, groundwater or surface water during construction. It also indicated an evaluation of the requirements for special handling of contaminated soils regarding disposal and/or reuse (USACE 1995:SEIS-56).

The evaluation of the data identified several features that would require additional investigations during the design phase to characterize the contamination. These features include: 1) Workshafts 2A, B and C and 3; 2) the Pinch Brook, Doremus Avenue, Kearny Point, Lister Avenue, and Newark Bay Levee Systems; 3) the Great Piece Weir; and 4) the Pequannock River Channel modifications (USACE 1995:SEIS-57).

Review of Sites

The sites identified in the 1987 and 1995 reports still appear on the various databases and lists for known contamination. For example, S and W Waste, Inc. in Kearny, a Commercial Resource

Conservation Recovery Act (RCRA) site, is the focus of a multi-phase remedial action, which includes groundwater remediation . BASF in Kearny has undergone limited remediation efforts in 1990 and 2005 and continues to have an unknown or controlled discharge to the soil and/or groundwater. The Sherwin Williams site in Newark initiated remediation in 1989 with the remediation of underground storage tanks (UST) in 2002 and 2004. The site summary an ongoing multi-phased remedial action with unknown or uncontrolled discharge to the soil and groundwater. Currently, Sherwin Williams, BASF, Benjamin Moore are being addressed under NJDEP cleanup programs (including Brownfields).

As part of this research, the NJDEP data base of Known Contaminated Sites (KCS) and the USEPA CERCLA site lists were reviewed to update any areas of concern throughout the Basin. Approximately 325 active sites, 44 pending and 47 NJDEP contaminated groundwater sites are located in close proximity to the Passaic River within the Highlands, Central and Lower Basin.

The KCS, located throughout the Basin range from gasoline stations, auto repair shops and residences with leaking underground home heating oil tanks, to larger manufacturing complexes and machine shops. Approximately 24 Active, four Pending and three NJDEP contaminated groundwater sites were identified in the Highlands area. The Central Basin has approximately 133 Active, 17 Pending and 25 NJDEP contaminated groundwater sites. The majority of sites were identified in the Lower Basin, including 168 Active, 23 Pending and 19 NJDEP contaminated groundwater sites.

There are a few additional superfund sites in the area within close proximity to the alignment of multiple alternatives. These sites include the recently (May 2013) named Riverside Industrial Park in Newark (~RM6.5), White Chemical Corp in Newark, Standard Chlorine in Kearny (directly adjacent Kearny Point) and Diamond Head Oil in Kearny.

There are three Superfund Sites (Diamond Alkali, Syncon Resins and the Sharkey Landfill) directly within the alignment which should be highlighted. Diamond Alkali and Syncon Resins are located in the Lower Basinand the Sharkey Landfill is located in the Central Basin.

Sharkey Landfill

The Sharky Landfill consists of five separate fill areas comprising a total of approximately 90 acres in and adjacent to the Rockaway and Whippany Rivers and the Parsippany-Troy Hills Wastewater Treatment Plant in Parsippany-Troy Hills and East Hanover in the Central Basin. The site began operating in 1945, accepting municipal, commercial, industrial and hazardous waste materials until 1972. It was listed on the NPL in 1983. The remedial design was completed in 2000 and construction activities were completed in 2003. Operation and maintenance activities are currently conducted on the site (USEPA 2011a).

Syncon Resins

The Syncon Resins site consists of approximately 15 acres on a peninsula at the confluence of the Hackensack and Passaic Rivers. The site is comprised of 13 building and two unlined lagoons, bulk storage tanks, underground storage tanks and two chemical reactor buildings. The site also contained approximately 12,800 55-gallon drums which were removed between 1982 and 1984. Syncon Resins produced alkyd resin carriers for pigments, paints and varnishes. The unlined lagoons were used for wastewater, after excess xylene and toluene were separated out. The wastewater was left to evaporate or percolate into the soil. Currently, the USEPA has assumed lead responsibilities for site activities and is working with the USACE Kansas City District to perform sampling and evaluation activities at the site. As of 2010, partial funding has been provided to start remedial design activities (USEPA 2011b).

Diamond Alkali

In 1984, the Diamond Alkali site at 80 Lister Avenue was included on the NPL and designated a Superfund site by USEPA. By 2001, an interim containment remedial action consisting of capping, subsurface slurry walls, and a groundwater treatment system was completed. In 1994, Occidental Chemical Corporation (OCC), the property owner, agreed to investigate a six-mile stretch of the Lower Passaic River, under USEPA oversight. The sampling results from this investigation showed that sediments contaminated with hazardous substances move into and out of the six-mile stretch, leading USEPA, in 2002, to expand its investigation to include the entire 17-mile tidal stretch of the Passaic River, from Dundee Dam to Newark Bay.

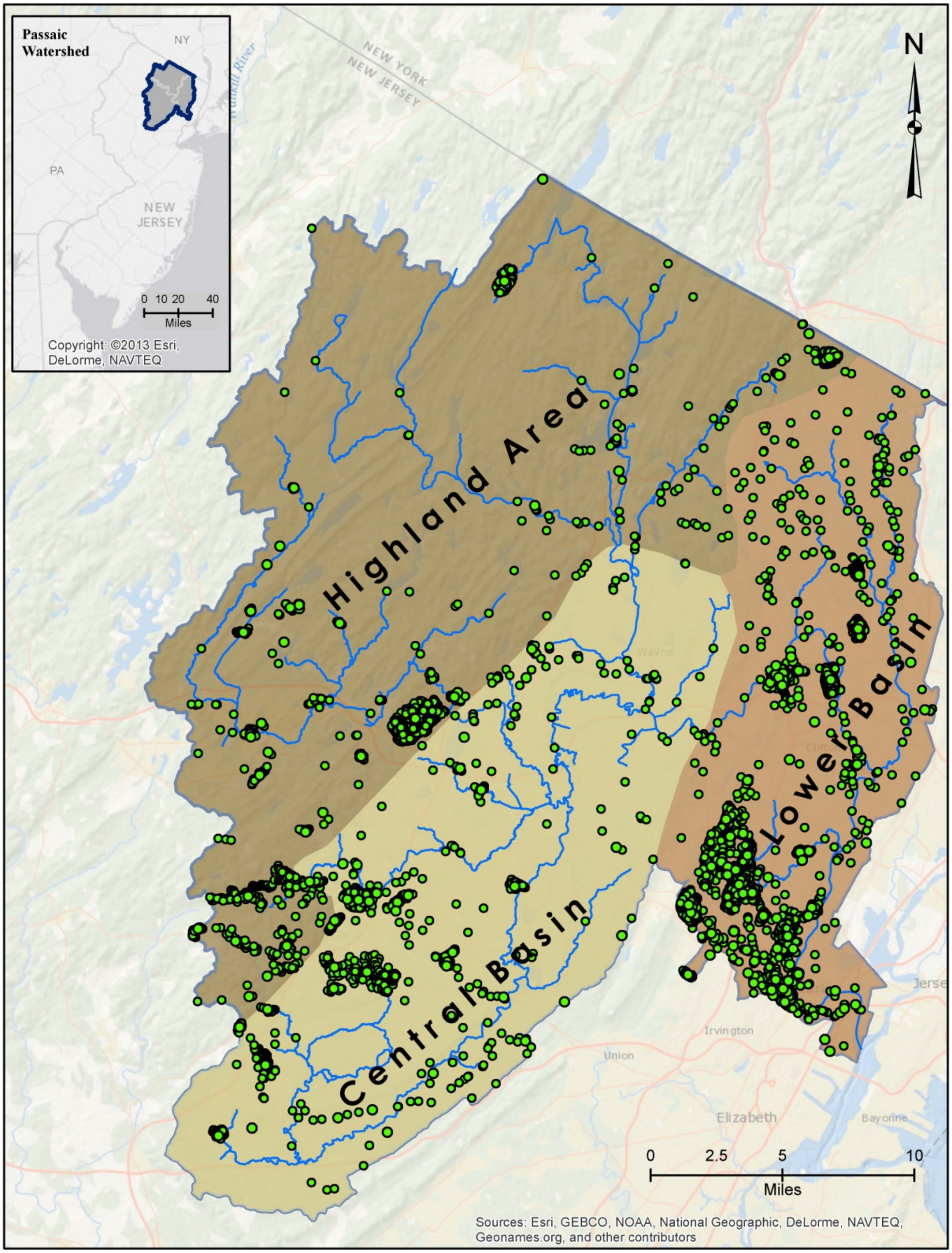
Concurrently, the USACE (New York District) began a feasibility study evaluating the restoration opportunities within the Lower Basin. In recognition of the coincidental study areas and the related roles and responsibilities of the USEPA and the USACE, along with the project sponsor, the New Jersey Department of Transportation (NJDOT), the agencies integrated their individual investigations into a single, comprehensive, cooperative effort. They formed a partnership with the Natural Resources Trustees (National Oceanic and Atmospheric Administration [NOAA], United States Fish and Wildlife Service [USFWS] and NJDEP) to conduct a joint study that would bring each agency's legal authorities to bear on the complex environmental problems of the Lower Passaic River.

Between 2004 and 2005, USEPA signed agreements with the Cooperating Parties Group (CPG), a group of over 70 companies potentially responsible for discharging a wide variety of contaminants into the Lower Passaic River, for them to fund and perform the Superfund component of the Lower Passaic River Restoration Project.

As the 17-mile study progressed, USEPA decided to pursue early remedial actions, which were subsequently segmented into the following four distinct initiatives: 1) USEPA/Tierra Removal Action; 2) USEPA Time Critical Removal Action at River Mile (RM) 10.9; 3) USEPA Potential Early Action Focused Feasibility Study (lower 8-miles); and 4) the Comprehensive 17-mile Remedial Investigation/Feasibility Study (Figure 18).

USEPA completed the Phase 1 Tierra Removal Action in 2012 consisting of the removal of 40,000 cubic yards (cy) of the most contaminated sediment and capping adjacent the Diamond Alkali facility (RM 3). As part of the Phase 2 Tierra Removal Action, the remaining 160,000 cy, awaits a renegotiated Administrative Order of Consent (AOC) between USEPA and Tierra Solutions. USEPA has also initiated a Time Critical Removal Action at RM 10.9 with the Cooperating Parties Group. In August 2013, removal and capping of ~20,000 cy of contaminated sediment within the top 2-ft of mudflat/river bottom was initiated adjacent to Riverside County Park in Lyndhurst, NJ.

USEPA also plans to release the Final Focused Feasibility Study (FFS) proposing an early remedial action within the lower 8.3 miles of the Passaic River within 2014. The proposed remedy will likely include a combination of dredging and capping. The dredging depth is dependent on current and future navigational use (USACE, 2008, revised July 2010) and flood modeling (USEPA 2007), followed by capping bank to bank. The completion of the 17-mile study will identify any further remedial actions to be taken by USEPA.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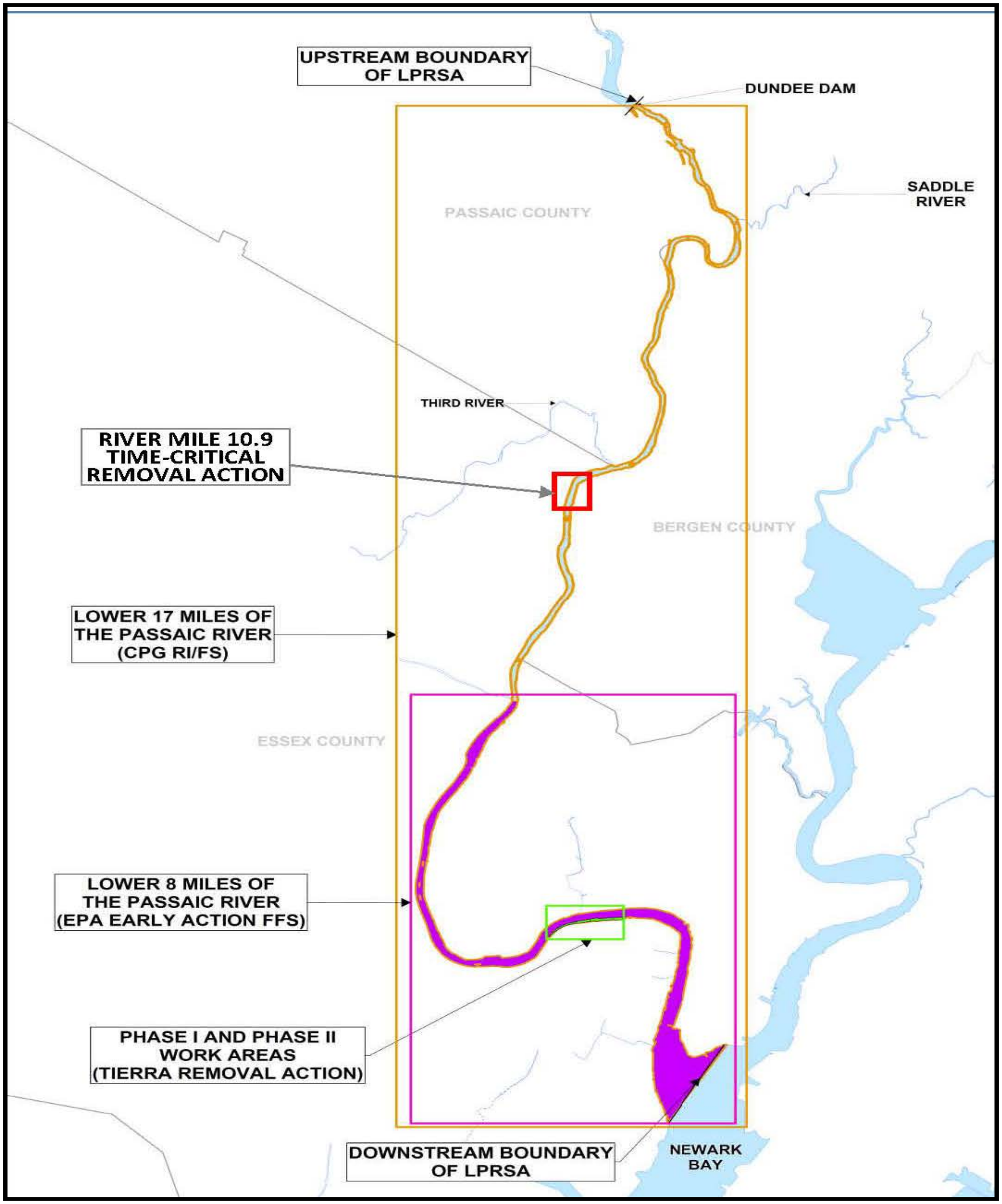

FIGURE 18: LOCATIONS OF THREE USEPA COMPLETED OR PROPOSED EARLY REMEDIAL ACTIONS ASSOCIATED WITH THE DIAMOND ALKALI SUPERFUND SITE, LOWER PASSAIC RIVER RESTORATION PROJECT STUDY AREA.

D. ECONOMIC EXISTING CONDITIONS

Purpose and Scope

The objective of the Preliminary Alternative Reevaluation phase of the Passaic River Main Stem Study is to determine whether there exists an economically justified alternative to reduce the risk of flood damage in the Passaic River Basin. Specifically, this phase of the study aims to determine whether structural and non-structural alternatives as formulated in the original 1987 feasibility report are likely to be economically justified if built in full compliance with current design standards.

The Preliminary Alternative Reevaluation phase involved estimating expected annual flood damages for the baseline without-project condition for the whole study area for comparison against damages expected with the various alternatives in place to determine the flood damage reduction benefits. Damages have been developed by extrapolating the results of the detailed analysis of 11 sample reaches to the remainder of the study area.

Location and Setting

The study area encompasses the 0.2% annual chance of exceedance (ACE), or "500-year" floodplain, along the Passaic River and its main tributaries in Morris, Essex, Passaic, Bergen, and Hudson Counties in northern New Jersey. The study area is divided into three basins for the purposes of the Preliminary Alternative Reevaluation phase of the study:

- Lower Passaic: Reaches on the Passaic River and minor tributaries downstream of Little Falls in Passaic County.
- Central Passaic: Reaches on the Passaic River upstream of Little Falls and downstream of the City of Summit in Union County, and those reaches on the Rockaway and Whippany Rivers.
- Passaic: Reaches on the Pompton, Pequannock, and Wanaque Rivers

The basins are divided into a series of economic reaches which have been delineated to allow analysis of specific sections of the river and to account for unique hydrologic and hydraulic conditions, such as bridges and distinct changes in river surface elevation at waterfalls. The extent of the study area, delineated into the three basins described above, is presented in Economics Appendix J. Further discussion of the economic reaches and the selection of reaches contributing to the study can be found in later sections of the Economic Analysis Appendix.

Without-Project Condition

1. Delineation of Economic Reaches

The original 1987 study reported existing condition damages for a total of 213 reaches. However, during this Phase 1 analysis the 11 sample reaches for which stage-damage relationships were provided in the 1987 GDM were selected for detailed analysis, in the expectation that the resulting updated damages could be extrapolated to all the remaining reaches in the study area. For these 11 sample reaches 2013 annual expected damages have been calculated for the without-project condition using version 1.2.5a of the Hydrologic Engineering Center Flood Damage Analysis software (HEC-FDA). See Economics Appendix J for the location of the sample reaches within the study area.

For the purposes of the extrapolation analyses, all the reaches in the study area were grouped into the three basins described in Section 1.0, separating areas where the nature and characteristics of flooding are different. While the 1987 GDM included 12 reaches in the Upper Passaic Basin (30010 – 30110, upstream of Chatham Borough), these 12 reaches have not been included in the 2013 analyses since they are assumed not to be affected significantly by any of the plans under consideration. In the 1987 GDM the 12 reaches in the Upper Passaic Basin contributed less than 0.75% of the total study area existing condition damages. Reaches at the upstream end of Molly Ann's Brook and the Peckman River were also excluded from the analysis since construction of a flood risk management project for Molly Ann's Brook is complete and a feasibility study for the Peckman River is at a more advanced stage. Details of the 11 sample reaches are presented in Table 7.

TABLE 7: ECONOMIC REACHES DEFINED

Topographic Regions	Economic Reaches	Hydraulic River Reach	Model Input Sources	Reach limits
Lower Valley	Lower Passaic	Tidal Passaic	Both 1990 NYD UNET model & 2011 FEMA HEC-RAS model	Mouth to Dundee Dam
		Lower Passaic	2011 FEMA HEC-RAS model	Dundee Dam to Little Falls
		Saddle	2007 NYD HEC-RAS model	Mouth to Lodi
Central Basin	Central Valley	Central Passaic	Both 1990 NYD UNET model & 2011 FEMA HEC-RAS model	Little Falls to Chatham
		Deepalvaal	1990 NYD UNET model	Mouth to near Bloomfield Ave
		Pompton	2011 FEMA HEC-RAS model	Entire river
		Lower Ramapo	2011 FEMA HEC-RAS model	Mouth to Pompton Lakes Dam
		Lower Wanaque	1990 NYD UNET model	Mouth to near Wanaque Reservoir
		Lower Pequannock	2011 FEMA HEC-RAS model	Mouth to near Riverdale
		Lower Rockaway	1990 NYD UNET model	Mouth to near Boonton Reservoir
		Lower Whippany	1990 NYD UNET model	Mouth to near Whippany
		Black/Pinch Brook	1990 NYD UNET model	Mouth to near Columbia Turnpike
	Upper Basin (No eco. model)	Upper Passaic	Not hydraulically modeled. Hydrology model only.	Chatham to headwaters
Highland Area	No economic model.	Upper Whippany, Upper Rockaway, Upper Pequannock, Upper Wanaque & the Upper Ramapo	Not hydraulically modeled. Hydrology model only.	N/A

TABLE 8: SUMMARY OF SAMPLE ECONOMIC REACHES

Basin	Stream	Reach	Bank	Description/Municipality	Beginning River Station	Ending River Station	Index Location Station
Lower Passaic	Passaic River	010102	R	Passaic	77644	86146	83378
		010171	L	Fair Lawn	109179	117194	113804
		010203	L	Paterson	125601	134141	131639
Central Passaic	Passaic River	020021	R	Wayne, Willowbrook Mall	167364	175954	170410
		020052	R	Fairfield	180342	219030	192445
	Rockaway River	020081	L	Montville	6715	12105	9370
		020102	R	Parsippany	22925	29510	24377
Pompton	Pompton River	600025	L	Wayne	13940	16764	15622
		600034	R	Lincoln Park, Pequannock	16764	22138	19194
		600042	R	Pequannock	22138	30102	26484
	Ramapo River	660021R*	L	Wayne	1336	7445	3938
		660021L*	R	Pompton Lakes	1336	7445	7046

*Reach 660021 is located on both left and right banks of the Ramapo River

2. Structure Inventory Method

The computation of flood damage using HEC-FDA requires a specific set of data for each affected structure, and the derivation of the structure inventory database for the 11 sample reaches required several steps, which are described below.

In each of the 11 sample reaches, structures within the 500-year floodplain were identified and numbered and an initial GIS database comprising 5,476 individual structures was developed. In addition to address, parcel, and spatial location attributes, the dataset also included the footprint area and ground elevation (derived from LiDAR) for each structure. For some of the 11 reaches, additional data was also available from the 1995 study update: this dataset included structure types, main floor elevations, and 1993 (1995 GDM) structure values for 2,407 single-family residential structures.

The Tchebychev Equation was used to determine the number of sample structures required to derive average structure characteristics in each reach at a 95% confidence interval. A random number generator was then used to select a number of structures in each reach corresponding to the Tchebychev sample number. The number of structures to be subject to a full field inventory survey to collect the data required by HEC-FDA in each reach was therefore equal to the Tchebychev number minus the number of selected structures for which relevant data was available from the 1993 inventory. Hence for each sample reach, the complete structure inventory to be input to HEC-FDA was compiled from up to three sources, for which numbers are summarized in Table 9:

- Structures subject to the detailed field survey.

- Structures for which limited data was available from the 1993 inventory, and for which the remaining required attributes were estimated based on average characteristics derived from the detailed field inventory.
- Structures for which no attribute data was available apart from footprint areas and ground elevations and for which all required attributes were extrapolated based on average characteristics derived from the field inventory.

TABLE 9: SAMPLE REACH STRUCTURE INVENTORY DATASET SOURCE

Reach	Reach	Detail Survey	1993 Data	Extrapolated	Total
Lower Passaic	010102	116	0	35	151
Lower Passaic	010171	130	166	227	523
Lower Passaic	010203	286	0	215	501
Lower Passaic Basin Total		*532*	*166*	*477*	*1,175*
Central Passaic	020021	59	63	20	142
Central Passaic	020052	115	209	279	603
Central Passaic	020081	18	0	0	18
Central Passaic	020102	87	57	38	182
Central Passaic Basin Total		*279*	*329*	*337*	*945*
Pompton	600025	106	38	34	178
Pompton	600034	184	285	947	1,416
Pompton	600042	242	209	1,065	1,516
Pompton	660021	145	16	34	195
Pompton Basin Total		*677*	*548*	*2080*	*3,305*
Study Area Total		***1,488***	***1,043***	***2,894***	***5,425***

Reach maps showing the location and distribution of structures by dataset source are presented in Figures located in Economics Appendix J.

Field Surveyed Structures

For the 1,488 structures subject to the full inventory, GIS data was available for footprint area and ground elevation. Hence the following attributes were recorded in the field to supplement the existing GIS data and to facilitate the development of files for import to HEC-FDA:

- Type/Damage Category (Residential, Apartment, Commercial, Industrial, Municipal, Utility)
- Usage (the structure configuration for residences and the actual usage for all non-residential structures)
- Number of stories
- Basement/foundation type
- Garage details
- Construction material
- Condition (used to estimate depreciation)

- Main floor height above grade
- Elevation of low openings into the structure

Detailed field survey collected data was collected for a total of 1,488 structures. During the field survey and subsequent verification activities for the structures in the 1993 data set and those for which attributes were extrapolated, it was found that a number of structures in the original dataset had either been demolished and not replaced, or were found to be not appropriate for inclusion in the damage estimate as separate structures (e.g. detached garages, swimming pools). Hence the final number of structures in the inventory input to HEC-FDA for the 11 sample reaches totaled 5,425 rather than 5,476.

One of the key components of the data required by HEC-FDA is the depreciated structure replacement value for each structure. Structure values were estimated using two separate methodologies for residential and non-residential structures. For the purposes of this analysis large apartment buildings were included in the "non-residential" category.

Valuation of Residential Structures

The depreciated structure replacement value of residential structures was estimated using a spreadsheet developed by USACE-NYD. The spreadsheet incorporates lookup tables of baseline square foot costs for residential structures of one to three stories with and without basements which vary with the total square footage of the structure. The spreadsheet uses this data to generate regression equations which enable the values to be calculated for residential structures of any combination of size, story, and basement type. The baseline square foot costs for finished living space and basements, plus unit costs for garages, were taken from RS Means Square Foot Costs 2013 for average quality one to three story single-family residential structures and bi-level houses. All calculated values were adjusted for location using RS Means location factors and for depreciation using standard depreciation factors as applied in previous flood risk reduction projects for USACE-NYD.

Valuation of Non-Residential Structures

The depreciated structure replacement value of non-residential structures was also estimated using a spreadsheet, but via a much simpler methodology than for residential structures. A lookup table was compiled of square foot costs for every non-residential and apartment building usage. Each usage was assigned separate typical square foot costs for masonry and non-masonry construction from RS Means Square Foot Costs 2013. Since the square foot costs developed by RS Means vary with structure size, a typical size was selected for each usage, based on a combination of the average size of structures of that usage in the Passaic study database and previous experience developing structure inventories for other flood risk management studies. All calculated values were adjusted for depreciation and location.

Depth-Damage Functions

The computation of flood damages in this analysis is based on the application in HEC-FDA of depth-damage functions to the structures in the study reaches to estimate damage incurred by structures, their contents, and other associated/ancillary components. Each function describes how damage as a percentage of value increases with inundation above the first floor. While there are various generic depth-damage functions accepted for use in USACE flood risk management studies, the functions used in this study were developed specifically for the original Passaic River Basin study in 1982. The Passaic River Basin functions comprise 12 separate functions for residential structures up to and including multi-family residences, two for apartment buildings, and 45 covering the various types of non-residential structures. For the purposes of this study content values were assumed to be 50% of the structure value for residential structures and 100% of the structure value for non-residential structures. For all structures surveyed in the field, a single spreadsheet was developed to process the raw data into a format suitable for direct import to HEC-FDA, which included the computation of values for all structures as described above, and the assignment of damage functions via lookup tables.

Structures with data from 1993

Of the 11 sample reaches, 1993 data was available for all except 10102, 10203, and 20081. The structures for which limited data was available from 1993 were all one of four types of single-family residential structures (Colonial, Cape Cod, Ranch, or Split Level). The footprint area, ground elevation, main floor height above grade, and structure value (at a 1993 price level) were all available for these structures. Damage functions were assigned using simple lookup tables and, instead of attempting to develop update factors to convert the 1993 structure values to a 2013 price level, depreciated structure replacement values were assigned in each reach using the average depreciated square foot costs for corresponding structure types observed in the same reach for the detailed survey data set of 1,488 structures. The depreciated square foot values used to populate the structure value attribute in each reach are presented in Table 10.

TABLE 10:
AVERAGE DEPRECIATED SQUARE FOOT VALUES FOR RESIDENTIAL STRUCTURE TYPES PRESENT IN THE 1993 DATASET

Reach	Colonial	Cape Cod	Ranch	Split Level
010171	$74.47	$80.17	$88.00	$73.19
020021	$74.00	$91.36	$93.64	*$75.42**
020052	$72.38	$61.50	$82.50	$70.55
020102	$89.38	$89.65	$100.29	*$75.42**
600025	$95.90	$87.70	$91.50	$76.33
600034	$77.17	$73.50	$89.23	$84.00
600042	$81.82	$86.76	$96.38	$80.55
660021	$78.33	$82.03	$85.15	$77.29

*Since no split-level type residences were observed in the field survey dataset in Reaches 020021 and 020102, split levels in the 1993 data for these two reaches were assigned values based on the overall average for split level residences in the remainder of the field survey dataset.

For all 1993 data structures, a simple spreadsheet was used to process the data into a format suitable for direct import to HEC-FDA. This included the computation of values for all structures based on a lookup table derived from Table 10, and the assignment of damage functions.

Extrapolated Structures

To complete the dataset for all structures in the 11 sample reaches, there remained a number of structures for which types and physical attributes were extrapolated based on the distribution of types and average characteristics of structures observed in the field survey and in the 1993 inventory dataset. This exercise was not required in Reach 020081, since all the structures in this reach were recorded during the field survey. For the remaining 10 sample reaches, the attributes required to compile a structure inventory import file for HEC-FDA were extrapolated for between 20 and 1,065 structures, as per Table 10. The baseline assumption in each reach was that all affected structures with a footprint area less than 3,000 square feet were single-, two-, or multi-family residential structures, with the usage types randomly distributed among the dataset in the same proportions as had been observed for the comparable subset of structures in the detailed field survey for that reach. In some reaches (010171, 020021, 020052, 020102, 660021), essentially all the remaining structures were known to be residential and these reaches contained relatively few structures with footprint areas greater than 3,000 square feet. In these reaches the random assignment of residential usages was extended to cover the limited number of structures with footprint areas greater than 3,000 square feet.

In the remaining reaches, structures with larger footprint areas were all initially assumed to be non-residential structures or apartment buildings, with the usage types randomly distributed among the dataset in the same proportions as had been observed the same subset of non-residential and apartment usages in the field survey for that reach. Additional detailed surveys were completed to refine the characteristics of larger structures as described in Section 3.2.5 of the Economic Appendix.

Structure Inventory Validation

Efforts to validate the structure inventory data comprised several exercises, including the verification of the largest structures in the inventory, and investigation of structures incurring the highest damages or damages at the highest frequencies.

In the 1987 GDM approximately two thirds of the expected annual damages in the without-project condition were attributable to non-residential structures (commercial, industrial, and municipal). Based on the assumption that non-residential structures are generally larger than residential structures; a limited verification exercise was undertaken for the 200 largest structures in the inventory by footprint area, which was intended to refine the non-residential damages in the 11 sample reaches. The 200 largest structures in the full sample reach inventory were identified and it was found that this subset of the inventory also comprised the subset of structures with footprint areas greater than 6,000 square feet. The majority of the largest 200 buildings were commercial structures (63%), followed by industrial (17%) and apartment buildings (14%). It was also found that 140 of these structures had already been surveyed in the field. Each of the remaining structures was subject to more detailed survey assessments including internet searches. These investigations were used to confirm or revise the usages, stories, and foundation heights originally assumed for each structure to provide a more accurate computation of the non-residential structure values and damages.

The second structure validation exercise was conducted following the initial computation of expected annual damages in HEC-FDA. Maps were generated for each reach showing (a) all structures color-coded by annual average damage, and (b) structures incurring damage at the highest frequency modeled flood event (the 50% annual chance exceedance or "two-year" event). These maps were studied to identify structures incurring damage which might be unrealistically high or occurring with an unrealistically high frequency. These structures were then subject to internet-based research similar to that performed for the largest structures. Attributes such as usage, stories and elevations were revised as necessary.

<u>Risk and Uncertainty Parameters</u>

This study has been conducted in accordance with Engineering Regulation ER 1105-2-101 and Engineering Manual EM 1110-2-1619, "Risk-Based Analysis for Flood Damage Reduction Studies (USACE, August 1, 1996), which require that primary elements of the damage estimation computations are explicitly subjected to probabilistic analyses. Estimates of annual flood damage were computed for the 11 sample reaches using version 1.2.5a of the Hydrologic Engineering Center's Flood Damage Analysis computer program (HEC-FDA), which applies Monte Carlo simulation techniques to calculate expected damage values while explicitly accounting for uncertainty in the input data.

Uncertainty associated with the main floor elevation of structures was applied using a normal distribution with a standard deviation of 1.0 feet. While Table 6-5 of EM 1110-2-1619 specifies a standard deviation of 0.6 feet for inventories compiled by visual survey and topographic mapping with two-foot contour intervals, 1.0 feet was applied to the full inventory to account for the fact that many of the structures in this dataset were assigned main floor elevations based on average characteristics for that particular structure usage.

The depreciated structure replacement value was subjected to uncertainty via the application of a normal probability distribution with a coefficient of variation of 10%. The content to structure value ratio for all structures was subjected to uncertainty via the application of a normal probability distribution with a coefficient of variation of 25%. These uncertainties are within the range of those which have been previously applied in similar flood risk reduction projects in the New York District area.

Uncertainty associated with the stage-frequency relationship in each reach is calculated in HEC-FDA using order statistics and equivalent record lengths. For this analysis the equivalent record lengths used to generate uncertainty bands were based on the duration of either a selected stream gage or an average of a group of stream gages for the selected rivers shown in Table 9.

TABLE 11: EQUIVALENT RECORD LENGTHS BY RIVER

Basin	River	Equivalent Record Length (years)
Lower Passaic	Passaic	114
Central Passaic	Passaic	114
	Rockaway	99
Pompton	Pompton	71
	Ramapo	90

Derivation of Full Study Area Without-Project Damages

On completion of the structure validation exercises, expected annual damages for the without-project condition were recomputed for the 11 sample reaches using HEC-FDA. The updated without-project annual damages are presented in Table 12. All updated annual damages were based on a January 2013 price level, and the FY 2013 Federal discount rate of 3.75%. The updated without-project damages total $31.6 million for the sample reaches, with $6.9 million in the Lower Passaic Basin, $14.1 million in the Central Passaic Basin, and $10.6 million in the Pompton Basin ($24.7M fluvial damages).

At the outset of the study it was envisioned that the 2013 without-project damages computed for the 11 sample reaches would be used to develop indices to update the 1987 damages for each of the 200 or so additional reaches. Each of the remaining reaches would be classified as one of the 11 sample reaches according to their structural and demographic characteristics. Table 12 presents direct comparisons of the expected annual damages from the 1987 GDM with the 2013 HEC-FDA damages for the 11 sample reaches.

As illustrated in Table 12, there are a number of anomalies and inconsistencies between the two sets of damages. In general, 2013 damages were expected to be substantially higher than the corresponding 1987 damages due to increased structure values and increases in flood frequency. The historic Consumer Price Index and Engineering News-Record Building Cost Index were used as an initial guide to anticipate the increase in expected annual damage since the initial study. These both suggested that a doubling of damage would be reasonable. However, as Table 13 illustrates the change in annual damages by reach ranges from a more than 3,000% increase to a 75% decrease. Some of these inconsistencies may have straightforward explanations, while others would be much harder to explain or incorporate into the analysis. Some of these inconsistencies and apparent causes are discussed below:

- Reach 010102 (Passaic City): This reach exhibits a very large increase in damages from industrial and commercial categories. Since this area is considered to have been fully developed at the time of the original survey, the increase is unlikely to have been caused by new development, but may possibly be driven by some economic stabilization of the area following the economic downturn of the 1970s and 1980s and an increase in flood frequency. The reach also shows damage to municipal structures reducing from 15% of the reach total to zero, for which no explanation is readily apparent.
- Reach 010171 (Fair Lawn): This reach exhibits a large drop in commercial damages (from almost 13% of the total to less than 1%) which is not readily explicable: The available

data (such as Google Earth historical imagery) suggests that development within this reach has always been overwhelmingly residential.

- Reach 020052 (Fairfield): This reach shows the most unexpected discrepancy of all the sample reaches in that while the total annual damage reported in 1987 was more than $7.5 million and composed predominantly of damage to commercial and industrial properties, the annual damage calculated in 2013 is less than $2 million and almost entirely from residential buildings. The 2013 damages are consistent with the type of development observed in the reach as currently delineated, and which is known to have existed in the reach since before 1987. It is apparent for a review of development trends for other reaches in the area that the boundaries of this reach were revised at some point to exclude large clusters of high-value non-residential properties. Reaches were amalgamated for the 1987 study – there are around 30 reaches in the study area for which no damages are recorded in the 1987 damage by reach summary table.
- Reach 020081 (Montville): The very large increases in damage to commercial structures observed in this reach reflect new development that took place in this area during the early 1990s. This reach lies in Montville Township, which also shows the greatest population increase of all the municipalities in the study area. The damage increase in this reach is likely to be an outlier and not representative of other reaches in the basin.
- Reach 600034 (Lincoln Park): Contrary to expectations, this reach exhibits a reduction in damages from 1987 to 2013 of around 10%, with significant reductions in residential and municipal damage. Based on local knowledge, the expectation for this reach was that while there has not been substantial new construction in the reach, the increasing value of the existing development would have increased the annual damages. Possible explanations for this discrepancy include the acquisition or elevation of vulnerable buildings, although only nine properties have been acquired in this reach.
- Reach 600042 (Pequannock): This reach has similar characteristic and development history to 600034, and also does not exhibit the expected increase in damages. This reach exhibits a large increase in commercial and industrial damages and a similar-sized decrease in residential damages, leading to an overall increase from 1987 to 2013 of only 1%. New construction may account for the increase in non-residential damages, and a significant number of acquired residential properties (48, or 8% of the assumed total in the 100-year floodplain) may help to explain the reduction in residential damages.

The results of initial comparison reveal that there are many unknown external factors that render the direct comparison of current expected annual damages with the damages reported in prior documents as inappropriate for the extrapolation of damages to the whole project area, therefore an alternative approach was sought.

TABLE 12: COMPARISON OF DAMAGES FOR SAMPLE REACHES (DAMAGES IN $000S) – OCTOBER 2012 PRICE LEVE

Reach	Expected Annual Damages: Tables V30-36, 1987 GDM							Expected Annual Damages: 2013 HEC-FDA							% Change
	APT	COM	IND	MUN	RES	UTL	*Total*	APT	COM	IND	MUN	RES	UTL	*Total*	
010102	$0	$8	$650	$129	$54	$2	*$843*	$0	$144	$4,368	$0	$151	$5	*$4,667*	454%
010171	$0	$57	$0	$68	$319	$2	*$446*	$0	$5	$0	$221	$530	$0.5	*$757*	70%
010203	$7	$582	$309	$256	$522	$0	*$1,676*	$11	$583	$152	$2	$742	$0	*$1,489*	-11%
Total: Lower Passaic Basin	$7	$647	$959	$452	$894	$4	***$2,964***	$11	$733	$4,519	$223	$1,423	$5	***$6,913***	133%
% Change								46%	13%	371%	-51%	59%	40%	*133%*	
020021	$0	$3,998	$0	$823	$1,143	$0	*$5,963*	$0	$7,687	$0	$0	$2,298	$3	*$9,987*	67%
020052	$0	$3,182	$1,624	$1,044	$1,715	$2	*$7,566*	$0	$21	$0	$2	$1,901	$0	*$1,924*	-75%
020081	$0	$40	$0	$6	$0.1	$0.1	*$47*	$12	$1,740	$0	$0	$0.3	$0.2	*$1,753*	3654%
020102	$0	$0	$0	$37	$233	$0	*$271*	$0	$38	$0	$0	$438	$0.04	*$476*	76%
Total: Central Passaic Basin	$0	$7,220	$1,624	$1,910	$3,091	$2	***$13,847***	$12	$9,485	$0	$2	$4,637	$3	***$14,140***	2%
% Change								∞%	31%	-100%	-99.0%	50%	35%	*2%*	
600025	$0	$887	$3	$202	$373	$0.4	*$1,465*	$0	$1,786	$66	$0	$1,360	$0	*$3,212*	19%
600034	$297	$196	$39	$352	$1,657	$10	*$2,549*	$306	$403	$122	$28	$1,439	$0.1	*$2,299*	-10%
600042	$5	$972	$74	$556	$2,421	$0	*$4,028*	$0	$1,158	$805	$6	$2,105	$0.03	*$4,074*	1%
660021	$0	$0	$0	$31	$207	$0	*$238*	$1	$91	$0	$0	$875	$0.1	*$968*	307%
Total: Pompton Basin	$301	$2,056	$116	$1,140	$4,657	$11	***$8,280***	$307	$3,438	$993	$34	$5,780	$0.2	***$10,553***	27%
% Change								2%	67%	760%	-97%	24%	-98%	*27%*	
Grand Total	$309	$9,922	$2,699	$3,502	$8,642	$17	$25,091	$330	$13,656	$5,512	$259	$11,841	$9	$31,606	**26%**
% Change								7%	38%	104%	-93%	37%	-49%	26%	

Selection of Approach

In general flood damage is a function of the value of property at risk, the type of property (as it affects the level of damage during a flood) and the characteristics of flooding (depth, frequency, and duration).Since recent assessed building values from 2010 (i.e. New Jersey Division of Taxation MOD IV data improved property data) were available for all structures in the study area, an approach was developed which generated basin-wide damage scaling factors based on relationships between the 2013 annual damages in the sample reaches and the associated improved property values. This approach aimed to account for the value of properties in each reach and differences in the characteristics of flooding in the different basins.

Assessed values of improved property (i.e. structures) were collated into the same damage categories used in HEC-FDA and total building values in each damage category in the 100-year and 500-year floodplains for all relevant reaches in the study area were compiled. For each of the 11 sample reaches, expected annual damage as a percentage of the value of buildings in the floodplain was calculated. On a reach-by-reach basis, the ratios of damage to floodplain value for the 11 sample reaches were more consistent and exhibited less variation when considering the 500-year floodplain property values, versus using the 100-year floodplain values. The next step of this approach was to calculate basin-wide damage factors based on the sample reaches within each of the three basins.

Four variations on this approach were examined, and a summary of the total annual damage/total floodplain value percentages is presented in Table 13:

1. % of total basin annual damage / total basin 100-Year floodplain value
2. Average % of sample reach annual damage / reach 100-Year floodplain value within basin
3. % of total basin annual damage / total basin 500-Year floodplain value
4. Average % of sample reach annual damage / reach 500-Year floodplain value within basin

For each of the four variations on the approach the damage factors based on the annual damage as a percentage of the floodplain value in each basin were applied to all the relevant reaches in the corresponding basins in the study area:

TABLE 13: TOTAL ANNUAL DAMAGE/TOTAL FLOODPLAIN VALUE

Damage Factor	**Approach 1**	**Approach 2**	**Approach 3**	**Approach 4**
Lower Passaic Basin	4.0%	5.2%	2.2%	2.8%
Central Passaic Basin	2.6%	2.8%	2.3%	2.1%
Pompton Basin	3.0%	3.5%	1.6%	2.6%

Subsequently, basin-wide totals of expected annual damage were generated for comparison with the total damages as originally reported in 1987. The damage totals were also compared to a simple price level update using the Consumer Price Index. The results are summarized in Table 14.

TABLE 14: POTENTIAL WITHOUT-PROJECT DAMAGE EXTRAPOLATION FACTORS(DAMAGES AND VALUES IN $,000S)

Basin	Reach	Total Annual Damage (HEC-FDA)	100-Year Floodplain Property Value	Annual Damage as % of 100-Year Property Value	Basin-Wide % (from Reach Totals)	Basin-Wide % (from Reach Average)	500-Year Floodplain Property Value	Annual Damage as % of 500-Year Property Value	Basin-Wide % (from totals)	Basin-Wide % (average)
Lower Passaic	010102	$4,667	$38,953	12.0%		**5.2%**	$71,349	6.5%		**2.8%**
	010171	$757	$38,337	2.0%			$82,344	0.9%		
	010203	$1,489	$96,492	1.5%			$161,959	0.9%		
	Totals	$6,913	$173,782		**4.0%**		$315,652		**2.2%**	
Central Passaic	020021	$9,987	$396,926	2.5%		**2.8%**	$396,926	2.5%		**2.1%**
	020052	$1,924	$55,943	3.4%			$133,226	1.4%		
	020081	$1,753	$67,503	2.6%			$70,997	2.5%		
	020102	$476	$17,183	2.8%			$21,945	2.2%		
	Totals	$14,140	$537,555		**2.6%**		$623,094		**2.3%**	
Pompton	600025	$3,212	$54,936	5.8%		**3.5%**	$65,022	4.9%		**2.6%**
	600034	$2,300	$150,072	1.5%			$303,379	0.8%		
	600042	$4,073	$118,360	3.4%			$268,653	1.5%		
	660021	$967	$30,184	3.2%			$30,615	3.2%		
	Totals	$10,551	$353,552		**3.0%**		$667,669		**1.6%**	
Coefficient of Variation				0.81				0.73		

TABLE 15: SUMMARY OF WITHOUT-PROJECT DAMAGE EXTRAPOLATION APPROACHES

Approach	**Lower Passaic**	**Central Passaic**	**Pompton**	***Total***	**% Δ to CPI**
As Reported 1987	$30,027	$24,840	$28,574	*$83,440*	
Updated Using CPI	$61,462	$50,845	$58,489	*$170,795*	
1. 100-Yr FP, Basin Total %	$122,249	$67,318	$28,193	*$217,760*	27%
2. 100-Yr FP, Basin Average %	$156,850	$71,409	$31,133	*$259,392*	52%
3. 500-Yr FP, Basin Total %	$91,683	$85,521	$24,807	*$202,011*	18%
4. 500-Yr FP, Basin Average %	**$114,802**	**$79,314**	**$33,716**	***$227,832***	**33%**

The selected approach is Variation 4, in which the damage escalation factor for each basin is the average % of the sample reach annual damage to the reach 500-year floodplain value. This approach results in a study area-wide increase in without-project expected annual damage of approximately 173% overall. This is greater than the increase that would result from a simple application of the Consumer Price Index or Building Cost Index, which is expected given higher stage versus frequency relationships. While the overall study area annual damage increases resulting from all four variations appear within the bounds of preliminary expectations, Variation 4 resulted in the largest increase in damage within the Pompton Basin, which is considered to be the most realistic among the four variations. While an increase in annual damage of 18% may initially appear low in this basin, it is reasonably consistent with the change that resulted from a direct comparison of the 2013 HEC-FDA damages with those in the 1987 GDM, and may be influenced by the significant number of acquired properties in this basin, as mentioned above.

Without-Project Damages Summary

The result of applying the selected approach to all the relevant reaches in the study area in which improved property was recorded in the 500-year floodplain is presented in Tables 15**.** All updated annual damages were based on a January 2013 price level, and shaded reaches in Table 16 are the 11 sample reaches, with damages computed in HEC-FDA based on the updated structure inventory. Price level: January 2013

TABLE 16: EXTRAPOLATED WITHOUT-PROJECT CONDITION EXPECTED ANNUAL DAMAGES

Basin Description	**Total Damages Without Project**		**Expected Annual Damages Without Project**
Lower Passaic Basin Total	*$4,168,834,000*		*$114,802,000*
Central Passaic Basin Total	*$3,726,606,000*		*$79,314,000*
Pompton Basin Total	*$1,558,557,000*		*$33,716,000*
Study Area Total	***$9,453,997,000***		***$227,832,000***

E. BUYOUT ANALYSIS & PRESERVATION (1995 TO PRESENT DAY)

Analysis of Building Acquisition Data using Geographic Information Systems (GIS)

1. Building Acquisition Data

The goal of this task was to create a GIS shapefile presenting a comprehensive listing of structures acquired or elevated for the purpose of flood risk management in the Passaic River Basin study area. This report does not provide a review of demolition permits not related to flood risk management.

The spatial analysis of the properties acquired or elevated was based on available data containing locational attributes such as street address or block and lot. The data received consisted of multiple Microsoft (MS) Excel spreadsheets, pdf documents and e-mails from federal, state and county agencies. The variety in data sources and formats required a thorough review and reformatting to create a comprehensive database of the affected properties. The data provided by FEMA Region II had the most comprehensive list of properties with addresses, details about treatment (acquisition or elevation) and the program under which the funding was provided. Therefore, the data available from the USACE and that received from Counties was organized within a similar format with details of all the data available.

Data requests were sent to FEMA and all the affected Counties regarding the properties targeted for flood risk mitigation efforts.

2. Parcel Data

To ensure that the properties were correctly located, the best available tax parcel data was obtained and used as the base map. This data is known as the MOD-IV[12] tax list search database digital tax map made available to the public by New Jersey Geographic Information Network (NJGIN), and it provides detailed and uniform tax information about each property in the state of New Jersey. The MOD IV data includes information about property address, block/lot, owner, property class (use), land value, improvement value, net value, and some further description of the property.

3. Reach and Floodplain Data

Shapefiles delineating the 100 year (1% Annual Chance of Exceedance) and 500 year (0.2% Annual Chance of Exceedance) floodplain and the Economic Damage Reach shapefile were used as part of the project base-mapping. The source of these shapefiles is the current FEMA Digital Flood Insurance Rate Maps (DFIRM) covering the study area. In addition, this data was used as a check to ensure the acquired properties were located in the floodplain and the overall study area.

12 The MOD-IV data was downloaded from the New Jersey Geographic Information Network (NJGIN) website at https://njgin.state.nj.us/. Comprehensive metadata for this dataset is available at https://njgin.state.nj.us/NJ_NJGINExplorer/ShowMetadata.jsp?docId={46F721BD-6F4C-11DF-8B62-0003BA2C919E}

4. Location of Acquired Structures

The acquired structures were geocoded using the compiled address data. The list resulted in 610 properties spread across 29 economic reaches within the 500-year floodplain. The properties were analyzed by location within the economic reaches, counties, municipalities and by treatment. All the summary tables are provided in the following section.

The treatment of the properties includes acquisition or elevation. In the FEMA dataset, 58 properties were listed both as acquisition and elevation structures. Staff at FEMA Region II provided the explanation that certain properties were approved for acquisition or elevation, depending on the homeowner's preference, and the availability of funding.

TABLE 17: DISTRIBUTION OF STRUCTURES FOR ACQUISITION OR ELEVATION

Location	**Number**
Properties within Economic Reach and Passaic Basin	610
Properties within Basin Drainage Basin but outside Economic Reaches	60
Properties outside Basin (and Economic Reach)*	54
Total	**724**

*There are 54 properties entirely outside the Passaic drainage basin. They are spread across Cranford, Manville, Middlesex, New Milford, and Westwood Municipalities in NJ. These properties have not been mapped or discussed in this report.

TABLE 18: NUMBER OF STRUCTURES WITHIN ECONOMIC REACH BY TREATMENT

Treatment	**Buyout Property**
Acquired	320
Elevated	71
Acquisition or Elevation (Different treatment in different sources)	58
Treatment not specified	161
Total	**610**

Figures plotting the distribution of affected structures within the Passaic River drainage basin are presented in the Buyout Analysis Appendix K.

Summary Tables

TABLE 19: NUMBER OF BUYOUT PROPERTIES WITHIN ECONOMIC REACH BY BASIN

Basin	Number of Economic Reaches	Buyout Properties
Pompton	41	379
Central Passaic	84	204
Lower Passaic	87	27
Other*	31	0
Total	**243**	**610**

* While the 1987 GDM included 12 reaches in the Upper Passaic Basin (30010 – 30110, upstream of Chatham Borough), these 12 reaches have not been included in the 2013 analyses since they are assumed not to be affected significantly by any of the plans under consideration. In the 1987 GDM the 12 reaches in the Upper Passaic Basin contributed less than 0.75% of the total study area existing condition damages. Reaches at the upstream end of Molly Ann's Brook and the Peckman River were also excluded from the analysis since construction of a flood risk management project for Molly Ann's Brook is complete and a feasibility study for the Peckman River is at a more advanced stage.

TABLE 20: PERCENTAGE BY NUMBER AND AREA OF BUYOUT PROPERTIES
(WITHIN SAMPLE ECONOMIC REACHES)

Sample Economic Reach	Total No. of Properties in Reach	Area (Acres)	Buyout Properties in Reach	Percentage by No.	Buyout Acres	Percentage by Acres
010102	177	103.97	0	0%	0	0%
010171	835	178.72	0	0%	0	0%
010203	759	139.76	16	2.11%	1.16	0.83%
020021	183	55.17	0	0%	0	0%
020052	582	372.40	0	0%	0	0%
020081	9	450.17	0	0%	0	0%
020102	183	312.07	27	14.75%	5.38	1.72%
600025	223	1,778.06	19	8.52%	6.12	0.34%
600034	1,477	1135.81	9	0.61%	3.90	0.34%
600042	1,727	172.54	48	2.78%	10.93	6.33%
660021	229	154.04	17	7.42%	3.61	2.34%
Total	**6,384**	**4,852.71**	**136**	**2.13%**	**31.10**	**2.34%**

TABLE 21: NUMBER OF BUYOUT PROPERTIES (WITHIN ECONOMIC REACH BY COUNTY)

County	Total No. of Parcels within Economic Reach and 500 year Flood Plain	Buyout Properties	Percentage
Essex	3,897	14	0.36%
Morris	8,940	205	2.29%
Passaic	10,350	391	3.78%
Total	**23,187**	**610**	**2.63%**

TABLE 22: NUMBER OF BUYOUT PROPERTIES
(WITHIN ECONOMIC REACH BYMUNICIPALITIES)

County	Municipality	Total Parcels in Municipality	Buyout Properties	Percentage of Total Properties in Reach
Essex	Fairfield Borough	3,762	14	0.37%
Morris	Riverdale Borough	1,966	3	0.15%
Morris	Pequannock Twp.	5,458	56	1.03%
Morris	Parsippany-Troy Hills Twp.	15,947	52	0.33%
Morris	Lincoln Park Borough	5,099	94	1.84%
Passaic	Pompton Lakes Borough	3,451	51	1.48%
Passaic	Wayne	18,708	235	1.26%
Passaic	Totowa Borough	3,882	6	0.15%
Passaic	West Paterson	4,676	3	0.06%
Passaic	Paterson City	24,661	16	0.06%
Passaic	Hawthorne Borough	6,185	2	0.03%
Passaic	Little Falls	5,212	78	1.50%
Total		**99,007**	**610**	**0.62%**

TABLE 23: NUMBER OF BUYOUT PROPERTIES
(WITHIN ECONOMIC REACH BY FUNDING SOURCE)

Primary Funding Source	Funding Program*	No. of Buyout Properties	Percentage
FEMA	FMA-2009	25	4.10%
FEMA	HMGP-4021	221	36.23%
FEMA	RFC-2009	1	0.16%
FEMA	RFC-2009, SRL-2011	3	0.49%
FEMA	SRL-2010	134	21.97%
FEMA	SRL-2011	120	19.67%
FEMA	SRL-2012	30	4.92%
No Information	No Information	76	12.46%
Total		**610**	**100.00%**

*Flood Mitigation Assistance (FMA), Hazard Mitigation Grant Program (HMGP), repetitive Flood Claims (RFC), Severe Repetitive Loss (SRL)

TABLE 24: NUMBER OF BUYOUT PROPERTIES
(WITHIN DRAINAGE BASIN BUT OUTSIDE ECONOMIC REACH BY TREATMENT)

Properties within Basin but outside Economic Reaches	**Number**
Acquired Properties	38
Elevated Properties	21
Treatment not specified	1
Total	**60**

TABLE 25: NUMBER OF BUYOUT PROPERTIES
(WITHIN DRAINAGE BASIN BUT OUTSIDE ECONOMIC REACH BY MUNICIPALITIES)

Municipality	**County**	**Number**
Boonton (Town)	Morris	2
Denville	Morris	14
Parsippany	Morris	20
Riverdale	Morris	6
Hawthorne	Passaic	1
Little Falls	Passaic	1
Paterson	Passaic	2
Wayne	Passaic	11
Nutley	Sussex	3
Total		**60**

5. Improvement values of properties in Economic Reaches within 500 year Flood Plain

For the purpose of analyzing how the value of property is affected with respect to its location, improvement values were investigated in more detail. The economic reach shape file and the shape files for 500 year flood plains provided by USACE were used to clip the reaches within 500 year flood plain. Then, the parcels in clipped reaches were extracted and using the Spatial Join tool, were then joined to the Reach shapefile. This resulted in association of economic reach data with the tax. It was confirmed from NJ Division of Taxation that the improvement values within MOD IV are not equalized.

Equalization is the leveling process by which assessed values of real property in a taxing district are converted to their true or market values for the purposes of equitable distribution of the amount of county government and shared budgets. Since the municipalities in the study area assess properties at different percentages of market value, equalization rates obtained from the NJ Division of Taxation for the year 2010 were applied to all affected municipalities in the study area to raise all assessed values to 100% of market value and thus facilitate valid comparison of values between different economic reaches and municipalities.

The equalization rate was joined with MOD IV data using municipality codes. The formula used to compose Equalized Improvement Values (Eq_Imp_Val field in shapefile) is:

Equalized Improvement Values = (100/Equalization Rate) x Improvement Value

The following table shows the equalized improvement values of buyout properties

TABLE 26: EQUALIZED IMPROVEMENT VALUES OF BUYOUT PROPERTIES BY ECONOMIC REACH

Reach ID	Basin	Total Parcels	Buyout Properties	Total Equalized Improvement Value ($)	Equalized Improvement Value of Buyout Properties ($)	Percentage Equalized Improvement Values of Buyout Properties
010191	Lower Passaic	132	2	24,548,013	270,154	1.10%
010203	Lower Passaic	759	16	161,958,251	1,555,920	0.96%
010242	Lower Passaic	275	1	100,379,122	108,102	0.11%
010244	Lower Passaic	636	2	79,990,390	429,351	0.54%
010251	Lower Passaic	135	6	14,696,066	432,775	2.94%
020012	Central Passaic	875	73	54,315,075	8,974,841	16.52%
020015	Central Passaic	30	8	1,879,191	670,505	35.68%
020021	Central Passaic	183	30	396,925,656	3,339,595	0.84%
020022	Central Passaic	538	5	61,023,056	574,187	0.94%
020031	Central Passaic	186	22	27,784,040	1,796,363	6.47%
020032	Central Passaic	50	5	7,257,844	741,097	10.21%
020040	Central Passaic	434	9	56,603,095	720,692	1.27%
020094	Central Passaic	513	25	84,760,146	2,483,110	2.93%
020102	Central Passaic	183	27	21,945,802	2,399,672	10.93%
600011	Pompton	135	8	77,756,767	421,010	0.54%
600012	Pompton	222	8	28,358,814	1,044,225	3.68%
600014	Pompton	258	61	28,777,417	8,171,964	28.40%
600021	Pompton	111	92	3,315,723	2,929,494	88.35%
600022	Pompton	572	16	134,542,053	1,701,382	1.26%
600025	Pompton	223	19	65,021,212	3,262,020	5.02%
600031	Pompton	503	54	38,343,636	7,111,111	18.55%
600034	Pompton	1477	9	303,378,558	1,357,255	0.45%
600042	Pompton	1727	48	268,654,094	4,152,816	1.55%
660021	Pompton	229	17	30,614,136	2,937,772	9.60%
660022	Pompton	839	14	179,715,849	2,921,912	1.63%
660023	Pompton	66	12	10,266,426	1,996,490	19.45%
660024	Pompton	105	10	7,978,504	1,972,581	24.72%
660026	Pompton	80	10	9,769,799	671,003	6.87%
680012	Pompton	83	1	16,255,510	176,126	1.08%
Total		**11,559**	**610**	**2,296,814,258**	**65,323,539**	**2.84%**

Passaic River Coalition (PRC) Acquired Land

In West Milford, the Passaic River Coalition's (PRC) purchase of a vast tract dubbed the Emerald Forest means the land — many times surveyed for condo complexes and recently the center of a commercial logging operation — will be permanently preserved. The coalition purchased the 221-acre property, with $2.4 million in Green Acres funds. The property stretches from Bald Eagle Village to Pinecliff Lake and is part of a critical watershed in the Highlands, the source of water for some 5 million New Jersey residents.

Thirty years ago, developers made proposal after proposal to build town houses and condos on the land, but the proposals never panned out. More recently, over the past decade, an owner of the property had loggers strip it of at least 48 mature oak trees, including three where bald eagles had nested. The Passaic River Coalition purchased the property in July 2012 that was planned to have 400 town houses constructed. However, the proposal was dissolved with the passage of the 2004 Highlands Act, which heavily restricts new building in watershed communities.

The Emerald Forest purchase is the second-largest piece of land acquired by the coalition. The largest purchase was of 302 acres of forest and wetlands in Ringwood known as Tory Rocks. The coalition now owns about 1,500 acres in New Jersey.

Land Trust Properties including information such as Municipality/Acreage/County etc., is provided below. Note that those highlighted in Yellow are either proposed acquisitions or under contract and the PRC is not the deed holder at this time. However, the total acreage is included in the analysis of existing conditions and is assumed to have been acquired for this Phase 1 analysis. The total acreage of land acquisition by PRC is approximately 2,000. This information was provided after the buyout analysis was performed and mapped. Therefore, the following information will be incorporated during the Detailed Analysis Phase 2. Based on the information provided, this information will not affect (albeit negligible) the damage assessment and ultimate benefit to cost calculation and analysis.

TABLE 27: LAND TRUST PROPERTIES

Property #	Name	County	Town	Acres
1995-01	Lyndhurst Greenway 2	Bergen	Lyndhurst	0.012
1996-01	Bat Cave	Morris	Rockaway	2.24
1998-01	Russia Brook Sanctuary 1	Morris/Sussex	Sparta/Jefferson/Hardyston	242.82
1999-01	Russia Brook Sanctuary 2	Morris	Jefferson	125.33
1999-02	River Road Acres 2	Morris	Chatham Twp.	7.97
1999-03	River Road Easement	Morris	Chatham Twp.	4.67
2000-01	Lyndhurst Greenway 1	Bergen	Lyndhurst	1.36
2001-01	Tory Rocks	Passaic	Ringwood	302
2001-02	Long Hill Wetlands 2	Morris	Long Hill	0.5
2002-01	Cynthia's Landing	Morris	Denville	9
2002-02	Federal Hill	Passaic	Bloomingdale	34.7
2003-01	Lyndhurst Greenway 3	Bergen	Lyndhurst	0.05
2003-02	Long Hill Wetlands 3	Morris	Long Hill	5.9
2004-01	Hickory Road	Passaic	Ringwood	5.96
2004-02	Waterview	Passaic	Ringwood	67.8
2004-03	Highlands Meadow	Passaic	Ringwood	16.97
2004-04	Mahwah River	Bergen	Mahwah	0.53
2004-07	Pine Island	Passaic	West Milford	6.8
2004-08	Lyndhurst Greenway 4	Bergen	Lyndhurst	0.04
2004-09	Allendale Wetlands	Bergen	Allendale	20
2005-01	Farley Road Easement	Essex	Millburn	0.29

2005-02	Long Hill Wetlands 1	Morris	Long Hill	0.7
2006-01	Warren Riverside	Somerset	Warren	28.38
2006-02	Butler Raceway	Morris	Butler	2.7
2006-03	Morsetown Brook	Passaic	West Milford	9.808
2006-04	Stony Brook	Morris	Butler	7.38
2006-06	Hope Forest Reserve	Passaic	West Milford	10.29
2007-01	River Road Acres 1	Morris	Chatham Twp.	6.2
2007-02	Twin Brooks	Passaic	Ringwood	18.6
2007-03	Butler Forest Preserve	Morris	Butler	12.2
2007-04	Landau Wildlife Sanctuary	Morris	Chatham Twp.	3.9
2008-01	King George Wetlands	Somerset	Bernards Twp.	82.77
2008-02	Willow Hall	Morris	Morristown	6.49
2008-03	Indian Grave Brook	Somerset/Morris	Bernardsville/Mendham Boro	19.8
2008-05	Dragonfly Meadows	Passaic	Bloomingdale	8.5
2008-07	Central Valley Wetlands	Morris	Florham Park	35
2008-08	Wanaque Ridge	Passaic	Wanaque	45.9
2008-10	Yapewi Park	Morris	Butler	3.516
2009-01	Taylor	Passaic	Little Falls	0.128
2009-02	Emerald Forest	Passaic	West Milford	221.23
2009-03	Ponderosa 2	Passaic	Ringwood	16.541
2009-04	Waterview 2	Passaic	Ringwood	48.84
2009-06	Troy Meadows	Morris	Parsippanny	12.85
2009-08	Two Sisters Wetland Preserve	Passaic	Wayne	28.05
2009-10	Rockburn Springs	Passaic	West Milford	28.52
2010-01	Burnt Meadow Brook	Passaic	Ringwood	3.454
2010-03	Cooley Brook	Passaic	West Milford	40.58
2010-07	Deepeval Brook	Essex	West Caldwell	5.9
2010-08	Norris	Passaic	Little Falls	0.0854
2011-02	Kimble	Passaic	West Milford	18.1
2011-03	Waterview 3	Passaic	Ringwood	4.12
2011-04	Speciale	Morris	Pequannock	5.437
2011-05	Piraneo	Morris	Chatham	4.62
2012-08	Capasso	Passaic	Wanaque	20.2
Total				**1,615.7314 acres**

Preservation of Natural Storage

The Preservation of Natural Flood Storage was authorized as part of the overall Passaic River Flood Protection Project by the Water Resources Development Act (WRDA) of 1990, as modified by WRDA 1992. This separable project element consists of the acquisition of 5,350 acres of natural flood storage areas (of which 5,200 acres are wetlands) in the Central Passaic River Basin to prevent increases in flood flows caused by the loss of such areas to development. The Preservation of Natural Flood Storage was addressed in the Final Environmental Impact Statement which was filed with the Environmental Protection Agency on January 17, 1989. The Record of Decision was signed on March 8, 1990. The Preservation of Natural Flood Storage separable project element was recommended for construction at a fully funded cost of $19,710,000.

Future Acquisitions include:

- Wildlife Preserves, Inc - 789 acres
- City of East Orange Water Dept - 419 acres
- Township of Wayne - 172 acres
- City of East Orange - 150 acres
- Borough of Lincoln Park - 125 acres
- Montville Township - 121 acres

Authorized Acres: 5,350
Total Acres Acquired to date: 3,340

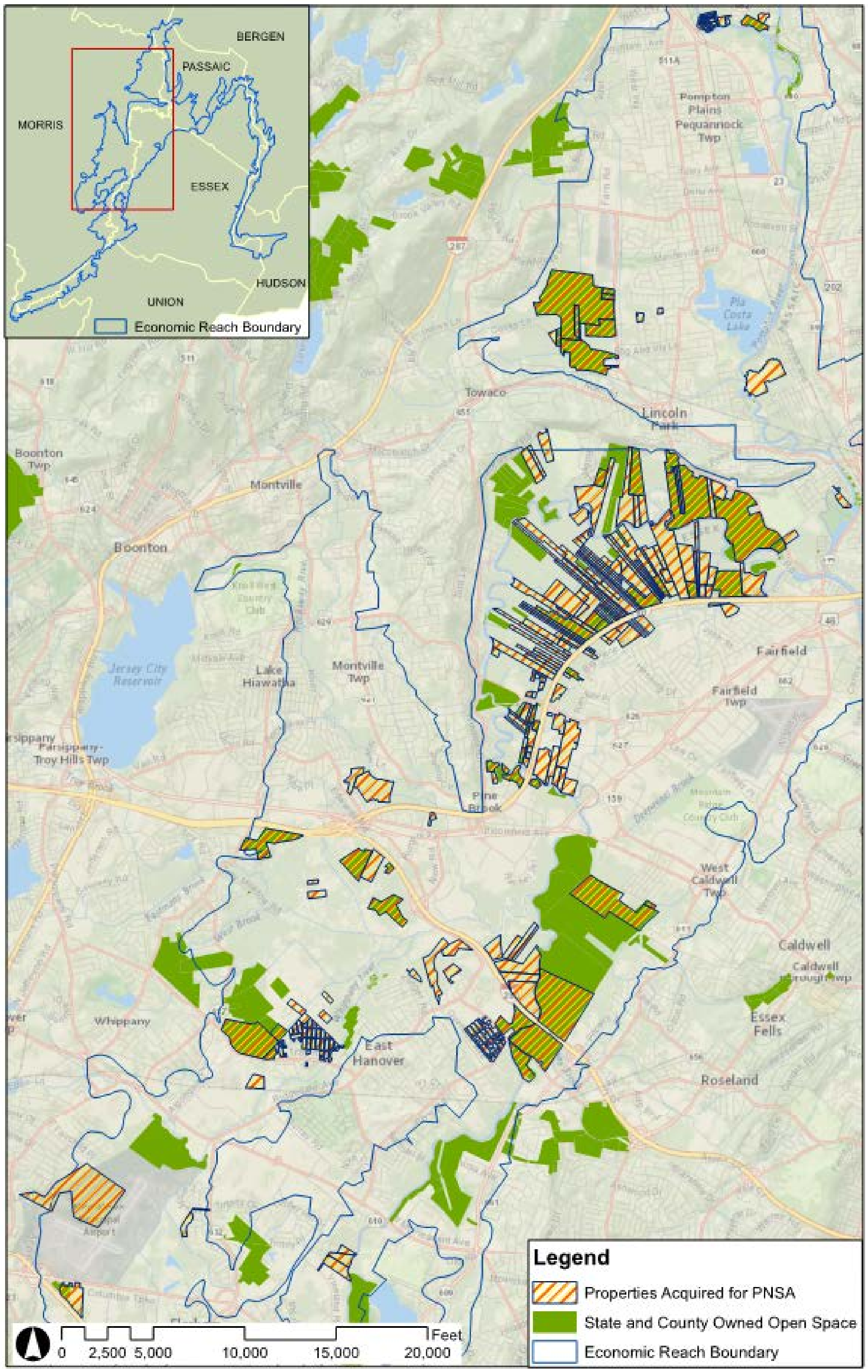

FIGURE 19: PRESERVATION OF NATURAL STORAGE AND OPEN SPACE

8. ALTERNATIVE ANALYSIS

A. HYDROLOGY & HYDRAULICS

Improved Conditions Hydrology

No "improved condition" hydrology was done for any of these plans because the attenuation of the discharge hydrographs was conducted in unsteady HEC-RAS, where the structural components of these alternatives will be developed. The only input needed from hydrology is the existing conditions discharge hydrographs at selected inputs within the unsteady HEC-RAS model. Other input for interior runoff hydrographs along the unsteady HEC-RAS model (i.e. point inflow, uniform or lateral flow) was given at define locations within the HEC-RAS model.

Improved Conditions Hydraulics

1. Levee and Non-structural Plan: Alternative #14A

Alternative 14A, as described in the 1987 Phase 1 GDM Feasibility Study, was modified during this study by removing levees upstream of the Great Piece Meadows, for the reasons explained in the following paragraphs**.** *See Figure 20.*

Alternative 14a is a Levee and Non-structural plan with the levees being distributed throughout the upper and lower areas of the basin and the non-structural being limited to the middle part of the basin. Plan 16a from the Phase 1 GDM Feasibility Study is a Channel, Levee and Non-structural plan. All the plans in the Phase 1 GDM consist of Building Blocks which were placed or removed from an alternative to create each plan. With the exception of the channel area building block and some levees upstream of the Great Piece Meadows, Plan 14a and 16a are identical. It should be noted, however, that plan 16a was taken to a more detailed level of design in the 1987 GDM and it is assumed that 16a had fewer levees because more information was gathered and obtained about those levees and they were either unnecessary or unjustified. Therefore, some levees were removed from Plan 14a as discussed above to make the levee systems identical to plan 16a in this area for direct comparison purposes. This also made it easier and faster to develop the hydraulic model, costs and benefits for both these plans.

Plan Description and Intent

Figure 20, Table 28 and Plates located in Engineering Appendix H provide a description of Alternative 14a however, a brief summary is as follows. Non- Structural measures such as flood-proofing, raisings structures and permanent evacuations (buyouts) to a 10 year annual risk of flooding (as identified in the 1987 Phase 1 GDM) where developed for the Pompton River, Pequannock River, Wanaque River, Ramapo River and the Passaic River between Beatties Dam & the headwaters of Deepavaal Brook. These features are further described in the 10 Year Non-structural Alternative/Plan section near the end of the Engineering Appendix H.

FIGURE 20: : LEVEE & NON-STRUCTURAL PLAN - ALTERNATIVE #14

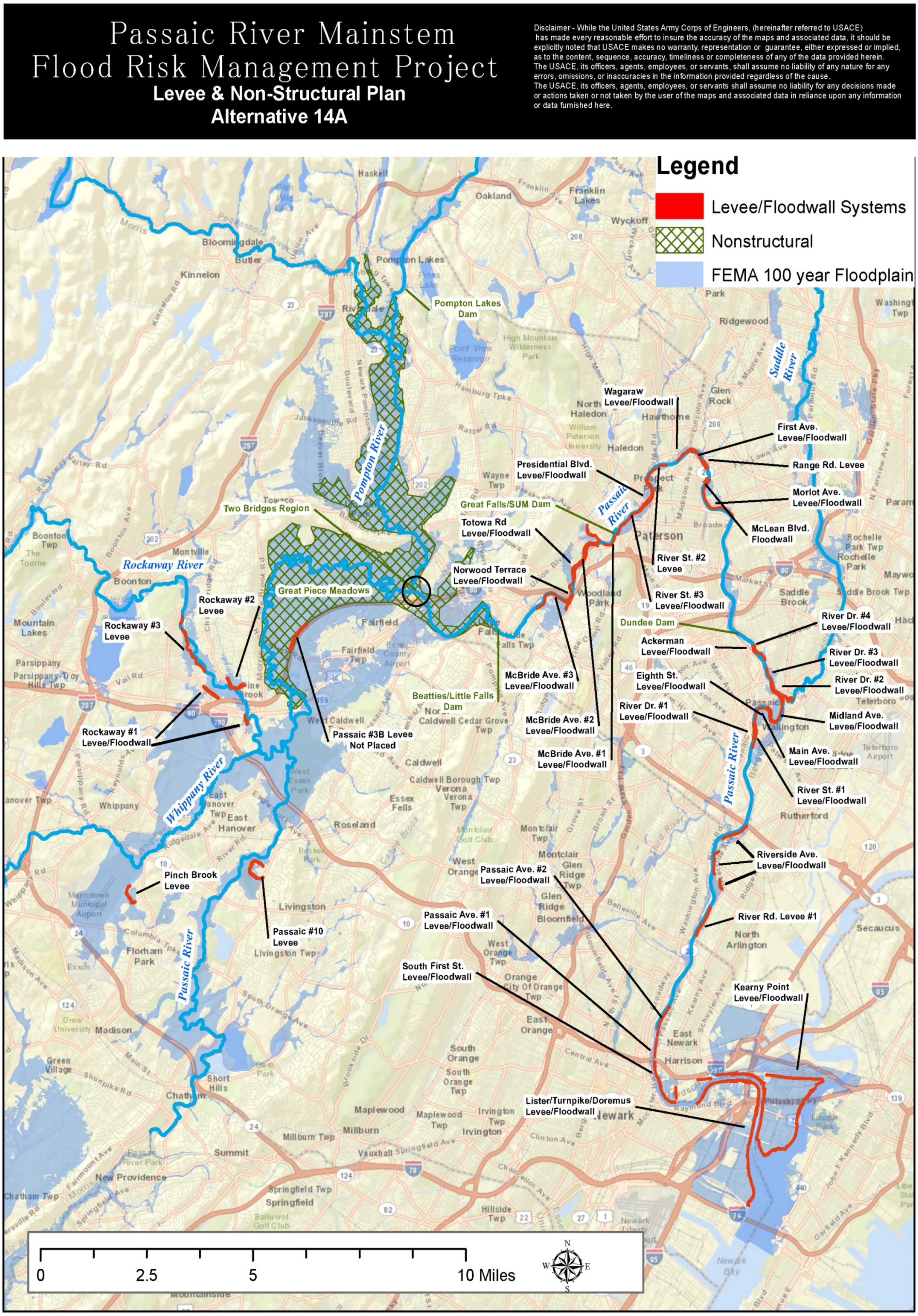

TABLE 28: ALTERNATIVE 14A LEVEE/FLOODWALL SUMMARY

Feature	Average Levee Length (ft)	Average Levee Height (ft)	Average Levee Width (ft)	Floodwall Length (ft)	Average Floodwall Height (ft)	Total Length (ft)	# of Ponding Areas	Pond Area Size (ac)	# of Pump Stations	Pump Stations Size (cfs)
Kearny Point Levee/ Floodwall	3908	5.2	41	33771	7.4	37679	1	120	1	75
Lister/Turnpike/ Doremus Levee Floodwall	5599	5.5	44	17657	8.1	23256	0	0	2	100, 50
South First Street Levee/Floodwall	1750	6.5	50	5700	6.2	7450	0	0	3	75, 70, 30
Passaic Avenue #1 Levee/Floodwall	200	3	28	2180	5.5	2380	0	0	2	44,91
Passaic Avenue #2 Levee/Floodwall	2760	4	34	1400	5	4160	2	7.1, 8.2	1	137
River Road #1	3700	6	46	0	0	3700	0	0	1	299
Riverside Avenue Levee/Floodwall	3310	6	46	4390	6.5	7700	0	0	1	429
Main Avenue Levee/Floodwall	2400	8.5	61	3110	8	5510	0	0	1	325
River Street #1 Levee/Floodwall	2000	6	46	660	6	2660	0	0	1	62
River Drive #1 Levee/Floodwall	650	8	58	1250	8.5	1900	0	0	1	358
Eighth Street Levee/Floodwall	2020	10	70	5170	17	7190	1	0	0	0
Midland Avenue Floodwall	300	5	35	1300	8.6	1600	0	0	0	0
River Drive #2 Levee/Floodwall	800	11	76	3900	18.5	4700	0	0	2	173, 220
River Drive #3 Levee/Floodwall	450	10	70	950	10	1400	0	0	2	173, 332
River Drive #4 Levee/Floodwall	400	10	70	2130	18	2530	0	0	1	173
Ackerman Levee/Floodwall	200	9	64	700	22	900	0	0	0	0
Morlot Avenue Levee/Floodwall	4870	9	64	2540	11.5	7410	0	0	0	0
McLean Boulevard Floodwall	0	0	0	600	8.3	600	0	0	1	49
Range Road Levee	1150	10	70	0	0	1150	1	5.3	0	0

First Avenue Levee/Floodwall	120	1.5	19	2860	10.5	2980	0	0	3	50,10,78
River Street #2 Floodwall	0	0	0	1170	9.5	1170	0	0	2	50,10
River Street #3 Levee/Floodwall	1050	9	64	9800	10	10950	0	0	2	148,271
Wagaraw Levee/Floodwall	1550	8.5	61	1600	18	3150	0	0	2	209,237
Presidential Boulevard Levee/Floodwall	930	10.5	73	3550	12.5	4480	0	0	2	213,226
Totowa Road Levee/Floodwall	5000	7	52	5480	8.5	10480	0	0	2	25,403
Totowa Road Levee/Floodwall	5000	7	52	5480	8.5	10480	0	0	2	25,403
McBride Avenue #1 Levee/Floodwall	300	7	52	2000	11	2300	0	0	1	192
McBride Avenue #2 Levee/Floodwall	2850	9	64	5150	12	8000	2	4.4, ?	1	238
Norwood Terrace Levee/Floodwall	150	12.5	85	900	13	1050	0	0	1	64
Riverview Drive Levee/Floodwall	950	13	88	2100	11	3050	0	0	2	89, 126
Passaic #10 Levee	4853	8	60	97	11.00	4950	1	10	2	3,3
Rockaway River #1 Levee (N)	2421	10.3	52	0	0	2421	2	30.1, 7.4	0	0
Rockaway River #1 Levee (S)	818	5.9	45	521	3.3	1339	3	7.5, 15	1	1
Rockaway River #2 Levee	3172	10	70	0	0	3172	1	41.80	1	10
Passaic River 3B (Not Placed)	3660	17.5	115	0	0	3660	0	0	0	0
McBride Avenue #3 Levee/Floodwall	3680	7	52	2600	9	6280	0	0	2	48, 108
Rockaway River # 3 Levee/Floodwall	825	8	58	6702	4.70 to 9.70	7527*	0	0	0	0
Pinch Brook Levee (N)	1127	2	25	0	0.00	1127	0	0	0	0
Pinch Brook Levee/Floodwall (S)	1270	8	60	415	9.40	1685	1	10.5	1	3

*Total system length including existing levee Note: Levee top widths are 10 feet

The plan includes: 33 levee/floodwall systems in the Lower Valley (Below Beatties Dam) and 6 levee/floodwall systems in the Central Basin (above Beatties Dam). The heights of the levees in the HEC-RAS model were generally set to the same elevations determined in the 1987 and 1995 GDMs but in a few areas they were set above the 500 year elevation for simplicity. Note that the design heights of the levees were not changed or re-evaluated from the GDM so what was originally considered to be a 100 year levee now has a considerably lower annual risk of flooding. The flow area under several bridges was enlarged either by dredging or by changing the bridge structure as can be seen in Table 28.

Modeling

The existing conditions model was used to create the Plan 14a model. The levees were modeled as single line vertical structure because there was not enough accurate topographic information available to model them as trapezoidal structures. The levee systems that were in common with the Tunnel Plan levees shown in the 1995 GDM were set at the elevations shown in that report. However, no accurate levee heights or elevations were available in the 1987 GDM which could be used for the levees that were not common with the Tunnel Plan. As a result the levees that were unique to Plan 14a were set at an elevation well above the FEMA 500 year flood elevation.

Assumptions Made & Risks Identified During Phase I

For cost and quantity purposes the levee heights and elevations were not raised or adjusted to account for the latest hydrology and/or modeling results. This was to keep the Plan quantities unchanged for cost estimating purposes. Keeping all the improved plans at their original dimensions was a critical assumption made to keep the study duration and costs consistent. By keeping all the dimensions relatively the same as the historical reports it was more consistent for cost estimating to work concurrent with H&H. Changes in flow, elevation and annual chance non-exceedance were captured in the WSELs that were provided for the economic analysis annual risk of flooding.

In summary, the size of most the project features remained the same as the historical reports but the level of project protection decreased with the updated flows which was captured as part of the economic analysis. Some of the levee systems appear to be causing some increases in downstream flows (downstream impacts). This impact is particularly evident along the Rockaway River and was evident in all the plans with levees on the Rockaway River.

2. Channel, Levee and Non-structural Plan: Alternative #16A

This Alternative is very similar to Plan 16a in the 1987 GDM Feasibility Study**.** See Figure 21.

Alternative 16a is a Channel, Levee and Non-structural plan with many features in common with Alternative 14a. The main difference between Alternative 16a and 14a is that in Alternative 16a all the levees from North Arlington in the lower Valley to Little Falls have been replaced with channel modification. The levees in the upper and tidal/coastal areas of the basin are the same as the non-structural measures in the middle part of the basin.

The exact extent, slope and depth of the channel plan as documented in the 1987 GDM Feasibility Report was not completely clear. The channel in this updated version of Alternative 16a was developed using known total excavation quantities per reach, available descriptions and professional judgment.

<u>Plan Description and Intent</u>

Figure 21, Table 29 & 30 and Plates in Engineering Appendix H provide a description of Alternative 16a however, a brief summary is as follows.

Non- Structural measures such as flood-proofing, raisings structures and permanent evacuations (buyouts) to a 10 year annual risk of flooding (as identified in the 1987 GDM) where developed for the Pompton River, Pequannock River, Wanaque River, Ramapo River and the Passaic River between Beatties Dam & the headwaters of Deepavaal Brook. These features are further described in the 10 Year Non-structural Alternative/Plan section near the end of the Engineering Appendix H.

This plan includes: 3 levee/floodwall systems in the tidal/coastal area and 6 levee/floodwall systems in the Central Basin (above Beatties Dam). The heights of the levees in the HEC-RAS model were generally set to the same elevations determined in the 1987 and 1995 GDMs. Note that the design heights of the levees were not changed or re-evaluated from the GDM so what was originally considered to be a 100 year levee now has a considerably lower annual risk of flooding based on the current water surface elevations (WSELs) calculated for this analysis.

Approximately 93,032 linear feet (17.2 miles) of channel modifications will be required, beginning from just downstream of Beatties Dam and ending approximately one mile downstream of the Route 3 Bridge crossing in Lyndhurst. Channel bottom widths ranged from 30 feet to 540 feet at the downstream end; channel depths ranged from 20 feet to 30 feet; side slopes were at 1V:3H.

The flow area under many bridges was enlarged either by dredging or by changing the bridge structure as can be seen in Table 27.

Passaic River Mainstem Flood Risk Management Project

Levee, Non-Structural & Channel Plan Alternative 16A

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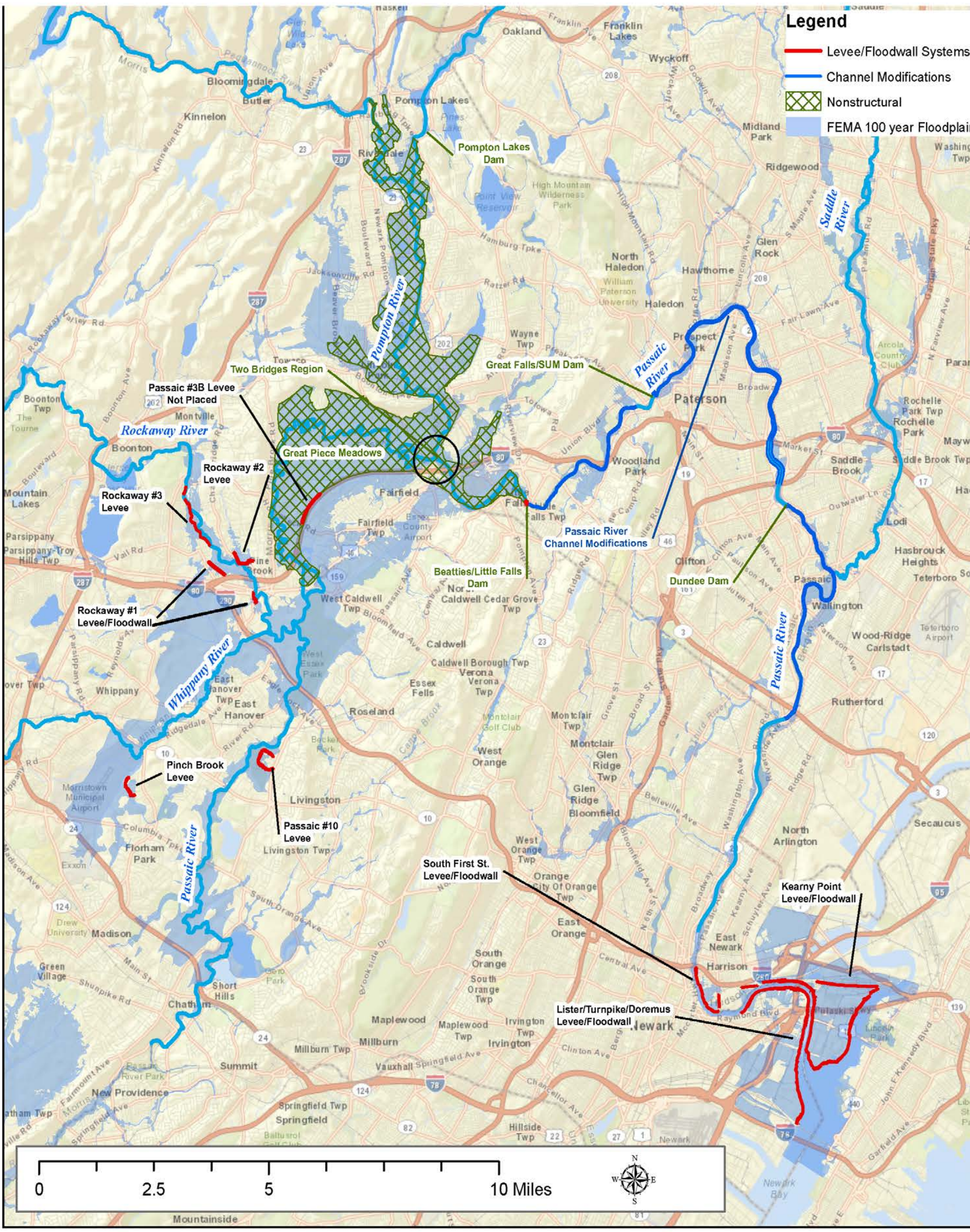

FIGURE 21: LEVEES, CHANNEL & NON-STRUCTURAL PLAN - ALTERNATIVE #16A

Modeling

The Plan 14A model was the primary basis for this Plan 16A model and a portion of the existing conditions model was used in the area of the channel modifications. As stated above channel modifications extended from of Beatties Dam and ending approximately one mile downstream of the Route 3 Bridge crossing in Lyndhurst. The excavation volumes documented in the 1987 GDM were largely used to help develop the amount of channel excavation. The cut and fill volumes taken directly from the HEC-RAS model were compared to the volumes from the 1987 GDM and the slopes and depths were adjusted until the volumes matched to within 10%. Although the total excavation volume from the HEC-RAS model is within 10% of the total volume determined in the 1987 GDM, the net volumes vary considerably when the estimates are based on a per-reach basis. The total net volume to be excavated from reaches 4 & 5 for the channel modification alternative is 8.83 million cubic yards.

A fair amount of effort was made to ensure that the channel excavation did not undermine the bridge footings. For 24 bridges channel cuts under bridges will require some form of supported for the footing such as sheet piling or underpinning. For the purpose of estimating which footing would need support the following assumptions were made:

1. Support is needed around bridge pilings if the depth of cut exceeds 5 feet
2. Support is needed adjacent to abutments if the depth of cut exceeds 5 feet and the side slope exceeds 1V:3H.

Assumptions Made & Risks Identified During Phase I

As with all other plans the sizes of the improved features were not adjusted to increase the annual risk of flooding. The quantities from the 1987 Phase 2 GDM were held relatively constant to make the cost updating consistent with the H&H efforts. All adjustment related to the lower annual risk of flooding were captured in the economics portion of this study.

Downstream impacts of the channel improvements were not mitigated for in this phase of the study.

General Results and Findings

The levee systems and the channel improvements are causing increases in the downstream flows and flood elevations (downstream impacts). This impact is cumulative and is largest in the lowest reach of the Passaic River. However the largest impacts are near the head of tide and mitigation may not have to extend very far downstream.

TABLE 29: ALTERNATIVE 16A CHANNEL MODIFICATION SUMMARY

Location	Section	Station	Length (ft)	Average Depth of Cut (ft)	Cut Volume (cy)
Dundee Dam to Below Route 3	A/Dredge	592+16 to 679+94	8,778	1.6	68,905
Dundee Dam to Below Route 3	B	679+94 to 793+66	113,72	7.5	661,811
Dundee Dam to Below Route 3	C	793+66 to 820+00	2,634	11.5	152,913
Dundee Dam to Below Route 3	D	820+00 to 921+48	6,853	12.6	307,934
Dundee Dam to Below Route 3	E	942+57 to 995+06	5,249	17.2	452,929
Great Falls to Dundee Dam	F	995+06 to 1018+95	2,389	14.7	1,757,397
Great Falls to Dundee Dam	G	1018+95 to 1042+30	2,335	11.8	1,072,541
Great Falls to Dundee Dam	H	1042+30 to 1122+63	8,033	9.3	248,695
Great Falls to Dundee Dam	I	1122+63 to 1249+98	12,735	12.7	426,392
Great Falls to Dundee Dam	J	1249+98 to 1292+71	4,273	12.9	1,452,713
Great Falls to Dundee Dam	K	1292+71 to 1342+24	4,953	12.6	551,247
Great Falls to Dundee Dam	K-mod	1342+24 to 1370+09	2,785	14.6	255,378
Beatties Dam to Great Falls	L	1371+03 to 1480+41	10,938	12.5	904,981
Beatties Dam to Great Falls	M	1480+41 to 1577+46	9,705	9.7	518,338

TABLE 30: ALTERNATIVE 16A LEVEE/FLOODWALL SUMMARY

Feature	Average Levee Length (ft)	Average Levee Height (ft)	Average Levee Width (ft)	Floodwall Length (ft)	Average Floodwall Height (ft)	Total Length (ft)	# of Ponding Areas	Pond Area Size (ac)	# of Pump Stations	Pump Stations Size (cfs)
Kearny Point Levee/ Floodwall	3908	5.2	41	33771	7.4	37679	1	120	1	75
Lister/Turnpike/Doremus Levee Floodwall	5599	5.5	44	17657	8.1	23256	0	0	2	100, 50
South First Street Levee/Floodwall	1750	6.5	50	5700	6.2	7450	0	0	3	75, 70, 30
Passaic #10 Levee	4853	8	60	97	11.00	4950	1	10	2	3,3
Rockaway River #1 Levee (N)	2421	10.3	52	0	0	2421	2	30.1, 7.4	0	0
Rockaway River #1 Levee (S)	818	5.9	45	521	3.3	1339	3	7.5, 15	1	1
Rockaway River #2 Levee	3172	10	70	0	0	3172	1	41.80	1	10
Rockaway River # 3 Levee/Floodwall	825	8	58	6702	4.70 to 9.70	7527	0	0	0	0
Passaic River 3B (Not Placed)	3660	17.5	115	0	0	3660	0	0	0	0
Pinch Brook Levee (N)	1127	2	25	0	0.00	1127	0	0	0	0
Pinch Brook Levee/Floodwall (S)	1270	8	60	415	9.40	1685	1	10.5	1	3

*Total system length including existing levee. Note: Levee top widths are 10 feet

3. Dual Inlet Tunnel with a Newark Bay Outlet, Levees & Channels

This plan is identical to the plan developed in the 1995 GDM. See Figure 22**.** Please note that this plan is commonly referred to as Alternative 30E, as previously explained in Section 7 of this report. Alternative 30E in the 1987 Feasibility Report has an outlet at Third River and includes many levees in Bergen County. The Dual Inlet Tunnel with an outlet in Newark Bay is not the same as Alternative 30E, as described in 1987, as it does not include levees in Bergen County and the outlet is 1,850 feet off shore of Kearney Point in Newark Bay in accordance with WRDA 1990.

Plan Description and Intent

This plan that was developed extensively in the 1995 GDM and therefore has the most complete design and contains the most details. All the features that other plans had in common with this plan were taken directly from the design and details contained in the 1995 report for this plan. Figure 22, Tables 31 - 34 and Plates in Engineering Appendix H provides a description of Dual Inlet, Newark Outlet Plan, however a brief summary is as follows. This plan includes:

- 20.4 mile long 42 foot inner diameter main tunnel
- 1.3 mile long 23 foot inner diameter spur tunnel
- 11 access, air and work shafts for the tunnel
- 5.5 miles of channel modification along Passaic, Pequannock, Wanaque and Ramapo rivers to direct water into the tunnels
- 1 mile of levees and flood walls just upstream of the tunnel inlets
- A structure in the Great Piece Meadows for erosion and environmental purposes
- Channel modifications along Deepavaal Brook
- 3 Levee Systems on the Rockaway
- 2 Levee Systems on the Passaic upstream of the Great Piece Meadows
- Levee System of Black/Pinch Brook
- 3 Hurricane Levee Systems in the Harrison, Newark and Kearney Point areas

Once again note that most the basic design dimensions were not changed or re-evaluated from the GDM so what was originally considered to be a 100 year annual risk of flooding is now a considerably lower annual risk of flooding. The flow area under several bridges was enlarged either by dredging or by changing the bridge structure**.**

Modeling

Portions of the existing conditions model and the Plan 14a model were combined to create the basis for this model. Dr Michael Gee of the Hydrologic Engineering Center (HEC) converted the original improved conditions 1995 tunnel UNET model into a new HEC-RAS model which was also used to create the new Tunnel Model. The dual inlet tunnel features of model were modified to accurately reflect the diversion of water directly into Newark Bay. It is assumed that the results of this model have overestimated the tunnel ability to convey portions of the 200 and 500 year flows, which are above and beyond the original design capacity of the tunnel.

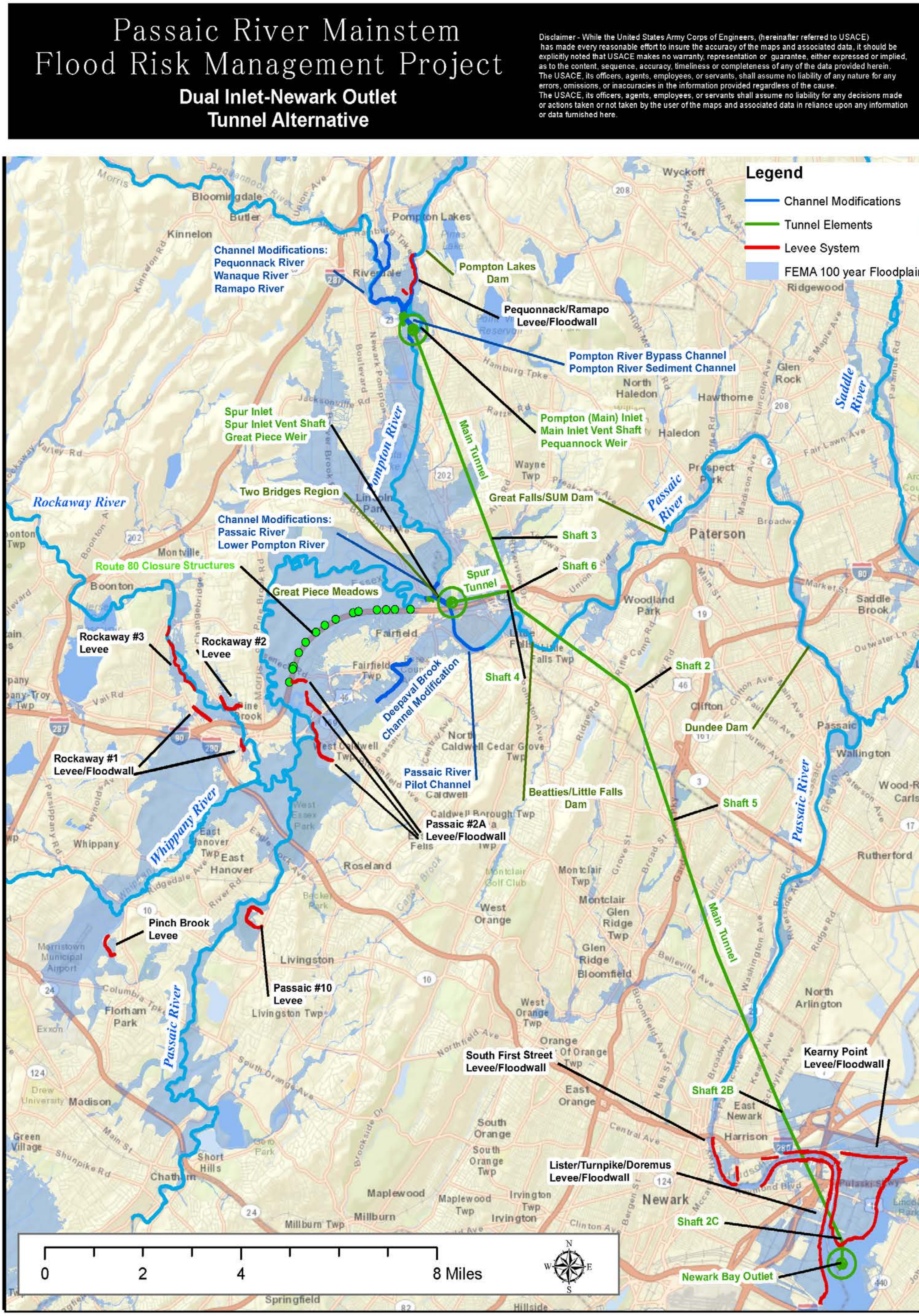

FIGURE 22: DUAL INLET, NEWARK BAY OUTLET – TUNNEL PLAN (NEWARK OUTLET TUNNEL ALTERNATIVE)

TABLE 31: DUAL INLET – NEWARK OUTLET TUNNEL ALTERNATIVE CHANNEL MODIFICATION SUMMARY

Location	Average Bottom Width (ft)	Length (ft)	Average Depth of Cut (ft)	Notes
Deepaval Brook Channel Modification	30	8237	N/A	Top width range = 60-85 ft, 50 ft bottom width up/downstream of Fairfield Office Center
Lower Pompton River Channel Modification	240	1584	4.5	Deepening Figure is Average
Pilot Channel (Passaic)	-	6336	N/A	Average width = 20 ft, Total Depth = 3 ft
Wanaque River Channel Modification	74	5808	7	Deepening Figure is maximum, 650 ft of riprap, 2650 ft crushed stone
Pompton Sediment Channel	-	1584	N/A	
Pequannock River Channel Modification	100	12672	10	Deepening Figure is maximum, 2000 ft of riprap, 150 ft crushed stone
Ramapo River Channel Modification	80	6864	10	Deepening Figure is maximum, Bottom width range = 60-100 ft, Mostly lined with riprap (5415 ft)
Passaic River Channel Modification	240	2112	4.5	Deepening Figure is Average
Pompton Bypass Channel	-	2640	N/A	Channel width range: 130-230 ft, Channel depth range: 2-14 ft

TABLE 32: DUAL INLET – NEWARK OUTLET TUNNEL ALTERNATIVE LEVEE/FLOODWALL SUMMARY

Feature	Average Levee Length (ft)	Average Levee Height (ft)	Average Levee Width (ft)	Average Floodwall Length (ft)	Average Floodwall Height (ft)	Total Length (ft)	# of Ponding Areas	Pond Area Size (ac)	# of Pump Stations	Pump Stations Size (cfs)
Lister/Turnpike/ Doremus Levee Floodwall	5599	5.5	44	17657	8.10	23256	0	0	2	100, 50
Kearny Point Levee/ Floodwall	3908	5.2	41	33771	7.40	37679	0	0	1	75
South First Street Levee/Floodwall	1750	6.5	50	5700	6.20	7450	0	0	3	75, 70, 30
Pequannock Ramapo Levee Floodwall	2200	5.9	45	2910	5.70	5110	4	8.5,0.3, 0.4, 5	1	3
Rockaway River #1 Levee (N)	2421	10.3	72	0	0.00	2421	2	30.1, 7.4	0	0
Rockaway River #1 Levee (S)	818	5.9	45	521	3.30	1339	3	7.5, 15, 16.6	1	1
Rockaway River #2 Levee	3172	10	70	0	0.00	3172	1	41.8	1	10
Rockaway River # 3 Levee/Floodwall	825	8	58	6702	4.70 to 9.70	7527*	0	0	0	0
Passaic_River_2 A Levee/Floodwall	6216	7	52	3082	5.50	9298	5	42.5, 117, 53.3, 26, 3.9	4	5, 3, 1, 2
Passaic #10 Levee	4853	8	60	97	11.00	4950	1	10	2	3, 3
Pinch Brook Levee (N)	1127	2	25	0	0.00	1127	0	0	0	0
Pinch Brook Levee/Floodwall (S)	1270	8	60	415	9.40	1685	0	1	1	3

*Total system length including existing levee. Note: Levee top widths are 10 feet

TABLE 33: DUAL INLET – NEWARK OUTLET TUNNEL ALTERNATIVE SUMMARY OF TUNNEL FEATURES

Feature	Feature Type	Length (miles)	Diameter (ft)	Depth (ft)	# of Gates	Notes
Pompton (Main) Inlet	Inlet	-	-	-	11	Vertical Lift Gates 50 ft (w) x 12 ft (h); Semi-circular sloping inlet, 216-ft radius access basin
Passaic (Spur) Inlet	Inlet	-	-	-	5	Vertical Lift Gates 50 ft (w) x 13 ft (h); 150 x 300 ft access basin
Main Tunnel	Tunnel	20.4	42	-	-	
Spur Tunnel	Tunnel	1.3	23	-	-	
Pequannock Weir	Weir	-	-	-	4	Taniter Gates 50 ft (w) x 12 ft (h); Supplements existing Morris Canal Feeder Dam System
Great Piece Weir	Weir	-	-	-	5	Torque tube bascule gates 30-ft wide
Newark Bay Outlet	Outlet	-	-	-	3	Vertical Lift Gates 26 ft (w) x 30 ft (h); From -26 ft to +25 MSL Purpose: Ventilation, additional access via main inlet
Main Inlet Vent Shaft	Vent Shaft	-	15	160	-	Purpose: Ventilation, additional access via main inlet
Spur Inlet Vent Shaft	Vent Shaft	-	12	156	-	Purpose: Ventilation, additional access via spur inlet
Shaft 2	Work shaft /Operations Center	-	42	349	-	Purpose: Tunnel Operations Center, TBM access, Muck removal; See map for location
Shaft 2B	Work Shaft	-	42	390	-	Purpose: Tunnel Boring Machine (TBM) Access, Muck removal, General Access, Ventilation; See map for location
Shaft 2C	Work shaft /Pump Station	-	42	400	-	Purpose: Pump Station, Muck Removal, General Access; See map for location
Shaft 2C	Vent Shaft	-	15	400	-	Purpose: Ventilation; See map for location
Shaft 3	Work Shaft	-	42	167	-	Purpose: TBM access, ventilation (to be retained as vent shaft); See map for location
Shaft 4	Vent Shaft	-	23	160	-	Purpose: TBM access, muck removal, ventilation; See map for location
Shaft 5	Vent Shaft	-	15	170	-	Purpose: General access, ventilation (to be retained as vent shaft); See map for location
Shaft 6	Vent Shaft	-	15	140	-	Purpose: Ventilation, (at main/spur juncture); See map for location

TABLE 34:
ROUTE 80 CLOSURE STRUCTURES SUMMARY (DUAL INLET-NEWARK OUTLET AND TWO BRIDGES/BEATTIESDAM ALTERNATIVES)

Feature	Feature ID	Existing Structure	New Gate Diameter (in)	Existing Structure Invert Elevation (ft, NGVD29)	Location
Flap and Sluice Gate	1	Reinforced Concrete Pipe	48	160.6	See Figure 22
Flap and Sluice Gate	2	Reinforced Concrete Pipe	36	161.8	See Figure 22
Swing Gate	3	None	35’ x 14’ ft*	None	Horseneck Road
Flap and Sluice Gate	4	Reinforced Concrete Pipe	84	162.8	See Figure 22
Flap and Sluice Gate	5	Reinforced Concrete Pipe	42	163.9	See Figure 22
Flap and Sluice Gate	6	Reinforced Concrete Pipe	36	165.4	See Figure 22
Flap and Sluice Gate	7	Reinforced Concrete Pipe	60	162.4	See Figure 22
Flap and Sluice Gate	8	Reinforced Concrete Pipe	36	166.6	See Figure 22
Flap and Sluice Gate	9	Reinforced Concrete Pipe	36	164.3	See Figure 22
Flap and Sluice Gate	10	Reinforced Concrete Pipe	36	164.5	See Figure 22
Flap and Sluice Gate	11	Reinforced Concrete Pipe	60	160.9	See Figure 22
Flap and Sluice Gate	12	Reinforced Concrete Pipe	36	166.8	See Figure 22
Flap and Sluice Gate	13	Box Culvert	7’ x 12’ (ft)	160.3	See Figure 22
Flap and Sluice Gate	14	Reinforced Concrete Pipe	60	162.1	See Figure 22

*With additional floodwall, 155 ft length, 14 ft height.

Assumptions Made & Risks Identified During Phase I

As with all other plans the size of the tunnel was not adjusted to increase the annual risk of flooding. The quantities from the 1995 GDM were held relatively constant to make the cost updating less labor intensive and concurrent with the H&H efforts. All adjustment related to the lower annual risk of flooding were captured in the economics portion of this study.

General Results and Findings

The tunnel as modeled appears to be diverting a considerable amount of flow beyond the original design capacity. Since there are two inlets and the peak flow at each inlet occur about two days apart it is possible that the tunnel is truly able to perform well at flows above its original design (100 year).

4. Beatties Dam / Two Bridges Alternative

This plan is the only plan in this GRR that has not been studied before. The 1976 USACE report recommended a reservoir in the Great Piece Meadows with a diversion tunnel from the Upper Pompton River into the Great Pier Meadows. Plans to remove, lower or modify Beatties Dam have been studied and presented many times including a USACE Reconnaissance from 1989. This new plan however, combines both concepts and uses the Great Piece Meadows as a reservoir and modifies Beatties Dam along with some channel deepening and widening. This plan does not protect as extensive an area as the other plans but should cost considerably less.

Plan Description and Intent

This plan involves the replacement of Beattie's dam with a longer structure and the construction of a new dam just downstream of the confluence between the Passaic and Pompton Rivers. It also involves channel improvements upstream of Beatties Dam, along the Pompton River, along Deepavaal Brook and in the Great Piece meadows. Finally, there are levees and floodwalls that prevent the Passaic from diverting into Deepavaal Brook and treatment of the Rt. 80 to prevent water in the Great Piece meadows from flowing south through the Rt 80 embankment into the Deepavaal drainage basin. See Figure 23 for a layout of this plan. The hydraulic profiles Plates show the reduction in WSELs and the channel improvements. Tables 35 - 37 describe some of the project features.

Beatties Dam will be replaced with a new deeply arched structure that has the same crest elevation and height of about 8 feet, but the crest length will be increased from about 300 feet to 580 feet long. Normal daily WSELs will remain about the same and operation of the water intakes and hydropower should be unaffected. A detailed comparison between the cost of renovating the water supply intakes and the hydropower facility and the cost of this new dam can be conducted if this alternative is selected for further analysis. Water surface elevations (WSELs) during large flooding events will be lower because of the increased weir length and efficiency. This design does not involve gate operation. The old dam and some of the rock downstream of this arched dam will have to be removed.

The channel upstream of Beatties Dam will be excavated to the confluence with the Pompton for a distance of about 3.3 miles with a new width of about 200 feet and a maximum excavation depth of about seven feet.

A new earthen dam about 1,770 feet long will be constructed at Two Bridges just downstream of the confluence. The center of the dam will be concrete about 550 feet long with a maximum height of 25 and will contain a large number of large openings through the dam. The earthen section will be about 1,220 feet long with a maximum height of 15 feet. About six houses will need to be removed to facilitate the currently proposed alignment. The purposes of this dam are to force large storm discharges from the Pompton into the Great Piece Meadows, to store storm flows in the Great Piece Meadows such that the downstream impact of the Beatties dam improvements are mitigated and to allow smaller non damaging storms to pass through the dam without being impounded. The multipurpose objectives of this ungated structure will require considerable design and analysis to achieve. The current design involves a small amount of downstream impacts for smaller events. Achieving the optimal design and performance either with or without gates will be conducted if this alternative is selected for further analysis in Phase 2 of this study.

The channel along the Pompton River and in the Great Piece Meadows upstream of the new dam will be excavated. The Great Piece Meadow channel work will be about 2.32 miles long, widen the current channel will be widened to a 200 foot bottom width but will maintain the same channel invert primarily to improve water flow from the Pompton into the Meadows. The lower portion of the Pompton channel from the confluence to the NJ Transit RR Bridge will be about 2.6 miles long, will have a 120 foot bottom width and will lower the invert by a maximum of seven feet largely to offset the increased WSELs caused by the new dam. The upper portion of the Pompton Channel from the RR Bridge to Jackson Ave. will be about 4.0 miles long, will increase the bottom width to 160 feet and will lower the invert by a maximum of 7 feet to reduce flooding in the area.

Deepavaal Brook will also be improved as part of this alternative. The new channel will be about 1.0 miles long, with a 40 foot bottom width and will lower the invert a maximum of 6 feet.

Two levee/floodwalls will be constructed at the upstream end of Deepavaal Brook to prevent high Passaic flow from diverting into the brook. The new levees will each be about 12 feet high and over 3,000 feet long. The floodwall will be about 16 feet high and 1920 feet long. Finally, the Rt. 80 embankment will have to be treated to keep ponded water in the Great Piece Meadow from flowing into Fairfield and the Deepavaal drainage basin. At least 10 flap gates will be added onto existing four and five foot diameter pipes and one large closure structure about 14 feet high and 35 feet wide will be needed at Horseneck Rd.

Modeling

The existing conditions model was used as the basis of this model into which the new dams and channels were coded.

Passaic River Mainstem
Flood Risk Management Project

Two Bridges/Beatties Dam Alternative

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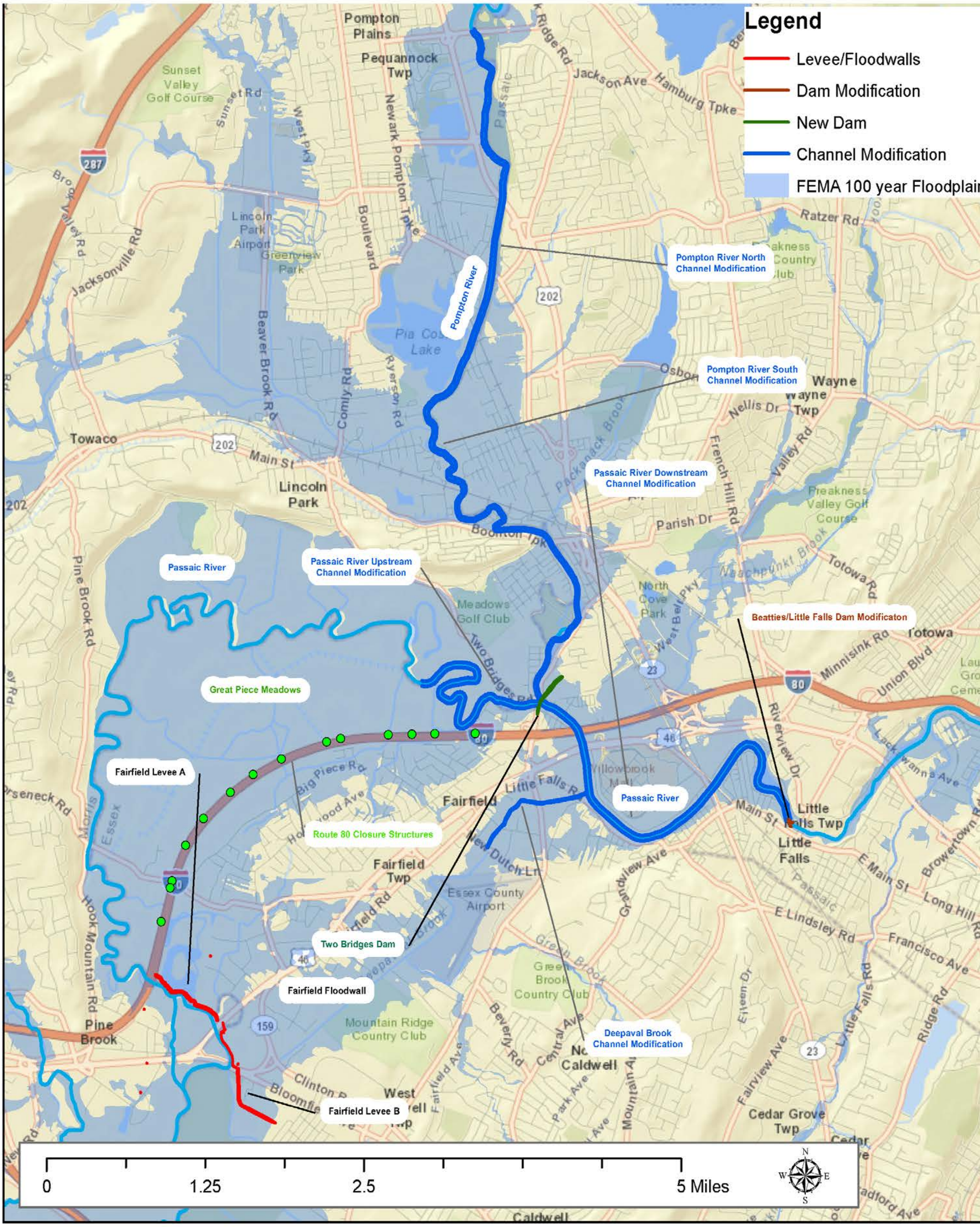


FIGURE 23: TWO BRIDGES/BEATTIES DAM ALTERNATIVE

TABLE 35:
TWO BRIDGES/BEATTIES DAM ALTERNATIVE, CHANNEL MODIFICATION SUMMARY-NOTE: ALL CHANNEL SIDE SLOPES = 1H:2.5V

Location	Average Bottom Width (ft))	Length (ft)	Channe l Slope	Cut Volume Soil (c yd)	Cut Volume Rock (c yd)	Cut Volume Total (c yd)
Deepaval Brook Channel Modification	40	5,280	.02	117,145	2,185	119,330
Pompton River North Channel Modification (NJ Transit RR Bridge to Jackson Ave Bridge)	160	21,278	.08	1,433,699	0	1,433,699
Pompton River South Channel Modification (Mouth to NJ Transit RR Bridge)	120	13,728	.015	236,738	270,088	506,826
Passaic River Downstream Channel Modification (Beatties to Two Bridges)	200	17,424	.01	235,000	406,655	641,655
Passaic River Upstream Channel Modification (Great Piece Meadows)	200	11,616	.01	491,635	0	491,635

TABLE 36: TWO BRIDGES/BEATTIES DAM ALTERNATIVE, LEVEE/FLOODWALL SUMMARY

Feature	Average Levee Length (ft)	Average Levee Height (ft)	Levee Top Width (ft)	Total Fill (c yd)	Floodwall Length (ft)	T-wall Height (ft)	T-wall Foundation (ft)	T-Wall width (ft)
Fairfield Levee A	3360	12.5	12.0	90,100	-	-	-	
Fairfield Floodwall	-	-	-	-	1920	16.0	14.0	1.5
Fairfield Levee B	3020	11	12.0	66,100	-	-	-	-

TABLE 37: TWO BRIDGES/BEATTIES DAM ALTERNATIVE, SUMMARY OF DAMS

Feature	Average Length (ft)	Average Height (ft)	Average Top Width (ft)	Maximum Bottom Width (ft)	Material	Elev. (ft, NAVD88)	Notes
Two Bridges Dam (Left Bank)	1100	10	25	100	Earth	175.5	
Two Bridges Dam (Ogee Spillway)	550	25	na	38	Concrete	173.5	Damn opening is 6' H x 200' W, 170ft of Riprap downstream
Two Bridges Dam (Right Bank)	230	10	25	100	Earth	175.5	
Beatties Dam Modification	580	10	na	50	Concrete	157.5	Deep Concave Arch Weir, Remove existing dam, Length increase from 270' to 580 ' Elevation unchanged

Assumptions Made & Risks Identified During Phase I

The downstream impacts associated with this plan were not eliminated during this phase of the study in accordance with the approved June 2012 Project Management Plan. Balancing the additional storage in the Great Piece Meadows with the loss of storage behind Beatties Dam and the loss of overbank flood storage without using operable gates over a full range of storms became a labor intensive effort. We believe that there is combination of dam height, opening width and channel depth that will reduce upstream flooding without increasing flood damages downstream. We also suspect that the use of operable gates would make this balance easier to achieve but we were trying to design a simple system that does not require gates. Currently this design produces significant increases in flow for the smaller non-damaging events, no increases for middle range events and minor increases in flow for larger 100, 200 & 500 year events.

It should also be noted that the cost to remove and replace Beatties Dam with a longer structure appears to be more expensive than the cost to lower Beatties Dam and modify the water and hydropower intakes that the dam supplies. Therefore it is likely that the cost of this concept design can be reduced if this alternative is carried forward.

The design of the Two Bridges Dam is currently based on the 500 year event and not on the larger Probable Maximum Flood (PMF) which would require a separate hydrologic analysis. In addition the foundation conditions at Two Bridges are largely unknown. Give the unknowns associated with this alternative the cost contingencies used for this alternative are very high.

General Results and Findings

While this plan has much potential there is the possibility that the plan may not be able to achieve a cost effective balance between preventing downstream impacts, storing flow in the Great Piece Meadows and reducing flooding along the Pompton. The balance between downstream impacts and flood damage reduction upstream will be fully determined in the next phase of this study should this alternative be selected for further analysis.

5. Non-structural Alternative

In an effort to limit the cost of this first phase of the GRR, the Non-structural plans and features were largely derived from information documented in the 1987 GDM (Feasibility Report). The following is a brief description of the non-structural features and findings from the 1987 GDM and how those features and findings were used for this analysis.

There are non-structural features in a total of three alternatives: Alternative 14a, Alternative 16a and in the 10 yr Non-structural Alternative/Plan. The non-structural features in 14a and 16a are identical to each other and include some of the areas upstream of Little Falls primarily along the Passaic and Pompton Rivers. The non-structural features in the 10 Year Non-structural Alternative/Plan not only includes the features proposed for Alternatives 14a and 16a but also includes much of the remainder of the basin both upstream and downstream of those features included in 14a and 16a. Please note that while this section of the report is entitled “10yr Non-structural Alternative” the non-structural features of all three alternatives are described here for clarity. See Figure 24.

1. Plans. The nonstructural and structural elements of the 1987 Passaic River Basin GDM included the following:

a. Single Measure Building Block 1 (Permanent Evacuation).
b. Single Measure Building Block 2 (Floodproof, Raise).
c. Combination Measure Building Block 3 (Floodproof, Raise, Permanent Evacuation).
d. Basin-Wide Plan 14 (Levee, Floodwall, Dam, Bridge Modification, Floodproof, Raise, Permanent Evacuation).
e. Basin-Wide Plan 16 (Channel Modification, Levee, Floodwall, Floodproof, Raise, and Permanent Evacuation).

2. Sizes. The sizes of the plans evaluated were designated with suffixes as follows:

a. Plan 3A: Structures in the 10-year floodplains, designed to withstand a 10-year water surface elevation for nonstructural features.
b. Plan 14A: Structures in select 10-year floodplains, designed to withstand a 10-year water surface elevation for nonstructural features, 100-year annual risk of flooding for structural features in other reaches.
c. Plan 16A: structures in select 10-year floodplains, designed to withstand a 10-year water surface elevation for nonstructural features, and 100-year to 500-year annual risk of flooding for structural features in other reaches.

3. Measures. The nonstructural components included the following measures:

a. "Floodproofing. This measure would be applied to all structures where the damageable components of structures of all types were examined for flooding up to the design flood elevation. For structures that are susceptible to basement seepage, floodproofing would consist of the installation of a sump pump, a utility check valve, and a concrete "utility chamber" (waterproofed concrete wall around the utility). This measure was not developed to create a watertight basement; however damage from seepage would be minimized in a cost effective manner by preventing damage to utilities. Floodsheilding would protect the structure against overland flooding not higher than the main floor. (Floodsheilding consists of closing all openings such as doors and windows.) In cases where the main floor would be inundated by the design flood, the floodproofing measures described would not suffice in eliminating flood damages, due to the extensive hydrostatic forces associated with such flooding; raising was one option which was considered in such a case."

b. "Raising. This measure was considered for all structures where the design flood stage is above the main floor. Raising a structure would consist of extending the height of the foundation walls (or constructing new walls for structures without basements) to an elevation such that the main floor would be higher than the design level. Fill would be placed on the existing basement floor slab and a new slab constructed. The original height from the basement floor would, therefore, be maintained. The wall and slab would then be waterproofed. This condition would result in a watertight basement which would be structurally stable under flooding conditions, with the main floor at a higher elevation than the design level. A sump pump would be installed in the basement, and the land around the structure would be filled and regraded. Raising was considered for both residential and non-residential frame structures, with main floor areas up to 4,000 square feet."

c. "Nonstructural Wall. This measure, which can be considered a form of floodproofing, was utilized for all structures whose main floor area is greater than 4,000 square feet, and whose main floor would be inundated by the design flood. In this case, a waterproofed concrete wall would be constructed around the building and joined to the existing walls of the structure. An impervious bentonite slurry wall would extend into the ground to a depth sufficient to prevent any seepage from entering the structure from under the wall. The wall would be architecturally treated at minimal cost for aesthetic purposes. This improvement would yield a watertight structure for floods up to the design level".

d. "Permanent Evacuation. Permanent evacuation was considered for all structures. The cost to evacuate a structure was compared to the cost of implementing a, b, or c, above, and the least costly alternative chosen. Permanent evacuation was also the alternative selected in cases where the depth of flooding exceeded practical engineering constraints to floodproof or raise a particular structure."

4. Detailed Descriptions of 1987 Plans. Single Building Block Plans 1 and 2 were ruled out fairly early in the 1987 document. The following description includes the 10-year Building Block 3A, Basin-Wide Plans 14A, and 16A.

a. Plan 3A: Permanent Evacuation, Floodproof/Raise. In 1987 an inventory was developed for the structures within the floodplain. This structure inventory was keyed to the structures location on 1"=200' scale topographic mapping with a 2' contour interval. Next, construction cost curves were generated for each alternative under consideration for different flood depths, and for each type of structure. Table 37 shows the results of the analysis of Building Block 3A (10,821 structures; Lower Passaic, Central Passaic, Upper Passaic, Pompton, Wanaque, Pequannock, and Ramapo; Total First Cost (1985 Price level) $192,500,000; Total Annual Cost (8-5/8%) $19,100,000). Figure 24 shows Plan 3A (also called the Nonstructural Plan).

b. Plan 14A. Plan 14A utilized intermittent levees and floodwalls in the Tidal Reach (south of NJ State Route. 3) and from Rt. 3 to Little Falls. Nonstructural was utilized between Little Falls and Two Bridges and in the Pompton Valley. A combination of levee, floodwall and nonstructural was utilized in the Central Basin. The total investment cost for all of Plan 14A was $395,000,000 (Oct 1985 Price level), and the annual cost was $34,200,000 (discount rate of 8-5/8%). Table 39 shows a summary of the nonstructural measures used in Plan 14A. Figure 20 shows Plan 14A.

c. Plan 16A. Plan 16A utilized intermittent levees and floodwalls in the Tidal Reach (south of NJ State Route. 3). 100-Year annual risk of flooding channel modification was utilized from Rt. 3 to Beatties Dam in Little Falls. Nonstructural was utilized between Little Falls and Two Bridges and in the Pompton Valley. A combination of levee, floodwall and nonstructural features were utilized in the Central Basin. The total investment cost for all of Plan 16A was $433,800,000 (Oct 1985 Price level), and the annual cost was $37,500,000 (discount rate of 8-5/8%).

d. Table 39 shows a summary of the nonstructural measures used in Plan 16A. Figure 21 shows Plan 16A.

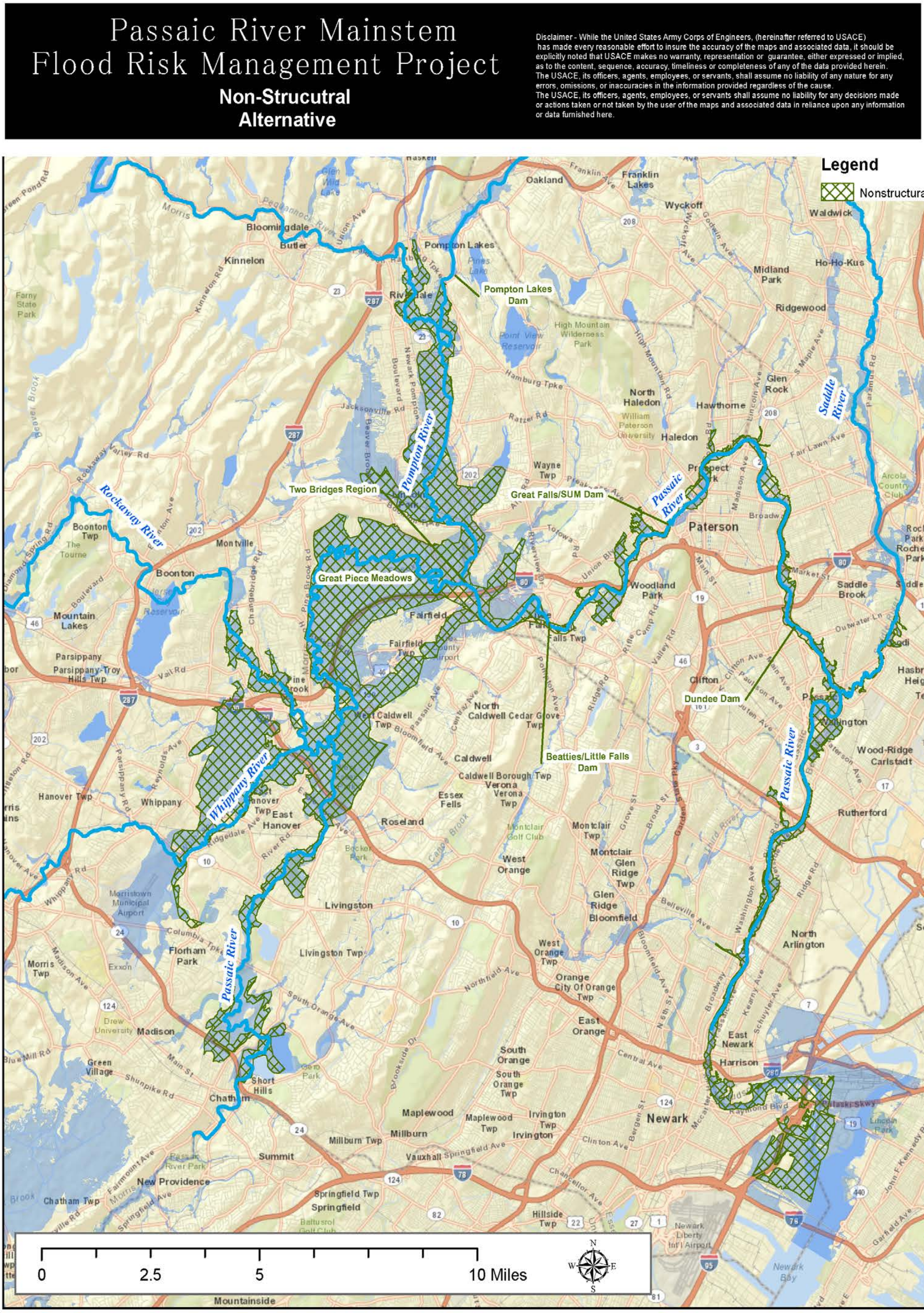


FIGURE 24: 10YR NON-STRUCTURAL ALTERNATIVE

TABLE 38:
SUMMARY OF BUILDING BLOCK 3A – FLOODPROOF, RAISE, RINGWALLS & PERMANENT EVACUATION

Summary of Building Block 3A: Floodproof, Raise, Permanent Evacuation											
	Number of Structures										
	Floodproof		Raise		Wall Around Structure		Permanent Evacuation		Subtotal	Total First Cost (Oct. 1985 Price Level)	Total Annual Cost (Oct 1985 Price Level, 8-5/8%)
Subbasin	R	NR	R	NR	R	NR	R	NR			
Lower Passaic	3,868	397	82	42	14	143	2	16	4,564	$ 95,700,000	
Central Passaic	1,690	82	74	5	45	76	19	9	2,000	$ 32,900,000	
Upper Passaic	464	31	1	-	1	2	4	1	504	$ 4,400,000	
Pompton	2,034	54	469	12	105	128	8	14	2,824	$ 49,400,000	
Wanaque	102	3	1	-	-	6	-	-	112	$ 1,300,000	
Pequannock	209	-	2	-	-	2	-	-	213	$ 1,800,000	
Ramapo	526	2	44	-	28	1	2	1	604	$ 7,000,000	
Subtotal	8,893	569	673	59	193	358	35	41	10,821	$ 192,500,000	$ 19,100,000
Notes: R=Residential											
NR=Non-Residential											

TABLE 39: PLAN 14A AND 16A NON-STRUCTURAL MEASURES

Plan 14A and 16A Nonstructural Measures				
	Total Number of Structures			
Subbasin	Floodproofing	Raising	Permanent Evacuation	Subtotal
Central Basin				
Residential	1,176	46	12	1,234
Non-residential	81	4	6	91
Pompton Valley				
Residential	3,004	516	10	3,530
Non-residential	196	12	15	223
Subtotal	4,457	578	43	5,078

5. Plans. The plans of the 2013 Phase 1, Passaic River Basin Flood Risk Management GRR included the following nonstructural elements:

a. 10-Year Nonstructural Plan Combination: Floodproof, Raise, and Permanent Evacuation (equivalent to Building Block 3 in 1987 GDM).

b. Plan 14A: Levee, Floodwall, Dam, Bridge Modification, Floodproof, Raise, and Permanent Evacuation (equivalent to Plan 14A in 1987 GDM).

c. Plan 16A: Channel Modification, Levee, Floodwall, Floodproof, Raise, Permanent Evacuation (equivalent to Plan 16A in 1987 GDM).

6. Sizes. The sizes of the plans evaluated were designated with suffixes as follows:

a. Plan 3A: 10-year floodplains and design to withstand a 10-year return interval water surface elevation for nonstructural features.

b. Plan 14A: 10-year floodplains and design to withstand a 10-year return interval water surface elevation for nonstructural features, 100-year annual risk of flooding for structural features.

c. Plan 16A: 10-year floodplains and design to withstand a 10-year return interval water surface elevation for nonstructural features, and 100-year to 500-year annual risk of flooding for structural features.

7. Measures. The nonstructural components included exact measures (floodproofing, raising, nonstructural wall, permanent evacuation) identified in the 1987 GDM (refer to summary of 1987 nonstructural alternatives for details).

8. Number of Structures. The following assumptions were made for updating the 1987 number of structures to 2012. The assumptions were made for the 10-Year Nonstructural Plan, Plan 14A, and Plan 16A.

a. It was assumed that new structures, constructed between 1987 and 2012, followed sound floodplain management and the main floor elevations are above the 100 year flood elevation, or were constructed using flood proof features.

b. It was assumed that any structure which had significant reconstruction (say a house rebuilt following a significant flood where the repair cost was greater than 50% of the value of the structure) between 1987 and 2012, also had the main floor above the 100 year flood elevation, or were constructed using flood proof features. We removed 1% of the structures from the total amount of structures to be permanently evacuated. Since no data was available to support this assumption there is a high level of uncertainty associated with this assumption. We are assuming a possible data range may be from 0% to 10%, with 1 or 2% being the best guess or mostly likely amount.

c. The local authorities have already begun permanent evacuation of some floodplains areas. The number of structures purchased and eliminated between 2010 and 2012 and between 1987 and 2003 was provided. The number of structures purchased between 1987 and 2003 was converted to a yearly rate and this rate was applied to the remaining years as a best guess of all the structures removed by the locals from the amount of structured to be evacuated.

<u>Plan Description and Intent</u>

1. Detailed Descriptions of 2012 Plans.

a. 2012 10-Year Nonstructural Plan Description: This plan consists of Permanent Evacuation and Floodproof/Raise. The same floodplain delineation (10-year annual risk of flooding in Pompton Valley, Central Passaic, Lower Passaic, and Upper Passaic) and nonstructural analysis was assumed for this Plan as for the 1987 Plan 3A with the exception of the number of structures as adjusted per the previous paragraphs**.** Table 39 shows the results of the analysis of 2012 10-Year Nonstructural Plan (9,947 structures; Lower Passaic, Central Passaic, Upper Passaic, Pompton Valley (Pompton, Wanaque, Pequannock, and Ramapo); Total First Cost (Oct 2012 Price level) $587,000,000; Total Annual Cost (3.75%) $28,400,000. Figure 24 shows Plan 3A (also called the 10 Year Nonstructural Plan).

b. 2012 Plan 14A: 2012 Plan 14A utilized intermittent levees and floodwalls in the Tidal Reach (south of NJ State Route. 3) and from Rt. 3 to Little Falls and nonstructural measures between Little Falls and Two Bridges and in the Pompton Valley. A combination of levee, floodwall and nonstructural was utilized in the Central Basin. The number of structures was adjusted as per the above paragraphs to 4,262. The subtotal cost for the nonstructural features only of 2012 Plan 14A was $362,200,000 (Oct 2012 Price Level), and the annual cost was $17,500,000 (discount rate of 3.75%). Table 38 shows a summary of the nonstructural measures used in 2012 Plan 14A. Figure 20 shows Plan 14A.

c. 2012 Plan 16A. Plan 16A utilized intermittent levees and floodwalls in the Tidal Reach (south of NJ State Route. 3). 100-Year annual risk of flooding channel modification was utilized from Rt. 3 to Beatties Dam in Little Falls. Nonstructural was utilized between Little Falls and Two Bridges and in the Pompton Valley. A combination of levee, floodwall and nonstructural features were utilized in the Central Basin. The number of structures was adjusted as per the above paragraphs to 4,262. The subtotal cost for the nonstructural features only of 2012 Plan 16A was $362,200,000 (Oct 2012 Price Level), and the annual cost was $17,500,000 (discount rate of 3.75%). Table 38 shows a summary of the nonstructural measures used in 2012 Plan 16A. Figure 21 shows Plan 16A

TABLE 40: 2012 10YR NON-STRUCTURAL PLAN

2012 10-Year Nonstructural Plan							
		Number of Structures					
Treatment Type	Structure Type	Pompton Valley	Central Passaic	Lower Passaic	Upper Passaic	**Subtotal**	**Cost (Oct 2012 Price Level)**
Floodproof	Residential	2,474	1,439	3,819	464	8,196	$ 219,025,847
Floodproof	Non-Residential	51	70	392	31	544	$ 32,789,040
Raise	Residential	445	63	81	1	590	$ 66,837,407
Raise	Non-Residential	10	4	41	-	56	$ 8,507,963
Ringwall	Residential	115	38	14	1	168	$ 63,805,041
Ringwall	Non-Residential	118	65	141	2	326	$ 168,155,769
Buyout	Residential	9	16	2	4	31	$ 9,231,057
Buyout	Non-Residential	13	8	16	1	37	$ 18,692,915
Subtotal		3,234	1,703	4,506	504	**9,947**	**$ 587,045,038**

B. ENVIRONMENTAL

Environmental Resources

New Jersey Environmental Rules and Regulations of Concern

In 1961, The Green Acres Program was created to meet New Jersey's growing recreation and conservation needs. The purposes and objectives of the Green Acres laws help ensure that there is access to and an adequate supply of lands for either public outdoor recreation or conservation of natural resources, or both. Green Acres assists local government units and nonprofits in their efforts to increase and preserve permanent outdoor recreation areas for public use and enjoyment, and conservation areas for the protection of natural resources such as waterways, wildlife habitat, wetlands, forests, and viewsheds.

Land diverted from recreational to flood damage reduction purposes that is part of the Green Acres program requires replacement with land of equal or greater value. The land included in the Green Acres program includes all recreational land within a municipality at the time it signs a contract to receive Green Acres funds, not just those lands purchased with Green Acres money. The Green Acres lands involved include 40 acres of land in Passaic County Park Department lands located in Wayne Township and the Borough of Pompton Lakes and Essex County Park Department lands in the Borough of Fairfield and Livingston Township. New Jersey DEP has instituted a special Hurricane Sandy section of the Green Acres program to acquire Sandy damaged property as Green Acres. This may set aside more land as Green Acres reducing the amount of land available for mitigation or structural placement.

In August of 2004 New Jersey adopted The Highlands Water Protection and Planning Act in order to preserve open space and protect the state's greatest diversity of natural resources including water resources that supply drinking water. The Highlands Act documents the geographical boundary of the Highlands Region and establishes the Highlands Preservation Area and the Highlands Planning Area. It required the department to establish regulations in the Highlands Preservation Area to create a Highlands Water Protection and Planning Council and to develop a regional master plan for the entire Highlands Region. This law may affect how many mitigation measures and structures are implemented in the Highlands Area.

In November 2007, the state of New Jersey adopted New Jersey Flood Hazard Area Control Act, N.J.S.A. 58:16A-50 et seq., The Department discourages activities within the channel, unless absolutely necessary. This is because the Department must preserve aquatic habitat and passage. In addition, by limiting work out of the channel, this can play a role in limiting flood damage and minimizing erosion along stream banks. Activities with the riparian zone, land and vegetation within a regulated water and extending either 50 feet, 150 feet or 300 feet from the top of bank along both sides of the regulated water, depending on the environmental sensitivity of the water is also regulated with this act. Current regulations require a 2:1 mitigation ratio. Compliance with this law will be necessary through close coordination with the state and the issuance of permits as necessary.

Cultural Resources

Based on larger sensitivity studies in the Passaic Basin (Williams, et al 1978; Bodie and Klein 1983) and the more focused work (MAAR Associates 1991 Cavallo, et al 1993; Hartwick, et al 1995; Bzdak and Howson 1995) as well as the NJHPO databases it is clear that the potential to encounter significant resources, both archaeological and extant structures is high within the proposed projects areas of Alternatives 14A, 16A, Newark Outlet Tunnel Alternative and Beatties Dam/Two Bridges. The occupation by Native American populations was widespread and although large swaths of the basin have been developed the potential for archaeological remains is high. Higher grounds surrounding wetlands and above waterways are most sensitive. Historic occupation has left standing structures and archaeological remains throughout the basin as well. Roadways and nucleated settlements are most sensitive but remains of farmsteads and industrial properties in more isolated locales are also anticipated. The potential for encountering sites "in the wet," such as fish weirs, mills and dams, and Native American sites deep under alluvial deposits is quite high. It should be noted that excavation of such environments is generally more costly than work on dry sites due to logistics of dewatering, including possible need for coffer dams, need for specialized equipment and increased time to complete excavations. The proposed non-structural alternative has the potential to impact historic structures. A historic architectural evaluation of structures proposed for non-structural measures must be undertaken.

A Programmatic Agreement (PA) will be drafted in the next phase of study. The PA will stipulate the actions the USACE must undertake to remain in compliance with Section 106 and will include the direction of future study as well as spell out steps for mitigation if resources cannot be avoided. This document will be developed in consultation with the NJHPO, Tribes, and interested parties. The Advisory Council on Historic Preservation will also be given an opportunity to participate in the consultation process. Any work stipulated in the PA will be undertaken prior to initiation of project construction unless otherwise agreed with the NJHPO.

HTRW Resources

It should be mentioned that not all locations of contaminated soil or sediments are known. There is the very real possibility that once excavation of soils begins previously unknown pockets of contamination will be discovered. Any excavation within the Basin, particularly the Lower Basin, must be fully prepared to manage that contingency. The specific matching of alternative elements with existing NJDEP KSC and Superfund sites (especially the lower 17-mile operable unit of the Diamond Alkali Site) to identify and pinpoint impacts will take place as part of the next phase of activities.

Conclusion

A complete environmental impact statement (EIS), which will also include Cultural Resource and HTRW analyses, will be completed in Phase 2 Report. Investigation into the federally endangered Indiana bat will be required, including informal consultation with USFWS. The delineation of wetlands within the Basin will be conducted. Field-based surveys for avian, reptile, amphibian and fish communities above the Dundee Dam may be necessary, but given the extent of available data in the Lower Passaic River, surveys in the Lower Basin would likely be minimal or focused on data gaps within the alignment of the selected plan and possible mitigation measures required.

Depending on the selected plan identified in the Phase 2 Report, mitigation may be required. The assessment of the need for mitigation and the type of mitigation measures to be evaluated will be based upon the most current state and Federal regulations and methods and USACE policies. In general, typical mitigation measures associated with structural alternatives include but are not limited to:

- Restricting channel modifications to one side of the waterway or implementation of a low flow channel;
- Installation of aquatic habitat enhancement structures;
- On-site or off-site wetlands creation, restoration or enhancement;

- Vegetative invasive species management and replanting native species;

Coordination with the restoration planning effort within the lower 17-miles of the Lower Passaic River and tributaries (i.e., 49 restoration opportunities have been identified) could be utilized to fulfill such mitigation requirements in the Lower Basin. Coordination with federal and state governmental regulatory agencies (NJDEP, USFWS, NOAA, USEPA, SHPO), public and private Passaic River interest groups as well as the public (EIS scoping meetings) in general will be necessary. Historically, Passaic River NGOs have been very vocal in their views on the District's plans for flood control along the river. The utilization of the existing Community Advisory Group (CAG), established for the Lower Passaic River Restoration Project will be maximized as much as possible for outreach in the Lower Passaic Basin.

C. STRUCTURAL

The structural task for this phase of the study was to compile information in order to determine preliminary costs for four plans; these include the Newark Outlet Tunnel Alternative, 16A, 14A and a combined plan for Beatties Dam & Two Bridges. The analysis is divided into three main components consisting of bridges, floodwalls and dams.

The 1995 GDM contained preliminary type structural designs for features in the Newark Outlet Tunnel Alternative. However, structural computations for Plans 16A, 14A and Beatties Dam were not found in any of the GDMs listed above. In addition, very limited information is available for the two new dams proposed for the Beatties Dam & Two Bridges Dam Alternative.

Bridges

There are approximately 150 bridges within the Passaic Main Stem Project. The bridge name, location and other information was compiled using previous GDMs, GIS, Google Earth and HEC-RAS cross-sections and can be found in Table S.1 Passaic Main Stem Bridges. It is important to note, that the names and types of modification required for the bridges were never stated in building block 13a of the 1987 GDM. In addition, the GDMs did not include bridge stability calculations in areas of channelization.

Many of the bridges within the project may have changed over the past 20 years and can only be verified through bridge as-builts and bridge inspection reports. Due to the limited information at this time, the actual type of bridge modification (i.e. bridge raising, abutment/pier underpinning, complete replacement, combination of raising and underpinning etc.) for each bridge cannot be determined and may be refined during Phase II of this reevaluation. However, an estimated number of bridges possibly impacted at the time of the previous GDM reports was determined and narrowed down based on existing condition water elevations and floodwall/levee tie-in locations. Refer to Table S.1 Passaic Main Stem Bridges for this information.

Summary of the number of bridges in each alternative as per the existing GDMs:

- Newark Outlet Tunnel Alternative: 1 bridge
- Alternative 14A : 11 bridges
- Alternative 16A: 11 bridges

Table S.1 Passaic Main Stem Bridges also contains the names and number of bridges that may be impacted due to channelization for the proposed alternatives. After completion of the hydraulic analysis, the new water elevations will need to be compared to the bridge low chords in order to ensure a minimum freeboard clearance of 2 ft. This is assuming freeboard based design concepts are being used. If risk based design concepts are being adopted, then minimum freeboard clearance requirements may change. Bridges that do not meet minimum freeboard clearances may need to be raised or replaced.

Summary of the number of bridges that may possibly be impacted after re-evaluation as a result of channelization (note this number will be refined in future phases once bridge as-built information is secured):

- Newark Outlet Tunnel Alternative: 16 bridges
- Alternative 14A: 5 bridges
- Alternative 16A: 46 bridges
- Beatties Dam & Two Bridges Alternative: 17 bridges

For bridge design and modifications, the design criteria will need to be updated as per new NJDOT and AASHTO specifications. The 1995 GDM designs are not in LRFD (Load Resistance Factor Design) and may have to be updated accordingly in Phase 2 of this reevaluation.

<u>Floodwalls</u>

Newark Outlet Tunnel Alternative

According to the 1995 GDM, I -walls were chosen because to minimize impact due to suspected hazardous waste sites. Due to new I -2 -wall design guida 6066 dated April 1, 2011) published after Hurricane Katrina, all I -walls heights in the 1995 GDM were reverted back to T-wall sections as shown in the 1987 plans for preliminary cost purposes. Costs may increase significantly due to (1) increased erosion protection for proposed I-walls and (2) increased footprint areas of proposed T -wall sections.

Many of the levees in this alternative may need to be reconsidered as floodwalls due to space limitations and new development in the area. This may be evaluated in Phase 2. Refer to Table S.2 Alternative Newark Outlet Tunnel Alternative Floodwalls for the height, length, wall type and names of each levee/floodwall systems for preliminary cost. All reference cross-sections from 1987 and 1995 GDMs are tabbed in PDF for ease.

Alternative 14A

Very limited information exists in terms of floodwall types and design for this alternative. The heights and lengths indicated on Google Earth layouts for this alternative were used. Refer to Table S.3 Alternative 14A Floodwalls for the height, length, wall types and names of the corresponding levee/floodwalls systems associated with this plan.

This alternative consists of approximately 66 different levee systems. For simplification, the walls were broken down into four wall height categories using weighted averages:

Walls < 10 ft
10ft <= Walls < 15ft
15 ft <= Walls < 20ft
20 ft >= Walls

[Refer to Table S.3 Alternative 14A floodwalls for wall types assumed for each wall height category.]

The T-wall cross sections with the appropriate average exposed heights from the 1987 GDM plans were used for determining preliminary cost for each category of wall height. Whenever the same floodwall system existed in both 14A and the Newark Outlet Tunnel Alternative, T-wall cross-sections provided for preliminary costs for the Newark Outlet Tunnel Alternative were used since this plan was developed the furthest in both the 1987 and 1995 GDMs. Wall heights for the levee systems may change after hydraulic modeling is completed in the next phase. In addition, many of the levees in this alternative may need to be switched to floodwalls due to space limitations and new development in the area.

Alternative 16A

Very limited information exists in terms of floodwall types and design for this alternative. The majority of the levee/floodwall systems in this alternative are the same as the systems in the Newark Outlet Tunnel Alternative except for the heights. The heights and lengths indicated on Google Earth layouts for this alternative were used. The floodwall heights for this alternative are the same as for the Newark Outlet Tunnel Alternative on Google Earth. However, according to the 1987 GDM, wall heights for many of the walls are not the same as the Newark Outlet Tunnel Alternative and may need to be raised by 1 to 2.5 ft. Wall heights will be revised accordingly after the completion of H&H analysis.

Many of the levees in this alternative may need to be reconsidered as floodwalls due to space limitations and new development in the area. This may be evaluated in Phase II. Refer to Table S.4 Alternative 16A Floodwalls for the height, length, wall types and names of the corresponding levee/floodwalls systems associated in this plan. All reference cross-sections from 1987 and 1995 GDMs are tabbed in PDF for ease.

Dams

A typical cross-section was given for preliminary cost purposes. In order to choose the most economical dam, several preliminary designs and estimates of several types of dams are typically required. This will need to be developed in the next phase. Very limited information was available at the time of evaluation. Detailed site conditions and geotechnical data will need to be obtained for development of dam designs in the next phase.

<u>Two Bridges Dam</u>
Design of Small Dams by United States Department of the Interior, Bureau of Reclamation was used as a reference. Rock elevation was assumed to be at Elevation 122 ft based upon limited geotechnical data. However, the rock elevation may vary at this location and may need to be verified with further geotechnical investigations in the Detailed Analysis Phase 2. If this plan is chosen, extensive boring information at this location will be required for further design of dam.

<u>Beatties Dam</u>
The arch shape as shown in Figure S5 may need to be revised after further evaluation. If this plan is carried forward, extensive boring information at this location will be required for further design of dam.

D. GEOTECHNICAL

The geotechnical-related tasks associated with the Phase 1 Report analysis were to: review existing USACE geotechnical data and search for additional sources of information; summarize the data for internal use; review any changes to USACE regulations or guidance since preparation of the last report (1995 GDM); and initially analyze the information to identify areas of concern.

<u>Review of Available Geotechnical Information</u>

The subsurface conditions from approximately 50 borings from the 1987 and 1995 reports were reviewed. The soil profile included in 1987 GDM that accounts for the length of Passaic River as well as Ramapo River, Rockaway River, and Deepavaal Brook references a "1948 A.C.E. Report" as the resource. This report could not be located; therefore, this profile was only used as guidance, and not for direct assumptions. The 1995 GDM information contains a significant amount of site geology information that was not fully utilized in this phase, but may be used in Phase 2 (see referenced document Appendix E Volume III).

Additional Sources of Geotechnical Information – NJDOT. The best resource has been an online database and mapping system of all boring logs for NJDOT projects. A summary of all the logs found along the project area was created in Excel. From that list, 2-3 logs were randomly selected for each system, due to the significant number of borings found in certain locations. Depth was the only factor included in selecting random samples (those with the greatest depth were attempted to be selected from the group).

Additional Sources of Geotechnical/Geologic Data – Others. USGS maps were used to identify the general rock type in the area and can be found in the attached references, and also show bedrock surface topography

NJDEP water well permits were able to be searched in the referenced website, however the accuracy of this information was not high enough to be considered in this phase (see reference list for link). Additionally these permits would have to be obtained directly from NJDEP and are not available online.

Available Aerial Information: The location of levee systems was generated in Google Earth. These system names, locations, and details were used to for the geotechnical assessment as well. For many of the levee systems included in the 14A and 16A plans, the exact locations of levee/floodwall are not defined. Due to the level of detail needed for this phase, specific locations were not determined, causing the assessment of structural impact to be very limited.

<u>Summary of Findings – Plans 14A, 16A, Newark Outlet Tunnel Alternative</u>

Available soil boring information was assessed for possible subsurface conditions of concern. The majority of boring logs referenced were obtained via the NJDOT Borings website (see reference list), with a limited number of USACE borings that were able to be located. Each location of NJDOT borings is able to be seen on their resource map, but it was not able to be directly analyzed in Google Earth. Due to this fact, all distances from systems to borings were estimated, and during Phase 2 each location should be obtained for greater accuracy.

Based on this selected collection of borings, 3 areas were identified as major areas of focus. Those areas are Wagaraw Levee/Floodwall, Passaic River #12 Levee, and Pinch Brook Levee. These areas were considered for a major focus because there is neither a USACE boring nor NJDOT boring within 3,000+ ft of the system. Of the three areas of focus, Pinch Brook Levee system was the only included in the plans for the Newark Outlet Tunnel Alternative. That area received has a higher level of design detail, so an assumption was made to utilize the information provided in the 1995 GDM.

Typical Levee Cross Sections

If a system was listed in the 14A/16A plans (1987 GDM) as well as the Newark Outlet Tunnel Alternative plans (1995 GDM), then typical sections provided in the 1995 GDM would be recommended. Most areas for the 14A/16A plan were not included in the 1995 GDM, in those cases it was determined the 1987 typical cross sections would be recommended.

The typical cross section types were limited to cross sections showing the following:

1) Standard Fill Material
2) Standard Fill Material with Toe Drain
3) Impervious Core

Summary of Findings – Two Bridges Dam and Beatties Dam

1. **Two Bridges Dam Information**

All available information was gathered from "GDM Appendix Part III Foundations/Boring Logs". Additionally, a large amount of water well information in the area as well as one boring (approx. 2,000 feet south of proposed dam location). Water well information was not considered the most accurate account although it is an official document. Therefore, only boring log data was assessed.

From "Bedrock Geologic Map of Northern New Jersey", the Two Bridges area was identified as Towaco Formation consisting of sandstone, siltstone, and silty mudstone (see attached reference).

Four NJDOT borings were found in the general area of the proposed Two Bridges Dam (the closest is approximately 1,400 ft. south of proposed site). Two of the located boring logs were used to assess a general soil profile, those borings were NJDOT ID Numbers B0031425 and B0031426 (see attached reference).

Typical Earthen Embankment: A typical cross section was generated after using multiple references including. Due to the uncertainty of the top of rock line, a combination of cutoff trench, cutoff wall, and internal drain was recommended. During the second phase analysis of this study, soil information and top of rock line will need to be identified in order to optimize this cross section.

2. Beatties Dam Information

The original Beatties Dam report was not able to be obtained, therefore a boring from the general area was used to establish top of rock line. Original report title: "Passaic River, Vicinity of Beatties Dam Reconnaissance Report – Appendix B Section 3 (August 1989). Please note that tunnel alignment is slightly different in 1987 GDM map than it is placed in Google Earth, because of this the stationing was used with evaluated horizontal distance from boring.

From "Bedrock Geologic Map of Northern New Jersey", the Beatties Dam area was identified as Preakness Basalt (see attached reference). Bedrock elevation (MSL) at closest points is shown as follows: PTI-3 = 155, DH-10 = 185, DH-19 = 167

<u>Changes to USACE Standards and Guidance</u>

Since preparation of the 1995 GDM, the following USACE standards and guidance have changed and will need to be accounted for design and planning of project features:

TL 1110-2-571 *Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures, dated 10 April 2009,* indicates the minimum width of the Vegetation-Free Zone surrounding structures is 15 feet. Therefore, it is assumed that the real estate within 15' of all levees and floodwalls will need to be purchased and declared permanent easements. In addition, clearing of existing trees from within the vegetation free zone will need to be performed.

EC 1110-2-6066 *Design of I-Walls*, dated 1 April, 2011, limits the height of I-Walls to six feet. Therefore, all I-Walls in the previous designs will need to be changed to T-Walls. This will require redesign, and could increase the difficulty of installation due to the larger footprint area of a T-Wall.

E. COST ESTIMATES

The basis of the cost estimates for the above mentioned alternatives are cost engineering appendices referenced in the 1987 General Design Memorandum (GDM) and the 1995 GDM. The design branch and Hydraulics & Hydrology (H&H) section of Civil Resource Branch (CRB) provided updated information such as typical cross sections of levees, floodwalls, dams, etc. The quantities were developed based on these cross sections and quantities for other construction features were extracted from the 1987 GDM & the 1995 GDM and coordinated with respective branches. The cost for the tunnel in the Newark Outlet Tunnel Alternative were escalated by using the Civil Works Construction Cost Index Systems, EM 1110-2-1304 dated 31 March 2012. The contingencies for the alternatives were developed based on the PDT discussions on various features of the project using the Abbreviated Risk Analysis (ARA) template provided by cost Mandatory Center of Expertise (MCX), Walla Walla District. These contingencies were applied to the construction cost estimates to develop the Total Project First Cost. Detailed MCACES and MII cost estimates were not developed during Phase I.

Further, the fact that a number of flood prone properties have been purchased since the 1995 Phase 2 GDM was completed, these structures were addressed in both the cost of the non-structural plans and in the economic analysis of the existing damage pool. To remove the non-structural treatment costs of the structures that no longer existed, involved obtaining lists of buy-outs from the local sponsor, local contacts and USACE files. The list of bought-out structures was missing data for a few years. The missing years of data were approximated by using buy-out rates from the years for which we had data. The total approximate number of bought-out structures was then removed from the original 1987 number of structures to be treated. See the Non-structural Plan description in the Hydraulic sections for more details of this process.

The loss of potential benefits from the bought-out structures was indirectly accounted for in the economic analysis. The property and structural values in each economic reach were based on the assessed property values available on local tax maps. If a structure was bought-out the property would have been removed from the tax maps and therefore would not have been mistakenly counted as a flooded structure.

<u>Alternative Cost Estimates</u>

1. Alternative #14A

The scope of the alternative #14A was based on the 1987 GDM and the 1995 GDM, with an update to levee and floodwall quantities, along with the levee cross sections to reflect the current requirements based on the latest H&H model. Alternative #14A consists of a combination of levees, floodwalls, bridge modifications/replacements, floodproofing, raising and removal of structures from flood prone areas. The Lower Valley and the Central Basin above the upstream reach of Deepavaal Brook would be protected against flood events by the levee/floodwall systems. The Pompton Valley and the Passaic River between Beatties Dam and the upper limit of Deepavaal Brook would be protected against flood events through the floodproofing, raising and excavation of structures.

This alternative consists of 203,546 linear feet (LF) of levees and floodwalls. Associated items include ponding areas, pressure interceptors, and the gate structures. Typical levee and floodwall cross sections were provided by design branch and were used to develop the quantities on a per linear foot basis. Using this quantity, a cost per linear foot was developed utilizing cost resources such as RS Means, MII Cost Libraries, vendor quotations and historical data on similar construction features. The miscellaneous items such as gates, headwall, ditches, fencing, etc. were added to this unit cost to develop an overall cost per unit for these systems.

The quantity of the pressure interceptors was based on the 1987 GDM along with its respective cost escalated to the October 2012 price level. The quantity for the ponding areas was also based on the 1987 GDM. However its cost was formulated with the use of the 2012 cost book and the RS Means based on its features.

Eleven (11) bridge modification/replacement quantities that were provided by the design branch, approved by the H&H, and confirmed by the Technical Manager were utilized in the estimate under CWBS #08 Roads, Railroads & Bridges. The cost of the bridge modification/replacement was obtained from the 1995 GDM, escalated to October 2012 price level.

A pump curve, shown in Figure 25 was developed based on the Greenbrook Segment T (Dec 2001), Seabrings Mills Rd (Aug 2010), and Greenbrook Segment R2 (March 2008) at 30 CFS, 50 CFS, and 90 CFS respectively. An equation was formulated to generate the costs of various flow rates with exception of any flow rates below 30 CFS, which was assumed to carry a cost of $830K.

The cost of the stop log structures, a feature of a CWBS #04 DAM under alternative #14A is based on the 1987 GDM, and the cost for Fish & Wildlife facilities was provided by the respective environmental office in reference to the Finderne Mitigation Project of the Greenbrook project in 1996. Both costs were escalated to the October 2012 Price Level.

The nonstructural components includes exact measures (floodproofing, raising, nonstructural wall, permanent excavation) indentified in the 1987 GDM. The quantities were extracted from the 1987 GDM and utilized to develop the nonstructural cost using the RS Means. No new data was incorporated for this preliminary assessment.

The cost of the Cultural Resources Preservation facilities was provided by the respective environmental team where archaeological data recovery, potential deep testing/monitoring during construction, mitigation for bridge replacement/modifications, HABS/HAER level documentation or alternate mitigation (Levee/Floodwall alignment), public outreach, and the environmental mitigation were taken into consideration to develop the cost.

The construction duration for this alternative was developed based on crew outputs referenced from RS Means, similar projects such as Greenbrook Flood Risk Management (FRM) and assuming multiple contracts awarded simultaneously. The total construction duration is estimated to be approximately eight (8) years and two (2) months.

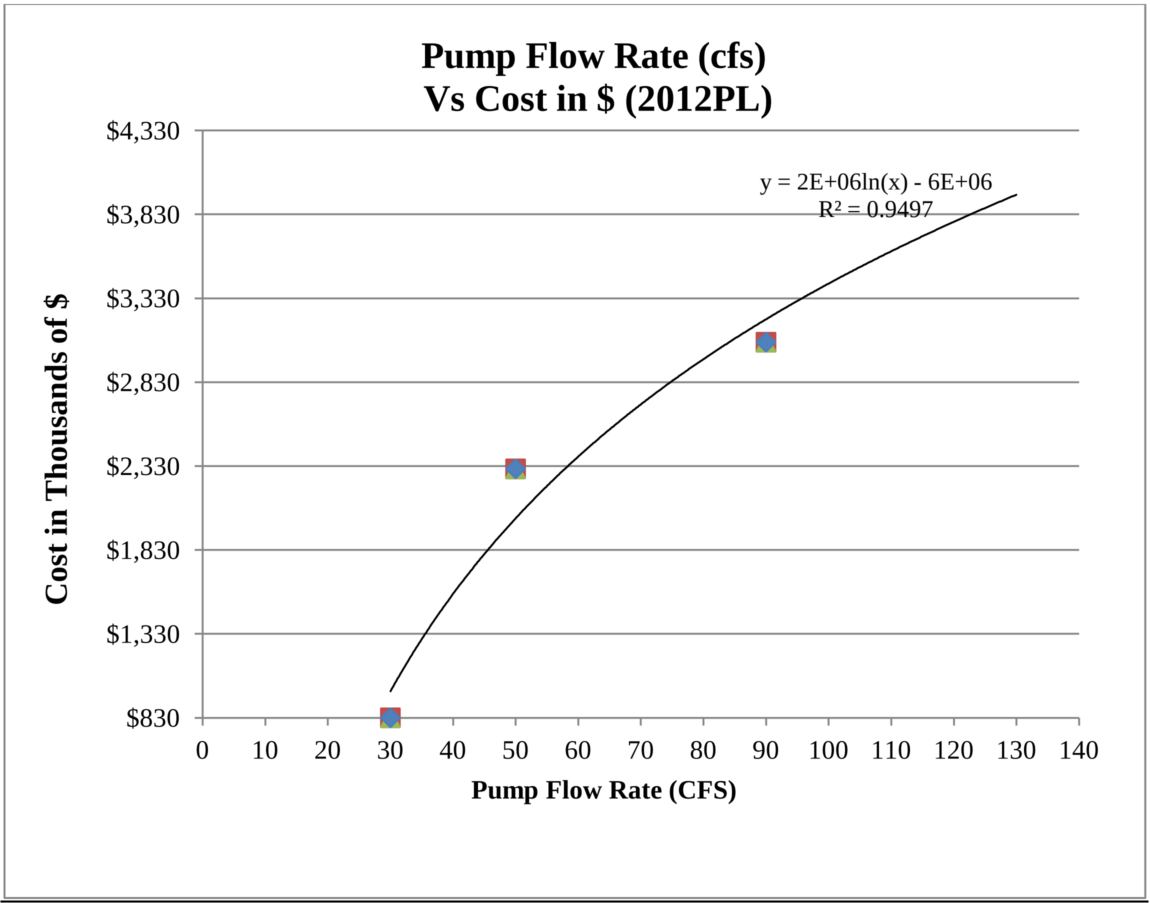


FIGURE 25: PUMP CURVE

2. Alternative #16A

The scope of the alternate #16A was based on the 1987 GDM and 1995 GDM, with an update to the levee, floodwall, and channelization quantities, along with the levee cross sections to reflect the current requirement based on the latest H&H model. It consists of a combination of levees, floodwalls, channel modifications and nonstructural measures. The central feature of the plan was the channel modification, protected against flood events. The remaining elements in this alternative were identical to alternative #14A, with levees and floodwalls along the Passaic River downstream to Route 3, and in the Central Basin above the upstream limit of Deepavaal Brook; however, no levee/floodwall systems would be located between Route 3 and Beatties Dam along the lower Passaic River. Identical to alternative #14A, the Pompton Valley and the Passaic River between Beatties Dam and the upper limit of Deepavaal Brook would be protected against flood events through the floodproofing, raising and excavation of structures.

The cost of the stop log structures, weir efficiency, and lower crest height, features of the CWBS #04 DAM are based on the 1987 GDM, and the Fish & Wildlife facilities cost was provided by the respective environmental office in reference to the Finderne Mitigation Project of the Greenbrook project in 1996. Both costs were escalated to the October 2012 Price Level.

The channelization cost was developed per historical data obtained from Greenbrook Segment U – Alternate #2 with the quantities provided by the respective design team to reflect the current requirements per H&H model.

The costs for the bridge modification/replacement, levees & floodwalls project features, pump stations, and the cost for the culture resource preservation facilities and nonstructural measures were developed using the same approach as in Alternative #14A.

The construction duration for this alternative was developed based on crew outputs referenced from RS Means, similar projects such as Greenbrook Flood Risk Management (FRM) and assuming multiple contracts awarded simultaneously. The total construction duration is estimated to be approximately seven (7) years and six (6) months.

3. Newark Outlet Tunnel Alternative

The scope of the Newark Outlet Tunnel Alternative was based on the 1995 GDM. The overall Newark Outlet Tunnel Alternative cost estimate was developed by escalating the cost estimate from the 1995 GDM price level to October 2012 price level utilizing the escalation factor developed from the Civil Works Construction Cost Index System (EM1110-2-1304 dated 31 March 2012).

The Newark Outlet Tunnel Alternative consists of the construction of 21 miles long, 42-foot diameter and a 1.2 miles long, 23-foot diameter concrete lined tunnels. Two tunnel boring machines (TBMs) will be utilized through basalt (rock). The basalt has an average strength of 24,000 psi. The acquisition cost quotation for 48 feet TBM that is needed to construct a 42 feet diameter tunnel was obtained from The Robbins Company on 7 May 2013 at a cost of $70 million each with a lead time for the acquisition of approximately 14 months in duration. The 1995 GDM assumed this alternative would require two (2) TBMs working simultaneously.

An internet search was performed to collect data on similar projects to analyze the cost patters and its relations with the current estimated alternative #Newark Outlet Tunnel Alternative tunnel cost. Table 41 shows the historical cost data of similar projects, including the Passaic Alternative #Newark Outlet Tunnel Alternative tunnel cost at both the 1995 and 2012 price level that require the use of a TBM or similar construction equipments along with production rates. The column titled “$/LF (cost escalated to Oct 2012 PL)” shows the approximate unit cost of the finish project. Deviations in cost can be due to project scope and contractor’s means and method. Further research and investigation may be required to analyze the scope of these projects for a better comparison to Alternative #Newark Outlet Tunnel Alternative, during Phase II.

TABLE 41: HISTORICAL TUNNEL COST DATA

Project Name	Tunnel Length (ft)	Finish Diameter (ft)	TBM Production Rate	Contract Cost	Contract Cost (escalated to Oct 2012 PL)	$/LF (cost escalated to Oct 2012 PL)	Construction Start	Construction Completion
Niagara Tunnel	33,264	42	10 ft/hr	$ 1,500,000,000	$ 1,500,000,000	$ 45,094	2005	2013
East Side Access Manhattan Tunnels	25,000	22	6.25 ft/hr	$ 504,587,035	$ 504,587,035	$ 20,183	2006	N/A
Atlantic City-Brigantine Connector	13,200	N/A	N/A	$ 519,917,121	$ 519,917,121	$ 39,388	1998	2001
Lincoln Tunnel	23,704	31	N/A	$ 1,197,743,056	$ 1,197,743,056	$ 50,529	1934	1957
Port of Miami Tunnel	7,800	42.3	3.14 ft/hr	$ 607,000,000	$ 607,000,000	$ 77,821	2010	2014
Passaic 30E Tunnel (1995 PL)	110,880	42	4 ft/hr	$ 2,540,477,639	$ 2,540,477,639	$ 22,912	TBD	TBD
Passaic 30E Tunnel (2012 PL)	110,880	42	4.6 ft/hr	$ 3,819,550,600	$ 3,819,550,600	$ 34,448	TBD	TBD

Notes: (1)
Data for Niagara Water Tunnel is obtained from http://www.niagarafrontier.com/tunneltechnical.html
(2) The cost for the East Side Access Manhattan Tunnels includes the cost for boring, cavern excavation, the tunnels and caverns will be lined with both shot crete and cast-in place concrete. Referenced from http://www.judlau.com/projects/current/east-side-access-tunnels.
(3) The cost for the Atlantic City-Brigantine Connector was escalated utilizing Civil Works Construction Cost Index.
(4) The cost for the Lincoln Tunnel was escalated utilizing the Consumer Price Index.
(5) The cost for the Port of Miami Tunnel includes 3,900 LF split portal automotive trafffic tunnel, as well as road improvements around the port of Miami. (http://www.fhwa.dot.gov/ipd/project_profiles/fl_port_miami_tunnel.htm)
(6) The tunnel production rate for Alternative #30E Tunnel is about 3 to 5 feet per hour for rock and about 7 to 13 feet per hour for sedimentary materials. Information gathered from the 1995 GDM, Appendix D.
(7) The production rate for Alternative #30E Tunnel was obtained from The Robbins Company via email dated 07 May 2013.

The construction duration for this alternative was extracted from the 1987 GDM. The total construction duration is estimated to be approximately 10 years and 10 months.

4. Beatties Dam/Two Bridges Improvement Alternative

The scope of Beatties Dam/Two Bridges Improvement consists of dam modification combined with channel modification, upstream of the dam along with approximately 8,300 feet of levee/floodwall installation in the right bank of the Passaic River, nearby the area of Fairfield. Earth levees are divided by a floodwall due to space limitation. As part of the dam modification, the existing Beatties Dam with 7.5 feet high by 270 feet long spillway over rock will be removed in its entirety and replaced with the new Beatties Dam at 600 feet in length and 7.5 feet in height.

The new Two Bridges dam of approximately 1,770 feet long with a high of approximately 27 feet at its highest point, consist of a 7.5 feet high by 550 feet long concrete spillway crossing the Passaic River just downstream of the Two Bridges area, and earth abutments tying into the existing ground in both sides.

The quantities for the level/floodwall, channel modification, and dam modifications were provided by the H&H and were used by the cost engineering branch to develop the cost for this alternative using cost resources such as RS Means, MII Cost Libraries, vendor quotations and historical data on similar construction features.

The construction duration for this alternative was developed based on crew outputs referenced from RS Means and assuming multiple contracts awarded simultaneously with multiple crews on site. The total construction duration is estimated to be approximately 10 years and 7 months.

5. 10-Year Nonstructural

The nonstructural components included exact measures (floodproofing, raising, nonstructural wall, permanent evacuation) as identified in the "Alternatives Evaluated" section of this report and also identified in the 1987 GDM (refer to summary of 1987 nonstructural alternatives for details).

The cost for the nonstructural was based on an October 2012 price level for labor, material, and equipment. The quantities for the 10-Year Non-Structural Plan have been developed from the plan summaries shown in the 1987 GDM. No new data was incorporated for this preliminary assessment. The estimate was developed using the RS Means Estimating Guides and parametric methods.

The construction duration for this alternative was developed based on the assumption that multiple contracts will be awarded simultaneously and the properties in the close proximity with each will be combined together in a single contract. The total construction duration is estimated to be approximately 3 years.

First Costs

First costs include charges arising from the acquisition or construction of each individual alternatives and its component, as well as the cost of preparation of the Project Partnership Agreement (PPA), contingencies, preconstruction engineering and design (PE&D), monitoring, engineering during construction, construction management (supervision & administration – S&A), and real estate assessment, administration, and processing.

1. Lump Sum Items

Based on experience, certain items of costs such as mobilization, demobilization, dewatering and diversion of steams, and maintenance and protection of traffic were assigned a lump sum cost due to the multiplicity of activities required to accomplish such items.

2. Lands and Damages

In order to construct the proposed plan of improvement, local interests would be required to provide certain lands and easements. Studies are to be conducted by the Real Estate Division to determine the estimated value of lands and easements needed for the channel improvement, acquisition, local protection works and tunnel construction.

Fee takings, natural storage acquisition, and permanent (including that portion of permanent easements which lie between the existing stream banks) and temporary easements for the tunnel, levee/floodwall systems and ponding area costs are researched and included in the estimate.

3. Contingencies

As stated in ER 1110-2-1302, the goal in contingency development is to identify the uncertainty associated with an item of work or task, forecast the risk/cost relationship, and assign a value to this task that would limit the cost risk to an acceptable degree of confidence. Consideration must be given to the details available at each stage of planning, design, or construction for which a cost estimate is being prepared. During development of the cost estimates, sufficient contingencies developed via PDT discussions during ARA were applied to develop the Total Project First Cost.

Contingencies may vary throughout the cost estimate and could constitute significant portion of the overall costs when the lack of investigated data or design detail are available. Final contingency development and assignment that describes the potential for cost growth must be included in the cost estimate as a part of the project narrative. The contingency factors used in various alternatives are summarized in Table 42 thru 46.

TABLE 42: ALTERNATIVE #14A CONTINGENCY FACTORS

Element	Contingency Factor
Lands and Damages	48.33%
Dams	46.66%
Fish and Wildlife Facilities	42.59%
Roads, Railroads, and Bridges	46.08%
Levees and Floodwalls	54.08%
Pumping Plant	55.75%
Cultural Resource Preservation	42.59%
Buildings, Grounds, and Utilities	50.51%
Planning, Engineering, and Design	20.00%
Construction Management	20.00%

TABLE 43: ALTERNATIVE #16A CONTINGENCY FACTORS

Element	Contingency Factor
Lands and Damages	48.23%
Dams	46.66%
Fish and Wildlife Facilities	42.59%
Roads, Railroads, and Bridges	46.08%
Channels and Canals	47.58%
Levees and Floodwalls	54.08%
Pumping Plant	55.75%
Cultural Resource Preservation	42.59%
Buildings, Grounds, and Utilities	50.51%
Planning, Engineering, and Design	20.00%
Construction Management	20.00%

TABLE 44: ALTERNATIVE –
NEWARK OUTLET TUNNEL ALTERNATIVE CONTINGENCY FACTORS

Element	Contingency Factor
Lands and Damages	48.98%
Relocations	56.45%
Fish and Wildlife Facilities	42.59%
Roads, Railroads, and Bridges	46.08%
Channels and Canals	47.58%
Levees and Floodwalls	54.08%
Pumping Plant	55.75%
Floodway Control and Diversion Structures	46.69%
Cultural Resource Preservation	42.59%
Planning, Engineering, and Design	20.00%
Construction Management	20.00%

TABLE 45:
CONTINGENCY FACTORS FOR BEATTIES DAM/TWO BRIDGES IMPROVEMENT ALTERNATIVE

Element	Contingency Factor
Lands and Damages	49.13%
Dams	58.78%
Fish and Wildlife Facilities	42.59%
Channels and Canals	47.58%
Levees and Floodwalls	54.08%
Cultural Resource Preservation	42.59%
Planning, Engineering, and Design	20.00%
Construction Management	20.00%

TABLE 46: CONTINGENCY FACTORS FOR 10-YEARS NONSTRUCTURAL ALTERNATIVE

Element	Contingency Factor
Buildings, Grounds, and Utilities	50.51%
Planning, Engineering, and Design	20.00%
Construction Management	20.00%

Estimates of Additional Costs

1. **Engineering and Design**

The costs were developed for all activities associated with the engineering and design effort. The cost for this account includes the preparation of each construction contract and support during construction through project completion. It also include all the in-house labor based upon work-hour requirements, material and facility costs, architect-engineer studies, travel, overhead, and contingencies. It was provided by the Technical Manager with input from respective offices in accordance with the CWBS.

2. **Construction Management**

The costs were developed for all construction management activities from pre-award requirements through final contract closeout. These costs include the in-house labor based upon work-hour requirements, materials, facility costs, support contracts, travel, overhead, and contingencies. Costs were developed and provided by the construction division in accordance with the CWBS and include but are not limited to anticipated items such as the salaries of the resident engineer and staff, survey men, inspectors, draftsmen, clerical, and custodial personnel; construction cost or rental for field office, operation, maintenance and fixed charges for transportation and for other field equipment; field supplies; construction management, general construction supervision; project office administration, distributive cost of area office and general overhead charged to the project. The work items and activities for the tunnel work would include, but not be limited to: the salaries of all supervisory, engineering (including resident geologist and geological staff), office and safety field personnel; all on site expenses including supplies, rent, telephone and automobiles.

3. **Interest During Construction**

Interest during construction (IDC) is the cost of construction money invested before the beginning of the period of economic analysis and before the accumulation of benefits by the project. IDC costs have been added to the project cost to determine investment costs. The pre-base year benefits were estimated using the Federal interest rate of 3.75 percent. Pre-base year benefits are similar to IDC in that benefits will be accruing to the project before all the construction have been completed and must therefore be included in the equivalent annual benefit calculation.

First Costs

Project first costs for the five (5) alternatives are presented in Tables 47-51.

TABLE 47: FIRST COST FOR ALTERNATIVE #14A

Acct Code	Description		Cost(1)	Contingency (%)		Total Cost
01	Lands & Damages	$	47,883,310	49.34%	$	71,509,504
02	Relocation	$	1,504,099	56.45%	$	2,353,162
04	Dam	$	327,832	46.66%	$	480,807
06	Fish & Wildlife Facilities	$	94,941,595	42.59%	$	135,381,060
08	Roads, Railroads & Bridges	$	73,472,905	46.08%	$	107,332,547
11	Levees & Floodwalls	$	701,625,329	54.08%	$	1,081,093,257
13	Pumping Plant	$	225,525,701	55.75%	$	351,266,247
18	Cultural Resource Preservation	$	17,433,263	42.59%	$	24,858,794
19	Buildings, Grounds & Utilities	$	361,928,809	50.51%	$	544,724,264
30	Engineering & Design	$	221,545,016	20.00%	$	265,854,019
31	Construction Management	$	88,605,572	20.00%	$	106,326,686
TOTAL FIRST COST FOR ALTERNATIVE #14A					**$**	**2,691,180,348**

(1) October 2012 Price Level.
(2) Account 01 - Costs of this account was provided from RE Division on June 4, 2013.
(3) Account 30 - Costs of this account was provided by TM with input from respective offices.
(4) Account 31 - Costs of this account was provided by Construction Division.
(5) Contingencies are developed thru Abbreviated Risk Analysis for all construction accounts.
(6) Contingencies for Account 01, 30 & 31 is based on historical data.

TABLE 48: FIRST COST FOR ALTERNATIVE #16A

Acct Code	Description	Cost(1)	Contingency (%)	Total Cost
01	Lands & Damages	$ 65,791,540	49.15%	$ 98,125,300
02	Relocation	$ 1,504,099	56.45%	$ 2,353,162
04	Dam	$ 1,658,564	46.66%	$ 2,432,492
06	Fish & Wildlife Facilities	$ 101,629,392	42.59%	$ 144,917,461
08	Roads, Railroads & Bridges	$ 73,472,905	46.08%	$ 107,332,547
09	Channels & Canals	$ 1,897,286,548	47.58%	$ 2,800,061,608
11	Levees & Floodwalls	$ 342,674,942	54.08%	$ 528,007,691
13	Pumping Plant	$ 22,957,433	55.75%	$ 35,757,217
18	Cultural Resource Preservation	$ 30,891,127	42.59%	$ 44,048,907
19	Buildings, Grounds & Utilities	$ 361,928,809	50.51%	$ 544,724,264
30	Engineering & Design	$ 425,160,229	20.00%	$ 510,192,275
31	Construction Management	$ 170,040,229	20.00%	$ 204,048,275
TOTAL FIRST COST FOR ALTERNATIVE #16A				**$ 5,022,001,199**

(1) October 2012 Price Level.
(2) Account 01 - Costs of this account was provided from RE Division on June 4, 2013.
(3) Account 30 - Costs of this account was provided by TM with input from respective offices.
(4) Account 31 - Costs of this account was provided by Construction Division.
(5) Contingencies are developed thru Risk Analysis for all construction accounts.
(6) Contingencies for Account 01, 30 & 31 is based on historical data.

TABLE 49:
FIRST COST FOR NEWARK OUTLET TUNNEL ALTERNATIVE

Acct Code	Description	Cost(1)	Contingency (%)	Total Cost
01	Lands & Damages	$ 47,032,940	48.98%	$ 70,069,287
02	Relocations	$ 2,886,584	56.45%	$ 4,516,058
06	Fish & Wildlife Facilities	$ 56,155,948	42.59%	$ 80,075,037
08	Roads, Railroads & Bridges	$ 6,679,355	46.08%	$ 9,757,504
09	Channels & Canals	$ 37,589,803	47.58%	$ 55,475,945
11	Levees & Floodwalls	$ 367,990,415	54.08%	$ 567,014,816
13	Pumping Plant	$ 27,957,433	55.75%	$ 43,544,938
18	Floodway Control & Div Structure	$ 1,659,839,336	46.69%	$ 2,434,816,513
19	Cultural Resource Preservation	$ 23,110,989	42.59%	$ 32,954,894
30	Engineering & Design	$ 325,531,856	20.00%	$ 392,852,898
31	Construction Management	$ 130,194,472	20.00%	$ 157,119,110
TOTAL FIRST COST FOR ALTERNATIVE #30E				**$ 3,848,197,000**

(1) October 2012 Price Level.
(2) Account 01 - Costs of this account was provided from RE Division on June 4, 2013.
(3) Account 30 - Costs of this account was provided by TM with input from respective offices.
(4) Account 31 - Costs of this account was provided by Construction Division.
(5) Contingencies are developed thru Abbreviated Risk Analysis for all construction accounts.
(6) Contingencies for Account 01, 30 & 31 is based on historical data.

TABLE 50:
FIRST COST FOR BEATTIES DAM/TWO BRIDGES IMPROVEMENT ALTERNATIVE

Acct Code	Description	Cost(1)	Contingency (%)	Total Cost
01	Lands & Damages	$ 33,195,865	50.35%	$ 49,909,030
02	Relocation	$ 1,355,209	56.45%	$ 2,120,224
04	Dam	$ 60,761,551	58.78%	$ 96,476,096
06	Fish & Wildlife Facilities	$ 70,335,693	42.59%	$ 100,294,510
09	Channels & Canals	$ 709,623,889	47.58%	$ 1,047,280,185
11	Levees & Floodwalls	$ 18,704,747	54.08%	$ 28,821,046
19	Cultural Resource Preservation	$ 9,807,811	42.59%	$ 13,985,354
30	Engineering & Design	$ 130,606,661	20.00%	$ 156,727,993
31	Construction Management	$ 52,235,334	20.00%	$ 62,682,401
TOTAL FIRST COST FOR BEATTIES DAM ALTERNATIVE				**$ 1,558,296,840**

(1) October 2012 Price Level.
(2) Account 01 - Costs of this account was provided from RE Division on June 4, 2013.
(3) Account 30 - Costs of this account was provided by TM with input from respective offices.
(4) Account 31 - Costs of this account was provided by Construction Division.
(5) Contingencies are developed thru Abbreviated Risk Analysis for all construction accounts.
(6) Contingencies for Account 01, 30 & 31 is based on historical data.

TABLE 51: FIRST COST FOR 10-YEAR NONSTRUCTURAL ALTERNATIVE

Acct Code	Description	Cost(1)	Contingency (%)	Total Cost
19	Buildings, Grounds & Utilities	$ 587,045,038	50.51%	$ 883,561,486
30	Engineering & Design	$ 88,069,113	20.00%	$ 105,682,936
31	Construction Management	$ 35,222,702	20.00%	$ 42,267,242
TOTAL FIRST COST FOR 10-YEAR NON-STRUCTURAL ALTERNATIVE				**$ 1,031,511,700**

(1) October 2012 Price Level.
(2) Account 01 - Costs of this account is $0.
(3) Account 30 - Costs of this account was provided by TM with input from respective offices.
(4) Account 31 - Costs of this account was provided by Construction Division.
(5) Contingencies are developed thru Abbreviated Risk Analysis for all construction accounts.
(6) Contingencies for Account 01, 30 & 31 is based on historical data.

Annual Costs

1. **Operation & Maintenance, and Replacement**

The operation, maintenance, repairs and replacement (OMR&R) costs were estimated by using 0.50% of the total construction cost at this stage for each alternative except nonstructural alternative. These costs represent the anticipated annual costs necessary to maintain the project at full operating efficiency throughout the project life. Below are the primary activities that will be performed under OMR&R.

Project facilities that would require periodic operation to assure readiness would be the pump stations and gates at the inlets, outlets, and weir structures. Periodic maintenance would also be required at these features.

The major task associated with this project would be the annual maintenance associated with the channels, levees and floodwalls. These tasks would include but not be limited to: inspection, maintenance, repair and replacement of riprap; clearing of debris from the channel and bridges; sediment removal as needed, shoal removal, brush and tree control, trash pickup; cutting of grass along the channel banks and levees; the repair of concrete structures; and the painting of miscellaneous metal parts.

The fish and wildlife mitigation features have been designed to be self maintaining, as recommended by the US Fish and Wildlife Service and the New Jersey Bureau of Freshwater Fisheries. Therefore, there is no O&M cost associated with the mitigation features. The wetlands would also be self-perpetuating once established, and the nesting trees are expected to degenerate over time. They are not scheduled to be maintained or replaced since new trees and nestling niches would become available as the riparian corridor becomes reestablished.

Nonstructural measures are actions which support the interconnection of the natural floodplain, reducing flood risk and flood damages incurred to the homes, businesses, and utilities within the floodplains. Nonstructural measures are sustainable by the owners/inhabitants over the long term period. Therefore we assume there is no OMR&R cost for this alternative.

The major federal activities associated with the operation and maintenance of the tunnel include the following:

- Periodic Pump-Out

The tunnel would be pumped out for both a visual inspection and allow necessary sediment clean out. The schedule for this pump out would be after five years of operation and at least once every ten years thereafter or after a major flood event.

- On-Site Personnel

Qualified personnel would be provided on-site to receive flood warning messages and operate the various gates during flood events. Other personnel would perform routine daily tasks such as general inspection and to guard against vandalism to the inlets, outlets, and weir structures. Personnel would also ensure the proper working order of the related electrical components and hydraulic machinery through periodic testing of the equipment. An annual testing program of the entire system would be initiated along with a training program for personnel in preparation for a flood emergency.

- Mechanical Maintenance

Coupled with the need for on-site personnel, a yearly maintenance schedule would be initiated for the gates at the Pequannock Weir, Great Piece Weir, Pompton (Main) Inlet, the Passaic (Spur) Inlet, and the Newark Bay Outlet. Annual maintenance would generally include the replacement of seals, lubricating equipment and the painting of miscellaneous metal parts.

- Inlet and Outlet Structures

An annual scheduled maintenance program would be initiated for the inlet structures at the Pompton (Main) Inlet, Passaic (Spur) Inlet, and the Newark Bay Outlet. At the Pompton Inlet, maintenance would include trash pick-up and grass cutting, clearing the inlet from debris, and inspection of any repair of the concrete due to weather exposure. At Passaic (Spur) Inlet, the work would include trash pick-up and grass cutting, debris removal at the gated diversion spillway and necessary concrete repairs. At the Newark Bay Outlet scheduled maintenance would include any debris removal at the gates.

- Tunnel Sediment Removal

Scheduled sediment removal of the tunnel would occur at least ten times during the 100 year life of the structure. Other periodic clean-outs may possibly occur, especially after major flood events. The clean out would involve the removal of any silt or alluvial deposits trapped within the tunnel. To perform this maintenance, crews and equipment would be lowered by crane into the tunnel from any suitable workshaft. Also during the sediment removal phase, a visual inspection of the tunnel could be made to check the lining for excessive war, cracks or seepage.

<u>Abbreviated Risk Analysis</u>

The ARA for each of the five (5) alternatives as show in attachment C-1 is included in Appendix I. Please note that the costs are in 1,000th of a dollar ($1 = $1,000).

F. ECONOMIC ANALYSIS OF ALTERNATIVES

Evaluation of Alternatives

<u>Overview</u>

While the original 1980s study evaluated more than 150 alternatives, the Preliminary Alternative Reevaluation study phase (Phase 1) is focused on five with-project alternatives, in addition to the No Action Alternative, for a total of six (6) Alternatives/Plans. The five alternatives evaluated include various combinations of levees and floodwalls, channel modifications, diversion tunnels, dam improvements, and nonstructural treatments applied to individual buildings. An overview of the five alternatives, identifying the location of each measure by reach, is presented in this analysis and also in detail. Shaded rows in the following tables indicate the 11 sample reaches for which with-project damages were computed using HEC-FDA. It should be noted that some alternative measures such as channel modifications and dam improvements may also influence water surface elevations and hence flood damages in reaches outside those in which they are physically located.

Further, the fact that a number of flood prone properties have been purchased since the 1995 Phase 2 GDM was completed, these structures were addressed in both the cost of the alternatives and in the economic analysis of the existing damage pool. To remove the non-structural treatment costs of the structures that no longer existed, involved obtaining lists of buy-outs from the local sponsor, local contacts and USACE files. The list of bought-out structures was missing data for a few years. The missing years of data were approximated by using buy-out rates from the years for which we had data. The total approximate number of bought-out structures was then removed from the original 1987 number of structures to be treated. See the Non-structural Plan description in the Hydraulic sections for more details of this process.

The loss of potential benefits from the bought-out structures was indirectly accounted for in the economic analysis. The property and structural values in each economic reach were based on the assessed property values available on local tax maps. If a structure was bought-out the property would have been removed from the tax maps and therefore would not have been mistakenly counted as a flooded structure.

1. Alternative 14A

Alternative 14A includes a combination of measures including levees, floodwalls, nonstructural treatments, and bridge and dam modifications. Levees and floodwalls are provided for reaches along the Passaic River in the Lower, Central and Highlands Basins , with some dredging and the replacement of two bridges undertaken on the Pompton River. In the Lower Passaic Basin, this alternative includes approximately 114,000 feet of levees and floodwalls downstream of the Dundee Dam (tidal reaches), and approximately 62,000 feet of levees and floodwalls upstream of the dam. This alternative includes approximately 13,000 feet of levees and floodwalls along the Rockaway River, and a further 6,000 feet of levees and floodwalls for several isolated reaches on the Passaic River in the Central Basin. In addition to these structural components, nonstructural treatments (including elevation, floodproofing, and property acquisition) would be implemented in the 10% annual chance exceedance floodplain in all reaches in the Highlands Basin, which includes the Pompton River. Nonstructural treatments would also be applied in the same floodplain in a number of reaches in the Central Passaic Basin between Beattie's Dam and the upstream limit of Deepalval Brook.

With-Project Damages

Expected annual damages with Alternative 14A in place were calculated for the 11 sample reaches using HEC-FDA and with-project stage-frequency relationships for all streams in the study area, and the results are presented in Table 11a-c. These results were used to extrapolate with-project damages for the remaining affected reaches using the following assumptions:

Lower Passaic Basin:

- Reaches downstream of Dundee Dam for which levees are proposed as part of 14A were assumed to be subject to the same percentage damage reduction as that computed in HEC-FDA for sample reach 010102 with the Alternative 14A levee in place. Reaches downstream of Dundee Dam for which no levees are proposed were assumed to be subject to no damage reduction.
- Reaches upstream of Dundee Dam for which levees are proposed were assumed to be subject to the average damage reduction computed in HEC-FDA for sample reaches 010171 and 010203 with the Alternative 14A levee in place. Reaches upstream of Dundee Dam for which no levees are proposed under Alternative 14A were assumed to be subject to no damage reduction.

Central Passaic Basin:

- Reaches in this basin for which levees are proposed as part of 14A were assumed to be subject to the same percentage damage reduction as that computed in HEC-FDA for sample reach 020102 with the Alternative 14A levee in place.
- Reaches in this basin for which are assigned nonstructural treatments as part of 14A were assumed to be subject to the same percentage damage reduction as that computed in HEC-FDA for sample reach 020021 with a levee of crest elevation equal to the existing condition 10% annual chance exceedance water surface elevation plus one foot in place..
- Reaches in this basin assigned neither levees or nonstructural measures under Alternative 14A were assumed to be subject to no damage reduction.

Highlands (Pompton River) Basin:

- All the reaches in this basin are subject to nonstructural measures and the majority of reaches are also affected by the dredging and bridge replacement components of Alternative 14A. All reaches in the Pompton basin were assumed to be subject to a damage reduction equal to the average damage reduction computed in HEC-FDA for sample reaches 600025, 600034, 600042 and 660021 with all the Alternative 14A components in place.

The with-project expected annual flood damages with Alternative 14A in place were computed using the method outlined above and the results are presented by reach in Tables 11a-c of the

Economics Appendix J. A summary of annual flood damage reduction benefits by basin is presented in Table 16 of the Economic Appendix in Section 6.1. Shaded rows indicate the 11 sample reaches for which with-project damages were computed using HEC-FDA. The results of the HEC-FDA computations for sample reaches 020052 and 020081 indicate that small amounts of induced damages may be generated by this alternative in the Central Passaic Basin, on both the Passaic and Rockaway Rivers. For the Preliminary Alternative Reevaluation phase of the study the possibility of induced damage is acknowledged but has not been quantified in reaches other than in those where damages were computed using HEC-FDA.

2. Alternative 16A

Description

Alternative 16A includes a combination of measures including includes levees, floodwalls, nonstructural treatments, and channel modifications. The central feature of this alternative is approximately 16 miles of channel modifications on the Passaic River in the Lower Passaic Basin, between Beattie's Dam and the Route 3 bridge over the Passaic River in the Borough of Rutherford. This alternative also features approximately 68,000 feet of levees and floodwalls at the far downstream end of the Passaic River in the Lower Passaic Basin, approximately 13,000 feet of levees and floodwalls along the Rockaway River, and a further 6,000 feet of levees and floodwalls for several isolated reaches on the Passaic River in the Central Basin. In addition to the structural components, Alternative 16A includes nonstructural treatments covering the same reaches and to the same annual risk of flooding as Alternative 14A.

With-Project Damages

Expected annual damages with Alternative 16A in place were calculated for the 11 sample reaches using HEC-FDA and with-project stage-frequency relationships for all streams in the study area, and the results are presented in Table 12a-c of the Economics Appendix. These results were used to extrapolate with-project damages for the remaining affected reaches using the following assumptions:

Lower Basin:

- Comparison of the water surface profiles for the without-project condition and Alternative 16A indicated that the channel modifications in the Lower Passaic basin would produce benefits in all reaches upstream of reach 010102. These reaches were assumed to be subject to the average damage reduction computed in HEC-FDA for sample reaches 010171 and 010203 with Alternative 16A in place.
- Reaches downstream of reach 010102 for which levees are proposed as part of 16A were assumed to be subject to the same percentage damage reduction as that computed in HEC-FDA for sample reach 010102 with the Alternative 14A levee in place, since the levee system for Alternative 16A at this location is identical to that proposed for 14A.
- Reaches downstream of reach 010102 for which no levees are proposed were assumed to be subject to no damage reduction.

Central Basin:

- Comparison of the water surface profiles for the without-project condition and Alternative 16A indicated that this alternative would produce benefits on the Passaic River up to the confluence with the Rockaway River. Reaches in this section also covered by the nonstructural plan component were assumed to be subject to a damage reduction equal to that computed in HEC-FDA for sample reach 020021 with all alternative components in place.
- Reaches downstream of the Rockaway River confluence were assumed to be subject to a damage reduction equal to that computed in HEC-FDA for reach 020052 and arising only from reductions in the water surface elevation.
- Reaches on the Passaic River upstream of the Rockaway River confluence were assumed to be subject to no damage reduction, with the exception of two reaches where levees are proposed, which were assumed to be subject to a damage reduction equal to that computed in HEC-FDA for sample reach 020102 with the Alternative 16A levee in place.
- Comparison of the water surface profiles for the without-project condition and Alternative 16A indicated that this alternative would produce benefits on the Rockaway River up to and including sample reach 020102.
- Reaches on the Rockaway River where levees or floodwalls are proposed were assumed to be subject to a damage reduction equal to that computed in HEC-FDA for sample reach 020102 with all components of Alternative 16A in place.
- Reaches on the Rockaway River downstream of reach 020102 where no levees or floodwalls are proposed were assumed to be subject to a damage reduction equal to that computed in HEC-FDA for reach 020081 and arising only from reductions in the water surface elevation.
- Reaches on the Rockaway River upstream of the reach 020102 were assumed to be subject to no damage reduction.
-

Highlands (Pompton River) Basin:

- All the reaches in this basin are subject only to nonstructural measures and hence all reaches in the Pompton basin were assumed to be subject to a damage reduction equal to the average damage reduction computed in HEC-FDA for sample reaches 600025, 600034, 600042 and 660021 with only the nonstructural measures in place.

The with-project expected annual flood damages with Alternative 16A in place were computed using the methodology outlined above and the results are presented by reach in Tables 12a-c in the Economics Appendix. A summary of annual flood damage reduction benefits by basin is presented in Table 16 in Section 6.1 of the Economics Appendix. Shaded rows indicate the 11 sample reaches for which with-project damages were computed using HEC-FDA. The results of the HEC-FDA computations for sample reach 010102 indicate that small amounts of induced damages may be generated by this alternative in the Lower Passaic Basin, on the Passaic River downstream of Passaic City. For the Preliminary Alternative Reevaluation phase (Phase 1) of the study the possibility of induced damage is acknowledged but has not been quantified in reaches other those where damages were computed using HEC-FDA.

3. Modified Tunnel Alternative

Description

The recommended plan after the 1987 study was Alternative Newark Outlet Tunnel Alternative, and for the Preliminary Alternative Reevaluation phase (Phase 1) of the 2013 study a modified version of this alternative has been evaluated. By far the most significant feature of this alternative is a dual inlet diversion tunnel with a maximum diameter of 42 feet and a total length of more than 21 miles. The tunnel would draw water from the Pompton River (with an inlet near the confluence with the Ramapo River) and from the Passaic River (with an inlet just downstream of the confluence with the Pompton River) to an outlet in Newark Bay. This alternative also features approximately 68,000 feet of levees and floodwalls at the far downstream end of the Passaic River in the Lower Passaic Basin, approximately 13,000 feet of levees and floodwalls along the Rockaway River, 10,000 feet of levees and floodwalls on the Passaic River between Interstate 80 and the confluence with the Rockaway River, and 5,000 feet of levees and floodwalls on the Ramapo River downstream of the Pompton Dam. There are also further 6,000 feet of levees and floodwalls for two isolated reaches at the upstream end of the Central Basin under this alternative. Channel modifications also form part of the Modified Tunnel Alternative, with modification along 10,700 of the Passaic River at the confluence with the Pompton River, 7,600 feet of modification on Deepalval Brook, and 25,000 feet of channel modification upstream of the tunnel inlet on the Pompton River.

With-Project Damages

Expected annual damages with the Modified Tunnel Alternative in place were calculated for the 11 sample reaches using HEC-FDA and with-project stage-frequency relationships for all streams in the study area, and the results are presented in Table 102 in the Economic Appendix. These results were used to extrapolate with-project damages for the remaining affected reaches using the following assumptions:

Lower Passaic Basin:

- Reaches downstream of reach Dundee Dam for which levees are proposed as part of the Modified Tunnel Alternative were assumed to be subject to the same percentage damage reduction as that computed in HEC-FDA for sample reach 010102 with the Alternative 14A levee in place, since the levee system for the Modified Tunnel Alternative at this location is identical to that proposed for 14A.
- Reaches downstream of Dundee Dam for which no levees are proposed were assumed to be subject to the same damage reduction as that computed in HEC-FDA for sample reach 010102.
- Reaches upstream of Dundee Dam were assumed to be subject to damage reduction equal to the average damage reduction computed in HEC-FDA for sample reaches 010171 and 010203 with The Modified Tunnel Alternative in place.

Central Basin:

- Reaches in the Central Passaic Basin on the Passaic River downstream of the confluence with the Rockaway River and north of Interstate 80 were assumed to be subject to the damage reduction computed in HEC-FDA for sample reach 020021 with the Modified Tunnel Alternative in place.

- Reaches south of Interstate 80 and east of the Pine Brook area (for which the primary source of flooding is from Deepalval Brook under this alternative) were assumed to be subject to the damage reduction computed in HEC-FDA for sample reach 020052 with the Modified Tunnel Alternative in place.
- Reaches on the Rockaway and Passaic Rivers upstream of the confluence with the Rockaway River for which no levees are proposed under the Modified Tunnel Alternative were assumed to be subject to the damage reduction computed in HEC-FDA for sample reach 020081 with the Modified Tunnel Alternative in place, based similar reductions in water surface elevations observed in a comparison of the water surface profiles for the without-project condition and the Modified Tunnel Alternative.
- Reaches on the Rockaway River and Passaic Rivers (upstream of the confluence with the Rockaway River) for which levees are proposed as part of the Modified Tunnel Alternative were assumed to be subject to the damage reduction computed in HEC-FDA for sample reach 020102 with the Modified Tunnel Alternative levee in place.

Highlands (Pompton River) Basin:

- Reaches downstream of the Pompton tunnel inlet were assumed to be subject to a damage reduction equal to the average damage reduction computed in HEC-FDA for reaches 600025, 600034, and 600042 with the Modified Tunnel Alternative in place.
- Reaches on the Ramapo River for which levees are proposed as part of the Modified Tunnel Alternative were assumed to be subject to the damage reduction computed in HEC-FDA for sample reach 660021R with the Modified Tunnel Alternative levee in place.
- Reaches upstream of the Pompton tunnel inlet for which no levees are proposed were assumed to be subject to the damage reduction computed in HEC-FDA for sample reach 660021L with the Modified Tunnel Alternative in place.
- Comparison of the water surface profiles for the without-project condition and the Modified Tunnel Alternative indicated that reaches at the far upstream ends of the Pequannock and Wanaque Rivers would incur no significant benefits under the Modified Tunnel Alternative.

The with-project expected annual flood damages with the Modified Tunnel Alternative in place computed using the methodology outlined above are presented by reach in Tables 13a-c, and a summary of annual flood damage reduction benefits by basin is presented in Table 16 in Section 6.1 of the Economics Appendix. Shaded rows indicate the 11 sample reaches for which with-project damages were computed using HEC-FDA.

4. Beattie's Dam/Two Bridges Alternative

<u>Description</u>

The principal features of this alternative are the replacement of Beattie's Dam in Little Falls, and the construction of a new dam at Two Bridges at the confluence of the Passaic and Pompton Rivers. Beattie's Dam will be replaced by a new structure with a longer weir, while the Two Bridges Dam will take the form of a spillway in the river bed with earth embankments across both overbanks. This alternative also includes 27,700 feet of channel modification on the Passaic River upstream of Beattie's Dam, 33,000 feet of channel modification on the Pompton River upstream of the confluence with the Passaic River, and 5,000 feet of channel modification on Deepalval Brook. This alternative also includes two short levee sections on the Passaic River area upstream of Interstate 80.

With-Project Damages

Expected annual damages with the Beattie's Dam / Two Bridges Alternative in place were calculated for the 11 sample reaches using HEC-FDA and with-project stage-frequency relationships for all streams in the study area, and the results are presented in Table 103 of the Economic Appendix. These results were used to extrapolate with-project damages for the remaining affected reaches using the following assumptions:

Lower Basin:

- This alternative is anticipated to realize benefits only in the Central Passaic and Pompton Basins, and is likely to induce damages in the Lower Passaic Basin. Since it is beyond the scope of the Preliminary Alternative Reevaluation phase of the study to quantify induced damages, it is assumed for the purposes of this analysis that the reaches in the Lower Passaic Basin are subject to no damage reduction under this alternative.

Central Basin:

- Comparison of the water surface profiles for the without-project condition and the Beattie's Dam / Two Bridges Alternative indicated that this alternative would not realize significant flood damage reductions on the Passaic River upstream of reach 020043, in the Pine Brook area of Montville Township.
- Under this alternative, it is assumed that a number of reaches in the Boroughs of Fairfield and West Caldwell would see their principal source of flooding transition from the Passaic River to Deepalval Brook, hence these reaches were assumed to be subject to a damage reduction equal to that computed using HEC-FDA for reach 020052, which was modeled using Deepalval Brook as the source of flooding.
- The remaining reaches in the Central Passaic Basin downstream of Pine Brook were assumed to be subject to a damage reduction equal to that computed in HEC-FDA for reach 020052 with all the components of the Beattie's Dam / Two Bridges Alternative in place.
- All reaches on the Rockaway River and upstream of Pine Brook on the Passaic River were assumed to be subject to no damage reduction.

Highlands (Pompton River) Basin:

- Reaches on the Pompton River south of the confluence with the Pequannock River were assumed to be subject to a damage reduction equal to the average damage reduction computed in HEC-FDA for sample reaches 600025, 600034 and 600042 with the Beattie's Dam / Two Bridges Alternative in place.

- Comparison of the water surface profiles for the without-project condition and the Beattie's Dam / Two Bridges Alternative indicated that this alternative would not realize significant flood damage reductions on the Ramapo River upstream of reach 660021. For reaches upstream of this point no damage reduction was assumed, while for other reaches on the Ramapo River a damage reduction equal to that computed in HEC-FDA for reach 660021 with the Beattie's Dam / Two Bridges Alternative in place was assumed.

The with-project expected annual flood damages with the Beattie's Dam / Two Bridges alternative in place computed for the whole study area using the methodology outlined above are presented by reach in Tables 14a-c, and a summary of annual flood damage reduction benefits by basin is presented in Table 16 in Section 6.1 located in the Economic Appendix. Shaded rows indicate the 11 sample reaches for which with-project damages were computed using HEC-FDA. The results of the HEC-FDA computations for some sample reaches indicate that small amounts of induced damages may be generated by this alternative throughout the Lower Passaic Basin and on the Rockaway River in the Central Passaic Basin. For the Preliminary Alternative Reevaluation phase of the study (Phase 1 Report) the possibility of induced damage is acknowledged but has not been quantified in reaches other those where damages were computed using HEC-FDA.

5. Nonstructural Alternative

Description and Method

As part of a comprehensive alternatives analysis, a nonstructural-only alternative has been evaluated. The nonstructural treatments considered for individual structures includes (but is not limited to) floodproofing and elevation above the 10% annual chance exceedance water surface, structure acquisition, and ringwalls (floodwalls constructed around individual structures for which the physical characteristics make it infeasible to apply other nonstructural treatments). For this Preliminary Alternative Reevaluation phase of the reevaluation study, the comprehensive nonstructural plan was assumed to cover the 10% annual chance exceedance floodplain in all relevant reaches in the study area in which improved property was recorded in the 500-year floodplain. The implementation of the nonstructural plan in the 11 sample reaches was modeled in HEC-FDA by assigning a levee with a crest elevation equal to the existing condition 10% annual chance exceedance water surface elevation plus one foot to each reach.

With-Project Damages

Expected annual damages with the Beattie's Dam / Two Bridges Alternative in place were calculated for the 11 sample reaches using HEC-FDA and with-project stage-frequency relationships for all streams in the study area, and the results are presented in Table 104 of the Economic Appendix. The with-project expected annual flood damages with the Nonstructural Alternative in place computed for the whole study area using the methodology outlined above are presented by reach in Tables 15a-c, and a summary of annual flood damage reduction benefits by basin is presented in Table 16 in Section 6.1 located in the Economic Appendix. Shaded rows indicate the 11 sample reaches for which with-project damages were computed using HEC-FDA.

COST COMPARISONS

Summary of Costs

A summary of costs for all evaluated alternatives is presented in Table 52.

TABLE 52: SUMMARY OF ALTERNATIVE COSTS

Cost Component	14A	16A	Modified Tunnel	Beattie's Dam / Two Bridges	Nonstructural
Total First Cost	$ 2,691,180,348	$ 5,022,001,199	$ 3,848,197,000	$ 1,558,296,840	$1,031,511,700
Interest During Construction	$ 443,517,143	$ 752,899,067	873,168,244	$344,230,953	$121,024,707
Total Investment Cost	$3,134,697,491	$5,774,900,266	$4,721,365,244	$1,902,527,793	$1,152,536,407
Interest and Amortization	$139,726,700	$257,411,700	$210,451,200	$84,803,700	$51,373,400
O&M	$ 11,237,500	$ 21,048,200	$ 16,140,800	$ 6,444,900	$0
Annual Costs	$150,964,200	$271,581,800	$221,362,000	$89,156,700	$51,373,400

Price Level: October 2012, Discount Rate 3.75%

The total investment cost for each alternative includes construction costs, real estate, engineering design, construction management, contingencies, and Interest During Construction (IDC). Annual costs represent the amortized total investment cost using a 3.75% discount rate and a 50-year project life, plus annual operation and maintenance costs. All cost estimates were based on a price level of October 2012.

Summary of Benefits and Benefit-Cost Ratios

A summary of all damages, benefits, costs, and subsequent benefit-cost ratios for all structural and nonstructural alternatives evaluated for the Passaic Main Stem River, NJ study area is presented in Table 53.

For all evaluated alternatives significant benefits are assumed to accrue in advance of the project base year, as some first-constructed components of the alternatives (for example, levees at the downstream end of the Lower Passaic Basin) will be actively reducing the risk of flood damage prior to the project base-year, which is defined by the full completion of all components of the selected plan. For the Preliminary Alternative Reevaluation phase of the study pre-base year benefits were estimated for structural alternatives based on those estimated for Alternatives 16A and Newark Outlet Tunnel Alternative in the 1987 study. In the 1987 GDM pre-base year benefits were estimated to be 12.4% of base year inundation reduction damages for Alternative 16A and 18.8% for Alternative Newark Outlet Tunnel Alternative. Pre-base-year benefits were not reported in the 1987 GDM for any other alternatives that have been evaluated in 2013. For Alternative 16A the same percentages were applied to the updated flood damage reduction benefits to estimate updated pre-base year benefits, while the pre-base year benefits for the Modified Tunnel Alternative were assumed to follow the same percentage as Alternative Newark Outlet Tunnel Alternative. Pre-base year benefits for Alternatives 14A and Beattie's Dam were assumed to be of the same percentage as for Alternative 16A, due to similar assumed construction times and levels of protection. For the nonstructural alternative, pre-base year benefits were assumed to be equal to the IDC; as soon as each individual structure treatment is completed it would begin to accrue benefits that cumulatively may offset the IDC.

In addition to flood inundation damage benefits, the 1987 GDM also evaluated benefits associated with future hydrologic considerations, residential contents affluence factors, residential intensification, traffic flows, industrial content growth, flood insurance administration cost reductions, and PATH train delays. For the Preliminary Alternative Reevaluation phase of the study additional benefits were estimated for structural alternatives based on those reported for Alternatives 16A and Newark Outlet Tunnel Alternative in the 1987 study. In the 1987 GDM these additional benefits were equal to 16.6% and 14.5% of the total baseline benefits (inundation benefits plus pre-base year benefits) for Alternatives 16A and Newark Outlet Tunnel Alternative, respectively. Similarly to the application of pre-base year benefits, additional benefits for Alternative 16A and the Modified Tunnel Alternative were generated using the 16A and Newark Outlet Tunnel Alternative percentages from 1987, while those for Alternatives 14A and Beattie's Dam were assumed using the same 1987 percentage as for Alternative 16A. Additional benefits were assumed to be not significant for the nonstructural alternative.

TABLE 53: SUMMARY OF DAMAGES, BENEFITS, AND COSTS: CSRA CONTINGENCY ON COSTS (APPROX 50%)

Alternative	Basin	Annual Flood Damages		Annual Benefits	Total Investment Cost	Total Annual cost	Average Annual Net Benefits	Benefit-Cost Ratio
		Without Project	With Project					
14A	Lower Passaic	$114,802,000	$44,790,000	$70,012,000	*$3,134,697,449*	*$150,964,200*	*($29,854,200)*	***0.8***
	Central Passaic	$79,314,000	$70,101,000	$9,213,000				
	Pompton	$33,716,000	$20,470,000	$13,246,000				
	Pre-Base Year Benefits			$11,424,000				
	Additional Benefit Categories			$17,215,000				
	Total	*$227,832,000*	*$135,361,000*	*$121,110,000*				
16A	Lower Passaic	$114,802,000	$40,358,000	$74,444,000	*$5,774,900,266*	*$271,581,800*	*($139,483,800)*	***0.5***
	Central Passaic	$79,314,000	$60,497,000	$18,817,000				
	Pompton	$33,716,000	$26,116,000	$7,600,000				
	Pre-Base Year Benefits			$12,461,000				
	Additional Benefit Categories			$18,776,000				
	Total	*$227,832,000*	*$126,971,000*	*$132,098,000*				
30E	Lower Passaic	$114,802,000	$38,966,000	$75,836,000	*$4,721,365,244*	*$221,362,300*	*$5,224,700*	***1.02***
	Central Passaic	$79,314,000	$21,377,000	$57,937,000				
	Pompton	$33,716,000	$5,227,000	$28,489,000				
	Pre-Base Year Benefits			$35,570,000				
	Additional Benefit Categories			$28,755,000				
	Total	*$227,832,000*	*$65,570,000*	*$226,587,000*				
Beattie's Dam / Two Bridges	Lower Passaic	$114,802,000	$115,936,000	($1,134,000)	*$1,902,527,793*	*$89,156,700*	*($38,451,700)*	***0.6***
	Central Passaic	$79,314,000	$55,376,000	$23,938,000				
	Pompton	$33,716,000	$17,805,000	$15,911,000				
	Pre-Base Year Benefits			$4,783,000				
	Additional Benefit Categories			$7,207,000				
	Total	*$227,832,000*	*$189,117,000*	*$50,705,000*				
Nonstructural	Lower Passaic	$114,802,000	$79,978,000	$34,824,000	*$1,152,536,407*	*$51,373,400*	*$14,887,600*	***1.3***
	Central Passaic	$79,314,000	$60,751,000	$18,563,000				
	Pompton	$33,716,000	$26,237,000	$7,479,000				
	Pre-Base Year Benefits			$5,395,000				
	Additional Benefit Categories			N/A				
	Total	*$227,832,000*	*$166,966,000*	*$66,261,000*				

Price levels: Benefits – January 2013; Costs – October 2012, 3.75% Discount rate - 50 Year Project Life

TABLE 54: 20% CONTINGENCY ON COSTS

Alternative	Basin	Annual Flood Damages		Annual Benefits	Total Investment Cost	Total Annual cost	Average Annual Net Benefits	Benefit-Cost Ratio
		Without Project	With Project					
14A	Lower Passaic	$114,802,000	$44,790,000	$70,012,000	*$2,564,609,517*	*$121,699,300*	*($589,300)*	***1.0***
	Central Passaic	$79,314,000	$70,101,000	$9,213,000				
	Pompton	$33,716,000	$20,470,000	$13,246,000				
	Pre-Base Year Benefits			$11,424,000				
	Additional Benefit Categories			$17,215,000				
	Total	*$227,832,000*	*$135,361,000*	*$121,110,000*				
16A	Lower Passaic	$114,802,000	$40,358,000	$74,444,000	*$5,774,900,266*	*$229,140,800*	*($97,042,800)*	***0.6***
	Central Passaic	$79,314,000	$60,497,000	$18,817,000				
	Pompton	$33,716,000	$26,116,000	$7,600,000				
	Pre-Base Year Benefits			$12,461,000				
	Additional Benefit Categories			$18,776,000				
	Total	*$227,832,000*	*$126,971,000*	*$132,098,000*				
30E	Lower Passaic	$114,802,000	$38,966,000	$75,836,000	*$4,721,365,244*	*$187,284,200*	*$39,302,800*	***1.21***
	Central Passaic	$79,314,000	$21,377,000	$57,937,000				
	Pompton	$33,716,000	$5,227,000	$28,489,000				
	Pre-Base Year Benefits			$35,570,000				
	Additional Benefit Categories			$28,755,000				
	Total	*$227,832,000*	*$65,570,000*	*$226,587,000*				
Beattie's Dam / Two Bridges	Lower Passaic	$114,802,000	$115,936,000	($1,134,000)	*$1,902,527,793*	*$75,315,100*	*($24,610,100)*	***0.7***
	Central Passaic	$79,314,000	$55,376,000	$23,938,000				
	Pompton	$33,716,000	$17,805,000	$15,911,000				
	Pre-Base Year Benefits			$4,783,000				
	Additional Benefit Categories			$7,207,000				
	Total	*$227,832,000*	*$189,117,000*	*$50,705,000*				
Nonstructural	Lower Passaic	$114,802,000	$79,978,000	$34,824,000	*$952,414,669*	*$42,453,100*	*$23,807,900*	***1.6***
	Central Passaic	$79,314,000	$60,751,000	$18,563,000				
	Pompton	$33,716,000	$26,237,000	$7,479,000				
	Pre-Base Year Benefits			$5,395,000				
	Additional Benefit Categories			N/A				
	Total	*$227,832,000*	*$166,966,000*	*$66,261,000*				

TABLE 55: 0% CONTINGENCY ON COSTS SUMMARY OF DAMAGES, BENEFITS AND COSTS

Alternative	Basin	Annual Flood Damages		Annual Benefits	Total Investment Cost	Total Annual cost	Average Annual Net Benefits	Benefit-Cost Ratio
		Without Project	With Project					
14A	Lower Passaic	$114,802,000	$44,790,000	$70,012,000	*$2,137,174,631*	*$102,646,700*	*$18,463,300*	***1.2***
	Central Passaic	$79,314,000	$70,101,000	$9,213,000				
	Pompton	$33,716,000	$20,470,000	$13,246,000				
	Pre-Base Year Benefits			$11,424,000				
	Additional Benefit Categories			$17,215,000				
	Total	*$227,832,000*	*$135,361,000*	*$121,110,000*				
16A	Lower Passaic	$114,802,000	$40,358,000	$74,444,000	*$5,774,900,266*	*$193,312,400*	*($61,214,400)*	***0.7***
	Central Passaic	$79,314,000	$60,497,000	$18,817,000				
	Pompton	$33,716,000	$26,116,000	$7,600,000				
	Pre-Base Year Benefits			$12,461,000				
	Additional Benefit Categories			$18,776,000				
	Total	*$227,832,000*	*$126,971,000*	*$132,098,000*				
30E	Lower Passaic	$114,802,000	$38,966,000	$75,836,000	*$4,721,365,244*	*$157,888,700*	*$68,698,300*	***1.44***
	Central Passaic	$79,314,000	$21,377,000	$57,937,000				
	Pompton	$33,716,000	$5,227,000	$28,489,000				
	Pre-Base Year Benefits			$35,570,000				
	Additional Benefit Categories			$28,755,000				
	Total	*$227,832,000*	*$65,570,000*	*$226,587,000*				
Beattie's Dam / Two Bridges	Lower Passaic	$114,802,000	$115,936,000	($1,134,000)	*$1,902,527,793*	*$63,488,100*	*($12,783,100)*	***0.8***
	Central Passaic	$79,314,000	$55,376,000	$23,938,000				
	Pompton	$33,716,000	$17,805,000	$15,911,000				
	Pre-Base Year Benefits			$4,783,000				
	Additional Benefit Categories			$7,207,000				
	Total	*$227,832,000*	*$189,117,000*	*$50,705,000*				
Nonstructural	Lower Passaic	$114,802,000	$79,978,000	$34,824,000	*$793,678,965*	*$35,377,600*	*$30,883,400*	***1.9***
	Central Passaic	$79,314,000	$60,751,000	$18,563,000				
	Pompton	$33,716,000	$26,237,000	$7,479,000				
	Pre-Base Year Benefits			$5,395,000				
	Additional Benefit Categories			N/A				
	Total	*$227,832,000*	*$166,966,000*	*$66,261,000*				

Price levels: Benefits – January 2013; Costs – October 2012, 3.75% Discount rate, 50 Year Project Life

Sensitivity of Benefit-Cost Ratios

Inherent in the analyses described is a significant amount of uncertainty, as briefly introduced in previous sections of the Economics Appendix. While this section describes how there are well established procedures and guidelines to incorporate uncertainty associated with the specific input parameters that are critical to an estimation of flood damage using HEC-FDA (such as structure main floor elevations, structure values, and stage-frequency relationships), it does not cover the wider areas of uncertainty in the Preliminary Alternative Reevaluation phase analysis, such as those associated with the extrapolation of damages from the 11 sample reaches to the other 200 reaches in the overall study. Since the limited budget and schedule of the Preliminary Alternative Reevaluation phase of the study precluded a detailed statistical analysis of these wider uncertainties, the sensitivity of the computed benefit-cost ratios has been broadly assessed using the project-performance-related HEC-FDA outputs for the 11 sample reaches.

Standard HEC-FDA outputs associated with the calculation of with-project expected annual damage include the annual damages reduced that have a 75% chance and a 25% of being exceeded in each sample reach for each alternative. For the purposes of evaluating the sensitivity of the benefit-cost ratios to the overall uncertainty in flood risk reduction benefits, these damages have been taken respectively to compute the upper and lower bound with-project damages. The full with-project damage extrapolation processes outlined in Sections 5.2.2, 5.3.2, 5.4.2, 5.5.2, and 5.6.2 of the Cost Engineering Appendix I were then repeated twice, incorporating the upper and lower bound sample reach with-project annual damages, to generate a range of BCRs for each alternative. A summary of the results of the sensitivity analyses is presented in Tables 55 and 56**.**

TABLE 56:
BENEFIT-COST RATIO SENSITIVITY:UPPER BOUND WITH-PROJECT ANNUAL DAMAGES
(Costs at 50% Contingency – CSRA contingency)

Alternative	Basin	Annual Flood Damages		Annual Benefits	Total Investment Cost	Total Annual cost	Benefit-Cost Ratio
		Without Project	With Project				
14A	Lower Passaic	$114,802,000	$71,004,000	$43,798,000	*$3,134,700,000*	*$150,964,000*	***0.53***
	Central Passaic	$79,314,000	$71,844,000	$7,470,000			
	Pompton	$33,716,000	$23,659,000	$10,057,000			
	Pre-Base Year Benefits			$7,576,000			
	Additional Benefit Categories			$11,416,000			
	Total	*$227,832,000*	*$166,507,000*	*$80,317,000*			
16A	Lower Passaic	$114,802,000	$67,203,000	$47,599,000	*$5,774,900,000*	*$278,456,000*	***0.32***
	Central Passaic	$79,314,000	$65,220,000	$14,094,000			
	Pompton	$33,716,000	$27,177,000	$6,539,000			
	Pre-Base Year Benefits			$8,430,000			
	Additional Benefit Categories			$12,702,000			
	Total	*$227,832,000*	*$159,600,000*	*$89,364,000*			
Newark Outlet Tunnel Alternative	Lower Passaic	$114,802,000	$65,822,000	$48,980,000	*$4,721,365,000*	*$226,592,000*	***0.68***
	Central Passaic	$79,314,000	$36,316,000	$42,998,000			
	Pompton	$33,716,000	$15,443,000	$18,273,000			
	Pre-Base Year Benefits			$24,168,000			
	Additional Benefit Categories			$19,538,000			
	Total	*$227,832,000*	*$117,581,000*	*$153,957,000*			
Beattie's Dam / Two Bridges	Lower Passaic	$114,802,000	$116,331,000	($1,529,000)	*$1,902,518,000*	*$91,249,000*	***0.36***
	Central Passaic	$79,314,000	$63,969,000	$15,345,000			
	Pompton	$33,716,000	$22,788,000	$10,928,000			
	Pre-Base Year Benefits			$3,057,000			
	Additional Benefit Categories			$4,606,000			
	Total	*$227,832,000*	*$203,088,000*	*$32,407,000*			
Nonstructural	Lower Passaic	$114,802,000	$91,678,000	$23,124,000	*$1,152,500,000*	*$51,373,000*	***1.00***
	Central Passaic	$79,314,000	$63,034,000	$16,280,000			
	Pompton	$33,716,000	$27,279,000	$6,437,000			
	Pre-Base Year Benefits			$5,395,000			
	Additional Benefit Categories			N/A			
	Total	*$227,832,000*	*$181,991,000*	*$51,236,000*			

TABLE 56: BENEFIT-COST RATIO SENSITIVITY: LOWER BOUND WITH-PROJECT ANNUAL DAMAGES

Alternative	Basin	Annual Flood Damages		Annual Benefits	Total Investment Cost	Total Annual cost	Benefit-Cost Ratio
		Without Project	With Project				
14A	Lower Passaic	$114,802,000	$22,681,000	$92,121,000	*$3,134,700,000*	*$150,964,000*	***1.03***
	Central Passaic	$79,314,000	$69,219,000	$10,095,000			
	Pompton	$33,716,000	$17,663,000	$16,053,000			
	Pre-Base Year Benefits			$14,611,000			
	Additional Benefit Categories			$22,017,000			
	Total	*$227,832,000*	*$109,563,000*	*$154,897,000*			
16A	Lower Passaic	$114,802,000	$24,392,000	$90,410,000	*$5,774,900,000*	*$278,456,000*	***0.57***
	Central Passaic	$79,314,000	$57,165,000	$22,149,000			
	Pompton	$33,716,000	$25,012,000	$8,704,000			
	Pre-Base Year Benefits			$14,981,000			
	Additional Benefit Categories			$22,575,000			
	Total	*$227,832,000*	*$106,569,000*	*$158,819,000*			
Newark Outlet Tunnel Alternative	Lower Passaic	$114,802,000	$21,167,000	$93,635,000	*$4,721,365,000*	*$226,592,000*	***1.18***
	Central Passaic	$79,314,000	$15,024,000	$64,290,000			
	Pompton	$33,716,000	$892,000	$32,824,000			
	Pre-Base Year Benefits			$41,814,000			
	Additional Benefit Categories			$33,803,000			
	Total	*$227,832,000*	*$37,083,000*	*$266,366,000*			
Beattie's Dam / Two Bridges	Lower Passaic	$114,802,000	$115,514,000	($712,000)	*$1,902,518,000*	*$91,249,000*	***0.69***
	Central Passaic	$79,314,000	$50,384,000	$28,930,000			
	Pompton	$33,716,000	$13,679,000	$20,037,000			
	Pre-Base Year Benefits			$5,962,000			
	Additional Benefit Categories			$8,983,000			
	Total	*$227,832,000*	*$179,577,000*	*$63,200,000*			
Nonstructural	Lower Passaic	$114,802,000	$69,261,000	$45,541,000	*$1,152,500,000*	*$51,373,000*	***1.56***
	Central Passaic	$79,314,000	$58,451,000	$20,863,000			
	Pompton	$33,716,000	$25,158,000	$8,558,000			
	Pre-Base Year Benefits			$5,395,000			
	Additional Benefit Categories			N/A			
	Total	*$227,832,000*	*$152,870,000*	*$80,357,000*			

G. BUYOUT ANALYSIS & PRESERVATION INITIATIVES (50 YEAR FUTURE PERIOD OF ANALYSIS)

Moving forward, there may be a need for considering preservation of these flood plains or following a smart development pattern without compromising the natural ability of the areas to manage excess water.

1. United States USACE, Passaic River, Floodway Buyout Program: Passaic County, New Jersey

Section 1148 of WRDA 1996 and Section 327 of WRDA 2000 provides specific authorization to conduct a Passaic River Floodway Buyout project. The cost sharing is set at 75% Federal and 25% non-Federal. The State of New Jersey through the New Jersey Department of Environmental Protection (NJDEP) is the non-Federal sponsor. The authorization specifies that the buy-outs are to be from willing sellers. The State began to implement the buy-outs through the State's Blue Acres Program in the late 1990's utilizing $15,000,000 in State funding, which has been expended and has been incorporated into the "existing conditions" Buyout Analysis section of this report.

The current analysis focuses on two areas of the floodway in the Township of Wayne and Borough of Pompton Lakes and analyzes the acquisition of only thirty (30) homes out of approximately 800 homes in the basin. The remaining structures will be analyzed for floodway buyout once the initial buyout of the referenced 30 homes has been approved.

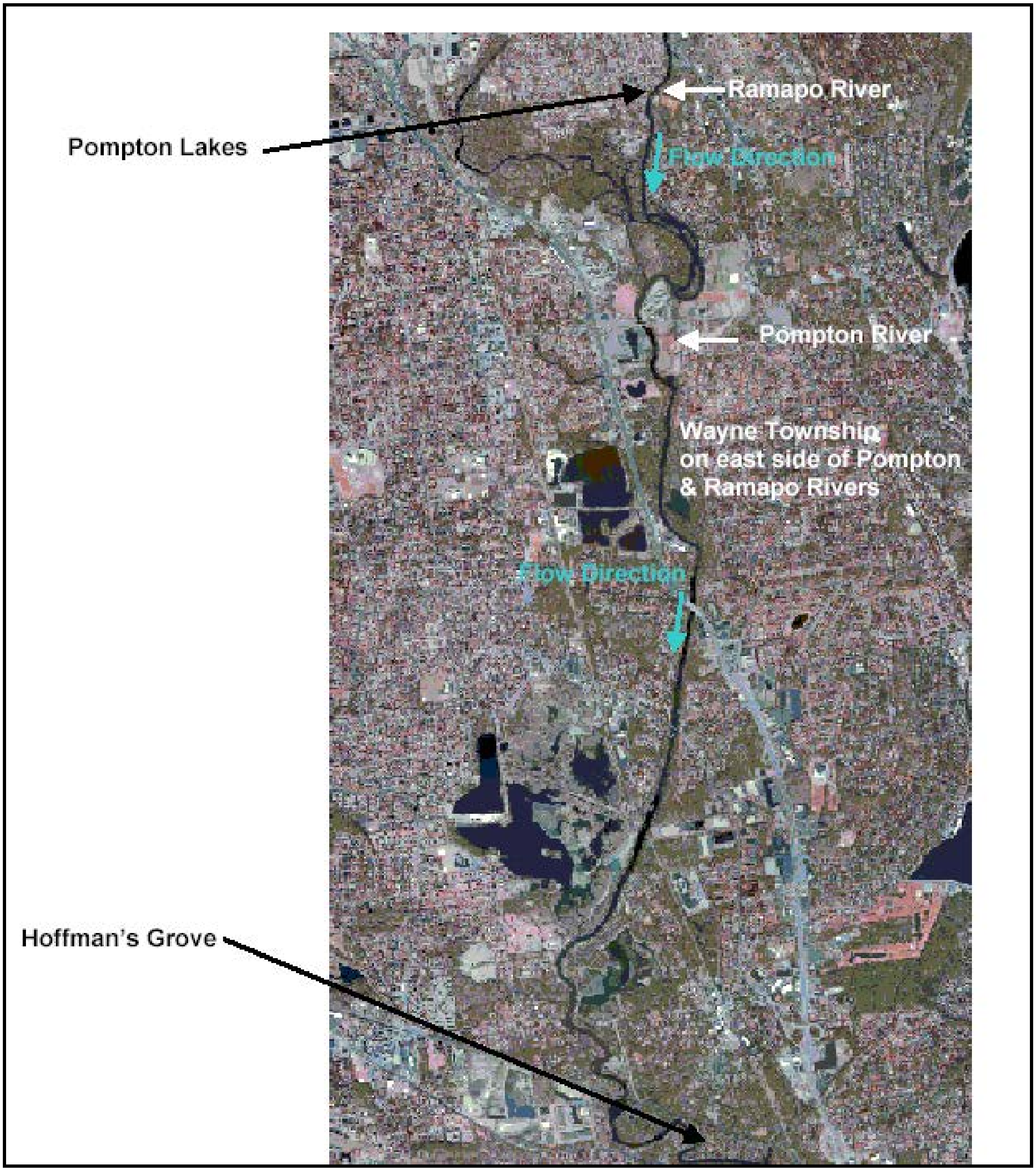


FIGURE 26: FLOODWAY BUYOUT AUTHORITY

FIGURE 27: HOFFMAN GROVE - TOWNSHIP OF WAYNE

FIGURE 28: POMPTON LAKES – BOROUGH OF POMPTON LAKES

Permanent evacuation of the floodway involves acquisition of land and structures by fee purchase or by exercising powers of eminent domain. Following acquisition, all structures and improvements are demolished or relocated. If flood protection can be achieved without structural measures, the benefits of a buyout alternative are many-fold. Besides avoiding difficult aspects of tunnel construction while returning the river closer to its natural state, removing the root causes of flood damage losses by simply clearing the flood plains should reap considerable advantages. Moreover, precluding future, developmentally-caused environmental damages in the flood plains through public ownership of affected lands, abundant open space would become available.

The authorization specifies that the buy-outs are to be from willing sellers. Land owners in the project area will be informed of the project's intent. Properties will then be acquired by fee simple purchase on a first come first serve basis until all available funds are expended. It is estimated that 5.4 acres will be acquired.

2. Preservation of Natural Storage, United States Army Corps of Engineers

As noted in the "Existing Conditions" Buyout Analysis (Section XX) of this Phase 1 report, **t**he Preservation of Natural Flood Storage was authorized as part of the overall Passaic River Flood Protection Project by the Water Resources Development Act (WRDA) of 1990, as modified by WRDA 1992. This separable project element consists of the acquisition of 5,350 acres of natural flood storage areas (of which 5,200 acres are wetlands) in the Central Passaic River Basin to prevent increases in flood flows caused by the loss of such areas to development. The Preservation of Natural Flood Storage separable project element was recommended for construction at a fully funded cost of $19,710,000. A total of 3,340 acres have been acquired to date and approximately 2,010 acres remain to be acquired, pending funding.

<u>Future Acquisitions include:</u>

- Wildlife Preserves, Inc - 789 acres
- City of East Orange Water Dept - 419 acres
- Township of Wayne - 172 acres
- City of East Orange - 150 acres
- Borough of Lincoln Park - 125 acres
- Montville Township - 121 acres

It can be assumed that future upstream development will create more impervious surface to give rise to inland flooding in the downstream areas. Sterling forest preservation can be looked as a model for protecting the environmentally sensitive areas from excess development. This 25 year-long effort resulted in the preservation of about 20000 acres of land in Orange County, NY approximately 40 miles northwest of New York City (Figure 26). The preservation brought together a large coalition of environmental groups, government entities, non-profit organization and unaffiliated citizens.

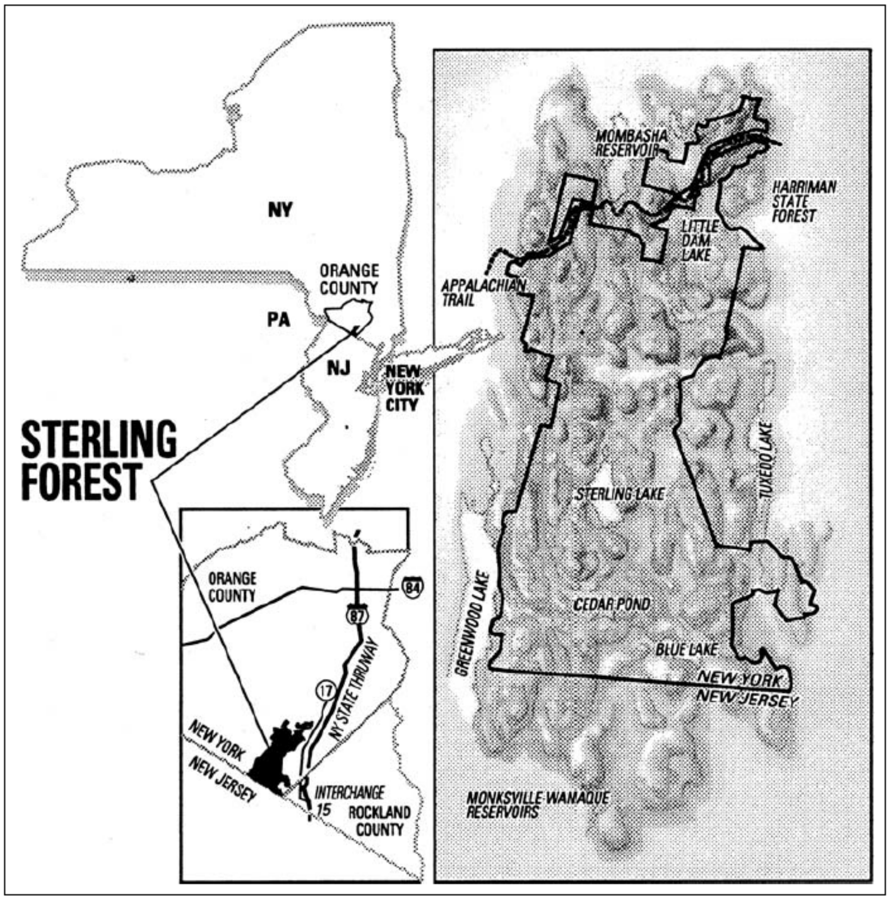


FIGURE 9: STERLING FOREST PRESERVATION

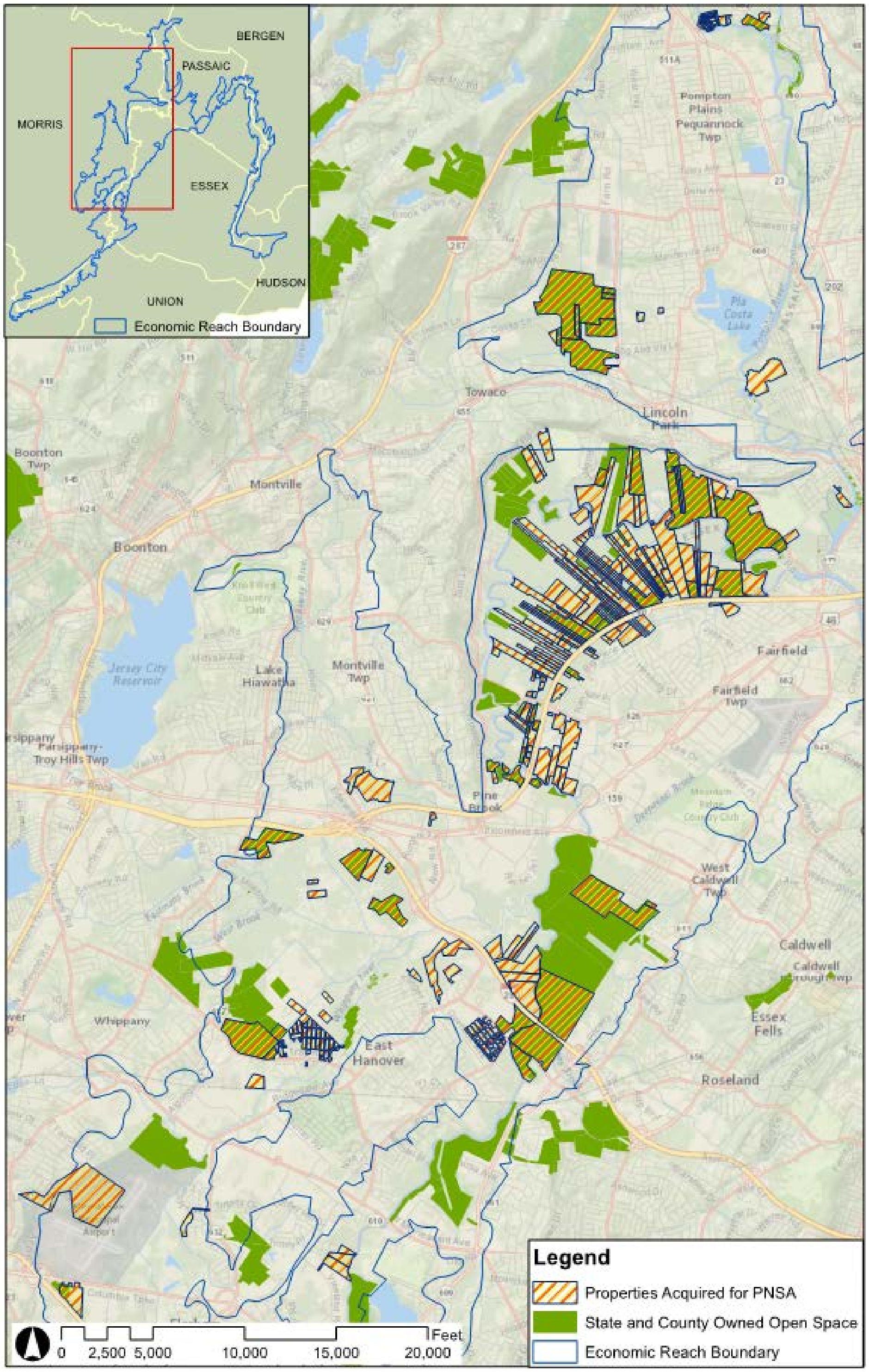


FIGURE 26: PRESERVATION OF NATURAL STORAGE

3. State of New Jersey Proposed Buyout Analysis

<u>Blue Acres</u>

The buyout analysis traced the funding source through FEMA the Blue Acres program. Created in 1995, Blue Acres enables acquisition of flood-prone properties or properties damaged by flooding from willing sellers, and leverages preservation dollars through matching funds from federal, state, county and local entities.

Blue Acres helps families move out of flood-prone areas to higher ground. Many public benefits result as homes are removed from the flood plain and land is able to return to a more natural state. Blue Acres acts as leverage for federal money, with Federal Emergency Management Agency funds covering 75 to 90 percent of buyout costs and Blue Acres funds providing the remainder. As a result, Blue Acres provides state funds to help reduce long-term local and federal costs of the National Flood Insurance Program, which pays for repetitive damages to numerous homes and commercial buildings in New Jersey's flood plains on an almost annual basis.

The Green Acres program is a land-conservation program created within the state Department of Environmental Protection to meet New Jersey's preservation and recreation needs. To date, more than 648,000 acres have been preserved because of this program, (funds can be used to acquire flood-prone lands, but generally not homes) - and the Blue Acres program rely on a dedicated source of funding by the Federal government.

Further, U.S. Sen. Frank Lautenberg, D-NJ (deceased), and U.S. Rep. Bill Pascrell Jr., D-Paterson, announced that $16 million would be available to purchase 149 (84 of which are flood-damaged homes in Wayne, Pompton Lakes and Little Falls) of the most flood prone homes throughout the state. About half of those homes are in Passaic County. In October 2010, the federal government allocated $19.8 million for buyouts in Wayne alone. The buyout and elevation of flood-prone homes in Pompton Lakes started in September 2012 with the acquisition of seven properties.

THOMAS E. FRANKLIN/STAFF PHOTOGRAPHER

Thirty-one homes are being bought out or elevated during this first phase of Federal funding. During the next phase of FEMA funding, the borough will apply for money for another 11 buyouts. Over a period of several years, hundreds of homes could be acquired, at which point the borough will have to take another look at its budget. Tropical Storm Irene cost Pompton Lakes about $1 million in police, public works and repair costs. FEMA only reimburses 75 percent of such expenses, leaving the rest to the borough. Once the properties are demolished, the borough will transform the land they occupied into a recreational site.

In other flood-prevention efforts, area communities have spent the past year clearing log jams and silt from the Wanaque, Ramapo and Pequannock rivers.

Additionally on March 1, 2012, the Governor of New Jersey announced that New Jersey will receive $21.6M in FEMA Hazard Mitigation Grant Plan funds. The primary beneficiaries of these funds is Parsippany ($7.2M), where hundreds of homes were damaged during Tropical Storm Irene/Lee in 2011 when the Rockaway River overtopped its banks and a retaining wall in the Lake Hiawatha neighborhood and $2M in Denville, where 11 homes were substantially damaged. In Parsippany, over 50 homes were declared to be "substantially damaged" in this neighborhood. Homes that are declared to be "substantially damaged" are defined by greater than 50% of the market value of the home in damages. The FEMA funding will help buyout or elevate homes out of the 100-year floodplain. The official use for the Hazard Mitigation Grant funds is for the Townships to buy out recurring flooded homes, demolish the properties and return the land to green space. In addition to buyouts, the Townships will assist in elevating selected dwellings above the base flood elevation. Reportedly, approximately 50% of the homeowners of substantially damaged houses in Parsippany are opting to elevate, the other half are choosing to sell. These funds are cost shared 75% by the referenced FEMA funds and 25% by the State's Blue Acres funds.

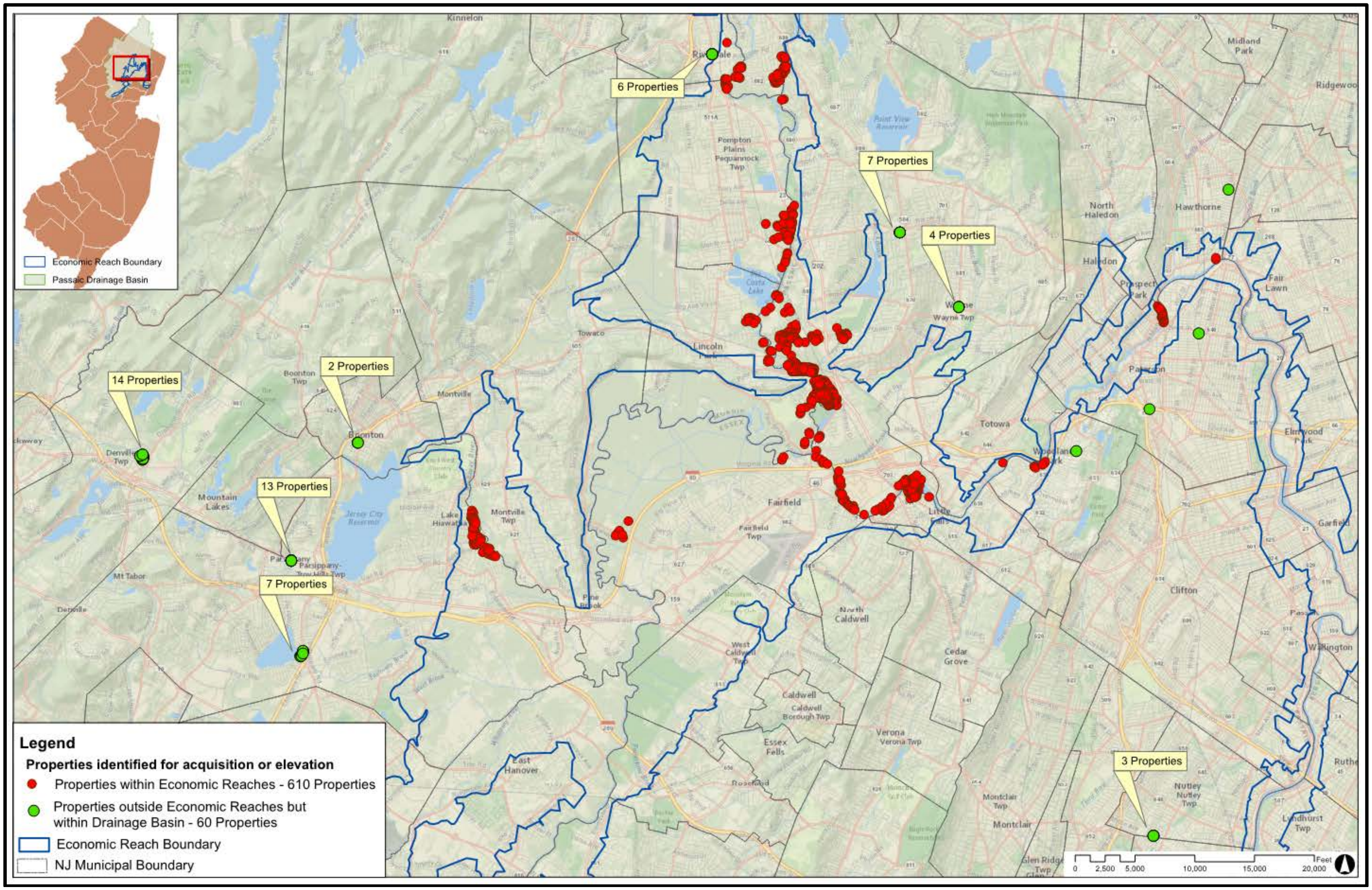
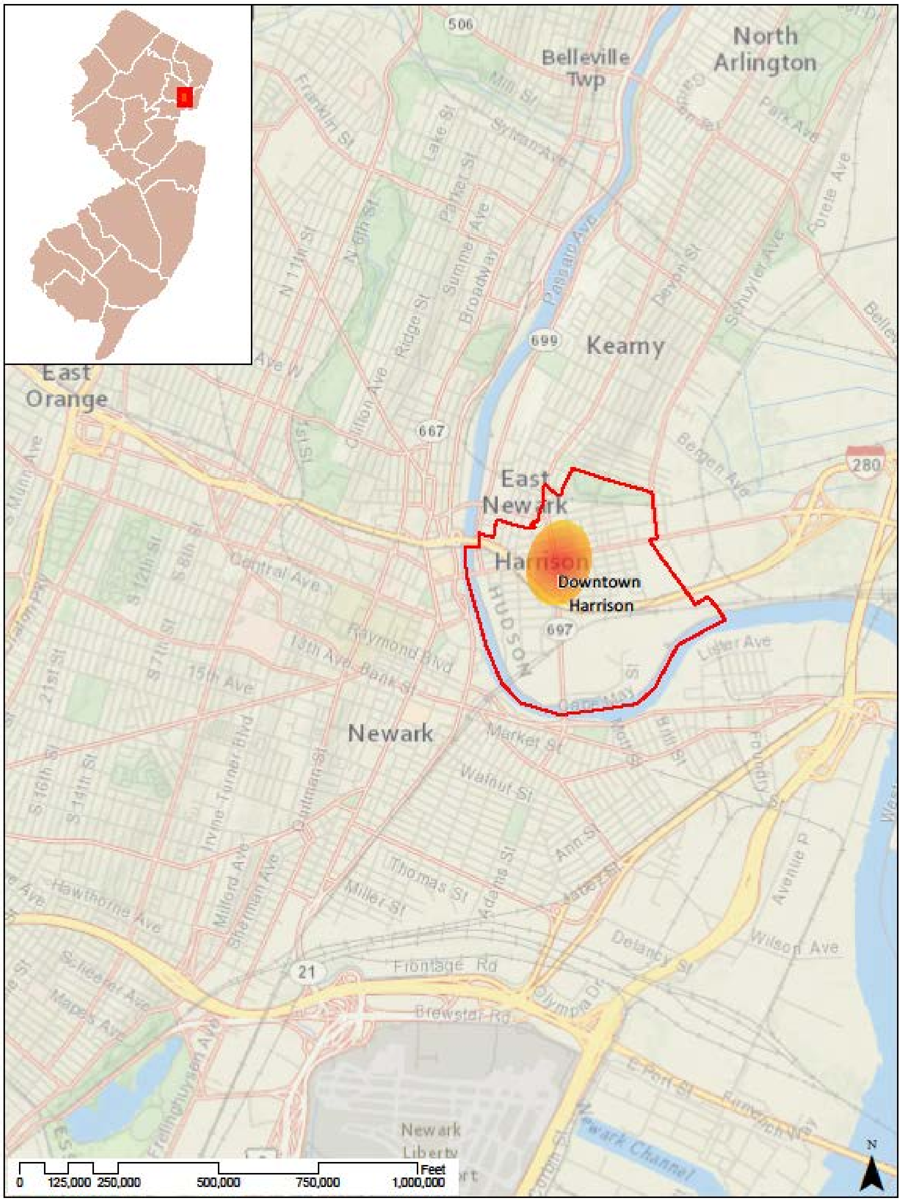


FIGURE 27: PROPOSED ACQUISITION OR ELEVATION

The town of Harrison in Hudson County (Figure 32) has recently redeveloped its downtown. Situated along a bend in the Passaic River Harrison has seen new residential development along with Red Bull soccer arena. As per a news article *Next Stop: Harrison*13 “This year, developers are expected to break ground on at least six more multimillion-dollar residential projects, and the Port Authority of New York & New Jersey will begin updating its PATH station.”



<u>FIGURE 28:</u>
<u>PROPOSED DEVELOPMENT IN THE TOWN OF HARRISON: LOWER BASIN</u>

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13 http://njmonthly.com/articles/towns_and_schools/next-stop-harrison.html

H. Changes in Land cover and land use in the Passaic River Watershed

The data collected for this section show that urban development in the nation's most densely populated watershed has increased and in fact gained momentum. One of the consequences of expansive development patterns is the loss of important undeveloped land (farmlands, forest, wetlands, etc.) to urbanization. As of 2010, the State of New Jersey has more acres of subdivision and shopping centers than it has of upland forest. From a hydrological perspective, one of the more significant landscape impacts attributable to land development is the creation of impervious surface. These changes have significant environmental consequences including impact to ground water recharge and frequency/magnitude of flooding.

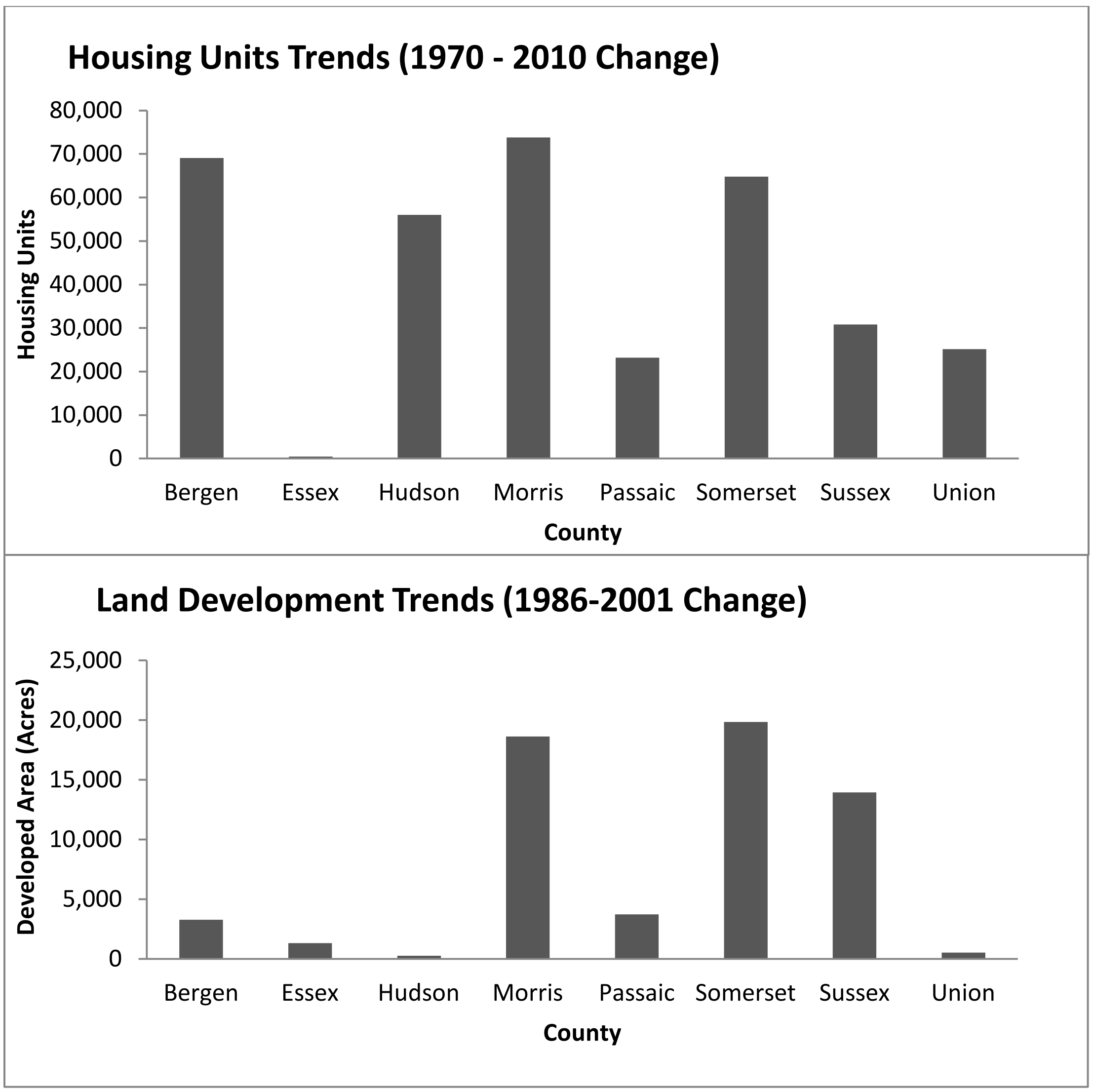


FIGURE 29: LAND USE LAND COVER TRENDS

1. Bergen County

Bergen County is the most populous county of the state of New Jersey. As of the 2010 Census, its population was 905,116 and there were 352,388 housing units at an average density of 1,512.3 per square mile (583.9/km^2). The county had a total area of 246.671 square miles (638.87 km^2), of which 233.009 square miles (603.49 km^2) was land and 13.662 square miles (35.38 km^2) (5.54%) was water.

Recent Development

Bergen County is a highly developed, primarily suburban area in New Jersey with several urban municipalities. While the County is one of the most densely populated in the state, the population is not evenly distributed by number or character. Northern Bergen County municipalities tend to be less densely populated than South Bergen municipalities. Overall, the land devoted to residential development currently represents the greatest amount of developed land county, rising from 24.1% to 42.6 between 1982 and 2010.

Because of the highly developed nature of Bergen County, much of the development that is occurring across the County is through redevelopment. Several towns are currently undergoing efforts to revitalize their downtown areas. Brownfield development also continues, as the lack of vacant land forces developers to look at redevelopment.

Several major projects were developed in the past decade at the site of Giants Stadium in East Rutherford. The recent developed Meadowlands Sports Complex is a sports and entertainment complex. The total land area of the complex is approximately 270 acres (11.8 million square feet). Some of the developed facilities are summarized below:

- MetLife Stadium: Is a venue facility home of two NFL teams, with an area of 2.1 million square-feet.

- American Dream Meadowlands: Is a large mall and entertainment complex. The project includes a retail space area of 4.8 million square foot.

- The Meadowlands Station: The project provides 2.3 miles of rail alignment that connect the NJ Transit Pascack Valley line with the station platform centrally located on the west site of the meadowlands Sports Complex.

Other highly developed areas include the Paramus shopping area. This is one of the largest shopping districts in the country. The region has over 50 shopping centers, many of them developed or expanded in the past decades. In general land devoted to commercial spaces has risen from 4,896 acres to 12,065 acres between 1982 and 2010.

Buyouts/Cleanouts/Preserved Areas

There is ongoing legislation for buyouts on many of the communities affected by hurricane Sandy. The buyouts are part of the NJ administration plan to purchase 1,000 homes damaged by Sandy and 300 homes in the Passaic River Basin that have been chronically impacted by floods in the past. As of today, it is unknown how many properties will be bought out in Bergen County and what will be the effect on the local hydrology.

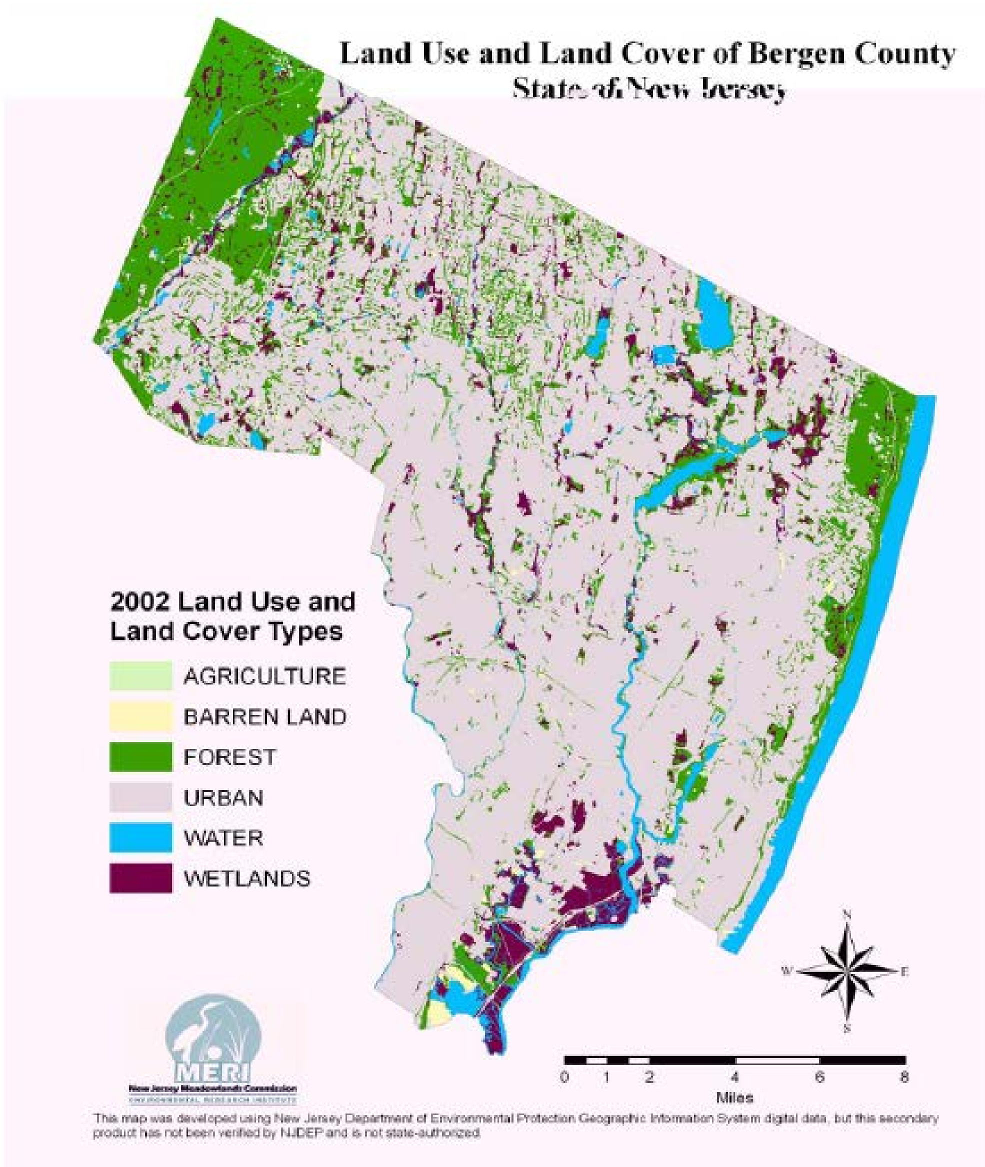


FIGURE 30: LAND USE AND LAND COVER BERGEN COUNTY

2. Essex County

Essex County is the second-most densely populated county in the state after Bergen County. As of the 2010 census the population was 783,969 and there were 312,954 housing units at an average density of 2,479.6 per square mile (957.4 /km^2). The county had a total area of 129.631 square miles (335.74 km^2), of which 126.212 square miles (326.89 km^2) is land and 3.419 square miles (8.86 km^2) (2.64%) is water.

Recent Development

Since its inception, Essex County has been the industrial and financial hub of New Jersey. With Newark International Airport and Port Newark located within its borders, Essex County is a major national transportation hub with a superior network of rail, highway, air and sea transportation and is home to one of the world's largest containerized shipping ports. However, Newark, the largest city in Essex County and the State of New Jersey, is one of the poorest cities in the country. Furthermore, in the past decades Essex County has experienced a dramatic economic turndown. In fact, it is expected that Essex County will experience further decline in their industrial/manufacturing and textile sectors.

In general, the development of the western section of the County was slowed because of the geographic barrier that represents the Watchung Mountains. As consequence, the demand for modern industrial development and new residential spaces forced development to the west. With the completion of Route 280 in late 1950's, communities such as Livingston, Fairfield, Roseland, Cedar Grove, Essex Fells and the Caldwells became the County's fastest growing communities. Additionally in the past decade, new industrial and professional office parks, hi-tech centers, and luxury condominiums and townhouses were developed on the western portion of the County. As of today, with the economic turndown of major cities in the County, the area of developed land has remained constant, rising from 62,065 acres to 63,368 acres between 1986 and 2001.

Buyouts/Cleanouts/Preserved Areas

Essex County has been largely impacted by recent tropical storms. As a result of tropical depression Irene, 26 substantially damaged properties have been approved for buyouts, while another 11 have qualified as non-substantially damaged. As of today it is unknown the number of properties in the county that will be impacted by buyouts that are part of the NJ administration plan to purchase 1,000 homes damaged by Sandy and 300 homes in the Passaic River Basin that have been chronically impacted by floods in the past.

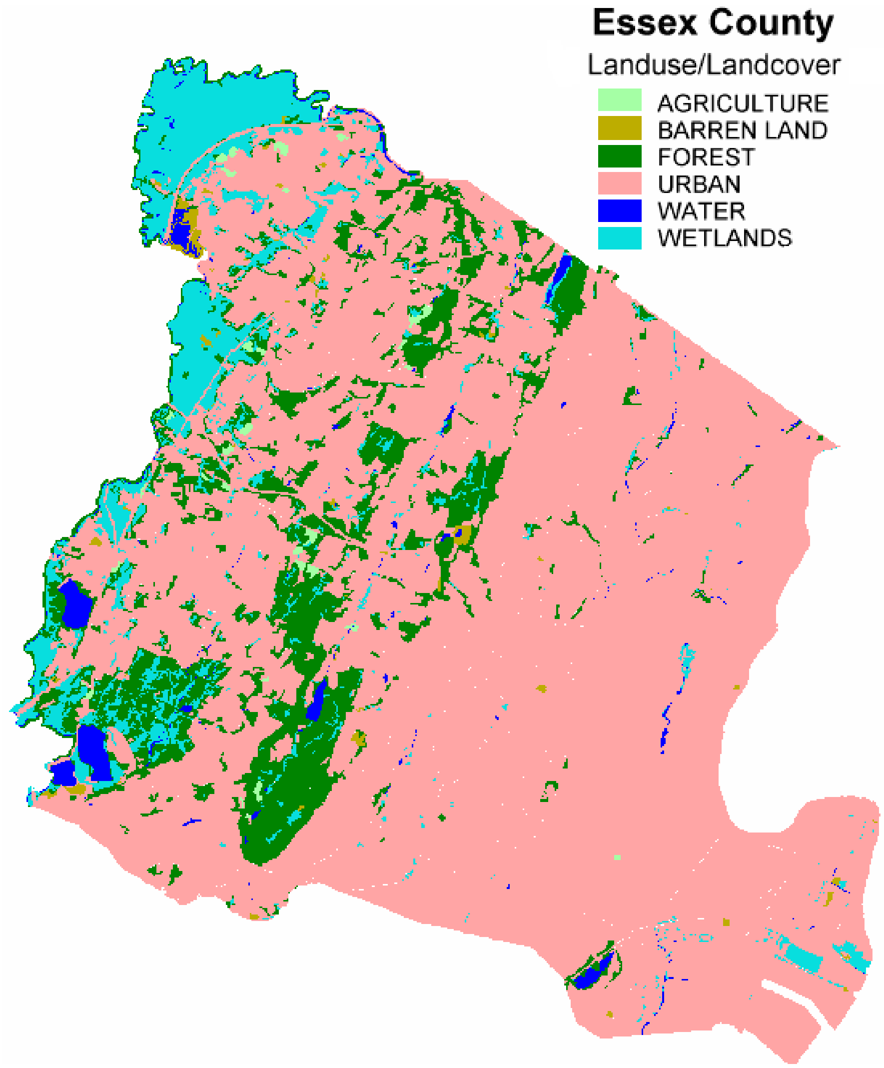


FIGURE 31: LAND USE AND LAND COVER ESSEX COUNTY

3. Passaic County

Passaic County is a county located in the State of New Jersey. As of the 2010 Census, the population was 501,226 and there were 170,048 housing units at an average density of 918 per square mile (354/km^2). Passaic County had a total area of 197.10 square miles (510.5 km^2), of which 184.59 square miles (478.1 km^2) (or 93.65%) is land and 12.51 square miles (32.4 km^2) (or 6.35%) is water.

Existing Development

The County of Passaic is an extremely diverse region with Highland mountains containing watershed areas, large publicly owned areas of open space, floodplain areas along rivers, residential suburban communities and urban centers that are economically challenged. The developed and developable land within the county is about 69,090 acres.

Buyouts/Cleanouts/Preserved Areas

Passaic County is approximately 118,438 acres in size of which 49,348 acres are preserved as public open space, nonprofit land or watershed land. In 2004, the New Jersey Legislature passed the Highlands Water Protection and Planning Act, which regulates the New Jersey Highlands region. For reference, the New Jersey Highlands is a 1,250 square-mile area that stretches across the northwestern part of the State. The northwestern area of the county, comprising the municipalities of Bloomingdale, Pompton Lakes, Ringwood, Wanaque and West Milford, was included in the highlands preservation area and is subject to the rules of the act and the Highlands Water Protection and Planning Council, a division of the New Jersey Department of Environmental Protection. Some of the territory in the protected region is classified as being in the highlands preservation area, and thus subject to additional rules and regulations.

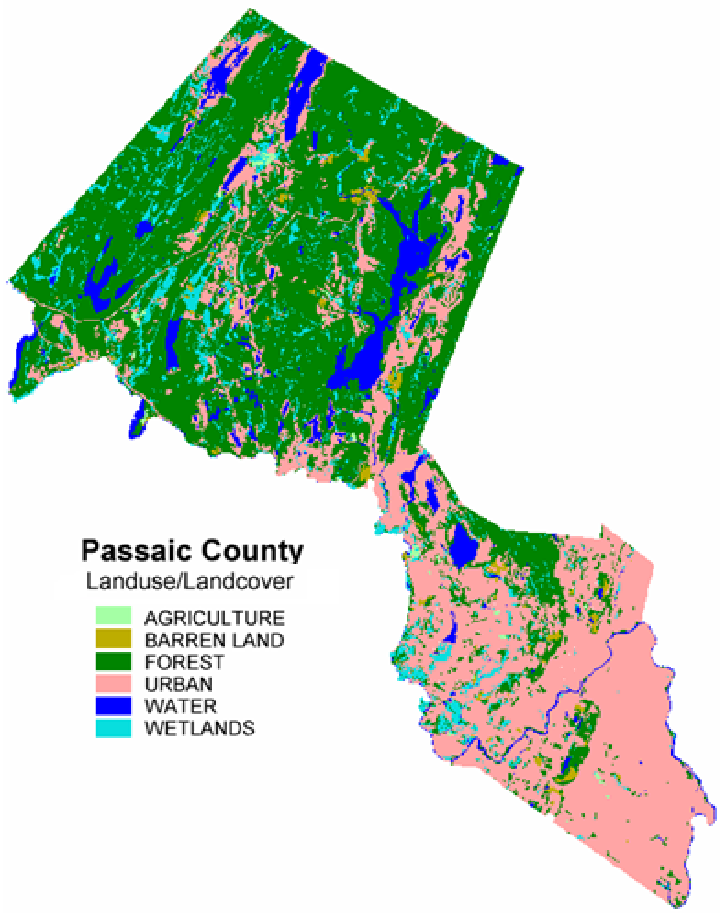


FIGURE 32: LAND USE AND LAND COVER PASSAIC COUNTY

4. Somerset County

Somerset County. As of the 2010 Census, the county's population was 323,444 and there were 123,127 housing units at an average density of 408 per square mile (158 /km^2). The county had a total area of 304.86 square miles (789.6 km^2), of which 301.81 square miles (781.7 km^2) (or 99.00%) is land and 3.04 square miles (7.9 km^2) (or 1.00%) is water.

Recent Development

Somerset County includes rural landscape, residential areas, commercial industrial areas and various transportation systems (local and state roadways, railway, airport, etc.). With approximately 304.85 acres of land area, it is the largest urbanized are in the United States. County data estimates that there are 89,019 structures in Somerset County, with a total building replacement values (structure and content) of greater than $41.6 billion. Approximately 98% of the total buildings in the County are residential, which make up 81% of the building stock structural value associate with residential housing. Currently, agricultural lands occupies 15.8% of County, however, agricultural land area has been declining over the last 20 years.

Significant changes have been seen throughout the County, especially in agriculture and urban developed land. Agricultural land has lost 36% (17,038 acres) of its total land area since 1986, while developed land experience and increase of 27% (17,359 acres). The largest gain in urban developed are was seen in Montgomery, which increased by 73% (3,500 acres) from 1986 to 2002. In general, urban and developed land made up 82,483 acres (43%) of the total County land in 2002. Between 1987 and 2000, the County experienced a large growth in residential housing units, located in large rural lots. This development pattern has led to increased the suburban sprawl.

Buyouts/Cleanouts/Preserved Areas

As of 2006, Somerset County open space inventory showed that approximately 9,800 acres have been preserved in permanent open space. Since 1994, many towns in the County have added substantial amounts of land to their open space and parklands. Bedminster added 116 acres, bringing the municipal park total to 409. Hillsborough, through a combination of land donations and purchases, added 479 acres, for a municipal open space of total 1,489 acres. Additionally, Somerset County park system consists of 21 sites, totaling over 8,400 acres.

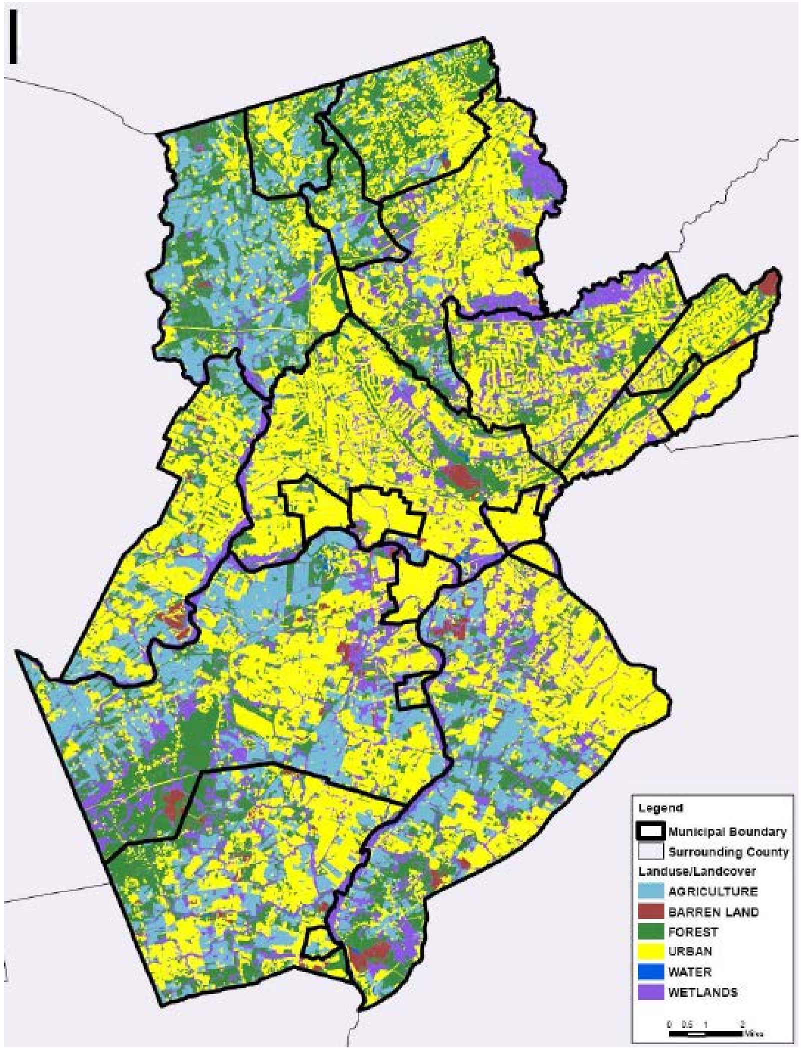


FIGURE 33: LAND USE AND LAND COVER SOMERSET COUNTY

5. Morris County

Morris County. As of the 2010 Census, the county's population was 492,276 and there were 189,842 housing units at an average density of 412.5 per square mile (159.3 /km^2). The county had a total area of 481.62 square miles (1,247.4 km^2), of which 460.18 square miles (1,191.9 km^2) (or 95.55%) is land and 21.45 square miles (55.6 km^2) (or 4.45%) is water.

Recent Development

Thirty-three Fortune 500 businesses have headquarters, offices or a major facility in Morris County. These include AT&T, Honeywell, Colgate-Palmolive, Pfizer, Johnson & Johnson, Exxon-Mobile, Novartis, BASF, Verizon, Bayer and Wyeth. There are 13,000 acres (53 km^2) set aside for 28 county parks.

The land use in the county has changed dramatically since the last comprehensive land use survey was conducted in the 1970. As documented in the 1975 Plan, only 37% county was considered “developed as of 1970”. In contrast, approximately 81% of the county is currently developed (as of 2005). Because of the highly developed nature of Morris County, much of the future development that will occur across the County is through redevelopment.

Overall, land devoted to residential development currently represents the greatest amount of developed land in the county, rising from 16% to 33% between 1970 and 2005. Land in commercial use (non-farm, office and retail) and industrial uses have risen from a combined total of just 2% in 1970 to about 7% in 2005. Commercial land use rise from 1% to 5% with a significant expansion of corporate office and business campuses. The amount of land devoted to industrial uses has risen slightly, up from 1% in 1978 to just 2% in 2005. Examples of significant contributors in this category include the Sussex Turnpike Industrial Campus in Randolph Township, and the Iron Mountain Industrial Park in Mine Hill. The most notable development is the International Trade Center and the Foreign Trade Zone in Mount Olive, which includes nearly 684 acres and 7 million square feet of mixed office, industrial and warehouse development. In 2005, there were approximately 116 million square of combined commercial, office, and industrial space in Morris County. Lastly, road and highway right-of-way increased from about 4% to 6%. Part of this increase can be attributed to major road building projects, including the Route 287, Route 80 and Route 24.

Future Development and potentially developed lands includes the available vacant lands that make up roughly 52,800 acres or 17% of all the county land.

<u>Buyouts/Cleanouts/Preserved Areas</u>
In Morris county substantial gains have been made in the area of open space acquisition with approximately 44,000 acres preserved by federal, state, county and municipal governments over the last 30 years (since 1975). In 1970, parks accounted for less than 3% of the total land area; by 2005, public parkland and preserved open space in the county accounted for about 22%. The Increase is primarily the result of the local and county aggressive parkland/open space acquisitions. Although not considered “open space”, over 6,000 acres of preserved farmland have also been added. Furthermore, lands have been preserved by private non-profit groups.

Additionally, the “Highlands Water Protection and Planning Act” (2004) is another recent law that will have a profound impact on the local and county planning board activities. Of Morris County’s 39 municipalities, 32 are included in the Highlands Region. As example, of an estimated of 36,100 acres of “potentially” developable unconstrained land, the Highland Act places more than half i.e. 19,000 acres (53%), within the Highlands Preservation Area.

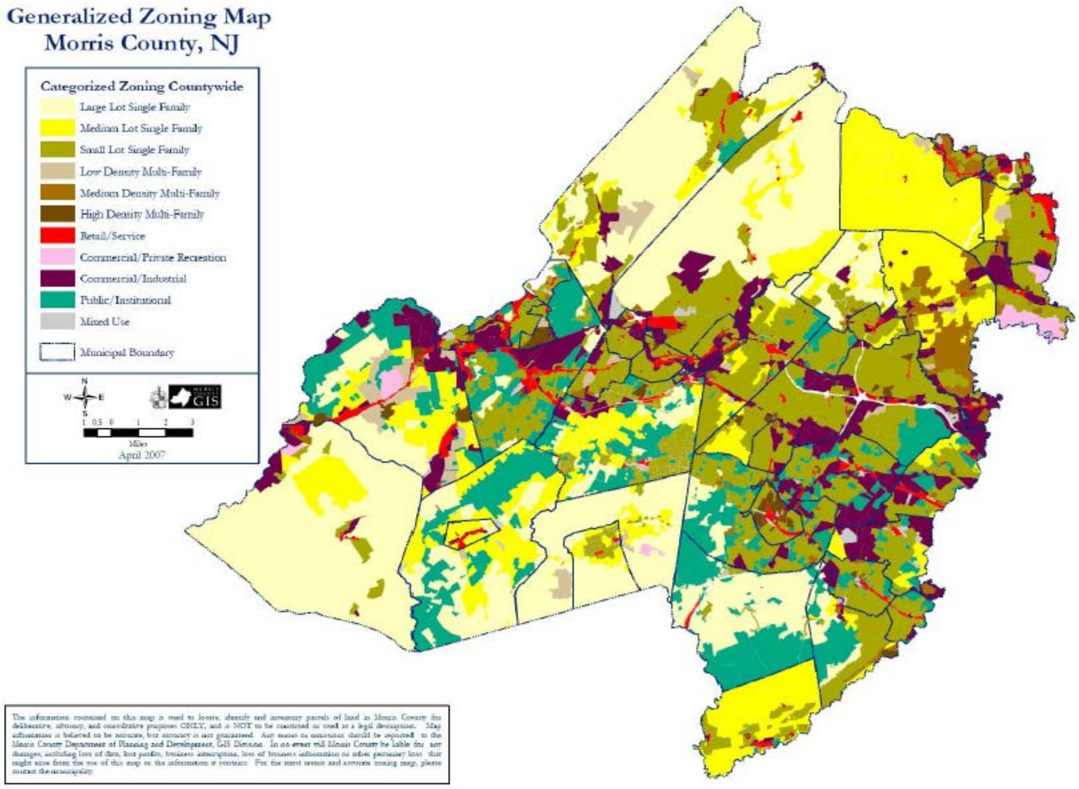


FIGURE 34: LAND USE AND LAND COVER MORRIS COUNTY

6. Hudson County

Hudson County is the smallest county in New Jersey and one of the most densely populated in United States. As of the 2010 Census, the county's population was 634,266 and there were 270,335 housing units at an average density of 5,852.5 per square mile (2,259.7 /km^2).The county had a total area of 62.31 square miles (161.4 km^2), of which 46.19 square miles (119.6 km^2) (or 74.13%) is land and 16.12 square miles (41.8 km^2) (or 25.87%) is water. It is the smallest of New Jersey's 21 counties.

Recent Development

Although largely developed, Hudson County has been experiencing significant surges in growth development and especially redevelopment. Since mid 1970's many changes have taken place which have dramatically altered the Hudson county landscape.

Overall, residential land uses comprise 5,634 acres or 14% of the County area in 2000. The residential land area has increased by 254 acres or 4.7% between 1974 and 2000. As well, the commercial land uses comprise a total of 1,942 acres or 4.9%, increasing 508 acres or 43% between 1974 and 2000. The industrial lands comprise 5,129 acres or 12.9% of the total land area. The industrial land area in the Hudson County increased by 580 acres or 12.8% between 1974 and 2000, significant increases occurred in Bayonne, Secaucus, Jersey City and North Bergen. As an example, the increase in industrial land in Bayonne is attributable to the development along the waterfront in the industrial zone and the reclassification of the US army

Marine Ocean Terminal (MOT) from public use to an industrial use. As of 2003, land used for streets, railroads and public utility rights-of-way total 6,664 or 16.7% of the total County area. In contrast with other land use categories, the amount of land used for streets and rights-of-way decreased by 23.6% or 2,060 acres between 1974 and 2000. This was caused by the abandonment of large tract of railroad properties which were redeveloped for Liberty State Park and commercial developments. Most of the decrease occurred in Jersey city, where 1,200 acres of land were abandoned.

In the past 30 years over 2,000 acres of abandoned rail yards have been redeveloped for a variety of residential and commercial uses. According to the 2000 Census, almost 11,000 new housing units have been constructed in the County since 1990. The Hudson River waterfront has become a premier location for Class A office space and luxury apartments. Wholesale distribution centers in Secaucus have evolved into retail outlets and underutilized industrial lands along the Passaic River water from have started to redevelop. Major mass transit projects have been carried out like the construction of the Hudson-Bergen Light Rail Transit (HBLRT) System.

Buyouts/Cleanouts/Preserved Areas

Parks and open space land area increased by 482 acres between 1974 and 2000 with the establishment of the Liberty State Park in Jersey City and 104 acres for the Laurel Hill Park in Secaucus.

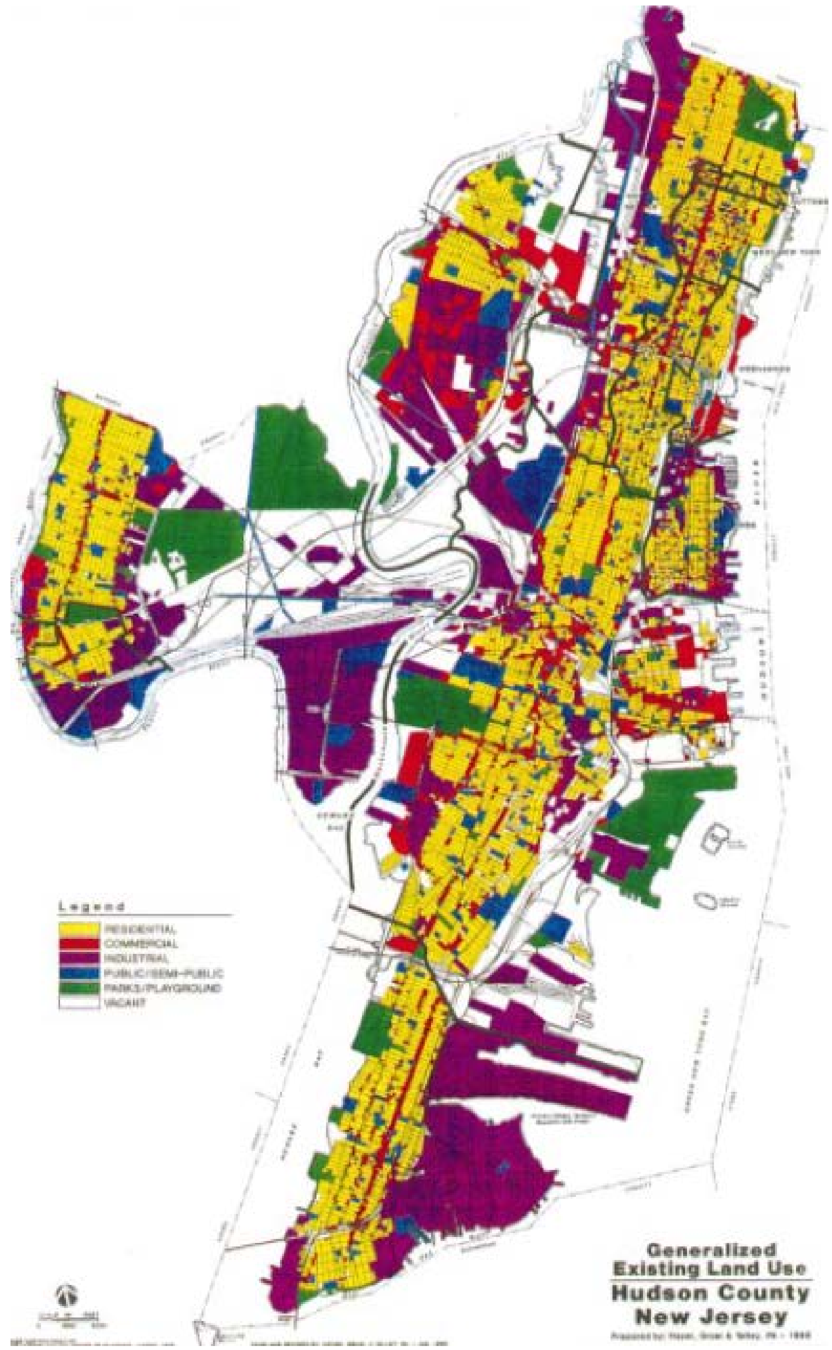


FIGURE 35: LAND USE AND LAND COVER HUDSON COUNTY

7. Union County

Union County is a county located in the state of New Jersey. As of the 2010 census, the population was 536,499 and there were 192,945 housing units at an average density of 1,868 per square mile (721/km²). The county had a total area of 105.40 square miles (273.0 km^2), of which 102.86 square miles (266.4 km^2) (or 97.59%) is land and 2.55 square miles (6.6 km^2) (or 2.42%) is water.

Recent Development
Overall, developed land currently represents the greatest amount of land class in the county for a total of 55,186 acres. In general, Union County land use and cover changes has been moderately steady during the past decade.

Buyouts/Cleanouts/Preserved Areas
In Union County has been impacted by recent tropical storms. As of today, is unknown the number of properties in county that will be impacted by buyouts.

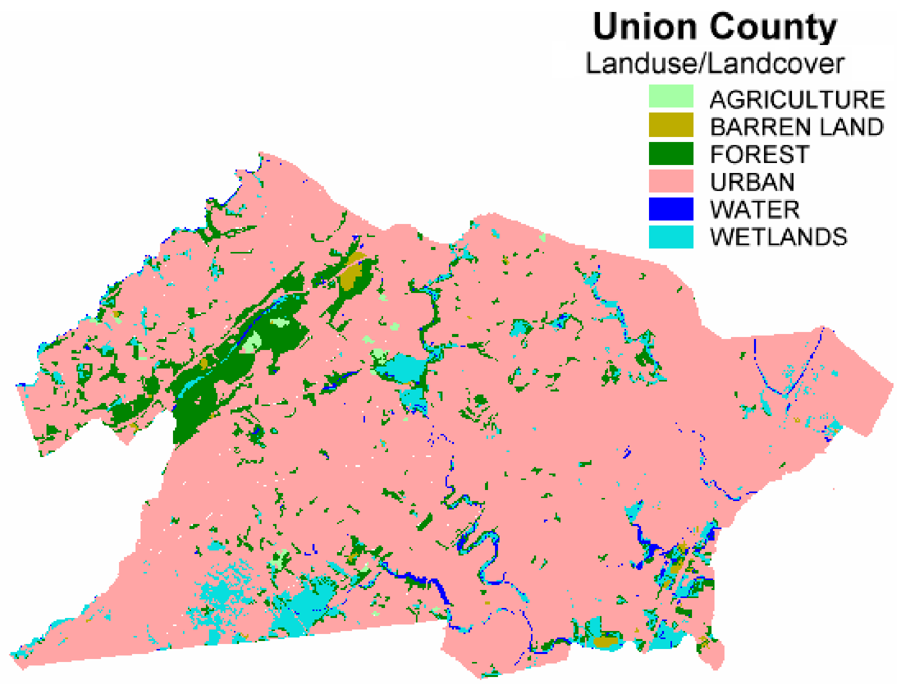


FIGURE 36: LAND USE AND LAND COVER UNION COUNTY

8. Sussex County

Sussex County is the northernmost county in the State of New Jersey. As of the 2010 Census, the county had 149,265 residents and there were 56,528 housing units at an average density of 108 per square mile (42/km^2). The county had a total area of 535.74 square miles (1,387.6 km^2), of which 519.01 square miles (1,344.2 km^2) (or 96.88%) is land and 16.73 square miles (43.3 km^2) (or 3.12%) is water.

Recent Development
The largest of the landscapes in the County is the Rural/Agricultural landscape comprising 175,106 acres. This landscape, along with the Parks and Wildlife Management Area landscape (111,981 acres), gives the County its character as a scenic and generally undeveloped area. The

remaining landscapes, of lesser extent, are: Traditional Centers 38,800 acres; Lake Communities 17,730 acres; Industrial Centers 335 acres. The Highlands, which incorporates parts of all landscapes, comprises 126,233 acres in total with 72,825 acres in the core preservation area. With the Highlands preservation and planning areas extracted, the remaining landscapes acreages are as follows:

Rural/Agricultural	145,386 acres
Traditional Centers	37,058 acres
Industrial Centers	335 acres
Parks and Wildlife Mgmt. Areas	76,964 acres
Lake Communities	11,384 acres

The Industrial Centers (Commerce Park in Sparta, North Church Industrial Park in Hardyston) are Located along major highways, these are the focus of industrial development and serve as employment centers for relatively intense land uses. Overall, Sussex County has not experienced an accelerated development, like many counties in New Jersey State.

Buyouts

As consequence, large portions of Sussex County are permanently set aside as public/conservation open space. Accounting for more than one-third of the total County land area, they are expansive, with minimal disturbance. They are home to threatened and endangered species of plants and animals, pristine streams, and are a place isolated from the fast pace of daily living.

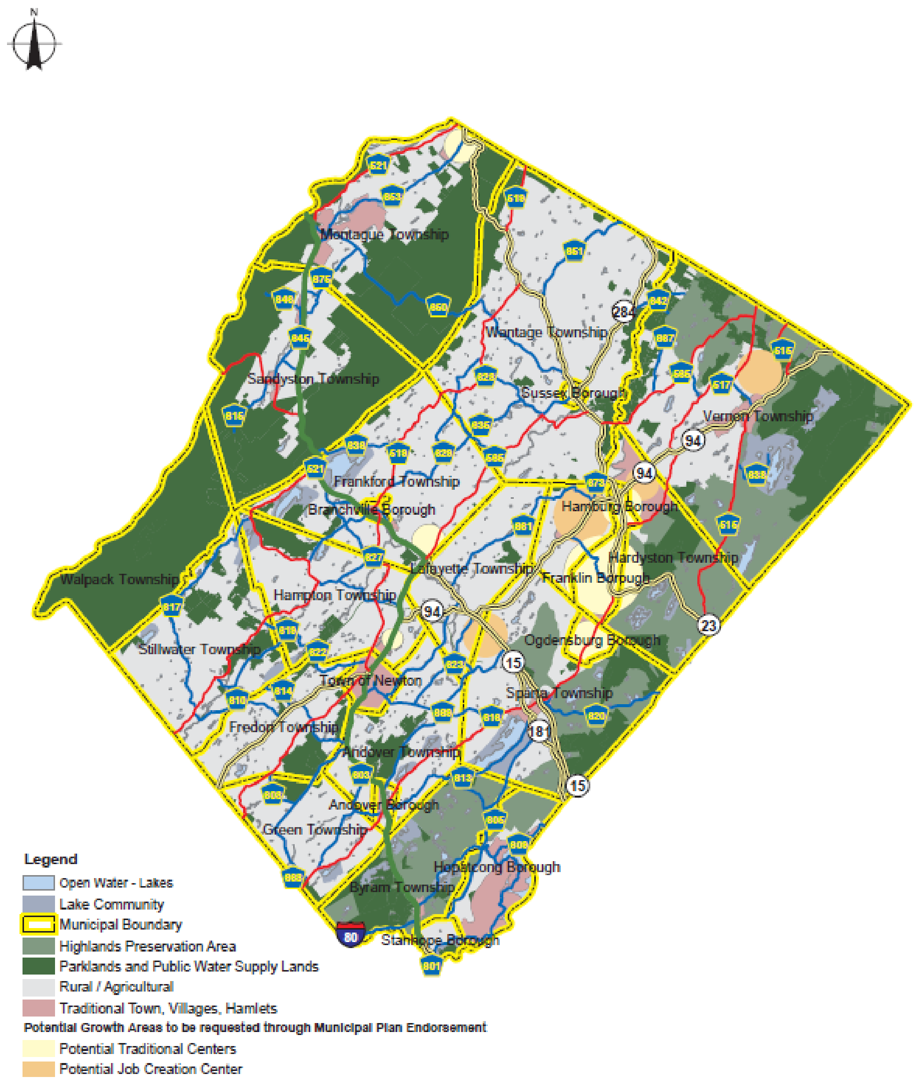


FIGURE 37: LAND USE AND LAND COVER SUSSEX COUNTY

9. P.L. 113-2 PASSAIC TIDAL LIMITED RE-EVALUATION REPORT

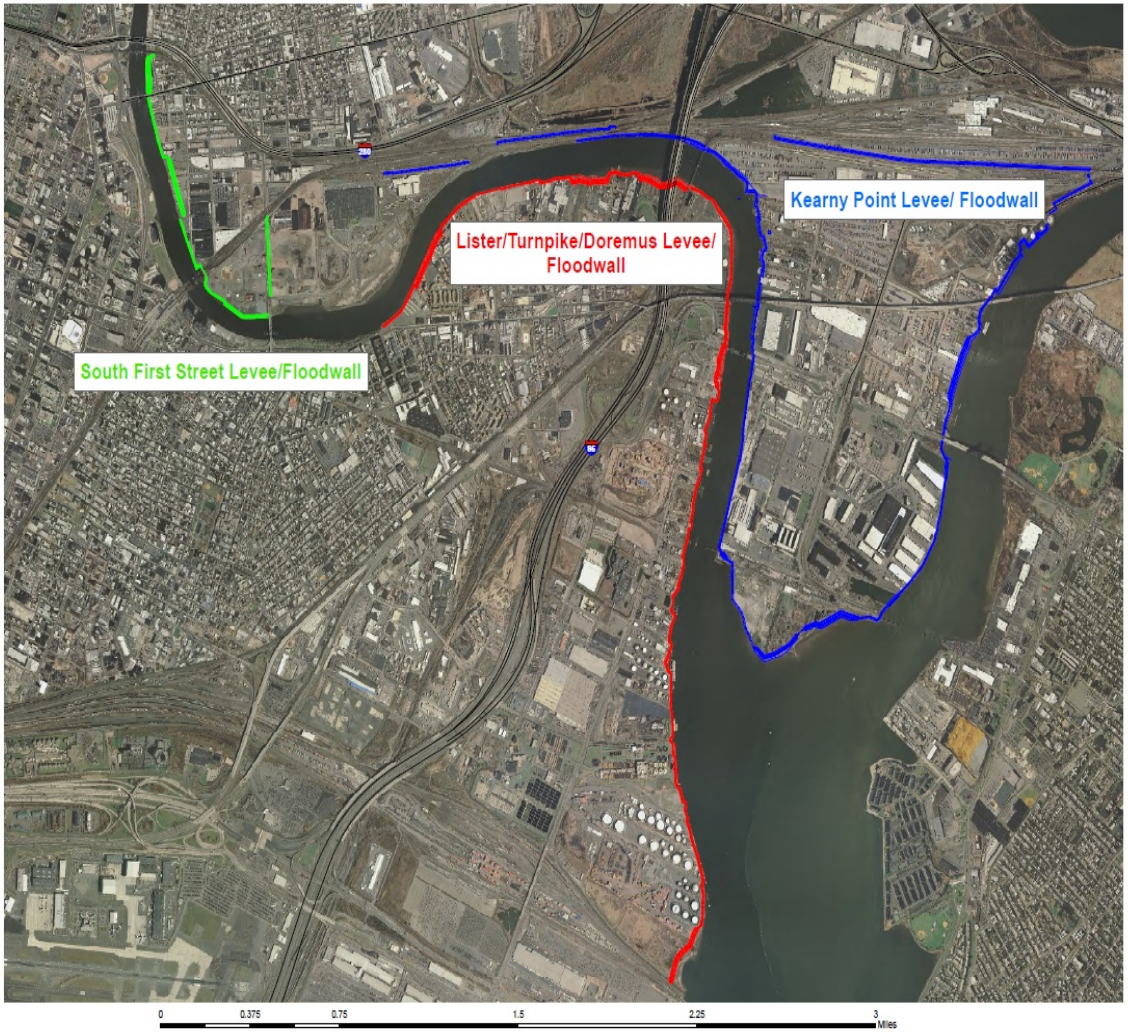
Because of the devastation sustained during Hurricane Sandy in the region on 29 October 2013 Public Law 113-2, the Disaster Relief Appropriation Act of 2013, the tidally influenced "Lower Passaic Basin" will be separated from the overall study as a separable element.

The 1990 authorization for the Passaic River Main Stem includes an area known as the Tidal Area Protection and provided "Protection in the Lower Passaic Valley included 5.5 miles of levees and 5.0 miles of floodwalls lying downstream of Interstate 280 to Newark Bay which provide 500 year protection against hurricane and tidal surges." The area provides flood risk reduction to Newark, Kearny, and Harrison. This reach is considered to be a separable element because it is hydraulically separated from the rest of the basin (it is located below Dundee Dam) and is incrementally justified.

The waterfront areas of Newark, Kearny, and Harrison were severely impacted by Hurricane Sandy. The storm surge inundated an extensive area of highly developed industrial, commercial, and residential neighborhoods. The highly utilized urban transit systems of the PATH, NJ Transit, and Amtrak were also severely impacted and operate through this area and the transportation infrastructure was extensively damaged from the storm surge (USACE had a FEMA assigned unwatering mission at the Amtrak facilities located in Kearny in the areas that have an authorized levee and floodwall to provided flood risk management). There was one documented fatality in this area due to the storm surge.

The authorized levees and floodwalls would have reduced the risk in these areas significantly. A preliminary survey of the areas indicates that the benefits of protecting the area with the authorized levees and floodwalls would be economically justified under today's conditions.

The 1995 Phase 2 General Design Memorandum estimated the fully funded cost to be $120,826,320 (approximately $300M at October 2012 price level).



System	Levee Height (ft)	Levee Width (ft)	Levee Length (ft)	Floodwall Height (ft)	Floodwall Length (ft)	Total Length (ft)
Kearny Point Levee/Floodwall	5.2	41	3908	7.4	33771	37679
Lister/Turnpike/ Doremus Levee/Floodwall	5.5	44	5599	8.1	17657	23256
South 1st Street Levee/Floodwall	6.5	50	1750	6.2	5700	7450

* Design and dimensions based on 1995 Passaic Main Stem Tunnel Plan

* Passaic Main Stem Alternative 14A (1987) also includes two levee/floodwalls systems directly north of the South 1st Street System. These systems (Passaic Ave. #1 and Passaic Ave. #2) would provide protection on the left bank of the Passaic River directly north of Route 280 for approximately 6500 ft.

FIGURE 38: STUDY AREA

10. SUMMARY AND CONCLUSIONS

Prior to the Phase 1 study, it was assumed there have been significant changes in engineering requirements, land usage and river flow records that may affect how various alternatives would be analyzed today. Previously evaluated alternatives from the 1987 General Design Memorandum (1987 GDM) were updated to account for changes in technology, design requirements, costs, economic factors and the frequency of flooding.

Results of this Phase 1 reevaluation of the changes in the frequency of flooding show that all flows provided by current gages in the basin, except Chatham, are now greater than those predicted in the 1987 study. Predicted flows for the 100 year storm event have generally increased between 6% and 34% and some water surface elevations (WSELs) have increased up to 1.6 feet. Additionally, the annual risk of flooding has decreased to an estimated 50 or 60 year annual risk of flooding (versus a 100 year annual risk of flooding of any plan analyzed in the 1987 GDM). Reevaluation of alternatives included in this Phase 1 report that were analyzed in 1987 include Alternative 14A, Alternative 16A, the Newark Outlet Tunnel Alternative, and the 10 year floodplain non-structural alternative. Further, a new alternative that evaluates a plan called the Beatties/Two Dams Alternative was also included in this Phase 1 analysis.

Reevaluation of alternatives deemed to be economically justified in the 1987 GDM indicates that Alternative 14A, the Newark Outlet Tunnel Alternative and the 10 year floodplain non-structural plan all appear to be marginally economically justified. All benefits and costs were calculated at fiscal year 2013 price levels, a 3.75% discount rate, and a 50-year period of analysis.

It should be noted that Alternative 14A has a 1% annual chance of flooding (a 100 yr annual risk of flooding) for much of the plan with the exception of the non-structural measures in the Central Basin and therefore is a more comprehensive watershed solution than the non-structural 10 year floodplain alternative. The non-structural measures in Alternative 14a and the Non-Structural alternative have a greater than 10% annual chance of flooding (less than 10-year annual risk of flooding).

Although the Newark Outlet Tunnel Alternative was determined to be economically justified in this preliminary reevaluation, USACE is prohibited from expending any federal funds for the design or construction of this project. Analysis was conducted on this alternative for comparison purposes only as required by ER 1105-2-100.

Alternative 16A and the Beatties Dam/Two Bridges alternative appear to have BCRs that are below 1.0 for all iterations of ranges of costs and damages and therefore, are probably not in the Federal interest for analysis in the Detailed Analysis Phase. However, because the Beatties Dam/Two Bridges alternative was not included in the 1987 GDM as an alternative, there is a lower confidence as to the economical justification at this juncture. It should also be noted that the cost of excavation, which was very variable and is greatly dependant on the means and location of disposal, does have a very significant impact on the BCR for both of these alternatives.

Design requirement changes as a result of Hurricane Katrina to features such as "I" walls, have increased project costs and buyouts of frequently damaged structures have somewhat decreased the available benefits. Thus, benefits appear to have slightly underperformed the increase in cost of the implementation of any alternative. Subsequently, , the Benefit to Cost ratios appear to have only marginally decreased since the 1987 and 1995 studies.

The Non-structural plan does not appear to have increased in cost as much as some of the other alternatives . The following factors have affected the cost and benefit estimates which explain why this alternative's benefit to cost ratio (BCR)appears to have changed significantly when compared to previous study results:

1. The unit costs used by the NY District Corps of Engineers for non-structural treatments have recently been updated and decreased based on experience, actual bid results and Fire Island to Montauk Point Project data.

2. No structural inventory was available when the Non-structural features were developed and the costs were estimated. Since first floor elevations, foundation types and building types were not available, therefore average values were used for features and treatment such as but not limited to raising heights, ring wall heights, flood proofing treatment and raising costs. The cost estimate for this particular alternative was heavily impacted by the fact that no structural inventory was available.

3. Due to the updated hydrologic frequency analysis, the level of protection afforded by this alternative has dropped from a 10 year to about a 6 year level of protection. This lower level of protection or performance has probably increased the comparative BCR because non-structural plans tend to optimize at fairly low levels of performance.

Therefore it is very possible that a 5 year non-structural plan is more cost effective than a 10 year plan and that may be affecting the results of this analysis. Given the increases uncertainty associated with this alternative, it is recommended that the costs and BCR of this particular alternative be considered less reliable than the results developed for the other alternatives.

TABLE 56: TOTAL FLOOD DAMAGES SINCE 1903

Year	**Damages (October 2012 price levels)**
Flood of 1903 (flood of record)	$2.4B
Flood of 1984	$892M
Flood of 1999 (Hurricane Floyd)	$357M
April 2007	$792M
March 2010 & 2011	>$1B
Tropical Storm Irene/Lee August/September 2011	>$1B
TOTAL DAMAGES SINCE 1903	**>$6.5B**
Range of Investment Costs Presented in this Report	$1.1B- $5.7B

Over $6B in damages have been realized since the authorization of the 1995 Feasibility Plan that indicated a cost of $1.2B to construct a comprehensive, basin-wide flood risk management project ($2.1B at a October 2012 price level). The frequency and intensity of these storms appear to be increasing and catastrophic damages continue to recur. Furthermore, 26 lives have been lost as a direct result of the flooding. There is Federal interest in the protection of property, businesses, infrastructure and the lives of the people in the basin and Flood Risk Management is a major USACE mission area. Implementing an economically, environmental acceptable, publicly supported plan in 1995 if constructed could have avoided over $3.5B in damages.

Alternative	Total Cost 2013	Total Cost 1987 (2013 Price Level)	Benefit-Cost Ratio 2013	Benefit-Cost Ratio 1987	Annual Costs 2013	Annual Damages 2013	Net Excess Average Annual Benefits (Annual Damages – Annual Costs[14] Range
14A	***$3.1B***	***$876M***	***0.8 – 1.2***	***1.06***	***$150,964,200***	***$121,110,000***	***-($30M - $18.5M)***
16A	***$5.8B***[15]	***$1B***	***0.5 – 0.7***	***1.1***	***$271,581,800***	***$132,098,000***	***-($139M - $61M)***
Modified Tunnel	***$4.7B***	***$2.1B***	***1.02 – 1.44***	***1.1***	***$221,362,300***	***$266,578,000***	***$45M - $69M***
Beattie's Dam / Two Bridges	***$1.9B***	***Not Analyzed in 1987 GDM***	***0.6 – 0.80***	***Not Analyzed in 1987 GDM***	***$89,156,700***	***$50,705,000***	***-($38M - $13M)***
Nonstructural (10-year LOP)	***$1.2B***	***$1.3B***	***1.3-1.9***	***0.8***[16]	***$51,373,400***	***$66,261,000***	***$15M - $31M***

14 Net Excess Average Annual Benefits are calculated by subtracting Annual Damages by Annual Costs. Net Excess Average Annual Benefits are calculated using costs whose costs were subject to Cost Risk Analysis where the average cost contingency exceed 50%.

15 Costs for Alternative 16A and Beatties Dam /Two Bridges Alternative assume that excavated material (dredged during channelization) will be disposed (tipping fee) and not re-used for levee construction. Any HTRW disposal would be funded by NJDEP.

16 With regards to the non-structural benefits for the sampled reaches, the 10yr non-structural plan benefits were evaluated as if it were a levee at the 10 year stage. This will overstate some benefits (some damage will still occur below the 10 yr event) while under estimating others (elevation or acquisition will reduce damage above the 10 yr event). Since there is no building specific data to use for this model this is considered a reasonable approach. Because flood-proofing is proposed for the vast majority of the buildings the overall damage reduction may be somewhat high. For the 11 reaches modeled the non-structural damage reduction varied between 2% to 42% of the without project damage. This suggests that there is tremendous uncertainty in the estimated benefits.

LESSONS LEARNED – PHASE I APPLIED TO PHASE II

1. PDT members expressed concern regarding lack of field investigation work performed at this stage. This resulted in high risk of uncertainty in quantities (such as construction materials), design and large variance in construction methodology that may be performed by a contractor when executing the work. This uncertainty resulted in a rather high contingency for each alternative.

2. Quantities for the alternatives in the 1987 Phase 1 GDM Feasibility Report were not broken down individually and could not be used as planned so new very rough and approximate quantities had to be used to develop cost for several of the alternatives. The use of rough estimates feeds the risk and uncertainty discussed above.

3. The updated flood flows for the 100 year event have increased from 5% to 30% and the resulting Water Surface Elevations (WSEL) have increased from about 0.5 to 1.6 feet and the annual risk of flooding (if fixed) has dropped to about 50 or 60 year annual risk of flooding.

4. Design requirement changes as a result of Hurricane Katrina to features such as "I" walls, have increased project costs.

5. Purchases of frequently damaged structures (buy outs) have decreased the available benefits.

6. Redevelopment in Harrison may have an impact on benefits associated with that area.

7. Increased damages and thus benefits appear to have underperformed the increase in costs.

8. During Phase I, structure inventory was attempted via GIS. This sampling approach was only marginally successful in that ultimately, because the GIS inventory sampling method was not complete or updates are sporadic , ultimately there has to be in-field surveys taken in Phase II. Over 20,000 structures are located within the 100 year floodplain.

9. The B/C ratios do not appear to have changed significantly from the 1987 and 1995 studies.

10. No new "highly" effective alternative has materialized.

11. PUBLIC INVOLVEMENT

This Preliminary Alternative Reevaluation (Phase 1) Report will be provided to New Jersey Department of Environmental Protection to assist the non-Federal sponsor with a determination of likely alternatives for detailed analyses in the next phase of the study, to be contained in the Phase 2 Report.

The decision by the NJDEP identifying the path forward will be predicated on review of the Phase 1 Report, as well as the results of public input derived from ten (10) Public Meetings, tentatively scheduled to be conducted between September and December 2013 (in accordance with the Phase 1 Report schedule). Tentative dates and locations are presented below:

<u>Proposed Dates:</u>

September 10th Tuesday
September 17th Tuesday
October 2nd Wednesday
October 9th Tuesday
October 17th Thursday
October 30th Wednesday
November 7th Thursday (election day is the 5th)
November 20th Wednesday
December 10th Tuesday

<u>Proposed Locations:</u>

Fairfield - Essex County (requested)
Lincoln Park - Morris County (requested)
Pompton Lakes - Passaic County (requested)
Lodi - Bergen County
Parsippany - Morris County (requested)
Paterson - Passaic County
Oakland - Bergen County
Little Falls - Passaic County
Pequannock Township - Morris County
Wayne - Passaic County

<u>Historical Public Awareness and Concerns:</u>

Coordination and collaboration with the local residents, businesses and municipalities are critical for the success of any comprehensive solution for flood risk management in the Passaic River Basin. Public involvement during the formulation of the 1987 GDM identified many concerns and lack of consensus on how to proceed, regardless of the unanimous recognition of the urgent need for flood risk management measures in the Passaic River Basin.

Through the years, the concerns of the basin's constituents to the previous alternatives can be partially characterized based on geographic location. Geographic regions define similar political and economic interest, as well as similar problems, both with flooding and with the potential solutions. The constituents of the western portions of the Central Basin tend to greet the Dual Inlet Tunnel with interest and positive attitude. The interest in the Pompton Valley and Two Bridges vicinity of the Central Basin, the region most affected by frequent flooding, are also supportive of the Tunnel plan, but are concerned with the lack of progress at implementing a solution. Most of the public problems expressed in this region are related to dissatisfaction that the flood problem has not already been resolved.

The major divergence in opinion comes from the Lower Basin communities, which do not have frequent flood problems. Their concerns are related to the relatively large amount of structural measures, which would be required to solve the main stem flood problem. The main complaint of the Lower Basin municipalities was that all the proposed plans will force them to take responsibility for the Central Basin's problems.

Opposition to the Alternative plans evaluated, was constrained by technical, environmental, economic, and social considerations. All the Structural alternatives include channel modification, levees, floodwalls, detention ponds. For these alternatives, issues and concerns expressed by the public revolve around:

- Channel modification can contribute to worsening flood problems at downstream areas, and is not an acceptable alternative.
- Levees and floodwall were aesthetically unpleasant, and because they are designed to protect against a specific floods they create a false sense of security and limited the public access to the river.
- It would degrade the quality of life into the Passaic Basin to an unacceptable degree.

Overall, the Dual Inlet Tunnel plan was the most controversial and highly polarized alternative. However, big support was voiced for the tunnel, specifically because of the high level of protection it would provide. The opposition came from the negative factors including but not limited to the high cost of the plan, the long time frame for implementation, the outlet location and concern about potential induced effects along the lower Passaic River.

The Non-Structural measures such as flood proofing, buyouts and preservation and/or creation of open space in the floodplain, were criticized because the low level of protection they offer. As a consequence of the controversy and lack of consensus, there was an overwhelming response for additional information regarding other alternative plans.

In general, from the views expressed at the feasibility report of 1987, there is a desire of the Lower Basin Public to see wide spread buyouts, dredging or measures relying on non-structural solutions instead of a Dual Inlet Tunnel or massive structural measures. The upper Lower Valley, Pompton Valley and Central Basin publics endorsed the Tunnel plan, but have concerns regarding the implementation of interim measures.

On the whole, the interests of the public in the Basin are harder to define than those of the municipalities and counties as governmental bodies.

12. PATH FORWARD

The submission of this Preliminary Alternative Reevaluation, Phase 1 Report will provide the non-Federal sponsor an opportunity to determine alternative(s) on which to proceed to the Detailed Analysis Phase 2 Report based on conceptual costs and economics derived from updated engineering and environmental requirements with sufficient detail to allow the non-Federal sponsor to discuss with the public and make an appropriate decision for the path forward.

Following the public information meetings and the selection of the alternative toadvance, the District will update its Phase 2 Project Management Plan and execute a new cost sharing agreement with NJDEP. Phase 2 will examine the selected alternative(s) in detail to fully develop the plan, identify environmental issues and prepare a NEPA document, identify real estate requirements and prepare a cost estimate. If a viable project is identified, the Phase 2 report will make a recommendation that Congress authorize it for construction. While waiting for construction authorization and appropriation, the District will proceed into Pre-construction Engineering and Design (PED) and begin the preparation of the first of many construction plans and specifications. If no solution is implemented, there remains potential for loss of property and life during future storm events.

13. PROPOSED SCHEDULE

TABLE 57: PROPOSED SCHEDULE

Milestone	**Date**
Detailed Analysis PMP Rescoping	Dec 2013[17]
Cost-Sharing Funding Agreement Execution & Waiver	Jan 2014
NEPA Scoping	Apr 2014
TSP Milestone	Jun 2016
Agency Decision Milestone	Aug 2017
Final Report	Jan 2018
Chief’s Report	Sep 2018

17 Dependent upon Public Meetings and Local Support

References

33 CFR 208.10	Local Flood Protection Works; Maintenance and Operation of Structures and Facilities
40 CFR 1500-1508	Council on Environmental Quality (CEQ) NEPA regulations
EC 1105-2-408	Peer Review of Decision Documents
EC 1105-2-409	Planning in a Collaborative Environment
EC 1165-2-203	Technical and Policy Compliance Review
EC 1110-2-6066	Design of I-walls
EM 1110-1-1003	NAVSTAR Global Positioning System Survey)
EM 1110-1-1005	Topographic Surveying
EM 1110-1-1802	Geophysical Exploration
EM 1110-1-1804	Geotechnical Investigations
EM 1110-1-2909	Geospatial Data and Systems
EM 1110-2-1205	Environmental Engineering and Local Flood Control Channels
EM 1110-2-1304	Civil Works Construction Cost Index System
EM 1110-2-1415	Hydrologic Frequency Analysis
EM 1110-2-1416	River Hydraulics
EM 1110-2-1417	Flood Run-off Analysis
EM 1110-2-1419	Hydrologic Engineering Requirements for Flood Damage Reduction Studies
EM 1110-2-1601	Hydraulic Design of Flood Control Channels Change 1 ENG 4794-R
EM 1110-2-1607	Tidal Hydraulics
EM 1110-2-1614	Design of Coastal Revetments, Seawalls, and Bulkheads
EM 1110-2-1901	Seepage Analysis and Control for Dams with CH 1
EM 1110-2-1906	Laboratory Soils Testing
EM 1110-2-2200	Gravity Dam Design
EM 1110-2-2201	Arch Dam Design
EM 1110-2-2300	Earth & Rock Fill Dam Considerations
EM 1110-2-2300	General Design and Construction Considerations for Earth and Rock-Fill Dams
EM 1110-2-2503	Design of Sheet Pile Cellular Structures
EM 1110-2-2906	Design of Pile Foundations
EM 1110-2-3104	Structural & Architectural Design of Pumping Stations
EM 1110-2-3800	Systematic Drilling and Blasting for Surface Excavations
EM 1110-2-6053	Earthquake Design & Evaluation of Concrete Hydraulic Structures
EM 385-1-1	Corps of Engineers Safety Manual
ER 1105-2-100	Planning Guidance Notebook
ER 1105-2-5	Periodic Inspection and Continuing Evaluation of Completed Works
ER 1110-1-12	Quality Management
ER 1110-1-263	Sample Handling Protocol for Low, Medium, and High Concentration Samples of Hazardous Waste
ER 1110-1-8155	Specifications
ER 1110-2-1150	Engineering and Design of Civil Works Projects

ER 1110-2-1200	Plans and Specifications
ER 1110-2-1302	Civil Works Cost Engineering
ER 1110-2-1405	Hydraulic Design for Local Flood Protection Projects
ER 1110-2-1450	Hydrologic Frequency Estimates
ER 1110-2-1464	Hydrologic Analysis of Watershed Runoff
ER 1110-2-1806	Earthquake Design Analysis for Corps of Engineers
ER 1110-2-8154	Water Quality & Environmental Management of Civil Works Projects
ER 1165-2-131	Local Cooperative Agreements for New Start Construction Projects
ER 1180-1-6	Construction Quality Management
ER 200-2-2	Procedures for Implementing NEPA
ER 385-1-92	Safety and Occupational Health Requirements for Hazardous, Toxic, and Radioactive Waste
ER 405-1-12	Real Estate Handbook
ER 415-1-11	Biddability, Constructability, Operability and Environmental Review
ER 5-1-11	Program and Project Management
ER 715-1-20	Architect-Engineer Contracting

ETL 1110-1-142	Blasting Vibration Damage and Noise Prediction and Control

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Water Resources Development Act of 1986 (P.L. 99-662)
Water Resources Development Act of 2007 (P.L. 110-114)

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