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SOUTH RIVER, RARITAN RIVER BASIN HURRICANE & STORM DAMAGE REDUCTION AND ECOSYSTEM RESTORATION

COMMUNICATION

FROM

THE ASSISTANT SECRETARY OF THE ARMY (CIVIL WORKS), THE DEPARTMENT OF THE ARMY

TRANSMITTING

THE INTEGRATED FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT STATEMENT FOR THE SOUTH RIVER, RARITAN RIVER BASIN HURRICANE AND STORM DAMAGE REDUCTION AND ECOSYSTEM RESTORATION.

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US ARMY CORPS
OF ENGINEERS
NEW YORK DISTRICT

NEW JERSEY
DEPARTMENT OF
ENVIRONMENTAL
PROTECTION

SOUTH RIVER, RARITAN RIVER BASIN

HURRICANE & STORM DAMAGE REDUCTION AND ECOSYSTEM RESTORATION

INTEGRATED FEASIBILITY REPORT & ENVIRONMENTAL IMPACT STATEMENT

Volume 1

September 2002

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South River, Raritan River Basin

Hurricane & Storm Damage Reduction
and
Ecosystem Restoration

Integrated Feasibility Report & Environmental Impact Statement

New York District
U.S. Army Corps of Engineers

September 2002

(3)

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LIST OF STUDY TEAM MEMBERS AND REPORT PREPARERS

The following individuals were primarily responsible for the preparation of this integrated feasibility report and environmental impact statement.

Individual	Responsibility
Joseph H. Redican	Project Planner
Mark H. Burlas	Biologist; National Environmental Policy Act Compliance; Mitigation
Yvonne Spraggins	Project Manager
Josephine R. Axt	Restoration Biologist
Robert M. Greco	Engineering Specialist
Frank A. Santangelo	Hydrology & Hydraulics
Stuart Chase	Hydrology & Hydraulics
Premkumar Harimohan	Cost Engineering
Johnny C. Chan	Economics
John J. Killeen	Cultural Resources
Richard P. Dabal	Hazardous, Toxic, and Radioactive Wastes
Robert Hass/Alex Dorman	Real Estate

GLOSSARY OF TERMS, ACRONYMS, AND ABBREVIATIONS

AAHU	Average Annual Habitat Units
ADCIRC	Advanced Circulation Model
APE	Area Of Potential Effect
CAFRA	Coastal Area Facility Review Act
CE	Cost Effectiveness
CEQ	Council On Environmental Quality
CFR	Code Of Federal Regulations
CMSA	Consolidated Metropolitan Statistical Area
Corps	U.S. Army Corps Of Engineers
dBA	Decibels
DEP	Department Of Environmental Protection (New Jersey)
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EM	Engineering Manual
EPA	U.S. Environmental Protection Agency
EPW	Evaluation Of Planned Wetlands
ER	Engineering Regulation
FCU	Functional Capacity Units
FEMA	Federal Emergency Management Agency
FR	Feasibility Report
FR/EIS	Feasibility Report/Environmental Impact Statement
FWCA	Fish and Wildlife Coordination Act
GWCE	Generalized Wave Continuity Equation
HEP	Habitat Evaluation Procedures
HSDR	Hurricane and Storm Damage Reduction
HSI	Habitat Suitability Index
HTRW	Hazardous, Toxic, And Radiological Wastes
HU	Habitat Units
ICA	Incremental Cost Analysis
IWR	Institute For Water Resources
MLT	Mean Low Tide
NAAQS	National Ambient Air Quality Standards
NEFMC	New England Fishery Management Council
NEPA	National Environmental Protection Act
NFIP	National Flood Insurance Program
NGVD	National Geodetic Vertical Datum
NHP	National Heritage Program
NHPA	National Historic Preservation Act
NJCPA	New Jersey Coastal Plain Aquifer
NJDEP	New Jersey Department Of Environmental Protection
NJDOT	New Jersey Department Of Transportation
NJHPO	New Jersey Historic Preservation Officer
NMFS	National Marine Fisheries Service
O&M	Operations And Maintenance
P&G	Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies

PED	Preconstruction Engineering And Design
PMP	Project Management Plan
ppt	Parts Per Thousand
PSI	Pollution Standards Index
S&A	Supervision And Administration
TCL	Target Compound List
USACE	U.S. Army Corps Of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish And Wildlife Service
USGS	United States Geological Survey
VOC	Volatile Organic Compounds
WES	Waterways Experiment Station
WSEL	Water Surface Elevation

EXECUTIVE SUMMARY (UPDATED)

This updated Executive Summary reflects the current discount rate (FY 2003) of $5^7/_8$% and the price level as of October 2002. The original Executive Summary remains in this document for the purpose of providing consistency with the main report, the writing of which was completed prior to FY 2003. The change in the discount rate and price level did not affect the plan formulation and selection of the recommended plan.

This report presents the results of an investigation to determine the feasibility of hurricane and storm damage reduction (HSDR) and ecosystem restoration along the South River in Middlesex County, New Jersey. The South River, Raritan River Basin Multipurpose Feasibility Study has been conducted by U.S. Army Corps of Engineers (Corps) with the non-Federal project partner, the New Jersey Department of Environmental Protection (NJDEP).

The study area initially included the entire South River basin. The South River is the first major tributary of the Raritan River, located approximately 8.3 miles upstream of the Raritan River's mouth at Raritan Bay. The South River is formed by the confluence of the Matchaponix and Manalapan Brooks, just above Duhernal Lake, and flows northward from Duhernal Lake a distance of approximately 7 miles, at which point it splits into two branches, the Old South River and the Washington Canal. Both branches flow northward into the Raritan River. The South River is tidally controlled from its mouth upstream to Duhernal Lake Dam; fluvial conditions prevail above the dam. Based on coordination with NJDEP, County and local governments, it was determined that there are no widespread flooding problems in the South River watershed upstream of the Duhernal Lake dam. Consequently, the study area was modified, focusing on river reaches below the dam, specifically flood-prone areas within the Boroughs of South River and Sayreville, the Township of Old Bridge, and the Historic Village of Old Bridge (located within the Township of East Brunswick). The downstream river reaches encompass virtually all the flood-prone structures in the watershed and the areas of greatest ecological degradation (and greatest potential for ecosystem restoration).

Periodic hurricanes and storms have caused severe flooding along the South River. Flood damages downstream of Duhernal Lake are primarily due to storm surges with additional damages associated with basin runoff. The communities repeatedly affected by storm surges are the Boroughs of South River and Sayreville, the Township of Old Bridge, and the Historic Village of Old Bridge in East Brunswick Township. There are approximately 1,247 structures (1,082 residential; 165 commercial) in the 100-year floodplains of these communities and 1,597 structures in the 500-year floodplains (1,399 residential; 198 commercial). Storm surges create the greatest damages in the study area occurring during hurricanes and northeasters that generate sustained onshore winds through multiple tidal cycles. For example, the northeaster of March 1993 (a 25-year event) resulted in approximately $17 million damage (2001 dollars) and closed the highway bridge connecting the Boroughs of South River and Sayreville.

The area under consideration for ecosystem restoration encompasses 1,278 acres along the Old South River and the Washington Canal and includes the 380-acre Clancy Island bounded by these waterways and by the Raritan River. Wetland plant communities account for 786 acres (61 percent) of the study area land cover. Uplands account for the remaining 492 acres, of which

234 acres are occupied by residential, commercial, and industrial development. These wetlands and uplands are ecologically degraded. Approximately 527 acres (41 percent of the study area) are dominated by monotypic stands of common reed (*Phragmites australis*). Other wetland communities are scattered around the site in a patchwork of fragmented parcels. The uplands are dominated by low quality scrub-shrub land cover. The current degraded ecological conditions appear to be the result of: (1) construction and maintenance dredging associated with the Federal navigation channels in the South River, Washington Canal, and Raritan River and (2) clay excavation and industrial activity associated with the defunct Sayreville brick industry.

HSDR plan formulation considered a full range of structural and nonstructural measures. Alternative plans that survived the initial screening of alternatives included: (1) a storm surge barrier at the confluences of the South River and Washington Canal with the Raritan River, (2) multiple levee and floodwall configurations, and (3) buy-out of flood-prone properties. Further investigation determined that the storm surge barrier alternative at the confluence of the Washington Canal and the Raritan River was not economically feasible and that there would be significant adverse environmental effects on study area wetlands. It was also determined that acquisition of structures in the floodplains was not economically feasible. In contrast, preliminary analysis indicated that levee and floodwall protection of flood-prone properties in the study area was found to be economically and technically feasible.

More detailed analysis indicated that levees and floodwalls along the eastern and western banks of the lower South River would be economically justified and would have minimal effects on study area wetlands. It was also determined that structural protection of upstream reaches would not be economically justified. A storm surge barrier (different location than previously described), located just downstream (north) of the Veterans Memorial Bridge, was subsequently evaluated in combination with levees/floodwalls in the lower reaches. The barrier was found to be an economically feasible means to protect upstream reaches. In addition, it would: (1) minimize environmental impacts on wetlands, (2) avoid potential HTRW sites upstream, and (3) preclude the need for nonstructural protection in upstream communities by providing comprehensive storm surge protection.

Economic analysis of alternative HSDR plans indicated that the levee/floodwall system with upstream storm surge barrier would result in the greatest net benefits. Subsequent optimization of this plan determined that a 500-year level of protection would provide the greatest net benefits. Consequently, the levee/floodwall system with upstream storm surge barrier providing a 500-year level of protection was designated as the National Economic Development (NED) plan and was selected as the recommended plan. It is anticipated that implementation of the selected HSDR plan will cost approximately $55.2 million with average annual costs estimated at $4.1 million. With average annual benefits estimated at $9.1 million, the average annual net benefits associated with the selected HSDR plan will be approximately $5.0 million. The selected HSDR plan is expected to have a benefit-cost ratio of 2.2 to one.

Even though the selected HSDR plan was specifically designed to avoid and minimize environmental impacts, there were some unavoidable impacts to the natural resources in the South River. Based on a Habitat Evaluation Procedures (HEP) study and an Evaluation of Planned Wetlands (EPW) assessment, the selected NED plan will result in a loss of 1.07 Average Annual Habitat Units (AAHUs) and 20.74 Functional Capacity Units (FCUs). Consequently, to offset these impacts it was determined that the mitigation goal will replace at least 100% of the combined loss of Average Annual Habitat Units (AAHUs) summed across evaluation species and FCUs summed across wetland functions, and at least 50% (agreed upon by HEP Team) of the loss of AAHUs per evaluation species and FCUs lost per function, as a result of implementation of the selected HSDR plan.

To achieve the mitigation goal, a screening analysis was conducted to evaluate the feasibility of improving the available habitat on the proposed levee (*e.g.*, plant shrubs to improve songbird habitat); improving the existing habitats (*e.g.*, increase the density/cover of the vegetation by planting more shrubs and/or herbaceous species); and, converting one habitat/cover type to another more valuable habitat (*e.g.*, convert areas of *Phragmites* to salt marsh or wetland scrub-shrub).

Based on an analysis of the acreages, costs, benefits, and incremental cost/output for each of these plans it was determined that Mitigation Alternative 2 had ecological outputs that were worth its associated costs. The selected mitigation plan will fulfill the mitigation goal and will involve the conversion of 11.1 acres of degraded wetland *Phragmites* and disturbed habitat to a combination of wetland scrub-shrub (7.8 acres) and salt marsh (3.3 acres). This plan is estimated to cost $2,865,300 and is included in the HSDR cost provided above.

Plan formulation for ecosystem restoration considered a wide variety of restoration measures to address opportunities associated with ecosystem restoration along the South River. Restoration goals and objectives were specified early in the plan formulation process. Restoring biodiversity and ecological functioning were established as the restoration goals; the restoration objectives included: restoring habitat for threatened and endangered species, increasing site biodiversity, increasing tidal flushing, reducing *Phragmites*, improving water quality, and stabilizing and protecting desirable wetland habitat. After a preliminary restoration screening process that the assessed ecological benefits and engineering constraints of eleven different alternatives, four priority habitats were chosen for ecological restoration of the study area: low emergent marsh, intertidal mudflat, wetland forest scrub-shrub, and open water (*i.e.*, tidal creeks and tidal ponds). Using different proportions of each habitat, more than 250 potential mathematical combinations of these habitats were evaluated.

These combinations were then applied to four potential restoration areas delineated in the study area using four different scales of restoration for degraded acreage in each area: 25 percent, 50 percent, 75 percent, and 100 percent. Cost effectiveness and incremental cost analysis was applied to the resultant 40,000 potential restoration plans, resulting in identification of eight "best buy" restoration plans for the study area. These plans represent the most efficient means to achieve ecosystem restoration in the study area. Based upon the incremental analysis and the ability of the alternative plans to achieve the restoration planning goals and objectives, one of the Best Buy plans was selected as the National Ecosystem Restoration (NER) plan.

The NER plan will restore 100 percent of the 379 acres of degraded wetlands in the potential restoration areas. The NER plan will restore the following habitats: low emergent marsh (151 acres: 40 percent), wetland forest/scrub-shrub (170 acres: 45 percent; plus an additional 19 acres, or 5 percent, as upland forest/scrub-shrub), mudflat (19 acres: 5 percent), and open water (19 acres: 5 percent). It is expected that implementation of the NER plan will cost approximately $48.1 million with an average annual cost of approximately $3.5 million.

The costs of project implementation for the HSDR features and ecosystem restoration features will be shared by the Federal government and the non-Federal project partner (NJDEP) on a 65 percent / 35 percent basis. All operations and maintenance costs will be borne by the non-Federal project partner. For the HSDR features, the project implementation costs ($55,171,900) will be shared as follows: $35,861,700 Federal and $19,310,200 non-Federal with annual O&M costs of $221,000 (non-Federal). This includes mitigation costs associated with the implementation of these features ($2,959,700 total with $1,923,800 Federal and $1,035,900 non-Federal). For the ecosystem restoration features, the project implementation costs ($48,096,300) will be shared as follows: $31,262,600 Federal and $16,833,700 non-Federal with O&M costs of $79,800 (non-Federal).

Potential beneficial cumulative impacts to migratory waterfowl and songbirds are likely to result from implementation of the selected mitigation and ecosystem restoration plans. These plans, in conjunction with similar projects in the South River watershed, should increase the overall ecological value of the area. Specifically, the mitigation and restoration plans will add large areas of more desirable wetland communities and increase the study area's biodiversity (*i.e.*, improve the areas composition and abundance of plant and animal species).

The construction and maintenance of both the HSDR features and the ecosystem restoration features will not adversely affect any Federally or state listed endangered or threatened species, areas of designated critical habitat, or essential fish habitat. By providing increased cover and opportunities for foraging and nesting, the selected plans will also improve habitat for the Federally listed threatened bald eagle thought to utilize habitats in the general vicinity, and for many of the State of New Jersey endangered and threatened species observed in the restoration area (*e.g.*, black skimmer, northern harrier, peregrine falcon, yellow-crowned night heron, osprey, black-crowned night heron, and American bittern).

In sum, the recommended plan will efficiently reduce hurricane and storm damages along the South River and improve the structure and function of degraded ecosystems in the study area. The non-Federal project partner, NJDEP, has indicated its support for the recommended plan and is willing to enter into a Project Cooperation Agreement with the Federal Government for the implementation of the plan. At this time, there are no known major areas of controversy or unresolved issues regarding the study and selected plan among agencies or the public interest.

PERTINENT DATA

DESCRIPTION

The identified plan provides for hurricane and storm damage reduction and ecosystem restoration along the South River, Raritan River Basin.

LOCATION

Middlesex County, New Jersey: Borough of Sayreville, Borough of South River, the Township of Old Bridge, and the Historic Village of Old Bridge (located within the Township of East Brunswick.

HURRICANE AND STORM DAMAGE REDUCTION

Level of Protection (storm with probability of exceedance)	0.002 (500-year event)
Levee/ Floodwall	
Levee Length	10,712 feet
Floodwall Length	1,655 feet
Top Elevation	21.5 feet NGVD
Levee Crest Width	10 feet
Levee Slopes	2.3:1
Fill Volume	304,400 cubic yards
River Segment	
Storm Surge Barrier Length	320 feet
Clear Opening	80 feet
Top Elevation	21.5 feet NGVD
Interior Drainage	
East Segment	
Facility	Minimum Facilities with 100 cubic feet per second (cfs) diversion structure in upper drainage area
Gravity Outlets (number and size)	930-foot, 60-inch diameter diversion pipe; 5@36" diameter (dia.) 3@60" dia. 1@18"dia.
West Segment	
Facility	Minimum Facilities 2@24" dia. 9@60" dia.
Main Channel	
Pump Station Capacity	1,200cfs
Gravity Outlets (number and size)	5@10'x10' box culverts 4@60" dia.

REAL ESTATE REQUIREMENTS

Lands and Damages: Hurricane and Storm Damage Reduction Features

Permanent Easement		25.30 acres
Temporary Easement (for construction)		9.70 acres
Severance Damages		55.00 acres
Fee Simple Purchase (for mitigation)		11.10 acres
	Subtotal	101.10 acres

Lands and Damages: Ecosystem Restoration Features

Fee Simple Purchase		435.55 acres
	Total	536.65 acres

ECOSYSTEM RESTORATION

Area Restored	379.3 acres
Habitat Restored/Created	
Wetland forest/scrub-shrub	170.7 acres (45 percent)
Low emergent marsh	151.7 acres (40 percent)
Mudflat	19.0 acres (5 percent)
Open water	19.0 acres (5 percent)
Upland forest/scrub-shrub	19.1 acres (5 percent)

HURRICANE AND STORM DAMAGE REDUCTION MITIGATION

Conversions:

Wetland *Phragmites* to:	3.3 acres Salt Marsh; 1.7 acres Wetland Scrub-Shrub
Upland Disturbed to:	6.1 acres Wetland Scrub-Shrub
	Total: 11.1 acres

ECONOMICS

Hurricane and Storm Damage Reduction

Initial Project Cost (October 2002 price level)	$55,861,700
Mitigation Cost (included in Initial HSDR Project Cost)	$2,959,700
Annual Initial Cost (discounted at 5.875 % over a 50-year period)	$3,439,400
Annual Interest During Construction (IDC) Costs	$478,200
Annual Operations and Maintenance (O&M) Costs	$221,000
Total Annual Cost (discounted at 5.875 % over a 50-year period)	$4,138,600
Average Annual Benefits (discounted at 5.875 % over a 50-year period)	$9,161,400
Average Annual Net Benefits	$5,022,800
Benefit-to-Cost Ratio	2.2

Ecosystem Restoration	
Initial Project Cost	$48,096,300
Annual Initial Cost (Discounted at 5.875 % over a 50-year period)	$2,998,300
Annual IDC Costs	$407,500
Annual O&M Costs	$79,800
Total Annual Cost (discounted at 5.875 % over a 50-year period)	$3,485,600
Total Project	
Initial Project Cost	$103,268,200
Annual Initial Cost (Discounted at 5.875 % over a 50-year period)	$6,437,700
Annual IDC Cost	$885,700
Annual O&M Costs	$300,800
Total Annual Cost (Discounted at 5.875 % over a 50-year period)	$7,624,200

COST APPORTIONMENT

		Federal Share (65%)	Non-Federal Share (35%)	Total
HSDR Features	Initial Project Costs	$35,861,700	$19,310,200	$55,171,900
	Real Estate Costs*		$3,413,800	
	Cash Contribution	$35,861,700	$15,353,600	
	O&M Costs		$221,000	$221,000
Ecosystem Restoration Features	Initial Project Costs	$31,262,600	$16,833,700	$48,096,300
	Real Estate Costs*		$6,008,800	
	Cash Contribution	$31,262,600	$10,824,900	
	O&M Costs		$79,800	$79,800
Total Project	Initial Project Costs	$67,124,300	$36,143,900	$103,268,200
	Real Estate Costs*		$9,422,600	
	Cash Contribution	$67,124,300	$26,721,300	
	O&M Costs		$300,800	$300,800

* Applicable to required non-Federal cash contribution.

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Economic analysis of alternative HSDR plans indicated that the levee/floodwall system with upstream storm surge barrier would result in the greatest net benefits. Subsequent optimization of this plan determined that a 500-year level of protection would provide the greatest net benefits. Consequently, the levee/floodwall system with upstream storm surge barrier providing a 500-year level of protection was designated as the National Economic Development (NED) plan and was selected as the recommended plan. It is anticipated that implementation of the selected HSDR plan will cost approximately $53.3 million with average annual costs estimated at $4.2 million. With average annual benefits estimated at $9.1 million, the average annual net benefits associated with the selected HSDR plan will be approximately $4.9 million. The selected HSDR plan is expected to have a benefit-cost ratio of 2.2 to one.

Even though the selected HSDR plan was specifically designed to avoid and minimize environmental impacts, there were some unavoidable impacts to the natural resources in the South River. Based on a Habitat Evaluation Procedures (HEP) study and an Evaluation of Planned Wetlands (EPW) assessment, the selected NED plan will result in a loss of 1.07 Average Annual Habitat Units (AAHUs) and 20.74 Functional Capacity Units (FCUs). Consequently, to offset these impacts it was determined that the mitigation goal will replace at least 100% of the combined loss of Average Annual Habitat Units (AAHUs) summed across evaluation species and FCUs summed across wetland functions, and at least 50% (agreed upon by HEP Team) of the loss of AAHUs per evaluation species and FCUs lost per function, as a result of implementation of the selected HSDR plan.

To achieve the mitigation goal, a screening analysis was conducted to evaluate the feasibility of improving the available habitat on the proposed levee (*e.g.*, plant shrubs to improve songbird habitat); improving the existing habitats (*e.g.*, increase the density/cover of the vegetation by planting more shrubs and/or herbaceous species); and, converting one habitat/cover type to another more valuable habitat (*e.g.*, convert areas of *Phragmites* to salt marsh or wetland scrub-shrub).

Based on an analysis of the acreages, costs, benefits, and incremental cost/output for each of these plans it was determined that Mitigation Alternative 2 had ecological outputs that were worth its associated costs. The selected mitigation plan will fulfill the mitigation goal and will involve the conversion of 11.1 acres of degraded wetland *Phragmites* and disturbed habitat to a combination of wetland scrub-shrub (7.8 acres) and salt marsh (3.3 acres). This plan is estimated to cost $2,865,300 and is included in the HSDR cost provided above.

Plan formulation for ecosystem restoration considered a wide variety of restoration measures to address opportunities associated with ecosystem restoration along the South River. Restoration goals and objectives were specified early in the plan formulation process. Restoring biodiversity and ecological functioning were established as the restoration goals; the restoration objectives included: restoring habitat for threatened and endangered species, increasing site biodiversity, increasing tidal flushing, reducing *Phragmites*, improving water quality, and stabilizing and protecting desirable wetland habitat. After a preliminary restoration screening process that the assessed ecological benefits and engineering constraints of eleven different alternatives, four priority habitats were chosen for ecological restoration of the study area: low emergent marsh, intertidal mudflat, wetland forest scrub-shrub, and open water (*i.e.*, tidal creeks and tidal ponds). Using different proportions of each habitat, more than 250 potential mathematical combinations of these habitats were evaluated.

These combinations were then applied to four potential restoration areas delineated in the study area using four different scales of restoration for degraded acreage in each area: 25 percent, 50 percent, 75 percent, and 100 percent. Cost effectiveness and incremental cost analysis was applied to the resultant 40,000 potential restoration plans, resulting in identification of eight "best buy" restoration plans for the study area. These plans represent the most efficient means to achieve ecosystem restoration in the study area. Based upon the incremental analysis and the ability of the alternative plans to achieve the restoration planning goals and objectives, one of the Best Buy plans was selected as the National Ecosystem Restoration (NER) plan.

The NER plan will restore 100 percent of the 379 acres of degraded wetlands in the potential restoration areas. The NER plan will restore the following habitats: low emergent marsh (151 acres: 40 percent), wetland forest/scrub-shrub (170 acres: 45 percent; plus an additional 19 acres, or 5 percent, as upland forest/scrub-shrub), mudflat (19 acres: 5 percent), and open water (19 acres: 5 percent). It is expected that implementation of the NER plan will cost approximately $46.5 million with an average annual cost of approximately $3.5 million.

The costs of project implementation for the HSDR features and ecosystem restoration features will be shared by the Federal government and the non-Federal project partner (NJDEP) on a 65 percent / 35 percent basis. All operations and maintenance costs will be borne by the non-Federal project partner. For the HSDR features, the project implementation costs ($53,325,100) will be shared as follows: $34,661,300 Federal and $18,663,800 non-Federal with annual O&M costs of $221,500 (non-Federal). This includes mitigation costs associated with the implementation of these features ($2,865,300 total with $1,862,400 Federal and $1,002,900 non-Federal). For the ecosystem restoration features, the project implementation costs ($46,499,300) will be shared as follows: $30,224,500 Federal and $16,274,800 non-Federal with O&M costs of $80,000 (non-Federal).

Potential beneficial cumulative impacts to migratory waterfowl and songbirds are likely to result from implementation of the selected mitigation and ecosystem restoration plans. These plans, in conjunction with similar projects in the South River watershed, should increase the overall ecological value of the area. Specifically, the mitigation and restoration plans will add large areas of more desirable wetland communities and increase the study area's biodiversity (*i.e.*, improve the areas composition and abundance of plant and animal species).

The construction and maintenance of both the HSDR features and the ecosystem restoration features will not adversely affect any Federally or state listed endangered or threatened species, areas of designated critical habitat, or essential fish habitat. By providing increased cover and opportunities for foraging and nesting, the selected plans will also improve habitat for the Federally listed threatened bald eagle thought to utilize habitats in the general vicinity, and for many of the State of New Jersey endangered and threatened species observed in the restoration area (*e.g.*, black skimmer, northern harrier, peregrine falcon, yellow-crowned night heron, osprey, black-crowned night heron, and American bittern).

In sum, the recommended plan will efficiently reduce hurricane and storm damages along the South River and improve the structure and function of degraded ecosystems in the study area. The non-Federal project partner, NJDEP, has indicated its support for the recommended plan and is willing to enter into a Project Cooperation Agreement with the Federal Government for the implementation of the plan. At this time, there are no known major areas of controversy or unresolved issues regarding the study and selected plan among agencies or the public interest.

PERTINENT DATA

DESCRIPTION

The identified plan provides for hurricane and storm damage reduction and ecosystem restoration along the South River, Raritan River Basin.

LOCATION

Middlesex County, New Jersey: Borough of Sayreville, Borough of South River, the Township of Old Bridge, and the Historic Village of Old Bridge (located within the Township of East Brunswick.

HURRICANE AND STORM DAMAGE REDUCTION

Level of Protection (storm with probability of exceedance)	0.002 (500-year event)
Levee/ Floodwall	
Levee Length	10,712 feet
Floodwall Length	1,655 feet
Top Elevation	21.5 feet NGVD
Levee Crest Width	10 feet
Levee Slopes	2.3:1
Fill Volume	304,400 cubic yards
River Segment	
Storm Surge Barrier Length	320 feet
Clear Opening	80 feet
Top Elevation	21.5 feet NGVD
Interior Drainage	
East Segment	
Facility	Minimum Facilities with 100 cubic feet per second (cfs) diversion structure in upper drainage area
Gravity Outlets (number and size)	930-foot, 60-inch diameter diversion pipe; 5@36" diameter (dia.) 3@60" dia. 1@18"dia.
West Segment	
Facility	Minimum Facilities 2@24" dia. 9@60" dia.
Main Channel	
Pump Station Capacity	1,200cfs
Gravity Outlets (number and size)	5@10'x10' box culverts 4@60" dia.

REAL ESTATE REQUIREMENTS

Lands and Damages: Hurricane and Storm Damage Reduction Features

Permanent Easement		25.30 acres
Temporary Easement (for construction)		9.70 acres
Severance Damages		55.00 acres
Fee Simple Purchase (for mitigation)		11.10 acres
	Subtotal	101.10 acres

Lands and Damages: Ecosystem Restoration Features

Fee Simple Purchase		435.55 acres
	Total	536.65 acres

ECOSYSTEM RESTORATION

Area Restored	379.3 acres
Habitat Restored/Created	
Wetland forest/scrub-shrub	170.7 acres (45 percent)
Low emergent marsh	151.7 acres (40 percent)
Mudflat	19.0 acres (5 percent)
Open water	19.0 acres (5 percent)
Upland forest/scrub-shrub	19.1 acres (5 percent)

HURRICANE AND STORM DAMAGE REDUCTION MITIGATION

Conversions:	
Wetland *Phragmites* to:	3.3 acres Salt Marsh; 1.7 acres Wetland Scrub-Shrub
Upland Disturbed to:	6.1 acres Wetland Scrub-Shrub
	Total: 11.1 acres

ECONOMICS

Hurricane and Storm Damage Reduction

Initial Project Cost (October 2001 price level)	$53,325,100
Mitigation Cost (included in Initial HSDR Project Cost)	$2,865,300
Annual Initial Cost (discounted at 6.125 % over a 50-year period)	$3,442,300
Annual Interest During Construction (IDC) Costs	$499,800
Annual Operations and Maintenance (O&M) Costs	$221,500
Total Annual Cost (discounted at 6.125 % over a 50-year period)	$4,163,600
Average Annual Benefits (discounted at 6.125% over a 50-year period)	$9,092,400
Average Annual Net Benefits	$4,928,800
Benefit-to-Cost Ratio	2.2

Ecosystem Restoration	
Initial Project Cost	$46,499,300
Annual Initial Cost (Discounted at 6.125% over a 50-year period)	$3,001,700
Annual IDC Costs	$426,000
Annual O&M Costs	$80,000
Total Annual Cost (discounted at 6.125 % over a 50-year period)	$3,507,700
Total Project	
Initial Project Cost	$99,824,400
Annual Initial Cost (Discounted at 6.125% over a 50-year period)	$6,444,000
Annual IDC Cost	$925,800
Annual O&M Costs	$301,500
Total Annual Cost (Discounted at 6.125% over a 50-year period)	$7,671,300

COST APPORTIONMENT

		Federal Share (65%)	Non-Federal Share (35%)	Total
HSDR Features	Initial Project Costs	$34,661,300	$18,663,800	$53,325,100
	Real Estate Costs*		$3,310,200	
	Cash Contribution	$34,661,300	$15,353,600	
	O&M Costs		$221,500	$221,500
Ecosystem Restoration Features	Initial Project Costs	$30,224,500	$16,274,800	$46,499,300
	Real Estate Costs*		$5,772,800	
	Cash Contribution	$30,224,500	$10,502,000	
	O&M Costs		$80,000	$80,000
Total Project	Initial Project Costs	$64,885,900	$34,938,500	$99,824,400
	Real Estate Costs*		$9,083,000	
	Cash Contribution	$64,885,900	$22,855,500	
	O&M Costs		$301,500	$301,500

* Applicable to required non-Federal cash contribution.

SOUTH RIVER, RARITAN RIVER BASIN HURRICANE AND STORM DAMAGE REDUCTION AND ECOSYSTEM RESTORATION

INTEGRATED FEASIBILITY REPORT & ENVIRONMENTAL IMPACT STATEMENT

1. INTRODUCTION

This integrated feasibility report and environmental impact statement (FR/EIS) investigates the feasibility of alternative plans to address problems and opportunities associated with hurricane and storm damage reduction (HSDR) and ecosystem restoration along the South River in Middlesex County, New Jersey. This FR/EIS has been prepared by the New York District of the U.S. Army Corps of Engineers (Corps) under the General Investigations Program of the Corps. The New Jersey Department of Environmental Protection (NJDEP) is the non-Federal partner for this study and for any subsequent project implementation.

* 1.1 Study Authority

The South River Multipurpose Feasibility Study was authorized by resolution of the U.S. House of Representatives Committee on Public Works and Transportation and adopted 13 May 1993. The resolution states that:

> *Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, that, the Secretary of the Army, acting through the Chief of Engineers, is requested to review the report of the Chief of Engineers, titled Basinwide Water Resources Development Report on the Raritan River Basin, New Jersey, published as House Document 53, Seventy-first Congress, Second Session, and other pertinent reports, to determine whether modifications of the recommendations contained therein are advisable at the present time in the interest of flood control and related purposes on the South River, New Jersey.*

Under this study authorization, a reconnaissance report was completed in May 1995. The reconnaissance study concluded that there is Federal interest in addressing problems and opportunities of HSDR and ecosystem restoration along the South River. Based on preliminary analysis, the reconnaissance report identified at least one project that would be in the Federal interest. It recommended 100-year level of HSDR for the Boroughs of South River and Sayreville using levees along the South River and a closure structure at the railroad bridge that connects the two Boroughs. In addition, the reconnaissance study recommended ecosystem restoration of 250 acres of degraded wetlands along the South River and Washington Canal north of the two Boroughs. On the basis of these findings, the Corps and the State of New Jersey entered into an agreement to perform a cost-shared multipurpose feasibility study of the South River.

1.2 Study Purpose and Need

The purpose of the South River study is to evaluate the feasibility of Federal participation in implementing solutions to problems and opportunities of HSDR and ecosystem restoration along this waterway. More specifically, the study:

- Identifies flooding problems associated with hurricanes and other storms along the South River, particularly at the Borough of South River and the Borough of Sayreville,
- Identifies opportunities for restoration of degraded ecosystems in the South River basin,
- Evaluates the technical, economic, environmental, and institutional feasibility of Federal action to address flooding problems associated with hurricanes and other storms and ecosystem restoration opportunities, and
- Determines if there is local support for implementation of the recommended plan.

As part of the plan formulation process, reconnaissance phase plans were re-evaluated, and other potential HSDR and ecosystem restoration measures were formulated in order to evaluate and select those plans that maximize contributions to National Economic Development (NED) and to National Ecosystem Restoration (NER). In this document, the NED plan and the NER plan have been developed to a level of engineering, economic, and environmental detail sufficient to proceed to the Preconstruction Engineering and Design (PED) phase, pending recommendation by the New York District, approval by the North Atlantic Division Commander, support by Corps Headquarters and the Assistant Secretary of the Army (Civil Works), and authorization for construction by Congress.

1.3 Study Scope

This FR/EIS investigates the feasibility of Federal action to address flooding problems associated with hurricanes and other storms and ecosystem restoration opportunities along the South River, consistent with Federal water resources policies and practices, including *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G, 1983), the Corps *Planning Guidance Notebook* (ER-1105-2-100, 22 April 2000), and *Procedures for Implementing NEPA* (ER 200-2-2, 4 March 1988). Throughout this investigation, the Corps has worked closely with the non-Federal project partner, NJDEP, to (1) describe the range of potential Federal participation in HSDR and ecosystem restoration along the South River and (2) explain the roles and responsibilities of the Corps and the non-Federal project partner in project planning and implementation.

As an integrated report, this FR/EIS also fully complies with requirements of the National Environmental Policy Act (NEPA) of 1969, as amended (42 U.S.C. 4321 et seq.). The integration of the NEPA documentation with the feasibility report is consistent with NEPA guidance to combine required documents with other documents, when practicable.

1.4 Report Organization

This document has been organized in a manner consistent with both Corps requirements for feasibility reports and with NEPA requirements. The integrated report reflects an integrated planning process where positive environmental effects associated with proposed restoration action have been maximized and adverse environmental effects associated with HSDR have been avoided, minimized, and mitigated.

The main report summarizes the results of feasibility studies and contains sections appropriate for EIS documentation. Technical appendices, which present details of technical investigations conducted during the feasibility study, are attached. Some section headings are hyphenated to indicate consistency with requirements of feasibility studies and NEPA documents. When the section heading is preceded by an asterisk (*), the section is required to comply with NEPA.

* 1.5 Study Area

The South River watershed is located within the lower Raritan River Basin in Middlesex County, New Jersey (see Figure 1). The South River is the first major tributary of the Raritan River, located approximately 8.3 miles upstream of the Raritan River's mouth at Raritan Bay. The South River is formed by the confluence of the Matchaponix and Manalapan Brooks, just above Duhernal Lake, and flows northward from Duhernal Lake a distance of approximately 7 miles, at which point it splits into two branches, the Old South River and the Washington Canal. Both branches flow northward into the Raritan River. The South River is tidally controlled from its mouth upstream to Duhernal Lake Dam. Fluvial conditions prevail above the dam.

Early in the feasibility phase, scoping and public meetings and site visits were held with NJDEP, County and local governments, and area residents to determine the extent of flooding problems in the upstream reaches. As anticipated during the reconnaissance investigation, it was determined from this coordination and initial evaluation that there are no widespread flooding problems in the South River watershed upstream of the Duhernal Lake dam, located in the Towns of Spotswood, Jamesburg, and Helmetta. Consequently, subsequent investigations focused on river reaches below the dam, specifically flood-prone areas within the Boroughs of South River and Sayreville, the Township of Old Bridge, and the Historic Village of Old Bridge (located within the Township of East Brunswick). In this document, the term "study area" refers to flood-prone areas downstream of Duhernal Lake dam, unless otherwise noted. Downstream river reaches encompass virtually all flood-prone structures in the watershed and areas of greatest ecological degradation (and greatest potential for ecosystem restoration). The study area includes the South River to the west, the Washington Canal to the east, and the 380-acre Clancy Island bounded by these waterways and by the Raritan River.

1.6 National Environmental Policy Act Requirements

In the NEPA statutory language, Congress recognized the responsibility of each generation to prepare for succeeding generations and the right of all Americans to a safe, healthful, and productive life and aesthetically and culturally pleasing surroundings. The Act requires that Federal agencies utilize a systematic interdisciplinary approach to insure the integrated use of the natural and social sciences and environmental design in planning and decision-making when the

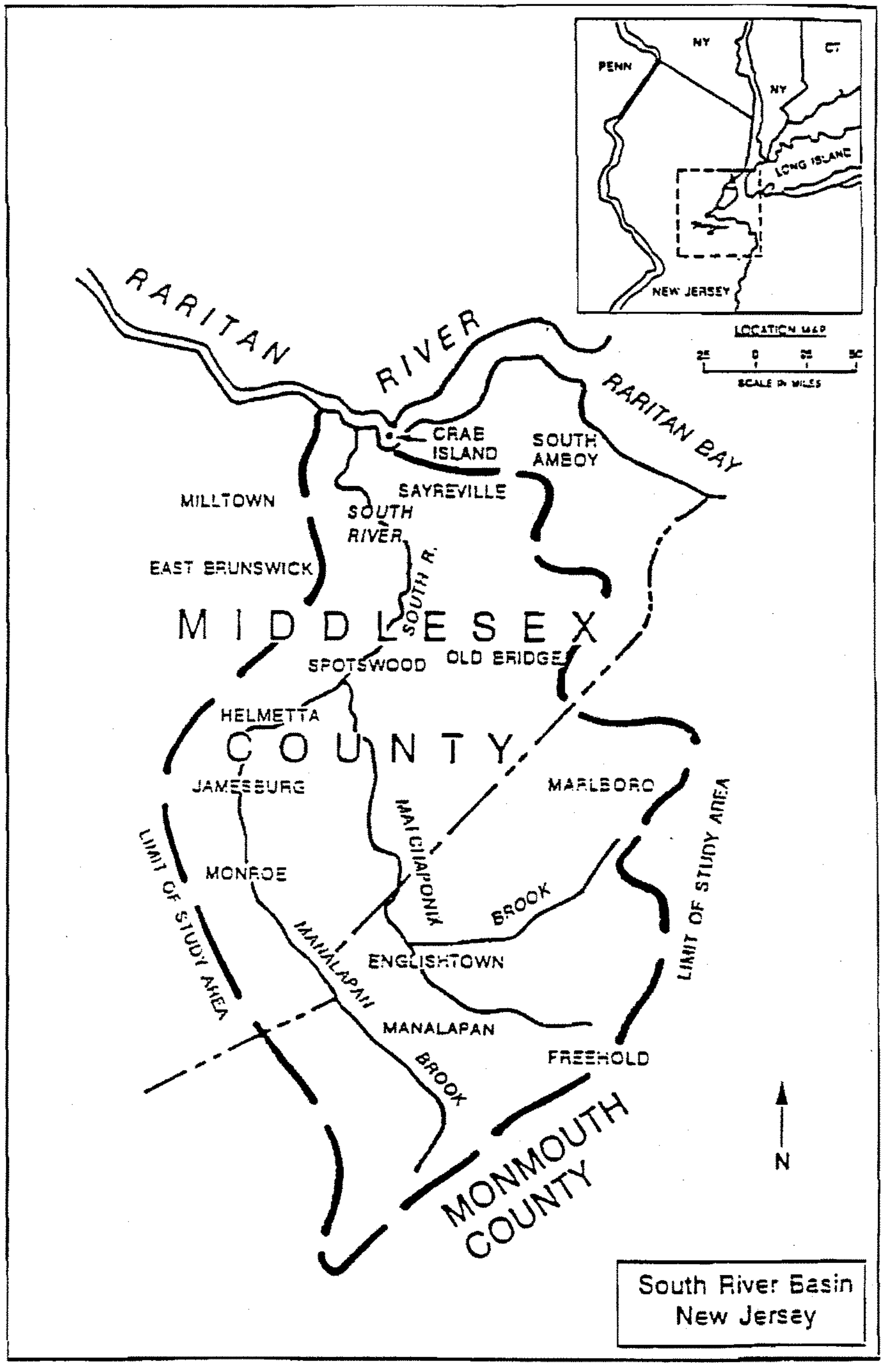

FIGURE 1
SOUTH RIVER BASIN

action may have a significant impact on the environment. Section 102(2) of the Act contains action-forcing provisions to ensure that Federal agencies prepare a detailed EIS, or other NEPA-compliance document, on the effects of a proposed Federal action.

Council on Environmental Quality (CEQ) regulations [40 CFR 1500-1508] require that EISs provide full and fair discussion of significant environmental impacts and inform decisionmakers and the public of the reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the environment. The regulations specify that EISs should be clear and concise and should be supported by evidence that the agency has made the necessary environmental analyses. The analyses should be analytic, rather than encyclopedic.

As required in Sec 102 of the Act, proposals for major Federal actions significantly affecting the quality of the human environment shall include a detailed statement on:

- The environmental impact of the proposed action,
- Any adverse environmental effects that cannot be avoided if the action is implemented,
- Alternatives to the proposed action,
- The relationship between short-term uses of the environment and long-term productivity, and
- Any irreversible and irretrievable commitments of resources that would be involved if the proposed action is implemented.

This integrated FR/EIS is fully consistent with NEPA statutory requirements. The integrated report reflects an integrated planning process, which maximizes beneficial impacts on the environment resulting from ecosystem restoration and avoids, minimizes, and mitigates adverse project effects associated with HSDR.

1.6.1 Areas of Controversy

At this time, there are no known major areas of controversy regarding the study and selected plan among agencies or the public interest.

1.6.2 Unresolved Issues

The General Conformity provisions relating to the Clean Air Act require a conformity demonstration for each pollutant where the total direct and indirect emissions from the Federal action exceed the corresponding de minimis level. Detailed information on the construction activities (type and size of equipment, construction schedule, etc.) is not currently available. ThereforPreliminary emission estimates have been made based on emission estimates generated from similar activities for other projects.

Based on the preliminary estimates, total direct and indirect NOx emissions appear to exceed the de minimis threshold of 25 tons per year. The preliminary projected total direct and indirect VOC and CO emissions from the proposed project are estimated to be below the de minimis threshold levels. In close consultation with the United States Environmental Protection Agency and the New Jersey Department of Environmental Protection, the Corps will conduct a detailed, comprehensive quantitative analysis in the next project phase (Preconstruction, Engineering and Design, in Fall 2002) to more precisely quantify all emissions from the South River project and to determine conformity accordingly. Upon completion of the revised emission estimates, a Draft General Conformity Determination will be prepared and undergo formal agency and public review. Results and conclusions of this process will be part of the South River project's Record of Decision, including, as necessary, detailed analyses of mitigation alternatives, such as emission offsets, emission credits, emission reduction technologies, and operational modifications to reduce emissions.

1.7 Study Process

The New York District is responsible for conducting the overall feasibility study in cooperation with the non-Federal project partner, NJDEP. The feasibility study and eventual implementation of the project continue to receive strong support from NJDEP and from local governments, including the Borough of South River and the Borough of Sayreville (see Appendix F). These non-Federal interests are committed to working with the Corps to address flooding problems associated with hurricanes and other storms and opportunities for ecosystem restoration along the South River.

As will be explained in detail in this document, plan formulation for ecosystem restoration and for mitigation of adverse effects of HSDR features of this project were conducted in close coordination with Federal and State of New Jersey regulatory and resource agencies, including: U.S. Fish and Wildlife Service, National Marine Fisheries Service, and NJDEP.

As part of scoping activities, a public scoping meeting was held to invite comment on the range of issues to be examined in the EIS in accordance with the CEQ Regulations (40 CFR 1500-1508) and the U.S. Army Corps of Engineers Regulation (ER-200-2-2). The purpose of the scoping process is to 1) formally establish dialog and coordination with local, County, State, and Federal agencies; and, 2) identify issues and concerns that may be associated with proposed actions. Specifically, the preliminary information provided to resource agencies and the public during scoping presents the potential solutions for HSDR and ecosystem restoration; discusses the existing biological and cultural resources located within the study area; preliminarily identifies the direct, indirect, and cumulative impacts of the Project; and, identifies the local, County, and State policies and permits applicable to proposed actions.

1.8 Existing Projects

As illustrated in Figure 2, there are two Federal navigation projects in the study area: (1) the Washington Canal and South River and (2) the Raritan River. In addition, there is a State of New Jersey environmental mitigation project located in the study area. These projects are described below.

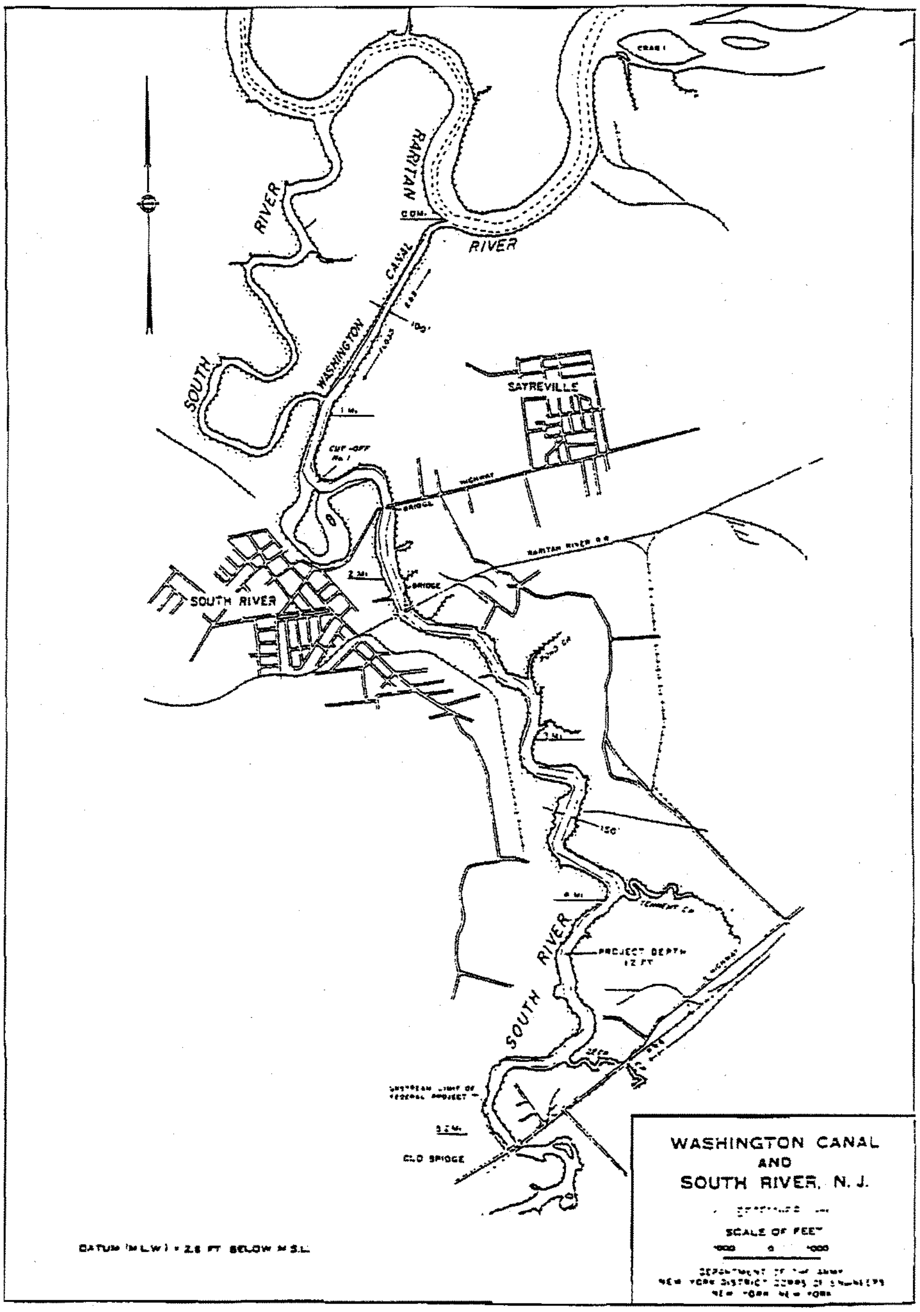

FIGURE 2
WASHINGTON CANAL & SOUTH RIVER NAVIGATION PROJECT

1.8.1 The Washington Canal and South River

As illustrated in Figure 2, this navigation project connects communities along the South River with the Raritan River. Private interests constructed the Washington Canal in the 1830's by widening and deepening a large pre-existing tidal channel. The Canal and South River navigation channel were Federalized in 1871. The authorized project is a 12-foot deep, 100-foot wide channel in the Washington Canal for a distance of 0.8 miles upstream of the Raritan River and then a 12-foot deep, 150-foot wide channel in the South River to Old Bridge. The total length of the Canal is 5.2 miles. In 1929, when the last improvements to the project were authorized, the channel was used to transport brick, hollow tile, sand, clay, crushed stone, and coal to/from New York Harbor.

The last Corps involvement was for maintenance dredging in the early 1940s. The 1941 contract documents specified that dredged material should be transported and disposed of in designated disposal areas with disposal of dredged material to aid the improvement or betterment of the land. Historically, such disposal sites were in close proximity of the actual dredging location, often within open shallow water or wetlands.

Currently, small recreation vessels are the sole users of the Washington Canal and South River; there is no commercial traffic. As will be included in problem identification discussions, degradation of the South River ecosystem can be partially attributed to construction and operation of navigation channels in these waterways.

1.8.2 The Raritan River

This Federal navigation project along the Raritan River main stem includes channel depths up to 25-feet deep with various associated widths, turning basins and navigation features from the Great Beds light at the turn in the New York and New Jersey Channel to the Raritan Arsenal. The channel continues at a 15-foot depth to the Washington Canal, then at a 10-foot depth upstream beyond New Brunswick to the terminus of the Delaware and Raritan Canal.

1.8.3 NJDOT Wetland Mitigation Project Along Washington Canal

The New Jersey Department of Transportation (NJDOT) is currently completing restoration of approximately 20 acres of salt marsh in an area northwest of the Route 535 bridge (South River/Sayreville) along the eastern edge of the Washington Canal. This project, which mitigates adverse environmental effects of local highway construction, is establishing a wetland community dominated by salt marsh species with an upland scrub-shrub island in its center. This area was previously dominated by a monotypic stand of *Phragmites*. *Phragmites* on the site was removed, the site was regraded, and native wetland vegetation was planted. This project reinforces the ecosystem restoration potential of the study area and could compliment Federal restoration and mitigation actions.

1.9 Prior Studies and Reports

The South River Basin has been subjected to frequent and severe flooding from hurricanes and other storms and has been the subject of various studies. Reports relevant to this study have been compiled, reviewed, and utilized as appropriate. The following is a listing and description of those reports:

- Basinwide Water Resource Development Report on the Raritan River Basin. House Document 53, Seventy-First Congress, Second Session. This report, published in the early 1930's, focused on navigation and flood control for the entire Raritan River Basin.

- Delineation of Flood Hazard Areas, Raritan River Basin, Flood Hazard Report #18, South River and Manalapan Brook, NJDEP, Division of Water Resources, October 1972. This report delineated the floodplain in the South River and its tributary, Manalapan Brook.

- Delineation of Flood Hazard Areas, Raritan River Basin, Flood Hazard Report #17, Matchaponix Brook System, NJDEP, Division of Water Resources, March 1973. This report delineated the floodplain of the Matchaponix Brook, which is a tributary to the South River.

- Survey Report for Flood Control, Raritan River Basin, New Jersey, Final Report, New York District, USACE, March 1985. This report served as a comprehensive study of the Raritan River Basin and recommended several additional studies. Although the South River was studied, none of the proposed improvements were determined to be economically feasible at that time. Since that time, Middlesex County has experienced significant economic development.

- South River, Raritan River Basin, New Jersey, Multi-Purpose Study, Final Reconnaissance Report, Department of the Army, Corps of Engineers, New York District, May 1995. The South River Reconnaissance Study determined that there is Federal interest in HSDR and ecosystem restoration along the South River. The reconnaissance report evaluated a variety of structural and nonstructural HSDR plans for the Boroughs of South River and Sayreville. This preliminary investigation concluded that a 100-year level of structural protection would be technically and economically feasible. The recommended plan included levees at Sayreville (9,500 feet) and at South River (9,000 feet), a railroad closure structure, and road raisings. The ecosystem restoration component of the recommended plan consisted of saltmarsh restoration along the Washington Canal. The restoration action would replace habitat lost in part due to Federal involvement in dredging the Washington Canal. It would involve replacement of 250 acres of low-quality, low-diversity *Phragmites australis* with high-quality wetland vegetation, such as *Spartina alterniflora* and associated community species. Stream bank stabilization would be included to protect the restored habitat. Excavation of the marsh to create meandering channels, open water, and ecotones would be included to promote diversity and fish spawning/nursery habitat.

2. PRE-DEVELOPMENT CONDITIONS

Historic records and maps indicate that, pre-1850, the study area was predominately forested, with the exception of areas immediately adjacent to the original South River channel and the perimeter of Clancy Island. There is a great deal of evidence suggesting that much of the study area was heavily disturbed in the past. Local historical records suggest that significant physical modification of the Washington Canal area and Clancy Island occurred in association with the brick industry in Sayreville which arose following discovery of significant clay deposits in the area.

The brick industry in Sayreville thrived from the early 1800s through the early 1900s and lasted until the late 1960s. Maps of the area in 1876 suggest that Clancy Island and much of the east bank of the Canal were forested uplands. Much of the area east of the Canal was occupied by factories, drying yards, and worker housing of multiple brick manufacturers. Significant portions of the east bank of the Canal and of Clancy Island were excavated in the 1800s to extract clay deposits.

During early exploration of the area in 1720, trip reports noted a large tidal channel of significant enough size to allow for passage of large vessels along the eastern perimeter of the study area island. This large tidal channel, now known as the Washington Canal, was dredged by the U.S. government in 1870 and used primarily for transportation of goods such as brick, tile, sand, clay, and coal products into and out of New York Harbor. Maintenance dredging of the canal and South River channel last occurred in the early 1940s. Dredged material disposal sites are evident in some upland areas along the channels.

Some areas in Sayreville that were previously occupied by the brick works were converted to residential land uses. Clancy Island and much of the excavated area on the east bank of the Canal have been allowed to revert to vegetation. These areas are currently characterized by low-quality wetlands, dominated by *Phragmites australis*, and scrub-shrub uplands. Consequently, much of the ecological degradation of Clancy Island and of the east bank of the Canal can be traced to the brick industry, through: (1) construction and maintenance of the Washington Canal, (2) clay excavation, and (3) deposition of waste materials from brick manufacturing. These disturbances and those associated with nearby navigation channels appear to be the primary causes of degraded conditions on the island and along the east bank of the Canal.

Past disturbance makes it infeasible for any restoration action to return the site to its pre-development condition. However, as will be evident, there is significant opportunity to return the site to a more natural condition.

* 3. AFFECTED ENVIRONMENT / EXISTING CONDITIONS

The following discussions describe existing conditions in the study area, including physical setting, water resources, socioeconomic conditions, and biological resources. The profile of existing conditions leads to two conclusions about downstream reaches of the South River: (1) large portions of the Boroughs of South River and Sayreville have been and continue to be subject to flooding from the South River and (2) there has been significant ecological degradation along the South River and the Washington Canal.

In order to provide a detailed characterization of the South River study area and to better understand the physical and chemical parameters associated with the area, the Corps conducted a number of ecological studies/investigations. These studies include:

- *South River, New Jersey, Wetland Delineation Report*, November 1999. This report documents the occurrence and location of the upland/wetland boundaries located in the South River study area. The survey was conducted in accordance with New Jersey State requirements. Approximately 449 acres of wetland habitat was delineated during this investigation.

- *South River, New Jersey, Vegetation Mapping and Biobenchmarking Report*, December 1999. The objectives of this investigation were to provide a detailed characterization of the plant communities present in the South River area and to establish critical elevation data, or biological benchmarks, for the elevational limits of the existing vegetation communities.

- *South River, New Jersey, Restoration Screening Report*, April 2000. This report identifies and evaluates several alternatives designed to successfully restore and/or diversify the existing ecosystems within the South River watershed. The alternatives were established through a multi-step process that included identification of the Study's project goals and objectives; development of restoration alternatives; evaluation of each alternative according to its potential ecological benefits, engineering and environmental constraints, and its likelihood of success; and, selection of the most desirable alternatives.

- *South River, New Jersey, Wildlife Survey Report*, May 2000. This study evaluated and documented the presence/absence of most species of birds and mammals using the South River area during the breeding season and winter/dispersal season.

- *South River, New Jersey, Fish Survey Report*, July 2000. The purpose of this study was to characterize the fish community within the South River. A sampling plan was designed to qualitatively assess the existing fish species composition and relative abundance during the summer months. In addition, the report characterizes the distribution and habitat use of fish species within the South River study area.

- *Literature Review: Success of Conversion of Phragmites australis to Other Wetland Plant Communities*, October 2000. This literature review assessed the feasibility of converting plant communities dominated by *Phragmites australis* to more desirable wetland plant communities such as salt marsh, wetland scrub-shrub, and tidal creeks/ponds.

- *South River, New Jersey, Essential Fish Habitat Assessment*, October 2000. This assessment provides a description of the existing fish habitat, a listing of EFH-designated species in the study area, a summary of evidence relating to the presence/absence of EFH-designated species in the study area, and an analysis of potential adverse impacts and benefits of the proposed activities on EFH for designated species that occupy the area.

- *South River, New Jersey, Topographic Survey*, November 2000. This study provided additional data for the assessment of plant community elevations in the South River and was intended to support the previous biobenchmarking surveys/data.

- *South River, New Jersey, Restoration Monitoring Plan*, November 2000. This report provides an evaluation of several restoration monitoring designs and techniques that could be implemented as part of South River ecosystem restoration.

- *South River, New Jersey, Plant Community Elevation Report*, November 2001. This report presents an evaluation of the relationship between elevation and plant community change at five potential restoration areas located with the South River Basin. The results of this evaluation were used to aid in the development of a successful ecosystem restoration plan.

- *South River, New Jersey, Hydrolab and Soil Salinity Report*, November 2001. This study was conducted to measure the existing surface water and soil salinity characteristics in five potential restoration areas located in the South River. The results from this study were used to assist in the development of the recommended restoration actions/options (*i.e.*, conversion of wetland *Phragmites* to salt marsh).

- *South River, New Jersey, Ecosystem Restoration Plan*, October 2001. This report identifies a number of cost-effective and incrementally justified restoration plans that will restore biodiversity and ecological function in the study area and selects the National Ecosystem Restoration (NER) plan. Based on the results of this report, the NER plan will result in a significant increase in wildlife habitat and an improved level of wetland function when compared to the existing conditions. It will also meet the goals and objectives for many programs, acts, and policies on an institutional (international, national, regional, state, and local), public, and technical level.

In addition to these surveys, a detailed *Impact Assessment and Mitigation Analysis* report was prepared (USACE 2002). In cooperation with an interagency advisory team including the National Marine Fisheries Service (NMFS), United States Fish and Wildlife Service (USFWS), and the New Jersey Department of Environmental Protection (NJDEP), Habitat Evaluation Procedures (HEP) were used to quantify the ecological impacts of potential HSDR features, and formulate and evaluate alternative mitigation and restoration plans. HEP provides a means of quantifying and comparing wildlife habitat value in the form of Habitat Units (HUs) and Average Annual Habitat Units (AAHUs). HUs are calculated by multiplying an estimate of quality, the Habitat Suitability Index (HSI), by a measurement of quantity, the acres of habitat of a specific type and condition. Quality was measured by a unit-less HSI ranging from 0 to 1 assigned through field estimation of the suitability of a specific habitat type and condition for a specific evaluation species. Quantity was calculated using the standard measure of acres. Six evaluation species were selected for the South River HEP study: American black duck, marsh wren, clapper rail, eastern cottontail, American woodcock, and yellow warbler.

In cooperation with the interagency advisory team, the Evaluation for Planned Wetlands (EPW) method was implemented to characterize and assess impacts to wetland functions and values. The EPW method was designed such that it can be used in conjunction with the HEP method to provide a more robust assessment of the quality of wetlands through an assessment of wetland functions and values (Bartoldus *et al.* 1994). Similar to HEP, the information collected using the EPW method provides a numeric index (*i.e.*, functional capacity index [FCI]) that is useful in baseline and impact assessments to evaluate proposed actions that potentially result in a change in either wetland quantity or quality, and to evaluate the relative value of wetlands identified in mitigation plans. Specifically, the EPW assessment method uses seven to 20 elements to evaluate six major wetland functions (*i.e.,* shoreline bank erosion control, sediment stabilization, water quality, wildlife, fish, and uniqueness/heritage). These elements are environmental factors or variables that are used to assess a particular function. An element score is a unit-less number ranging in value from 0.0 to 1.0 (where 1.0 represents optimal score) and is assigned to each element based on criteria outlined in the EPW manual. Element scores are combined and weighted to produce an FCI value from 0.0 to 1.0 for each wetland function. Size of the wetland is multiplied by the FCI value to produce a wetland functional capacity unit (FCU), which represents the wetlands capacity to perform each wetland function. The FCU's are used as the quantitative basis for wetland comparisons.

3.1 Physical Setting

The physical characteristics of the study area are profiled below. Discussions address physiography, geology, topography, climate, and soils. A description of physical changes to the study area associated with the Sayreville brick industry is also provided.

3.1.1 Geology and Physiography

The study area is located along the western edge of the Coastal Plain Physiographic Province, which occupies approximately two-thirds of Middlesex County. The Coastal Plain is a gently seaward-sloping surface overlying poorly consolidated sediments of Tertiary and Cretaceous age. These sedimentary strata form a southeastward-thickening wedge of sediments that exceeds 2,480 feet (755 meters) along the coast. The sedimentary wedge thins and eventually disappears to the northeast where it overlaps strata of the Southern Piedmont and Newark Basin.

The stratigraphy of the study area consists of an underlying Triassic bedrock complex predominantly composed of diabase, shale and sandstone. The northwestward dipping bedrock complex is unconformably overlain by the southeastward dipping Raritan Formation (Cretaceous). The Raritan section is primarily composed of semi-consolidated sand and gravel but contains significant silt, clay and lignite layers. A variety of Quaternary deposits including glacial, fluvial, and shallow marine sediments overly the Raritan.

In the study area, the Cape May Formation (Quaternary) consists of stratified sand and gravel with some silt and clay. The Cape May forms low terraces and plains along the edges of the South River drainage system and flood plain. Near-surface, unconsolidated, Holocene sediments that occur within the flood plain consist of fluvial sands deposited by the South River and organic silt, clay and peat layers that have been deposited in marshy areas adjacent to the river.

3.1.2 Topography

In general, the Coastal Plain Physiographic province is relatively flat. Elevations in the watershed range from 100 feet above National Geodetic Vertical Datum (NGVD) in upstream portions to 0.5 feet NGVD along the South River. Elevations in lower reaches of the South River in the Boroughs of South River and Sayreville range from 0.5 to 20.5 feet NGVD. Slopes on the Sayreville side of the Washington Canal are generally gentle (*i.e.,* 1 to 2 percent) and wetlands are located along the river. Slopes on the Borough of South River side of the South River are steeper (2 to 10 percent) and include steep cliffs and irregular depressions. Clancy Island is relatively flat with mounds of dredge material located along drainage ditches and along Washington Canal. Elevations on the island range from 0.5 to 6.0 feet NGVD.

3.1.3 Soils

Soils in the study area include a diversity of hydric/wetland soils and non-hydric/upland soils. Hydric soils tend to be concentrated in wetland areas along the South River. These nearly level, deep, and very poorly drained mineral and organic soils were formed from Coastal Plain materials. These soils typically have a grayish and/or black subsoil and occur on tidal mudflats in this area.

There are four soils in the study area that are prime farmland soils or soils of state or local importance. These prime farmland soils include Downer loamy sand (0-5 percent slopes), Fort Mott loamy sand (0-5 percent slopes), Hammonton loamy sand (0-3 percent slopes), and Klej loamy sand, with a clayey substratum (0-3 percent slopes). As described later in this document, soils in some locations within the study area have been heavily disturbed by dredging associated with the Washington Canal and South River navigation project, and by excavation associated with the Sayreville brick industry.

3.2 Climate and Weather

Despite its proximity to the Atlantic Ocean, Middlesex County has significant seasonal and daily temperature fluctuations. Winters are typically cool with moderate snowfall, and summers are moderate with hot mid-summer weather and frequent thunderstorms. Average temperatures range from 23 degrees Celsius (°C) or 73 degrees Fahrenheit (°F) in the summer months to 1°C or 34°F during winter months. Annual precipitation averages 44 inches with little seasonal variation in rainfall (NAEC, 1991). The growing season lasts approximately 180 days beginning in late April and ending in middle to late October.

3.3 Water Resources

The following profile of water resources in the study area focuses on its surface waters and on past and present flooding problems. The following sections discuss surface waters, regional hydrogeology, groundwater, tidal influences, and flooding problems.

3.3.1 Surface Waters

The South River flows north through the Townships of East Brunswick and Old Bridge and the Boroughs of South River and Sayreville and then splits into two branches, South River and Washington Canal, both of which flow into the Raritan River. The area of the South River watershed is approximately 135 square miles. Principal tributaries to the South River include Manalapan Brook, Matchaponix Brook, and Cedar Brook, which are upstream of Duhernal Lake, and Deep Run and Tennent Brook, which are downstream of the Lake.

Several tidal creeks drain into South River between Duhernal Dam and the Raritan River. Deep Run connects tidal drainage south of Route 18 and limited wetlands northwest of the roadway into South River. Farther downstream, Tennent Brook drains an additional smaller basin southeast of the roadway and a significant area of wetland between the roadway and South River.

In the South River near the Washington Canal, the deepest parts of the river (at the center of the channel) has depths ranging from 15.1 to 18.0 feet (4.6 to 5.5 meters) mean low tide (MLT). In the upstream section of South River, the river is shallower, and maximum depth ranges from 8.0 to 14.0 feet (2.4 to 4.3 meters) MLT. The mean water surface at the upstream section of the South River in the Township of Old Bridge is approximately 10.3 feet (3.2 meters) NGVD, and the mean water surface at the downstream section of the South River in the Townships of South River and Sayreville is nearly 0.5 feet (0.2 meters) NGVD.

According to the EPW field data, the FCI values for the shoreline bank function ranged from 0.00 to 0.26 in the East Bank, and 0.43 to 0.76 in the West Bank. The sediment stabilization FCI values in the East Bank ranged from 0.17 to 0.95 and from 0.37 to 0.90 in the West Bank. FCI values for the fish (tidal) function ranged from 0.41 to 0.80 in the East Bank and 0.00 to 0.52 in the West Bank (USACE 2002).

3.3.2 Water Quality

Tidal influences result in brackish water extending upstream to Duhernal Dam. Based on salinity sampling conducted in April, June, and September 2000, salinities in the South River generally range from 1.0 parts per thousand (ppt) to 6.3 ppt, with a minimum salinity of 0.0 ppt and a maximum of 15.3 ppt. Mean soil salinities range from 5.6 ppt to 14.4 ppt, with a minimum soil salinity of 4.0 ppt and a maximum soil salinity of 16.0 ppt. In general, salinity monitoring in the Washington Canal and South River bordering Clancy Island (on the west side) indicates higher salinity concentrations in the Canal. This suggests that greater tidal flushing occurs in the Canal, relative to the South River west of Clancy Island.

Water quality designations for the South River are: (1) FW2 Non-Trout – from Duhernal Lake to the Sayreville Water Department intake at Old Bridge, (2) Saline Estuarine – downstream of the intake, and (3) FW2 Non-Trout in Deep Run and Tennant Brook. The water quality FCI values in the East Bank ranged from 0.00 to 0.78 and from 0.53 to 0.77 in the West Bank (USACE 2002). Recreational activities in South River are generally limited to boating. Signs are posted along the river prohibiting swimming due to low pH levels, which result from native acidic soils.

The 1998 New Jersey State Water Quality Inventory, pursuant to section 305b of the Federal Clean Water Act, does not identify any specific water quality impairments for South River. However, South River is a part of the Raritan Bay complex, which has NJDEP fish and crab consumption advisories for striped bass (*Morone saxatilis*), bluefish (*Pomatomus saltatrix*), and blue crabs (*Callinectes sapidus*) because of potential PCB, dioxin, and/or chlordane contamination.

3.3.3 Regional Hydrogeology and Groundwater

The study area is located in the New Jersey North Atlantic Coastal Plain aquifer (NJCPA) system that consists of four regional aquifers that are vertically stacked and hydraulically connected. In vertical sequence from the surface, these are: 1) Chesapeake aquifer, 2) Castle Hayne-Aquia aquifer, 3) Severn-Magothy aquifer, and 4) Potomac aquifer. These aquifers are known locally as the Kirkwood-Cohansey aquifer, lower "800" foot sand aquifer of the Kirkwood formation, Wenonah-Mount Laurel aquifer, Englishtown aquifer, and the Potomac-Raritan-Magothy aquifer system. These aquifers are underlain by crystalline bedrock, which increases in depth from 600 feet at the interior Piedmont Province to greater than 4,500 feet at the Atlantic coastline.

The NJCPA system includes the area of Monmouth, Burlington, Ocean, Camden, Gloucester, Atlantic, Salem, Cumberland, Cape May, and portions of Mercer and Middlesex counties. Three million people in the New Jersey Coastal Plain area depend on the NJCPA for 75 percent of their drinking water. An estimated 24 to 26 million gallons of drinking water per day are pumped from the NJCPA aquifer system in Middlesex County alone.

The NJCPA has been designated as a Sole Source Aquifer by the U.S. Environmental Protection Agency (EPA). This designation protects drinking water supplies in areas with few or no alternative sources to the ground water resource, and where in the event of contamination, using an alternative source would be extremely expensive. Sole source aquifer designations require EPA review of any proposed project within the designated area that receives Federal financial assistance.

A variety of contaminant sources have been identified that threaten water quality in the NJCPA system. These contaminant sources include chemical storage leaks, highway deicing, agricultural chemicals, industrial waste lagoons, septic tank effluent, and saltwater intrusion/encroachment. Although there is limited data for the NJCPA system, a study by the United States Geological Survey (USGS) of the effect of human activity (land use) on groundwater quality showed that the underlying Potomac-Raritan-Magothy aquifer system had increased frequencies of detection of volatile organic compounds such as trichloroethylene and chloroform and some trace elements, when compared to less intensively developed aquifers. The increased frequency of contaminant detection in this aquifer was attributed to sources associated with overlying urban and industrial land uses in this area.

In 1986, NJDEP designated two "Critical Water Supply Management Areas" in the New Jersey Coastal Plain, and ground-water withdrawals from specified aquifers in these areas were reduced. However, long-term historical declines in water levels in Critical Area 1, which includes Middlesex County, reversed based on monitoring in several observation wells. This rise in water levels is attributed to a reduction in ground-water withdrawals and a shift toward using surface-water withdrawals for public water supply, as well as a shift in withdrawals from deep, confined aquifers to shallow aquifers.

The primary source of recharge, either directly or indirectly, to aquifers in the study area is through precipitation. Recharge may occur through direct infiltration of precipitation on outcrop areas, seepage from overlying surface waters, and vertical seepage from adjacent aquifers.

Based on records of fluctuations in the water table, only a small amount of recharge occurs from precipitation to aquifers during the growing season because much of the precipitation is lost to evaporation and transpiration.

3.3.4 Tidal Influences

Although the South River experiences diurnal tidal fluctuations, it is sheltered from direct ocean waves. The South River is tidal for much of its length, with brackish water extending as far upstream (south) as the Duhernal Dam. NOAA has established tidal stations at the Raritan River railroad bridge in the Borough of South River and at the confluence of the Raritan River and Washington Canal. At the railroad bridge tidal station, the mean spring tide range is 1.9 to 2.2 meters (6.1 to 7.1 feet) and the mean tide level at 1.1 meter (3.5 feet) NGVD. At the Washington Canal station, the mean spring tide range is 1.9 to 2.3 meters (6.1 to 7.4 feet) and the mean tide level is 1.1 meter (3.5 feet) NGVD. Based on the last documented dredging activity conducted in the early 1940s near the junction of the Washington Canal and South River, the mean tide range at Old Bridge is 1.9 meters (6.1 feet), the range of spring tide is 2.2 meters (7.1 feet), and the extreme range of storm tides is about 4.1 meters (13.3 feet). The average annual high tide in the Raritan River estuary is 1.8 meters (5.7 feet) NGVD. The elevation of South River at the confluence of the Raritan River is approximately 0.5 feet above NGVD. Tide stages in excess of 5.0 feet NVGD (the elevation at which developed areas are inundated and significant damage results) occur several times a year.

3.3.5 Flooding History

Hurricane and other storms have caused severe flooding along the South River. Flooding upstream of Duhernal Lake is fluvial. Flooding downstream of Duhernal Lake is primarily associated with storm surges, although runoff from the basin exacerbates flooding. The communities repeatedly affected by the tidal surges are the Boroughs of South River and Sayreville, the Township of Old Bridge, and the Historic Village of Old Bridge in East Brunswick Township. There are approximately 1,247 structures in the 100-year floodplains of these communities. Tidal flooding typically occurs during hurricanes and northeasters when sustained onshore winds push storm surges inland up tidal channels. In the Boroughs of South River and Sayreville, water surface elevations in excess of 5.0 feet NGVD inundate developed areas and cause significant hurricane and storm damages. In addition to damages resulting from tidal inundation, tidal surges often block existing stormwater drainage outlets, indirectly resulting in additional hurricane and storm damages.

The South River study area is prone to imminent and severe flooding from hurricanes and other storms. Unless otherwise specified, hurricane and storm damages described below occurred in the Boroughs of Sayreville and South River.

- **March 1962:** Significant damages occurred during the northeaster of March 1962. Tidal backwater flooding from the Raritan River resulted in severe damage to residential, commercial, and industrial properties in the Boroughs of Sayreville and South River and caused the Route 535 causeway (South River/Sayreville) to become impassable to vehicular traffic. Damages from this storm were estimated to be in excess of $4.2 million (2001 dollars).

- **May 1968:** Flooding associated with this 20-year storm occurred as a result of tidal backwater flooding. Damages were estimated at $8.8 million (2001 dollars), with significant structural damage to over 80 dwellings and 20 commercial buildings in the two Boroughs.

- **August and September 1971:** Hurricane Doria caused minor flooding in the area with estimated damages of $1.4 million (2001 dollars) in South River, Sayreville, and Spotswood. Fluvial flooding resulting from over eight inches of rain in the South River watershed was exacerbated by storm surge associated with this storm.

- **April 1984:** A fluvial event, the storm caused minor flooding above Duhernal Lake. No damage estimates are available.

- **December 1992:** This northeaster coastal storm stalled over the New York metropolitan area for three days. With heavy rain (four to five inches total), unusually high tides (over four feet above normal), and high winds (with gusts approaching 90 miles per hour), this storm produced severe coastal flooding. Over 200 people were evacuated from flooded areas in the study area. The bridge over the South River, connecting the Boroughs of South River and Sayreville, was closed for several days and rail movement was also shutdown. The study area flood associated with the December 1992 storm, which was chiefly a coastal and not fluvial event, is considered to have a 25-year recurrence interval.

- **March 1993:** The northeaster of March 1993 (also a 25-year event) resulted in over $17 million damage (2000 dollars) and closed the highway bridge connecting the Boroughs of South River and Sayreville (see cover photo showing flooding from March 1993 northeaster; location is along Francis Street in Sayreville, facing Weber Avenue).

In response to past and potential flooding problems in the Boroughs of Sayreville and South River, both of these communities, as well as East Brunswick and Old Bridge, have participated in the National Flood Insurance Program (NFIP) for at least 20 years. As required for NFIP participation, both communities have enacted municipal ordinances regulating floodplain development.

3.4 Socioeconomic Conditions

Most of the study area falls within the Borough of Sayreville and the Borough of South River. However, some of the study area is located in the historic Village of Old Bridge in East Brunswick and in the western part of Old Bridge Township. In general, the study area communities contain a mix of older suburban residential development, industrial facilities, and commercial highway corridors. In recent years, large planned unit residential developments have been added to these previously single-family home communities. Profiles of the four study area communities are presented below, followed by a description of flood-prone portions of the study area.

3.4.1 Borough Of Sayreville

The Borough of Sayreville, located along the east bank of the South River, is dominated by single-family residential neighborhoods. However, an increasing number of multi-family units built in the last two decades have resulted in smaller household sizes. The Borough's population in 1990 was 34,988, an increase of 17 percent from 1980 (see Table 1). About 66 percent of the Sayreville population is between 17 and 65 years of age (EPIC 1998a). Approximately 8 percent of the Borough's population, or 2,802 persons, was foreign-born, and the most common languages spoken in the community are English, Polish, Spanish, and Indic.

As indicated in Table 2, the Borough's 1989 median household income was $46,057, higher than incomes of the State or Middlesex County. Areas of undeveloped land in the Borough of Sayreville are increasingly attractive to developers because of the prime location of the Borough relative to the New York City and Newark metropolitan areas (Borough of Sayreville 1998).

Historically, Sayreville Borough has had a strong industrial and commercial economic base. As described above, local clay deposits supported a brick industry in Sayreville between 1850 and 1950. While the Borough began as an industrial center in the 19^{th} century, in the mid and latter parts of the 20^{th} century the Borough became a bedroom community, with a 1990 population to job ratio of 4.93. Nevertheless, industrial activity in the borough currently includes E.I. Dupont, Hercules, Inc., and New Jersey Steel. Sayreville residents are employed in a variety of industries, as shown in Table 3. Manufacturing provides the greatest share of jobs (21 percent), followed by retail trade (17 percent), finance/insurance/real estate (10 percent), education services (6 percent) and health services (6 percent).

Table 1
Population of Study Area Jurisdictions

	1970*	1980*	1990*	2000**	2010**	2020**
Middlesex County	583,813	595,893	671,811	722,573	778,933	823,162
Sayreville Borough	32,508	29,969	34,998	39,193	45,584	49,906
South River Borough	15,428	14,361	13,692	13,834	14,253	14,617
East Brunswick Township	34,166	37,711	43,548	45,935	47,841	49,514
Old Bridge Township	48,715	51,515	56,493	62,032	69,573	75,570

* Source: U.S. Bureau of the Census: 1970, 1980, 1990; 2000 data not available
** Source: Middlesex County Planning Department.

Table 2
Median Household Income of Study Area Jurisdictions

	1979	1989	Percent Change (1979-1989)
New Jersey	$19,800	$40,927	106.70%
Middlesex County	$25,023	$45,623	82.30%
Sayreville Borough	$24,683	$46,057	86.60%
South River Borough	$20,989	$37,998	81.00%
Old Bridge Township	$23,222	$47,482	104.50%
East Brunswick Township	$30,498	$58,709	92.70%
South Amboy City	$18,544	$37,933	104.50%
Edison Township	$25,206	$50,075	98.70%
Woodbridge Township	$26,054	$45,516	89.20%
Source: U.S. Bureau of the Census			

Table 3
Employment by Sector (1989)
Study Area Jurisdictions

Industry	Sayreville Borough	South River Borough	East Brunswick Township	Old Bridge Township	Middlesex County	New Jersey
Agriculture	60	21	141	199	2,297	38,208
Forestry / Fisheries	0	0	4	7	82	1,953
Mining	27	0	15	14	400	5,066
Construction	1,046	840	1,072	2,003	18,893	231,328
Manufacturing	3,835	1,779	4,096	5,034	69,634	653,436
Transportation / Communication	2,245	537	1,969	3,409	34,046	332,879
Wholesale Trade	1,182	290	1,477	1,931	22,464	207,413
Retail Trade	3,222	1,116	3,521	4,708	54,630	587,969
Finance / Insurance / Real Estate	1,897	420	2,334	4,002	33,651	346,037
Services	4,807	1,622	8,736	8,518	111,372	1,283,940
Public administration	816	269	648	1,229	13,040	180,469
Total	19,137	6,894	24,013	31,054	360,509	3,868,698

3.4.2 Borough Of South River

The Borough of South River is located on the western bank of the South River. Like Sayreville, the Borough of South River is primarily a residential community. Historically, single-family residential development overtook industrial development as the dominant form of land use at the turn of the century. Multi-family dwelling units and apartment complexes have been constructed to meet the changing demographic characteristics and economic needs of the Borough's residents.

The Borough of South River's population in 1990 was 13,692 (see Table 1). Approximately 63 percent of the population is between 17 and 65 years of age (EPIC 1998b), and 18.7 percent is foreign-born. The languages most commonly spoken in the Borough are English, Portuguese, Polish, and Spanish. The Borough's 1989 median household income was lower than the State and County medians, as shown in Table 2.

South River residents are employed in a variety of industries as shown in Table 3. The industry employing the highest percentage of Borough residents is manufacturing (26 percent), followed by services (24 percent), retail trade (16 percent), construction (12 percent) and finance/insurance/real estate (6 percent). Commercially, South River is primarily a "Needle Trade" community, producing fine ladies clothing, embroidery, and lace. Other commercial activities include: trades, sand and gravel, adhesives, road materials, aluminum recovery works, and general construction. The Central Business District is dominated by family-owned retail establishments. The most common type of employment is manufacturing (25.8 percent), followed by retail trade (16.2 percent).

3.4.3 Village of Old Bridge, East Brunswick Township

East Brunswick Township is one of the fastest growing suburban areas in Middlesex County. It proximity to transportation passenger and commercial transportation make this a desirable location for residential, commercial, and light-industrial development. (*e.g.*, computer, electronics, and publishing firms). The Township's population in 1990 was 43,548, as shown in Table 1. The Township's 1989 median household income was higher than the State and highest in the County as shown in Table 2.

East Brunswick Township residents are employed in a variety of industries as shown in Table 3. The industry employing the highest percentage of Borough residents is services (36 percent), followed by manufacturing (17 percent), retail trade (15 percent), finance/insurance/real estate (10 percent), and transportation/communication (9 percent).

The Historic Village of Old Bridge is located in southeastern East Brunswick Township. It is bordered on two sides, east and south, by the South River, by the Chestnut Hill Cemetery on the north and by Route 18 and Old Bridge Turnpike on the west. Old Bridge Village is listed as a historic district on the New Jersey State, September 1975, and on the National Register, June 1977.

The Historic District Master Plan restricts commercial activity to historically established areas of use. It confines commercial activities and uses to local or neighborhood-oriented services, sales, and offices. No new industrial uses are permitted, and will seek to terminate all present industrial activities. The residential community consists of single- family homes built on lots averaging 4,500 square feet. The general density of residences in the district should not be increased.[1]

3.4.4 Old Bridge Township

Old Bridge is a rapidly-developing community that is predominantly residential in character with a very low employment base. The 1990 population to job ratio is 8.99. The highest in Middlesex County, but is characteristic of some of the surrounding municipalities as shown in Table 3. The Township's population in 1990 is 56,493, an increased of 10 percent from 1980 as shown in Table 1. The Township's 1989 median household income was higher than the State and the third highest in the County as shown in Table 2. Old Bridge Township residents are employed in a variety of industries (see Table 3). The industry employing the highest percentage of Borough residents is services (27 percent), followed by manufacturing (16 percent), retail trade (15 percent), finance/insurance/real estate (13 percent), and transportation/communication (11 percent).

3.5 Land Use

Land use in the South River watershed is a combination of: (1) urban land uses primarily in the Boroughs of Sayreville and South River and the Townships of Old Bridge and East Brunswick, (2) limited suburban developments around the Boroughs, and (3) rural land uses. Ongoing economic development is expected to increase urban and suburban land uses via encroachment into rural areas of the watershed.

As populations in East Brunswick, South River, and Sayreville increased and brick production levels fell, much of the land in the study area was developed for commercial, industrial, and residential uses. Some lands east of the Washington Canal were abandoned and subsequently reclaimed by vegetation (Kupsch 2000).

The study area is currently dominated by single and multi-family residential land uses. Other common land uses include privately-owned undeveloped land, public and semi-public uses such as churches and civic organizations, commercial/industrial uses such as auto dealers, convenience stores, and a sewage treatment facility, infrastructure such as streets and rights-of-way, and parks and open space (Borough of Sayreville 1998, Borough of South River 1997).

3.5.1 Land Use in the Borough of Sayreville

Land use in Sayreville Borough is a mix of older suburban residential development; strong industrial base and highway commercial corridors that in recent decades have been supplemented by large planned unit residential developments. The Borough's development continues to be influenced by its strategic regional location, vacant land and infrastructure availability. The predominant land use in the Borough is residential land that comprises 2,667 acres, or 22.2 percent of the land area of the Borough. Privately owned undeveloped land constitutes 2,333 acres, or 19.5 percent of the land area and public and semi-public uses, including parks and open

[1] Township of East Brunswick, NJ, Master Plan, Historic District Amendment, September 1977.
[2] Township of East Brunswick, NJ, Master Plan, Historic District Amendment, September 1977.

space, compromise 2,160 acres, or 18 percent of the Borough's land area. Industrial uses account for 1,317 acres or 11.0 percent of the Borough's land area. Commercial land use accounts for 578 acres, or 4.8 percent of the Borough's land area. It should be noted that almost 14 percent of the Borough's open area is water.

The future development potential of Sayreville is based on development of approved projects not yet built and future development of vacant land. Underutilized existing, primarily nonresidential, sites are identified as potential redevelopment areas. Approximately 224 acres of privately owned vacant land over two acres in size is zoned residential and could produce 984 units. An additional 524 acres are zoned for residential and nonresidential uses. An estimated 1,550 housing units could be built on these parcels. The nonresidential portion could result in 1,352,538 square feet of commercial and industrial space. Over 1,170 acres of vacant land is zoned for commercial and industrial uses. A maximum of 24,996,992 square feet of new commercial and industrial space could be developed under the current zoning ordinance.[3]

3.5.2 Land Use in the Borough of South River

The Borough of South River is approximately 2.75 square miles, or 1,812 acres, in area. In addition, the Borough consists of claims to approximately 64 acres in water rights pertaining to the South River (located along the municipality's eastern boundary) and approximately 0.21 acres of Riparian Grants contained therein. The landmass of the Borough is comprised of an assortment of land use categories, specifically: residential, commercial, industrial, public, quasi-public, rights-of-ways, and vacant land. This community is predominantly residential with a mature suburban character.[4]

The Borough of South River is 86 percent developed. The predominant land use in the Borough is residential land that comprises 666 acres, or 37.8 percent of the land area of the Borough. Privately owned land constitutes 247 acres, or 13.7 percent of the land area and public and semi-public uses, including parks and open space, compromise 410 acres, or 6.3 percent of the Borough's land area. Industrial uses account for 93 acres or 5.2 percent of the Borough's land area. Commercial land use accounts for 83 acres, or 4.6 percent of the Borough's land area.[5]

The future development potential of the Borough of South River is based on development of approved projects not yet built and future development of vacant land. The Planning Board does not propose any radically different land use concepts that would dramatically change the character of the community. The continuation of current land development patterns is being encouraged, while redevelopment is proposed along the perimeter of the Downtown Business District and along the riverfront. Owners of the remaining few vacant tracts of land are encouraged to develop them in a manner that will be compatible with the surrounding area.[6]

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[3] Heyer, Gruel & Talley, PA, op. cit., p. III-8 to III-11
[4] Ibid., p. 13
[5] Ibid., p. 22
[6] Ibid., p. 127

3.5.3 Floodplain Management

All of the study area municipalities participate in the National Flood Insurance Program, and, as required for participation, have adopted floodplain management ordinances in their municipal codes. In flood insurance rate maps developed by the Federal Emergency Management Agency (FEMA), the base flood elevation is 10 feet NGVD (FEMA 1986 and FEMA 1987).

3.5.4 Coastal Zone Management

Pursuant to the Coastal Zone Management Act of 1972 and the Coastal Zone Reauthorization Act Amendments of 1990, New Jersey has defined its coastal zone boundaries and developed policies to evaluate and issue permits for Projects located within the designated coastal zone. These policies are set forth in New Jersey's Rules on Coastal Zone Management (N.J.A.C. 7:7, 7:7E, dated July 18, 1996 and addenda to 7:7 and 7:7E, dated August 19, 1996, and December 1999).

The NJDEP administers the coastal permit program through the Coastal Area Facility Review Act (CAFRA) (New Jersey State Act [N.J.S.A.] 13:19-1 *et seq.*), the Wetlands Act of 1970 (N.J.S.A. 13:9A-1 *et seq.*), and the Waterfront Development Law (N.J.S.A. 12:5-3). Each of these acts provides a slightly different definition of the coastal zone; therefore, the designated coastal zone consists of the cumulative total of these three definitions.

The Wetlands Act of 1970 (N.J.S.A. 13:9A) defines the coastal zone as all tidally-influenced wetlands, which includes the wetlands in the study area associated with the South River and Washington Canal. In addition, the Waterfront Development Law (N.J.S.A. 12:5-3) regulates any development occurring outside of the CAFRA's defined coastal zone boundary and in areas adjacent to tidal water, extending from the mean high water line to the first paved public road, railroad, or surveyable property line. Thus, the study area is located within the designated coastal zone under the Wetlands Act of 1970 and the Waterfront Development Law. Therefore, a Federal Consistency Determination would be required for construction activities that would be recommended by this investigation.

3.6 Biological Resources

Although the study area has been subject to considerable development and disturbance, the types and quality of habitats are suitable for a diverse group of migratory and resident wildlife, including finfish, shellfish, benthic invertebrates, reptiles, amphibians, birds, and mammals. These habitats include wetland and upland forest, scrub-shrub, and herbaceous communities, in addition to open water, mudflat, tidal creeks/ditches, and salt marsh communities.

3.6.1 Vegetation

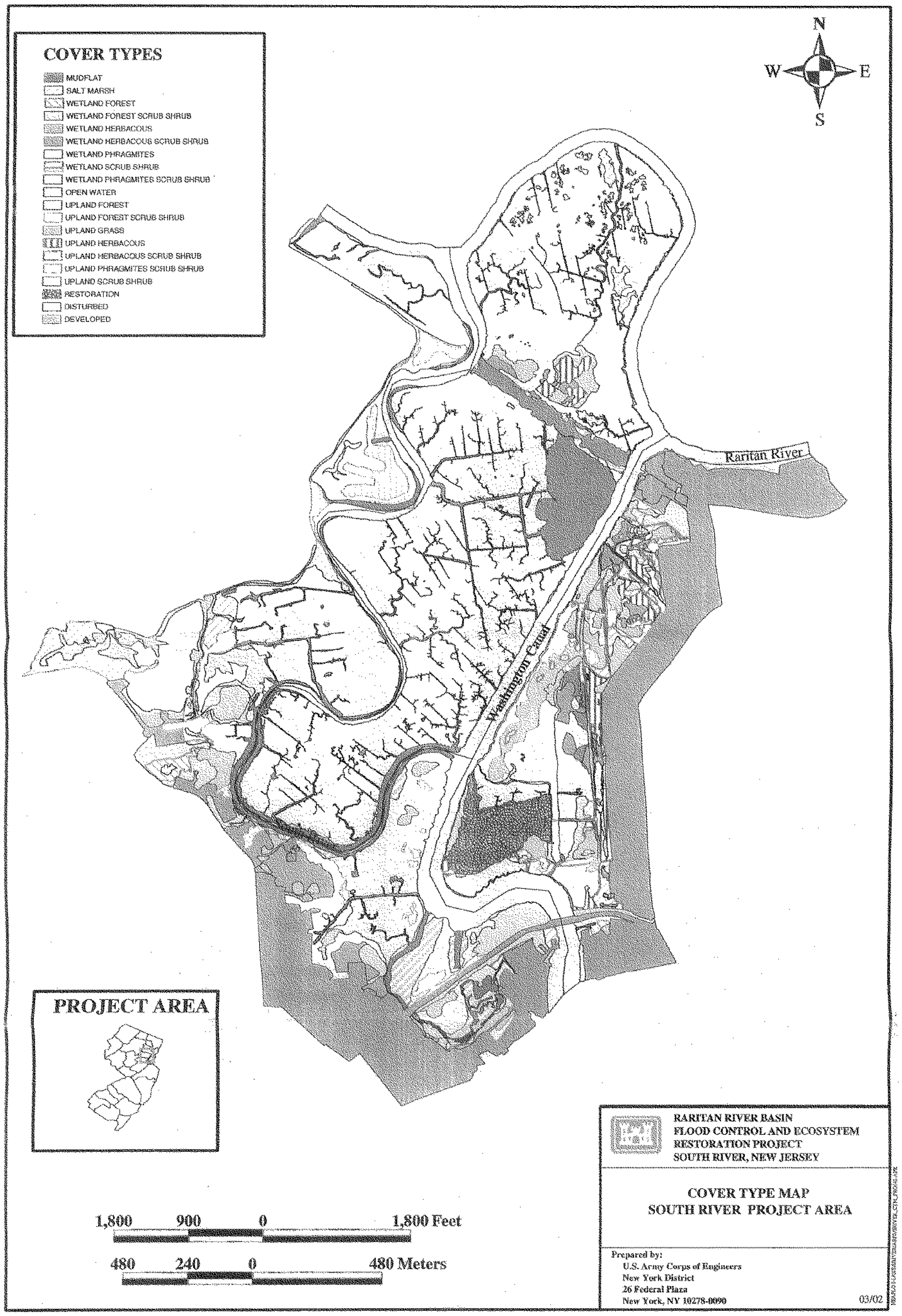
Field surveys indicate that the ecology of the approximately 1,278-acre South River study area is severely degraded due to the construction and operation of the navigation projects on the Raritan River, the Washington Canal, and the South River and to the past activities of the Sayreville brick industry.

Along the northeastern Atlantic coast, expansive stands of *Phragmites* have become synonymous with degraded and altered wetland ecosystems. Historically, *Phragmites* in salt marshes was limited to the upper edge of the high marsh, with normal salt marsh vegetation typically characterized by *Spartina patens, Spartina alterniflora,* and *Juncus gerardi.* Over time, *Phragmites* has become recognized as a nuisance wetland species. While the rapid expansion of *Phragmites* along the Atlantic coast has been attributed to a number of factors, it is clear that *Phragmites* can rapidly invade recently disturbed or hydrologically altered wetland areas, through seed dispersal and rhizome expansion. Tidal restrictions and mosquito ditches are among the disturbances that promote *Phragmites* colonization. Once established, *Phragmites* is an aggressive plant that can expand outward at rates ranging from 1 to 20 percent per year. *Phragmites* out-competes other wetland vegetation and can thrive in a wide range of hydrologic and soil conditions. The result of *Phragmites* invasion is a monotypic vegetative community with low habitat value for fish and wildlife and minimal biodiversity.

The portion of the study area that was identified as having a higher restoration potential is located on Clancy Island and along the Washington Canal (see Figure 3). As indicated in Table 4, this area is dominated by wetland habitat (approximately 61 percent) with some successional upland habitat (39 percent). For purposes of discussion, vegetated areas are divided into wetlands and uplands in the study area. A cover-type map and detailed descriptions of the vegetative communities of the study area are available in the *South River Wetland Delineation Report* (USACE 1999a) and in the Habitat Evaluation Procedures section of the *Impact Assessment and Mitigation Analyses Report* (USACE 2002).

Table 4
Land Cover & Land Uses
Restoration Evaluation Area

Land Cover/Use	Acres (percent of restoration evaluation area)
Wetlands	786 (61%)
Phragmites	527 (41%)
Uplands	492 (39%)
Developed	234 (18%)
Total	1,278 (100%)


COVER TYPES
MUDFLAT
SALT MARSH
WETLAND FOREST
WETLAND FOREST SCRUB SHRUB
WETLAND HERBACOUS
WETLAND HERBACOUS SCRUB SHRUB
WETLAND PHRAGMITES
WETLAND SCRUB SHRUB
WETLAND PHRAGMITES SCRUB SHRUB
OPEN WATER
UPLAND FOREST
UPLAND FOREST SCRUB SHRUB
UPLAND GRASS
UPLAND HERBACOUS
UPLAND HERBACOUS SCRUB SHRUB
UPLAND PHRAGMITES SCRUB SHRUB
UPLAND SCRUB SHRUB
RESTORATION
DISTURBED
DEVELOPED
N
W
E
S
Raritan River
Washington Canal
PROJECT AREA
1,800 900 0 1,800 Feet
480 240 0 480 Meters
RARITAN RIVER BASIN
FLOOD CONTROL AND ECOSYSTEM
RESTORATION PROJECT
SOUTH RIVER, NEW JERSEY
COVER TYPE MAP
SOUTH RIVER PROJECT AREA
Prepared by:
U.S. Army Corps of Engineers
New York District
26 Federal Plaza
New York, NY 10278-0090
03/02

3.6.1.1 Upland Habitat

Uplands account for approximately 492 acres in the study area. Most of the upland communities are low-quality and in early successional stages, reclaiming the disturbed areas containing dredge material and fill material from earlier industrial (brick) activity. Approximately 234 acres of these uplands are occupied by residential, commercial, and industrial development. The remaining 258 acres are comprised of eight upland plant communities: herbaceous, cultivated grass, scrub-shrub/herbaceous, *Phragmites*, *Phragmites*/scrub-shrub, scrub-shrub, forest, and forest/scrub-shrub.

Forest/scrub-shrub is the most common upland community in the study area and is fairly well distributed throughout the site. Most of the herbaceous and scrub-shrub communities are representative of early-successional communities that are reclaiming the disturbed areas containing dredge material. The vegetation is predominantly herbaceous and sparse at the tops of the dredge material piles and increases in shrub density and height downslope and along the outer edges of the dredge piles where there is often a transition into monotypic stands of *Phragmites*. The upland communities are typically dominated by species such as black cherry (*Prunus serotina*), black locust (*Robina pseudoaccacia*), gray birch (*Betula populifolia*), winged-sumac (*Rhus copallinum*), mugwort (*Artemisia vulgaris*), tree of heaven (*Alanthus altissima*), raspberry and blackberry species (*Rubus spp.*), switchgrass, little bluestem (*Schizochyrium scoparium*), various goldenrod species (*Euthamia spp.* and *Solidago spp.*), and invasive weed species, such as ragweed (*Ambrosia artemisiifolia*), poison ivy (*Rhus radicans*), Japanese honeysuckle (*Lonicera japonica*), and Japanese knotweed (*Polygonum cuspidatum*).

3.6.1.2 Wetland Habitat

Most of the wetlands within the South River study area have been subjected to human-induced alterations, including soil removal, dredge material deposition, brick/asphalt/concrete waste fill, and ditching for mosquito control. Extensive residential, commercial, and industrial development has encroached into the former edges of the wetlands. Wetland filling, including the disposal of brick material from brick manufacture, has resulted in areas of hydrologic obstruction and the segregation of formerly contiguous wetlands. In addition, excessive use of all-terrain recreational vehicles throughout the area has created water-filled ruts and wet depressions that are often devoid of vegetation.

Despite wetland losses and disturbance, a number of wetland communities remain in the study area. Approximately 786 acres of wetland are located within the 1,278-acre restoration evaluation area (61 percent of that area). Nine wetland plant communities have been confirmed in the South River study area (USACE 1999a): salt marsh, herbaceous, *Phragmites* (*Phragmites australis)*, scrub-shrub, herbaceous/scrub-shrub, *Phragmites*/scrub-shrub, forested, and forested/scrub-shrub. However, approximately 41 percent (527 acres) of the entire study area is dominated by mono-specific stands of wetland *Phragmites*. All tidally influenced wetlands within the Raritan Bay Estuary, including those found within the study area, are identified as priority wetlands (*i.e.*, most important and vulnerable) by the EPA (1994).

Although *Phragmites*-dominated communities are dispersed throughout the study area, the highest concentration of *Phragmites* occurs on Clancy Island. A 5- to 25-foot-wide band of low emergent salt marsh, dominated by smooth cord grass *(Spartina alterniflora)* occupies the shoreline along the South River and Washington Canal and small pockets on the study area Island. The largest sections of salt marsh occur in the southwestern reaches of the study area, where the South River flows beneath the South River/Sayreville Bridge through a storm surge gate. Other plant species commonly found in the wetland communities include switchgrass (*Panicum virgatum*), seaside goldenrod (*Solidago sempervirens*), soft rush (*Juncus effusus*), giant goldenrod (*Solidago gigantea*) narrow-leaved golden-rod (*Euthamia galetorum*), sensitive fern (*Onoclea sensibilis*), groundsel tree (*Baccharis hamilifolia*), marsh elder (*Iva frutescens*), indigo bush (*Amorpha fruticosa*), arrow-wood (*Viburnam dentatum*), red maple (*Acer rubrum*), Japanese honeysuckle (*Lonicera japonica),* and several small pockets of salt meadow grass (*Spartina patens)* and big cordgrass (*Spartina cynuseroides).*

The results of the EPW assessment are presented in Table 5. This table contains FCI values for the six wetland functions in Year 2002 for both the East Bank and West Bank areas.

As previously discussed, there is an active NJDOT mitigation project to restore approximately 20 acres of salt marsh in an area northwest of the Route 535 Bridge (South River/Sayreville) along the eastern edge of the Washington Canal. The goal of this project is to restore an existing monotypic stand of *Phragmites* to a salt marsh community dominated by *Spartina alterniflora* and *Spartina patens* (NJDOT 2000).

The only freshwater wetland identified in the study area is located in the southern portion of the study area, east of the South River channel. This 2.7-acre pond is located adjacent to an industrial facility, a dredge/fill disposal site, and major roadway. The perimeter of the pond is surrounded by a 5- to 10-foot wide band of scrub-shrub vegetation and is littered with household rubbish, car tires, and other miscellaneous trash. Despite the ponds' high algae content and turbid conditions it is utilized for recreational activities including fishing and swimming and contains several species of obligate water plants such as water arum (*Calla* spp.) and pond lilies (*Nuphar* spp.).

3.6.2 Fish and Wildlife Resources

Although the study area is located along the urbanized Northeast Corridor, the study area could support a variety of local and migratory fish and wildlife species. The following sections provide a brief description of the mammals, birds, reptiles and amphibians, shellfish, finfish, benthic, and threatened/endangered species resources likely to occur in the South River study area.

3.6.2.1 Mammals

Approximately 89 species of mammals can be found throughout New Jersey (NJDEP 2000c). However, based on the availability and types of habitats in the study area, 38 species of mammals potentially utilize the study area (Table 6). Twelve of these species were observed in the study area during field surveys conducted between 1998 and 2000 (USACE 1999a, USACE 1999b, USACE 2001b). Habitat generalists, such as the eastern cottontail rabbit *(Sylvilagus floridanus*), eastern chipmunk (*Tamias striatus)*, eastern gray squirrel (*Sciurus carolinensis)*, and

Table 5
FCI Values for East and West Banks

Cover Type	Shoreline Bank	Sediment Stabilization	Water Quality	Wildlife	Fish Tidal	Uniqueness / Heritage*
East Bank						
Salt Marsh	0.26	0.17	0.56	0.22	0.41	1.00
Wetland *Phragmites*	0.00	0.95	0.78	0.16	0.00	1.00
Wetland *Phragmites* / Scrub-Shrub	0.00	0.80	0.63	0.65	0.80	1.00
Wetland Scrub-Shrub	0.00	0.74	0.71	0.42	0.00	1.00
Wetland Herbaceous / Scrub-Shrub	0.00	0.75	0.60	0.51	0.00	1.00
Wetland Herbaceous	0.00	0.74	0.65	0.46	0.00	1.00
West Bank						
Salt Marsh	0.43	0.37	0.69	0.41	0.52	1.00
Wetland *Phragmites*	0.76	0.90	0.77	0.35	0.42	1.00
Wetland Forest	0.71	0.61	0.53	0.64	0.00	1.00

Source: USACE 2002a.
* Based on the rarity of wetlands in northern New Jersey, all wetland cover types received a value of 1.00.

white-tailed deer (*Odocoileus virginianus*) were the most commonly observed species. Based on the HEP field data, the HSI values for the eastern cottontail ranged from 0.58 to 1.00 in the East Bank and 0.77 to 1.00 in the West Bank (USACE 2002a).

3.6.2.2 Birds

Over 325 bird species are likely to be found throughout the State of New Jersey (NJDEP 2000a, and Walsh 1999), and 88 of these are likely to occur within the study area (Table 7). According to the New Jersey Breeding Bird Surveys conducted in the vicinity of the South River study area from 1993 through 1997, approximately 52 bird species breed within the study area. In addition to the 52 species known to breed in the study area, a number of additional bird species are likely to use the area for foraging, migratory stopover sites, and wintering grounds (NJDEP 2000a, Walsh 1999, Terres 1996, Stokes and Stokes 1996, Ehrlich *et al.* 1988, DeGraaf and Rudis 1983, and Peterson 1980).

Table 6
Mammals Likely to be Found in the Study Area

Order	Scientific Name	Common Name
Artiodactyla		
	Odocoileus virginianus	White-tailed deer*
Carnivora		
	Canis latrans	Coyote
	Vulpes vulpes	Red fox*
	Urocyon cinereoargenteus	Gray fox
	Mephitis mephitis	Striped skunk
	Mustela frenata	Longtail weasel
	Procyon lotor	Raccoon*
Chiroptera		
	Lasionycteris noctivagans	Silver-haired bat
	Myotis subulatus	Small footed myotis
	Lasiurus borealis	Red bat
	Myotis keeni	Keen myotis
	Lasiurus cinereus	Hoary bat
	Eptesicus fuscus	Big brown bat
	Pipistrellus subflavus	Eastern pipistrel
	Myotis lucifugus	Little brown myotis
Didelphimorphia		
	Didelphis virginiana	Opossum
Insectivora		
	Cryptotis parva	Least shrew
	Sorex cinereus	Masked shrew*
	Scalopus aquaticus	Eastern mole
	Blarina brevicauda	Shorttail shrew
Rodentia		
	Peromyscus maniculatus	Deer mouse
	Tamias striatus	Eastern chipmunk*
	Sylvilagus floridanus	Eastern cottontail*
	Sciurus carolinensis	Eastern gray squirrel*
	Mus musculus	House mouse*
	Zapus hudsonius	Meadow jumping mouse
	Microtus pennsylvanicus	Meadow vole
	Mustela vison	Mink
	Ondatra zibethicus	Muskrat
	Rattus norvegicus	Norway rat*
	Tamiasciurus hudsonicus	Red squirrel
	Synaptomys cooperi	Southern bog lemming
	Glaucomys volans	Southern flying squirrel
	Clethrinomys gapperi	Southern red-backed vole*
	Condylura cristata	Starnose mole
	Peromyscus leucopus	White-footed mouse*
	Marmota monax	Woodchuck*
	Napaeozapus insignis	Woodland jumping mouse

*Observed during field surveys
Source: NJDEP 2000c, USACE 1999a, USACE 1999b, Walsh 1999, Stokes and Stokes 1996, USACE 1995b, Whittaker 1988, Godin 1977, and Burt and Grossenheider 1976.

Table 7
Birds Likely to be Found in Study Area

Order	Scientific Name	Common Name
Pelecaniformes	*Phalacrocorax auritus*	Double-crested cormorant*
Anseriformes	*Anas rubripes*	American black duck*
	Aix sponsa	Wood duck*
	Anas platyrhynchos	Mallard*
	Bucephala albeola	Bufflehead*
	Branta canadensis	Canada goose*
	Mergus merganser	Common merganser*
	Anas crecca	Green-winged teal
	Branta bernicula	Brant
	Aythya marila	Greater scaup
	Clangula hyemalis	Oldsquaw
Charadriiformes	*Scolopax minor*	American woodcock*
	Sterna hirundo	Common tern*
	Larus marinus	Great black backed gull*
	Tringa melanoleuca	Greater yellowlegs*
	Larus argentatus	Herring gull*
	Charadrius vociferous	Killdeer*
	Larus delawarensis	Ring billed gull*
	Actitus macularia	Spotted sandpiper*
Ciconiiformes	*Botarus lentiginosus*	American bittern
	Nycticorax nycticorax	Black-crowned night heron*
	Ardea heroides	Great blue heron*
	Casmerodius albus	Great egret*
	Ixobrychus exilis	Least bittern*
	Egreytta thula	Snowy egret*
	Nycticorax violaceus	Yellow-crowned night-heron*
Columbiformes	*Zenaida macroura*	Mourning dove*
Coraciiformes	*Ceryle alcyon*	Belted kingfisher*
Falconiformes	*Falco sparverius*	American kestrel*
	Haliaeetus leucocephalus	Bald eagle
	Accipiter cooperii	Cooper's hawk
	Pandion haliaetus	Osprey*
	Falco peregrinus	Peregrine falcon*
	Buteo jamaicensis	Red-tailed hawk*
	Accipiter striatus	Sharp-shinned hawk*
	Circus cyaneus	Northern harrier*
	Cathartes aura	Turkey vulture*
Galliformes	*Colinus virginianus*	Northern bobwhite*
	Phasianus colchicus	Ring-necked pheasant*
Gruiformes	*Fulica americana*	American coot*
	Rallus longirostris	Clapper rail*
	Rallus limicola	Virginia rail*
Piciformes	*Picoides pubescens*	Downy woodpecker*
	Picoides villosus	Hairy woodpecker*
	Colaptes auratus	Northern flicker*
	Melanerpes carolinus	Red-bellied woodpecker
Passeriformes	*Corvus brachyrhynchos*	American crow *

Table 7
Birds Likely to be Found in Study Area

Passeriformes *(continued)*	*Carduelis tristis*	American goldfinch*
	Turdus migratorius	American robin*
	Spizella arborea	American tree sparrow*
	Riparia riparia	Bank swallow*
	Hirundo rustica	Barn swallow*
	Parus atricapillus	Black-capped chickadee*
	Cyanocitta cristata	Blue jay*
	Molothrus ater	Brown headed cowbird*
	Toxostoma rufum	Brown thrasher*
	Thryothorus ludovicianus	Carolina wren*
	Dumetella carolinensis	Catbird*
	Bombycilla cedrorum	Cedar waxwing*
	Spizella passerina	Chipping sparrow*
	Quiscalus quiscula	Common grackle*
	Geothlypis trichas	Common yellowthroat*
	Junco hyemalis	Dark-eyed junco*
	Megaceryle alcyon	Eastern kingbird*
	Sturnus vulgaris	European starling*
	Corvus ossifragus	Fish crow*
	Dumetella carolinensis	Gray catbird*
	Myiarchus crinitus	Great-crested flycatcher*
	Carpodacus mexicanus	House finch*
	Passer domesticus	House sparrow*
	Troglodytes aedon	House wren
	Cistothorus palustris	Marsh wren*
	Cardinalis cardinalis	Northern cardinal*
	Mimus polyglottos	Northern mockingbird*
	Icterus galbula	Northern oriole*
	Spizella arborea	American tree sparrow*
	Ammospiza caudacuta	Sharp-tailed sparrow*
	Carpodacus purpureus	Purple finch*
	Agelaius phoeniceus	Red-winged blackbird*
	Columbia livia	Rock dove*
	Melospiza melodia	Song sparrow*
	Melospiza georgiana	Swamp sparrow*
	Parus bicolor	Tufted titmouse*
	Sitta carolinensis	White breasted nuthatch*
	Empidonax traillii	Willow flycatcher*
	Dendroica coronata	Yellow-rumped warbler*
	Dendroica petechia	Yellow warbler*

*Observed during field surveys

Source: NJDEP 2000c, USACE 1999a, USACE 1999b, Walsh 1999, Stokes and Stokes 1996, Terres 1996, USACE 1995b, Erhlich *et al.* 1988, and DeGraaf and Rudis 1983.

A total of 80 bird species were observed during point count surveys and field surveys conducted in the study area (USACE 2001b, USACE 1999a, and USACE 1999b). The most commonly observed bird species included habitat generalists such as the black-capped chickadee (*Parus atricapillus*), American robin (*Turdus migratorius*), song sparrow (*Melospiza meloida*), house sparrow (*Passer domesticus),* house finch (*Carpodacus mexicanus),* American goldfinch (*Carduelis tristis*), northern mockingbird (*Mimus polyglottos),* mourning dove (*Zenaida macroura),* blue jay (*Cyanocitta cristata*), crow species (*Corvus* spp.), and gull species (*Larus* spp.). Numerous shorebirds, wading birds, and birds of prey also were observed foraging over the South River and in mudflats adjacent to the South River study area island.

According to the HEP field data collection efforts concentrated in the East Bank of the South River study area, the HSI values in Table 8 were generated for the five bird species selected as evaluation species (USACE 2002).

Table 8
HSI Values in East Bank

Cover Type	Black Duck	Clapper Rail	Marsh Wren	Yellow Warbler	American Woodcock
Wetlands					
Salt Marsh	0.31	0.14	0.98	NA*	NA
Wetland *Phragmites*	0.05	0.38	0.49	0.05	NA
Wetland *Phragmites* / Scrub-Shrub	0.06	0.45	0.3	0.65	0.33
Wetland Forest / Scrub-Shrub	0.06	0	0	0.52	0.55
Wetland Scrub-Shrub	0.08	0.45	0.15	0.56	0.32
Wetland Herbaceous	0.29	0	0.34	0.11	0.39
Wetland Herbaceous / Scrub-Shrub	0.14	0.47	0.19	0.41	0.32
Mudflat	0.06	0.64	0	0	NA
Open Water	0.01	0	0	NA	NA
Uplands					
Upland *Phragmites* / Scrub-Shrub	NA	NA	NA	0.28	0.18
Upland Forest	NA	NA	NA	0.21	0.5
Upland Forest / Scrub-Shrub	NA	NA	NA	0.55	0.55
Upland Grass	0	NA	NA	0	0.41
Upland Herbaceous	0.03	NA	NA	0.06	0.39
Upland Herbaceous Scrub-Shrub	NA	NA	NA	0.37	0.31
Upland Scrub-Shrub	NA	NA	NA	0.58	0.36
Disturbed	NA	NA	NA	0.02	NA

* NA = not applicable

Source: USACE 2002.

According to the HEP field data collection efforts concentrated in the West Bank of the South River study area, the HSI values in Table 9 were generated for the five bird species selected as evaluation species (USACE 2002).

Table 9
HSI Values in West Bank

Cover Type	American Black Duck	Clapper Rail	Marsh Wren	Yellow Warbler	American Woodcock
Wetlands					
Salt Marsh	0.45	0.77	0.87	NA*	NA
Wetland *Phragmites*	0.13	0.46	0.38	0	NA
Wetland *Phragmites* / Scrub-Shrub	0.22	0.75	0.37	0.37	0.36
Wetland Forest	0.21	NA	0	0.20	0.46
Wetland Forest / Scrub-Shrub	0.21	0	0.01	0.73	0.51
Mudflat	0.22	0.77	0	0	NA
Open Water	0.02	0	0	NA	NA
Uplands					
Upland *Phragmites* / Scrub-Shrub	NA	NA	NA	0.44	0.27
Upland Forest	NA	NA	NA	0.23	0.52
Upland Forest / Scrub-Shrub	NA	NA	NA	0.46	0.55
Upland Grass	0.01	NA	NA	0	0.41
Upland Herbaceous Scrub-Shrub	NA	NA	NA	0.35	0.23
Upland Scrub-Shrub	NA	NA	NA	0.38	0.38
Disturbed	NA	NA	NA	0	NA

* NA = not applicable
Source: USACE 2002a.

3.6.2.3 Reptiles and Amphibians

Reptiles and amphibians occupy a wide diversity of habitats during their lifecycle, including vegetated uplands, permanently and seasonally flooded vegetated wetlands, and open water. Of the 68 species of reptiles and amphibians that may occur in New Jersey, 17 species are likely to occur within the study area (NJDEP 2000b, Behler 1995, USACE 1995b, Conant and Collins 1991, and DeGraaf and Rudis 1983). A list of these species is provided in Table 10.

Incidental observations of reptiles or amphibians during field surveys include: eastern box turtle (*Terrapenne carolina*), diamond-backed terrapin (*Malaclemys terrapin*), common garter snake (*Thamnophis sirtalis*), snapping turtle (*Chelydra serpentina*), Fowler's toad (*Bufo woodhousii* *fowleri*), spring peepers (*Hyla crucifer*), and black rat snake (*Elaphe obsolete*) (USACE 2001b, USACE 1999a, and USACE 1999b).

Table 10
Reptiles & Amphibians Likely to Be Found In the Study Area

Order	Scientific Name	Common Name
Anura		
	Bufo woodhousii fowleri	Fowler's toad*
	Hyla crucifer	Northern spring peeper*
Caudata		
	Plethodon cinereus	Red-backed salamander
Salientia		
	Hyla versicolor	Common gray tree frog
	Rana catesbeiana	Bullfrog
	Rana clamitans melonota	Green frog
	Rana palustris	Pickerel frog
Squamata		
	Elaphe obsoleta	Black rat snake*
	Thamnophis sirtalis	Common garter snake*
	Nerodia sipedon	Northern water snake
Testudines		
	Clemmys muhlenbergii	Bog turtle
	Terrapenne carolina	Eastern box turtle*
	Chrysemys picta	Eastern painted turtle
	Malaclemys terrapin	Northern diamondback terrapin*
	Chelydra serpentina	Snapping turtle*
	Clemmys guttata	Spotted turtle
	Sternotherus odoratus	Stinkpot turtle

*Observed during field surveys
Source: NJDEP 2000b, USACE 1999a, USACE 1999b, Walsh 1999, Stokes and Stokes 1996, Terres 1996, Behler and King 1995, USACE 1995b, Conant and Collins 1991, Erhlich *et al.* 1988, DeGraaf and Rudis 1983, Godin 1977, and Burt and Grossenheider 1976.

3.6.2.4 Shellfish

There are no commercial shellfish populations located in the South River (USACE 1995b). Soft-shell clams (*Mya arenaria*) were reported in the Raritan River in 1957-1960 (Dean and Haskin 1964), but this species probably cannot tolerate the low salinity levels in the South River. Blue crabs are harvested near the confluence of the Washington Canal and the Raritan River and were common in bottom trawl catches in a section of the South River near the Route 535 Bridge during May and September, 2000 (USACE 2001b).

3.6.2.5 Finfish

Aquatic habitats in the South River and in the Washington Canal function as a typical east coast estuary. It serves as nursery area for permanent and temporary resident larval and juvenile fish, and reproductive waters for freshwater and anadromous fish populations. Finfish found in the river include the American eel (*Anguilla rostrata*), American shad (*Alosa sapidissima*), alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), bluefish, largemouth bass (*Micropterus salmoides*), yellow perch (*Perca flavescens*), white perch (*Monroe americana*), brown bullheads (*Amerius melas*), and silversides species (*Atherinidae spp.*).

Three finfish surveys have been conducted in the South River in recent years. The first was an electroshocking survey conducted by the NJDEP Division of Fish, Game, and Wildlife in the South River during August 1994 (Barno 1995, data summarized in USACE 1995b). Fish sampling was also conducted using gill nets, seines, minnow traps, and trap nets at a number of locations around the Island during the summer of 1998 (USACE 2000a). The third survey was completed in May and September 2000 with a bottom trawl in the main channel of the South River in the vicinity of the Route 535 Bridge (USACE 2002). Relative abundance information (numbers caught) was available for the two Corps surveys, but not for the 1994 NJDEP survey.

A total of 37 species were identified in these three surveys, including six anadromous species, one catadromous species, two estuarine species, 16 marine species, and 12 freshwater species (Table 11). White perch constituted almost 30 percent of the total catch in 1998. Other commonly caught species included Atlantic menhaden (*Brevoortia tyrannus*), inland silversides (*Menidia berlyllina*), and mummichogs (*Fundulus heteroclitus*). Of particular note from these surveys were: (1) the presence of juvenile blueback herring, which suggests that the South River may be used as a spawning habitat for this anadromous species, (2) the presence of juvenile menhaden, which indicates that the South River may be a nursery area for this species, and (3) the presence of shad, which have been reported to be reproducing naturally in the Raritan River. A few striped bass, bluefish, crevalle jacks (*Caranx hippos*), silver seatrout (*Cynoscion nothus*), and striped mullet (*Mugil cephalus*) were also collected.

3.6.2.6 Benthic Resources

No literature was found relating to benthic sampling in the South River. However, benthic sampling programs conducted in the Raritan River near the confluence of the South River, and in some of the freshwater tributary streams in the vicinity of the South River, are representative of the study area benthic community (Table 12). The low density of benthic macroinvertebrates recorded in the Raritan River near the mouth of the South River is likely due to stress induced by fluctuating salinity levels (Dean and Haskin 1964).

3.6.3 Threatened and Endangered Species

This section identifies and discusses the presence of Federal- and state-listed plant and animal species potentially occurring in the general vicinity (*i.e.*, within a two-mile radius) of the study area. It also identifies significant habitats such as designated critical habitat and rare plant communities known to occur within or near the study area. Table 13 summarizes the endangered and threatened species identified by the NJDEP, Natural Heritage Program (NHP), and the USFWS and includes species that have been directly observed by field personnel.

Table 11
Finfish Known to Occur in the Study Area

Species Type	Scientific Name	Common Name
Anadromous	*Alosa pseudoharengus*	Alewife
	Alosa sapidissima	American Shad
	Alosa aestivalis	Blueback Herring
	Alosa mediocris	Hickory Shad
	Morone saxatilis	Striped Bass
	Clupeidae	Unidentified Herring
Catadromous	*Anguilla rostrata*	American Eel
Estuarine	*Fundulus heteroclitus*	Mummichog
	Morone americana	White Perch
	Microgadus tomcod	Tomcod
Marine	*Brevoortia tyrannus*	Atlantic Menhaden
	Opisthonema oglinum	Atlantic Thread Herring
	Anchoa mitchilli	Bay Anchovy
	Pomatomus saltatrix	Bluefish
	Caranx hippos	Crevalle Jack
	Trinectes maculatus	Hogchoker
	Menidia beryllina	Inland Silverside
	Cynoscion nothus	Silver Seatrout
	Leiostomus xanthurus	Spot
	Mugil cephalus	Striped Mullet
	Anchoa hepsetus	Striped Anchovy
	Cynoscion regalis	Weakfish
	Pleuronectes americanus	Winter Flounder
	Brevoortia smithi	Yellowfin Menhaden
	Atherinidae	Unidentified Silverside
Freshwater	*Amerius melas*	Black Bullhead
	Lepomis macrochirus	Bluegill
	Ictalurus nebulosus	Brown bullhead
	Dorosoma cepedianum	Gizzard Shad
	Notemigonus	Golden shiner
	Micropterus salmoides	Largemouth Bass
	Lepomis gibbosus	Pumpkinseed
	Ictiobus bubalus	Smallmouth Buffalo
	Amerius catus	White Catfish
	Pomoxis annularis	White Crappie
	Perca flavescens	Yellow Perch
	Catostomidae	Unidentified Suckers

Sources: USACE 2001b, and Barno 1995.

Table 12
Benthic Macroinvertebrate Species Likely to Occur in South River

Taxon		Species (Scientific Name)
Annelida		
	Oligochaeta	*Naidae (LPIL)*
		Lumbriculidae (Lpil)
		Tubificidae (LPIL)
		Unidentified
	Polychaeta	*Eteone alba*
		Heteromastus filiformis
		Nereis succinea
		Polydora ligni
		Spio filicornis
		Spio setosa
		Streblospio benedicti
Arthropoda		
	Amphipoda	*Carinogammarus mucronatus*
	Cirripeda	*Balanus improvisus*
	Decapoda	*Cambarinae (LPIL)*
		Callinectes sapidus
		Cragon septemspinosa
		Rhithropanopeus harrisi
	Insecta	*Chironomidae (LPIL)*
		Corydalidae (LPIL)
		Hydrophilidae (LPIL)
		Hydropsychidae (LPIL)
		Odonata
		Polycntropodidae (LPIL)
		Sialidae (LPIL)
		Simulidae (LPIL)
		Tipulicae
	Hirudinea	Unidentified
	Hydroida	*Cordylophora lascustris*
Mollusca		
	Pelecypoda	*Macoma* sp.
		Mya arenaria
	Gastropoda	Unidentified
		Sphaeridae (LPIL)
	Osteroida	*Crassostera virginica*
Platyhelminthes		
	Turbellaria	*Turbellaria (LPIL)*

Key: LPIL = lowest possible identification level
Source: Dean and Haskin 1964, and Kurtz 1995

Table 13
Threatened and Endangered Species Sighted Within or Identified by Agencies as Possibly Occurring in the Study Area

Scientific Name	Common Name	Federal Status*	State Status
Plants			
Helionas bullata	Swamp Pink	T	E
Amphibians/Reptiles			
Clemmys muhlenbergii	Bog Turtle	T	E
Birds			
Botarus lentiginosus	American Bittern**		E/S
Haliaeetus leucocephalus	Bald Eagle	T	E
Rynchops niger	Black Skimmer**		E
Circus cyaneus	Northern Harrier**		E/U
Falco peregrinus	Peregrine Falcon		E
Nyctanassa violacea	Yellow-crowned Night Heron**		T
Pandion haliaetus	Osprey**		T
Nycticorax nycticorax	Black-crowned Night Heron**		T/S
Ammodramus henslowii	Henslow's Sparrow		E
Podilymbus podiceps	Pied-billed Grebe		E/S

* Key: E = endangered; T = threatened; S = stable; T = threatened; U = undetermined, not enough information available to determine status
** Sighted during USACE field sampling activities
Sources: NJDEP 2000d, NJDFGW 2000a, NJDFGW 2000b, USACE 2000, USFWS 2000a, USACE 1999a, USACE 1999b, and USFWS 1999.

3.6.3.1 Federal Species of Concern

Under Section 7(a)(2) of the Federal Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*) all Federally-listed rare, threatened, and endangered species are legally protected (USFWS 1999). The USFWS evaluated the study area from the Raritan River, south to Old Bridge for the presence of any Federally-listed species. Based on the USFWS search, no federally endangered or threatened wildlife species have been identified within the boundaries of the study area (USFWS 1999, and USACE 1998). However, the Federally-listed threatened bald eagle (*Haliaeetus leucocephalus*) (USFWS 2000a) may utilize habitats in the general vicinity of the study area (USACE 1998) and the Federally-listed threatened bog turtle (*Clemmys muhlenbergii*) (USFWS 2000a) has been documented in Middlesex County (NJDEP 2000d). However, due to the lack of suitable habitat for the bog turtle (*i.e.*, marshy meadows and slow-moving rivulets), this species is not likely to occur in the study area. No incidental sightings of the above mentioned species were made during field surveys conducted in June and December 1998, October 1999, and March, May, August, and September 2000 (USACE 2001b, USACE 1999a, and USACE 1999b).

No Federally-listed threatened or endangered vascular plant species are documented as occurring within the study area (USFWS 1999, and USACE 1998). The Federally listed swamp pink

(*Helonias bullata*) has historically occurred within the general vicinity of the study area, specifically in the Township of Old Bridge, NJ. The last confirmed record for the swamp pink in the general vicinity of the study area was in 1946 (NJDEP 2000d). It is not anticipated that this species or its likely habitat would be affected by Federal action to address flooding problems associated with hurricanes and other storms or ecosystem restoration along the South River (USFWS 1999, and USFWS 2000a). No incidental sightings of Federally-listed endangered or threatened plant species were made during field activities in June and December 1998, October 1999, and March, May, August, and September 2000 (USACE 2001b, USACE 1999a, and USACE 1999b).

3.6.3.2 State Species of Concern

The NJNHP evaluated an area extending from the Raritan River Road Bridge north to the confluence of the South River and Raritan River, including Washington Canal, for the presence of any species of special status, including those plant and wildlife species listed rare, threatened, or endangered by the State of New Jersey. Based on the NJNHP's record search, five wildlife species were identified as possibly occurring in the "general vicinity" (*i.e.*, within approximately two miles) or "possibly on" the study area (NJDEP 2000d). Specifically, the state-endangered northern harrier (*Circus cyaneus*) was listed as possibly occurring in the study area; the state-endangered Henslow's sparrow (*Ammodramus henslowii*), bog turtle, and pied-billed grebe (*Podilymbus podiceps*), and the state-threatened yellow-crowned night-heron (*Nyctanassa violacea*) were listed as potentially occurring within the general vicinity of the study area. As mentioned above, the lack of suitable habitat for the bog turtle makes this species unlikely to occur in the study area.

During field surveys, the state-endangered black skimmer and northern harrier, as well as a peregrine falcon (*Falco peregrinus*), were observed foraging above the study area. In addition, the state-threatened yellow-crowned night heron, osprey (*Pandion haliaetus*), black-crowned night heron (*Nycticorax nicticorax*), and American bittern were observed during field surveys in 1999 and 2000 (USACE 2001b, USACE 1999a, and USACE 1999b). An osprey was also observed next to a nest on a buoy tower located at the confluence of the Raritan and South River channels.

There are no documented occurrences of state-listed threatened or endangered vascular plant species within the study area (NJDEP 2000d, NJDFGW 2000a, NJDFGW 2000b, and USACE 1998). However, the NJDEP has identified the state-listed swamp pink as potentially occurring in Middlesex County (NJDEP 2000d). There were no incidental sightings of state-listed endangered or threatened plant species during field activities conducted in June and December 1998, October 1999, and March, May, August, and September 2000 (USACE 2001b, USACE 1999a, and USACE 1999b).

The NJDEP, NHP, and The Nature Conservancy have identified two species of special concern that may occur within the study area (NJDEP 2000d). While not legally protected, special concern species have the potential to be legally protected if populations decline further, therefore they warrant consideration. The yellow giant hyssop (*Agastache nepetoides*), and the fritillary butterfly (*Speyeria idalia*) are documented by NJDEP to have historically occurred within the general vicinity of the study area (NJDEP 2000d). However, according to records from the

NJDEP, both species are presumed to have been extirpated (NJDEP 2000d). There were no incidental sightings of any species of special concern during field activities conducted in June and December 1998, October 1999, and March, May, August, and September 2000 (USACE 2001b, USACE 1999a, and USACE 1999b).

3.6.3.3 Designated Critical Habitat

Evaluations of the study area by NJDEP and USFWS did not reveal any designated critical habitats within the South River study area (NJDEP 2000d, and USFWS 1999).

3.6.3.4 Essential Fish Habitat

The 1996 amendments to the Magnuson-Stevens Fishery Management and Conservation Act set forth a number of new mandates for the National Marine Fisheries Services (NMFS), regional fishery management councils (Councils), and other Federal agencies to identify and protect important marine and anadromous fish habitat. The Councils, with assistance from NMFS, are required to delineate "essential fish habitat" (EFH) for all managed species. Federal action agencies which fund, permit, or carry out activities that may adversely impact EFH are required to consult with NMFS regarding the potential effects of their actions on EFH, and respond in writing to the fisheries service's recommendations. In addition, NMFS is required to comment on any state agency activities that would impact EFH (NMFS 1998).

Based on the amendments to the Magnuson-Stevens Fishery Management and Conservation Act, the New England Fishery Management Council (NEFMC), Mid-Atlantic Fishery Management Council, South Atlantic Fishery Management Council, and NMFS have compiled and assigned EFH designations for species and life stages of fish, shellfish, and mollusks in Raritan Bay. Although NMFS has not assigned any EFH designations for the South River study area, its proximity to the Raritan Bay requires that an EFH impact assessment report be prepared in advance of Federal action to address flooding problems associated with hurricanes and other storms and/or ecosystem restoration opportunities along the South River.

The NMFS, in accordance with the NEFMC, have assigned 15 species with EFH designation that may occur in the vicinity of the South River study area. In order to verify the presence/absence of these species in the study area, a literature review was conducted to compare the species habitat requirements to the existing environment of the study area. In addition, the above fish surveys of the South River study area were performed. Based on the scientific literature and survey results, bluefish and winter flounder (*Pleuronectes americanus*) were the only EFH species inhabiting the waters of South River (USACE 2000a, USACE 2000b, and Barno 1995).

3.7 Cultural and Historic Resources

Under NEPA and other statutory requirements, the Corps has certain responsibilities for the identification, protection, and preservation of cultural and historic resources that may be impacted by proposed Federal action. Present statutes and regulations governing the identification, protection and preservation of these resources include the National Historic Preservation Act of 1966 (NHPA), as amended through 1992, the National Environmental Policy Act of 1969, Executive Order 11593, the regulations implementing Section 106 of the NHPA (36

CFR Part 800, Protection of Historic Properties, May, 1999), the Abandoned Shipwreck Act of 1987, and the Corps of Engineers Identification and Administration of Cultural Resources (33 CFR 305). Significant cultural resources include any material remains of human activity eligible for inclusion on the National Register of Historic Places (NRHP). The following discussions summarize cultural, prehistoric, and historic resources of the study area.

3.7.1 Cultural Resources

The South River cultural resources investigation supplemented cultural resources research conducted as part of the 1983 cultural resource investigation for the Lower Raritan River Multipurpose Study and as part of the 1985 survey report for flood control in the Raritan River Basin. Recent cultural resource reports, updates of the National Register of Historic Places and the New Jersey Historic Bridge Survey were consulted for additional study area information.

Supplemental research was conducted at the New Jersey Historic Preservation Office, the New Jersey State Museum and the New Jersey State Library. Studies by others were also evaluated including a 1990 archaeological investigation at the Sayre and Fisher Brickworks and Price Pottery Site prepared as part of a waterfront development proposal.

Cultural resource investigations performed in support of the South River feasibility study include the following. In 1995, a cultural resource investigation was conducted of the South River study area, specifically the Townships of East Brunswick and Old Bridge and the Boroughs of Sayreville, South River, and Spotswood. In 2001, a Phase I cultural resource survey was performed in the Boroughs of Sayreville and South River. As a result of these investigations, cultural resources were documented within the study area even though the terrain in the study area was found to be over 90 percent disturbed by excavation, dredging, and fill activities.

3.7.2 Prehistoric Resources

Numerous prehistoric sites have been documented in Middlesex County. There is only one documented prehistoric site within the South River watershed (Site 28Mi9). This site, which was previously disturbed by housing construction, would not be impacted by implementation of potential HSDR or ecosystem restoration measures along the South River. The site is not within the current Area of Potential Effect (APE) and therefore was not subjected to subsurface investigations.

3.7.3 Historic Resources

The historical archeological investigation of the South River study area, undertaken as part of the larger Lower Raritan River Multipurpose Study, was conducted to the level of a cultural resource reconnaissance. This involved the examination of pertinent historical material relating to the study area and a pedestrian survey designed to locate surface indications of historical archeological sites. In addition, the architectural resources of the study area were examined. The survey identified a large number of potentially significant features, both architectural and archeological in nature. These represent the full range of the region's history and include sites of transportation, industrial, agricultural, and domestic significance.

A cultural resources investigation was conducted for the original "Lower Raritan River Multipurpose Study" undertaken by the Corps in 1982 (Louis Berger & Associates, Inc. 1983). This study included an examination of published and unpublished documents, pedestrian survey, and subsurface testing at selected sites. Several cultural resource investigations have been conducted since the original 1982 Corps study entitled "Lower Raritan River Multipurpose Study" (USACE 1982; Louis Berger & Associates, Inc. 1983; USACE 1995; Panamerican Consultants, Inc. 2001). These investigations characterize the area as one dominated by the brick industry due, no doubt to the readily available high quality clay in the vicinity. The remains of these brick industry structures are mostly not extant. Evidence for subsurface remains of the structures has been encountered in the study area (Panamerican Consultants, Inc. 2001).

3.8 Air Quality

The EPA assesses overall air quality according to the National Ambient Air Quality Standards (NAAQS) for six criteria pollutants: carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO2), ozone (O3), particulate matter (PM), and sulfur dioxide (SO2). Commonly cited sources of criteria pollutants include automobile exhaust emissions, fossil fuel (coal and oil) fired power plants, oil refineries, ore smelters, storage and transfer operations involving solvents, and industrial emissions, among others (USEPA 1998).

The study area is located in the New York-Northern New Jersey-Long Island Consolidated Metropolitan Statistical Area (CMSA). According to the National Air Quality and Emissions Trends Report (USEPA 1998), the New York-Northern New Jersey-Long Island CMSA is considered a nonattainment maintenance area for CO and is classified as an extreme/severe nonattainment area for O3 (NJDEP 1999b). The study area is also located within the Middlesex-Somerset-Hunterdon, New Jersey Primary Metropolitan Statistical Area (PMSA). Air quality trends from 1988 to 1997 in this PMSA have shown a decrease in CO, Pb, particulate matter, SO2, and one measure of O3, while a second measure of O3 showed no significant change (USEPA 1998). In addition, the U.S. EPA has recently stated that the area will be designated as attainment for CO effective October 22, 2002 (67 FR 54575).

The USEPA's Pollution Standards Index (PSI) is a measure of community-wide air quality based on daily measured concentrations of six criteria pollutants. The PSI index corresponds to a health descriptor that ranges between 0 and 500: 0-50 is good, 50-100 is moderate, 100-200 is unhealthful, 200-300 is very unhealthful, and >300 is hazardous. PSI values reported for Middlesex County in 2001, exceeded 100 only two times out of 182 reported values for that year. The air quality in Middlesex County was "good" for 79 percent of the reported data during 2001.

3.9 Noise

Noise is generally defined as unwanted sound. Noise regulations in residential communities are based on residents' reaction to environmental noise that have been studied through community social surveys and analyzed together with data on physical noise levels that have been measured or estimated (Fields 1990). The day-night average sound level (Ldn) is the most widely used descriptor of community noise levels. The unit of measure of the Ldn is the A-weighted decibel (dBA), which closely approximates the frequency responses of human hearing.

The primary source of noise in the South River study area is from: (1) vehicular traffic on local roadways, (2) New Jersey Transit passenger rail traffic, and (3) commercial aircraft arriving/departing Newark International Airport, which is approximately 12 miles away (by air). In lieu of field measurements, the noise levels in the study area can be approximated by studying existing land uses and identified noise sources and comparing them to published average noise levels for those land uses. The USEPA (1978) document, "Protective Noise Levels," lists typical day-night sound level ranges for various environmental noises. Highly developed residential, industrial, and commercial areas are the dominant noise sources in the study area. Mean outdoor day-night sound levels characteristic of these sources range from 60 to 80 dBA (USEPA 1978). However, sound levels greater than 80 dBA are also likely to occur given the nature and frequency of passenger rail transits through the study area and commercial aircraft approaching/departing Newark International Airport.

3.10 Recreation

Recreational activities in the study area include use by all-terrain vehicles, boaters, birders, and fishermen. Shore access points allow entry for boating and fishing. Numerous marinas, boatyards, and public landings are available in the Boroughs of South River and Sayreville and in Old Bridge. Although there are no designated wildlife refuges or preserves in the study area, the South River supports estuarine wildlife populations and provides opportunities for land- and water-based wildlife observation, particularly resident and migratory wildfowl.

The Boroughs of South River and Sayreville maintain several open spaces, town parks, and recreational areas in the study area. The most notable of these include the Edward A. Grekoski Memorial Park (formerly Bissett's Pond Park or Recreation Area) and Varga Park and Recreation Area (Pacer's Field) in South River, and Old Bridge Park in Sayreville Keystone Park (MMOCA 1998, and USACE 1998). In addition, the Borough of Sayreville maintains 20 acres of undeveloped parkland north of the Sayreville/South River Bridge (Borough of Sayreville 1998). There are no state or county parklands or recreational areas in the study area. However, as part of its Green Acres Program, NJDEP owns approximately 115 acres of undeveloped land south of the study area in Sayreville. There are two small Green Acre parcels located in the study area along the South River. One parcel is located near the Sayreville/South River Bridge; the other is the Varga Park and Recreation Areas and is located west of Clancy Island (see map located in Environmental Appendix D – NJDEP Response to Comments).

There is currently no commercial boat traffic on the Washington Canal and South River. Small recreational vessels are the sole users of this waterway. The Rivers End Marina in Old Bridge, and the South River Boat Club, both of which berth small pleasure craft, are the primary users of the channel. Boat traffic on these waterways is seasonal and ranges from light to moderate.

3.11 Aesthetics

Currently, the study area offers limited aesthetic and scenic resources due to its developed/disturbed nature. The majority of the South River channel is bounded by private property, and access is restricted. Areas of saltmarsh and mudflat, unique communities in the study area, are only visible via boat on the Washington Canal and South River or from the bridge between Sayreville and South River (Route 535).

3.12 Hazardous, Toxic, and Radioactive Wastes

As part of the Hazardous, Toxic, and Radioactive Wastes (HTRW) analysis, sub-surface soil and surface water samples were collected. These samples were collected in those areas potentially impacted by implementation of HSDR, mitigation, or ecosystem restoration actions. The number of samples collected per area ranged from five to twenty-eight, depending on the size of the area being characterized. The following analyses on soil and water samples were conducted: Target Compound List Volatile Organic Compounds (TCL VOC, Target Compound List Semi-volatile Organic Compounds (TCL SVOC), Pesticides/PCB's and RCRA Metals.

HTRW characterization was accomplished in three phases. The first phase (completed in April 1997) investigated the area on the west side of the South River channel and on the riverbank upstream of the Veteran's Memorial Bridge. Only one sample, SR2-B2, located at the former South River Causeway Bridge at Jackson Street, yielded elevated numbers. In RCRA metals, lead came up above the New Jersey Department of Environmental Protection Residential Direct Contact – Soil Cleanup Criteria (NJDEP-RDCSCC) and for the SVOC's benzo(a)anthracene, benzo(p)pyrene and benzo(b)fluoranthene. Per the DEP's April 12, 1999 revision of the RDCSCC, lead and the SVOC's are now below threshold levels. This area would not be impacted by project implementation.

The second phase (completed in December 1998) collected soil and surface water samples around the perimeter of and within the interior of Clancy Island. A total twenty-soil/sediment samples were collected along with eight surface water samples. These 28 samples were collected in a grid pattern. Soil/sediment samples were analyzed for VOC/SVOC, Pesticides/PCB's, Target Analyte List Metals (the TAL Metals list contains the same metals as the RCRA Metals list, except TAL analyzes 23 metals and RCRA has eight). The samples on the north end of the island, directly facing the main flow of the Raritan River were the ones most noted for SVOC's, PCB's, and arsenic and beryllium. The SVOC numbers exceed the RDCSCC, and all except one were below the Non Residential Direct Contact SCC levels (NRDCSCC). PCB numbers were 30 per cent above the RDC level but substantially below the NRDC threshold. Locations on the north end of the island with the high numbers had high levels of arsenic and beryllium. Five interior island samples had elevated numbers for arsenic. These levels ranged from barely above threshold to three times threshold.

The third phase (completed in September 2000) collected sub-surface soil samples from the east or Sayreville side of the planned footprint of the levee. Five samples were collected and analyzed for VOC, SVOC, Pesticides/PCB's and RCRA Metals. Only one constituent yielded elevated numbers. The arsenic in sample SB-1-2 was 23 PPM and the RDC-SCC threshold is 20 PPM. Sample SB-1-2 is located on the north/northeast leg of the planned levee. This area is adjacent to the local sewer authority's pump station. Construction of a levee in this area could potentially be impacted by the elevated arsenic levels. However, it should be noted that the sample is marginally above state levels and well within the range of background concentrations of native soils (USGS Professional Paper 1270). The NJDEP "Historic Fill" database summary table (Appendix D to the Technical Requirements of Site Remediation 7:26E) indicates a range of arsenic concentrations of 0.05 – 1,098 PPM. The latter is typical of disturbed urban soils.

The HTRW investigation did not identify any significant HTRW issues in the South River study area. No HTRW contamination was found within portions of the study area potentially affected by the project. In addition, based on the industrial history of the study area (i.e., brick manufacture), it is unlikely that any HTRW problems would be encountered during project construction. While one soil sample suggested the presence of relatively low levels of arsenic, concentrations are within the range found in native soils, a possibility which is supported by the geology of the study area. Irrespective of the source of arsenic, identified concentrations would not pose a health hazard during construction or thereafter to construction workers or to study area residents.

3.13 Transportation and Other Infrastructure

As described above, the navigation channel of the South River and Washington Canal connects communities along the South River with the Raritan River. The authorized project is a 12-foot deep, 100-foot wide channel in the Washington Canal for a distance of 0.8 miles upstream of the Raritan River and then a 12-foot deep, 150-foot wide channel in the South River to Old Bridge. This waterway does not support commercial navigation, and the only users are recreational boaters.

The study area is located within the New York metropolitan region with direct access to excellent road, rail, and air networks. A network of arterial and collector streets and highways provide access to regional highways, such as State Route 18, the Garden State Parkway, and the New Jersey Turnpike. The Garden State Parkway lies east of the study area and is directly accessible from the Borough of Sayreville via Main Street, which passes east-west through the borough. The Borough of South River is directly accessible to State Route 18 and the New Jersey Turnpike, which lies a mile to the north. The majority of roads in the study area are classified as local streets, which primarily function to provide access to abutting residential properties.

New Jersey Transit Corporation provides commuter rail service to study area communities. The nearest stations are in New Brunswick, to the west, along the Northeast Corridor line and in South Amboy, to the east, along the North Jersey Coast line. The railway provides access to regional and national rail facilities. New Jersey Transit also provides bus service directly to New York City from the study area.

The study area also contains a network of active and inactive commercial freight rail tracks. The rail line approximately one-half mile to the south of Route 535 is an active freight line, formerly part of the Raritan River Railroad network. The rail line that crosses the South River approximately 2.5 miles to the south of Route 535 is also an active freight line belonging to the successors of Conrail.

At the confluence of the Washington Canal and the Raritan River, there is a wastewater treatment plant on the east side of the Canal serving the Borough of Sayreville. Protection of this facility from flooding was established early in plan formulation as a desirable component of any HSDR plan.

* 4. NO-ACTION ALTERNATIVE / FUTURE WITHOUT- PROJECT CONDITION

The without-project condition was determined by projecting conditions in the study area over a 50-year period of analysis (2010-2059). In the absence of Federal action, flooding problems associated with hurricanes and other storms in the study area are expected to continue. These problems may be exacerbated by increased damage potential in the floodplains of communities along the South River based upon increases in the values of structures and contents, and by sea level rise. It is anticipated that the degraded condition of the study area ecosystem (*e.g.*, low levels of species diversity and abundance) will continue into the future in the absence of Federal action.

The no-action alternative reflects the continuation of existing economic, social, and environmental conditions and trends within the affected area. Implicit in taking no action would be the continuation of Federally subsidized flood insurance coverage for property owners that is currently available through the National Flood Insurance Program and the enforcement of local floodplain zoning ordinances.

Failure to provide the South River study area with hurricane and storm damage protection measures could, in the predictable occurrence of a significant flood, contribute to the loss of life and physical as well as environmental damage to study area communities. Significant flooding can result in the overtopping of sewage treatment works, contamination of drinking water supplies, dispersion of hazardous, toxic, and/or radioactive waste (HTRW) and dispersion of large quantities of solid waste. Experience has shown that vast quantities of debris (*e.g.*, homes, vehicles, mobile homes, etc.) and sediment must be removed from the floodplain after a flooding event. The physical removal of the debris from the floodplain typically involves large, heavy equipment and requires the removal of trees and vegetation to provide points of ingress and egress for the cleanup equipment. Hauling the collected debris to the local municipal landfill requires significant transportation resources, and involves huge quantities of solid waste that fill available landfill space.

4.1 Study Area Conditions That Are Unlikely To Change

Some existing conditions are not expected to undergo significant change during the period of analysis (2010-2059). For example, most aspects of the physical setting are expected to remain largely unchanged over the planning period, specifically: geology, physiography, topography, and soils. In addition, no significant changes are anticipated for cultural and historic resources, air quality, noise, HTRW, aesthetics, and infrastructure.

4.2 Study Area Conditions That Are Likely To Change

It is likely that other aspects of existing conditions are likely to change during the period of analysis. In particular, it is likely that several study area conditions related to flooding would undergo some changes over time. Ongoing urbanization of the South River watershed could exacerbate flood risks by accelerating runoff from the watershed during storms. Sea level rise could affect flood elevations during storm surges. Growth and development in the study area communities could increase people and property at risk to flooding, although future increases in vulnerability would be mitigated by municipal floodplain management ordinances.

It is possible that there could be additional biological degradation in the study area. However, field investigations and an understanding of how and where *Phragmites* expands have determined that the existing *Phragmites* in the study area has nearly completed colonization of areas that would support this invasive species. Due to the domination of much of the study area wetlands by *Phragmites*, the very low biological diversity of much of the study area cannot be further degraded.

In addition to continuing development of the study area communities, the principal socioeconomic change in the study area would be continuing growth of recreation demand. Demand for recreation opportunities is expected to result from increases in population, income, and leisure time.

* 5. PURPOSE OF AND NEED FOR PROPOSED ACTION / PROBLEMS AND OPPORTUNITIES

Plan formulation for the South River multipurpose feasibility study has been conducted in accordance with the six-step planning process described in *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (1983) and the *Planning Guidance Notebook* (1105-2-100, dated April 2000). The six steps in the iterative plan formulation process are:

- Specify the water and related land resources problems and opportunities of the study area;
- Inventory and forecast existing conditions;
- Formulate alternative plans;
- Evaluate alternative plans;
- Compare alternative plans; and
- Select the recommended plan.

5.1 Problems And Opportunities

As described above in discussions of existing conditions and without-project future conditions, it is anticipated that in the absence of Federal action, flooding in the study area will continue to threaten human life, safety, well-being, and cause significant economic damages. Flooding problems may be exacerbated by floodplain development and sea level rise. In the absence of Federal action, it is anticipated that the study area ecosystem will remain in a degraded condition, with wetland areas dominated by *Phragmites*.

There is a significant opportunity for Federal action in the study area to reduce hurricane and storm damages and to restore degraded ecosystems and thereby address adverse effects of Federal navigation projects in the Raritan River and in the Washington Canal. Technical studies conducted as part of this investigation indicate that the construction and maintenance of the Washington Canal and perhaps the Raritan River navigation channels significantly contributed to ecological degradation in the study area.

The predevelopment condition of much of the study area – including Clancy Island and the east bank of the Washington Canal – appears to have been forested uplands. Accordingly, it would not be feasible to restore the existing low-lying wetlands, which were formed by clay excavation, to their "original" or "predevelopment" condition. However, restoration to a more ecologically valuable condition is feasible and could restore vital tidal saltwater marsh habitat along the Raritan River that was once abundant and is currently scarce in the State of New Jersey.

Tidal saltwater marshes, which are classified as EPA priority wetlands, can support diverse and thriving communities that provide spawning and nursery habitats for commercially valuable anadramous fish (*e.g.*, striped bass, shad, herring, bluefish and weakfish [*Cynoscion regalis*]) and for shellfish (*e.g.*, blue crabs and oysters [*Crassosterea virginica*]), as well as many species of waterfowl that nest and/or use the marshes as a migratory stopover. There are few diverse, fully-functional tidal wetlands remaining in the study area or the larger Raritan River Basin. In areas along the mainstem Raritan River and tributaries where *Spartina*-dominated marshes still exist, they have become degraded and are subject to *Phragmites* encroachment. As in the case of the South River study area, where *Spartina* still persists, it has been relegated to the margins of the *Phragmites* marsh. As a result, ecosystem restoration along the South River would provide an important contribution to the local and regional ecology in the New York metropolitan area.

There is a significant opportunity to address these problems in a single, integrated project. The non-Federal project partner, NJDEP, is fully supportive of measures to address flooding problems and ecosystem degradation along the South River. In addition, the local governments of the Boroughs of Sayreville and South River also support Federal action in this area. It is also expected that implementation of an integrated project would result in cost efficiencies for both project purposes.

5.2 Planning Objectives, Constraints, and Key Assumptions

The following discussions identify critical objectives, constraints, and assumptions used during formulation of alternative plans to address problems and opportunities of Federal interest along the South River.

5.2.1 Planning Goals And Objectives

The Federal objectives in making investments in water resource projects are to contribute to National Economic Development (NED) and National Ecosystem Restoration (NER). The pursuit of planning objectives must be consistent with Federal, State and local laws and policies, and technical, economic, environmental, regional, social, and institutional considerations. Recommended plans should avoid, minimize, and then mitigate, if necessary, adverse project impacts to the environment. They should also maximize net economic benefit (for HSDR features), avoid adverse social impacts, and meet local preferences to the fullest extent possible.

The specific planning objectives for the South River study area are to reduce hurricane and storm damages and to restore degraded ecosystems. An additional objective for this study is to integrate HSDR measures and ecosystem restoration measures in a single, integrated project that efficiently and effectively accomplishes the multiple project purposes.

In pursuit of the goal to reduce hurricane and storm damages in the study area, the following objectives for HSDR were established:

- Reduce the threat of potential future damages due to the effects of tidal flooding from the mouth of the South River to the Duhernal Lake Dam.

- Protect and maintain traffic corridors to ensure the operability of emergency and rescue facilities during storm events.

- Provide a plan that is compatible with future HSDR and economic development opportunities. Any plan considered for implementation must not contravene or preclude other plans to address the needs and well-being of those who live in and work in the basin.

- Avoid and minimize adverse environmental and ecological impacts.

In pursuit of the goal to restore degraded ecosystems in the study area, the following restoration objectives were established:

- Increase biodiversity of habitat,

- Restore under-represented habitat;

- Restore habitat for rare or special-interest species;

- Increase tidal flushing of wetlands;

- Stabilize/protect existing desirable wetland habitats;

- Reduce *Phragmites*;

- Improve water quality; and

- Increase recreational opportunities (as a secondary consequence of restoration activities).

5.2.2 Public Concerns

A public scoping meeting was held in the study area on July 16, 1998. Corps representatives discussed flooding problems associated with hurricanes and other storms and ecosystem restoration opportunities along the South River with interested parties, and solicited their input to the study. Specifically, local interests and the public at large were invited to identify their issues and concerns regarding the direction, process, and potential findings of this investigation.

5.2.3 Planning Constraints

The formulation and evaluation of alternative plans was constrained by a variety of considerations. The planning constraints used to guide this feasibility study are listed below:

- Technical constraints include the need for plans to be: (1) sound, safe, and acceptable solutions, (2) in compliance with sound engineering practice, (3) realistic and state-of-the-art, (4) consistent with existing local plans, and (5) complete and not dependent on future projects.

- Economic constraints include: 1) the need for HSDR features to be efficient (*i.e.*, average annual benefits exceed average annual costs); 2) the requirement to select the HSDR plan that maximizes net excess benefits (*i.e.*, the NED plan) unless there are overwhelming reasons to select a different plan and an exception is granted by the Assistant Secretary of the Army (Civil Works); and 3) the requirement to conduct a cost effectiveness and incremental cost analysis to identify the plans which maximize contributions to NER at the least cost ("best buy" plans).

- Environmental constraints affecting the formulation and selection of HSDR features include the need for plans to: (1) not unreasonably impact environmental resources, (2) first consider avoidance followed by minimization, mitigation, and replacement, and (3) incorporate measures to enhance significant environmental resources where opportunities exist.

- Environmental constraints affecting the formulation and selection of ecosystem restoration features include the need for plans to: 1) be evaluated in a systems context in order to improve the ability of the features to function as self-sustaining systems; 2) be formulated in consideration of intended and unintended effects, both on and off of the project site; and 3) be formulated recognizing the attainable restoration state, given the influences of human activities and culturally induced changes in the landscape which are likely to persist and influence system conditions after project completion.

- Regional and social constraints include the need for plans to: (1) weigh the interests of State and local public institutions and the public at large, and (2) consider the potential impacts of the project on other areas and groups.

- Institutional constraints include the need for plans to: (1) be consistent with existing Federal, State and local laws, (2) be locally supported, (3) provide public access to the project in accordance with Federal and State laws and regulations, and (4) find overall support in the region and state.

5.2.4 Critical Assumptions Guiding Plan Formulation

Critical assumptions guiding plan formulation for HSDR and ecosystem restoration include the following:

- The project will be designed based on a 50-year project life.
- A Preconstruction Engineering and Design phase that will include development of a Design Documentation Report and Plans and Specifications will follow the feasibility phase.
- Prevailing Federal discount rate (.06125) will be utilized in cost/benefit estimation.
- The line of protection and interior drainage features are separately formulated and optimized.
- Hurricane and storm damages in the study area will worsen and ecosystem degradation will continue in the absence of Federal action.

* 6. ALTERNATIVES INCLUDING PROPOSED ACTION / PLAN FORMULATION AND EVALUATION

A variety of structural and nonstructural plans were evaluated to satisfy the study objectives and constraints. Formulation and evaluation of the alternative plans was conducted consistent with Federal water resources policies and practices, including the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G, 1983) and the Corps *Planning Guidance Notebook* (ER-1105-2-100). As stipulated by this guidance, the alternative plans were evaluated by comparing conditions expected under with- and without-project scenarios.

The purpose of South River plan formulation is to first identify all possible structural and nonstructural measures that may be applicable to the flooding problems associated with hurricanes and other storms and ecosystem restoration opportunities. An iterative screening process then reduces the alternative plans to those that are potentially technically, economically, and institutionally feasible. Those plans with greatest potential are then subjected to more detailed evaluation.

The following discussions of South River plan formulation include these sections:

- Identification of alternative plans,
- Screening of alternative plans,
- Plan evaluation and comparison, and
- Selection of the NED plan and the NER plan.

Parallel discussions of HSDR plan formulation, HSDR mitigation, and ecosystem restoration plan formulation are presented. This organization is appropriate for two reasons. First, plan formulation activities for these project purposes were conducted concurrently. Second, no conflicts are expected between these project purposes. Instead, it is anticipated that implementation of these diverse project purposes will lead to cost efficiencies.

6.1 Identification of Alternative Plans

The initial step in plan formulation is to identify those structural or nonstructural measures that may be effective in addressing the flooding problems associated with hurricanes and other storms and ecosystem restoration opportunities and be suitable for the planning contexts in the study area. The following sections describe the process and results of the initial evaluation of alternative plans for HSDR and for ecosystem restoration.

6.1.1 No-Action Alternative

For HSDR and ecosystem restoration plan formulation, the no-action alternative is equivalent to the without-project conditions described previously. This alternative precludes Federal action to address flooding problems associated with hurricanes and other storms or ecosystem restoration opportunities. It represents the default condition if a Federal project is not recommended and provides a reference for evaluation of with-project future conditions.

The no-action plan fails to meet any of the study objectives. Under this alternative, flooding problems associated with hurricanes and other storms along the South River would continue with recurrent threats to life and property, and degraded conditions of study are ecosystems would be unchanged.

The no-action alternative would not be accompanied by potential adverse environmental and other impacts associated with implementation of a HSDR plan. However, this alternative would also not result in hurricane and other storm damage reduction or beneficial environmental effects.

6.1.2 Alternative Hurricane and Storm Damage Reduction Measures

The following discussions of the identification of alternative HSDR measures are divided into three sections: delineation of hurricane and storm damage reaches, potential structural measures, and potential nonstructural measures.

6.1.2.1 Damage Reaches

The South River study area was divided into five reaches based on damage reaches (see Figures 4a and 4b). These reaches were used to evaluate the costs of structural and nonstructural HSDR measures and to estimate the benefits of the alternative plans, based on avoided hurricane and storm damages.

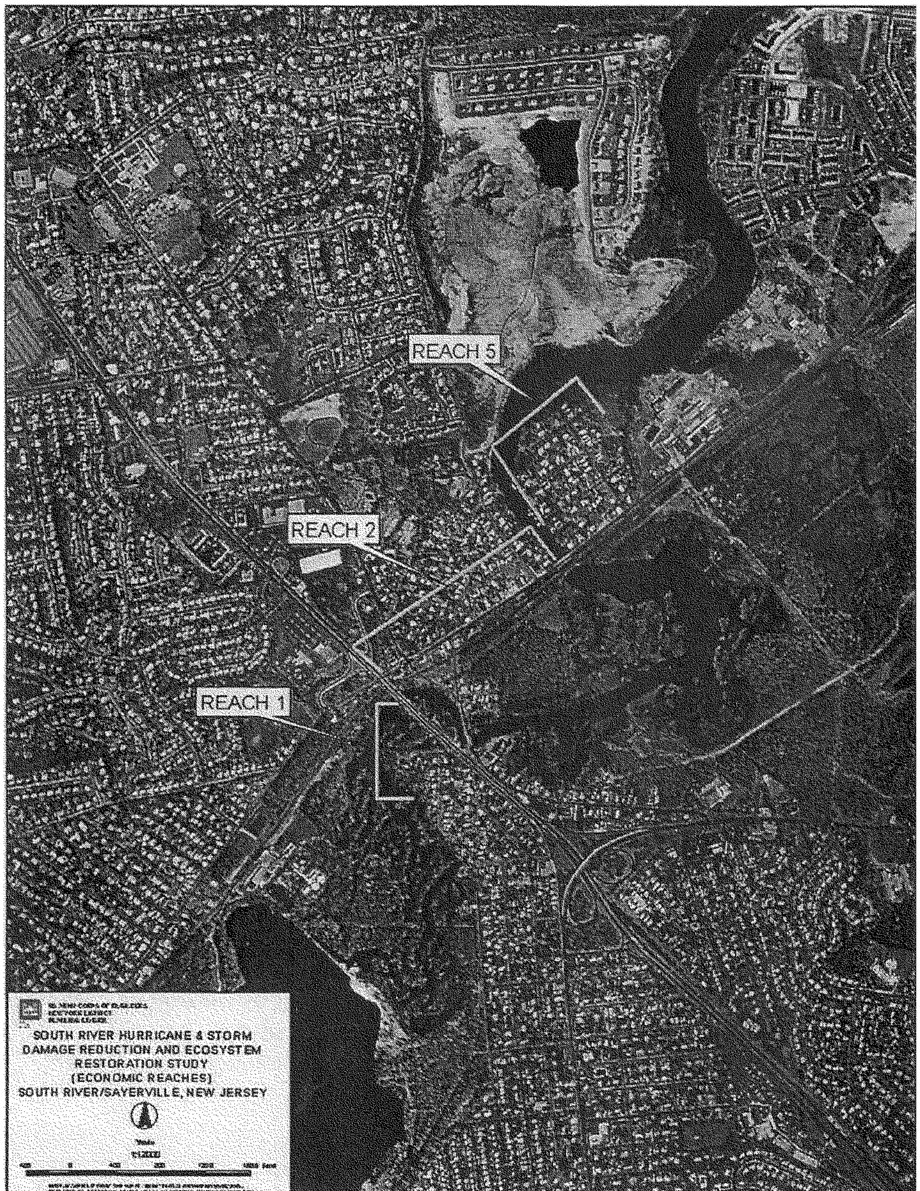


FIGURE 4a
DAMAGE REACHES (1,2, & 5)

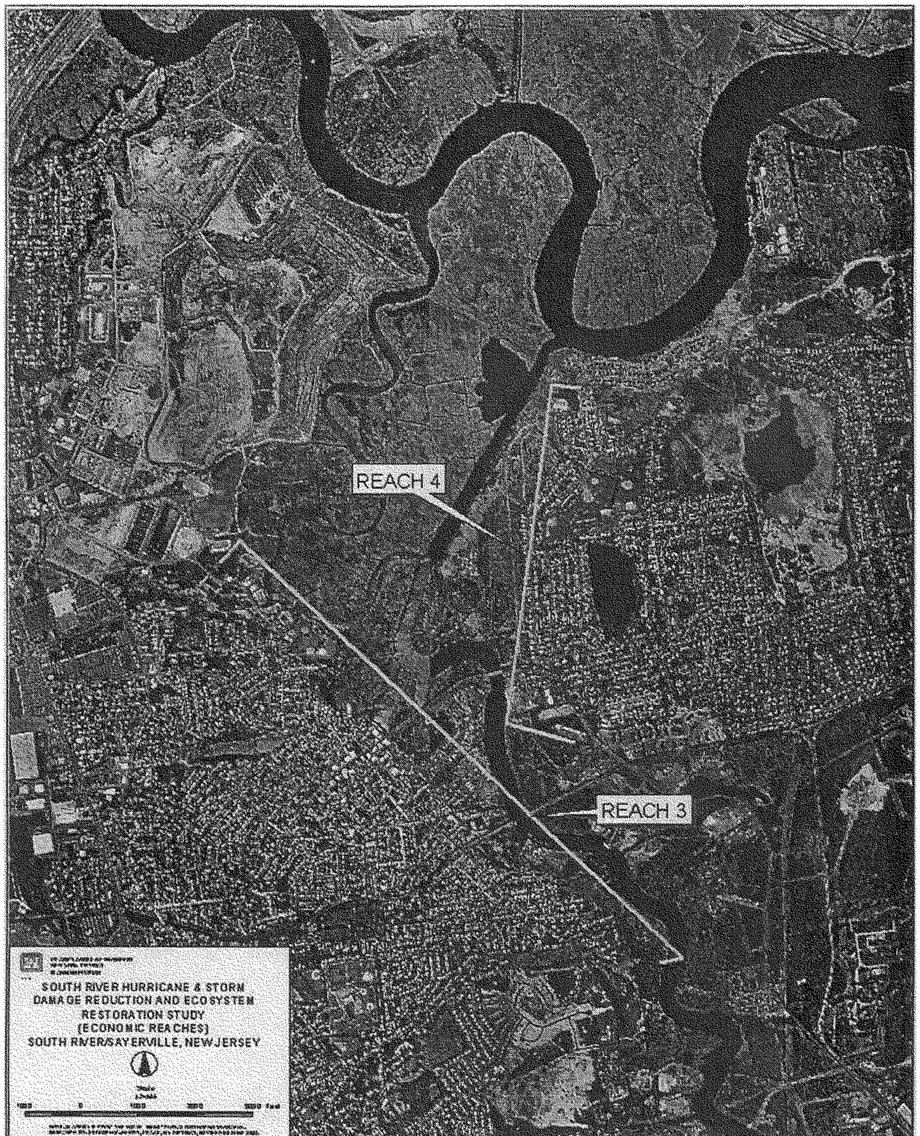


FIGURE 4b
DAMAGE REACHES (3 & 4)

The five reaches are delineated as follows:

- Reach 1: Right bank of the South River in Old Bridge Township.
- Reach 2: Left bank of the South River in the Historic Village of Old Bridge immediately downstream of Reach 1.
- Reach 3: Left bank of the South River in the Borough of South River.
- Reach 4: Right bank of the South River and the Washington Canal in the Borough of Sayreville, across from Reach 3.
- Reach 5: Right bank of South River just downstream from the Historic Village of Old Bridge (Reach 2).

Reach 1 (Old Bridge Township), Reach 2 (Village of Old Bridge), and Reach 5 (East Brunswick Township) are upstream reaches. Reach 3 (Borough of South River) and Reach 4 (Borough of Sayreville) are downstream reaches.

Figures 4a and 4b illustrate the mature development and dense population of the study area. Table 14 presents the result of the inventory of flood-prone structures in the 100-year and 500-year floodplains. As indicated in this table, there are 1,399 residential and 198 non-residential structures in the 500-year floodplain. For additional information about the inventory of flood-prone structures, see the Economics Appendix (Appendix E).

The without-project future condition for the flood-prone areas within the study area assumes a stable level of development. Since floodplain regulations minimize new construction in areas that are subject to damage by the 100-year flood, it was assumed that future reallocations of new residential, commercial, and industrial uses are not likely. If the areas are considered to remain a viable segment of the respective communities in the future, the most probable future is expected to be one of a stable, nearly fully-developed floodplain with relatively few new developments.

Table 14
Residential & Nonresidential Structures in the 100-year and 500-year Floodplains

			Residential Structures By Reach*			
Floodplain	**R1**	**R2**	**R3**	**R4**	**R5**	**Total**
100-year	27	65	400	400	57	1,082
500-year	64	109	452	452	57	1,399
			Non-Residential Structures By Reach			
Floodplain	**R1**	**R2**	**R3**	**R4**	**R5**	**Total**
100- year	0	10	26	26	2	165
500-year	2	16	26	26	2	198

* Reach numbers denoted by "R"

6.1.2.2 Water Surface Elevations and Hurricane and Storm Damage Potential

Table 15 and Table 16 present the water surface elevations with standard deviations associated with various flood events under Year 2000 and Year 2059 without-project conditions. The Year 2059 water surface elevations in Tables 15 and 16 reflect a 0.826 foot increase in sea level at the study area during the 50-year period of analysis. A storm surge model incorporated sea level rise into storm surge water surface elevations. Based on the analysis, the sea level is expected to rise 0.014 feet per year. Development of the storm surge model and estimation of the effects of sea level rise are presented in the Hydrology, Hydraulics, and Design Appendix (Appendix A). This appendix also included detailed discussions of statistical procedures used to account for uncertainty in estimation of water surface elevations associated with storm events of specific exceedance probabilities.

Table 15
Reaches 3 and 4
Water Surface Elevations
Without Project Conditions (2000, 2059)

Exceedance Probability	Water Surface Elevation Year 2000 (feet NGVD)	Standard Deviation (feet)	Water Surface Elevation Year 2059 (feet NGVD)	Standard Deviation (feet)
0.5	6.9	0.43	7.7	0.43
0.2	8.7	0.63	9.5	0.62
0.1	10.1	1.33	10.9	1.33
0.04	11.9	1.58	12.7	1.57
0.02	13.3	2.13	14.1	2.13
0.01	14.7	3.14	15.5	3.13
0.005	16.1	3.46	16.9	3.46
0.002	18	2.77	18.8	2.77

6.1.2.3 Structural Hurricane and Storm Damage Reduction Measures

Based on the physical layout of the study area, the flood hydrology, and the profiles of structures at risk, it was determined that the following structural HSDR measures could potentially be applied to flooding problems associated with hurricanes and other storms in the study area: (1) floodwalls and levees, (2) storm surge barrier, (3) stream modification, and (4) detention basin. These structural measures are described below.

Floodwalls and Levees: Floodwalls and levees are intended to provide protection against flooding to homes, commercial buildings, municipal buildings, roadways and bridges. While floodwalls and levees provide a cost-effective means to prevent flooding of low-lying areas, interior drainage facilities are required to handle stormwater ponding behind them.

Table 16
Reaches 1, 2, and 5
Water Surface Elevations
Without Project Conditions (2000, 2059)

Exceedance Probability	Water Surface Elevation Year 2000 (feet NGVD)	Standard Deviation (feet)	Water Surface Elevation Year 2059 (feet NGVD)	Standard Deviation (feet)
0.5	7.2	0.41	8	0.41
0.2	9	0.85	9.8	0.85
0.1	10.4	1.29	11.2	1.29
0.04	12.2	1.66	13.1	1.66
0.02	13.6	2.28	14.5	2.28
0.01	15	3.48	15.9	3.48
0.005	16.4	3.34	17.3	3.34
0.002	18.3	2.64	19.1	2.64

Storm Surge Barrier: Storm surge barriers are designed to reduce damages associated with storm surges. Storm surge barriers provide storm surge flood protection to all structures located upstream of the barrier. While the storm surge barrier provides flood protection against storm surges, it will not address fluvial flooding generated by runoff from the basin upstream of the barrier. The barrier traps watershed runoff behind it, requiring interior drainage facilities.

Stream Modifications: Stream modifications are used to protect communities against riverine flooding and stream blockages. Stream modifications can include dredging, channel deepening and widening, as well as modification of bridge and culvert openings. While stream modifications can be an effective means to prevent fluvial flooding, they are not effective against tidal flooding conditions and were dropped from further consideration.

Detention Basins: Detention basins are used to attenuate the peak flow rate of run-off by temporarily storing large volumes of stormwater, then releasing them at a controlled rate of flow. While detention basins can be an effective means to lowering stream water surface elevations, they are only effective against riverine flooding and were dropped from further consideration.

6.1.2.4 Nonstructural Hurricane And Storm Damage Reduction Measures

Nonstructural measures were fully considered in plan formulation. However, nonstructural measures were screened out early in plan formulation due to: (1) the number, age, condition, and location of flood-prone structures in the study area as identified through the inventory of flood-prone structures and (2) water surface elevations associated with storm surges of various probabilities of exceedance. Some nonstructural measures were identified as potentially applicable to HSDR in South River communities, including: (1) acquisition of flood-prone property, (2) floodplain zoning, (3) floodproofing, and (4) flood warning. These nonstructural measures are described below.

Acquisition of Flood-Prone Properties: Permanent evacuation of the floodplain 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.

Floodplain Zoning: Through proper land use regulation, floodplains can be managed to ensure that their use is compatible with the severity of a flood hazard. Several means of regulation are available, including zoning ordinances, subdivision regulations, and building and housing codes. Their purpose is to reduce losses by controlling the future use of floodplain lands. As indicated above, the Boroughs of Sayreville and South River and the Townships of Old Bridge and East Brunswick already participate in the National Flood Insurance Program and manage floodplain land uses consistent with the program. Most of the buildings in the study area were built prior to the adoption of zoning and are not subject to current floodplain zoning regulations. Therefore, zoning can not be considered independently of as a long-term mitigation solution for hurricane and storm damage to existing structures. However, it is a necessary component of a comprehensive hurricane and storm reduction plan.

Floodproofing: Floodproofing is a body of techniques for reducing hurricane and storm damages by adjustments to structures and to building contents. It involves keeping water out of the structure, as well as reducing the effects of inundation. Nonstructural adjustments, such as elevating structures, can be applied by an individual or as part of a collective action either when flood-prone buildings are under construction or through retrofitting of an existing structure.

Flood Warning: Flood warning systems can be utilized to warn property owners of pending floods and provide time for their evacuation and relocation of movable property subject to hurricane and storm damage. Although a state-of-the-art flood warning system would increase the awareness of the citizenry and allow for a more orderly evacuation of residents, a warning system alone would not provide sufficient time to significantly reduce hurricane and storm damages.

6.1.3 Alternative Mitigation Measures

As required by NEPA, all practicable means should be taken to avoid and minimize environmental damages. Consequently, the proposed levee/floodwall was specifically sited in upland areas wherever possible. However, in some areas it was necessary to locate portions of the selected plan in wetlands due to the developed nature of the area and a lack of available space. The alignment in these wetland areas was further refined to avoid natural features such as great blue heron and great horned owl nests, and to minimize wetland impacts. In addition, a detailed mitigation plan was developed to offset the adverse and unavoidable impacts associated with the selected plan.

The mitigation goal was to develop an array of mitigation alternatives/actions that individually or combined will replace at least 100% of the combined loss of Average Annual Habitat Units (AAHUs) summed across evaluation species, 100% of the Functional Capacity Units (FCUs) summed across wetland functions, and at least 50% of the loss of AAHUs per evaluation species and 50% of the FCUs lost per function, as a result of implementation of the selected HSDR measures. The process of identifying alternative mitigation measures involved: determining which areas would best be suited for mitigation, and conducting a preliminary screening to identify measures with potential applicability to this planning context. These activities are summarized below.

6.1.3.1 Mitigation Areas

To facilitate the formation of mitigation plans, the study area was divided into on-site and off-site components. Three onsite mitigation areas were evaluated: (1) on the island, (2) on the East Bank (east of the Washington Canal and adjacent to an existing NJDOT mitigation site), and (3) on the West Bank (to the west and south of the South River). The island area was removed from consideration as a potential area for onsite mitigation due the difficulty of access and the associated costs of mobilization/demobilization of construction equipment.

A total of eight offsite areas were evaluated as potential mitigation sites; however, these sites were eliminated from further consideration based on the following conditions:

- Low potential for ecological improvement (*i.e.*, poor hydrologic conditions);
- Acquisition issues (*i.e.*, designated as a superfund site or landfill);
- Significant costs associated with offsite mitigation activities (*i.e.*, mobilization/demobilization costs will be higher and mitigation activities will take place separately from flood control construction activities); and,
- Distance from the impact area (*i.e.*, in order to preserve the ecological integrity of an area, mitigation areas should be located as close as possible to impact areas).

6.1.3.2 Potential Mitigation Measures

To achieve the mitigation goal, a screening analysis was conducted to evaluate the feasibility of the following three potential mitigation measures:

1) Improvement/enhancement of the available habitat on the proposed levee (*e.g.*, plant shrubs to improve songbird habitat);

2) Improvement/enhancement of existing habitats (*e.g.*, increase the density/cover of the vegetation by planting more shrubs and/or herbaceous species); and,

3) The conversion of one habitat/cover type to another more valuable habitat (*e.g.*, convert areas of *Phragmites* to salt marsh or wetland scrub-shrub).

6.1.4 Alternative Ecosystem Restoration Measures

The process of identifying alternative ecosystem restoration measures involved dividing the study area into restoration areas and conducting a preliminary screening to identify measures with potential applicability to this planning context. These activities are summarized below.

6.1.4.1 Restoration Areas

To facilitate formulation of ecosystem restoration plans, the study area was divided into five areas (Figure 5; note: Area 6 is a mitigation area). Three areas are located on Clancy Island: Area 1 (149.6 acres), Area 2 (195.9 acres), and Area 3 (56.8 acres). Area 4 (119.2 acres) is an undeveloped marsh located adjacent to the Sayreville/South River Bridge.

Area 5 is an undeveloped, highly disturbed area located east of the Washington Canal, between the canal and a residential community. Based on field surveys, Area 5 appears to be situated on historic dredge material that was placed during the original dredging of the Washington Canal. This site is dominated by upland habitats, including upland disturbed, upland scrub-shrub, and upland herbaceous. Area 5 has been removed from consideration as a potential restoration site for the reasons outlined below:

- The predominant cover type is upland scrub-shrub, which is desirable for migratory bird habitat,
- Structural HSDR measures (*e.g.*, levees) for Sayreville would bisect the area, limiting the restoration potential of the site,
- Excavation of material in Area 5 would not be economically feasible due to the high volume of material and the shortage of nearby disposal sites,
- The area is currently the most ecologically diverse site within the study area, and
- A portion of this area (approximately 20 acres) has recently undergone ecosystem restoration as part of the NJDOT mitigation project described previously.

6.1.4.2 Potential Restoration Measures

Restoration of the tidal wetlands, aquatic environs, and uplands characteristic of a *Phragmites*-dominated mid-Atlantic mesohaline estuary, such as the South River study area, would typically involve the following measures:

- Control *Phragmites* via excavation, burning, spraying, or other measures,
- Prepare potential wetland areas (*e.g.*, excavate soil material to establish salt marsh hydrology favorable to *Spartina* and poorly-suited for *Phragmites),*
- Regrade existing channels and mosquito ditches (*e.g.*, to promote salt marsh hydrology, increase fish habitat, and restore edge communities), and
- Plant native vegetation to speed restoration and prevent re-establishment of *Phragmites.*

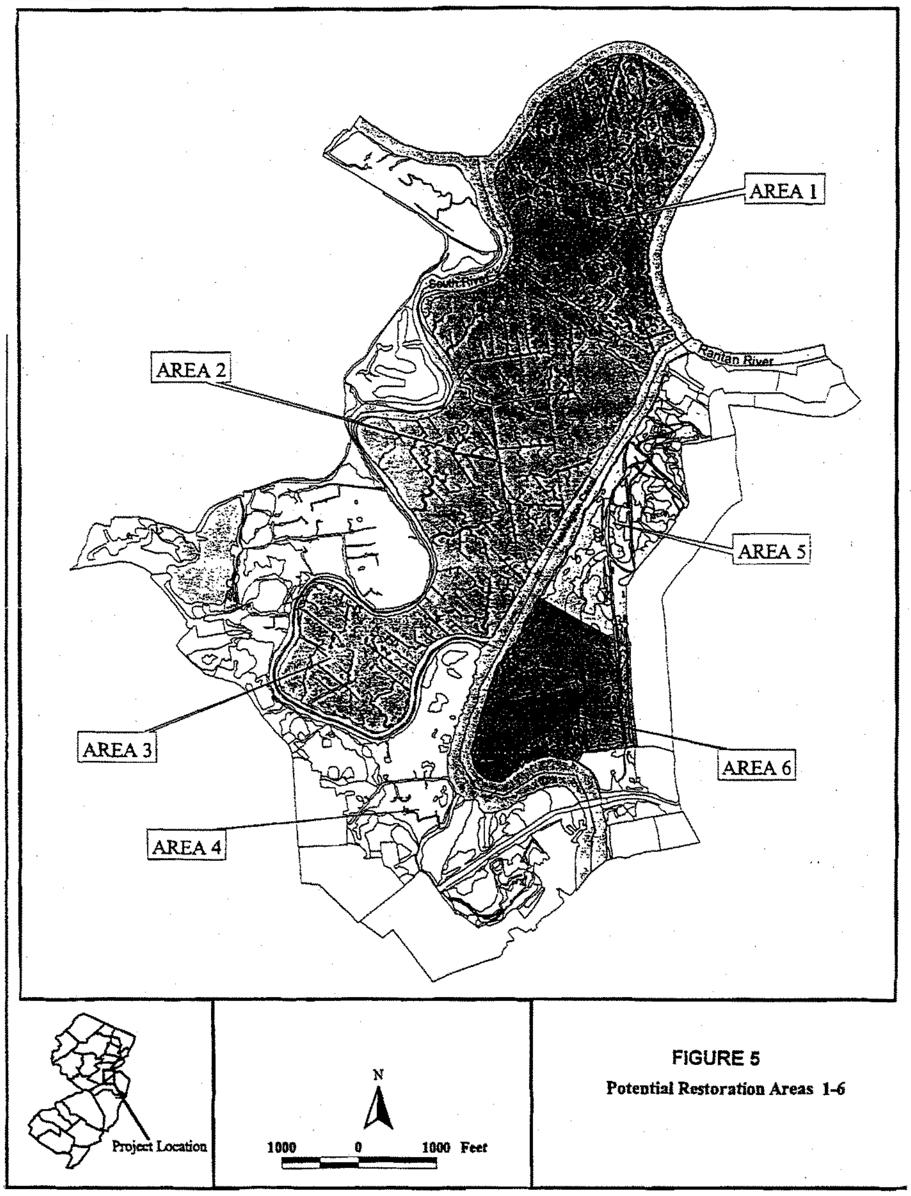


FIGURE 5
Potential Restoration Areas 1-6

6.2 Screening of Alternative Plans

Screening alternative plans includes an assessment of the potential engineering, economic, environmental, institutional, public, financial, and institutional feasibility of alternative HSDR and ecosystem restoration measures. Those plans that are not screened out are carried forward for more detailed analysis. The process and results of screening of alternative plans are discussed below. The no-action alternatives for HSDR and ecosystem restoration were the first alternatives to be screened out, since they would not meet the planning objectives for the study area.

6.2.1 Screening of Alternative Hurricane and Storm Damage Reduction Plans

On the basis of a preliminary feasibility assessment, several structural alternatives for HSDR were screened out early in plan formulation. Specifically, stream modification and detention basins were eliminated from more detailed study, since they would not provide protection from storm surges, which are the primary cause of hurricane and storm damages.

Analysis of the nonstructural measures to reduce hurricane and storm damages eliminated most of these measures as potential stand-alone alternatives. However, some measures were carried forward as potential complements to structural measures. The screening of nonstructural measures is summarized below:

- Floodplain Zoning: It was concluded that floodplain zoning would not be effective, since most of the floodplain was developed before community participation in the National Flood Insurance Program.

- Floodproofing: With 1,247 structures in the 100-year floodplain, floodproofing was found to be prohibitively expensive, since a majority of structures would require costly raising. In addition, floodproofing can create a false sense of security and discourage timely evacuations.

- Flood warning: warning systems can be utilized to warn property owners of pending floods and provide time for their evacuation and relocation of movable property subject to flood damage. Although a state-of-the-art flood warning system would increase the awareness of the citizenry and allow for a more orderly evacuation of residents, a warning system alone would not provide sufficient time to significantly reduce property damages due to flooding.

- Acquisition: permanent evacuation of the floodplain involves acquisition of land and structures by fee purchase or by exercising powers of eminent domain. With 1,247 structures in the 100-year floodplain, the depreciated replacement cost of structures (approximately $224 million) and relocation costs make acquisition prohibitively expensive.

As a result of the screening process, three nonstructural measures (acquisition, floodproofing, and flood warning) were carried forward as potential complements to the levee/floodwall alternative for protection of upstream areas, if a storm surge barrier was not feasible (technically, economically, or institutionally). Specifically, these nonstructural alternatives (in the Historic Village of Old Bridge) were being considered to work in conjunction with the "levees/floodwalls only" option for protection in Reach 3 and Reach 4.

Consequently, the initial screening of HSDR alternatives resulted in the following structural and nonstructural measures being carried forward for more detailed investigations: (1) storm surge barrier, (2) floodwalls and levees, (3) acquisition of flood-prone properties, (4) floodproofing, and (5) flood warning.

6.2.2 Screening of Alternative Mitigation Plans

As described in the *South River Impact Assessment and Mitigation Analysis* (USACE 2002), the mitigation goal was to develop an array of mitigation alternatives/actions that individually or combined will replace at least 100% of the combined loss of Average Annual Habitat Units (AAHUs) summed across evaluation species, 100% of the Functional Capacity Units (FCUs) summed across wetland functions, as a result of implementation of the selected HSDR measures. Given the difficulty in assessing trade-offs of AAHUs among indicator species and of FCUs among different wetland functions, the mitigation goal also included replacing a minimum of 50 percent of the total AAHUs lost per indicator species and 50% of the FCUs lost per function.

Based on the three potential mitigation measures identified in Section 6.1.3.2, it was determined that levee improvements, such as planting shrubs on the landward side of the levee to create upland scrub-shrub habitat, would increase the quality of the habitat for wildlife, and would reduce the overall impacts of the selected plan. It was also determined that improvements of existing habitat would not be possible. Therefore, habitat conversion would be necessary to mitigate for HSDR activities. Two potential mitigation areas that contained wetland *Phragmites* and upland disturbed habitat were identified - the East Bank and the West Bank (Section 6.1.3.1). Evaluation of habitat conversion alternatives resulted in the selection of five potential habitat conversions in each area:

East Bank

Wetland *Phragmites* (WPH) to	Salt Marsh (SM)
	Wetland Scrub-Shrub (WSS)
	Wetland Herbaceous/Scrub-Shrub (WHSS)
Upland Disturbed (DIST)	Wetland Scrub-Shrub (WSS)
	Wetland Herbaceous/Scrub-Shrub (WHSS)

West Bank

Wetland *Phragmites* (WPH) to	Salt Marsh (SM)
	Wetland Herbaceous/Scrub-Shrub (WHSS)
Upland Disturbed (DIST)	Wetland Scrub-Shrub (WSS)
	Wetland Herbaceous/Scrub-Shrub (WHSS).

All possible combinations of the five habitat conversions, from zero to 20 acres, or 200 percent (which is a ratio of 2:1) of the wetland acres impacted by the selected plan, were evaluated, creating 53,130 potential mitigation alternatives. Results from the HEP and EPW assessments were used to calculate outputs for each mitigation alternative. Those alternatives that resulted in no net gain in ecological or wetland functional value were eliminated from further analysis. This screening resulted in 15,837 potential mitigation alternatives for the East Bank and 230 for the West Bank.

6.2.3 Screening of Alternative Ecosystem Restoration Plans

Early in ecosystem restoration plan formulation, 11 restoration options were identified as having potential application to the study area. These options consisted of alternative habitat types that could be established or restored in the South River study area. They were evaluated using the following parameters: potential ecological benefits, methods of implementation, requirements for success, performance standards, and potential costs. The options were then ranked according to ecological benefits, engineering constraints, environmental constraints, and likelihood of success. The score assigned to the potential benefits of each habitat was weighted according to the restoration objectives. Based on this initial screening, the following four highest-scoring habitat types were selected for detailed consideration:

- Low emergent marsh,
- Intertidal mudflat,
- Wetland forest shrub-scrub, and
- Open water (*i.e.*, tidal creeks and tidal ponds).

6.2.3.1 Combinations of Restoration Measures into Alternative Plans

As described in detail in the *South River Ecosystem Restoration Plan* (USACE, 2001), potential combinations of these four priority habitats were then generated by combining them in different ratios (using 5 percent, 10 percent, 15 percent, 20 percent, 30 percent, 40 percent, 50 percent, 60 percent, 70 percent, and 80 percent) that added up to 100 percent. The only cover type targeted for conversion was wetland *Phragmites*. To promote habitat diversity, all four habitats were included in each combination. Also, the analysis was limited to a minimum of 5 percent and a maximum of 50 percent of each habitat type considered for each restoration option except for salt marsh, because of its designation as a priority wetland in New Jersey. The result was 167 possible habitat "ratio combinations." These combinations were applied to the four restoration areas at four "scales" of restoration (25 percent, 50 percent, 75 percent, and 100 percent). The scales refer to the percent of degraded acreage to be restored in each area. The result was 16 restoration "scenarios" (four scales of restoration in four areas).

The 167 ratio combinations were applied to each restoration scenario, and the ecological outputs in AAHUs for the 50-year period of analysis were calculated using the Habitat Evaluation Procedures (HEP). The process that was used to identify the ecological outputs (*i.e.*, AAHUs) of each ratio combination for each restoration scenario is described below:

1) Calculate the acreages for all 16 restoration scenarios based on the percent of each habitat type identified in the 167 ratio combinations, resulting in 167 habitat type acreage combinations for each restoration scenario.

2) Multiply the HSI values for the targeted habitat types by the acreages to calculate the number of HUs for each of the six selected species.

3) Add the HUs for all six species together to obtain total HUs attributable to restoration for each ratio combination for each restoration area.

4) Subtract the number of future HUs associated with the future no-action condition of wetland *Phragmites* (HSI for *Phragmites* multiplied by the number of acres restored) from the total number of HUs attributable to restoration. The difference (net gain or loss) in HUs was used to calculate the number of AAHUs for all 167 ratio combinations for each restoration scenario.

5) Eliminate the ratio combinations for which implementation would result in a negative AAHU (*i.e.*, no net gain or ecological output) from further analysis, resulting in 131 ratio combinations for Areas 1-3 and 145 ratio combinations for Area 4.

6.2.3.2 Potential Effects of Sea Level Rise

The advantages and disadvantages of addressing sea level rise as part of plan formulation were discussed. It was concluded that without accurate sediment accretion rate data, incorporating sea level could lead to erroneous conclusions. That is, since tidal marsh systems constantly accumulate dead organic material and, without a change is sea level, would actually increase their elevation, not accounting for this process could overestimate the effects of sea level rise. Consequently, it was decided to defer studies of sea level rise as part of the restoration effort to the PED Phase. In that phase, studies would be conducted to measure both sediment accretion and average sea level rise on-site, so that this information can be used in the existing hydrodynamic model to predict potential changes in flood frequency and duration and their effects on cover types and their corresponding elevations.

Regardless of the results of the on-site studies, the AAHUs attributable to alternative plans do not rely on the assumption that sedimentation rates are the same as the expected rate of sea level rise during the course of the project life. If, after additional study and analysis in the PED phase, it is found that sediment accretion will not keep pace with projected sea level rise (or, conversely, that sediment accretion will exceed projected sea level rise) then the elevation for each plant community cover type will be adjusted accordingly. That is, for different alternatives, factoring in sea level rise will not result in changes to plant community cover type acreages (and therefore no changes in corresponding AAHUs).

6.3 Plan Evaluation and Comparison

For those HSDR and ecosystem restoration plans that were carried forward from the initial screening of alternatives, more detailed studies evaluated their engineering and economic feasibility, environmental impacts, social consequences, institutional acceptability (by regulatory agencies), local support (by the non-Federal partner), and public acceptability. As part of the evaluation, the completeness, efficiency, effectiveness, acceptability, and risk and uncertainty of the plans were assessed.

6.3.1 Intermediate and Final Evaluation & Comparison of Hurricane and Storm Damage Reduction Plans

The HSDR alternatives were evaluated and compared on the basis of their costs, benefits, and other effects. Hydraulic studies were conducted to evaluate the performance of the final alternative plans. Criteria used for that evaluation include a frequency-of-occurrence and error analysis for each design feature. In addition, influences that the plans may have on the South River and Raritan River were also identified. Nonlinear interactions that final design features might have on hydrodynamics were also evaluated.

Intermediate alternative HSDR plans were initially evaluated using a tidal flood event with a 1 percent chance of being exceeded in any year, excluding sea level rise and uncertainty (*i.e.*, a 100-year recurrence interval).

6.3.1.1 Costs of Alternative Hurricane and Storm Damage Reduction Plans

Preliminary cost estimates, which were utilized for preliminary screening of alternative plans, were prepared using February 1998 price levels. Initial levee costs were based on the reuse of required levee excavation for levee embankment fill which will be supplemented by trucked-in embankment fill. The required impervious materials were assumed to be trucked from a Sayreville clay quarry averaging approximately three miles in distance. Erosion control costs were included to account for the prevention of channel sedimentation from construction activities.

In order to provide a fair basis for economic cost comparisons, preliminary estimates of wetland mitigation costs and structure acquisition costs were included. Estimated wetland mitigation costs included $100,000 per acre of wetlands directly impacted by plan features. Based on structures typical of the area, an average cost of $169,000 per structure was assumed for the analysis of acquisition plans.

Cost estimates for alternatives along the South River were based on calculated quantities and unit prices. Operations and maintenance (O&M) costs were estimated based on the anticipated conditions over a 50-year project life.

*6.3.1.2 Benefits of Alternative Hurricane and Storm Damage Reduction Plans / * Risk-Based Analysis*

Benefits from HSDR measures at South River would include hurricane and storm damages avoided over the 50-year period of analysis and reduced flood insurance administration costs. These benefits are based on the differences between the with- and without-project future conditions. Hurricane and storm benefits are the average annual value of the private and public damages that would be prevented by a project and reduction in average annual emergency costs and average annual maintenance as a result of flooding. Benefits derived from reduced flood insurance administration costs include the annual portion of administrative cost included in National Flood Insurance Program (NFIP) premiums of study area structures.

Hurricane and storm damages under future with- and without-project conditions were estimated through: (1) an inventory of floodplain development, (2) estimation of depreciated structure replacement costs and content damages, (3) preparation of generalized stage-damage functions, and (4) combination stage/frequency relationships and stage/damage relationships into frequency/damage relationships. The process and results of benefit estimation for South River, which are described in detail in the Economics Appendix (Appendix E), are summarized below.

As indicated in Table 14, there are 1,247 structures (1,082 residential and 165 non-residential) in the 100-year floodplain within the study area. An inventory of all flood-prone properties in the study area showed that these structures have a total depreciated replacement value of approximately $224,000,000 (estimated using procedures from Means Square-Foot Costs).

Detailed surveys of residential structures (two percent of residential structures) and commercial structures (five percent of commercial structures) were conducted through interviews of owners and a detailed examination of the structure to estimate damage potential. Current FIA depth-percent damage functions were used for all floodplain structures.

Table 17 presents total hurricane and storm damages by reach expected to result from storm surges of various probabilities of exceedance. As shown in this table, expected damages were estimated for 2000 (current), 2010 (base year), and 2059 (final year) were developed. The hurricane and storm damages were estimated by combining the inventory of flood-prone structures with water surface elevations anticipated to accompany storm surges of various probabilities of exceedance. The total hurricane and storm damages associated with each event represent a combination of structure and content damages for residential and commercial structures, automobile damages, and public emergency costs. In the Economics Appendix (Appendix E), these damage categories are tabulated for each damage reach under 2000 and 2059 conditions.

The damage estimates in Table 17 are average annual damages and represent the result of the interval calculation up to the exceedance probability shown for each row of the table. For example, the total damages of $1,052,580 shown to be associated with a 0.200 exceedance probability for Year 2000 in Table 17 are not the damages from a 0.200 exceedance event (5 year flood). Rather the damages shown are the summation of average annual damages up to the 0.200 exceedance probability event.

Table 18 average annual equivalent damages anticipated under without-project conditions over the 50-year period of analysis. As for Table 17, the damage estimates in Table 18 are average annual damages, representing the result of the interval calculation up to the exceedance probability shown for each row of the table. Table 19 provides a representative illustration of the distribution of average annual damages among the three damage categories (*i.e.*, structures and contents, automobile, and public emergency) for a storm with an exceedance probability of 0.01. Table 20 presents residual damages for the range of levels of protection considered in this investigation.

Table 17
Total Hurricane And Storm Damages* By Reach
Expected Under Without-Project Conditions
2000, 2059
October 2001 Price Levels

Exceedance Probability	R1	R2	R3	R4	R5	Total
Year 2000						
0.5	$16,900	$1,600	$382,700	$188,700	$2,400	$592,300
0.2	$56,000	$38,500	$1,681,800	$707,000	$23,600	$2,506,900
0.1	$81,700	$81,100	$2,845,400	$1,110,400	$49,300	$4,168,000
0.04	$109,500	$143,600	$4,027,400	$1,577,500	$90,500	$5,948,500
0.02	$125,400	$184,000	$4,500,800	$1,825,100	$117,300	$6,752,700
0.01	$138,000	$216,800	$4,828,500	$1,998,300	$137,900	$7,319,400
0.005	$146,900	$239,800	$5,169,400	$2,111,600	$151,500	$7,819,200
0.002	$153,900	$258,000	$5,335,500	$2,197,000	$161,800	$8,106,200
SPF**	$159,200	$271,700	$5,460,600	$2,260,900	$169,500	$8,322,000
Year 2059						
0.5	$29,000	$18,300	$654,600	$353,800	$7,000	$1,062,700
0.2	$85,500	$91,800	$2,678,900	$1,149,400	$47,900	$4,053,500
0.1	$119,400	$158,300	$4,297,300	$1,694,000	$90,100	$6,359,200
0.04	$154,200	$242,600	$5,803,700	$2,274,700	$146,000	$8,621,300
0.02	$173,500	$293,200	$6,374,700	$2,569,000	$179,500	$9,589,900
0.01	$188,400	$332,000	$6,761,400	$2,768,000	$203,400	$10,253,300
0.005	$198,700	$358,700	$7,157,600	$2,894,300	$218,900	$10,828,200
0.002	$206,800	$379,600	$7,345,900	$2,987,100	$230,500	$11,149,900
SPF	$213,000	$395,500	$7,485,800	$3,055,900	$239,100	$11,389,300

Table 18
Average Annual Damages by Reach
Without-Project Conditions
2010-2059
October 2001 price levels; 6 1/8% discount rate

Exceedance Probability	R1	R2	R3	R4	R5	Total
0.50	$23,100	$8,800	$521,700	$256,400	$4,500	$814,600
0.20	$72,100	$63,700	$2,208,600	$887,900	$35,500	$3,267,700
0.10	$102,800	$118,900	$3,639,900	$1,376,900	$69,700	$5,308,200
0.04	$135,200	$194,500	$5,029,100	$1,861,000	$119,800	$7,339,500
0.02	$153,500	$241,700	$5,573,000	$2,127,100	$151,100	$8,246,400
0.01	$167,900	$279,000	$5,945,800	$2,310,400	$174,400	$8,877,400
0.005	$177,900	$305,000	$6,331,100	$2,428,800	$189,600	$9,432,300
0.002	$185,800	$325,500	$6,516,800	$2,516,900	$201,100	$9,746,100
SPF	$191,800	$341,000	$6,655,800	$2,582,600	$209,700	$9,981,000

Table 19
Average Annual Damages By Category and Reach
Storm with .01 Exceedance Probability
2010-2059
October 2001 price levels; 6 1/8% discount rate

Damage Category	R1	R2	R3	R4	R5	Total
Structures & Contents	$161,400	$268,200	$5,233,900	$2,210,400	$164,100	$8,037,900
Automobile	$4,000	$6,900	$647,800	$66,700	$7,600	$733,100
Public Emergency	$2,500	$3,900	$64,100	$33,300	$2,600	$106,400
Total	$167,900	$279,000	$5,945,800	$2,310,400	$174,300	$8,877,400

Table 20
Prevented and Residual Equivalent Annual Damages
With Project Conditions
October 2001 price levels; 6 1/8% discount rate

Exceedance Probability	Total Prevented Equivalent Annual Damages	Residual Damages at Level of Protection
0.500	$814,600	$9,166,400
0.200	$3,267,700	$6,713,300
0.100	$5,308,200	$4,672,800
0.040	$7,339,500	$2,641,500
0.020	$8,246,400	$1,734,600
0.010	$8,877,400	$1,103,600
0.005	$9,432,300	$548,700
0.002	$9,746,100	$234,900
SPF	$9,981,000	$0

Corps planning guidance requires that risk and uncertainty be incorporated in HSDR studies. The following areas of uncertainly were incorporated into the estimation of hurricane and storm damages (with- and without-project):

- Depth-damage curves,
- First-floor elevation,
- Structure values, and
- Content-to-structure values.

The *@Risk* program was used to incorporate uncertainty from damage input variables into the analysis. The process applies a procedure (Monte Carlo Simulation) that computes the expected value of damage while accounting for uncertainty in each input variable.

Emergency cost curves from the Corps Green Brook, NJ feasibility study for flood damage reduction have been adjusted for this analysis based on coordination with local governments in the study area. FEMA and local governments have been contacted to determine the percentage of floodplain structures that have flood insurance. Savings in administrative costs were calculated accordingly.

Stage-frequency elevations are the mean water surface elevations heights and their associated standard deviations that were incorporated in the *@RiskNormal* function. Damages in years 2010 through 2058 were interpolated and discounted and the 50 years were amortized at a discount rate of 6.125 percent to calculate equivalent annual damages. Generalized FEMA damage functions for structure and contents damages were applied to the residential and non-residential structures. Public emergency damages were calibrated as a percentage of structure value based on local FEMA damage reports. The damage functions reflect damages as a percent of structural value over a full range of water depths and were applied on a structure-by-structure basis to determine damages at one-tenth-of a foot increments of flood stage. Similarly, depth damage functions developed by the Natural Resource Conservation Service were applied to calculate automobile damages.

On-site interviews were conducted in the study area. However, so much time has passed between the most significant flood event in 1992 and the interviews, that memories had faded and as a consequence the kind of numeric information necessary to perform the calibration of the stage damage function was not generated. Consequently, the FEMA stage-damage function was used.

The storm damages were broken down into three categories: structure and content damage, public emergency costs and infrastructure damage, and automobile damage. The size of the database spreadsheet necessitated that the commercial/municipal and residential structure/content damages to be consolidated into one output when performing risk analysis.

6.3.1.3 Intermediate Hurricane and Storm Damage Reduction Plans

Based on the screening of alternative HSDR plans, three plans were carried forward for more detailed analysis: storm surge barrier, levees and floodwalls, and potentially-complementary nonstructural measures (*i.e.*, acquisition of flood-prone properties, floodproofing, and flood warning). The more detailed studies considered different approaches to providing flood protection for each of the damage reaches. The results of the more detailed analyses of these plans are discussed below.

Intermediate Storm Surge Barrier Plan - Among the HSDR plans considered was a storm surge barrier plan, consisting of a storm surge barrier with sector gate and a levee perpendicular to the Washington Canal and the South River just upstream from their confluences of the Raritan River (see Figure 6). This alternative would provide 100-year flood protection for most of the study area. Elevation +15.5 feet NGVD was used to evaluate this alternative and the other alternatives during the intermediate screening. This elevation includes mean sea level rise but does not include hydraulic uncertainty. It would consist of a 200-foot long storm surge barrier in the Washington Canal to maintain the navigable waterway. It would also include approximately 2,500 feet of levee with an average height of 8.6 feet and an approximately 2,300-foot long

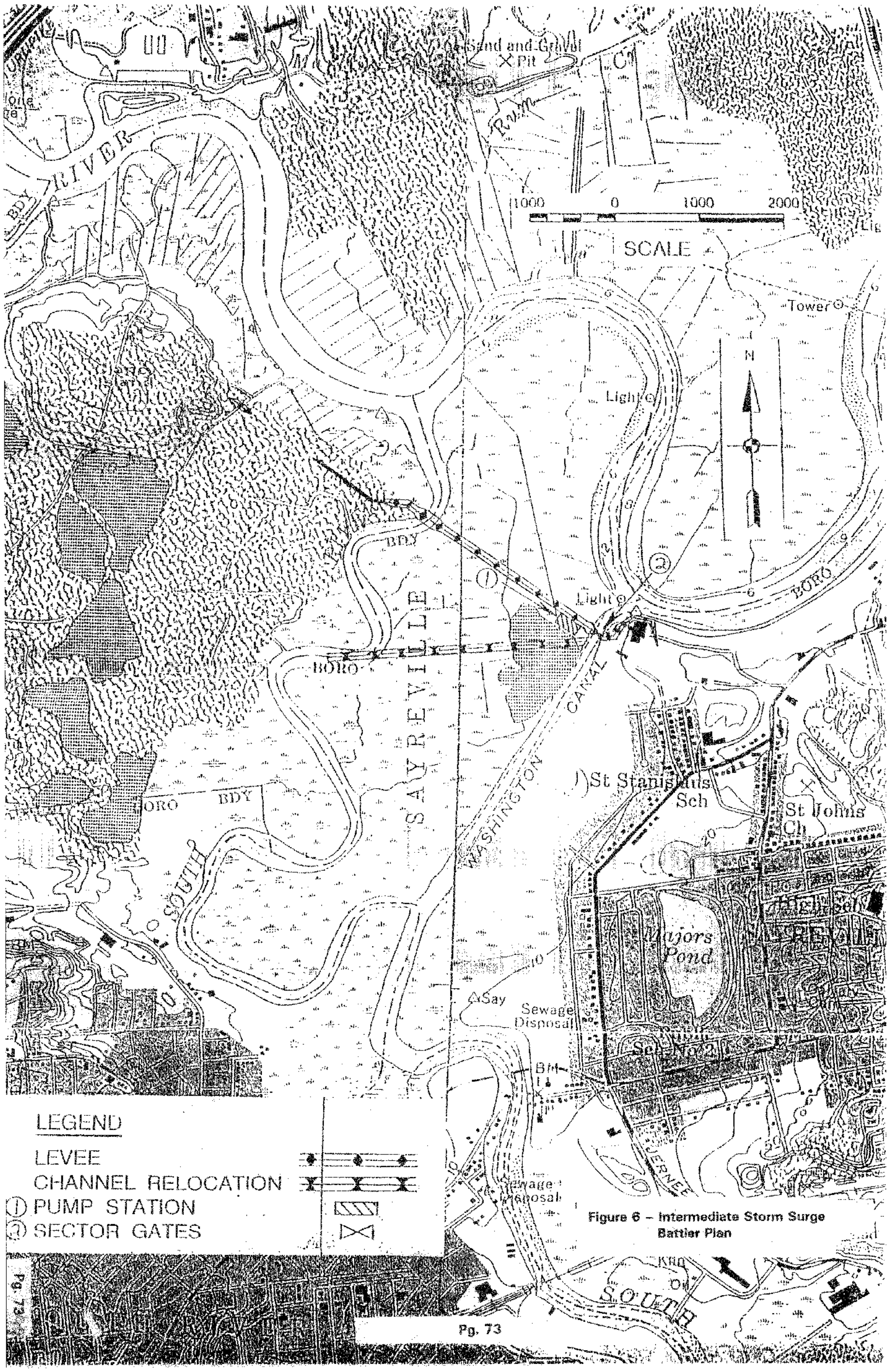


Figure 6 – Intermediate Storm Surge Battier Plan

diversion channel to divert flow from the South River channel to the Washington Canal. The storm surge barrier levee would tie into high ground east of the Washington Canal and west of the South River. The diversion channel would be needed to handle the flow from the South River, which would be blocked by the levee. The diversion channel would pass through the middle of Clancy Island. The channel was added to avoid the cost of an additional storm surge barrier across the South River. Under non-flood conditions, the storm surge gate would remain open, allowing the flushing of the Washington Canal and the South River while maintaining a navigable waterway. During flood stages, the gate would be closed. With the gate closed, the normal South River discharges would be impounded. Tidal modeling determined that a pump station for interior drainage would not be necessary due to the large storage capacity in the low-lying wetland area.

The primary impacts of this plan include: (1) loss of existing wetlands (approximately 36 acres) and existing uplands (approximately 5 acres) for the levee footprint and for the diversion channel across Clancy Island and (2) rerouting the flow of the South River to the Washington Canal. In addition, preliminary analysis indicated that this plan was not economically feasible. Based on the adverse environmental effects of this plan and its lack of economic feasibility, this plan was dropped from further consideration.

Intermediate Levee/Floodwall Plans - These plans could consist of all, or any combination, of five levee alignments consistent with the damage reaches described in above. Each of the levees/floodwalls could be constructed separately without disturbing the technical feasibility of the project. A separable component would also have to function on its own per Corps policies and guidance regarding urban HSDR.

Levees and floodwalls were aligned as efficiently as possible, to protect the groups of structures in each reach. Accordingly, lines-of-protection comprised of levee systems that could function separately were developed. Levee/floodwall systems are described below:

- Preliminary analysis assumed that the top of all levees would be +15.5 NGVD, as discussed above. A preliminary soil analysis has been performed to determine if levee layouts were on good soil or on poor soil. Non-marsh areas are considered good soil whereas marsh soil is considered poor soil.

- Levee Reach 1, located in the Spotswood area, would be approximately 3,000 feet in length.

- Reach 2, which is immediately east of Rt. 18, would provide protection for the Historic Village of Old Bridge. The Reach 2 levee length would be approximately 3,740 feet. Common to both Reaches 1 and 2 would be replacement of the Old Matawan Road Bridge with associated road raising of 4 feet. This plan component would also require channel realignment of 400 feet of the South River.

- Levee Reach 3, located along the west bank of the South River, would protect the Borough of South River. The total levee length would be approximately 8,410 feet, and would require a railroad bridge closure structure.

- Levee Reach 4, located along the east bank of the Washington Canal and the South River, would protect the Borough of Sayreville. The total proposed levee length for this reach is approximately 9,090 feet, and would require raising Jernee Mill Road by 2.6 feet to provide closure for the levee.

- Levee Reach 5, located near the confluence of Deep Run and the South River, would protect both sides of the Bordentown-South Amboy Turnpike. The total proposed levee length is approximately 7,240 feet. This plan (along with levee reach 2) would include: (1) raising the Bordentown-South Amboy Turnpike Bridge 6 feet over Deep Run, (2) raising of the Turnpike 6 feet, (3) sealing the bottom of the railway bridge, and (4) constructing 3.5 feet of parapets.

As indicated in Table 21, levee protection (for a 100-year event) of the upstream reaches (*i.e.*, Reaches 1, 2, and 5) would also not be economically feasible with costs greatly exceeding the benefits. These findings were discussed with the residents of Reaches 1, 2 and 5 on 28 January 1999 in the Historic Village of Old Bridge. Representatives of the communities along these reaches indicated that they would not support structural measures along these reaches. They requested additional analysis of nonstructural alternatives.

Evaluation of levee protection for upstream reaches (Reaches 1, 2 and 5) was conducted using best-case scenarios for levee construction costs. For example, it was assumed that only levees would be required (when, in fact, more expensive floodwalls and buyouts would be required due to proximity of homes to the South River). It was also assumed that interior drainage facilities would not be required. For the evaluation of benefits, it was assumed that all structures would be protected and that there would be no residual damages. Notwithstanding these best-case assumptions, benefit-cost ratios for levee plans in reaches 1, 2 and 5 did not surpass 0.1. Based on the unfavorable economics, local opposition, and the intrusive nature of the plan from social and environmental perspectives, it was considered prudent to eliminate incremental levee plans for reaches 1, 2 and 5. Accordingly, levees were only considered in downstream reaches (3 and 4) in the next phase of plan formulation.

Table 21
Levee/Floodwall Costs And Benefits
100-Year Level of Protection
(February 1998 Price Level, 6-7/8% Discount Rate, 50-Year Period of Analysis)

Levee Reach	Construction Cost	Construction + Interest During Construction	Annualized Cost	Average Annual Benefits	Net Benefits	Benefit/ Cost Ratio
1	$6,799,560	$7,018,000	$540,501	$49,749	($490,752)	0.1
2	$9,648,480	$9,958,400	$750,201	$66,116	($684,085)	0.1
3	$10,663,926	$11,006,500	$824,948	$1,366,223	$541,275	1.7
4	$9,3328,674	$9,628,300	$726,659	$850,941	$124,282	1.2
5	$11,816,144	$12,195,00	$909,758	$43,866	($865,892)	0.1
1 & 2	$12,613,080	$13,018,200	$988,416	$115,865	($872,551)	0.1
2 & 5	$18,747,826	$19,350,000	$1,439,979	$109,982	($1,329,997)	0.1
1, 2, &5	$23,528,986	$24,284,700	$1,821,906	$159,731	($1,662,175)	0.1

As indicated in Table 21, preliminary screening levees/floodwalls for Reaches 3 and 4 suggested favorable economics (*i.e.*, anticipated benefits exceeded costs). Consequently, further evaluation of structural and nonstructural protection of these reaches was warranted.

Complementary Nonstructural Measures - The lack of economic feasibility of levee protection of the upstream reaches (Reaches 1, 2, and 5) and limited support by local interests for structural measures led to evaluation of nonstructural measures for these reaches. The three categories of nonstructural measures previously identified as potentially applicable to the South River (*i.e.*, acquisition of flood-prone properties, floodproofing, and flood warning) were to be evaluated for application to the upstream reaches. This evaluation would consider these measures as potential complements to the levee/floodwalls option for protection of the downstream reaches (Reach 3 and Reach 4).

For Reach 3 and Reach 4, nonstructural measures for lower levels of protection were not feasible as a stand-alone element or in combination with a structural plan, as the topography and alignment of homes were not conducive. Lower levels of nonstructural improvements would not eliminate the need for structural flood protection for higher levels of protection, and the costs for the structural component would be similar to full levee protection.

6.3.1.4 Refinement of Hurricane and Storm Damage Reduction Plans

The intermediate analysis of alternative plans established that the levee/floodwall alternatives are the only economically feasible HSDR alternatives for the South River. The storm surge barrier plan at the mouth of the South River and the acquisition of flood prone properties were eliminated as potential alternatives. Levee configurations identified as having greatest potential included levees along the eastern and western banks of the downstream reaches (Reaches 3 and 4). Initial testing of the levee and floodwall system was made without a storm surge barrier, allowing the surge to move upstream of Sayreville. A storm surge barrier was later considered as a potential complementary feature to levee protection along the lower reaches (Reaches 3 and 4). The barrier could be located immediately downstream (north) of the Veterans Memorial Bridge. The storm surge barrier would intercept storm surges, protecting upstream reaches (*i.e.*, Reaches 1, 2, and 5). It would preclude need for levees or nonstructural protection south (upstream) of the bridge, and it would avoid potential adverse effects (direct and indirect) on wetland areas and potential HTRW sites.

The technical approach for the study involved two phases of numerical modeling. The first phase estimated the storm surge frequencies in Raritan Bay as a boundary for driving the second phase of modeling. Phase 1 storm surge modeling was performed with the ADCIRC (ADvanced CIRCulation) model. The ADCIRC model solves the depth-averaged Generalized Wave Continuity Equation (GWCE) formulation of the governing equations and has been extensively applied to projects requiring frequency analysis of storm surges within the New York area. That model grid was modified to include the details of the study area.

The second phase of the effort modeled the impact of the storm surge elevations in Raritan Bay as the surge moves up the Raritan River and into the South River study area. The TABS-MD modeling system was used for the Phase 2 modeling. The RMA-2 model is part of that system and it was used to simulate the wetting and drying effects on the storm surge as the storm wave moved through the study area. The Phase 2 effort essentially was performed as a means of transforming the flood frequency curves from Raritan Bay into the study area.

Selected flood events were simulated as a part of the Phase 2 modeling for detailed spatial variation in the peak flood elevations throughout the study area. An estimated full frequency curve was then developed from the complete boundary frequency curve and the selected simulations.

The return periods selected for analysis were the 2-year, 25-year, 100-year and 500-year storm events. These events were used as a means of estimating the transformation of the full stage-frequency curve from Raritan Bay into the study area and to estimate the effects of alternatives on the stage-frequency curves..

The closed storm surge barrier was tested for the 500-year storm to evaluate any downstream impacts of the barrier. The storm surge barrier was tested in the model in the open position for three sizes under more normal tidal conditions. A "highest astronomical tide" (HAT) was used for boundary conditions, which was taken to be the peak spring tidal range in late June. Additional refinement of the barrier will be occur during PED, including risks of overtopping and the expected performance of the barrier under those circumstances.

In addition to the hydrodynamic modeling studies, a steady state HEC-RAS model was run to evaluate upstream water levels. As expected, the flat water surface profile supported the conclusions that flooding in the South River is tidally-controlled.

Selection of the type of gate for South River incorporated reviews of US Army Corps of Engineers Manuals and discussions with the New Orleans District, where gates are used extensively on navigation and flood control projects. Engineering Manual No. 1110-2-2703, "Engineering and Design, Lock Gates and Operating Equipment", was specifically reviewed for information on various gate types and associated advantages and disadvantages both in gate operation and construction.

Based on a review of EM 1110-2-2703, it appeared that a sector gate would be the most appropriate gate type for use along the South River. Though sector gates have generally higher construction cost due to the need for larger recesses in the gate monolith, they have operational and maintenance advantages over other types of gates. Coordination with the New Orleans District confirmed that sector gates operate well under high sediment conditions since they can divert sediment during closing and opening operations. In addition, sector gates can be closed under flow conditions that could be experienced under a storm surge. Other types of gates, such as miter gates, do not perform as well under conditions that may generate a differential hydraulic head. Sector gates also provide maintenance advantages since they can be removed and replaced. Other types of gates require coffer damming and dewatering for gate removal and maintenance.

6.3.1.5 Comparison of Final HSDR Plans

The main objectives of a HSDR project are the protection of human life and property. Additional objectives include avoidance of inconveniences and costs of nuisance flooding. The principal elements considered in the evaluation of the alternatives included engineering feasibility, environmental impacts, economic implications and social consequences.

Table 22 contains the average annual costs and benefits of the three alternative HSDR plans for the South River. The three final alternative HSDR plans include: (1) levee/floodwall protection for all reaches, (2) levee/floodwall protection for the downstream reaches, and (2) levee/floodwall protection for the downstream reaches in conjunction with a storm surge barrier to protect upstream reaches.

Table 22
Average Annual Costs And Benefits Of
Hurricane and Storm Hurricane and Storm Damage Reduction Alternatives
(100-Year Storm Event; 6 3/8% discount rate, Oct 2000 price levels, 50-year period)*

Plan	Description	Average Annual Cost	Average Annual Benefit	Average Annual Net Benefits	Benefit/ Cost Ratio
1	Storm surge barrier with levees in the lower reaches (Reaches 3 and 4),	$2,865,000	$3,319,000	$454,000	1.16
2	Levees for all reaches (Reaches 1-5)	$3,752,000	$3,319,000	($433,000)	0.88
3	Levees for Reaches 3 and 4	$2,919,000	$2,930,000	$11,000	1.0

* prevailing discount rate and price level at time of analysis

Plan 1 (storm surge barrier with levees) would result in the same HSDR benefits as Plan 2 (levees for all reaches) by protecting all reaches. Plan 1 would also have cost advantages over Plan 3 (levees for Reaches 3 and 4), since significant costs of levee construction north of the barrier would be avoided. As indicated in this table, Plan 1 and Plan 3 are the only plans that are economically feasible (*i.e.*, average annual benefits exceed average annual costs). The net benefits for Plan 1 greatly exceeded those of Plan 3. Consequently, Plan 1 is the selected plan to be optimized. In addition to yielding the greatest net benefits, Plan 1 would cost-effectively protect the upstream reaches, thereby eliminating nonstructural measures from further consideration for those reaches.

Potential environmental impacts as well as economic performance were also evaluated as part of HSDR plan formulation. The storm surge barrier with levee/floodwalls (Plan 1) would also have significant advantages over the other plans in terms of anticipated environmental effects. As described in the *Avoidance and Minimization Plan* for South River HSDR (January 2001), Plan 1 would have a significantly smaller impact than Plan 3. Plan 1 would directly impact 9.4 acres of wetlands and 16.5 acres of uplands, with indirect impacts on 0.3 acres of wetlands.

Levee/floodwall protection for the lower reaches (Plan 3) would directly impact approximately 12.2 acres of wetlands and 20.3 acres of uplands, with indirect impacts on 5.8 acres of wetlands.

Based on its anticipated economic performance and environmental effects, Plan 1 is the selected plan. It is also the only plan that is implementable, and the only HSDR plan that will be subject to NEPA documentation in this investigation.

6.3.2 Cost Effectiveness and Incremental Cost Analysis of Mitigation Plans

Following a detailed assessment of environmental impacts associated with the selected HSDR measures (see Section 7.1) and the elimination of potential mitigation plans that resulted in no net ecological gain (Section 6.2.2), potential mitigation alternatives that did not meet the mitigation goal were eliminated, resulting in 423 potential mitigation alternatives for the East Bank and 180 for the West Bank. The habitat conversion acreages for each potential mitigation alternative were compared to the number of acres of wetland *Phragmites* and upland disturbed habitat available in each potential mitigation area. The West Bank would not provide enough upland disturbed habitat for any of the potential mitigation alternatives for the West Bank, and it was eliminated as a potential mitigation area. The East Bank area would provide enough wetland *Phragmites* and upland disturbed habitat for 352 of the potential mitigation alternatives.

Cost effectiveness analysis (CEA) is used to screen out plans that are inefficient or ineffective. Incremental cost analysis (ICA) is used to reveal and evaluate incremental changes in costs for increasing levels of ecological output (*i.e.*, AAHUs and FCUs). The primary purpose of ICA is to explicitly compare the incremental costs and the incremental outputs associated with each successively larger mitigation plan. The explicit comparisons of incremental costs and outputs allow evaluation of alternative scales of plans and plan components. The incremental evaluation of project costs and outputs provides more insight than average or total costs, since it can be used to identify significant increases in project costs necessary to achieve additional units of ecological output for the full range of ecosystem mitigation plans. Incremental cost analysis does not provide a discrete decision criterion (*i.e.*, it does not identify one "best" plan). However, it does provide information to decision-makers that allows explicit comparisons to be made between the relative changes in costs and outputs for each mitigation plan.

Cost effectiveness and incremental cost analyses (CE/ICA) were conducted during the development of mitigation alternatives to identify the mitigation plans that are "Best Buys" at different mitigation levels (*i.e.*, different ecological outputs). *IWR-PLAN* software was used to conduct CE/ICA. The software combines mitigation measures into alternative plans. *IWR-PLAN* then identifies the "best" set of possible financial investments using CEA and ICA. Each combination of measures comprises an alternative mitigation plan. The CE/ICA process used for South River is described in the following sections.

6.3.2.1 Mitigation Benefits and Costs

The HEP and EPW assessments were used to quantify the ecological and wetland functional benefits/outputs for each potential mitigation combination. Following the HEP process, HSI values were calculated for each of the targeted habitat types for the six evaluation species. HSI values were combined with acreages to calculate the ecological benefits (outputs) in terms of the number of HUs per species, or summed across species and calculated in terms of AAHUs attained over the 50-year Project life. For the calculation of AAHUs per mitigation combination, the assumption was made that plans would attain their full HSI value in the first year (*i.e.*, original HSI values are achieved immediately following construction). This facilitated the initial review and comparison of the mitigation combinations.

For the EPW method, FCI values were calculated for each of the targeted habitat types for the six evaluation functions. FCI values were combined with acreages to calculate the wetland functional benefits (outputs) in terms of the number of FCUs per function, or summed across functions to produce one FCU value for the entire mitigation alternative.

Cost estimates for the implementation of potential mitigation alternatives were calculated based on estimates of real estate, construction, site preparation, habitat conversion, disposal, planting, mobilization/demobilization, erosion and sediment control, and monitoring costs. A contingency cost of 20% was included to account for uncertainty in the final design and/or implementation of the selected mitigation plan. These costs have been estimated for the purpose of determining Project feasibility, and providing a means of comparing potential mitigation alternatives.

6.3.2.2 Cost-Effectiveness and Incremental Cost Analyses

All 352 mitigation alternatives identified during the screening process were entered into the *IWR-PLAN* for CE/ICA. CE/ICA are conducted within the *IWR-PLAN* in a stepwise process, comparing alternative plans with successive levels of output, identifying those plans that are cost-effective and incrementally justified, and eliminating those plans that are not. All mitigation alternatives were considered non-combinable, resulting in 353 possible alternatives, including the No-Action alternative. Based on the results of the *IWR-PLAN*, nine of these alternatives were cost-effective, and three were identified within the *IWR-PLAN* as "best buy" mitigation alternatives.

The three "best buy" plans identified in the *IWR-PLAN* are summarized below.

- Mitigation Alternative 1 – No-Action
- Mitigation Alternative 2 –

Conversions	WPH:	6 acres SM
		3 acres WSS
	DIST:	11 acres WSS
	Total:	20 acres
Costs	Total:	$2.66 million*
	AAC:	$177,354
Benefits	AAHUs:	34.7
	FCUs:	29.9
Incremental Cost/Output:		$5,126

- Mitigation Alternative 3 –

Conversions	WPH:	6 acres SM
		2 acres WSS
	DIST:	12 acres WSS
	Total:	20 acres
Costs	Total:	$2.79 million*

	AAC:	$186,537
Benefits	AAHUs:	35.6
	FCUs:	32.8
Incremental Cost/Output:		$9,183

* The cost ($524,000) associated with levee improvements (*i.e.*, creation of USS habitat) were considered a constant cost across all mitigation alternatives, and are not included in the cost estimates presented above.

6.3.3 Cost Effectiveness and Incremental Cost Analysis of Restoration Plans

Corps ecosystem restoration policies require that restoration projects include cost effectiveness and incremental cost analyses (CE/ICA) to allow informed decision making by evaluating incremental costs and incremental outputs (*i.e.*, the ecological benefits of restoration plans). CE/ICA can be used to support ecosystem restoration studies through the: (1) formulation of alternative plans from combinations of possible restoration measures and (2) evaluation of plan effects (*i.e.*, outputs). The analysis does not identify the best plan. Rather, it identifies those plans that are "Best Buys" at different restoration levels (*i.e.*, different ecological outputs). CE/ICA generates information that supports sound financial investments by comparing the costs and non-monetary outputs (benefits) of alternative investment choices. CE/ICA was used to formulate, evaluate, and identify the plan that maximizes contributions to national ecosystem restoration (i.e., the NER plan).

6.3.3.1 Restoration Benefits and Costs

The benefits of the 131 ratio combinations for Areas 1-3 and 145 ratio combinations for Area 4 were estimated using HEP, calculating AAHUs for the 50-year period of analysis, as described above. Preliminary costs used to conduct the CE/ICA were calculated based on estimates of real estate, surveying, mobilization/demobilization, site access, construction, site preparation and excavation, disposal, planting, erosion and sediment control, and monitoring costs. A contingency of 20 percent was included to account for uncertainty in design and implementation of the selected restoration plan. Item-specific contingency costs were included in the feasibility level cost estimate for the selected plan.

6.3.3.2 Preliminary Cost Effectiveness Analysis (CEA)

CEA begins with a comparison of the costs and outputs of alternative plans to identify the least cost plan for every possible level of restoration. CEA screens out plans that are inefficient or ineffective. The ratio combinations for each restoration scenario that resulted in a positive ecological output were combined with costs specific to each restoration area, creating over 2,150 conceptual restoration plans. Because of the large number of restoration plans, a preliminary cost-effectiveness analysis was conducted. This analysis was performed by sorting the alternative restoration plans in order of increasing output, and eliminating those plans that were inefficient or ineffective. Preliminary cost-effectiveness analysis reduced the number of conceptual restoration plans from between 131 – 145 to 1 – 5 per restoration area and scale, creating 63 cost-effective conceptual restoration plans.

6.3.3.3 Cost Effectiveness/Incremental Cost Analysis (CE/ICA)

After the cost effective alternatives had been identified, conceptual restoration plans for each of the four areas were combined, AAHUs and costs were included, and cost effectiveness and incremental cost analyses were performed on the combined plans. The 63 conceptual restoration plans that were carried forward from the preliminary cost-effectiveness analysis for input to *IWR-PLAN* for combination and CE/ICA were comprised of 20 conceptual restoration plans for both Area 1 and Area 2, 19 conceptual restoration plans for Area 3, and 4 for Area 4. All restoration plans within a given area were designated non-combinable, and all combinations of plans among areas were combinable. In estimating costs of combined (area) restoration plans, cost adjustments were made based on expected efficiencies in combining plans (*e.g.*, joint mobilization costs).

All combinations of the conceptual restoration plans for each area were examined, creating more than 40,000 actual combinations. The habitat profiles of the eight "best buy" conceptual restoration plans for the study area are presented in Table 23. The acreage of restored habitat ranges from 46 acres (Plan 2) to complete restoration of the degraded portion of the four restoration areas (379 acres). Plans 5 through 8 would involve complete restoration, but as indicated in Table 23, they would have different combinations of habitats that would produce a range of ecological outputs (AAHUs).

Table 23
Habitat Profiles Of Best Buy Restoration Plans

		Habitat Restored (acres)						
Plan	Description	Low Emergent Marsh	Mudflat	Wetland Forest/ Scrub-Shrub	Upland Forest/ Scrub-Shrub	Open Water	Total Acres	AAHUs
1	No-Action	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	100% of Area 4	18.4	2.3	20.7	2.3	2.3	46.0	48.3
3	100% of Areas 1 & 4; 75% of Area 2	114.1	14.3	128.4	14.3	14.3	285.4	254.1
4	100% of Areas 1, 2, & 4	130.5	16.3	146.8	16.3	16.3	326.3	289.3
5	100% of all Areas	151.7	19.0	170.7	19.0	19.0	379.3	334.9
6	100% of all Areas	217.2	19.0	110.1	14.1	19.0	379.3	339.6
7	100% of all Areas	238.4	19.0	90.4	12.5	19.0	379.3	341.1
8	100% of all Areas	285.0	19.0	47.3	9.0	19.0	379.3	344.3

The average annual costs of the "best buy" plans are presented in Table 24. This table includes implementation costs and operations and maintenance costs. Capital (first) costs are expected to range from $4.6 million to over $56 million. Estimated average annual costs of the best buy plans range from $306,000 to $3.8 million.

Table 24
Average Annual Costs Of Best Buy Restoration Plans

Plan	Description	Capital Costs	Interest During Construction*	Average Annual Implementation Costs**
1	No-Action	$0	$0	$0
2	100% of Area 4	$4,578,000	$167,633	$305,1730
3	100% of Areas 1 & 4, 75% of Area 2	$27,970,000	$1,555,667	$1,868,120
4	100% of Areas 1, 2, & 4	$31,973,,000	$1,778,486	$2,135,443
5	100% of all Areas	$37,324,000	$2,795,834	$2,492,859
6	100% of all Areas	$46,582,000	$2,810,588	$3,111,139
7	100% of all Areas	$49,577,000	$2,912,768	$3,311,202
8	100% of all Areas	$56,164,000	$3,716,418	$3,751,134

* Assumes: 12 month construction period for Plan 2; 18 months for Plans 3 & 4; and 24 months for Plans 5-11.
**O&M Costs not included.

Other than the No-Action plan, the smallest "best buy" plan is the plan with the lowest average cost per unit of output – in this case, Plan 2. In comparing Plan 2 to the No-Action plan, a modest number of acres would be restored for approximately $4.6 million. Although this plan has the lowest cost, restoration action would be limited to Area 4, and none of the Island would be restored if this plan were selected. Selecting Plan 3 would result in restoration of almost 240 acres of the Island in addition to all the *Phragmites*-dominated wetlands (46 acres) in Area 4. Plan 4 would result in additional increases in the number of acres and subsequent increases in AAHUs and total cost. Plan 5 would result in restoration of all the *Phragmites*-dominated wetlands for the entire study area. Moving from Plan 5 to any of the other Plans (Plans 6 –8) would not increase the number of acres restored, but would result in modest increases in AAHUs and variable increases in cost.

Table 25 presents the incremental costs and outputs of the eight "best buy" plans. This table shows the increase in ecological output (AAHUs) and in average annual costs associated with each of the best buy plans. The incremental cost per unit of output indicates the unit cost of moving to greater levels of restoration. For example, between Plan 5 and Plan 6 the incremental costs increase by a factor of more than 16.

Table 25
Incremental Costs Of Best Buy Restoration Plans

Plan	Description	AAHUs	Total Cost	Average Annual Cost	Incremental Effects		
					Outputs	Costs	Costs per Output
1	No-Action	0.0	$0	$0	0	$0	$0
2	100% of Area 4	48.3	$4,578,000	$305,730	48.3	$305,730	$6,330
3	100% of Areas 1 & 4, 75% of Area 2	254.1	$27,970,000	$1,868,120	205.8	$1,562,390	$7,592
4	100% of Areas 1, 2, & 4	289.3	$31,973000	$2,135,443	35.2	$267,323	$7,594
5	100% of all Areas	334.9	$37,324,000	$2,492,859	45.6	$357,416	$7,838
6	100% of all Areas	339.6	$46,582,000	$3,111,139	4.7	$618,280	$131,549
7	100% of all Areas	341.1	$49,577,000	$3,311,202	1.5	$200,063	$133,375
8	100% of all Areas	344.3	$56,164,000	$3,751,134	3.2	$439,932	$137,479

The "best buy" conceptual restoration plans were compared based on each plan's ability to efficiently and effectively restore degraded ecosystems in the study area. In addition, each plan was evaluated using the following criteria:

- **Institutional Significance:** The importance of the environmental resource as evidenced by existing laws, plans, and policy statements from international, national, regional, state, local and tribal entities.

- **Public Significance:** The importance of the environmental resource as evidenced by the general public's interest, participation and funding of resource-related groups and activities.

- **Technical Significance:** The importance of the environmental resource as evidenced by the scientific knowledge and understanding of critical characteristics of the resource, such as its scarcity, representativeness, status of disturbance, level of biodiversity, and observed or potential use by threatened and endangered species of animals and plants.

- **Acceptability:** Is the plan acceptable to Federal and state resource agencies, and local government?

- **Completeness:** Does the plan provide and account for all necessary investments and actions?

- **Effectiveness:** Does the plan make a significant contribution to addressing the specified restoration problems or opportunities?

- **Efficiency:** Does the plan represent a cost-effective means of addressing the restoration problems or opportunities?

- **Risk:** What is the likelihood of success/failure associated with the desired restoration outcome?

- **Uncertainty:** What level of confidence is associated with the estimation of ecological outputs (AAHUs)?

A ranking matrix was used to score each restoration plan with respect to the above criteria. Plan 5 received the highest score among the alternatives, with 43 out of a possible 45 points. Based on this evaluation and its ability to meet the planning objectives, Plan 5 was identified as the selected plan. This selection is supported by the significant increase in incremental costs associated with using different habitat ratios to restore the same amount of acreage (Plans 6 through 8).

6.4 Selected NED/NER Multipurpose Plan

As described above, the HSDR and ecosystem restoration plans are components of an integrated multipurpose plan for the South River. The above plan formulation identified Plan 1 (storm surge barrier with levees in Reaches 3 and 4) as the plan that meets the planning objectives and provides the greatest net benefits. This plan is therefore selected as the NED plan for HSDR. The optimization of the level of HSDR and description of the recommended plan are presented in the following section. Subsequent sections describe: (1) optimization of interior drainage features to address ponding behind the levee and (2) selected ecosystem restoration features based on the eight restoration plans identified by the incremental analysis as "best buys."

6.4.1 Selected Hurricane and Storm Damage Reduction Plan – Line of Protection

Economic analysis was used to optimize the level of protection to be provided by the selected plan (Plan 1). This plan consists of a storm surge barrier and two levee/floodwalls located in Reaches 3 and 4, to form a single line-of-protection system with no separable elements. This plan would act as one system; no segment of this line-of-protection could function on its own. The plan would provide protection to the entire study area (Reaches 1 through 5). Analysis was not performed for individual reaches or project segments, as no one segment provides benefits on its own. All segments are needed to provide any benefits.

As indicated in Table 26, costs were developed for the selected plan with alternative levee/floodwall heights of +16.0, +18.5, +20.5, and +21.5 NGVD. These levels of protection correspond to the 50-year, 100-year, 200-year, and 500-year recurrence intervals. As described in the Hydrology, Hydraulics, and Design Appendix (Appendix A), the alternative levels of protection are approximately equal to the storm stages allowing for risk and uncertainty associated with the 50-, 100-, 200- and 500-year frequencies, with additional height added to account for the effects of sea level rise over the 50-year life of the flood control measures. Additional discussion of the uncertainty analysis is provided below.

The uncertainty in the hydraulic analysis is based upon the Empirical Simulation Technique (EST) used in the storm surge modeling. This analysis includes repetitive simulations based upon a random combination of input parameters for both tropical and extra-tropical events. From the results of this analysis, a stage frequency curve with standard deviations was developed at the boundary of the RMA-2 model. The RMA-2 model computed water levels at various locations throughout the study area. The standard deviations at each location were adjusted as a ratio of the surge heights. The details of the uncertainty analysis are contained in the Hydrology, Hydraulics and Design Appendix (Appendix A), pages 67-68.

The final surge barrier height was computed as a sum of the 500 year water elevation of 16.8 NAVD88 (from Figure 37K in Appendix A), plus the standard deviation as a measure of uncertainty of 2.8 ft, plus 1.1 ft for the datum conversion from NAVD88 to NGVD27, plus 0.7 ft for sea level rise, and conservatively rounded to 21.5 ft NGVD29. As discussed in Appendix A, the more conservative water levels in Figure 37K (Appendix A) were used rather than the levels in Figure 40 (Appendix A) in order to provide consistency is developing comparable levee heights for various frequency events.

It is expected that the detailed modeling work to be conducted in the PED phase, utilizing updated topography, will provide more accurate results, eliminate the conservative assumptions used in the feasibility study, and most likely lower the final barrier heights.

Table 26
Costs of Alternative Levels of Protection
Selected Plan
(Plan 1: Storm Surge Gate And Levees Along Reaches 3 &4)
6 1/8% discount rate, Oct 2001 price levels, 50-year period

	Probability of Exceedance			
	0.02	0.01	0.005	0.002
Levee/Floodwall Height (feet NGVD)	16	18.5	20.5	21.5
Construction Cost	$32,809,800	$35,886,600	$39,069,500	$41,184,400
Engineering & Design (15%)	$4,921,500	$5,383,000	$5,860,400	$6,177,700
Supervision & Administration (7%)	$2,296,700	$2,512,100	$2,734,900	$2,882,900
Interest During Construction (2.5 years)	$3,122,200	$3,415,000	$3,717,900	$3,919,100
Total Investment Cost	$43,150,100	$47,196,600	$51,382,700	$54,164,100
Annualized First Cost	$2,785,500	$3,046,700	$3,317,000	$3,496,500
O&M Costs	$209,500	$209,500	$209,500	$209,500
Total Annual Costs	$2,995,000	$3,256,200	$3,526,500	$3,706,000

The alignment of the line of protection was refined based on physical, environmental, and economic criteria. The optimal alignment was identified by:

- Avoiding and minimizing adverse effects on study area wetlands,

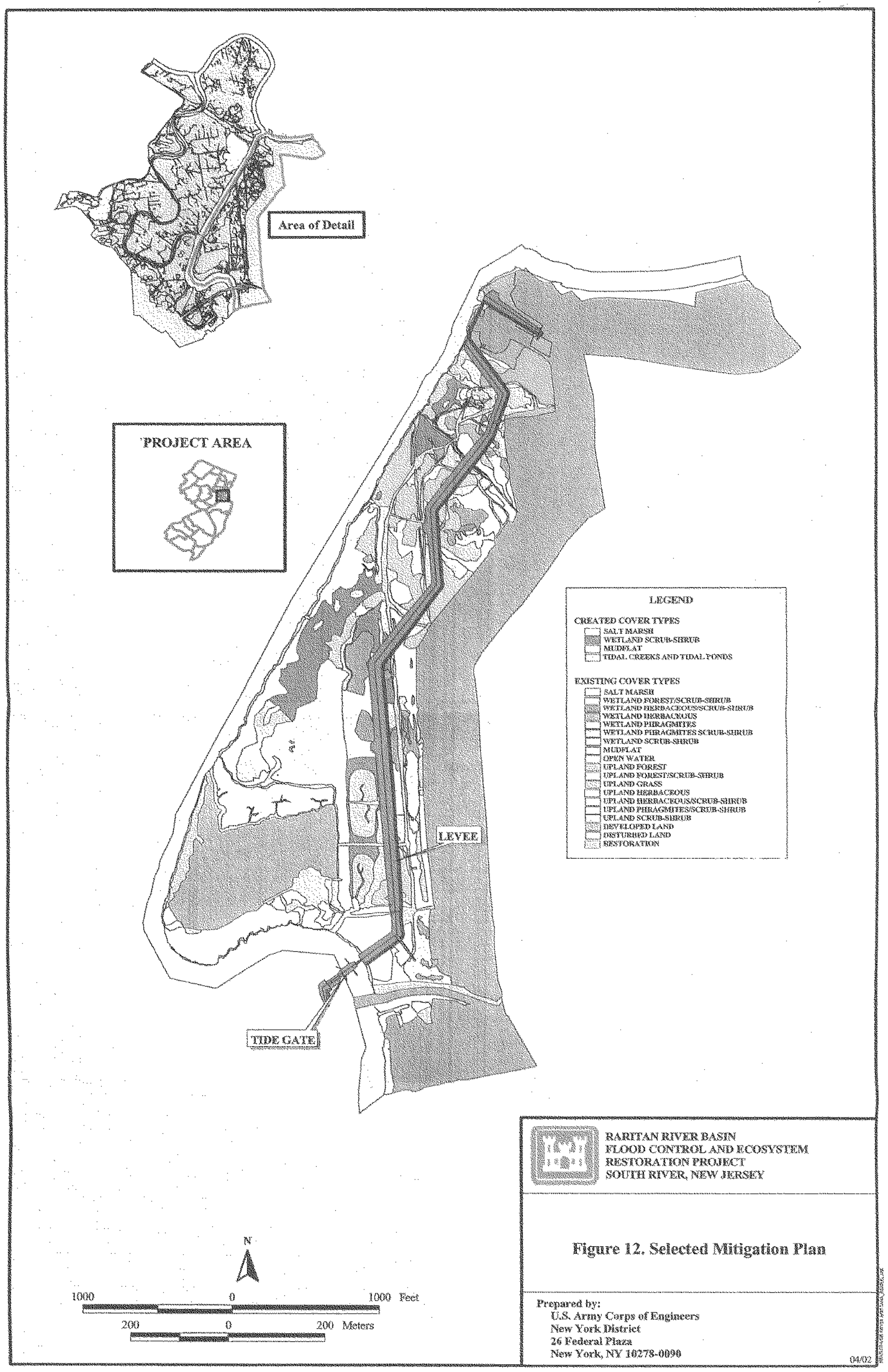
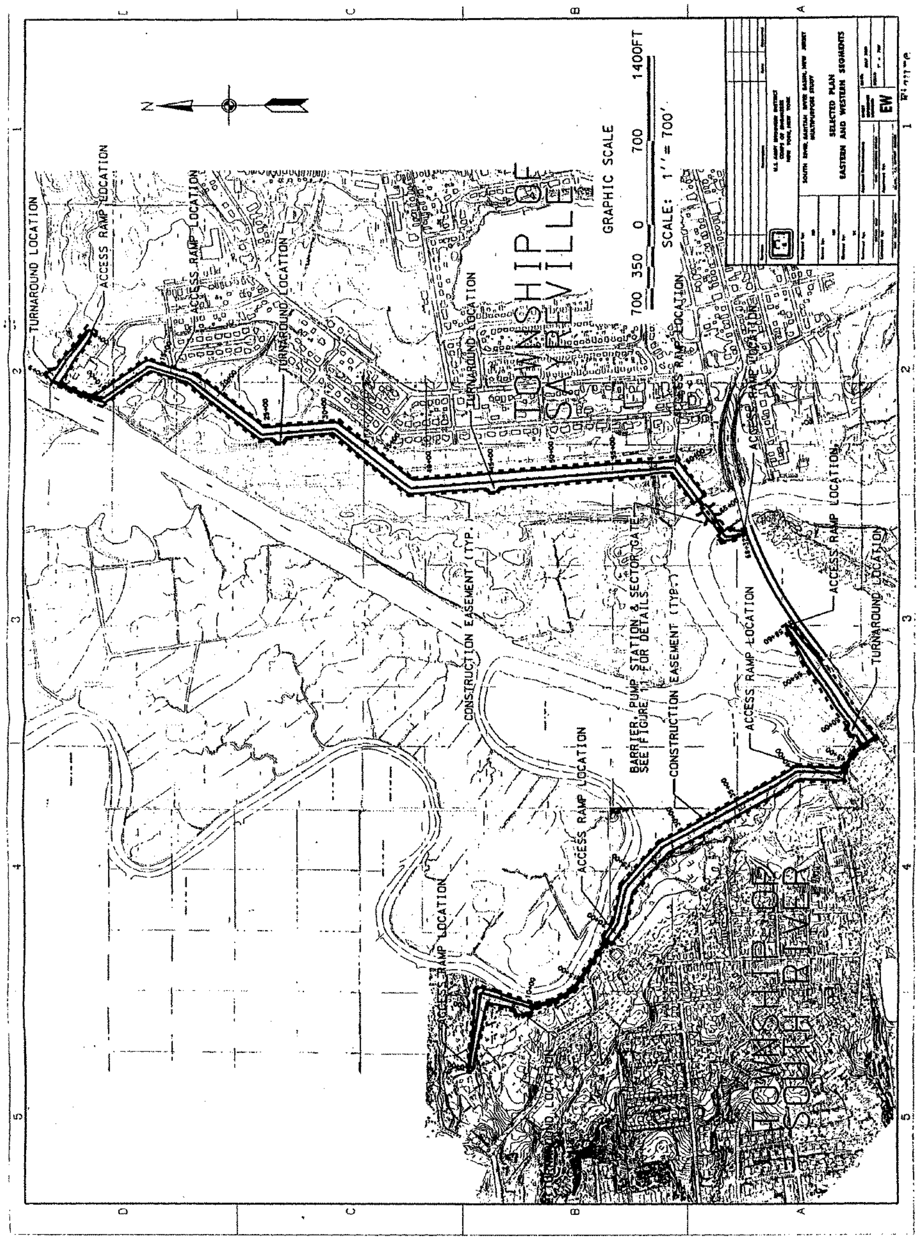


Figure 12. Selected Mitigation Plan


TURNAROUND LOCATION
ACCESS RAMP LOCATION
CONSTRUCTION EASEMENT (TYP.)
BARRIER, PUMP STATION & SECTOR GATE SEE FIGURE 1 FOR DETAILS
GRAPHIC SCALE
700 350 0 700 1400FT
SCALE: 1'' = 700'
EW

- Following high ground to the extent possible to minimize levee costs, and
- Protecting flood-prone structures, which are located in high-density concentrations.

In Table 27, the costs and benefits of four levels of protection for the selected plan are compared. As shown in this table and discussed in the Economics Appendix (Appendix E), the level of protection with the greatest net benefits was determined to be elevation +21.5 NGVD, which would provide protection for 500-year floods. As a result, this level of protection was selected as the NED hurricane and storm damage reduction plan. It is anticipated that the selected NED plan (500-year) hurricane and storm reduction portion of this project would have average annual benefits of $9.7 million and average annual costs estimated at $3.9 million. Annual net benefits are estimated to be approximately $5.2 million subject to optimization of interior drainage features. The benefit-cost ratio is anticipated to be 2.32 to one. Subsequent to plan optimization, the final estimate of the average annual costs for the NED plan was calculated to be $4,163,600. The average annual damages prevented are $9,092,400, and average annual net benefits are $4,928,800. The benefit-cost ratio is 2.2.

Table 27
Optimization Of Selected Plan
(Plan 1: Storm Surge Gate And Levees Along Reaches 3 &4)
6 1/8% discount rate, Oct 2001 price levels, 50-year period

Exceedance Probability	Average Annual Damages Prevented	Average Annual Interior Drainage Damages Incurred	Reduced Annual FIA Costs	Total Average Annual Damages Prevented	Average Annual Costs*	Average Annual Net Benefits	BCR
0.02	$8,246,400	$681,500	$0	$7,564,900	$3,169,700	$4,395,200	2.39
0.01	$8,877,400	$681,500	$27,800	$8,223,700	$3,446,100	$4,777,600	2.39
0.005	$9,432,300	$681,500	$27,800	$8,778,600	$3,730,000	$5,048,700	2.35
0.002	$9,746,100	$681,500	$27,800	$9,092,400	$3,922,100	$5,170,300	2.32

* Costs do not conform to Table 26 due to refinement of interest during construction to 4-year construction period, rather than previous 2.5 years

The HSDR features of the recommended plan, which would provide a 500-year level of protection for flood-prone areas of the study area, are described below.

Eastern Alignment - The eastern portion of the line of protection is located mostly within the Borough of Sayreville (see Figure 7). The top of protection is at +21.5 NGVD. The existing grade elevations along the entire line of protection excluding the segment that crosses the South River, range between +4.0 and +20.0 NGVD. Therefore, the height of protection ranges between 0.5 feet and 16.5 feet.

The line of protection with a total 426 feet of floodwall and 6,081 feet of levee begins at the northeastern end as a levee starting at a point approximately 250 feet west of the intersection of Anderson Court and Canal Street behind some newly constructed residential properties. There will be maintenance vehicle access to the top of the levee at this point. The levee then extends in a northwesterly direction between the rear property lines of the residential development and the municipal sewage facility for approximately 500 feet where it meets the eastern bank of the Washington Canal. The top of the levee will be widened in this area to accommodate a vehicle turnaround. The levee then transitions to a floodwall due to space restrictions, which runs southwest along the bank of the canal at the frontage of the sewage facility for approximately 300 feet where it turns south for an additional 100 feet before switching back to levee for the remainder of its length. The remainder of the 10-foot wide crested and 1V: 2.3H side-sloped levee is located in an undeveloped area located between the Washington Canal and the South River to the west and residential development to the east. At this point, the levee runs in a southeasterly direction for approximately 450 feet then turns to a southwesterly course for 350 feet passing the eastern termination of Hinton Street. Another access ramp will be located at the end of Hinton Street. The levee makes another slight turn to the west and continues in a southwesterly direction for nearly 750 feet before turning south for another 600 feet. There will be another turnaround located in this segment. The levee turns to a southwesterly direction again and runs parallel to Weber Avenue at a 300 feet offset for nearly 800 feet, then turns south and runs again parallel to Weber Avenue this time at a 450 feet offset for approximately 2,150 feet. There will be a turnaround located approximately at 1/3 of the length of this segment. The levee then turns southwest and continues for approximately 350 feet until it meets the eastern bank of the South River where it terminates against a bulkhead, which is essentially the east side of a storm surge barrier. A maintenance access ramp is to be located at this last change in direction in the levee. The last 200 feet of levee for closure to elevation +21.5 is located on the western side of the South River in the Borough of South River. Once across the river, there is a bulkhead similar to that on the eastern side. The levee begins again and immediately turns to the south where it continues until it meets high ground alongside Veteran's Highway within 50 feet of the western bridge abutment.

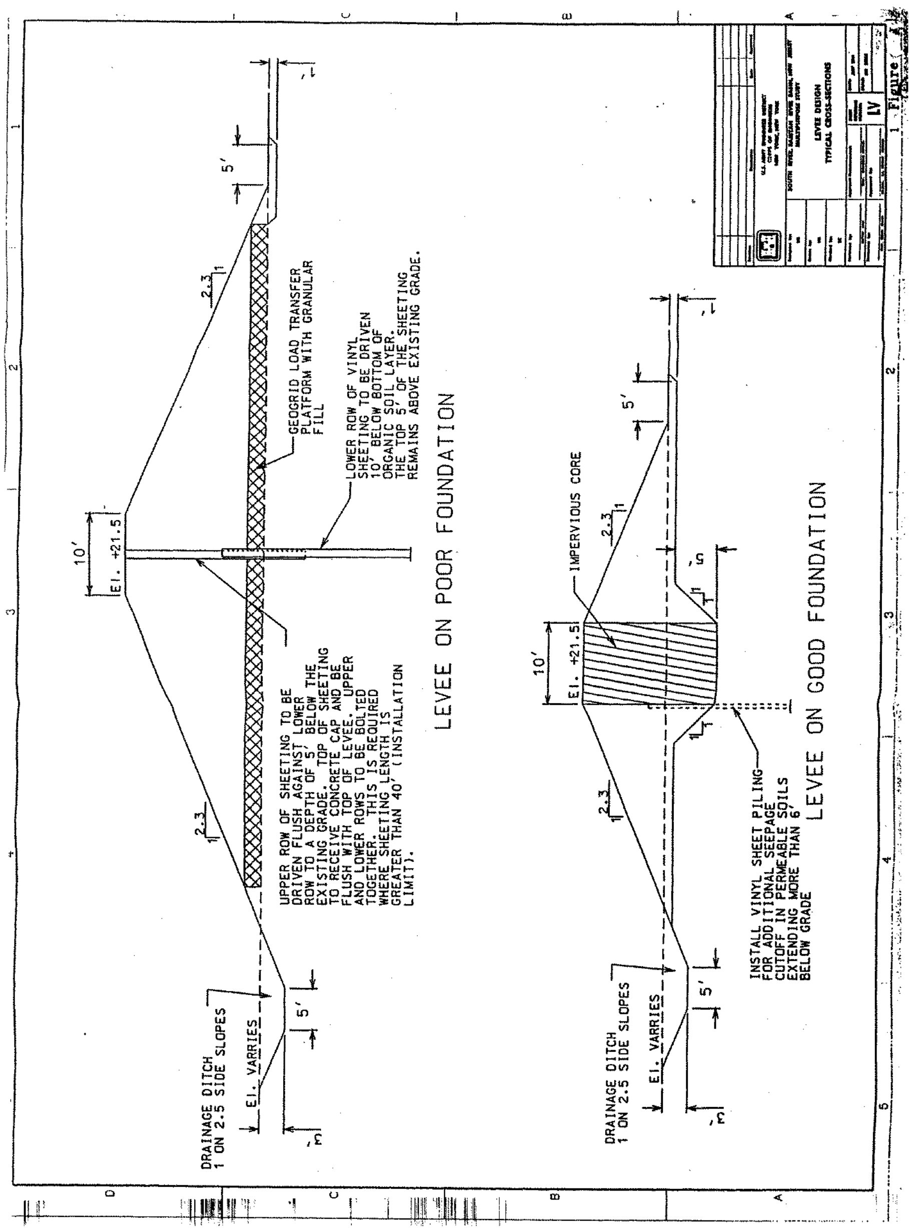
Storm Surge Barrier Alignment - The line of protection continues across the river for 320 feet in the form of a storm surge barrier and a tentatively sized 80-foot wide clear opening storm surge gate which lies collinear with the levee. A pump station is to be located within the barrier between the South River west bank and the storm surge gate. Between the eastern side of the storm surge gate and the east bank of the South River, there will be gravity drains with backflow prevention of a sufficient size to alleviate build-up of interior drainage in the event that the pumps fail and the gate does not open. Like the rest of the line of protection, the barrier and storm surge gate provide protection to an elevation of +21.5 NGVD.

Western Segment - The western portion of the line of protection is located entirely within the Borough of South River. As with the eastern segment, the top of protection is located at +21.5 NGVD. The grades on the western side of the river are similar to those on the eastern side. Therefore, the height of protection also ranges from 1.5 feet to 17.5 feet NGVD. The line of protection with a total of 4,631 feet of levee and 1,229 feet of floodwall begins at the northwestern corner as a levee starting at a point located at the southeast corner of an unpaved trailer lot off of Tices Corner Road. There will be maintenance vehicle access to the top of the levee from this lot. The levee runs southeast for approximately 600 feet thorough a wooded area until it is within 150 feet of the river bank where it turns to a southwesterly direction. The 10 feet wide crest width with 1 on 2.5 side slope levee then continues along the river bank for an additional 400 feet where the levee transitions to a floodwall due to space restrictions. There will be a turnaround provided at the end of the levee in this location. The floodwall is located at the riverbank. It parallels the river for approximately 900 feet as it bends to the southeast. The cross-section then reverts back to levee where space becomes available and continues to parallel the river for an additional 450 feet. There will be vehicle access provided in this segment. At this location, the levee turns slightly southward and continues in a southeasterly direction, no longer parallel to the river for approximately 450 feet where it turns slightly further south and continues on for another 1,250 feet. The levee then turns further south and continues in a southerly direction for approximately 350 feet where it ends and a floodwall begins to minimize impacts to the adjacent wetlands. Vehicle access to the levee will be provided at this end of the levee as well. As before, the floodwall runs directly adjacent to and parallel with the river for 400 feet until it meets Veteran's Highway approximately 100 feet northeast of its intersection with Water Street. The final segment of the line of protection is a levee which extends from the end of the last floodwall segment directly adjacent to and parallel with Veteran's Highway on the north side for approximately 1,150 feet where it terminates at high ground at elevation +21.5 NGVD. There will be a turnaround at the beginning of this segment and vehicle access at the end.

Levee Design - Due to differing soil conditions along the alignment, various methods of levee construction were reviewed to determine the most suitable cross-sections to be used. Two sections were chosen based on two general recurring soil conditions.

The first condition is a sandy soil foundation which provides adequate structural stability to support the levee, but has an high permeability rate at several locations based on initial subsurface testing. Therefore, the levee which will be placed in these areas will include an impervious core and an estimated length of levee core with a cutoff wall of continuous vinyl sheet piling driven beneath the levee to insure proper cutoff from under-seepage. These estimated lengths will be refined based on additional borings to be taken during the subsequent preconstruction engineering and design phase.

The second soil condition is one in which the soils include large quantities of organic material. These soils provide poor stability and may be subject to long term settlement, but have very low rates of permeability. In the areas where these soils occur, they lie in a layer that has a maximum thickness of 12 feet and is located approximately 5 feet below the surface. The levee cross-section which is proposed for this soil condition includes a continuous vinyl sheet pile core which will extend from the top of the levee to an appropriate depth of embedment below the bottom of the organic soil layer. The sheet piling will provide seepage cutoff for the levee above grade as well as maintain the required height of protection in the event that long term settlement of the levee occurs. A soil stabilizing fabric placed under the levee footprint will also be applied at the surface prior to levee construction to minimize settlement of the levee fill (see Figure 8).

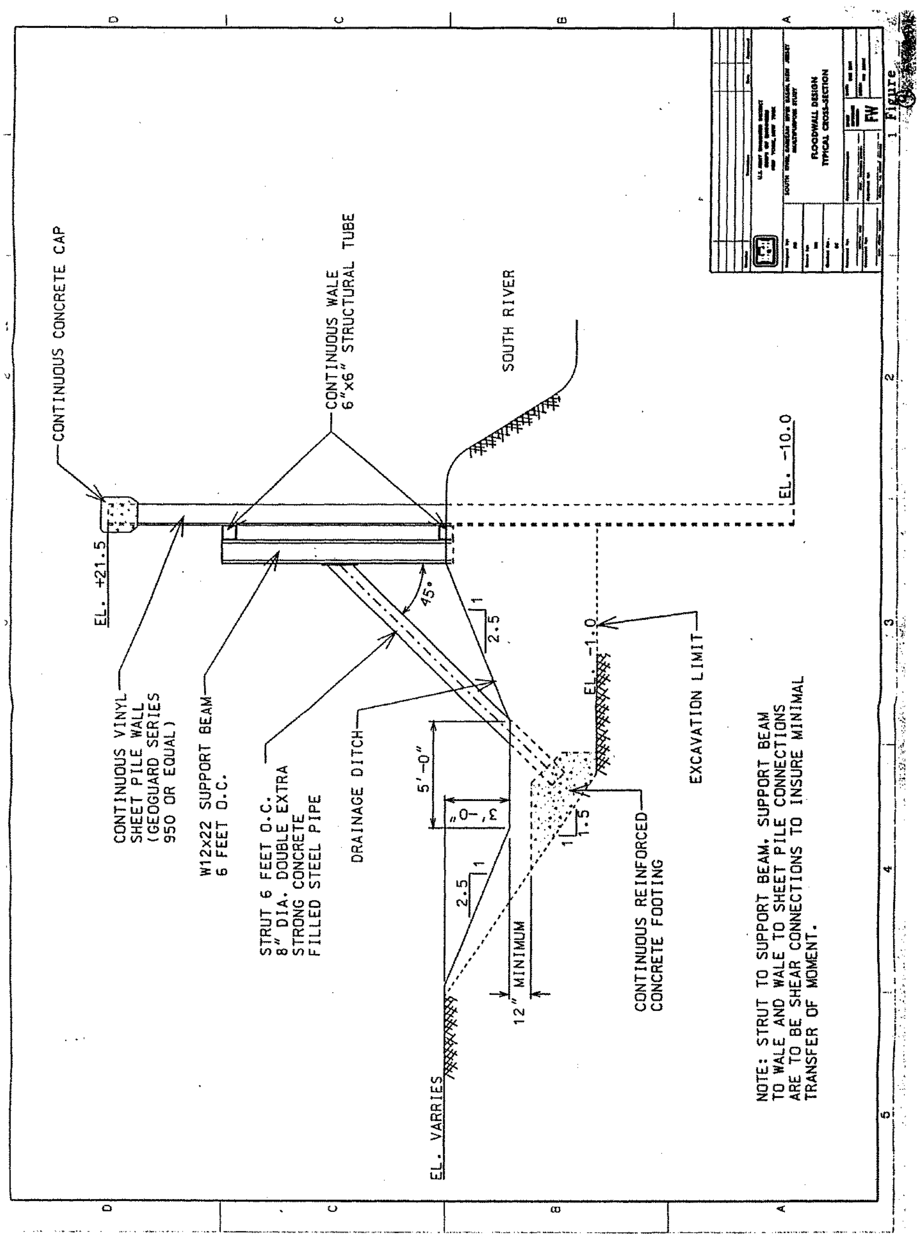

LEVEE ON POOR FOUNDATION
DRAINAGE DITCH
1 ON 2.5 SIDE SLOPES
El. VARRIES
5'
3'
2.3
1
El. +21.5
10'
7'
GEOGRID LOAD TRANSFER PLATFORM WITH GRANULAR FILL
LOWER ROW OF VINYL SHEETING TO BE DRIVEN 10' BELOW BOTTOM OF ORGANIC SOIL LAYER. THE TOP 5' OF THE SHEETING REMAINS ABOVE EXISTING GRADE.
UPPER ROW OF SHEETING TO BE DRIVEN FLUSH AGAINST LOWER ROW TO A DEPTH OF 5' BELOW THE EXISTING GRADE. TOP OF SHEETING TO RECEIVE CONCRETE CAP AND BE FLUSH WITH TOP OF LEVEE. UPPER AND LOWER ROWS TO BE BOLTED TOGETHER. THIS IS REQUIRED WHERE SHEETING LENGTH IS GREATER THAN 40' (INSTALLATION LIMIT).
LEVEE ON GOOD FOUNDATION
IMPERVIOUS CORE
INSTALL VINYL SHEET PILING FOR ADDITIONAL SEEPAGE CUTOFF IN PERMEABLE SOILS EXTENDING MORE THAN 6' BELOW GRADE
LEVEE DESIGN
TYPICAL CROSS-SECTIONS
Figure

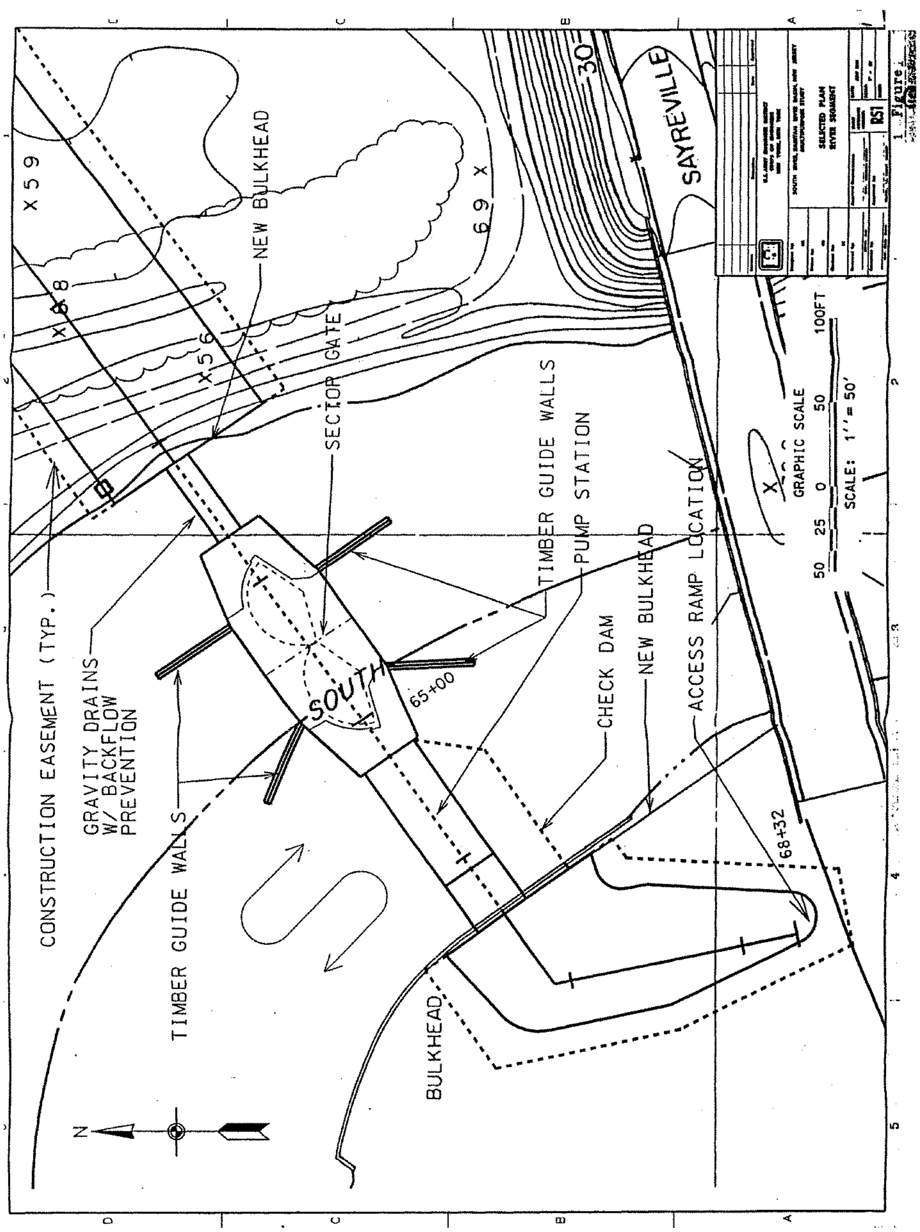
Floodwall Design - Due to severe space restrictions between developed properties and the bank of the river in some areas, it is necessary to use a floodwall in place of levee. This floodwall had to meet several design constraints including: accommodating the limited area for foundation, ease of construction, providing heights up to 15 feet with full hydrostatic pressure applied, providing cost effectiveness, providing watertight closure and meeting aesthetic expectations.

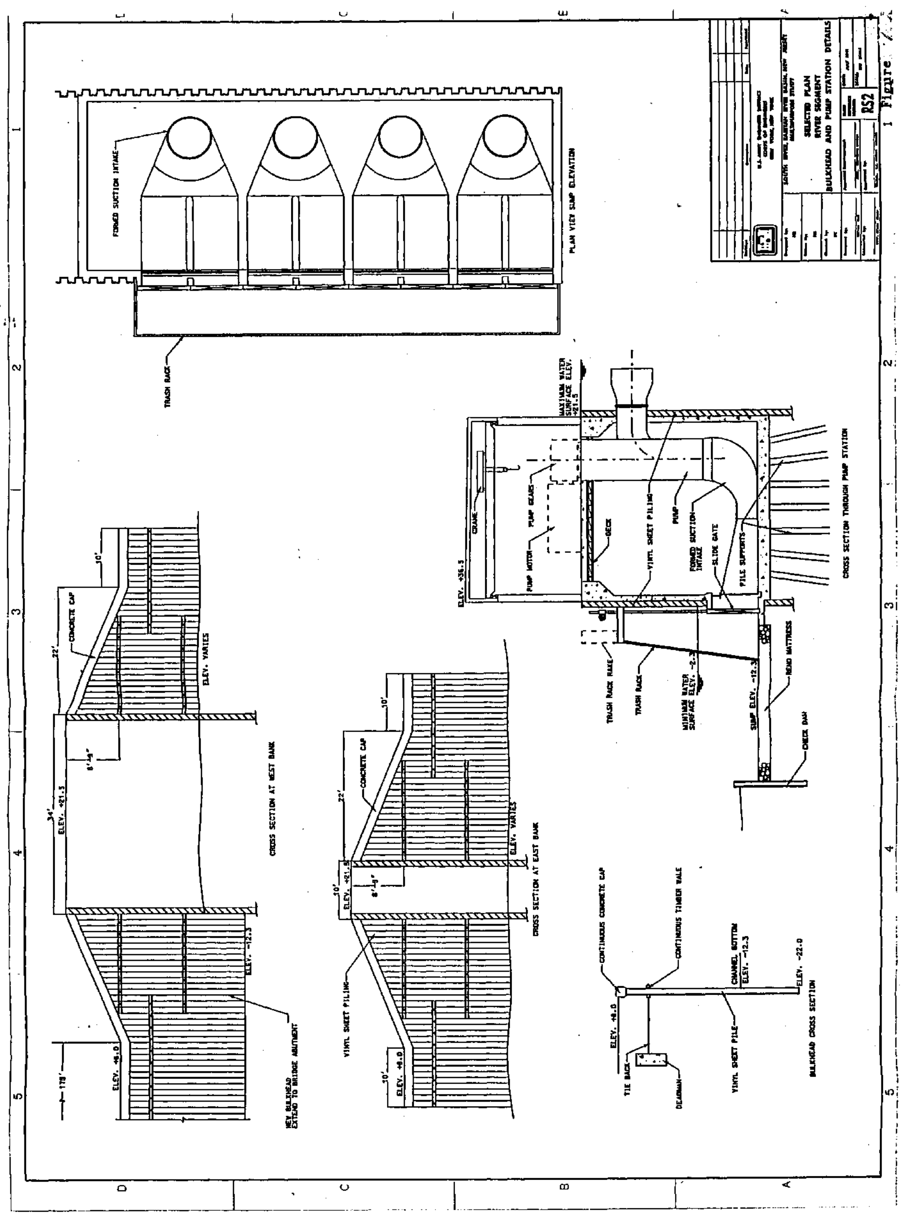
Several standard floodwall types were considered including concrete T-walls, and I-walls as well as a combined concrete with steel sheet wall, but each of these failed to meet all of the requirements. Therefore, a unique, innovative floodwall design had to be developed. Refer to Sub-Appendix A of the Hydrology, Hydraulics, and Design Appendix (Appendix A) for preliminary design computations.

The proposed floodwall will be of watertight jointed vinyl sheet piling that is partially supported by a strut beam anchored to a bearing footing to withstand the large hydrostatic forces acting on the wall. Two continuous wales connected to a support beam will be fixed to the back side of the wall and angled struts will be placed at an approximate 6 feet spacing along the wall. The struts will be reinforced concrete filled steel pipes for added strength that will terminate in a continuous concrete footing which will be below grade. This design can be placed in both soil conditions described above. Required soil replacement or pile support of the concrete footing (to be developed in the PED phase) will be included in areas where the organic soils are near the surface (see Figure 9). It is noted that the use of vinyl sheeting will be substantiated during final wall design in PED. Vinyl costs are slightly less than steel sheeting, and provide better life cycle properties. If steel sheeting is found to be required, current vinyl costs plus associated contingencies cover the cost of the steel sheeting.

Storm Surge Barrier - In order to complete the line of protection, a storm surge barrier must be placed across the South River just north of the Veteran's Memorial Bridge. This barrier ties into the levee and floodwall system on both sides of the river to form continuous blockage from storm tides insurgence into the flood prone low lying areas of South River and Sayreville. This barrier will include a large sector type gate providing a tentatively sized 80 feet clear opening, which will remain open during normal conditions to maintain the natural condition of the waterway upstream as well as to allow boat traffic to pass freely. During a storm event that has the potential to cause flooding, the gates will be closed so that storm surges can not translate further upstream or flank the levees and floodwalls. In order to alleviate any build up of interior drainage behind the gates during closed times, a pump station will be included in the barrier as well. Enclosing the pump station within the barrier (as opposed to locating the pump station with a large concrete sump chamber on the bank) was chosen in order to significantly reduce project costs. The proposed pumping units are direct drive, diesel powered units with no electrical backup required for cost effectiveness. A check dam protruding above the river bottom fronting the intakes was included to preclude shoaling interference. To the east of the gate, included with the barrier, there will be gravity drains (5ft. X 5ft. box culverts) with backflow prevention to alleviate build-up of interior drainage along with the pump station (see Figure10 and 11).


CONTINUOUS CONCRETE CAP
CONTINUOUS WALE 6"x6" STRUCTURAL TUBE
SOUTH RIVER
EL. +21.5
EL. -10.0
45°
2.5
1
CONTINUOUS VINYL SHEET PILE WALL (GEOGUARD SERIES 950 OR EQUAL)
W12x22 SUPPORT BEAM 6 FEET O.C.
STRUT 6 FEET O.C. 8" DIA. DOUBLE EXTRA STRONG CONCRETE FILLED STEEL PIPE
DRAINAGE DITCH
EL. -1.0
EXCAVATION LIMIT
5'-0"
3'-0"
1.5
12" MINIMUM
CONTINUOUS REINFORCED CONCRETE FOOTING
EL. VARRIES
NOTE: STRUT TO SUPPORT BEAM, SUPPORT BEAM TO WALE AND WALE TO SHEET PILE CONNECTIONS ARE TO BE SHEAR CONNECTIONS TO INSURE MINIMAL TRANSFER OF MOMENT.
FLOODWALL DESIGN
TYPICAL CROSS-SECTION
Figure 1


CONSTRUCTION EASEMENT (TYP.)
GRAVITY DRAINS W/ BACKFLOW PREVENTION
TIMBER GUIDE WALLS
NEW BULKHEAD
SECTOR GATE
TIMBER GUIDE WALLS
PUMP STATION
CHECK DAM
NEW BULKHEAD
ACCESS RAMP LOCATION
BULKHEAD
SOUTH
65+00
68+32
SAYREVILLE
GRAPHIC SCALE
50 25 0 50 100FT
SCALE: 1'' = 50'
N


PLAN VIEW SUMP ELEVATION
FORMED SUCTION INTAKE
TRASH RACK
CROSS SECTION THROUGH PUMP STATION
CROSS SECTION AT WEST BANK
CROSS SECTION AT EAST BANK
BULKHEAD CROSS SECTION
CONCRETE CAP
VINYL SHEET PILING
SELECTED PLAN
BULKHEAD AND PUMP STATION DETAILS
Figure

6.4.2 Selected Hurricane and Storm Damage Reduction Features – Interior Drainage

The storm gate barrier and levee/floodwall protection plan was selected to provide the most cost-effective protection from storm induced flooding. The three general areas protected are: (1) the Main River or Main Channel, which includes all areas of the river basin subject to storm surge inundation south of Main Street and the Veterans Memorial Bridge, (2) the West Segment, in the Borough of South River north of Main Street, and (3) the East Segment, in the Borough of Sayreville north of Main Street (see Figure 7). The areas protected from storm surges are subject to interior residual flooding from storm water runoff. The areas were studied to determine the specific nature of residual flooding and to formulate and evaluate interior drainage alternatives.

Damage Reach 3 and Reach 4 were modified to facilitate: (1) analysis of interior drainage behind levees and floodwalls and (2) estimation of residual damage associated with interior flooding. Reach 3 was divided into Reach 3A and Reach 3B, and Reach 4 was divided into Reach 4A and Reach 4B.

Following the guidance in Engineering Manual (EM) 1110-2-1413, *Hydrologic Analysis of Interior Areas*, the interior drainage facilities were planned and evaluated separately from the line-of-protection. First, the minimum drainage facility plan or minimum facilities plan was identified. The minimum facilities were the starting point from which additional interior drainage facilities were compared. As stated in the EM, the minimum facilities should provide interior flood relief such that during low exterior stages the storm drainage system functions essentially as it did without flood protection in place, up to that of the local storm sewer design. The minimum facilities represent the minimum drainage required such that no induced flooding occurs as a result of construction of the line-of-protection.

Next, the benefits accrued from alternative interior drainage plans were attributable to the reduction in the residual hurricane and storm damages which may have remained under the minimum facility condition. Finally, optimum drainage alternatives were selected based on meeting NED objectives.

6.4.2.1 Analysis Approach

The HSDR features will trap local runoff behind the line-of-protection. In order to release the runoff to the South River or the Washington Canal, outlet pipes with flap valves and sluice gates to control backflow will be provided along the line-of-protection. In areas where wetlands exist on both sides of the line-of-protection, some tidal flushing is expected to be required. In these areas, the outlet or outlets will not have flap gates installed. This will allow ebb and flow flushing of the wetlands during the normal tidal cycle. During times of storm surges, the flushing outlets' sluice gates will be manually closed in conjunction with closure of the sector gate to prevent backflow behind the line-of-protection.

Since the gravity structures cannot discharge runoff against high tailwater or exterior stages, it was important to develop an understanding of the relationship between the precipitation events creating significant interior runoff and the storm events creating high exterior stages that block the gravity outlets.

Review of historical rainfall and storm data indicated that there was only limited correlation between significant precipitation events and storm surges. It was expected that only limited runoff will coincide with a severe storm surge and, conversely, only a limited storm surge may be expected during moderately severe rainfall. Historical data indicated that the majority of interior runoff events coincided with a storm surge level less than or equal to a 2-year storm. Similarly, the majority of significant storm surge events were likely to coincide with runoff equivalent to a 2-year event or less.

The analysis was conducted for five (5) interior storm events: the 2-year, 10-year, 50-year, 100-year, and 500-year frequency events. In order to develop a stage-frequency relationship, the interior precipitation events were routed against exterior tidal marigrams. For the expected scenarios, the five interior precipitation events were routed against a 2-year exterior storm surge, and a 2-year interior precipitation event was routed against the five exterior storm surge frequencies. The highest interior water surface elevation (WSEL) determined for corresponding coincidental frequencies (*e.g.*, a 2-year interior and 10-year exterior, or a 10-year interior and 2-year exterior) was identified as the most damaging flood level for the coincidental frequency. The analysis was performed for both the current and future conditions, including sea level rise.

In order to address risk and uncertainty regarding the dependency of significant precipitation events and storm surge events, additional analyses were conducted using a normal tide stage and the 10-year storm surge to establish lower and upper confidence bands, respectively. The analysis is fully described in the Interior Drainage Appendix (Appendix H).

6.4.2.2 Minimum Facilities

The strategy outlined in EM 1110-2-1413 follows the premise that interior facilities will be planned and evaluated separately from the line-of-protection, and should provide adequate drainage at least equal to that of the existing infrastructure. The initial plan represents the minimum drainage facilities required to implement the line-of-protection plan.

Main River Storm Gate - The main river storm gate consists of an 80-foot wide sector gate across the South River, just north of the Veterans Memorial Bridge. The drainage area impacting the gate is approximately 135 square miles. Discharges impacting the proposed gate location are shown in Table 28.

Table 28
Maximum Discharges – South River

Frequency	Maximum Discharge (cfs)
2-year	2,680
10-year	4,500
50-year	6,500
100-year	7,500
500-year	10,200

The minimum facilities for the main tide gate include: (1) an 80-foot wide sector gate, and (2) five 10-foot wide by 10-foot high box culverts located in the eastern portion of the storm barrier.

West Segment Line of Protection - The West Segment line of protection consists of approximately 5,850 feet of levees and floodwalls along the South River in the Borough of South River, north of Main Street and the Veterans Memorial Bridge. The drainage area behind the levee is approximately 0.69 square miles. The minimum facilities for the West Segment, shown in Table 29, consist of 8 primary and 3 secondary outlets.

Table 29
West Segment Minimum Facilities

Outlet	Location (Approximate Levee Station)	Size	Interior Invert(1) (ft NGVD)	Exterior Invert(1) (ft NGVD)	Tie to Existing Drainage System
Secondary	11+00	24" RCP	0.1	0.0	No
Primary	15+00	60" RCP	0.1	0.0	No
Secondary	24+50	24" RCP	0.1	0.0	No
Primary	32+00	60" RCP 60" RCP 60" RCP 60" RCP	0.1	0.0	Yes
Primary	36+00	60" RCP 60"RCP(2) 60"RCP(2)	0.1	0.0	Yes
Secondary	44+00	60" RCP	0.1	0.0	Yes

(1) Estimated invert elevation.
(2) No flap gate installed in order to allow flushing of wetlands.

East Segment Line of Protection - The East Segment line of protection consists of approximately 6,500 feet of levees and floodwalls, along the South River and Washington Canal in the Borough of Sayreville, north of Main Street and the Veterans Memorial Bridge. The drainage area behind the levee is approximately 0.54 square miles. The minimum facilities for the East Segment, shown in Table 30, consist of 4 primary and 3 secondary outlets.

Table 30
East Segment Minimum Facilities

Outlet	Location (Approximate Levee Station)	Size	Interior Invert(1) (ft NGVD)	Exterior Invert(1) (ft NGVD)	Tie to Existing Drainage System
Primary	6+00	36" RCP	0.1	0.0	No
Secondary	13+20	36" RCP	5.1	5.0	Yes
Primary	20+00	60" RCP	2.1	2.0	Yes
Primary	38+20	60" RCP(2)	0.1	0.0	No
Primary	49+30	60" RCP(2)	0.1	0.0	No
Secondary	49+50	18" RCP(3)	0.1	0.0	No
Secondary	58+00	36" RCP(4)	5.1	5.0	Yes

Notes:
(1) Estimated invert elevation.
(2) Requires drainage ditch construction outside of the line-of-protection.
(3) Required for environmental purposes; no flap gate installed.
(4) Downstream of NJDOT Mitigation Site pump station.

6.4.2.3 Alternative Interior Drainage Plans

Alternatives considered during the development of the interior drainage facilities included pumping and diversion plans. The costs of pumping and diversion alternatives were additive to the minimum facility cost. The construction of a pump station creates additional capital expenditures (or first costs) and also increases annual O&M costs. Additional first costs for the addition of pump stations include mechanical equipment and associated housing. Pump station O&M costs include power consumption and equipment replacement. Additional first costs for the addition of diversion pipes or channels primarily include excavation and construction of the diversion facilities.

6.4.2.4 Selected Interior Drainage Plans

Alternative interior drainage plans were formulated to provide safe and reliable protection from interior residual flooding. Due consideration was given to evaluating only alternatives that were implementable and could be expected to provide equitable protection to properties within the line-of-protection. Selection of a recommended plan focused on economics, that is, providing the optimum reduction in damages for the cost of protection.

Using the above criteria, a 100 cfs diversion of upper drainage area runoff was selected for recommendation for the East Segment line-of-protection, minimum facilities were selected for recommendation for the West Segment line-of-protection, while a 1,200 cfs pumping station was selected for recommendation for the Main Channel line-of-protection. Table 31 summarizes the selected plan costs and annual damages.

6.4.3 Selected Mitigation Plan

Both Mitigation Alternative 2 and Mitigation Alternative 3 are "best buy" plans that are cost-effective and incrementally justified. The acreages, costs, benefits, and incremental cost/output were evaluated for each of these plans to determine which plan had ecological outputs that were worth its associated costs. Both plans would involve the conversion of 20 acres of habitat to wetlands. Mitigation Alternative 2 would result in a gain of 34.7 AAHUs for $5,126 per AAHU on an average annual basis, or $2.66 million total for mitigation. For one additional AAHU, offered by Mitigation Alternative 3, it would cost an additional $9,183 on an average annual basis, or approximately $130,000 total for mitigation. Selection of Mitigation Alternative 2 would result in a gain of 29.9 FCUs over the No-Action plan. Mitigation Alternative 3 would result in a gain of an additional 2.9 FCUs. Based on this assessment, it was determined that Mitigation Alternative 2 was the preferred mitigation alternative of the "best buy" plans.

Table 31
Selected Interior Drainage Plan Summary

Basin	Facility	Number of Gravity Outlets & Size	Total Pump Station Size	First Construction Cost*	Land Cost	O&M Cost	Annual Cost	Annual Residual Damages	Significant Damage Elevation (ft NGVD)	Street Flooding Elevation (ft NGVD)
East Segment	100 cfs Diversion	930ft 60" dia. diversion pipe; 5@36" dia. 3@60" dia. 1@18"dia.	N/A	$1,193,600	$22,800	$7,550	$84,650	$119,400	5.0	4.5
West Segment	Minimum Facilities	2@24" dia. 9@60" dia.	N/A	$1,029,700	$0	$8,450	$74,950	$209,100	7.0	6.5
Main Channel	1,200cfs Pump Station	5@10'x10' box culverts 4@60" dia.	1,200 cfs	$6,186,340	$0	$44,600	$444,000	$326,250	5.0	4.5
TOTAL				$8,409,640	$22,800	$60,600	$603,600	$654,750		

All costs at January 2001 price level.
*includes Minimum Facilities, Engineering & Design (E&D), Supervision and Administration (S&A), and Contingeneies.

Mitigation Alternative 2 was further evaluated based on the site conditions and the South River mitigation goal. The goal of mitigation was to replace the total combined number of AAHUs lost, and a minimum of 50% of the AAHUs lost per evaluation species. Trade-offs can occur between evaluation species as long as the total combined number of AAHUs is met. Mitigation Alternative 2 would mitigate for approximately 340% of the total AAHU impacts and would replace more than 100% of the AAHU impacts for all the species except the clapper rail (68%) and marsh wren (85%). Because Mitigation Alternative 2 greatly over-compensates for the overall AAHU impacts, successively smaller percentages of the selected alternative were evaluated, and recalculated outputs (AAHUs) and costs, until it reached 50% of the clapper rail AAHUs. All other evaluation species would meet the mitigation goal of > 50% of the AAHUs lost, and the total combined number of AAHUs would be 190% of the AAHU lost.

An evaluation of the FCUs gained through implementation of the optimized mitigation alternative (Mitigation Alternative 2 at 55%) shows that only 80% of the total combined FCUs lost would be replaced by mitigation. However, the evaluation of FCU gains/losses assumed that any wetland habitat that would be enhanced or created would be based on the wetland functions and values (FCIs) already present in the study area (*i.e.*, analysis used the FCI values for the existing habitats). Based on an assessment of potential FCI improvements for each of the target wetland communities, and as per EPW manual guidelines, it was decided that the same wetland functions would be provided at a level of performance (*i.e.*, increased FCIs per function) needed to meet minimum FCU replacement goals. Therefore, the additional FCUs needed to fulfill the mitigation goal and obtain 100% replacement for the total combined number of FCUs lost would be obtained by improving specific wetland elements in the planned wetlands for each wetland function.

Based on these refinements of Mitigation Alternative 2, two conceptual design plans (Plans A and B) were developed based on the location, hydrology, acreages, and conversions specified in the selected mitigation plan. Because Plan B is located further from the NJDOT mitigation site, it was selected. This plan was primarily focused in the largest area of disturbed habitat located on the unprotected side of the levee. The northern portion of this disturbed habitat was selected based on the presence of existing hydrology and close proximity to an existing access road.

6.4.4 Selected (NER) Ecosystem Restoration Plan

Using the selected combination of habitats and state-of-the-art wetland design principles, three site layouts were developed for the NER plan along a continuum of habitat interspersion/juxtaposition. The layout with the highest degree of habitat continuity, an intermediate level of interspersion/juxtaposition, and almost continuous bands of the two major habitats (low emergent marsh and wetland forest/scrub-shrub) was chosen (see Figure 12). Subsequent design refinements to the chosen layout of the NER plan included: removing tidal creeks and mudflat from most wetland forest/scrub-shrub areas to decrease the number of potential areas (in terms of elevation) for wetland *Phragmites* colonization; replacing the acres of mudflat and tidal creek removed in the wetland forest/scrub-shrub areas by enlarging and increasing the sinuosity and density of existing channels; creating more natural channel morphology and increasing tidal flushing on the marsh surface; and, inserting low emergent marsh habitat to transition between a large expanse of mudflat habitat and wetland forest/scrub-shrub habitat in Area 3. The anticipated benefits to ecosystem function and biodiversity from implementation of the NER plan are expected to be significant (in terms of institutional, public, and technical significance) and consistent with the Federal, State, and local laws and advance the goals of the resource management plans contained in Table 32.

*7. ENVIRONMENTAL CONSEQUENCES

Consistent with NEPA and CEQ regulations, plan formulation of HSDR features and ecosystem restoration features have avoided adverse project effects (project implementation or O&M) to the fullest extent possible. As described in the *South River Avoidance and Minimization Plan*, when adverse effects could not be fully avoided, they were minimized. If minimum adverse effects of project implementation or O&M are unavoidable, they will be mitigated (see Section 6.4.3). Following is a summary of anticipated adverse effects of the environmental consequences anticipated to accompany the alternative plans for HSDR and ecosystem restoration.

The discussion of environmental effects of HSDR measures focuses on the selected HSDR plan. This is the only plan identified through the plan formulation process as implementable. It has been optimized at a 500-year level of protection with a levee/floodwall elevation of +21.5 NGVD. The discussions describe the anticipated effects of this plan relative to benchmarks provided by the no-action alternative.

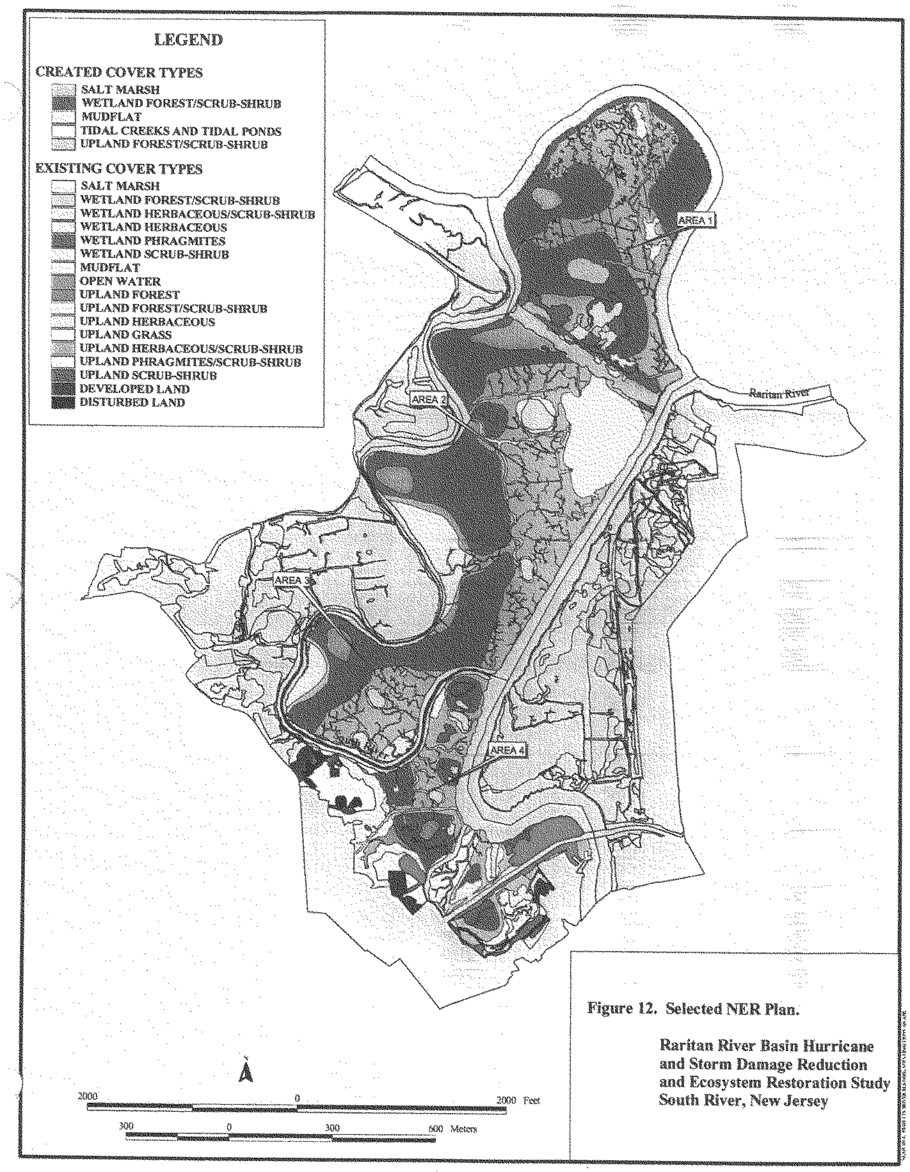


Figure 12. Selected NER Plan.

Raritan River Basin Hurricane and Storm Damage Reduction and Ecosystem Restoration Study South River, New Jersey

Table 32
Resource Significance
South River NER Plan

Program/Act /Policy	Institutional	Public	Technical
INTERNATIONAL			
North American Waterfowl Management Plan (NAWMP)	X	X	
North American Wetlands Conservation Act of 1989	X	X	
U. N. Environment Program: Convention on Biological Diversity	X		
Partners in Flight	X		
NATIONAL			
National Estuary Program	X	X	
Anadromous Fish Conservation Act of 1965	X		X
Endangered Species Act of 1973	X		X
National Wetlands Priority Conservation Plan	X		X
National Environmental Policy Act (NEPA)	X		
Migratory Bird Treaty Act of 1918	X	X	
Water Resources Development Act of 1990, Section 307(a)	X		
Executive Order 11990 of May 1977 (Protection of Wetlands)	X		
Executive Order 11988 of May 1977 (Floodplain Management)	X		
Coastal Zone Management Act (CZMA) of 1972	X	X	
Public Trust Doctrine of the CZMA	X	X	
Essential Fish Habitat (EFH)	X	X	X
Sikes Act of 1974	X		
Clean Water Act	X		
REGIONAL			
Coastal America Partnership	X		
Emergency Wetlands Resources Act of 1986	X	X	
American Littoral Society	X		
National Estuary Program (NEP): NY-NJ Harbor Estuary	X	X	
STATE			
New Jersey Natural Heritage Program	X		X
New Jersey Audubon Society (Watch List of Species)	X	X	X
New Jersey Rare, Threatened, and Endangered Species Act	X		X
USEPA – New Jersey Designated Priority Wetlands	X		X
Endangered and Non-game Species Program	X		
Association of New Jersey Environmental Commissions	X		
New Jersey Coastal Management Program	X	X	
NJDEP: Freshwater and Coastal Programs	X		
New Jersey Landscape Project	X		
New Jersey Conservation Foundation	X	X	
State & County Mosquito Control Commissions	X	X	
New Jersey Ducks Unlimited	X	X	
Green Acres Program	X	X	
Watershed Associations: Upper Raritan & South Branch	X	X	

7.1 Environmental Effects of Hurricane and Storm Damage Reduction Measures

The primary impacts of the levee system would be the footprint of the levee on tidal wetlands, changed tidal flows, and ponding associated with interior drainage behind the levees/floodwalls. The selected HSDR measures reduce the total acreage of *Phragmites* habitats by direct removal and replacement of *Phragmites*-dominated cover types with levees/floodwalls. These cover type conversions reduce the amount of *Phragmites* available to encroach into adjacent wetland habitats, thus slowing the encroachment of *Phragmites*. Albeit, when compared to the No-Action Plan, construction of the selected plan will result in an overall gain of 1.77 habitat units (HUs) at year 2005 (estimated year for completion of construction) and an overall loss of 1.07 AAHUs at year 2055 (USACE 2002).

The levee design includes culverts that would continue to allow tidal flow to the wetland areas located on the landward side. The only time the hydrology of these wetland areas would be affected is during storm events when the culverts would be closed to prevent flooding in the residential areas on the landward side of the levee. Consequently, impacts to these wetland areas are temporary and minor, and would not require mitigative measures.

The ponding areas were designed to maximize use of existing wetland and/or low-lying areas. Impacts associated with the interior drainage areas may result in a conversion in wetland cover type but not a loss of wetlands. The following sections identify the temporary and long-term beneficial and adverse impacts associated with the selected HSDR measures.

7.1.1 Physical Setting

Impacts on geology, topography, and soils resulting from construction and maintenance of the HSDR measures are expected to be minimal. No impacts on geology will occur because bedrock elevations would be below the depth of proposed excavation, fill, and structure foundations.

A change in topography would occur, but is expected to be minimal. The levee would be constructed of clean fill to a height of +21.5 ft NGVD.

Soil erosion is expected to be minimal during construction because the surrounding topography is flat, reducing stormwater runoff capability. No significant or long-term impacts would occur on native soil grain size, structure, nutrient status, or organic matter content, because only clean material will be used for levee construction. In addition, soil erosion and sedimentation would be minimized during construction through the use of a soil erosion and sediment control plan.

7.1.2 Climate and Weather

Climate and weather will not be adversely affected by construction and maintenance of the HSDR measures.

7.1.3 Water Resources

Construction and maintenance of the proposed HSDR measures would have no adverse impact to regional hydrogeology and groundwater resources. Surface water quality will be temporarily impacted during construction of the storm gate and pump station, and levees/floodwalls because of increased suspended sediments in the water column. However, implementation of soil erosion and sediment control measures will minimize any adverse impacts.

Storm gate closure will result in significant benefits to the local residents by reducing damage caused by hurricanes and other storm events. The frequency and magnitude of storm surges within the study area and in adjacent local residential areas would significantly decrease.

The only indirect impact would be a localized reduction in salinity of tidal water behind the storm gate when it is closed. However, the storm gate only will be closed during unusually severe storms, when the mean high tide approaches +5ft NGVD. The alteration in salinity associated with the salt marsh is expected to be minimal. Once the storm gate is open, normal circulation and tidal inundation patterns will be re-established at the next tidal exchange. Therefore, the effects of daily tidal exchange are expected to be minimal, because the gate would open at the next ebb tide event, allowing water exchange and reducing the costs associated with prolonged pump operation.

7.1.4 Socio-Economics

The HSDR measures would not have significant growth-inducing, or growth-inhibiting, impacts on existing or future demographic characteristics because the area is almost completely developed. The Study will have no impact on the number, density, or racial composition of residents living within the South River area.

The selected HSDR plan would have a direct positive economic impact on existing business in the study area due to reduced potential for future hurricane and storm damages and to improved accessibility to businesses during storm events. There also will be a minor, indirect beneficial economic impact on the local economy during construction as a result of the introduction of construction workers and the resulting purchase of supplies and food during the construction phase.

The Project will have a direct positive impact on housing and structures in the study area due to a reduction in the potential for future hurricane and storm damage to existing properties, and the subsequent reduction in associated costs to repair such damages. The Plan also will have a positive impact on residential property values along the South River due to an increase in flood protection.

7.1.5 Land Use

Construction of the selected HSDR measures will not adversely affect the current land use in the South River study area. The area's economic growth and development will not be restricted by the levees/floodwalls since they have been specifically located in areas that are not suitable for residential, commercial, or industrial use. Implementation of the selected plan will benefit the current and future land uses in the South River area by offering improved protection to homes, businesses, roads, churches, schools, parks, stores, and various other provided services.

7.1.6 Biological Resources

The construction of the selected HSDR measures will result in adverse and beneficial impacts to the biological resources in the South River study area. The following sections describe the impacts to the vegetation, fish and wildlife, and threatened/endangered species located in the study area.

7.1.6.1 Vegetation

Long-term effects of the selected HSDR plan include changes to vegetation cover types due to the construction and maintenance of the levees/floodwalls and the storm gate and pump station. Specifically, a total of 9.41 acres of wetland habitat and 16.49 acres of upland habitat will be permanently converted to 3.29 acres of wetland herbaceous (*i.e.*, vegetated swale), 2.26 acres of upland herbaceous, 19.55 acres of upland grass, and 0.80 acres of developed habitat.

The study was specifically designed such that the levees/floodwalls would avoid and minimize impacts to wetland areas. However, there were several areas where it was impossible to avoid wetlands due to engineering and/or economic constraints. Based on the EPW assessment, the selected HSDR plan, and associated habitat impacts and conversions, will result in the loss of 20.74 wetland FCUs at year 2005. As indicated in Table 33, the uniqueness/heritage function has the highest FCU loss (5.26) followed by sediment stabilization (4.69), water quality (4.54), shoreline bank (2.75), fish tidal (2.24), and wildlife (1.26). However the proposed mitigation plan will offset these impacts (see Sections 6.4.3 and 8.2).

Table 33
Results of EPW Assessment
Hurricane and Storm Damage Reduction
(FCUs)

	Shoreline Bank	Sediment Stabilization	Water Quality	Wildlife	Fish Tidal	Uniqueness/ Heritage	Totals
East Bank	-0.01	-2.71	-2.16	-0.77	-0.61	-2.92	-9.18
West Bank	-2.74	-1.98	-2.38	-0.49	-1.63	-2.34	-11.56
Project	-2.75	-4.69	-4.54	-1.26	-2.24	-5.26	-20.74

7.1.6.2 Fish and Wildlife Resources

In general, construction of the proposed HSDR measures could have minor, short-term and long-term impacts on fish and wildlife habitat and populations occurring in the area. During construction, the clearing and grading of work areas could result in the loss of aquatic, vegetative, and some subsurface cover due to the movement and excavation of soil. These construction activities could result in the temporary and permanent loss of habitat and possible mortality of less mobile, burrowing, and/or denning species of wildlife such as mollusks, small rodents, snakes, turtles, and amphibians. Based on the HEP study, the selected HSDR plan, and associated habitat impacts and conversions, will result in the loss of 1.07 HUs at year 2055. As indicated in Table 34, the yellow warbler has the highest AAHU loss (5.49) followed by clapper rail (3.18), and marsh wren (2.13). However, the American black duck, American woodcock, and eastern cottontail would benefit from the proposed project and would gain 0.57, 3.25, and 5.91 AAHUs, respectively.

Table 34
Results of HEP Analysis at Year 2055*
Hurricane and Storm Damage Reduction
(AAHUs)

	Black Duck	Clapper Rail	Marsh Wren	Yellow Warbler	Woodcock	Eastern Cottontail	Totals
East Bank	0.21	-1.83	-1.60	-3.41	1.97	3.32	-1.34
West Bank	0.36	-1.35	-0.53	-2.08	1.28	2.59	0.27
Project	0.57	-3.18	-2.13	-5.49	3.25	5.91	-1.07

* AAHU values do not include the benefits associated with the selected mitigation plan.

Following construction, wildlife species are expected to resume their normal habits consistent with post-construction habitat availability in and around the study area. In addition, impacts to wildlife will be fully compensated through implementation of the selected mitigation plan (see Sections 6.4.3 and 8.2).

Mammals: Mammals in the South River study area may be temporarily affected by construction activities. During construction, heavy machinery activity and increased noise levels may cause mortality of some individuals of less mobile species of small mammals (*e.g.*, mice and voles), or indirectly cause displacement of individuals near construction activities. However, the mammals most likely to occur in the area are mobile and tolerant to human activities. Therefore, disturbances from construction activities would temporarily displace mammals from construction areas, but these individuals would likely avoid direct mortality and would return to the area once construction activities cease.

Birds: Birds in the study area would be temporarily or permanently affected by implementation of the Project. During construction, increased noise and heavy machinery activity could cause displacement of individuals, nest failure and/or nest disruption in the vicinity of construction. Species that use the existing wetland habitats, such as the American black duck, Canada goose, marsh wren, clapper rail, yellow warbler, and red-winged blackbird may be temporarily or permanently displaced by the habitat alterations that would occur due to construction activities. Species that use the existing upland habitats such as the downy woodpecker, blue jay, mourning dove, and cedar waxwing may also be temporarily or permanently displaced by the habitat alterations that would occur due to construction activities.

There are benefits to birds anticipated from the creation of habitats associated with the HSDR activities. Created habitats (*i.e.*, upland and wetland herbaceous) associated with the revegetation of the levee and creation of a 10-foot wide retention ditch/swale along the levee/floodwall would provide additional foraging habitat. In addition, a variety of bird species are likely to benefit from the proposed mitigation plan.

Reptiles and Amphibians: Amphibian and reptilian mortality and habitat loss is expected to be minimal since construction impacts would be concentrated in and around saltwater marsh habitats, and the majority of the amphibians and reptiles that are likely to occur in the study area are freshwater species. Similarly, the installation of the floodwall and levee may disrupt or impede terrestrial migration patterns of reptiles and amphibians, but this effect is expected to be minimal because they will typically be placed between suitable freshwater habitats and unsuitable habitats with higher salinities. The majority of the amphibians and reptiles likely to occur within the construction area will tend to burrow and hide rather than flee. Therefore, construction activities could result in the possible mortality of some individuals.

Reptiles and amphibians are expected to see some benefits from the selected storm damage reduction plan due to the creation of a 10-foot wide freshwater wetland retention ditch that would be constructed along the landward side of the levee/floodwall. In addition to the retention ditch, the ponding areas would provide additional freshwater habitats that could be used as breeding and feeding grounds for various species of amphibians and reptiles.

Shellfish: Construction of the HSDR measures will have an immediate adverse effect on shellfish species within the South River study area, but is expected to be minimal given the small footprint of the area that will actually be affected. During construction of the storm gate, any sessile shellfish in the immediate area would be buried while most motile shellfish species (*e.g.*, crabs) would relocate to an area outside of the immediate impact area.

Levee and floodwall construction will be limited to the upland areas adjacent to the salt marshes and some wetland areas along the edge of the marsh. In areas where levees or floodwalls are constructed in the marsh/wetlands, a short, one-time direct burial of existing shellfish will occur if any are present at the time. No long-term adverse impacts to the shellfish are expected as a result of the construction of the levees and floodwalls (USACE 1989).

Finfish: Construction of the levees/floodwalls will not directly impact finfish. However, construction of the storm gate will have an indirect, short-term impact on fish species in the immediate study area. Motile species would likely avoid burial during installation of the storm gate by relocating outside of the placement area. However, the potential for some fish mortality and burial of eggs may exist and some benthic feeding fish species may also experience temporary displacement of food until appropriate food sources recolonize the area. However, these and other fish that are present at the time of construction are expected to feed in the surrounding area and will be unaffected by the temporary localized reduction in available benthic food sources.

Daily or seasonal migratory patterns of anadromous fish species could be impacted by construction of the storm gate. Long-term effects may include impacts to fish located on the protected side of the storm gate. Fish trapped on the protected side of the storm gate may experience mortality by being drawn through the pump intake during periods of operation. However, the gate would open at the next ebb tide event, allowing water exchange and reducing the costs associated with prolonged pump operation.

An increase in suspended solids can affect fish populations by delaying hatching time of fish eggs (Schubel and Wang 1973), and potentially clog and damage the gills of fish species (Uncles *et al.* 1998). However, suspended sediment would settle quickly out of the water column thus causing minimal impacts to the fish community. Harper (1973) found fish utilizing the increase in turbidity as a way of providing temporary protection from predators.

***Benthic Resources*:** Negative impacts to the benthic community would include direct smothering of sessile benthic invertebrates within the construction area of the storm gate. During construction activities, motile invertebrates will be able to escape without injury. Maurer *et al.* (1978) found some infaunal bivalves, crustaceans, and invertebrates migrating vertically through more than 0.3 meter of sediment for survival. The burial of benthic prey organisms could cause a temporary decrease in food availability for fish and shellfish in the study area, causing them to temporarily relocate to nearby unaffected areas to feed.

The placement of the storm gate would provide long-term beneficial impact to the benthic community by increasing hard substrate for attachment of sessile plants and animals; providing more shelter for small fish; and, increasing food supply for predatory fish.

Construction of the levees/floodwalls will be limited to the upland areas adjacent to some wetland areas. In areas where levees or floodwalls are constructed in the marsh/wetlands, a short, one-time direct burial of existing marsh invertebrates will occur if any are present at the time. No long-term adverse impacts to the existing marsh surface benthic invertebrates are expected as a result of the construction of the levees/floodwalls.

7.1.6.3 Threatened and Endangered Species

The construction and maintenance of the proposed HSDR measures will not impact any Federally or state listed endangered or threatened species, areas of designated critical habitat, or essential fish habitat (USFWS 2000b, USFWS 1999, and NMFS 1999) (Appendix D).

7.1.7 Cultural and Historic Resources

In order to determine the impact of the proposed project upon cultural and historic resources, investigations were conducted for the Area of Potential Effect (APE) to ascertain if cultural resources were present. The APE consists of the area impacted by the proposed levee/floodwall system and storm surge gate or barrier, the proposed ecosystem restoration area, and the areas selected for mitigation of the wetlands impacted by the construction of the levees/floodwalls (Figure 7). The APE lies in the Boroughs of Sayreville and South River, Middlesex County, New Jersey. There are remains extant that are probably from the brick industry that thrived into the second half of the twentieth century. Intact subsurface cultural resources from the brick industry have been encountered in a previous project just north and east of the APE (Louis Berger & Associates, Inc. 1990). Even though 90 percent of the terrain within the APE was shown to be disturbed, undisturbed, culturally sterile, strata were encountered within the APE of the east levee footprint (Panamerican Consultants, Inc. 2001).

Results of the Phase I survey (Panamerican Consultants, Inc. 2001) of areas potentially affected by the selected hurricane and storm damage plan are as follows.

East Levee/Floodwall Footprint: Three archaeological sites were documented including five historic period structural features and one artifact locus. In addition, the geomorphologist identified a location that contained buried natural surfaces. The project, as currently designed, will not impact any significant cultural resources, including the viewshed.

West Levee/Floodwall Footprint: No cultural resources were encountered within the APE of the west levee/floodwall footprint. While this area has a documented rich cultural past, no intact remains were encountered. If no changes are made to the current project design, further investigation is not being recommended. Viewshed will not be impacted.

Should cultural resources be encountered during construction, all work should be halted and the find reported to the Corps project archaeologist. Construction should not resume until an assessment of the resources involved has been carried out by the project archaeologist and coordination with the New Jersey Historic Preservation Office (NJHPO) has been completed.

Natural ponding areas will not be investigated, but ponding areas requiring excavation, pump stations, the storm surge gate/barrier and access roads will require Phase I cultural resource investigation as will any changes to existing project plans. Staging areas not located on macadam or other hard surface will also be subjected to investigation. The areas selected for mitigation have not yet been subjected to subsurface investigation. All future cultural resource investigations will be coordinated with the NJHPO.

The proposed construction within the APE will have no impact on significant cultural resources as long as work is conducted as described, the project design does not change, and existing historic property is avoided. These areas will be indicated on project plans. The plans and specifications will be coordinated with the New Jersey Historic Preservation Office (NJHPO) through the Corps archaeologist.

7.1.8 Air Quality

A conformity demonstration is required for each pollutant where the total direct and indirect emissions from a Federal action exceed the corresponding de minimis level. To evaluate the applicability of General Conformity requirements, all sources of emissions associated with the Federal activity must be evaluated. As the first step in the process, a preliminary air quality assessment was conducted for the construction, operation, and maintenance of the hurricane and storm damage reduction measures as well as the mitigation and restoration measures.

Preliminary air emission estimates for direct and indirect sources were made based on emission estimates generated from similar activities for the Environmental Impact Statement for the proposed Meadowlands Mills Project (Environmental Impact Statement for the Department of the Army, Application Number 95-07440-RS by Empire LTD, 2002). Rough emissions estimates were based on a comparison of the relative sizes (i.e. ratio of fill material) of the two projects for the associated activity. This emissions estimation methodology will be refined in the Statement of Conformity, factors such as fill material transport distance and operating parameters will be incorporated in the final emissions calculations.

Direct emissions are those emissions that are caused or initiated by the Federal action and occur at the same time and place as the action. For the proposed project, the direct emissions would be those emissions generated from levee construction activities and from the mitigation and restoration activities.

Indirect emissions are those emissions that are caused by the Federal action, but may occur later in time and/or may be further removed in distance from the action itself but are still reasonably foreseeable, and the Federal agency will maintain control over them. For the proposed project, the indirect emissions would include emissions during construction activities from transport of fill material to the site from off-site locations and from construction workers commuting to the site, and future emissions generated from the pump station. The projected emissions are summarized in Table 35.

Table 35
Summary of Project Air Emissions

	NOx		VOC		CO	
	Ton/year	Ton/day	Ton/year	Ton/day	Ton/year	Ton/day
Direct (Construction)						
Levee construction	1.32	0.007	0.13	<0.001	0.65	0.004
Wetlands construction	46.05	0.148	3.62	0.012	28.6	0.092
Total Construction	47.37	0.155	3.75	0.012	29.25	0.096
Indirect (Transportation)						
Fill material transport	1.33	0.004	0.22	0.0006	1.03	0.003
Employee commuting	1.8	0.005	1.40	0.0038	10.2	0.028
Total Transportation	3.13	0.009	1.62	0.0044	11.23	0.031
Project Total	50.5	0.164	5.37	0.017	40.5	0.126

The preliminary total direct and indirect NOx emissions are projected to exceed the de minimis threshold of 25 tons per year. Projected total direct and indirect VOC and CO emissions are expected to be below the de minimis threshold levels of 25 tons per year and 100 tons per year, respectively.

These preliminary estimates will be refined in the next project phase (Preconstruction, Engineering and Design) when the Corps conducts a detailed, comprehensive quantitative analysis to more precisely quantify all emissions from the South River Project and to determine conformity accordingly. At this point, the Corps has established an approximate timeline for demonstrating conformity:

- Conduct detailed emissions analyses (Dec 2002 – Jan 2003)
- Assess emissions results (Feb 2003)
- Evaluate conformity options (Feb 2003)
- Conduct detailed mitigation assessment (Mar 2003)
- Formal agency/public review of proposed mitigation and draft General Conformity Determination (Apr 2003)

- Respond to agency/public comments (May 2003)
- Publish final General Conformity Determination and summarize process/results/mitigation in ROD (May 2003).

The Corps will conduct this process in close consultation with the USEPA and the NJDEP.

As necessary, in addition to pursuing mitigation alternatives like emission offsets, emission credits, emission reduction technologies, and operational modifications to reduce emissions, the Corps is aware that, per 40 CFR 93.158(a)(5)(i)(A), conformity can be demonstrated if the emissions from the action along with all other emissions in the area would not exceed the emission budget specified in the SIP. For example, the preliminary NOx emissions from the project represent an insignificant portion of the emissions budgeted in the New Jersey SIP for 2005, so the potential exists for direct and indirect NOx emissions from the project to demonstrate conformity with the SIP. Once detailed information is available, the Corps will explore this option with the NJDEP.

7.1.9 Noise

Construction of the HSDR measures would result in a temporary, but minor increase in noise as a result of the use of construction equipment. Maintenance and operation of the proposed storm gate, floodwalls, and levee would have no impact on noise.

Minor short-term impacts on noise levels would result from the construction phase. Site preparation (generally two weeks prior to construction), construction activities, and the necessary heavy equipment are likely to produce noise levels in the 70 to 90 dBA range (50 feet from the source). These noises would be masked by the high background levels of traffic and community activity or dissipated by distance. Additional noise may be created during the operation of the pump station; however, this noise would be minimal due to the infrequency of its use.

7.1.10 Recreation

The Washington Canal and South River navigation project was designed to handle the commercial navigation associated with the brick industry. The channel is now oversized for the small pleasure craft, which are the sole users of this waterway.

The width of the navigation channel at the location of the storm surge barrier is 150 feet. Of concern is whether the 80-foot gate opening is adequate for the current vessel traffic. There is a Conrail railroad swing bridge a short distance upstream of the sector gate. This swing bridge has a clear opening of approximately 40 feet, which is half the opening of the sector gates. Since vessels safely transit the 40-foot railroad bridge, the proposed 80-foot sector gate should be more than adequate. The gate was sized to limit velocities through the gate, during the highest astronomical tide, to 4 feet per second to allow vessels to transit through the gate at all phases of the tide. Under normal, mean tide, conditions, it can be expected that currents would be weaker.

The United States Coast Guard was contacted to evaluate the impacts of the proposed gate on vessel navigation. Their response stated they had no objection to the completion of the project, as discussed in the Hydrology, Hydraulics, and Design Appendix (Appendix A).

The Project will directly impact two Green Acre areas, including Varga Park and Recreation Area and an unnamed parcel located in the southeastern portion of the Project Area near the Sayreville/South River Bridge. Although the District has specifically aligned the levee/floodwall footprint to minimize impacts to these two areas, due to their proximity to the South River and adjacent residential/developed areas it was impossible to avoid them. Consequently, the District will coordinate with the NJDEP and NJ State House Commission to obtain the necessary permits and approvals to traverse these areas.

There will be no long-term direct or indirect impacts to any existing or planned recreational areas after construction of the proposed hurricane and storm damage reduction measures. Minor, temporary impacts associated with bird watching, hiking, fishing, biking, and boating may occur during construction activities. Once construction is complete, there will be additional recreational opportunity such as walking, running, or biking along the top of the levee. In addition, the mitigated and restored habitats in the study area will increase the aesthetic value of the area.

Although the storm gate will be located downstream of a small boat marina, access to the Raritan River will only be restricted during severe storm events when the gate is closed for HSDR purposes.

7.1.11 Aesthetics

Due to the highly developed nature of the study area, the proposed HSDR measures would not adversely impact the aesthetic and visual character of the South River study area.

The earthen levee will create a raised, curving, linear landscape element that is different from the surrounding natural environment. The vegetation cover for the earthen levee will be different from the adjacent plant communities, creating an abrupt edge effect in both color and texture at the toe of the levee. The differences in the form, line, color and texture of the levee will also serve to visually encapsulate the wetlands landscape from certain isolated viewsheds or visual vantage points.

7.1.12 Hazardous, Toxic, and Radioactive Waste

No HTRW issues are anticipated to arise during project implementation. Should any concerns arise during the construction phases, procedures for this contingency will be specified in the construction contract. Due to the geology of the region, arsenic in the soil and sediment on Clancy Island is a constituent of potential concern and may, in some locations, exceed NJDEP Soil Clean Up Criteria. However, for proposed ecosystem restoration and mitigation activities, arsenic levels are not anticipated to affect project implementation.

7.1.13 Transportation and Other Infrastructure

Construction activities will result in minor, temporary impacts to traffic flow and volume. An increase in large slow-moving construction vehicles needed for floodwall/levee and tide gate construction will decrease traffic flow and increase traffic volume in the area. To help alleviate the temporary impacts associated with construction activities, flagmen could be available and construction signs will be posted. Upon completion of construction, no adverse impacts to local transportation systems would occur.

Conversely, the proposed levees/floodwalls will allow the local roadways to remain accessible during storm and flood events, including routine and emergency access to and from residences and businesses. In addition, the proposed Project will reduce the incidence and cost of road damage due to flooding.

7.1.14 Unavoidable Adverse Environmental Effects of Hurricane and Storm Damage Reduction Measures

The construction of the selected HSDR measures would result in certain unavoidable adverse impacts on the environmental resources located within the South River study area. Initial construction activities primarily involve ground disturbance to accommodate permanent HSDR structures and an increase in elevation from the installation of levee/floodwalls. Temporary and localized adverse environmental effects that may occur during construction include: an increase in traffic, an increase in noise levels due to construction equipment, an increase of sedimentation into water resources during construction, loss of less mobile wildlife, disturbance of existing vegetation, and disruption of aesthetic, visual, and recreational resources.

The implementation of the selected HSDR plan is expected to generate numerous long-term beneficial impacts that would offset temporary adverse environmental impacts. These long-term beneficial impacts include a potential increase in property values due to reduced flooding concerns, a potential reduction in the cost of flood insurance, an increase in available recreational areas, and restoration/creation of an expansive salt marsh ecosystem that would subsequently provide valuable wildlife habitat. Implementation of the levee planting plan would offset some of the direct impacts to wildlife habitat and wetland resources associated with installation of permanent HSDR structures. Additionally, impacts to the quality and quantity of wildlife habitats and wetland functions would be fully compensated through implementation of the selected mitigation plan.

7.2 Environmental Effects of Restoration Measures

Implementation of the restoration measures associated with the NER Plan will convert 379.3 acres of *Phragmites* to: 151.7 acres of tidal salt marsh, 19.0 acres of mudflat, 19.0 acres of open water (equally divided between tidal creeks and tidal ponds), and 170.7 acres of wetland forest/scrub-shrub (with 19.0 acres of interspersed upland forest/scrub-shrub islands). When compared to the No-Action alternative, the selected NER Plan will result in a net gain of 299.4 AAHUs (14,969 total cumulative HUs) during the course of the 50-year Project life and a net gain of 116.2 FCUs at the year of construction (USACE 2001a).

The primary impacts of the restoration measures associated with the selected NER Plan will be a change in habitat cover type and corresponding plant community elevation on the island (Restoration areas 1-3; 333.3 acres) and on one section adjacent to the island (Restoration area 4; 46.0 acres). The habitat conversations and resulting changes in community elevation will indirectly impact the entire restoration area (Restoration areas 1-4) by modifying the magnitude and duration of tidal fluctuations. As currently designed, tidal flushing should increase throughout the interior and perimeter (*e.g.*, the old South River channel) of the island, increasing water circulation and more consistently maintaining the area's salinity within mesohaline concentrations.

The following sections identify the temporary and long-term beneficial and adverse impacts associated with implementation of the restoration measures in the selected NER Plan.

7.2.1 Physical Setting

Impacts on geology, topography, and soils resulting from construction and maintenance of the restoration measures associated with the NER Plan are expected to be minimal. No impacts on geology will occur because bedrock elevations are estimated to be well below the maximum depth of proposed excavation: 6.4 feet of excavation for permanently flooded tidal pond habitat (USACE 1999c). [Note: all elevation data in section 7.2.1 are in NAD83 coordinates and referenced to the New Jersey State Plane Grid].

Topography changes will occur throughout the entire restoration area (379.3 acres), but they will not exceed a reduction of elevation by 6.4 feet (permanently flooded tidal pond; 9.5 acres) and an increase in elevation of approximately 3.0 feet (upland forest/scrub-shrub; 19 acres). In addition, salt marsh habitat (151.7 acres) will require excavation of 2.1 feet, tidal creeks (9.5 acres) will require excavation of 4.7 feet, and wetland forest/scrub-shrub (170.7 acres) will require the deposition of 1.0 feet of soil. The excavation and deposition of material outlined above is based on the results of an extensive vegetation mapping and biobenchmarking survey (USACE 1999c) that determined the mean elevation of *Phragmites* (2.5 feet) and the mean elevation of each proposed habitat in the restoration area.

Soil erosion during construction will be minimized to the fullest extent possible by strict implementation of a sediment and erosion control plan, developed in the PED phase. Approximately $1.5 million has been estimated for sediment and erosion control in the construction phase. Potential negative effects on water turbidity will also be reduced by blocking the primary hydrologic influence (*i.e.*, tidal flushing) in those areas where construction is actively occurring. Since the existing and proposed topography of the restoration area is generally level, the erosive capability of stormwater runoff should be minimal.

Soil erosion with the NER Plan is estimated to be less than with the No-Action alternative. The EPW wetland functional assessment measures the potential for soil erosion in two ways – through a category for sediment stabilization (*i.e.*, a measure of the wetland's capacity to stabilize and retain previously deposited sediments within the wetland) and a category for shoreline bank erosion control (*i.e.*, a measure of the wetland's capacity to provide erosion control and dissipate erosive forces at the shoreline bank). As with the calculation for all FCUs, the sediment stabilization FCU was estimated by multiplying the FCIs of the existing habitats by their respective acreages, and then subtracting the product of the FCIs of the proposed habitats multiplied by their respective acreages. Although the FCU for sediment stabilization for the NER Plan is –47.41, the difference is primarily due to the zero rating mudflat and open water cover types received as compared to *Phragmites*, not to *Phragmites* performing the sediment stabilization function significantly better than salt marsh or wetland forest/scrub-shrub (both of which had FCI values within .04 of that for *Phragmites*). In addition, the FCU for shoreline bank erosion control for the NER Plan is 75.27.

No significant or long-term impacts will occur to native soil grain size or structure because the NER Plan does not require the placement of any offsite material. The need for fertilizer amendments to facilitate the growth of planted species will be assessed in the PED phase. The need for amendments will be based on replicating the soil nutrient and organic matter content most suited for plant growth in the different habitat types.

7.2.2 Climate and Weather

Climate and weather will not be adversely affected by construction and maintenance of the restoration measures associated with the NER Plan.

7.2.3 Water Resources

The restoration measures associated with the NER Plan will positively impact surface water quality in the South River watershed in two primary ways. First, the increased tidal circulation within and around the island will act to keep the system well flushed and aerated, promoting nutrient and detritus exchange among the salt marsh, mudflat, and tidal creek/tidal pond systems. Second, by decreasing the elevation of a large section of the island to create salt marsh (151.7 acres) and mudflat (19.0 acres), a greater percentage of the tidal cycle will be captured. That is, currently the mean elevation of *Phragmites* in the restoration area, 2.5 feet (USACE 1999c), is at a height where the mean daily duration of flooding is less than about 25% (WES 2000). In the same report, it was found that the lower zone of existing *Spartina alterniflora* had a mean daily duration of flooding greater than 50%.

The importance of the extent to which the tidal cycle interfaces with intertidal habitat is fundamental to the ability of a wetland to remove sediment from incoming waters. *S. alterniflora* in the lower elevation reaches of an intertidal salt marsh exists in a much more energetic zone than the higher elevation reaches of a wetland, and correspondingly has the potential and capacity to trap more suspended sediments. In this way, water clarity (*i.e.*, a reduction in turbidity) can be positively correlated with the duration and frequency of flooding in an intertidal wetland. The NER Plan will increase the duration and frequency of flooding in the restoration area, and at the time of construction will generate 10.9 water quality FCUs (USACE 2001a).

It is not anticipated that any negative impacts will occur to regional hydrogeology and groundwater resources. Impairments to water quality during construction due to increased suspended sediments will be minimized to the fullest extent possible by strict implementation of a sediment and erosion control plan, developed in the PED phase, as well as meeting all requirements of State and local permits necessary for construction. Potential negative effects on water turbidity will also be reduced by blocking the primary hydrologic influence (*i.e.*, tidal flushing) in those areas where construction is actively occurring.

7.2.4 Socio-Economics

The restoration measures associated with the NER Plan will not have significant growth-inducing, or growth-inhibiting, impacts on existing or future demographic characteristics because the restoration area is all currently wetlands and not suitable for most residential, commercial, or industrial uses.

7.2.5 Land Use

The restoration measures associated with the NER Plan will not adversely affect current land use practices in the South River study area in general or in the restoration area in particular, because the NER Plan will not alter the jurisdictional status of the wetlands in the restoration area.

7.2.6 Biological Resources

Implementation of the NER Plan will produce both ecological (measured via HEP as AAHUs) and wetland functional (measured via EPW as FCUs) benefits to the South River watershed, as well as the larger Raritan River estuary. HEP (Table 36) and EPW (Table 37) demonstrate that implementation of the selected NER Plan will measurably improve biodiversity and ecological function in the South River study area. The wildlife benefits quantified by AAHUs and the wetland functional benefits quantified by FCUs reflect landscape level changes in plant community composition and in wetland structure and organization, respectively, that directly translate into ecological benefits like increasing habitat biodiversity, restoring under-represented wetland habitat, restoring habitat for rare or special interest species, increasing tidal flushing of wetlands, improving water quality, and reducing shoreline erosion.

Table 36
Results of HEP Analysis
Ecosystem Restoration
(AAHUs)

	Black Duck	Clapper Rail	Marsh Wren	Yellow Warbler	Woodcock	Eastern Cottontail	Totals
No-Action Alternative	69.1	230.0	186.7	22.2	28.0	52.8	588.8
NER Plan	114.0	174.1	142.5	131.0	120.2	206.3	888.1
Difference	44.9	-55.9	-44.2	108.8	92.2	153.5	299.3

Table 37
Results of EPW Assessment
Ecosystem Restoration
(FCUs)

	Shoreline Bank	Sediment Stabilization	Water Quality	Wildlife	Fish Tidal	Uniqueness/ Heritage*	Totals
No-Action Alternative	163.8	345.7	294.3	155.4	53.9	NA	1,013.1
NER Plan	239.1	298.3	305.2	185.2	101.5	NA	1,129.3
Difference	75.3	-47.4	10.9	29.8	47.6	NA	116.2

* The uniqueness/heritage function was not included in the calculation because the FCI value was already optimal, and implementation of the NER Plan will not lower the value.

7.2.6.1 Restoration Impacts

The NER Plan design provides a template for converting one cover type (*Phragmites*) to several others (salt marsh, tidal creek, tidal pond, mudflat, wetland forest/scrub-shrub, and upland forest/scrub-shrub). Since an environment's physical structure is integrally linked to its ability to perform certain ecosystem processes, any conversion in cover type has corresponding real world effects that directly relate to changes in ecosystem processes. For example, when *Phragmites* is converted to salt marsh, nutrient and energy flow are impacted by the subsequent increase in the frequency and duration of flooding on the marsh surface. Salt marshes are among the most productive ecosystems in the world; regular and sustained tidal flushing transports detritus (*i.e.*, dead organic matter – and corresponding nutrients and energy) to nearby aquatic areas where it is available for consumption by a variety of small fish, crabs, mussels, and snails. These species then provide food for numerous other species in the interconnected salt marsh food web (*e.g.*, shorebirds, wading birds, waterfowl, and predatory fish).

This change in ecosystem processing is reflected in the almost doubling of the Fish Tidal function, as measured by EPW, from 53.9 FCUs with the No-Action alternative to 101.5 FCUs with the NER Plan (Table 37). The net increase in the Fish Tidal function (47.6 FCUs) is partly the result of the specific layout of mudflat, tidal creeks, tidal ponds, and salt marsh specified in the NER Plan design, which was designed to mimic the natural pattern of zonation typically found in salt marsh communities. Essential Fish Habitat (EFH) will also benefit from this design; bluefish and winter flounder EFH species have been found in the South River (USACE 2000a, USACE 2000b, and Barno 1995). The NER Plan will also improve the value and availability of spawning and nursery habitat for anadromous fish species; American shad and alewife have been found in the South River (USACE 2000b).

The NER Plan will replace the vast monotypic *Phragmites* community, which has relatively low value to wildlife, with more biologically diverse habitat with value to a wide variety of wildlife species (Table 36). Relative to the six species used in the HEP evaluation, HEP calculations yielded the greatest benefits to the yellow warbler and woodcock, increasing by 5.9 and 4.3 times, respectively, their AAHUs relative to the No-Action alternative (Table 36). The New

Jersey Audubon Society has compiled a Watch List that identifies high priority bird species based on lists developed by Partners in Flight (National Audubon Society 2001). The American woodcock is on this Watch List for the State of New Jersey. Another HEP species used in the calculations for the NER Plan, the American black duck (AAHUs increased 1.65 times more than the No-Action Alternative; Table 36) is also on the New Jersey Watch List. Implementation of the NER Plan will restore habitat for both of these species, with 44.9 AAHUs for the American black duck and 92.2 AAHUs for the woodcock.

In addition, the American black duck has been identified by the Atlantic Coast Habitat Joint Venture partnership, under the North American Waterfowl Management Plan (NAWMP), as a species of concern in New Jersey. Since the goals of the NAWMP include protecting and restoring wetland habitat for migratory waterfowl, and the South River watershed is located along the major Atlantic migratory bird flyway, the NER Plan will restore important migratory bird habitat, for the American black duck and numerous other species, in an area where open space and high quality wetland habitat is limited.

Although the total AAHUs for both the clapper rail and the marsh wren are reduced by approximately 75% under the NER Plan (Table 36), in both cases this result is a function of a large amount of poor quality habitat (*i.e.*, *Phragmites,* with a low HSI rating) being replaced by a smaller amount of high quality habitat (*i.e.*, salt marsh, with a high HSI rating) (USACE 2001a). In the case of the clapper rail on the island, 347 acres of *Phragmites* (HSI = 0.55) will be converted to, among other things, 131 acres of salt marsh (HSI = .92) (most of the HUs for the clapper rail are accrued through the salt marsh cover type) (USACE 2001a). Similarly, in the case of the marsh wren on the island, 347 acres of *Phragmites* (HSI = 0.47) will be converted to, among other things, 131 acres of salt marsh (HSI = 0.83).

7.2.6.2 Construction Impacts

In general, construction of the restoration measures associated with the NER Plan will have minor, short-term impacts on fish and wildlife resources in the area as a result of temporary loss of habitat and possible mortality of less mobile, burrowing, and/or denning species of wildlife such as crabs, mollusks, small rodents, snakes, turtles, and amphibians. Since construction activities will not occur across the entire restoration area at one time (*i.e.*, construction in the different restoration areas will most likely be phased in over time, depending on available funds) motile organisms will have undisturbed areas available for short-term relocation.

Mammals in nearby upland areas that utilize *Phragmites* (*e.g.*, mice, voles) might be temporarily displaced during construction, but will likely avoid direct mortality and return to the area once construction activities cease. Bird species utilizing the existing wetland complex, such as American black duck, Canada goose, marsh wren, clapper rail, yellow warbler, and red-winged blackbird, will be temporarily displaced by the construction activities and could experience nest failure and/or nest disruption, but are also expected to return once construction activities cease. Increased noise and heavy machinery activity in the wetlands could disturb nearby upland bird species as well.

Negative impacts to the benthic community will include direct smothering of benthic invertebrates (*e.g.*, shellfish, crabs, snails, worms, etc.) and slow-moving vertebrates (*e.g.*, turtles). It is expected that these species, after construction, will return to the restored areas from nearby wetlands. Although some fish and fish eggs might experience direct mortality, most species will be able to relocate during construction and return after construction is complete.

7.2.6.3 Threatened and Endangered Species

Although no Federally listed species have been identified within the restoration area, the Federally listed threatened bald eagle (*Haliaeetus leucocephalus*) may utilize habitats in the vicinity, and the NER Plan will improve habitat for the bald eagle and provide more opportunities for foraging in the open marsh. A Federal species of concern in the region, the diamondback terrapin, will also benefit from a restored estuarine environment.

By providing increased cover and opportunities for foraging and nesting, the proposed ERP will improve habitat for many of the State of New Jersey endangered and threatened species observed in the restoration area (Section 3.6.3.2; *e.g.*, black skimmer, northern harrier, peregrine falcon, yellow-crowned night heron, osprey, black-crowned night heron, and American bittern). Restoration of wetland habitat for these rare and special interest species can aid in their recovery.

7.2.7 Cultural and Historic Resources

As discussed previously, investigations were conducted for the Area of Potential Effect (APE) to ascertain if cultural resources were present. Results of the Phase I survey (Panamerican Consultants, Inc. 2001) of areas potentially affected by the selected ecosystem restoration and mitigation plans are as follows.

Wetland Restoration Area/South River Meander Belt: Due to field conditions, only one of eight proposed test locations was tested. The test revealed four natural strata. To date, no cultural materials have been found. The remaining seven test locations should be tested in the subsequent field effort. If further natural strata are located, they will be dated by radiocarbon.

The Washington Canal: Cultural resource investigations have determined that the Washington Canal may be eligible for the National Register of Historic Places and may be impacted by the ecosystem restoration portion of the current project. Since the Canal facilitated economic growth of the South River and Sayreville communities, it is potentially eligible to be listed on State and/or National Registers of Historic Places. A Determination of Eligibility for the Canal will need to be carried out if this portion of the project is carried out. Since project impacts are possible, a Phase II investigation is recommended to determine the Canal's eligibility if it will be impacted.

Should cultural resources be encountered during construction, all work should be halted and the find reported to the Corps project archaeologist. Construction should not resume until an assessment of the resources involved has been carried out by the project archaeologist and coordination with the New Jersey Historic Preservation Office (NJHPO) has been completed.

The proposed construction within the APE will have no impact on significant cultural resources as long as work is conducted according to recommendations of the Phase I cultural investigation feasibility report (Panamerican Consultants, Inc. 2001). This area will be indicated on project plans. The plans and specifications will be coordinated with the New Jersey Historic Preservation Office (NJHPO) through the Corps archaeologist.

7.2.8 Air Quality

As noted in Section 7.1.8, a preliminary air quality assessment was conducted for the construction, operation, and maintenance of the hurricane and storm damage reduction measures as well as the ecosystem restoration measures. Based on this assessment, projected total direct and indirect NOx emissions are projected to exceed the de minimis threshold of 25 tons per year. Total direct and indirect VOC and CO emissions are estimated to be below the de minimis threshold levels of 25 tons per year and 100 tons per year, respectively.

These preliminary estimates will be refined in the next project phase (Preconstruction, Engineering and Design) when the Corps conducts a detailed, comprehensive quantitative analysis to more precisely quantify all emissions from the South River Project and to determine conformity accordingly. At this point, the Corps has established an approximate timeline for demonstrating conformity:

- Conduct detailed emissions analyses (Dec 2002 – Jan 2003)
- Assess emissions results (Feb 2003)
- Evaluate conformity options (Feb 2003)
- Conduct detailed mitigation assessment (Mar 2003)
- Formal agency/public review of proposed mitigation and draft General Conformity Determination (Apr 2003)
- Respond to agency/public comments (May 2003)
- Publish final General Conformity Determination and summarize process/results/mitigation in ROD (May 2003).

The Corps will conduct this process in close consultation with the USEPA and the NJDEP.

As necessary, in addition to pursuing mitigation alternatives like emission offsets, emission credits, emission reduction technologies, and operational modifications to reduce emissions, the Corps is aware that, per 40 CFR 93.158(a)(5)(i)(A), conformity can be demonstrated if the emissions from the action along with all other emissions in the area would not exceed the emission budget specified in the SIP. For example, the preliminary NOx emissions from the project represent an insignificant portion of the emissions budgeted in the New Jersey SIP for 2005, so the potential exists for direct and indirect NOx emissions from the project to demonstrate conformity with the SIP. Once detailed information is available, the Corps will explore this option with the NJDEP.

7.2.9 Noise

The NER plan will not have any direct or indirect negative impacts on noise levels in the South River study area. Construction of the NER Plan will result in temporary, minor increases in noise as a result of the use of construction equipment – with the necessary heavy equipment likely to produce noise levels in the 70 to 90 dBA range (50 feet from the source). However, the majority of the restoration area is on the island, and therefore largely isolated from residential and commercial areas.

7.2.10 Recreation

Implementation of the NER Plan will positively impact passive recreation opportunities by providing habitat for species of recreational interest, like shorebirds (*e.g.*, spotted sandpiper [*Actitis macularia*]), wading birds (*e.g.*, snowy egret [*Egretta thulla*], glossy ibis [*Plegadis falcinellus*]), waterfowl (*e.g.*, American black duck), and predatory fish (*e.g.*, bluefish [*Pomatomus saltatrix*], and striped bass [*Morone saxatilis*], which are of special interest to people. There will be no long-term direct or indirect negative impacts to boating opportunities after construction of the selected restoration measures. Minor, temporary disruption to boating activities will occur during construction activities.

7.2.11 Aesthetics

The proposed restoration measures of the NER Plan will positively enhance the aesthetic and visual character of the South River study area by diversifying the landscape. From the vantage point of a boat on the Washington Canal or the old South River channel, or from the shoreline of the east bank, the existing *Phragmites* monoculture visually blocks any view into the island. The selected restoration measures will replace 10-12 feet *Phragmites* stands with 4-5 feet *S. alterniflora* stands. The NER Plan will diversify the topography of the island and restoration area 4, so that, for example, the wetland forest/scrub-shrub areas will be visible from the east bank and Washington Canal (in the distance, adjacent to the tidal salt marsh complex) as well as from the old South River channel.

7.2.12 Hazardous, Toxic, and Radioactive Waste

Implementation of the NER Plan is not anticipated to generate any HTRW issues. Due to the geology of the region (naturally occurring high concentrations of arsenic), arsenic in the soil and sediment on Clancy Island is a constituent of potential concern and may, in some locations, exceed NJDEP Soil Clean Up Criteria. However, for proposed restoration measures, arsenic levels are not anticipated to affect project implementation.

7.2.13 Transportation and Other Infrastructure

Construction activities associated with implementation of the NER Plan will result in minor, temporary impacts to traffic flow and volume. An increase in large slow-moving construction vehicles needed for will decrease traffic flow and increase traffic volume in the area. To help alleviate the temporary impacts associated with construction activities, flagmen could be available and construction signs will be posted. Upon completion of construction, no adverse impacts to local transportation systems would occur.

7.3 Environmental Justice Summary

In accordance with Executive Order 12898 (dated February 11, 1994) Federal agencies are required to identify and address the potential for disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations.

The neighborhoods within the proposed study area are not considered to be low-income or minority neighborhoods. According to the 1997 Economic Census, seven percent of the population of the Borough of South River has income below the poverty level. The Borough of Sayreville has three percent living below the poverty level. Similarly, according to the 1990 Census of Population, 83.5 percent of the population of the Borough of South River is white, with 6.1 percent black and 3.5 percent Asian. The Borough of Sayreville is 76.5 percent white, with 8.6 percent black and 10.6 percent Asian.

Per capita incomes in these small communities are lower than the county and state averages, and approximately 4.1 percent of the population had incomes below the poverty level in 1989. However, the selected HSDR plan would have a beneficial impact on these low-income communities by reducing future storm damages and their subsequent repair costs, and could potentially increase property values. Similarly, the selected ecosystem restoration plan could increase the property values by adding a unique wetland complex in an urban New Jersey suburb.

No adverse human health impacts are anticipated to result from the implementation of the selected plan. It is not expected that residential relocations would be required for implementation of the selected plan. Avoidance of relocations was one of the considerations that led to selection of floodwalls, rather than levees, for some portions of the line of protection. The selected plan would provide an increased level of flood protection to study area communities, and residents would experience beneficial impacts in terms of protection of property and life. In addition, the selected plan would allow for improvement of the business and recreational amenities in the community. Therefore, no mitigation measures are required to address disproportionately high and adverse impacts to minority and low-income populations.

The recommended South River plan would not adversely affect any populations within the study area, with the exception of temporary effects associated with construction activities (*e.g.*, noise and traffic). Rather, residents of the study area communities would realize significant benefits from flood protection provided by the project. It can therefore be concluded that the selected plan would not disproportionately affect minority or low-income populations.

7.4 Relationship Between Short Term Uses And Long Term Productivity

The selected HSDR plan will entail a short-term commitment of resources, including construction equipment; construction materials; labor; public monies to fund the Project and to purchase property easements; and, equipment necessary for minimization and mitigation of environmental impacts.

Some areas within the study area will be subject to removal of vegetation, disruption of natural habitat, and ground disturbance during construction. There will be a short-term temporary disruption of transportation systems and infrastructure along roads in the study area during construction. There also will be a disruption of the availability of recreational and scenic uses. These disruptions will preclude the use of local recreational facilities and transportation routes by local residents and tourists, and habitats by indigenous animal species.

To contrast this short-term commitment of resources, there are several long-term enhancements in productivity that will result from the selected HSDR and ecosystem restoration plans. There will be beneficial impacts on the local economy, such as decreased costs to local businesses as hurricane and storm damages are reduced. There may also be a greater attraction to the community resulting from the newly created salt marsh ecosystem, and a decreased potential for flooding.

In the long-term, the selected HSDR plan is anticipated to result in a more economically and environmentally stable community, both in the immediate study area and in the surrounding municipalities. Therefore, the long-term productivity of the overall region may experience benefits from this short-term impact of the environment.

7.5 Irreversible And Irretrievable Commitments Of Resources

Irreversible and irretrievable resource commitments are related to the use of nonrenewable resources and the effects that use of these resources will have on future generations. Irreversible effects primarily result from use or destruction of a specific resource (*e.g.*, energy and mineral) that cannot be replaced within a reasonable time frame. Irretrievable resource commitments involve the loss in value of an affected resource that cannot be restored as a result of the action (*e.g.*, extinction of a threatened or endangered species).

Irreversible and irretrievable resources would be committed to the study area by the Federal government, the non-Federal project partner (NJDEP), and any involved local agencies and municipalities. Resources committed include construction and mitigation materials and costs; labor costs for project planning; natural resources such as soil, water, energy resources such as fossil fuels (gasoline, petroleum products, and lubricants) and electricity; and, land to accommodate the HSDR features.

Not all of these resources are irretrievable. The monies committed to the selected HSDR and ecosystem restoration plans will be offset through savings in municipal, residential, and commercial hurricane and storm damage costs in the future, and potentially through increased commercial success for the community as a result of enhanced recreational opportunities, and a more safe and secure business area. This may also result in an increase in the revenues of the local municipalities in the event of increasing property tax values.

Investments of materials and disposable goods associated with construction of the ecosystem restoration plan, would be an irretrievable commitment of resources. This commitment will enhance success and diversity of wildlife and vegetation in the study area.

7.6 Unavoidable Adverse Environmental Effects and Considerations That Offset Adverse Effects

The construction of the selected HSDR plan would result in certain unavoidable adverse impacts on the environmental resources located within the study area. Initial construction activities primarily involve ground disturbance to accommodate permanent HSDR structures and an increase in elevation from the installation of levee/floodwalls. The ecosystem restoration activities would involve a decrease in the elevation of the Island. Temporary and localized adverse environmental effects that may occur during construction include: an increase in traffic, an increase in noise levels due to construction equipment, an increase of sedimentation into water resources during construction, an increase in air emissions, loss of less mobile wildlife, disturbance of existing vegetation, and disruption of aesthetic, visual, and recreational resources.

The implementation of the selected HSDR plan is expected to generate numerous long-term beneficial impacts that would offset temporary adverse environmental impacts. These long-term beneficial impacts include a potential increase in property values due to reduced flooding concerns, a potential reduction in the cost of flood insurance, an increase in recreational use of the area, and the restoration/creation of salt marsh ecosystem that would provide valuable wildlife habitat. Implementation of the levee planting plan would offset some of the direct impacts to wildlife habitat and wetland resources associated with installation of permanent flood control and shore protection structures. Additionally, impacts to the quality and quantity of wildlife habitats and wetland functions would be fully compensated through implementation of the selected mitigation plan as discussed in Section 8.

7.7 Cumulative Impacts

The implementation of the selected HSDR plan and other similar projects will significantly benefit the local residents by increasing storm protection and reducing the amount of property and infrastructure damage due to flooding and tidal surges. As a result, community costs associated with evacuations during flooding events and home repair will be reduced in the South River area and emergency vehicle access will be improved.

The implementation of the selected mitigation and ecosystem restoration plans, in conjunction with other projects in the area, are expected to benefit wetlands as well as the overall value of wildlife habitat in the study area. The construction of HSDR structures such as levees and floodwalls are likely to reduce the spread of *Phragmites*, because they can function like a barrier across which the rhizomes that propagate *Phragmites* cannot spread. This will limit the encroachment of *Phragmites* into wetlands and salt marsh, and will facilitate the maintenance of more diverse and sustainable wetland ecology on the unprotected side of the levees/floodwalls. In addition, mitigation plans to offset impacts to wetlands involve the conversion of wetland *Phragmites* to salt marsh. The implementation of several other plans that involve the conversion of wetland *Phragmites* to salt marsh could improve the overall quality and value of wetlands in the region.

Potential beneficial cumulative impacts to migratory waterfowl and songbirds are likely to result from implementation of the selected mitigation and ecosystem restoration plans. These plans, in conjunction with similar projects in the South River watershed, should increase the overall value of the area. Specifically, the mitigation and restoration plans will add large areas of more desirable wetland communities and increase the study area's biodiversity (*i.e.*, improve the areas composition and abundance of plant and animal species).

Data collected during proposed monitoring programs will contribute to the overall knowledge of the South River watershed, which in turn would contribute significantly to the overall understanding of the energy flow and nutrient cycling among aquatic and wetland resources in the area. This knowledge may assist in the development of sustainable management, restoration, and the long-term preservation of the area's severely degraded natural resources.

The extent of proposed housing or other proposed structural development in the vicinity of the study area has not been formally identified. However, based on the current land development practices, building construction would not be permitted where the selected plan will be constructed. Therefore, there are no known or expected cumulative impacts to local development projects. Overall, this project and similar projects in the South River watershed, can contribute to a more stable environment for planned growth and development as a result of reduced regional flooding concerns and expenses. Improvements to roads, culverts, and stormwater drainage systems should result from reduced hurricane and storm damage infrastructure. This may provide an opportunity for limited development that will yield increased tax revenues from taxes and reduced damage costs to infrastructure.

* 8 RECOMMENDED PLAN

The Recommended Plan is summarized below.

8.1 Hurricane and Storm Damage Reduction

The recommended plan will provide hurricane and storm damage protection for a storm with an exceedance probability of .002 (500-year event). This plan consists of a storm surge barrier and two levee/floodwalls located in Reaches 3 and 4. These structures will be integrated to form a single line-of-protection system with no separable elements. The plan would provide structural protection for the entire study area (Reaches 1 through 5) to an elevation of +21.5 feet NGVD. The levees will extend 10,712 feet in length, and the floodwalls will extend 1,655 feet in length. The storm surge barrier will span the South River for a length of 320 feet and will have a clear opening of 80 feet.

8.2 Environmental Mitigation

The mitigation goal is to replace at least 100% of the combined loss of AAHUs summed across evaluation species and FCUs summed across wetland functions, and at least 50% of the loss of AAHUs per evaluation species and FCUs lost per function, as a result of implementation of the selected HSDR measures. To achieve this goal, mitigation of impacted habitats, will involve planting shrubs on the levee and the conversion of wetland *Phragmites* to salt marsh and wetland-scrub-shrub, and the conversion of upland disturbed areas to wetland-scrub-shrub on the East Bank of the study area as described below. The selected mitigation plan is illustrated in Figure 13.

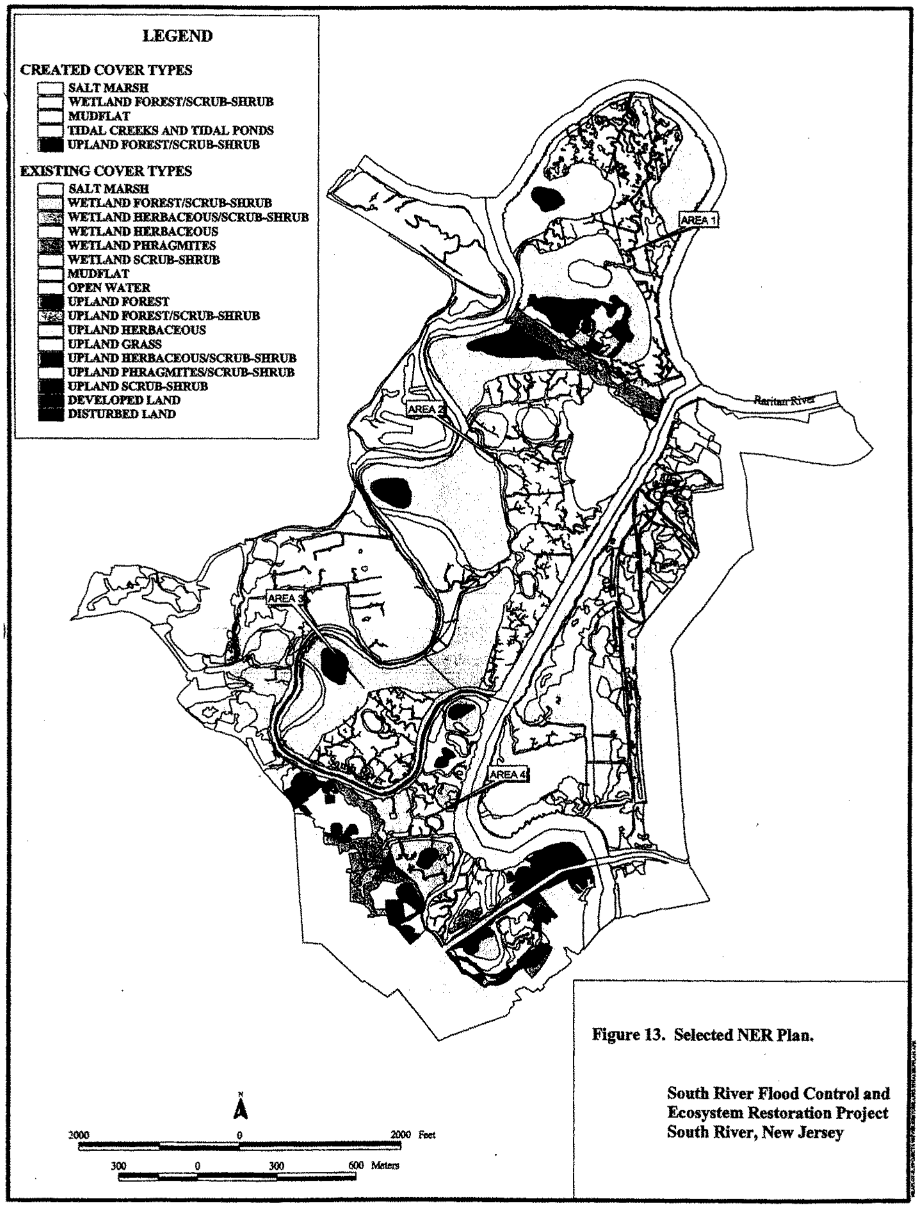


Figure 13. Selected NER Plan.

South River Flood Control and Ecosystem Restoration Project South River, New Jersey

Selected Mitigation Plan –

Conversions:	Wetland *Phragmites*:	3.3 acres salt marsh
		1.7 acres wetland-scrub-shrub
	Upland Disturbed:	6.1 acres wetland-scrub-shrub
	Total:	11.1 acres

With implementation of the selected HSDR measures the mitigation goal of replacement of at least 100% of the combined AAHUs for all evaluation species and at least 50% of the AAHUs for each evaluation species is met. The combined AAHUs lost due to implementation of the selected plan was determined to be 1.07, and implementation of the selected mitigation plan results in a gain of 17.57 AAHUs at year 2055 when compared to the No-Action alternative. In addition, the replacement of FCUs for each wetland function would also be met by the selected mitigation plan. Gains in total FCUs greater than 100% would be realized for all wetland functions.

8.3 Interior Drainage

To provide interior drainage, facilities for the east segment, west segment, and main channel have been formulated and optimized. East segment interior drainage facilities will include a 100 cfs facility (930-foot, 60-inch diameter diversion pipe) with the following gravity outlets: 5@36" diameter, 3@60" diameter, and 1@18" diameter. West segment interior drainage facilities will include the following minimal facilities: 2@24" diameter and 9@60" diameter. Main channel interior drainage will be accomplished by a 1,200 cfs pump station, 5@10'x10' box culverts, and 4@60" gravity outlets.

8.4 Ecosystem Restoration

The NER plan would involve restoration of those portions of the study area degraded by severe *Phragmites* colonization. Specifically, 379.3 acres of *Phragmites* wetlands would be restored to the targeted habitats in the following proportions: 45 percent wetland forest/scrub-shrub (and an additional 5 percent upland forest/scrub-shrub), 40 percent low emergent marsh, 5 percent mudflat, and 5 percent open water (2.5 percent tidal creek and 2.5 percent tidal pond). The specific conversions, benefits, and costs associated with the NER Plan are summarized below.

Conversions	Wetland *Phragmites*:	151.7 acres low emergent marsh
		170.7 acres wetland forest/scrub-shrub
		19.0 acres mudflat
		9.5 acres tidal creek
		9.5 acres tidal pond
		19.0 acres upland forest/scrub-shrub
	Total:	379.3 acres

The results of this restoration plan are expected to be significant (in terms of institutional, public, and technical significance) and consistent with the Federal, State, and local laws and resource management plans presented in Table 32.

8.5 Real Estate

As described in the Real Estate Appendix (Appendix G) and summarized in Table 38, the estimated total acreage required for the Selected Plan is approximately 536.65 acres, comprised of approximately 33 affected tracts and 15 affected ownerships. This acreage consists of the following combination of fee simple purchase, permanent easements, temporary easements (for construction), and severance damages. Costs were estimated using a January 2001 valuation (Gross Appraisal). As indicated below, HSDR real estate requirements would be met using permanent easements; restoration and HSDR mitigation real estate requirements would be met via fee simple purchase.

TABLE 38
LANDS AND DAMAGES

Hurricane and Storm Damage Reduction Features		
Permanent Easement	25.30 acres	$1,265,000
Temporary Easement (for construction)	9.70 acres	$77,600
Severance Damages	55.00 acres	$1,050,000
Fee Simple Purchase (for mitigation)	11.10 acres	$110,381
	Subtotal 101.10 acres	$2,502,981
	Administrative Costs (15% of lands and damages)	$375,447
	Contingency (15% of lands & damages and administrative costs)	$431,764
	Subtotal	$3,310,192 (say $3,310,200)
Ecosystem Restoration Features		
Fee Simple Purchase	435.55 acres	$4,365,069
	Administrative Costs (15% of lands and damages)	$654,760
	Contingency (15% of lands & damages and administrative costs)	$752,974
	Subtotal	$5,772,804 (say $5,772,800)
	Total (536.65 acres)	**$9,082,996 (say $9,083,000)**

8.6 Ecological Monitoring and Adaptive Management

In order to monitor the success of the selected restoration and mitigation plans, several specific performance criteria and potential corrective actions were developed as part of the *South River Restoration Monitoring Plan* (USACE 2000). In particular, the ecological success of the restored/mitigated habitats will be evaluated during the first five years following construction based on the following performance criteria:

- Successful establishment of each habitat type (*e.g.*, low emergent marsh, mudflat, wetland and upland forest/scrub-shrub, tidal creeks and tidal ponds) relative to similar habitats in the region;
- Vegetation should occur in proper zones (*e.g.*, hydric species in wet sites) in all layers (*e.g.*, tree, shrub, and herbaceous) and be of adequate density, height, and distribution compared to similar habitats in the region; Presence of benthic invertebrate species should be comparable to similar marshes in the region both in species richness and diversity;
- Use of restored habitats by fish and wildlife species should be similar to other marshes in the region;
- Water quality, mean bank slope, sinuosity, and water depth should be similar to natural tidal creeks and tidal ponds occurring in the region; and,
- Physical parameters, such as soil characteristics, particle size distribution, degree of colonization by undesirable vegetation (*e.g., Phragmites*), level of tidal flushing, and rates of nutrient and sediment deposition should be similar to other marshes in the region.

The process of adaptive management will be used to initiate any necessary significant corrective action in the restoration area. Adaptive management is appropriate for the proposed ecosystem restoration at South River because of the importance of elevation in the establishment of desired habitat types and the inherent difficulty in constructing large tracts of certain elevations. Corrective action will be taken if performance criteria are not met. Such action may include:

- Replanting vegetation in areas where plantings do not meet predetermined criteria;
- Enhancing survival of planted vegetation (*e.g.*, by applying a fertilizer such as Osmocote®);
- Improving tidal flushing;
- Installing erosion control devices;
- Suppressing encroachment by *Phragmites* (*e.g.*, through application of a herbicide such as Rodeo®);
- Preventing herbivory (*e.g.*, by installing fencing);

- Adjusting channel morphology and hydrology, or stabilizing banks; and,
- Installing breakers (*e.g.*, to adjust tidal flows).

8.7 Cost Estimate

The costs of the selected HSDR plan, mitigation plan, and ecosystem restoration plan are summarized below.

Hurricane and Storm Damage Reduction	
Initial Project Cost	$53,325,100
Mitigation (included in Initial Project Cost)	$2,865,300
Annual Initial Cost (discounted at 6.125 % over a 50-year period)	$3,442,300
Annual Interest During Construction Costs	$499,800
O&M Costs	$221,500
Total Annual Cost (discounted at 6.125 % over a 50-year period)	$4,163,600
Ecosystem Restoration	
Initial Project Cost	$46,499,300
Annual Initial Cost (Discounted at 6.125% over a 50-year period)	$3,001,700
Annual Interest During Construction Costs	$426,000
Annual O&M Costs	$80,000
Total Annual Cost (Discounted at 6.125% over a 50-year period)	$3,507,700
Total Project	
Initial Project Cost	$99,824,400
Annual Initial Cost (Discounted at 6.125% over a 50-year period)	$6,444,000
Annual Interest During Construction Costs	$925,800
Annual O&M Costs	$301,500
Total Annual Cost (Discounted at 6.125% over a 50-year period)	$7,671,300

9. PLAN IMPLEMENTATION

As non-Federal project partner, NJDEP must sign a Design Agreement that will carry the project through the PED phase, which includes development of Plans and Specifications (P&S). The PED phase will be followed by project construction. Funds must be budgeted by the Federal Government and the non-Federal partner to support these activities. A Project Management Plan (PMP) has been prepared to identify tasks, responsibilities, and financial requirements of the Federal Government and the non-Federal partner during PED. A project schedule will be established based on reasonable assumptions for the design and construction schedules.

9.1 General

The South River HSDR and ecosystem restoration project may be authorized in Water Resources Development Act (WRDA) of 2002. Following Congressional authorization, the project would be eligible for construction funding. The project will be considered for inclusion in the president's budget on the basis of national priorities, magnitude of the Federal commitment, economic and environmental feasibility, level of local support, willingness of the non-Federal partner to fund its share of the project cost, and budgetary constraints that may exist at the time of funding.

9.2 Local Cooperation

In accordance with Section 105 (a)(l) of WRDA 1986, the feasibility study of South River, Raritan River Basin was cost shared 50 percent between the Federal Government and the State of New Jersey. The fact that funds were contributed by the non-Federal project partner, NJDEP, and the local municipalities, indicates their intent to support a project for South River, New Jersey.

A fully coordinated Design Agreement (DA) package, which will include the non-Federal partner's financing plan, would have to be prepared subsequent to the approval of the feasibility phase. It will reflect the recommendations of the Feasibility Study. The non-Federal partner , NJDEP, has indicated support for recommendations presented in this Feasibility Report and its desire to execute a DA for the selected plan. Other non-Federal interests, such as the Borough of South River and the Borough of Sayreville, have indicated their support of the project.

As the non-Federal project partner, NJDEP must comply with all applicable Federal laws and policies and other requirements, including but not limited to:

- Provide all lands, easements, rights-of-way, and relocations and disposal/borrow areas (LERRD) uncontaminated with hazardous and toxic wastes .

- Provide of an additional cash contribution if the value of LERRD contributions toward total project costs is less than 35 percent, so that the total share equals 35 percent .

- Provide of all improvements required on lands, easements, and rights-of-way to enable the proper disposal of dredged or excavated material associated with the construction, operation, and maintenance of the project. Such improvements may include, but are not necessarily limited to, retaining dikes, wasteweirs, bulkheads, embankments, monitoring features, stilling basins, and dewatering pumps and pipes.

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

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

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

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

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

- Assume complete financial responsibility, as between the Federal Government and the non-Federal project partner for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be necessary for the construction, operation, or maintenance of the Project.

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

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

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

- Provide the non-Federal share of that portion of the costs of mitigation and data recovery activities associated with historic preservation, that are in excess of 1 percent of the total amount authorized to be appropriated for the project, in accordance with the cost sharing provisions of the agreement.

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

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

- Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in preventing unwise future development in the flood plain and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with the protection provided by the project.

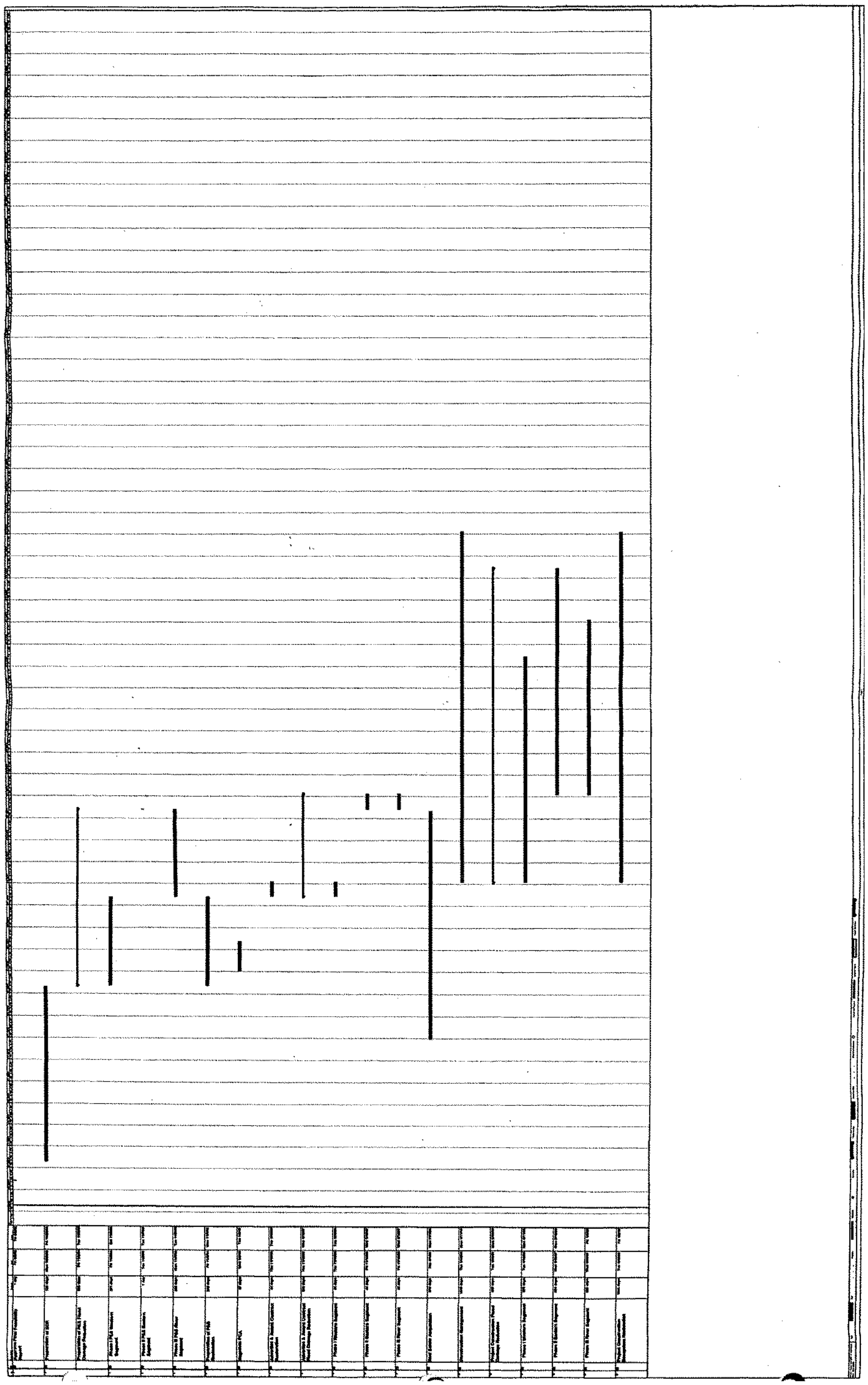
- Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms.

- Enter into an agreement, which provides, prior to construction, 25 percent of preconstruction, engineering and design costs for HSDR features and 25 percent for ecosystem restoration features.

- Provide, during construction, any additional funds needed to cover the non-Federal share of PED costs.

- Grant the Government a right to enter, at reasonable times and in a reasonable manner, upon land which the non-Federal project partner owns or controls for access to the project for the purpose of inspection and, if necessary, for the purpose of completing, operating, maintaining, repairing, replacing or rehabilitating the project.

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



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

- Perform, or cause to be performed, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601-9675, that may exist in, on, or under lands, easements or rights-of-way necessary for the construction, operation, and maintenance of the project; except that the non-Federal sponsor shall not perform such investigations on lands, easements, or rights-of-way that the Government determines to be subject to the navigation servitude without prior specific written direction by the Government.

- Participate in and comply with applicable Federal floodplain management and flood insurance programs.

- Do not use Federal funds to meet the non-Federal sponsor's share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds is authorized.

In an effort to keep the non-Federal project partner involved and the local government informed, meetings were held throughout the feasibility phase. Coordination efforts will continue, including coordination of this study with other State and Federal agencies. It is currently anticipated that a public meeting will be held upon approval of this Feasibility Study.

9.3 Cost Apportionment

Table 39 apportions initial project costs and O&M costs between the Federal government and the non-Federal project partner. The table includes costs associated with HSDR features and with ecosystem restoration features. The total project first costs - including Lands, Easements, Rights-of-way, Relocations, and Disposal areas (LERRD) - are shared on a 65/35 basis by the Federal government and the non-Federal partner. As indicated in Table 39, the Federal share of the entire project's total first cost is $64,885,900; the non-Federal share is $34,938,500. The Federal Government will design the project, prepare detailed plans/specifications and construct the project, exclusive of those items specifically required of the non-Federal partner.

The non-Federal partner is responsible for all LERRD costs and all O&M costs. The LERRD costs are applicable to the non-Federal share of the initial project costs. For example, the total LERRD costs ($9,083,000) borne by the non-Federal partner are applicable to the $34,938,500 share of total initial non-Federal project costs.

9.4 Pre-Construction Engineering and Design Cost Sharing

The PED phase of the project is cost-shared between the Federal Government and the non-Federal partners. PED expenditures are cost-shared at a rate of 35 percent non-Federal and 65 percent Federal. Adjustments are made during construction to bring the cost of PED in line with actual cost sharing of the project. The PED phase is expected to begin in 2002 with the preparation of the Engineering Documentation Report and will continue until the plans and specifications are developed; construction is expected to begin shortly thereafter.

TABLE 39
COST APPORTIONMENT*

Project Features	Cost Category	Federal Share	Non-Federal Share	Total
Hurricane & Storm Damage Reduction Features	Initial Project Costs	$34,661,300	$18,663,800	$53,325,100
	Real Estate Costs (LERRD)**		$3,310,200	
	Cash Contribution	$34,661,300	$15,353,600	
	O&M Costs		$221,500	$221,500
Ecosystem Restoration Features	Initial Project Costs	$30,224,500	$16,274,800	$46,499,300
	Real Estate Costs LERRD)**		$5,772,800	
	Cash Contribution	$30,224,500	$10,502,000	
	O&M Costs		$80,000	$80,000
Total Project	Initial Project Costs	$64,885,900	$34,938,500	$99,824,400
	Real Estate Costs LERRDS)**		$9,083,000	
	Cash Contribution	$64,885,900	$25,855,500	
	O&M Costs		$301,500	$301,500

* Does not include PED cost estimate.
** Applicable to required non-Federal cash contribution.

9.5 Construction Schedule

A preliminary construction schedule was developed for the selected plan. The schedule is based on information available to date, and is predicated on the assumptions listed below. A preliminary construction schedule for South River HSDR and ecosystem restoration is presented in the Gantt chart in Figure 14.

9.6 Financial Analysis

For purposes of executing the Design Agreement (DA), the New Jersey Department of Environmental Protection (NJDEP) has stated its intention to seek authorization from the State of New Jersey to act as the non-Federal partner. The state has a stable source of funding for HSDR and ecosystem restoration projects and has further indicated its intent to enter into a DA at the conclusion of the study. The State of New Jersey has provided funding for the first year of the PED phase.

9.7 Views of Non-Federal Partners and Other Agencies

The selected plan has received strong support from the non-Federal project partner, NJDEP, as well as other agencies of the State of New Jersey. Affected local governments, including Middlesex County, the Borough of South River, and the Borough of Sayreville, have also expressed their support for the project. This support is documented in the Study Correspondence Appendix (Appendix F). Through project planning and NEPA scoping, a variety of other Federal agencies have been involved in this investigation.

* 9.8 Major Conclusions And Findings

This investigation has determined that (1) periodic hurricane and storms pose a severe threat to life and property along the South River and (2) much of the ecosystem along the South River has been degraded by past development activities. In addition, there is significant potential to reduce hurricane and storm damages along the South River and restore degraded ecosystems.

In response to these problems and opportunities, plan formulation activities considered a wide variety of structural and nonstructural measures. Through an iterative plan formulation process, potential alternative HSDR measures and ecosystem restoration measures were identified, evaluated, and compared.

Alternative HSDR plans that survived the initial screening of alternatives included: (1) a storm surge barrier at the confluences of the South River and Washington Canal with the Raritan River, (2) multiple levee and floodwall configurations, and (3) buy-out of flood-prone properties. Further investigation determined that the storm surge barrier alternative was not economically feasible and that there would be significant adverse environmental effects on study area wetlands. It was also determined that acquisition of structures in the floodplains was not economically feasible. In contrast, preliminary analysis indicated that levee and floodwall protection of flood-prone properties in the study area was found to be economically and technically feasible.

More detailed analysis indicated that levees and floodwalls along the eastern and western banks of the lower South River would be economically justified and would have minimal effects on study area wetlands. It was also determined that structural protection of upstream reaches would not be economically justified. A storm surge barrier, located just downstream (north) of the Veterans Memorial Bridge, was subsequently evaluated in combination with levees/floodwalls in the lower reaches. The barrier was found to be an economically feasible means to protect upstream reaches. In addition, it would: (1) minimize environmental impacts on wetlands, (2) avoid potential HTRW sites upstream, and (3) preclude nonstructural protection in upstream communities.

Economic analysis of the hurricane and storm reduction plans indicated that the levee/floodwall system with upstream storm surge barrier would result in the greatest net benefits. Subsequent optimization of this plan determined that a 500-year level of protection would provide the greatest net benefits. Consequently, the levee/floodwall system with upstream storm surge barrier providing a 500-year level of protection was designated as the National Economic Development (NED) plan and was selected as the recommended plan.

Even though the selected HSDR plan was specifically designed to avoid and minimize environmental impacts, there were some unavoidable impacts to the natural resources. Accordingly, the mitigation goal was to develop an array of mitigation alternatives/actions that individually or combined will replace at least 100% of the combined loss of AAHUs summed across evaluation species and 100% of the combined loss of FCUs summed across wetland functions, and at least 50% of the loss of AAHUs per evaluation species and 50% of the FCUs lost per function, as a result of implementation of the selected HSDR plan.

To achieve the mitigation goal, a screening analysis was conducted to evaluate the feasibility of improving the available habitat on the proposed levee (*e.g.*, plant shrubs to improve songbird habitat); improving the existing habitats (*e.g.*, increase the density/cover of the vegetation by planting more shrubs and/or herbaceous species); and, converting one habitat/cover type to another more valuable habitat (*e.g.*, convert areas of *Phragmites* to salt marsh or wetland scrub-shrub).

Based on these three potential mitigation measures identified, it was determined that levee improvements, such as planting shrubs on the landward side of the levee to create upland scrub-shrub habitat, would increase the quality of the habitat for wildlife, and would reduce the overall impacts of the selected plan. It was also determined that improvements of existing habitat would not be possible. Therefore, habitat conversion would be necessary to mitigate for the selected HSDR plan. Two potential mitigation areas that contained wetland *Phragmites* and upland disturbed habitat were identified - the East Bank and the West Bank.

All possible combinations of five different habitat conversions, from zero to 20 acres, or 200% of the wetland acres impacted by HSDR activities, were evaluated, creating 53,130 potential mitigation alternatives. Results from the HEP and EPW assessments were used to calculate ecological outputs for each mitigation alternative. Those alternatives that resulted in no net gain in ecological or wetland functional value were eliminated from further analysis. This screening resulted in 15,837 potential mitigation alternatives for the East Bank and 230 for the West Bank. Next, those alternatives that did not meet the mitigation goal were eliminated, resulting in 423 potential mitigation alternatives for the East Bank and 180 for the West Bank. The habitat conversion acreages for each potential mitigation alternative were compared to the number of acres of wetland *Phragmites* and upland disturbed habitat available in each potential mitigation area. The West Bank area would not provide enough upland disturbed habitat for any of the potential mitigation alternatives identified for the West Bank; therefore, it was eliminated as a potential mitigation area. The East Bank area would provide enough wetland *Phragmites* and upland disturbed habitat for 352 of the identified 423 potential mitigation alternatives.

All 352 mitigation alternatives identified during the screening process were entered into the *IWR-PLAN* for CE/ICA. Based on the results of the *IWR-PLAN*, nine of these alternatives were cost-effective, and three were identified within the *IWR-PLAN* as "best buy" mitigation alternatives. Two of the best buy plans were cost-effective and incrementally justified. Based on an analysis of the acreages, costs, benefits, and incremental cost/output for each of these plans Mitigation Alternative 2 was selected. Mitigation Alternative 2 was further optimized and involves the conversion of 11.1 acres of degraded wetland *Phragmites* and disturbed upland habitat to a combination of wetland scrub-shrub and salt marsh .

Plan formulation for ecosystem restoration along the South River considered a wide variety of restoration measures to address opportunities associated with ecosystem restoration along the South River. Restoration objectives were specified early in plan formulation. These included: restoring habitat for threatened and endangered species, increasing site biodiversity, increasing tidal flushing, reducing *Phragmites*, improving water quality, and stabilizing and protecting desirable wetland habitat. Four priority habitats were considered for ecological restoration of the study area: low emergent marsh, intertidal mudflat, wetland forest scrub-shrub, and open water (i.e., tidal creeks and tidal ponds). Using different proportions of each habitat, more than 250 potential mathematical combinations of these habitats were evaluated.

Using different proportions of each habitat, more than 250 potential mathematical combinations of these habitats were evaluated. These combinations were then applied to potential restoration areas delineated in the study area using four different scales of restoration for degraded acreage in each area: 25 percent, 50 percent, 75 percent, and 100 percent. Cost effectiveness and incremental cost analysis was applied to the resultant 24,000 potential restoration plans, resulting in identification of eight "best buy" restoration plans for the study area. These plans represent the most efficient means to achieve ecosystem restoration in the study area.

Based upon the incremental analysis and the ability of the alternative plans to achieve the restoration planning objectives, one of the Best Buy plans has been selected as the National Ecosystem Restoration (NER) plan. The NER plan would restore 100 percent of the 379 acres of degraded wetlands in the potential restoration areas. The NER plan would restore the following habitats: low emergent marsh (151 acres: 40 percent), wetland forest/scrub-shrub (170 acres: 45 percent; plus an additional 19 acres, or 5 percent, as upland forest/scrub-shrub), mudflat (19 acres: 5 percent), and open water (19 acres: 5 percent).

The non-Federal project partner, NJDEP, has indicated its support for the selected plan and are willing to enter into a Project Cooperation Agreement with the Federal Government for the implementation of the plan.

* 9.9 Areas Of Concern

There are no outstanding areas of concern regarding the selected plan for South River HSDR and ecosystem restoration. The plan is fully supported by the non-Federal project partner, NJDEP, as well as affected local governments and interested Federal agencies. These parties have full confidence in the anticipated performance of the selected plan in terms of HSDR, ecosystem restoration, and impacts on the environment.

* 10. NEPA SCOPING

In accordance with the NEPA, two scoping meetings were locally held to introduce the study and to solicit public and agency comments. Specifically, the purpose of the meetings was to identify public and agency concerns, agency requirements, environmental issues, and alternative solutions.

The first scoping meeting was open to the public and was held at the South River Public Library, on July 16, 1998. Public notices were published in two local newspapers, the Star-Ledger and the Home News Tribune. In addition, postcards announcing the meeting were sent directly to property owners in the study area, interested parties, and elected officials. The second scoping meeting was attended by Federal, state, county, and local agency representatives, and was held at the National Marine Fisheries Service office in Sandy Hook, on July 21, 1998. These agencies were notified directly by postcard announcing the meeting place and time. Comments and questions were recorded at both meetings and have been summarized in the *South River Response to Comments Document* (USACE 1998).

* 11. COMPLIANCE WITH ENVIRONMENTAL REQUIREMENTS

Preparation of this Integrated Feasibility Report and Environmental Impact Statement has included coordination with appropriate Federal and State resource agencies. During the public review of the DEIS, a Water Quality Certificate, in accordance with Section 401 of the Clean Water Act, and a concurrence of Federal consistency with the New Jersey Coastal Zone Management program, in accordance with Section 307 of the Coastal Zone Management Act, were requested from NJDEP. A Conditional Consistency letter has been received from NJDEP and can be found in Appendix D. A Section 404(b) (1) evaluation has been prepared and is also included in Appendix D. In accordance with the Fish and Wildlife Coordination Act (FWCA), planning aid reports were obtained from USFWS and are provided in Appendix D of this report. A Section 2(b) report was also obtained from USFWS and is contained in Appendix D.

For this stage of the planning process, compliance was met for all environmental quality statutes and environmental review requirements. Following is a list of Federal environmental quality statutes to which this planning process and recommended plan are in compliance:

- National Environmental Policy Act of 1969,
- Fish And Wildlife Coordination Act Of 1958 (see Appendix D),
- Endangered Species Act Of 1973,
- National Historic Preservation Act Of 1966,
- Clean Water Act Of 1972 (see Appendix D),
- Clean Air Act Of 1972,
- Farmland Protection Policy Act Of 1981,
- Wild And Scenic River Act Of 1968,
- Federal Water Project Recreation Act Of 1965,
- Resource Conservation And Recovery Act Of 1976,
- Toxic Substances Control Act Of 1976,
- E.O. 11988, Floodplain Management,
- E.O. 11990, Protection Of Wetlands, and

- E.O. 12898, Environmental Justice.

12. RECOMMENDATIONS

In making the following recommendations, I have given consideration to all significant aspects in the overall public interest, including environmental, social and economic effects, engineering feasibility and compatibility of the project with the policies, desires and capabilities of the State of New Jersey and other non-Federal interests.

I recommend that the selected plan for HSDR (and associated mitigation) and ecosystem restoration along the South River, Raritan River Basin, New Jersey project, as fully detailed in this integrated feasibility report and environmental impact statement, be authorized for construction as a Federal project for HSDR and ecosystem restoration, subject to such modifications as may be prescribed by the Chief of Engineers.

The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to Congress as proposals for authorization and implementation funding. However, prior to transmittal to Congress, the non-Federal project partner (the New Jersey Department of Environmental Protection) interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

I recommend authorization of the selected HSDR and ecosystem restoration plan for the South River, Raritan River Basin with such modifications thereof as in the discretion of the Commander, HQUSACE, as may be advisable. These recommendations are made with the provisions that local interests will:

a. Provide to the United States all necessary lands, easements, rights-of-way, relocations, and suitable borrow and/or disposal areas deemed necessary by the United States for initial construction and subsequent maintenance of the project.

b. Hold and save the United States free from claims for damages which may result from construction and subsequent maintenance, operation, and public use of the project, except damages due to the fault or negligence of the United States or its contractors.

c. Maintain continued public ownership and public use of the shorefront areas upon which the amount of Federal participation is based during the economic life of the project.

d. Maintain, repair, rehabilitate, and replace the protective measures and/or structures during the economic life of the project as required to serve the intended purposes at their design levels of storm damage protection and in accordance with regulations prescribed by the Secretary of the Army.

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

f. Contribute the local share of non-Federal costs for initial construction and operation and maintenance over the economic life of the project, as required to serve the intended purposes.

g. Upon completion of each project feature, acquire, rehabilitate, repair, replace, operate and maintain easements for public access to areas created or enhanced by the project. The cost of the operation, and maintenance of these easements will be the responsibility of the non-Federal sponsor.

The recommendations contained herein reflect the information available at this time and current departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of highest review levels within the Executive Branch. Consequently, the recommendations may be modified (by the Chief of Engineers) before they are transmitted to the Congress as proposals for authorization and implementing funding. However, prior to transmittal to Congress, the sponsor, the States, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

John B. O'Dowd
Colonel, Corps of Engineers
District Engineer

CENAD-DE (CENAN/Sept 02) (1105-2-10c) 1st End Mr. Cocchieri/718-765-7071
SUBJECT: South River, Raritan River Basin, New Jersey, Hurricane and Storm Damage Reduction and Ecosystem Restoration Study Final Integrated Feasibility Report and Final Environmental Impact Statement

Commander, North Atlantic Division, Corps of Engineers, ATTN: CENAD-CM-PP
Fort Hamilton Military Community Bldg. 301, Brooklyn, N.Y. 11252 30 Sept 2002

FOR COMMANDER, HQUSACE, ATTN: CECW-PC, Policy Compliance Support Branch, Planning & Policy Division, 441 G Street, N.W. Washington, DC 20314-1000

I generally concur in the Conclusion and Recommendations of the District Commander. The plan developed is technically sound, economically justified and socially and environmentally acceptable. Federal participation in design and construction of this hurricane and storm damage reduction and ecosystem restoration project is recommended.

M. STEPHEN RHOADES
Brigadier General, USA
Commanding

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SOUTH RIVER RARITAN RIVER BASIN

HURRICANE AND STORM DAMAGE REDUCTION
AND
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VOLUME 2

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SOUTH RIVER BASIN

MIDDLESEX AND MONMOUTH COUNTIES, NEW JERSEY

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I. INTRODUCTION

Description of Study Area and Vicinity

General

1. The study area is located within the lower Raritan River Basin in Middlesex County, New Jersey (see Figure 1). The South River is the first major tributary of the Raritan River, located approximately 7 miles upstream of the Raritan River's mouth at Raritan Bay. The South River begins at the confluence of the Matchaponix and Manalapan Brooks, just above Duhernal Lake, and flows northward from Duhernal Lake a distance of approximately 7 miles, at which point it splits into two branches, the Old South River and the Washington Canal (see Figure 2). Both branches flow northward into the Raritan River. The South River is tidally controlled from its mouth upstream to Duhernal Lake Dam. Fluvial conditions prevail above the dam.

2. Early in the feasibility phase, meetings and site visits were held with NJDEP, County and local governments, and area residents to determine the extent of flooding in the South River basin. It was determined from this coordination, along with an evaluation of the economic data, that there are no widespread flooding problems in the South River watershed upstream of the Duhernal Lake Dam, located in the Towns of Spotswood, Jamesburg, and Helmetta. Consequently, the study area was modified, focusing on river reaches below the dam, specifically flood-prone areas within the Boroughs of South River and Sayreville and the Historic Village of Old Bridge (located within the Township of East Brunswick). In discussions that follow, use of the term "study area" refers to areas downstream of Duhernal Lake Dam, unless otherwise noted. The downstream river reaches encompass virtually all the flood-prone structures in the watershed. This revised study area includes the downstream reaches of the South River to the west, the Washington Canal to the east, and the

380-acre Clancy Island (or simply 'the Island') just upstream of the confluences of the river and the canal.

Federal Navigation Projects

3. There are two Federal navigation projects in the study area: (1) the Washington Canal and South River and (2) the Raritan River. These projects are described below.

4. The Washington Canal and South River: As illustrated in Figure 2, this navigation project connects communities along the South River with the Raritan River. Private interests constructed the Washington Canal in the 1830's by widening and deepening a large pre-existing tidal channel. The Canal and the South River navigation channel were Federalized in 1871. The authorized project is a 12-foot deep, 100-foot wide channel in the Washington Canal for a distance of 0.8 miles upstream of the Raritan River and then a 12-foot deep, 150-foot wide channel in the South River to Old Bridge. The total length of this channel navigation project is 5.2 miles. In 1929, when the last improvements to the project were authorized, the channel was used to transport brick, hollow tile, sand, clay, crushed stone, and coal to/from New York Harbor. The last Corps involvement was for maintenance dredging in the early 1940s. The 1941 contract documents specified that dredged material should be transported and disposed of in designated disposal areas with disposal of dredged material to aid the improvement or betterment of the land. Historically, such disposal sites were in close proximity of the actual dredging location, often within open shallow water or wetlands. Currently, small recreation vessels are the sole users of the Washington Canal and South River; there is currently no commercial traffic.

5. The Raritan River: This Federal navigation project along the Raritan River main stem includes channel depths up to 25 feet deep with various associated widths, turning basins and navigation features from the Great Beds light at the turn in the New York and New Jersey Channel to the Raritan Arsenal approximately 5.6 miles upstream. The channel continues with a 15-foot depth to the Washington Canal approximately 8.3 miles upstream of the NY-NJ Channel, with a subsequent 10-foot depth upstream beyond New Brunswick to the terminus of the Delaware and Raritan Canal approximately 13.8 miles upstream of the NY-NJ Channel.

Problem Identification

6. Periodic storms have caused severe flooding along the South River. Flooding upstream of Duhernal Lake is fluvial. Flood damages downstream of Duhernal Lake are tidally-dominated with additional damages associated with basin runoff. The communities repeatedly affected by the tidal surges are the Boroughs of South River and Sayreville and the Historic Village of Old Bridge in East Brunswick Township. There are approximately 1,247 structures in the 100-year floodplains of these communities. Tidal flooding typically occurs during hurricanes and northeasters when sustained onshore winds push storm surges inland up tidal channels. In the Boroughs of South River and Sayreville, water surface elevations in excess of 4.5 feet NGVD, which can occur several times a year, begin to inundate developed areas and lead to significant flood damages. In addition to damages resulting from tidal inundation, tidal surges often block existing storm water drainage outlets, indirectly resulting in additional flood damages.

Authorization

7. The South River Multipurpose Feasibility Study is being conducted under the Corps' General Investigations Program. The study was authorized by resolution of the U.S. House of Representatives Committee on Public Works and Transportation and adopted 13 May 1993. The resolution states that:

Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, that, the Secretary of the Army, acting through the Chief of Engineers, is requested to review the report of the Chief of Engineers, titled Basinwide Water Resources Development Report on the Raritan River Basin, New Jersey, published as House Document 53, Seventy-first Congress, Second Session, and other pertinent reports, to determine whether modifications of the recommendations contained therein are advisable at the present time in the interest of flood control and related purposes on the South River, New Jersey.

8. Under this study authorization, a reconnaissance report was completed in May 1995. This study concluded that there was at least one potential project in the Federal interest. The report recommended 100-year level of flood protection for the Boroughs of South River and Sayreville using levees along the South River and a closure structure at the railroad bridge that connects the two

Boroughs. Based on these findings and recommendations, the Corps and the State of New Jersey entered into an agreement to perform a cost-shared multipurpose feasibility study of the South River.

Prior Federal Studies

9. The South River Basin has been subjected to frequent and severe flooding and has been the subject of various studies. The reports considered applicable to this study have been compiled, reviewed, and utilized as appropriate. The following is a listing and description of those reports:

- Basinwide Water Resource Development Report on the Raritan River Basin. House Document 53, Seventy-First Congress, Second Session. This report, published in the early 1930's, focused on navigation and flood control for the entire Raritan River Basin.

- Delineation of Flood Hazard Areas, Raritan River Basin, Flood Hazard Report #18, South River and Manalapan Brook, NJDEP, Division of Water Resources, October 1972. This report delineated the floodplain in the South River and its tributary, Manalapan Brook.

- Delineation of Flood Hazard Areas, Raritan River Basin, Flood Hazard Report #17, Matchaponix Brook System, NJDEP, Division of Water Resources, March 1973. This report delineated the floodplain of the Matchaponix Brook, which is a tributary to the South River.

- Survey Report for Flood Control, Raritan River Basin, New Jersey, Final Report, New York District, USACE, March 1985. This report served as a comprehensive study of the Raritan River Basin and recommended several additional studies. Although the South River was studied, none of the proposed improvements were determined to be economically feasible at the time. Since that time, Middlesex County has experienced rapid and significant growth.

- South River, Raritan River Basin, New Jersey, Multi-Purpose Study, Final Reconnaissance Report, Department of the Army, Corps of Engineers, New York District, May 1995. The South River Reconnaissance Study determined that there is Federal interest in flood damage reduction and ecosystem restoration along the South River. The reconnaissance report evaluated a variety of structural and nonstructural flood damage reduction plans for the Towns of South River and Sayreville. This study anticipated engineering and economic feasibility of 100-year level of structural protection. The recommended plan included levees at Sayreville (9,500 feet) and at South River (9,000 feet), a railroad closure structure, and road raisings.

Study Participants and Coordination

10. The New York District is responsible for conducting the overall Feasibility Study in cooperation with the non-Federal sponsor, NJDEP. The feasibility study and implementation of the recommended project continues to receive strong support from the State (NJDEP) and from local governments, including the Borough of South River and the Borough of Sayreville. These non-Federal interests are committed to working with the Corps to address flooding problems and opportunities for ecosystem restoration along the South River.

Existing Conditions

Water Resources

11. The South River flows north through the Townships of East Brunswick and Old Bridge and the Boroughs of South River and Sayreville and then splits into two branches, South River and Washington Canal, both of which flow into the Raritan River. The area of the South River watershed is approximately 135 square miles. Principal tributaries to the South River include Manalapan Brook, Matchaponix Brook, and Cedar Brook, which are upstream of Duhernal Lake, and Deep Run and Tennent Brook, which are downstream of the Lake.

12. Several tidal creeks drain into South River between Duhernal Dam and the Raritan River. Deep Run Creek connects tidal drainage south of the Bordentown/South Amboy Turnpike and limited wetlands northwest of the Turnpike into South River. Further downstream, Tennent Brook drains an additional smaller basin southeast of the Turnpike and a significant area of wetland between the Turnpike and South River.

13. Land use in the watershed is a combination of: (1) urban land uses primarily in the Boroughs of Sayreville and South River and the Township of Old Bridge, (2) limited suburban developments around the Boroughs, and (3) rural land uses.

14. In the South River near the Washington Canal, the maximum water depth ranges from 13.5 to 16.4 feet below NGVD, with the deepest part of the river at the center of the channel. In the upstream reach of South River, the river is shallower and the maximum depth ranges from 6.4 to 16.4 feet below NGVD. The water surface at the upstream reach of the South River in the Township of Old Bridge is approximately 9.8 feet above NGVD, and the water surface at the downstream reach of the South River in the Boroughs of South River and Sayreville is nearly equal to NGVD.

15. The South River below Duhernal Lake experiences diurnal tidal fluctuations. The National Oceanic and Atmospheric Administration has tidal gauges at the Raritan River railroad bridge in the Borough of South River and at the confluence of the Raritan River and Washington Canal. At the railroad bridge tidal station, the mean tide range is 5.6 feet, the spring tide range is 6.6 feet and the mean tide level is 3.0 feet above mean sea level (NGVD). At the Washington Canal station, the mean tide range is 5.6 feet, the spring tide range is 6.9 feet and the mean tide level is 3.0 feet above NGVD. The mean tide range at Old Bridge is 5.6 feet, the range of spring tide is 6.6 feet, and the extreme range of storm surge is about 12.8 feet.

Sea Level Rise

16. Based on NOAA tide gauge readings between 1933 and 1986 at Sandy Hook, sea level has been increasing by an average of approximately 0.014 feet per year. Tidal flooding is expected to increase in severity in direct relation to this 0.7 foot increase over a 50-year period. There is no significant reduction in the effect of sea level rise on water surface elevations in the South River and Washington Canal as a result of their upstream location. Therefore, since the expected life of this project is 50 years, any structures which are proposed for flood protection purposes must be at an appropriate height to accommodate 0.7 feet of sea level rise.

Historical Flooding

17. The South River study area is prone to imminent and severe flooding. Unless otherwise specified, flooding damages described below occurred in the Boroughs of Sayreville and South River.

- **March 1962:** Significant flood damages occurred during the northeaster of March 1962. Tidal backwater flooding from the Raritan River resulted in severe damage to residential, commercial, and industrial properties in the Boroughs of Sayreville and South River and caused the Route 535 causeway (South River/Sayreville) to become impassable to vehicular traffic. Damages from this storm were estimated to be in excess of $4.3 million (2000 dollars).

- **May 1968:** Flooding associated with this 20-year storm occurred as a result of tidal backwater flooding. Damages were estimated at $9.1 million (2000 dollars), with significant structural damage to over 80 dwellings and 20 commercial buildings in the two Boroughs.

- **August and September 1971:** Hurricane Doria caused minor flooding in the area with estimated damages of $1.5 million (2000 dollars) in South River, Sayreville, and Spotswood. The flooding had a minor fluvial component, as high tides combined with over eight inches of rain produced flood damages.

- **April 1984:** A fluvial event, the storm caused minor flooding above Duhernal Lake. No damage estimates are available.

- **December 1992 and March 1993:** The December 1992 storm is regarded as the worst on record for the region. Flooding occurred as a result of northeaster storms combined with unusually high tides (over four feet above normal). Over 200 people were evacuated from the flood areas, which in South River was estimated to be 25% of the Borough. Estimated damages, as compiled by the Middlesex County Office of Emergency Management immediately after the March 1993 storm, were estimated to be $8.1 million in South River, $6.9 million in Old Bridge, and $2.3 million in Sayreville (2000 dollars). These damage estimates generally emphasize damages to structures and contents, which often do not become apparent until weeks or even months after the floodwaters subside. In addition the bridge over the South River, connecting the Boroughs of South River and Sayreville, was closed for several days and rail movement was also shutdown. The flood from the December 1992 storm is considered to be a 25-year event. In contrast, tropical storm Floyd (September 1999), a devastating storm farther up the Raritan River at Bound Brook, produced stages of 5.1 ft NGVD at Perth Amboy, and was only a minor event in the project area.

18. In response to past and potential flooding problems in the Boroughs of Sayreville and South River, both of these communities have participated in the National Flood Insurance Program (NFIP) for at least 20 years. As required for NFIP participation, both communities have enacted municipal ordinances regulating floodplain development.

Without Project Future Conditions

19. The without-project condition was determined by projecting conditions in the study area over a 50-year period of analysis (2000-2050). It is expected that the current level of development within the floodplain is essentially stable with moderate increases anticipated over the life of the project. In the absence of Federal action, flooding problems in the study area are expected to continue and perhaps be exacerbated by increased damage potential in the floodplains of the Boroughs of Sayreville and South River based upon increases in the values of structures and contents and by sea level rise.

II. DEVELOPMENT OF ALTERNATIVES

Screened Alternatives

20. The following alternatives were considered earlier in the study phase. Each of these plans except the levee/floodwall plan for Reaches 3 & 4 failed to meet the objectives as described in the Plan Formulation section and was screened out. All plans at this stage of analysis were considered at a 100 level of protection in order to maintain consistency.

No Action Alternative

21. This plan involves no additional Federal action to provide flood damage reduction. The no action alternative would avoid environmental and other impacts associated with implementation of other plans for flood damage reduction however, this plan fails to meet any of the study objectives. The result would be the continuation and potential exacerbation of flooding problems in the study area. This alternative represents the default condition if a Federal project is not recommended and provides a reference for evaluation of without-project future conditions.

Non-Structural Alternatives

22. The following four non-structural alternatives were considered and then subsequently screened out during the course of the study.

23. Zoning: Through proper land use regulation, floodplains can be managed to ensure that their use is compatible with the severity of a flood hazard. Several means of regulation are available, including zoning ordinances, NJ floodplain regulations, subdivision regulations, and building and housing codes. Their purpose is to reduce losses by controlling the future use of floodplain lands. As indicated above, the Boroughs of Sayreville and South River and the Township of Old Bridge already participate in the National Flood Insurance Program and manage floodplain land uses consistent with the program. Most of the buildings in the study area were built prior to the adoption of zoning and are not subject to current floodplain zoning regulations. Therefore, zoning can not be considered independently as a long-term mitigation solution for flood damage to existing structures.

24. Floodproofing: Floodproofing is a body of techniques for reducing flood damages by adjustments to structures and to building contents. It involves keeping water out of the structure, as

well as reducing the effects of inundation. Such adjustments can be applied by an individual or as part of a collective action either when flood-prone buildings are under construction or through retrofitting of an existing structure. In this case, flood proofing the 1,247 affected structures would be prohibitively expensive since a majority of structures would require costly raising and would generate a false sense of security potentially discouraging timely evacuations.

25. Flood Warning: Flood warning systems can be utilized to warn property owners of pending floods and provide time for their evacuation and relocation of movable property subject to flood damage. Although a state-of-the-art flood warning system would increase the awareness of the citizenry and allow for a more orderly evacuation of residents, a warning system alone would not provide sufficient time to significantly reduce property damages due to flooding.

26. Acquisition of Flood Prone Properties: Permanent evacuation of the floodplain 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. There are 1,247 structures within the 100-year floodplain. Since the depreciated replacement cost of structures in the 100-year flood plain is estimated to be approximately $224 million, the cost of this plan, including land and relocation would be prohibitively expensive and was dropped from further consideration.

Structural Alternatives

27. Storm surge Barrier Plan: Among the flood damage reduction plans considered was a storm surge barrier plan, consisting of a storm surge barrier with sector gate and a levee perpendicular to the Washington Canal and the South River just upstream from its confluences with the Raritan River. (see Figure 3). This alternative would provide 100-year interior flood protection for most of the study area. The storm surge barrier levee would tie into high ground east of the Washington Canal and west of the South River. There would also be a 100-ft wide storm surge (sector) gate in the Washington Canal to maintain the navigable waterway. A diversion channel would be needed to handle the flow from the South River branch, which would be blocked by the levee. The diversion channel would pass through the middle of Clancy Island. The channel was added to avoid the cost of an additional set of gates across the South River. Under non-flood conditions, the tide gate would remain open allowing the flushing of the Washington Canal and the South River while maintaining a navigable waterway. During abnormally high flood stages, the gate would be closed. With the gate

closed, the normal South River discharges would be impounded. Numerical modeling utilizing HECIFH, an interior flood control model, determined that a pump station for interior drainage would not be warranted due to storage capacity in the low-lying wetland area.

28. The primary impacts of this plan include: (1) the levee footprint on an existing wetland, (2) rerouting the flow of the South River to the Washington Canal, and (3) disturbance of the Island wetlands to create the diversion channel. In addition, preliminary analysis indicated that this plan was not economically feasible primarily due to the size of the sector gate with its deep bottom elevations i.e. an approximate 50 foot high gate would be required for the 100 foot opening. There was also the potential that this plan could exacerbate tidal flooding upstream along the Raritan River. As a result of these considerations, this plan was dropped from further consideration.

29. Levee/Floodwall Plans: This plan consists of levees/floodwalls for 5 reaches, as shown on Figures 4 & 5. This plan consists of five levee alignments consistent with the 100-year damage reaches described as follows:

30. Reach 1: Right bank of the South River in Historic Village of Old Bridge (East Brunswick Township). This Reach contains approximately 0 commercial structures and 27 residential structures.

31. Reach 2: Left bank of the South River in the Historic Village of Old Bridge immediately downstream of Reach 1. This Reach contains approximately 10 commercial structures and 65 residential structures.

32. Reach 3: Left bank of the South River in the Borough of South River. This Reach contains approximately 127 commercial structures and 533 residential structures.

33. Reach 4: Right bank of the South River and the Washington Canal in the Sayreville area, across from Reach 3. This Reach contains approximately 26 commercial structures and 400 residential structures.

34. Reach 5: Right bank of South River just downstream from Old Bridge (Reach 2). This Reach contains 2 commercial structures and 57 residential structures within the 100-year floodplain.

35. Levees and floodwalls were aligned as efficiently as possible, to protect the groups of structures in each reach. Accordingly, lines-of-protection comprised of levee and floodwall systems that could function separately were developed. Levee/floodwall systems are described below.

36. Preliminary analysis assumed that the top of all levees would be 100-year storm tide plus three feet to account for risk and uncertainty in the tidal stage frequency. A preliminary soil analysis was performed to determine if levee layouts were on good soil or on poor soil. Non-marsh areas were considered good soil whereas marsh soil was considered poor soil.

37. Levee Reach 1, located in the Spotswood area, was approximately 3,000 feet in length.

38. Levee Reach 2, which is immediately east of Rt. 18, provided protection for the Historic Village of Old Bridge. The Reach 2 levee/floodwall length was approximately 3,740 feet. Common to both Reaches 1 and 2 was replacement of the Old Matawan Road Bridge with associated road raising of 4 feet. This plan component also required channel realignment of 400 feet of the South River.

39. Levee Reach 3, located along the west bank of the South River, protected the Borough of South River. The total levee/floodwall length would be approximately 8,410 feet, and required a railroad closure structure.

40. Levee Reach 4, located along the east bank of the Washington Canal protected the Borough of Sayreville. The total levee/floodwall length for this reach was approximately 9,090 feet, and required raising Jernee Mill Road by 2.6 feet to allow for the levee.

41. Levee Reach 5, located near the confluence of Deep Run and the South River, protected both sides of the Bordentown-South Amboy Turnpike. The total levee/floodwall length was approximately 7,240 feet. This plan (along with the Reach 2 plan) would include: (1) raising the Bordentown-South Amboy Turnpike Bridge 6 feet over Deep Run, (2) raising of the Turnpike 6 feet, (3) sealing the bottom of the railway bridge, and (4) constructing 3.5 feet parapets.

42. The primary impacts of the levee/floodwall system will be the footprint of the levee/floodwall on tidal wetlands and indirect impacts to west bank of the South River from changed tidal flows. An indirect impact to all the reaches will be ponding associated with interior drainage behind the levee.

43. Based on the initial screening processes and public involvement it was determined that Federal participation is not warranted in providing individual structural protection against tidal flooding in reaches 1, 2, and 5. The benefit-cost ratio for each of these three reaches based on the above plan descriptions was approximately 0.1.

44. Based on the preliminary screening of levees/floodwalls for reaches 3 and 4 it has been determined that these two plans satisfy the planning objectives outlined in the Plan Formulation section of the report.

45. Based on the negative Net Benefits for Reaches 1, 2, and 5 for 100-Year level of protection, it was determined that a levee system would not be justified for these reaches. Therefore, further study for structural solutions in these reaches was not recommended.

46. These findings were discussed with the residents of Reaches 1, 2 and 5 on 28 January 1999 in the Historic Village of Old Bridge. Representatives of the community were present along with representatives of the Borough of East Brunswick. Participants explained that they would not like to see any structural measures along the river but would request that additional analysis of non-structural plans take place, however, the non-structural plan assessment for the three reaches resulted in the costs far exceeding the benefits.

Design Layout Alternatives

47. After screening out preliminary alternatives, it was determined that the most viable alternative for providing flood protection to the affected areas was to install a combination of levees and floodwalls with associated interior drainage facilities along the banks of the river in reaches 3 & 4 only as discussed above. For the next phase of more detailed development, two alternative alignments for reaches 3 & 4 were investigated, i.e. levees and floodwalls upstream (south) of Veterans Memorial Highway Bridge vs. a storm surge barrier across the South River just downstream of the same bridge. By eliminating all levee/floodwall alignments in Reaches 3 and 4

south of the Veterans Memorial Highway Bridge in lieu of a storm surge barrier with an associated tide gate and interior drainage pump station, additional benefits could be achieved at a lower cost. Closure of this gate during storm events would create a continuous barrier against tidal surges inundating low-lying areas and moving further upstream. Therefore, not only would Reaches 3 & 4 benefit, but the previously eliminated Reaches 1, 2 and 5 would also be protected.

48. Plan 3 - Levees/Floodwalls Only: Elimination of the storm surge barrier plan at the mouth of the South River and acquisition and floodproofing of flood prone properties as feasible alternatives resulted in levees as the most feasible flood damage reduction alternative, subject to additional refinement. Levee configurations identified as having greatest potential would include levees along the eastern and western banks of the lower South River. The initial testing of the levee and floodwall system was made without a tide barrier so that the surge moved upstream of Sayreville. This alternative effectively protects the flood prone areas of both South River and Sayreville, but does not prevent tidal surges from moving further upstream and causing damages to Reaches 1, 2 and 5 (see Figure 6).

49. Plan 1 - Levees/Floodwalls with Storm surge Barrier: A storm surge barrier is included just downstream (north) of the Veterans Memorial Highway Bridge across the South River, eliminating need for the levees and floodwalls south of the bridge. The storm surge barrier would yield additional NED benefits for protection of structures within Reaches 1, 2 and 5, and would also reduce impacts to environmentally sensitive lands as well as limit HTRW concerns due to existing potentially hazardous sites south of the bridge (see Figure 7).

Comparison of Alternatives

50. Preliminary designs were performed of the various components of each plan. This included structural components as well as interior drainage facilities. Quantities were then estimated for these features as well as environmental mitigation and real estate acquisition. A preliminary cost estimate was prepared for each of the two remaining alternatives using industry standard cost estimating methods and sources (see Figures 6a & 7a). (Note: All interior drainage, environmental and real estate quantities and costs were used here for comparison purposes only and may not correlate with final data seen elsewhere in this report., however incorporation of the final cost data would not have effected the comparison of alternatives. See the respective appendices for actual values related to this

study.) Both plans were designed based on a 100-year event with a top of protection elevation, including allowances for risk and uncertainty, of +17.0 NGVD. As indicated in Table 1, Plan 1 has the greatest net benefits when compared with Plan 3. From an economic perspective, Plan 1 is the most desirable plan. From a practical perspective, this plan is a lower cost plan that will require the lowest expenditures by the Federal government and the non-Federal project partner.

Table 1
Average Annual Costs and Benefits of
Hurricane and Storm Damage Reduction Alternatives

Plan	Description	Average Annual Costs	Average Annual Benefit	Average Annual Net Benefits	Benefit/ Cost Ratio
1	Storm surge barrier with levees in the lower reaches (Reaches3 & 4)	$2,865,000	$3,319,000	$454,000	1.16
2	Levees for all reaches (Reaches 1-5)	$3,752,000	$3,319,000	($433,000)	0.88
3	Levees for reaches 3 and 4	$2,919,000	$2,930,000	$11,000	1.0

*(100-Year Storm Event; 6 3/8% discount rate, Oct 2000 price levels, 50-year period)

Note: The annual costs include O&M and replacement costs.

III. HYDROLOGIC ANALYSIS

Introduction

51. This section presents basic hydrologic data and its analysis and interpretation in conjunction with the formulation of a plan of improvement for hurricane and storm damage reduction and ecosystem restoration in the Raritan River basin along the South River. The improvement plan consists of levees and interior drainage facilities. The basic hydrologic data analyzed herein includes precipitation, surface runoff, the development of rainfall depth and stream peak discharge frequencies, development and use of unit hydrographs, and flood routing in the derivation of existing and improved conditions. All of these computations are accomplished by a comprehensive basin-wide HEC-1 model.

Watershed Descriptions

Raritan River Basin.

52. The Raritan River drains an area of 1108.5 square miles in northeastern New Jersey. It enters tidewater in Raritan Bay near the southern tip of Staten Island, which is also the southernmost point of New York City. Its basin is roughly trapezoidal, with a maximum length of about 40 miles and maximum width of about 28 miles. Its major tributaries are the North and South Branches and the Millstone and South Rivers. Important minor tributaries are Lawrence, Middle and Green Brooks. Figure 8 shows the South River basin and its confluence with the Raritan River.

Climatology

Climate

53. The climate of the Raritan River Basin is characteristic of the entire Middle Atlantic seaboard. Marked changes of weather are frequent, particularly during the spring and fall. The winters are moderate, with moderate snowfall and the summers are moderate, with hot, sultry weather midway, and frequent thunderstorms. Precipitation also is moderate, with about 44 inches falling annually, well distributed throughout the year. Summer totals of precipitation are slightly higher than those of the winter. The relative humidity is high. Average annual temperature varies from 49 F to 53 degrees F. with extremes ranging from 24 degrees below zero at Long Valley, N.J.

to 109 degrees above at Somerville, N.J. The growing season averages 174 days and the mean annual relative humidity varies from 67 to 71 percent. Prevailing winds are from the northwest with an average annual velocity of about 12 miles per hour. The number of days with rainfall of 0.01 inch or greater averages from about 111 to 123 per year.

Precipitation stations.

54. The amount of precipitation observed at climatic stations is reported by the various state offices of the National Weather Service. Records from rainfall stations maintained by the Weather Service and other public and private agencies are collected and published monthly by the National Climatic Data Center, Asheville, North Carolina. The Raritan River basin is presently covered by a network of 11 official stations. Of these, three are equipped with automatic recording rainfall gages and the remainder with standard non-recording gages read one or more times daily. One daily precipitation gaging station is located within the South River basin.

Precipitation stations used.

55. The precipitation stations used in this study are given in the following Table 2:

Table 2
Precipitation Stations

August 1971 Storm		December 1992 Storm	
Hourly	**Daily**	**Hourly**	**Daily**
Rahway		Springfield	Somerville
New Brunswick 3SE	(NONE)*	Rahway	Plainfield
Hightstown 2W		Watchung	Long Branch – Oakhurst
Freehold		Bound Brook 2W	
		New Brunswick 3SE	
		Hightstown 2W	

* Green Brook GRR isohyetal map used, instead.

Snowfall.

56. The average annual snowfall of 29.7 inches for the Raritan River Basin is equivalent to about 3.0 inches of rain.

Annual and Monthly Precipitation.

57. The average annual precipitation for the watershed is approximately 43.6 inches, as derived from a compilation of past records at the stations in and adjoining the basin. The observed extreme annual values were 82.37 in. at Plainfield (in 1889) and 28.43 inches at Bound Brook (in 1965). The monthly extremes ranged from 19.65 inches at Blackwells Mills (in July 1975) to 0.02 at Plainfield and New Brunswick (in June 1949).

58. The distribution of precipitation throughout the year is fairly uniform with higher amounts during the summer months. Comparative rainfall data for gaging stations in and adjacent to the watershed are contained in Table 3. Locations are shown on Figure 9.

Storm types.

59. The storms which occur over the Northeastern states have their origins in or near the Pacific and South Atlantic Oceans and may be classified as thunderstorms, cyclonic trans- continental storms, extra tropical storms, and West Indies hurricanes. The thunderstorms, occurring usually in July, are limited in extent and cause local flooding on flashy streams. The cyclonic storms are due to transcontinental air mass movement, with attendant "highs" and "lows", and occur usually in the winter or early spring. They are potential flood producers over large areas due to their widespread extent. The extra tropical storms cause heavy rain usually in the summer and fall seasons. The West Indies hurricanes of tropical origin proceed northward along the coastal area. They have high winds and torrential rains of several days' duration. A northeaster (Nor'easter in New England) is a type of storm of extra-tropical origin having intense areas of low pressure which moves northward along the North American Atlantic coast accompanied by easterly or northeasterly winds often blowing at gale or storm speeds. Northeasters occur during the late fall, winter and early spring, often bringing heavy rain, heavy snow and severe coastal flooding and beach erosion. These storms have a long duration with three days being normal. If this type of storm is unusually intense and develops quickly it is

known as a bomb cyclone. Some storms cause big ocean surges but don't have much flooding from rainfall, while for others the reverse is true. Fluvial – tidal correlations are discussed in more detail later in this report.

Table 3
Monthly Average, Annual Average. And Extreme Rainfall, in Inches, By Station

REF. NO.*	STATION	ELEV FEET MSL	PERIOD OF RECORD	ITEM	RAINFALL IN INCHES - MONTHLY: WINTER JAN.	FEB.	MAR	SPRING APR.	MAY	SUMMER JUN	JUL	AUG	FALL SEP.	OCT.	NOV	DEC.	ANN	DATE OF MAXIMUM AND MINIMUM RAINFALL: MONTHLY	ANNUAL
1	NEW BRUNSWICK EXP.STA.	86	1854-1986	MAX	9.18	6.46	9.18	9.22	9.16	11.42	11.10	13.77	12.03	8.53	8.77	9.01	85.65	Aug. 1955	1975
				MIN	0.50	0.76	0.75	0.55	0.29	0.02	0.28	0.77	0.64	0.25	0.34	0.72	27.51	June 1949	1965
				AVG	3.45	2.96	4.04	3.77	3.90	3.26	4.30	4.90	3.93	0.35	0.32	3.75	45.50		
2	LONG BRANCH 2N	10	1907-1966	MAX	8.72	6.76	9.03	9.51	9.43	9.04	16.17	11.53	14.83	10.89	9.33	10.40	83.63	July 1938	1919
				MIN	0.41	1.08	1.08	0.96	0.15	0.04	0.22	0.25	0.08	0.11	0.40	0.24	31.83	Sept. 1941	1965
				AVG	3.60	3.59	4.63	3.78	3.85	3.12	3.88	5.11	0.66	5.65	0.35	4.24	46.92		
3	FREEHOLD	194	1874-1925	MAX	8.94	7.16	8.06	9.25	11.13	10.03	13.60	12.22	11.61	9.96	10.53	8.42	70.75	July 1897	1869
			1931-1956	MIN	0.46	0.92	1.08	0.95	0.28	0.06	0.27	0.21	0.04	0.17	0.44	0.25	31.75	Sept. 1941	1965
				AVG	3.55	3.28	4.44	3.66	3.75	3.47	4.04	4.64	3.57	3.52	3.96	3.91	44.72		
4	HIGHTSTOWN IN	100	1891-1986	MAX	5.64	6.56	8.01	8.27	8.87	10.43	12.19	13.86	11.70	9.35	8.56	7.75	60.62	Aug. 1955	1963
				MIN	0.37	0.93	0.62	0.81	0.55	0.03	0.45	0.27	0.02	0.16	0.36	0.11	29.29	Sept. 1941	1965
				AVG	3.31	2.95	3.96	3.65	3.60	3.25	4.53	4.72	3.99	3.42	8.32	6.56	44.39		
5	PLAINFIELD	90	1888-1996	MAX	8.48	7.65	8.77	9.13	9.27	10-.14	15.52	15.64	13.13	9.47	11.13	9.89	82.37	Aug. 1955	1869
				MIN	0.66	0.79	0.88	0.87	0.84	0.02	0.33	0.42	0.14	0.23	0.36	0.21	82.56	Jan. 1949	1965
				AVG	3.55	3.30	4.56	3.96	4.11	3.42	4.76	5.37	4.00	3.56	3.91	4.05	48.76		
6	WATCHUNG	260	1948-1986	MAX	9.12	5.09	9.05	9.06	9.65	10.28	12.97	14.80	10.68	6.80	10.27	9.27	66.91	Aug. 1955	1975
				MIN	0.33	1.07	1.38	0.79	0.90	0.13	0.67	0.10	1.10	0.49	0.40	0.02	34.51	Dec. 1955	1970
				AVG	2.96	3.16	3.91	3.85	3.18	2.71	4.17	4.52	3.33	3.04	3.79	3.83	42.90		
7	BLACKWELLS MILLS	27	1956-1986	MAX	10.89	4.88	8.16	9.13	9.26	8.46	19.65	12.79	11.34	7.35	8.09	8.01	74.40	July 1975	1975
				MIN	0.55	0.53	1.32	0.57	0.73	0.65	0.63	1.25	1.05	0.49	0.45	0.59	28.09	Nov. 1976	1965
				AVG	2.97	2.87	3.33	3.96	2.77	2.32	4.63	3.75	4.27	2.82	3.32	3.72	40.67		
8	MANVILLE	50	1945-1967	MAX	6.76	5.62	7.58	6.78	8.62	8.28	8.14	15.47	7.07	7.36	7.10	6.75	57.62	Aug. 1955	1956
				MIN	0.80	1.35	1.64	0.44	1.05	0.55	1.34	1.42	0.59	0.28	0.80	0.29	26.67	Oct. 1963	1965
				AVG	2.90	2.84	3.71	3.49	3.92	3.24	4.51	4.71	3.39	2.88	3.47	3.31	42.23		
9	BOUND BROOK 2W	50	1957-1986	MAX	7.96	4.70	7.82	9.60	9.07	8.30	11.69	11.32	10.44	6.29	7.90	8.70	64.16	July 1975	1975
				MIN	0.37	0.37	1.20	0.42	0.99	0.53	1.30	0.51	0.51	0.33	0.23	0.42	25.45	Nov. 1976	1965
				AVG	2.56	2.50	3.31	3.65	2.69	2.31	4.48	3.75	3.75	2.56	3.20	3.51	38.45		
10	SOMERVILLE	90	1880-1986	MAX	9.56	6.74	8.12	9.14	9.64	11.66	12.33	14.51	11.05	9.97	9.51	9.43	66.92	Aug. 1955	1975
				MIN	0.53	0.90	0.73	0.48	0.42	0.06	0.64	0.45	0.18	0.26	0.61	0.53	29.61	June 1949	1965
				AVG	3.33	2.93	4.04	3.76	3.66	3.49	4.54	4.92	3.86	3.42	3.63	3.74	45.36		
11	PRINCETON WATER WORK	60	1941-1986	MAX	10.50	5.38	8.28	9.41	9.37	8.03	18.96	14.33	10.64	8.96	9.17	8.68	71.02	July 1975	1975
				MIN	0.48	0.86	1.09	0.89	0.58	0.28	0.06	0.33	0.71	0.12	0.36	0.13	29.17	July 1965	1965
				AVG	3.35	3.11	4.11	3.57	3.50	3.36	4.76	4.89	3.97	3.32	3.59	3.75	42.02		
12	WARTSVILLE	160	1956-1986	MAX	7.59	5.15	7.33	10.29	8.11	9.57	9.26	10.69	9.05	8.96	8.32	8.35	59.20	Aug. 1971	1975
				MIN	0.50	0.69	0.91	0.70	0.96	0.75	0.74	0.51	1.57	0.34	1.47	0.50	26.15	Oct. 1963	1965
				AVG	2.69	2.49	3.00	3.79	2.40	2.38	4.86	3.50	3.67	2.61	3.41	3.41	38.31		
13	FLEMINGTON INE	140	1887-1986	MAX	11.33	6.42	8.36	10.41	9.14	9.61	13.06	16.23	11.24	7.94	9.66	8.66	70.06	Aug. 1955	1869
				MIN	0.77	0.72	1.12	0.75	0.42	0.20	0.22	0.16	0.26	0.20	0.20	0.22	30.86	Aug. 1964	1965
				AVG	3.43	3.69	4.18	4.02	3.68	3.75	4.36	4.60	3.93	3.45	3.45	3.95	44.10		
14	OLDWICK	260	1956-1968	MAX	4.60	4.82	6.19	6.94	4.95	4.60	8.25	7.59	7.76	6.04	6.44	7.82	49.55	July 1967	1958
				MIN	1.59	0.78	1.69	0.67	0.94	0.97	0.66	0.45	1.17	0.55	1.99	1.20	29.20	Aug. 1964	1965
				AVG	3.43	2.95	3.47	4.02	2.95	2.40	3.86	3.55	3.97	2.80	3.47	3.96	40.22		
15	CLINTON	200	1943-1968	MAX	5.73	5.19	6.00	8.50	9.05	6.70	11.22	17.99	8.57	10.15	7.75	6.45	56.21	Aug. 1955	1945
				MIN	0.88	0.82	1.76	0.71	0.60	0.95	0.23	0.50	0.45	0.18	0.74	0.20	28.87	Oct. 1963	1965
				AVG	3.11	2.86	3.77	4.07	3.82	3.00	4.57	4.51	3.29	2.06	2.77	3.05	42.42		
16	LONG VALLEY	550	1931-1956	MAX	12.37	6.01	8.64	11.43	10.69	14.52	12.56	15.51	10.72	9.16	12.46	9.64	88.65	Aug. 1955	1945
				MIN	0.67	0.11	1.62	0.78	0.65	0.22	0.83	0.77	0.39	0.40	0.80	0.64	32.86	Feb. 1973	1965
				AVG	3.86	3.30	4.43	4.33	4.07	3.91	4.68	5.22	4.22	3.92	4.30	4.26	50.56		
	AVERAGE				3.27	3.08	3.93	3.84	3.49	3.09	4.43	4.54	3.81	3.20	3.08	3.79	43.60		

Insert Table 3

Past Storms

60. The following paragraphs give brief descriptions of a few of the storms that resulted in flood conditions in the South River basin over the past century.

Storm of 26-28 August 1971.

61. A frontal zone, stationary along the Carolina coast, began moving northward as a warm front during the afternoon and evening hours of 26 August 1971. Rain from this warm front reached southern New Jersey at about 2100 hours EDT on 26 August and spread northward over the entire state by 0600 hours EDT on 27 August. The storm traversed New Jersey along a path from Delaware Bay through Cumberland County northward through the center of the state. It turned northeast on the morning of 28 August. From New Brunswick, the storm center passed over Newark and reached southwestern Connecticut by 0800 hours EDT on 28 August. It then continued on up the Hudson River valley. Heavy thunderstorm rainfall on the morning and afternoon of 27 August combined with rain from Hurricane Doria on the evening of 27 and 28 August and the early morning hours of 29 August. The combination resulted in total storm rainfall in the New York District area that ranged from 0.41 inch on Eastern Long Island to 10.29 inches at Little Falls, New Jersey. Storm totals in the area of the South River basin were 8.59 inches at New Brunswick, 9.40 inches at Hightstown and 8.20 inches at Freehold, New Jersey.

Storm of 10-12 December 1992.

62. The northeaster coastal storm of 10-12 December 1992 stagnated over the tri-state area for three days. It moved little, maintaining a pattern of heavy rain, high winds (gusting up to 90 miles per hour), high tides, severe coastal flooding, and extensive beach erosion. Severe damage to beachfront properties occurred all along the ocean fronts of New York and New Jersey. Thousands of people were left temporarily homeless. Downed trees and power lines caused power failures in many areas. A drop in temperature early on the morning of Saturday, 12 December caused the rain to change to snow, with accumulations of three inches in coastal areas, up to eight inches inland, and up to thirty-seven inches in the Catskills. Total storm precipitation in inches of water equivalent for sixteen stations sampled in New York and New Jersey ranged from 1.07 inches at Martinsville, New Jersey to 5.61 inches at Hightstown. Storm totals in the area of the South River basin were 4.79

inches at New Brunswick, 5.61 inches at Hightstown, and 4.60 inches at Bound Brook. The December 1992 northeaster was chiefly a coastal and not a fluvial flood event. Streams exceeded flood stage at only three of twenty-one stream gages sampled in New York and New Jersey. These were all in the Raritan River basin within six miles of each other.

Storm of 28-29 May 1968.

63. This storm resulted from a low pressure disturbance that originally formed along the Atlantic coast south of Cape Hatteras, North Carolina. It later reorganized into a low pressure center near the mouth of Delaware Bay with a strong high pressure ridge over northern New England. The total rainfall for this storm varied from 7.96 inches recorded at Canoe Brook, New Jersey (28 to 31 May 1968) to 3.48 inches recorded at Princeton, New Jersey. The maximum daily rainfall recorded at Plainfield, New Jersey was 5.75 inches. Average rainfall over the Raritan River basin was approximately 4.5 inches.

Storm of 15-23 July 1945.

64. This extra-tropical storm consisted of six days of moderate rains followed by about 15 hours of heavy showers on 22 and 23 July. The storm centered over the eastern edge of the Passaic River basin, with maximum recorded values of 14.73 inches at Midland Park, New Jersey and 14.64 inches at Suffern, New York. The heavy showers were localized and spotty, resulting in flash floods on many small streams. Total storm precipitation in the area of the South River basin was about 8 inches.

Storm of 6-8 November 1977.

65. An extra-tropical storm traveled into the New Jersey coast on November 6. Strong east winds with speeds of 50 miles per hour were experienced at the shore on November 7th, then decreased on November 8th. Rain began on the evening of November 6th and continued into the afternoon of November 8th. The heaviest rainfall was in the northeastern part of the state, where 2 inches fell on the 7th followed by 8 inches or more on the 8th. The total storm precipitation at Newark was 9.25 inches. The storm of November 1977 caused extensive flooding throughout northeastern New Jersey.

Hypothetical Rainfall

Specific Frequency Hypothetical Storm Rainfall.

66. A 48-hour duration hypothetical storm was modeled so that the basin-wide HEC-1 model would be accurate for watersheds with times of concentration between 24 and 48 hours. The Raritan River, at its USGS gage at Bound Brook, NJ, has a time of concentration of 21.4 hours. Its time of concentration increases to 24 hours and greater, but not more than 48 hours, as it flows downstream to the study area (South River) and then to its mouth (Raritan Bay). The South River, at its USGS gage at Old Bridge, NJ, has a time of concentration of 25.2 hours. Its time of concentration increases as it flows downstream to its mouth, but to less than 48 hours.

67. Average point rainfall depths were taken for the Raritan River and South River basins from isopluvial (lines of equal rainfall) maps in the following publications:

- Point rainfall data for duration of 48 hours and return periods of 1, 2, 10, 50 and 100 years was taken from Technical Paper No. 49, Two to ten-day Precipitation for Return Periods of 2 to 100 Years in the Contiguous United States, U.S. Department of Commerce, Weather Bureau, Washington, D.C. 1964.

- Point rainfall was determined for return periods of 1, 2, 10, 50, and 100 years and durations of 1, 2, 3, 6, 12 and 24 hours. using Technical Paper No. 40, Rainfall Frequency Atlas of the United States, U.S. Department of Commerce, Weather Bureau, Washington, D.C. 1961.

- Point rainfall data for durations of 5 and 15 minutes for interior drainage studies was taken from Technical Memorandum Hydro-35, Five-to 60-Minute Precipitation Frequency for the Eastern and Central United States, National Weather Service, Silver Spring, Maryland, June 1977.

- Point rainfall depths for return periods of 150 and 500 years for all durations were determined by extrapolation on logarithmic probability paper of annual series point rainfall depths of return periods of 2 to 100 years.

68. Point rainfall depths were part of the HEC-1 model input and were converted to finite area rainfall depths with transposition storm areas and procedures contained in program HEC-1. A time

step of 1 hour was used for the HEC-1 models because of the sizes and times of concentration of the HEC-1 model sub-basins. The time series data of the hypothetical storms modeled is therefore in 1 hour increments. The hypothetical point rainfall data is given in Table 4. The resultant hypothetical storm time series data is given in Table 5. Storm areas in square miles used to reduce point rainfall values to finite drainage area values are given in Table 6

Table 4
Hypothetical Point Precipitation Depths (Inches)

Frequency (Years)	Duration						
	60 Minute	2-HOUR	3-HOUR	6-HOUR	12-HOUR	24-HOUR	48-HOUR
1-YEAR	1.19	1.48	1.63	1.95	2.30	2.70	3.11
2-YEAR	1.40	1.78	1.95	2.40	2.90	3.30	3.81
10-YEAR	2.15	2.70	3.00	3.60	4.30	5.10	5.83
50-YEAR	2.78	3.50	3.85	4.70	5.65	6.70	7.78
100-YEAR	3.10	3.80	4.30	5.20	6.30	7.35	8.53
150-YEAR	3.23	4.03	4.50	5.45	6.55	7.75	9.00
500-YEAR	3.72	4.66	5.23	6.31	7.65	9.00	10.44

Table 5
One-Hour Precipitation Increments in Inches for Specific Frequency Hypothetical Storms

Hour Ending	1-Year	2-Year	10-Year	50-Year	100-Year	150-Year	500-Year
Day 1 - 0100	.01	.02	.03	.04	.04	.04	.05
0200	.01	.02	.03	.04	.04	.05	.05
0300	.02	.02	.03	.04	.04	.05	.05
0400	.02	.02	.03	.04	.05	.05	.06
0500	.02	.02	.03	.04	.05	.05	.06
0600	.02	.02	.03	.05	.05	.05	.06
0700	.02	.02	.03	.05	.05	.05	.06
0800	.02	.02	.03	.05	.05	.06	.07
0900	.02	.02	.04	.05	.06	.06	.07
1000	.02	.03	.04	.05	.06	.06	.07
1100	.02	.03	.04	.06	.06	.07	.08
1200	.02	.03	.04	.06	.07	.07	.08
1300	.03	.03	.06	.08	.08	.09	.10
1400	.03	.03	.06	.08	.08	.09	.11
1500	.03	.03	.07	.09	.09	.10	.11
1600	.04	.04	.07	.09	.10	.11	.12
1700	.04	.04	.08	.10	.10	.12	.13
1800	.04	.05	.09	.11	.12	.13	.15
1900	.05	.08	.11	.14	.17	.17	.20
2000	.06	.09	.12	.16	.19	.19	.23
2100	.07	.10	.14	.19	.22	.22	.27
2200	.10	.14	.18	.26	.27	.29	.33
2300	.13	.18	.25	.34	.37	.39	.44
2400	.32	.40	.59	.77	.78	.87	1.01
Day 2 – 0100	.83	.97	1.50	1.94	2.16	2.25	2.59
0200	.17	.20	.34	.41	.54	.52	.63
0300	.11	.15	.21	.29	.31	.33	.38
0400	.08	.11	.16	.21	.24	.24	.29
0500	.07	.09	.13	.18	.20	.20	.25
0600	.06	.08	.11	.15	.18	.18	.21
0700	.05	.05	.09	.12	.12	.14	.16
0800	.04	.04	.08	.11	.11	.12	.14
0900	.04	.04	.07	.10	.10	.11	.13
1000	.03	.04	.07	.09	.09	.10	.12
1100	.03	.03	.06	.08	.09	.10	.11
1200	.03	.03	.06	.08	.08	.09	.10
1300	.02	.03	.04	.06	.07	.07	.08
1400	.02	.03	.04	.06	.06	.07	.08
1500	.02	.03	.04	.06	.06	.06	.07
1600	.02	.03	.04	.05	.06	.06	.07
1700	.02	.02	.03	.05	.05	.06	.07
1800	.02	.02	.03	.05	.05	.06	.06
1900	.02	.02	.03	.05	.05	.05	.06
2000	.02	.02	.03	.04	.05	.05	.06
2100	.02	.02	.03	.04	.05	.05	.06
2200	.02	.02	.03	.04	.04	.05	.05
2300	.02	.02	.03	.04	.04	.05	.05
2400	.01	.02	.03	.04	.04	.04	.05
Total	**2.93**	**3.59**	**5.49**	**7.32**	**8.03**	**8.47**	**9.82**

Note: The transposition drainage area is 134.91 square miles (that of South River at its mouth) for the temporal distributions shown above.

Table 6 STORM AREA "TRSDA" (SQUARE MILES)		
Sub Basin	**TRSDA**	**Description**
403060	785.00	Raritan River at Bound Brook USGS gage
MDC2	17.00	Middle Brook at mouth
GRMO	65.12	Green Brook at mouth
INCRGL	898.63	Raritan River above Lawrence Brook
405000	46.18	Lawrence Brook at mouth
LAWRS1	46.18	Lawrence Brook at mouth
405500	134.91	South River at mouth
SRS1	134.91	South River at mouth
DEEPS1	134.91	South River at mouth
DEEPS2	134.91	South River at mouth
DEEPS3	134.91	South River at mouth
SRS2	134.91	South River at mouth
TENNS1	134.91	South River at mouth
TENNS2	134.91	South River at mouth
TENNS3	134.91	South River at mouth
SRS3	134.91	South River at mouth
SRS4	134.91	South River at mouth
INCRLM	1108.50	Raritan River at mouth

Stream Flow

Streamflow Records

69. The U.S. Geological Survey is the Federal agency primarily responsible for the collection and tabulation of surface and ground water data. These data for the Raritan River Basin are published annually in the Water Supply Papers of the U S Geological Survey. There are at present 27 active recording stream gaging stations in the Raritan River Basin. The stations have records varying in length from 1 to 70 years. The gages of particular impact to this study are described briefly in the following paragraphs. Stream flow data for these gages is shown in Table 7.

Table 7 USGS Gaging Stations – Stream Discharge Data				
Stream Gage	**Raritan River below Calco Dam at Bound Brook, NJ**	**Lawrence Brook at Farrington Dam, NJ**	**Manalapan Brook at Spotswood, NJ**	**South River at Old Bridge, NJ**
D.A. (Sq. Mi.) Water Years	785 1903-2000	34.4 1927-1990	40.7 1957-2000	94.6 1939-1988
Annual Discharge				
Max Water Year CFS	1975 2046	1975 * 79.1	1973 101	1975/1984 * 225
Min Water Year CFS	1985 480	1981 * 18.0	1981 34.3	1965 * 67.6
Average Year CFS	1198	38.9	62.0	142
Monthly Discharge				
Max Month CFS	Jan 1979 5825	Jul 1975 198	Jan 1978 186	Jan 1979 485
Min Month CFS	Aug 1957 69.9	Nov 1953 0.00	Jul 1966 4.40	Aug 1957 7.37
Daily Discharge				
Max Day CFS	17 Sep 1999 61000	21 Jul 1975 2040	30 May 1968 1390	28 Aug 1971 3740
Min Day CFS	6 Sep 1964 37.0	Various 0.00	16 Jun 1957 0.00	16 Sep 1967 0.00
Peak Discharge				
Day CFS	17 Sep 1999 67000 **	21 Jul 1975 4920	20 Sep 1989 1700	15 Sep 1944 4250

Note: * indicates data based upon calendar year, not water year
** indicates value determined by Corps of Engineers, not USGS

Raritan River Below Calco Dam at Bound Brook, N.J.

70. This gage, with a drainage area of 785 square miles, is located about 0.4 miles above Middle Brook and about a mile above Green Brook. The total period of record is 60 years, consisting of two water-year periods 1904-1909 and 1945-1998. Peaks of the floods of 1882 and 1896 are also published. The discharge records are rated excellent. This gaged basin is HEC-1 model sub-basin 403060. The gage was known and published as "Raritan River at Bound Brook" before October 1966. The gage was then upstream of Calco Dam and Cuckold Brook and had a drainage area of 779 square miles.

Lawrence Brook at Farrington Dam, N.J.

71. This gage, with a drainage area of 34.4 square miles, is located on the left bank 300 feet upstream from Farrington Dam , 0.7 miles southwest of Milltown and 5.4 miles upstream from the

mouth of Lawrence Brook. The total period of record is 63 years, from Water Year 1927 to Water Year 1990. The gage was discontinued during June 1990. The discharge records are rated fair except those below 15 cfs, which are poor. This gaged basin is HEC-1 model sub-basin 405000. The flow at this gage is regulated by Farrington Lake.

Manalapan Brook at Spotswood, N.J.

72. This gage, with a drainage area of 40.7 square miles, is located on the right bank of DeVoe Lake Dam in Spotswood, 0.1 miles upstream from Cedar Brook, and 0.6 miles upstream from the confluence with Matchaponix Brook. The period of record of this gage is 41 years, from Water Year 1957 to Water Year 1998. The discharge records for this gage are fair. The flow at this gage is affected by some regulation by Lake Manalapan, Helmetta Pond and DeVoe Lake.

South River at Old Bridge, N.J.

73. This gage, with a drainage area of 94.6 square miles, is located on the right abutment of Duhernal Dam, 0.6 miles south of Old Bridge, 2.3 miles upstream from Deep Run and 9.1 miles upstream from the mouth of South River. The total period of record of this gage is 49 years, from Water Year 1940 to Water Year 1988. The gage was discontinued at the end of Water Year 1988. The discharge records are rated good, except for periods when the waste gates were open which are poor. This gaged basin is HEC-1 model sub-basin 405500. Flow past this station is affected by pumpage from well fields for industrial use by Duhernal Water System. There is some regulation by Duhernal Lake, Lake Manalapan, DeVoe Lake, and several small ponds in headwater tributaries. The average discharge at this gage, based on 49 years of record, is 142 cfs, unadjusted.

Historic Floods

74. Flood of August 1971 had a peak flow at the Raritan River at Bound Brook stream gage of 46,100 cfs (frequency of about 70 years.) Runoff volume there was 3.66 inches, out of a total rainfall volume of 8.28 inches. This flood, and the August 1973 flood, were well documented in that many accurate floodmarks were recorded throughout the basin. Damage from these floods was severe.

Annual Series Peak Discharges vs Frequency Relations

75. Annual series peak discharges vs frequency relations were determined in accordance with Guidelines for Determining Flood Flow Frequency, Bulletin 17B, United States Water Resources

Council, Washington D.C., revised September 1981. The procedure uses the Log-Pearson Type III distribution. This procedure assumes that the common logarithms of the annual peak discharges are normally distributed and that statistical procedures are applicable. This minimizes personal, subjective judgment in plotting for economic studies. The annual peak discharges for the Raritan River at Bound Brook, Lawrence Brook at Farrington Dam and South River at Old Bridge are shown in Table 8.

Partial Duration Peak Discharges vs Frequency Relations

76. The annual series peak discharge versus frequency curves were augmented with partial duration series curves which take into account peak flows of magnitude less than the annual peak flow, regardless of interval of occurrence. These were determined by Weibull plotting position analyses of all peak flows above a base flow on record for the stream gages. Two weeks are required for hydrologic independence of flood peaks, and to clean up and repair flood damages, caused by flooding of Lawrence Brook, South River and the Raritan River, based on past experience. Therefore, all partial peak discharges that occurred within two weeks of preceding partial peak discharges were removed from the records before computing curves from them. The resulting existing conditions peak discharge vs. frequency curves for the three gages listed above are shown on Figures 10, 11, and 12.

Hydrologic Model

77. A comprehensive hydrologic model was developed to most accurately simulate the rainfall - runoff - streamflow - diversion - routing – hydrograph combination behavior of the Raritan River, Lawrence Brook, and South River basins because of the complexity of the South River and Lawrence Brook basins and the confluence with the Raritan River. The sub-basins of the model are shown on Figure 13. A schematic diagram of the stream network in shown in Figure 13a. A time step of 1 hour was used for the models because of the sizes and times of concentration of the model sub-basins. Tables 9 and 10 identify the nodes in the HEC-1 model for the Raritan and South River basins, respectively.

Water Year	Raritan River below Calco Dam at Bound Brook, NJ		Lawrence Brook at Farrington Dam, NJ		South River at Old Bridge, NJ USGS Gaging Sta. #01405500	
	Date	Peak Discharge (cfs)	Date	Peak Discharge (cfs)	Date	Peak Discharge (cfs)
1882	09/24/1882	* 47840				
1896	02/06/1896	* 54740				
1904	10/10/1903	32100				
1905	01/07/1905	24200				
1906	03/04/1906	17800				
1907	09/29/1907	16100				
1908	01/12/1908	15400				
1909	02/25/1909	14100				
1927			07/17/27	1720.0		
1928			07/06/28	1900.0		
1929			04/16/29	705.0		
1930			02/14/30	505.0		
1931			03/29/31	429.0		
1932			03/28/32	1040.0		
1933			11/19/32	795.0		
1934			03/05/34	535.0		
1935			09/06/35	675.0		
1936	03/12/1936	21300	01/03/36	825.0		
1937	12/20/1936	16600	12/20/36	505.0		
1938	09/22/1938	31000	09/21/38	2660.0		
1939	02/04/1939	19500	02/03/39	885.0		
1940			05/31/40	1260.0	06/01/40	1190.0
1941			02/08/41	816.0	07/05/41	1380.0
1942	08/09/1942	26200	08/09/42	700.0	02/08/42	673.0
1943			03/07/43	732.0	12/31/42	931.0
1944			09/15/44	2220.0	09/15/44	4250.0
1945	01/02/1945	15800	09/19/45	749.0	07/19/45	3200.0
1946	06/03/1946	24800	06/02/46	1280.0	07/23/46	2430.0
1947	04/05/1947	10700	05/04/47	457.0	05/05/47	809.0
1948	11/09/1947	15000	11/12/47	664.0	08/21/48	3030.0
1949	12/31/1948	30600	12/31/48	944.0	12/31/48	2060.0
1950	03/23/1950	11600	07/10/50	884.0	07/17/50	876.0
1951	11/26/1950	20200	11/25/50	686.0	03/31/51	1100.0
1952	12/21/1951	22500	06/01/52	925.0	06/02/52	2360.0
1953	01/25/1953	17300	03/13/53	1110.0	03/14/53	2030.0
1954	12/14/1953	11500	09/11/54	643.0	09/12/54	1970.0
1955	08/19/1955	30800	08/13/55	1450.0	08/13/55	2650.0
1956	10/15/1955	26700	10/16/55	658.0	04/09/56	1060.0
1957	04/06/1957	15400	04/05/57	567.0	04/06/57	801.0

Table 8
Annual Peak Discharges

Table 8
Annual Peak Discharges (continued)

Water Year	Date	Peak Discharge (cfs)	Date	Peak Discharge (cfs)	Date	Peak Discharge (cfs)
1958	02/28/1958	21500	04/06/58	1010.0	03/01/58	1670.0
1959	10/26/1958	12300	07/24/59	1610.0	07/24/59	1750.0
1960	09/13/1960	19200	09/12/60	1400.0	09/13/60	2430.0
1961	03/24/1961	15600	03/23/61	828.0	07/30/61	1640.0
1962	03/13/1962	19500	03/12/62	845.0	03/13/62	1620.0
1963	03/07/1963	15300	03/06/63	690.0	03/07/63	914.0
1964	01/10/1964	16000	01/09/64	387.0	11/08/63	764.0
1965	02/08/1965	16900	02/08/65	494.0	02/09/65	876.0
1966	02/14/1966	18800	09/22/66	1170.0	02/14/66	1480.0
1967	03/07/1967	29300	03/07/67	1510.0	03/08/67	1910.0
1968	05/30/1968	27800	05/29/68	1750.0	05/29/68	4180.0
1969	07/29/1969	18600	03/25/69	480.0	11/14/68	760.0
1970	04/03/1970	29600	04/02/70	775.0	04/03/70	1380.0
1971	08/28/1971	46100	08/28/71	2920.0	08/28/71	4210.0
1972	06/23/1972	26900	06/24/72	1580.0	11/30/71	1600.0
1973	02/01/1973	28000	02/02/73	2710.0	07/04/73	2060.0
1974	12/21/1973	31000	12/21/73	1720.0	12/21/73	2680.0
1975	07/14/1975	27100	07/21/75	4920.0	07/21/75	3560.0
1976	01/28/1976	20200	01/27/76	810.0	01/28/76	1600.0
1977	03/23/1977	26300	03/22/77	1040.0	03/23/77	1280.0
1978	01/26/1978	30000	01/26/78	1430.0	11/08/77	3160.0
1979	01/25/1979	34600	01/21/79	1870.0	01/22/79	3320.0
1980	03/22/1980	25300	04/10/80	757.0	04/10/80	2040.0
1981	05/12/1981	18200	05/12/81	365.0	05/12/81	534.0
1982	01/05/1982	22900	01/04/82	927.0	01/05/82	1190.0
1983	04/16/1983	28100	03/21/83	946.0	04/11/83	1980.0
1984	07/07/1984	28600	12/13/83	1150.0	05/30/84	3820.0
1985	09/28/1985	14100	09/27/85	535.0	09/28/85	1260.0
1986	04/17/1986	20100	04/16/86	993.0	04/17/86	2710.0
1987	04/05/1987	21100	07/14/87	618.0	01/03/87	1670.0
1988	07/27/1988	12600	07/26/88	816.0	02/13/88	1100.0
1989	09/21/1989	23500	09/21/89	4360.0		
1990	10/21/1989	17900	10/20/89	899.0		
1991	12/04/1990	11400				
1992	06/06/1992	15000				
1993	12/12/1992	20000				
1994	01/29/1994	22900				
1995	03/09/1995	11200				
1996	01/20/1996	32700				
1997	10/20/1996	40100				

Note: * indicates an historic peak

Table 9 HEC-1 Node Identification – Raritan River	
SUB-BASIN (HEC-1 ISTAQ)	**DESCRIPTION**
403060	RARITAN RIVER AT BOUND BROOK NJ USGS GAGE
MDC2	MIDDLE BROOK AT MOUTH
GRMO	GREEN BROOK AT MOUTH
RADSGR	RARITAN RIVER BELOW GREEN BROOK
INCRGL	INCREMENT: GREEN BROOK TO LAWRENCE BROOK
RCLLIN	DIVERTED HALF OF SUB-BASIN HYDROGRAPH
RSDLIN	RESIDUAL HALF OF SUB-BASIN HYDROGRAPH
RRINFL	INFLOW TO ROUTING REACH
RARTLB	ROUTE TO LAWRENCE BROOK CONFLUENCE
RAUSLB	RARITAN RIVER ABOVE LAWRENCE BROOK
405000	LAWRENCE BROOK AT FARRINGTON DAM USGS GAGE
LAWRR1	ROUTE TO MOUTH
LAWRS1	SUB-BASIN - DAM TO MOUTH
LAWRC1	LAWRENCE BROOK AT MOUTH
RADSLB	RARITAN RIVER DOWNSTREAM OF LAWRENCE BROOK
RARTSR	ROUTE TO SOUTH RIVER CONFLUENCE (RARITAN RIVER ABOVE SOUTH RIVER)
SRR4	SOUTH RIVER AT MOUTH
RADSSR	RARITAN RIVER DOWNSTREAM OF SOUTH RIVER
INCRLM	INCREMENT: LAWRENCE BROOK TO MOUTH
RRINF2	RARITAN RIVER INFLOW TO LAST ROUTING REACH
RARTMO	RARITAN RIVER AT MOUTH

Table 10

HEC-1 Node Identification – South River

SUB-BASIN (HEC-1 ISTAQ)	DESCRIPTION
405500	USGS GAGE: SOUTH RIVER AT OLD BRIDGE, NJ
SRR1	ROUTE TO CONFLUENCE WITH DEEP RUN
SRS1	INCREMENT: USGS GAGE AT OLD BRIDGE TO CONFLUENCE WITH DEEP RUN
SRC1	SOUTH RIVER ABOVE DEEP RUN
DEEPS1	DEEP RUN NEAR INTERSECTION RTS. 9 AND 18
DEEPS2	INCREMENT TO RT. 9 CROSSING
DEEPC1	DEEP RUN AT RT. 9
DEEPR1	ROUTE TO HEC-RAS REACH
DEEPR2	ROUTE TO MOUTH (HEC-RAS REACH)
DEEPS3	INCREMENT: ROUTE 9 TO MOUTH
DEEPC2	DEEP RUN AT MOUTH
SRC2	SOUTH RIVER BELOW DEEP RUN
SRR2	ROUTE TO CONFLUENCE WITH TENNENT BROOK
SRS2	INCREMENT: TO TENNENT BROOK
SRC3	SOUTH RIVER ABOVE TENNENT BROOK
TENNS1	TENNENT BROOK AT GOLF COURSE
TENNS2	INCREMENT: TO TENNENT POND DAM
TENNC1	INFLOW TO ROUTING REACH
TENNR1	TENNENT BROOK AT TENNENT POND DAM
TENNS3	INCREMENT: TO MOUTH
TENNC2	INFLOW TO ROUTING REACH
TENNR2	TENNENT BROOK AT MOUTH
SRC4	SOUTH RIVER BELOW TENNENT BROOK
SRS3	INCREMENT: TO VETERANS MEMORIAL BRIDGE
SRC5	INFLOW TO ROUTING REACH
SRR3	SOUTH RIVER AT VETERANS MEMORIAL BRIDGE
SRS4	INCREMENT: TO MOUTH
SRC6	INFLOW TO ROUTING REACH
SRR4	SOUTH RIVER AT MOUTH (RARITAN RIVER)

Modeling Technique.

78. The basic modeling tool selected for this study was the computer program HEC-1 (Flood Hydrograph Package) developed by the Hydrologic Engineering Center. The program is capable of performing a variety of hydrologic modeling tasks. The particular capability used for the Raritan River and South River basins was the "generalized stream network" option. The HEC-1 program was used to optimize parameters of the precipitation, runoff hydrograph, streamflow, routing, and combining processes to best reproduce observed hydrographs with known precipitation.

79. The optimizing algorithm minimizes the sum of the squares of the differences between concurrent flow ordinates of the observed and computed hydrograph for any given stream gage and historic flood.

Simulation Processes.

80. There are several techniques within program HEC-1 with which to input and distribute rainfall, compute infiltration loss, and determine sub-basin outflow hydrographs. The initial loss plus constant loss rate option, modified by sub-basin percent impervious cover, was used in the present study to determine infiltration loss and rainfall excess from input rainfall.

81. Infiltration loss is subtracted from input time series rainfall data by program HEC-1 to generate time series rainfall excess data. The Raritan River-South River HEC-1 model uses the initial loss and constant loss rate option. These input parameters are adjusted by trial and error until the desired hydrograph volume or peak is obtained. Adopted parameter values are those which best match the observed hydrographs of the gaged basins, and which result in peak flows which best replicate high water marks at other locations within the basin for the August 71 and December 92 events, or statistically computed peak Q vs. frequency curves. Adopted values of initial loss in inches (STRTL) and constant loss rates in inch/hour (CNSTL) used within the HEC-1 models are shown in Table 11 on a sub-basin basis.

Table 11
Infiltration Loss Parameters

Sub-Basin	December 1992		August 1971		1 – Year		2 – Year		10 - Year	
	STRTL	CNSTL	STRTL	CNSTL	STRTL	CNSTL	STRTL	CNSTL	STRTL	CNSTL
403060	-	-	-	-	1.0	0.1005	1.0	0.1116	1.0	0.1721
MDC2	1.00	0.0700	-	-	1.0	0.6300	1.0	0.5882	1.0	0.6350
GRMO	1.00	0.2300	-	-	1.0	0.7370	1.0	0.5760	1.0	0.5650
INCRGL	1.00	0.1700	3.58	0.3400	1.0	0.6700	1.0	0.5800	1.0	0.5900
405000	1.00	0.0900	3.80	0.1800	1.0	0.5800	1.0	0.5900	1.0	0.6300
LAWRS	1.00	0.0900	3.80	0.1800	1.0	0.5800	1.0	0.5900	1.0	0.6300
405500	1.77	0.0600	3.24	0.2540	1.0	0.2460	1.0	0.2260	1.0	0.2600
SRS1	1.77	0.0600	3.24	0.2540	1.0	0.2460	1.0	0.2260	1.0	0.2600
DEEPS1	1.77	0.0600	3.24	0.2540	1.0	0.2460	1.0	0.2260	1.0	0.2600
DEEPS2	1.77	0.0600	3.24	0.2540	1.0	0.2460	1.0	0.2260	1.0	0.2600
DEEPS3	1.77	0.0600	3.24	0.2540	1.0	0.2460	1.0	0.2260	1.0	0.2600
SRS2	1.77	0.0600	3.24	0.2540	1.0	0.2460	1.0	0.2260	1.0	0.2600
TENNS1	1.77	0.0600	3.24	0.2540	1.0	0.2460	1.0	0.2260	1.0	0.2600
TENNS2	1.77	0.0600	3.24	0.2540	1.0	0.2460	1.0	0.2260	1.0	0.2600
TENNS3	1.77	0.0600	3.24	0.2540	1.0	0.2460	1.0	0.2260	1.0	0.2600
SRS3	1.77	0.0600	3.24	0.2540	1.0	0.2460	1.0	0.2260	1.0	0.2600
SRS4	1.77	0.0600	3.24	0.2540	1.0	0.2460	1.0	0.2260	1.0	0.2600
INCRL	1.37	0.1200	2.78	0.2200	1.0	0.1800	1.0	0.1800	1.0	0.2300

Sub-Basin	50 - Year		100 - Year		150 – Year		500 – Year		PMF	
	STRTL	CNSTL	STRTL	CNSTL	STRTL	CNSTL	STRTL	CNSTL	STRTL	CNSTL
403060	1.0	0.2155	1.0	0.2380	1.0	0.2455	1.0	0.2383	1.0	0.10
MDC2	1.0	0.5050	1.0	0.4040	1.0	0.3630	1.0	0.2698	1.0	0.10
GRMO	1.0	0.4620	1.0	0.2110	1.0	0.2020	1.0	0.1962	1.0	0.10
INCRGL	1.0	0.4800	1.0	0.3100	1.0	0.2700	1.0	0.2300	1.0	0.10
405000	1.0	0.5170	1.0	0.4380	1.0	0.3740	1.0	0.2780	1.0	0.10
LAWRS	1.0	0.5170	1.0	0.4380	1.0	0.3740	1.0	0.2780	1.0	0.10
405500	1.0	0.2486	1.0	0.2410	1.0	0.2290	1.0	0.2180	1.0	0.10
SRS1	1.0	0.2486	1.0	0.2410	1.0	0.2290	1.0	0.2180	1.0	0.10
DEEPS1	1.0	0.2486	1.0	0.2410	1.0	0.2290	1.0	0.2180	1.0	0.10
DEEPS2	1.0	0.2486	1.0	0.2410	1.0	0.2290	1.0	0.2180	1.0	0.10
DEEPS3	1.0	0.2486	1.0	0.2410	1.0	0.2290	1.0	0.2180	1.0	0.10
SRS2	1.0	0.2486	1.0	0.2410	1.0	0.2290	1.0	0.2180	1.0	0.10
TENNS1	1.0	0.2486	1.0	0.2410	1.0	0.2290	1.0	0.2180	1.0	0.10
TENNS2	1.0	0.2486	1.0	0.2410	1.0	0.2290	1.0	0.2180	1.0	0.10
TENNS3	1.0	0.2486	1.0	0.2410	1.0	0.2290	1.0	0.2180	1.0	0.10
SRS3	1.0	0.2486	1.0	0.2410	1.0	0.2290	1.0	0.2180	1.0	0.10
SRS4	1.0	0.2486	1.0	0.2410	1.0	0.2290	1.0	0.2180	1.0	0.10
INCRL	1.0	0.2500	1.0	0.2400	1.0	0.2400	1.0	0.2300	1.0	0.10

82. Clark unit hydrographs were used to transform rainfall excess to sub-basin outflow hydrographs. Tables 12 through 14 give the adopted values for each HEC-1 model sub-basin. Figures 14a-14f show one hour unit hydrographs for three important locations.

Table 12

Sub-Basin Data

SUB-BASIN	DRAINAGE AREA (SQ-MI)	CLARK UNITGRAPH PARAMETERS: Tc, HRS.	CLARK UNITGRAPH PARAMETERS: R, HRS.	RTIMP (PERCENT IMPERVIOUS AREA)	BASE FLOW: STRTQ (CFS)	BASE FLOW: QRCSN (CFS)	BASE FLOW: RTIOR (CFS/CFS)
403060	785.00	21.40	20.50	5.10	-0.81	-0.0600	1.0102
MDC2	17.00	(1)	(1)	13.30	-0.26	-0.0120	1.0552
GRMO	65.12	(2)	(2)	34.80	-1.44	-0.0670	1.0195
INCRGL	31.51	1.57	2.00	31.50	-0.81	-0.0600	1.0102
405000	34.40	7.87	8.74	5.00	-0.15	-0.0360	1.0270
LAWRS1	11.78	5.63	5.38	29.80	-0.15	-0.0360	1.0270
405500	94.60	25.21	19.01	7.60	-1.22	-0.0707	1.0148
SRS1	1.75	0.75	0.78	30.90	-1.22	-0.0707	1.0148
DEEPS1	7.28	3.32	3.25	6.00	-1.22	-0.0707	1.0148
DEEPS2	5.78	2.20	2.17	8.40	-1.22	-0.0707	1.0148
DEEPS3	3.86	7.46	6.88	18.70	-1.22	-0.0707	1.0148
SRS2	1.04	0.63	0.69	24.00	-1.22	-0.0707	1.0148
TENNS1	4.69	1.58	1.60	19.40	-1.22	-0.0707	1.0148
TENNS2	5.79	1.70	1.74	13.60	-1.22	-0.0707	1.0148
TENNS3	0.69	(3)	(3)	13.60	-1.22	-0.0707	1.0148
SRS3	5.72	1.19	1.24	25.70	-1.22	-0.0707	1.0148
SRS4	3.71	0.38	0.42	25.40	-1.22	-0.0707	1.0148
INCRLM	28.78	1.46	1.49	50.00	-0.81	-0.0600	1.0102

INPUT UNITGRAPHS (END-OF-HOUR ORDINATES IN CFS):

(1),(2) - See Table 13 for input unitgraph

(3): 448

Table 13
Gaged and Ungaged Sub-Basin Unit Hydrograph Ordinates and Parameters

Sub-Basin (HEC1 Istaq)	Drainage Area (sq. Mi.)	Clark Unitgraph Parameters or 1 Hour Unit Hydrograph Ordinates in CFS										Source of Unit Hydrograph
		Tc (hrs)	R (hrs)									
403060	785.00	21.4	20.5									Green Brook GRR: Support Document F: Hydrology (May 1997): Optimized values
MDC2	17.00	1100	2431	2323	1755	1124	678	461	329	232	165	Same as above, from calibrated HEC-1 model (See text for complete description of derivation)
		117	83	59	42	30	21	15	6	0.7		
GRMO	65.12	662	1051	1190	1355	1557	1772	1984	2162	2357	2451	Same as above, from calibrated HEC-1 model
		2479	2432	2311	2130	1900	1729	1564	1395	1218	1061	
		929	815	715	641	587	482	411	356	309	269	(See text for complete description of derivation)
		232	201	175	153	134	118	104	91	80	71	
		62	55	48	42	37	33	29	25	22	20	
		17	15	14	12	11						
INCRG	31.51	1.57	2.00									Green Brook GRR: Area-averaged values
405000	34.40	7.87	8.74									Unit hydrograph optimization work: August 1971 flood
405500	94.60	25.21	19.01									Same as above

NOTES:

- One hour unit hydrograph ordinates given above for sub-basins MDC2 and GRMO are in chronological order, at intervals of one hour, reading from left to right, then down to the next line.
- See Table 9 for identification of all sub-basins.

(Insert Table 13)

Table 14

Ungaged Sub-Basin Clark Unit Hydrograph Parameter Derivation

SUB-BASIN (HEC-1 ISTAQ)	DRAINAGE AREA (square miles)	Longest Length		RTIMP (percent impervious)	Tc10=8.318X (1)			
		L (miles)	Slope (ft/mi)		DA -0.68	L 1.36	SLOPE -	RTIMP -
LAWRS1	11.78	8.30	15.2	29.8	0.187	17.78	0.224	0.873
SRS1	1.75	1.33	28.1	30.9	0.683	1.47	0.160	0.872
DEEPS1	7.28	5.11	19.6	6.0	0.259	9.19	0.195	0.931
DEEPS2	5.78	3.54	19.6	8.4	0.303	5.58	0.195	0.918
DEEPS3	3.86	5.98	10.0	18.7	0.399	11.38	0.282	0.889
SRS2	1.04	1.52	83.3	23.7	0.974	1.77	0.088	0.881
TENNS1	4.69	3.03	28.6	9.3	0.350	4.52	0.158	0.915
TENNS2	5.79	3.60	31.5	13.6	0.303	5.71	0.150	0.901
TENNS3	0.69	0.76	29.8	13.6	1.287	0.689	0.155	0.901
SRS3	5.72	2.97	35.9	25.7	0.305	4.39	0.140	0.878
SRS4	3.71	1.40	61.9	25.4	0.410	1.58	0.103	0.879
INCRLM	28.78	5.15	25.9	50.0	0.102	9.29	0.167	0.855

SUB-BASIN (HEC-1ISTAQ)	R_{10} = 6.516 X (1)				Tc_{10} (hours)	R_{10} (hours)	$(DA/10)^{0.25}$	CLARK UNITGRAPH PARAMETERS	
	$DA^{-0.67}$	$L^{1.34}$	$SLOPE^{-0.47}$	$RTIMP^{-0.04}$				Tc (hours)	R (hours)
LAWRS1	0.192	17.04	0.278	0.873	5.40	5.16	1.042	5.63	5.38
SRS1	0.687	1.47	0.209	0.872	1.16	1.21	0.647	0.75	0.78
DEEPS1	0.264	8.90	0.247	0.931	3.59	3.52	0.924	3.32	3.25
DEEPS2	0.309	5.44	0.247	0.918	2.52	2.49	0.872	2.20	2.17
DEEPS3	0.405	10.98	0.339	0.889	9.47	8.73	0.788	7.46	6.88
SRS2	0.974	1.75	0.125	0.881	1.11	1.21	0.568	0.63	0.69
TENNS1	0.355	4.42	0.207	0.915	1.91	1.93	0.828	1.58	1.60
TENNS2	0.308	5.56	0.198	0.901	1.95	2.00	0.872	1.70	1.74
TENNS3	1.282	0.692	0.203	0.901	1.03	1.06	0.513	0.53	0.54
SRS3	0.311	4.30	0.186	0.878	1.37	1.43	0.870	1.19	1.24
SRS4	0.416	1.57	0.144	0.879	0.49	0.54	0.780	0.38	0.42
INCRLM	0.105	8.99	0.217	0.855	1.12	1.14	1.303	1.46	1.49

Unitgraph Tc and R from physical parameters via Green Brook regression equations; See Green Brook Flood Control Project GRR, May 1997, Appendix x F, Paragraphs F153-F157

Tc(hours) = Tc_{10} (hours) X $(DA/10)^{0.25}$; R(hours) = R_{10} (hours) X $(DA/10)^{0.25}$

(1) X=multiplying times the product of the following parameters

(Insert Table 14)

83. The HEC-1 program computes a runoff hydrograph for any given sub-basin by applying the rainfall excess record it has generated to a unit hydrograph by using the linear superposition principle. The outflow hydrographs for each subbasin are then combined with those of other sub-basins at appropriate confluences, or nodes. Stream routing is then applied to move hydrographs down- stream. The HEC-1 model output is the response of the basin to input time series storm rainfall data, in the form of discharge versus time (hydrographs).

84. HEC-1 is a lumped parameter model. That is, the parameters or computations for a particular sub-basin are assumed to be uniform over, and apply over, its entire area.

Rainfall.

85. The driving input of the HEC-1 model is time series rainfall data applied to each sub-basin. There are several hourly and daily rainfall gages within and surrounding the Raritan River, Lawrence Brook and South River basins. The hourly gage 'Watchung', sets the hourly distribution of rainfall for the basins. This gage is located in the steep upper Green Brook watershed. The daily station 'Plainfield' is located in the Cedar Brook watershed. The hourly station 'New Brunswick' sets the hourly distribution of rainfall for the upper Lawrence Brook and South River basins. It is located in the city of New Brunswick, N.J. outside the Lawrence Brook and South River basins but still within the Raritan River basin. The locations of these gages are shown on Figure 9.

Isohyetal Maps.

86. The rainfall gages are few in number and far apart with respect to the South River basin. Isohyetal maps (maps showing lines, or contours, of equal rainfall) or Thiessen networks were therefore developed to adequately define total rainfall for each HEC-1 model sub-basin. A Thiessen network showing total and hourly rainfall for the December 1992 storm, and a combined isohyetal map for the Raritan River basin appears as Figures 15. A Thiessen network showing hourly rainfall in the South River basin for the August 1971 storm appears as Figures 16. For the August 1971 storm, hourly precipitation weights were determined as the percentage of a sub-basin that fell within the Thiessen polygon for a particular hourly rain gage. Likewise, for the December 1992 storm, hourly and total storm precipitation weights were determined from separate respective Thiessen

polygons. Time series rainfall data for the August 1971 and December 1992 storms used in the HEC-1 models of the important historic floods produced by these storms, is shown in Tables 15 through 18.

Table 15
HISTORIC PRECIPITATION DATA 26 – 28 AUGUST 1971 STORM

SUBAREA	TOTAL STORM PRECIPITATION, INCHES	HOURLY PRECIPITATION GAGE	HOURLY PRECIPITATION WEIGHT
INCRGL	8.85	NWBR	1.00
405000	8.43	NWBR	0.79
		HIGH	0.21
LAWRS1	8.50	NWBR	1.00
405500	8.48	NWBR	0.17
		HIGH	0.22
		FREE	0.61
SRS1	8.50	NWBR	1.00
DEEPS1	8.23	FREE	1.00
DEEPS2	8.30	FREE	1.00
DEEPS3	8.36	NWBR	1.00
SRS2	8.45	NWBR	1.00
TENNS1	8.25	NWBR	1.00
TENNS2	8.34	NWBR	1.00
TENNS3	8.40	NWBR	1.00
SRS3	8.45	NWBR	1.00
SRS4	8.50	NWBR	1.00
INCRLM	8.38	NWBR	0.70

HOURLY PRECIPITATION GAGES:

NWBR NEW BRUNSWICK 3 SE

HIGH HIGHTSTOWN 2 W

FREE FREEHOLD

RHWY RAHWAY

Table 16
HOURLY PRECIPITATION DATA 26 – 28 AUGUST 1971 STORM

HOUR ENDING:		HOURLY PRECIPITATION GAGE			
DATE	**TIME**	**RHWY**	**NWBR**	**HIGH**	**FREE**
27 AUG 71	0000	0.00	0.00	0.00	0.10
27 AUG 71	0100	0.03	0.01	0.00	0.00
27 AUG 71	0200	0.01	0.19	0.00	0.00
27 AUG 71	0300	0.01	0.16	0.40	0.10
27 AUG 71	0400	0.04	0.15	0.20	0.20
27 AUG 71	0500	0.12	0.25	0.40	0.10
27 AUG 71	0600	0.02	0.34	0.40	0.20
27 AUG 71	0700	0.05	0.70	0.80	0.30
27 AUG 71	0800	0.23	0.25	0.60	1.30
27 AUG 71	0900	0.56	0.26	0.10	1.70
27 AUG 71	1000	0.83	0.74	0.40	0.70
27 AUG 71	1100	0.40	0.94	0.50	0.30
27 AUG 71	1200	0.75	1.39	1.20	0.30
27 AUG 71	1300	1.75	0.07	1.40	0.00
27 AUG 71	1400	1.30	0.09	0.10	0.10
27 AUG 71	1500	0.18	0.27	0.20	0.80
27 AUG 71	1600	0.06	0.00	0.10	0.00
27 AUG 71	1700	0.00	0.00	0.00	0.10
27 AUG 71	1800	0.08	0.00	0.10	0.00
27 AUG 71	1900	0.00	0.00	0.00	0.20
27 AUG 71	2000	0.00	0.00	0.00	0.00
27 AUG 71	2100	0.02	0.01	0.00	0.00
27 AUG 71	2200	0.01	0.00	0.00	0.00
27 AUG 71	2300	0.01	0.01	0.00	0.00
28 AUG 71	0000	0.01	0.12	0.10	0.00
28 AUG 71	0100	0.01	0.22	0.40	0.30
28 AUG 71	0200	0.10	0.46	1.10	0.90
28 AUG 71	0300	0.47	0.67	0.70	0.50
28 AUG 71	0400	0.90	0.95	0.10	0.00
28 AUG 71	0500	0.13	0.21	0.10	0.10
28 AUG 71	0600	0.05	0.08	0.00	0.00
28 AUG 71	0700	0.02	0.03	0.00	0.00
TOTAL		**8.15**	**8.59**	**9.40**	**8.20**

Table 17
HISTORIC PRECIPITATION DATA 10-13 December 1992 STORM

SUBAREA	HOURLY PRECIPITATION GAGE	HOURLY PRECIPITATION WEIGHT	TOTAL STORM PRECIPITATION GAGE	TOTAL STORM PRECIPITATION WEIGHT
MDC2	BB2W	92	WTCH	2
	WTCH	8	PLFD	8
			BB2W	57
			SMRV	33
GRMO	SPRF	3	SPRF	3
	WTCH	54	WTCH	27
	RHWY	7	PLFD	54
	BB2W	20	NWBR	1
	NWBR	16	BB2W	15
INCRGL	BB2W	38	BB2W	38
	NWBR	62	NWBR	62
405000	NWBR	1	NWBR	1
LAWRS1	NWBR	1	NWBR	1
405500	NWBR	62	NWBR	58
	HIGH	38	HIGH	37
			LBOH	5
SRS1	NWBR	1	NWBR	1
DEEPS1	NWBR	1	NWBR	1
DEEPS2	NWBR	1	NWBR	1
DEEPS3	NWBR	1	NWBR	1
SRS2	NWBR	1	NWBR	1
TENNS1	NWBR	1	NWBR	1
TENNS2	NWBR	1	NWBR	1
TENNS3	NWBR	1	NWBR	1
SRS3	NWBR	1	NWBR	1
SRS4	NWBR	1	NWBR	1
INCRLM	NWBR	58	PLFD	11
	RHWY	42	RHWY	37
			NWBR	52

HOURLY PRECIPITATION GAGES:

NWBR NEW BRUNSWICK 3 SE
HIGH HIGHTSTOWN 2 W
SPRF SPRINGFIELD
RHWY RAHWAY
2.85
WTCH WATCHUNG
BB2W BOUND BROOK 2 W

TOTAL STORM PRECIPITATION GAGES / VALUES (INCHES):

SMRV SOMERVILLE 3 NW 2.85
PLFD PLAINFIELD 2.82
LBOH LONG BRANCH OAKHURST 3.70
RHWY RAHWAY
SPRF SPRINGFIELD 2.86
WTCH WATCHUNG 2.75
BB2W BOUND BROOK 2 W 4.60
HIGH HIGHTSTOWN 2 W 5.61
NWBR NEW BRUNSWICK 3 SE 4.79

Table 18
HOURLY PRECIPITATION DATA 10-13 December 1992 STORM

HOUR ENDING:		HOURLY PRECIPITATION GAGE					
DATE	TIME	SPRF	RHWY	WTCH	BB2W	NWBR	HIGH
10 DEC 92	1400	0.00	0.00	0.01	0.00	0.00	0.00
10 DEC 92	1500	0.00	0.00	0.01	0.00	0.00	0.00
10 DEC 92	1600	0.01	0.02	0.00	0.00	0.00	0.00
10 DEC 92	1700	0.02	0.00	0.01	0.00	0.00	0.00
10 DEC 92	1800	0.01	0.00	0.00	0.00	0.00	0.00
10 DEC 92	1900	0.00	0.00	0.00	0.00	0.00	0.00
10 DEC 92	2000	0.00	0.09	0.02	0.00	0.00	0.00
10 DEC 92	2100	0.08	0.13	0.10	0.20	0.20	0.30
10 DEC 92	2200	0.11	0.17	0.12	0.10	0.18	0.24
10 DEC 92	2300	0.17	0.16	0.15	0.20	0.19	0.25
11 DEC 92	0000	0.20	0.15	0.18	0.20	0.19	0.25
11 DEC 92	0100	0.16	0.11	0.12	0.20	0.17	0.25
11 DEC 92	0200	0.12	0.16	0.14	0.20	0.19	0.26
11 DEC 92	0300	0.20	0.12	0.16	0.10	0.20	0.25
11 DEC 92	0400	0.12	0.05	0.20	0.30	0.18	0.25
11 DEC 92	0500	0.08	0.09	0.10	0.30	0.17	0.28
11 DEC 92	0600	0.14	0.21	0.12	0.10	0.18	0.23
11 DEC 92	0700	0.17	0.20	0.18	0.30	0.19	0.25
11 DEC 92	0800	0.16	0.13	0.25	0.40	0.18	0.11
11 DEC 92	0900	0.09	0.14	0.10	0.20	0.08	0.10
11 DEC 92	1000	0.06	0.09	0.06	0.20	0.11	0.11
11 DEC 92	1100	0.04	0.12	0.06	0.20	0.11	0.10
11 DEC 92	1200	0.11	0.14	0.07	0.10	0.10	0.08
11 DEC 92	1300	0.05	0.10	0.03	0.10	0.10	0.00
11 DEC 92	1400	0.05	0.14	0.02	0.10	0.11	0.00
11 DEC 92	1500	0.05	0.04	0.05	0.20	0.09	0.00
11 DEC 92	1600	0.03	0.00	0.03	0.10	0.11	0.00
11 DEC 92	1700	0.05	0.13	0.02	0.00	0.00	0.00
11 DEC 92	1800	0.08	0.01	0.10	0.10	0.00	0.00
11 DEC 92	1900	0.04	0.01	0.01	0.10	0.00	0.20
11 DEC 92	2000	0.04	0.01	0.02	0.00	0.00	0.21
11 DEC 92	2100	0.02	0.02	0.03	0.10	0.00	0.21
11 DEC 92	2200	0.01	0.00	0.01	0.00	0.20	0.21
11 DEC 92	2300	0.02	0.00	0.00	0.00	0.22	0.22
12 DEC 92	0000	0.00	0.00	0.00	0.00	0.22	0.22
12 DEC 92	0100	0.00	0.00	0.00	0.00	0.21	0.22

Table 18 (continued)							
DATE	**TIME**	**SPRF**	**RHWY**	**WTCH**	**BB2W**	**NWBR**	**HIGH**
12 DEC 92	0200	0.00	0.00	0.00	0.00	0.27	0.22
12 DEC 92	0300	0.00	0.00	0.01	0.00	0.02	0.23
12 DEC 92	0400	0.01	0.02	0.01	0.10	0.08	0.15
12 DEC 92	0500	0.02	0.00	0.03	0.00	0.00	0.00
12 DEC 92	0600	0.04	0.00	0.00	0.00	0.00	0.00
12 DEC 92	0700	0.02	0.00	0.01	0.00	0.00	0.00
12 DEC 92	0800	0.00	0.00	0.03	0.00	0.02	0.00
12 DEC 92	0900	0.00	0.01	0.02	0.00	0.03	0.02
12 DEC 92	1000	0.00	0.04	0.00	0.00	0.02	0.01
12 DEC 92	1100	0.01	0.02	0.00	0.00	0.02	0.01
12 DEC 92	1200	0.03	0.01	0.00	0.00	0.04	0.01
12 DEC 92	1300	0.03	0.01	0.01	0.10	0.06	0.01
12 DEC 92	1400	0.04		0.03	0.00	0.05	0.01
12 DEC 92	1500	0.05		0.00	0.10	0.04	0.01
12 DEC 92	1600	0.03		0.03	0.00	0.06	0.01
12 DEC 92	1700	0.02		0.03	0.10	0.02	0.01
12 DEC 92	1800	0.01		0.01	0.00	0.01	0.01
12 DEC 92	1900	0.00		0.01	0.10	0.03	0.01
12 DEC 92	2000	0.00		0.00		0.01	0.01
12 DEC 92	2100	0.00		0.01		0.01	0.01
12 DEC 92	2200	0.00		0.00		0.01	0.01
12 DEC 92	2300	0.00		0.01		0.02	0.01
13 DEC 92	0000	0.00		0.00		0.04	0.01
13 DEC 92	0100	0.00		0.00		0.01	0.01
13 DEC 92	0200	0.00		0.01		0.02	0.01
13 DEC 92	0300	0.00		0.01		0.04	0.02
13 DEC 92	0400	0.02					
13 DEC 92	0500	0.02					
13 DEC 92	0600	0.02					
TOTAL		**2.86**	**2.85**	**2.75**	**4.60**	**4.79**	**5.61**

HOURLY PRECIPITATION GAGES:

- SPRF SPRINGFIELD
- RHWY RAHWAY
- WTCH WATCHUNG
- BB2W BOUND BROOK 2 W
- NWBR NEW BRUNSWICK 3 SE
- HIGH HIGHTSTOWN 2 W

Percent impervious area

87. Percent impervious area (RTIMP) of each HEC-1 model sub-basin was estimated from U.S. Geological Survey 7.5 minute topographic maps and existing conditions aerial photography of the South River proposed improvement reaches. The scale of the latter mapping is large enough to show individual houses and other buildings within urbanized areas that appear as solid pink or purple tint on the USGS quadrangles. This detail was used to accurately determine percent impervious cover within these urbanized areas.

88. The HEC-1 program uses input variable RTIMP to reduce the computed sub-basin initial loss and constant loss rate from nominal input values. The resulting effective value is then used for the entire sub-basin. These values are summarized in Table 12.

Base Flow and Recession.

89. Historic flood hydrographs recorded at gaged locations within the Raritan River-Lawrence Brook-South River HEC-1 model were analyzed to determine base flow and recession parameters required for input to computer program HEC-1. Input variable STRTQ is average channel base flow at the start of a runoff-producing storm. HEC-1 input variable QRCSN is the discharge on the falling limb of a flood hydrograph at which direct runoff ceases and pure base flow begins. It was determined by semi-logarithmic plots of the recorded historic flood mentioned above. The same plots were used to determine HEC-1 input variable RTIOR, the ratio of base flow at any time after QRCSN to base flow occurring one hour later. The general expression for base flow, Q, used within program HEC-1 is:

$$Q = QRCSN\,(RTIOR)^{N}$$

where

QRCSN=failing limb discharge where direct runoff ceases and pure base flow begins.

Q=base flow occurring N hours after QRCSN.

RTIOR=base flow at or any time after QRCSN/ base flow occurring one hour later.

Final adopted base flow parameters are given in Table 17.

Channel Routing.

90. The Muskingum and the Modified Puls methods were the HEC-1 routing procedures selected for use in this study. The Modified Puls method is based on the equation of continuity (conservation of mass), and outflow as a single-valued function of reach storage. The storage versus outflow data was taken from a comprehensive set of water surface profile (program HEC-RAS) runs which capture the full channel and overbank storage in the Raritan River-South River stream system. The hydraulic water surface profile HEC-RAS models used were calibrated to data for the August 1971 and December 1992 floods. Muskingum routing was used in the few reaches where HEC-RAS data was not available. Muskingum parameters for the few reaches where HEC-RAS data was not available are given in Table 19; existing conditions storage-outflow relationships for Modified Puls routing reaches are given in Table 20.

Table 19

Existing Conditions Channel Routing Data – Muskingum Routing

ROUTING REACH HEC-1 MODEL LOCATION:	Number of Routing Stops	Muskingum K (hours)	Muskingum X
Lawrence Brook: LAWRR1 - Route to Mouth	1	7.47	0
Deep Run DEEPR1 - Route to HECRAS Reach	1	6.30	0
Tennent Brook TENNR1 – Tennent Bk at Tennent Pond Dam	1	3.60	0

Table 20

Existing Conditions Channel Routing Data – Modified Puls Routing

ROUTING REACH HEC-1 MODEL LOCATION:	SV/SQ	DATA PAIRS:								
RARITAN RIVER:										
RARTLB	SV	0	6958	8399	12094	16226	18659	19819	24450	37188
ROUTE TO LAWRENCE BROOK	SQ	0	21700	26920	39070	52780	60440	63540	78480	120770
RARTSR	SV	450	5037	5885	6747	7826	8399	9778	17496	
ROUTE TO SOUTH RIVER	SQ	0	9615	24890	35660	48200	54720	70960	177103	
SOUTH RIVER:										
SRR1	SV	669	738	865	1042	1294	1448	1927	4434	
ROUTE TO DEEP RUN	SQ	0	725	2050	3500	5170	6050	8350	26590	
DEEP RUN:										
DEEPR2	SV	148	177	229	315	467	575	845	1592	
ROUTE TO MOUTH	SQ	0	285	800	1360	2000	2330	3170	8170	
SOUTH RIVER:										
SRR2	SV	417	434	465	506	567	604	705	1700	
ROUTE TO TENNENT BROOK	SQ	0	830	2320	3950	5780	6780	9270	28890	
TENNENT BROOK:										
TENNR2	SV	73	84	103	124	147	158	185	316	
ROUTE TO MOUTH	SQ	0	375	1040	1710	2460	2860	3730	8080	
SOUTH RIVER:										
SRR3	SV	149	1586	1742	1930	2194	2350	2765	6228	
ROUTE TO VETS MEM BRIDGE	SQ	0	895	2490	4230	6160	7220	9820	29550	
SRR4	SV	192	2153	2505	2928	3503	3822	4621	9757	
ROUTE TO MOUTH	SQ	0	1030	2630	4400	6330	7440	9910	28430	
RARITAN RIVER:										
RARTMO	SV	309	31310	31833	32474	33411	33973	35534	49079	
ROUTE TO MOUTH	SQ	0	10630	27780	40460	54900	62460	81000	202820	

- Storage (SV) in acre-feet vs. Outflow (SQ) in cubic feet per second (from HEC-RAS)

91. The HEC-1 models were then run as part of the calibration process described below.

Calibration and Verification

Recent Historic Floods

92. The HEC-1 model of the Raritan River-Lawrence Brook-South River basins was calibrated, where possible, to flood hydrographs recorded by the following USGS stream gages for the August 1971 and December 1992 floods:

- South River at Old Bridge, NJ
- Lawrence Brook at Farrington Dam
- Manalapan Brook at Spotswood, NJ

A verification run to a third flood was not made due to the fact that the majority of the model had been well calibrated in previous studies. Much unitgraph work had also been done with other storms. The two storms chosen to calibrate represent a predominantly coastal event and a predominantly fluvial event.

August 1971 (Tropical Storm "Doria") flood:

93. This large, severe, well-known and well-documented historic flood was thoroughly calibrated to and reproduced in the hydrology and hydraulics of the Green Brook GRR (General Re-evaluation Report), dated May 1997. This included an excellent reproduction of the flood hydrograph recorded by the Raritan River below Calco Dam at Bound Brook USGS stream gage, and good reproductions of recorded hydrographs , peak flows and flood marks throughout the Green and Middle Brook basins. The existing conditions hydrograph, computed for the Raritan River below Green Brook, by the calibrated HEC-1 model of the Green Brook GRR, was therefore considered accurate, and was therefore input directly as the start of the HEC-1 model of the August 1971 flood, in the Raritan River, Lawrence Brook, and South River basins, in the present study.

December 1992 (northeaster) flood:

94. This was a severe tidal or ocean flood in the South River basin, with a small river, or fluvial, component. Many historic floods were reproduced well at the Raritan River at Bound Brook stream gage with the one adopted unit hydrograph, historic rain data, and reasonable loss and base flow parameters, in the hydrology of the Green Brook GRR. Therefore, to save time and money in the present study, no attempt was made to reproduce the flood discharge hydrograph recorded by the

Raritan River at Bound Brook stream gage for the December 1992 flood. Rather, it was input directly as the start of the HEC-1 model of this flood for the Raritan River, Lawrence Brook, and South River basins. Peak flows of Middle Brook at mouth (1640 cfs) and Green Brooks at mouth (1630 cfs) were estimated for the December 1992 flood from observed values of peak flows of this flood at the West Branch Middle Brook near Martinsville, NJ and Bound Brook at Middlesex (Green Brook below Bound Brook) stream gages, and peak flow relationships in the Green Brook GRR hydrology. These estimated peak flows were reproduced by December 1992 rainfall data and the unit hydrographs of Green and Middle Brooks at their mouths. A peak flow at the Lawrence Brook at Farrington Dam stream gage (1270 cfs) was reproduced in the same way. No hydrograph or peak flow data was available to calibrate to at the South River at Old Bridge gage for the December 1992 flood, but a full hydrograph was reproduced at the Manalapan Brook at Spotswood gage. This gaged basin lies within, is part of, and is about half the area of the South River at Old Bridge gage. Loss rates adopted for the December 1992 flood for Manalapan Brook at Spotswood, NJ were reasonable and were adopted and applied to the entire South River basin in the HEC-1 model of the December 1992 flood done for this study.

Specific Frequency Hypothetical Floods.

95. The hypothetical storms in Table 5 were applied to the calibrated HEC-1 model to compute the specific frequency hypothetical flood hydrographs throughout the basin. Hypothetical flood infiltration loss parameter values are set by the need to reproduce peak flows at selected frequencies of peak flow vs. frequency curves computed from stream gage data by accepted statistical procedures. Values of infiltration loss parameters adopted for the hypothetical floods are given in Table 11.

Documentation.

96. The computed existing conditions hypothetical and August 1971 and December 1992 flood peak discharges are shown in Table 21. The computed existing conditions August 1971, December 1992, 10 year, 150 year, Probable Maximum Flood and Half Probable Maximum Flood hydrographs at important locations throughout the basin are shown on Figures 17a through 17dd. Existing conditions peak discharges versus drainage area for the Raritan River and the South River are shown on Figures 18a and 18b. Existing conditions peak discharge versus frequency curves at the three

Table 21
Existing Conditions Peak Flow (CFS)

ISTAQ	DA, SQ. MI.	1-YEAR	2-YEAR	10-YEAR	50-YEAR	100-YEAR	150-YEAR	500-YEAR	PMF	AUG 1971	DEC 1992	HALF PMF
403060	785.00	18450	23500	32800	43510	48200	50500	59400	324730	46100	20000	162370
MDC2	17.00	1510	2120	3810	6060	7300	8020	10320	31130	6010	1640	15560
GRMO	65.12	2260	3230	5440	7960	10670	12340	17890	47620	7580	1630	23810
RADSGR	867.12	19810	25390	35980	48140	54300	57540	69850	353620	51530	21030	176810
RAUSLB	898.63	18800	24300	34560	46360	52430	55590	67390	336460	50590	20510	168230
405000	34.40	810	1110	2130	3570	4400	5000	6910	29090	3010	1270	14550
LAWRC1	46.18	940	1230	2160	3370	4050	4520	6100	24460	3470	1480	12230
RADSLB	944.81	19240	24890	35650	48210	54750	58200	70960	352810	52300	21950	176400
RARTSR	944.81	19190	24820	35510	47990	54500	57970	70680	351610	52180	21900	175810
405500	94.60	1450	2050	3500	5170	6050	6600	8350	52750	4200	2550	26370
SRC1	96.35	1470	2070	3510	5170	6030	6540	8230	52230	4210	2570	26110
DEEPC1	13.06	1190	1690	2910	4210	4900	5280	6430	30020	2090	1090	15010
DEEPC2	16.92	470	670	1130	1660	1940	2110	2650	18150	1180	690	9070
SRC2	113.27	1700	2400	4060	5950	6930	7520	9450	58100	5160	3020	29050
SRC3	114.31	1720	2410	4090	5990	6970	7560	9490	58170	5170	3040	29080
TENNR1	10.48	740	1030	1730	2500	2900	3130	3830	17490	1750	740	8740
TENNR2	11.17	750	1040	1730	2500	2890	3120	3830	17920	1770	750	8960
SRC4	125.48	1830	2570	4350	6350	7380	8000	10010	59850	6040	3290	29930
SRR3	131.20	1920	2640	4460	6490	7540	8160	10190	59800	6580	3410	29900
SRR4	134.91	1910	2680	4490	6510	7550	8160	10180	58900	6200	3480	29450
RADSSR	1079.72	21100	27450	39920	54250	61720	65760	80280	408500	57520	25230	204250
RARTMO	1108.50	21390	27840	40500	54960	62480	66510	81130	407730	58090	25600	203860

- Using revised existing conditions storages from HEC-RAS

USGS gages and at important locations on The Raritan River and on the South River and its tributaries, are shown on Figures 19a – 19c.

Insert Table 21

Probable Maximum Flood.

97. The Probable Maximum Flood (PMF) is, by definition, the flood produced in the study basin by the Probable Maximum Storm (PMS). The PMS is defined as the storm that represents the most severe flood-producing rainfall – depth –area – duration relationship and isohyetal pattern considered reasonably possible for the study basin.

98. The PMF is computed here so that the half PMF can be computed and displayed to comply with the requirements of residual and induced flooding documentation in Appendix A of ER 1110-2-1150, Engineering and Design for Civil Works Projects, U.S. Army Corps of Engineers, Washington D.C. 31 March 1994. It is defined by taking half the ordinates of the PMF hydrograph at any given location. Data on the half PMF in the South River and Raritan basins under the Recommended Plan is given in the separate section, Residual and Induced Flooding, Recommended Plan.

99. The PMS was computed in a simplified way in this study for the South and Raritan River basins because, as noted above, there are no high hazard dams proposed as flood control measures whose sudden and catastrophic failure must be considered. Rather, the only need for the PMF is so that the residual flooding of the half PMF may be computed and displayed.

100. A 10 square mile Probable Maximum Storm (PMS) had already been computed for the upper Green Brook basin in New Jersey, using Probable Maximum Precipitation (PMP) data valid for the entire Raritan River basin, for the Green Brook Flood Control Project – General Re-evaluation Report (GRR), U.S. Army Corps of Engineers, New York District, December 1996. The computation was done in a rigorous and thorough manner using Corps-supported computer program HMR-52, Probable Maximum Storm : Eastern United States. See Table 22 for the Raritan River basin PMP input data. See Support Document F : Hydrology of the Green Brook GRR for a detailed explanation of the PMS computation.

Table 22 Probable Maximum Precipitation Depths in Inches					
Area (Square Miles)	**Duration (hours)**				
	6	**12**	**24**	**48**	**72**
10	26.50	30.60	33.30	37.60	39.30
200	16.20	21.40	25.30	28.80	30.00
1000	13.20	16.50	20.50	23.80	24.50
5000	8.00	11.40	14.30	17.80	19.00
10000	6.10	9.20	11.80	14.80	16.00
20000	4.35	7.37	9.80	13.15	14.05

- Data taken from Hydrometeorological Report No. 51, Probable Maximum Precipitation Estimates, United States East of the 105th Meridian, U.S. Department of Commerce, NOAA, Office of Hydrology, Silver Spring, MD. September 1976

101. The 10 square mile Probable Maximum Storm computed for upper Green Brook was placed alongside 100 and 1000 square mile storm PMP depths in 6-hour increments determined by program HMR-52 from the PMP input data, and arranged in the same critical pattern as the 10 square mile PMS. Each 6-hour increment of the 100 and 1000 square mile PMP data was broken into hourly increments according to the hourly time distribution of the 10 square mile Probable Maximum Storm. The result appears in Table 23. The three sets of time series data (10, 100 and 1000 square miles) were then input to a HEC-1 model of the PMF for the Raritan and South River basins.

Table 23

Raritan River Basin - Probable Maximum Storm Data – Hourly and Total Rainfall in Inches

TIME	STORM AREA			TIME	STORM AREA			TIME	STORM AREA		
(HOURS)	10 SQ. MI.	100 SQ. MI.	1000 SQ. MI.	(HOURS)	10 SQ. MI.	100 SQ. MI.	1000 SQ. MI.	(HOURS)	10 SQ. MI.	100 SQ. MI.	1000 SQ. MI.
1	0.07	0.06	0.06	26	0.22	0.23	0.20	51	0.19	0.18	0.17
2	0.07	0.06	0.06	27	0.23	0.23	0.21	52	0.18	0.18	0.17
3	0.07	0.06	0.06	28	0.25	0.25	0.23	53	0.18	0.18	0.16
4	0.07	0.07	0.06	29	0.26	0.26	0.24	54	0.18	0.18	0.16
5	0.07	0.07	0.06	30	0.27	0.27	0.26	55	0.13	0.12	0.12
6	0.08	0.07	0.07	31	0.45	0.62	0.48	56	0.13	0.12	0.11
7	0.08	0.07	0.07	32	0.48	0.66	0.52	57	0.13	0.12	0.11
8	0.08	0.07	0.07	33	0.53	0.73	0.57	58	0.13	0.12	0.11
9	0.09	0.08	0.07	34	0.61	0.84	0.66	59	0.13	0.12	0.11
10	0.09	0.08	0.08	35	0.70	1.02	0.80	60	0.12	0.12	0.11
11	0.09	0.09	0.08	36	0.82	1.06	0.83	61	0.11	0.09	0.09
12	0.09	0.09	0.08	37	1.25	1.20	0.83	62	0.10	0.09	0.09
13	0.09	0.09	0.09	38	2.13	1.28	0.87	63	0.10	0.09	0.09
14	0.10	0.10	0.09	39	3.64	2.67	1.83	64	0.10	0.09	0.08
15	0.11	0.10	0.10	40	14.21	10.43	7.14	65	0.10	0.09	0.08
16	0.11	0.11	0.10	41	2.93	2.15	1.47	66	0.09	0.09	0.08
17	0.12	0.11	0.10	42	1.82	1.34	0.91	67	0.08	0.08	0.07
18	0.13	0.11	0.10	43	0.41	0.45	0.39	68	0.08	0.07	0.07
19	0.15	0.14	0.13	44	0.38	0.41	0.36	69	0.08	0.07	0.07
20	0.15	0.14	0.13	45	0.35	0.38	0.33	70	0.08	0.07	0.07
21	0.15	0.14	0.13	46	0.32	0.35	0.30	71	0.08	0.07	0.07
22	0.15	0.15	0.14	47	0.31	0.34	0.29	72	0.07	0.07	0.06
23	0.15	0.15	0.14	48	0.28	0.30	0.27				
24	0.16	0.15	0.14	49	0.19	0.19	0.17	**TOTAL**	**38.54**	**32.83**	**25.00**
25	0.21	0.22	0.19	50	0.19	0.18	0.17				

Insert Table 23

102. Two sets of weighting factors were then computed for use in the Raritan and South River basins HEC-1 model.

103. One set was for the drainage area of the Raritan River above the South River (944.81 square miles, HEC-1 node RARTSR) and the second set was for the drainage area of the South River at its mouth (134.91 square miles, HEC-1 node SRR4). The weighting factors are logarithmic and are input to HEC-1 to allow it to interpolate PMS time series data for the two drainage areas above from the input 100 and 1000 square mile time series data input. The weighting factors, and their application in the HEC-1 model, are given in Table 24 below.

Table 24
PMS Weighting Factors in the HEC-1 Model

Factors		Drainage Area (Sq. Mi.)	Description	Used for Sub-Basins
100 Sq.Mi.	1000 Sq.Mi.			
0.025	0.975	944.81	Raritan River above South River	Raritan R. @ Bound Brook (USGS gage),Middle, Green and Lawrence Brooks, Raritan increment: Middle Brook to South River
0.870	0.130	134.91	South River at mouth	All South River sub-basins

104. For the last sub-basin (INCRLM), Raritan River increment, South River to mouth, the controlling drainage area for PMP is that of the Raritan River at its mouth (1108.50 sq. mi., HEC-1 node RARTMO) but the 1000 square mile PMS is close enough, and is a little conservative, and therefore used at a weight of unity for this sub-basin.

105. The approach described above represents a double centering of the PMS isohyetal pattern (Raritan River above South River and South River at mouth) and is permissible according to both report and computer program HMR-52. The approach was taken to compute a conservative half PMF for the improvement reaches of the South River, taking into full account the backwater effect of a half PMF of the Raritan River upon the South River.

106. The result of this approach approximates a Probable Maximum Storm computed in the rigorous and complete way with computer program HMR-52 for both the South River at its mouth and the Raritan River above the South River (100 and 1000 square mile Probable Maximum Storms, respectively).

107. For the HEC-1 model of the PMF, the peaks of the unit hydrographs of all the HEC-1 model sub-basins were increased 25 percent above the values used in the HEC-1 models of the other hypothetical floods, and the two (August 1971 and December 1992) historic floods, in compliance with paragraph 8 (b) of ER 1110-8-2 (FR), Inflow Design Floods for Dams and Reservoirs, U.S. Army Corps of Engineers, Washington D.C. 1 March 1991. The rationale behind this is to provide as conservative an estimate as possible of the PMF peak flows, in light of the fact that unit hydrographs are usually determined from floods much smaller than the PMF, and that watersheds tend to become more efficient flood peak producers under so large a storm as the PMS.

108. The HEC-1 model of the PMF developed as described above was run with an initial loss of 1.00 inch and a constant loss rate of 0.10 inch per hour. This constant loss rate is lower than that used for any of the specific frequency hypothetical floods (1 to 500 year) but is higher than that used for the December 1992 flood (0.06 inch per hour) for the South River basin. It is still a conservative loss rate for the PMF because, for the South River basin, a higher initial loss is used for the December 1992 flood than for the PMF (1.77 inches as opposed to 1.00 inch) because the December 1992 flood consisted of some snowmelt, and because the Probable Maximum Flood is so much larger than the December 1992 flood in the South and Raritan River basins.

109. The PMF peak flows computed as described above are given in Table 21 along with the half PMF peak flows.

Fluvial-Tidal Correlation.

110. An analysis was done to answer the question, for existing conditions, and for the proposed improvements on the South River, what frequency fluvial, or river, flood, occurs at the same time (coincident with) a tidal, or ocean surge or flood, of a given magnitude or frequency? An answer to this question is needed for the analysis presented here because the Raritan River between its confluence with the South River and its mouth (Raritan Bay, Atlantic Ocean) is so flat, and its

floodplain so flat and wide, that its flood elevations are almost exclusively controlled by the Atlantic Ocean. The same is true for the reach of the South River under consideration for improvement (USGS gage at Duhernal Dam, South River at Old Bridge NJ, to mouth, or confluence with Raritan River). This reach of the South River is also affected by tidal backwater. It is noted that the largest storm or record, the December 1992 event, reached near the top of Duhernal Lake Dam, but did not flood upstream.

111. The interaction of river and ocean must therefore be considered to determine if flood elevation vs. frequency for the South River reaches to be protected by the proposed improvements are also fluvial (river) influenced.

112. Peak river discharge and peak ocean elevation data was obtained for major coastal storms and major river (fluvial) floods from the September 1938 hurricane flood to the present. These included (but were not limited to) the aforementioned hurricane flood, the September 1944 hurricane flood, Hurricane Donna (September 1960), the March 1962 Nor'Easter, the August 1971 ("Doria") flood, the flood of November 1977, Hurricanes David (September 1979), Gloria (September 1985) and Hugo (September 1989), the Halloween '91 Nor'Easter, the December '92 Nor'Easter (tidal flood of record in the study area) and the October '96 Nor'Easter.

113. Peak river discharge data was obtained for three USGS gaged basins in the study area : Raritan River at Bound Brook, NJ, Lawrence Brook at Farrington Dam, NJ and South River at Old Bridge NJ. Peak ocean elevation data was obtained for the two tide gages, Perth Amboy NJ, and Sandy Hook NJ, respectively, at and close to, the mouth of the Raritan River. The data is shown in Table 25. The peak flow and surge data was transformed to common (base 10) logarithms. Peak flow data from each of the three stream gages was correlated with peak ocean surge data from both tide gages to produce 3 x 2 = 6 correlations, or data sets, of river and ocean peak data. Coincidence, or timing, was not considered in this analysis but looked at separately within the August 1971 ("Doria") flood and the December '92 Nor'Easter, the two historic floods used in the calibration of the South River hydrologic and hydraulic models (HEC-1 and HEC-RAS, respectively).

Table 25
Fluvial Tidal Correlation – Peak Elevations vs Peak Flow

Storm Date	Peak Elev. (NGVD)		Peak Discharges (CFS)			Storm Date	Peak Elev. (NGVD)		Peak Discharges (CFS)		
	A	B	C	D	E		A	B	C	D	E
24 SEP 1882			47840	ND	ND	14 JUL 1975	3.49		27100	1330	1790
06 FEB 1896			54740	ND	ND	21 JUL 1975	3.72		24300	3560	4920
10 OCT 1903			32100	ND	ND	26 SEP 1975	4.27		23900	1940	1940
17 JUL 1927			ND	ND	1720	23 MAR 1977	4.05		26300	1280	1040
06 JUL 1928			ND	ND	1900	08 NOV 1977	6.00	6.91	19000	3160	900
21 SEP 1938	5.90	6.60	31000	ND	2660	26 JAN 1978	5.21		30000	3000	1430
14 SEP 1944	7.70	7.40	ND	4250	2220	25 JAN 1979	5.86		34600	3320	1870
19 JUL 1945			12500	3200	ND	24 MAY 1979	4.57		18800	1230	1430
03 JUN 1946			24800	2320	1280	04 AUG 1979	4.44		E 3200	E 400	E 90
23 JUL 1946			14900	2430	1050	06 SEP 1979	5.91		12300	E 940	1180
21 AUG 1948			ND	3030	ND	20 DEC 1979		5.52	D 860	D 100	D 20
31 DEC 1948			30600	2060	940	25 OCT 1980		7.04	E 3680	E 390	D 30
25 NOV 1950	7.20	9.50	20200	780	690	15 NOV 1981		5.44	D 120	D 30	D 50
02 JUN 1952	3.06		15200	2360	930	18 MAR 1983		5.79	14000	790	950
6-7 NOV 1953	7.90		D 410	E 430	ND	16 APR 1983	4.78		28100	1300	750
31 AUG 1954	6.40		E 4380	E 270	D 30	29 MAR 1984	7.14	7.92	E 8470	2570	E 460
13 AUG 1955	4.16		27300	2650	1450	30 MAY 1984	4.67		24200	3820	1040
19 AUG 1955	4.36		30800	ND	570	07 JUL 1984	3.98		28600	1350	630
14-16 OCT 1955	6.20	7.70	26700	1040	660	12 FEB 1985		7.00	E 9220	1260	E 230
20 MAR 1958	6.20		D 2070	750	E 250	27 SEP 1985	7.05		14100	1260	540
24 JUL 1959	3.26		ND	1750	1610	05 NOV 1985		6.38	D 2240	E 320	D 70
12 SEP 1960	8.60	10.00	19200	2430	1400	17 APR 1986	4.14		20100	2710	990
13 APR 1961	6.90		14400	1500	790	01 JAN 1987	7.10	7.20	D 1120	1670	E 440
23 OCT 1961	5.90		D 220	E 120	D 20	20 JAN 1988		5.87	E 5000	E 640	E 170
6-8 MAR 1962	7.80		19500	1620	850	22 OCT 1988		5.86	3160	ND	240
23 JAN 1966		8.42	D 250	190	D 0.3	05 JUL 1989	4.58		ND	ND	1600
07 MAR 1967	4.26		29300	1910	1510	19 SEP 1989	5.39		23500	ND	4360
24 MAY 1967		6.05	D 690	D 80	D 20	19 OCT 1989		6.62	17900	ND	900
30 MAY 1968	3.76		27800	4180	1750	09 AUG 1991		5.60	E 3420	ND	450
10 JUN 1968		5.86	18000	2230	900	19 AUG 1991	4.60		E 4950	ND	ND
12 NOV 1968		8.45	E 2590	760	E 210	31 OCT 1991	7.03	7.25	D 170	ND	ND
26 DEC 1969		7.04	D 1160	E 570	D 50	06 JAN 1992	5.71		E 1220	ND	ND
03 APR 1970	4.80		29600	1380	780	26 SEP 1992	5.69		D 470	ND	ND
05 FEB 1971		7.95	E 12000	1380	480	10 DEC 1992	8.70	10.10	20000	ND	1270
28 AUG 1971	3.99	4.68	46100	4210	2920	12-13 MAR 1993	7.13		D 1530	ND	ND
13 SEP 1971	3.82	4.22	21400	2490	480	03 MAR 1994		7.24	D 840	ND	ND
19 FEB 1972		7.50	E 3170	1190	E 230	24 DEC 1994	5.11		E 1350	ND	ND
23 JUN1972	4.87		26900	1350	1580	08 JAN 1996	6.03		E 1160	ND	ND
01 FEB 1973	4.04		28000	1940	2710	19-21 JAN 1996	5.14		32700	ND	ND
12 FEB 1973		5.42	D 1580	E 360	D 50	19-20 OCT 1996	6.61		40700	ND	ND
21 DEC 1973	3.76		31000	2680	1720						

COLUMN HEADING LEGEND:

- A SANDY HOOK, NJ
- B PERTH AMBOY, NJ / RARITAN ARSENAL, NJ
- C RARITAN RIVER BELOW CALCO DAM AT BOUND BROOK, NJ
- D SOUTH RIVER AT OLD BRIDGE, NJ
- E LAWRENCE BROOK AT FARRINGTON DAM

FLOW LEGEND:

- D MEAN DAILY FLOW
- E ESTIMATED FLOW
- ND NO DÀTA

114. Within each of the six correlations, or data sets, two best-fit lines were computed :

- River peak flow as the "y" value, the ordinate, the dependent variable, assumed to have all the error, which cannot be observed and must therefore be predicted, with peak ocean elevation as the "x" value, the abscissa, the independent variable, assumed to be completely without error, which can always be observed.
- The inverse of the above : Peak ocean elevation as the "y" value, the ordinate, the dependent variable, assumed to have all the error, which cannot be observed and must therefore be predicted, with river peak flow as the "x" value, the abscissa, the independent variable, assumed to be completely without error, which can always be observed.

115. The two lines cross at the average value of the common (base 10) logarithms of the river peak flows and peak ocean elevations. The average of the two lines was determined by computing the average of their slopes and then plotting a line of this average slope through the intersection of the two best-fit lines. This was done because both the peak ocean elevation and river peak flow data contain some uncertainty. Neither should be assumed to be error-free. Also, for some historic storms, peak ocean elevation is available but not river peak flow. The reverse is true for other historic storms. Therefore, neither quantity can always be observed for the historic storms considered, and neither should be considered as the dependent or independent variable.

116. The results of the correlations are shown in Table 26. One of the correlations is shown on Figure 20. The correlations show a weak inverse relationship between river and ocean flooding for the lower Raritan River basin and the Atlantic Ocean at the mouth of the Raritan River. The correlation is weak because the correlation coefficients are all less than 0.5000. The correlation coefficient is a measure of the extent to which the variation of the value of the dependent variable is explained by the relationship between the independent and dependent variable (the best-fit line). It is also a measure of how well the dependent variable is predicted from the independent variable by the best-fit line. The relationship is inverse because, for the best-fit lines and their average, ocean elevation decreases as river peak flow increases, and vice versa. This inverse relationship is shown by the negative values of the correlation coefficients. High ocean peak elevation with low river peak flow is exemplified by the September 1960 (Hurricane Donna) storm, the March 1962 Nor'Easter, and the December 1992 Nor'Easter. High river peak flow with low ocean peak elevation is

exemplified by the September 1944, August 1971 (Tropical storm Doria) and November 1977 floods.

Table 26
Results of Fluvial – Tidal Correlations

Number Of Data Points	Variable "y" (fluvial)	Correlation Coefficient "r"	Mean Log x	Mean Log y	y as Dependent Variable: Slope m	y as Dependent Variable: y Intercept "b"	x as Dependent Variable: Slope m	x as Dependent Variable: y Intercept "b"
Fluvial – tidal correlations with Sandy Hook, NJ peak stages (ft, NGVD) as tidal. (Variable "x")								
39	South River At Old Bridge, NJ	-0.2350	0.7122	3.2028	-0.6233	3.6467	-0.0886	0.9959
49	Raritan River At Bound Brook, NJ	-0.3901	0.7217	4.0218	-2.2696	5.6596	-0,0688	0.9994
40	Lawrence Brook At Farrington Dam, NJ	-0.2029	0.7026	3.0416	-0.5523	3.4296	-0.0746	0.9294
Fluvial – tidal correlations with Perth Amboy / Raritan Arsenal, NJ peak stages (ft, NGVD) as tidal. (Variable "x")								
24	South River At Old Bridge, NJ	+0.4872	0.86	2.80	3.6739	-0.2419	0.0646	0.6612
29	Raritan River At Bound Brook, NJ	+0.3114	0.84	3.62	2.8825	1.1749	0.0336	0.7229
26	Lawrence Brook At Farrington Dam, NJ	+0.4928	0.84	2.55	3.8208	-0.6771	0.0636	0.6796

117. In a separate analysis, hourly water surface elevations were obtained from the gage at Sandy Hook for the time period from Jan 1933 to Feb 2000. These data were reduced to obtain daily high tide records for that time period. (It should be noted that since these are hourly readings and not peak values, the actual peak values may have been slightly higher.) Daily rainfall data for the same time period was also obtained from the New Brunswick precipitation gage. These data were combined, and after cleaning the data for unpaired data points and other suspect data, approximately 24,000 data pairs were assembled. This data is plotted in Figure 21. Also included on the plot along the

upper right axis is the stage frequency information for Sandy Hook based upon preliminary numerical model results, and the rainfall frequency information.

118. As can be seen from the data, most of the higher tide events occurred with little rainfall, and most high rainfall events occurred with normal tides. There are only a handful of events that had both rainfall and tide levels greater that a two year event.

119. This brief analysis supports the conclusions reached above – that there is, at best, a weak correlation between rainfall and tidal surge. Although the numbers show little correlation, it is understood that the storms that typically produce tidal surges, i.e. hurricanes and northeasters, also can produce significant rainfall. And many of the high rainfall events are accompanied by some degree of tidal surge. For the purpose of this study, it is assumed that the most likely condition to be expected would be that fluvial events will be accompanied by a 2-year tide, and tidal events will be accompanied with a 2 year rainfall. Uncertainty in the interior drainage analysis is represented by varying the exterior water surface, with normal high tide being the minimum exterior water surface, and a 10 year tide representing the maximum exterior water surface.

IV. HYDRAULIC ANALYSIS

Modeling Approach

General

120. The technical approach for the study involved three phases of numerical modeling. The first phase confirmed the assumptions that the South River, below Duhernal Lake Dam is tidally controlled. Steady state HEC-RAS models of the Raritan River, South River, Tennent Brook and Deep Run were developed and run for historic and hypothetical conditions. The essentially flat-water surface profiles confirmed that the study area is, in fact, tidally controlled, and that more intensive, dynamic modeling was warranted.

121. The second phase estimated the storm surge frequencies in Raritan Bay as a boundary for driving the third phase of modeling. The phase 2 storm surge modeling was performed with the ADCIRC (Advanced CIRCulation) model. The ADCIRC model solves the depth-averaged Generalized Wave Continuity Equation (GWCE) formulation of the governing equations and has been extensively applied to projects requiring frequency analysis of storm surges along the south shore of Long Island Sound and adjacent waters. That model grid was modified to include the details of the study area.

122. The third phase of the effort modeled the impact of the storm surge elevations in Raritan Bay as the surge moves up the Raritan River and into the South River study area. The TABS-MD modeling system was used for the phase 3 modeling. The RMA-2 model is part of that system and it was used to simulate the wetting and drying effects on the storm surge as the storm wave moved through the study area. The phase 3 effort essentially was performed as a means of transforming the flood frequency curves from Raritan Bay into the study area.

123. Selected storm events were simulated as a part of the phase 3 modeling for detailed spatial variation in the peak flood elevations throughout the study area. An estimated full frequency curve is then developed from the complete boundary frequency curve and the selected simulations.

124. The return periods selected for analysis were the 2-year, 25-year, 100-year and 500-year storm events. These events were used as a means of estimating the transformation of the full stage-frequency curve from Raritan Bay into the study area and to estimate the effects of alternatives on the stage-frequency curves.

HECRAS Modeling

Introduction

125. A steady state HEC-RAS model of the Raritan River, South River, Tennent Brook and Deep Run was developed and run for historic and hypothetical conditions. The model was developed from channel cross-section data surveyed in 1995. The surveyed channel sections were supplemented with overbank data obtained from 1965 topographic mapping available at the time. The overbank data was later confirmed with 1999 topo of Sayreville and 1982 topo of South River.

Model Description

126. The existing conditions HEC-RAS model of the study area included the Raritan River, South River, Tennent Brook and Deep Run, divided into 7 reaches as shown in Figure 22. It included a total of 149 channel cross-sections and 13 bridges, as described in Tables 27 & 28 below. Based upon a composite of the channel bottom and banks, the channel n values were initially set at 0.035, and overbank areas set at 0.060. Contraction and expansion coefficients for the open channel sections were set at 0.1 and 0.3.

Table 27
HECRAS Model Summary

Reach	Sections	Length	D/S Limit	U/S Limit
Raritan River 1	21	37588	Raritan Bay	Confluence w/ South R.
Raritan River 2	6	15245	Confluence w/ South River	
South River 3	27	20506	Confluence w/ Raritan River	Confluence w/ Tennent Br.
South River 2	6	4670	Confluence w/ Tennent Br.	Confluence w/ Deep Run
South River 1	32	12313	Confluence w/ Deep Run	Duhernal Lake Dam
Tennent Brook	34	6478	Confluence w/ South River	Dam
Deep Run	23	5255	Confluence w/ South River	Waterworks Bridge

Table 28
HECRAS Model Bridge Data

Reach	Bridge	Model Station	Invert Elevation	High Chord	Low Chord	Width	Piers
South R. 3	Veterans Memorial Br.	8542.5	-16.8	10*	28*	313	2
	Raritan River Railroad Br	11251	-15.3	12.6	6.2	174	4
South R. 1	Bordentown Pike Br.	28278	-7.2	15.0	7.4	120	1
	Conrail RR.	28363	-9.8	13.3	7.4	120	3
	Emerson Rd.	32438	-7.5	10.9	9.3	90	2
Tennent Bk.	Bordentown Pike Br.	4462	0.6	12.4	7.5	60	
	Conrail RR.	4582	1.2	14.1	11.8	48	3
	Abandoned Conrail Spur	5158	-0.6	11.9	7.9	28	2
	Waterworks Br.	6207	1.7	7.6	6.7	10	2 – 5' Culv.
	U/S Dam w/ Gates	6475	5.3	12.2	10.7	80	5
Deep Run	Bordentown Pike Br.	1576	-6.9	8.5	4.2	41	
	Conrail RR.	1637	-4.5	10.4	4.5	28	
	Waterworks Br.	5237	1.9	8.7	6.0	30	

*perched bridge, high chord is on left bank away from channel centerline

Model Calibration

127. It was intended to calibrate the HECRAS model to a recent storm event in the basin. Floodmarks were obtained for the Northeaster storm of 11-12 December 1992. This storm has been generally regarded as a 25-year event in this area. Five floodmarks were obtained for this event during the reconnaissance study, as shown in Table 29 below.

Table 29 Floodmarks – December 1992 Northeaster			
Location	**Station**	**Floodmark Elev.**	**HECRAS Elev.**
Victory Bridge, Raritan River	9130	10.4	10.1
103 Weber Ave. Sayreville	5080	10.4	10.3
Laffin Chevrolet, Main St. South R.	8520	10.3	10.3
8 River Rd. East Brunswick	28200	10.4	10.3
D/S - Duhernal Lake Dam	37409	10.9	10.9

128. The relatively constant floodmark elevations indicate that the flooding is tidal in nature along the Raritan and South Rivers downstream of the Duhernal Lake Dam. Elevations are dependent upon the tidal levels in Raritan Bay, and insensitive to discharges in the South River. The minor adjustments to channel roughness, expansion and contraction coefficients, and effective flow areas, typical of model calibration for a more traditional fluvial model, have minimal impact to the flow line computations. Figure 23a is the HEC-RAS water surface profile for the December 1992 event.

Flowline Computations - Existing Conditions

129. The HEC-RAS models of the Raritan River, South River, Tennent Brook and Deep Run were developed and run for a variety of hypothetical conditions. They included peak discharges run with the 2 year tide as the starting water surface elevation, the 2 year discharge run with peak tide stages, and as a worst case scenario, peak discharges run with peak tide stages. As can be seen from the water surface profiles shown in Figures 23b through 23c, water surface levels in the South River are essentially flat, confirming that the South River is tidally dominated. That being the case, it was decided that a 2-dimensional hydrodynamic model would be more appropriate for the hydraulic analysis of improvement alternatives.

Improvement Alternatives

130. As a result of the Reconnaissance Study, 2 alternative plans of improvement were identified. The first alternative was a storm surge barrier and sector gate at the mouth of the South River. The second alternative was the development of levees protecting the communities of Sayreville and South River. Later in this study, a third alternative, linking the two levees together with a sector gate

while eliminating a large length of upstream levees and floodwalls, was identified. This alternative is discussed in more detail later in Section V, Selected Plan.

Improved Conditions Analysis

131. The final selected plan of improvement includes both levees and floodwalls north (downstream) of the Veterans Memorial Bridge along the right bank (east side) protecting the town of Sayreville, and along the left bank (west side) protecting the Town of South River. These levees are connected by a storm surge barrier across the South River 300 ft downstream of the Veterans Memorial Bridge. Within the storm surge barrier, two 40 ft sector gates providing an 80 ft clear opening would permit the South River to discharge freely during normal (non storm) conditions. At the onset (or the forecast) of a storm event, the sector gate is closed, and a 1200 cfs pump station pumps the river discharge through the storm surge barrier. In addition to the sector gate and the pump station, five 10' x 10' gravity outlets with flap gates are included to provide additional gravity capacity. During the storm event, should the falling tide drop below the interior water elevation, the gates will be opened to discharge the as much of the retained South River as possible. The routing of the storm hydrographs through the sector gate was analyzed with a custom developed spreadsheet. The spreadsheet utilized the simple reservoir routing theory: Storage = Inflow – Outflow, and assumed the pool behind the gate is flat. Based upon the water surface profiles developed for existing conditions, this assumption is considered reasonable. Rules for gate opening and closing, and pump operations are programmed into the spreadsheet. Complete details of this operation can be found in the Interior Drainage Appendix.

132. The gate was sized to minimize head loss through the gate, provide acceptable current velocities at the gate to minimize scour potential and to satisfy navigation requirements. 50ft, 80 ft and 100 ft gate openings were evaluated with the TABS-MD hydrodynamic model as described below. The sill of the gate was set at an elevation of –14 NGVD, which is approximately 2 ft below the navigation channel invert of –10 mlw. The existing thalweg of South River at the gate location is –17 NGVD. It was desired to keep velocities through the gate below 4 fps during the entire spring tide cycle to minimize the potential for scour and to allow for safe navigation for vessel traffic at all times during non storm conditions.

133. The paragraphs that follow describe in detail the hydrodynamic modeling efforts conducted to evaluate the improvement alternatives leading to the selection of the recommended plan of improvement. Included in this effort was the development of base conditions, evaluation of the levee/floodwall alternative, evaluation of the gate closed condition, and additional runs to size the gate opening.

Storm Surge Modeling

Introduction

134. The storm surge modeling, and the subsequent TABS-MD modeling, was conducted at the ERDC Coastal and Hydraulics Lab at Waterways Experiment Station in Vicksburg, MS. The primary purpose of the storm surge model was to define the spatial variability of surge in Raritan Bay, at locations far enough removed from the study area as to not be influenced by study alternatives. This phase of the study involves modeling of numerous historic events that have impacted the study area. Additionally, the track and radius to maximum winds of several severe tropical events were slightly altered to generate worst-case scenario surge data to define probable extremes for the frequency analysis. 16 tropical and 15 extra-tropical events were simulated to define the potential range of surge elevations possible for present conditions. This simulated data provided input to the frequency analysis that ultimately defined peak elevation frequency-of-occurrence relationships for selected locations within the domain. These frequency relationships were used to identify specific frequency-indexed storm surge hydrograph input for the high-resolution (TABS-MD) modeling phase of the project.

Storm Surge Model Mesh Development

135. An existing storm surge model mesh, previously developed for analysis of the South Shore of Long Island was modified to include the study area. The previous mesh, which only included the Raritan River with crude resolution, was modified to provide the level of resolution needed to define all elements of the alternative plans.

Storm Surge Model Application

136. The primary purpose of the storm surge model was to develop a database of historical tropical and extratropical event hydrographs that have impacted the domain. First, historic events

were identified, then the track or radius to maximum wind of the two most severe tropical events was modified to generate worst-case scenario storm impacts. Each of the identified events was simulated over the computational domain and the results archived for input to the EST. An extremely low frequency storm was simulated with a completely closed storm surge barrier as proposed in the reconnaissance study to estimate the greatest potential downstream impact from the project. This simulation was used for final boundary condition location in the TABS-MD model.

Uncertainty Analysis

137. The EST is a statistical procedure for simulating time sequencing and frequency-of-occurrence relationships for non-deterministic multi-parameter systems. The approach utilized a random number seed to select an initial storm event from a database of historic and historically based storms. This database was constructed to contain events that either have occurred in the past at a specific location or could have occurred, such as an historic event with a modified track. The procedure then used this seed storm to define a new event characterized by parameters computed via a nearest neighbor, random walk, and subsequent smoothing technique. In this approach, a new storm event was defined which is similar, but not identical, to past events and contains parameter joint probabilities that are inherent in the historical data.

138. Output of the EST is multiple life-cycle scenarios of storm activity and the associated impact. In this application, 100 repetitions of a 200-year sequence of storm activity were generated. The maximum surface elevation magnitudes for each 200 year simulation were rank ordered such that surge versus frequency-of-occurrence relationships were computed. Because 100 relationships are predicted, mean value frequency relationships were made with error band estimates computed for both tropical and extra-tropical events. These relationships were subsequently used to select specific frequency-indexed events from the historical event database for input to the TABS-MD model.

139. Descriptive parameters for both tropical and extra-tropical events were identified and appropriate EST input files created. Input and response parameters were used to simulate 100 repetitions of a 200-year sequence of tropical and extra-tropical events.

140. The life cycle simulations of the EST were post-processed to develop frequency-of-occurrence relationships. These relationships were then used to define a 2-year, 10-year, 25-year, 50-year and 100-year storm for input to the TABS-MD model.

141. The actual development of the probability curve comes from repeating a sampling of a "T-year" period to develop the storm levels for the T-year return. By repeating the sampling some N times a variance can be developed about the expected return surge level.

142. The standard deviation is computed as a recursive statistic that takes all of the observed (or sampled) storms below the current storm surge return interval level to define a standard deviation that will increase with flood level. For a ranked set of sampled storms the standard deviation is defined as

$$\sigma = \sqrt{\left[(1/N)\sum_{n=1}^{n=N}\left(x_n - \bar{x}\right)^2\right]}$$

where the variable N represents the N repetitions of the sampling process of the storm population.

143. This standard deviation, as a measure of uncertainty, was provided as input to the risk and uncertainty analysis, as well as to the determination of the final levee height.

TABS-MD Model Development

Model Mesh Construction

144. The numerical model mesh was constructed from several data sources. The Raritan Bay bathymetry was taken from NOAA charts (12332 and 12327). The bathymetry within the Raritan River, South River and Washington Canal were taken from cross-section data surveyed in 1995. A detailed topographic survey conducted in 1965 was also utilized for much of the flood plain elevations. Much of the numerical model mesh away from the study area was taken from previous numerical model studies within the harbor conducted by CE-ERDC. The data for the bathymetry in the numerical model mesh was adjusted to NAVD88. Model results, output, plots, etc are therefore in NAVD 88. These results were eventually converted back to NGVD29 to be consistent with the topographic survey, interior drainage and economic analysis. The plane of NAVD 88 is approximately 1.1 ft above the plane of NGVD 29

145. For the purpose of simplifying the specification of the complex tidal boundary conditions in the main portion of New York harbor the primary 2D model domain for the project study area was connected to a 1-dimensional model mesh for the rest of New York Harbor as shown in Figure 24.

The 1D resolution included the Hudson River to Albany, Long Island Sound, Arthur Kill, Kill van Kull, Newark Bay, Passaic River, Hackensack River, Harlem River, East River and the Upper Bay as shown in Figure 25.

146. The primary domain of the model (see Figure 26) for this study was primarily the Upper portion of Raritan Bay, Raritan River, South River upstream to Duhernal Dam, Washington Canal, Tennent Brook, and Deep Run. The model mesh also included the flood plains for the Raritan and South Rivers up to the +20 ft contour (Figure 27). These sections were developed using 2D horizontal spatial resolution.

147. The Veterans Memorial Bridge on the South River was included with very high resolution in the TABS-MD mesh because of its location relative to the proposed tide gate (Figure 28). The bridge piers were explicitly resolved in the mesh.

148. The general bathymetry of the 2-D portion of the model mesh is presented in Figure 29. The extent of the flood plains of the Raritan River and the South River are clearly seen to represent the majority of the surface area of the model mesh.

TABS-MD Model Verification

149. The RMA-2 model was calibrated to basic tidal propagation and to general tidal current observations using data published in the NOAA Tide Tables. It was then verified to the December 1992 storm event (USAE District, New York, 1995). The tidal boundary conditions for the simulation are presented in Figure 30. The nominal Sandy Hook forcing is actually in the middle of Raritan Bay and includes some additional surge elevation over the observed tide at Sandy Hook. That additional surge was determined from the storm surge model.

150. The river discharges for the verification period of 10-12 December 1992 are shown in Figure 31. The Raritan River peaked at approximately 22,000 cfs around 6 AM on 12 December, while the South River peaked at about 6 PM on the 12^{th}. The flows on Deep Run peaked at about 760 cfs around 6AM on 12 December, and Tennent Brook peaked at 4 AM at 750 cfs.

151. The profile of peak surge elevations up the Raritan and South Rivers is presented in Figure 32 for the model verification. The flood marks were taken from the study reconnaissance report.

The model profile is approximately a half foot below the flood marks on average. The model predictions do not include any high frequency wave influence that could be present in the recorded flood marks. Any wind-generated wave presence could cause an additional finite wave run-up that could account for slight increases in the flood marks. The difference between the flood marks and the model show a general downward trend, with the exception of the farthest upstream flood mark. Such a downward trend would be consistent with a reduction in wave run-up effect as the distance upriver increases. Turbulence downstream of the dam could account for the higher uppermost flood mark. Such a trend is qualitatively consistent with a reduction in wave heights anticipated with greater sheltering upriver.

152. The model parameters adjusted to achieve calibration included bottom roughness, marsh porosity coefficients, refinements in mesh resolutions as needed and the method of computation and the coefficients for eddy viscosity. For model stability the number of iterations per time step was required to be set very high (12) to insure reasonable convergence. The convergence was most critical at the structures, which tended to exhibit numerical ringing of the Newton-Raphson scheme. The Smagorinsky turbulence calculation for eddy viscosity helped reduce the ringing in some cases.

TABS-MD Model Testing

153. The testing program conducted by the model included a levee plan and two storm surge gate/levee plans, as described in Table 30. Plan A was a levee across the mouth of the South River and Washington Canal, roughly parallel with the Raritan River. That plan also included a tide gate on the Washington canal and a flushing enhancement channel between Old South River and the Washington canal just inside the tide gate. Plan A was dropped from further consideration early in the study due potential environmental impacts to wetlands. The testing program is presented in Table 32.

Table 30
Plan Description

Description	**Modeling Nomenclature**	**Design Nomenclature**
Existing conditions, no improvements	Base	-
Levee at mouth of South River, with storm surge gate and flushing channel	Plan A	Preliminary alternative

Levees (reaches 3 and 4) and storm surge barrier at bridge	Plan 1	Plan 1
Levees in all reaches (reaches 1-5)	Plan 2	Plan 2
Levees in reaches 3 and 4	Plan 3	Plan 3

154. The general Plan 3 levees are aligned more parallel to the South River and included no protection for the wetlands of the northern portion of the system. In addition, the Veterans Memorial Bridge abutments are utilized as part of the levee system as well. The initial testing of the Plan 3 levee system was made without a tide gate so that the surge moved upstream of Sayreville, with flanking levees. A tide gate was later included (previously identified as Plan 1) just downstream of the Sayreville Bridge. The closed tide gate was only tested for the worst-case scenario, the 500-year storm. The tide gate was tested in the model in the open condition for three sizes under more normal tidal conditions. A "highest astronomical tide" (HAT) was used for boundary conditions, which was taken to be the peak spring tidal range in late June.

Boundary Condition Development

155. As discussed, the study was designed to utilize detailed flood frequency curves developed for the New York Harbor in the Raritan Bay area. Selected flood events would then be simulated for detailed spatial variation in the peak flood elevations. An estimated full frequency curve is then developed from the complete boundary frequency curve and the selected simulations.

156. The harbor boundary condition flood frequency curves were developed for both tropical and extra-tropical storms using the ADCIRC model of the eastern seaboard. The study involved the simulation of a number of representative storms (16 tropical and 15 extra-tropical storms). The return frequency curves are presented in Figure 33 for the tropical, extra-tropical and the combined frequencies at the boundary condition for the South River TABS model. Combined return frequencies were computed as

$$T_c = \frac{1}{\frac{1}{T_t} + \frac{1}{T_e}}$$

where T_c = combined return period

T_t = return period for tropical storms

T_e = return period for extratropical storms

157. The finite element TABS modeling consisted of simulating three storms: a nominal 25-year storm, a 100-year storm and a 500-year storm. The 25-year storm was developed with the characteristics of the December 1992 northeaster, since the December event was generally regarded as a 25-year event in this region. The December 1992 storm in the study area was used as the verification storm and the actual observed tidal conditions were used as tidal forcing for both base and plan testing (Figure 30). The tidal boundary conditions for the 100-year (Figure 34) and 500-year (Figure 35) storms were generated by combining a normal predicted tide with a subtidal storm surge signal which when added to the tidal signal matched the associated stage for that return period.

158. The assumption was made that the storm surge stage elevations are not strongly correlated with the rainfall and subsequent river discharges. Therefore, the 25-year observed river discharges that occurred for the December 1992 storm were used for both the 100-year and 500-year tidal surge events. This was believed to be a reasonable approximation, perhaps a bit conservative. The river discharges for South River, Raritan River, Deep Run and Tennent Brook are presented in Figure 32. The discharges for the Hudson, Passaic and Hackensack rivers were specified as a constant mean discharge. These flows are summarized in Table 31.

Table 31
River Boundary Condition Discharges (cfs)

River Boundary	**Average Discharge**	**Peak Discharge**
Hudson River	12,000	-
Passaic River	1,000	-
Hackensack River	500	-
Raritan River	5263	21,917
South River	568	2,545
Deep Run	154	762
Tennent Brook	128	748

Baseline Simulations

159. The model was run for the three flood events for the existing conditions to define a base condition for comparison of the alternative simulations.

Testing Program

160. The testing program performed for the study is shown in Table 32 below. The results for Plan A are not presented within this report, but the results were provided to CENAN. The tide gate was added to Plan 3 late in the testing program and only the 500-year storm was tested for the gate, which had the gate closed for the flood event. It was felt that the 500-year storm was the critical storm for defining the levee heights.

Table 32
TABS-MD Testing Program

Alternative	**Storm Event**			
	HAT	**25-Year**	**100-Year**	**500-Year**
Base	X	X	X	X
Plan A	X	X	X	X
Plan 3	X	X	X	X
Plan 1 (with 50-ft Tide Gate)	X			X (gate closed)
Plan 1 (with 80-ft Tide Gate)	X			
Plan 1 (with 100-ft Tide Gate)	X			

Results

161. The base test results were analyzed and stage-frequency curves developed at 23 locations throughout the system. These locations are shown in Figures 36a-36c. There were 3 locations in the Raritan River (stations R1-R3), 4 locations in Washington Canal (W1-W4) and 12 stations along the South River, S1 and S2 in the Old South River and another 10 on the lower South River. For the tide gate stations 4a and 4B were located just north and south of the structure, respectively. Stations S5-S11 were all upstream of the tide gate. Station TB was located in Tennent Brook upstream of the constriction and station DR was on Deep Run upstream of its constriction at the highway.

162. The results of the frequency analysis for the base runs and the Plan 3 runs are presented in Figures 37a-37w for each of the stations described above. Figure 37a presents only the results for the base test because that station is essentially boundary condition controlled. Figures 37b-37w each have Plan 3 presented as well. Each of the figures includes the +/- one standard deviation for the frequency analysis.

163. The effects of the Plan 3 alternative were very subtle and are almost indiscernible in the full frequency curves. Figures 38a-38d present the flood peak profiles for 50-, 100-, 200- and 500-year storms. Stages for frequencies other than 25-, 100- and 500-year were interpolated from model results. The differences between the base and plan water surface elevations for both the 50-and 100-year flood frequencies are essentially the same. In each case, the levees produce water levels that are about 0.4-0.6 ft higher than base conditions between the levees. For the 200-year storm the levees do not show much increase over the baseline in South River, particularly above Sayreville (Station 4b). For the 500-year flood the peak levels for the levees drops relative to the base over most of the system, but most dramatically above Sayreville. This is largely because the only way for water to reach the upstream portion of the system is to flow past the constriction at the Veterans Memorial Bridge. For the base the bridge is flanked at the 500-year flood stages and water can bypass the bridge.

164. The schematization of the 80 ft gate in an open position is presented in Figure 39. The resolutions were comparable for the 50- and 100-ft gates as well. The results of the 500-year storm with the tide gate closed are presented in Figure 40 for all stations downstream of the tide gate. The portion of the model upstream of the tide gate was not included in the 500-year simulation. Also plotted in the figure is the profile for the Plan 3 levees without the tide gate. The results show that the tide gate will result in a general increase in peak flood levels of approximately 0.2 ft in the lower (northern) portion of the system, including the Raritan River. That increase is due primarily to the levees' blocking effect on the surge resulting in increased local amplification of the surge height, extending into the Raritan River as a backwater effect.

165. The tide gate simulations were then performed to assist in sizing the tide gate. The primary concern was the strength of the currents through the tide gate under relatively normal tidal flows.

The tidal conditions tested were the mid-June spring tide, which is the highest astronomical tide (HAT) for any given year.

166. The maximum currents observed in the model within the primary channel at the location of the Sayreville control structure are presented in Table 33 below. The peak currents have been slightly higher at the corners of the structure, but the values presented in the table are for within the throat of the structure. For the base ebb, the peak current was actually some distance north of the bridge span.

Table 33
Peak Tidal Currents in Storm Surge Gate

	Maximum Flood		Maximum Ebb	
Alternative	**Time after Base High Water (hr)**	**Current Magnitude (fps)**	**Time after Base High Water (hr)**	**Current Magnitude (fps)**
Base	10.5	1.5	3.5	1.2
50 ft Gate	10.5	5.9	*	*
80 ft Gate	10.5	4.0	2.0	2.5
100 ft Gate	10.5	3.2	2.0	2.0

* No ebb current was obtained for the 50-ft gate due to model instability

167. The peak currents at each of the stations described earlier are presented in Table 34. The results are also plotted in Figure 41. The primary differences are in the vicinity of the tide gate. The largest changes are just downstream of the tide gate on peak ebb and just upstream of the tide gate on peak flood currents. This is the result of the jetting effect of the currents as they leave the gate on each phase of the tide. Note here that station S4 is in the middle of the tide gate and station TG-D is just north of the gate and TG-U is south (upstream) of the gate (within 100 ft of the proposed structure).

168. The high and low water profiles for the HAT simulations are presented in Figure 42a-42b for the 100-ft and 80-ft gate, respectively. The gate alternatives are compared to the baseline simulation water levels. The resulting tide range profiles are presented in Figure 43. There is essentially no change in the water levels and tide ranges. These results are also summarized in Tables 35 and 36.

169. The peak stages for the three model runs at the stations analyzed are presented in Table 37 for the 25-year, 100-year and 500-year storms, respectively. Each table includes the difference between the alternative peak stage and the base test peak stage. For the 25-year storm, the largest difference was an increase at station R2 of 0.03 ft, while over most of South River the differences are all less than 0.02 ft in magnitude. For the 100-year storm, the stages were slightly raised between 0.04 and 0.07 feet with the levee over the base condition. For the 500-year storm, the increase in stages in the northern part of the system is low (generally less than 0.03 ft) while south of the Veterans Memorial Bridge the peak stages were increased by about 0.1 ft (0.07- 0.10 ft).

Table 34
Effects of Tide Gate on Peak Tidal Current Velocities

Station	Peak Flood Current				Peak Ebb Current		
	Base	100-ft Gate	80-ft Gate	50-ft Gate	Base	100-ft Gate	80-ft Gate
R1	1.82	1.61	1.61	1.62	2.05	2.02	2.02
R2	2.27	2.10	2.10	2.08	1.66	1.68	1.68
R3	0.78	0.71	0.71	0.68	0.83	0.83	0.83
W1	3.20	2.94	2.93	2.91	1.94	1.94	1.95
W2	2.60	2.86	2.84	2.79	2.16	2.37	2.38
W3	2.49	2.32	2.30	2.26	1.91	1.85	1.85
W4	1.76	1.66	1.64	1.59	1.07	1.04	1.04
S1	0.89	0.82	0.82	0.79	0.62	0.59	0.59
S2	0.38	0.37	0.37	0.35	0.35	0.29	0.29
S3	1.30	1.20	1.18	1.15	0.64	0.65	0.67
TG-D	1.07	1.20	1.11	1.01	0.79	1.81	2.12
S4	1.44	3.13	3.81	5.29	1.09	2.04	2.55
TG-U	1.46	2.60	3.16	3.56	0.90	1.00	1.01
S5	1.35	1.32	1.31	1.25	0.78	0.78	0.78
S6	0.93	0.91	0.91	0.86	0.70	0.69	0.68
S7	0.49	0.48	0.47	0.45	0.32	0.32	0.32
S8	1.06	1.02	1.00	0.95	0.68	0.69	0.69
S9	0.60	0.61	0.60	0.57	0.37	0.37	0.37
S10	0.21	0.21	0.20	0.19	0.35	0.35	0.36
S11	0.25	0.25	0.25	0.24	0.09	0.09	0.09
TB	0.18	0.17	0.17	0.15	0.14	0.14	0.14
DR	0.59	0.58	0.58	0.55	0.45	0.45	0.45

Table 35 Comparison of 80 ft Gate with Base												
Sta.	High Water (ft NAVD88)			Low Water (ft NAVD88)			Mean WSE (ft NAVD88)			Tide Range		
ID	Base	Gate	Diff	Base	Gate	Diff	Base	Gate	Diff	Base	Gate	Diff
R1	3.79	3.92	0.13	-3.37	-3.36	0.01	.024	0.24	0.00	7.15	7.28	0.13
R2	3.92	3.94	0.02	-3.07	-3.07	0.00	0.39	0.39	0.00	7.00	7.01	0.01
R3	4.07	4.05	-0.02	-2.96	-2.96	0.00	0.51	0.50	-0.01	7.03	7.01	-0.02
W1	3.97	3.95	-0.02	-2.97	-2.98	-0.01	0.43	0.42	-0.01	6.94	6.93	-0.01
W2	3.98	4.01	0.03	-2.90	-2.91	-0.01	0.46	0.44	-0.02	6.88	6.92	0.04
W3	4.00	4.00	0.00	-2.84	-2.84	0.00	0.47	0.47	0.00	6.85	6.84	-0.01
W4	4.02	4.05	0.03	-2.83	-2.83	0.00	0.50	0.49	-0.01	6.85	6.88	0.03
S1	4.04	4.05	0.01	-2.82	-2.83	-0.01	0.50	0.49	-0.01	6.86	6.88	0.02
S2	4.03	4.01	-0.02	-2.80	-2.81	-0.01	0.49	0.49	0.00	6.84	6.82	-0.02
S3	4.03	4.01	-0.02	-2.83	-2.82	0.01	0.50	0.50	0.00	6.86	6.83	-0.03
TG-D	4.04	4.02	-0.02	-2.83	-2.83	0.00	0.51	0.49	-0.02	6.88	6.85	-0.03
S4	4.04	4.09	0.05	-2.83	-2.83	0.00	0.50	0.45	-0.05	6.88	6.92	0.04
TG-U	4.04	4.04	-0.03	-2.83	-2.82	0.01	0.50	0.49	-0.01	6.88	6.83	-0.05
S5	4.07	4.10	0.03	-2.83	-2.81	0.02	0.50	0.50	0.00	6.90	6.91	0.01
S6	4.10	4.11	0.01	-2.80	-2.78	0.02	0.50	0.51	0.01	6.91	6.89	-0.02
S7	4.12	4.11	-0.01	-2.80	-2.78	0.02	0.51	0.52	0.01	6.92	6.89	-0.03
S9	4.13	4.12	-0.01	-1.78	-1.77	0.01	0.74	0.75	0.01	5.91	6.89	-0.02
S9	4.14	4.11	-0.03	-1.78	-1.77	0.01	0.74	0.75	0.01	5.92	5.88	-0.04
S10	4.16	4.14	-0.02	-1.77	-1.76	0.01	0.75	0.76	0.01	5.93	5.90	-0.03
S11	4.18	4.14	-0.04	-1.74	-1.72	0.02	0.77	0.79	0.02	5.91	5.86	-0.05
TB	4.11	4.09	-0.02	-2.41	-2.39	0.02	0.60	0.61	0.01	6.52	6.48	-0.04
DR	4.12	4.09	-0.03	-2.41	-239	0.02	0.60	0.61	0.01	6.53	6.48	-0.05

Table 36 Comparison of 100 ft Gate with Base												
Sta.	High Water (ft NAVD88)			Low Water (ft NAVD88)			Mean WSE (ft NAVD88)			Tide Range		
ID	Base	Gate	Diff	Base	Gate	Diff	Base	Gate	Diff	Base	Gate	Diff
R1	3.79	3.78	-.01	-3.37	-3.36	0.01	.024	0.24	0.00	7.15	7.15	0.00
R2	3.92	3.92	0.00	-3.07	-3.07	0.00	0.39	0.39	0.00	7.00	6.99	-0.01
R3	4.07	4.06	-0.01	-2.96	-2.96	0.00	0.51	0.50	-0.01	7.03	7.02	-0.01
W1	3.97	3.95	-0.02	-2.97	-2.98	-0.01	0.43	0.42	-0.01	6.94	6.93	-0.01
W2	3.98	3.97	-0.01	-2.90	-2.92	-0.02	0.46	0.44	-0.02	6.88	6.88	0.02
W3	4.00	3.99	-0.01	-2.84	-2.84	0.00	0.47	0.47	0.00	6.85	6.83	-0.01
W4	4.02	4.01	-0.01	-2.83	-2.83	0.00	0.50	0.49	-0.01	6.85	6.84	0.01
S1	4.04	4.03	-0.01	-2.82	-2.84	-0.02	0.50	0.49	-0.01	6.86	6.86	0.00
S2	4.03	4.02	-0.01	-2.80	-2.82	-0.02	0.49	0.48	-0.01	6.84	6.82	-0.02
S3	4.03	4.02	-0.01	-2.83	-2.83	0.00	0.50	0.49	-0.01	6.86	6.85	-0.01
TG-D	4.04	4.03	-0.01	-2.83	-2.84	-0.01	0.51	0.49	-0.02	6.88	6.87	-0.01
S4	4.04	4.02	-0.02	-2.83	-2.84	-0.01	0.50	0.46	-0.04	6.88	6.86	0.02
TG-U	4.04	4.03	-0.01	-2.83	-2.83	0.00	0.50	0.49	-0.01	6.88	6.86	-0.02
S5	4.07	4.06	-0.01	-2.83	-2.83	0.00	0.50	0.50	0.00	6.90	6.89	-0.01
S6	4.10	4.10	0.00	-2.80	-2.80	0.00	0.50	0.50	0.00	6.91	6.90	-0.01
S7	4.12	4.12	0.00	-2.80	-2.79	0.00	0.51	0.51	0.00	6.92	6.91	-0.01
S9	4.13	4.13	0.00	-1.78	-1.78	0.00	0.74	0.74	0.00	5.91	6.90	-0.01
S9	4.14	4.13	-0.01	-1.78	-1.78	0.00	0.74	0.74	0.00	5.92	5.90	-0.02
S10	4.16	4.14	-0.02	-1.77	-1.77	0.00	0.75	0.75	0.00	5.93	5.91	-0.02
S11	4.18	4.16	-0.02	-1.74	-1.73	0.01	0.77	0.78	0.01	5.91	5.89	-0.02
TB	4.11	4.11	0.00	-2.41	-2.40	0.01	0.60	0.60	0.00	6.52	6.51	-0.01
DR	4.12	4.10	-0.02	-2.41	-240	0.01	0.60	0.60	0.00	6.53	6.50	-0.03

Table 37
Peak Storm Stages

Sta.	25-Year (ft NAVD88)			100-Year (ft NAVD88)			500-year (ft NAVD88)			500-year (ft NAVD88)		
ID	Base	Levee	Diff	Base	Levee	Diff	Base	Levee	Diff	Base	Gate	Diff
R1	10.4	10.4	0.00	13.15	13.15	0.00	16.34	16.35	0.01	16.34	16.36	0.02
R2	10.75	10.78	0.03	13.53	13.59	0.06	16.75	16.79	0.04	16.75	16.92	0.17
R3	10.99	11.01	0.02	13.67	13.72	0.05	16.86	16.88	0.02	16.86	17.01	0.15
W1	10.81	10.83	0.02	13.58	13.62	0.04	16.80	16.82	0.02	16.80	16.95	0.15
W2	10.79	10.81	0.02	13.58	13.62	0.04	16.81	16.82	0.01	16.81	16.96	0.15
W3	10.81	10.84	0.03	13.60	13.65	0.05	16.86	16.84	-0.02	16.86	16.99	0.13
W4	10.81	10.84	0.03	13.60	13.65	0.05	16.86	16.84	-0.02	16.86	16.97	0.11
S1	10.81	10.83	0.02	13.60	13.64	0.04	16.84	16.84	0.00	16.84	16.97	0.13
S2	10.82	10.84	0.02	13.61	13.65	0.04	16.87	16.85	-0.02	16.87	16.97	0.10
S3	10.83	10.85	0.02	13.62	13.66	0.04	16.88	16.85	-0.03	16.88	16.97	0.09
S4A	10.83	10.85	0.02	13.62	13.65	0.03	16.87	16.81	-0.06	16.87	16.98	0.11
S4B	10.81	10.83	0.02	13.60	13.62	0.02	16.88	16.75	-0.13			
S5	10.86	10.88	0.02	13.67	13.72	0.05	16.95	16.88	-0.07			
S6	10.97	11.00	0.03	13.82	13.87	0.05	17.11	17.03	-0.08			
S7	11.06	11.08	0.02	13.89	13.92	0.03	17.17	17.08	-0.09			
S9	11.13	11.15	0.02	13.94	13.97	0.03	17.22	17.12	-0.10			
S9	11.14	11.16	0.02	13.94	13.98	0.04	17.22	17.12	-0.10			
S10	11.16	11.19	0.03	13.95	14.00	0.05	17.23	17.13	-0.10			
S11	11.2	11.23	0.03	13.98	14.03	0.05	17.24	17.14	-0.10			
TB1	10.99	11.02	0.03	13.84	13.89	0.05	17.14	17.06	-0.08			
DR1	11.06	11.08	0.02	13.89	13.92	0.03	17.17	17.08	-0.09			

V. SELECTED PLAN

Plan Optimization

170. Once the Plan (Plan 1) was selected, an optimization of the height of protection was performed. In order to effectively compare the potential benefits associated with each level of damage, an associated height of protection needed to be determined. Table 38 indicates the four levels of protection that were analyzed for optimization. The levels of protection were established based upon computed water levels as well as consideration to long term sea level rise and uncertainty.

Table 38
Levels of Protection

Return Period	Levee Height (ft-NGVD)
50	16.0
100	18.5
200	20.5
500	21.5

171. The design was modified accordingly for the four heights of protection and a cost estimate was prepared for each (see Figures 44a – d). As with the alternative screening phase described in section III, the cost estimate was prepared for each level using industry standard cost estimating methods and sources. (Note: All interior drainage, environmental and real estate quantities and costs were used here for comparison purposes only and may not correlate with information seen elsewhere in this report. See the respective appendices for actual values related to this study.) These annualized costs were then compared with the projected benefits for each of the storm events (refer to the main report for more information on this analysis). This analysis determined that the levee height of 21.5 had the highest net excess benefits and was therefore the optimum level of protection (see Figure 44). Although this plan represents the largest plan evaluated, the local sponsor has indicated that there is no local interest in any plan with a level of protection greater than a 500-year. Further refinements were made to the alignment and some of the structural components in order to improve the overall design as well as accommodate interior drainage and environmental concerns

raised while coordinating with those disciplines. The following sections describe the resulting plan. See the environmental, interior drainage, real estate and cost appendices for additional information regarding the selected plan.

Design Detail and Alignment Description

Levee Design Considerations

172. Due to differing soil conditions along the alignment, various methods of levee construction were reviewed to determine the most suitable cross-sections to be used. Two sections were chosen based on two general recurring soil conditions (see Figure 45). Both sections include a 10' crest width, 1 on 2.3 side slopes, crest elevation of +21.5 NGVD and 5 inches of topsoil and seeding.

173. The first condition is a sandy soil foundation, which provides adequate structural stability to support the levee, but has an excessively high permeability rate at several locations based on initial subsurface testing. Therefore, the levee which will be placed in these areas will include an impervious core with an approximate 6 foot deep inspection trench. Wherever necessary, a cutoff wall of continuous vinyl sheet piling will be driven beneath the levee to depths greater than the 6 feet reached by the impervious core to insure additional cutoff from under-seepage. This sheet pile cutoff wall will an additional 8 to 10 feet below the existing surface. These estimated lengths will be refined based on additional borings to be taken during the subsequent detailed design phase. This levee section applies to Stations 0+00 to 5+27, 9+53 to 63+15 and 66+40 to 68+32 of the Sayreville Alignment and to Stations 0+00 to 7+00 of the South River Alignment.

174. The second soil condition is one in which the soils include large quantities of organic material. These soils provide poor stability and are subject to long-term settlement, but have very low rates of permeability. In the areas where these soils occur, they lie in a layer that has a maximum thickness of 12 feet and are located approximately 5 feet below the surface. The levee cross-section proposed for this soil condition includes a continuous vinyl sheet pile core which will extend from the top of the levee to approximately 5 feet below the bottom of the organic soil layer. The sheet piling will provide seepage cutoff for the levee above grade as well as maintain the required height of protection in the event that long-term settlement of the levee occurs. A soil stabilizing fabric placed under the levee footprint will also be applied at the surface prior to construction of the levee to attempt to minimize the potential settlement of the levee fill (see Figure

45). This levee section applies to stations 7+00 to 10+31, 19+23 to 43+94 and 47+31 to 58+60 of the South River Alignment.

Floodwall Design Considerations

175. Due to severe space restrictions between developed properties and the bank of the river in some areas, it is necessary to use a floodwall in place of levee. This floodwall had to meet several design constraints including: providing construction in a limited area for foundation; ease of construction due to access limitations; heights up to 15.5 feet above grade (to top elevation of +21.5 NGVD) with full hydrostatic pressure applied; cost effectiveness; watertight closure; meet aesthetic expectations; as well as have low maintenance requirements (see Figure 46).

176. Several standard floodwall types were considered including concrete T-walls, and I-walls as well as a combined concrete with steel sheet wall, but each of these failed to meet all of the requirements. Therefore, a unique, high strength floodwall design had to be developed.

177. The proposed floodwall will be of watertight jointed vinyl sheet piling that is partially supported by a strut beam anchored to a bearing footing to withstand the hydrostatic forces acting on the wall. Two lines of continuous wale will be fixed to the back side of the wall at elevations +16.0 and +6.0 NGVD. Angled struts will be placed behind the wall at an approximate 6 foot spacing. At each strut location, a 10.5 foot long W12x22 I-beam will span vertically between the upper and lower wales. The strut will be connected at the midpoint of this beam. The opposite end of each strut will be embedded in a continuous reinforced concrete footing which will be below grade. The struts will be concrete filled steel pipes for added strength. This design can be placed in both soil conditions described above. The bottom of the concrete footing is at or near good foundation material from the limited number of borings taken to date. Therefore, additionally, soil and/or foundation stabilization measures like a pile support for the concrete footing, may be included during the project design phase if it is determined from sufficient soil testing that it is required. This floodwall section applies to stations 10+31 to19+23 and 43+94 to 47+31 of the South River Alignment and stations 5+27 to 9+53 of the Sayreville Alignment. See Sub-Appendix A for design calculations.

178. The proposed floodwall is in concurrence with all of the requirements as stated above. The wall will sufficiently withstand the expected loads. The wall system will be relatively easy to

construct requiring fewer resources than other wall types such as concrete. The vinyl wall is aesthetically pleasing due to color and texture choices available and it is the most cost effective option and virtually maintenance free.

Storm surge Barrier Design Considerations

179. In order to complete the line of protection, a storm surge storm is to be placed across the South River just north of the Veteran's Memorial Bridge (see Figures 47 – 49). This barrier ties into the levee and floodwall system on both sides of the river to form a continuous line of protection from storm insurgence into the flood prone low lying areas of South River, Sayreville and Historic Old Bridge Township. This barrier will include a large sector type gate providing a tentatively sized 80 feet clear opening, which will remain open during normal conditions to maintain the natural condition of the waterway upstream as well as to allow boat traffic to pass freely. During a storm event that has the potential to cause flooding, the gates will be closed so that storm surges can not translate further upstream or flank the levees and floodwalls. In order to alleviate any build up of interior drainage behind the gates during closed times, a sufficiently sized pump station including diesel powered pumps will be included in the barrier as well. The design backup for pump sizing is included in the Interior Drainage Appendix. Enclosing the pump station within the barrier was developed vs. locating the pump station with a large concrete sump chamber on the bank in order to significantly reduce project costs. The proposed pumping units are direct drive, diesel powered units, and therefore, no electrical backup required. This decision was made because the magnitude of electrical backup power required is not readily available in the area of the barrier. A meeting with representatives from the local power companies concluded that the cost to provide a redundant power supply would be prohibitive. A check dam protruding above the river bottom fronting the intakes is included to preclude shoaling interference. To the east of the gate, included along and within the barrier, are control structures with backflow prevention gates that will also alleviate build-up of interior drainage during lower storm tide levels o the unprotected side of the barrier. The storm surge barrier, for cost effectiveness, consists of a double line of high strength vinyl sheeting lined with reinforced concrete to a crest elevation of +21.5 NGVD and structurally connected with steel beams for structural stability (see Figure 48).

180. Although there are several types of closure gates that are used by the Corps of Engineers in applications such as this, the sector gate is best suited for this particular location. Referencing EM

1110-2-2703, the miter gate, the vertical-lift gate and the tainter gate were all considered. The disadvantage of the miter gate is its inability to close against hydraulic head differentials such as incoming storm surges. In addition, the miter gate does not generate the thrust required to overcome an accumulation of silt in the gate's path which can prevent the gate from closing. As with the miter gate, the vertical-lift and tainter gates would have difficulty closing against a silted bottom which could compromise the gates effectiveness in cutting off the storm surges to the protected side of the gate. The vertical lift gate will have trouble achieving a positive seal against storm surges with a significant reversed head against the backside of the gate and with shoaling interference. The tainter gate's foundation is not supported in rock; it is pile supported. Due to its pile foundation and skewed high center of gravity, long and short term alignment problems can develop from slight differential settlements causing the gate to lose its effectiveness. These disadvantages interfere with the gate's operability and increase the risk of closure failure. The sector gate was selected because none of these disadvantages are inherent in its operation. The risk of inoperability is extremely low based on an extensive track record. The sector gate is electrically operated with a diesel generator as backup.

Eastern Segment

181. The eastern portion of the line of protection is located mostly within the Borough of Sayreville (see Figures 50-54). The top of protection is set at +21.5 NGVD. The grade elevations along the entire line of protection excluding the segment that crosses the South River, range between +4.0 and +20.0 NGVD. Therefore, the height of protection above grade ranges between 1.5 feet and 17.5 feet. All levee sections have a 10 –foot top width, with 1:2.3 side-slopes.

182. The line of protection with a total 426 feet of floodwall and 6081 feet of levee begins at the northeastern end as a levee starting at a point approximately 250 feet west of the intersection of Anderson Court and Canal Street behind some newly constructed residential properties. There will be maintenance vehicle access to the top of the levee at this point. The levee then extends in a northwesterly direction between the rear property lines of the residential development and the municipal sewage facility for approximately 500 feet where it meets the eastern bank of the Washington Canal. The top of the levee will be widened in this area to accommodate a vehicle turnaround. The levee then becomes a floodwall due to space restrictions, which runs southwest along the bank of the canal at the frontage of the sewage facility for approximately 300 feet where it turns south for an additional 100 feet before switching back to levee for the remainder of its length.

The remainder of the 10 foot wide crest and 1 on 2.5 side sloped levee is located in an undeveloped area between the Washington Canal and the South River to the west and residential development to the east. The remainder of the levee runs in a southeasterly direction for approximately 450 feet then turns to a southwesterly course for 350 feet passing the eastern termination of Hinton Street. Another access ramp will be located at the end of Hinton Street. The levee makes another slight turn to the west and continues in a southwesterly direction for nearly 750 feet before turning south for another 600 feet. There will be another turnaround located in this segment. The levee turns to a southwesterly direction again and runs parallel to Weber Avenue at a 300 foot offset for nearly 800 feet, then turns south and runs again parallel to Weber Avenue this time at a 450 foot offset for approximately 2150 feet. There will be a turnaround located approximately at 1/3 of the length of this segment. The levee then turns southwest and continues for approximately 350 feet until it meets the eastern bank of the South River where it terminates against a bulkhead. An access ramp is to be located at this last change in direction in the levee. The last 200 feet of levee for closure to elevation +21.5 is located on the western side of the South River in the Borough of South River. Once across the river, there is a bulkhead similar to that on the eastern side. The levee begins again and immediately turns to the south where it continues until it meets high ground alongside Veteran's Highway within 50 feet of the western abutment.

River Segment

183. The line of protection continues across the river for approximately 320 feet in the form of a storm surge barrier and an 80 feet wide clear opening tide gate which lies collinear with the levee. A pump station is to be located within the barrier between the South River west bank and the tide gate. Between the eastern side of the tide gate and the east bank of the South River, there will be control structures with backflow prevention of a sufficient size to partially alleviate build-up of interior drainage in the event that all pumps fail and the gate does not open. Like the rest of the line of protection, the barrier and tide gate provide protection to an elevation of +21.5 NGVD (see Figures 47-49).

Western Segment

184. The western portion of the line of protection is located entirely within the Borough of South River (see Figures 55-59). As with the eastern segment, the top of protection is set at +21.5 NGVD.

The grades on the western side of the river are similar to those on the eastern side. Therefore, the height of protection also ranges from 1.5 feet to 17.5 feet NGVD. All levee sections have a 10 -foot top width, with 1:2.3 side-slopes.

185. The line of protection, with a total of 4631 feet of levee and 1229 feet of floodwall, begins at the north western corner as a levee starting at a point located at the southeast corner of an unpaved trailer lot off of Tices Corner Road. There will be vehicle access to the top of the levee from this lot. The levee runs southeast for approximately 600 feet thorough a wooded area until it is within 150 feet of the river bank where it turns to a southwesterly direction. The 10 foot wide crest width with 1 on 2.5 side slope levee then continues along the river bank for an additional 400 feet where it becomes a floodwall due to space restrictions. There will be a turnaround provided at the end of the levee in this location.

186. The floodwall is located at the riverbank. It parallels the river for approximately 900 feet as it bends to the southeast. The cross-section then reverts back to levee where space becomes available and continues to parallel the river for an additional 450 feet. There will be vehicle access provided in this segment. At this location, the levee turns slightly south. It runs in a southeasterly direction, no longer parallel to the river for approximately 450 feet where it turns slightly further south and continues on for another 1250 feet. The levee then turns further south and continues in a southerly direction for approximately 350 feet where it ends and a floodwall begins to minimize impacts to the adjacent wetlands. Vehicle access to the levee will be provided at this end of the levee as well. As before, the floodwall runs directly adjacent to and parallel with the river for 400 feet until it meets Veteran's Highway approximately 100 feet northeast of its intersection with Water Street. The final segment of the line of protection is a levee, which extends from the end of the last floodwall segment directly adjacent to and parallel with Veteran's Highway on the north side for approximately 1150 feet where it terminates at high ground at elevation +21.5 NGVD. There will be a turnaround at the beginning of this segment and vehicle access at the end.

Hurricane and Storm Damage Reduction System Operation

187. The operation and maintenance of all of the features of the plan will be the responsibility of the local sponsors. The hurricane and storm damage reduction system will be activated by dedicated personnel, from either the local municipality, county or state, as dictated by the Project Cooperation

Agreement. One assigned individual will act as chief of operations for the system. This individual will be responsible for checking weather forecasts and warnings by accessing the National Weather Service website for the New York area at http://www.nws.noaa.gov/er/okx/. In the event that a severe storm is forecast, the assigned individual will contact all of the personnel responsible for implementing the plan and instruct them to convene at a predetermined meeting location where they will await warning signals that signify further action to be taken. There will be two signals. A "yellow" alert and a "red" alert will be received from the location of the storm surge barrier. The "yellow" alert signifies that although the critical water surface elevations have not yet been reached they are impending. It could be based on a forecast of an impending storm, in which case the gates could be closed early at low tide to preserve storage behind the gate. Or it may be that the tide levels have exceeded a set elevation, and are still expected to rise further. At that point, all personnel should be in place and prepared to implement the project operation. The "red" alert signifies that the critical water surface elevations have been reached and that project operation is required in order to prevent damages. All personnel will commence their respective components of the project operation. In the event that the personnel involved are not alerted in advance of a "yellow" alert or if any alert is not acknowledged in a specified amount of time, automatic telephone dialers will be incorporated with the alarm systems to insure that all of the appropriate personnel are notified. Minor street flooding occurs at elevation 5.0 NGVD, which is less than 2 ft above MHW, it can be expected that project operation will occur several times per year. Initial operation of the gate will be manual, with subsequent operations programmed. The following paragraphs describe a general schedule of personnel and procedures required for the most efficient implementation of the hurricane and storm damage reduction system based on the operational requirements of the system components. This plan will be detailed during the subsequent design phase of this project.

Interior Drainage Closure Gates.

188. All of the interior drainage outlets incorporated in the Plan have sluice type closure gates (see the interior drainage appendix for more detailed information). At many of these outlets, these sluice gates will act only as back-up in the event that the A.D. (flap valve) type gates which are placed at the downstream ends of these outlets fail. A system for determining the operational status of the flap valves will be incorporated in the final Operations and Maintenance Manual which will be developed during the design phase. While all of the outlets include sluice gates, they do not all

include flap valves. Certain areas exist where tidally influenced wetlands will be isolated by the construction of the levee and floodwall. The outlet structures feeding these areas will require dedicated operation during storm events. The expected time required for each gate to be closed is approximately 5 minutes. This time includes visually inspecting the drainage channel to insure that it is free from obstruction and then activating the closure gate. The drainage gate crews will deploy at the time of a "yellow" alert. Once at their respective gate locations, they will await further notification via two-way radio from the chief of operations that a "red" alert has been received at which time they will proceed to close the gates.

Sector Gate.

189. The sector gate can be operated by a single individual. At a "yellow" alert, the individual will deploy to the gate structure. The operator will visually inspect the channel to insure that it is free from obstruction and at a "red" alert, the operator will activate the gate closing mechanism. The sector gate is operated by an electric motor which requires no warm up. The operator will be at the gate structure and ready to close the gate prior to a "red" alert. Once a "red" alert sounds, the gate can be in the fully closed position in less than ten minutes. As previously stated, initial operation of the gate will be manual, with subsequent operations programmed.

Pump Station.

190. The pump station will be switched on once the sector gate has been completely closed. Due to the fact that the pump station sump interfaces with the stream, very little time is required to prime the pumps once the pump intake gates are opened. Therefore, there is no lead time required. One individual will deploy to the pump station at a "yellow" alert, make an inspection of the pump intakes and await further instruction from the chief of operations. The chief of operations will notify the pump crew via two-way radio when to engage and disengage the pumps. The pumps can be in operation immediately upon notification.

Hurricane and Storm Damage Reduction System Maintenance

191. Maintenance and operation of the project will be conducted as follows:

- Levees and floodwalls require maintenance to assure continued required performance levels such as vegetation maintenance, control of earthen settlements and sloughs, piping, animal borrows, repair of damaged wall joints and wall caps and maintenance of drainage ditching adjacent to levees and walls by removing debris.

- Maintenance of all drainage structure chambers and flap and sluice gates, including cleanout, concrete repair, pipe repair, gate performance with required repair maintenance and operation and replacement (every 25 years).

- Pump stations require trash removal, cleanout, testing of pumping systems 4 times/year, repair and replacement (every 20 years) of pumps and controls, gate repair and replacement (every 25 years).

- Closure gate (interior drainage) - operation and maintenance includes pertinent lubrication, testing, periodic painting and replacement of gates and seals and concrete repair.

- Sector gate requires testing 4 times per year plus use during storm occurrences, repair of electrical/mechanical systems including gate members and gate and equipment replacement (approximately 25 years).

192. A detailed Operation and Maintenance manual, along with gate regulation requirements, will be developed during subsequent design/construction phases.

Impacts to Navigation

193. As previously discussed, the authorized federal navigation project in South River is a 12-foot deep, 100-foot wide channel in the Washington Canal for a distance of 0.8 miles upstream of the Raritan River and then a 12-foot deep, 150-foot wide channel in the South River to Old Bridge. The total length of this channel navigation project is 5.2 miles. In 1929, when the last improvements to the project were authorized, the channel was used to transport brick, hollow tile, sand, clay, crushed stone, and coal to/from New York Harbor. There is currently no commercial traffic; small recreation vessels are the sole users of the Washington Canal and South River. The Rivers End Marina in Old Bridge, and the South River Boat Club, both mainly small pleasure craft, are the primary users of the channel. The last Corps involvement was for maintenance dredging in the early 1940s.

194. The channel was designed to handle the commercial traffic from the brick industry, and therefore is now oversized for the small pleasure craft now using the channel. Of concern is whether

the 80 ft gate opening is adequate for the current vessel traffic. There is a Conrail RR swing bridge a short distance upstream of the sector gate. This swing bridge has a clear opening of approx. 40 ft, which is half the opening of the sector gates. Obviously, if the vessels can safely transit the 40 ft RR bridge, the proposed 80 ft sector gate will be more that adequate.

195. The gate was sized to limit velocities through the gate, during the highest astronomical tide, to 4 fps to allow vessels to transit through the gate at all phases of the tide. Under normal, mean tide, conditions, it can be expected that currents would be weaker.

196. The United States Coast Guard was contacted to evaluate the impacts of the proposed gate on vessel navigation. Their response stated they had no objection to the completion of the project.

Impacts to Hydrodynamics

197. The results of the hydrodynamic model indicates that normal daily tide conditions will remain virtually unchanged with the project in place. The maximum change in high tide is 0.05 ft within the project area. Outside the immediate area of the gate, peak current velocities were reduced by less than 0.3 fps. Together, this results indicate that there would be virtually no impact to tidal exchange and flushing. Maximum current velocities at the gate structure will be less that 4 fps, minimizing any scour potential near the structure.

198. Sedimentation has not been as issue in the South River. The navigation project, authorized to a depth of −12 mlw was last maintained in the 1940's. Within the project area, depths are still several feet below the authorized depth, indicating that sedimentation is not been a problem.

VI. RESIDUAL FLOODING

General.

199. The requirements for residual flooding documentation are contained in ER 1110-2-1150, *Engineering and Design – Engineering and Design for Civil Works Projects*, dated 31 Aug 1999, Appendix C, paragraph C-2.2. Residual flooding within the limits of the South River Hurricane and Storm Damage Reduction and Ecosystem Restoration project will only occur due to interior

flooding. Information on the residual flooding associated with the South River Hurricane and Storm Damage Reduction and Ecosystem Restoration project is presented in the following paragraphs. The information is only provided for the 100-year and 500-year events for the protected areas designated as the East Segment (100 cfs diversion plan), West Segment (minimum facility plan) and Main Gate (1200 cfs pump plan). Much of the information that is included here is related to the elevation where the first significant damages begin. For the East Segment, the first significant damage occurs at elevation 5.0 feet NGVD. At the West Segment, the first significant damage occurs at elevation 7.0 feet NGVD. The Main Gate has a first significant damage elevation of 6.0 feet NGVD.

Warning time of impending inundation.

200. The warning time of impending inundation is measured beginning at the time when the heavy rainfall (at a rate of about 0.30 inches per hour) starts to the time when the interior water surface reaches the first significant damage elevation. Rainfall, not elevation, is used, because flood rate of rise is too rapid for elevation to yield any useful warning time. The start of heavy rainfall is used as the start of warning time to a) avoid false alarms from less than heavy rainfall, b) avoid a false sense of security resulting from an overestimated warning time based on light rainfall at the very start of a storm. Warning times for the South River project interior areas are given in Table.39

Table 39
Warning Time of Impending Inundation
For Residual Interior Flooding

Location	Event	Warning Time
West Segment	100-year	6 hours
	500-year	6 hours
East Segment	100-year	13.5 hours
	500-year	17.5 hours
Main Gate	100-year	26 hours
	500-year	25 hours

Rate of rise, duration, depth, and velocity of inundation.

201. The rate of rise is defined as how fast the interior water surface is rising when it reaches the first significant damage elevation. The duration is defined as the length of time that the interior water surface remains above the level of first significant damage. The depth is defined as the difference between the maximum interior water surface elevation and the first significant damage elevation. The velocity of inundation is defined as the velocity (flow) of the water flooding the interior areas. The rate of rise, duration, depth, and velocity of inundation for the South River project interior areas are given in Table 40. The velocity of inundation is listed as minimal for all conditions in the table below since as interior flooding the water is only rising slowly behind the line of protection.

Table 40
Rate of Rise, Duration, Depth and Velocity of Inundation
For Residual Interior Flooding

Location	Event	Rate of Rise	Duration	Depth (feet)	Velocity of Inundatio
West Segment	100-year	2.50	3	2.0	Minimal
	500-year	2.50	3	2.3	Minimal
East Segment	100-year	2.33	15	2.2	Minimal
	500-year	2.00	16	2.8	Minimal
Main Gate	100-year	0.30	18	1.3	Minimal
	500-year	0.28	21	2.0	Minimal

Delineation.

202. Delineation of the extent of inundation for the 1% and 0.2% chance of exceedance floods (100-year and 500-year) for the South River project due to interior flooding is shown in Figures 60a and b, respectively. The maximum interior water surface elevations for the selected plan are also presented in the following table.

Access and egress problems created by flooding.

203. The residual interior flooding associated with the South River Hurricane and Storm Damage Reduction and Ecosystem Restoration project will cause some access and egress problems. Flooding in South River Boro for both the 100-year and 500-year floods will prevent the use of the Veterans

Memorial Bridge. In addition, small areas in both South River Boro and Sayreville that will not be flooded during the 100-year or 500-year floods will be left inaccessible due to the flooded areas around them. Please refer to the inundation limits mapping for the 100-year flood, Figure 60a and the 500-year flood, Figure 60b for clarification of the access and egress problems created by the residual interior flooding.

Table 41
Maximum Water Surface Elevation
For Residual Interior Flooding

Protected Area	Current/ Future Conditions	Flood	Max. Water Surface
East Segment	Current	100-year	7.0
	Future	100-year	7.3
	Current	500-year	7.3
	Future	500-year	7.6
West Segment	Current	100-year	9.2
	Future	100-year	9.3
	Current	500-year	9.8
	Future	500-year	10.1
Main Gate	Current	100-year	7.3
	Future	100-year	7.8
	Current	500-year	8.0
	Future	500-year	8.2

Potential for loss of life.

204. The potential for loss of life within the limits of the residual flooding is assumed to be minimal to none. The flooding only consists of slowly rising waters within the interior areas that do not exceed a few feet in depth.

Identification of any potential loss of public services.

205. Any public transportation routes through the area, such as bus lines, that use the Veterans Memorial Bridge to cross the South River will possibly be affected with a loss of service for the duration of residual interior flooding for both the 100-year and 500-year floods, since access to the bridge in South River Boro will be flooded.

Potential physical damages.

206. Residual flooding will affect protected structures with the project in place. The numbers of structures that will be damaged due to the 100-year and 500-year floods are shown in Table 42, listed by area of protection. A separate listing is given for residential structures and non-residential structures. Non-residential structures included in this data do not include any roads, bridges or railroads.

Table 42
Number of Structures Subject to Residual Flooding

Location	RESIDENTIAL		NON-RESIDENTIAL	
	100-year	500-year	100-year	500-year
MAIN GATE	49	63	28	30
EAST SEGMENT	29	47	1	3
WEST	7	13	7	7
TOTAL	85	123	36	40

207. The magnitude of the damage to the structures impacted by residual flooding can be shown by the dollar annual damages for the 100-year and 500-year events. These figures include both damage to the structure and its contents. This information is shown in Table 43, listed by area of protection.

Table 43 Annual Damages of Structures Impacted by Residual Flooding		
Location	**100-year**	**500-year**
MAIN GATE	$314,185	$344,653
East Segment	$125,078	$129,802
West Segment	$138,734	$144,837
Total	$577,997	$619,292

VII. REFERENCES

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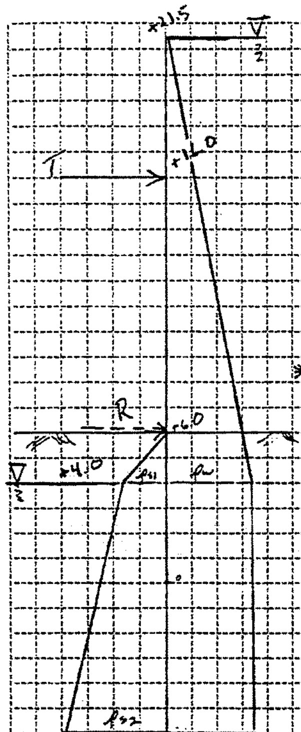
- Delineation of Flood Hazard Areas, Raritan River Basin, Flood Hazard Report #18, South River and Manalapan Brook. NJDEP, Division of Water Resources, October 1972.
- Delineation of Flood Hazard Areas, Raritan River Basin, Flood Hazard Report #17, Matchaponix Brook System, NJDEP, Division of Water Resources, March 1973.
- Survey Report for Flood Control, Raritan River Basin, New Jersey, Final Report, New York District, USACE, March 1985.
- South River, Raritan River Basin, New Jersey, Multi-Purpose Study, Final Reconnaissance Report, Department of the Army, Corps of Engineers, New York District, May 1995.
- Technical Paper No. 49, Two to ten-day Precipitation for Return Periods of 2 to 100 Years in the Contiguous United States, U.S. Department of Commerce, Weather Bureau, Washington, D.C. 1964.
- Technical Paper No. 40, Rainfall Frequency Atlas of the United States, U.S. Department of Commerce, Weather Bureau, Washington, D.C. 1961.

- Technical Memorandum Hydro-35, Five-to 60-Minute Precipitation Frequency for the Eastern and Central United States, National Weather Service, Silver Spring, Maryland, June 1977.
- Guidelines for Determining Flood Flow Frequency, Bulletin 17B, United States Water Resources Council, Washington D.C., revised September 1981.
- Appendix A of ER 1110-2-1150, Engineering and Design for Civil Works Projects, U.S. Army Corps of Engineers, Washington D.C. 31 March 1994
- Green Brook Flood Control Project – General Re-evaluation Report (GRR), U.S. Army Corps of Engineers, New York District, December 1996.
- Climatological Data, National Climate Data Center, Ashville, NC 28801

SUB-APPENDIX A

FLOODWALL DESIGN CALCULATIONS

Project: South River Feasibility Study Flood Wall Design HoP +21.5 NGVD		USACE New York District
Sheet No. 1 of 6	Date: Dec 2001	26 Federal Plaza
Computed By HB	Checked By [illegible]	New York, NY 10278



$K_a = 0.33$

$K_p = 2.75$

T = Strut Beam Support

$\gamma_w = 62.4\ lb/ft^3$

$\gamma_{sat} = 125\ lb/ft^3$

$\gamma = 65\ lb/ft^3$

Depth of Penetration Analysis

* ignore lower support for calculation of D *

Wall Pressures

$p_w = \gamma_w (21.5 - 4) = 1092\ lb/ft^2$

$p_{s1} = \gamma_{sat} K_p (6-4) - \gamma K_a (6-4) = 645\ lb/ft^2$

$p_{s2} = p_{s1} + \gamma K_p D - \gamma K_a D = 645 + 157 D$

Wall Forces

$P_{w1} = p_w (21.5-4)/2 = 9555\ lb/ft$

$P_{w2} = p_w (D) = 1092 D$

$P_{s1} = p_{s1} \left(\frac{6-4}{2}\right) = 645\ lb/ft$

$P_{s2} = (p_{s1} + p_{s2})/2\ (D) = 323D + 323D + 79D^2 = 645D + 79D^2$

$\Sigma F_H = 0$

$T + P_{s1} + P_{s2} = P_{w1} + P_{w2}$

$T = 9555 + 1092D - 645 - 645D - 79D^2 = 8910 + 447D - 79D^2$

$\Sigma M_T = 0$

$P_{w1}(16 - (4 + \frac{17.5}{3})) + P_{w2}(16 - (4 - \frac{D}{2}))$

$- P_{s1}(16 - (6 - \frac{2(2)}{3}))$

$- P_{s2}\left(16 - \left(4 - \left(D\left(\frac{p_{s2} + 2(p_{s1})}{3(p_{s2}) + 3(p_{s1})}\right)\right)\right)\right)$

$\Rightarrow D = 10.37\ ft$

Sheets will be driven to −10.0 NGVD for cut-off

Project:	South River Feasibility Study	USACE
	Floodwall Design HoP +215 NGVD	New York District
Sheet No. 2 of 6	Date: Dec 2001	26 Federal Plaza
Computed By HB	Checked By	New York, NY 10278

Forces (per LF of wall)

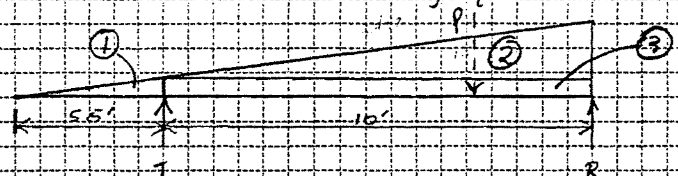
$P_{w1} = 9555$ lb

$P_{w2} = 11324$ lb

$P_{s1} = 645$ lb

$P_{s2} = 15184$ lb

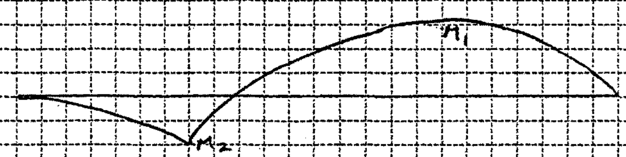
Calculate Maximum Moment using Equivalent Beam Method



Reaction Forces $M_{all} = 13350$ ft-lb

$\Sigma M_T = 0 = 62.4(15.5)^2/2 \, (\frac{2}{3} 15.5 - 5.5) - R(10)$

$R = 3623$ lb => $T = 62.4(15.5)^2/2 - R$
$= 3873$ lb



$M_2 = 62.4(5.5)^2/2 \, (\frac{5.5}{3}) = 1730$ ft-lb < 13350 OK

$M_1 \Rightarrow$ use $M = wl/8$ to approximate M_1 where W = ①+②+③

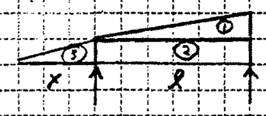
$M_1 = 62.4(15.5)^2/2 \, (10/8) = 9370$ ft-lb < 13350 OK

Calculate stress $S = 60 \, in^3$ $\sigma_{all} = 3200$ psi

$\sigma = M/S = 9730(12)/60 = 1874$ psi < 3200 OK

Project: South River Feasibility Study		USACE
Floodwall Design	H_oP +21.5 NGVD	New York District
Sheet No. 3 of 6	Date: Dec 2001	26 Federal Plaza
Computed By HB	Checked By [illegible]	New York, NY 10278

Calculate Deflection



Free End

$X = 5.5'$ $\quad l = 10'$

$E = 380000$ psi
$I = 360$ I^4

$$\Delta = \frac{w_2 l^3 x}{24EI} + \frac{P_1(\frac{1}{3}l)(\frac{2}{3}l)(x)}{6EIl}(l + \frac{1}{3}l) - \frac{W_3 X^3}{15EI}$$

$$= \frac{343(10)^3(5.5)(1728)}{24EI} + \frac{3120(3.3)(6.7)(5.5)(10+3.3)(1728)}{6EI(10)}$$

$$- \frac{944(5.5)^3(1728)}{15EI} = 0.99 + 1.06 - 0.13 = 1.92 \text{ in}$$

Using Beam Design Software
(see attached sheet)
$\Delta = 1.25$ in

Center Span

$$\Delta = \frac{5w_2 l^4}{384EI} + \frac{0.01304\, W_1 l^3}{EI}$$

$$= \frac{5(343)(10)^4(1728)}{384EI} + \frac{0.01304(3120)(10)^3(1728)}{EI}$$

$$= 0.56 + 0.51 = 1.07 \text{ in}$$

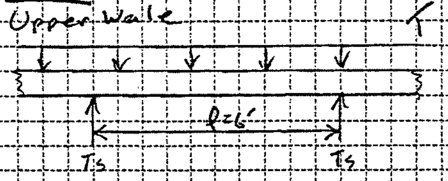
Using Beam Design Software
(see attached sheet)
$\Delta = 0.9$ in

Project:	South River Feasibility Study		USACE
	Floodwall Design	H_oP +21.5 NGVD	New York District
Sheet No. 4 of 6		Date: Dec 2001	26 Federal Plaza
Computed By: HB		Checked By: [illegible]	New York, NY 10278

Design Wales, Support Beams + Struts

Wale

Upper Wale



T = 3873 lb/ft

Ts = 3873(6)/2
= 11619 lb

F_y = 46 ksi for structural Tubing

$w_u = 1.4(3873) = 5422$ lb/ft

$M_u = w_u l^2/8 = 24.4$ ft-kip

$\phi_b = 0.9 \quad M_u = \phi_b M_n = \phi_b Z_x F_y$

try 6"x6" tubing @ 19.02 lb/ft

$Z = 11.9$ in³

$\phi_b M_n = 0.9(11.9)(46)/12 = 41$ ft-kips > M_u = 24 ft-kips

OK

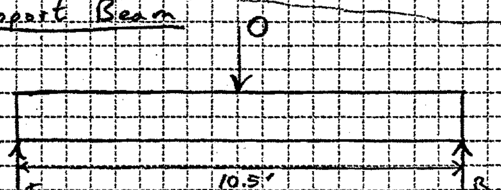
Lower Wale R = 3623 lb/ft

Use same section

$\Delta = \frac{5wl^4}{384EI}$ I = 30.3 in⁴

Δ = 0.18 in OK

Support Beam



Assume R = T

use R = T = 3900(6)/2 = 11.7 Kips

$M_{max} = \frac{Ol}{4} = 61.4$ ft-kips

O = T(2) = 23.4 kips

Project: South River Feasibility Study
Floodwall Design — HoP 21.5 NGVD
Sheet No. 5 of 6 — Date: Dec 2001
Computed By HB — Checked By [initials]

USACE
New York District
26 Federal Plaza
New York, NY 10278

required Z_x

$$Z_x = \frac{M_u(12)}{\phi_b F_y} = 61.4(12)/0.9(36)$$

$= 23\ in^3$

Use W12x22 => $Z_x = 29.3\ in^3$

$\phi_b M_p = 79.1$ ft-kip > 61.4 ft-kips

OK

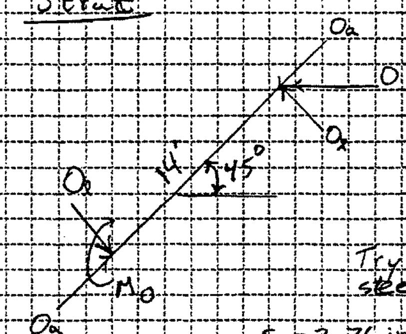
Check Deflection

$I = 156\ in^4$ $\Delta = \frac{PL^3}{48EI}$

$E = 29000$ ksi

$$\Delta = \frac{23.4(10.5)^3(1728)}{48EI} = 0.22\ in \quad OK$$

Strut



$O = 23400$ lb

$O_a = O \sin 45° = 16546$ lb

$O_\ell = O \sin 45° = 16546$ lb

$M_O = O_\ell(14)$

$= 232$ kip-ft

Try 8" ϕ double-extra-strong steel pipe filled with concrete

$r_m = 2.76$ in $A_s = 15.6\ in^2$ $A_g = 58.4\ in^2$

$D_o = 8.625$ $A_c = 37.1\ in^2$ $I_g = 272\ in^4$

$D_i = 6.875$ $Z_g = 107\ in^3$

$\gamma_c = 150\ lb/ft^3$ $F_y' = 36$ ksi

$f_c' = 3500\ lb/in^2$ $E = 29 \times 10^6 + 0.4 E_c(A_c/A_s)$

$E_c = 57000\sqrt{f_c'}$ $= 32.2 \times 10^6$ psi

$= 3.4 \times 10^6$ psi

$F_y = F_y' + 0.85 f_c'(A_c/A_s)$

$= 43$ ksi

Project: South River Feasibility Study
Floodwall Design Hop +21.5 NGVD
Sheet No. 6 of 6 Date: Dec 2001
Computed By HB Checked By [initials]

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New York District
26 Federal Plaza
New York, NY 10278

Factored Loads

$M_{nt} = 232$ kip-ft
$P_u = 1.4(Q_D) = 23.2$ kip

$K = 0.7$
$KL = 0.7(14) = 9.8$ ft

$KL/r = 9.8(12)/2.76 = 42.6$

$\phi_c P_n = 671$ kips (LRFD 4-99, First Edition)

$P_u/\phi_c P_n = 23.2/671 = 0.03 < 0.2$ OK

$\Rightarrow$ use $P_u/2\phi_c P_n + M_u/\phi_b M_n \leq 1.0$ to check selection

$M_n = M_p = F_y Z = 43(107)/12 = 383$ kip-ft

$\phi_b M_n = 0.9(383) = 345$ kip-ft

$P_e = \pi^2 EA/(KL/r)^2 = \pi^2(32.2\times10^6)(58.4)/(42.6)^2$
$= 10.2\times10^6$ lb

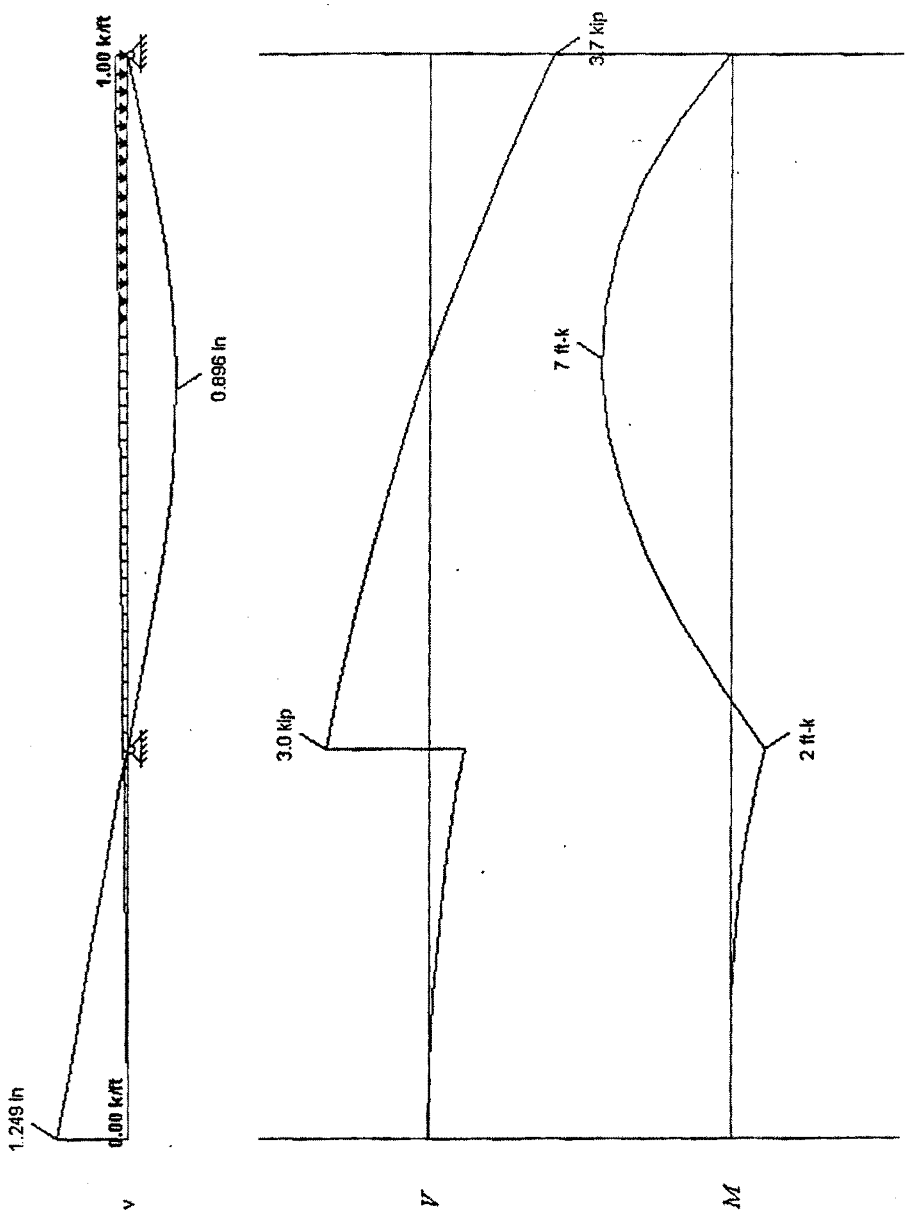
$C_m = 0.85$

$B_1 = C_m/(1 - P_u/P_e) = 0.85/(1 - 23200/10.2\times10^6)$
$= 0.85$

$M_u = M_{nt} B_1 = 0.85(232) = 197$ kip-ft

$P_u/2\phi_c P_n + M_u/\phi_b M_n = 23.2/2(671) + 197/345 = 0.59 < 1$ OK

∴ Use 8" diameter double extra-strong steel pipe filled with concrete


1.00 k/ft
0.896 in
1.249 in
0.00 k/ft
v
3.7 kip
3.0 kip
V
7 ft-k
2 ft-k
M

MATERIALS INTERNATIONAL

Characteristic	Units	GeoGuard ~~900~~ 950
Standard Color	n/a	Grey
Custom Colors	n/a	Beige Brown Green Sandstone
Standard Lengths	Feet	20, 22, 24
Standard Packaging	Sheet Piling per Bundle	12
Long-term allowable moment rating	Foot-pounds/Linear foot	13,350
Factor of safety for creep	n/a	1.5
Factor of safety for durability & construction	n/a	1.5
Transmissivity	Centimeters per second for SW soils	4.15×10^{-4}
Weight	Pounds per square foot	10.1
Nominal Thickness	Inches	0.600
Linear Coverage	Inches	12
Depth of section	Inches	12
Section modulus	Cubic Inches/Linear foot	60
Tensile strength by ASTM D-638	Pounds per square inch	6,300
Impact strength by ASTM D-4226	Inch-pounds/Square inch	20,000
Modulus of elasticity by ASTM D-790	Pounds/Square inch	380,000
I-Beam Lock™	n/a	Yes
Co-Extrusion	n/a	Yes
UV Protection	n/a	Yes
Strong Back Ribs™	n/a	Yes

950 Series

$I = 360\ in^4$

$A = 16.3\ in^2$

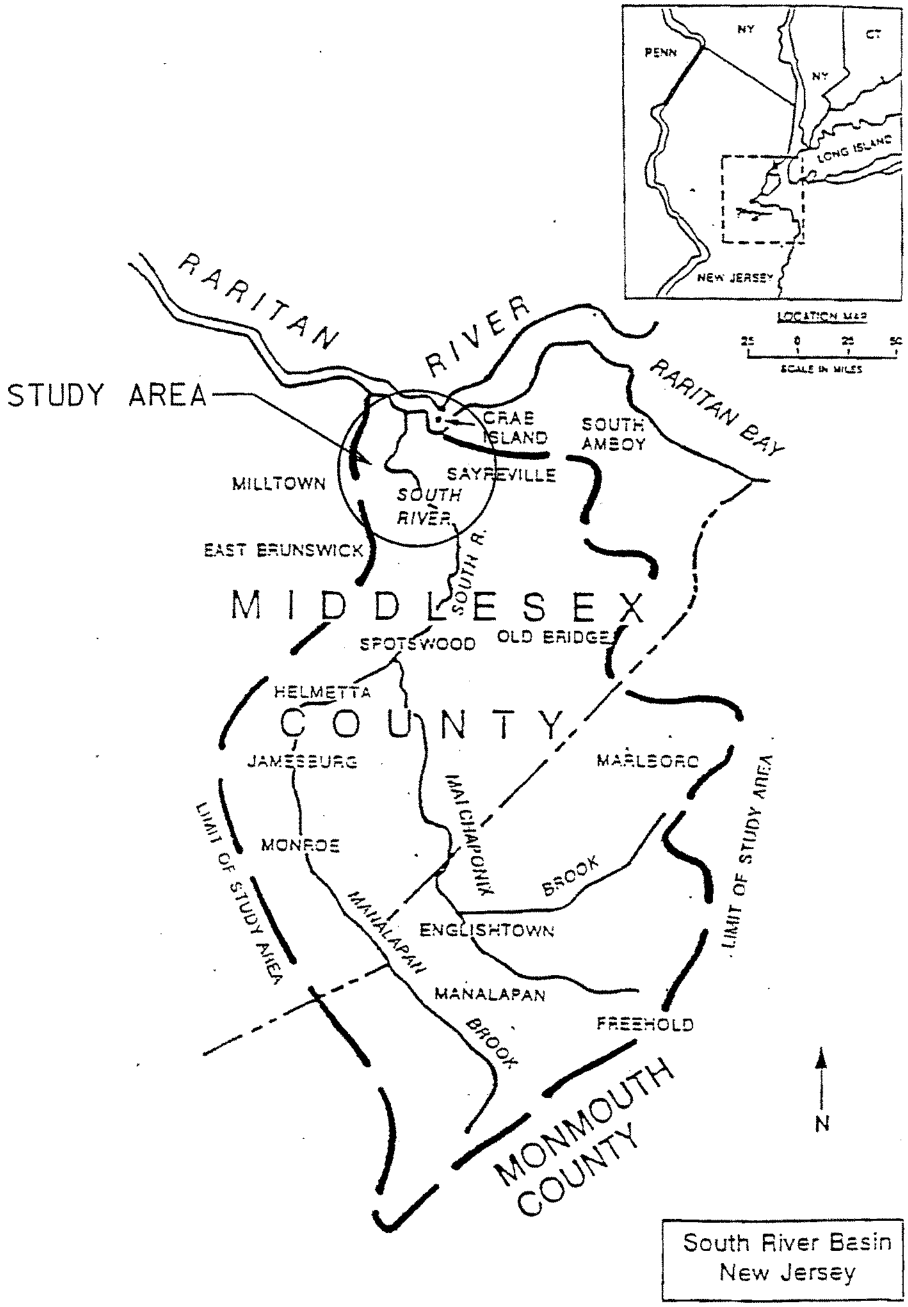


Figure 1 - Watershed/Study Area Location Map

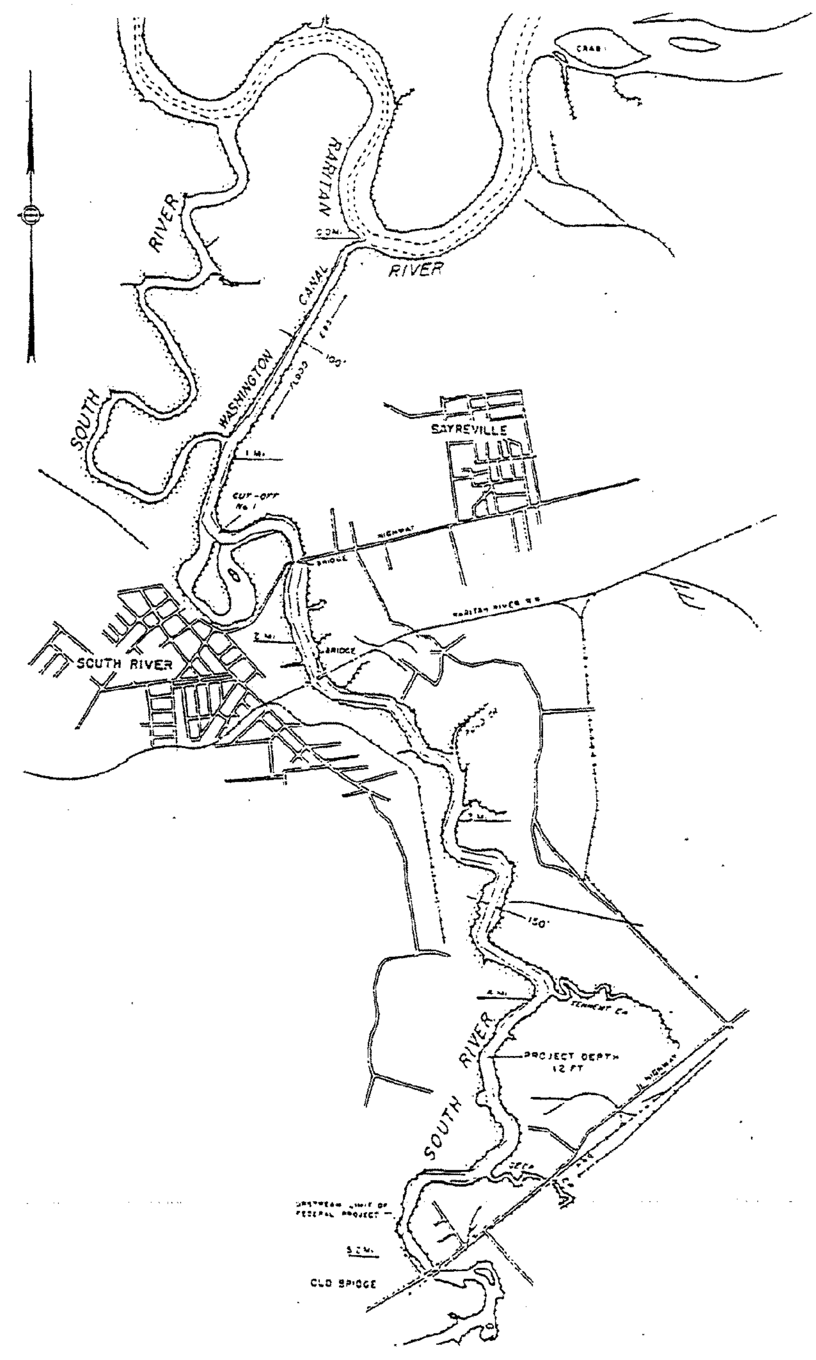


Figure 2 - Washington Canal & South River Project Area Map

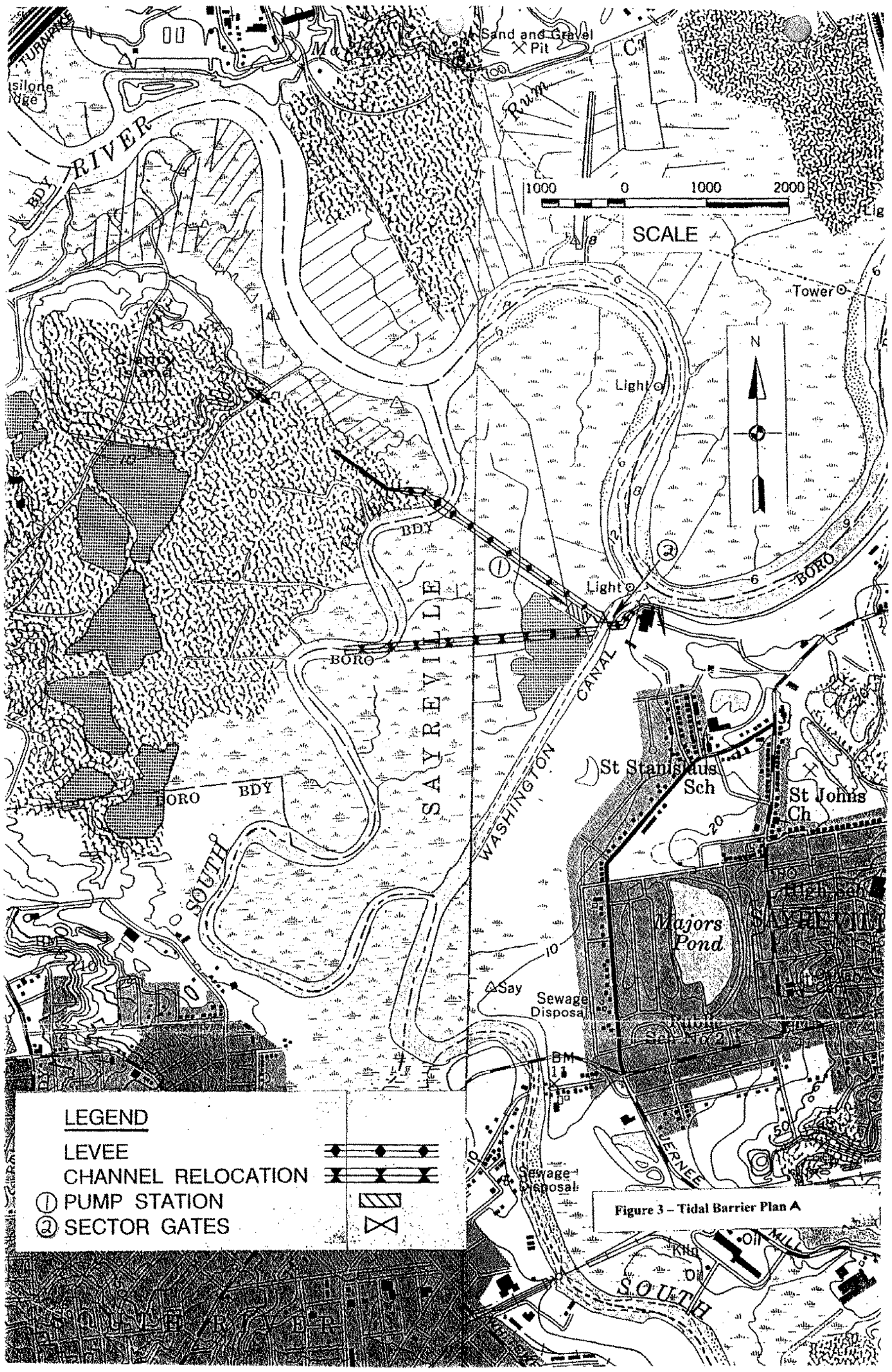


Figure 3 – Tidal Barrier Plan A

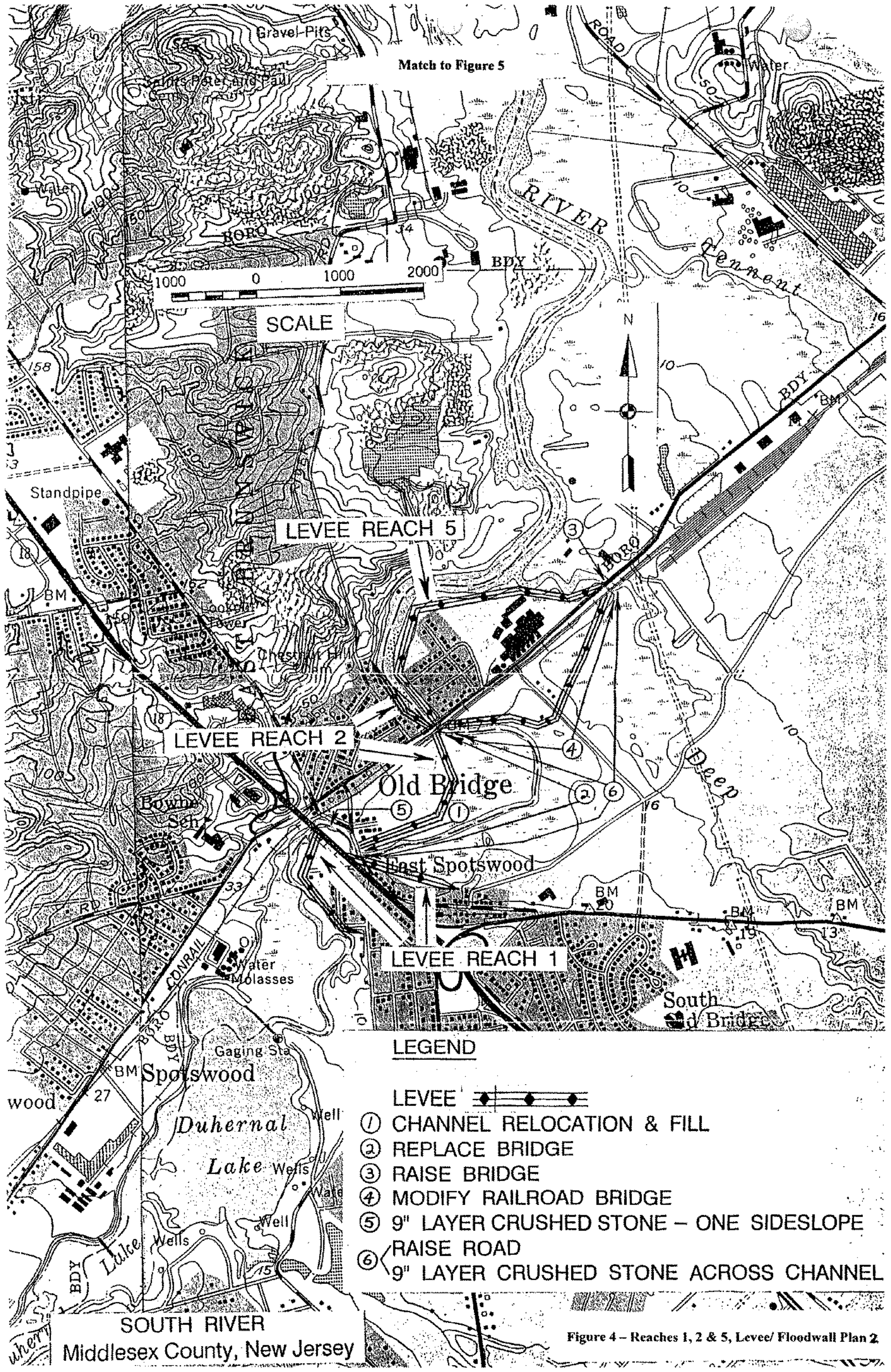


Figure 4 – Reaches 1, 2 & 5, Levee/ Floodwall Plan 2

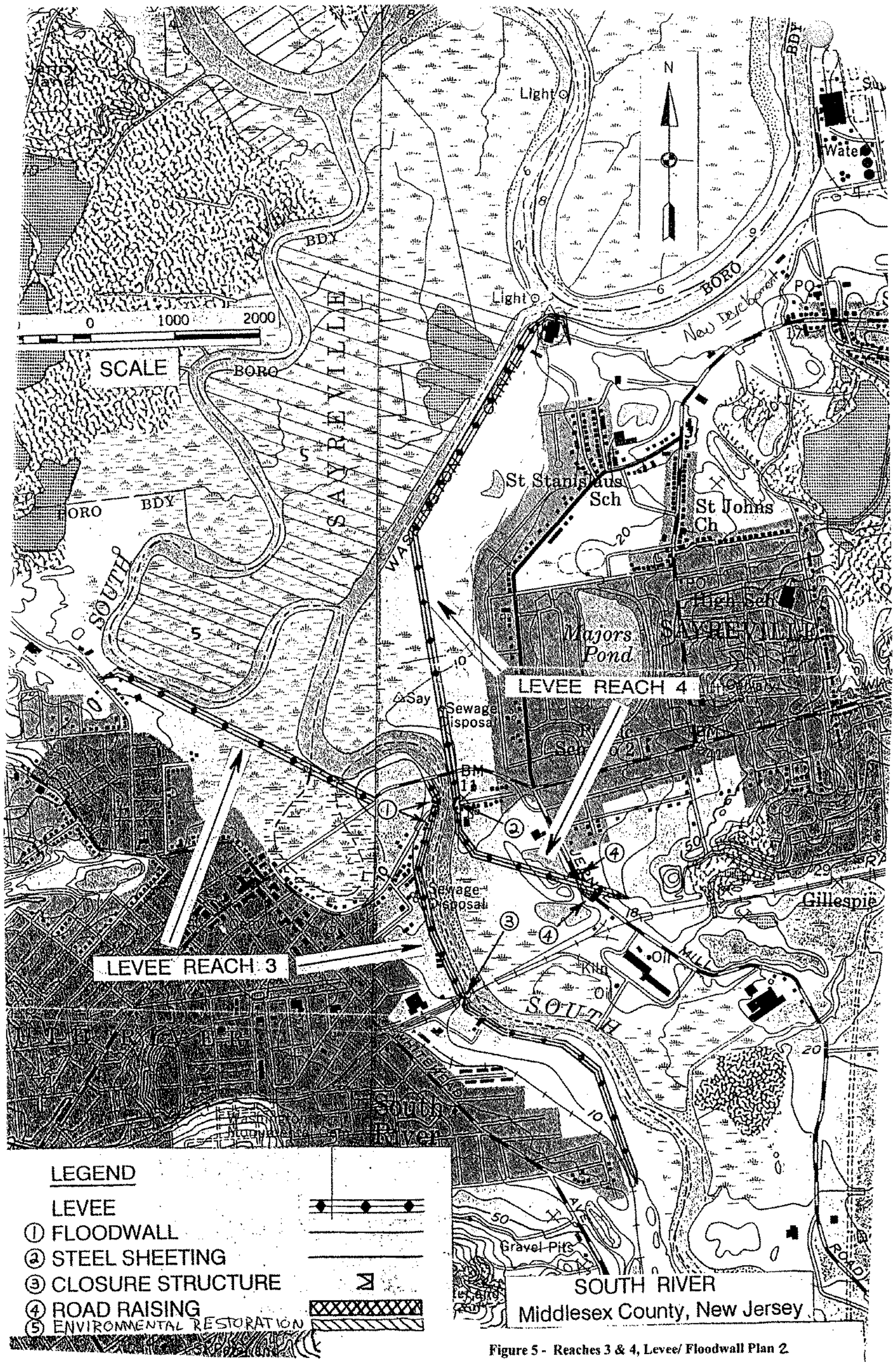
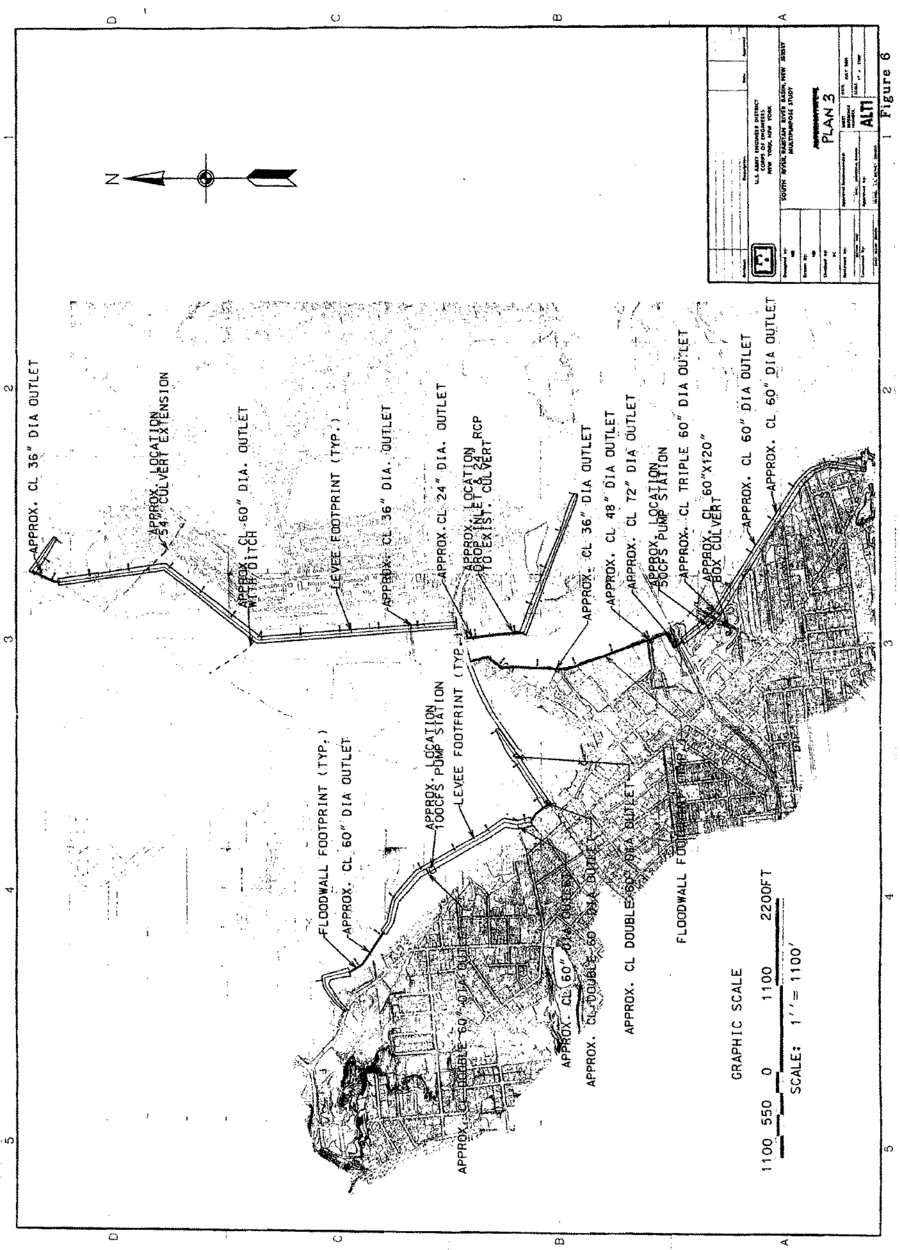


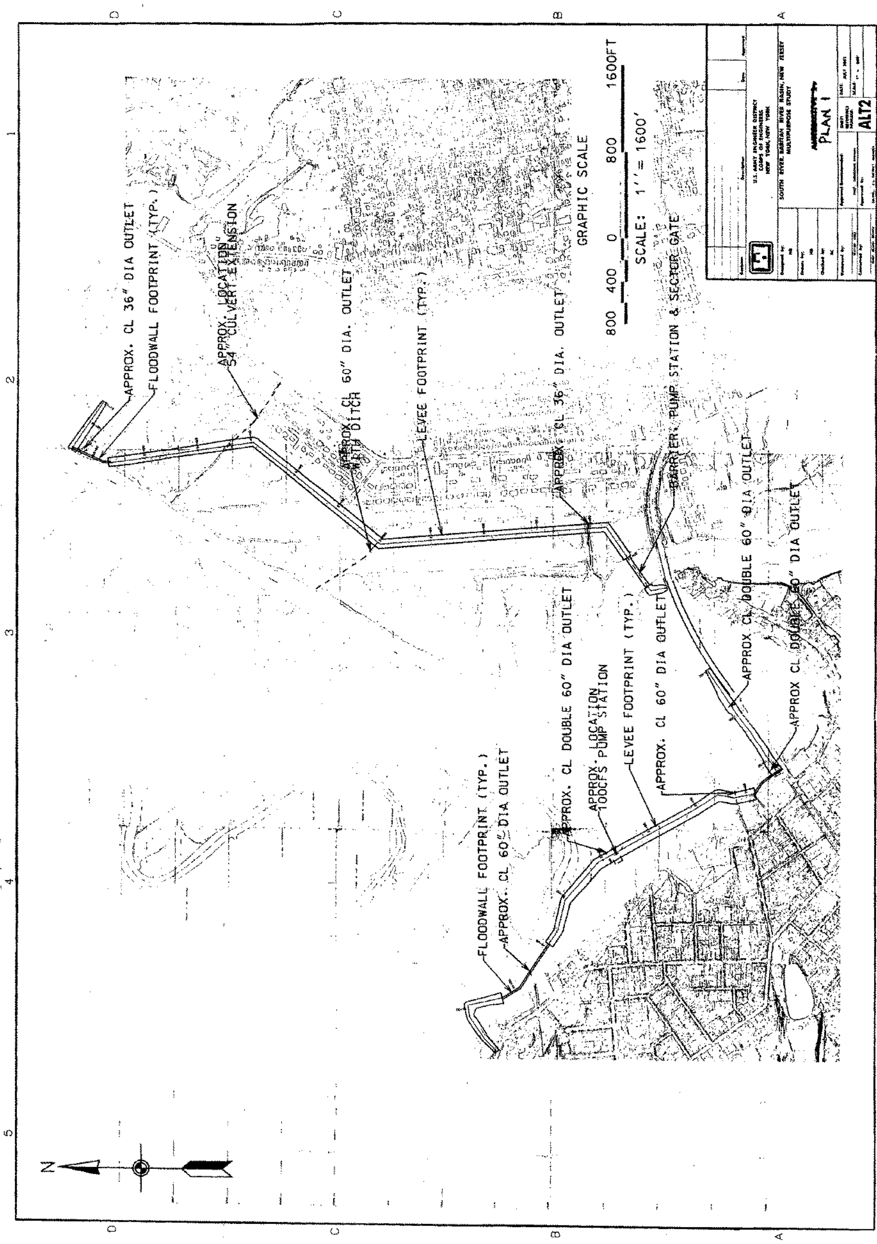
Figure 5 - Reaches 3 & 4, Levee/ Floodwall Plan 2


APPROX. CL 36" DIA OUTLET
APPROX. LOCATION 54" CULVERT EXTENSION
APPROX. CL 60" DIA. OUTLET WITH DITCH
LEVEE FOOTPRINT (TYP.)
APPROX. CL 36" DIA. OUTLET
APPROX. CL 24" DIA. OUTLET
APPROX. LOCATION DROP INLET & 24" RCP TO EXIST. CULVERT
APPROX. CL 36" DIA OUTLET
APPROX. CL 48" DIA OUTLET
APPROX. CL 72" DIA OUTLET
APPROX. LOCATION 50CFS PUMP STATION
APPROX. CL TRIPLE 60" DIA OUTLET
APPROX. CL 60"X120" BOX CULVERT
APPROX. CL 60" DIA OUTLET
APPROX. CL 60" DIA OUTLET
FLOODWALL FOOTPRINT (TYP.)
APPROX. CL 60" DIA OUTLET
APPROX. LOCATION 100CFS PUMP STATION
LEVEE FOOTPRINT (TYP.)
FLOODWALL FOOTPRINT
APPROX. CL DOUBLE 60" DIA OUTLET
APPROX. CL 60" DIA OUTLET
APPROX. CL DOUBLE 60" DIA OUTLET
GRAPHIC SCALE
1100 550 0 1100 2200FT
SCALE: 1''= 1100'
N
PLAN 3
ALT1
Figure 6

Excludes Barrier
Total First Cost & Annual Cost - South River
South River Flood Control Feasibility Study
Height of Protection – Elevation - 17.0

ACCOUNT CODE	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	AMOUNT	CONT. %	CONTINGENCY AMOUNT	TOTAL
1	LANDS AND DAMAGES							
	Acquiring Permanent Easements (upland)	21.8	AC	$160,000	$3,488,000	15%	$523,200	
	Acquiring Permanent Easements (wetland)	10.6	AC	$20,000	$212,000	15%	$31,800	
	Acquiring Temporary Easements (upland)	9.2	AC	$32,000	$294,400	15%	$44,160	
	Acquiring Temporary Easements (wetland)	3.1	AC	$4,000	$12,400	15%	$1,860	
	SUBTOTAL				$4,006,800			
	CONTINGENCY						$601,020	$4,607,820
	LANDS AND DAMAGES TOTAL							
6	FISH AND WILDLIFE FACILITIES							
	Wildlife Facilities & Sanctuaries							
	Wetland Mitigation	10.6	AC	$100,000	$1,060,000	15%	$159,000	
	Disruption of Wetland Hydrology	34.5	AC	$50,000	$1,725,000	15%	$258,750	
	SUBTOTAL				$2,785,000			
	CONTINGENCY						$417,750	
	FISH AND WILDLIFE TOTAL							$3,202,750
11	LEVEES AND FLOODWALLS							
	Levees							
	Mob. Demob & Preparatory Work	1.0	LS	$50,000	$50,000	15%	$7,500	
	Clear & Grub	32.0	AC	$9,800	$313,600	15%	$47,040	
	Excavation Common	36000.0	CY	$9	$306,000	15%	$45,900	
	Embankment Common (Fill)	235000.0	CY	$22	$5,170,000	15%	$775,500	
	Embankment Impervious	90600.0	CY	$26	$2,378,250	15%	$356,738	
	Stripping	61700.0	CY	$8	$462,750	15%	$69,413	
	Topsoil and Seeding	37.4	AC	$19,360	$724,064	15%	$108,610	
	Floodwalls							
	Excavation Common	8500.0	CY	$9	$72,250	15%	$10,838	
	Fill	16300.0	CY	$22	$358,600	15%	$53,790	
	Vinyl Sheeting	112400.0	SF	$30	$3,372,000	15%	$505,800	
	Concrete (incl. Reinforcing Steel and Forms)	1400.0	CY	$450	$630,000	15%	$94,500	
	Walers	5100.0	LF	$42	$214,200	15%	$32,130	
	Strut Beams	9700.0	LF	$50	$485,000	15%	$72,750	
	Topsoil and Seeding	1.6	AC	$19,360	$30,976	15%	$4,646	
	Demolition and backfill	800.0	LF	$150	$120,000	15%	$18,000	
	Interior Drainage Facilities							
	100cfs pump station	1	LS	$1,500,000.00	$1,500,000.00	15%	$225,000	
	50 cfs pump station	1	LS	$800,000.00	$800,000.00	15%	$120,000	
	24" diameter outlet structure	1	EA	$40,000.00	$40,000.00	15%	$6,000	
	36" diameter outlet structure	3	EA	$55,000.00	$165,000.00	15%	$24,750	
	48" diameter outlet structure	1	EA	$70,000.00	$70,000.00	15%	$10,500	
	60" diameter outlet structure	14	EA	$100,000.00	$1,400,000.00	15%	$210,000	
	72" diameter outlet structure	1	EA	$127,100.00	$127,100.00	15%	$19,065	
	54" culvert w/3 manholes, headwall & valve	800	LF	$200.00	$160,000.00	15%	$24,000	
	Drop inlet	1	EA	$3,000.00	$3,000.00	15%	$450	
	24" RCP	50	LF	$40.00	$2,000.00	15%	$300	
	60"x120" box culvert	1	LS	$800,000.00	$800,000.00	15%	$120,000	
	Drainage ditch/swale	2900	LF	$45.00	$130,500.00	15%	$19,575	
	Backflow prevention to existing inlets	1	LS	$30,000.00	$30,000.00	15%	$4,500	
	Scour Protection	2500	CY	$62.00	$155,000.00	15%	$23,250	
	54"x76" culvert outlet structure	1	LS	$100,000.00	$100,000.00	15%	$15,000	
	Railroad Closure Gate	1	LS	$350,000.00	$350,000.00	15%	$52,500	
	SUBTOTAL				$20,520,290			
	CONTINGENCY						$3,078,044	
	LEVEES AND FLOODWALLS TOTAL							$23,598,334
	Sub-total Construction Cost				$27,312,090		$4,096,814	$31,408,904
30	Engineering & Design (15%)							$4,711,336
31	S, I & A (7%)							$2,198,623
	TOTAL PROJECT FIRST COST							$38,318,862
	Intrest During Construction (2.5 year duration)							$3,218,784
	Total Investment Cost							$41,537,647
	O&M **(Annual)**							$145,000
	Annualized Project Cost @ 6.375% Over 50 Years			Capital Recovery Factor =	0.0668			$2,774,257
	TOTAL ANNUAL COST							$2,919,257

Figure 6a


APPROX. CL 36" DIA OUTLET
FLOODWALL FOOTPRINT (TYP.)
APPROX. LOCATION 54" CULVERT EXTENSION
APPROX. CL 60" DIA. OUTLET
LEVEE FOOTPRINT (TYP.)
APPROX. CL 36" DIA. OUTLET
GRAPHIC SCALE
800 400 0 800 1600FT
SCALE: 1'' = 1600'
BARRIER, PUMP STATION & SECTOR GATE
APPROX CL DOUBLE 60" DIA OUTLET
APPROX CL DOUBLE 60" DIA OUTLET
APPROX. CL DOUBLE 60" DIA OUTLET
APPROX. LOCATION 100CFS PUMP STATION
LEVEE FOOTPRINT (TYP.)
APPROX. CL 60" DIA OUTLET
FLOODWALL FOOTPRINT (TYP.)
APPROX. CL 60" DIA OUTLET
PLAN 1
ALT2
Figure 7

Includes Tidal Barrier
Total First Cost & Annual Cost – South River
South River Flood Control Feasibility Study
Height of Protection – Elevation +17.0

ACCOUNT CODE	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	AMOUNT	CONT. %	CONTINGENCY AMOUNT	TOTAL
1	LANDS AND DAMAGES							
	Acquiring Permanent Easements (upland)	12.3	AC	$100,000	$1,225,000	15%	$183,750	
	Acquiring Permanent Easements (wetland)	8.7	AC	$20,000	$174,000	15%	$26,100	
	Acquiring Temporary Easements (upland)	4.8	AC	$20,000	$95,000	15%	$14,250	
	Acquiring Temporary Easements (wetland)	2.9	AC	$4,000	$11,600	15%	$1,740	
	SUBTOTAL				$1,505,600			
	CONTINGENCY						$225,840	$1,731,440
	LANDS AND DAMAGES TOTAL							
6	FISH AND WILDLIFE FACILITIES							
	Wildlife Facilities & Sanctuaries							
	Wetland Mitigation	8.7	AC	$100,000	$870,000	15%	$130,500	
	Disruption of Wetland Hydrology	24.4	AC	$50,000	$1,220,000	15%	$183,000	
	SUBTOTAL				$2,090,000			
	CONTINGENCY						$313,500	
	FISH AND WILDLIFE TOTAL							$2,403,500
11	LEVEES AND FLOODWALLS							
	Levees							
	Mob, Demob & Preparatory Work	1.0	LS	$50,000	$50,000	15%	$7,500	
	Clear & Grub	21.1	AC	$9,800	$206,290	15%	$30,944	
	Excavation Common	22100.0	CY	$9	$187,850	15%	$28,178	
	Embankment Common (Fill)	166500.0	CY	$22	$3,663,000	15%	$549,450	
	Embankment Impervious	63800.0	CY	$26	$1,674,750	15%	$251,213	
	Stripping	42600.0	CY	$8	$319,500	15%	$47,925	
	Topsoil and Seeding	23.0	AC	$19,360	$445,280	15%	$66,792	
	Floodwalls							
	Excavation Common	1663.0	CY	$9	$14,136	15%	$2,120	
	Fill	3371.0	CY	$22	$74,162	15%	$11,124	
	Vinyl Sheeting	27560.0	SF	$30	$826,800	15%	$124,020	
	Concrete (incl. Reinforcing Steel and Forms)	340.0	CY	$450	$153,000	15%	$22,950	
	Walers	1378.0	LF	$42	$57,876	15%	$8,681	
	Strut Beams	2640.0	LF	$50	$132,000	15%	$19,800	
	Topsoil and Seeding	0.4	AC	$19,360	$6,776	15%	$1,016	
	Interior Drainage Facilities							
	100cfs pump station	1.0	LS	$1,275,000	$1,275,000	15%	$191,250	
	36" diameter outlet structure	2.0	EA	$55,000	$110,000	15%	$16,500	
	60" diameter outlet structure	9.0	EA	$100,000	$900,000	15%	$135,000	
	54" culvert w/3 manholes, headwall & valve	800.0	LF	$145	$116,000	15%	$17,400	
	Drainage ditch/swale	1400.0	LF	$45	$63,000	15%	$9,450	
	Backflow prevention to existing inlets	1.0	LS	$22,000	$22,000	15%	$3,300	
	Scour Protection	1000.0	CY	$62	$62,000	15%	$9,300	
	SUBTOTAL				$10,359,420			
	CONTINGENCY						$1,553,913	
	LEVEES AND FLOODWALLS TOTAL							$11,913,332
15	TOTAL FLOODWAY CONTROL DIVERSION STRUCTURES							
	Barrier	1.0	LS	$215,000	$215,000	15%	$32,250	
	Bulkhead	1.0	LS	$315,000	$315,000	15%	$47,250	
	Sector Gate 31'x80'	1.0	LS	$7,106,000	$7,106,000	15%	$1,065,900	
	Pump Station	1.0	LS	$4,556,050	$4,556,050	15%	$683,408	
	SUBTOTAL				$12,192,050			
	CONTINGENCY						$1,828,808	
	TOTAL FLOODWAY CONTROL DIVERSION STRUCTURES TOTAL							$14,020,858
	Sub-total Construction Cost				$26,147,070		$3,922,060	$30,069,130
30	Engineering & Design (15%)							$4,510,369
31	S, I & A (7%)							$2,104,839
	TOTAL PROJECT FIRST COST							**$36,684,339**
	Intrest During Construction (2.5 year duration)							$3,081,484
	Total Investment Cost							$39,765,823
	O&M (Annual)							$209,500
	Annualized Project Cost @ 6.375% Over 50 Years			Capital Recovery Factor =	0.0668			$2,655,918
	TOTAL ANNUAL COST							$2,865,418

Figure 7a

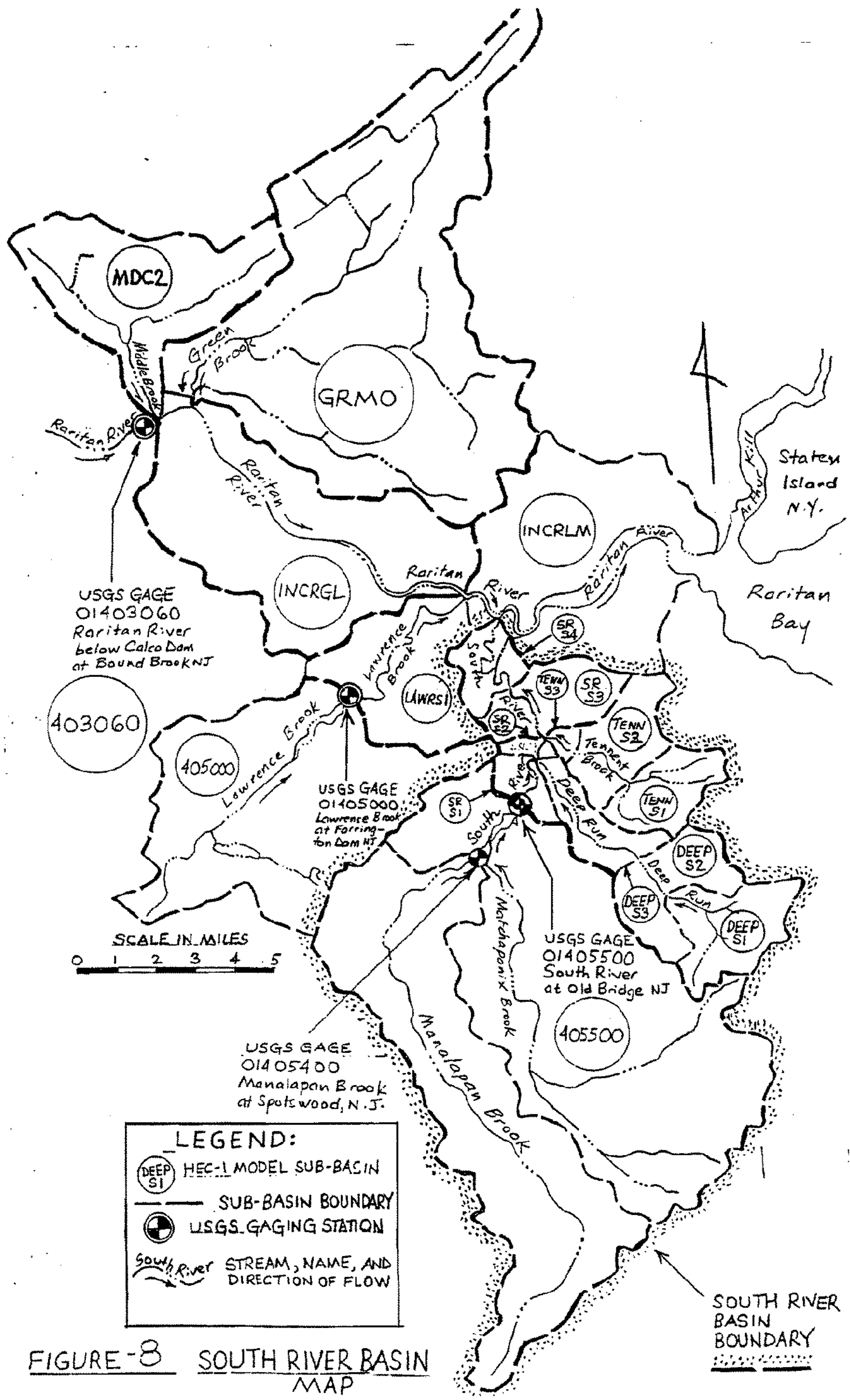


FIGURE-8 SOUTH RIVER BASIN MAP

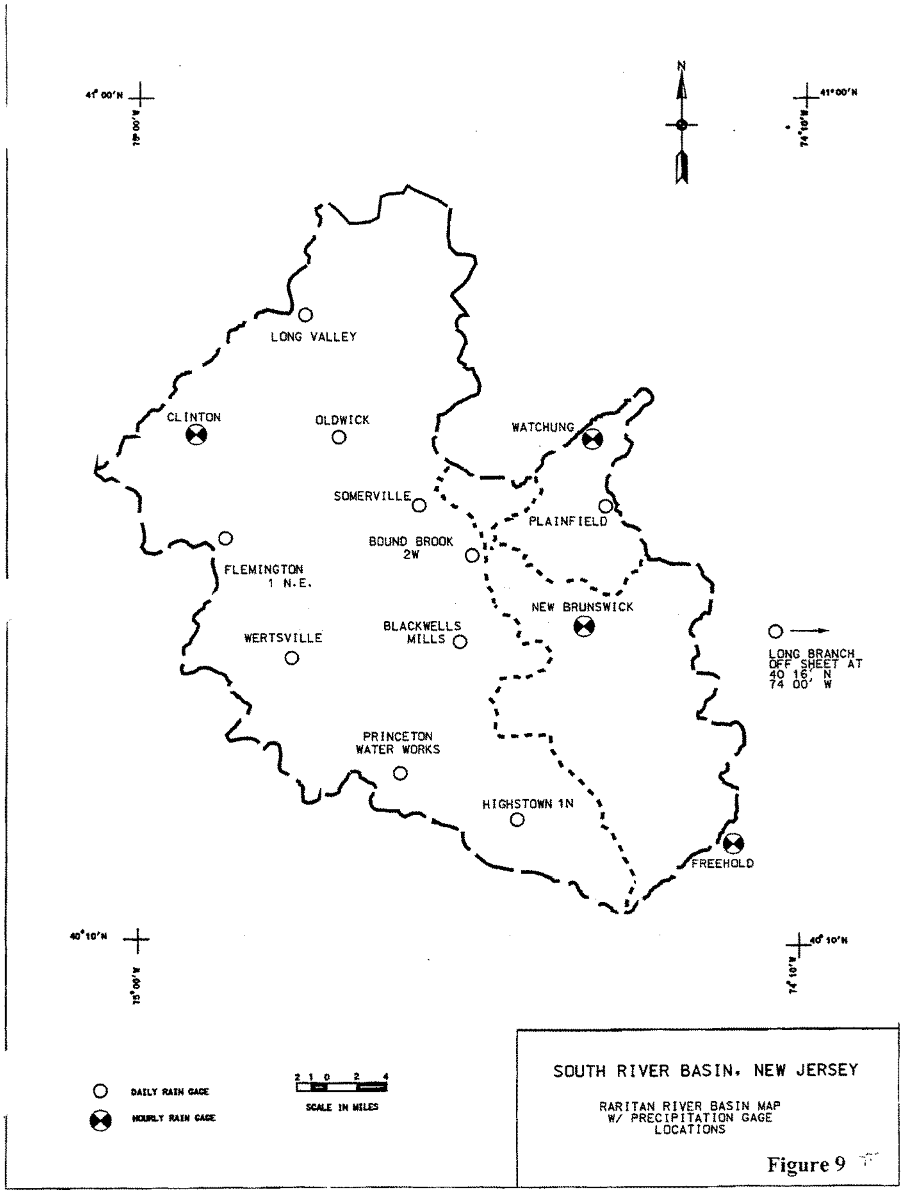

N
LONG VALLEY
CLINTON
OLDWICK
WATCHUNG
SOMERVILLE
PLAINFIELD
BOUND BROOK
2W
FLEMINGTON
1 N.E.
NEW BRUNSWICK
WERTSVILLE
BLACKWELLS
MILLS
LONG BRANCH
OFF SHEET AT
40 16' N
74 00' W
PRINCETON
WATER WORKS
HIGHSTOWN 1N
FREEHOLD
DAILY RAIN GAGE
HOURLY RAIN GAGE
2 1 0 2 4
SCALE IN MILES
SOUTH RIVER BASIN, NEW JERSEY
RARITAN RIVER BASIN MAP
W/ PRECIPITATION GAGE
LOCATIONS

Figure 9

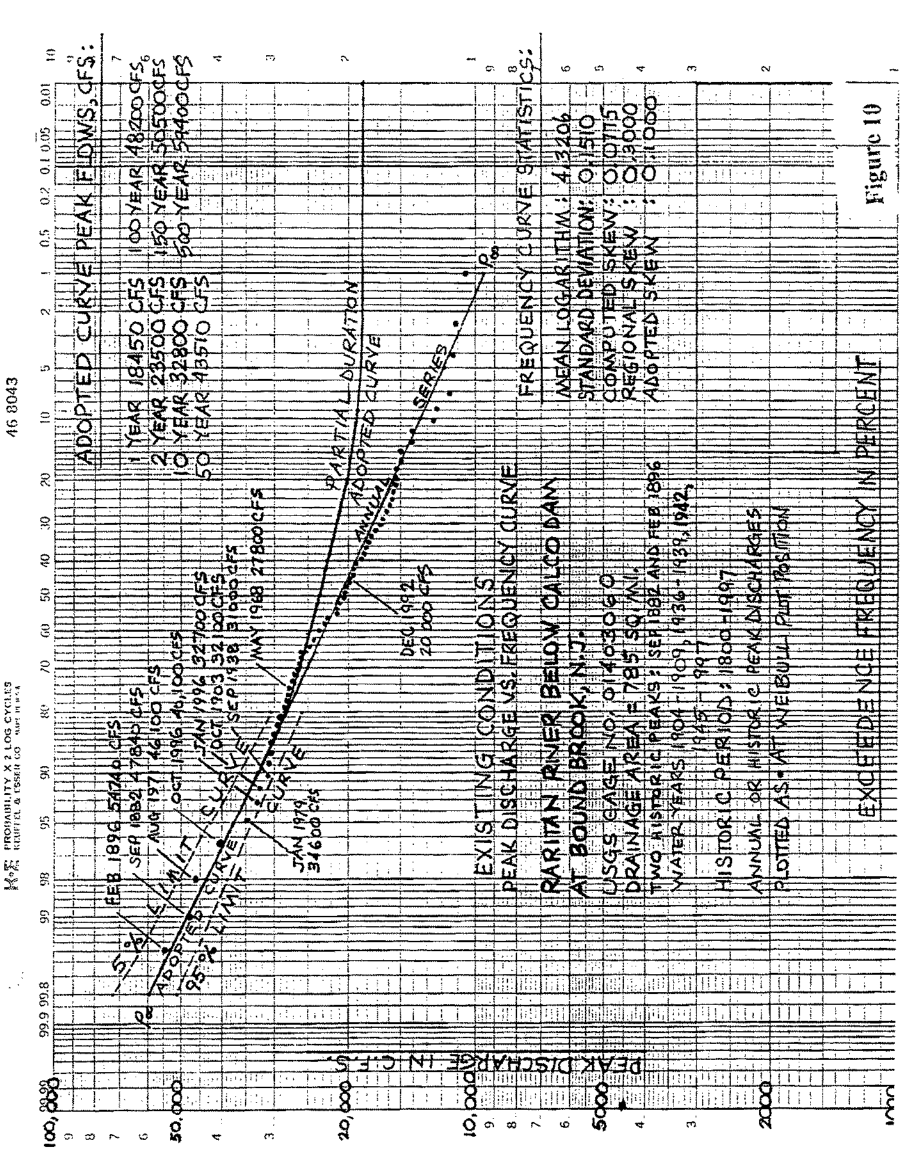
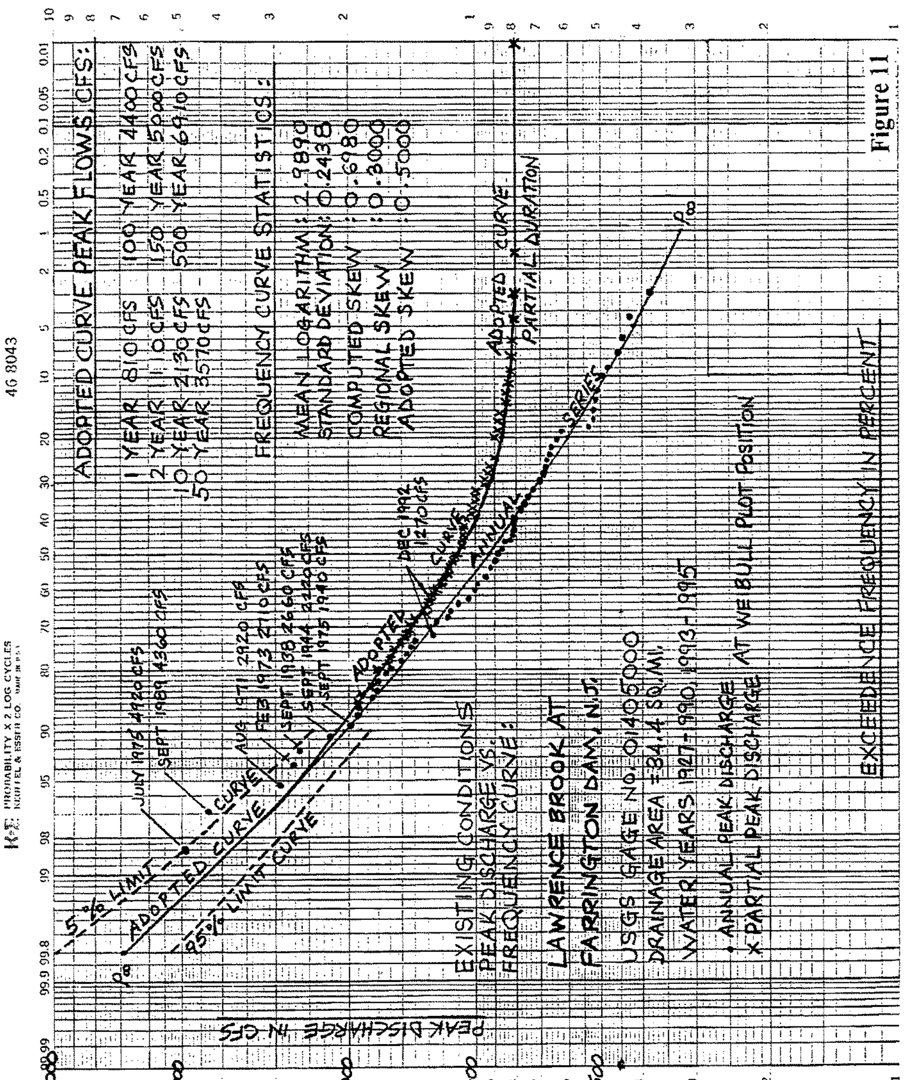
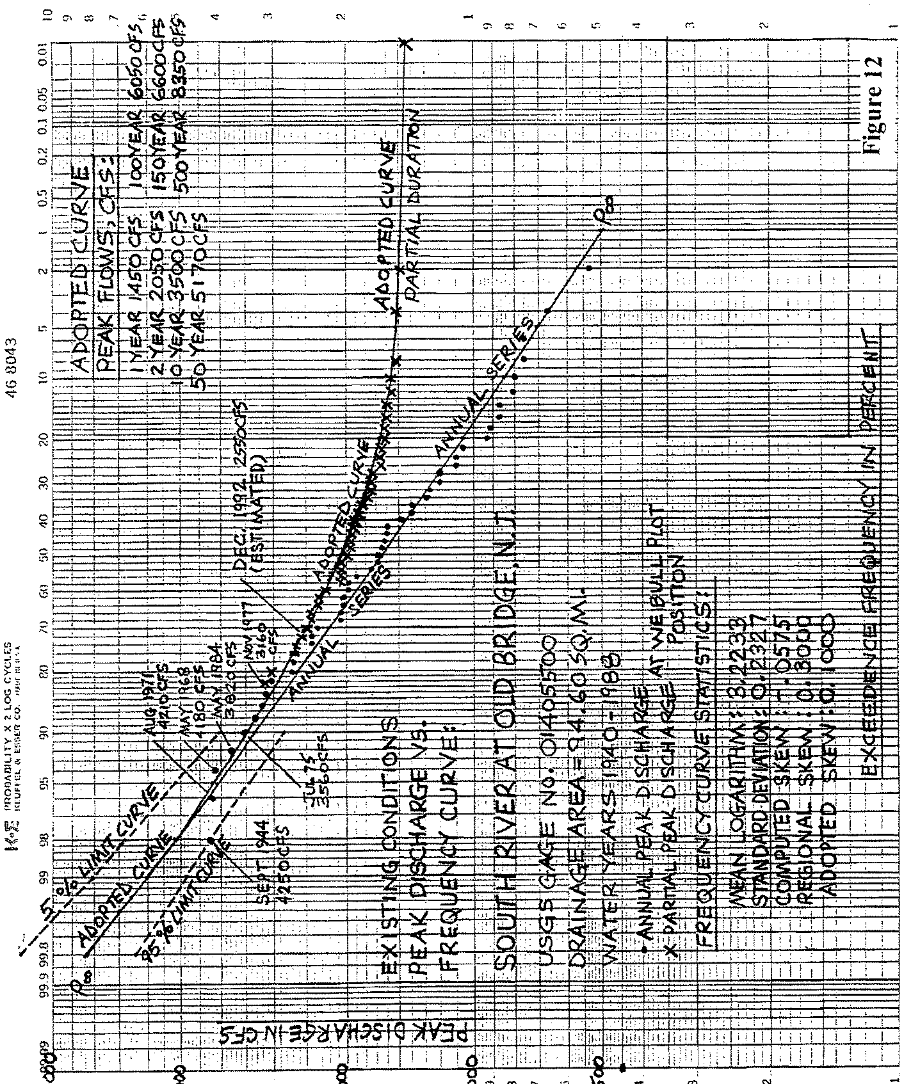

46 8043
PROBABILITY X 2 LOG CYCLES
KEUFFEL & ESSER CO.
ADOPTED CURVE PEAK FLOWS, CFS:
1 YEAR 18450 CFS
2 YEAR 23500 CFS
10 YEAR 32800 CFS
50 YEAR 43510 CFS
100 YEAR 48200 CFS
150 YEAR 50500 CFS
500 YEAR 57400 CFS
FREQUENCY CURVE STATISTICS:
MEAN LOGARITHM: 4.3206
STANDARD DEVIATION: 0.1510
COMPUTED SKEW: 0.0775
REGIONAL SKEW: 0.3000
ADOPTED SKEW: 0.1000
EXISTING CONDITIONS
PEAK DISCHARGE VS. FREQUENCY CURVE
RARITAN RIVER BELOW CALCO DAM
AT BOUND BROOK, N.J.
USGS GAGE NO. 01403060
DRAINAGE AREA = 785 SQ. MI.
TWO HISTORIC PEAKS: SEP 1882 AND FEB 1896
WATER YEARS: 1904-1909, 1936-1939, 1942, 1945-1997
HISTORIC PERIOD: 1800-1997
ANNUAL OR HISTORIC PEAK DISCHARGES
PLOTTED AS • AT WEIBULL PLOT POSITION
FEB 1896 54700 CFS
SEP 1882 47840 CFS
AUG 1971 46100 CFS
OCT 1996 40,100 CFS
JAN 1996 32700 CFS
OCT 1903 32100 CFS
SEP 1938 31000 CFS
MAY 1968 27800 CFS
JAN 1979 34600 CFS
DEC 1992 20000 CFS
5% LIMIT CURVE
95% LIMIT CURVE
ADOPTED CURVE
PARTIAL DURATION ADOPTED CURVE
ANNUAL SERIES
EXCEEDENCE FREQUENCY IN PERCENT
PEAK DISCHARGE IN C.F.S.

Figure 10


K+E PROBABILITY X 2 LOG CYCLES KEUFFEL & ESSER CO.
46 8043
ADOPTED CURVE PEAK FLOWS, CFS:
1 YEAR 810 CFS 100 YEAR 4400 CFS
2 YEAR 1110 CFS 150 YEAR 5000 CFS
10 YEAR 2130 CFS 500 YEAR 6910 CFS
50 YEAR 3570 CFS
FREQUENCY CURVE STATISTICS:
MEAN LOGARITHM: 2.9890
STANDARD DEVIATION: 0.2438
COMPUTED SKEW : 0.6980
REGIONAL SKEW : 0.3000
ADOPTED SKEW : 0.5000
5% LIMIT CURVE
ADOPTED CURVE
95% LIMIT CURVE
JULY 1975 4920 CFS
SEPT 1989 4360 CFS
AUG 1971 2920 CFS
FEB 1973 2110 CFS
SEPT 1938 2660 CFS
SEPT 1944 2220 CFS
SEPT 1975 1940 CFS
DEC 1992 1270 CFS
ADOPTED CURVE
ANNUAL SERIES
ADOPTED CURVE PARTIAL DURATION
PEAK DISCHARGE IN CFS
EXISTING CONDITIONS
PEAK DISCHARGE VS.
FREQUENCY CURVE:
LAWRENCE BROOK AT
FARRINGTON DAM, N.J.
USGS GAGE NO. 01405000
DRAINAGE AREA = 34.4 SQ. MI.
WATER YEARS 1927-1990, 1993-1995
• ANNUAL PEAK DISCHARGE
X PARTIAL PEAK DISCHARGE AT WEIBULL PLOT POSITION
EXCEEDENCE FREQUENCY IN PERCENT
Figure 11



ADOPTED CURVE
PEAK FLOWS, CFS:
1 YEAR 1450 CFS
2 YEAR 2050 CFS
10 YEAR 3500 CFS
50 YEAR 5170 CFS
100 YEAR 6050 CFS
150 YEAR 6600 CFS
500 YEAR 8350 CFS
EXISTING CONDITIONS PEAK DISCHARGE VS. FREQUENCY CURVE:
SOUTH RIVER AT OLD BRIDGE, N.J.
USGS GAGE No. 01405500
DRAINAGE AREA = 94.60 SQ.M.
WATER YEARS 1940 - 1980
• ANNUAL PEAK DISCHARGE AT WEIBULL PLOT
X PARTIAL PEAK DISCHARGE POSITION
FREQUENCY CURVE STATISTICS:
MEAN LOGARITHM: 3.2233
STANDARD DEVIATION: 0.2327
COMPUTED SKEW: -.0575
REGIONAL SKEW: 0.3000
ADOPTED SKEW: 0.1000
EXCEEDENCE FREQUENCY IN PERCENT
PEAK DISCHARGE IN CFS
5% LIMIT CURVE
95% LIMIT CURVE
ANNUAL SERIES
PARTIAL DURATION
DEC. 1992 2550 CFS (ESTIMATED)
SEPT. 1944 4250 CFS

Figure 12

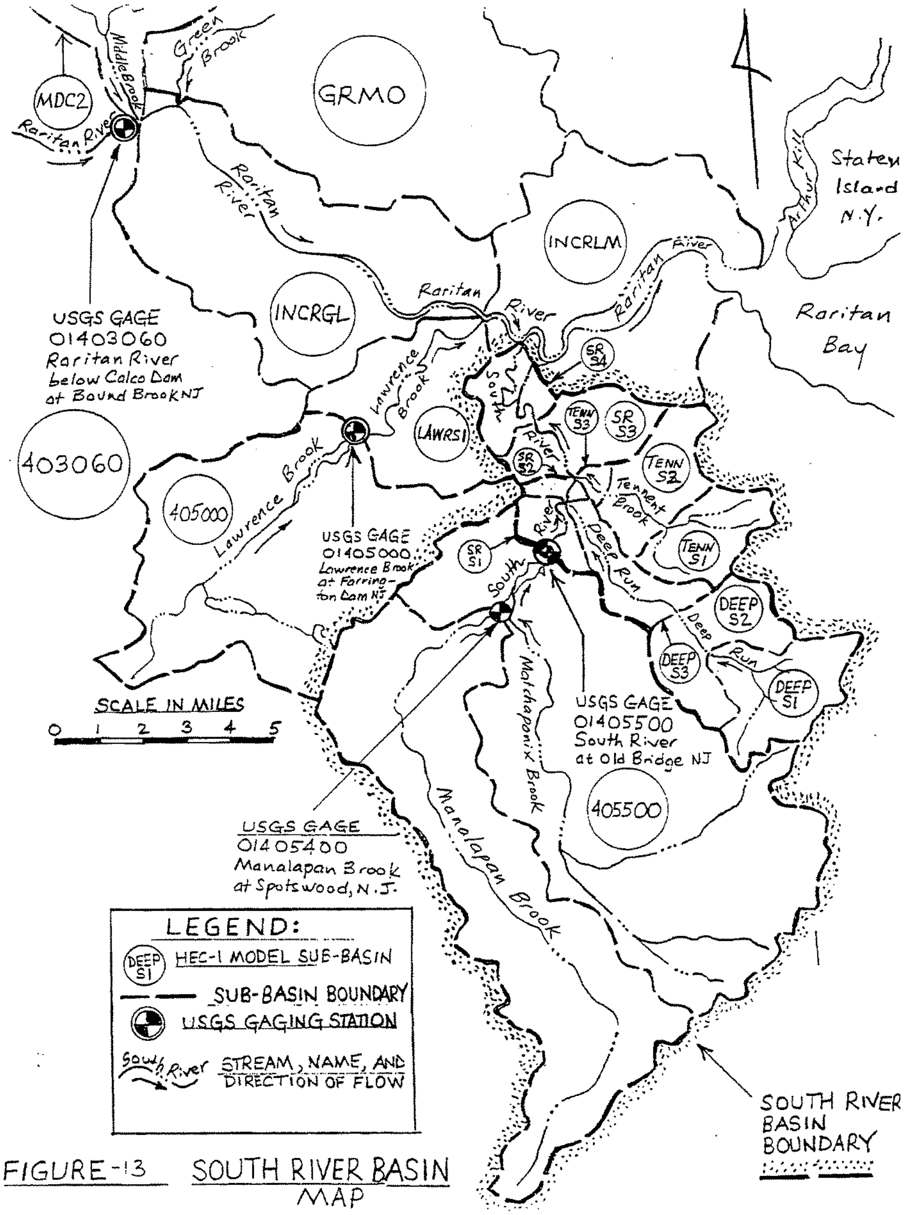


FIGURE-13 SOUTH RIVER BASIN MAP

SOUTH RIVER FEASIBILITY STUDY: HYDROLOGY
RARITAN BASIN-WIDE HEC-1 MODEL INPUT

SCHEMATIC DIAGRAM OF STREAM NETWORK

```
(V)   ROUTING            (--->)  DIVERSION OR PUMP FLOW
(.)   CONNECTOR          (<---)  RETURN OF DIVERTED OR PUMPED FLOW

403060 RARITAN RIVER AT BOUND BROOK NJ USGS GAGE
   .
   .
   .        MDC2 MIDDLE BROOK AT MOUTH
   .           .
   .           .
   .           .       GRMO GREEN BROOK AT MOUTH
   .           .           .
   .           .           .
RADSGR.......................  RARITAN RIVER BELOW GREEN BROOK
   .
   .
   .      INCRGL GREEN BROOK TO LAWRENCE BROOK
   .           .
   .           .
   .           .------->  RCLLIN DIVERTED HALF OF SUB-BASIN HYDROGRAPH
   .      RSDLIN RESIDUAL HALF OF SUB-BASIN HYDROGRAPH
   .           .
   .           .
RRINFL............  INFLOW TO ROUTING REACH
   V
   V
RARTLB ROUTE TO LAWRENCE BROOK CONFLUENCE
   .
   .
   .           .<-------  RCLLIN DIVERTED HALF OF SUB-BASIN HYDROGRAPH
   .      RCLLIN DIVERTED HALF OF SUB-BASIN HYDROGRAPH
   .           .
   .           .
RAUSLB............  RARITAN RIVER ABOVE LAWRENCE BROOK
   .
   .
   .      405000 LAWRENCE BROOK AT FARRINGTON DAM USGS GAGE
   .           V
   .           V
   .      LAWRR1 ROUTE TO MOUTH
   .           .
   .           .
   .           .       LAWRS1 SUBAREA - DAM TO MOUTH
   .           .           .
   .           .           .
   .      LAWRC1............  LAWRENCE BROOK AT MOUTH
   .           .
   .           .
RADSLB............  RARITAN RIVER DOWNSTREAM OF LAWRENCE BROOK
   V
   V
RARTSR ROUTE TO SOUTH RIVER CONFLUENCE (RARITAN RIVER ABOVE SOUTH RIVER)
   .
   .
   .      405500 USGS GAGE: SOUTH RIVER AT OLD BRIDGE, NJ
   .           V
   .           V
   .        SRR1 ROUTE TO CONFLUENCE WITH DEEP RUN
   .           .
   .           .
```

Figure 13a

```
.        .     SRS1 INCREMENT: USGS GAGE AT OLD BRIDGE TO CONFLUENCE WITH DEEP RUN
.        .        .
.        .        .
.   SRC1............ SOUTH RIVER ABOVE DEEP RUN
.        .
.        .
.        .   DEEPS1 DEEP RUN NEAR INTERSECTION RTS. 9 AND 18
.        .        .
.        .        .
.        .        .       DEEPS2 INCREMENT TO RT. 9 CROSSING
.        .        .          .
.        .        .          .
.        .   DEEPC1............ DEEP RUN AT RT. 9
.        .        V
.        .        V
.        .   DEEPR1 ROUTE TO HEC-RAS REACH
.        .        V
.        .        V
.        .   DEEPR2 ROUTE TO MOUTH
.        .        .
.        .        .
.        .        .       DEEPS3 INCREMENT: ROUTE 9 TO MOUTH
.        .        .          .
.        .        .          .
.        .   DEEPC2............ DEEP RUN AT MOUTH
.        .        .
.        .        .
.   SRC2............ SOUTH RIVER BELOW DEEP RUN
.        V
.        V
.   SRR2 ROUTE TO CONFLUENCE WITH TENNENT BROOK
.        .
.        .
.        .     SRS2 INCREMENT: TO TENNENT BROOK
.        .        .
.        .        .
.   SRC3............ SOUTH RIVER ABOVE TENNENT BROOK
.        .
.        .
.        .   TENNS1 TENNENT BROOK AT GOLF COURSE
.        .        .
.        .        .
.        .        .       TENNS2 INCREMENT: TO TENNENT POND DAM
.        .        .          .
.        .        .          .
.        .   TENNC1............ INFLOW TO ROUTING REACH
.        .        V
.        .        V
.        .   TENNR1 TENNENT BROOK AT TENNENT POND DAM
.        .        .
.        .        .
.        .        .       TENNS3 INCREMENT: TO MOUTH
.        .        .          .
.        .        .          .
.        .   TENNC2............ INFLOW TO ROUTING REACH
.        .        V
.        .        V
.        .   TENNR2 TENNENT BROOK AT MOUTH
.        .        .
.        .        .
.   SRC4............ SOUTH RIVER BELOW TENNENT BROOK
.        .
.        .
.        .     SRS3 INCREMENT: TO VETERANS MEMORIAL BRIDGE
.        .        .
.        .        .
.   SRC5............ INFLOW TO ROUTING REACH
.        V
.        V
```

Figure 13a (con't)

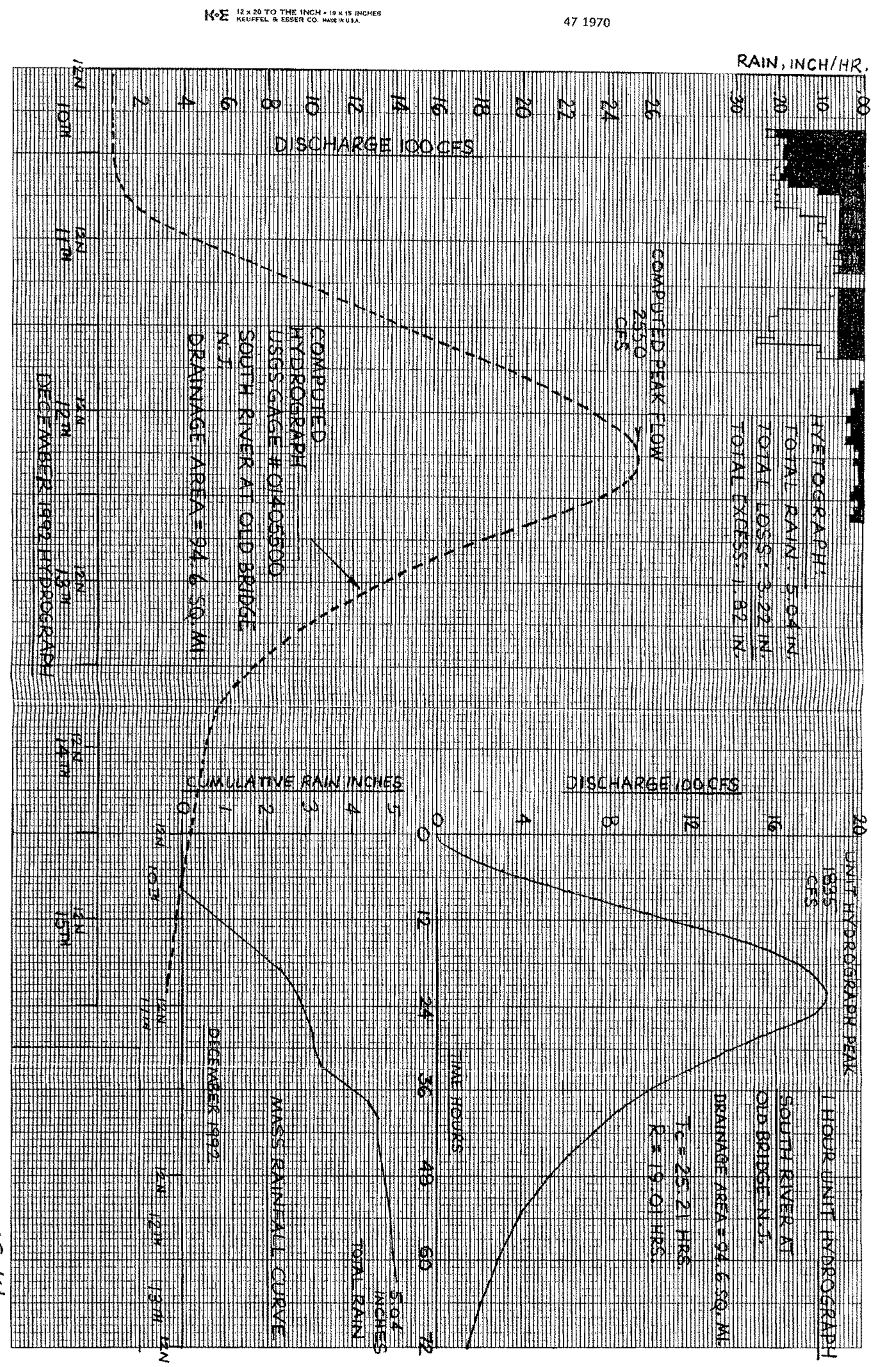


FIG 14 a Figure 14:

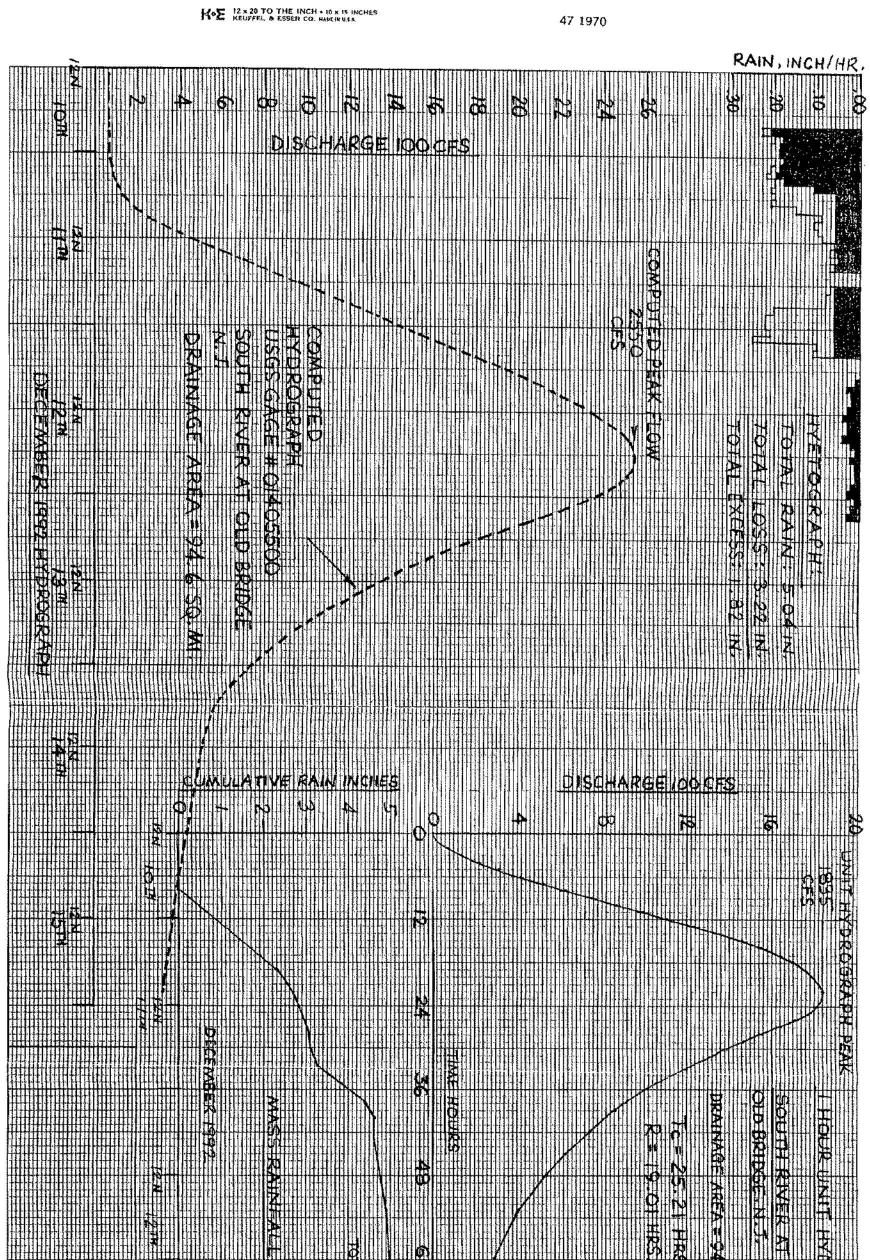


FIG 14a Figure 14:

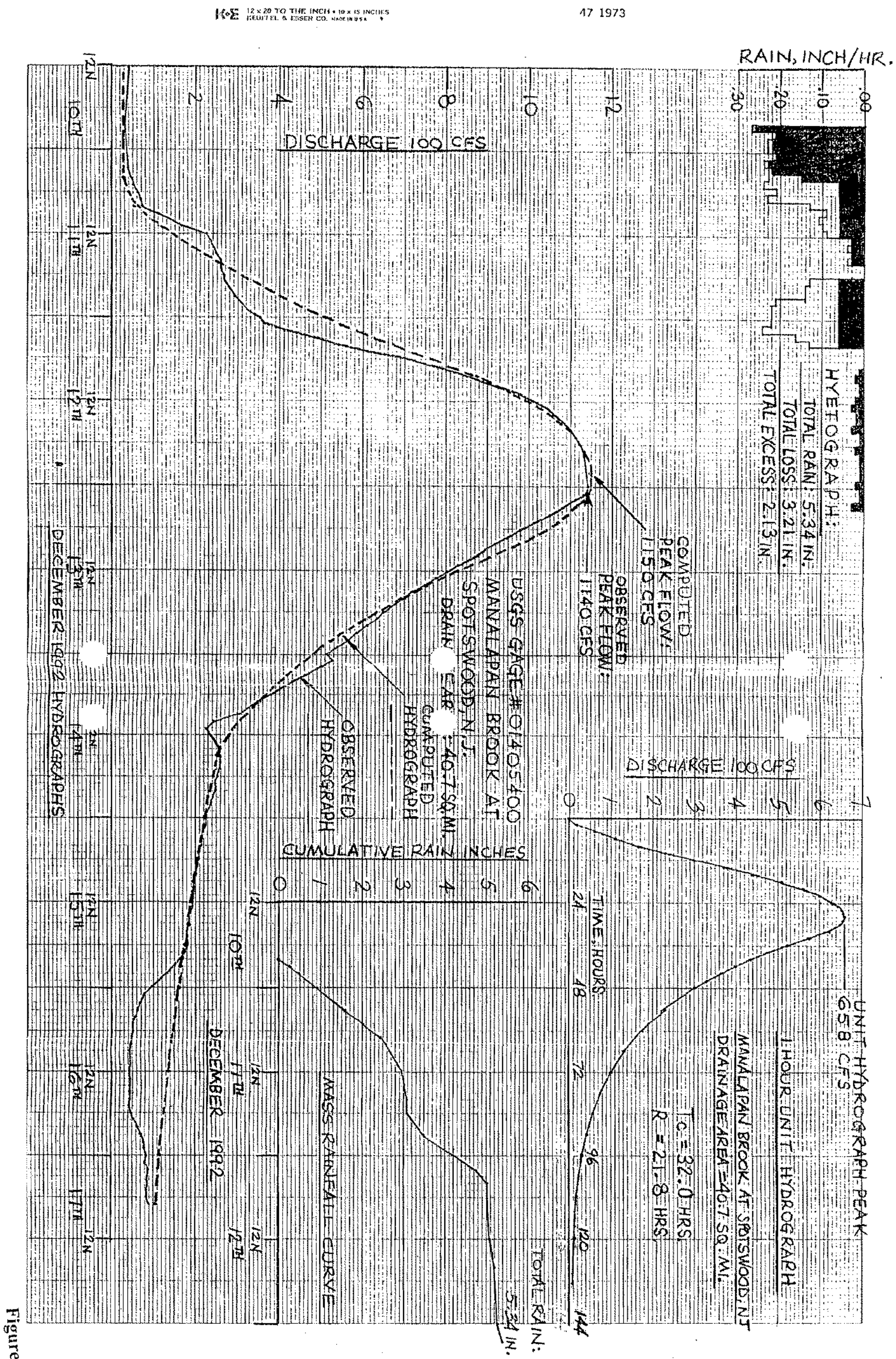

K+E 12 x 20 TO THE INCH
47 1973
RAIN, INCH/HR.
HYETOGRAPH:
TOTAL RAIN: 5.34 IN.
TOTAL LOSS: 3.21 IN.
TOTAL EXCESS: 2.13 IN.
DISCHARGE 100 CFS
COMPUTED PEAK FLOW: 1150 CFS
OBSERVED PEAK FLOW: 1140 CFS
USGS GAGE #01405400
MANALAPAN BROOK AT SPOTSWOOD, N.J.
DRAIN. AREA: 40.7 SQ.MI.
COMPUTED HYDROGRAPH
OBSERVED HYDROGRAPH
DECEMBER 1992 HYDROGRAPHS
UNIT HYDROGRAPH PEAK 658 CFS
1-HOUR UNIT HYDROGRAPH
MANALAPAN BROOK AT SPOTSWOOD, NJ
DRAINAGE AREA = 40.7 SQ. MI.
Tc = 32.0 HRS
R = 21.8 HRS
TIME, HOURS
CUMULATIVE RAIN, INCHES
MASS RAINFALL CURVE
DECEMBER 1992
TOTAL RAIN: 5.34 IN.

Figure 14

K+E 12 X 20 TO THE INCH • 10 X 15 INCHES KEUFFEL & ESSER CO.

47 1970

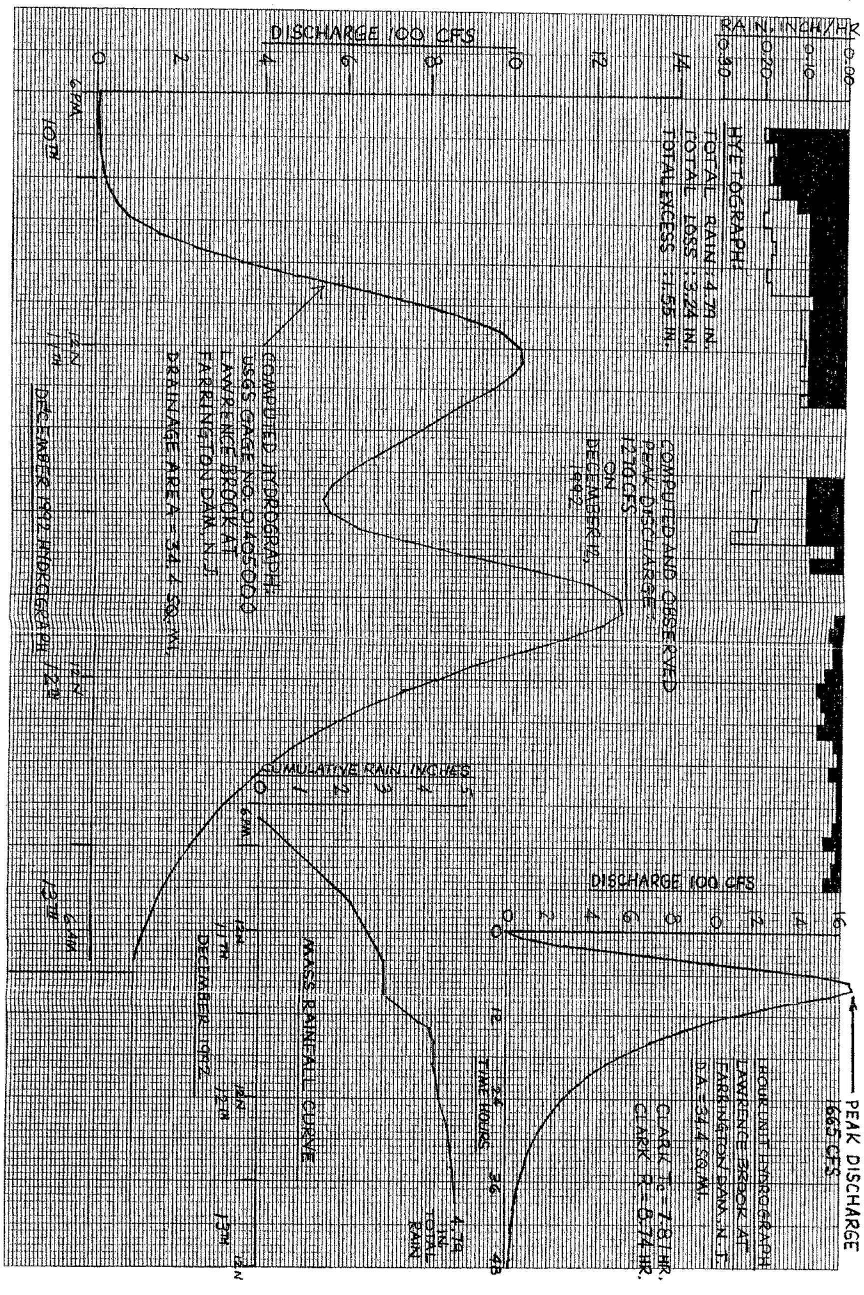


FIG 14C

Figure 14

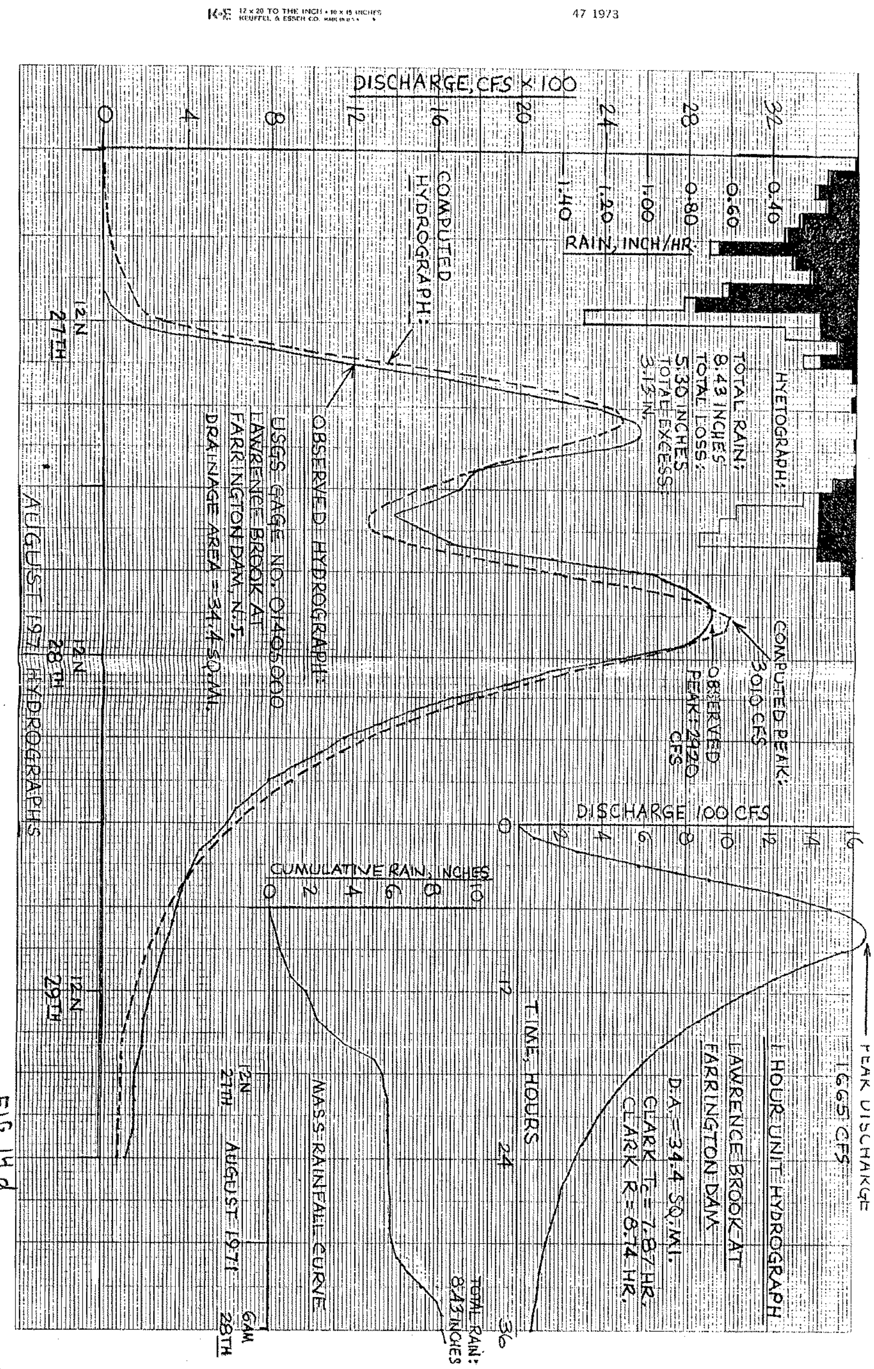

K+E 12 x 20 TO THE INCH • 10 x 15 INCHES KEUFFEL & ESSER CO.
47 1973
DISCHARGE, CFS x 100
RAIN, INCH/HR.
HYETOGRAPH:
TOTAL RAIN: 8.43 INCHES
TOTAL LOSS: 5.30 INCHES
TOTAL EXCESS: 3.13 IN.
COMPUTED HYDROGRAPH:
OBSERVED HYDROGRAPH:
USGS GAGE NO. 01405000
LAWRENCE BROOK AT FARRINGTON DAM, N.J.
DRAINAGE AREA = 34.4 SQ. MI.
COMPUTED PEAK: 3010 CFS
OBSERVED PEAK: 2920 CFS
AUGUST 1971 HYDROGRAPHS
12N 27TH
12N 28TH
12N 29TH
DISCHARGE 100 CFS
CUMULATIVE RAIN, INCHES
PEAK DISCHARGE 1665 CFS
1 HOUR UNIT HYDROGRAPH
LAWRENCE BROOK AT FARRINGTON DAM
D.A. = 34.4 SQ. MI.
CLARK T_c = 7.87 HR.
CLARK R = 8.74 HR.
TIME, HOURS
MASS-RAINFALL CURVE
TOTAL RAIN: 8.43 INCHES
12N 27TH
AUGUST 1971
6AM 28TH
FIG 14 d

Figure 14

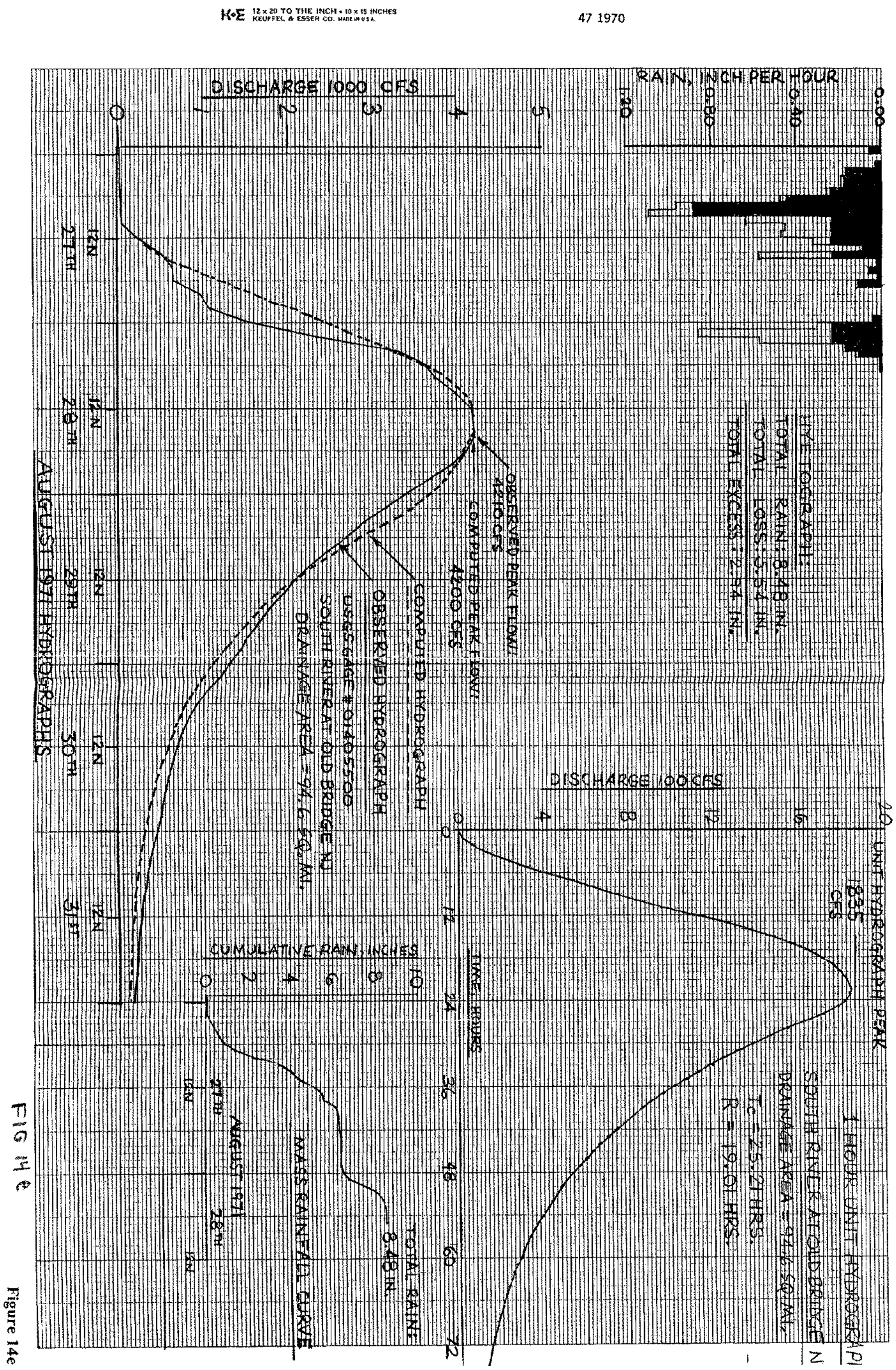

K+E 12 x 20 TO THE INCH • 10 x 15 INCHES
KEUFFEL & ESSER CO.
47 1970
DISCHARGE 1000 CFS
RAIN, INCH PER HOUR
HYETOGRAPH:
TOTAL RAIN: 8.48 IN.
TOTAL LOSS: 5.54 IN.
TOTAL EXCESS: 2.94 IN.
OBSERVED PEAK FLOW: 4210 CFS
COMPUTED PEAK FLOW: 4200 CFS
COMPUTED HYDROGRAPH
OBSERVED HYDROGRAPH
SOUTH RIVER AT OLD BRIDGE NJ
DRAINAGE AREA = 94.6 SQ. MI.
AUGUST 1971 HYDROGRAPHS
DISCHARGE 100 CFS
UNIT HYDROGRAPH PEAK
1835 CFS
1 HOUR UNIT HYDROGRAPH
SOUTH RIVER AT OLD BRIDGE N.J.
DRAINAGE AREA = 94.6 SQ. MI.
Tc = 25.27 HRS.
R = 19.01 HRS.
TIME, HOURS
CUMULATIVE RAIN, INCHES
AUGUST 1971
TOTAL RAIN
8.48 IN.
MASS RAINFALL CURVE
FIG 14e

Figure 14e

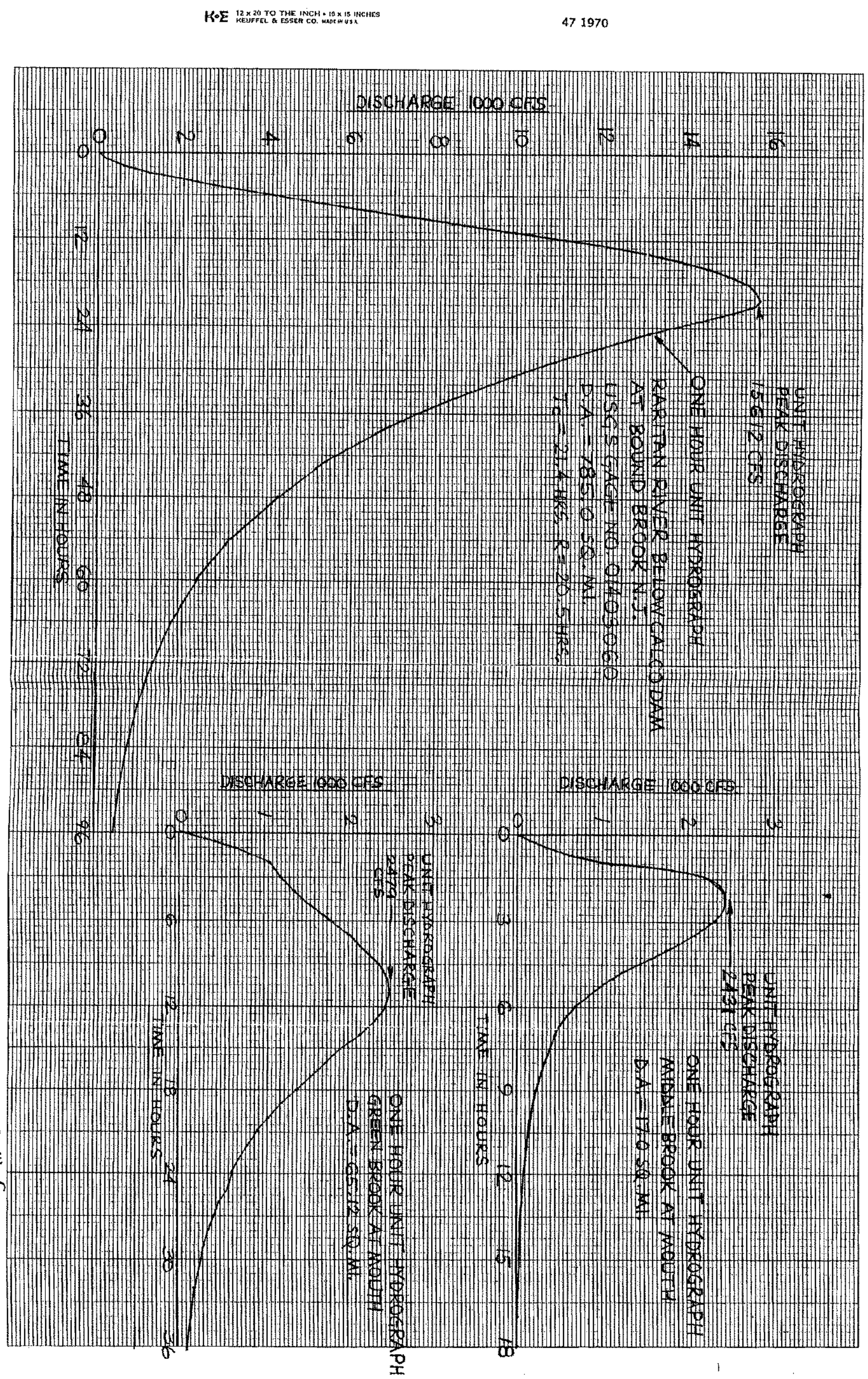
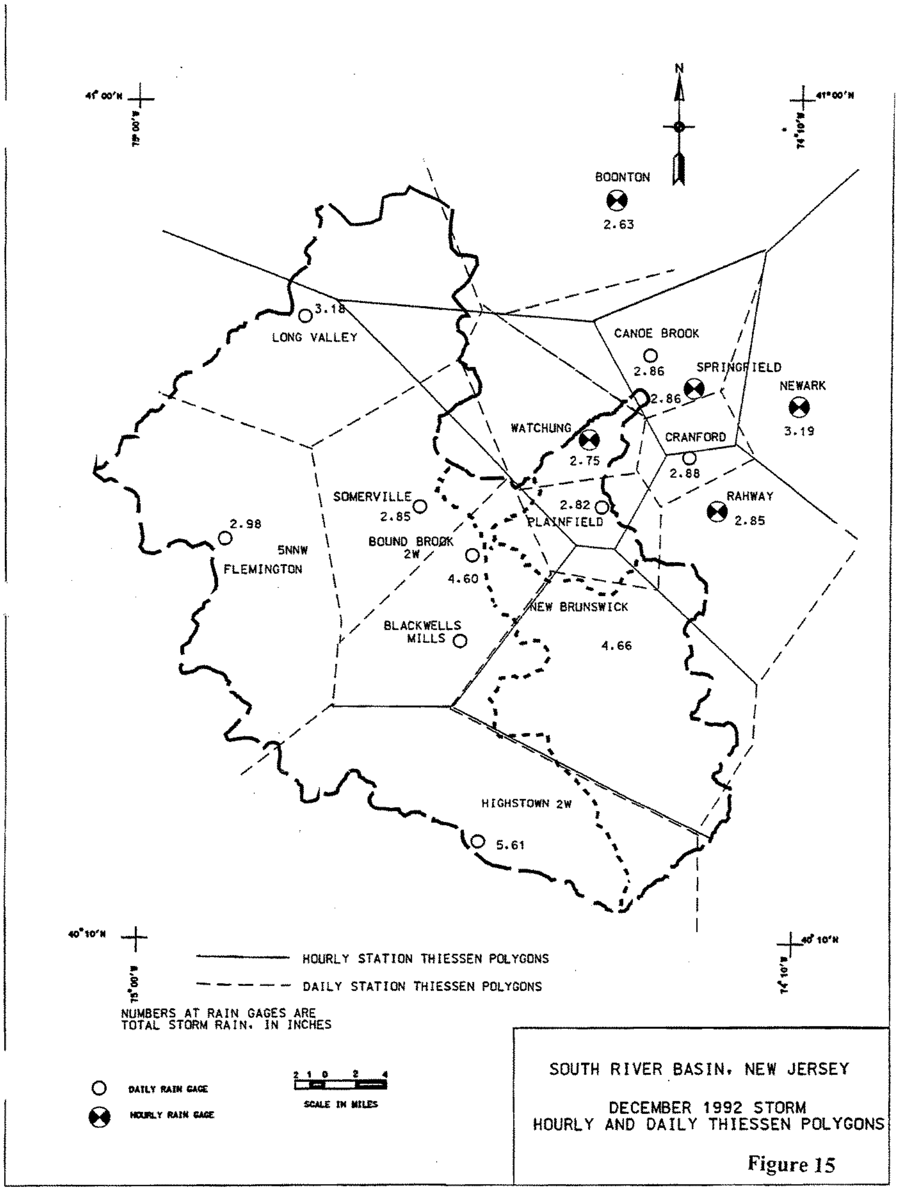

K•E 12 x 20 TO THE INCH • 10 x 15 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.
47 1970
UNIT HYDROGRAPH PEAK DISCHARGE 15612 CFS
ONE HOUR UNIT HYDROGRAPH
RARITAN RIVER BELOW CALCO DAM AT BOUND BROOK N.J.
USGS GAGE NO. 01403060
D.A. = 785.0 SQ. MI.
Tc = 21.4 HRS. R = 20.5 HRS.
DISCHARGE 1000 CFS
TIME IN HOURS
UNIT HYDROGRAPH PEAK DISCHARGE 2431 CFS
ONE HOUR UNIT HYDROGRAPH
MIDDLE BROOK AT MOUTH
D.A. = 17.0 SQ. MI.
UNIT HYDROGRAPH PEAK DISCHARGE 2479 CFS
ONE HOUR UNIT HYDROGRAPH
GREEN BROOK AT MOUTH
D.A. = 65.12 SQ. MI.
FIG 14 f

Figure 14f



N
BOONTON
2.63
3.18
LONG VALLEY
CANOE BROOK
2.86
SPRINGFIELD
2.86
NEWARK
3.19
WATCHUNG
2.75
CRANFORD
2.88
SOMERVILLE
2.85
2.82
PLAINFIELD
RAHWAY
2.85
2.98
5NNW
FLEMINGTON
BOUND BROOK 2W
4.60
NEW BRUNSWICK
4.66
BLACKWELLS MILLS
HIGHSTOWN 2W
5.61
HOURLY STATION THIESSEN POLYGONS
DAILY STATION THIESSEN POLYGONS
NUMBERS AT RAIN GAGES ARE TOTAL STORM RAIN, IN INCHES
DAILY RAIN GAGE
HOURLY RAIN GAGE
SCALE IN MILES
SOUTH RIVER BASIN, NEW JERSEY
DECEMBER 1992 STORM
HOURLY AND DAILY THIESSEN POLYGONS

Figure 15

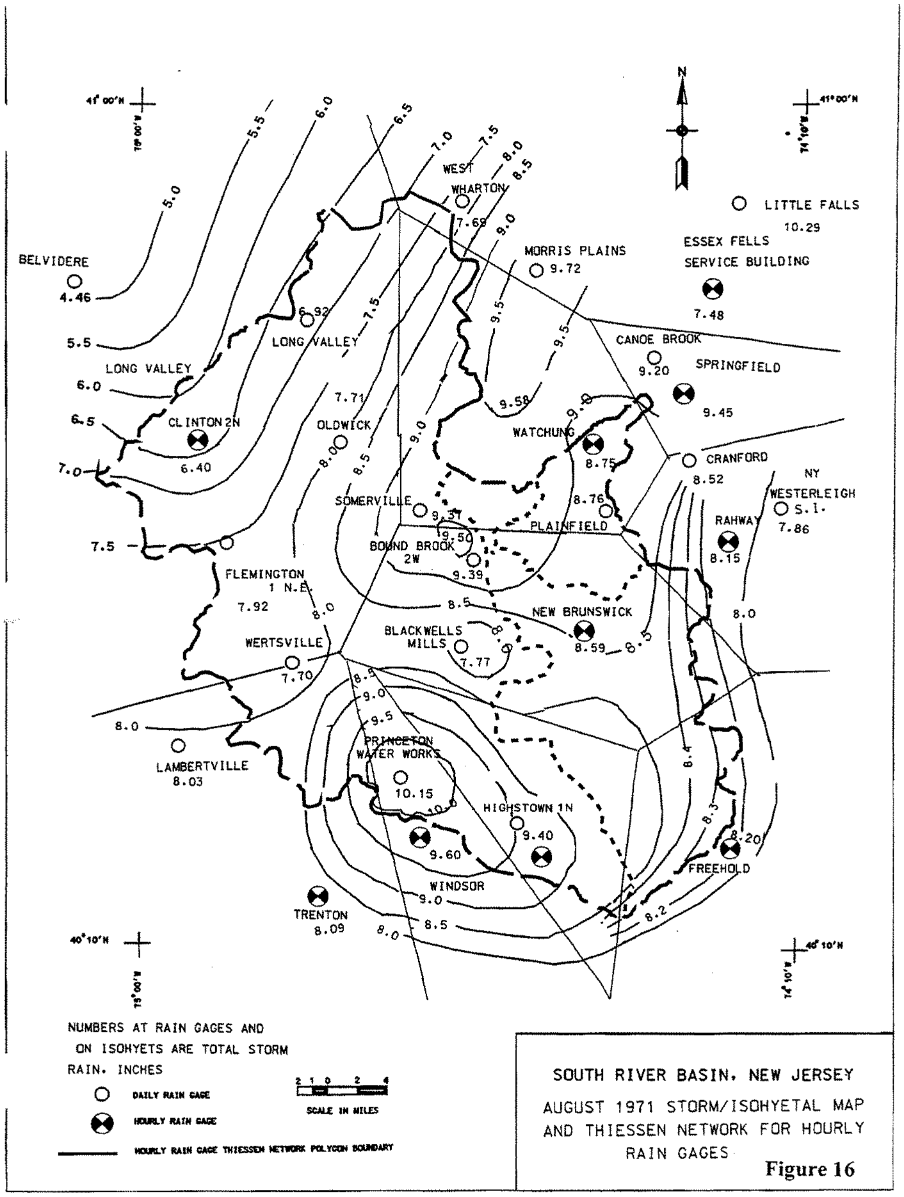

BELVIDERE
4.46
LONG VALLEY
6.92
CLINTON 2N
6.40
OLDWICK
8.00
7.71
WEST WHARTON
7.69
MORRIS PLAINS
9.72
LITTLE FALLS
10.29
ESSEX FELLS SERVICE BUILDING
7.48
CANOE BROOK
9.20
SPRINGFIELD
9.45
9.58
WATCHUNG
8.75
CRANFORD
8.52
NY WESTERLEIGH S.I.
7.86
RAHWAY
8.15
SOMERVILLE
9.57
PLAINFIELD
8.76
BOUND BROOK 2W
9.50
9.39
FLEMINGTON 1 N.E.
7.92
NEW BRUNSWICK
8.59
BLACKWELLS MILLS
7.77
WERTSVILLE
7.70
LAMBERTVILLE
8.03
PRINCETON WATER WORKS
10.15
HIGHSTOWN 1N
9.40
9.60
WINDSOR
FREEHOLD
8.20
TRENTON
8.09
NUMBERS AT RAIN GAGES AND ON ISOHYETS ARE TOTAL STORM RAIN, INCHES
DAILY RAIN GAGE
HOURLY RAIN GAGE
HOURLY RAIN GAGE THIESSEN NETWORK POLYGON BOUNDARY
SCALE IN MILES
SOUTH RIVER BASIN, NEW JERSEY
AUGUST 1971 STORM/ISOHYETAL MAP AND THIESSEN NETWORK FOR HOURLY RAIN GAGES

Figure 16

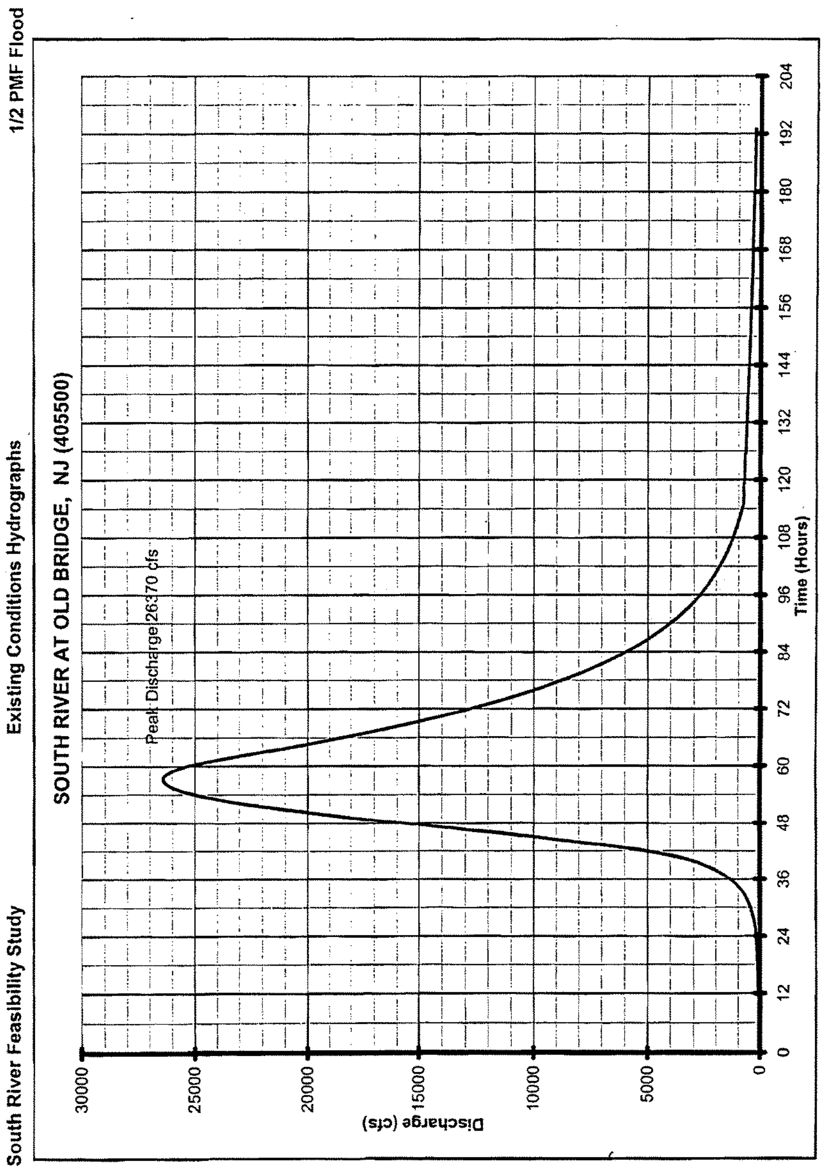

South River Feasibility Study
Existing Conditions Hydrographs
1/2 PMF Flood
SOUTH RIVER AT OLD BRIDGE, NJ (405500)
Peak Discharge 26370 cfs
Discharge (cfs)
Time (Hours)

Figure 17a

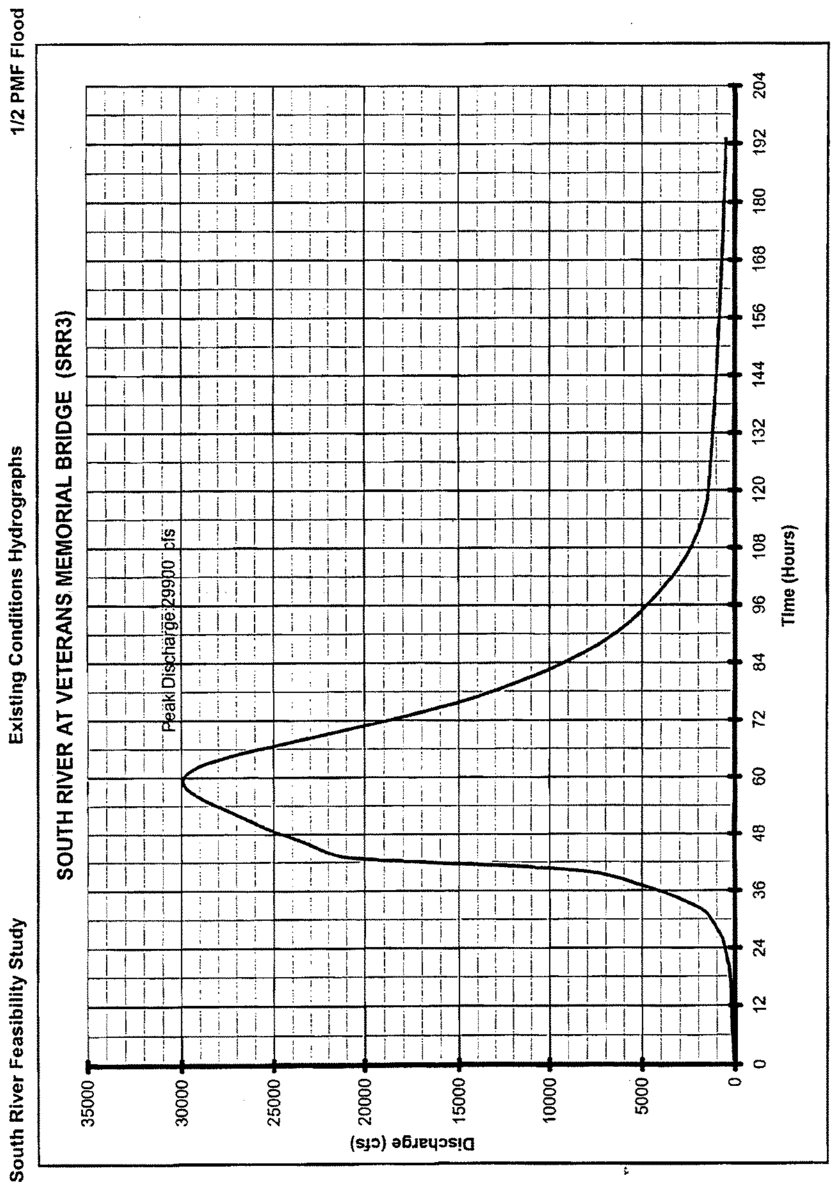

South River Feasibility Study
Existing Conditions Hydrographs
1/2 PMF Flood
SOUTH RIVER AT VETERANS MEMORIAL BRIDGE (SRR3)
Peak Discharge 29900 cfs
Discharge (cfs)
35000
30000
25000
20000
15000
10000
5000
0
0
12
24
36
48
60
72
84
96
108
120
132
144
156
168
180
192
204
Time (Hours)

Figure 17b

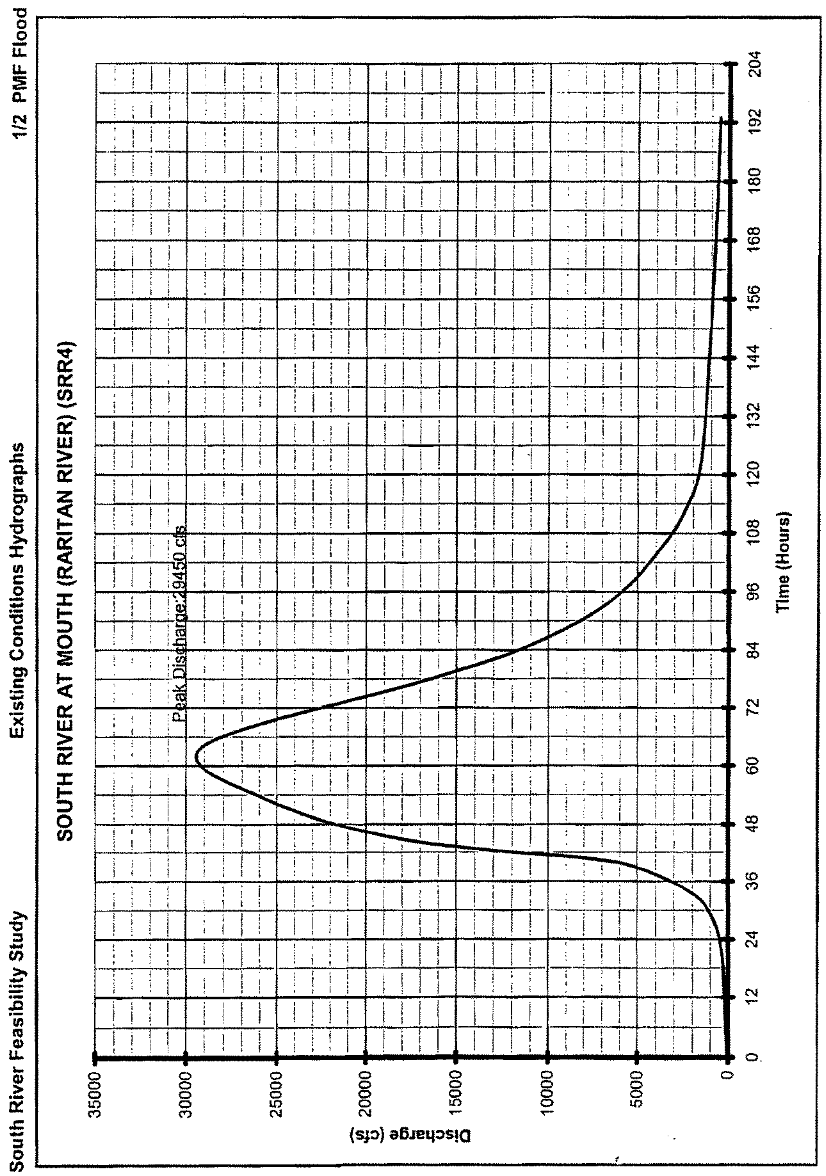

South River Feasibility Study
Existing Conditions Hydrographs
1/2 PMF Flood
SOUTH RIVER AT MOUTH (RARITAN RIVER) (SRR4)
Peak Discharge: 29450 cfs
Discharge (cfs)
35000
30000
25000
20000
15000
10000
5000
0
0
12
24
36
48
60
72
84
96
108
120
132
144
156
168
180
192
204
Time (Hours)

Figure 17c

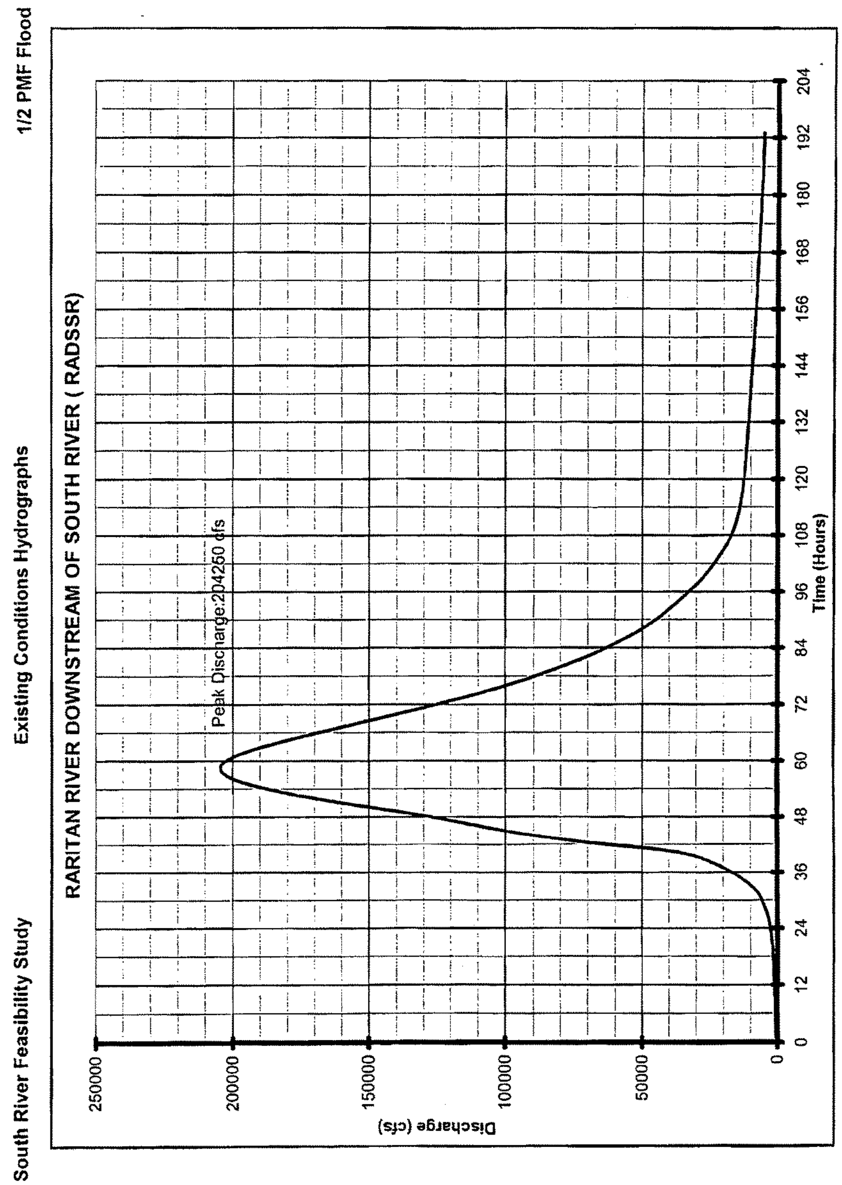

South River Feasibility Study
Existing Conditions Hydrographs
1/2 PMF Flood
RARITAN RIVER DOWNSTREAM OF SOUTH RIVER (RADSSR)
Peak Discharge:204260 cfs
Discharge (cfs)
Time (Hours)
250000
200000
150000
100000
50000
0
0
12
24
36
48
60
72
84
96
108
120
132
144
156
168
180
192
204

Figure 17d

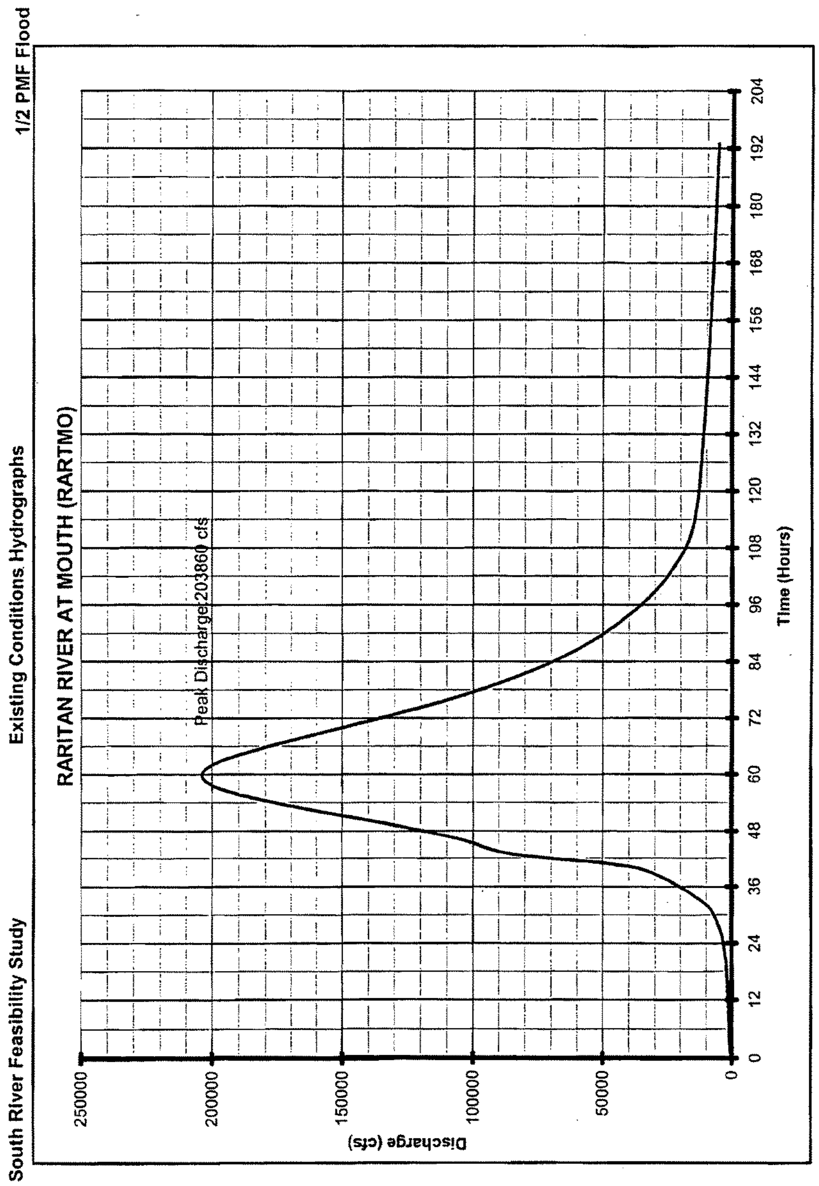

South River Feasibility Study
Existing Conditions Hydrographs
1/2 PMF Flood
RARITAN RIVER AT MOUTH (RARTMO)
Peak Discharge 203860 cfs
Discharge (cfs)
250000
200000
150000
100000
50000
0
Time (Hours)
0
12
24
36
48
60
72
84
96
108
120
132
144
156
168
180
192
204

Figure 17e

South River Feasibility Study | Existing Conditions Hydrographs | 150 - Year Flood

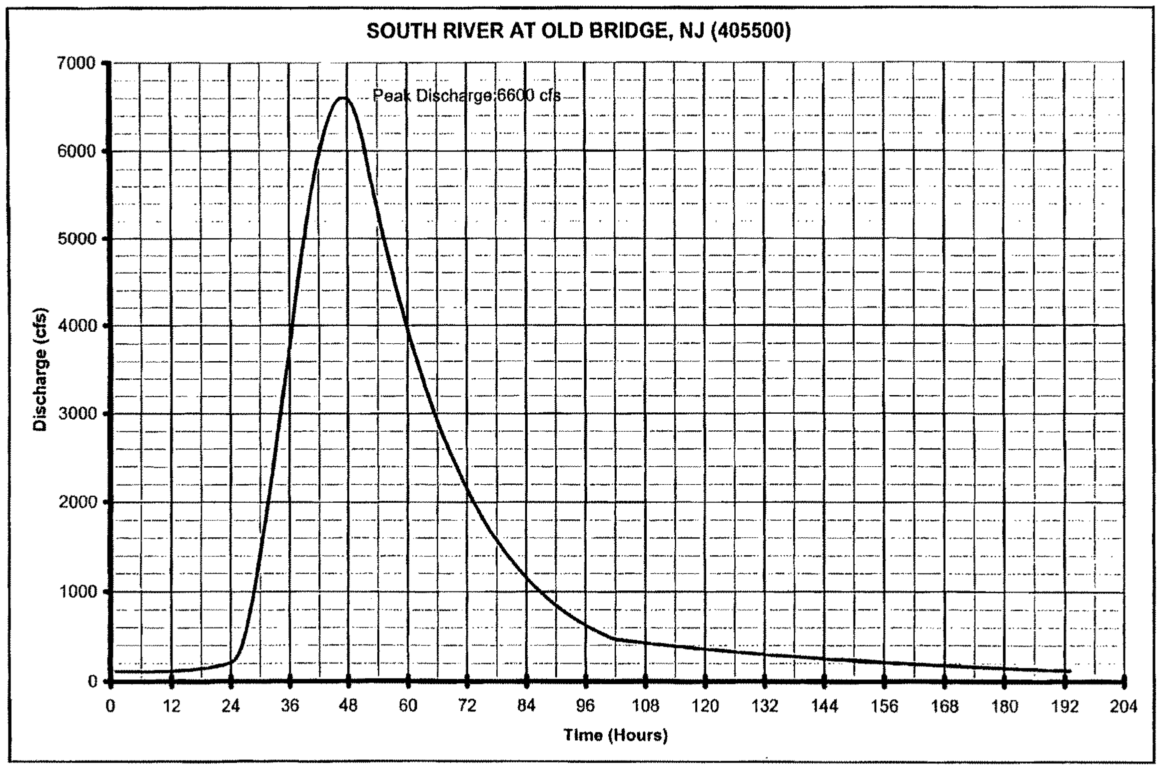


Figure 17f

South River Feasibility Study	Existing Conditions Hydrographs	150 - Year Flood

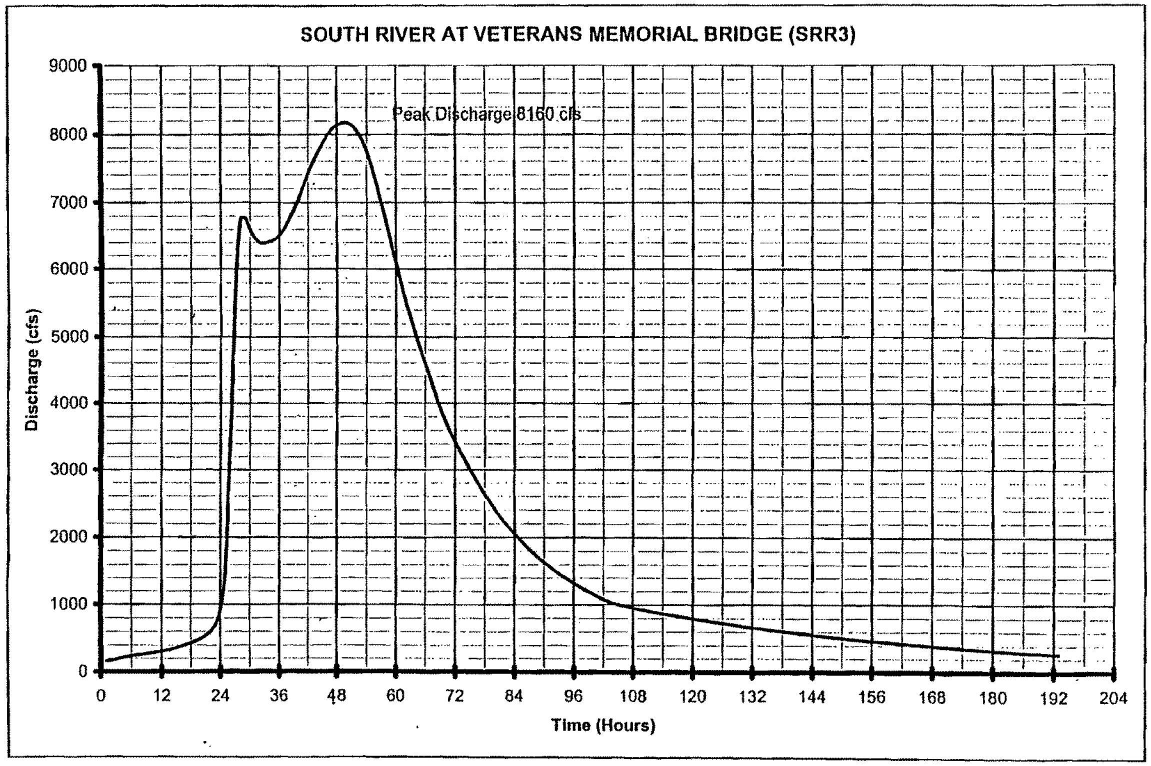


Figure 17g

South River Feasibility Study | Existing Conditions Hydrographs | 150 - Year Flood

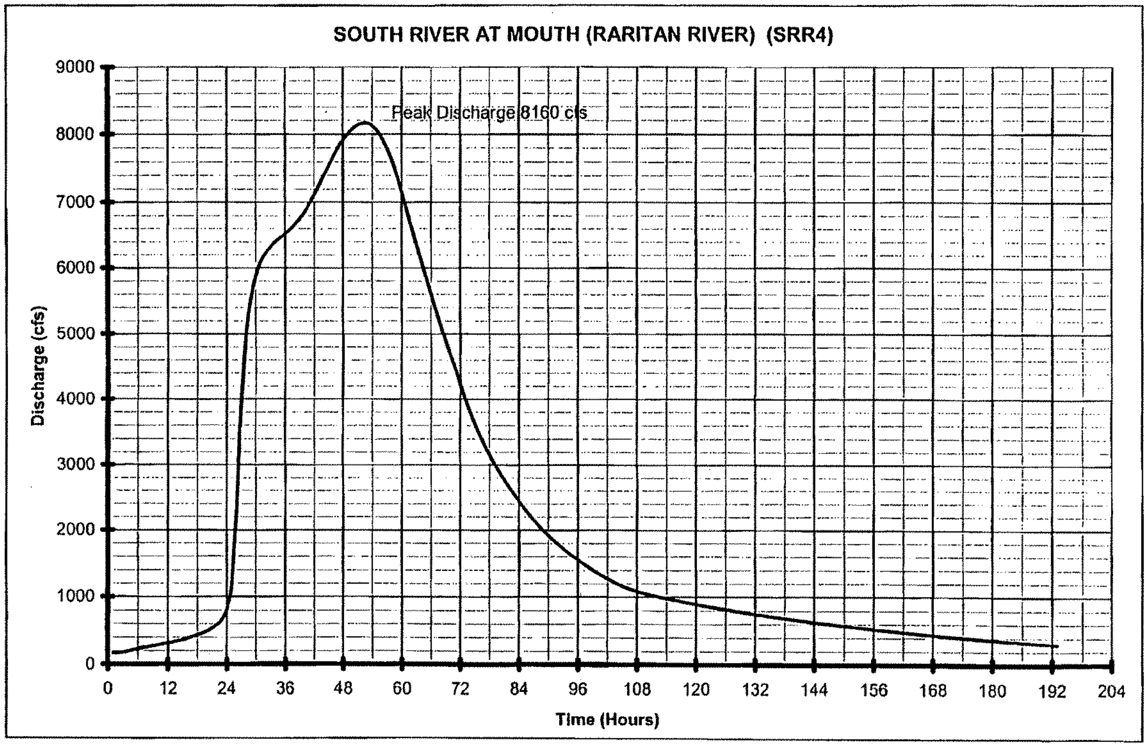


Figure 17h

South River Feasibility Study | Existing Conditions Hydrographs | 150 - Year Flood

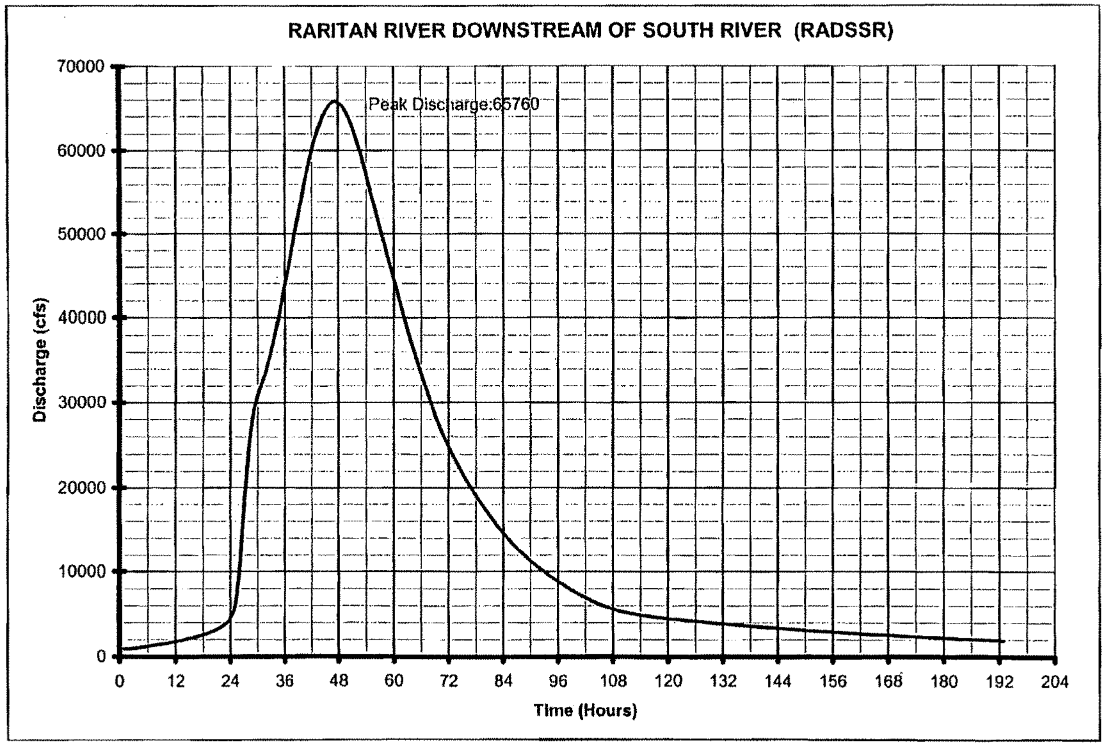


Figure 17i

South River Feasibility Study — Existing Conditions Hydrographs — 150 - Year Flood

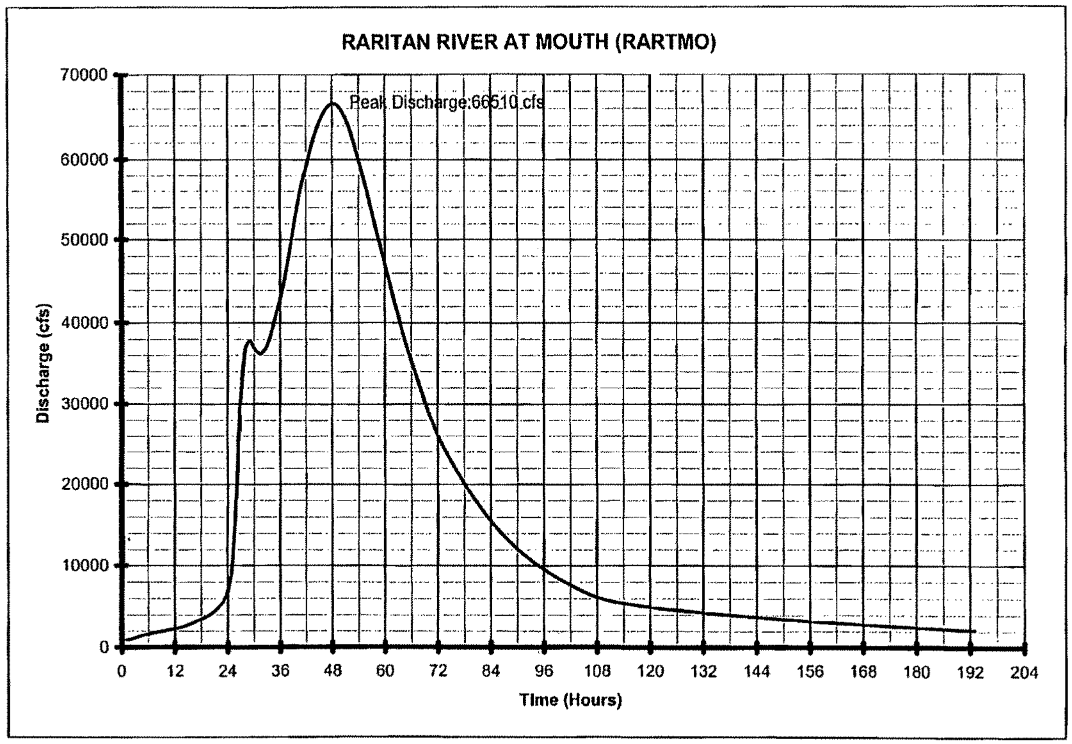


Figure 17j

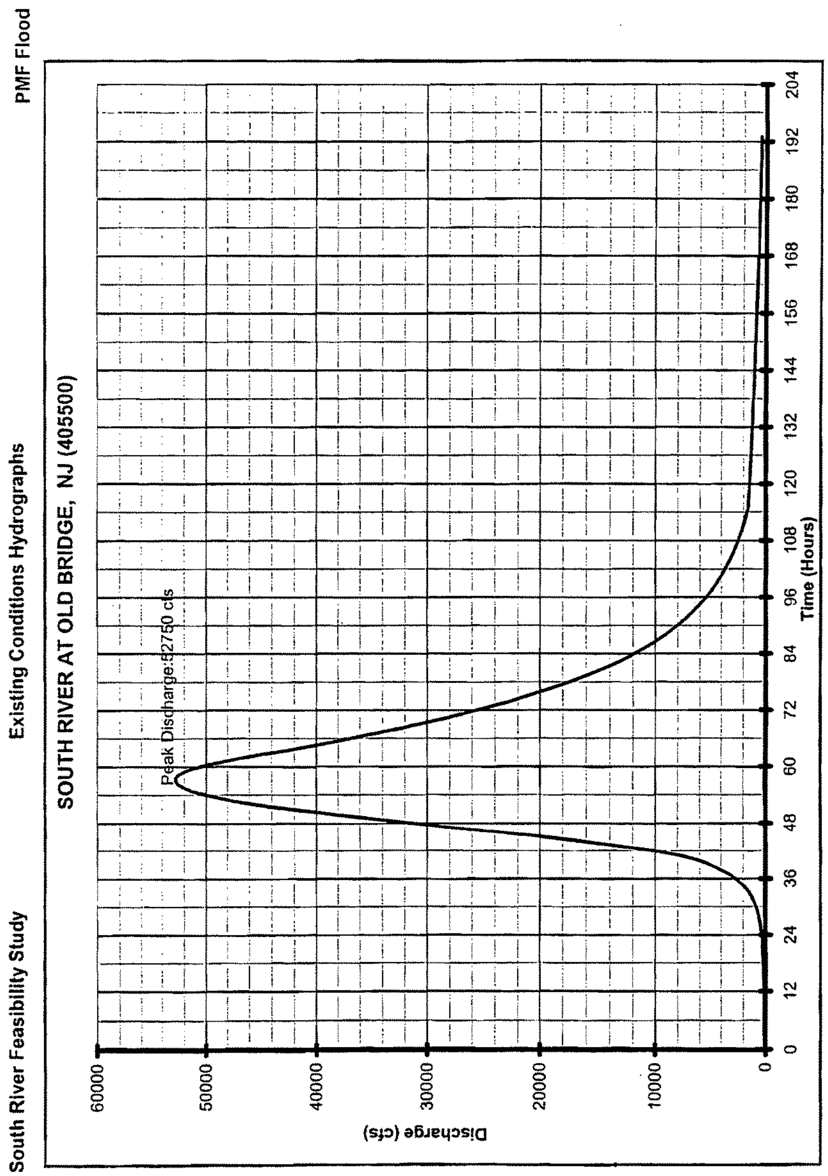

South River Feasibility Study
Existing Conditions Hydrographs
PMF Flood
SOUTH RIVER AT OLD BRIDGE, NJ (405500)
Peak Discharge:52750 cfs
Discharge (cfs)
60000
50000
40000
30000
20000
10000
0
0
12
24
36
48
60
72
84
96
108
120
132
144
156
168
180
192
204
Time (Hours)

Figure 17k

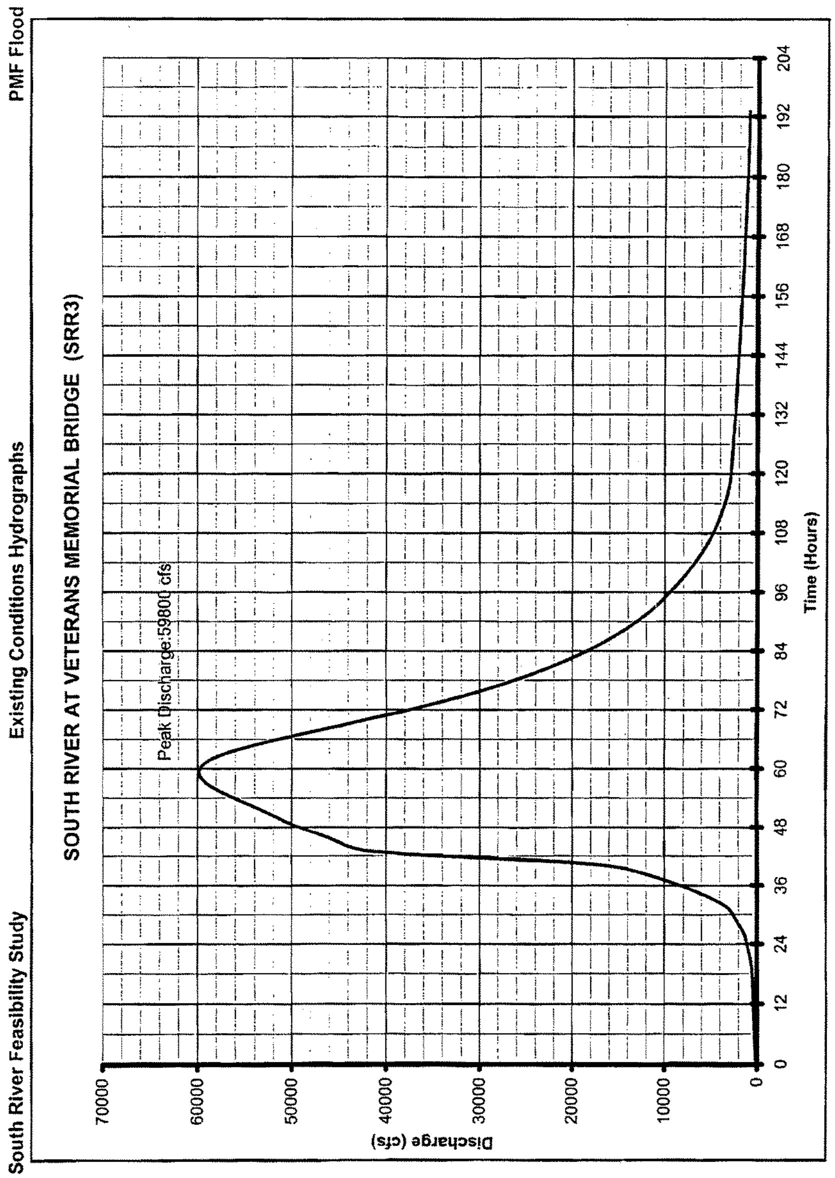

South River Feasibility Study
Existing Conditions Hydrographs
PMF Flood
SOUTH RIVER AT VETERANS MEMORIAL BRIDGE (SRR3)
Peak Discharge:59800 cfs
Discharge (cfs)
70000
60000
50000
40000
30000
20000
10000
0
0
12
24
36
48
60
72
84
96
108
120
132
144
156
168
180
192
204
Time (Hours)

Figure 171

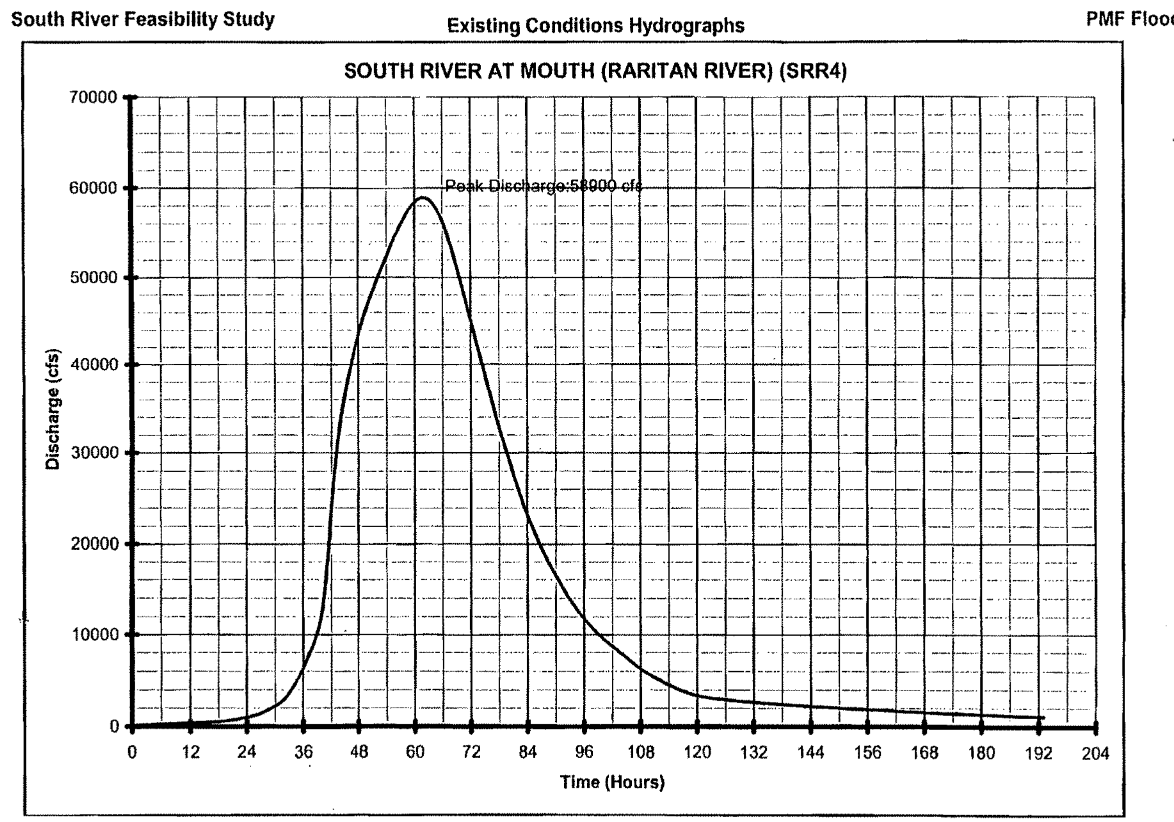

South River Feasibility Study
Existing Conditions Hydrographs
PMF Flood
SOUTH RIVER AT MOUTH (RARITAN RIVER) (SRR4)
Peak Discharge:58000 cfs
Discharge (cfs)
70000
60000
50000
40000
30000
20000
10000
0
0
12
24
36
48
60
72
84
96
108
120
132
144
156
168
180
192
204
Time (Hours)

Figure 17m

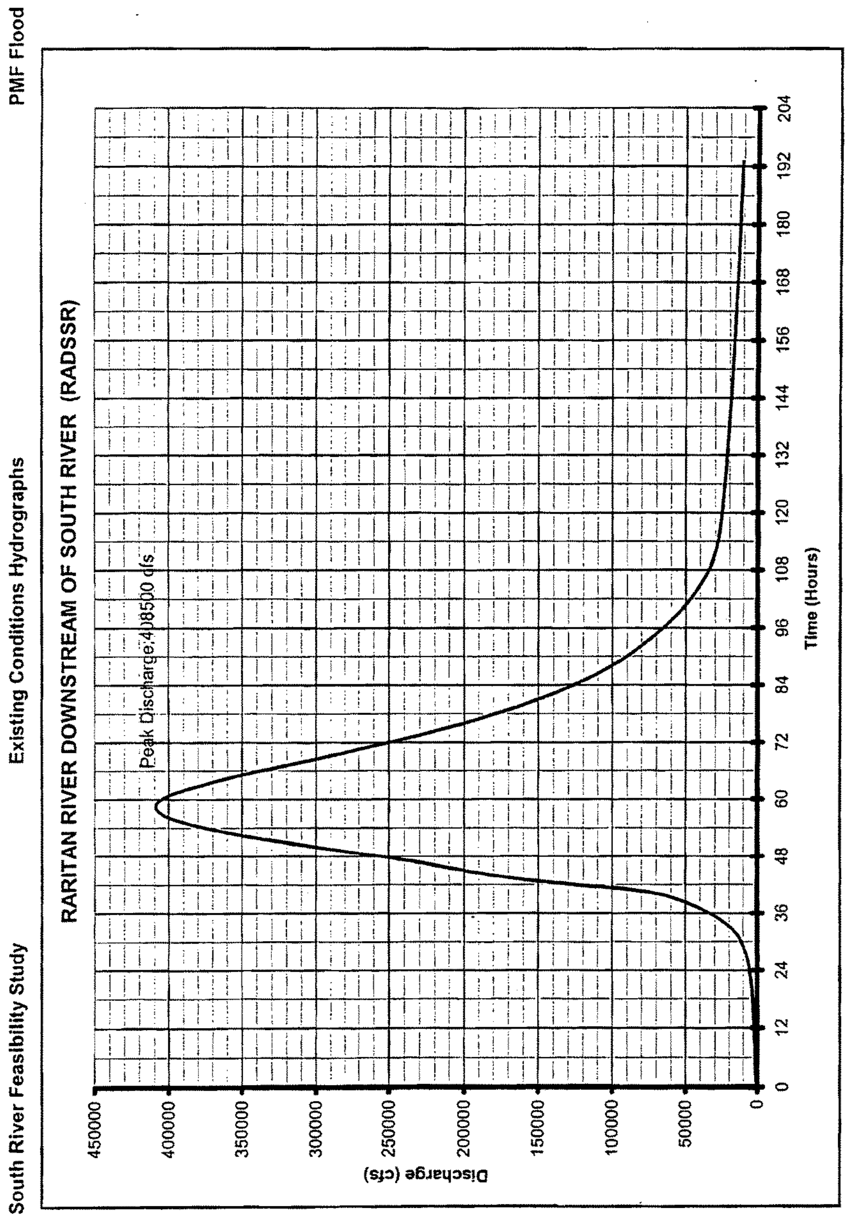

South River Feasibility Study
Existing Conditions Hydrographs
PMF Flood
RARITAN RIVER DOWNSTREAM OF SOUTH RIVER (RADSSR)
Peak Discharge:408500 cfs
Discharge (cfs)
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
0
12
24
36
48
60
72
84
96
108
120
132
144
156
168
180
192
204
Time (Hours)

Figure 17n

South River Feasibility Study | Existing Conditions Hydrographs | PMF Flood

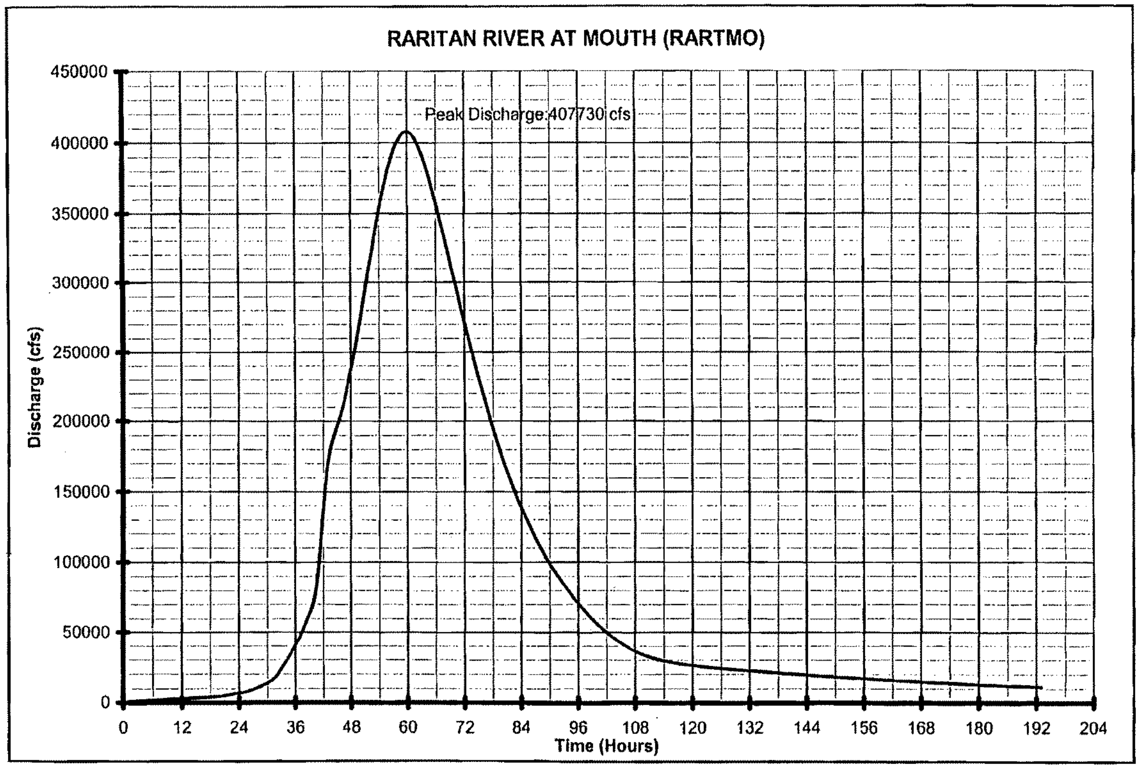


Figure 17o

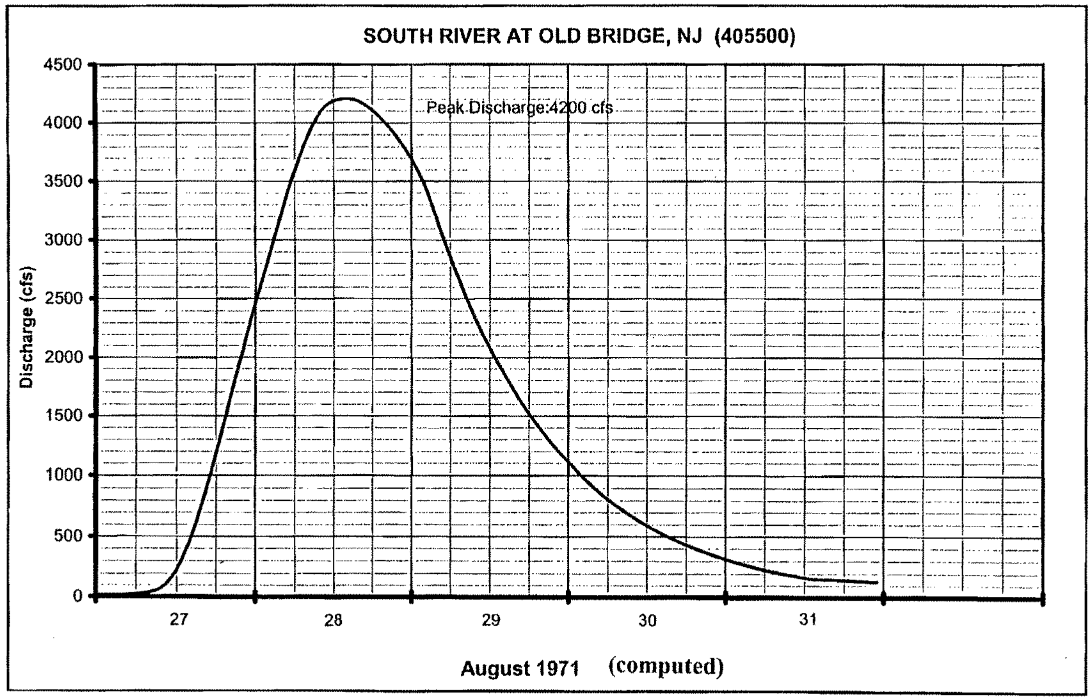

SOUTH RIVER AT OLD BRIDGE, NJ (405500)
Peak Discharge:4200 cfs
Discharge (cfs)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
27
28
29
30
31
August 1971 (computed)

Figure 17p

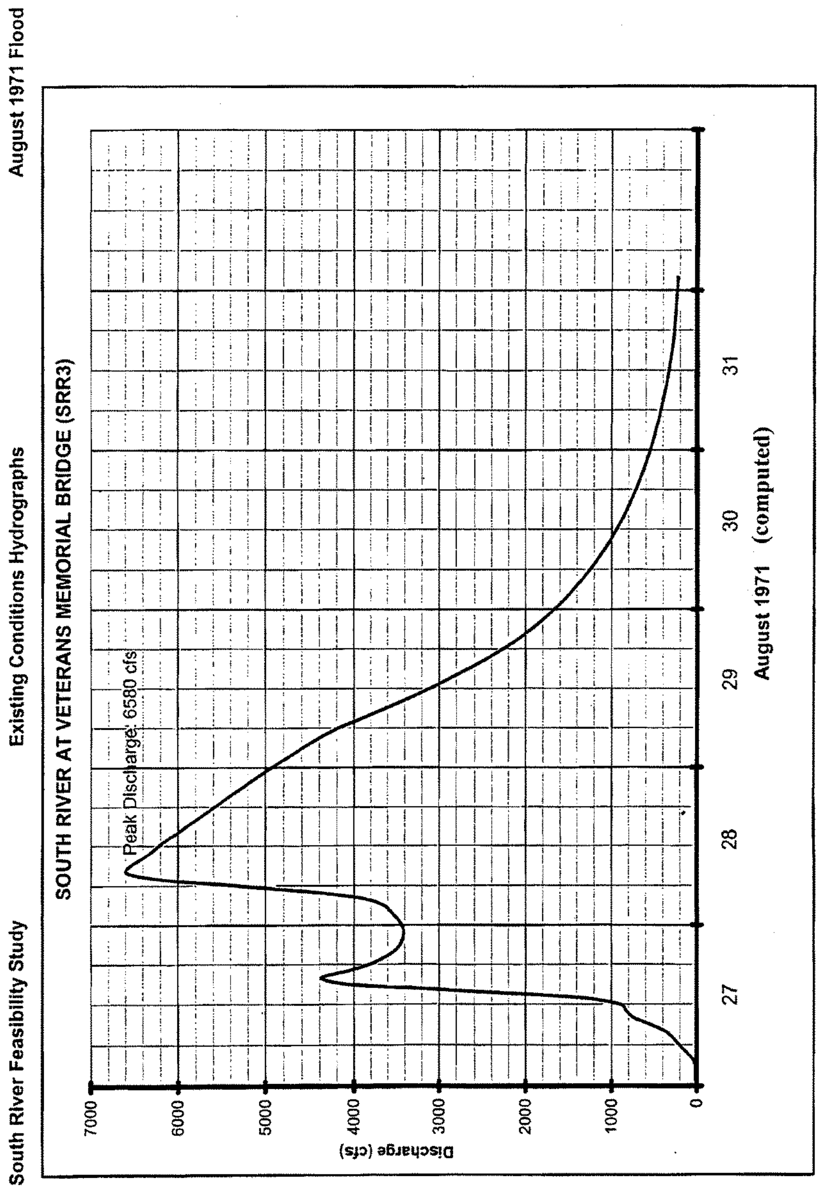
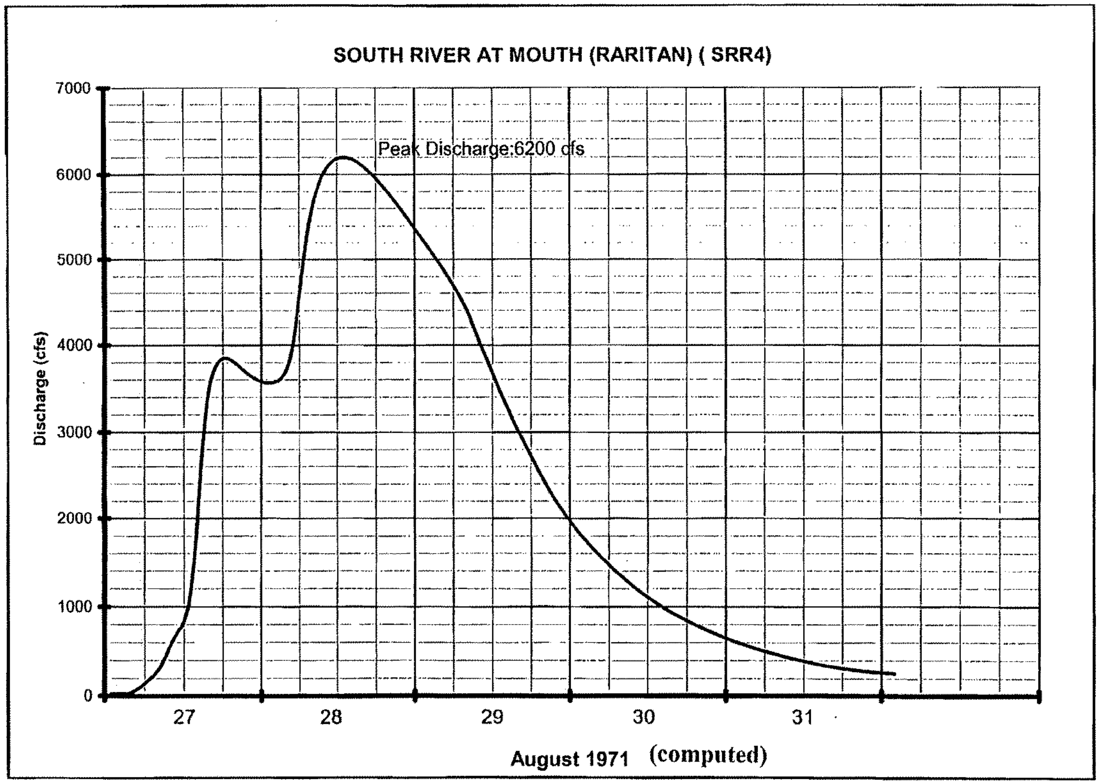

South River Feasibility Study
Existing Conditions Hydrographs
August 1971 Flood
SOUTH RIVER AT VETERANS MEMORIAL BRIDGE (SRR3)
Peak Discharge: 6580 cfs
Discharge (cfs)
7000
6000
5000
4000
3000
2000
1000
0
27
28
29
30
31
August 1971 (computed)

Figure 17q



SOUTH RIVER AT MOUTH (RARITAN) (SRR4)
Peak Discharge:6200 cfs
Discharge (cfs)
7000
6000
5000
4000
3000
2000
1000
0
27
28
29
30
31
August 1971 (computed)

Figure 17r

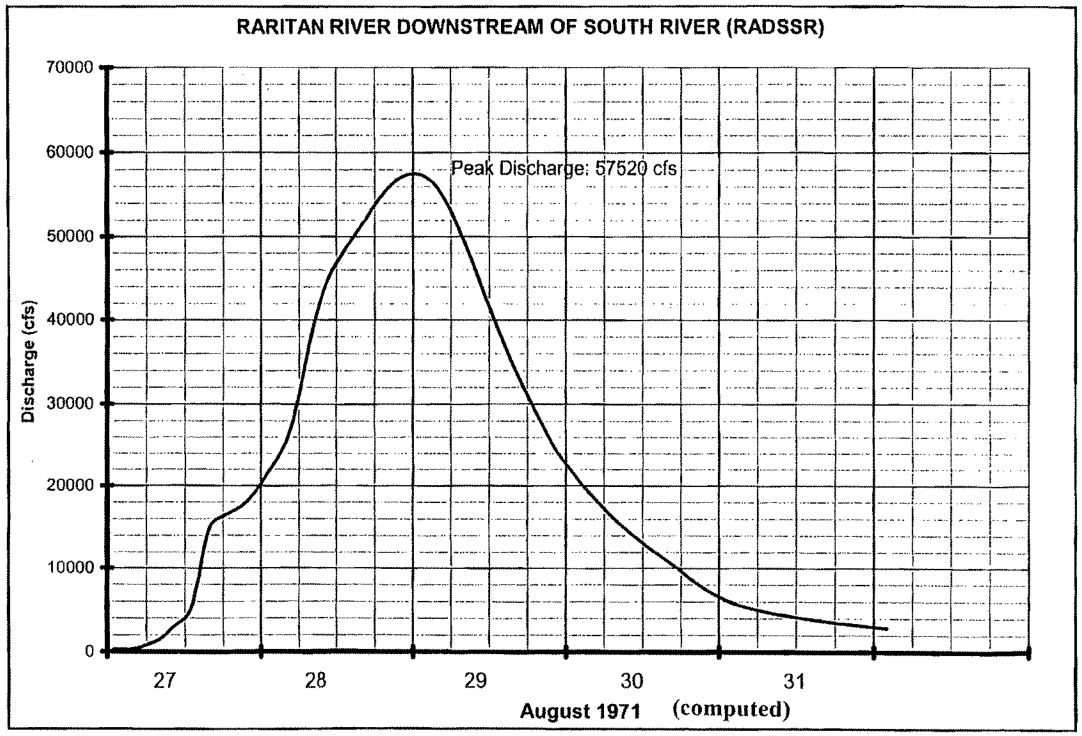

RARITAN RIVER DOWNSTREAM OF SOUTH RIVER (RADSSR)
Peak Discharge: 57520 cfs
Discharge (cfs)
70000
60000
50000
40000
30000
20000
10000
0
27
28
29
30
31
August 1971
(computed)

Figure 17s

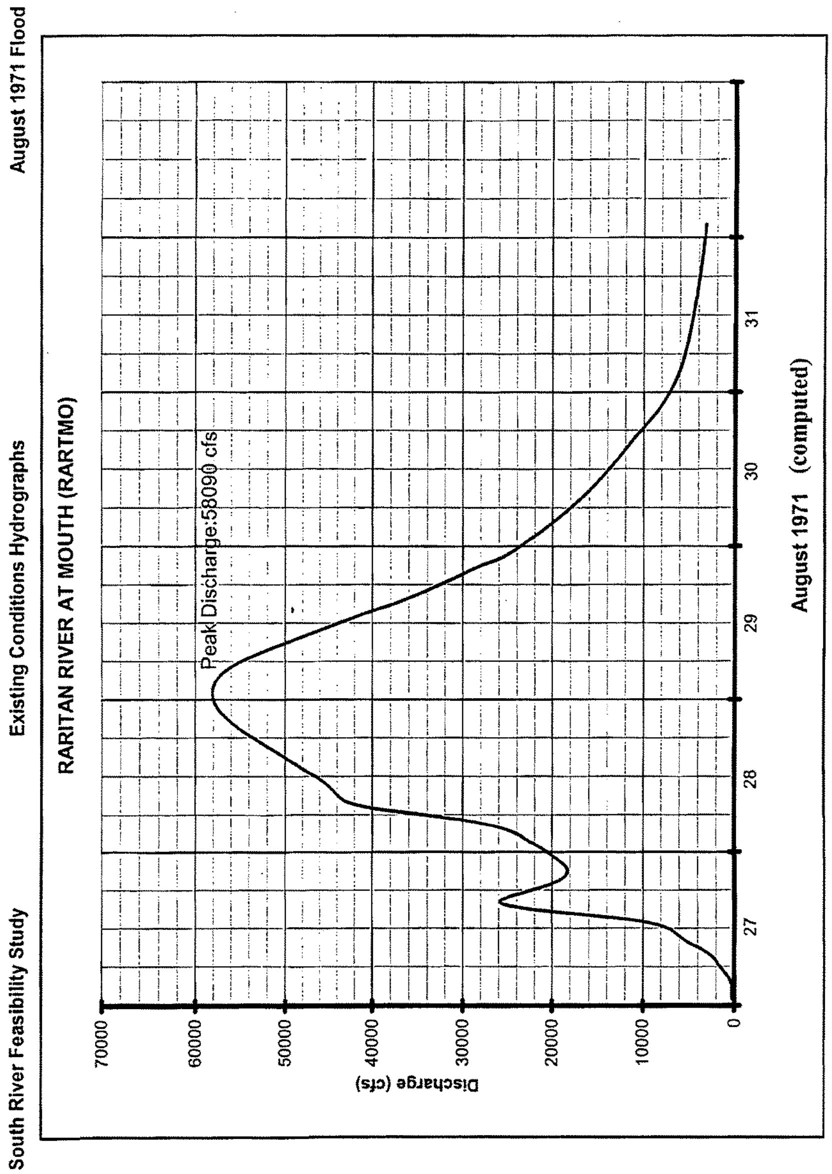

South River Feasibility Study
Existing Conditions Hydrographs
August 1971 Flood
RARITAN RIVER AT MOUTH (RARTMO)
Peak Discharge:58090 cfs
Discharge (cfs)
0
10000
20000
30000
40000
50000
60000
70000
27
28
29
30
31
August 1971 (computed)

Figure 17t

South River Feasibility Study

Existing Conditions Hydrographs

10 - Year Flood

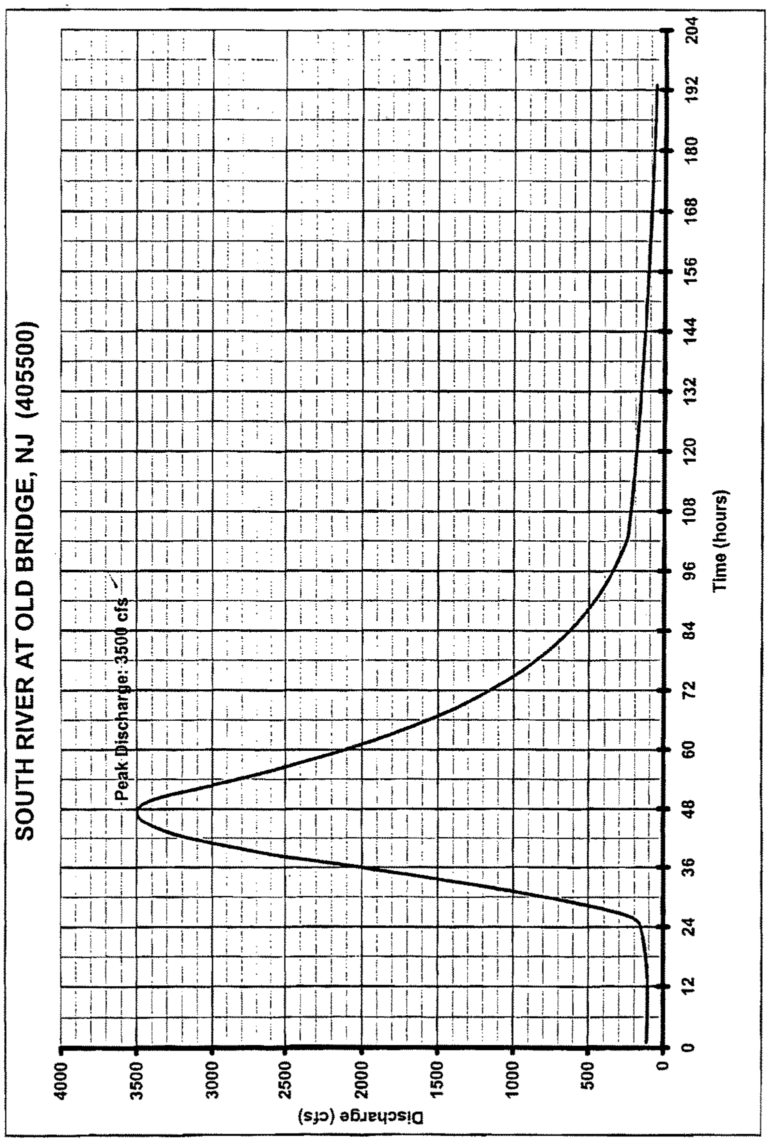


Figure 17u

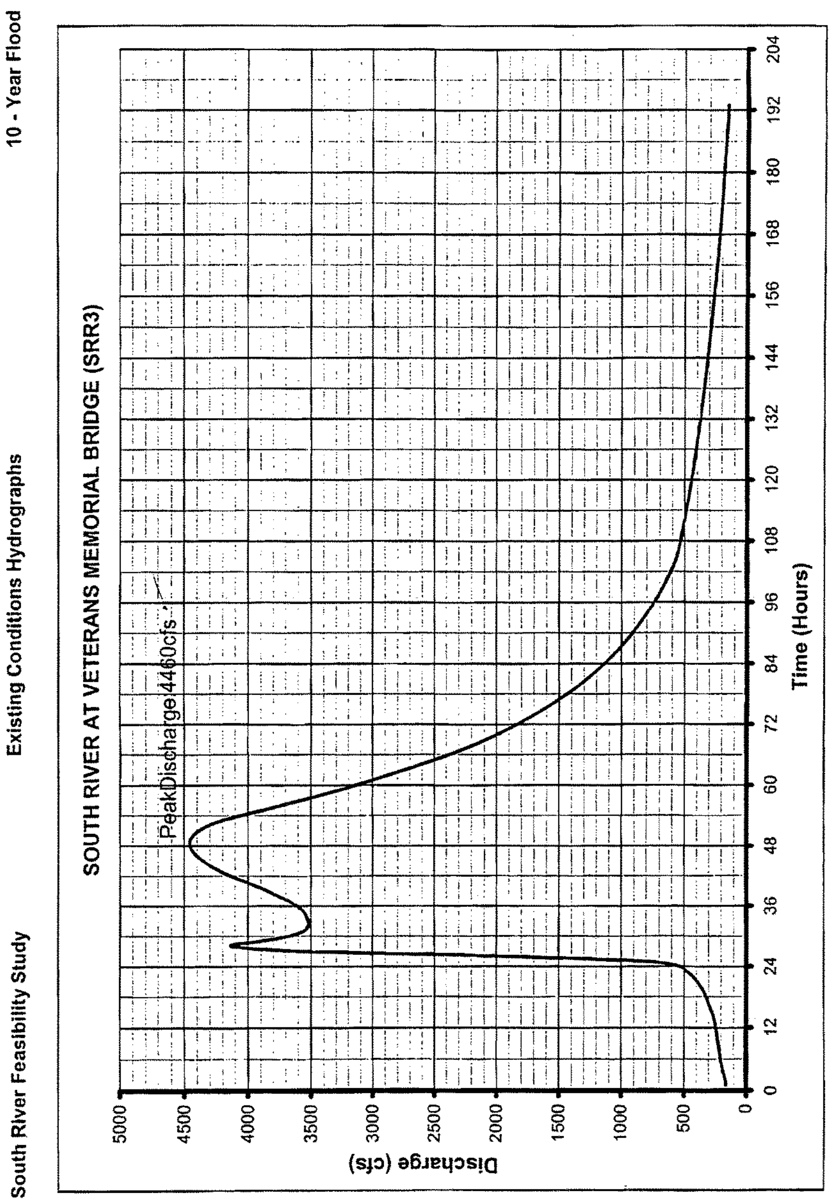

South River Feasibility Study
Existing Conditions Hydrographs
10 - Year Flood
SOUTH RIVER AT VETERANS MEMORIAL BRIDGE (SRR3)
Peak Discharge 4460cfs
Discharge (cfs)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
12
24
36
48
60
72
84
96
108
120
132
144
156
168
180
192
204
Time (Hours)

Figure 17v

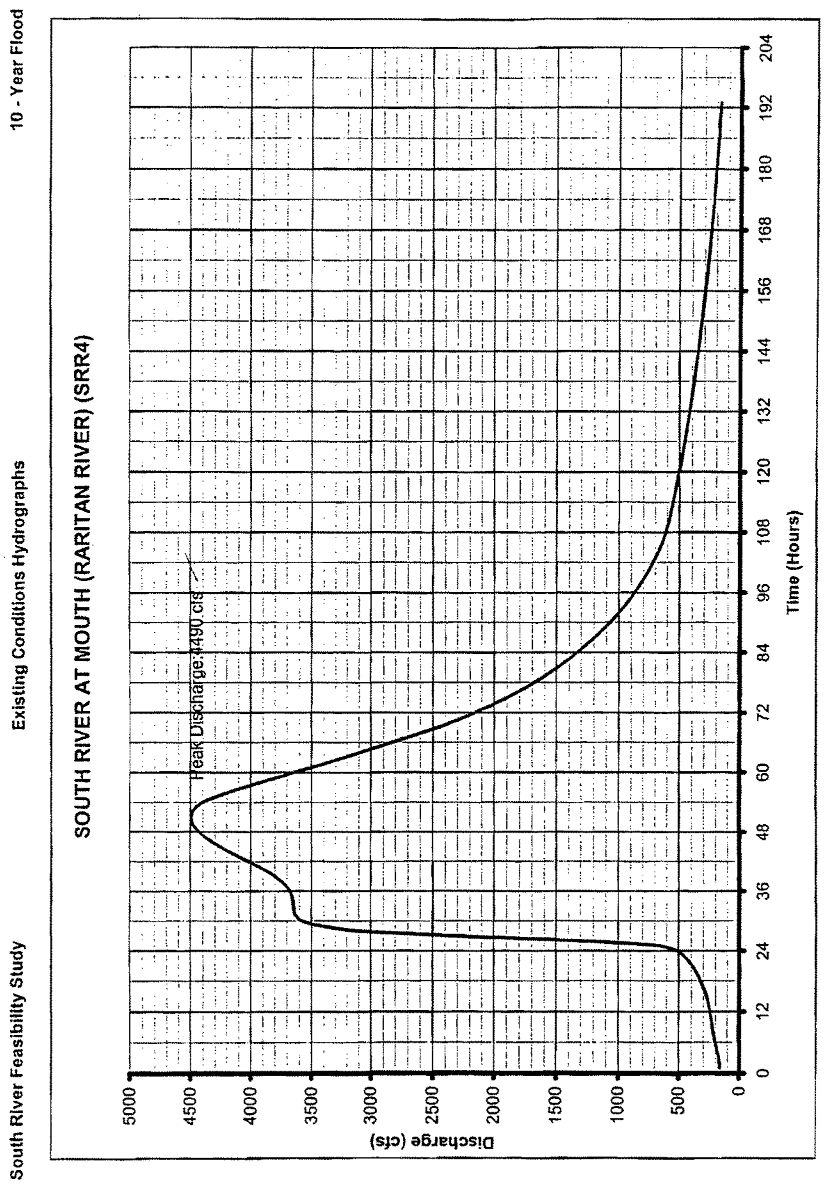

South River Feasibility Study
Existing Conditions Hydrographs
10 - Year Flood
SOUTH RIVER AT MOUTH (RARITAN RIVER) (SRR4)
Peak Discharge:4490 cfs
Discharge (cfs)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Time (Hours)
0
12
24
36
48
60
72
84
96
108
120
132
144
156
168
180
192
204

Figure 17w

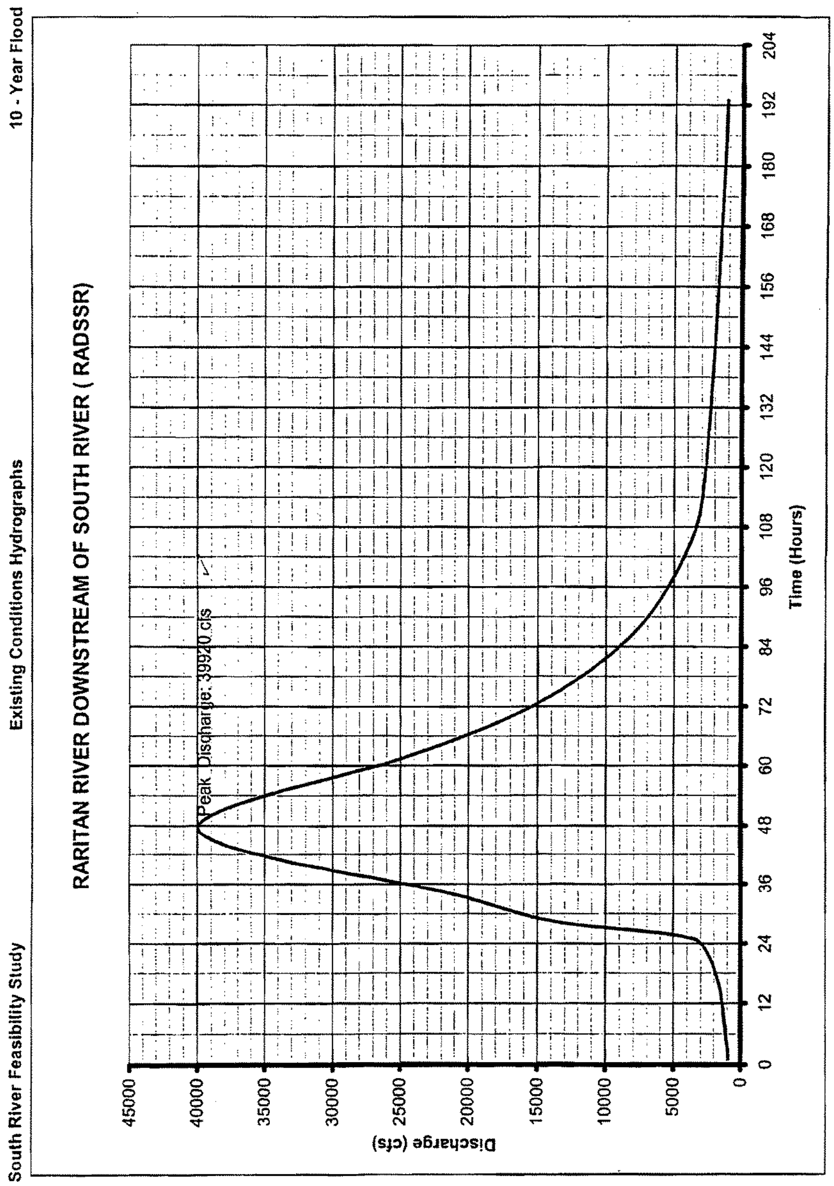

South River Feasibility Study
Existing Conditions Hydrographs
10 - Year Flood
RARITAN RIVER DOWNSTREAM OF SOUTH RIVER (RADSSR)
Peak Discharge: 39920 cfs
Discharge (cfs)
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
12
24
36
48
60
72
84
96
108
120
132
144
156
168
180
192
204
Time (Hours)

Figure 17x

South River Feasibility Study — Existing Conditions Hydrographs — 10 - Year Flood

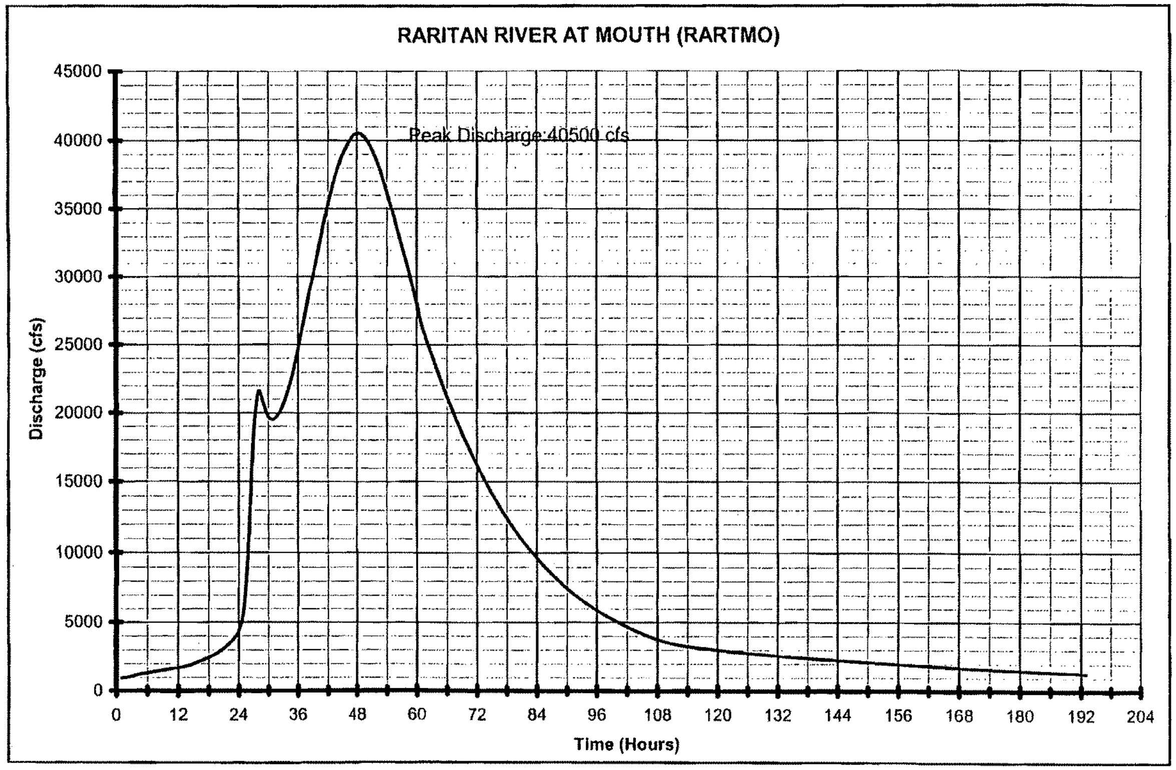


Figure 17y

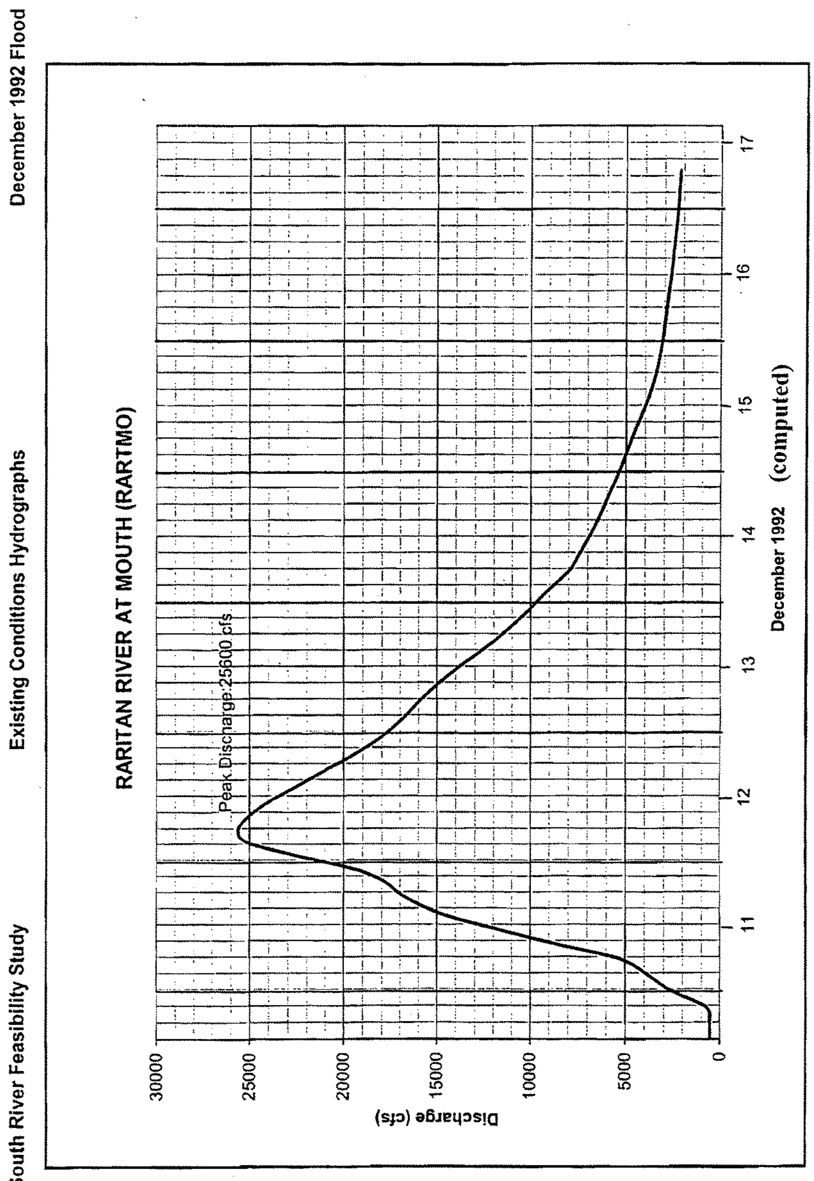

South River Feasibility Study
Existing Conditions Hydrographs
December 1992 Flood
RARITAN RIVER AT MOUTH (RARTMO)
Peak Discharge:25600 cfs
Discharge (cfs)
30000
25000
20000
15000
10000
5000
0
11
12
13
14
15
16
17
December 1992
(computed)

Figure 17z

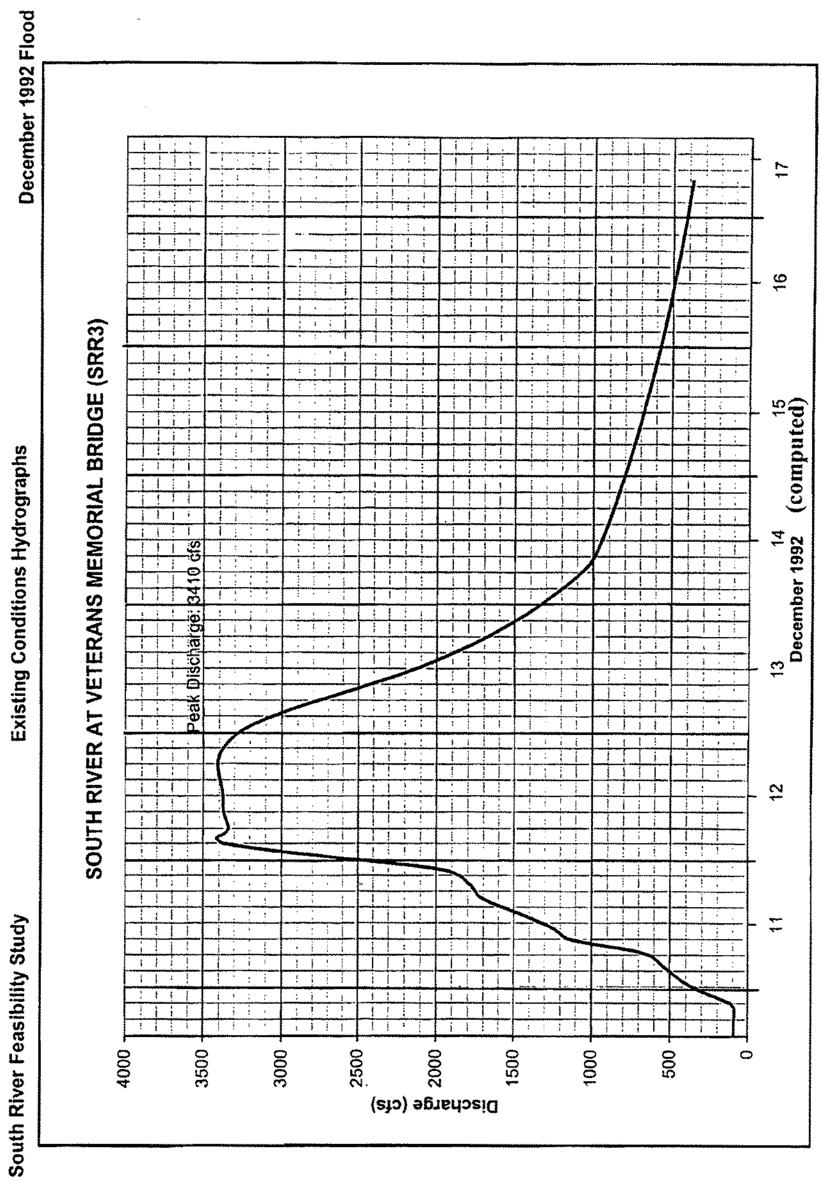

South River Feasibility Study
Existing Conditions Hydrographs
December 1992 Flood
SOUTH RIVER AT VETERANS MEMORIAL BRIDGE (SRR3)
Peak Discharge: 3410 cfs
Discharge (cfs)
4000
3500
3000
2500
2000
1500
1000
500
0
11
12
13
14
15
16
17
December 1992
(computed)

Figure 17aa

South River Feasibility Study — Existing Conditions Hydrographs — December 1992 Flood

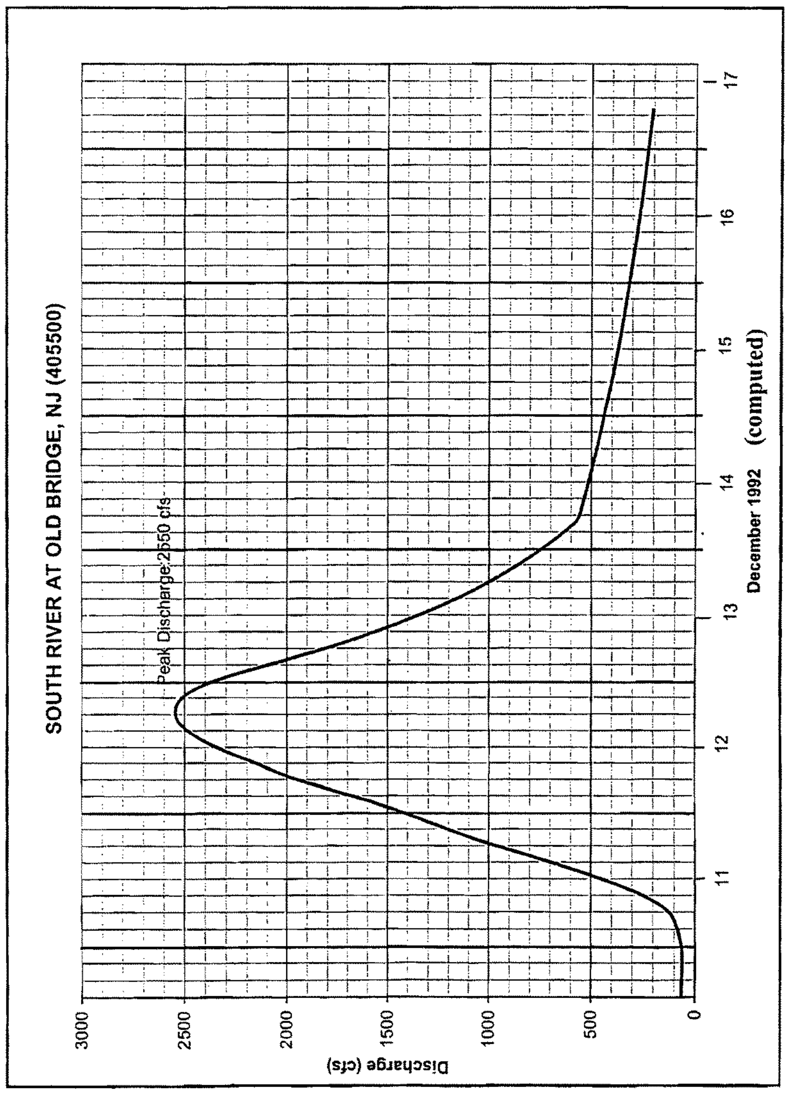


Figure 17bb

South River Feasibility Study | Existing Conditions Hydrographs | December 1992 Flood

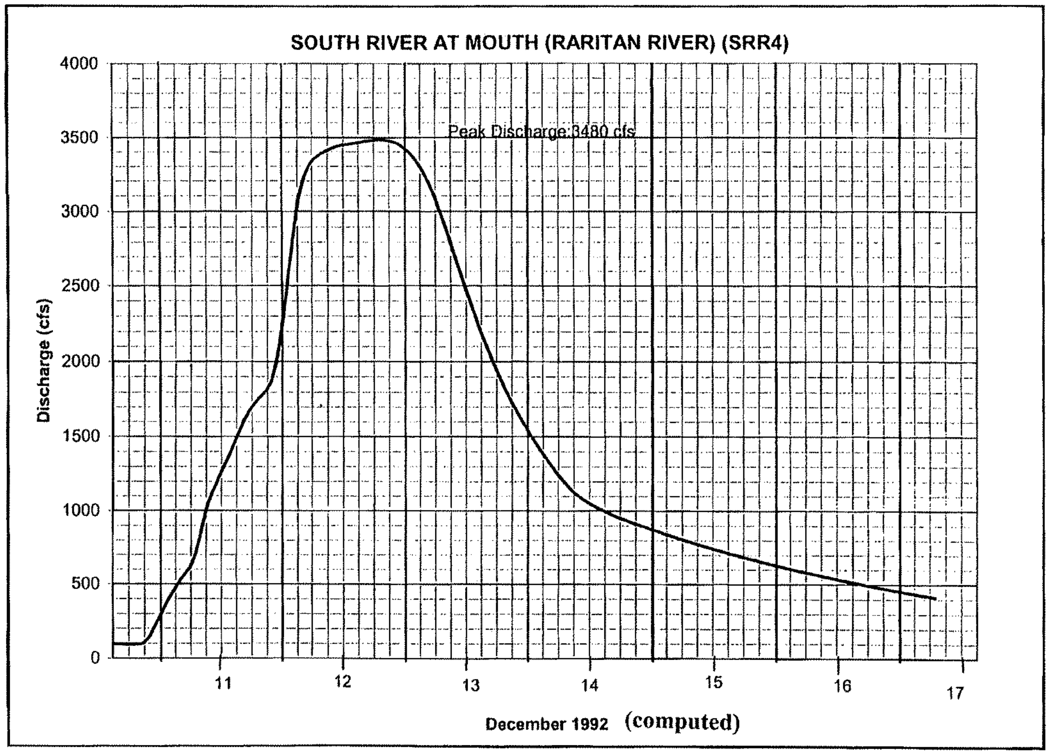


Figure 17cc

South River Feasibility Study | Existing Conditions Hydrographs | December 1992 Flood

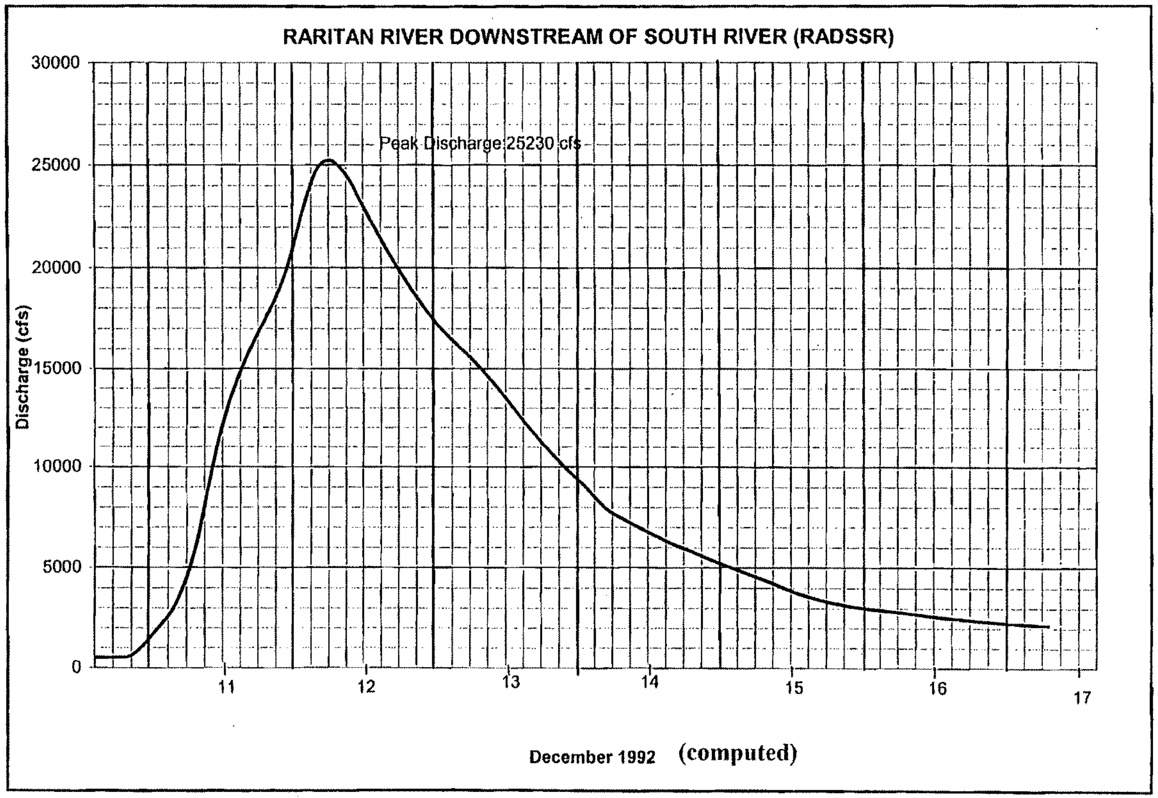


Figure 17dd

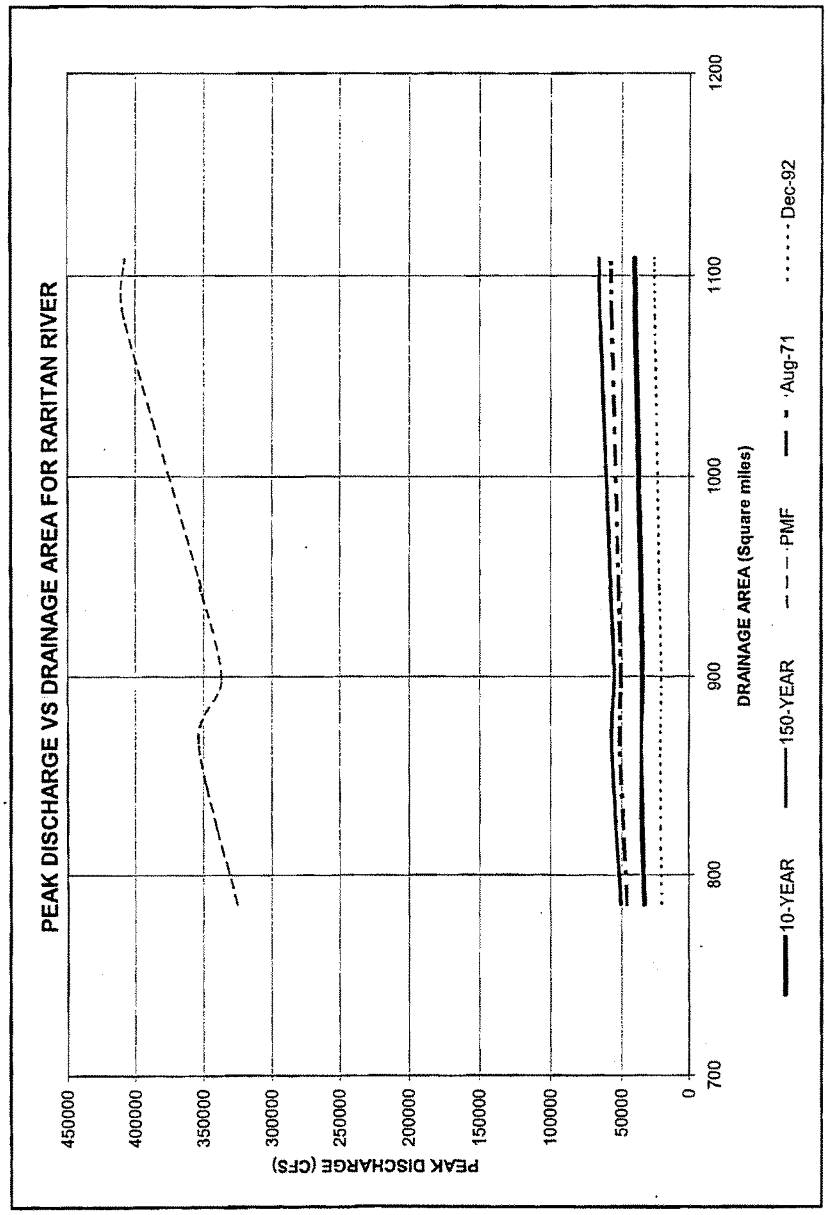
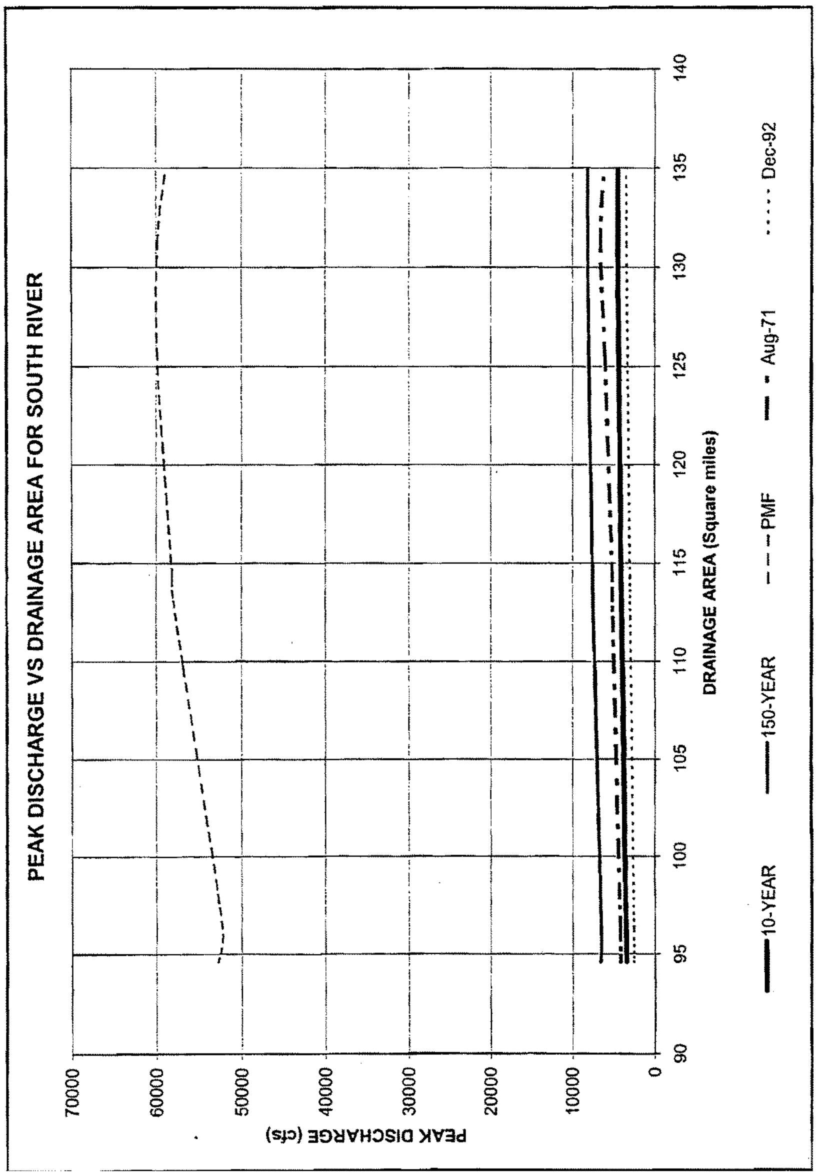

PEAK DISCHARGE VS DRAINAGE AREA FOR RARITAN RIVER
PEAK DISCHARGE (CFS)
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
700
800
900
1000
1100
1200
DRAINAGE AREA (Square miles)
10-YEAR
150-YEAR
PMF
Aug-71
Dec-92

Figure 18a



PEAK DISCHARGE VS DRAINAGE AREA FOR SOUTH RIVER
PEAK DISCHARGE (cfs)
70000
60000
50000
40000
30000
20000
10000
0
90
95
100
105
110
115
120
125
130
135
140
DRAINAGE AREA (Square miles)
10-YEAR
150-YEAR
PMF
Aug-71
Dec-92

Figure 18b

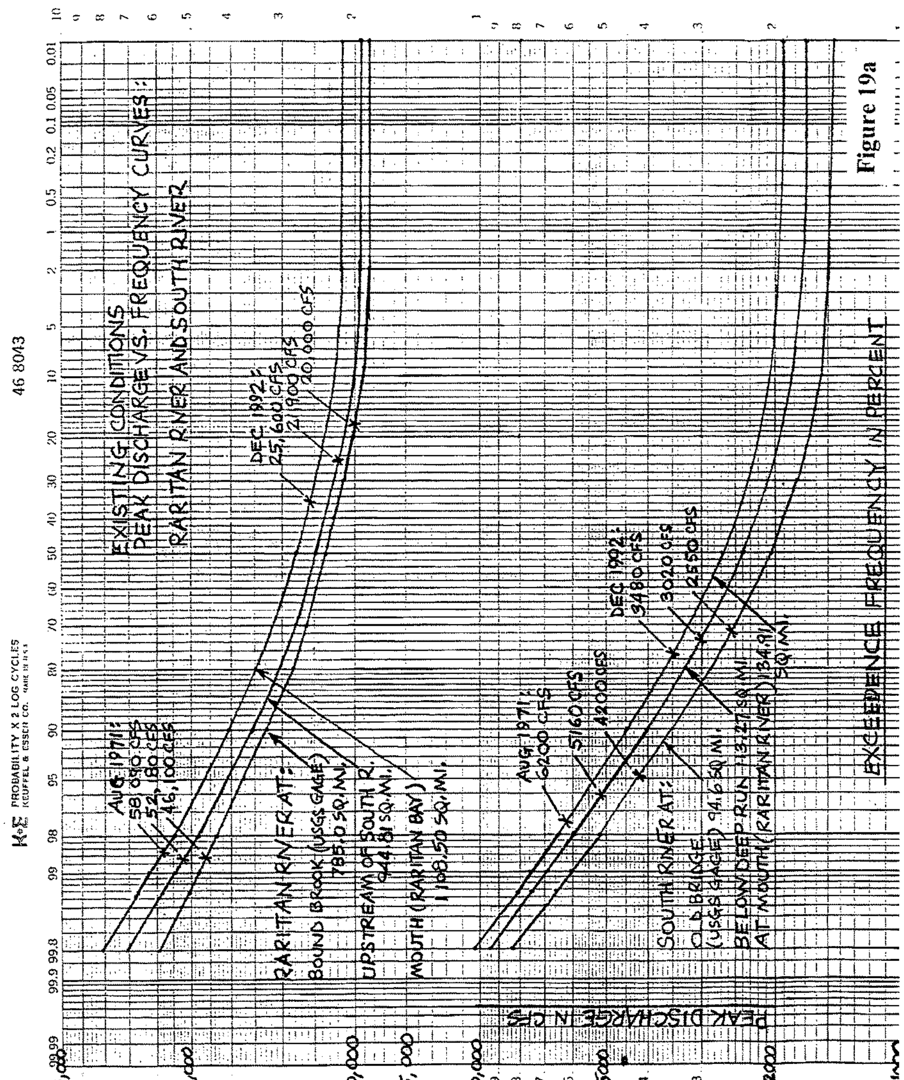
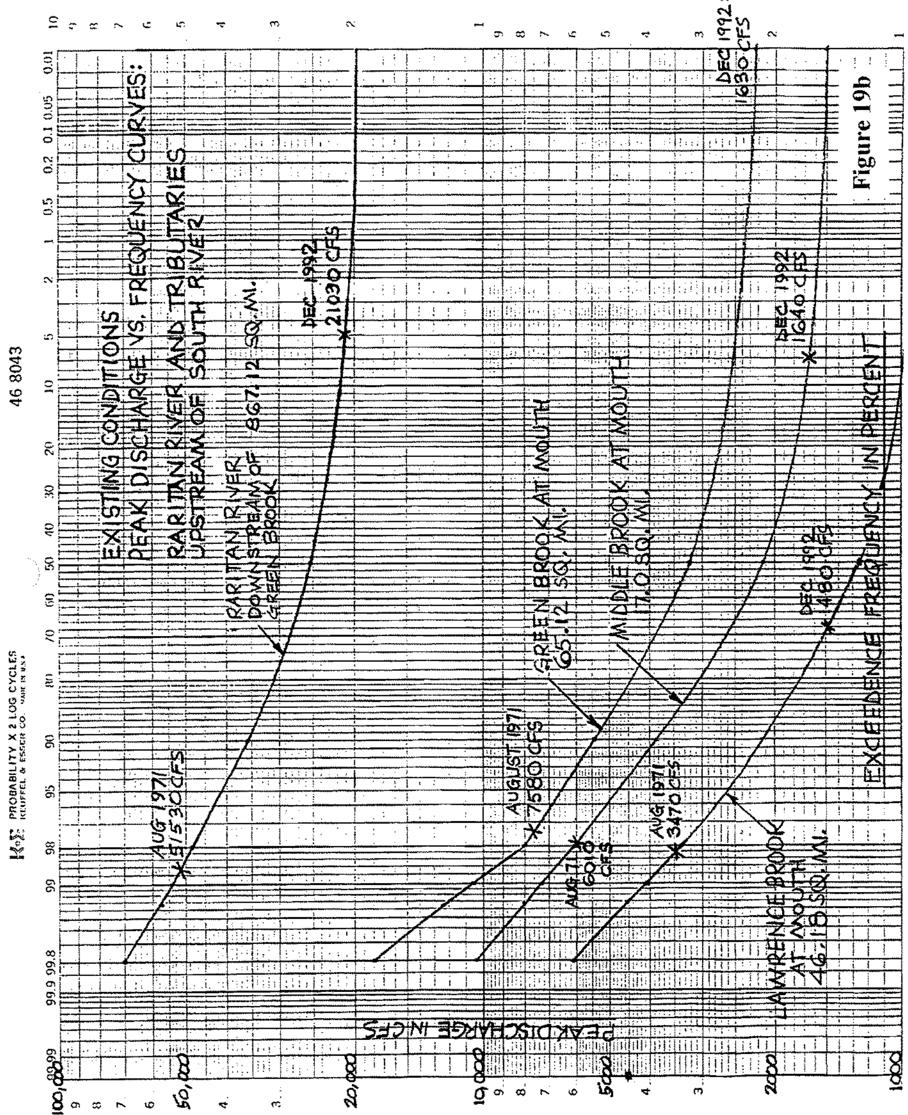

K&E PROBABILITY X 2 LOG CYCLES KEUFFEL & ESSER CO.
46 8043
EXISTING CONDITIONS
PEAK DISCHARGE VS. FREQUENCY CURVES:
RARITAN RIVER AND SOUTH RIVER
AUG 1971: 58,090 CFS 52,180 CFS 46,100 CFS
DEC 1992: 25,600 CFS 21,900 CFS 20,000 CFS
RARITAN RIVER AT:
BOUND BROOK (USGS GAGE) 785.0 SQ.MI.
UPSTREAM OF SOUTH R. 944.81 SQ.MI.
MOUTH (RARITAN BAY) 1108.50 SQ.MI.
AUG 1971: 6200 CFS 5160 CFS 4200 CFS
DEC 1992: 3480 CFS 3020 CFS 2550 CFS
SOUTH RIVER AT:
OLD BRIDGE (USGS GAGED) 94.6 SQ.MI.
BELOW DEEP RUN 132.27 SQ.MI.
AT MOUTH (RARITAN RIVER) 134.91 SQ.MI.
PEAK DISCHARGE IN CFS
EXCEEDENCE FREQUENCY IN PERCENT

Figure 19a


EXISTING CONDITIONS
PEAK DISCHARGE VS. FREQUENCY CURVES:
RARITAN RIVER AND TRIBUTARIES
UPSTREAM OF SOUTH RIVER
RARITAN RIVER DOWNSTREAM OF GREEN BROOK
867.12 SQ. MI.
DEC. 1992 21030 CFS
AUG 1971 51530 CFS
GREEN BROOK AT MOUTH 65.12 SQ. MI.
AUGUST 1971 7580 CFS
MIDDLE BROOK AT MOUTH 17.0 SQ. MI.
AUG 1971 3470 CFS
LAWRENCE BROOK AT MOUTH 46.18 SQ. MI.
DEC. 1992 1640 CFS
DEC 1992: 1630 CFS
DEC 1992 1480 CFS
PEAK DISCHARGE IN CFS
EXCEEDENCE FREQUENCY IN PERCENT
Figure 19b
46 8043
PROBABILITY X 2 LOG CYCLES
KEUFFEL & ESSER CO.

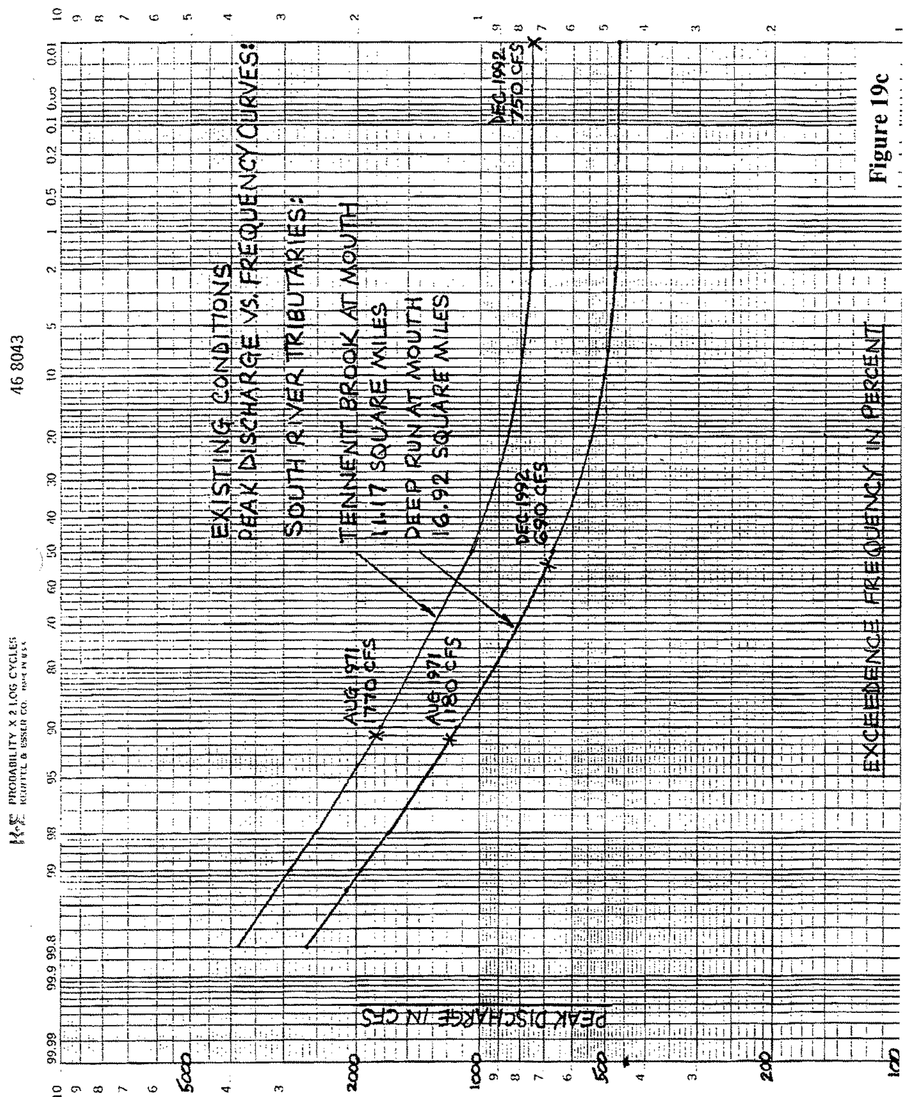

EXISTING CONDITIONS
PEAK DISCHARGE VS. FREQUENCY CURVES:
SOUTH RIVER TRIBUTARIES:
TENNENT BROOK AT MOUTH
11.17 SQUARE MILES
DEEP RUN AT MOUTH
16.92 SQUARE MILES
AUG 1971
1770 CFS
AUG 1971
1180 CFS
DEC 1992
750 CFS
DEC 1992
690 CFS
EXCEEDENCE FREQUENCY IN PERCENT
PEAK DISCHARGE IN CFS
46 8043

Figure 19c

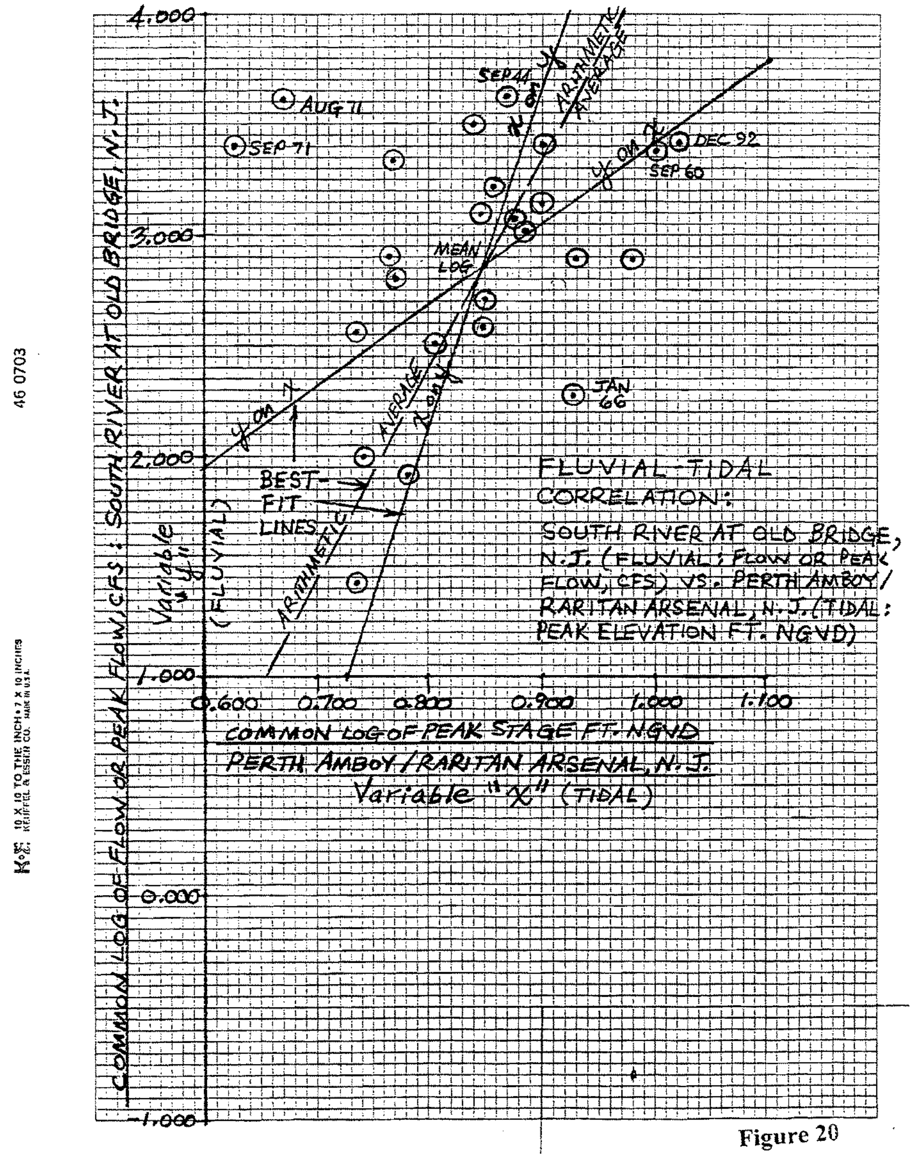

4.000
3.000
2.000
1.000
0.000
-1.000
0.600
0.700
0.800
0.900
1.000
1.100
COMMON LOG OF FLOW OR PEAK FLOW, CFS: SOUTH RIVER AT OLD BRIDGE, N.J.
Variable "Y" (FLUVIAL)
COMMON LOG OF PEAK STAGE FT. NGVD
PERTH AMBOY/RARITAN ARSENAL, N.J.
Variable "X" (TIDAL)
FLUVIAL-TIDAL CORRELATION:
SOUTH RIVER AT OLD BRIDGE, N.J. (FLUVIAL: FLOW OR PEAK FLOW, CFS) VS. PERTH AMBOY/RARITAN ARSENAL, N.J. (TIDAL: PEAK ELEVATION FT. NGVD)
BEST-FIT LINES
MEAN LOG
ARITHMETIC AVERAGE
Y ON X
X ON Y
AUG 71
SEP 71
SEP 44
DEC 92
SEP 60
JAN 66
46 0703
10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

Figure 20

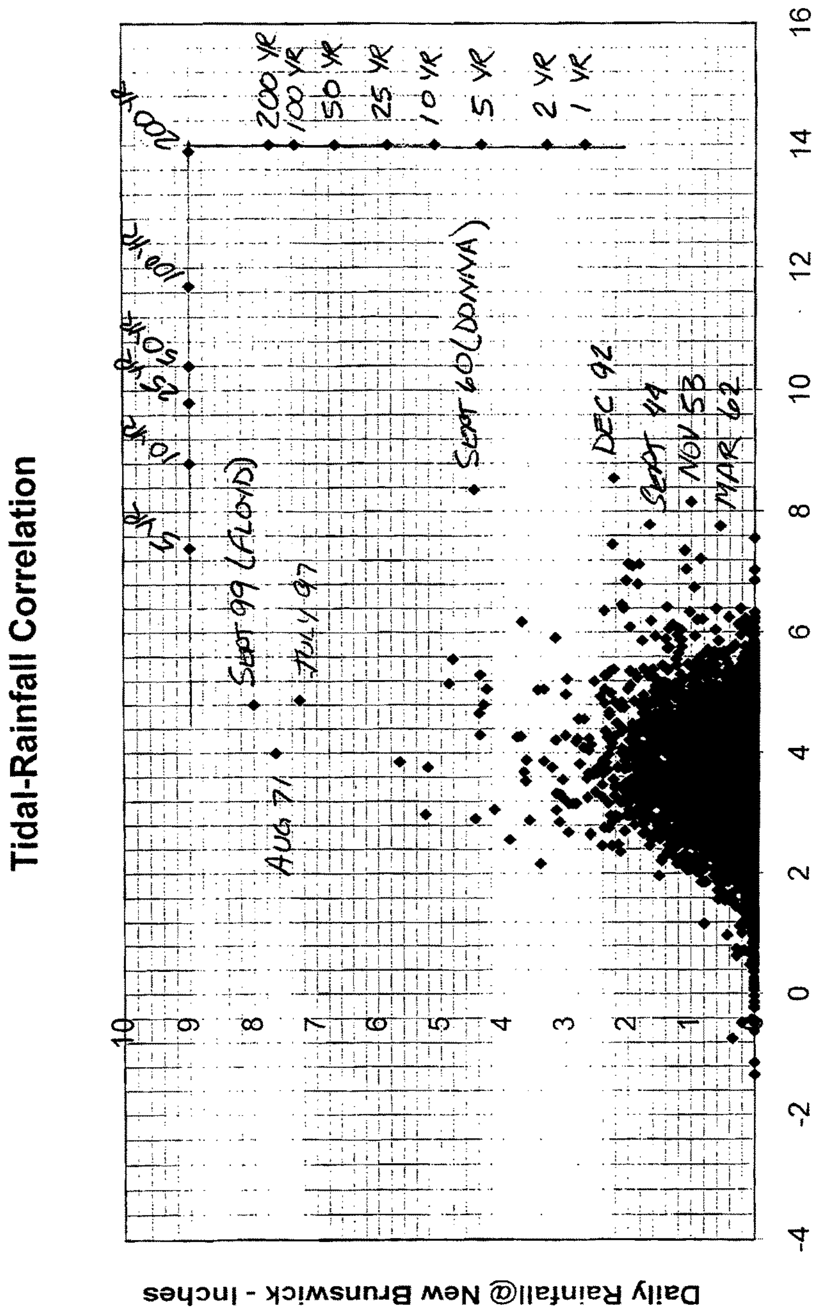
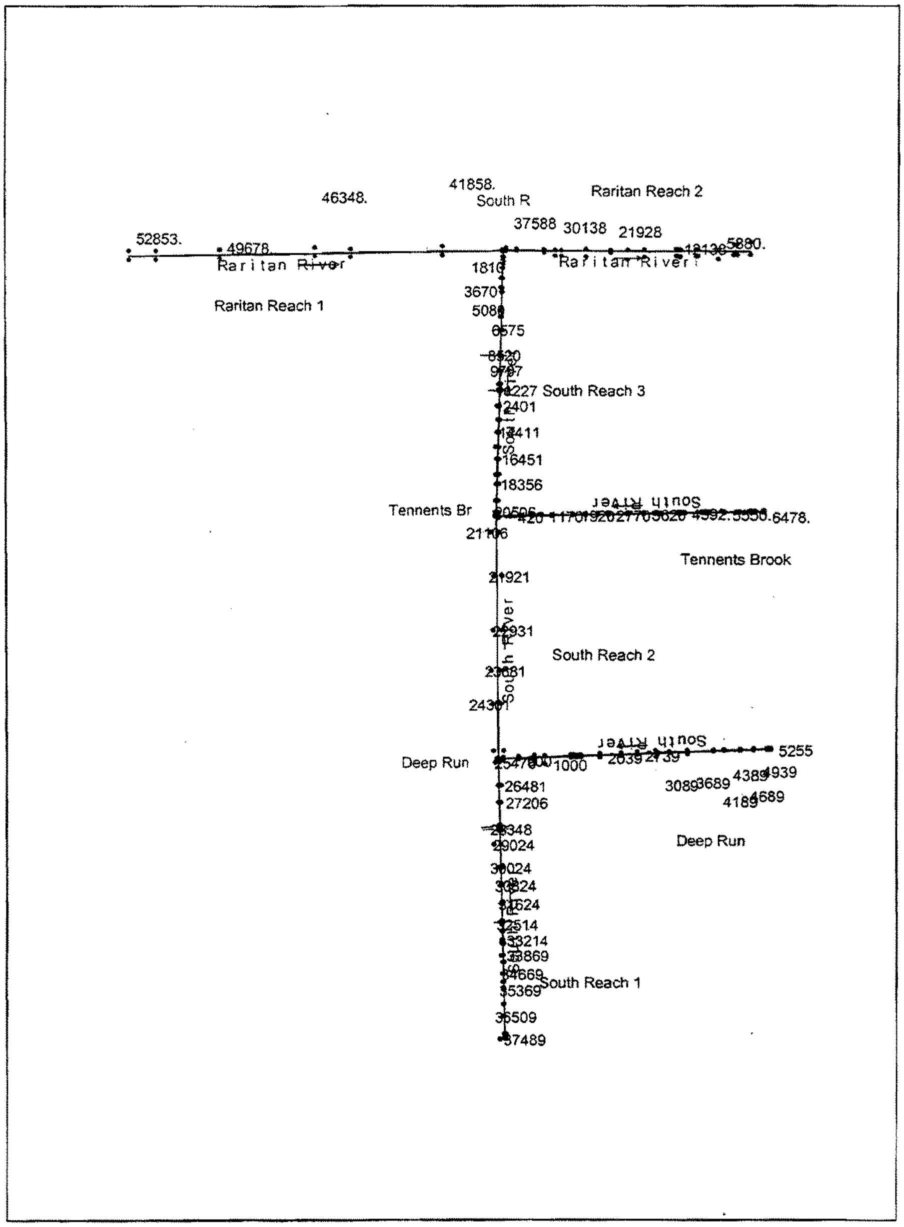

Tidal-Rainfall Correlation
Daily Rainfall@ New Brunswick - Inches
Tide Height @ Sandy Hook - Ft NGVD
SEPT 99 (FLOYD)
JULY 97
AUG 71
SEPT 60 (DONNA)
DEC 92
SEPT 44
NOV 53
MAR 62
200 YR
100 YR
50 YR
25 YR
10 YR
5 YR
2 YR
1 YR

FIGURE 21



IECRAS Model Schematic **Figure 22**

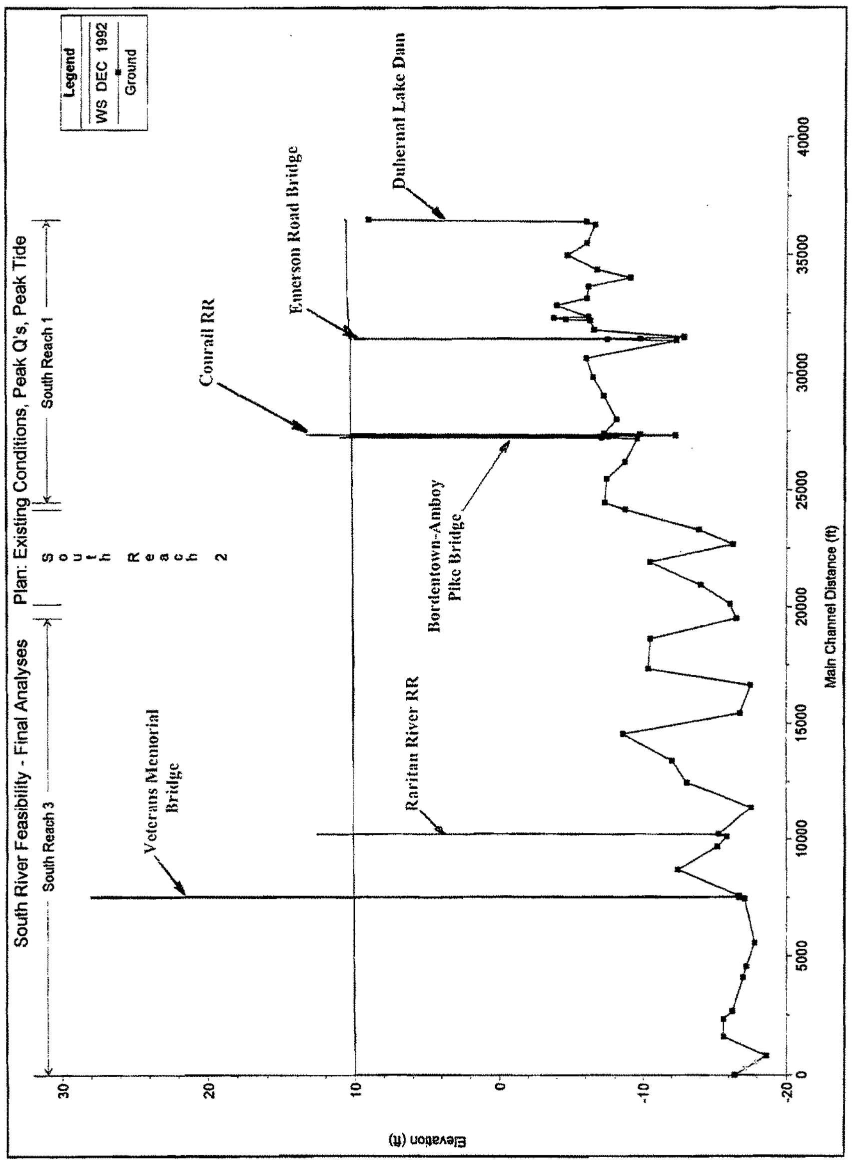

South River Feasibility - Final Analyses
Plan: Existing Conditions, Peak Q's, Peak Tide
South Reach 3
South Reach 2
South Reach 1
Legend
WS DEC 1992
Ground
Veterans Memorial Bridge
Raritan River RR
Bordentown-Amboy Pike Bridge
Conrail RR
Emerson Road Bridge
Duhernal Lake Dam
Elevation (ft)
30
20
10
0
-10
-20
Main Channel Distance (ft)
0
5000
10000
15000
20000
25000
30000
35000
40000

Figure 23a

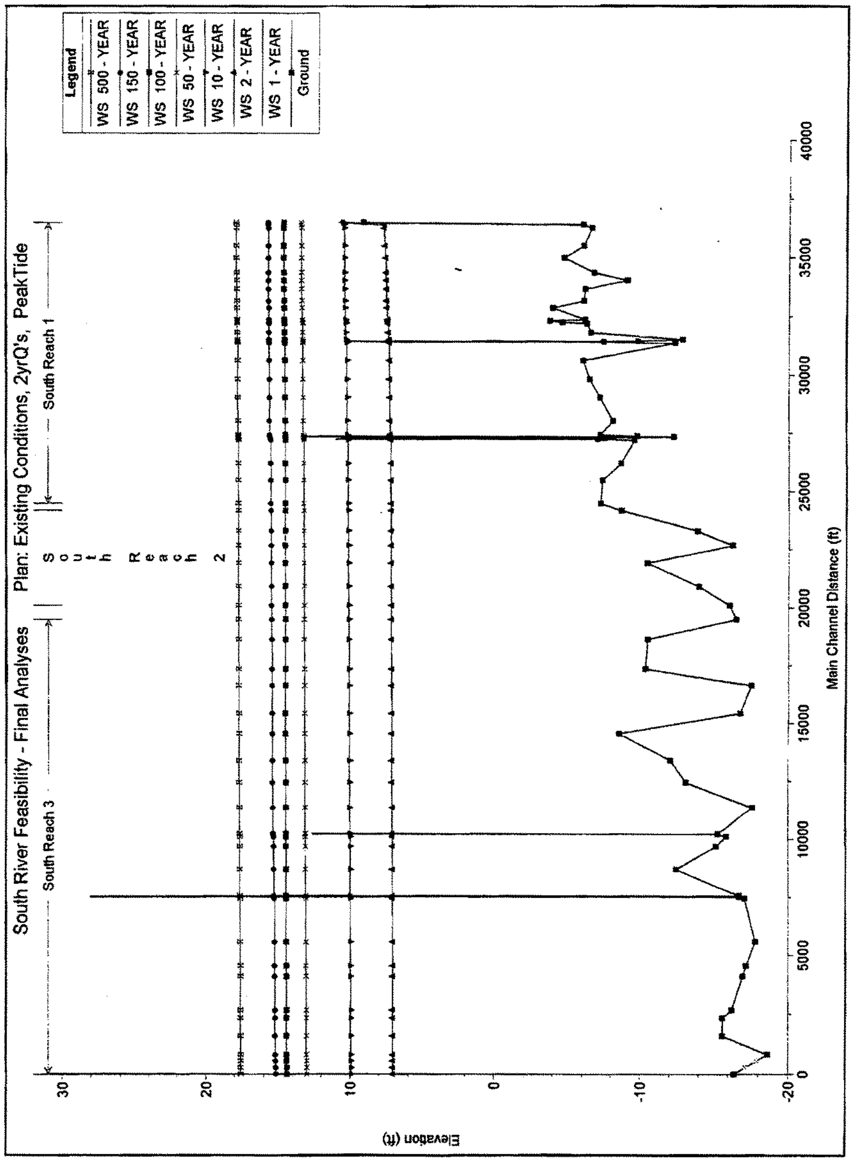

South River Feasibility - Final Analyses   Plan: Existing Conditions, 2yrQ's, PeakTide
South Reach 3
South Reach 2
South Reach 1
Legend
WS 500 - YEAR
WS 150 - YEAR
WS 100 - YEAR
WS 50 - YEAR
WS 10 - YEAR
WS 2 - YEAR
WS 1 - YEAR
Ground
Elevation (ft)
Main Channel Distance (ft)
30
20
10
0
-10
-20
0
5000
10000
15000
20000
25000
30000
35000
40000

Figure 23b

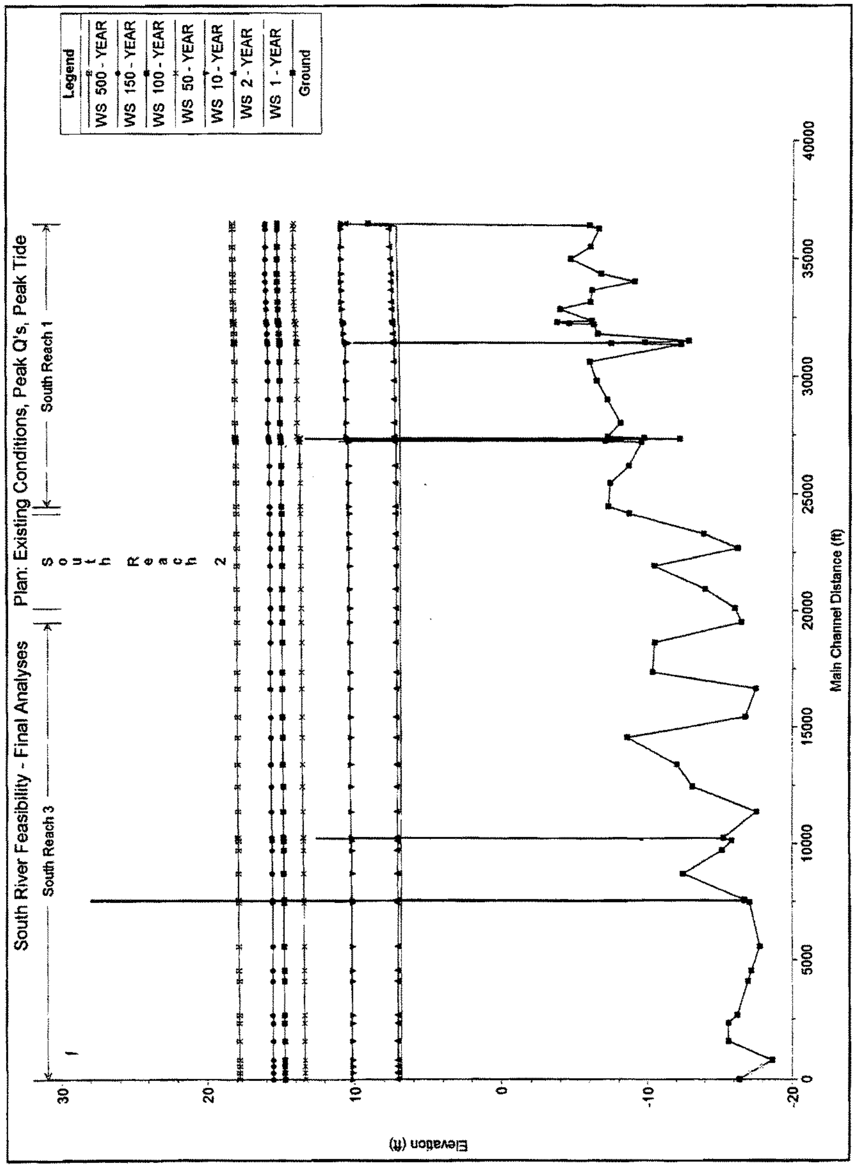

South River Feasibility - Final Analyses
Plan: Existing Conditions, Peak Q's, Peak Tide
South Reach 3
South Reach 2
South Reach 1
Legend
WS 500 - YEAR
WS 150 - YEAR
WS 100 - YEAR
WS 50 - YEAR
WS 10 - YEAR
WS 2 - YEAR
WS 1 - YEAR
Ground
Elevation (ft)
Main Channel Distance (ft)
30
20
10
0
-10
-20
0
5000
10000
15000
20000
25000
30000
35000
40000

Figure 23c

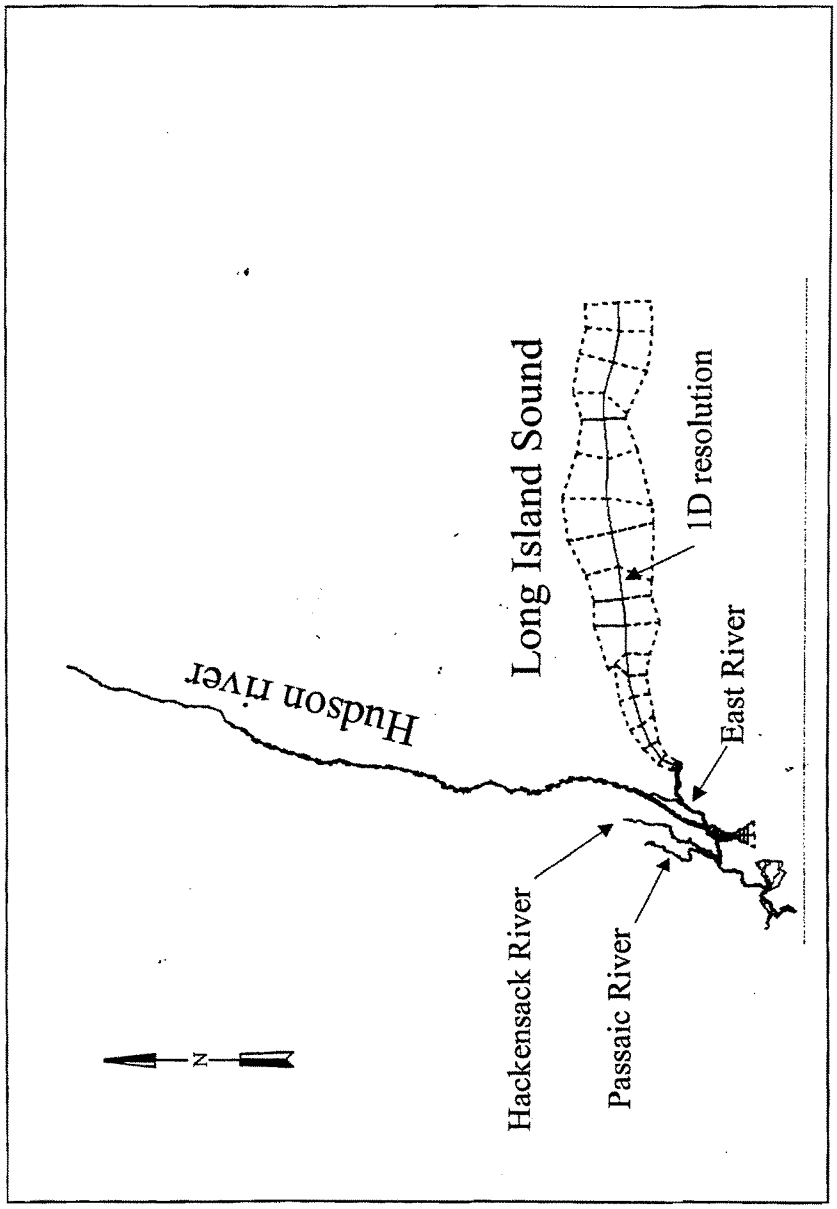


Figure 24 Tabs-MD model domain showing the 1D portions of the overall harbor.

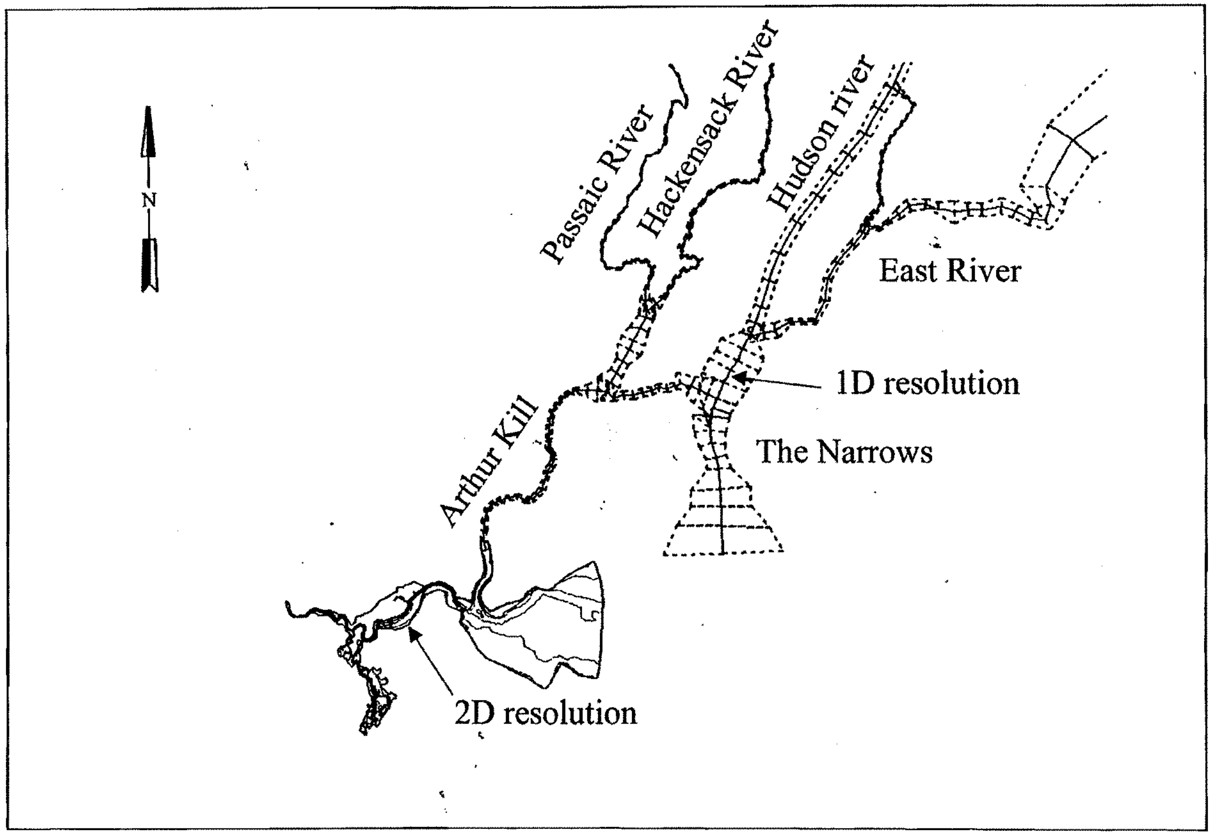


Figure 25. Tabs-MD model domain showing how 1D portions connect to the 2D portion.

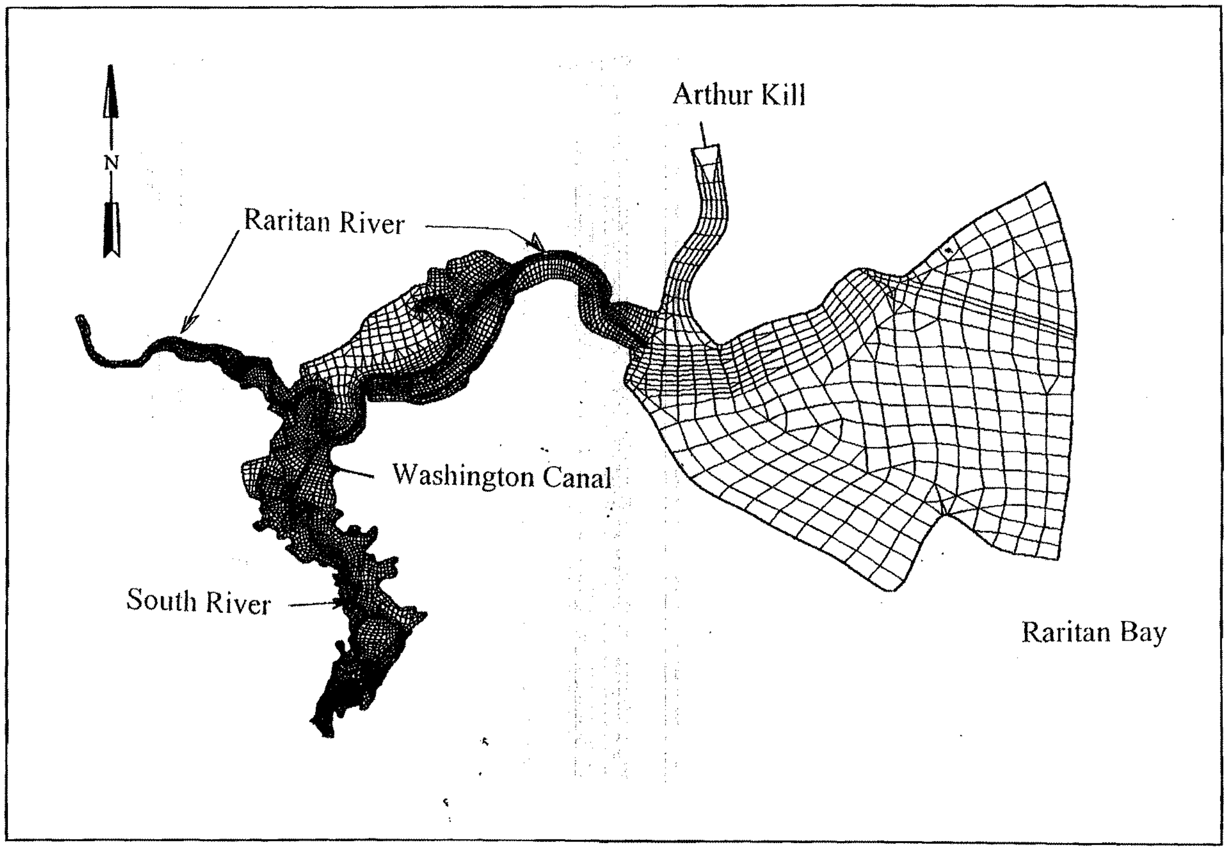


Figure 26. Resolution of 2D portion of the TABS-MD mesh

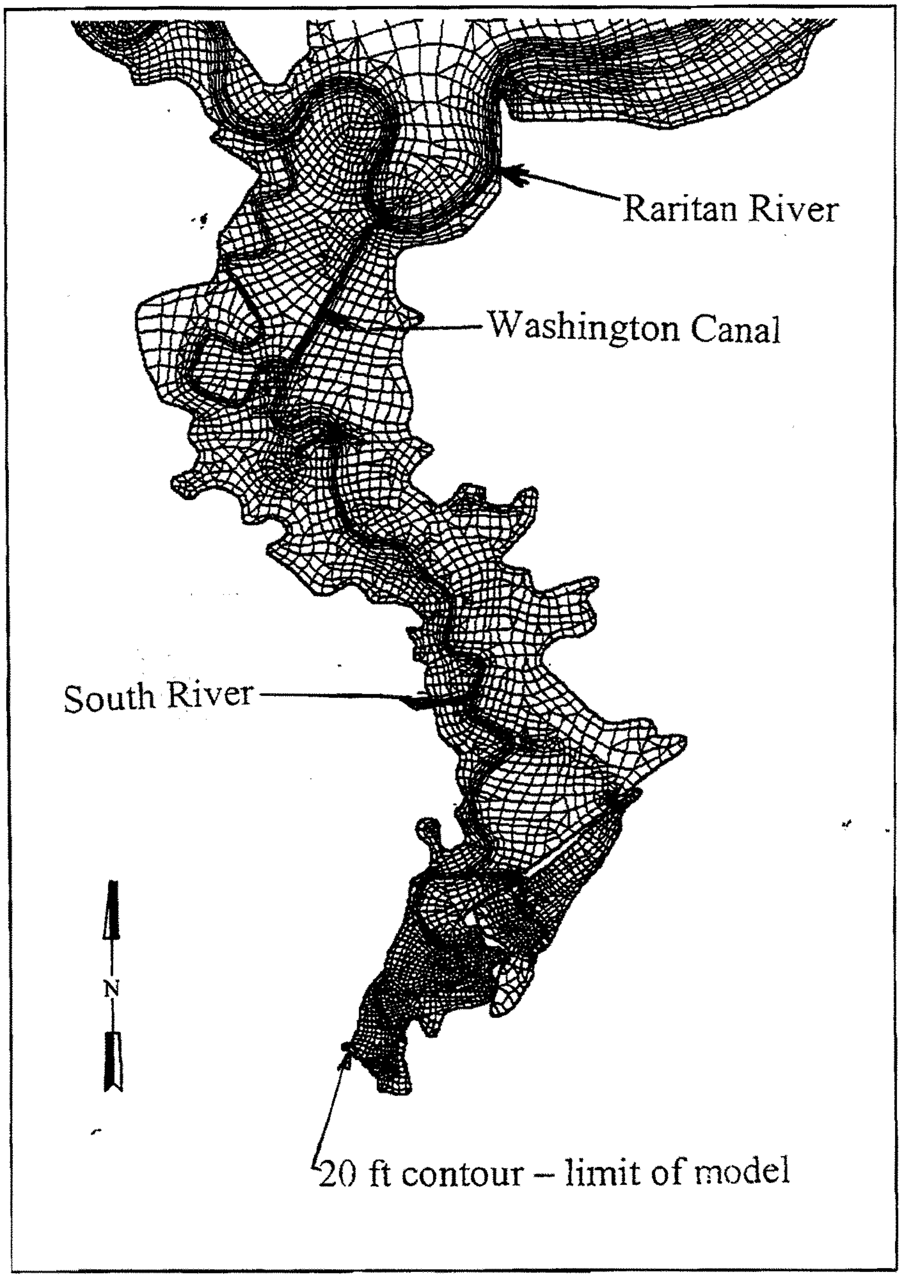


Figure 27 Model mesh resolution in South River area.

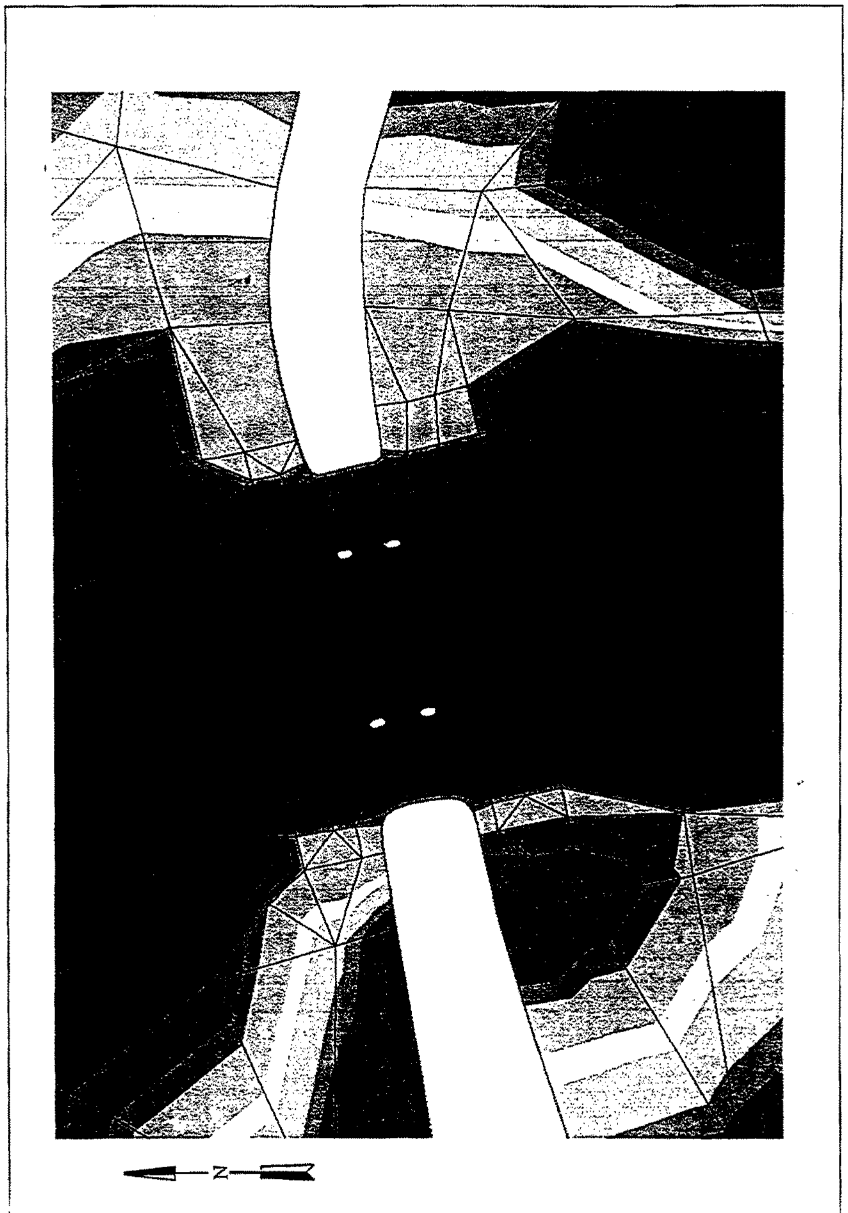


Figure 28. Resolution of TABS-MD mesh at Sayerville bridge

Figure 29 Bathymetry in TABS-MD mesh

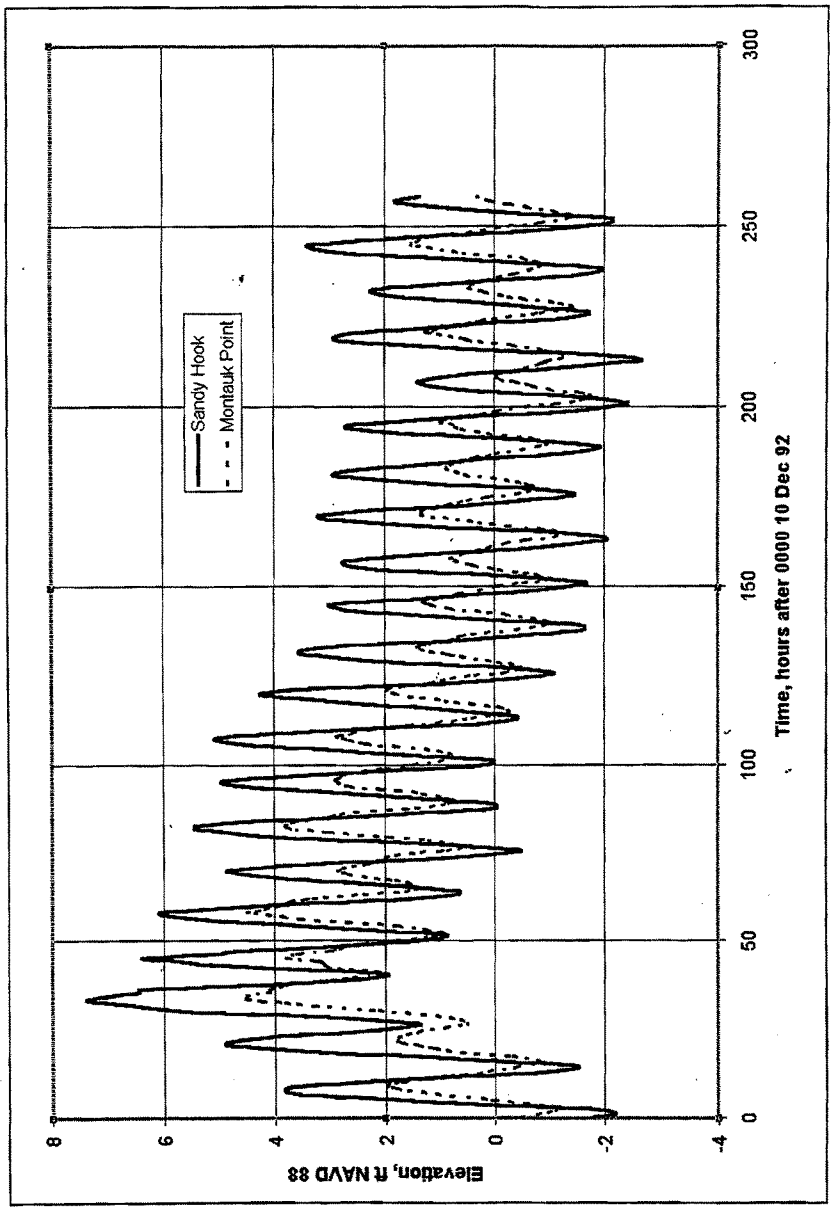


Figure 30 Boundary conditions for 25-year storm

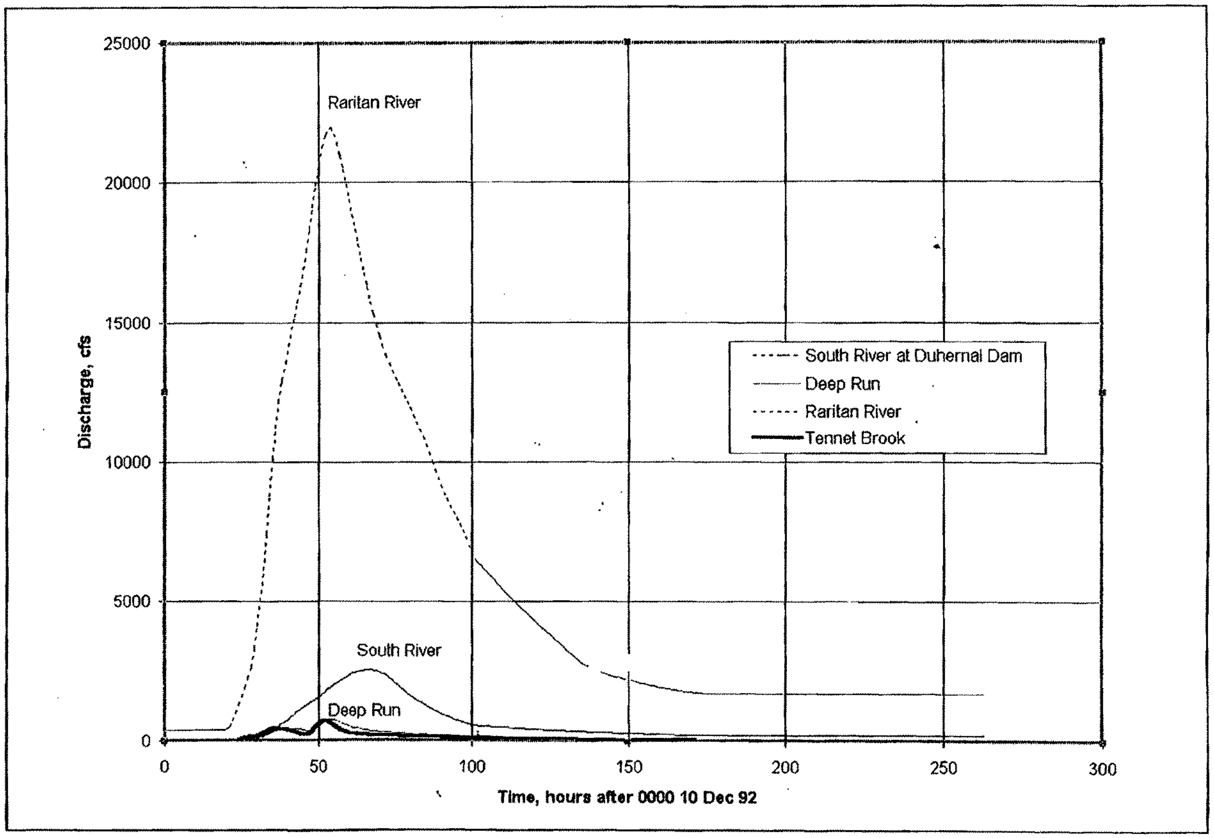
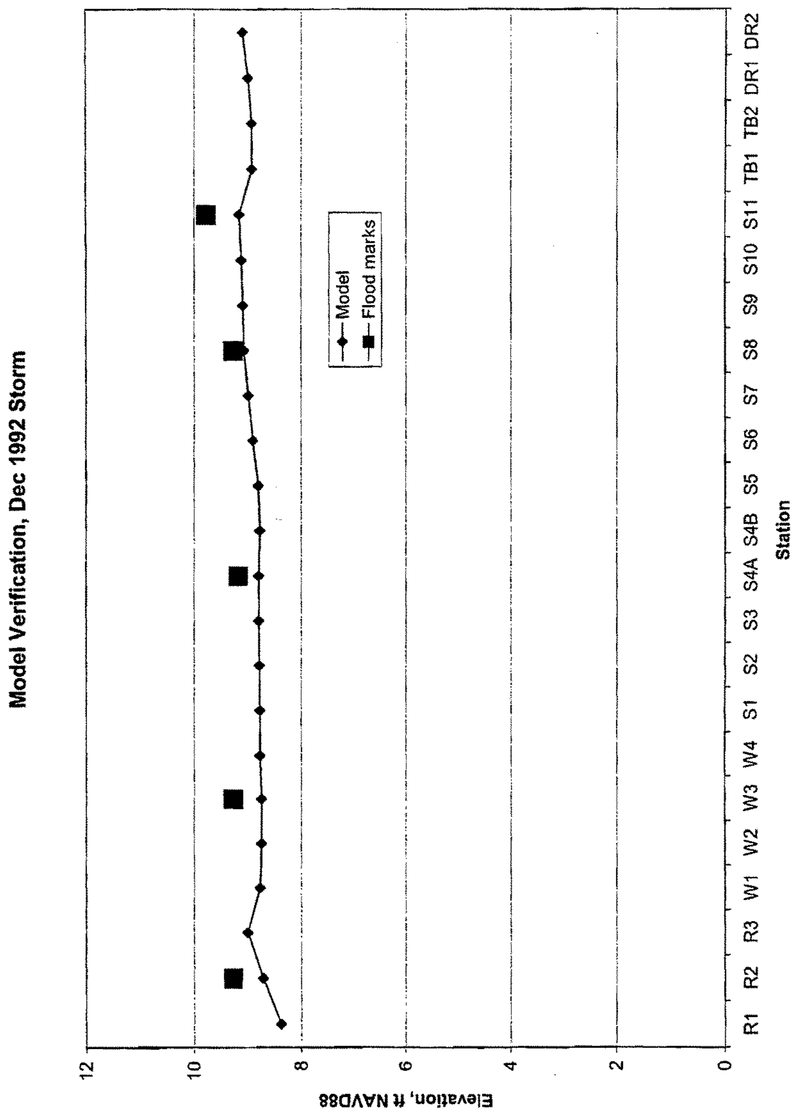


Figure 31. River discharge boundary conditions for all storms (for TABS-MD Model)



Model Verification, Dec 1992 Storm
Elevation, ft NAVD88
12
10
8
6
4
2
0
R1 R2 R3 W1 W2 W3 W4 S1 S2 S3 S4A S4B S5 S6 S7 S8 S9 S10 S11 TB1 TB2 DR1 DR2
Station
Model
Flood marks

Figure 32

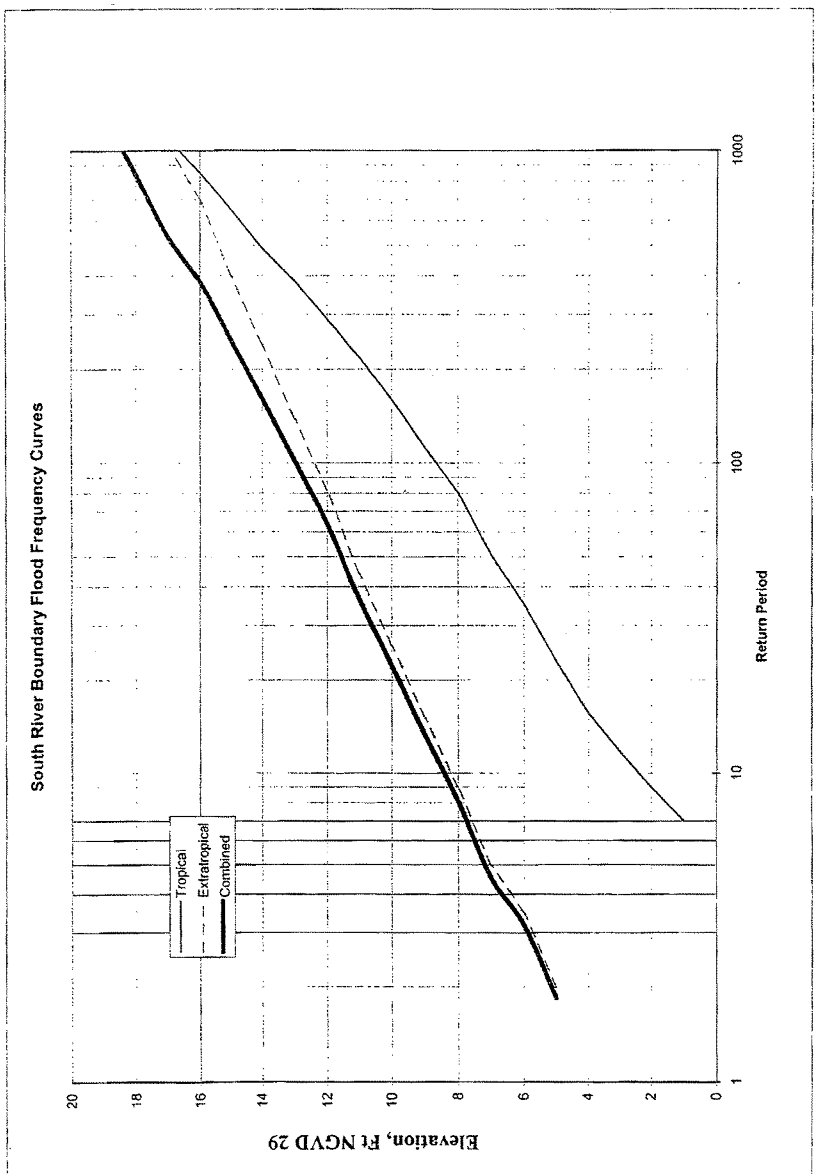

South River Boundary Flood Frequency Curves
Elevation, Ft NGVD 29
Return Period
Tropical
Extratropical
Combined
0
2
4
6
8
10
12
14
16
18
20
1
10
100
1000

Figure 33

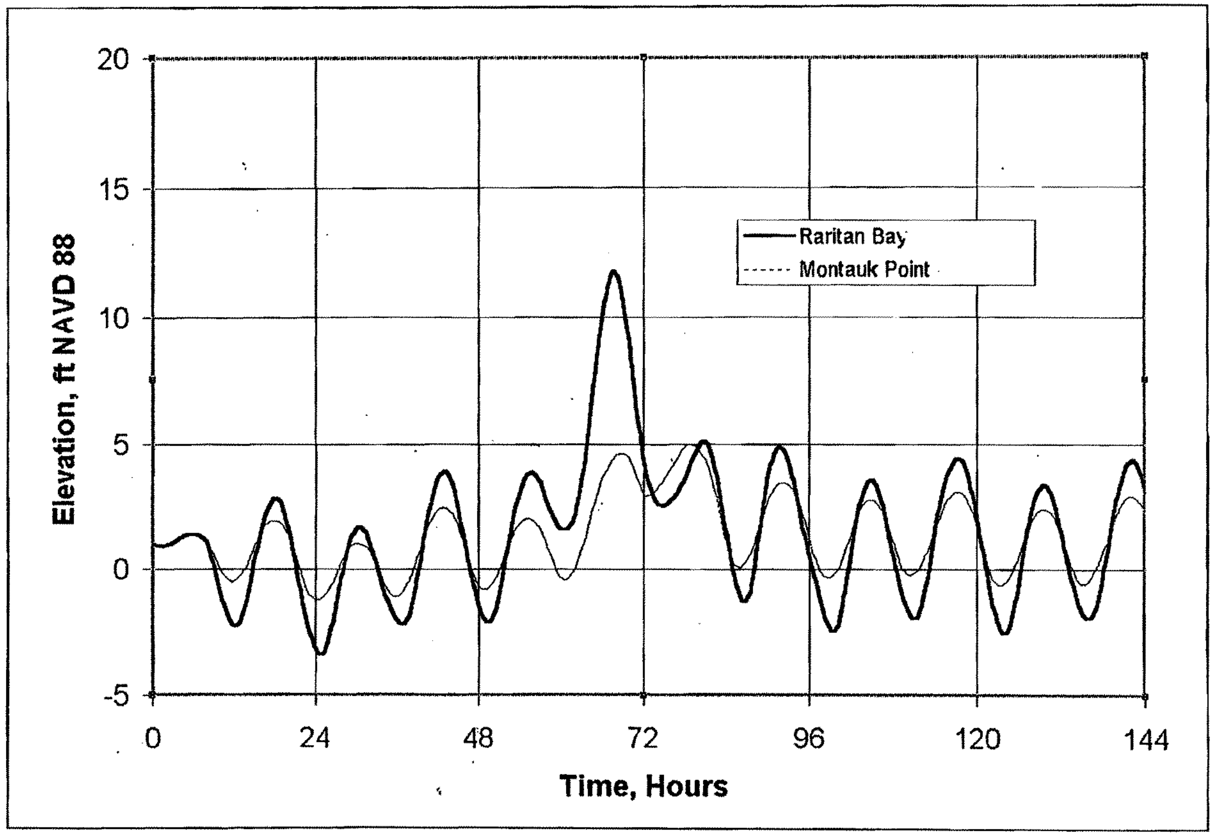


Figure 34 Boundary conditions for 100-year storm

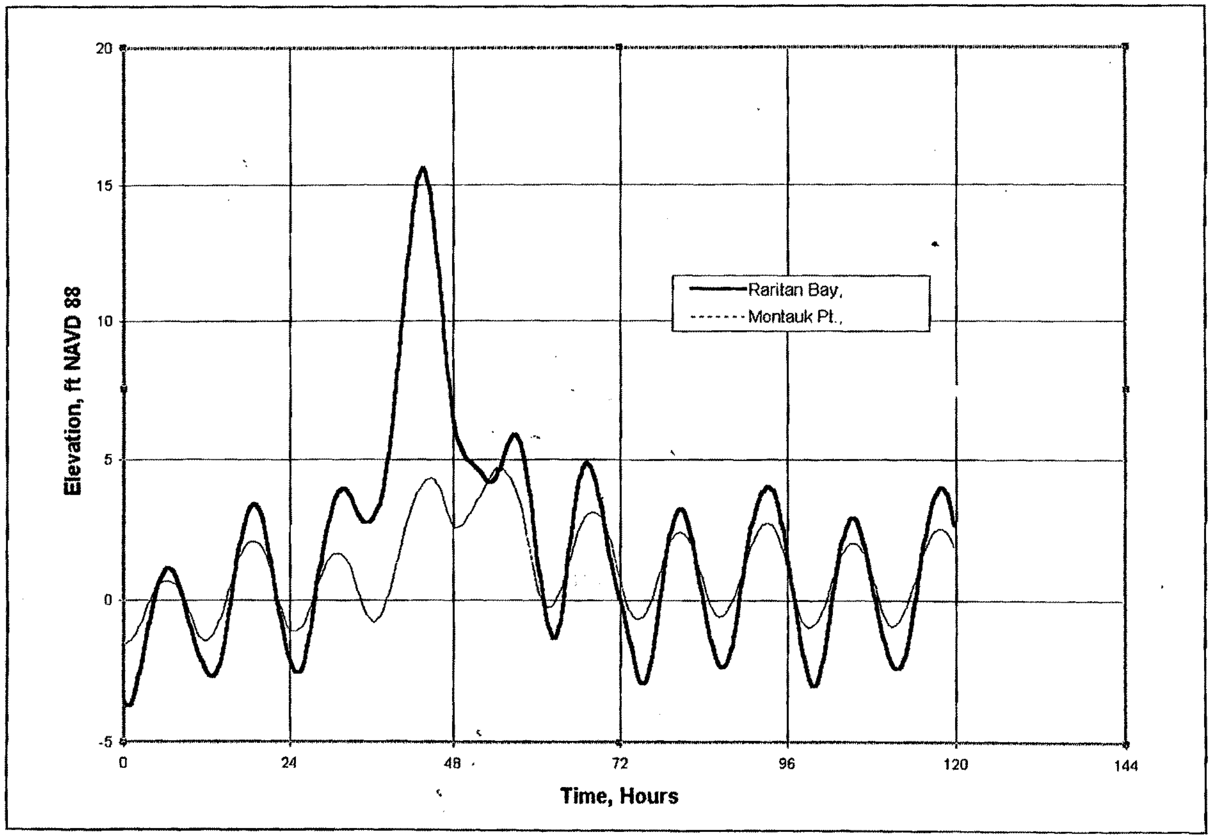


Figure 35. Boundary conditions for 500-year storm

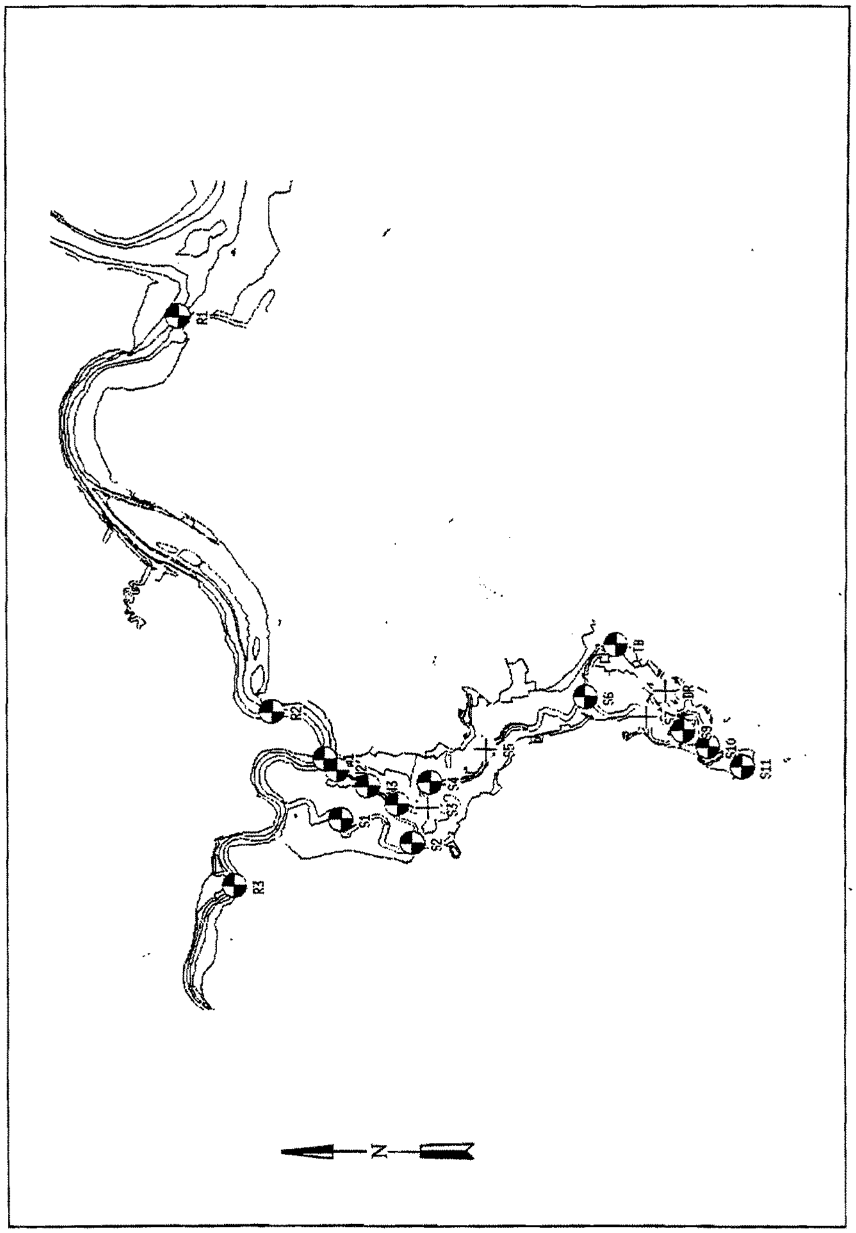


Figure 36a Station locations for model analysis

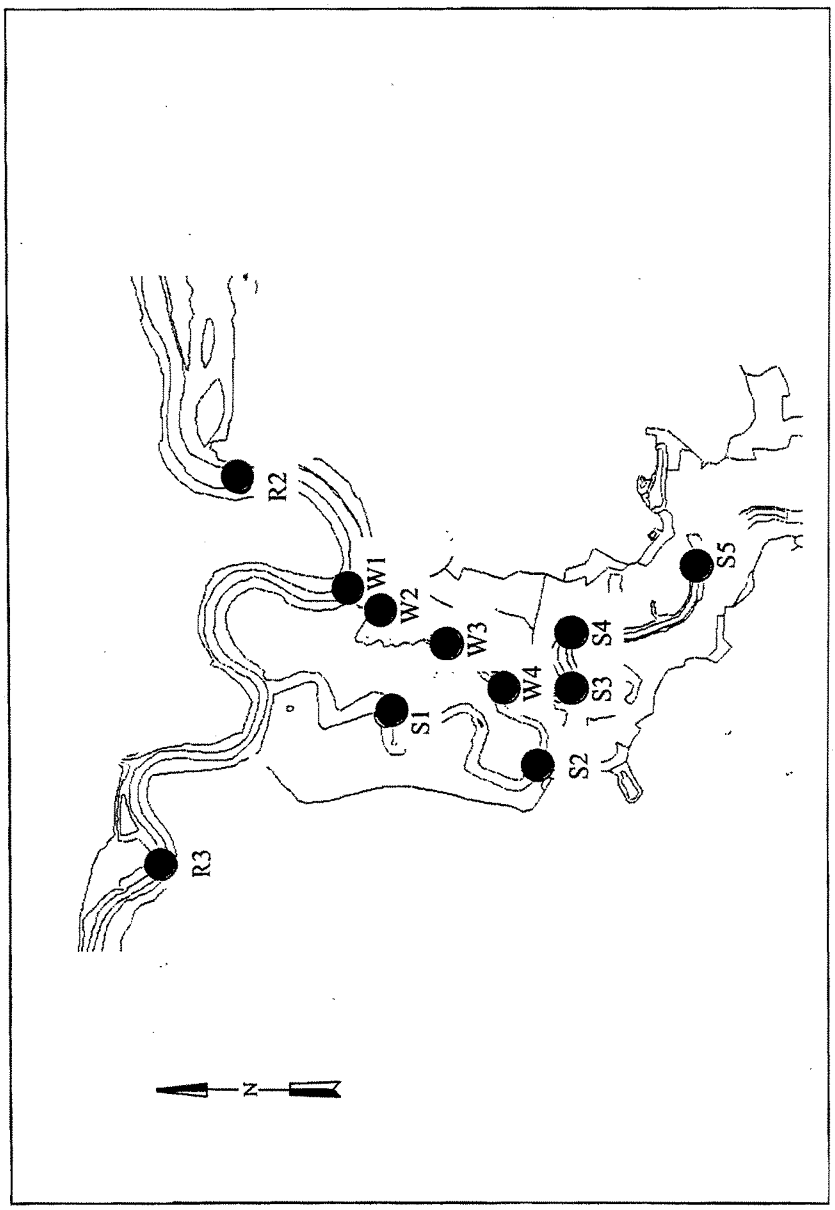


Figure 36b Station locations in northern part of system for model analysis

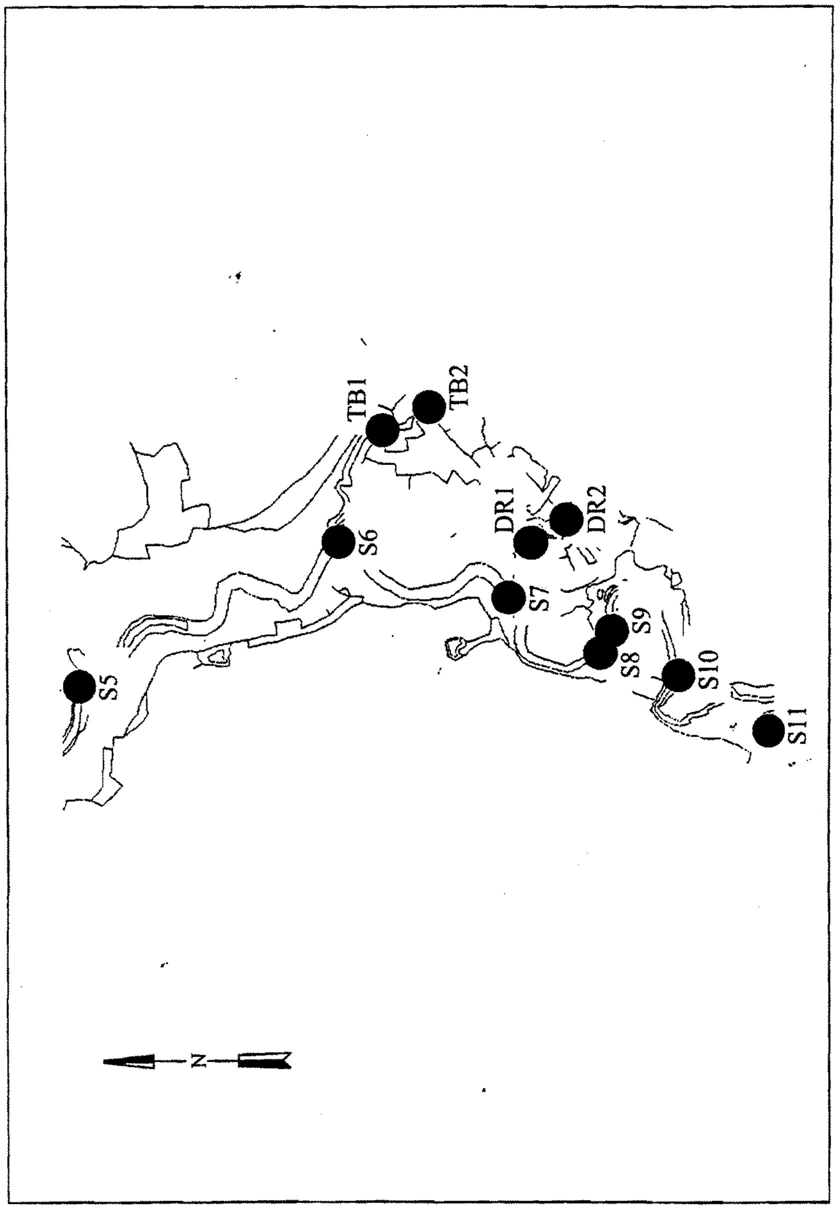


Figure 36c Station locations in lower system for model analysis

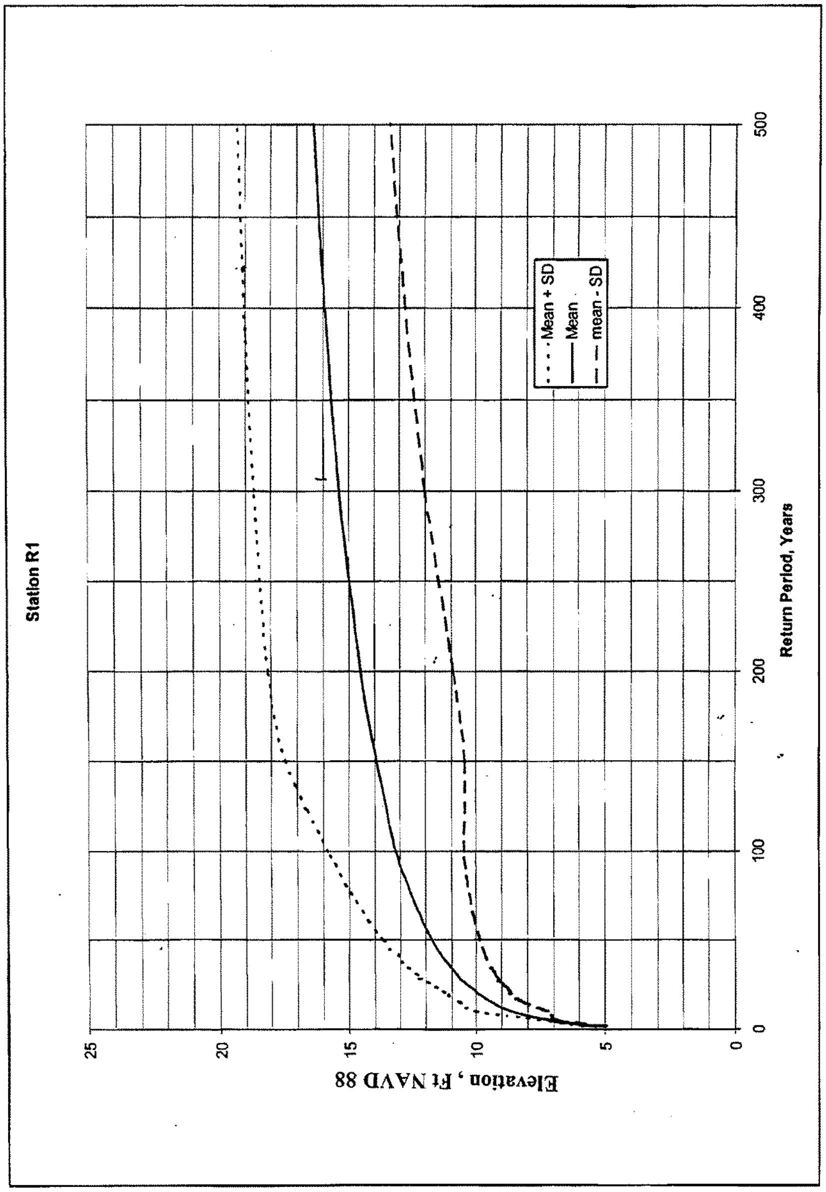


Figure 37a Frequency curve for Plan 3 levees for Station R1

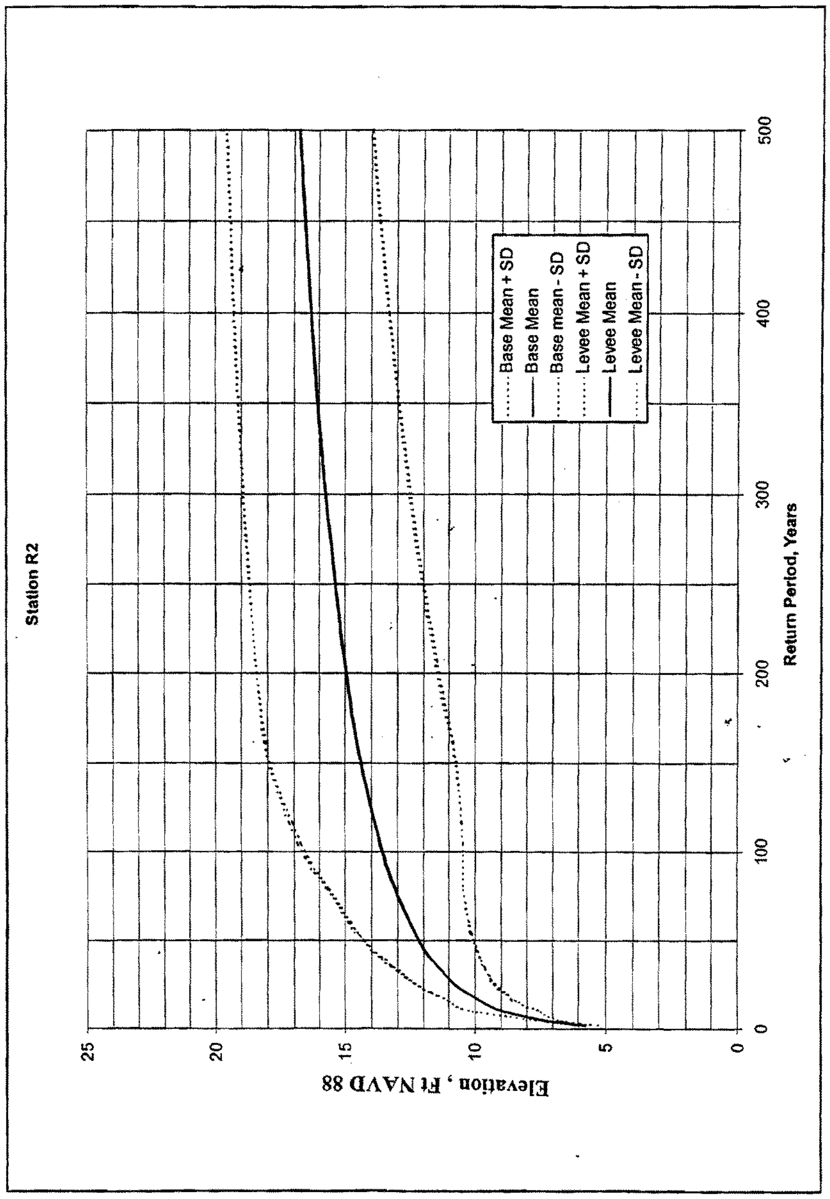


Figure 37b Frequency curve for Plan 3 levees for Station R2

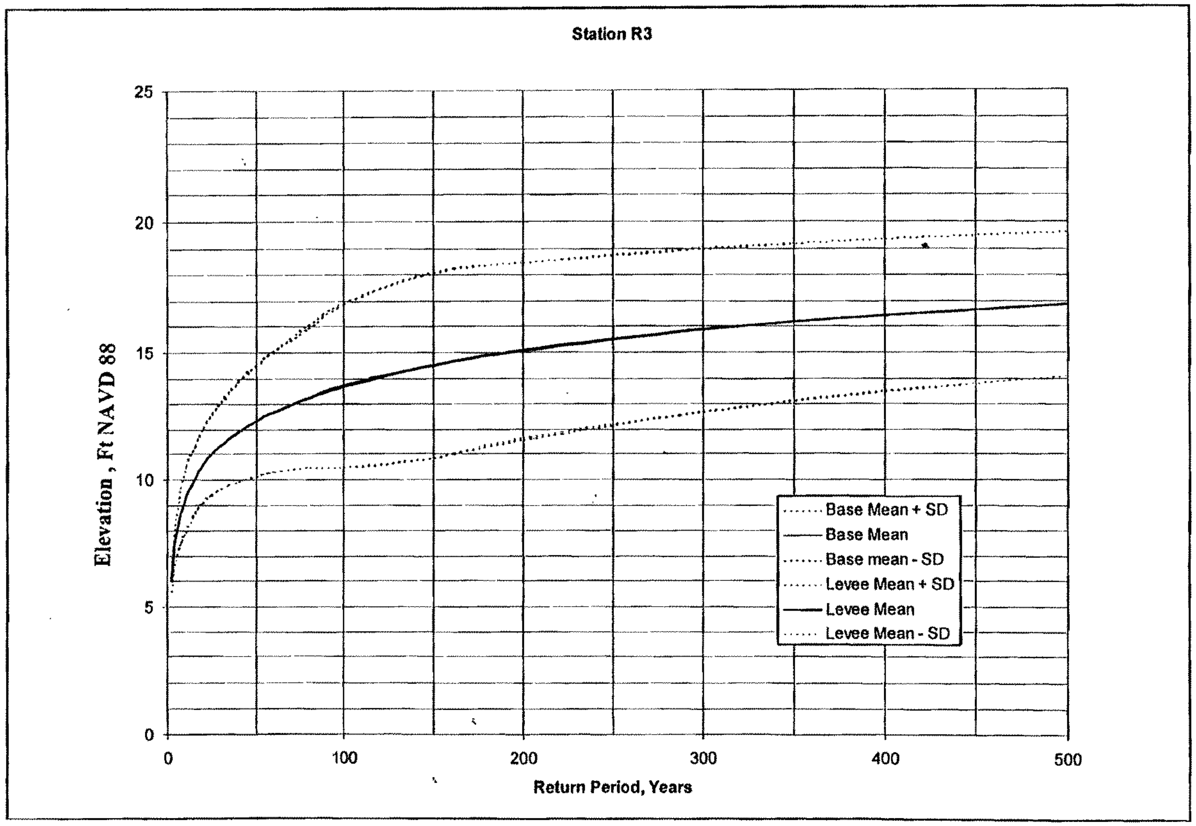


Figure 37c Frequency curve for Plan 3 levees for Station R3

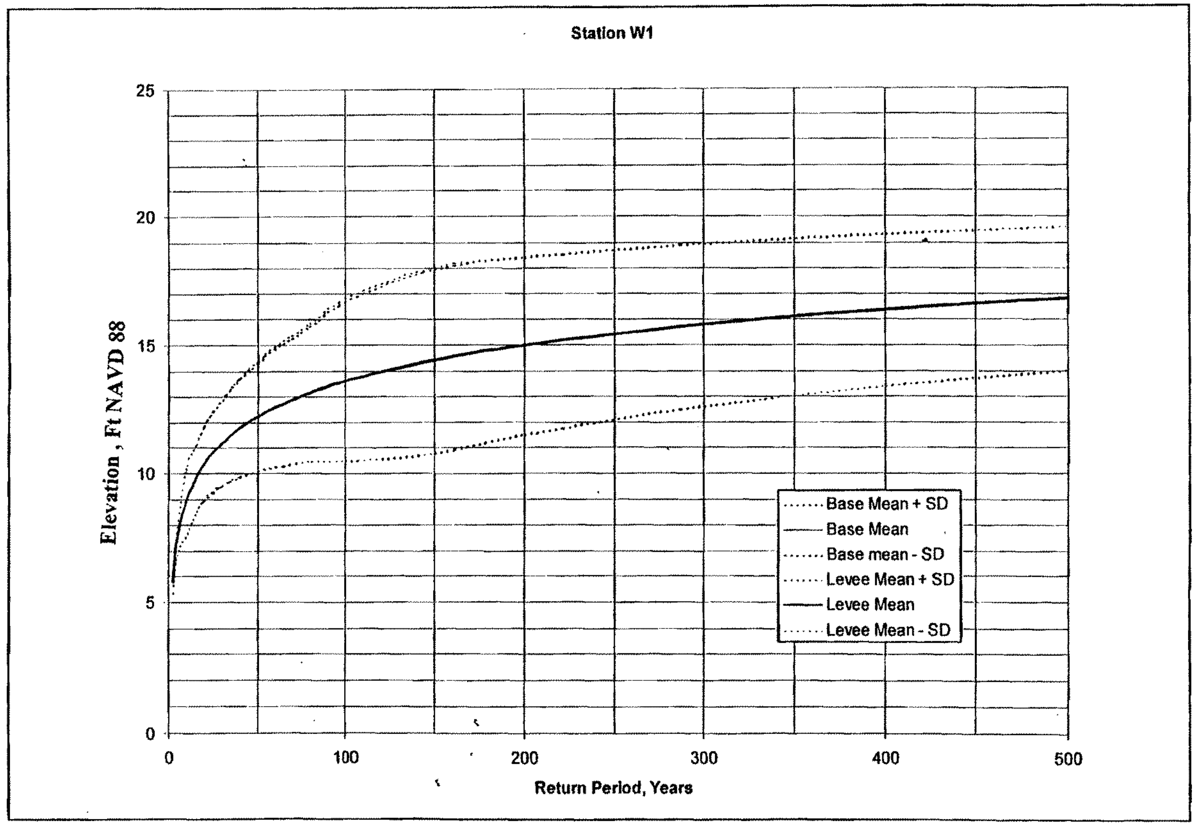


Figure 37d Frequency curve for Plan 3 levees for Station W1

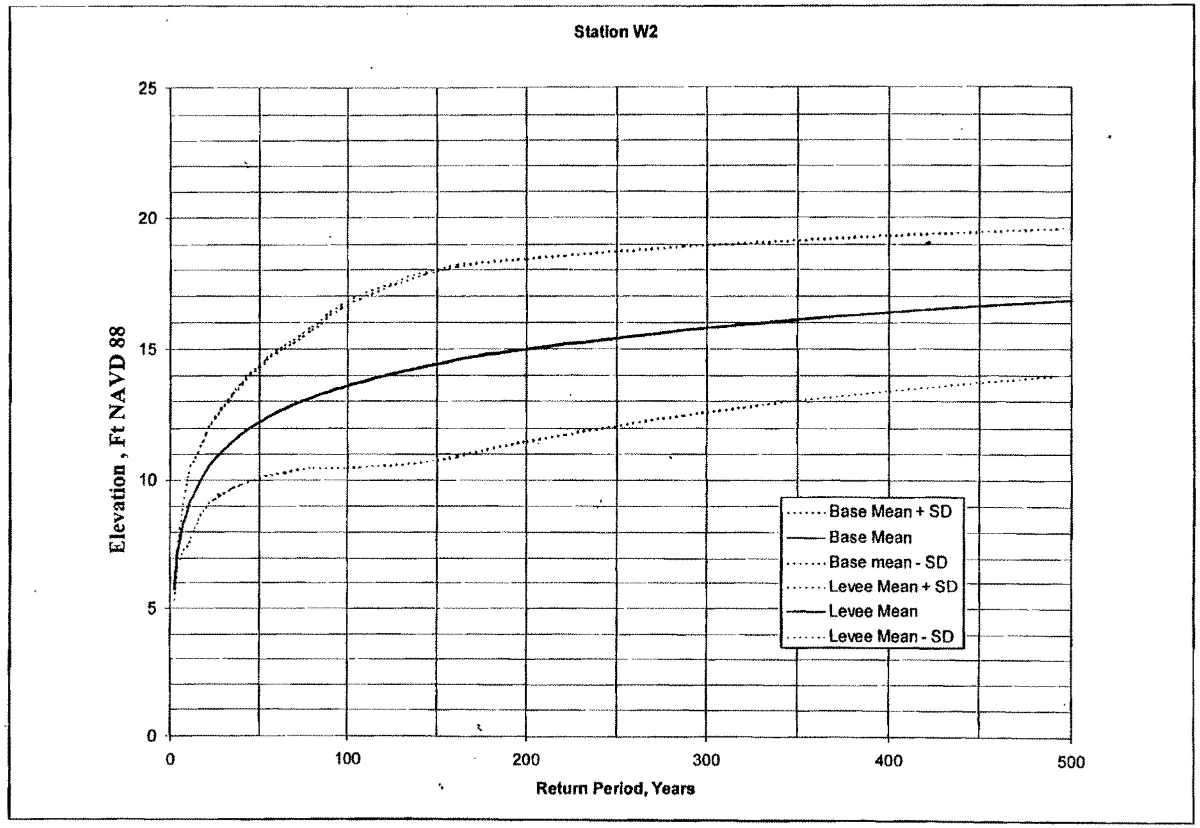


Figure 37e Frequency curve for Plan 2 levees for Station W2

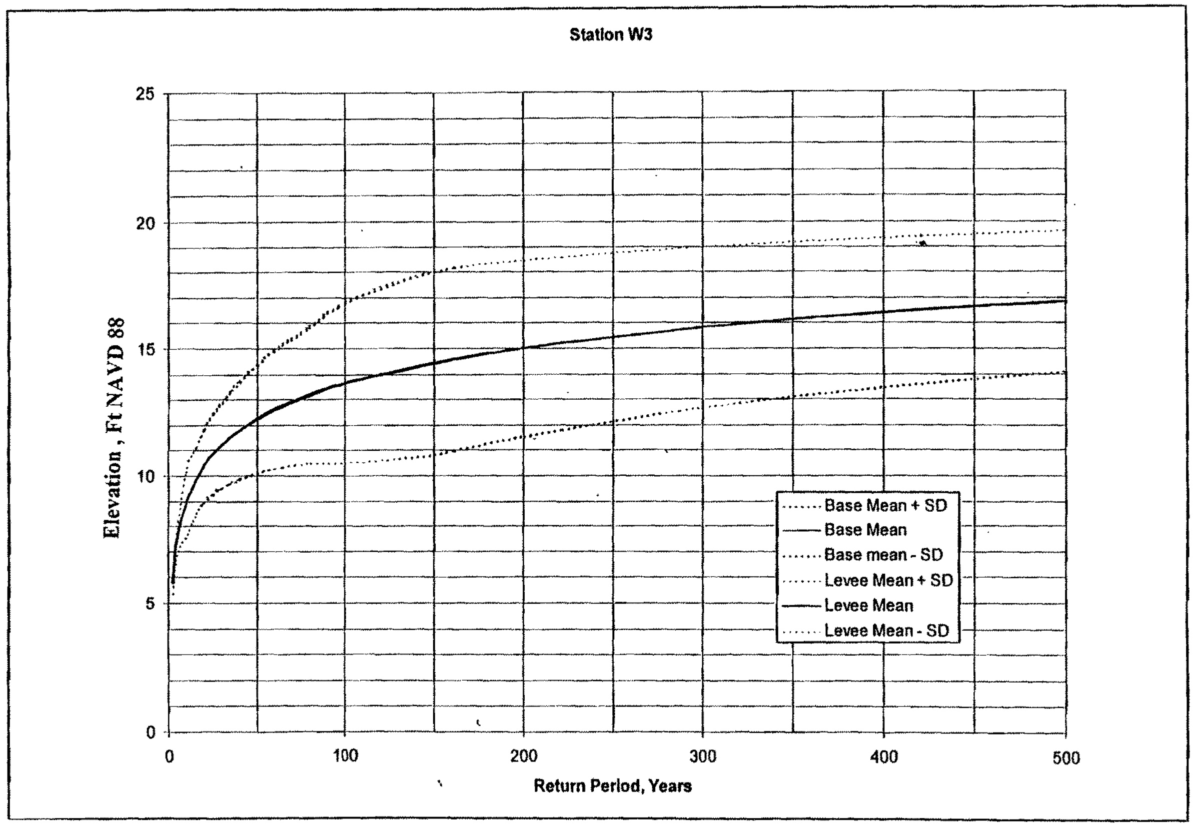


Figure 37f Frequency curve for Plan 3 levees for Station W3

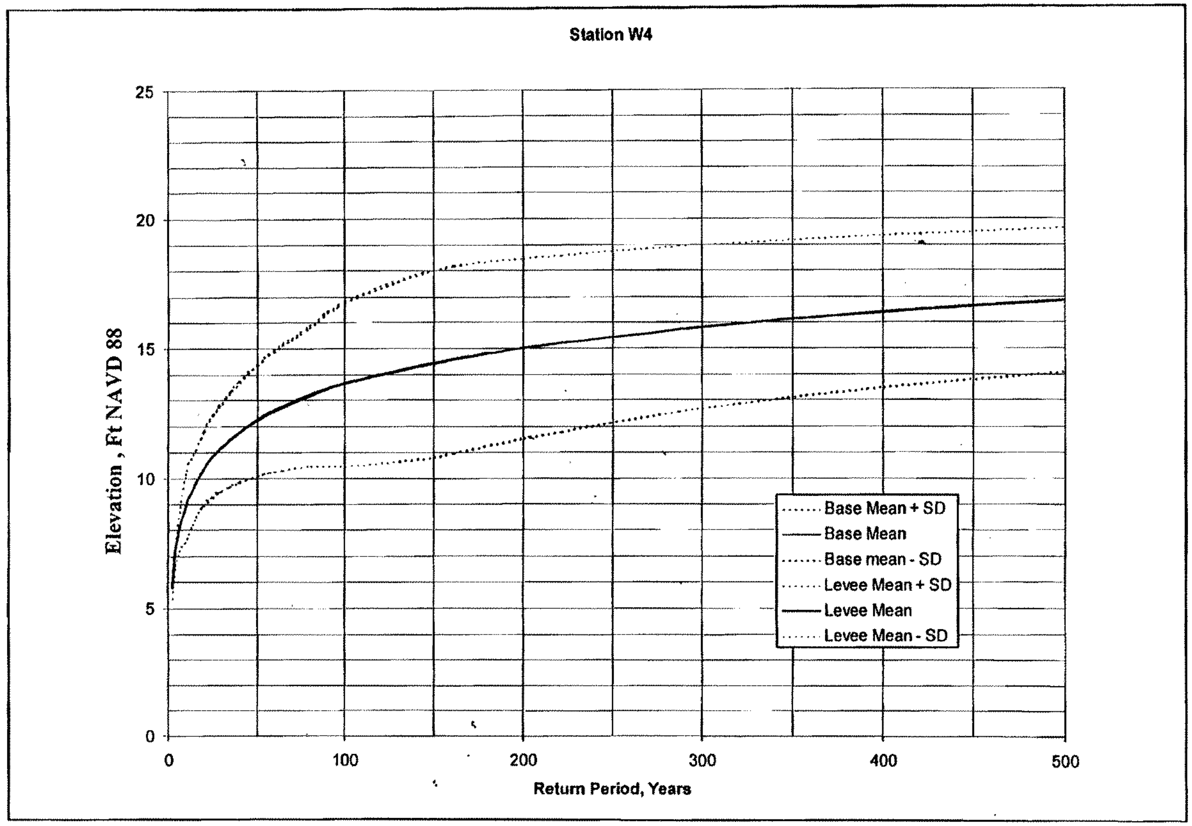


Figure 37g Frequency curve for Plan 3 levees for Station W4

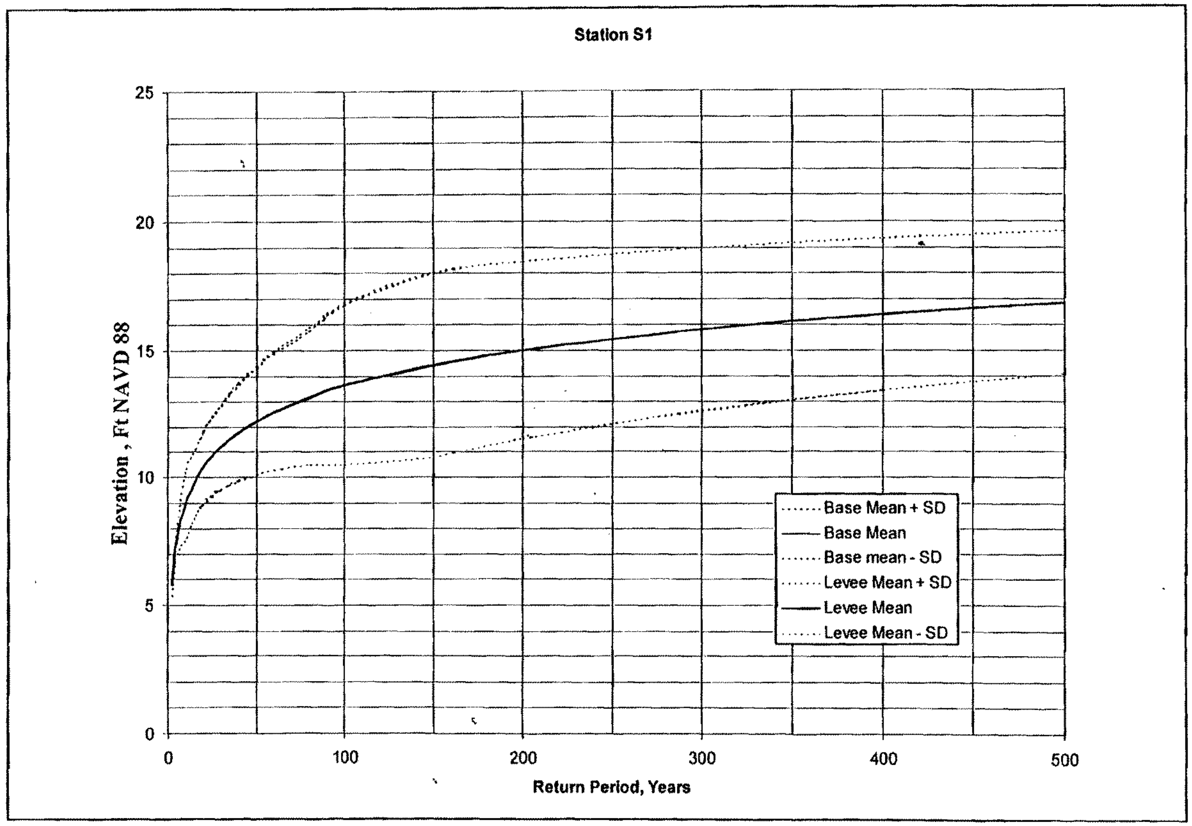


Figure 37h Frequency curve for Plan 3 levees for Station S1

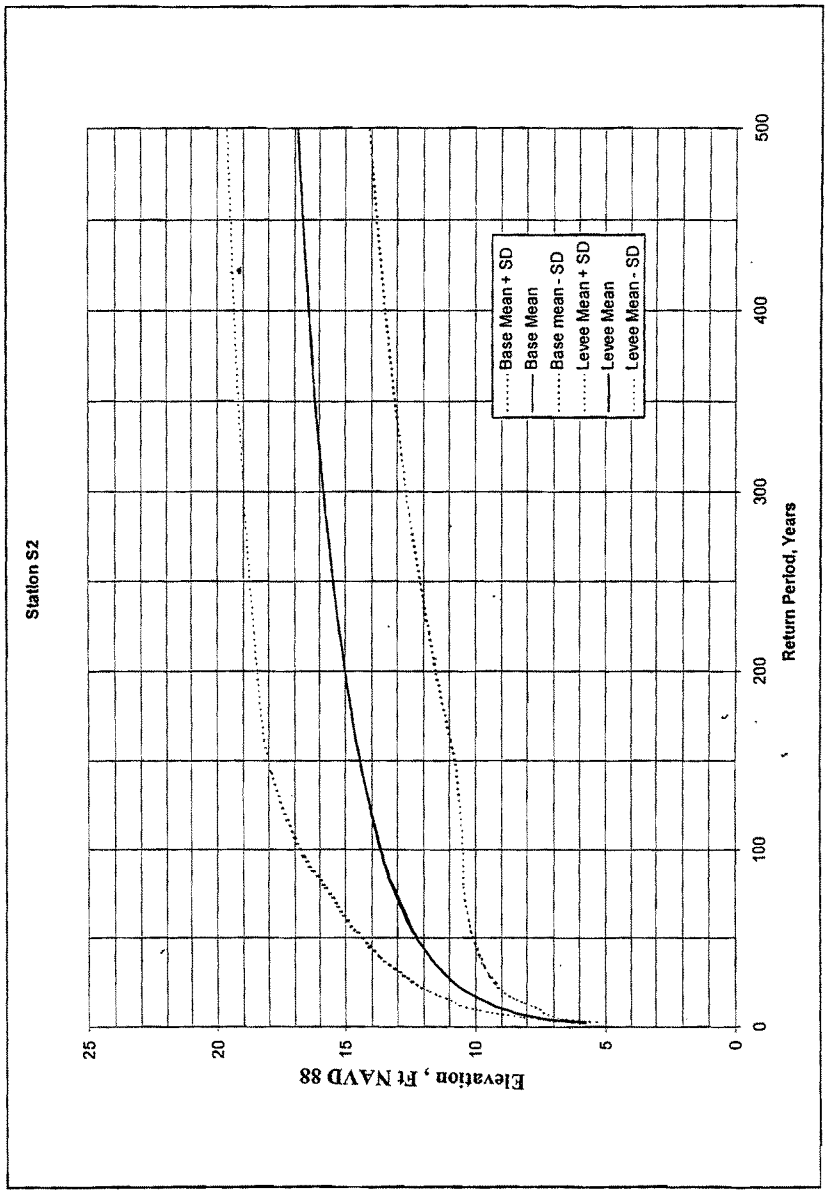


Figure 37i Frequency curve for Plan 3 levees for Station S2

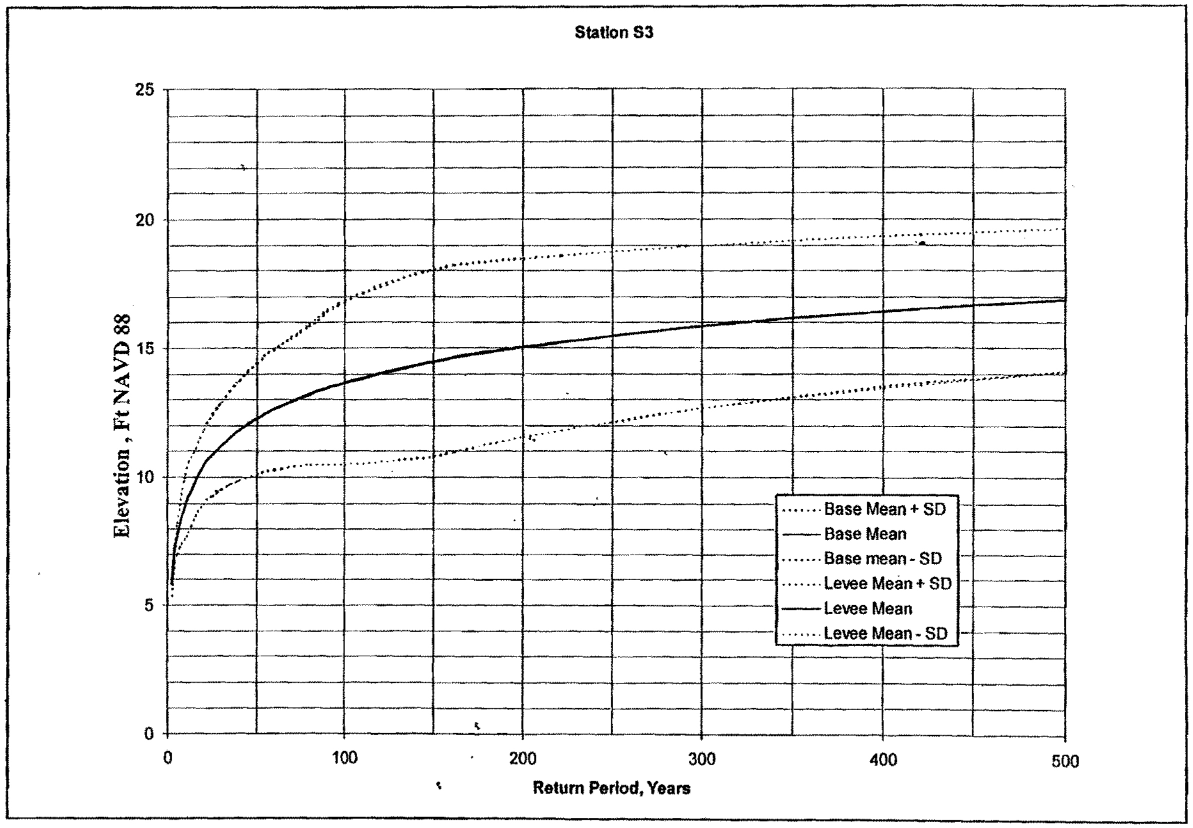


Figure 37j Frequency curve for Plan 3 levees for Station S3

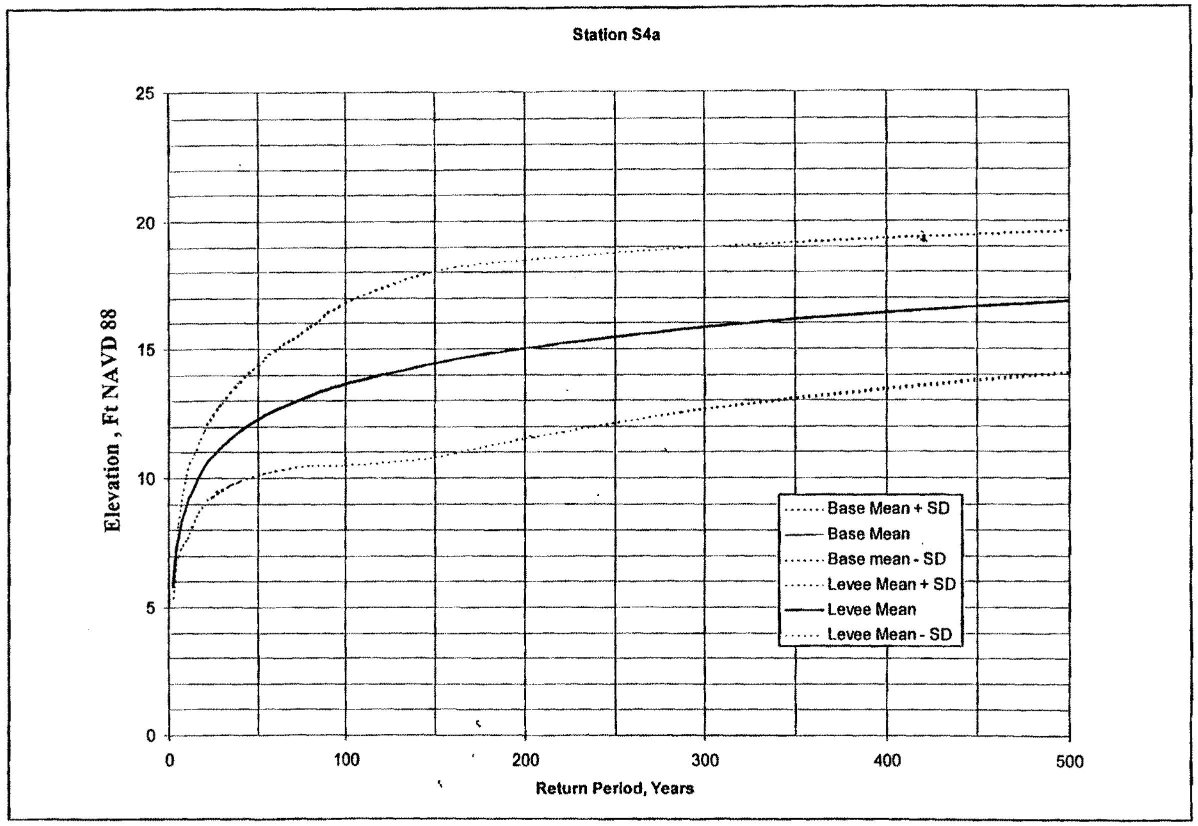


Figure 37k Frequency curve for Plan 3 levees for Station S4A

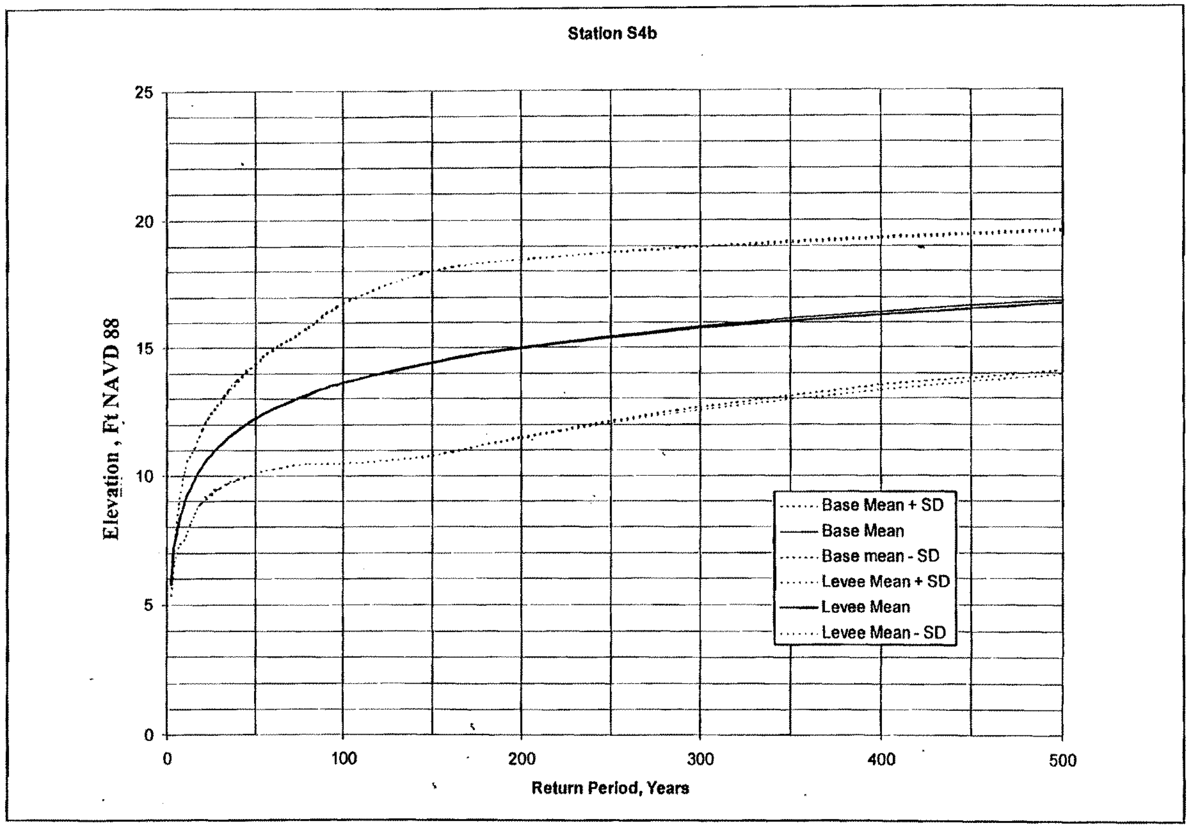


Figure 371 Frequency curve for Plan 3 levees for Station S4B

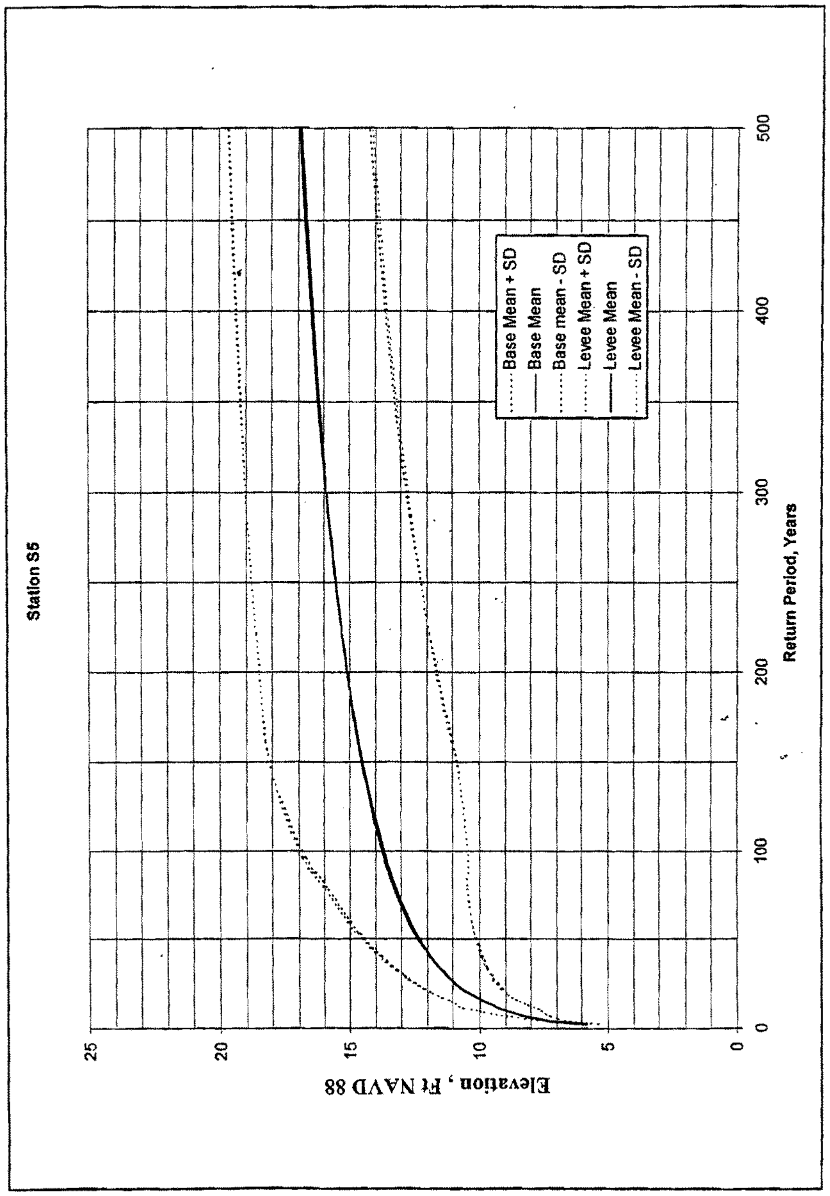


Figure 37m Frequency curve for Plan 3 levees for Station S5

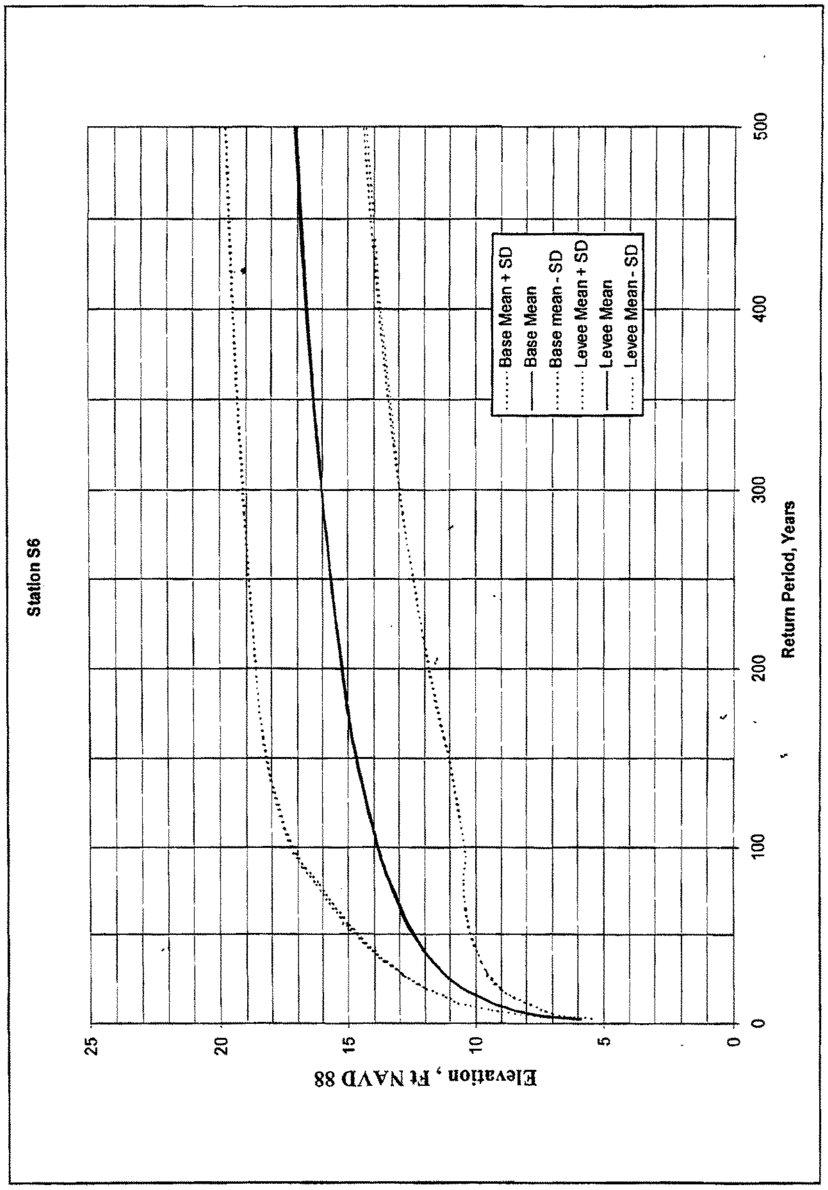


Figure **37n** Frequency curve for Plan **3** levees for Station S6

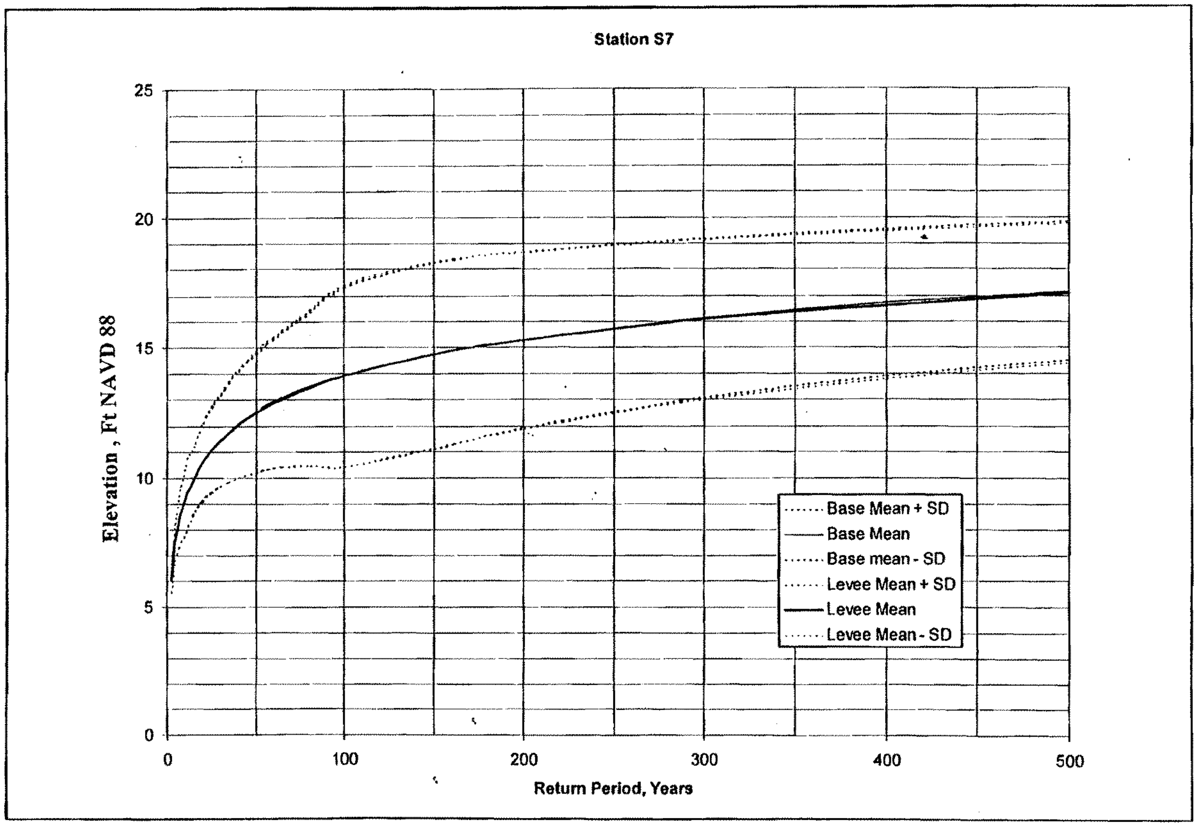


Figure 37o Frequency curve for Plan 2 levees for Station S7

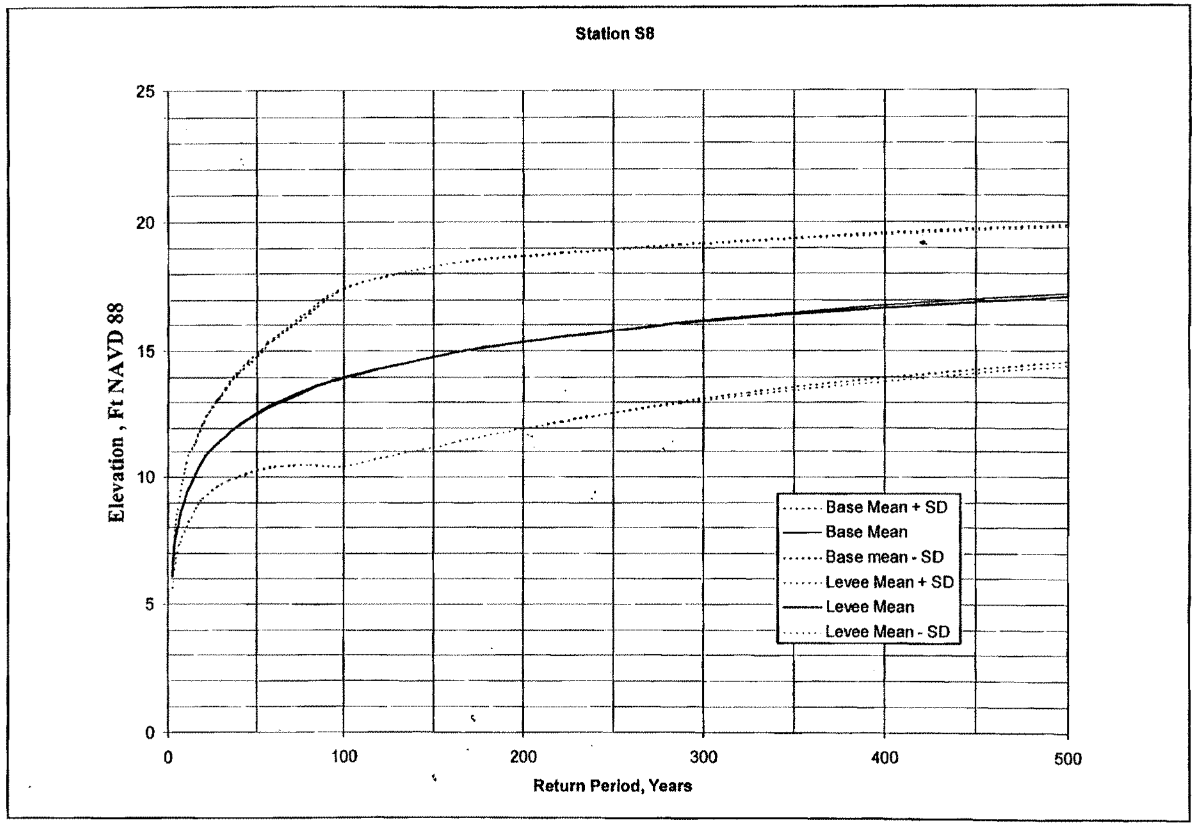


Figure 37p Frequency curve for Plan 3 levees for Station S8

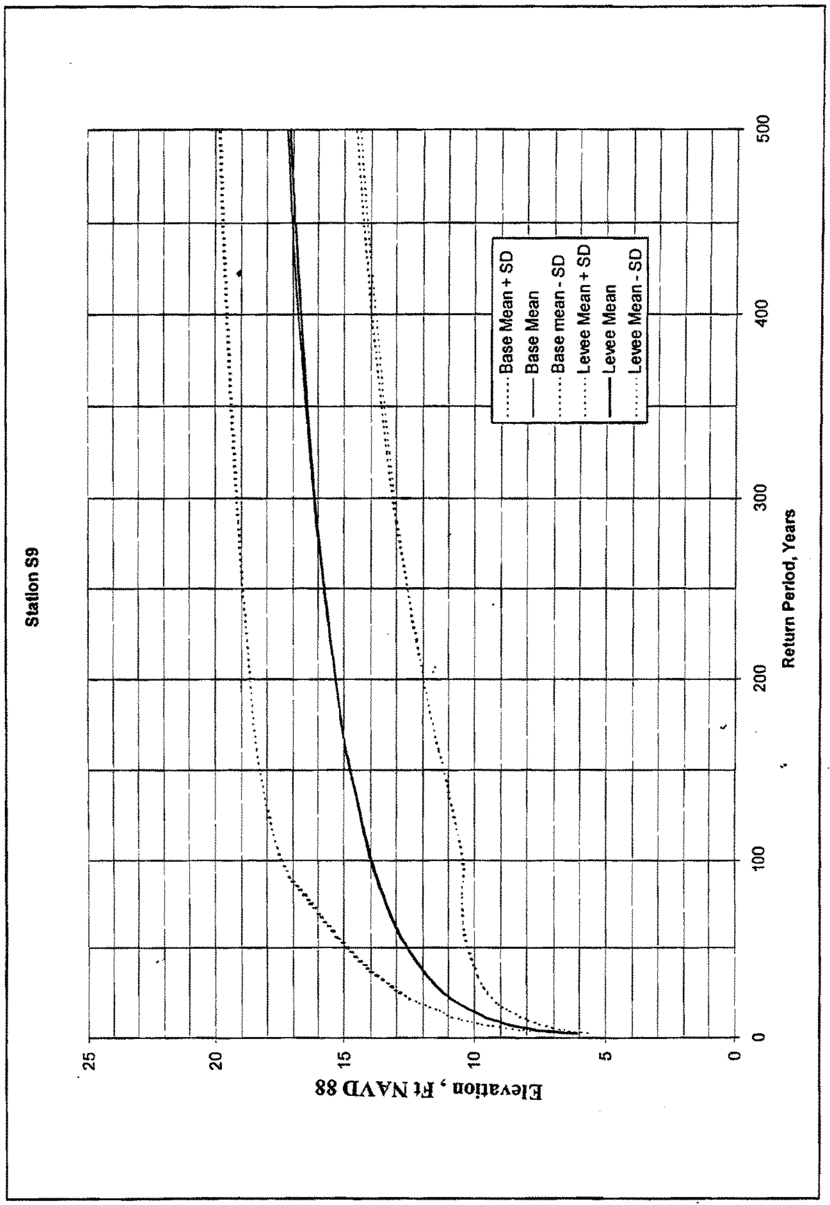


Figure 37q Frequency curve for Plan 3 levees for Station S9

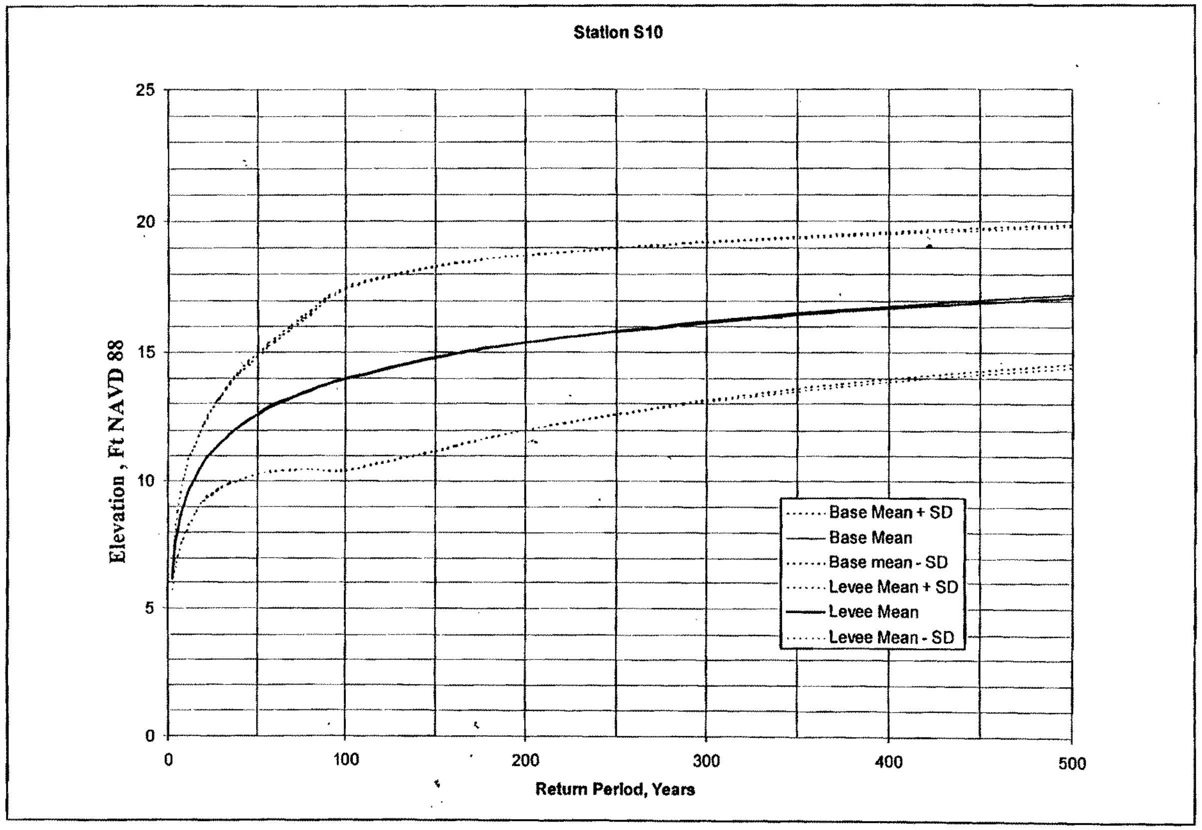


Figure 27r Frequency curve for Plan 2 levees for Station S10

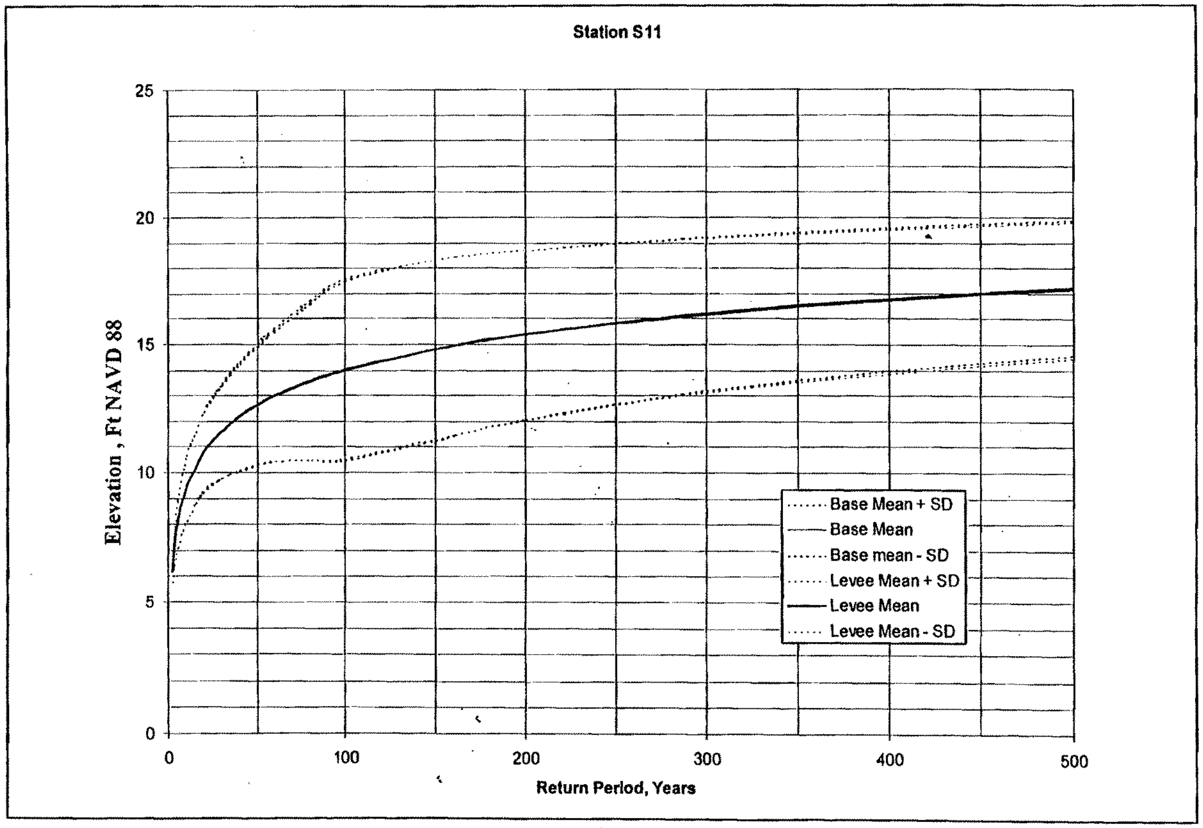


Figure 37s Frequency curve for Plan 3 levees for Station S11

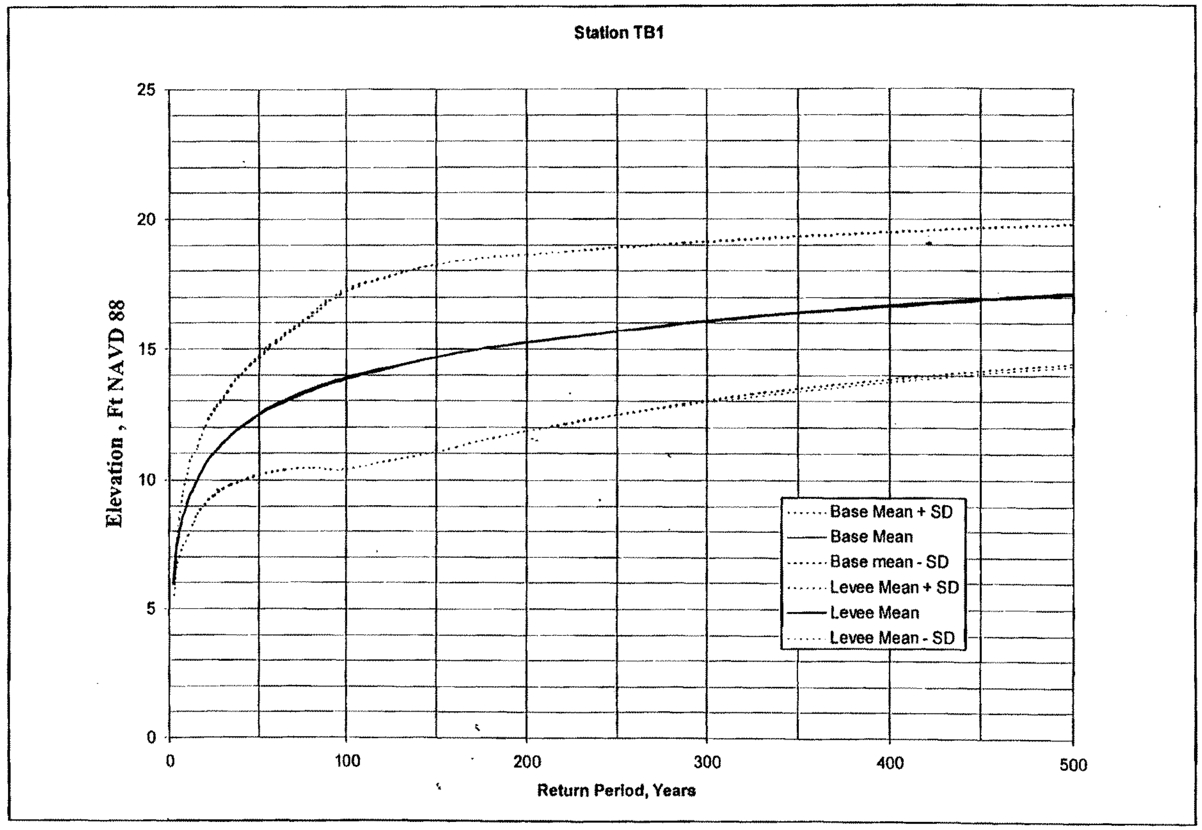


Figure 37t Frequency curve for Plan 3 levees for Station TB1

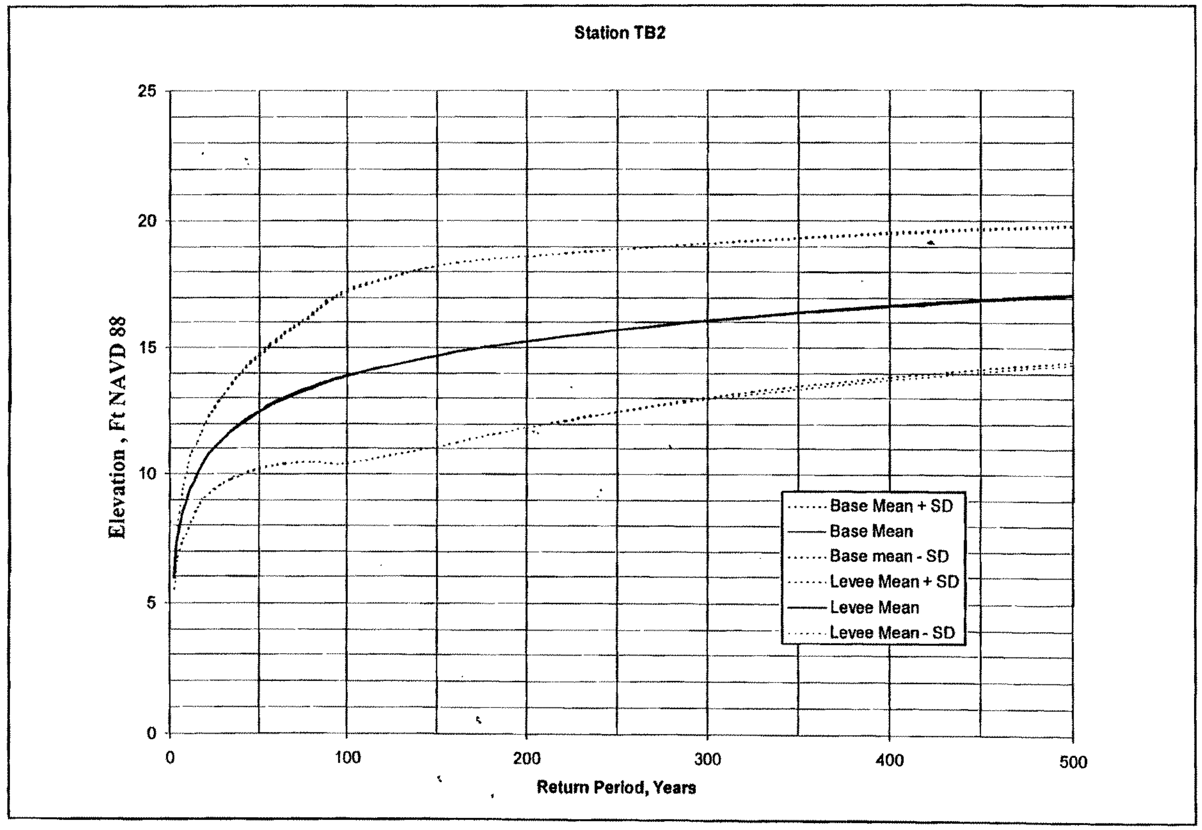


Figure 37u Frequency curve for Plan 2 levees for Station TB2

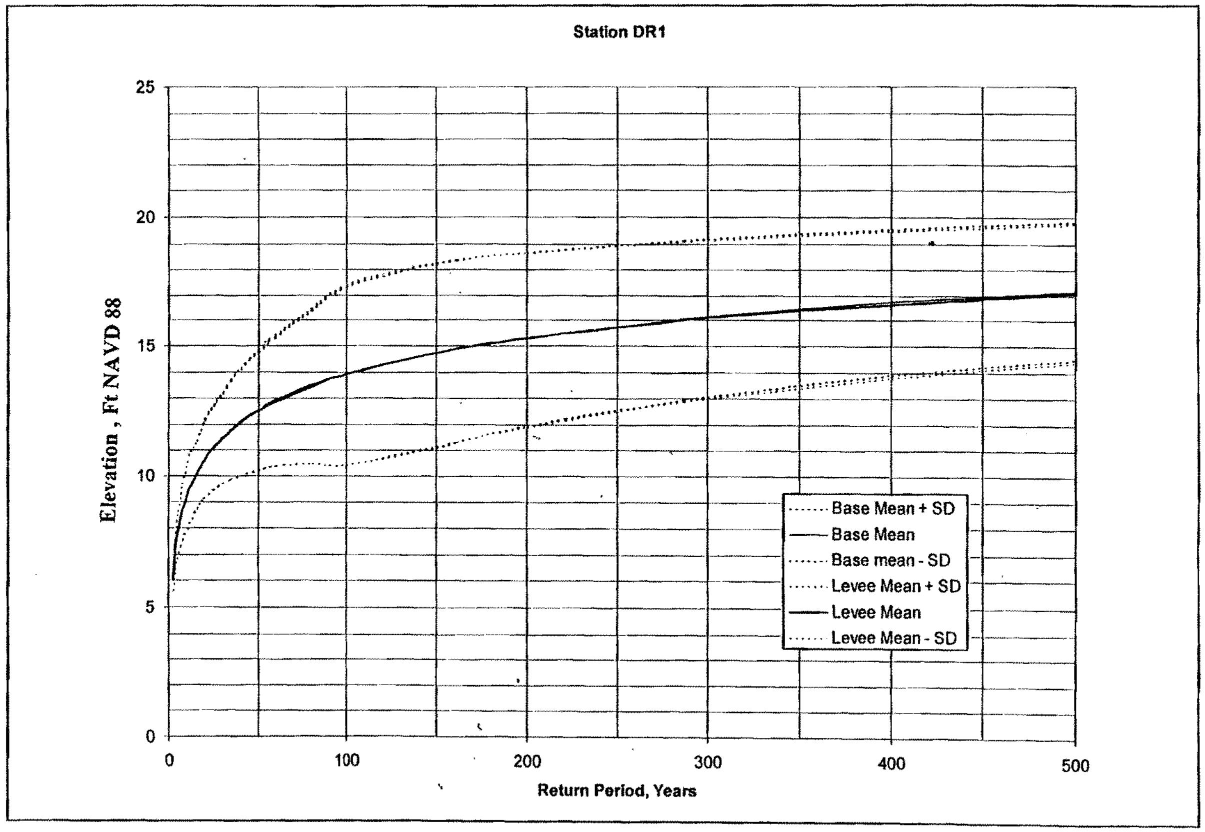


Figure 37v Frequency curve for Plan 2 levees for Station DR1

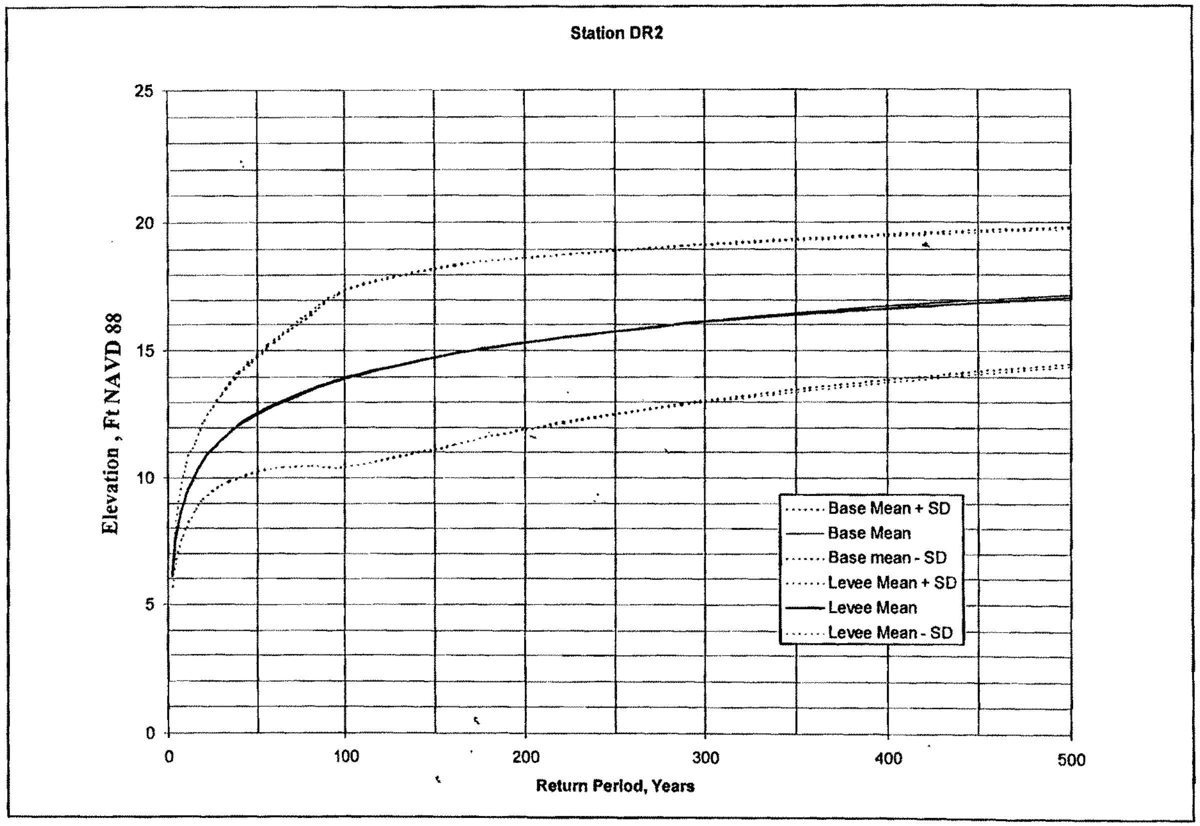


Figure 37w Frequency curve for Plan 3 levees for Station dr2

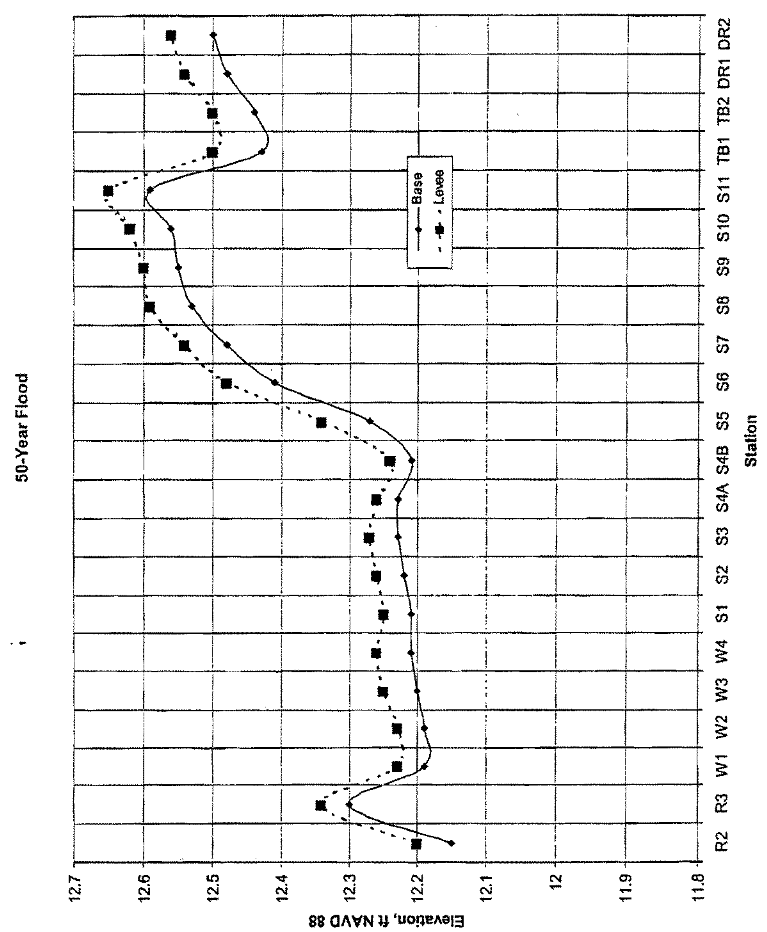


Figure 38a. Profile of peak elevation for 50-year flood

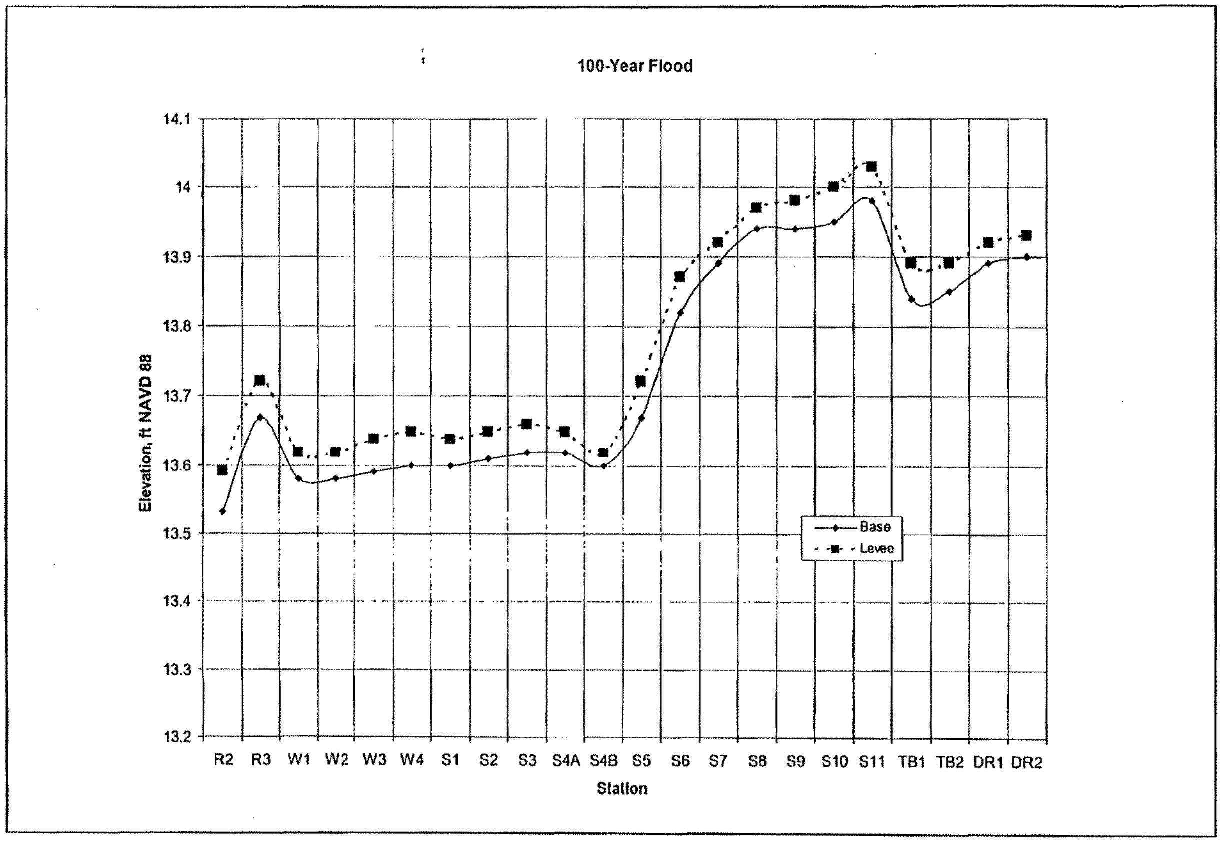


Figure 38b. Profile of peak elevation for 100-year flood

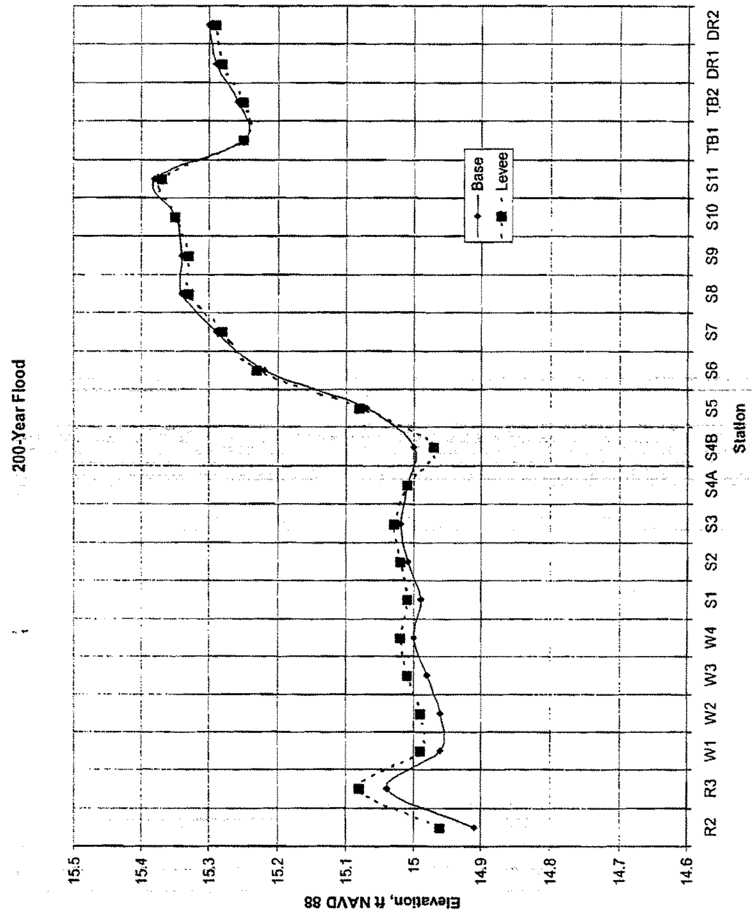


Figure 38c. Profile of peak elevation for 200-year flood

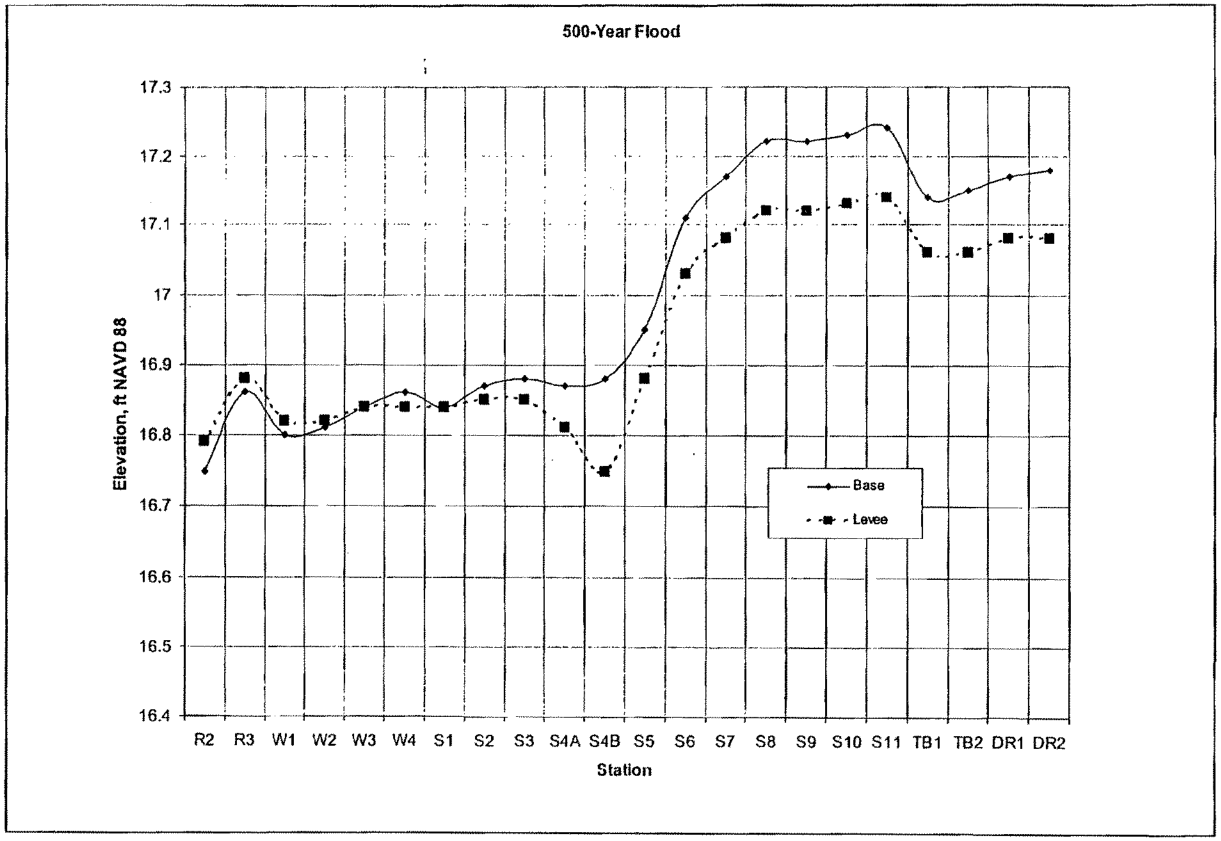


Figure 38d. Profile of peak elevation for 500-year flood

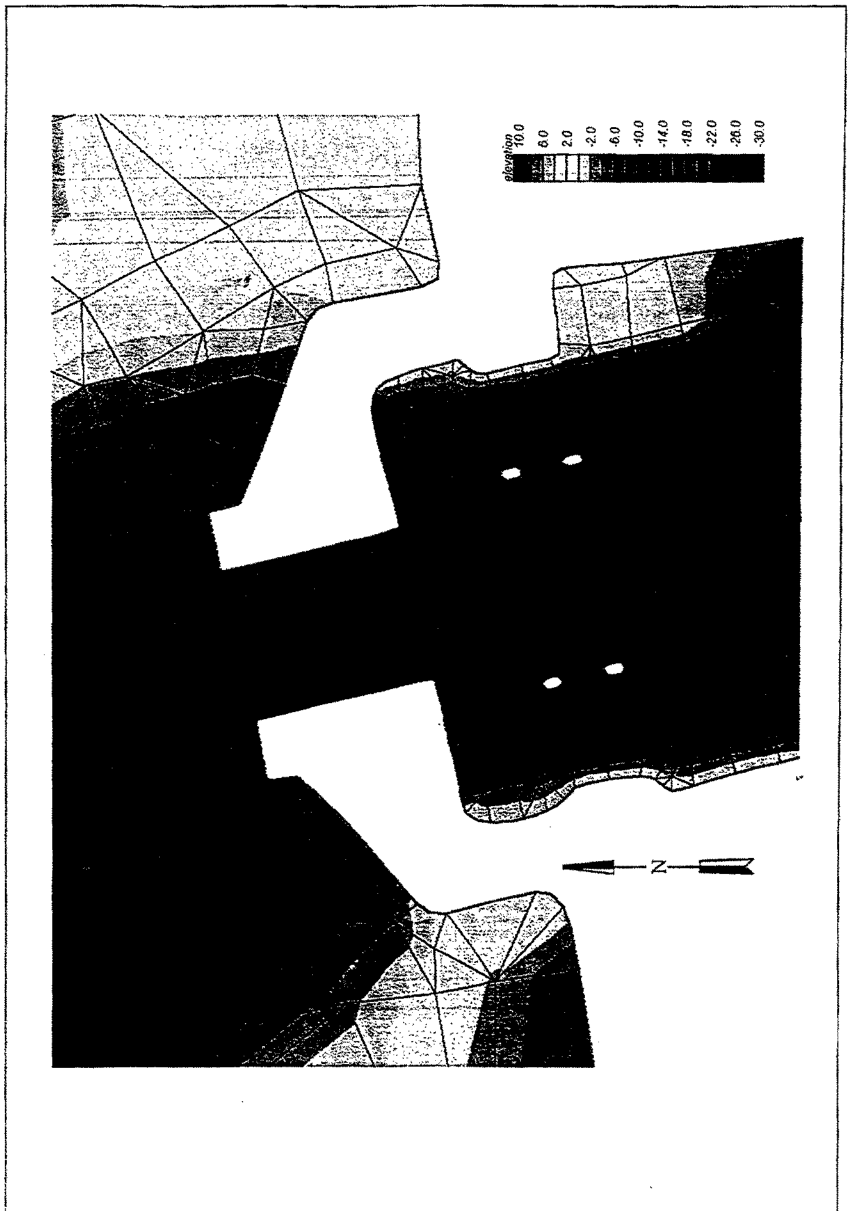


Figure 39. TABS-MD mesh with 80-ft tide gate for Plan 3

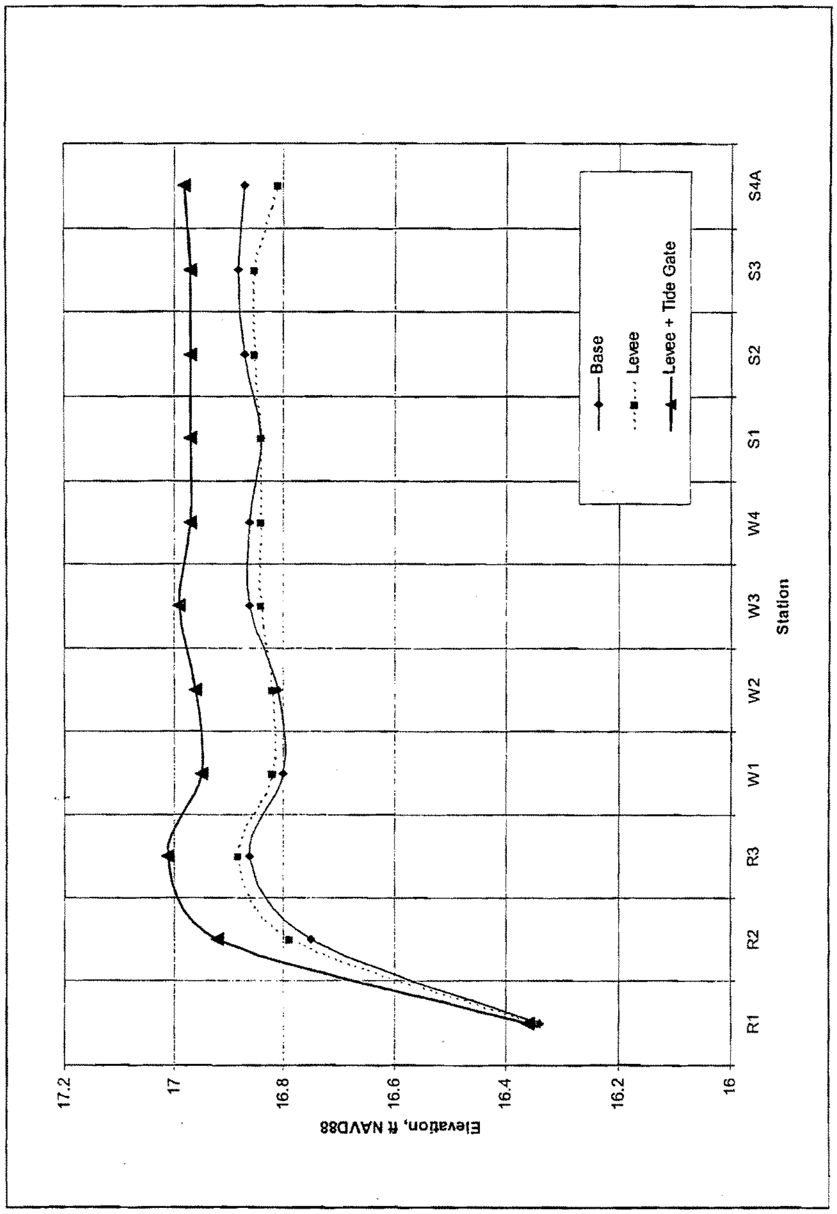


Figure 40. Downstream Effects of tide gate on 500-year flood levels

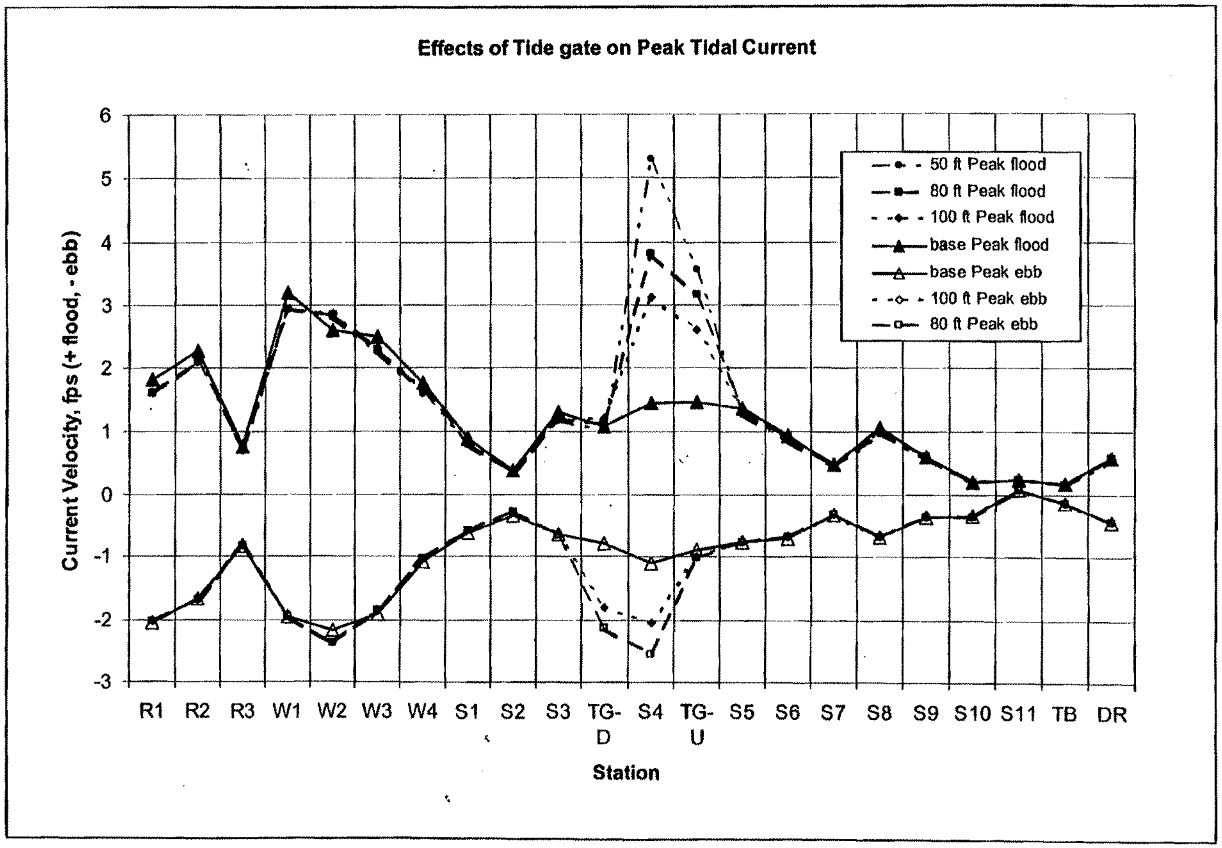


Figure 41. Effects of open tide gate on tidal currents for different gate sizes

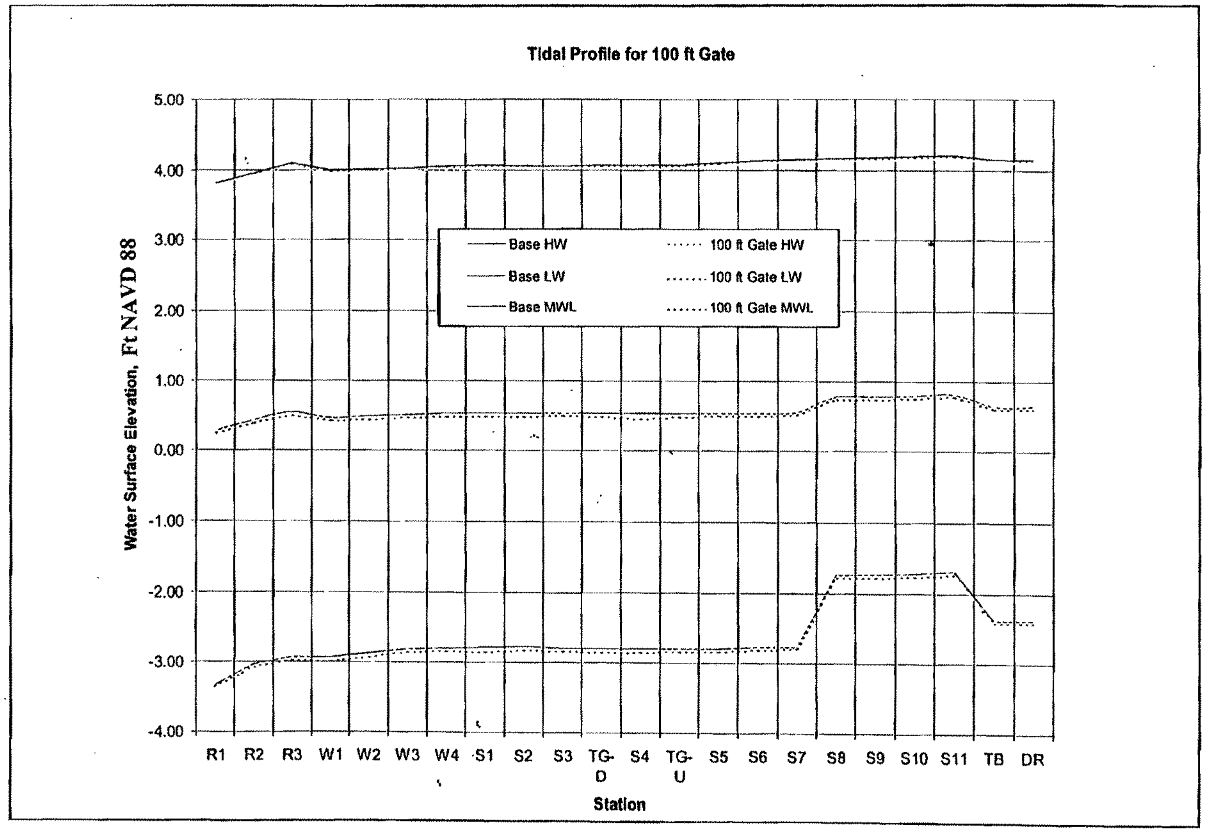


Figure 42a High and low water profiles for the HAT 100-ft gate simulation

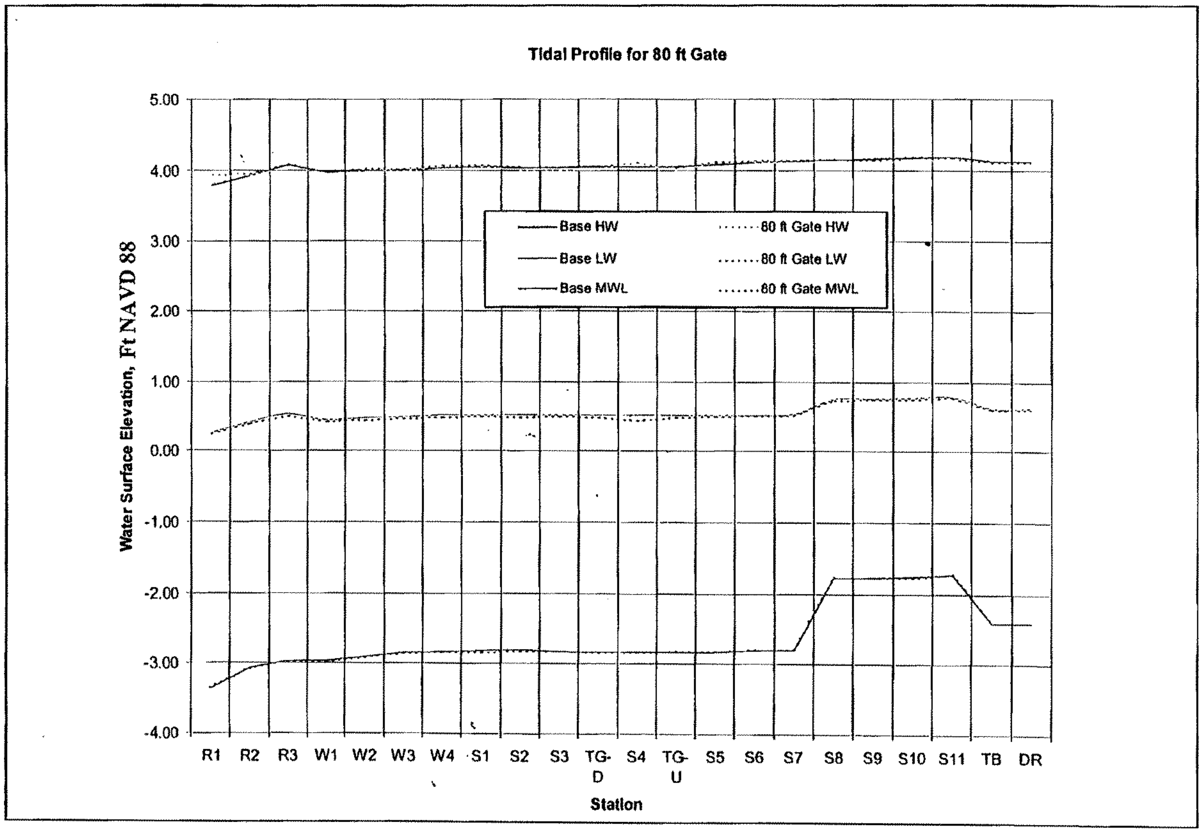


Figure 42b High and low water profiles for the HAT 80-ft gate simulation

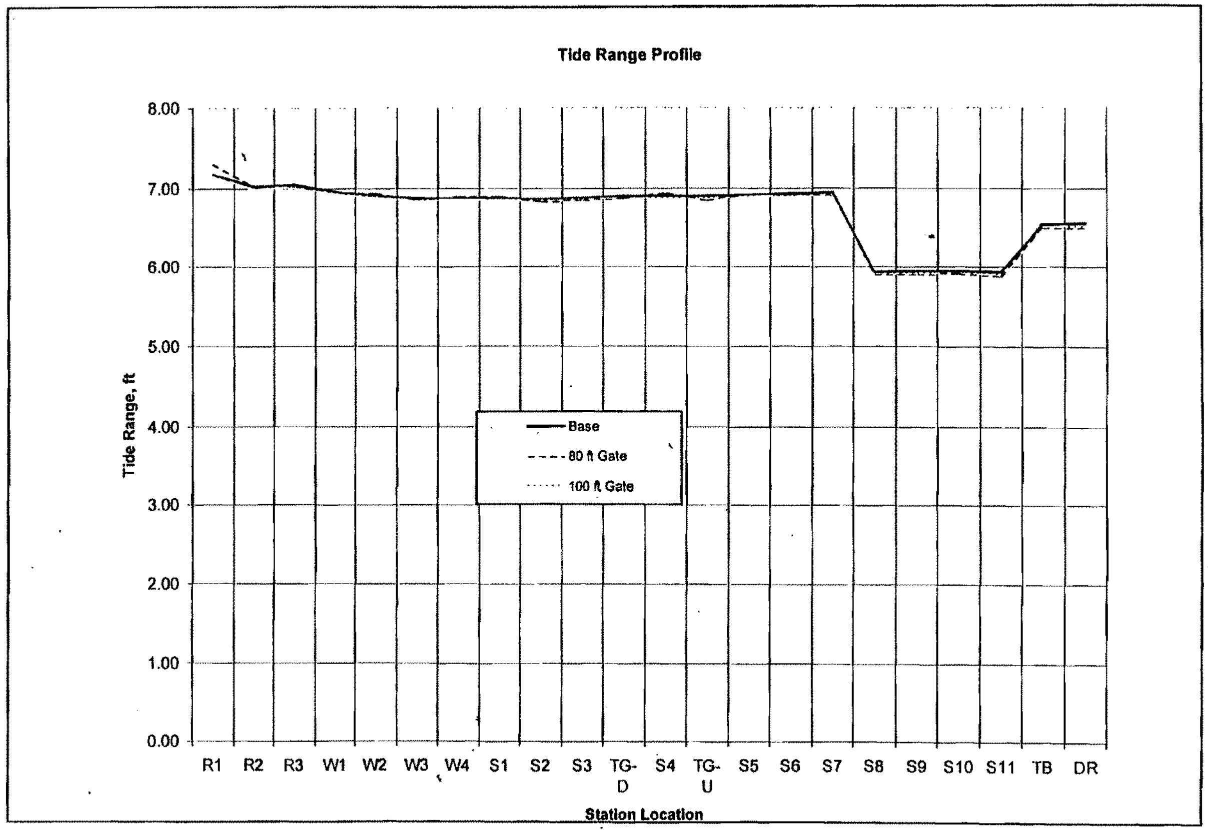


Figure 43 . Tide range profiles for the HAT simulations

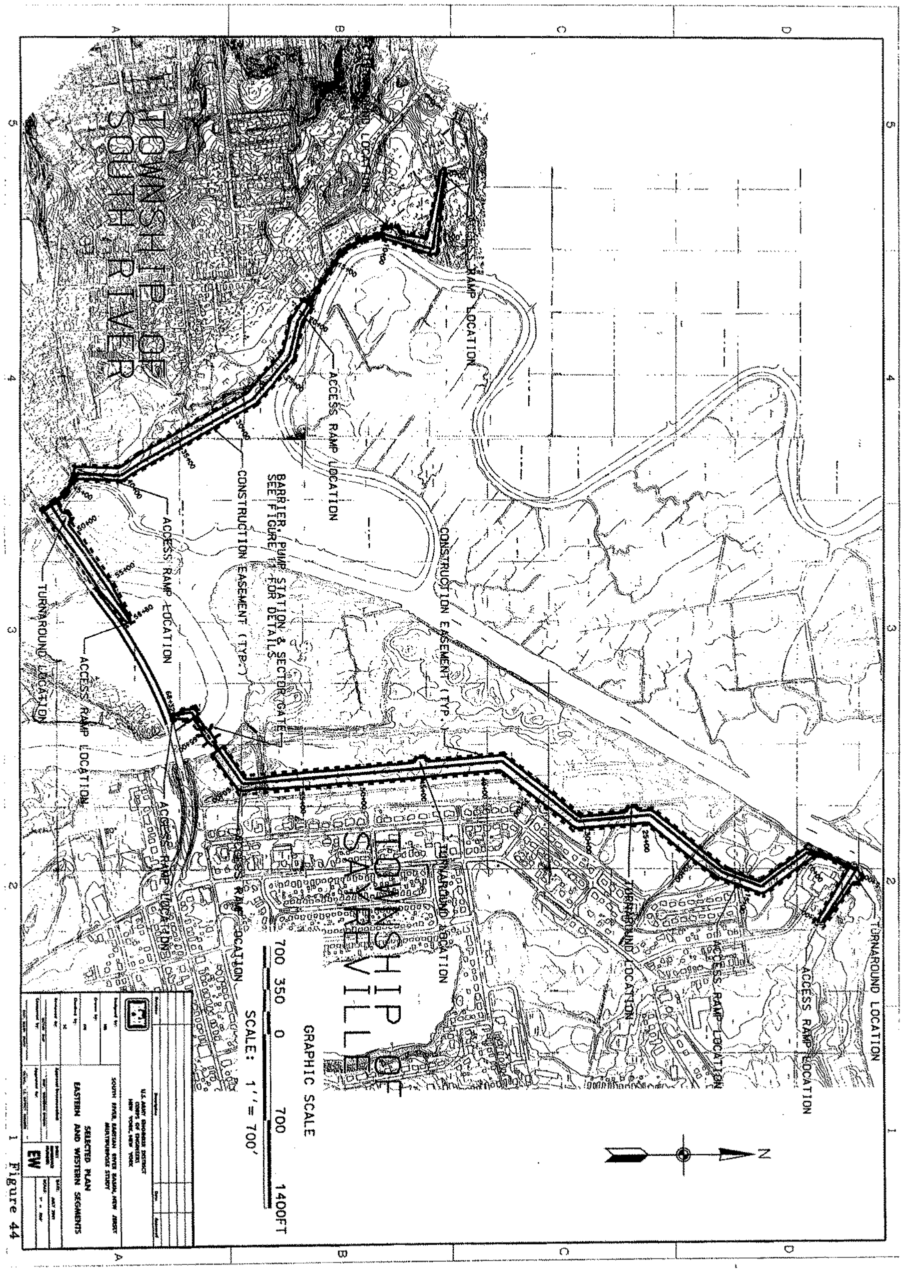

TOWNSHIP OF SOUTH RIVER
TOWNSHIP OF SAYREVILLE
ACCESS RAMP LOCATION
TURNAROUND LOCATION
CONSTRUCTION EASEMENT (TYP.)
BARRIER, PUMP STATION & SECTOR GATE
GRAPHIC SCALE
700 350 0 700 1400FT
SCALE: 1''= 700'
N
SELECTED PLAN
EASTERN AND WESTERN SEGMENTS
EW

Figure 44

TABLE C-1
Total First Cost (Selected Plan)

South River Flood Control Feasibility Study

Account Code	Description	QTY	UOM	Unit Price	Amount	% Cont'g	Cont'g Amt	Total
06	FISH AND WILDLIFE FACILITIES							
	Surveying	1	LS	7700.00	$ 7,700	20.00%	$ 1,500	$ 9,200
	Mobilization & Demobilization	1	LS	106800.00	$ 106,800	20.00%	$ 21,400	$ 128,200
	Site Access	1	LS	185,100	$ 185,100	20.00%	$ 37,000	$ 222,100
	Site preparation	11.21	ACR	26,521	$ 297,300	20.00%	$ 59,500	$ 356,800
	Levee Improvements	7	ACR	88,700	$ 620,900	20.00%	$ 124,200	$ 745,100
	Excavation for Marsh Creation	9.51	ACR	92,513	$ 879,800	20.00%	$ 176,000	$ 1,055,800
	Planting	11.1	ACR	12,054	$ 133,800	20.00%	$ 26,800	$ 160,600
	Erosion Control	1	LS	133,900	$ 133,900	20.00%	$ 26,800	$ 160,700
	Monitoring	1	LS	22,300	$ 22,300	20.00%	$ 4,500	$ 26,800
	SUBTOTAL				$ 2,387,600		$ 477,700	$ 2,865,300
11	LEVEES AND FLOODWALLS							
	Mob & Demob	1	LS		$ 150,000	15.00%	$ 22,500	$ 172,500
	LEVEES							
	Clear & Grub	25	ACR	9916.00	$ 247,900	15.00%	$ 37,200	$ 285,100
	Excavation, Common	33700	CY	11.00	$ 370,700	15.00%	$ 55,600	$ 426,300
	Embankment, Common	253600	CY	27.00	$ 6,847,200	15.00%	$ 1,027,100	$ 7,874,300
	Embankment, Impervious	50800	CY	30.00	$ 1,524,000	15.00%	$ 228,600	$ 1,752,600
	Stripping	28500	CY	7.50	$ 213,800	15.00%	$ 32,100	$ 245,900
	Geogrid	300000	SF	2.00	$ 600,000	15.00%	$ 90,000	$ 690,000
	Vinyl Sheeting	166500	SF	30.00	$ 4,995,000	15.00%	$ 749,300	$ 5,744,300
	Topsoil and seeding	28.2	ACR	19360.00	$ 545,952	15.00%	$ 81,900	$ 627,900
	FLOODWALLS							
	Excavation, Common	7500	CY	11.00	$ 82,500	15.00%	$ 12,400	$ 94,900
	Fill	13500	CY	27.00	$ 364,500	15.00%	$ 54,700	$ 419,200
	Vinyl Sheeting	52200	SF	30.00	$ 1,566,000	15.00%	$ 234,900	$ 1,800,900
	Concrete (incl rebar & forms)	720	CY	450.00	$ 324,000	15.00%	$ 48,600	$ 372,600
	Walers	3300	LF	44.00	$ 145,200	15.00%	$ 21,800	$ 167,000
	Struct Beams	3700	LF	65.74	$ 243,238	15.00%	$ 36,500	$ 279,700
	Topsoil and seeding	0.9	ACR	19360.00	$ 17,424	15.00%	$ 2,600	$ 20,000
	INTERIOR DRAINAGE							
	East Segment- Minimum Facilities							
	36" DIP through floodwall	5	LF	484.00	$ 2,420	15.00%	$ 400	$ 2,800
	Excavation & Hauiling for pipe	9	CY	6.56	$ 59	15.00%	$ -	$ 100
	Backfill & Compaction	7	CY	3.71	$ 26	15.00%	$ -	$ -
	Manhole frame & cover	7	EA	740.00	$ 5,180	15.00%	$ 800	$ 6,000
	Concrete for inlet/outlet MH	136.5	CY	540.00	$ 73,710	15.00%	$ 11,100	$ 84,800
	36" RCP (incl 130Ft from ditch drainage)	330	LF	81.10	$ 26,763	15.00%	$ 4,000	$ 30,800
	36" flap gates	3	EA	10420.33	$ 31,261	15.00%	$ 4,700	$ 36,000
	36" sluice gate	3	EA	14477.33	$ 43,432	15.00%	$ 6,500	$ 49,900
	36" X 36" trash rack	3	EA	739.00	$ 2,217	15.00%	$ 300	$ 2,500
	60" RCP	300	LF	178.70	$ 53,610	15.00%	$ 8,000	$ 61,600
	60" flap gate	3	EA	12954.00	$ 38,862	15.00%	$ 5,800	$ 44,700
	60" sluice gate	3	EA	36195.00	$ 108,585	15.00%	$ 16,300	$ 124,900
	60" X 60" trash rack	3	EA	1520.00	$ 4,560	15.00%	$ 700	$ 5,300
	18" RCP	100	EA	29.50	$ 2,950	15.00%	$ 400	$ 3,400
	18" sluice gate	1	EA	8684.00	$ 8,684	15.00%	$ 1,300	$ 10,000
	18" trash rack	2	EA	382.00	$ 764	15.00%	$ 100	$ 900
	Outlet ditch excavation	3040	CY	6.58	$ 19,991	15.00%	$ 3,000	$ 23,000
	East Segment- 100CFS diversion							
	Excavation & hauling for culvert	2790	CY	6.58	$ 18,347	15.00%	$ 2,800	$ 21,100
	Backfill & compaction for culvert	2790	CY	3.70	$ 10,323	15.00%	$ 1,500	$ 11,800
	MH Frame & cover	3	EA	740.00	$ 2,220	15.00%	$ 300	$ 2,500
	Trench shield (supplied by contractor)	1	EA		$ -			
	Dewatering	90	DAY	500.00	$ 45,000	15.00%	$ 6,800	$ 51,800

Figure 44A

TABLE C-1

Total First Cost (Selected Plan)

South River Flood Control Feasibility Study

Account Code	Description	QTY	UOM	Unit Price	Amount	% Cont'g	Cont'g Amt	Total
	48" CMP - Interim drainage	300	LF	84.60	$ 25,380	15.00%	$ 3,800	$ 29,200
	Precast concrete MH	5	EA	1500.00	$ 7,500	15.00%	$ 1,100	$ 8,600
	Reinforced concrete	10	CY	540.00	$ 5,400	15.00%	$ 800	$ 6,200
	60" RCP (in place of culvert)	930	LF	178.70	$ 166,191	15.00%	$ 24,900	$ 191,100
	18" flap gate - inside culvert	2	EA	6078.50	$ 12,157	15.00%	$ 1,800	$ 14,000
	36" flap gate -inside culvert	2	EA	10420.50	$ 20,841	15.00%	$ 3,100	$ 23,900
	Crushed stone	723	CY	20.00	$ 14,460	15.00%	$ 2,200	$ 16,700
	36" RCP	200	LF	81.10	$ 16,220	15.00%	$ 2,400	$ 18,600
	36 " flap gate - outlet	2	EA	10420.50	$ 20,841	15.00%	$ 3,100	$ 23,900
	36" sluice gate	2	EA	14477.50	$ 28,955	15.00%	$ 4,300	$ 33,300
	36" X 36" trash rack	2	EA	739.00	$ 1,478	15.00%	$ 200	$ 1,700
	Utility relocation	100	LF	100.00	$ 10,000	15.00%	$ 1,500	$ 11,500
	Channel - vegetated biomat	1074	SY	5.70	$ 6,122	15.00%	$ 900	$ 7,000
	West Segment - Minimum Facilities							
	1' X 24" DIP through floodwall	5	LF	107.60	$ 538	15.00%	$ 100	$ 600
	2' X 60" DIP through floodwall	10	LF	839.70	$ 8,397	15.00%	$ 1,300	$ 9,700
	Excavation & Hauling for pipe	27	CY	6.59	$ 178	15.00%	$ -	$ 200
	Backfill & Compaction	21	CY	3.71	$ 78	15.00%	$ -	$ 100
	Manhole frame & cover	11	EA	740.00	$ 8,140	15.00%	$ 1,200	$ 9,300
	Concrete for inlet/outlet MH	214.5	CY	540.00	$ 115,830	15.00%	$ 17,400	$ 133,200
	24" RCP	100	LF	40.60	$ 4,060	15.00%	$ 600	$ 4,700
	24" Dia flap gates	2	EA	9868.00	$ 19,736	15.00%	$ 3,000	$ 22,700
	24" sluice gate	2	EA	10420.50	$ 20,841	15.00%	$ 3,100	$ 23,900
	24" X 24" trash rack	2	EA	475.00	$ 950	15.00%	$ 100	$ 1,100
	60" RCP	700	LF	178.70	$ 125,090	15.00%	$ 18,800	$ 143,900
	60" Dia flap gate	7	EA	12954.00	$ 90,678	15.00%	$ 13,600	$ 104,300
	60" sluice gate	9	EA	36195.00	$ 325,755	15.00%	$ 48,900	$ 374,700
	60" X 60" trash rack	9	EA	1520.00	$ 13,680	15.00%	$ 2,100	$ 15,800
	Main Channel - Minimum Facility							
	Box Culvert	3000	SF	50.00	$ 150,000	15.00%	$ 22,500	$ 172,500
	Flap Gates (5)	5	EA	57600.00	$ 288,000	15.00%	$ 43,200	$ 331,200
	Sluice Gates (5)	5	EA	144000.00	$ 720,000	15.00%	$ 108,000	$ 828,000
	Trash Racks	5	EA	5000.00	$ 25,000	15.00%	$ 3,800	$ 28,800
	60" RCP	400	LF	178.70	$ 71,480	15.00%	$ 10,700	$ 82,200
	60" Dia Flap gate	4	EA	12954.00	$ 51,816	15.00%	$ 7,800	$ 59,600
	60" sluice gate	4	EA	36195.00	$ 144,780	15.00%	$ 21,700	$ 166,500
	60" X 60" trash rack	4	EA	1520.00	$ 6,080	15.00%	$ 900	$ 7,000
	Manhole Frame & Cover	4	EA	740.00	$ 2,960	15.00%	$ 400	$ 3,400
	Concrete for inlet/outlet/MH	78	CY	540.00	$ 42,120	15.00%	$ 6,300	$ 48,400
	SUBTOTAL				$ 21,308,110		$ 3,196,200	**$ 24,504,310**
13	PUMPING PLANT - 1200CFS							
	Mob & Demob	1	LS	150,000	$ 150,000	15.00%	$ 22,500	$ 172,500
	Dewatering	1	LS	100,000	$ 100,000	15.00%	$ 15,000	$ 115,000
	Cofferdam	1	LS	65,000	$ 65,000	15.00%	$ 9,800	$ 74,800
	Vinyl Sheeting	1	LS	150,000	$ 150,000	15.00%	$ 22,500	$ 172,500
	Check Dam (130' X 20')	2600	SF	25	$ 65,000	15.00%	$ 9,800	$ 74,800
	Reno Mattress	333	SY	45	$ 15,000	15.00%	$ 2,300	$ 17,300
	Crane (30T)	1	LS	90,000	$ 90,000	15.00%	$ 13,500	$ 103,500
	Misc. Building	1	LS	150,000	$ 150,000	15.00%	$ 22,500	$ 172,500
	Trash Rack	1	LS	45,000	$ 45,000	15.00%	$ 6,800	$ 51,800
	Steel	50000	LBS	2	$ 92,000	15.00%	$ 13,800	$ 105,800
	Piles (105 @35'/EA)	3675	LF	28	$ 102,000	15.00%	$ 15,300	$ 117,300
	Concrete (Wall 550CY + Floor 300CY)	850	CY	435	$ 370,000	15.00%	$ 55,500	$ 425,500
	Pump Equipment	1	LS	1,800,000	$ 1,800,000	15.00%	$ 270,000	$ 2,070,000
	Gates	1	LS	210,000	$ 210,000	15.00%	$ 31,500	$ 241,500
	Formed Suction Intake (4)	4	EA	45,000	$ 180,000	15.00%	$ 27,000	$ 207,000

Figure 44a

TABLE C-1
Total First Cost (Selected Plan)

South River Flood Control Feasibility Study

Account Code	Description	QTY UOM	Unit Price	Amount	% Cont'g	Cont'g Amt	Total
	Tideflex flap gates	4 EA	18,750	$ 75,000	15.00%	$ 11,300	$ 86,300
	SUBTOTAL			$ 3,659,000		$ 549,100	**$ 4,208,100**
15	FLOODWAY CONTROL AND DIVERSION STRUCTURES						
	Barrier						
	Sheeting 180' X 35'	6300 SF	25	$ 157,500	15.00%	$ 23,600	$ 181,100
	Backfill 35' X 35' x 26'	2000 CY	22	$ 44,000	15.00%	$ 6,600	$ 50,600
	Paving	230 SY	7	$ 1,610	15.00%	$ 200	$ 1,800
	Concrete	20 CY	450	$ 9,000	15.00%	$ 1,400	$ 10,400
	Bulkhead	1 LS	315,000	$ 315,000	15.00%	$ 47,300	$ 362,300
	Sector Gate 35' X 80'	1 LS		$ 8,700,000	20.00%	$ 1,740,000	$ 10,440,000
	SUBTOTAL			$ 9,227,110		$ 1,819,100	**$ 11,046,210**
	TOTAL CONSTRUCTION COST			$ 36,581,820		$ 6,042,100	**$ 42,623,920**
01	LANDS AND DAMAGES						
	Acquire Permanent Levee Easements	25.3 AC	91,887	$ 2,324,750	15.00%	$ 348,700	$ 2,673,500
	Severance Damage - Levee Easements	55 AC	19,257	$ 1,059,152	15.00%	$ 158,900	$ 1,218,100
	Acquire Permanent Conservation Easements for Mitigation	11.06 AC	7,000	$ 77,420	15.00%	$ 11,600	$ 89,000
	Acquire Temporary Work Area Easements	9.7 AC	6,400	$ 62,080	15.00%	$ 9,300	$ 71,400
	SUBTOTAL			$ 3,523,402		$ 528,500	$ 4,051,902
	Administrative cost of acquisition	1 LS	528,510	$ 528,510	15.00%	$ 79,300	$ 607,800
	TOTAL LANDS AND DAMAGES			$ 4,051,912		$ 607,800	**$ 4,659,712**
30	ENGINEERING & DESIGN						
	Flood damage reduction			$ 2,641,250	10.00%	$ 264,100	$ 2,905,400
	Mitigation			$ 977,500	10.00%	$ 97,800	$ 1,075,300
	SUBTOTAL			$ 3,618,750		$ 361,900	**$ 3,980,650**
31	CONSTRUCTION MANAGEMENT			$ 2,970,000	15.00%	$ 445,500	**$ 3,415,500**
	TOTAL PROJECT FIRST COST			$ 47,222,482		$ 7,457,300	**$ 54,679,782**

Figure 44A

TABLE C-1
Total First Cost (Selected Plan)

South River Flood Control Feasibility Study

Account Code	Description	QTY	UOM	Unit Price	Amount	% Cont'g	Cont'g Amt	Total
06	FISH AND WILDLIFE FACILITIES							
	Surveying	1	LS	7700.00	$ 7,700	20.00%	$ 1,500	$ 9,200
	Mobilization & Demobilization	1	LS	106800.00	$ 106,800	20.00%	$ 21,400	$ 128,200
	Site Access	1	LS	185,100	$ 185,100	20.00%	$ 37,000	$ 222,100
	Site preparation	11.21	ACR	26,521	$ 297,300	20.00%	$ 59,500	$ 356,800
	Levee Improvements	7	ACR	88,700	$ 620,900	20.00%	$ 124,200	$ 745,100
	Excavation for Marsh Creation	9.51	ACR	92,513	$ 879,800	20.00%	$ 176,000	$ 1,055,800
	Planting	11.1	ACR	12,054	$ 133,800	20.00%	$ 26,800	$ 160,600
	Erosion Control	1	LS	133,900	$ 133,900	20.00%	$ 26,800	$ 160,700
	Monitoring	1	LS	22,300	$ 22,300	20.00%	$ 4,500	$ 26,800
	SUBTOTAL				$ 2,387,600		$ 477,700	$ 2,865,300
11	LEVEES AND FLOODWALLS							
	Mob & Demob	1	LS		$ 150,000	15.00%	$ 22,500	$ 172,500
	LEVEES							
	Clear & Grub	25	ACR	9916.00	$ 247,900	15.00%	$ 37,200	$ 285,100
	Excavation, Common	33700	CY	11.00	$ 370,700	15.00%	$ 55,600	$ 426,300
	Embankment, Common	253600	CY	27.00	$ 6,847,200	15.00%	$ 1,027,100	$ 7,874,300
	Embankment, Impervious	50800	CY	30.00	$ 1,524,000	15.00%	$ 228,600	$ 1,752,600
	Stripping	28500	CY	7.50	$ 213,800	15.00%	$ 32,100	$ 245,900
	Geogrid	300000	SF	2.00	$ 600,000	15.00%	$ 90,000	$ 690,000
	Vinyl Sheeting	166500	SF	30.00	$ 4,995,000	15.00%	$ 749,300	$ 5,744,300
	Topsoil and seeding	28.2	ACR	19360.00	$ 545,952	15.00%	$ 81,900	$ 627,900
	FLOODWALLS							
	Excavation, Common	7500	CY	11.00	$ 82,500	15.00%	$ 12,400	$ 94,900
	Fill	13500	CY	27.00	$ 364,500	15.00%	$ 54,700	$ 419,200
	Vinyl Sheeting	52200	SF	30.00	$ 1,566,000	15.00%	$ 234,900	$ 1,800,900
	Concrete (incl rebar & forms)	720	CY	450.00	$ 324,000	15.00%	$ 48,600	$ 372,600
	Walers	3300	LF	44.00	$ 145,200	15.00%	$ 21,800	$ 167,000
	Struct Beams	3700	LF	65.74	$ 243,238	15.00%	$ 36,500	$ 279,700
	Topsoil and seeding	0.9	ACR	19360.00	$ 17,424	15.00%	$ 2,600	$ 20,000
	INTERIOR DRAINAGE							
	East Segment- Minimum Facilities							
	36" DIP through floodwall	5	LF	484.00	$ 2,420	15.00%	$ 400	$ 2,800
	Excavation & Hauling for pipe	9	CY	6.56	$ 59	15.00%	$ -	$ 100
	Backfill & Compaction	7	CY	3.71	$ 26	15.00%	$ -	$ -
	Manhole frame & cover	7	EA	740.00	$ 5,180	15.00%	$ 800	$ 6,000
	Concrete for inlet/outlet MH	136.5	CY	540.00	$ 73,710	15.00%	$ 11,100	$ 84,800
	36" RCP (incl 130Ft from ditch drainage)	330	LF	81.10	$ 26,763	15.00%	$ 4,000	$ 30,800
	36" flap gates	3	EA	10420.33	$ 31,261	15.00%	$ 4,700	$ 36,000
	36" sluice gate	3	EA	14477.33	$ 43,432	15.00%	$ 6,500	$ 49,900
	36" X 36" trash rack	3	EA	739.00	$ 2,217	15.00%	$ 300	$ 2,500
	60" RCP	300	LF	178.70	$ 53,610	15.00%	$ 8,000	$ 61,600
	60" flap gate	3	EA	12954.00	$ 38,862	15.00%	$ 5,800	$ 44,700
	60" sluice gate	3	EA	36195.00	$ 108,585	15.00%	$ 16,300	$ 124,900
	60" X 60" trash rack	3	EA	1520.00	$ 4,560	15.00%	$ 700	$ 5,300
	18" RCP	100	EA	29.50	$ 2,950	15.00%	$ 400	$ 3,400
	18" sluice gate	1	EA	8684.00	$ 8,684	15.00%	$ 1,300	$ 10,000
	18" trash rack	2	EA	382.00	$ 764	15.00%	$ 100	$ 900
	Outlet ditch excavation	3040	CY	6.58	$ 19,991	15.00%	$ 3,000	$ 23,000
	East Segment- 100CFS diversion							
	Excavation & hauling for culvert	2790	CY	6.58	$ 18,347	15.00%	$ 2,800	$ 21,100
	Backfill & compaction for culvert	2790	CY	3.70	$ 10,323	15.00%	$ 1,500	$ 11,800
	MH Frame & cover	3	EA	740.00	$ 2,220	15.00%	$ 300	$ 2,500
	Trench shield (supplied by contractor)	1	EA		$ -			
	Dewatering	90	DAY	500.00	$ 45,000	15.00%	$ 6,800	$ 51,800

Figure 44A

TABLE C-1

Total First Cost (Selected Plan)

South River Flood Control Feasibility Study

Account Code	Description	QTY	UOM	Unit Price	Amount	% Cont'g	Cont'g Amt	Total
	48" CMP - Interim drainage	300	LF	84.60	$ 25,380	15.00%	$ 3,800	$ 29,200
	Precast concrete MH	5	EA	1500.00	$ 7,500	15.00%	$ 1,100	$ 8,600
	Reinforced concrete	10	CY	540.00	$ 5,400	15.00%	$ 800	$ 6,200
	60" RCP (in place of culvert)	930	LF	178.70	$ 166,191	15.00%	$ 24,900	$ 191,100
	18" flap gate - inside culvert	2	EA	6078.50	$ 12,157	15.00%	$ 1,800	$ 14,000
	36" flap gate -inside culvert	2	EA	10420.50	$ 20,841	15.00%	$ 3,100	$ 23,900
	Crushed stone	723	CY	20.00	$ 14,460	15.00%	$ 2,200	$ 16,700
	36" RCP	200	LF	81.10	$ 16,220	15.00%	$ 2,400	$ 18,600
	36 " flap gate - outlet	2	EA	10420.50	$ 20,841	15.00%	$ 3,100	$ 23,900
	36" sluice gate	2	EA	14477.50	$ 28,955	15.00%	$ 4,300	$ 33,300
	36" X 36" trash rack	2	EA	739.00	$ 1,478	15.00%	$ 200	$ 1,700
	Utility relocation	100	LF	100.00	$ 10,000	15.00%	$ 1,500	$ 11,500
	Channel - vegetated biomat	1074	SY	5.70	$ 6,122	15.00%	$ 900	$ 7,000
	West Segment - Minimum Facilities							
	1' X 24" DIP through floodwall	5	LF	107.60	$ 538	15.00%	$ 100	$ 600
	2' X 60" DIP through floodwall	10	LF	839.70	$ 8,397	15.00%	$ 1,300	$ 9,700
	Excavation & Hauling for pipe	27	CY	6.59	$ 178	15.00%	$ -	$ 200
	Backfill & Compaction	21	CY	3.71	$ 78	15.00%	$ -	$ 100
	Manhole frame & cover	11	EA	740.00	$ 8,140	15.00%	$ 1,200	$ 9,300
	Concrete for inlet/outlet MH	214.5	CY	540.00	$ 115,830	15.00%	$ 17,400	$ 133,200
	24" RCP	100	LF	40.60	$ 4,060	15.00%	$ 600	$ 4,700
	24" Dia flap gates	2	EA	9868.00	$ 19,736	15.00%	$ 3,000	$ 22,700
	24" sluice gate	2	EA	10420.50	$ 20,841	15.00%	$ 3,100	$ 23,900
	24" X 24" trash rack	2	EA	475.00	$ 950	15.00%	$ 100	$ 1,100
	60" RCP	700	LF	178.70	$ 125,090	15.00%	$ 18,800	$ 143,900
	60" Dia flap gate	7	EA	12954.00	$ 90,678	15.00%	$ 13,600	$ 104,300
	60" sluice gate	9	EA	36195.00	$ 325,755	15.00%	$ 48,900	$ 374,700
	60" X 60" trash rack	9	EA	1520.00	$ 13,680	15.00%	$ 2,100	$ 15,800
	Main Channel - Minimum Facility							
	Box Culvert	3000	SF	50.00	$ 150,000	15.00%	$ 22,500	$ 172,500
	Flap Gates (5)	5	EA	57600.00	$ 288,000	15.00%	$ 43,200	$ 331,200
	Sluice Gates (5)	5	EA	144000.00	$ 720,000	15.00%	$ 108,000	$ 828,000
	Trash Racks	5	EA	5000.00	$ 25,000	15.00%	$ 3,800	$ 28,800
	60" RCP	400	LF	178.70	$ 71,480	15.00%	$ 10,700	$ 82,200
	60" Dia Flap gate	4	EA	12954.00	$ 51,816	15.00%	$ 7,800	$ 59,600
	60" sluice gate	4	EA	36195.00	$ 144,780	15.00%	$ 21,700	$ 166,500
	60" X 60" trash rack	4	EA	1520.00	$ 6,080	15.00%	$ 900	$ 7,000
	Manhole Frame & Cover	4	EA	740.00	$ 2,960	15.00%	$ 400	$ 3,400
	Concrete for inlet/outlet/MH	78	CY	540.00	$ 42,120	15.00%	$ 6,300	$ 48,400
	SUBTOTAL				$ 21,308,110		$ 3,196,200	$ 24,504,310
13	PUMPING PLANT - 1200CFS							
	Mob & Demob	1	LS	150,000	$ 150,000	15.00%	$ 22,500	$ 172,500
	Dewatering	1	LS	100,000	$ 100,000	15.00%	$ 15,000	$ 115,000
	Cofferdam	1	LS	65,000	$ 65,000	15.00%	$ 9,800	$ 74,800
	Vinyl Sheeting	1	LS	150,000	$ 150,000	15.00%	$ 22,500	$ 172,500
	Check Dam (130' X 20')	2600	SF	25	$ 65,000	15.00%	$ 9,800	$ 74,800
	Reno Mattress	333	SY	45	$ 15,000	15.00%	$ 2,300	$ 17,300
	Crane (30T)	1	LS	90,000	$ 90,000	15.00%	$ 13,500	$ 103,500
	Misc. Building	1	LS	150,000	$ 150,000	15.00%	$ 22,500	$ 172,500
	Trash Rack	1	LS	45,000	$ 45,000	15.00%	$ 6,800	$ 51,800
	Steel	50000	LBS	2	$ 92,000	15.00%	$ 13,800	$ 105,800
	Piles (105 @35'/EA)	3675	LF	28	$ 102,000	15.00%	$ 15,300	$ 117,300
	Concrete (Wall 550CY + Floor 300CY)	850	CY	435	$ 370,000	15.00%	$ 55,500	$ 425,500
	Pump Equipment	1	LS	1,800,000	$ 1,800,000	15.00%	$ 270,000	$ 2,070,000
	Gates	1	LS	210,000	$ 210,000	15.00%	$ 31,500	$ 241,500
	Formed Suction Intake (4)	4	EA	45,000	$ 180,000	15.00%	$ 27,000	$ 207,000

Figure 44a

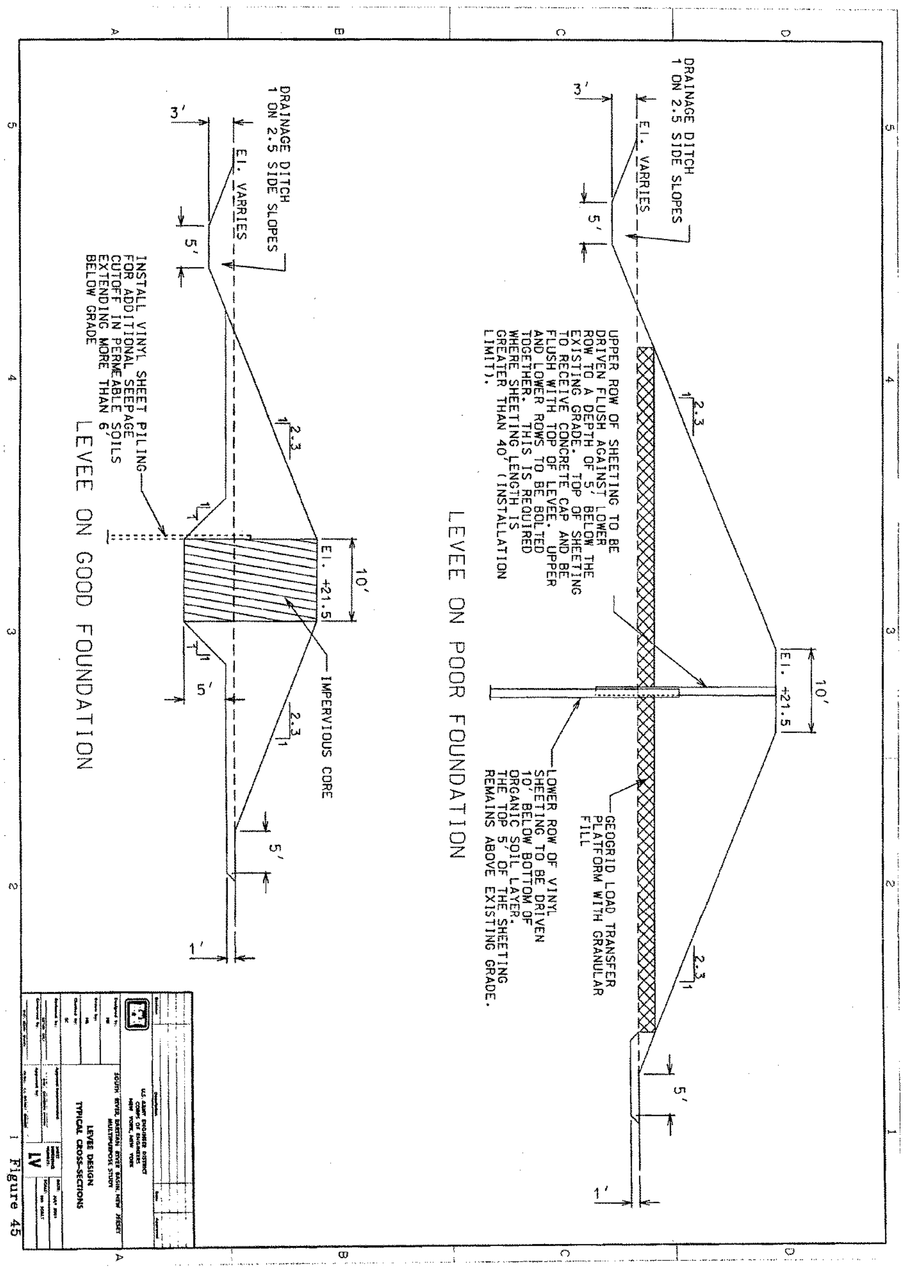
TABLE C-1

Total First Cost (Selected Plan)

South River Flood Control Feasibility Study

Account Code	Description	QTY	UOM	Unit Price	Amount	% Cont'g	Cont'g Amt	Total
	Tideflex flap gates	4	EA	18,750	$ 75,000	15.00%	$ 11,300	$ 86,300
	SUBTOTAL				$ 3,659,000		$ 549,100	**$ 4,208,100**
15	FLOODWAY CONTROL AND DIVERSION STRUCTURES							
	Barrier							
	Sheeting 180' X 35'	6300	SF	25	$ 157,500	15.00%	$ 23,600	$ 181,100
	Backfill 35' X 35' x 26'	2000	CY	22	$ 44,000	15.00%	$ 6,600	$ 50,600
	Paving	230	SY	7	$ 1,610	15.00%	$ 200	$ 1,800
	Concrete	20	CY	450	$ 9,000	15.00%	$ 1,400	$ 10,400
	Bulkhead	1	LS	315,000	$ 315,000	15.00%	$ 47,300	$ 362,300
	Sector Gate 35' X 80'	1	LS		$ 8,700,000	20.00%	$ 1,740,000	$ 10,440,000
	SUBTOTAL				$ 9,227,110		$ 1,819,100	**$ 11,046,210**
	TOTAL CONSTRUCTION COST				$ 36,581,820		$ 6,042,100	**$ 42,623,920**
01	LANDS AND DAMAGES							
	Acquire Permanent Levee Easements	25.3	AC	91,887	$ 2,324,750	15.00%	$ 348,700	$ 2,673,500
	Severance Damage - Levee Easements	55	AC	19,257	$ 1,059,152	15.00%	$ 158,900	$ 1,218,100
	Acquire Permanent Conservation Easements for Mitigation	11.06	AC	7,000	$ 77,420	15.00%	$ 11,600	$ 89,000
	Acquire Temporary Work Area Easements	9.7	AC	6,400	$ 62,080	15.00%	$ 9,300	$ 71,400
	SUBTOTAL				$ 3,523,402		$ 528,500	$ 4,051,902
	Administrative cost of acquisition	1	LS	528,510	$ 528,510	15.00%	$ 79,300	$ 607,800
	TOTAL LANDS AND DAMAGES				$ 4,051,912		$ 607,800	**$ 4,659,712**
30	ENGINEERING & DESIGN							
	Flood damage reduction				$ 2,641,250	10.00%	$ 264,100	$ 2,905,400
	Mitigation				$ 977,500	10.00%	$ 97,800	$ 1,075,300
	SUBTOTAL				$ 3,618,750		$ 361,900	**$ 3,980,650**
31	CONSTRUCTION MANAGEMENT				$ 2,970,000	15.00%	$ 445,500	**$ 3,415,500**
	TOTAL PROJECT FIRST COST				$ 47,222,482		$ 7,457,300	**$ 54,679,782**

Figure 44A


DRAINAGE DITCH
1 ON 2.5 SIDE SLOPES
3'
EL. VARRIES
5'
2.3
1
UPPER ROW OF SHEETING TO BE DRIVEN FLUSH AGAINST LOWER ROW TO A DEPTH OF 5' BELOW THE EXISTING GRADE. TOP OF SHEETING TO RECEIVE CONCRETE CAP AND BE FLUSH WITH TOP OF LEVEE. UPPER AND LOWER ROWS TO BE BOLTED TOGETHER. THIS IS REQUIRED WHERE SHEETING LENGTH IS GREATER THAN 40' (INSTALLATION LIMIT).
EL. +21.5
10'
GEOGRID LOAD TRANSFER PLATFORM WITH GRANULAR FILL
LOWER ROW OF VINYL SHEETING TO BE DRIVEN 10' BELOW BOTTOM OF ORGANIC SOIL LAYER. THE TOP 5' OF THE SHEETING REMAINS ABOVE EXISTING GRADE.
1'
LEVEE ON POOR FOUNDATION
DRAINAGE DITCH
1 ON 2.5 SIDE SLOPES
3'
EL. VARRIES
5'
INSTALL VINYL SHEET PILING FOR ADDITIONAL SEEPAGE CUTOFF IN PERMEABLE SOILS EXTENDING MORE THAN 6' BELOW GRADE
EL. +21.5
10'
IMPERVIOUS CORE
LEVEE ON GOOD FOUNDATION
LEVEE DESIGN
TYPICAL CROSS-SECTIONS
LV
Figure 45

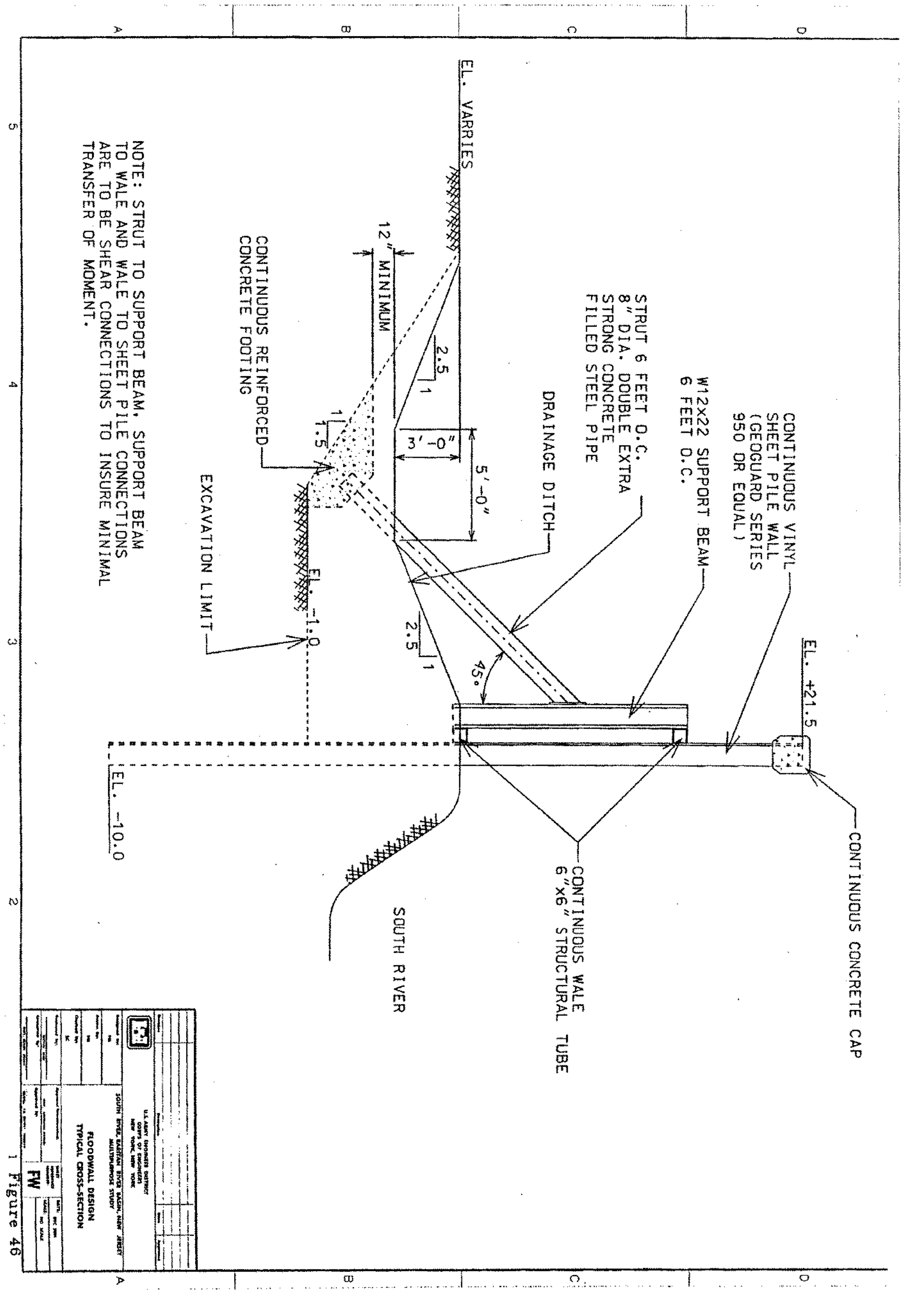

EL. VARRIES
12" MINIMUM
2.5
1
CONTINUOUS REINFORCED CONCRETE FOOTING
1
1.5
3'-0"
5'-0"
STRUT 6 FEET O.C. 8" DIA. DOUBLE EXTRA STRONG CONCRETE FILLED STEEL PIPE
DRAINAGE DITCH
W12x22 SUPPORT BEAM 6 FEET O.C.
CONTINUOUS VINYL SHEET PILE WALL (GEOGUARD SERIES 950 OR EQUAL)
EXCAVATION LIMIT
EL. -1.0
2.5
1
45°
EL. +21.5
CONTINUOUS CONCRETE CAP
EL. -10.0
CONTINUOUS WALE 6"x6" STRUCTURAL TUBE
SOUTH RIVER
NOTE: STRUT TO SUPPORT BEAM, SUPPORT BEAM TO WALE AND WALE TO SHEET PILE CONNECTIONS ARE TO BE SHEAR CONNECTIONS TO INSURE MINIMAL TRANSFER OF MOMENT.
FLOODWALL DESIGN
TYPICAL CROSS-SECTION
FW

Figure 46

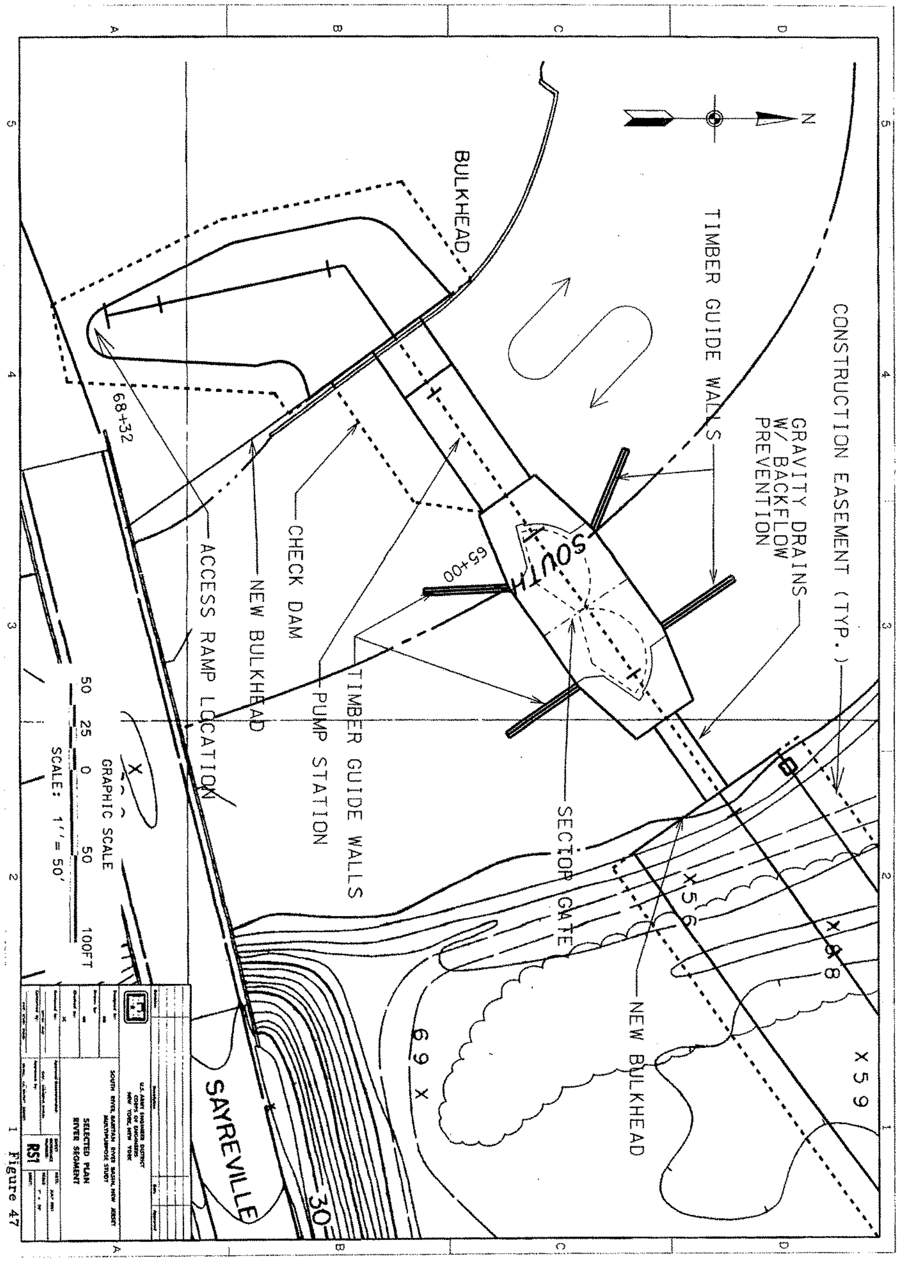

N
CONSTRUCTION EASEMENT (TYP.)
GRAVITY DRAINS W/ BACKFLOW PREVENTION
TIMBER GUIDE WALLS
BULKHEAD
SOUTH
65+00
68+32
CHECK DAM
NEW BULKHEAD
ACCESS RAMP LOCATION
TIMBER GUIDE WALLS
PUMP STATION
SECTOR GATE
NEW BULKHEAD
x 59
x 48
x 56
69 x
SAYREVILLE
30
GRAPHIC SCALE
50 25 0 50 100FT
SCALE: 1'' = 50'
SELECTED PLAN
RIVER SEGMENT
R51

Figure 47

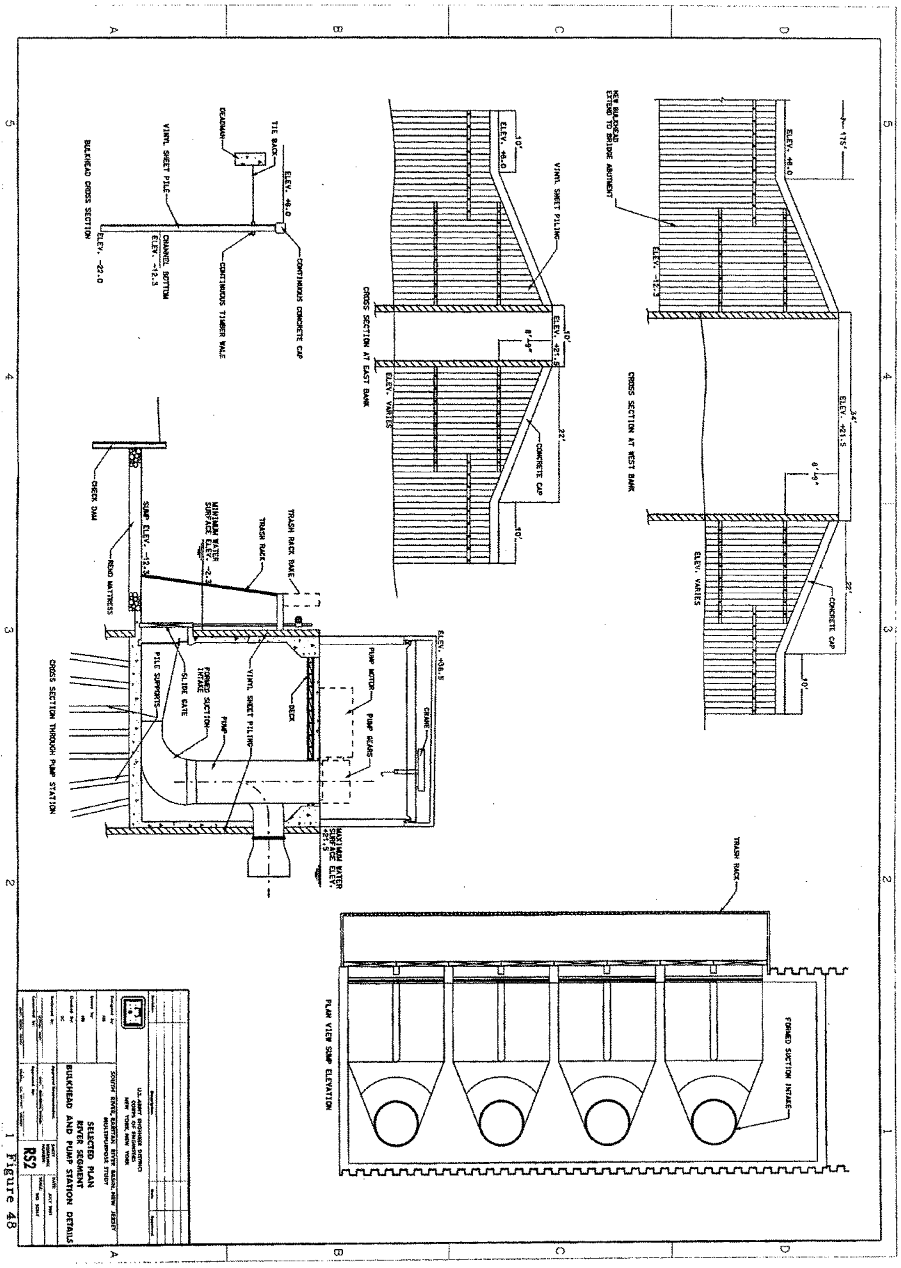

CROSS SECTION AT WEST BANK
CROSS SECTION AT EAST BANK
BULKHEAD CROSS SECTION
CROSS SECTION THROUGH PUMP STATION
PLAN VIEW SUMP ELEVATION
TRASH RACK
FORMED SUCTION INTAKE
CONCRETE CAP
VINYL SHEET PILING
SELECTED PLAN
RIVER SEGMENT
BULKHEAD AND PUMP STATION DETAILS
RS2

Figure 48

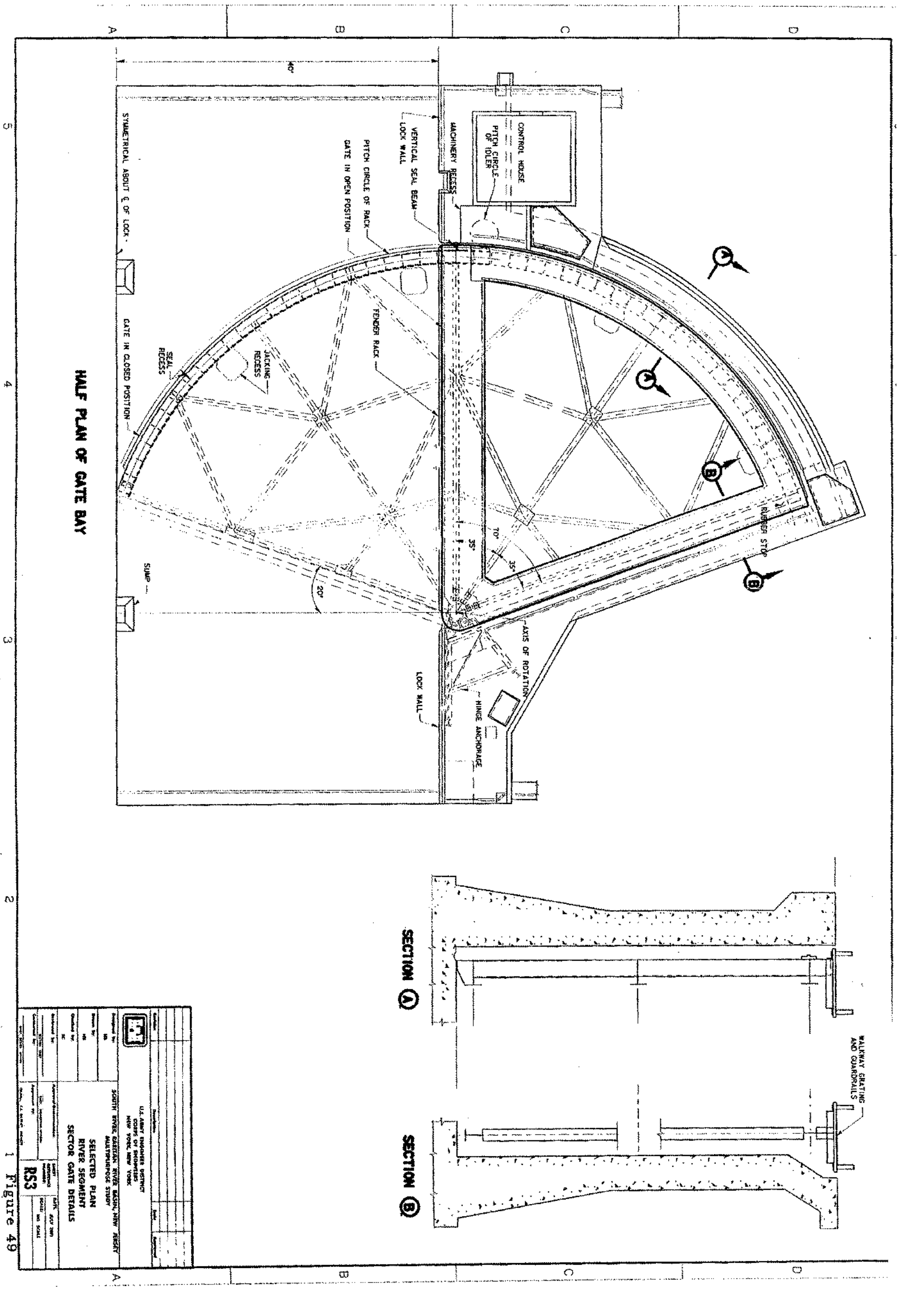

HALF PLAN OF GATE BAY
CONTROL HOUSE
PITCH CIRCLE OF IDLER
MACHINERY RECESS
VERTICAL SEAL BEAM
LOCK WALL
PITCH CIRCLE OF RACK
GATE IN OPEN POSITION
SYMMETRICAL ABOUT ℄ OF LOCK
GATE IN CLOSED POSITION
SEAL RECESS
JACKING RECESS
FENDER RACK
RUBBER STOP
AXIS OF ROTATION
HINGE ANCHORAGE
LOCK WALL
SUMP
SECTION A
SECTION B
WALKWAY GRATING AND GUARDRAILS
SELECTED PLAN
RIVER SEGMENT
SECTOR GATE DETAILS
RS3

Figure 49

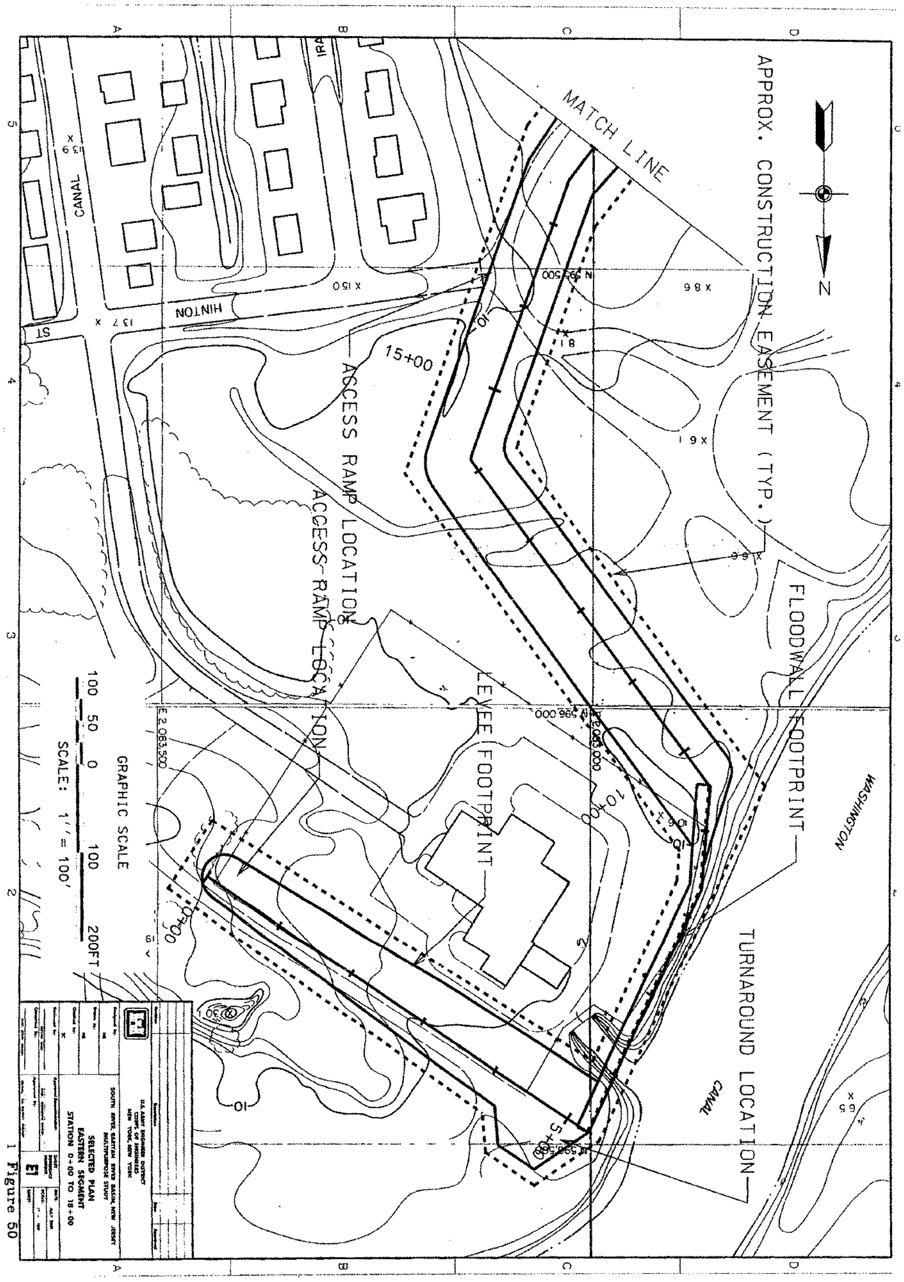

APPROX. CONSTRUCTION EASEMENT (TYP.)
MATCH LINE
N
FLOODWALL FOOTPRINT
TURNAROUND LOCATION
LEVEE FOOTPRINT
ACCESS RAMP LOCATION
ACCESS RAMP LOCATION
HINTON
ST
CANAL
CANAL
WASHINGTON
15+00
10+00
5+00
0+00
GRAPHIC SCALE
100 50 0 100 200FT
SCALE: 1'' = 100'

Figure 50

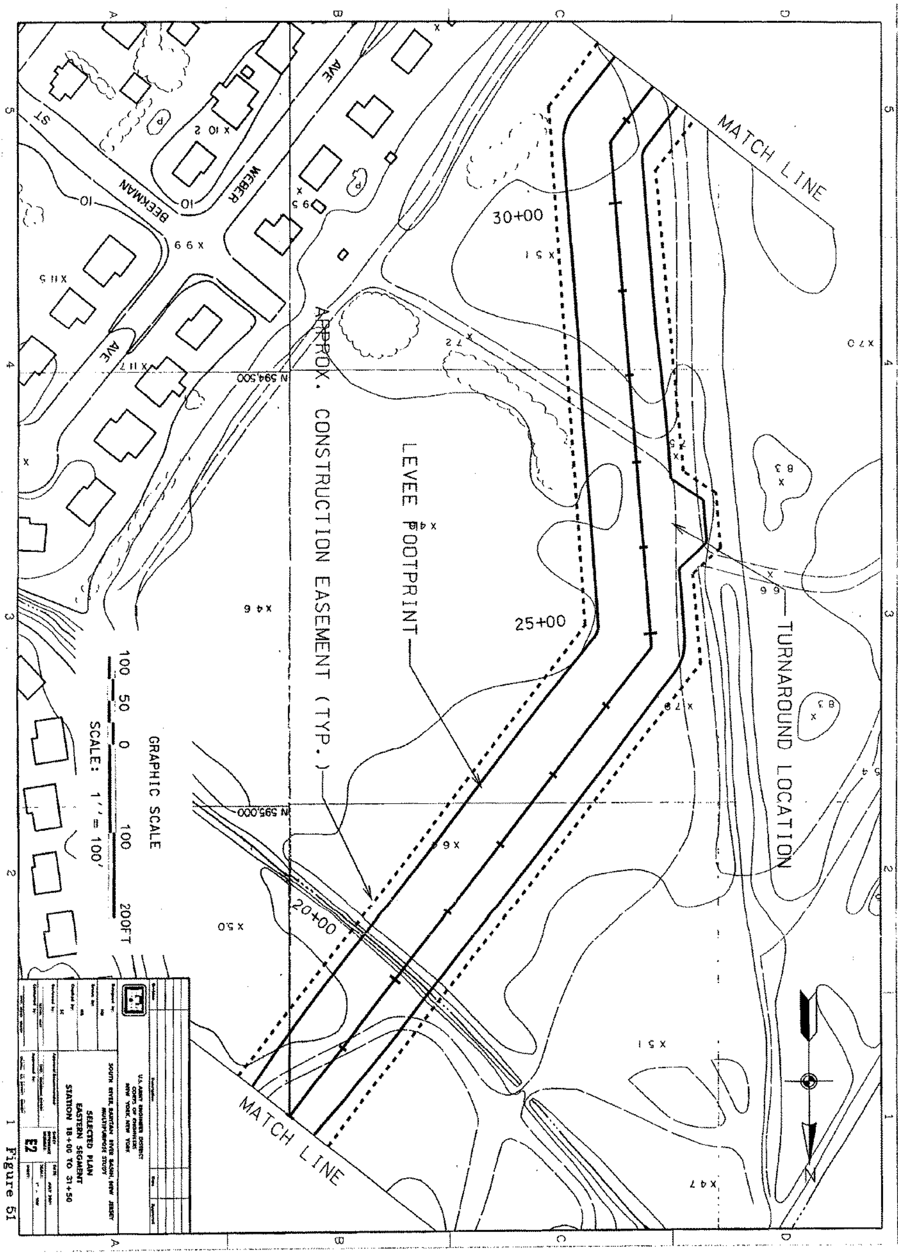

MATCH LINE
MATCH LINE
LEVEE FOOTPRINT
APPROX. CONSTRUCTION EASEMENT (TYP.)
TURNAROUND LOCATION
30+00
25+00
20+00
BEEKMAN
ST
WEBER
AVE
AVE
N 594,500
N 595,000
GRAPHIC SCALE
100 50 0 100 200FT
SCALE: 1'' = 100'
SELECTED PLAN
E2

Figure 5I

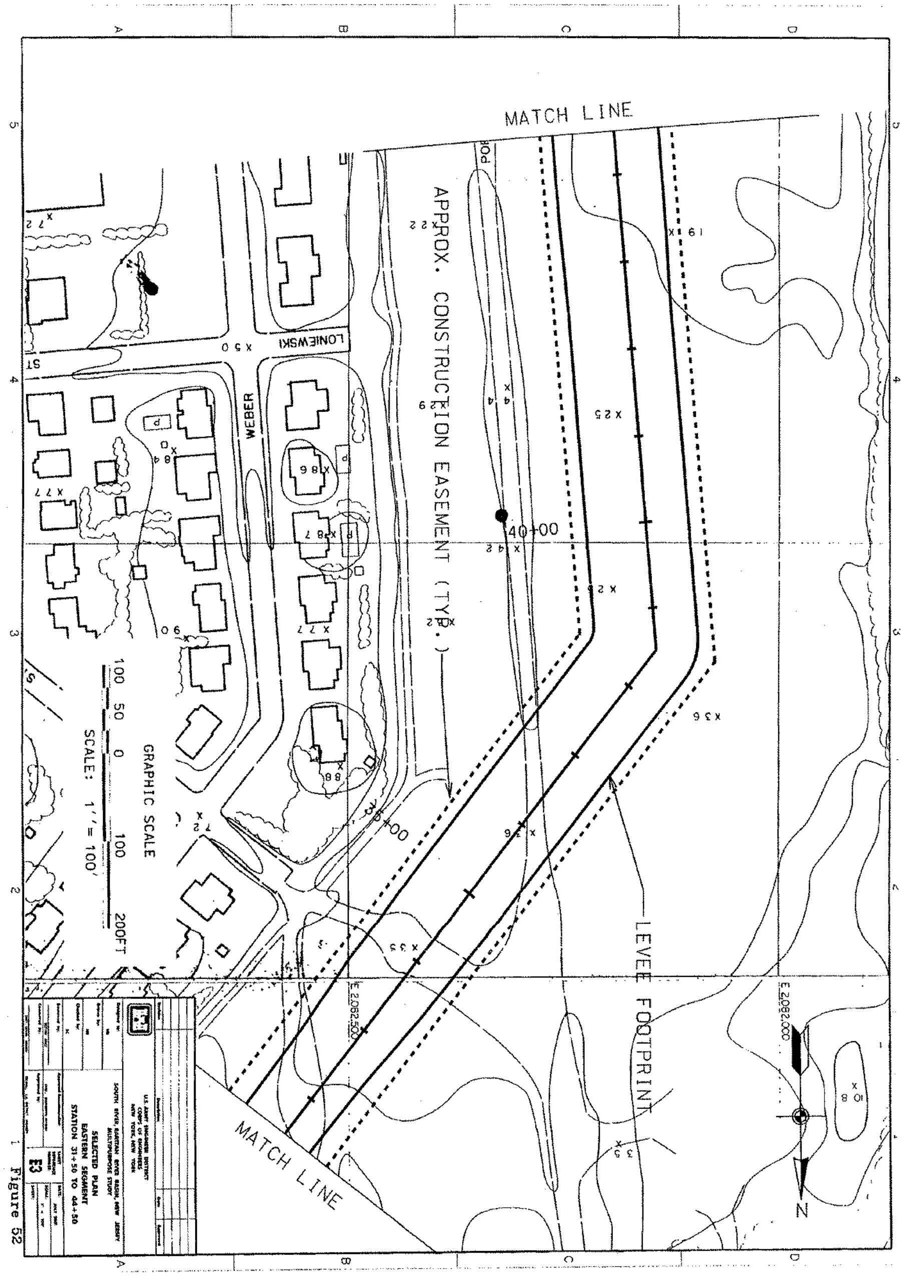

MATCH LINE
APPROX. CONSTRUCTION EASEMENT (TYP.)
LONIEWSKI
ST
WEBER
40+00
35+00
LEVEE FOOTPRINT
GRAPHIC SCALE
100 50 0 100 200FT
SCALE: 1'' = 100'
MATCH LINE
N
E3

Figure 52

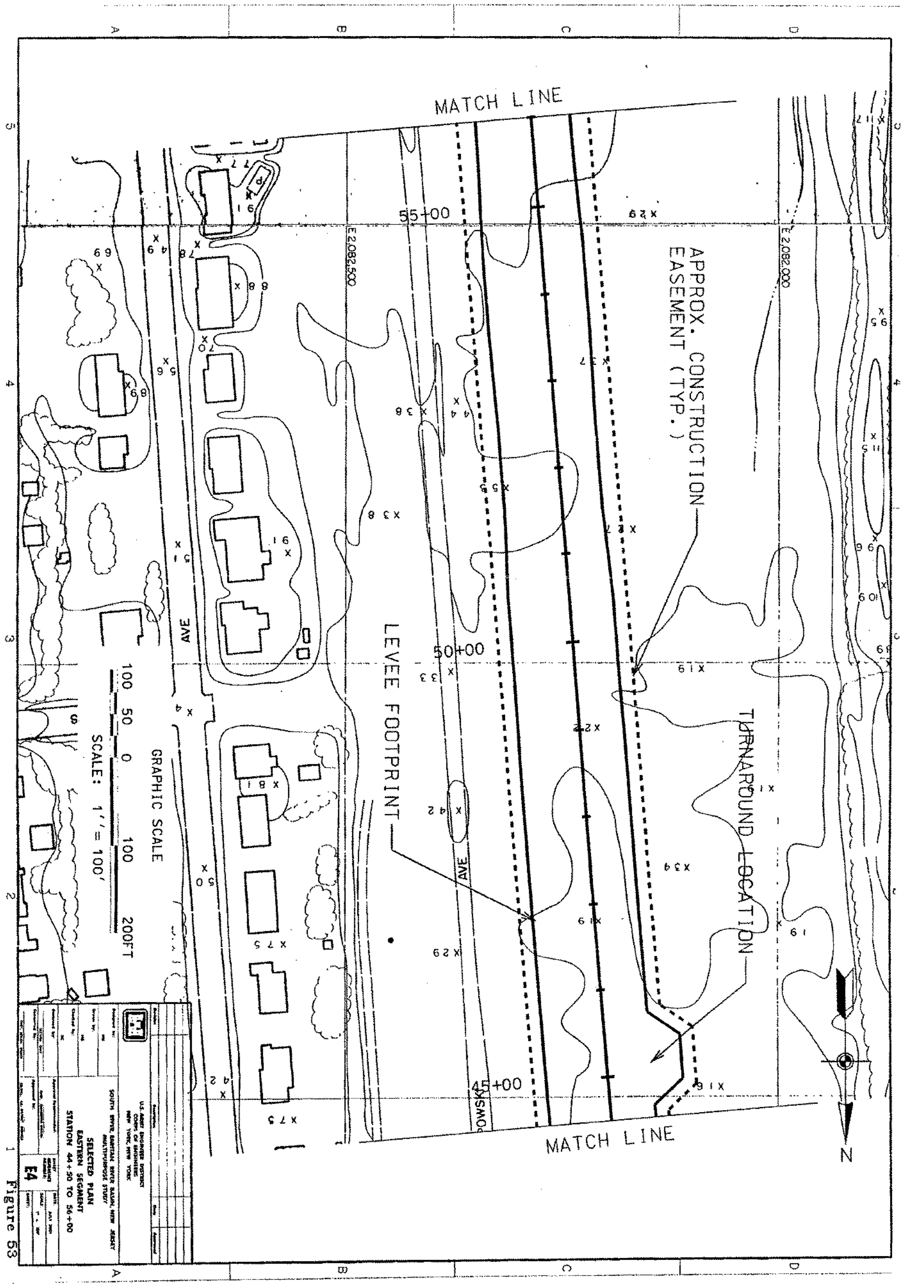

MATCH LINE
55+00
50+00
45+00
APPROX. CONSTRUCTION EASEMENT (TYP.)
LEVEE FOOTPRINT
TURNAROUND LOCATION
AVE
GRAPHIC SCALE
100 50 0 100 200FT
SCALE: 1'' = 100'
N
E4

Figure 53

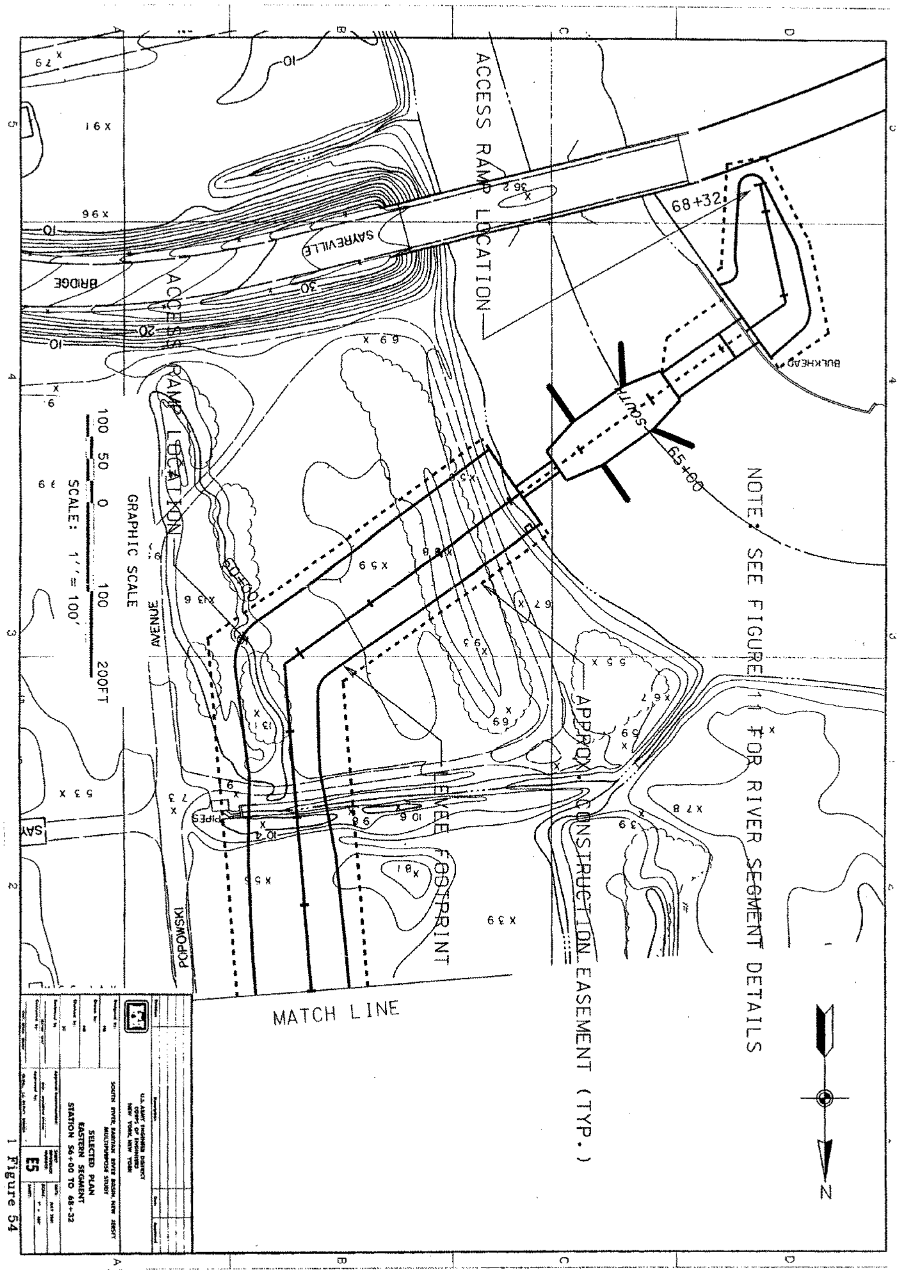

ACCESS RAMP LOCATION
ACCESS RAMP LOCATION
NOTE: SEE FIGURE 11 FOR RIVER SEGMENT DETAILS
APPROX. CONSTRUCTION EASEMENT (TYP.)
LEVEE FOOTPRINT
MATCH LINE
SAYREVILLE
BRIDGE
BULKHEAD
AVENUE
POPOWSKI
68+32
65+00
GRAPHIC SCALE
100 50 0 100 200FT
SCALE: 1'' = 100'
E5
N

Figure 54

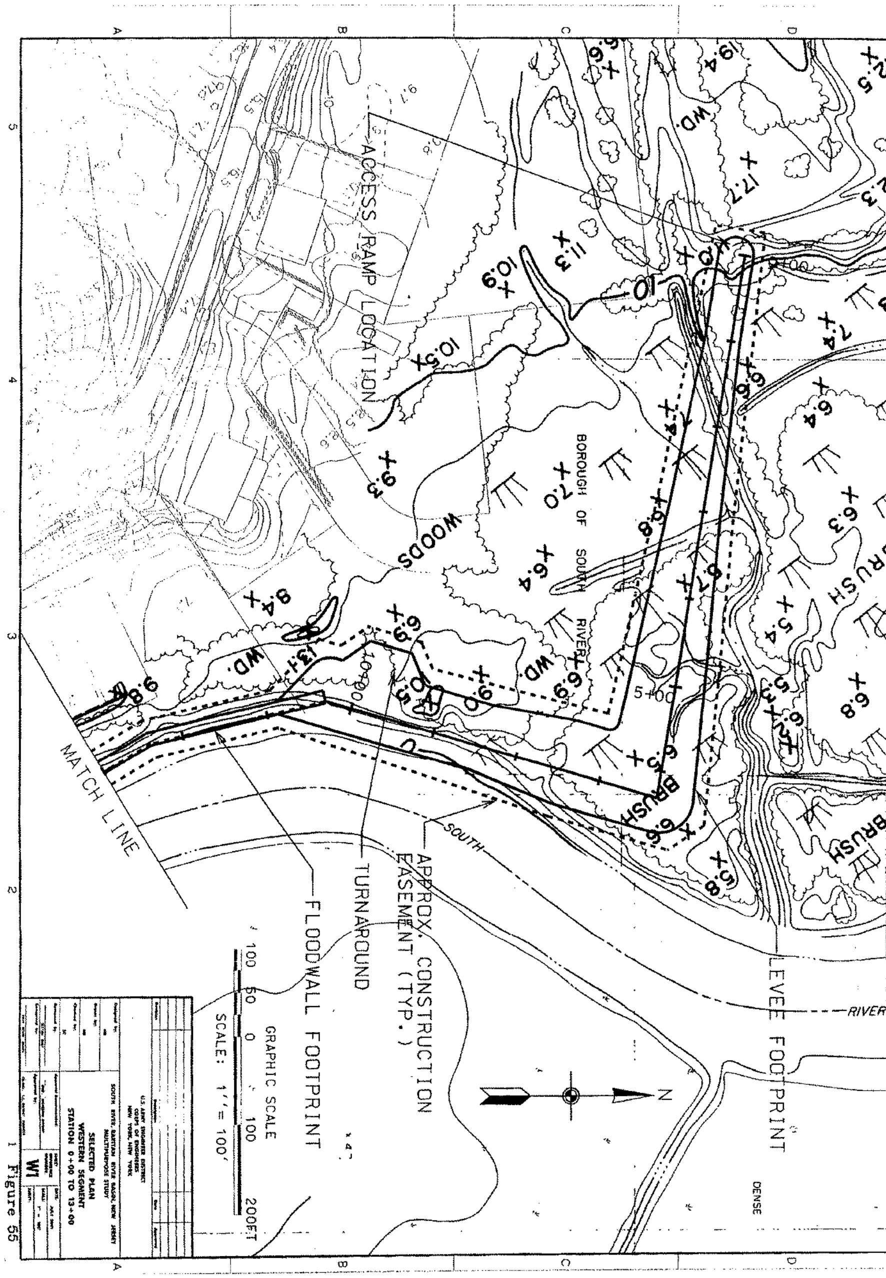

ACCESS RAMP LOCATION
WOODS
BOROUGH OF SOUTH RIVER
WD.
BRUSH
MATCH LINE
SOUTH
RIVER
5+00
APPROX. CONSTRUCTION EASEMENT (TYP.)
TURNAROUND
FLOODWALL FOOTPRINT
LEVEE FOOTPRINT
DENSE
N
GRAPHIC SCALE
100 50 0 100 200FT
SCALE: 1'' = 100'
SELECTED PLAN
WESTERN SEGMENT
W1

Figure 55

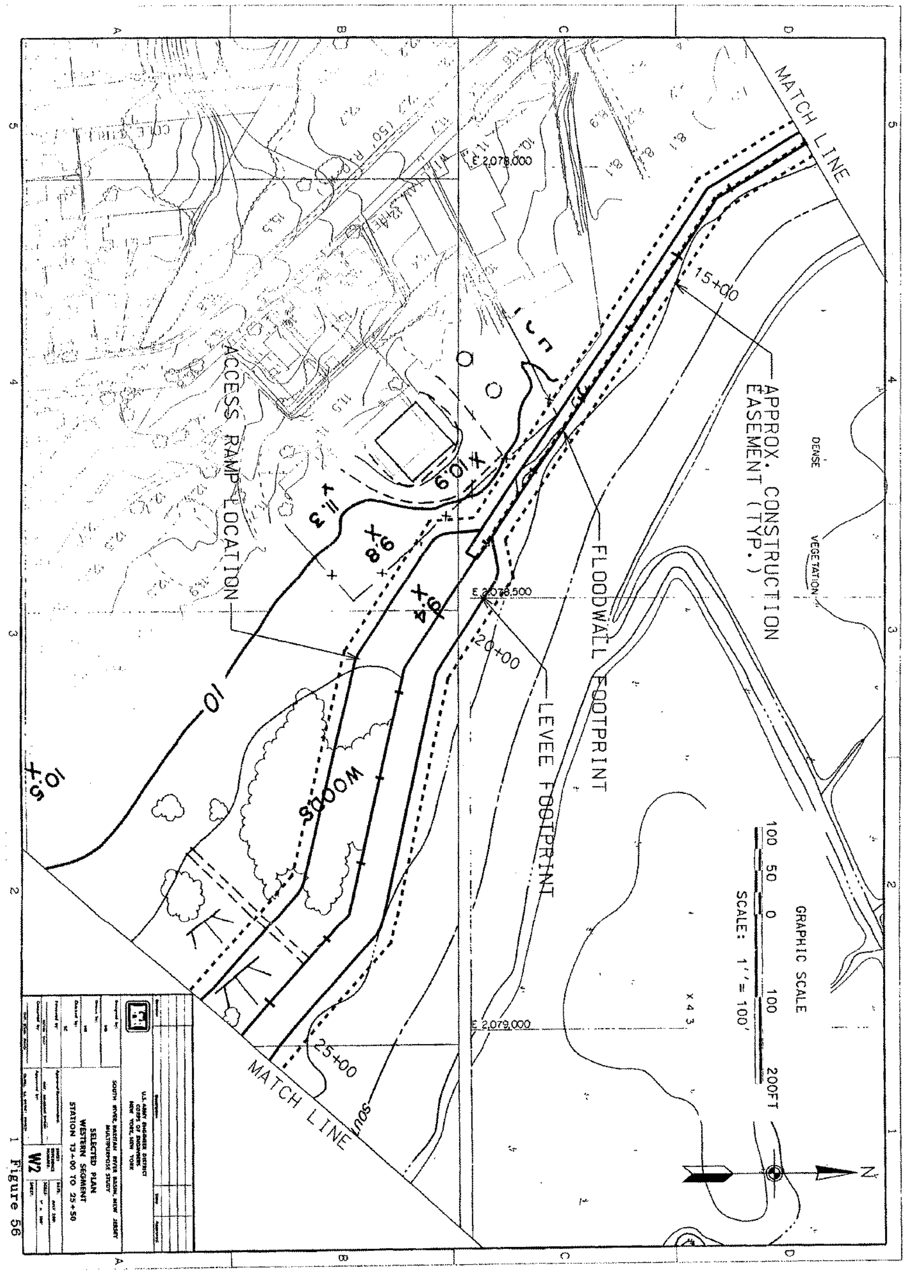
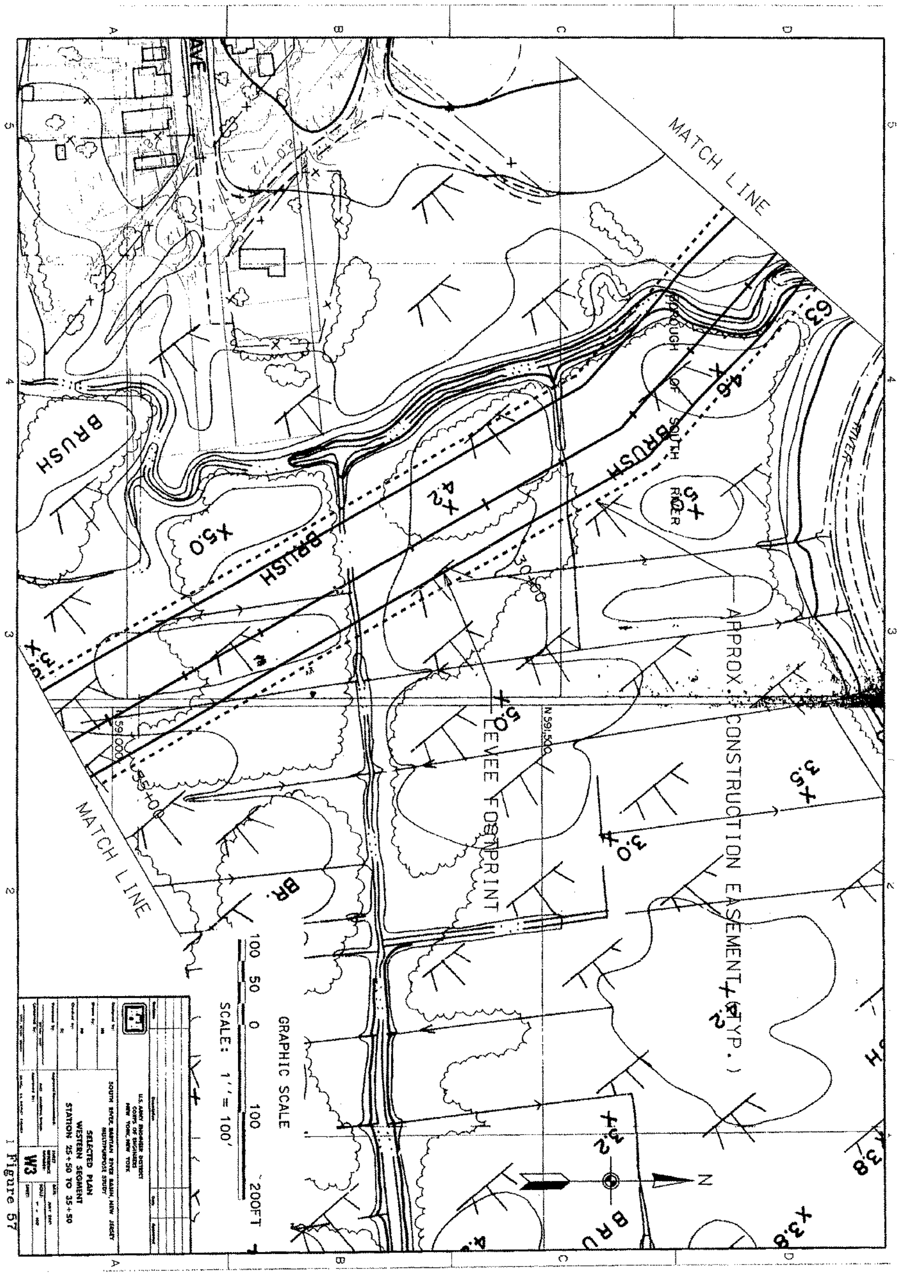
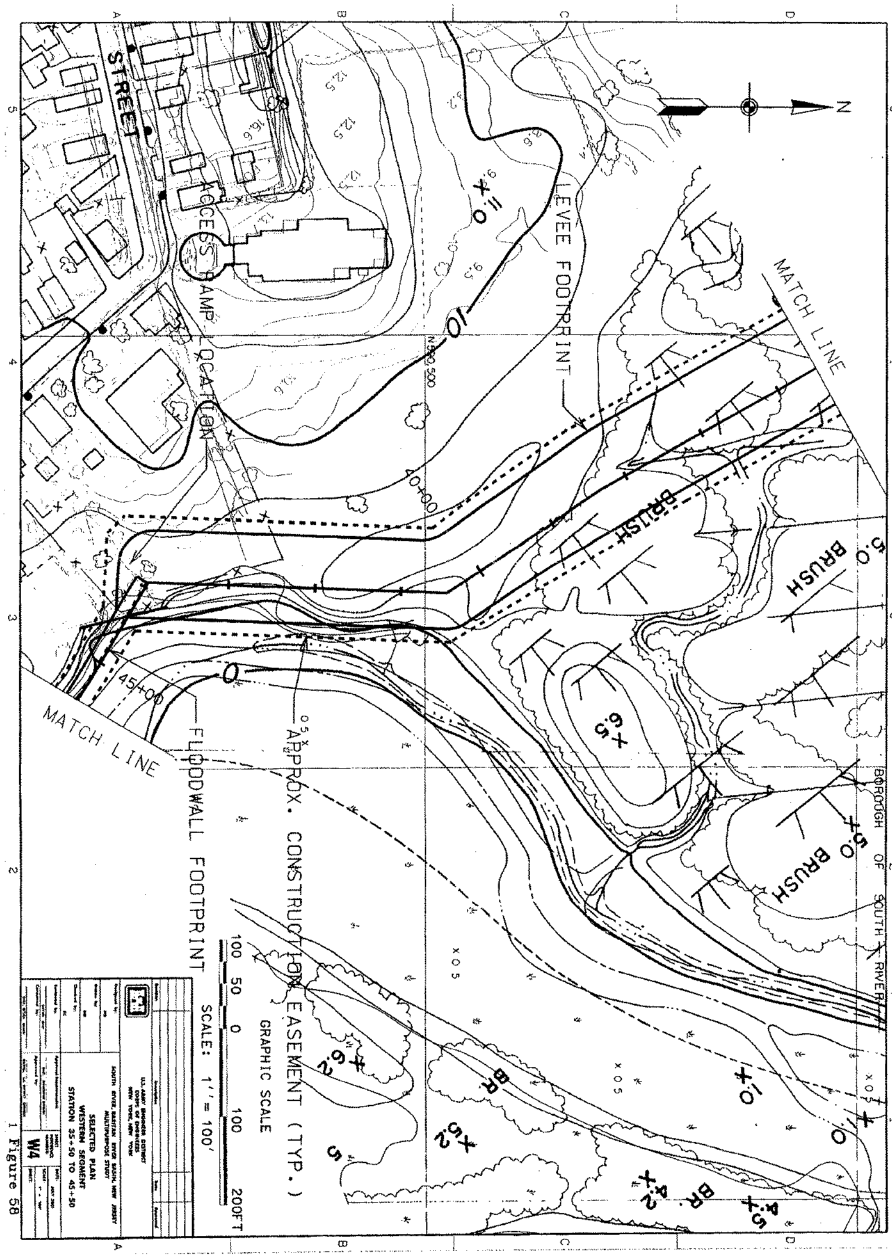

MATCH LINE
APPROX. CONSTRUCTION EASEMENT (TYP.)
FLOODWALL FOOTPRINT
LEVEE FOOTPRINT
ACCESS RAMP LOCATION
WOODS
15+00
20+00
25+00
DENSE VEGETATION
GRAPHIC SCALE
100 50 0 100 200FT
SCALE: 1''= 100'
E 2,078,000
E 2,078,500
E 2,079,000
MATCH LINE
W2

Figure 56


MATCH LINE
BRUSH
LEVEE FOOTPRINT
APPROX. CONSTRUCTION EASEMENT (TYP.)
BOROUGH OF SOUTH RIVER
GRAPHIC SCALE
100 50 0 100 200FT
SCALE: 1" = 100'
SELECTED PLAN
WESTERN SEGMENT
STATION 25+50 TO 35+50
W3
Figure 57


STREET
ACCESS RAMP LOCATION
LEVEE FOOTPRINT
MATCH LINE
BRUSH
BRUSH
BRUSH
40+00
45+00
MATCH LINE
FLOODWALL FOOTPRINT
APPROX. CONSTRUCTION EASEMENT (TYP.)
GRAPHIC SCALE
100 50 0 100 200FT
SCALE: 1'' = 100'
BOROUGH OF SOUTH RIVER
N
W4
1 Figure 58

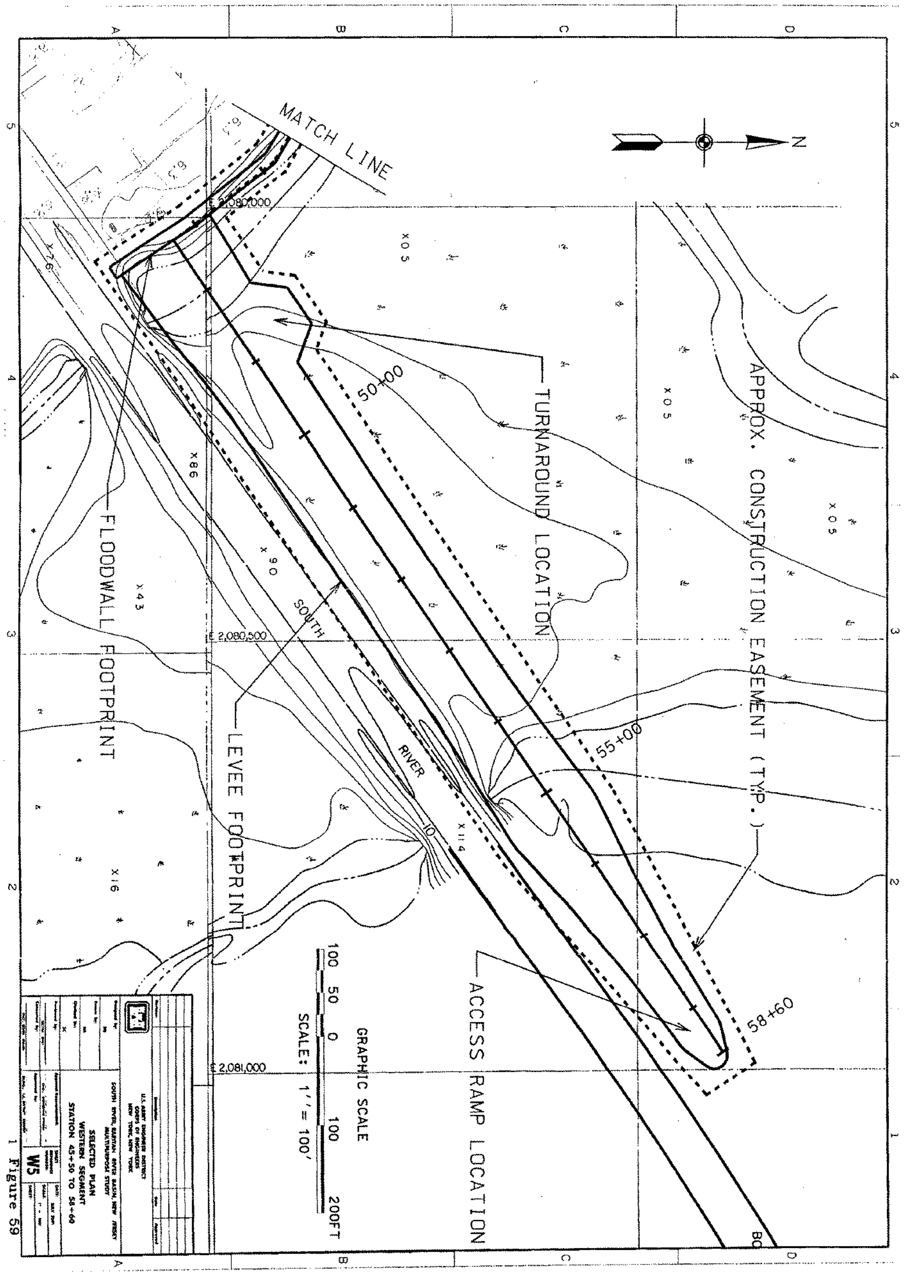
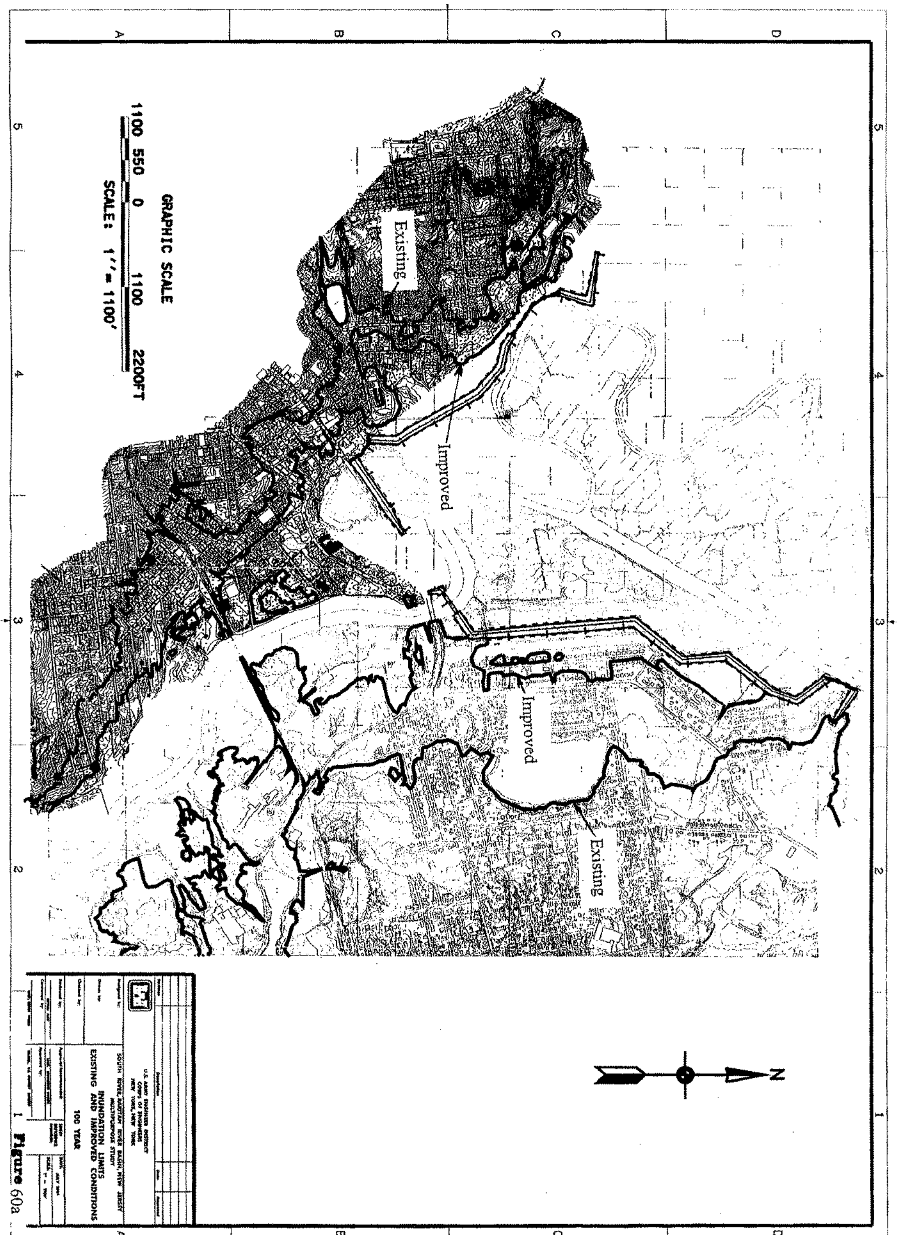
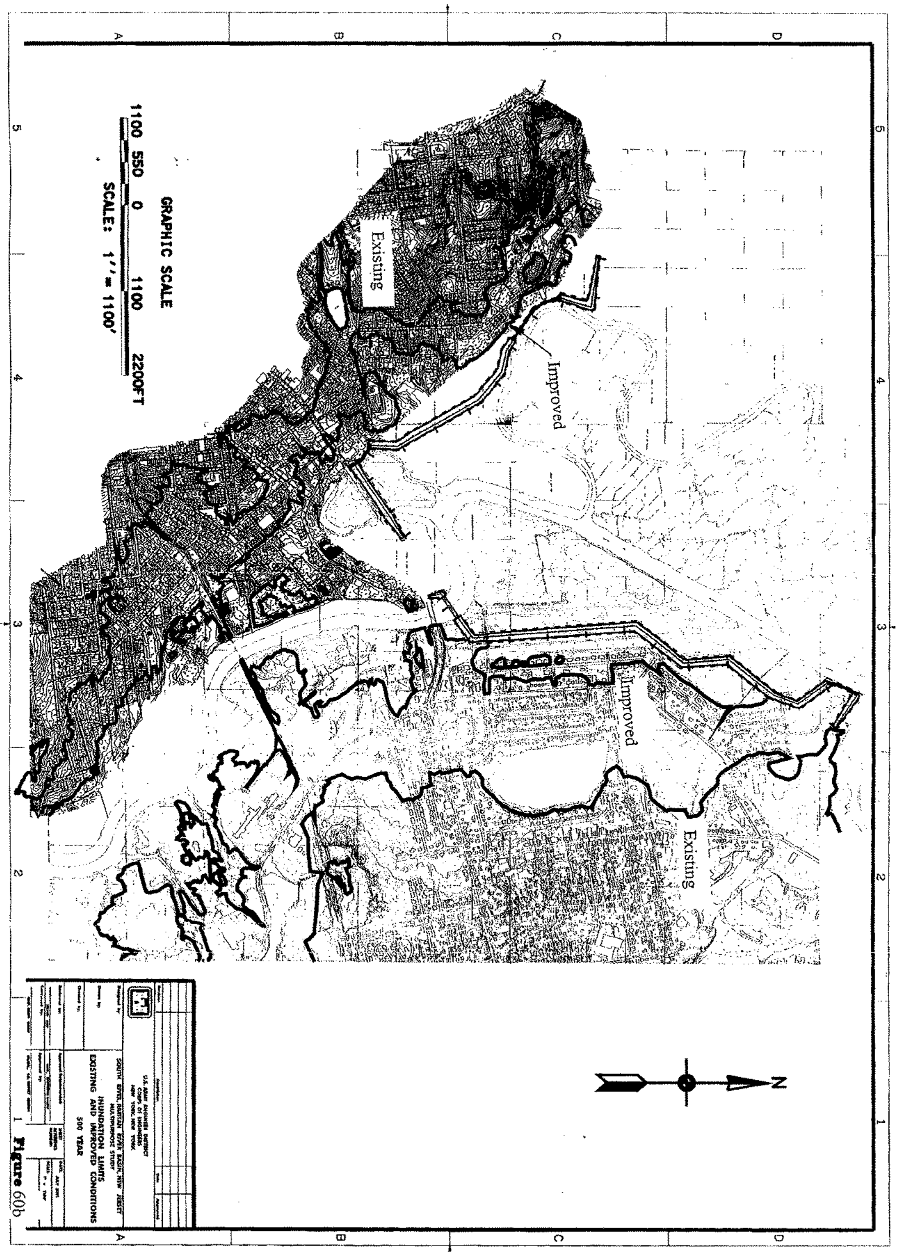

MATCH LINE
N
TURNAROUND LOCATION
APPROX. CONSTRUCTION EASEMENT (TYP.)
50+00
55+00
58+60
FLOODWALL FOOTPRINT
LEVEE FOOTPRINT
ACCESS RAMP LOCATION
SOUTH
RIVER
GRAPHIC SCALE
100 50 0 100 200FT
SCALE: 1' = 100'
SELECTED PLAN
WESTERN SEGMENT
STATION 45+50 TO 58+60
W5

Figure 59



GRAPHIC SCALE
1100 550 0 1100 2200FT
SCALE: 1" = 1100'
Existing
Improved
Improved
Existing
N
EXISTING AND IMPROVED CONDITIONS
INUNDATION LIMITS
100 YEAR

Figure 60a


GRAPHIC SCALE
1100 550 0 1100 2200FT
SCALE: 1'' = 1100'
Existing
Improved
Improved
Existing
N
INUNDATION LIMITS
EXISTING AND IMPROVED CONDITIONS
500 YEAR
Figure 60b

APPENDIX B
GEOTECHNICAL ANALYSIS

SOUTH RIVER FLOOD CONTROL PROJECT - GEOTECHNICAL SUMMARY

INTRODUCTION

The South River Flood Control Project (Figure 1) extends southward from the confluence of the South and Raritan Rivers upstream to the Memorial Bridge (State Route 53) linking the Boroughs of South River and Sayreville. The project area includes the Washington Canal, which was constructed by private interests in the 1830's as part of a larger navigation project designed to facilitate movement of brick, hollow tile, sand, clay, crushed stone and coal to and from New York Harbor. The canal and river are used today for small recreation boats and the original industries no longer exist.

The objective of this Appendix is to define the characteristics of the soil and/or rock that underlie the proposed levee-floodwall alignment so that these factors can be incorporated into preliminary levee, floodwall and gate design.

PHYSIOGRAPHIC SETTING

The project is located along the western edge of the Coastal Plain Physiographic Region. The Coastal Plain is a gently seaward-sloping surface overlying poorly consolidated sediments of Tertiary and Cretaceous age. These sedimentary strata form a southeastward-thickening wedge of sediments that exceeds 2,480 feet(755 meters) along the coast. The sedimentary wedge thins and eventually pinches-out to the northwest where it unconformably overlaps the strata of the Southern Piedmont and Newark Basin.

United States Geological Survey (USGS) maps indicate that the Raritan Formation (Upper Cretaceous) should underlie the project site. The "Raritan" is described as massive, cross-bedded, quartz sand containing thick clayey silt beds and thin silt-clay laminations. A variety of Quaternary (Holocene and Pleistocene) deposits including glacial, fluvial and shallow marine sediments overly the Raritan Formation in the region. The near surface sediments that occur in the project area are fluvial, sands (i.e. point bars) deposited by the South River and organic silt, clay, and peat layers that have been deposited in the marshy areas adjacent to the river.

SUBSURFACE EXPLORATION

A subsurface exploration program consisting of fifteen (15) borings was prepared to evaluate subsurface conditions along the proposed levee-floodwall alignment (Figure 1). Thirteen (13) borings were spaced approximately 800-1000 feet apart along the proposed levee-floodwall alignment and two (2) borings were located at the proposed floodgate near the Memorial Bridge (Highway 535). Borings obtained from the Department of Transportation yielded detailed subsurface information along the Memorial Bridge segment and two of the proposed borings were eliminated.

Standard penetration test methods and procedures (140# hammer, 30" drop, and 2 inch OD split spoon) were employed to collect continuous soil samples to a depth of sixteen (16) feet below grade. Intermittent samples were collected between sixteen feet (16') and total depth of thirty-seven feet (37'). Samples were described according to the Unified Soil Classification System and minor components were quantified according to the Bermister method. Borings obtained as part of this project and selected borings acquired from the DOT were drafted into a standard format and are attached.

Representative disturbed (split spoon) soil samples were selected for testing which included grain size distribution, moisture content, specific gravity, unit weight, liquid limits, and plastic limits. The results are summarized below in Table 1.

TABLE 1. SUMMARY OF DISTURBED SAMPLE TESTING

Boring	Sample	Depth, (ft)	USC Class	% Gravel	% Sand	% Silt+ Clay	Moisture Content %	Atterberg Limits LL	PL	PI	Specific Gravity
SR 00-1	4	6-8'	ML		5	95	32.3	40	26	14	
SR 00-1	8	14-16'	SP-SM		95	5	14.5				2.67
SR 00-2	2	2-4'	SC	19	63	18	10.1				
SR 00-2	8	14-16'	PEAT		21	79	68.3	88	75	13	
SR 00-3	9	19-21'	CL-ML		20	80	26	26	19	7	
SR 00-4	4	6-8'	MH		10	90	111	64	39	25	
SR 00-5	3	4-6'	GC	56	27	17	26.9				2.61
SR 00-5	6	10-12'	MH		2	98	80.8	64	37	27	
SR 00-6	7	12-14'	SM	3	67	30	22.6				
SR 00-6	11	29-31'	SP-SM	5	90	5	17				2.67
SR 00-9	3	4-6'	GP-GM	54	36	10	8.7				
SR 00-9	5	8-10'	SP-SM		95	5	25.2				
SR 00-10	3	4-6'	SP-GP	45	52	3	7.6				
SR 00-10	8	14-16	SC		77	23	68.3	46	27	19	
SR 00-10	11	29-31	CL		4	96	29.1	49	27	22	
SR 00-11	2	2-4'	SP-SM	2	93	5	29.1				
SR 00-12	3	4-6'	SP-SM	4	91	5	17.8				2.71
SR 00-13	5	8-10'	SP-SM		93	7	17.9				
SR 00-15	3	4-6'	CL		2	98	24.9	40	24	16	
SR 00-15	10	24-26'	SM		85	15	14.5				2.59

(Elevations (NGVD) that correspond to the depth intervals tested are shown on boring logs (Plan Sheet 14).)

Undisturbed (Shelby Tube) samples were recovered from fine-grained (Silt and Clay) zones. These undisturbed samples were tested for consolidation and sheer strength (triaxial test). Constant head tests were conducted in pervious, coarse-grained (Sand and Gravel) strata to determine permeability. These test were selected for the purpose of evaluating levee and wall stability, levee settlement, and the potential for seepage under the levee (underseepage). The result of these field-tests and an analysis of the undisturbed samples is attached.

LOCAL SITE CONDITIONS

Soil Profiles A-B, B-C, and C-D were constructed from boring logs to determine the elevation, thickness and continuity of soil units that samples were collected between sixteen feet (16') and total depth of thirty-seven feet (37'). Samples were described according to the Unified Soil Classification System and minor components were quantified according to the Bermister method. Borings obtained as part of this project and selected borings acquired from the DOT were drafted into a standard format and are attached.

Representative disturbed (split spoon) soil samples were selected for testing which included grain size distribution, moisture content, specific gravity, unit weight, liquid limits, and plastic limits. The results are summarized below in Table 1.

TABLE 1. SUMMARY OF DISTURBED SAMPLE TESTING

Boring	Sample	Depth (ft)	USC Class	% Gravel	% Sand	% Silt+ Clay	Moisture Content %	Atterberg Limits LL	PL	PI	Specific Gravity
SR 00-1	4	6-8'	ML		5	95	32.3	40	26	14	
SR 00-1	8	14-16'	SP-SM		95	5	14.5				2.67
SR 00-2	2	2-4'	SC	19	63	18	10.1				
SR 00-2	8	14-16'	PEAT		21	79	68.3	88	75	13	
SR 00-3	9	19-21'	CL-ML		20	80	26	26	19	7	
SR 00-4	4	6-8'	MH		10	90	111	64	39	25	
SR 00-5	3	4-6'	GC	56	27	17	26.9				2.61
SR 00-5	6	10-12'	MH		2	98	80.8	64	37	27	
SR 00-6	7	12-14'	SM	3	67	30	22.6				
SR 00-6	11	29-31'	SP-SM	5	90	5	17				2.67
SR 00-9	3	4-6'	GP-GM	54	36	10	8.7				
SR 00-9	5	8-10'	SP-SM		95	5	25.2				
SR 00-10	3	4-6'	SP-GP	45	52	3	7.6				
SR 00-10	8	14-16	SC		77	23	68.3	46	27	19	
SR 00-10	11	29-31	CL		4	96	29.1	49	27	22	
SR 00-11	2	2-4'	SP-SM	2	93	5	29.1				
SR 00-12	3	4-6'	SP-SM	4	91	5	17.8				2.71
SR 00-13	5	8-10'	SP-SM		93	7	17.9				
SR 00-15	3	4-6'	CL		2	98	24.9	40	24	16	
SR 00-15	10	24-26'	SM		85	15	14.5				2.59

(Elevations (NGVD) that correspond to the depth intervals tested are shown on boring logs (Plan Sheet 14).)

Undisturbed (Shelby Tube) samples were recovered from fine-grained (Silt and Clay) zones. These undisturbed samples were tested for consolidation and sheer strength (triaxial test). Constant head tests were conducted in pervious, coarse-grained (Sand and Gravel) strata to determine permeability. These test were selected for the purpose of evaluating levee and wall stability, levee settlement, and the potential for seepage under the levee (underseepage). The result of these field-tests and an analysis of the undisturbed samples is attached.

LOCAL SITE CONDITIONS

Soil Profiles A-B, B-C, and C-D were constructed from boring logs to determine the elevation, thickness and continuity of soil units that occur along the proposed alignment (Figure 1). Soil types that have similar foundation characteristics (ie Organic Silt, Organic Silty Clay, and Peat) and hydraulic characteristics (i.e., Poorly Graded Sand, Well Graded Sand, Poorly Graded Gravel and Well Graded Gravel) were grouped together in order to simplify correlations and to facilitate Geotechnical Analysis. Other factors considered in correlating the logs were color and soil density.

South River Segment

Soil Profile A-B (Figure 2) was constructed to illustrate the stratigraphy that occurs along the proposed alignment in the South River portion of the project. This stratigraphy can be subdivided into four major units that include the following:

1. Brown, Silty Sand and Gravel (Fill)
2. Dark Brown to Black, Organic Silt and Clay (Marsh-Holocene)
3. Loose to moderately dense Brown Sand (Fluvial-Holocene)
4. Dense to very dense Gray Sand (Raritan Formation-Cretaceous)

The upper surface of the dense gray sand (basal unit) is interpreted to be an erosional unconformity. During a low sea level stand, the South River cut (incised) its channel into the older Gray Sand. As sea level has risen the "ancient" channel and flood plain have been filled with fluvial sands and fine-grained marsh deposits (organic Silt/Clay and Peat). Urban expansion into the flood plain is evidenced by significant fill material that normally caps the stratigraphic sequence. The proposed levee-floodwall alignment crosses several low-lying, marshy areas where fill material is not present. Construction of the levee and wall in these areas will present significant engineering and construction challenges. The settlement problems that the organic layer presents will be addressed in a later section.

Memorial Bridge Segment

Soil Profile B-C (Figure 3) was constructed to illustrate the stratigraphy that occurs along the portion of the alignment that runs parallel to State Route 535 and at the proposed floodgate crossing the South River near the Memorial Bridge. The stratigraphy of the Memorial Bridge Segment can be subdivided into five major units which include the following:

1. Brown, Silty Sand and Gravel (Fill)
2. Dark Brown to Black, Organic Silt and Clay (Marsh-Holocene)
3. Loose to moderately dense, Brown Sand (Fluvial-Holocene)
4. Stiff to hard, blue-gray-blk Silt/Clay (Overbank-Holocene)
5. Dense to very dense, Gray Sand(Raritan Formation-Cretaceous).

Profile B-C is aligned perpendicular to the South River Channel/Flood Plane and shows significant geomorphological characteristics such as the existing channel, abandoned channels, and natural levees. The Organic Silt/Clay and Peat Layer is relatively thick (15-20') on the South River side (B) and thins dramatically to the west or Sayreville Side (C). The levee segment that runs parallel to State Route 535 overlies the thickest part of the organic Silt\Clay layer and has significance in terms of settlement which is discussed in a later section.

Sayreville Segment

Soil Profile C-D (Figure 4) was constructed to illustrate the stratigraphy that occurs along the Sayerville segment of the levee-floodwall system. The stratigraphic units observed in the Sayreville segment are the same as those observed in the Memorial Bridge Segment.

Although the stratigraphic units are the same as those observed in the Memorial Bridge Segment, their aerial distribution (depth, thickness and continuity) is significantly different. The loose to moderately dense, Brown Sand is present at the surface throughout most of this reach as opposed to being covered by the organic Silt/Clay layer in the other two segments. The organic Silt/Clay layer acts to some degree as an impervious blanket that may help to prevent under seepage in the other segments. Constant head tests indicate that the Brown sand has relatively high permeability and that under seepage may be a major consideration in the final design of this segment. Settlement will be a less significant problem in this segment. Seepage, settlement and stability analysis are addressed in the following segments.

STABILITY ANALYSIS

Stability analysis was performed for the levee section located within soil profile A-B using UTEXAS4 (Corps application). The section used in analyzing slope stability consists of the following soil strata:

LEVEE FILL MATERIAL
Unit Weight =125 pcf
cohesion = 100.0
Friction angle = 34°

FILL
Unit Weight =110 pcf
cohesion = 0.0
Friction angle = 33.0°

CLAY/SILT and PEAT
Unit Weight =102 pcf
cohesion = 100.0
Friction angle = 31°

FINE TO MEDIUM SAND
Unit weight =115 pcf
cohesion = 0.0
Friction angle = 33°

The stability analysis was performed with two types of failure surfaces. One surface was the circular surface and other was the non-circular surface. The water level or piezometer line for the levee section was taken at twenty (20) feet mean sea level (msl) at riverside and at three (3) feet msl at landside. The piezometric line at the these elevations are known as the rapid drawdown condition which is the most critical for a stability analysis.

UTEXAS4 (Corps application) was used to compute the lowest safety factor utilizing the search method of failure surfaces for both the circular and non-circular surfaces. Both failure surfaces begin in the middle or near the bottom of the SILT/CLAY stratum. The lowest safety factor for the circular failure surface is 1.511 (see figure 5). The lowest safety factor for the non-circular failure surface is 1.662 (see figure 6).

The SILT/CLAY stratum is present along most of the levee alignment. This type of stratum provides a poor foundation. To improve foundation performance, a geotextile would be placed at the base of the levee. This subsequently lowers the stability factor of safety. The factor of safety as computed from a single tube sample of SILT/CLAY was 1.5. This factor of safety may not represent the entire alignment. In this analysis, the laboratory testing for the sample had to be extrapolated to other areas of the project. Additional samples and testing will be needed to acquire more data in the SILT/CLAY strata.

SETTLEMENT ANALYSIS

Settlement analysis was computed for the levee section in Profile A-B using soil loads from the levee material. This analysis was performed to determine the amount of settlement of the silt/clay stratum. The Corps application CSETT was used to compute the settlement of the levee material within the silt/clay stratum. In this profile, the silt/clay layer was on the order of 10 feet thick and it is considered a compressible soil. Consolidation test data was obtained from a tube sample in borehole SR-14 at a depth of nine (9) feet below the surface. The void ratio and loading pressure data was used to obtain a consolidation curve.

The following parameters for the SILT/CLAY stratum were also used in CSETT:

Effective unit weight = 37.7 pcf
Re-compressive index = 0.01700
Coefficient of consolidation = 750 sqft/year
Drainage Condition = double drain

The above parameters were determined from the laboratory testing on tube sample from boring SR14 (see figure 1). The rate of consolidation calculations for the settlement was performed for time internals of .5, 1, 5, 10, 25, and 50 years and are shown in pages 1 thru 13 of the analysis section.

The highest settlement computed was 0.128 feet for the 10-year interval. The position or location of the settlement was at 30 feet, near the center of the levee. The height of the levee at this point is equal to 20 feet.

Locations where thick SILT/CLAY layers occur are considered to have potential settlement problems. Settlement in excess of 0.128 feet may occur. These areas may require vinyl sheet piling (extended to top of levee) to protect against excessive settlement.

It is recommended that additional undisturbed samples and consolidation tests be performed. This will provide a more complete settlement analysis and better design.

SEEPAGE ANALYSIS

Seepage analysis was performed for levee sections in Profiles A-B and C-D using LEVSEEP95 (Corps application). A more detailed seepage analysis using the GMS 3.1 program was used in Profile C-D.

The proposed levee section (Profile C-D) is located directly on top of two pervious sand strata resulting in a high potential for under seepage.

In Profile A-B the silt/clay layer falls between a fill layer and a fine to medium sand layer. The fill layer is directly underneath the levee base and is relatively pervious. The silt/clay layer is considered a relatively impervious layer.

The following permeability constants were used in the seepage analysis for the two soil profiles:

FILL
k= 0.01 cm/sec

SILT/CLAY LAYER
k= .00001 cm/sec

FINE TO MEDIUM SAND
k=0.042 cm/sec

DENSE TO VERY SAND
k=0.022 cm/sec

The permeability constants for the above soils except for the fill were determined from grain size analysis curves. The two constants for the sand layers were calculated from Hazen Formula using the D10 diameter size and Table 3-4. The constant for the clay/silt layer was estimated from Figure 2-4 in EM 1110 -2-1901 SEEPAGE DESIGN AND CONTROL FOR DAMS. The permeability constant for the Fill was determined by a borehole falling head test at five feet below the surface.

The LEVSEEP95 application uses the mathematic principals for calculating the underseepage as presented in EM 1110-2-1913 DESIGN AND CONSTRUCTION OF LEVEES. Quantities of seepage and exit gradients for the two profiles with and without a cutoff were calculated. The depth of the cutoff in both profiles is nine (9) feet from the base of the levee.

The seepage quantities and exit gradients are as follows:

SOIL PROFILE A-B
No Cutoff
Q= 171.4 gpm/100 feet of levee
Iexit = .603

9 foot Cutoff
Q= 152.41 gpm/100 feet of levee
Iexit = .337

SOIL PROFILE C-D
No Cutoff
Q= 124.75
Iexit = .681

9 foot Cutoff
Q= 122.23 gpm/100 feet of levee
Iexit = .507

The above seepage analysis for both profiles is shown in figures 7-10.

GMS 3.1 generated a flownet and determined the seepage for the levee section in Profile C-D. This profile was considered the most critical for seepage do the two pervious sand layers underneath the levee alignment in this profile. The total seepage rate from the flow net is 0.008 cubic feet per second (cf/s) for a one (1) foot section of levee. The exit gradient Ie was graphically estimated to be .25 (See figures 11-12). The flow net was generated with a 9-foot cutoff and no underlying SILT/CLAY stratum.

Additional falling head and permeability tests should be performed during the next phase of this project. Tests should be performed in both sand layers to determine the field permeability of each layer and to determine the location of the impervious boundary within the strata occurring along the levee alignment.

SEEPAGE ANALYSIS OF THE FLOODWALL

CFRAG (Corps application) was used to compute seepage analysis of the floodwall. It uses the Method of Fragnets by HARR to compute the seepage underneath structures with confined flows. Floodwall sections in Profile C-D were analyzed in the location of two pervious sand layers. The seepage flow was calculated to be .011 square feet per second (sf/s) with an exit gradient of .413. The lateral headwater force on the riverside is 30529.20 pounds (lbs) and the lateral tailwater force on the landside is 11434.8 lbs. The plot of the water pressures is shown in figure 13.

The same recommendation for additional field permeability tests in boreholes that apply for the levees would also apply for the floodwalls.

BEARING CAPACITY OF THE FLOODWALL ANCHOR BLOCK

The continuous reinforced concrete footing which supports the floodwall struts must be designed based on structural requirements and geotechnical constraints. A bearing capacity analysis along with a settlement analysis will be required to insure proper footing size and depth. This especially would applied to areas where the soils are found to be unsuitable for foundation material of the anchor footing. The design of this footing is contingent upon a detailed subsurface investigation including sufficient soil sampling and testing in order to determine the appropriate soil properties to be used in this design. This will be accomplished during the subsequent detailed design phase of this project. Soil replacement, soil stabilization, or foundation support methods may be implemented if required and cost contingencies have been included to address this.

RECOMENDATIONS AND CONCLUSIONS

The stratigraphy that occurs along the proposed flood control system is relatively diverse and complex. Due to the stratigraphy and soil characteristics at the individual units, significant stability, settlement, and seepage problems will need to be addressed in the next phase of design. The results of this investigation dictate the need for several additional borings, field, and laboratory tests.

South River Segment

Borings were acquired in areas that were accessible to a truck mounted, drill rig. In all of the borings the organic silt layer was covered by fill material. Due to the load of the fill on the organic layer it may have consolidated and/or compressed to some degree. In several areas along the alignment the organic layer has not been covered by fill and additional undisturbed samples may be necessary to more accurately define consolidation and settlement. Five additional borings should be acquired along this segment in order to define the stratigraphy and geotechnical parameters (consolidation) for final design. In order to obtain data in these wetland areas an all terrain vehicle (ATV) or tripod may be required.

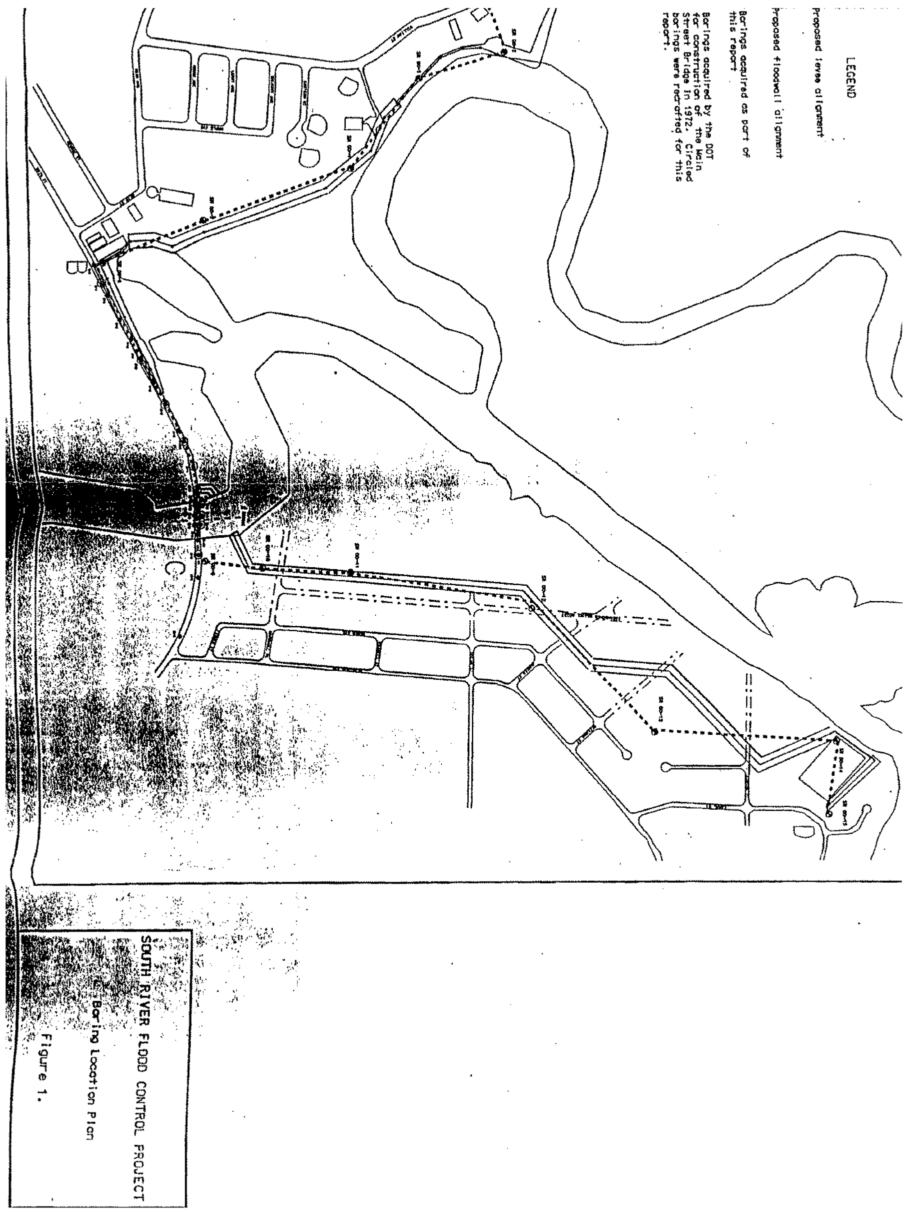
Memorial Bridge Segment

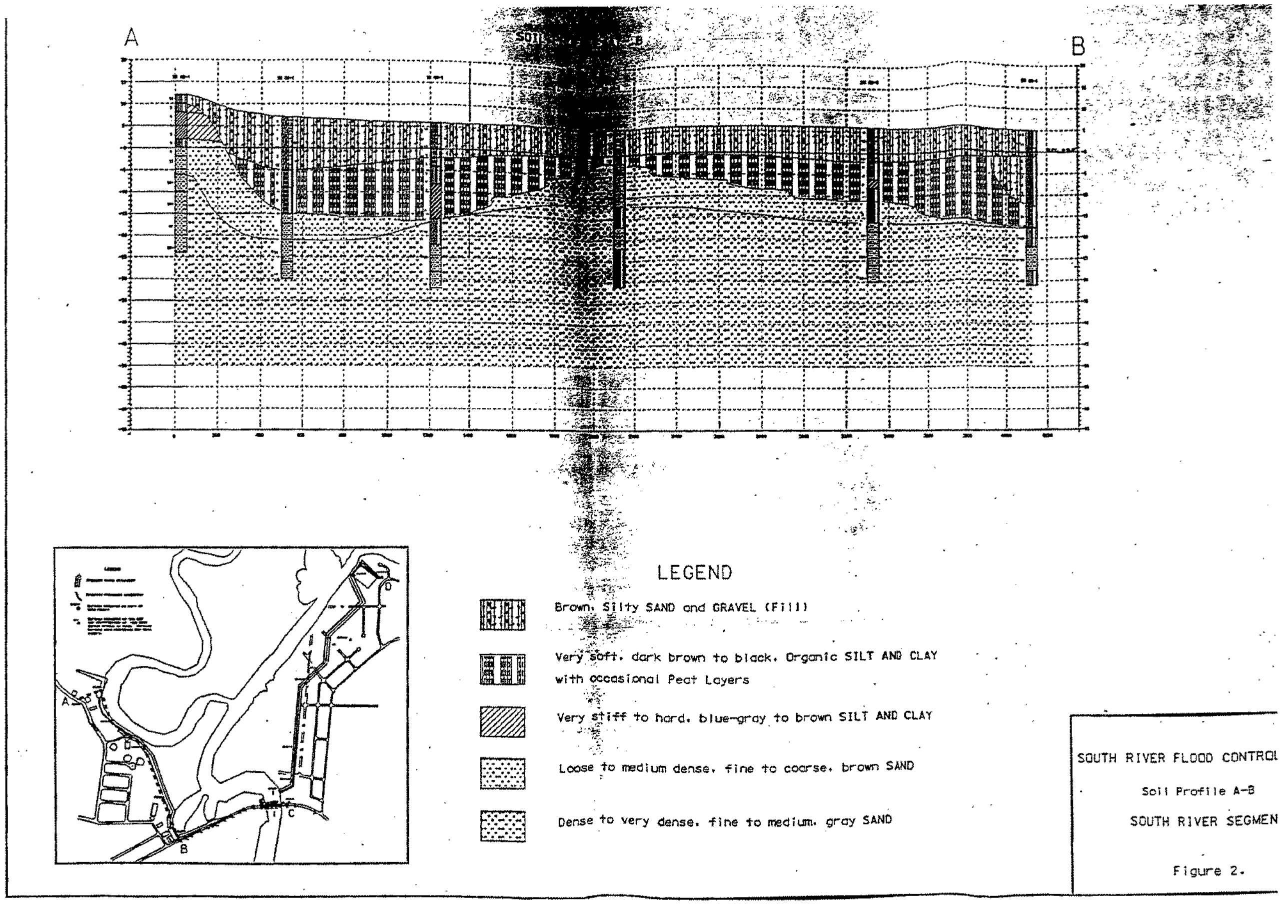
The borings acquired from the Department of Transportation are adequate enough to define the stratigraphy along this segment. However, three additional borings (two levee and one floodgate) and undisturbed samples should be acquired along the alignment to better define geotechnical parameters (consolidation and sheer strength) prior to final design.

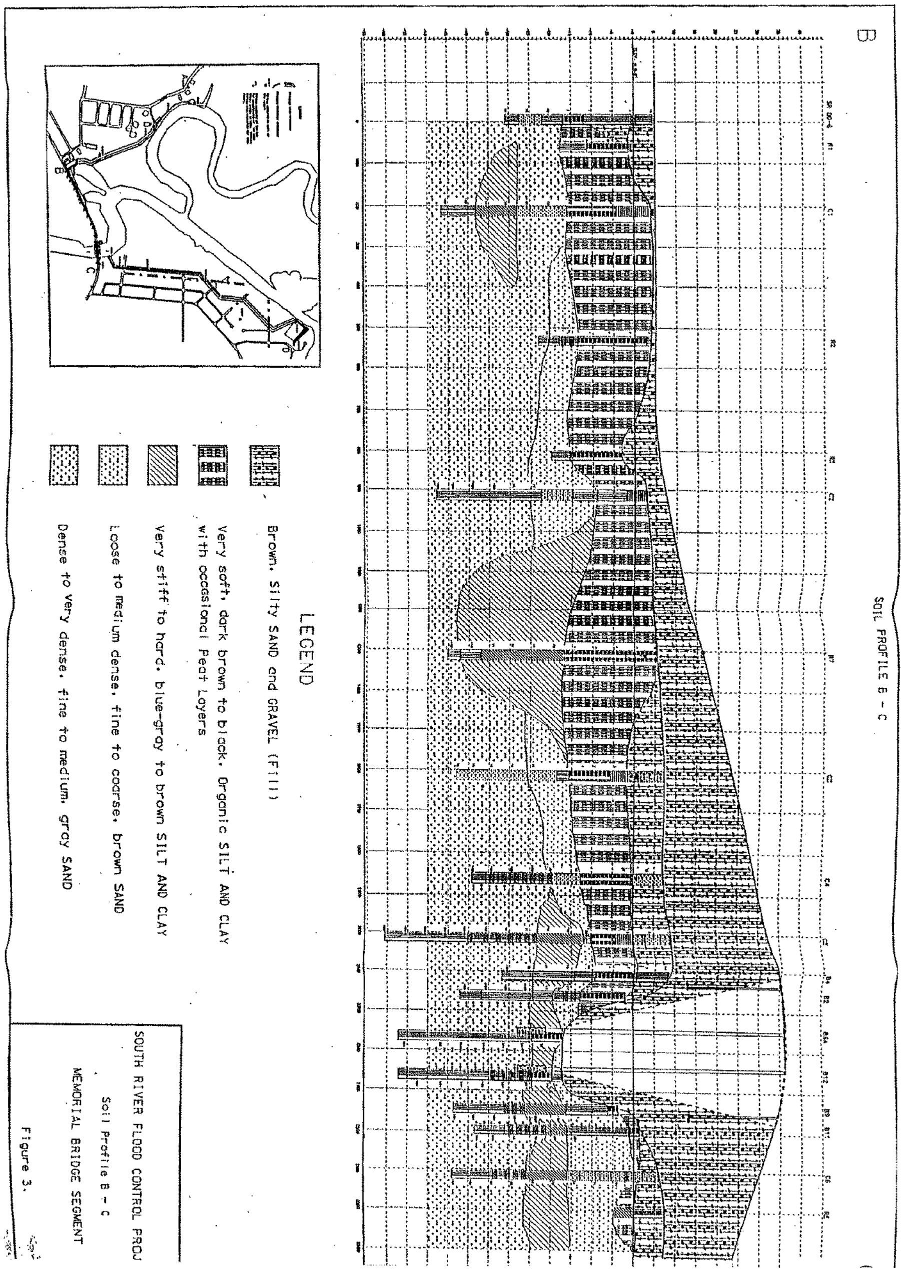
Sayreville Segment

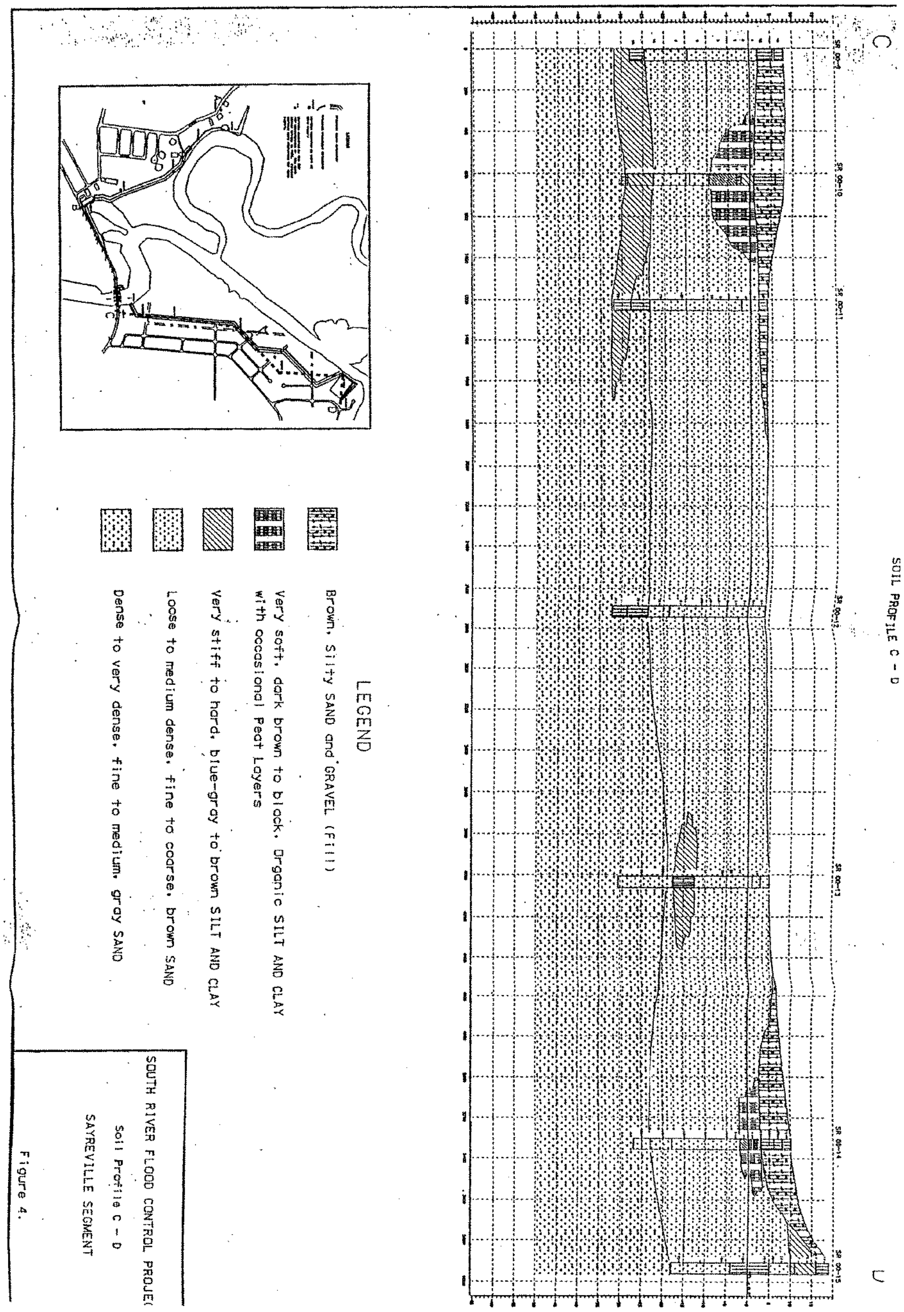
The proposed levee alignment crosses significant wetland areas (between borings SR 00-10 and SR00-13). Borings SR 00-11 and SR 00-12 were acquired along the edge of roads that were built across the wetlands. The sediments underlying these wetlands are thought to be predominantly sand. However, two (2) additional borings should be acquired to verify the stratigraphy. Additional testing should be conducted to better define permeability and the potential for under seepage prior to final design. An ATV or tripod will be required to obtain additional data in these areas.

Although the Organic Silt layer is less continuous and much thinner in the Sayreville Segment it may be significantly thicker in the vicinity of the proposed floodgate. The organic layer is also present in the vicinity of the proposed levee and floodwall that runs along the perimeter of the Sayreville Pumping Station. In order to adequately define the stratigraphy and geotechnical parameters three (3) additional borings should be acquired in these areas prior to final design. Additional permeability tests will be targeted within the fine to medium sand and dense sand strata.


LEGEND
Proposed levee alignment
Proposed floodwall alignment
Borings acquired as part of this report
Borings acquired by the DOT for construction of the Main Street Bridge in 1972. Circled borings were recrafted for this report.
B
C
D
SOUTH RIVER FLOOD CONTROL PROJECT
Boring Location Plan
Figure 1.


A
B
LEGEND
Brown, Silty SAND and GRAVEL (Fill)
Very soft, dark brown to black, Organic SILT AND CLAY
with occasional Peat Layers
Very stiff to hard, blue-gray to brown SILT AND CLAY
Loose to medium dense, fine to coarse, brown SAND
Dense to very dense, fine to medium, gray SAND
SOUTH RIVER FLOOD CONTROL
Soil Profile A-B
SOUTH RIVER SEGMEN
Figure 2.


B
SOIL PROFILE B - C
LEGEND
Brown, Silty SAND and GRAVEL (Fill)
Very soft, dark brown to black, Organic SILT AND CLAY with occasional Peat Layers
Very stiff to hard, blue-gray to brown SILT AND CLAY
Loose to medium dense, fine to coarse, brown SAND
Dense to very dense, fine to medium, gray SAND
SOUTH RIVER FLOOD CONTROL PROJ
Soil Profile B - C
MEMORIAL BRIDGE SEGMENT
Figure 3.


SOIL PROFILE C – D
C
D
SR 00-9
SR 00-10
SR 00-11
SR 00-12
SR 00-13
SR 00-14
SR 00-15
LEGEND
Brown, Silty SAND and GRAVEL (Fill)
Very soft, dark brown to black, Organic SILT AND CLAY with occasional Peat Layers
Very stiff to hard, blue-gray to brown SILT AND CLAY
Loose to medium dense, fine to coarse, brown SAND
Dense to very dense, fine to medium, gray SAND
SOUTH RIVER FLOOD CONTROL PROJE(
Soil Profile C – D
SAYREVILLE SEGMENT
Figure 4.

SOUTH RIVER FLOOD CONTROL PROJECT

CIRCULAR FALIURE SURFACE

LEVEE FROM PROFILE A-B

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Levee Fill Material	125	Cohesion: 100.0 Friction angle: 34	Piezometric Line no. 1
2	Fill	110	Cohesion: 0.0 Friction angle: 32	Piezometric Line no. 1
	Clay/Silt Layer	102	Cohesion: 100.0 Friction angle: 33.2	Piezometric Line no. 1
	Fine to Medium Sand	115	Cohesion: 0.0 Friction angle: 31	Piezometric Line no. 1

Factor of safety: 1.511

Side force Inclination: -13.93 degrees

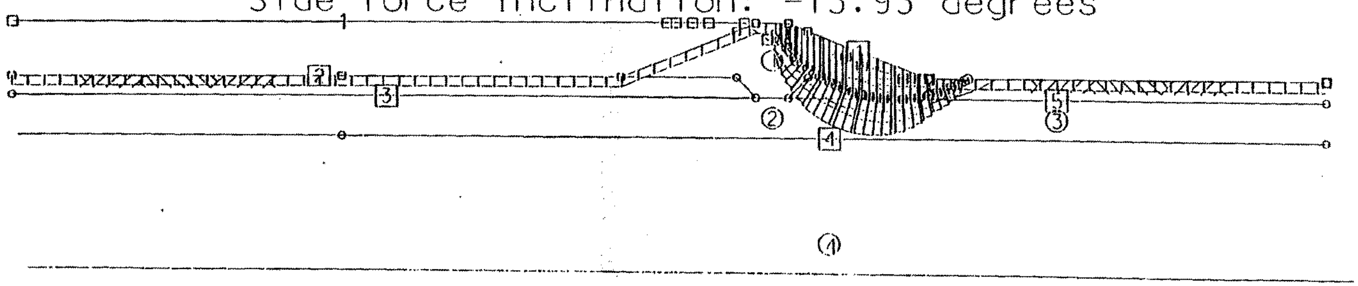


FIGURE 5

SOUTH RIVER FLOOD C[illegible]TROL PROJECT

NON-CIRCULAR FALIURE SURFACE

LEVEE FROM PROFILE A-B

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Levee Fill Material	125	Cohesion: 100.0 Friction angle: 34	Piezometric Line no. 1
2	Fill	110	Cohesion: 0.0 Friction angle: 33	Piezometric Line no. 1
3	Clay/Silt Layer	102	Cohesion: 100.0 Friction angle: 31	Piezometric Line no. 1
4	Fine to Medium Sand	115	Cohesion: 0.0 Friction angle: 33	Piezometric Line no. 1

Factor of safety: 1.662

Side force Inclination: -14.05 degrees

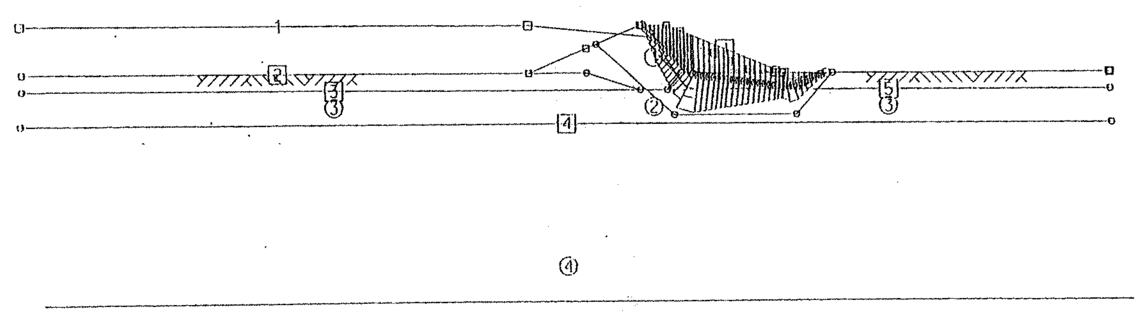
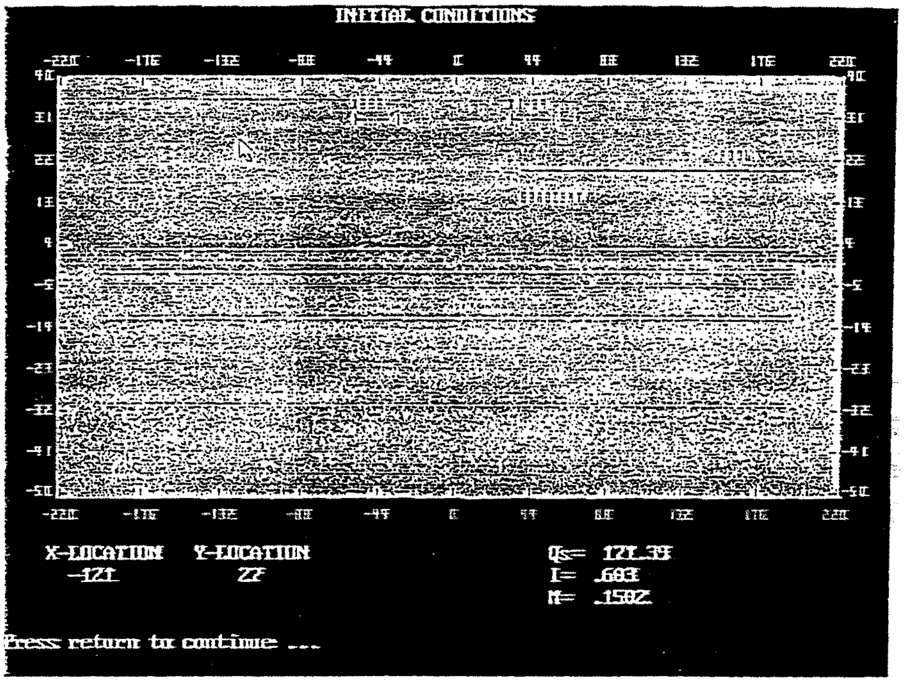


FIGURE 6

SOUTH RIVER FLOOD CONTROL PROJECT
SEEPAGE ANALYSIS

LEVEE SECTION ALONG SOUTH RIVER SEGMENT - SOIL PROFILE A-B

NO CUTOFF



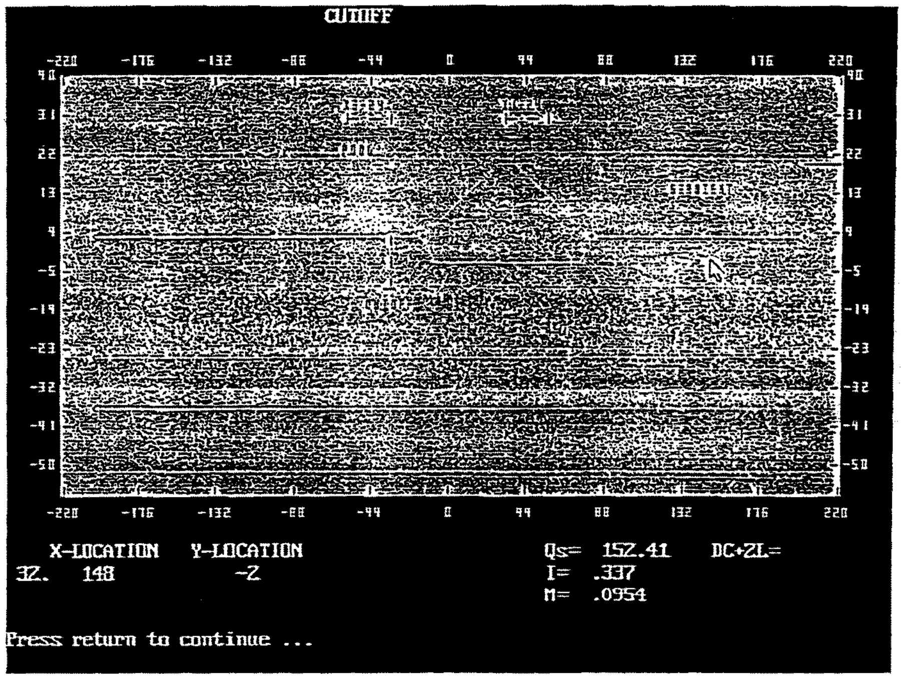
LEVSEEP95 PROGRAM

FIGURE 7

SOUTH RIVER FLOOD CONTROL PROJECT
SEEPAGE ANALYSIS

LEVEE SECTION ALONG SAYERVILLE SEGMENT - SOIL PROFILE C-D

9 FOOT CUTOFF



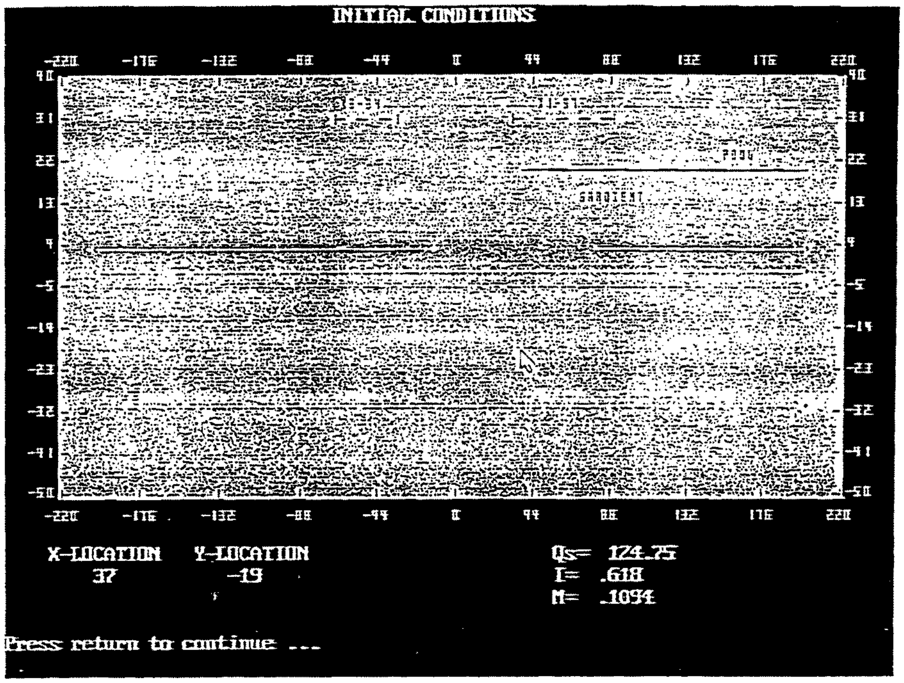
LEVSEEP95 PROGRAM

FIGURE 8

SOUTH RIVER FLOOD CONTROL PROJECT
SEEPAGE ANALYSIS

LEVEE SECTION ALONG SOUTH RIVER SEGMENT -PROFILE A-B

NO CUTOFF



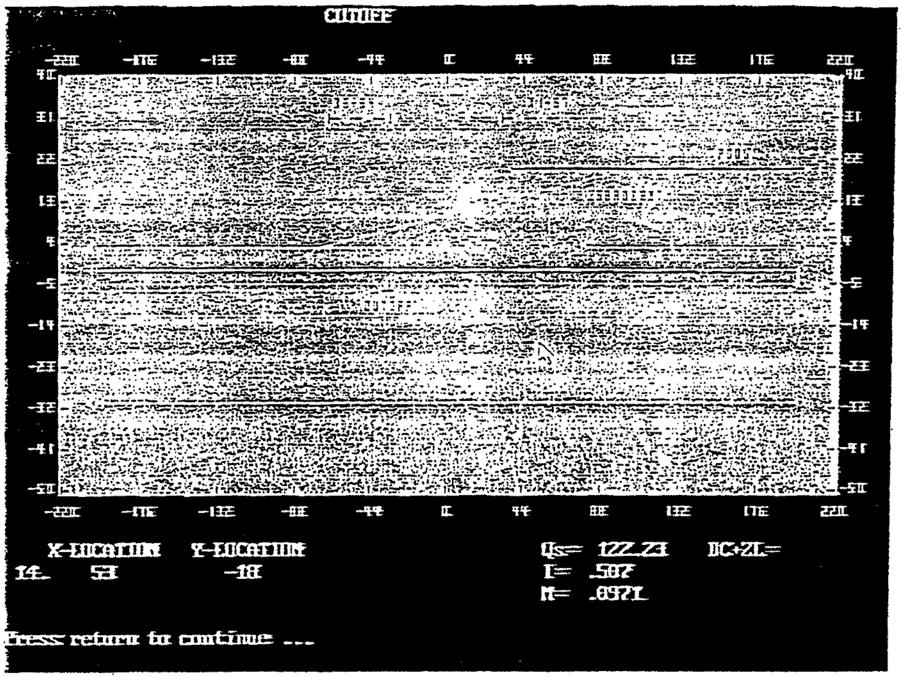
LEVSEEP95 PROGRAM

FIGURE 9

SOUTH RIVER FLOOD CONTROL PROJECT
SEEPAGE ANALYSIS

LEVEE SECTION ALONG SOUTH RIVER SEGMENT - PROFILE A-B

9 FOOT CUTOFF



LEVSEEP95 PROGRAM

FIGURE 10

SOUTH RIVER FLOOD CONTROL PROJECT

Total Flowrate = 0.008 (ft^3/s)/(ft)

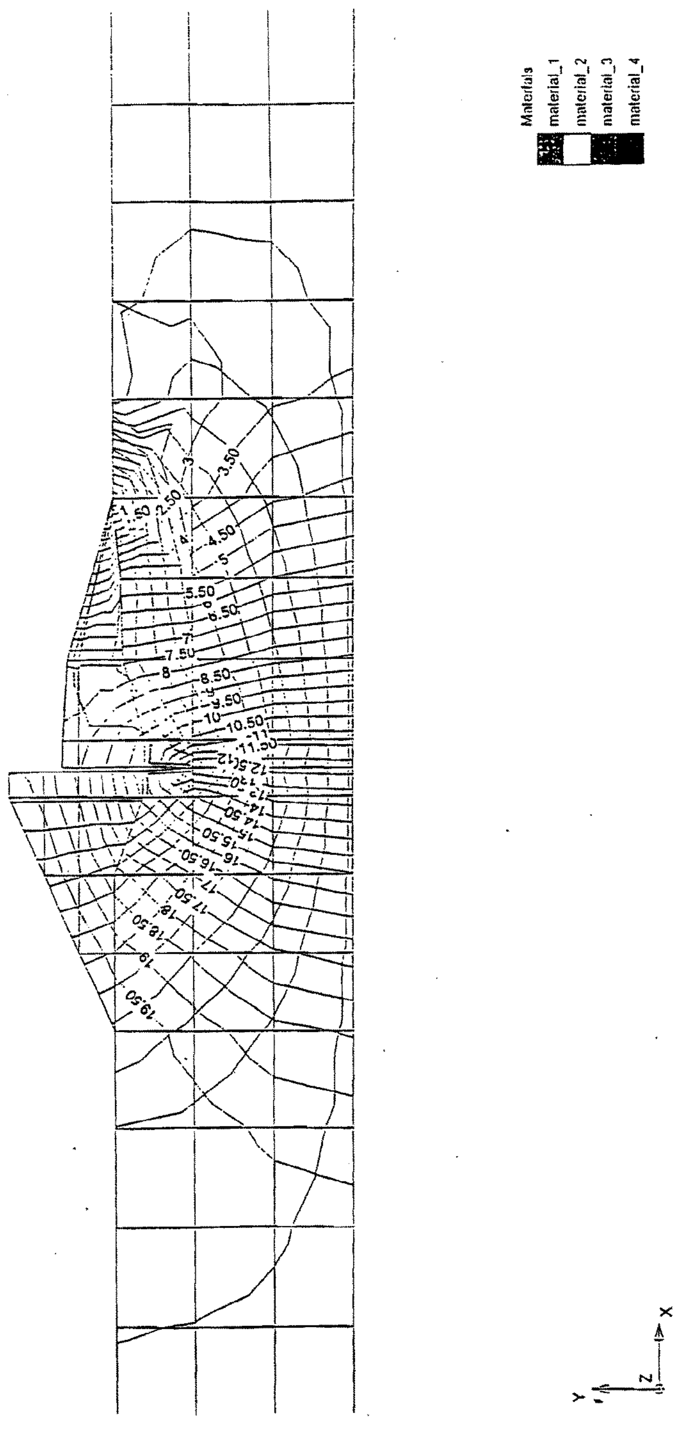


FIGURE 11

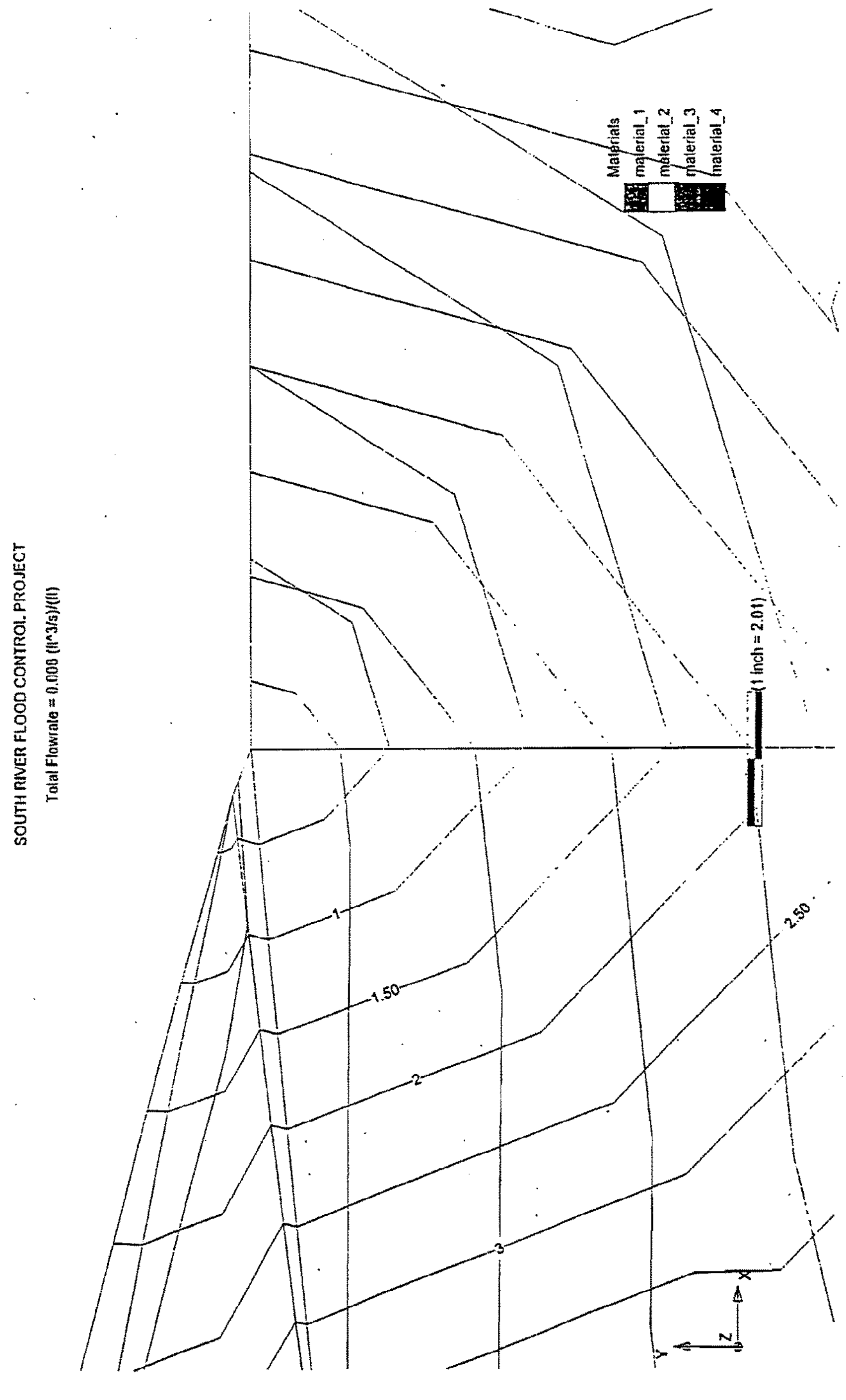

SOUTH RIVER FLOOD CONTROL PROJECT
Total Flowrate = 0.000 (ft^3/s)/(ft)
Materials
material_1
material_2
material_3
material_4
(1 inch = 2.01)
1
1.50
2
2.50
3
X
Y
Z

FIGURE 12

Plot of Water Pressures

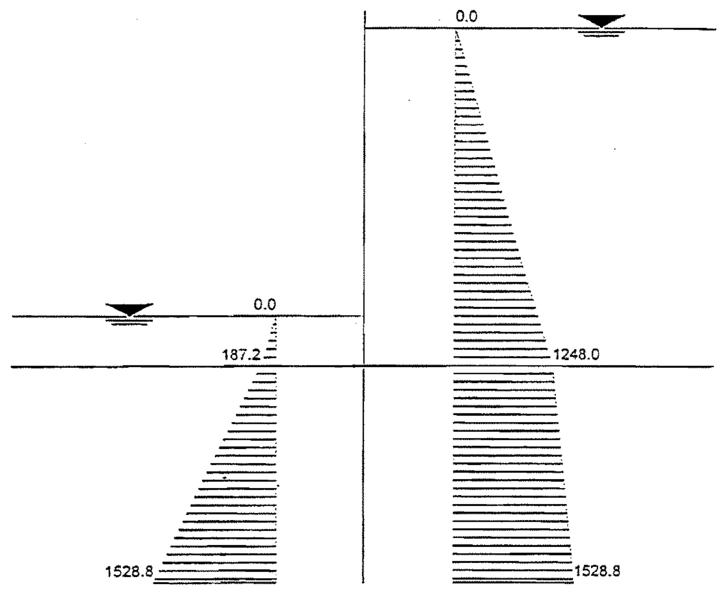


FIGURE 13

SR 00-1 | 592444

12.0' | 523341

ELEVATION	DEPTH	SAMPLE NUMBER	CLASSIFICATION OF MATERIALS (Description)	REMARKS (Drilling time, water loss, depth of weathering, etc. if significant)
	0–2	S1	Gray-brown, fine-med. SAND, some Silt and Clay, trace fine Gravel (SM)	10.0'
10.0	2–4	S2	Tan-brown, Clayey SILT, trace fine Gravel (ML)	8.0'
5.0	4–10	S3, S4, S5	Tan-brown, Silty CLAY, trace fine Gravel (CL)	Trace organics
	10–12	S6	Gray, very fine SAND and SILT (SM)	2.0'
0.0	12–14	S7	Gray-brown medium SAND (SP)	0.0'
	14–17	S8	Brown-gray fine-coarse SAND, trace Silt and Clay (SW)	-2.0'
-5.0	17–22	S9	Yellow-gray, fine-coarse SAND, trace Gravel (SP)	-5.0'
-10.0	22–36	S10, S11, S12	Yellow-gray, fine-coarse SAND (SW)	-10.0'
-25.0	36			TD = -24.0'

DEPTH	USCS	% G	% S	% F	LL	PL	PI	% H2O	SG
6-8'	ML		5	95	40	25	14	32.3	
14-16'	SP-SM		95	5				14.5	2.67

SR 00-2

592692

7.0'

523780

ELEVATION	DEPTH	SAMPLE NUMBER	CLASSIFICATION OF MATERIALS (Description)	REMARKS (Drilling time, water loss, depth of weathering, etc. if significant)
	0–5.0'	S1	Red-brown medium SAND and GRAVEL, trace to little Silt (SM-GM) 5.0'	Trace asphaltic material
		S2	Red-brown medium SAND, some GRAVEL, trace Silt (GW-SW)	3.0'
		S3, S4	Red, medium-coarse GRAVEL little to some fine Sand, trace to little Silt (GM)	Brick Fragments
				-1.0'
		S5, S6	Red-brown, fine-medium SAND and Gravel, some Silt (SM-GM)	
				-5.0'
		S7, S8	Red-brown to black, fibrous organic SILT and CLAY, trace fine Sand (OH-MH)	
		S9	Black, fibrous organic, Clayey SILT (OH)	
				-15.0'
		S10	Light brown, medium-coarse SAND (SP)	
				-21.0'
		S11	Red-brown, fine-coarse SAND, little Gravel (SW)	
				-26.0'
		S12	White-light brown, medium SAND (SP)	
				-30.0'

ELEV.	USCS	% G	% S	% F	LL	PL	PI	% H2O	SG
2-4'	SC	19	63	18				10.1	
14-16'	PEAT		21	79	88	75	13	68.3	

SR 00-3 | 592070

6.0' | 524070

ELEVATION	DEPTH	SAMPLE NUMBER	CLASSIFICATION OF MATERIALS (Description)	REMARKS (Drilling time, water loss, depth of weathering, etc. if significant)
5.0	1–3	S1, S2	Brown SAND and Clayey SILT, trace Gravel (SM-ML)	Brick Fragments
	3–6	S3	Brown-gray SAND and GRAVEL, little Silt (SM-GM)	3.0' Rock Fragments
0.0	6–8	S4	Brown SAND and SILT, trace Gravel (SM-ML)	0.0'
	8–10	S5	Brown-black Clayey organic SILT (OH)	-2.0'
-5.0	10–14	S6, S7	Gray-black, Clayey SILT, little Sand and very fine Gravel (ML)	-4.0'
-10.0, -15.0	14–22	S8, S9	Brown-dark gray Silty Clay (CH)	-8.0' Slightly micaceous
-20.0	22–28		Tan to orange, very fine SAND, little to some Silt (SM)	-16.0'
-25.0, -30.0	28–38	S11, S12	Gray fine-medium SAND, trace Silt and Gravel (SP)	-22.0'
	38			-32.0'

ELEV.	USCS	% G	% S	% F	LL	PL	PI	% H2O	SG
CL-ML	19-21'		20	80	25	19	7	26.0	

SR 00-4

591603

6.0'

524891

ELEVATION	DEPTH	BLOWS/6"	SAMPLE NUMBER	CLASSIFICATION OF MATERIALS (Description)	REMARKS (Drilling time, water loss, depth of weathering, etc. if significant)
5.0	1–2	4, 9, 10, 8	S1	Light -dark brown, medium-coarse SAND; some Gravel, trace Silt & Clay (SW)	4.0'
	2–4	7, 5, 4, 7	S2	Light-dark brown, medium-coarse SAND and GRAVEL, trace-little Silt (SW-GW)	
0.0	4–6	W, O, H, 1	S3	0.0'	
	6–8	4, 1, 1, 2	S4	Moist, brown, Clayey organic SILT, trace Sand (OH) -2.0'	Highly fiberous
	8–10		SST	Gray, fine-med. SAND and fine GRAVEL (SW-GW) -4.0'	Shelby Tube 8'-10'
-5.0	10–12	1, 2, 1, 5	S6	Gray-light brown, fine SAND (SP)	
-10.0	15–17	5, 8, 15, 16	S7		-12.0'
-15.0	20–22	20, 27, 50/4	S8	Gray-light brown, fine SAND, trace to little Silt (SP-SM)	-17.0'
-20.0	25–27	6, 18, 35, 43	S9	Grey medium-coarse SAND, trace Silt (SP)	-22.0'
-25.0	30–32	17, 34, 40, 51/3	S10	Tan-light brown, fine-medium SAND, trace to little Silt (SP-SM)	
-30.0	35–37	30, 40, 47, 51/3	S11		TD = -31.0'

ELEV.	USCS	% G	% S	% F	LL	PL	PI	% H2O	SG
6-8'	MH		10	90	64	39	25	111%	

SR 00-5 | 590567

6.0' | 525404

ELEVATION	DEPTH	SAMPLE NUMBER	CLASSIFICATION OF MATERIALS (Description)	REMARKS (Drilling time, water loss, depth of weathering, etc. if significant)
5.0	1–2	S1	Fine-medium SAND, some Silt, little Gravel (SM)	
	2–8	S2, S3, S4	Red, SAND and GRAVEL, little Silt (SM-GM)	Brick fragments Shell fragments
0.0	6			
	8–12	S/S/T, S6	Black organic Clayey SILT (OH)	Shelby Tube 8'–10'
-5.0	11			
	12–14	S7	Brown, plastic Silty CLAY (CH)	
	14–17	S8	Brown, Clayey SILT, some fine Sand (ML)	
-10.0	16			
	17–22	S9	Brown fine SAND, some SILT (SM)	
-15.0	21			
	22–28	S10	Gray to yellow brown fine SAND, trace to little Silt (SP-SM)	
-20.0	26			
	28–32	S11	Black, fine-medium SAND, little Silt (SM)	Thin organic seams
-25.0	31			
	32–35	S12	Gray, medium-coarse SAND, trace Silt (SP)	TD = -29.0'
-30.0	36			

ELEV.	USCS	% G	% S	% F	LL	PL	PI	% H2O	SG
4-6'	GC	56	27	17				26.9	2.61
10-12'	MH		2	98	64	37	27	80.8	

SR 00-6 | 589829

4.5' | 525880

ELEVATION	DEPTH	BLOWS 6"	SAMPLE NUMBER	LEGEND	CLASSIFICATION OF MATERIALS (Description)	REMARKS (Drilling time, water loss, depth of weathering, etc. if significant)
	1–4	AUG	S1, S2		Brown SAND and Clayey SILT, trace Gravel (SM-ML)	.5'
0.0	4–6		S3		Tan to gray-green SAND and GRAVEL, little Silt (SM-GM)	-1.5'
-5.0, -10.0	6–17		S4, S5, S6, S7, S8		Greenish-brown, fine-med. SAND, trace-little Silt, trace Gravel (SM-SP)	-13.0'
-15.0	17–22		S9		Dark gray-black, organic CLAY (OH)	-18.0'
-20.0	22–27	WOH, 18, 22, 32	S10		Dark gray, fine SAND, little Silt (SM)	-22.5'
-25.0, -30.0	27–36	WOH, 22, 36, 33; 18, 22, 38, 33	S11, S12		Gray-dark gray, fine SAND, trace Little Silt (SP-SM)	TD = -31.5'

DEPTH	USCS	% G	% S	% F	LL	PL	PI	% H2O	SG
12-14	SM	3	67	30				22.6	
29-31	SP-SM	5	90	5				17	2.67

SR 00-9 | 591037

8.0' | 528169

ELEVATION	DEPTH	BLOWS 6"	SAMPLE NUMBER	LEGEND	CLASSIFICATION OF MATERIALS (Description)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
	0–6.0'		S1		Yellow-brown fine SAND, little to some Silt and Clay (SM) 6.0'	tr. organic material
					Gray & yellow-brown Silty Clay (CL)	5.5'
5.0			S2, S3		Brown, very fine SAND, trace-little Silt, trace gravel-sized Shale fragments (SM)	
0.0			S4, S5, S6, S7, S8, S9		Red-brown, fine-medium SAND, trace Silt (SP)	2.0' Red-brown to orange
-15.0			S10, S11		Red-brown fine-coarse SAND, little Gravel, trace Silt (SW)	-14.5'
-25.0		10, 20, 35, 50/.3	S12		Dark gray to black, micaceous Clayey SILT (ML)	-24.5'
						TD = -28.0'

DEPTH	USCS	% G	% S	% F	LL	PL	PI	% H2O	SG
4-6'	GP-GM	54	36	10				8.7	
8-10'	SP-SM	0	95	5				25.2	

SR 00-10

8.0′

591492

528160

ELEVATION	DEPTH	SAMPLE NUMBER	CLASSIFICATION OF MATERIALS (Description)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
	1–2	S1	Brown, fine SAND, little-some Silt and Clay (SM)	6.0
5.0	3–7	S2, S3	Brown, fine-med. SAND, little Gravel, trace-little Silt (SP-SM)	
0.0	7–10	S4, S5	Gray-brown, slightly organic, Silty CLAY (CL)	1.0 Trace fibers and roots
	10–12	S6	Brown GRAVEL, little to some SAND, little Silt (GM)	-2.0
-5.0	12–17	S7, S8	Dark brown to black, fiberous organic Silty CLAY, trace fine Sand (OH)	-4.0 Grass-like mat
-10.0	18–22	S9	Gray-green, fine-medium SAND, trace-little Silt (SP-SM)	-9.5′
-15.0	22–27	S10	Yellow-brown, fine SAND, trace-little Silt, trace Gravel (SP-SM)	-14.0′
-20.0, -25.0	28–36	S11	Blue-gray CLAY (CL) -28.5′	-19.5′
	37	S12	Dark brown to black, organic SILT (OH)	-29.0′
-30.0	38		Dark brown fine SAND, little Silt (SM	TD = -30.0′

DEPTH	USCS	% G	% S	% F	LL	PL	PI	% H2O	SG
		-							
4-6′	SP-GP	45	52	3				7.6	
14-16′	SC		77	23	46	27	19	68.3	
29-31′	CL		4	96	49	27	22	29.1	

SR 00-11		592165
4.0'		528078

ELEVATION	DEPTH	BLOWS 6"	SAMPLE NUMBER	CLASSIFICATION OF MATERIALS (Description)	REMARKS (Drilling time, water loss, depth of weathering, etc. if significant)
	0–2	[illegible]	S1	Brown, fine SAND, little Silt (SM)	2.0'
0.0	2–6	[illegible]	S2, S3	Brown, fine SAND, trace-little Silt (SP-SM)	-2.0'
5.0 – -20.0	6–27.5	[illegible]	S4, S5, S6, S7, S8, S9, S10	Brown, fine-coarse SAND trace-little Silt, trace - little Gravel (SP-SM)	-23.5'
-25.0	27.5–32	[illegible]	S11	Gray-green, fine-medium SAND, little Silt (SM)	-28.0'
-30.0	32–36	[illegible]	S12	Dark-gray to black slightly organic Clayey, micaceous Silt (ML)	TD = -32.0'

DEPTH	USCS	% G	% S	% F	LL	PL	PI	% H2O	SG
2-4'	SP-SM	2	93	5				29.1	

SR 00-12 | 593600

4.0' | 528136

ELEVATION	DEPTH	SAMPLE NUMBER	CLASSIFICATION OF MATERIALS (Description)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
	1–3	S1, S2	Brown, fine-medium SAND, trace-little Silt, trace Gravel (SP-SM)	
0.0 to −18.5	4–22	S3, S4, S5, S6, S7, S9	Brown, fine-coarse SAND, trace-little Silt, trace Gravel (SP-SM)	
−18.5 to −23.5	23–27	S10	Tan, fine-medium SAND, trace Silt (SP)	−18.5'
−23.5 to −28.5	28–32	S11	Tan-brown, fine-coarse SAND little Gravel, trace-little Silt (SP-SM)	−23.5'
−28.5 to −31.5	33–35	S12	Tan-brown and black mottled fine to medium SAND, trace to little Silt (SP-SM)	−28.5'
				TD = −31.5'

Elevation scale: 0.0, −5.0, −10.0, −15.0, −20.0, −25.0, −30.0

Depth scale: 1–49

DEPTH	USCS	% G	% S	% F	LL	PL	PI	% H2O	SG
4-6'	SP-SM	4	91	5				17.8	2.71

SR 00-13

594709

5.0'

528945

ELEVATION	DEPTH	BLOWS / 6"	SAMPLE NUMBER	CLASSIFICATION OF MATERIALS (Description)	REMARKS (Drilling time, water loss, depth of weathering, etc. if significant)
	1–2	2, 2, 5, 4	S1	Red-brown, fine-med. SAND, trace Silt (SP)	
	2–4	5, [illegible], [illegible], [illegible]	S2	Gray-brown (mottled) fine-medium SAND, trace Silt (SP)	3.0' Mottled gray & brown
0.0	4–6	1, 2, 2, 2	S3	Gray, fine-med. SAND, trace Silt (SP)	1.0'
	6–8	WOH, 7, 12, 16	S4		
	8–10	3, 10, 20, 22	S5		
-5.0	10–12	7, 10, 20, 21	S6		
	12–14				Augered 12'–14' no Scmple
-10.0	14–16	7, 13, 22, 25	S7		
	17.5			Inter-laminated, dark gray, very fine SAND and dark brown to black, organic Silt (SM-ML)	-12.5'
-15.0	19–21	WOH, 1, 2, 3	S8		
	22.5			Gray, fine-coarse SAND, tr. Silt (SP)	-17.5'
-20.0	24–25	7, 32, 50/2	S9		
-25.0	29–31	20, 22, 32, 52	S10		
-30.0	34–35	12, 19, 50/4	S11		TD = -30.5'

DEPTH	USCS	% G	% S	% F	LL	PL	PI	% H2O	SG
8-10'	SP-SM		93	7				17.9	

SR 00-14 | 596036

10.0' | 528742

ELEVATION	DEPTH	BLOWS/6"	SAMPLE NUMBER	CLASSIFICATION OF MATERIALS (Description)	REMARKS (Drilling time, water loss, depth of weathering, etc. if significant)
	0–2	2, 2, 7, 9	S1	Brown, fine-medium SAND, little Silt, trace Gravel (SM) 8.0'	Tr. Brick Fragments
	2–4	10, 10, 12, 11	S2	Brown Clayey SILT and SAND, little Gravel (SM-ML) 6.0'	Tr. Brick Fragments
5.0	4–6	11, 11, 11, 7	S3	Red-brown SAND, little Gravel, little Silt and Clay (SM) 3.0'	Frequent Brick Fragments
	6–8	4, 7, 4, 5	S4	Dark brown to black, slightly organic (fibrous) Silty CLAY (CH-OH)	2.0'
	8–10	1, 2, 2, 1	ST	Dark-brown to black Silty PEAT (PT) 0.0'	Augered and pushed tube after sampling hole
0.0	10–12			Dark brown to black slightly organic (fiberous) Silty CLAY (CH-OH)	No Recovery -2.0'
	12–14	WOH, 2, 2, 2	S7	Greenish-brown, fine-coarse SAND, trace to little Silt and Gravel (SP)	
-5.0	14–16	WOH, 1, 2, 2	S8		
-10.0	19–21	2, 3, 4, 7	S9		
-15.0	25–27	6, 7, 6, 5	S10		-18.0'
-20.0	28–33	2, 7, 8, 5	S11	Tan-brown, fine-coarse SAND, trace Gravel, trace Silt (SW)	-23.0'
-25.0	33–37	10, 20, 31, 50/.4	S12	Tan-gray, fine-coarse SAND, trace Silt (SP)	TD = -27.0'

SR 00-15 — 596123

19.0' — 529338

ELEVATION	DEPTH	SAMPLE NUMBER	CLASSIFICATION OF MATERIALS (Description)	REMARKS (Drilling time, water loss, depth of weathering, etc. if significant)
	1–3	S1, S2	Brown, fine-medium SAND, little Silt and Clay, trace Gravel (SM)	Tr. Brick Fragments
15.0	3–8	S3, S4	Blue-gray Silty maccceous CLAY (CL)	16.0'
10.0	8–9	S5	Yellow-brown Silty CLAY, little Sand and Gravel (CL)	11.0'
	9–14	S6, S7	Yellow-brown fine SAND, trace-little Silt (SP-SM)	10.0'
5.0	14–23	S8, S9	Yellow-brown to gray fine SAND, little Silt and Clay (SM)	5.0'
0.0, -5.0, -10.0, -15.0	23–37	S10, S11, S12	Gray fine-medium SAND, trace-little Silt (SP)	-4.0'
				Running Sands no blows recorded
	37			TD = -18.0'

DEPTH	USCS	% G	% S	% F	LL	PL	PI	% H2O	SG
4-6'	CL		2	98	40	24	16	24.9	
24-26'	SM		85	15				14.5	2.59

B1		590806
8.0		527690

ELEVATION	DEPTH	CLASSIFICATION OF MATERIALS	REMARKS
8.0	0	Brown Silty SAND (SM)	Fill?
3.0	5	Gray Organic SILT (OL)	3.0
-7.0	15	Brown, Silty, Gravelly SAND (SW)	-7.0
-14.5	22.5	Gray, Silty CLAY (CL)	-14.5
-22.0	30	Gray, Silty SAND (SM)	-22.0
-30.8	38.8		TD = -30.8'

DEPTH	CASING BLOWS 12"	SS BLOWS 6"	SAMPLE NUMBER
1	10	8 / 9 / 12	1
2	23		
3	13		
4	13		
5	7		
6	2	2 / 3 / 7	2
7	10		
8	2		
9	4		
10	2	1 / 1 / 1	3
11	3		
12	2		
13	2		
14	3	2 / 2 / 3	4
15	3		
16	8		
17	8		
18	13		
19	21		
20	29	20 / 22 / 18	5
21	13		
22	30		
23	35		
24	52		
25	12	9 / 8 / 12	6
26	12		
27	13		
28	18		
29	19		
30	16		
31	30	11 / 12 / 14	7
32	32		
33	131		
34	135		
35	142		
36		22 / 36 / 55	8
39		50/4"	9

B2

590866

-1.8

527729

ELEVATION	DEPTH	CASING BLOWS 12"	SS BLOWS 6"	SAMPLE NUMBER	LEGEND	CLASSIFICATION OF MATERIALS	REMARKS
	1	1	P / P / P	1		Brown Organic SILT (OL)	
	2	P					
-5	3	P					
	4	P					
	5	1					
	6	1	1 / P / P	2			
	7	P					
-10	8	1					-9.8
	9	6				Brown SAND, some Silty Clay (SM).	
	10	16					
	11	20	2 / 5 / 12	3			
	12	15					
-15	13	17					
	14	26					
	15	43					
	16	9	15 / 19 / 8	4			
	17	14					-19.0
-20	18	12				Black, Clayey SILT (ML)	
	19	30					
	20	41					
	21	42	20 / 22 / 35	5			
	22	48					-24.0
-25	23	78				Brown, Silty SAND, trace Organic Silt (SM)	
	24	170					
	25	87					
	26		49 / 50/1	6			
	27						
-30	28						
	29						
	30						
	31		37 / 40 / 50/3	7			
	32						
-35	33						
	34						
	35						-36.8
	36		50/3	8		Gray Silty SAND (SM)	
	37						
-40	38						
	39						
	40		27 / 50/5	9			TD = -42.0'
	41						
	42						
	43						
	44						
	45						
	46						
	47						
	48						
	49						

B6A							590888
-17.0							527818
ELEVATION	DEPTH	CASING BLOWS 12"	SS BLOWS 6"	SAMPLE NUMBER	LEGEND	CLASSIFICATION OF MATERIALS	REMARKS
		D	P	1		Gray Silty CLAY (CL)	Root Hairs
	1	2	1 / 3				
	2	6					
-20	3	42					
	4	22	33 / 23 / 27	2			
	5	29					
	6	32					
	7	46					-24.5
-25	8	105				Gray, Silty, Clayey, SAND (SM)	
	9	230	50/4	3			
	10						
	11						
	12						
-30	13						
	14		50	4			
	15						
	16						
	17						
-35	18						
	19		50/3	5			
	20						
	21						
	22						
-40	23						
	24		55	6			
	25						
	26						
	27						
-45	28						
	29		72	7			
	30						
	31						
	32						
-50	33						
	34		35 / 50/3	8			
	35						
	36						
	37						
-55	38						
	39		55 / 87/3	9			TD = -57.3′
	40						
	41						
	42						
	43						
	44						
	45						
	46						
	47						
	48						
	49						

B12		590905
-17.0		527898

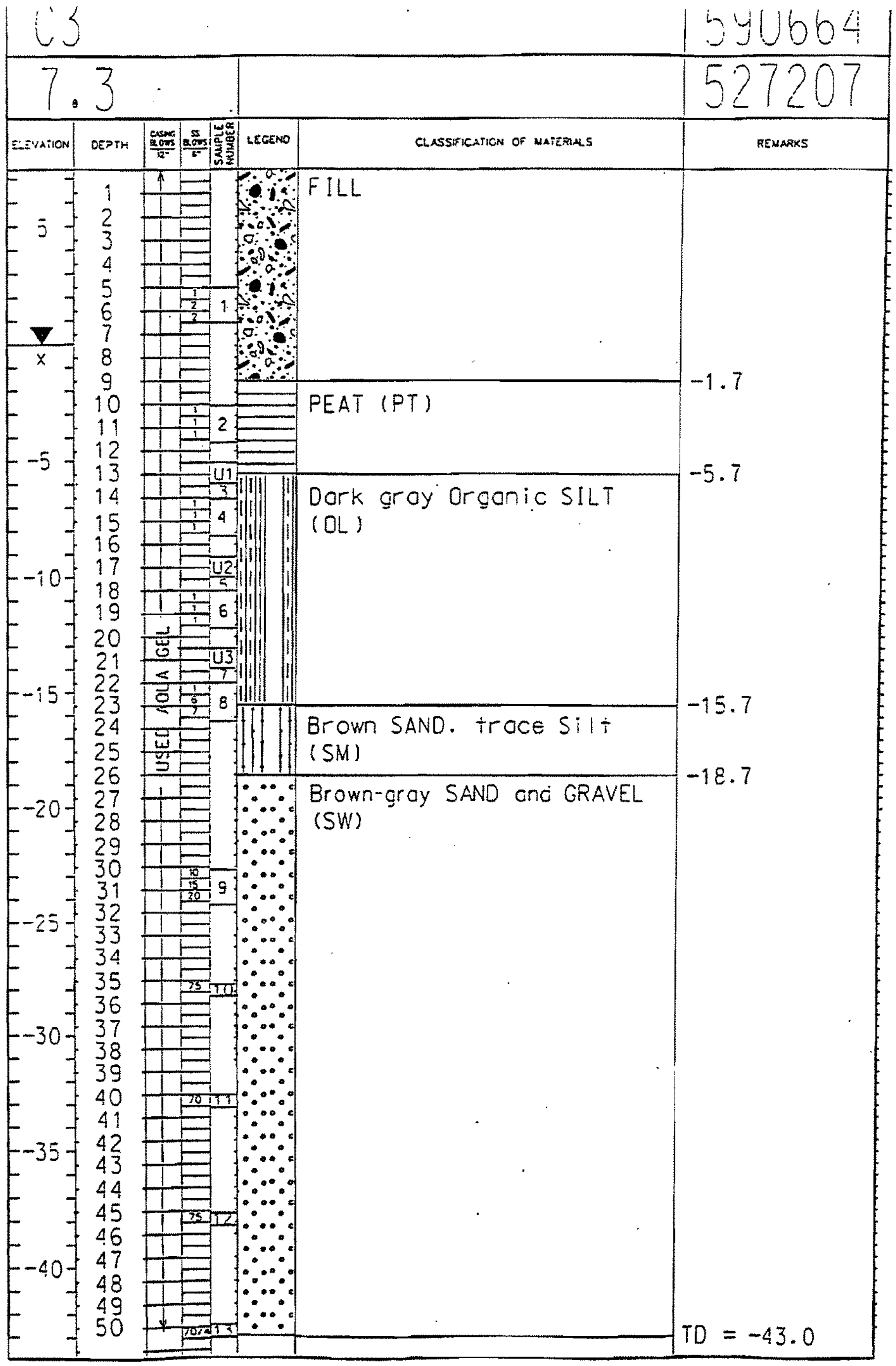
ELEVATION	DEPTH	CASING BLOWS 12"	SS BLOWS 6"	SAMPLE NUMBER	LEGEND	CLASSIFICATION OF MATERIALS	REMARKS
	1	2 / 2	1 / 3 / 4	1		Gray-brown SAND, some Silt (SM)	
	2	5					-19.5
-20	3	12				Black Organic SILT, trace to some Sand (ML)	
	4	15	10 / 14 / 20	2			
	5	20					
	6	30					
	7	40					
-25	8	40					
	9	40	10 / 26 / 56	3			
	10	60					
	11	130					
	12	350					
-30	13	200					
	14	310	31 / 50/4	4			
	15	50					-32.0
	16	110				Gray SAND, some Silt (SM)	
	17	170					
-35	18	150					
	19	290	30 / 39 / 60	5			
	20						
	21						
	22						
-40	23						
	24		38 / 54/3	6			
	25						
	26						
	27						
-45	28						
	29		38 / 50/3	7			
	30						
	31						
	32						
-50	33						
	34		50/4	8			
	35						
	36						
	37						
-55	38						
	39		58 / 50/2	9			
	40						TD = -57.2
	41						
	42						
	43						
	44						
	45						
	46						
	47						
	48						
	49						

C1	589854
3.8	526034

ELEVATION	DEPTH	CASING BLOWS 12"	SS BLOWS 6"	SAMPLE NUMBER	CLASSIFICATION OF MATERIALS	REMARKS
x		5			PEAT (PT)	
	1	3				
	2	2				
	3	2				
-0	4	2				
	5	3		1		
	6	2				
	7	3				
	8	2		2	Gray Organic SILT (OL)	-4.2
-5	9	3				
	10	WAHSED AHEAD		U1		Shelby Tube
	11					
	12			3		
	13					
-10	14			U2		Shelby Tube
	15					
	16			4		
	17					
	18			U3		
-15	19					Shelby Tube
	20		2	5	Brown SAND and GRAVEL (SW)	-15.8
	21		5			
	22					
	23	8				
-20	24	40				
	25	39	25 / 25 / 48	6		
	26	22				
	27	30				
	28	38				
-25	29	40				
	30	60	38 / 20 / 30	7		
	31	18				
	32	32			Brown Silty CLAY, some fine Sand (CL)	-28.2
	33	38				
-30	34	40				
	35	48	10 / 18 / 31	8		
	36	35				
	37	40				
	38	35				
-35	39	42				
	40	45	21 / 37 / 50/2	9		
	41	39				
	42	210			Gray SAND, some Gravel, trace Silty Clay (SM)	-38.2
	43	60				
-40	44	70				
	45	85	25 / 38 / 74	10		
	46	55				
	47	65				
	48	175				
-45	49	250				
	50	300/6	110	11		TD = -46.7

C2	590258
3.0	526616

ELEVATION	DEPTH	CASING BLOWS 12"	SS BLOWS 6"	SAMPLE NUMBER	CLASSIFICATION OF MATERIALS	REMARKS
▼ X	1	2			PEAT (PT)	
	2	2				
	3	1				
	4	2				
	5	1		1	Gray Clayey SILT. trace fine Sand (ML)	-2.0
	6	WASHED AHEAD		U1		
	7					Shelby Tube
-5	8					
	9			2		
	10					Shelby Tube
	11			U2		
	12				Gray SAND. some Silt (SM)	-9.0
-10	13		1/2/1/3	3		
	14	3				
	15	4				
	16	4				
	17	4				
-15	18	4			Brown fine SAND (SP)	-15.0
	19	5	10/7/15	4		
	20	2				
	21	9				
	22	13				
-20	23	13				
	24	30		5		
	25	11			White fine SAND. trace Clayey Silt (SM)	-22.5
	26	18				
	27	50				
-25	28	74				
	29	55	13/22/34	6		
	30	55				
	31	62				
	32	193				
-30	33	180				
	34	135	35/55/50/2	7		
	35	80				
	36	195				
	37	90				
-35	38	150				
	39	300	100/39	8		
	40	110				
	41	192				
	42	150				
-40	43	250				
	44	300	38/95	9		
	45	129				
	46	145				
	47	300				
-45	48	250				
	49	300	45/105	10		
	50					TD = -48.0'



C3
590664
7.3
527207
ELEVATION
DEPTH
CASING BLOWS 12"
SS BLOWS 6"
SAMPLE NUMBER
LEGEND
CLASSIFICATION OF MATERIALS
REMARKS
FILL
PEAT (PT)
-1.7
Dark gray Organic SILT (OL)
-5.7
Brown SAND, trace Silt (SM)
-15.7
Brown-gray SAND and GRAVEL (SW)
-18.7
USED VOLA GEL
TD = -43.0

C4 | 590757?

7.2 | 527405

ELEVATION | DEPTH | CASING BLOWS 12" | SS BLOWS 6" | SAMPLE NUMBER | LEGEND | CLASSIFICATION OF MATERIALS | REMARKS

Depth 0–7: Casing blows 12, 17, 15, 21, 20, 19, 18; Sample 1
Brown, fine SAND, some fine Gravel (SW)

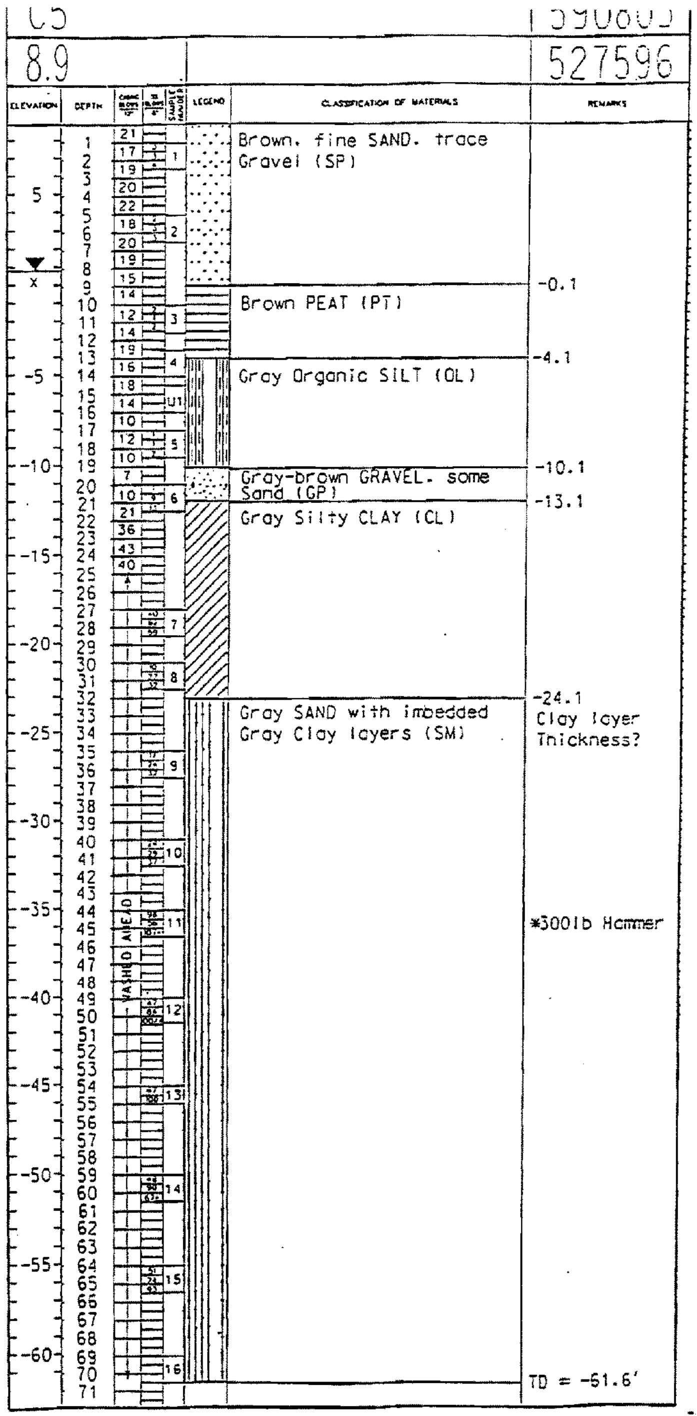
-0.3 Vegetation
Depth 7–20: Casing blows 10, then WASHED AHEAD; Samples U1, 2, U2, U3
Gray Organic SILT (OL)

-12.8
Depth 20–27: Casing blows 12, 18, 26, 30, 28, 19, 42; Samples 3, 4
Brown SAND, trace Silt and Gravel (SM)

-19.8 Clay layer Thickness?
Depth 27–46.5: Casing blows 47, 92, 250, 132, 344, 377, 465, 500, then WASHED AHEAD; Samples 5, 6, 7, 8
Gray SAND with imbedded Clay layers (SM)

TD = -39.3'

Elevation scale: 5, x, -5, -10, -15, -20, -25, -30, -35
Depth scale: 1–49


8.9
527596
ELEVATION
DEPTH
LEGEND
CLASSIFICATION OF MATERIALS
REMARKS
Brown, fine SAND, trace Gravel (SP)
-0.1
Brown PEAT (PT)
-4.1
Gray Organic SILT (OL)
-10.1
Gray-brown GRAVEL, some Sand (GP)
-13.1
Gray Silty CLAY (CL)
-24.1
Gray SAND with imbedded Gray Clay layers (SM)
Clay layer Thickness?
WASHED AHEAD
*300lb Hammer
TD = -61.6'

C6	590944
6.0	528140

Elevation	Depth	Casing Blows 12"	SS Blows 6"	Sample Number	Classification of Materials	Remarks
5	0–1	13			Brown, fine SAND, trace Silt and Gravel (SM)	
	1–2	24				
	2–3	25				
	3–4	33				
	4–5	32				
▼ x	5–6	35	4 / 6 / 5	1		
	6–7	37				
	7–8	42				
	8–9	43				
	9–10	39				
-5	10–11	48	4 / 4 / 5	2		
	11–12	43				
	12–13	43				
	13–14	44				
	14–15	41				
-10	15–16	50	5 / 10 / 11	3		
	16–17	64				
	17–18	61				
	18–19	65				
	19–20	72				
-15	20–21	63	6 / 6 / 11	4		
	21–22	79				
	22–23	97			Gray Clay with interbedded fine Sand layers (CL)	-16.0
	23–24	110				
	24–25	122				
-20	25–26	WASHED AHEAD	9 / 17 / 22	5		
-25	30–31		15 / 25 / 40	6		
	31.5				Gray, fine to medium SAND with Clay layers (SM)	-25.5'
-30	35–36		55 / 60 / 100/3	7		
-35	40–41		40 / 72 / 100/4	8		
-40	45–46		43 / 70 / 100/3	9		
	50		100/4	10		TD = -44.3'

R7 | 590479

5.3 | 526943

Elevation	Classification of Materials	Remarks
	Grey-black Organic SILT and SAND (OL)	Layered
		2.8
	Black Organic SILT and PEAT (OL)	
		-2.2
	Grey Organic SILT, trace to little Sand (OL)	
		-17.2
	Grey-black Silty CLAY (CL)	
		-37.2
	Black-brown Clayey SILT, some Sand, trace decomposed Wood (ML)	
		-42.2
	Gray SAND (SM)	
		TD = -49.5'

Depth	Casing Blows	Sample Number
1	4	1
2	11	
3	8	2
4	6	
5	6	
6	7	
7	5	
8	5	3
9	5	
10	5	
11	23	
12	12	
13	12	U1
14	11	
15	10	4
16	24	
17	19	
18	22	
19	27	
20	38	
21	41	5
22	35	
23	65	
24	77	
25	100	
26		6
31		7
36		8
41		9
48		10
54		11

HARDIN-KIGHT ASSOCIATES, INC.
CONSULTING ENGINEERS

November 21, 2000

Project No.: 00279

Chesapeake Geosystems, Inc.
6720 Ft. Smallwood Road
Baltimore, MD 21226

Attention: Mr. Kevin Huber

Reference: South River Flood Control
Laboratory Testing

Dear Mr. Huber:

Submitted herein are the results of the laboratory testing conducted on the samples recieved on 10/11/00, for the referenced project. The samples were tested for natural moisture content, liquid and plastic limits and grain size distribution, per the schedule of testing provided. Additionally, a consolidated-undrained with pore pressure compression test, and a consolidation test were preformed on the brown clay in the Shelby tube samples where possible. Enclosed are the grain size curves, consolidated-undrained with pore pressure compression curves and consolidation test curves.

If you have any questions concerning these results, please contact this office.

Very truly yours,

HARDIN-KIGHT ASSOCIATES, INC.

John G. Penn

00279tr.wpd

Triaxial Consolidated-Undrained with Pore Pressure
General Properties Data

Project: South River
Job #: 00279
Lab #: 000551
Identification: SR0014 8-10'
Description: Brown Clay

	Initial		Final Top		Final Bottom	
Tare #	149	Tare #	118, top1/3	Tare #	183, bot 1/3
Wet & Tare	177.52 g	Wet & Tare	246.80 g	Wet & Tare	283.56 g
Dry & Tare	141.26 g	Dry & Tare	195.71 g	Dry & Tare	222.05 g
Tare	52.99 g	Tare	52.40 g	Tare	52.58 g
Moisture	41.1%	Moisture	35.6%	Moisture	36.3%

Initail

Length		Diameter					
1	5.975 in	1	2.840 in	Wet Mass:	1099.91 g	Temperature:	20 °C
2	5.970 in	2	2.835 in	Dry Mass*:	789.63 g	S.G. of Water:	0.998 g/cc
3	5.975 in	3	2.820 in	Moisture Content*:	39.3%	S.G. of Solids:	2.68 g/cc
4	5.980 in	4	2.818 in				
Average	5.975 in	Average	2.828 in				

* Calculated from final moisture content

Area:	40.5 cm^2	Solids Volume:	294.6 cm^3	Void Ratio:	1.0877	Wet Density:	111.6 pcf
Total Volume:	615.1 cm^3	Pore Volume:	320.5 cm^3	Porosity:	52.1%	Dry Density:	80.1 pcf
				Saturation:	97.0%		

Final

Length		Diameter					
1	5.010 in	1, top	2.855 in	Wet Mass:	1073.68 g	Temperature:	20 °C
2	5.014 in	2, 1/3	3.109 in	Dry Mass*:	789.63 g	S.G. of Water:	0.998 g/cc
3	4.995 in	3, 1/2	3.108 in	Moisture Content:	36.0%	S.G. of Solids:	2.68 g/cc
4	4.995 in	4, 2/3	3.015 in				
Average	5.004 in	5, bottom	2.873 in				
		Average	2.992 in				

* Calculated from moisture content

Area:	45.4 cm^2	Solids Volume:	294.6 cm^3	Void Ratio:	0.9563	Wet Density:	116.3 pcf
Total Volume:	576.4 cm^3	Pore Volume:	281.8 cm^3	Porosity:	48.9%	Dry Density:	85.5 pcf
				Saturation:	101.0%		

HARDIN-KIGHT ASSOCIATES, INC.
7524 WB&A Road, Suite 100
Glen Burnie, Maryland

Phone: (410) 553-0802
Fax: (410) 553-0808
Email: HKAI@Erols.com

Shelby Tube Logs

Project: South River Flood Control
Job #: 00279

	Boring:	SR004
	Depth:	8.0'-10.0'
	Recovery:	19"
Top	0"-4"	Orange brown to black silty sand with gravel
	4"-17.5"	Black to brown silty clay with large organics(cattail stems) through
Tip	17.5"-19"	Yellow brown silty sand with gravel
Note:	Sample disturbed on extrusion, sample adheared to the sides of the tube.	

	Boring:	SR005
	Depth:	8.0'-10.0'
	Recovery:	18"
Top	0"-2"	Orange brown to green sandy clay
	2"-10"	Black to brown silty clay
Tip	10"-18"	Peat
Note:		

	Boring:	SR0014
	Depth:	8.0'-10.0'
	Recovery:	22"
Top	0"-11.5"	Brown Clay
	11.5"-14"	Brown Clay grading into peat
	14"-19"	Peat.
Tip	19"-22"	Peat grading into silty sand
Note:		

HARDIN-KIGHT ASSOCIATES, INC.
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Triaxial Consolidated-Undrained with Pore Pressure

General Properties Data

Project: South River
Job #: 00279
Lab #: 000551
Identification: SR0014 8-10'
Description: Brown Clay

	Initial		Final Top		Final Bottom	
Tare #	149	Tare #	118, top1/3	Tare #	183, bot 1/3
Wet & Tare	177.52 g	Wet & Tare	246.80 g	Wet & Tare	283.56 g
Dry & Tare	141.26 g	Dry & Tare	195.71 g	Dry & Tare	222.05 g
Tare	52.99 g	Tare	52.40 g	Tare	52.58 g
Moisture	41.1%	Moisture	35.6%	Moisture	36.3%

Initail

Length		Diameter					
1	5.975 in	1	2.840 in	Wet Mass:	1099.91 g	Temperature:	20 °C
2	5.970 in	2	2.835 in	Dry Mass*:	789.63 g	S.G. of Water:	0.998 g/cc
3	5.975 in	3	2.820 in	Moisture Content*:	39.3%	S.G. of Solids:	2.68 g/cc
4	5.980 in	4	2.818 in				
Average	5.975 in	Average	2.828 in				
Area:	40.5 cm^2	Solids Volume:	294.6 cm^3	Void Ratio:	1.0877	Wet Density:	111.6 pcf
Total Volume:	615.1 cm^3	Pore Volume:	320.5 cm^3	Porosity:	52.1%	Dry Density:	80.1 pcf
				Saturation:	97.0%		

* Calculated from final moisture content

Final

Length		Diameter					
1	5.010 in	1, top	2.855 in	Wet Mass:	1073.68 g	Temperature:	20 °C
2	5.014 in	2, 1/3	3.109 in	Dry Mass*:	789.63 g	S.G. of Water:	0.998 g/cc
3	4.995 in	3, 1/2	3.108 in	Moisture Content:	36.0%	S.G. of Solids:	2.68 g/cc
4	4.995 in	4, 2/3	3.015 in				
Average	5.004 in	5, bottom	2.873 in				
		Average	2.992 in				
Area:	45.4 cm^2	Solids Volume:	294.6 cm^3	Void Ratio:	0.9563	Wet Density:	116.3 pcf
Total Volume:	576.4 cm^3	Pore Volume:	281.8 cm^3	Porosity:	48.9%	Dry Density:	85.5 pcf
				Saturation:	101.0%		

* Calculated from moisture content

HARDIN-KIGHT ASSOCIATES, INC.
7524 WB&A Road, Suite 100
Glen Burnie, Maryland

Phone: (410) 553-0802
Fax: (410) 553-0808
Email: HKAI@Ercls.com

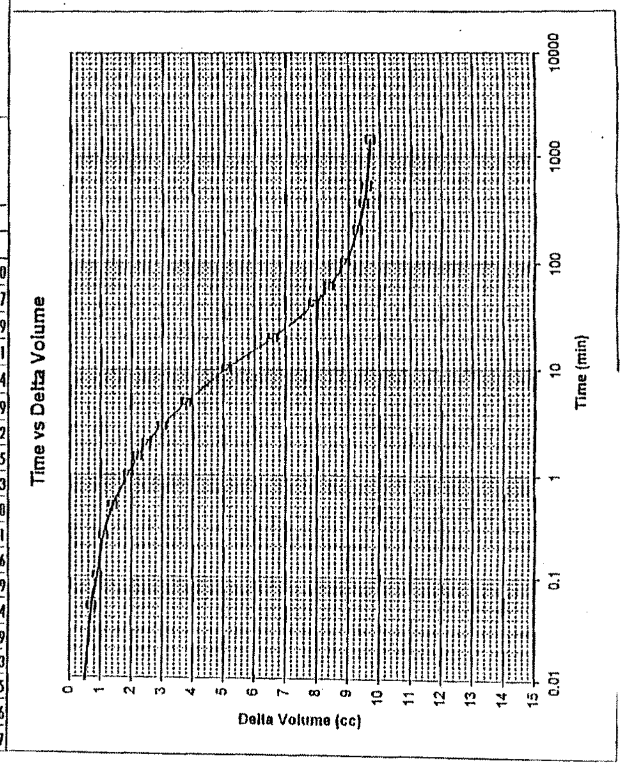
Triaxial Consolidated-Undrained with Pore Pressure

Consolidation Data

Project: South River
Job #: 00279
Lab #: 000551
Identification: SR0014 8-10'

Initial Length:	15.18 cm	Final Consol Δ Len	0.0179 cm
Initial Area	40.53 cm^2	Final Δ Vol	9.7 cm^3
Initial Vol	615.13 cm^3		

Date	Time	D time	v1	v2	d vol
11/13/00	8:10:00	0.0001	42	42	0
11/13/00	8:10:03	0.05	41.3	42	0.7
11/13/00	8:10:06	0.10	41.1	42	0.9
11/13/00	8:10:15	0.25	40.9	42	1.1
11/13/00	8:10:30	0.50	40.6	42	1.4
11/13/00	8:11:00	1.00	40.1	42	1.9
11/13/00	8:11:30	1.50	39.8	42	2.2
11/13/00	8:12:00	2.00	39.5	42	2.5
11/13/00	8:13:00	3.00	39	42	3
11/13/00	8:15:00	5.00	38.2	42	3.8
11/13/00	8:20:00	10.00	36.9	42	5.1
11/13/00	8:30:00	20.00	35.4	42	6.6
11/13/00	8:50:00	40.00	34.1	42	7.9
11/13/00	9:10:00	60.00	33.6	42	8.4
11/13/00	9:50:00	100.00	33.1	42	8.9
11/13/00	11:30:00	200.00	32.7	42	9.3
11/13/00	14:10:00	360.00	32.5	42	9.5
11/13/00	16:50:00	520.00	32.4	42	9.6
11/14/00	8:13:00	1443.00	32.3	42	9.7



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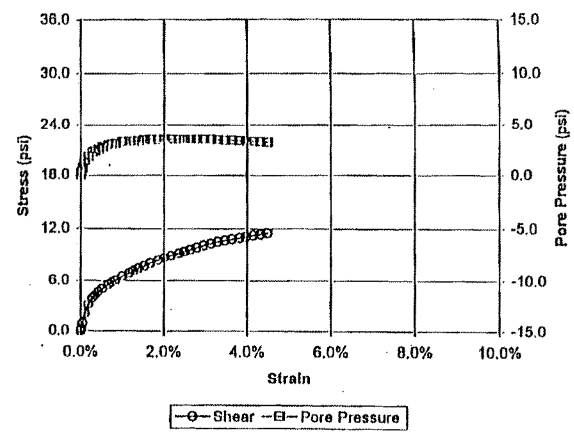
Triaxial Consolidated-Undrained with Pore Pressure

Stress Strain Data

Project: South River
Job #: 00279
Lab #: 000551
Identification: SR0014 8-10'

Initial Length:	15.18 cm		Final Consol Δ Len	0.106 cm
Initial Area	40.53 cm²		Final Δ Vol	9.7 cm³
Initial Vol	615.13 cm³			
			Initial Shear Vol	605.427 cm³
Target Shear Failure	4%		Initial Shear Len	15.071 cm
t_{50}	35.5	min		5.933 in
Target Shear Rate	0.0006685	in/min	Initial Shear Area	40.173 cm²
t_f	5.92	hr		6.227 in²
			$\sigma_{ch\,total}$:	57.0 psi
Ring Constant	0.739	lb/unit	$\sigma_{back\,pressure}$:	50.0 psi
Shear Rate:	0.0008	in/min	σ_{ch}:	7.0 psi



Shear	Ring	Pore Pressure	Length	ε	Area	Load	σ_1-σ_3	u	σ_3	σ_1	φ	0
in	units	psi	in		in²	lb	psi	psi	psi	psi		
0.000	0.0	50.0	5.933	0.0%	6.227	0.00	0.000	0.0	7.0	7.0	0.0	45.0
0.001	2.6	50.3	5.932	0.0%	6.228	1.92	0.309	0.3	6.7	7.0	1.3	45.6
0.003	8.0	50.7	5.930	0.1%	6.230	5.91	0.949	0.7	6.3	7.2	4.0	47.0
0.006	17.5	51.3	5.927	0.1%	6.233	12.93	2.075	1.3	5.7	7.8	8.9	49.4
0.011	26.5	51.8	5.922	0.2%	6.238	19.58	3.139	1.8	5.3	8.4	13.3	51.7
0.017	33.2	52.2	5.916	0.3%	6.245	24.53	3.929	2.2	4.8	8.7	16.9	53.4

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Glen Burnie, Maryland 21061

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Triaxial Consolidated-Undrained with Pore Pressure

Stress Strain Data

Shear	Ring	Pore Pressure	Length	ε	Area	Load	σ_1-σ_3	u	σ_3	σ_1	ϕ	0
in	units	psi	in		in^2	lb	psi	psi	psi	psi		
0.021	36.0	52.3	5.912	0.4%	6.249	26.60	4.257	2.3	4.7	9.0	18.2	54.1
0.026	39.5	52.5	5.907	0.4%	6.254	29.19	4.667	2.5	4.5	9.2	20.0	55.0
0.031	42.5	52.7	5.902	0.5%	6.260	31.41	5.0	2.7	4.3	9.3	21.6	55.8
0.040	46.8	52.9	5.893	0.7%	6.269	34.59	5.5	2.9	4.1	9.6	23.7	56.9
0.045	49.1	53.0	5.888	0.8%	6.274	36.28	5.8	3.0	4.0	9.8	24.8	57.4
0.050	51.2	53.1	5.883	0.8%	6.280	37.84	6.0	3.1	4.0	10.0	25.6	57.8
0.060	55.5	53.3	5.873	1.0%	6.290	41.01	6.5	3.3	3.8	10.3	27.7	58.9
0.070	58.8	53.3	5.863	1.2%	6.301	43.45	6.9	3.3	3.7	10.6	28.8	59.4
0.076	61.0	53.3	5.857	1.3%	6.308	45.08	7.1	3.3	3.7	10.8	29.4	59.7
0.083	63.5	53.4	5.850	1.4%	6.315	46.93	7.4	3.4	3.7	11.1	30.3	60.1
0.091	66.0	53.5	5.842	1.5%	6.324	48.77	7.7	3.5	3.6	11.3	31.4	60.7
0.100	68.8	53.5	5.833	1.7%	6.334	50.84	8.0	3.5	3.5	11.5	32.3	61.1
0.111	72.0	53.5	5.822	1.9%	6.346	53.21	8.4	3.5	3.6	11.9	32.8	61.4
0.120	74.8	53.6	5.813	2.0%	6.355	55.28	8.7	3.6	3.5	12.1	33.9	61.9
0.129	76.8	53.5	5.804	2.2%	6.365	56.76	8.9	3.5	3.5	12.4	34.1	62.0
0.141	79.5	53.5	5.792	2.4%	6.378	58.75	9.2	3.5	3.5	12.7	34.6	62.3
0.148	81.2	53.5	5.785	2.5%	6.386	60.01	9.4	3.5	3.5	12.9	35.0	62.5
0.157	83.5	53.5	5.776	2.6%	6.396	61.71	9.6	3.5	3.5	13.1	35.4	62.7
0.166	85.5	53.5	5.767	2.8%	6.406	63.18	9.9	3.5	3.5	13.4	35.8	62.9
0.176	87.9	53.5	5.757	3.0%	6.417	64.96	10.1	3.5	3.5	13.6	36.2	63.1

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Triaxial Consolidated-Undrained with Pore Pressure
Stress Strain Data

Shear in	Ring units	Pore Pressure psi	Length in	ε	Area in^2	Load lb	σ_1-σ_3 psi	u psi	σ_3 psi	σ_1 psi	ϕ	θ
0.186	89.9	53.5	5.747	3.1%	6.428	66.44	10.3	3.5	3.5	13.8	36.6	63.3
0.196	91.5	53.5	5.737	3.3%	6.440	67.62	10.5	3.5	3.6	14.1	36.6	63.3
0.206	93.0	53.4	5.727	3.5%	6.451	68.73	10.7	3.4	3.7	14.3	36.4	63.2
0.216	94.5	53.4	5.717	3.6%	6.462	69.84	10.8	3.4	3.6	14.4	36.9	63.4
0.227	96.0	53.4	5.706	3.8%	6.475	70.94	11.0	3.4	3.7	14.6	36.9	63.4
0.236	97.2	53.3	5.697	4.0%	6.485	71.83	11.1	3.3	3.7	14.8	36.8	63.4
0.246	98.8	53.3	5.687	4.1%	6.496	73.01	11.2	3.3	3.7	14.9	37.1	63.5
0.256	100.0	53.3	5.677	4.3%	6.500	73.90	11.4	3.3	3.8	15.1	37.0	63.5
0.266	101.5	53.2	5.667	4.5%	6.519	75.01	11.5	3.2	3.8	15.3	37.0	63.5

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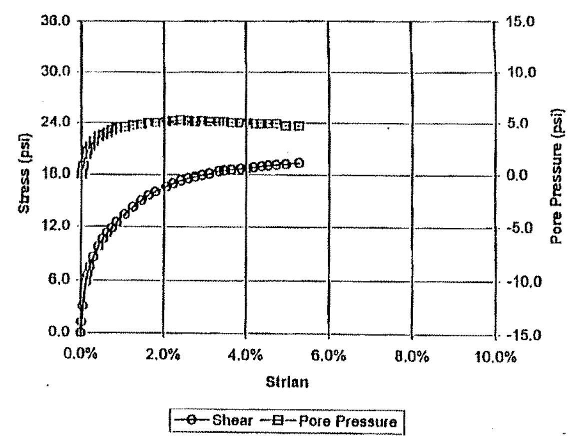
Triaxial Consolidated-Undrained with Pore Pressure

Stress Strain Data

Project: South River
Job #: 00279
Lab #: 000551
Identification: SR0014 8-10'

Initial Length:	15.10 cm		Final Consol Δ Len	0.006 cm
Initial Area	40.53 cm^2		Final Δ Vol	10.8 cm^3
Initial Vol	615.13 cm^3			
			Initial Shear Vol	596.327 cm^3
Target Shear Failure			Initial Shear Len	14.291 cm
t_{50}		min		5.626 in
Target Shear Rate		in/min	Initial Shear Area	41.727 cm^2
t_f		hr		6.468 in^2
			$\sigma_{ch\,total}$:	62.0 psi
Ring Constant	0.739	lb/unit	$\sigma_{back\,pressure}$:	50.0 psi
Shear Rate:	0.0008	in/min	σ_{ch}:	12.0 psi



Shear	Ring	Pore Pressure	Length	ε	Area	Load	σ_1-σ_3	u	σ_3	σ_1	φ	0
in	units	psi	in		in^2	lb	psi	psi	psi	psi		
0.000	0.0	50.0	5.626	0.0%	6.460	0.00	0.000	0.0	12.0	12.0	0.0	45.0
0.001	11.0	50.0	5.625	0.0%	6.469	8.13	1.257	0.0	12.0	13.3	2.9	46.4
0.003	27.0	50.7	5.623	0.1%	6.471	19.95	3.083	0.7	11.3	14.4	6.9	48.4
0.007	50.0	51.8	5.619	0.1%	6.476	36.95	5.706	1.8	10.2	15.9	12.6	51.3
0.009	57.5	52.2	5.617	0.2%	6.478	42.49	6.559	2.2	9.8	16.4	14.5	52.3
0.012	65.0	52.6	5.614	0.2%	6.482	48.04	7.411	2.6	9.4	16.8	16.4	53.2
0.017	74.5	53.1	5.609	0.3%	6.487	55.06	8.487	3.1	8.9	17.4	18.8	54.4

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Triaxial Consolidated-Undrained with Pore Pressure

Stress Strain Data

Shear	Ring	Pore Pressure	Length	ε	Area	Load	σ_1-σ_3	u	σ_3	σ_1	φ	0
in	units	psi	in		in^2	lb	psi	psi	psi	psi		
0.024	85.0	53.6	5.602	0.4%	6.495	62.82	9.671	3.6	8.4	18.1	21.4	55.7
0.030	92.8	53.8	5.596	0.5%	6.502	68.58	10.5	3.8	8.2	18.7	23.0	56.5
0.036	99.0	54.0	5.590	0.6%	6.509	73.16	11.2	4.0	8.0	19.2	24.4	57.2
0.042	104.2	54.3	5.584	0.7%	6.516	77.00	11.8	4.3	7.8	19.6	25.6	57.8
0.049	110.2	54.4	5.577	0.9%	6.525	81.44	12.5	4.4	7.6	20.1	26.8	58.4
0.060	118.2	54.6	5.566	1.1%	6.537	87.35	13.4	4.6	7.5	20.8	28.2	59.1
0.071	125.8	54.8	5.555	1.3%	6.550	92.97	14.2	4.8	7.3	21.4	29.6	59.8
0.082	133.0	54.8	5.544	1.5%	6.563	98.29	15.0	4.8	7.2	22.2	30.6	60.3
0.092	138.8	55.0	5.534	1.6%	6.575	102.57	15.6	5.0	7.0	22.6	31.8	60.9
0.101	142.5	55.0	5.525	1.8%	6.586	105.31	16.0	5.0	7.0	23.0	32.2	61.1
0.116	148.5	55.1	5.510	2.1%	6.604	109.74	16.6	5.1	6.9	23.5	33.1	61.6
0.125	151.8	55.2	5.501	2.2%	6.615	112.18	17.0	5.2	6.8	23.8	33.7	61.9
0.136	155.0	55.3	5.490	2.4%	6.628	114.55	17.3	5.3	6.7	24.0	34.3	62.1
0.146	157.5	55.2	5.480	2.6%	6.640	116.39	17.5	5.2	6.8	24.3	34.3	62.1
0.155	159.5	55.1	5.471	2.8%	6.651	117.87	17.7	5.1	6.9	24.6	34.2	62.1
0.165	161.5	55.2	5.461	2.9%	6.663	119.35	17.9	5.2	6.8	24.7	34.6	62.3
0.175	163.2	55.1	5.451	3.1%	6.675	120.60	18.1	5.1	6.9	25.0	34.5	62.3
0.188	165.8	55.1	5.438	3.3%	6.691	122.53	18.3	5.1	6.9	25.2	34.8	62.4
0.195	166.8	55.1	5.431	3.5%	6.700	123.27	18.4	5.1	6.9	25.3	34.8	62.4
0.205	168.0	55.0	5.421	3.6%	6.712	124.15	18.5	5.0	7.0	25.5	34.7	62.3

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Triaxial Consolidated-Undrained with Pore Pressure

Stress Strain Data

Shear	Ring	Pore Pressure	Length	ε	Area	Load	σ_1-σ_3	u	σ_3	σ_1	ϕ	0
in	units	psi	in		in^2	lb	psi	psi	psi	psi		
0.218	169.5	55.0	5.408	3.9%	6.728	125.26	18.6	5.0	7.0	25.6	34.8	62.4
0.227	170.2	55.0	5.399	4.0%	6.740	125.78	18.7	5.0	7.0	25.7	34.8	62.4
0.235	171.5	54.9	5.391	4.2%	6.750	126.74	18.8	4.9	7.1	25.9	34.7	62.4
0.246	172.8	54.9	5.380	4.4%	6.763	127.70	18.9	4.9	7.1	26.0	34.8	62.4
0.255	173.8	54.9	5.371	4.5%	6.775	128.44	19.0	4.9	7.1	26.1	34.9	62.4
0.266	175.0	54.9	5.360	4.7%	6.789	129.33	19.0	4.9	7.1	26.1	35.0	62.5
0.279	176.2	54.7	5.347	5.0%	6.805	130.21	19.1	4.7	7.3	26.4	34.6	62.3
0.297	178.0	54.7	5.329	5.3%	6.828	131.54	19.26	4.7	7.3	26.6	34.7	62.3

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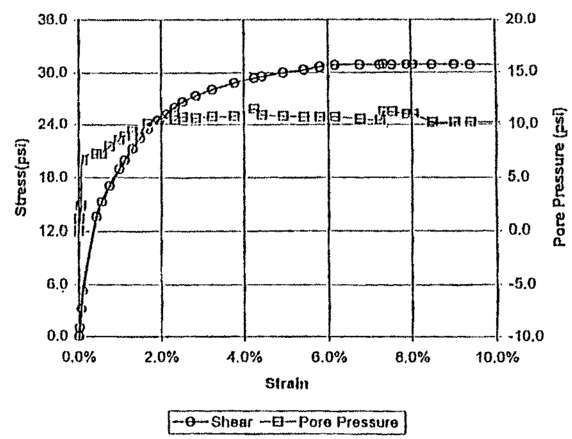
Triaxial Consolidated-Undrained with Pore Pressure

Stress Strain Data

Project: South River
Job #: 00279
Lab #: 000551
Identification: SR0014 8-10'

Initial Length:	15.18 cm		Final Consol Δ Len	1.665 cm
Initial Area	40.53 cm^2		Final Δ Vol	62.4 cm^3
Initial Vol	615.13 cm^3			
			Initial Shear Vol	552.746 cm^3
Target Shear Failure			Initial Shear Len	13.512 cm
t_{50}		min		5.319 in
Target Shear Rate		in/min	Initial Shear Area	40.909 cm^2
t_f		hr		6.341 in^2
			$\sigma_{ch\,total}$:	72.0 psi
Ring Constant	0.739	lb/unit	$\sigma_{back\,pressure}$:	50.0 psi
Shear Rate:	0.0008	in/min	σ_{ch}:	22.0 psi



Shear	Ring	Pore Pressure	Length	ε	Area	Load	σ_1-σ_3	u	σ_3	σ_1	φ	θ
in	units	psi	in		in^2	lb	psi	psi	psi	psi		
0.000	0.0	50.0	5.319	0.0%	6.341	0.00	0.000	0.0	22.0	22.0	0.0	45.0
0.001	8.8	51.1	5.318	0.0%	6.342	6.50	1.025	1.1	20.9	21.9	1.4	45.7
0.003	27.2	52.3	5.316	0.1%	6.345	20.10	3.160	2.3	19.7	22.9	4.3	47.1
0.005	45.2	56.6	5.314	0.1%	6.347	33.40	5.263	6.6	15.4	20.7	8.4	49.2
0.023	116.5	57.2	5.296	0.4%	6.360	86.09	13.519	7.2	14.8	28.3	10.3	54.1
0.030	130.8	57.2	5.289	0.6%	6.377	96.66	15.158	7.2	14.8	30.0	19.8	54.9

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Triaxial Consolidated-Undrained with Pore Pressure

Stress Strain Data

Shear	Ring	Pore Pressure	Length	ε	Area	Load	σ_1-σ_3	u	σ_3	σ_1	φ	θ
in	units	psi	in		in²	lb	psi	psi	psi	psi		
0.040	147.0	57.9	5.279	0.8%	6.389	108.63	17.003	7.9	14.1	31.1	22.1	56.0
0.053	164.0	58.5	5.266	1.0%	6.405	121.20	18.923	8.5	13.5	32.4	24.3	57.2
0.060	172.8	58.9	5.259	1.1%	6.413	127.70	19.9	8.9	13.2	33.1	25.5	57.8
0.070	184.5	59.3	5.249	1.3%	6.426	136.35	21.2	9.3	12.7	33.9	27.1	58.5
0.080	195.0	59.1	5.239	1.5%	6.438	144.11	22.4	9.1	12.9	35.3	27.7	58.8
0.090	204.5	60.1	5.229	1.7%	6.450	151.13	23.4	10.1	11.9	35.3	29.7	59.9
0.103	214.2	60.2	5.216	1.9%	6.466	158.29	24.5	10.2	11.8	36.3	30.6	60.3
0.114	221.0	60.4	5.205	2.1%	6.480	163.32	25.2	10.4	11.6	36.8	31.4	60.7
0.125	228.2	60.4	5.194	2.3%	6.494	168.64	26.0	10.4	11.6	37.6	31.9	60.9
0.135	234.0	60.7	5.184	2.5%	6.506	172.93	26.6	10.7	11.3	37.9	32.7	61.4
0.152	241.2	60.6	5.167	2.9%	6.527	178.25	27.3	10.6	11.4	38.7	33.0	61.5
0.173	248.8	60.8	5.146	3.3%	6.554	183.86	28.1	10.8	11.3	39.3	33.7	61.9
0.201	256.8	60.8	5.118	3.8%	6.590	189.78	28.8	10.8	11.2	40.0	34.2	62.1
0.226	263.0	61.5	5.093	4.2%	6.622	194.36	29.3	11.5	10.5	39.8	35.7	62.0
0.236	265.0	60.9	5.083	4.4%	6.635	195.84	29.5	10.9	11.1	40.6	34.8	62.4
0.263	270.2	60.8	5.056	4.9%	6.671	199.68	29.9	10.8	11.2	41.1	34.9	62.4
0.289	274.5	60.7	5.030	5.4%	6.705	202.86	30.3	10.7	11.3	41.6	34.9	62.5
0.309	278.5	60.7	5.010	5.8%	6.732	205.81	30.6	10.7	11.3	41.9	35.1	62.5
0.320	281.5	60.7	4.991	6.2%	6.758	208.03	30.78	10.7	11.3	42.1	35.2	62.6
0.360	283.5	60.5	4.959	6.8%	6.801	209.51	30.80	10.5	11.5	42.3	34.9	62.5

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000551cupp.xls

Triaxial Consolidated-Undrained with Pore Pressure

Stress Strain Data

Shear	Ring	Pore Pressure	Length	ε	Area	Load	σ_1-σ_3	u	σ_3	σ_1	ϕ	θ
in	units	psi	in		in²	lb	psi	psi	psi	psi		
0.385	285.0	60.4	4.934	7.2%	6.836	210.62	30.81	10.4	11.6	42.4	34.8	62.4
0.390	286.0	61.2	4.929	7.3%	6.843	211.35	30.89	11.2	10.8	41.7	36.0	63.0
0.401	286.0	61.2	4.910	7.5%	6.850	211.35	30.82	11.2	10.8	41.6	36.0	63.0
0.420	287.5	61.0	4.899	7.9%	6.885	212.46	30.86	11.0	11.0	41.9	35.7	62.9
0.428	288.0	61.0	4.891	8.0%	6.896	212.83	30.86	11.0	11.0	41.9	35.7	62.9
0.452	289.5	60.2	4.867	8.5%	6.930	213.94	30.87	10.2	11.8	42.7	34.5	62.3
0.480	291.0	60.2	4.839	9.0%	6.970	215.05	30.85	10.2	11.8	42.7	34.5	62.3
0.500	292.0	60.2	4.819	9.4%	6.999	215.79	30.83	10.2	11.8	42.6	34.5	62.3
0.535	294.0	60.2	4.784	10.1%	7.050	217.27	30.82	10.2	11.8	42.6	34.5	62.2

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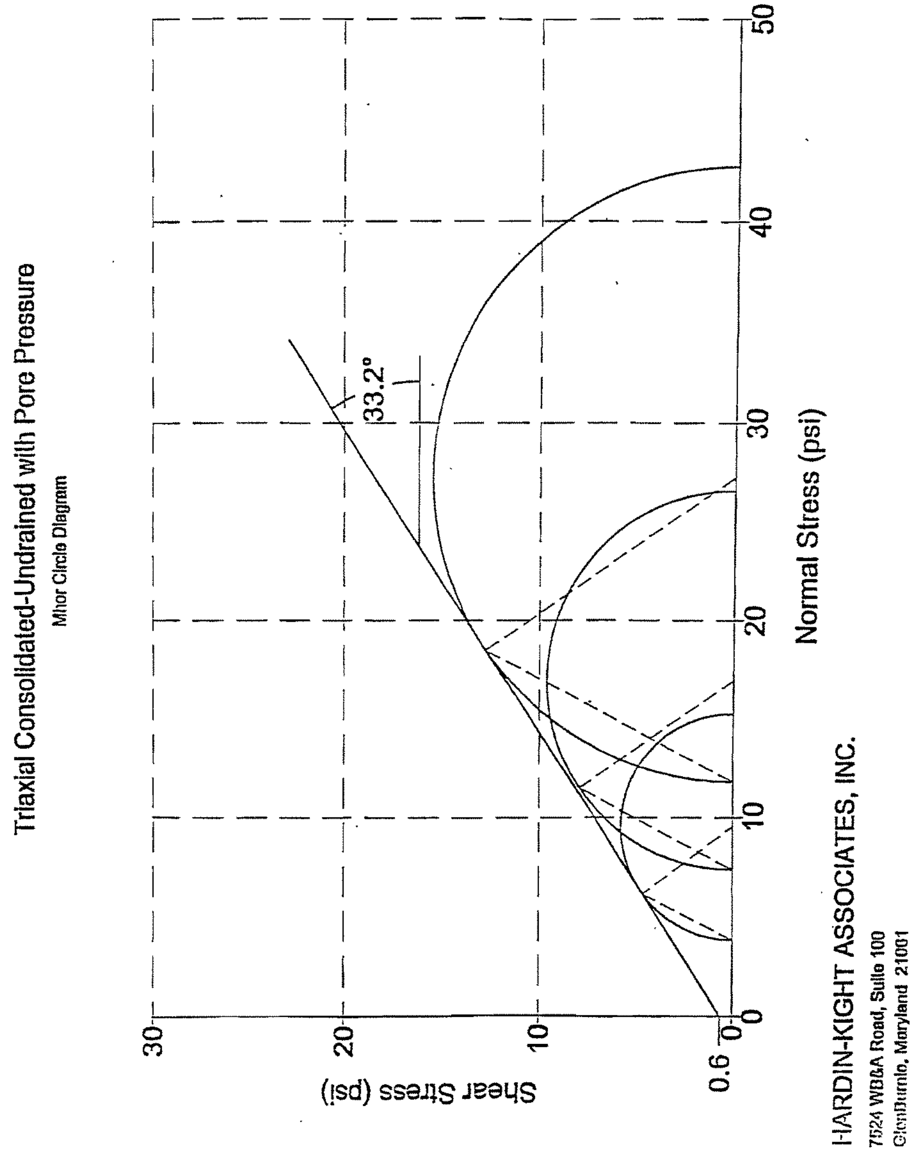


Triaxial Consolidated-Undrained with Pore Pressure
Mhor Circle Diagram
Shear Stress (psi)
30
20
10
0.6
0
Normal Stress (psi)
0
10
20
30
40
50
33.2°
HARDIN-KIGHT ASSOCIATES, INC.
7524 WB&A Road, Suite 100
GlenBurnie, Maryland 21061

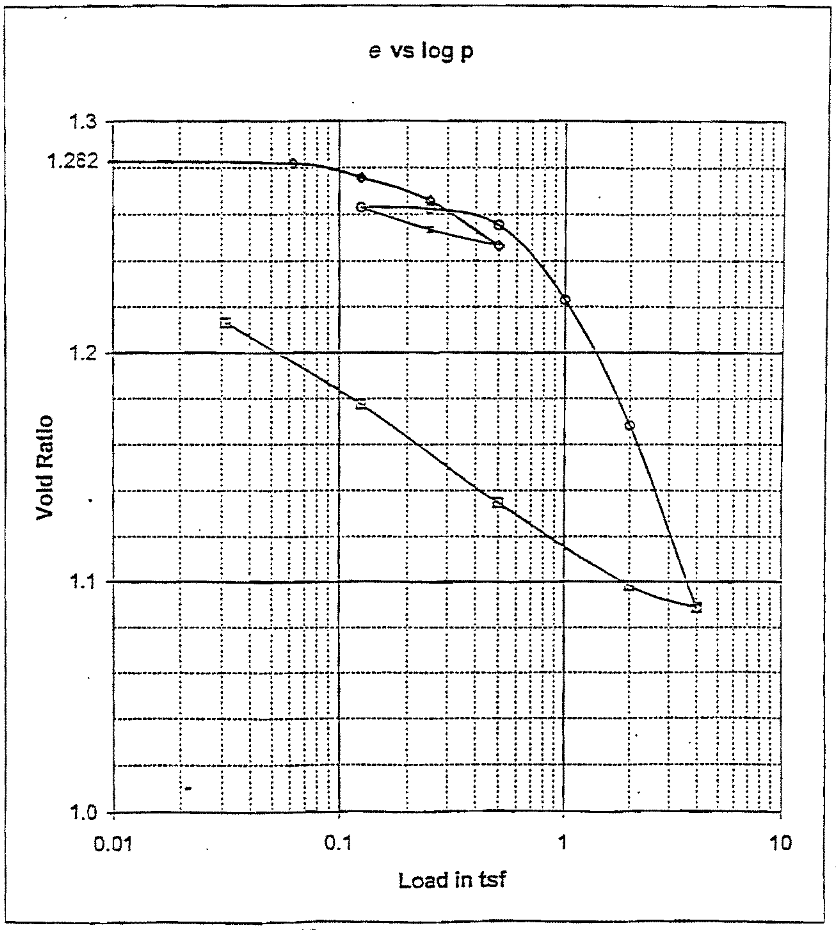
CONSOLIDATION

Project: South River Flood Control
Job #: 00279
Lab #: 000551
Sample Location: SR0014, 9'
Sample Description: Brown Silty Clay

Specific Gravity 2.68
Moisture Content 39.3%
Sample Dia 2.500"
Initial Sample Len 1.000"

Unit Wt. Wet 102.1 pcf
Unit Wt. Dry 73.3 pcf
Initial Void Ratio 1.28

Preconsolidation Pressure:



HARDIN-KIGHT ASSOCIATES, INC.
7524 WB&A Road, Suite 100
Glen Burnie, Maryland 21061

Phone: 410 553-0802
Fax: 410 553-0808
Emial: HKAI@Erols.com

CONSOLIDATION

Project: South River Flood Control
Job #: 00279
Lab #: 000551
Sample Location: SR0014, 9'
Sample Description: Brown Silty Clay

Specific Gravity	2.68
Wet Wt of Sample	131.52
Dry Wt of Sample	94.41
Moisture Content	39.3%

Sample Dia	2.500	Unit Wt. Wet	102.1 pcf
Sample Len	1.000	Unit Wt. Dry	73.3 pcf
Sample Vol	4.908739 ci 0.002841 cf	ei	1.282

Load tsf	d_{100} inches	Sum d_{100} inches	Sample Length inches	Sample Vol cu.ft.	e	t_{100} min
0	0.0000	0.0000	1.0000	0.00284	1.282	
1/16	0.0003	0.0003	0.9997	0.00284	1.282	80
1/8	0.0027	0.0030	0.9970	0.00283	1.276	20
1/4	0.0043	0.0073	0.9927	0.00282	1.266	35
1/2	0.0085	0.0158	0.9842	0.00280	1.246	81
Rebound						
1/2	0.0000	0.0158	0.9842	0.00280	1.246	
1/4	-0.0031	0.0127	0.9873	0.00280	1.253	
1/8	-0.0042	0.0085	0.9915	0.00282	1.263	
Reload						
1/8	0.0000	0.0085	0.9915	0.00282	1.263	
1/4	0.0003	0.0088	0.9912	0.00282	1.262	22
1/2	0.0030	0.0118	0.9882	0.00281	1.255	31
1	0.0142	0.0260	0.9740	0.00277	1.223	105
2	0.0240	0.0500	0.9500	0.00270	1.168	110
4	0.0350	0.0850	0.9150	0.00260	1.088	105
Rebound						
4	0.0000	0.0850	0.9150	0.00260	1.088	
2	-0.0043	0.0807	0.9193	0.00261	1.098	
1/2	-0.0159	0.0648	0.9352	0.00266	1.135	
1/8	-0.0188	0.0460	0.9540	0.00271	1.177	
1/32	-0.0156	0.0304	0.9696	0.00275	1.213	

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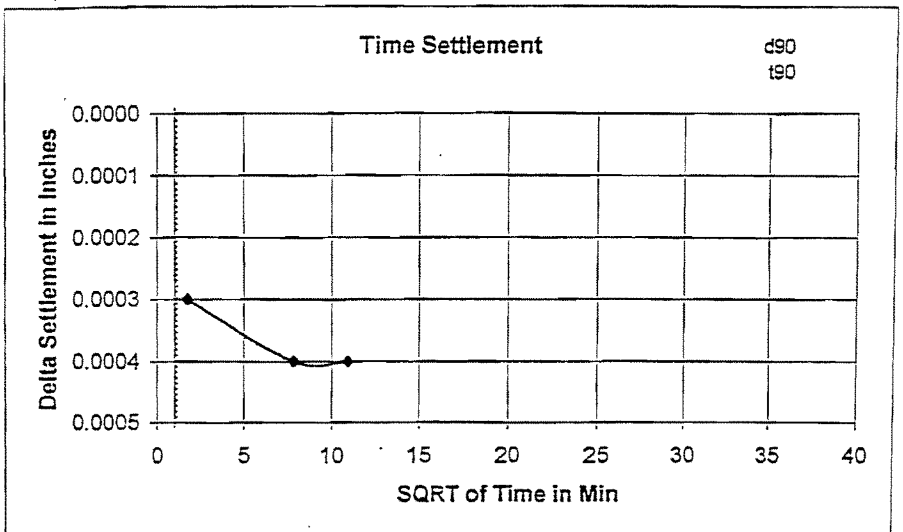
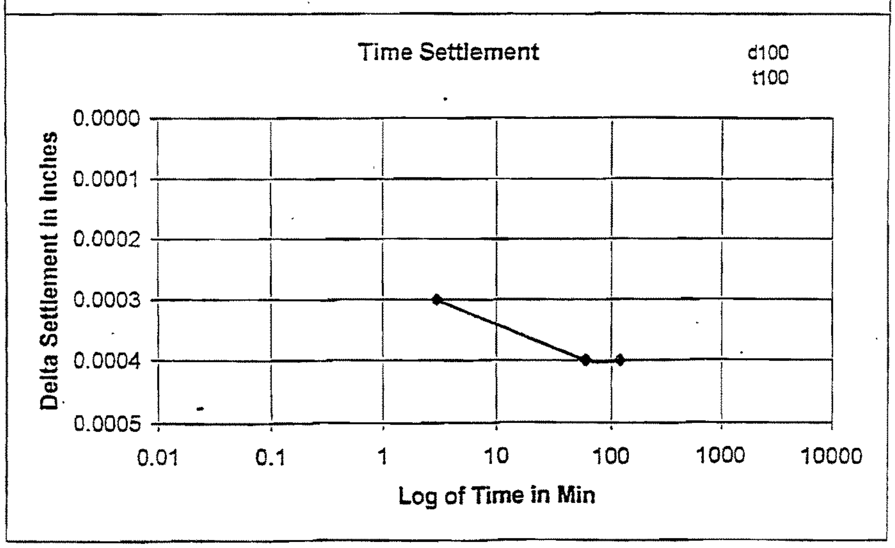
7524 WB&A Road, Suite 100
Glen Burnie, Maryland 21061

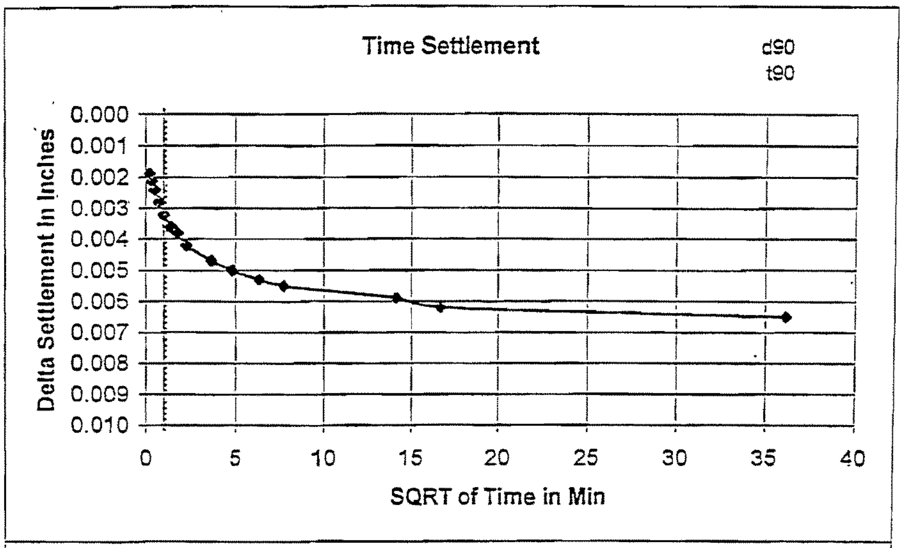
Phone: 410 553-0802
Fax: 410 553-0808
Emial: HKAI@Erols.com

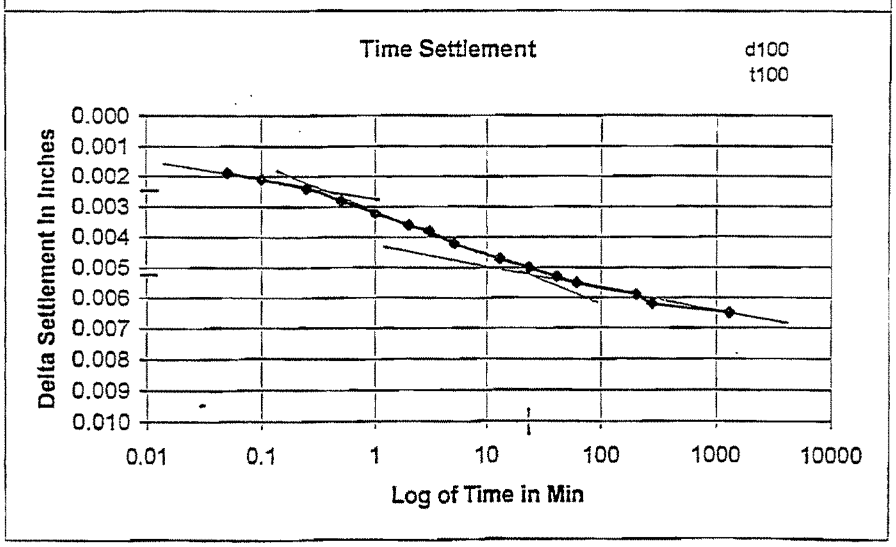
Project: South River Flood Control
Job #: 00279
Lab #: 000551
Sample Location: SR0014, 9'
Sample Description: Brown Silty Clay
Load: 1/16 tsf



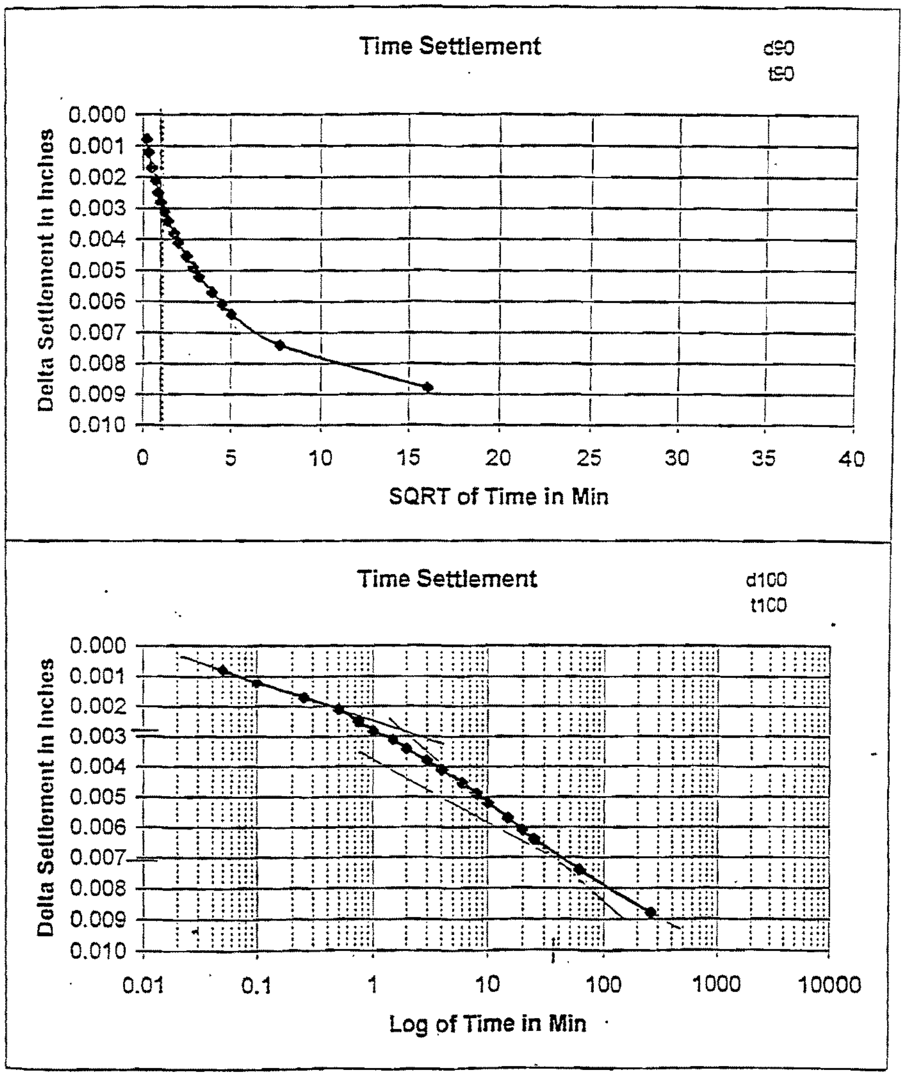


Project: South River Flood Control
Job #: 00279
Lab #: 000551
Sample Location: SR0014, 9'
Sample Description: Brown Silty Clay
Load: 1/8 tsf

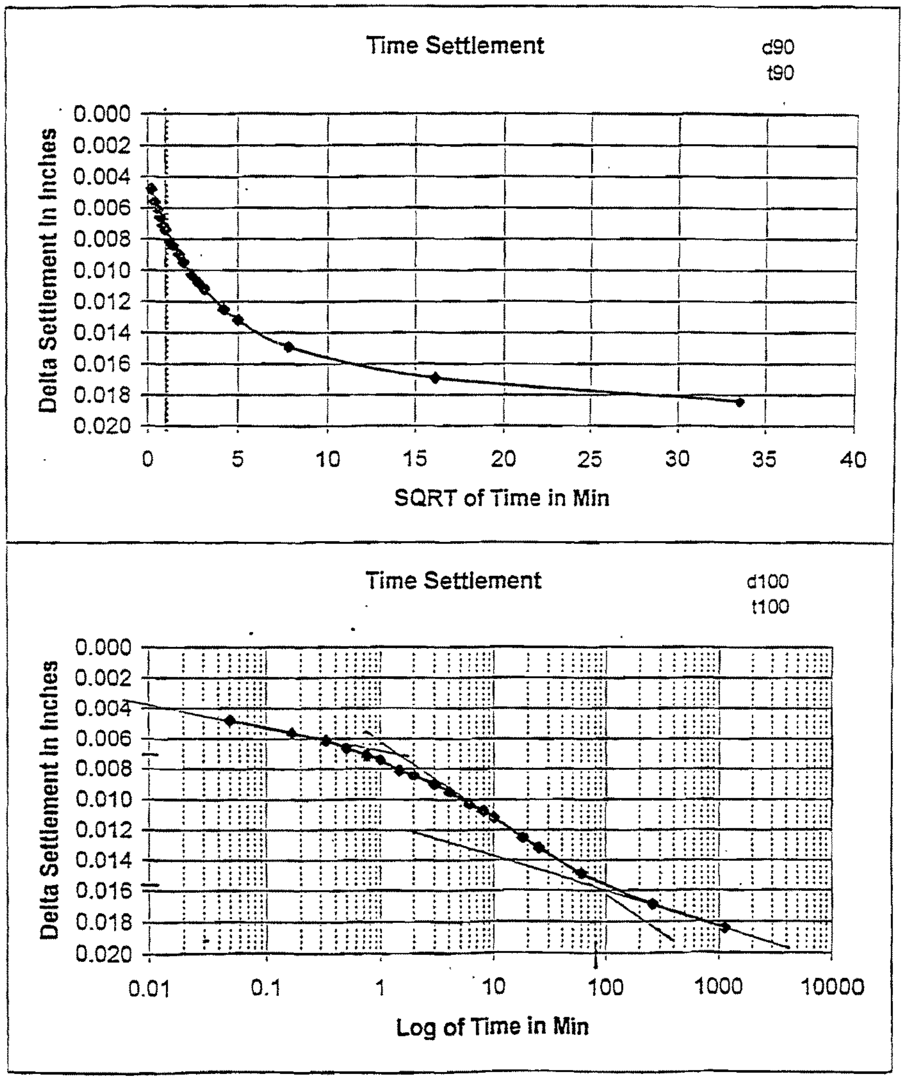




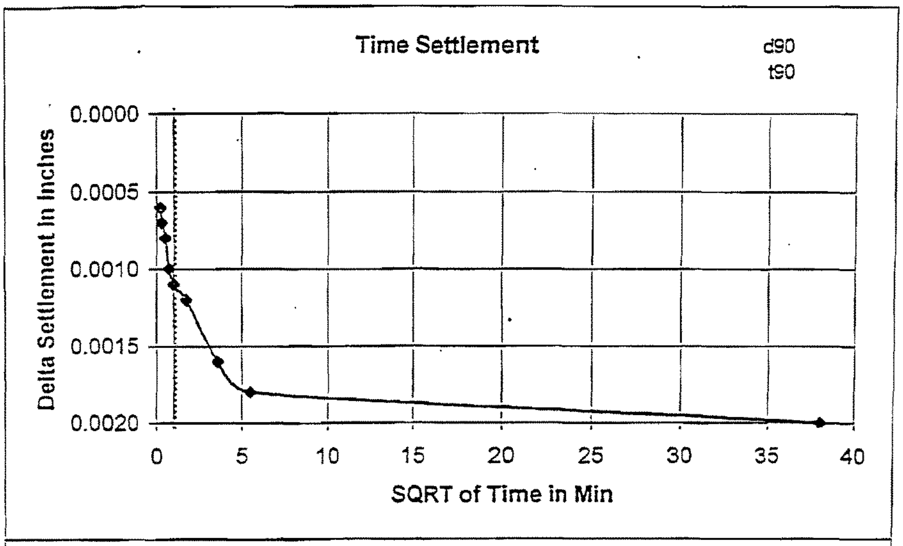
Project: Scuth River Flood Control
Job #: 00279
Lab #: 000551
Sample Location: SR0014, 9'
Sample Description: Brown Silty Clay
Load: 1/4 tsf

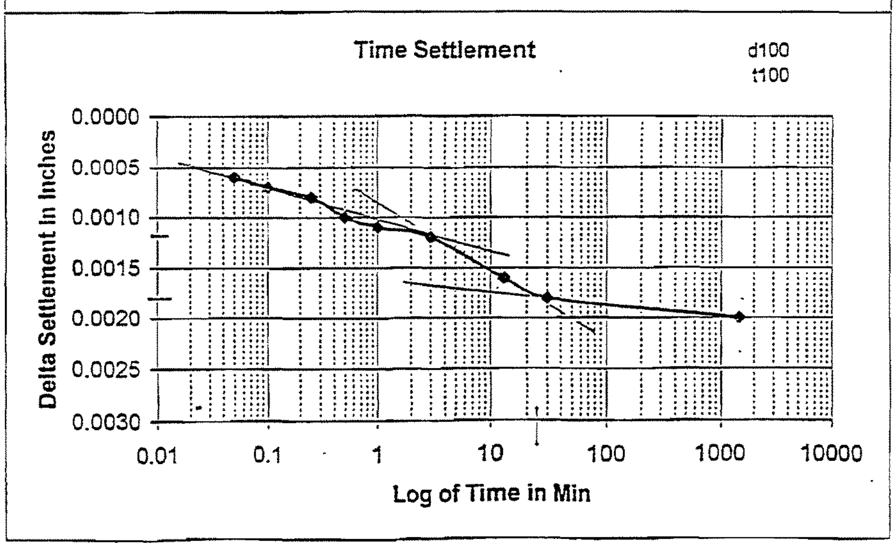


Project: South River Flood Control
Job #: 00279
Lab #: 000551
Sample Location: SR0014, 9'
Sample Description: Brown Silty Clay
Load: 1/2 tsf

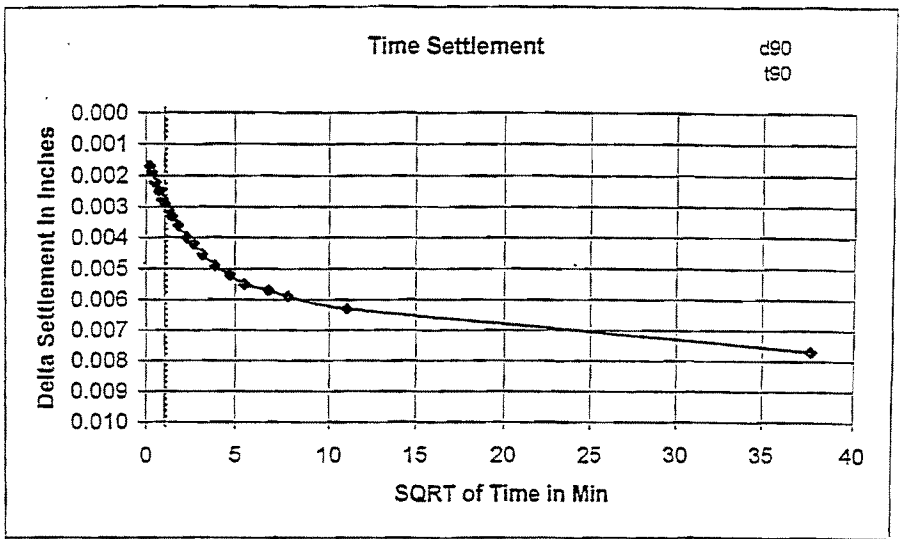


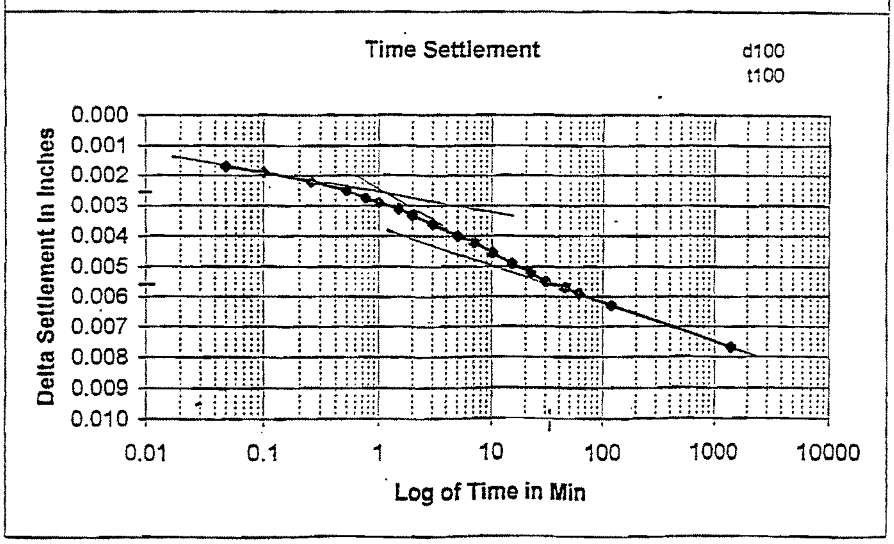
Project: South River Flood Control
Job #: 00279
Lab #: 000551
Sample Location: SR0014, 9'
Sample Description: Brown Silty Clay
Load: 1/4 tsf



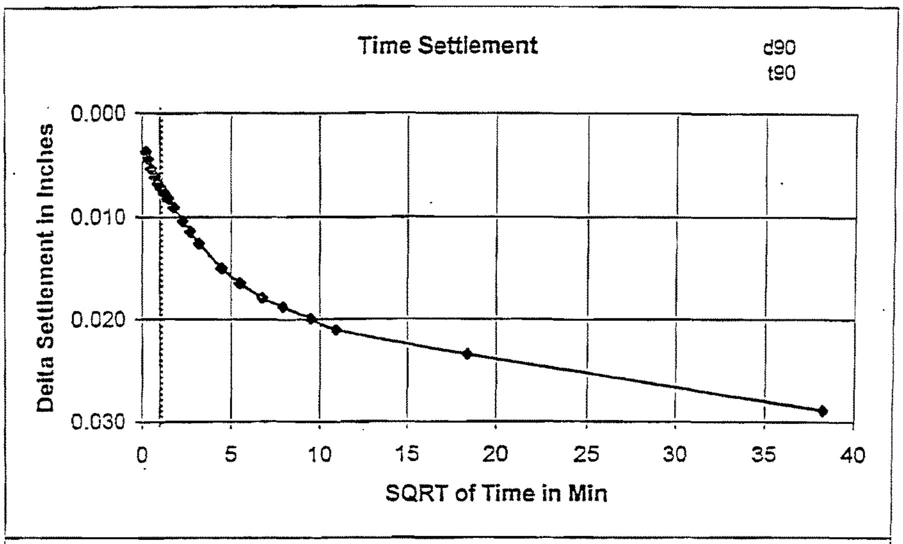


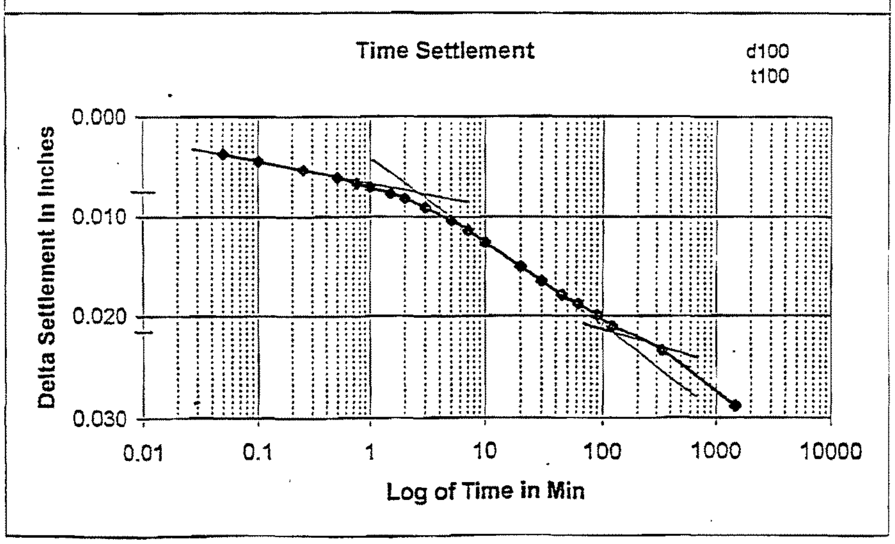
Project: South River Flood Control
Job #: 00279
Lab #: 000551
Sample Location: SR0014, 9'
Sample Description: Brown Silty Clay
Load: 1/2 tsf



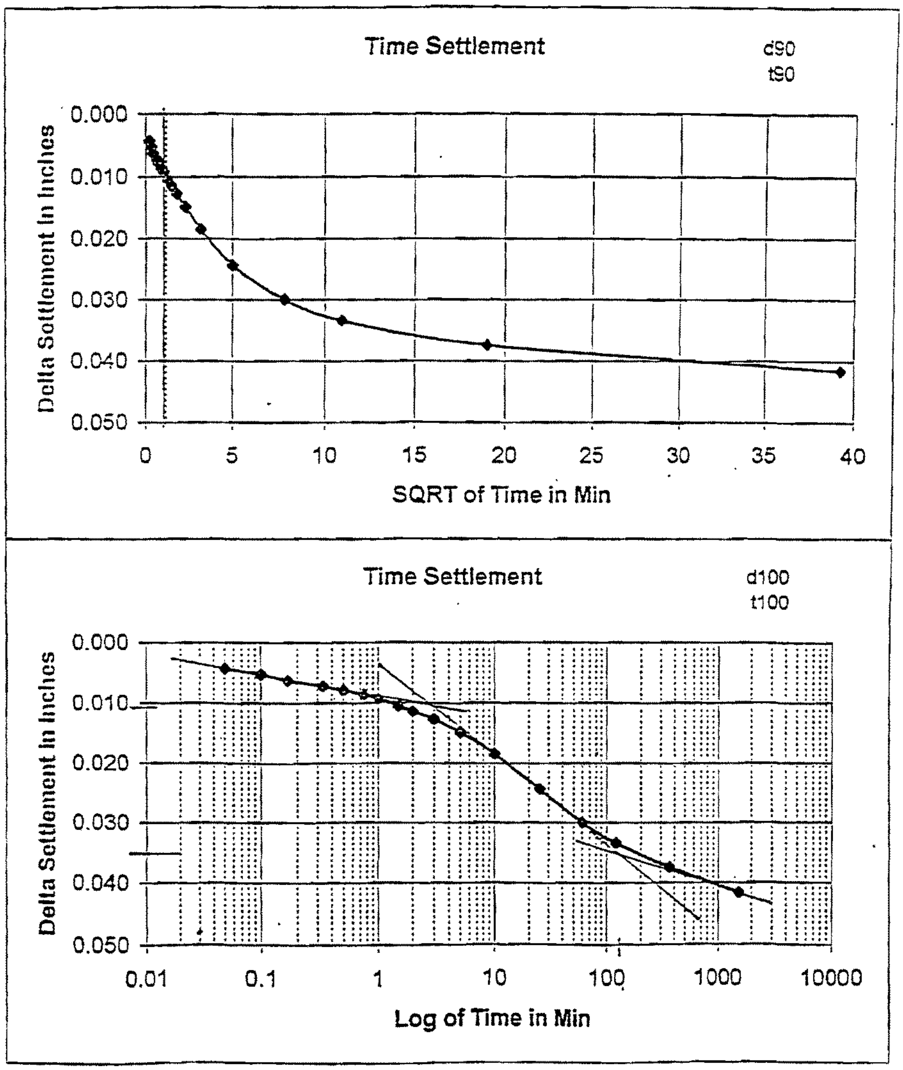


Project: South River Flood Control
Job #: 00279
Lab #: 000551
Sample Location: SR0014, 9'
Sample Description: Brown Silty Clay
Load: 1 tsf

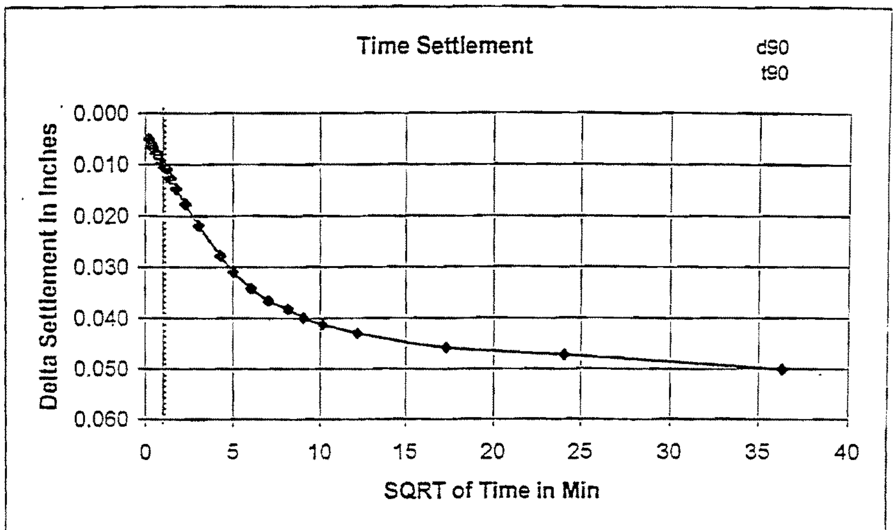


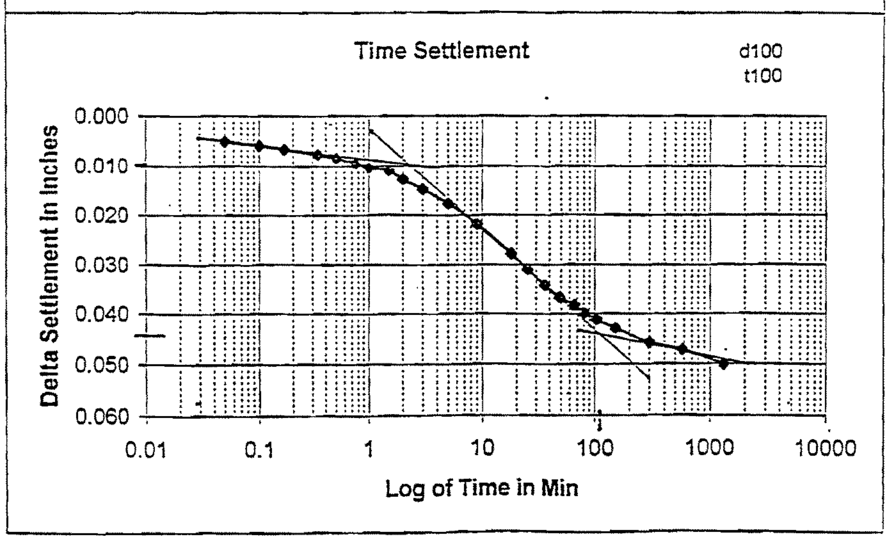


Project: South River Flood Control
Job #: 00279
Lab #: 000551
Sample Location: SR0014, 9'
Sample Description: Brown Silty Clay
Load: 2 tsf



Project: South River Flood Control
Job #: 00279
Lab #: 000551
Sample Location: SR0014, 9'
Sample Description: Brown Silty Clay
Load: 4 tsf





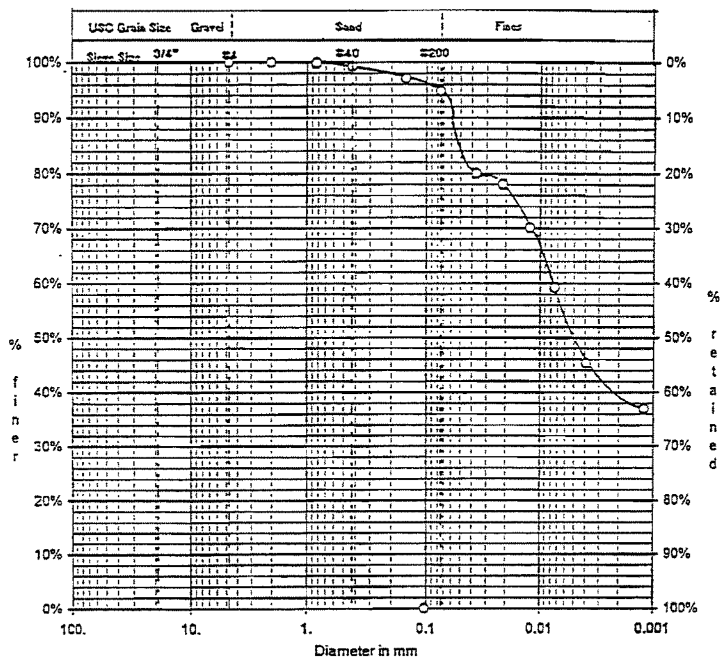
Grain Size Analysis

Project: South River Flood Control
Job #: 00279

Date: 10/20/00
Lab #: 000531

Identification: SR00-1, S-4, 6.0'-8.0'

Description: Gray w/ trace of orange Brown fine sandy Silt



Test Methods	Soil Properties	Classification
Moisture Content: ASTM D 2216	Moisture Content 32.3%	USC: ML
Grain Size Analysis: ASTM D422	Liquid Limit: 40	
Liquid & Plastic Limits: ASTM D4318	Plastic Limit: 26	
Specific Gravity:	Plastic Index: 14	
	Checked By:	Tested By:

HARDIN-KIGHT ASSOCIATES, Inc.
7524 WB&A Road, Suite 100
Glen Burnie, Maryland 21061

Phone: 410 553-0802
Fax: 410 553-0808
email: hkai@erols.com

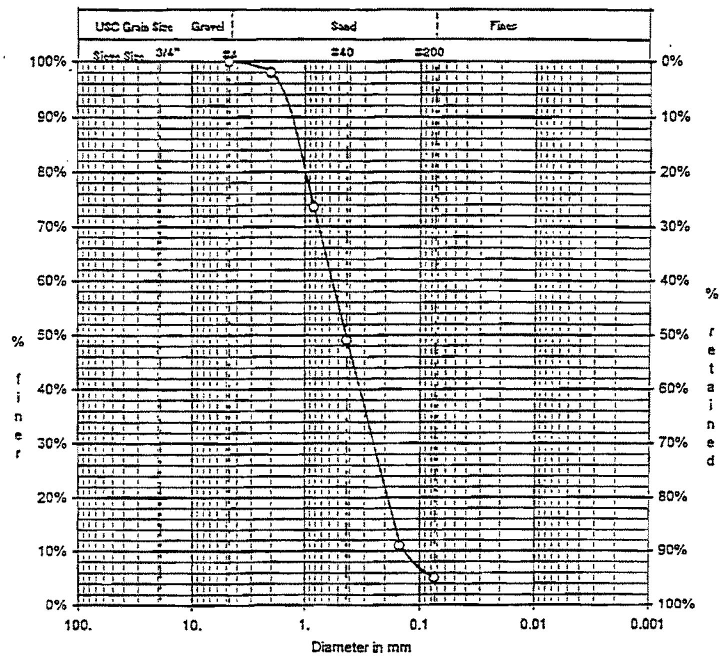
Grain Size Analysis

Project: South River Flood Control
Job #: 00279

Date: 10/20/00
Lab #: 000532

Identification: SR00-1, S-8, 14.0'-16.0'

Description: Gray wet clayey f-c Sand



Test Methods	Soil Properties	Classification
Moisture Content: ASTM D 2216 Grain Size Analysis: ASTM D422 Liquid & Plastic Limits: Specific Gravity: ASTM D854	Moisture Content 14.5% Specific Gravity: 2.67	USC: (SP-SM)
	Checked By:	Tested By:

HARDIN-KIGHT ASSOCIATES, Inc.
7524 WB&A Road, Suite 100
Glen Burnie, Maryland 21061

Phone: 410 553-0802
Fax: 410 553-0808
email: hkai@erols.com

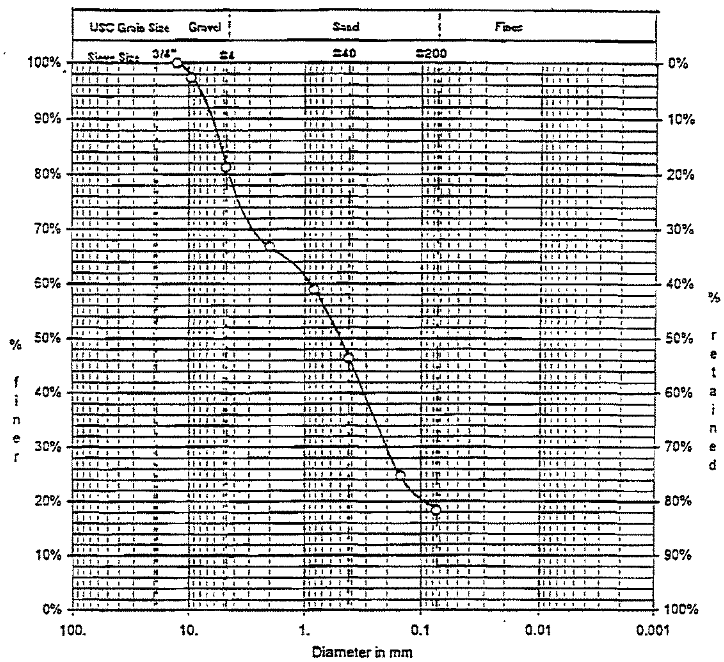
Grain Size Analysis

Project: South River Flood Control
Job #: 00279

Date: 10/20/00
Lab #: 000533

Identification: SR 00-2, S-2, 2.0'-4.0'

Description: Dark brown & orange brown clayey f-c Sand



Test Methods	Soil Properties	Classification
Moisture Content: ASTM D 2216 Grain Size Analysis: ASTM D422 Liquid & Plastic Limits: Specific Gravity:	Moisture Content 10.1%	USC: (SC)
	Checked By: [signature]	Tested By:

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Glen Burnie, Maryland 21061

Phone: 410 553-0802
Fax: 410 553-0808
email: hkai@erols.com

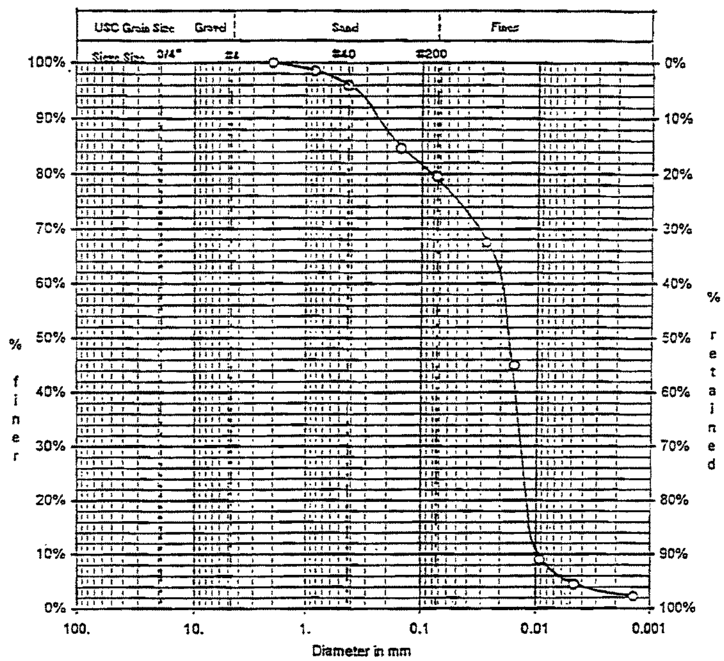
Grain Size Analysis

Project: South River Flood Control
Job #: 00279

Date: 10/20/00
Lab #: 000534

Identification: SR 00-2, S-8, 14.0'-16.0'

Description: Black Peat



Test Methods	Soil Properties		Classification
Moisture Content: ASTM D 2216	Moisture Content	68.3%	USC: (PEAT)
Grain Size Analysis: ASTM D422	Liquid Limit:	88	
Liquid & Plastic Limits: ASTM D4318	Plastic Limit:	75	
Specific Gravity:	Plastic Index:	13	
	Checked By:		Tested By:

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7524 WB&A Road, Suite 100
Glen Burnie, Maryland 21061

Phone: 410 553-0802
Fax: 410 553-0808
email: hkai@erols.com

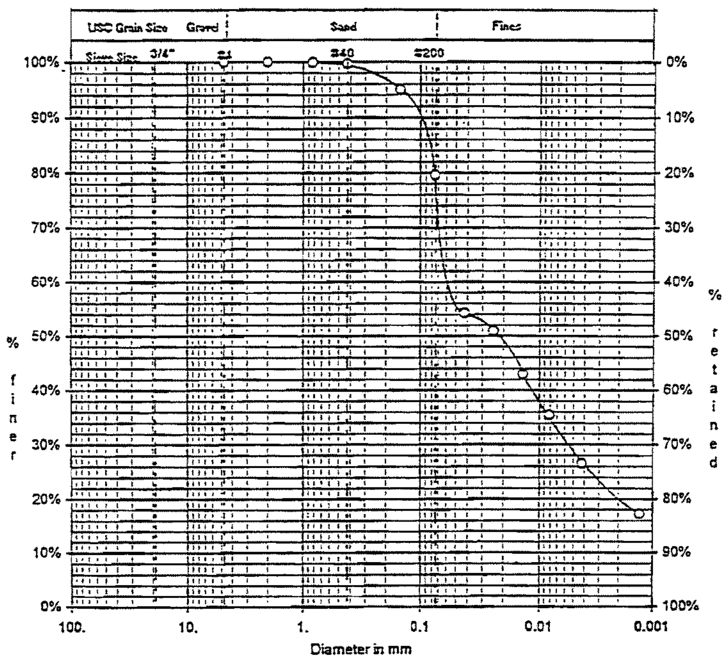
Grain Size Analysis

Project: South River Flood Control
Job #: 00279

Date: 10/20/00
Lab #: 000535

Identification: SR00-3, S-9, 19.0'-21.0'

Description: Dark gray brown fine sandy Silt w/ layers of fine sandy Clay



Test Methods	Soil Properties	Classification
Moisture Content: ASTM D 2216	Moisture Content 26.0%	USC: CL-ML
Grain Size Analysis: ASTM D422	Liquid Limit: 26	
Liquid & Plastic Limits: ASTM D4318	Plastic Limit: 19	
Specific Gravity:	Plastic Index: 7	
	Checked By: [signature]	Tested By:

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7524 WB&A Road, Suite 100
Glen Burnie, Maryland 21061

Phone: 410 553-0802
Fax: 410 553-0808
email: hkai@erols.com

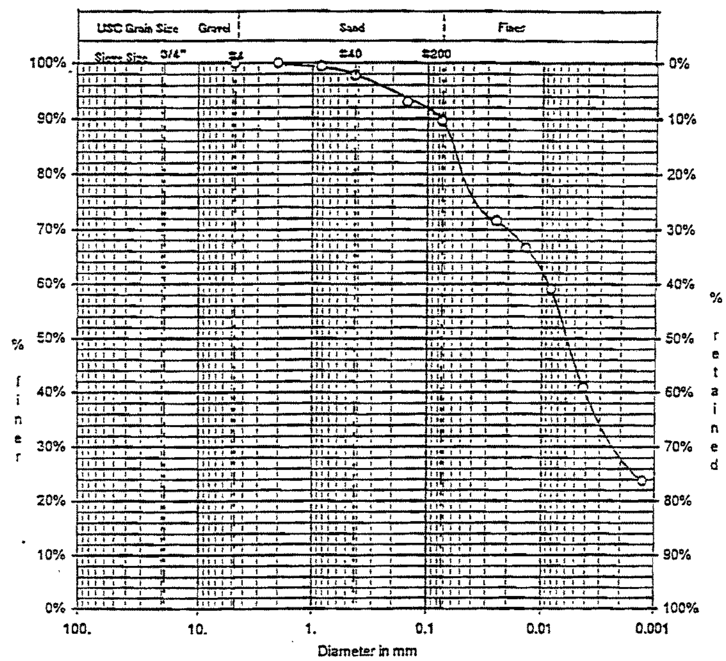
Grain Size Analysis

Project: South River Flood Control
Job #: 00279

Date: 10/20/00
Lab #: 000536

Identification: SR00-4, S-4, 6.0'-8.0'

Description: Dark brown to black clayey Silt w/ some organics



Test Methods	Soil Properties	Classification
Moisture Content: ASTM D 2216	Moisture Content 111.1%	USC: MH
Grain Size Analysis: ASTM D422	Liquid Limit: 64	
Liquid & Plastic Limits: ASTM D4318	Plastic Limit: 39	
Specific Gravity:	Plastic Index: 25	

Checked By: [signature] | Tested By:

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7524 WB&A Road, Suite 100
Glen Burnie, Maryland 21061

Phone: 410 553-0802
Fax: 410 553-0808
email: hkai@erols.com

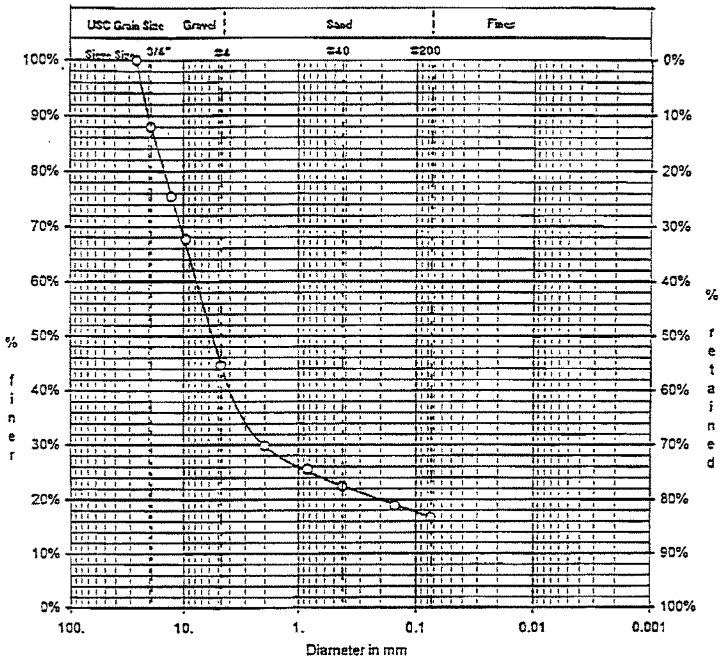
Grain Size Analysis

Project: South River Flood Control
Job #: 00279

Date: 10/20/00
Lab #: 000538

Identification: SR00-5, S-3, 4.0'-6.0'

Description: Brown wet soft clayey Sand w/ orange rock fragments



Test Methods	Soil Properties	Classification
Moisture Content: ASTM D 2216 Grain Size Analysis: ASTM D422 Liquid & Plastic Limits: Specific Gravity: ASTM D854	Moisture Content 26.9% Specific Gravity: 2.61	USC: (SC)
	Checked By:	Tested By:

HARDIN-KIGHT ASSOCIATES, Inc.
7524 WB&A Road, Suite 100
Glen Burnie, Maryland 21061

Phone: 410 553-0802
Fax: 410 553-0808
email: hkai@erols.com

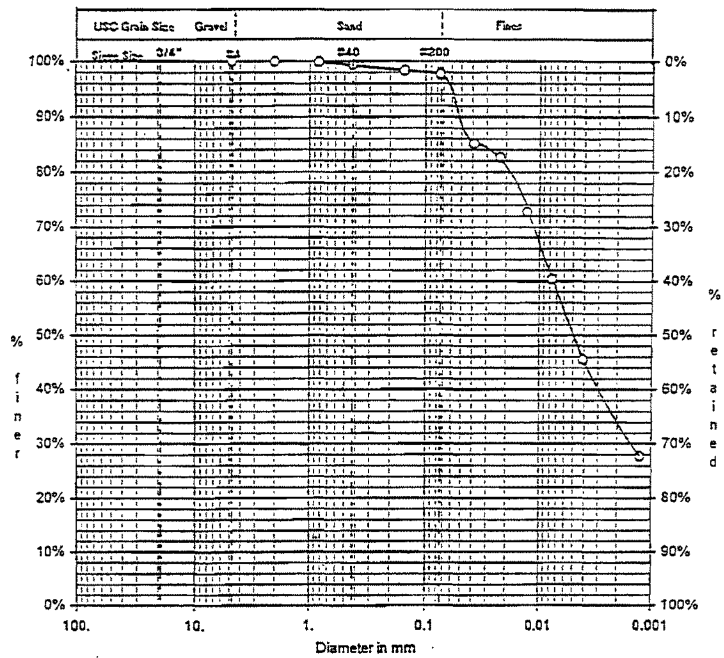
Grain Size Analysis

Project: South River Flood Control
Job #: 00279

Date: 10/20/00
Lab #: 000540

Identification: SR00-5, S-6, 10.0'-12.0'

Description: Gray soft clayey Silt w/ some organics



Test Methods	Soil Properties	Classification
Moisture Content: ASTM D 2216	Moisture Content 80.8%	USC: MH
Grain Size Analysis: ASTM D422	Liquid Limit: 64	
Liquid & Plastic Limits: ASTM D4318	Plastic Limit: 37	
Specific Gravity:	Plastic Index: 27	
	Checked By:	Tested By:

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7524 WB&A Road, Suite 100
Glen Burnie, Maryland 21061

Phone: 410 553-0802
Fax: 410 553-0808
email: hkai@erols.com

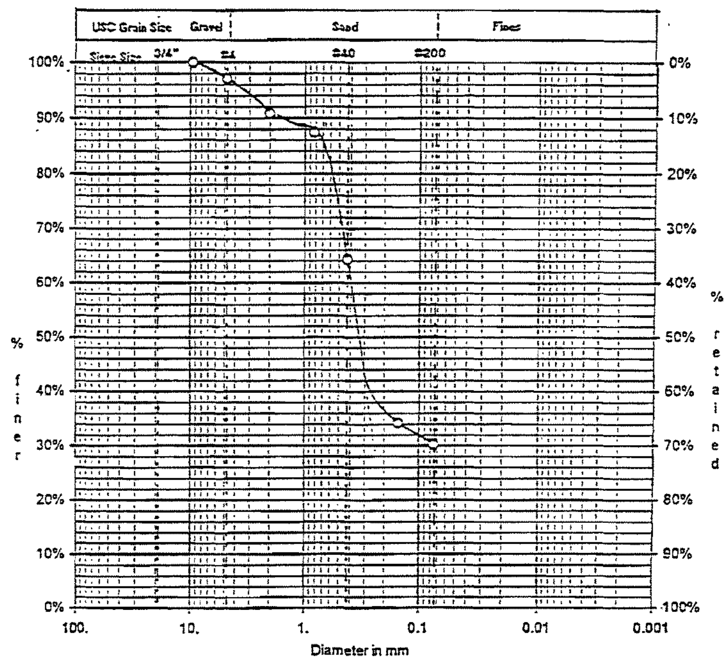
Grain Size Analysis

Project: South River Flood Control
Job #: 00279

Date: 10/20/00
Lab #: 000541

Identification: SR00-6, S-7, 12.0'-14.0'

Description: Brown & gray wet silty fine to coarse Sand w/ tr. fine gravel



Test Methods	Soil Properties	Classification
Moisture Content: ASTM D 2216 Grain Size Analysis: ASTM D422 Liquid & Plastic Limits: Specific Gravity:	Moisture Content 22.6%	USC: (SM)
	Checked By:	Tested By:

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Glen Burnie, Maryland 21061

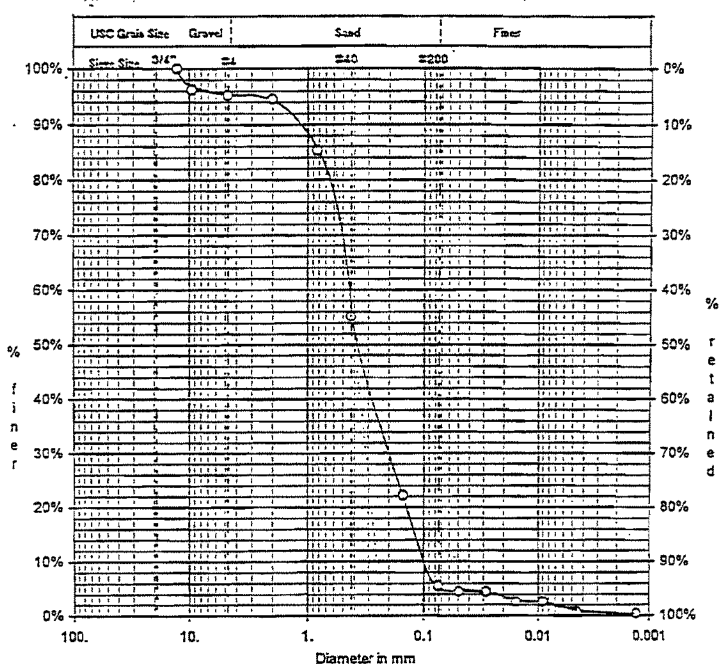
Phone: 410 553-0802
Fax: 410 553-0808
email: hkai@erols.com

Grain Size Analysis

Project: South River Flood Control
Job #: 00279
Date: 10/20/00
Lab #: 000542

Identification: SR00-6, S-11, 29.0'-31.0'

Description: Gray fine to medium Sand w/ trace fine gravel



Test Methods	Soil Properties	Classification
Moisture Content: ASTM D 2216 Grain Size Analysis: ASTM D422 Liquid & Plastic Limits: Specific Gravity: ASTM D854	Moisture Content 17.2% Specific Gravity: 2.67	USC: (SP-SM)
	Checked By:	Tested By:

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7524 WB&A Road, Suite 100
Glen Burnie, Maryland 21061

Phone: 410 553-0802
Fax: 410 553-0808
email: hkai@erols.com

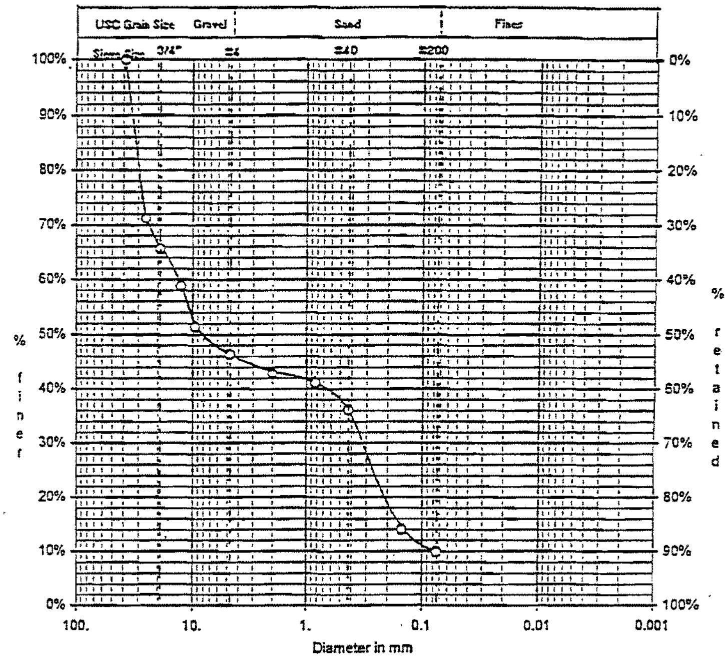
Grain Size Analysis

Project: South River Flood Control
Job #: 00279

Date: 10/20/00
Lab #: 000543

Identification: SR00-9, S-3. 4.0'-6.0'

Description: Med brown & orange brown f-m Sand w/ rock fragments



Test Methods	Soil Properties	Classification
Moisture Content: ASTM D 2216 Grain Size Analysis: ASTM D422 Liquid & Plastic Limits: Specific Gravity:	Moisture Content 8.7%	USC: (SP-SM)
	Checked By:	Tested By:

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7524 WB&A Road, Suite 100
Glen Burnie, Maryland 21061

Phone: 410 553-0802
Fax: 410 553-0808
email: hkai@erols.com

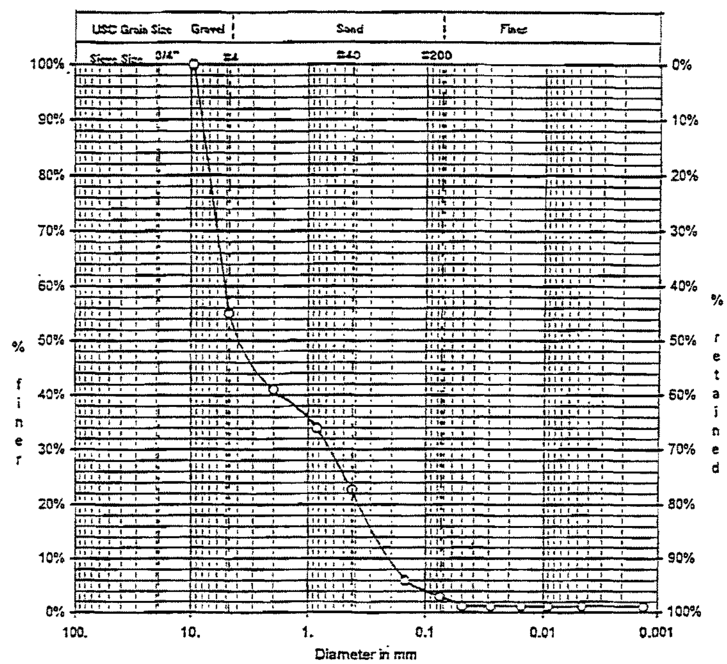
Grain Size Analysis

Project: South River Flood Control
Job #: 00279

Date: 10/20/00
Lab #: 000545

Identification: SR00-10, S-3, 4.0'-6.0'

Description: Gray fine to coarse Sand w/ some fine gravel



Test Methods	Soil Properties	Classification
Moisture Content: ASTM D 2216 Grain Size Analysis: ASTM D422 Liquid & Plastic Limits: Specific Gravity:	Moisture Content 7.6%	USC: (SP)
	Checked By:	Tested By:

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7524 WB&A Road, Suite 100
Glen Burnie, Maryland 21061

Phone: 410 553-0802
Fax: 410 553-0808
email: hkai@erols.com

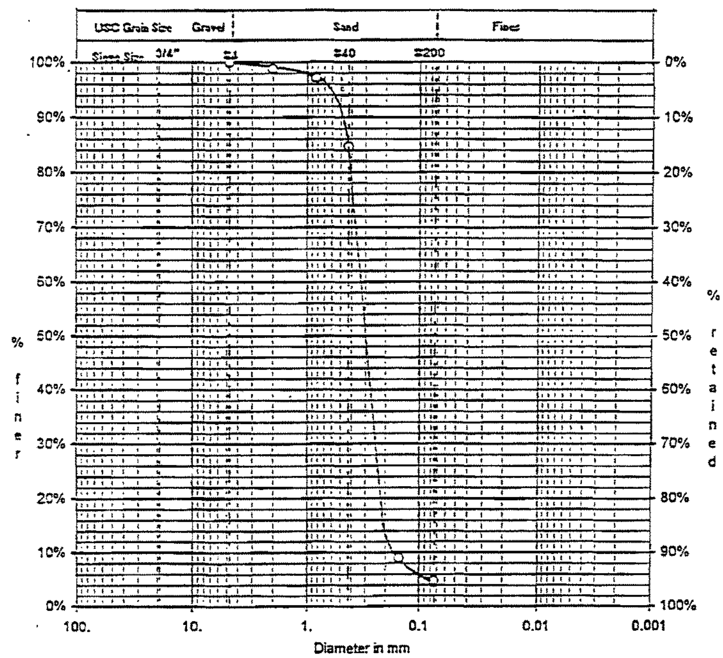
Grain Size Analysis

Project: South River Flood Control
Job #: 00279

Date: 10/20/00
Lab #: 000544

Identification: SR00-9, S-5, 8.0'-10.0'

Description: Orange brown wet f-m Sand



Test Methods	Soil Properties	Classification
Moisture Content: ASTM D 2216	Moisture Content 25.2%	USC: (SP-SM)
Grain Size Analysis: ASTM D422		
Liquid & Plastic Limits:		
Specific Gravity:		
	Checked By:	Tested By:

HARDIN-KIGHT ASSOCIATES, Inc.
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email: hkai@erols.com

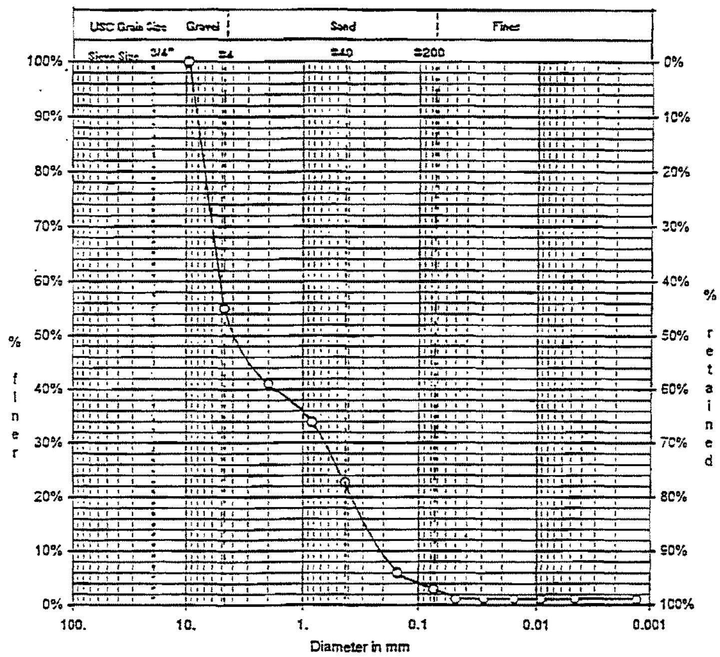
Grain Size Analysis

Project: South River Flood Control
Job #: 00279

Date: 10/20/00
Lab #: 000545

Identification: SR00-10, S-3, 4.0'-6.0'

Description: Gray fine to coarse Sand w/ some fine gravel



Test Methods	Soil Properties	Classification
Moisture Content: ASTM D 2216 Grain Size Analysis: ASTM D422 Liquid & Plastic Limits: Specific Gravity:	Moisture Content 7.6%	USC: (SP)
	Checked By:	Tested By:

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7524 WB&A Road, Suite 100
Glen Burnie, Maryland 21061

Phone: 410 553-0802
Fax: 410 553-0808
email: hkai@erols.com

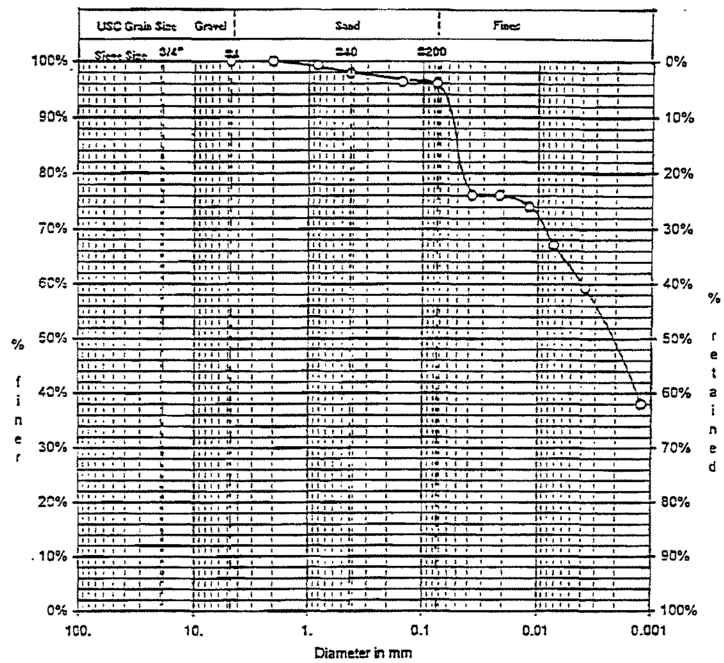
Grain Size Analysis

Project: South River Flood Control
Job #: 00279

Date: 10/20/00
Lab #: 000547

Identification: SR00-10, S-10, 20.0'-21.0'

Description: Gray moderately stiff Clay



Test Methods	Soil Properties	Classification
Moisture Content: ASTM D 2216	Moisture Content 29.1%	USC: CL
Grain Size Analysis: ASTM D422	Liquid Limit: 49	
Liquid & Plastic Limits: ASTM D4318	Plastic Limit: 27	
Specific Gravity:	Plastic Index: 22	
	Checked By:	Tested By:

HARDIN-KIGHT ASSOCIATES, Inc.
7524 WB&A Road, Suite 100
Glen Burnie, Maryland 21061

Phone: 410 553-0802
Fax: 410 553-0808
email: hkai@erols.com

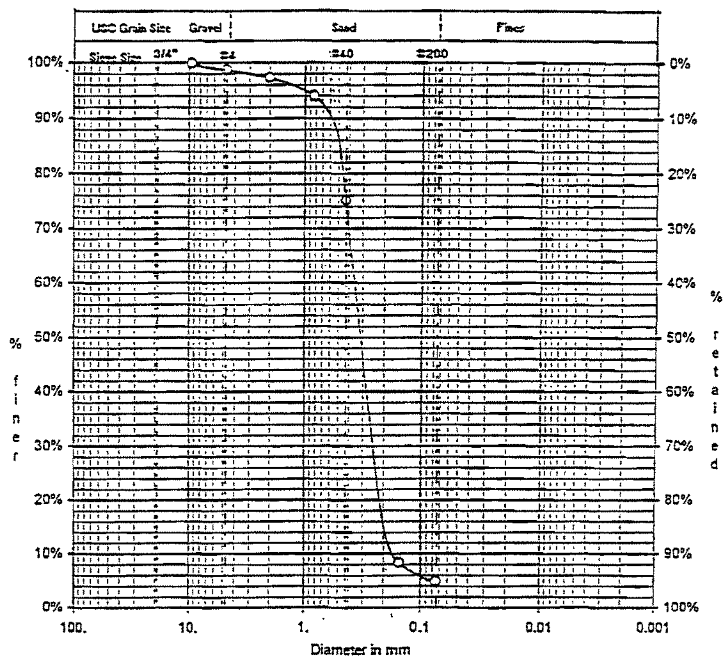
Grain Size Analysis

Project: South River Flood Control
Job #: 00279

Date: 10/20/00
Lab #: 000548

Identification: SR00-11, S-2, 2.0'-4.0'

Description: Orange brown wet fine to medium Sand



Test Methods	Soil Properties	Classification
Moisture Content: ASTM D 2216 Grain Size Analysis: ASTM D422 Liquid & Plastic Limits: Specific Gravity:	Moisture Content 29.1%	USC: (SP-SM)
	Checked By:	Tested By:

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email: hkai@erols.com

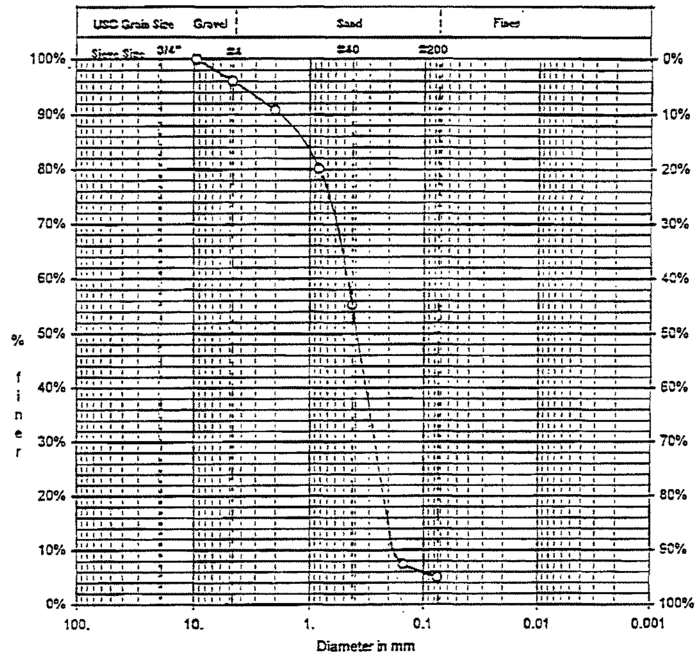
Grain Size Analysis

Project: South River Flood Control
Job #: 00279

Date: 10/20/00
Lab #: 000549

Identification: SR00-12, S-3, 4.0'-6.0'

Description: Yellow brown fine to medium Sand



Test Methods	Soil Properties	Classification
Moisture Content: ASTM D 2216	Moisture Content 17.8%	USC: (SP-SM)
Grain Size Analysis: ASTM D422	Specific Gravity: 2.71	
Liquid & Plastic Limits:		
Specific Gravity: ASTM D 854		
	Checked By:	Tested By:

HARDIN-KIGHT ASSOCIATES, Inc.
7524 WB&A Road, Suite 100
Glen Burnie, Maryland 21061

Phone: 410 553-0802
Fax: 410 553-0808
email: hkai@erols.com

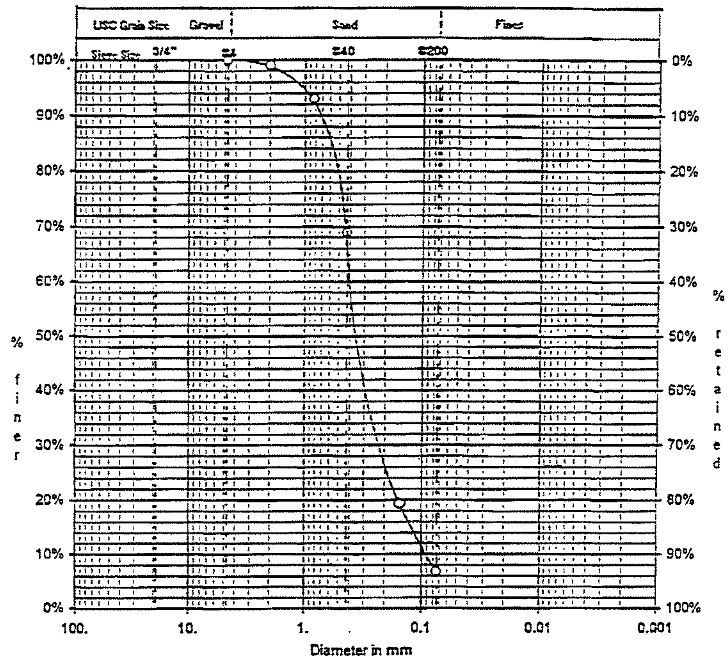
Grain Size Analysis

Project: South River Flood Control
Job #: 00279

Date: 10/20/00
Lab #: 000550

Identification: SR00-13, S-5, 8.0'-10.0'

Description: Light brown fine to medium Sand



Test Methods	Soil Properties	Classification
Moisture Content: ASTM D 2216 Grain Size Analysis: ASTM D422 Liquid & Plastic Limits: Specific Gravity:	Moisture Content 17.9%	USC: (SP-SM)

Checked By:	Tested By:

HARDIN-KIGHT ASSOCIATES, Inc.
7524 WB&A Road, Suite 100
Glen Burnie, Maryland 21061

Phone: 410 553-0802
Fax: 410 553-0808
email: hkai@erols.com

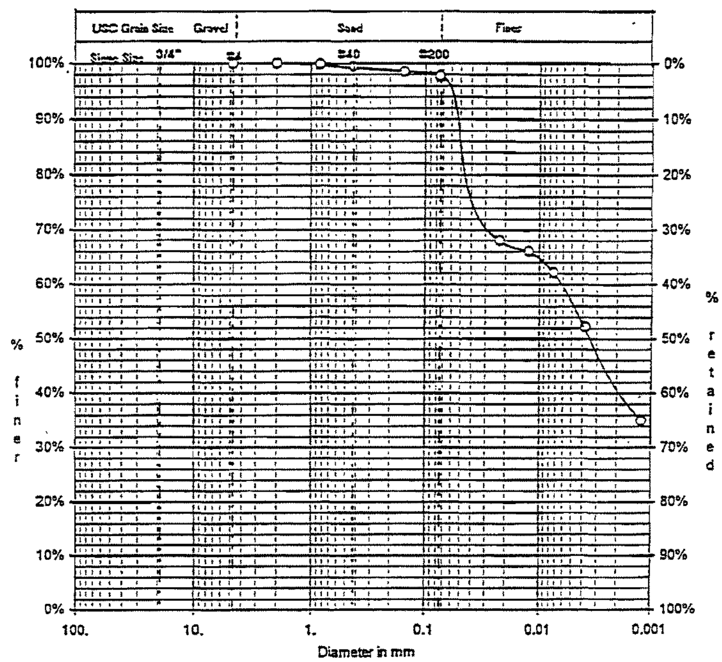
Grain Size Analysis

Project: South River Flood Control
Job #: 00279

Date: 10/20/00
Lab #: 000552

Identification: SR00-15, S-3, 4.0'-6.0'

Description: Gray stiff Clay & fine sandy Clay



Test Methods	Soil Properties	Classification
Moisture Content: ASTM D 2216	Moisture Content 24.9%	USC: CL
Grain Size Analysis: ASTM D422	Liquid Limit: 40	
Liquid & Plastic Limits: ASTM D4318	Plastic Limit: 24	
Specific Gravity:	Plastic Index: 16	

Checked By: [signature] Tested By:

HARDIN-KIGHT ASSOCIATES, Inc.
7524 WB&A Road, Suite 100
Glen Burnie, Maryland 21061

Phone: 410 553-0802
Fax: 410 553-0808
email: hkai@erols.com

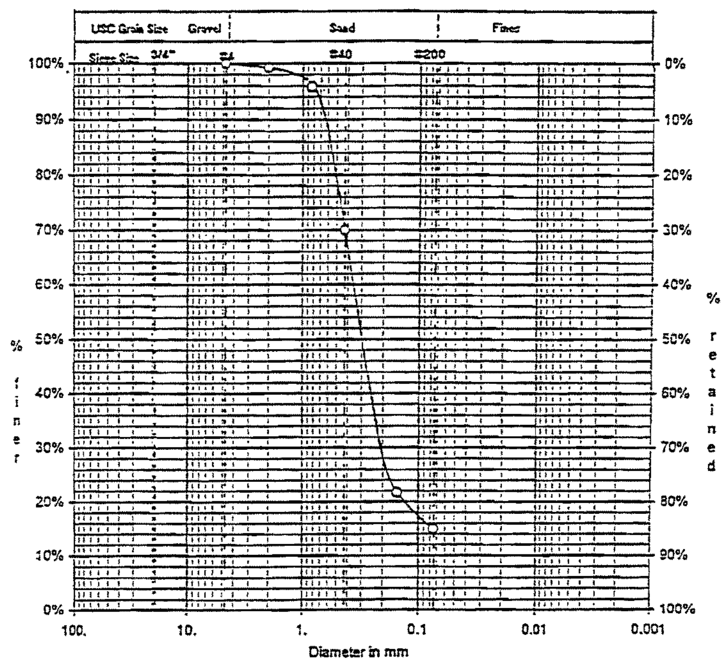
Grain Size Analysis

Project: South River Flood Control
Job #: 00279

Date: 10/20/00
Lab #: 000553

Identification: SR00-15, S-10, 24-26'

Description: Light gray-white silty fine to medium Sand



Test Methods	Soil Properties	Classification
Moisture Content: ASTM D 2216 Grain Size Analysis: ASTM D422 Liquid & Plastic Limits: Specific Gravity: ASTM D 854	Moisture Content 14.5% Specific Gravity: 2.59	USC: (SM)
	Checked By:	Tested By:

HARDIN-KIGHT ASSOCIATES, Inc.
7524 WB&A Road, Suite 100
Glen Burnie, Maryland 21061

Phone: 410 553-0802
Fax: 410 553-0808
email: hkai@erols.com

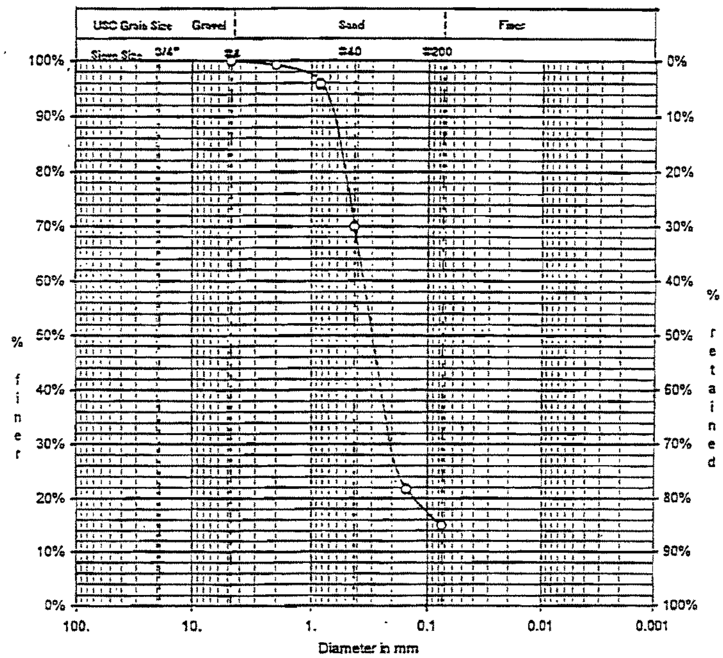
Grain Size Analysis

Project: South River Flood Control
Job #: 00279

Date: 10/20/00
Lab #: 000553

Identification: SR00-15, S-10, 24-26'

Description: Light gray-white silty fine to medium Sand



Test Methods	Soil Properties	Classification
Moisture Content: ASTM D 2216 Grain Size Analysis: ASTM D422 Liquid & Plastic Limits: Specific Gravity: ASTM D 854	Moisture Content 14.5% Specific Gravity: 2.59	USC: (SM)
	Checked By:	Tested By:

HARDIN-KIGHT ASSOCIATES, Inc.
7524 WB&A Road, Suite 100
Glen Burnie, Maryland 21061

Phone: 410 553-0802
Fax: 410 553-0808
email: hkai@erols.com

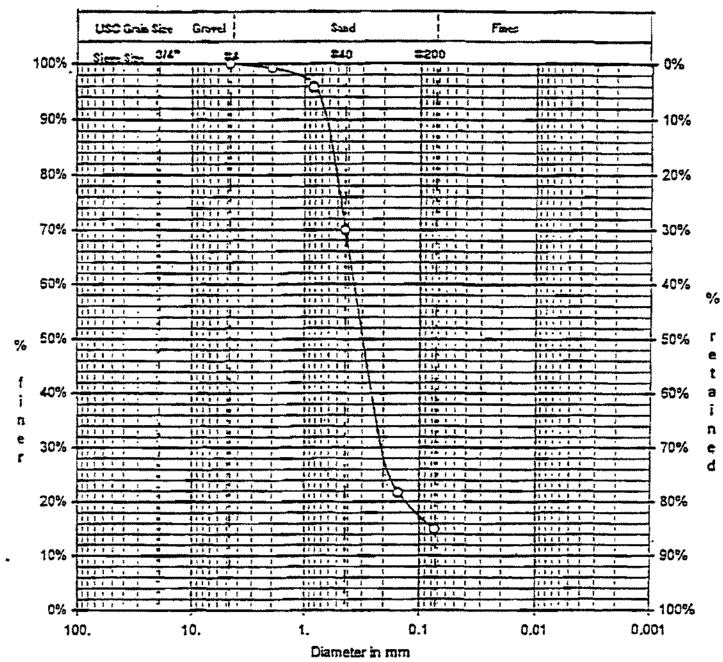
Grain Size Analysis

Project: South River Flood Control
Job #: 00279

Date: 10/20/00
Lab #: 000553

Identification: SR00-15, S-10, 24-26'

Description: Light gray-white silty fine to medium Sand



Test Methods	Soil Properties	Classification
Moisture Content: ASTM D 2216 Grain Size Analysis: ASTM D422 Liquid & Plastic Limits: Specific Gravity: ASTM D 854	Moisture Content 14.5% Specific Gravity: 2.59	USC: (SM)
	Checked By:	Tested By:

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Phone: 410 553-0802
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email: hkai@erols.com

Analysis Results

PROGRAM CSETT - VERTICAL STRESS INDUCTION AND SETTLEMENT PROGRAM
DATE: 17-JUN-2001 TIME: 15.03.30

I. INPUT DATA

1. TITLE - South River Levee Settlement

2. BOUSSINESQ SOLUTION WILL BE USED TO COMPUTE INDUCED STRESSES.
THE MAXIMUM DEPTH TO WHICH THE ANALYSIS WILL BE EXTENDED
IS 37.00 FEET.

3. 2-DIMENSIONAL PRESSURE LOAD DATA
NONE

4. 2-DIMENSIONAL SOIL LOAD DATA

PROFILE NUMBER 1 :NUMBER OF POINTS= 6
BEGINNING TIME OF APPLICATION = .5000 YRS.
ENDING TIME OF APPLICATION =10.0000 YRS.
EFFECTIVE UNIT WEIGHT OF SOIL LOAD= 128.00 PCF

POINT NO.	X (FT.)	Y (FT.)
1	-200.00	3.00
2	-14.00	3.00
3	27.50	20.00
4	37.50	20.00
5	80.00	3.00
6	200.00	3.00

5. 3-DIMENSIONAL RECTANGULAR LOAD DATA
NONE

6. 3-DIMENSIONAL IRREGULAR LOAD DATA

NONE

7. EXCAVATION DATA
NONE

8. SOIL DATA

STRATA NO.	EL. OF TOP OF STRATUM (FEET NGVD)	DRAINAGE CONDITION	EFF UNIT WEIGHT (PCF)	RECOMPR. INDEX	COEF. OF CONSOL. (SQFT/YR)	POISSON'S RATIO
1	3.00	N	110.00			
2	-3.00	D	37.70	.01700	750.00000	.32000

9. STRESS-STRAIN DATA

STRATUM NO. 1

INCOMPRESSIBLE STRATUM

STRATUM NO. 2

VOID RATIO	PRESSURE (PSF)
1.2820	20.0000
1.2800	120.0000
1.2650	520.0000
1.2450	1000.0000
1.2620	280.0000
1.2610	525.0000
1.2550	1000.0000
1.2300	2000.0000
1.1680	4000.0000

10. TIME SEQUENCE FOR CONSOLIDATION CALCULATIONS

TIME RATE OF CONSOLIDATION CALCULATIONS WILL BE MADE AT TIMES (YRS):

.50
1.00
5.00
10.00
25.00
50.00

Analysis Results

11. OUTPUT CONTROL DATA

```
     XXL=   -5.0000 FT.
     XUL=   80.0000 FT.
    DELX=    5.0000 FT.
```

1
PROGRAM CSETT - VERTICAL STRESS INDUCTION AND SETTLEMENT PROGRAM
DATE: 17-JUN-2001 TIME: 15.03.31

II. OUTPUT SUMMARY.

1. TITLE- South River Levee Settlement

POSITION: X= -5.0
****

2. SUMMARY OF ULTIMATE SETTLEMENTS.

STRATA NO.	MID-DEPTH OF STRATA (FEET)	IN-SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (LB/SQ FT)	ULTIMATE SETTLEMENT (FEET)
1	3.00	330.00	474.40	.000
2	8.50	754.25	496.15	.024

3. TIME-SETTLEMENT SUMMARY.

STRATA NO	ULT	(SETTLEMENT IN FEET AT SPECIFIED TIMES) .50 (YRS.)	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	25.00 (YRS.)	50.00 (YRS.)
1	.000	.000	.000	.000	.000	.000	.000
2	.024	.000	.002	.011	.024	.024	.024
TOTALS:	.024	.000	.002	.011	.024	.024	.024

POSITION: X= .0
****

Analysis Results

2. SUMMARY OF ULTIMATE SETTLEMENTS.

STRATA NO.	MID-DEPTH OF STRATA (FEET)	IN-SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (LB/SQ FT)	ULTIMATE SETTLEMENT (FEET)
1	3.00	330.00	734.85	.000
2	8.50	754.25	742.65	.038

3. TIME-SETTLEMENT SUMMARY.

(SETTLEMENT IN FEET AT SPECIFIED TIMES)

STRATA NO	ULT	.50 (YRS.)	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	25.00 (YRS.)	50.00 (YRS.)
1	.000	.000	.000	.000	.000	.000	.000
2	.038	.000	.002	.018	.038	.038	.038
TOTALS:	.038	.000	.002	.018	.038	.038	.038

POSITION: X= 5.0
****

2. SUMMARY OF ULTIMATE SETTLEMENTS.

STRATA NO.	MID-DEPTH OF STRATA (FEET)	IN-SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (LB/SQ FT)	ULTIMATE SETTLEMENT (FEET)
1	3.00	330.00	996.20	.000
2	8.50	754.25	996.00	.051

3. TIME-SETTLEMENT SUMMARY.

(SETTLEMENT IN FEET AT SPECIFIED TIMES)

STRATA NO	ULT	.50 (YRS.)	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	25.00 (YRS.)	50.00 (YRS.)
1	.000	.000	.000	.000	.000	.000	.000
2	.051	.000	.002	.024	.051	.051	.051
TOTALS:	.051	.000	.002	.024	.051	.051	.051

Analysis Results

POSITION: X= 10.0
****

2. SUMMARY OF ULTIMATE SETTLEMENTS.

STRATA NO.	MID-DEPTH OF STRATA (FEET)	IN-SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (LB/SQ FT)	ULTIMATE SETTLEMENT (FEET)
1	3.00	330.00	1257.75	.000
2	8.50	754.25	1250.25	.062

3. TIME-SETTLEMENT SUMMARY.

STRATA NO	ULT	(SETTLEMENT IN FEET AT SPECIFIED TIMES) .50 (YRS.)	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	25.00 (YRS.)	50.00 (YRS.)
1	.000	.000	.000	.000	.000	.000	.000
2	.062	.000	.004	.029	.062	.062	.062
TOTALS:	.062	.000	.004	.029	.062	.062	.062

POSITION: X= 15.0
****

2. SUMMARY OF ULTIMATE SETTLEMENTS.

STRATA NO.	MID-DEPTH OF STRATA (FEET)	IN-SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (LB/SQ FT)	ULTIMATE SETTLEMENT (FEET)
1	3.00	330.00	1518.90	.000
2	8.50	754.25	1501.15	.085

3. TIME-SETTLEMENT SUMMARY.

STRATA NO	ULT	(SETTLEMENT IN FEET AT SPECIFIED TIMES) .50 (YRS.)	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	25.00 (YRS.)	50.00 (YRS.)
1	.000	.000	.000	.000	.000	.000	.000

2	.085	.000	.004	.041	.085	.085	.085
TOTALS:	.085	.000	.004	.041	.085	.085	.085

POSITION: X= 20.0
****

2. SUMMARY OF ULTIMATE SETTLEMENTS.

STRATA NO.	MID-DEPTH OF STRATA (FEET)	IN-SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (LB/SQ FT)	ULTIMATE SETTLEMENT (FEET)
1	3.00	330.00	1778.35	.000
2	8.50	754.25	1740.25	.105

3. TIME-SETTLEMENT SUMMARY.

STRATA NO	ULT	(SETTLEMENT IN FEET AT SPECIFIED TIMES) .50 (YRS.)	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	25.00 (YRS.)	50.00 (YRS.)
1	.000	.000	.000	.000	.000	.000	.000
2	.105	.000	.006	.050	.105	.105	.105
TOTALS:	.105	.000	.006	.050	.105	.105	.105

POSITION: X= 25.0
****

2. SUMMARY OF ULTIMATE SETTLEMENTS.

STRATA NO.	MID-DEPTH OF STRATA (FEET)	IN-SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (LB/SQ FT)	ULTIMATE SETTLEMENT (FEET)
1	3.00	330.00	2027.00	.000
2	8.50	754.25	1942.40	.121

3. TIME-SETTLEMENT SUMMARY.

Analysis Results

STRATA NO	ULT	.50 (YRS.)	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	25.00 (YRS.)	50.00 (YRS.)
		(SETTLEMENT IN FEET AT SPECIFIED TIMES)					
1	.000	.000	.000	.000	.000	.000	.000
2	.121	.000	.006	.057	.121	.121	.121
TOTALS:	.121	.000	.006	.057	.121	.121	.121

POSITION: X= 30.0
****

2. SUMMARY OF ULTIMATE SETTLEMENTS.

STRATA NO.	MID-DEPTH OF STRATA (FEET)	IN-SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (LB/SQ FT)	ULTIMATE SETTLEMENT (FEET)
1	3.00	330.00	2155.85	.000
2	8.50	754.25	2055.15	.128

3. TIME-SETTLEMENT SUMMARY.

STRATA NO	ULT	.50 (YRS.)	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	25.00 (YRS.)	50.00 (YRS.)
		(SETTLEMENT IN FEET AT SPECIFIED TIMES)					
1	.000	.000	.000	.000	.000	.000	.000
2	.128	.000	.006	.061	.128	.128	.128
TOTALS:	.128	.000	.006	.061	.128	.128	.128

POSITION: X= 35.0
****

2. SUMMARY OF ULTIMATE SETTLEMENTS.

STRATA NO.	MID-DEPTH OF STRATA (FEET)	IN-SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (LB/SQ FT)	ULTIMATE SETTLEMENT (FEET)
1	3.00	330.00	2156.15	.000

2	8.50	754.25	2056.30	.128

3. TIME-SETTLEMENT SUMMARY.

STRATA NO	ULT	(SETTLEMENT IN FEET AT SPECIFIED TIMES) .50 (YRS.)	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	25.00 (YRS.)	50.00 (YRS.)
1	.000	.000	.000	.000	.000	.000	.000
2	.128	.000	.006	.061	.128	.128	.128
TOTALS:	.128	.000	.006	.061	.128	.128	.128

POSITION: X= 40.0
****

2. SUMMARY OF ULTIMATE SETTLEMENTS.

STRATA NO.	MID-DEPTH OF STRATA (FEET)	IN-SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (LB/SQ FT)	ULTIMATE SETTLEMENT (FEET)
1	3.00	330.00	2030.50	.000
2	8.50	754.25	1947.05	.121

3. TIME-SETTLEMENT SUMMARY.

STRATA NO	ULT	(SETTLEMENT IN FEET AT SPECIFIED TIMES) .50 (YRS.)	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	25.00 (YRS.)	50.00 (YRS.)
1	.000	.000	.000	.000	.000	.000	.000
2	.121	.000	.006	.058	.121	.121	.121
TOTALS:	.121	.000	.006	.058	.121	.121	.121

POSITION: X= 45.0
****

2. SUMMARY OF ULTIMATE SETTLEMENTS.

Analysis Results

STRATA NO.	MID-DEPTH OF STRATA (FEET)	IN-SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (LB/SQ FT)	ULTIMATE SETTLEMENT (FEET)
1	3.00	330.00	1787.65	.000
2	8.50	754.25	1749.90	.106

3. TIME-SETTLEMENT SUMMARY.

STRATA NO.	ULT	(SETTLEMENT IN FEET AT SPECIFIED TIMES) .50 (YRS.)	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	25.00 (YRS.)	50.00 (YRS.)
1	.000	.000	.000	.000	.000	.000	.000
2	.106	.000	.006	.050	.106	.106	.106
TOTALS:	.106	.000	.006	.050	.106	.106	.106

POSITION: X= 50.0
****

2. SUMMARY OF ULTIMATE SETTLEMENTS.

STRATA NO.	MID-DEPTH OF STRATA (FEET)	IN-SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (LB/SQ FT)	ULTIMATE SETTLEMENT (FEET)
1	3.00	330.00	1534.30	.000
2	8.50	754.25	1516.55	.086

3. TIME-SETTLEMENT SUMMARY.

STRATA NO	ULT	(SETTLEMENT IN FEET AT SPECIFIED TIMES) .50 (YRS.)	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	25.00 (YRS.)	50.00 (YRS.)
1	.000	.000	.000	.000	.000	.000	.000
2	.086	.000	.004	.041	.086	.086	.086
TOTALS:	.086	.000	.004	.041	.086	.086	.086

Analysis Results

POSITION: X= 55.0
****

2. SUMMARY OF ULTIMATE SETTLEMENTS.

STRATA NO.	MID-DEPTH OF STRATA (FEET)	IN-SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (LB/SQ FT)	ULTIMATE SETTLEMENT (FEET)
1	3.00	330.00	1279.30	.000
2	8.50	754.25	1271.50	.064

3. TIME-SETTLEMENT SUMMARY.

STRATA NO	ULT	.50 (YRS.)	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	25.00 (YRS.)	50.00 (YRS.)
		(SETTLEMENT IN FEET AT SPECIFIED TIMES)					
1	.000	.000	.000	.000	.000	.000	.000
2	.064	.000	.004	.031	.064	.064	.064
TOTALS:	.064	.000	.004	.031	.064	.064	.064

POSITION: X= 60.0
****

2. SUMMARY OF ULTIMATE SETTLEMENTS.

STRATA NO.	MID-DEPTH OF STRATA (FEET)	IN-SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (LB/SQ FT)	ULTIMATE SETTLEMENT (FEET)
1	3.00	330.00	1023.95	.000
2	8.50	754.25	1022.90	.051

3. TIME-SETTLEMENT SUMMARY.

STRATA NO	ULT	.50 (YRS.)	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	25.00 (YRS.)	50.00 (YRS.)
		(SETTLEMENT IN FEET AT SPECIFIED TIMES)					
1	.000	.000	.000	.000	.000	.000	.000

2	.051	.000	.002	.024	.051	.051	.051
TOTALS:	.051	.000	.002	.024	.051	.051	.051

POSITION: X= 65.0
****

2. SUMMARY OF ULTIMATE SETTLEMENTS.

STRATA NO.	MID-DEPTH OF STRATA (FEET)	IN-SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (LB/SQ FT)	ULTIMATE SETTLEMENT (FEET)
1	3.00	330.00	768.60	.000
2	8.50	754.25	774.70	.040

3. TIME-SETTLEMENT SUMMARY.

STRATA NO	ULT	(SETTLEMENT IN FEET AT SPECIFIED TIMES) .50 (YRS.)	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	25.00 (YRS.)	50.00 (YRS.)
1	.000	.000	.000	.000	.000	.000	.000
2	.040	.000	.002	.019	.040	.040	.040
TOTALS:	.040	.000	.002	.019	.040	.040	.040

POSITION: X= 70.0
****

2. SUMMARY OF ULTIMATE SETTLEMENTS.

STRATA NO.	MID-DEPTH OF STRATA (FEET)	IN-SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (LB/SQ FT)	ULTIMATE SETTLEMENT (FEET)
1	3.00	330.00	514.00	.000
2	8.50	754.25	531.80	.026

3. TIME-SETTLEMENT SUMMARY.

Analysis Results

STRATA NO	ULT	(SETTLEMENT IN FEET AT SPECIFIED TIMES) .50 (YRS.)	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	25.00 (YRS.)	50.00 (YRS.)
1	.000	.000	.000	.000	.000	.000	.000
2	.026	.000	.002	.013	.026	.026	.026
TOTALS:	.026	.000	.002	.013	.026	.026	.026

POSITION: X= 75.0
****

2. SUMMARY OF ULTIMATE SETTLEMENTS.

STRATA NO.	MID-DEPTH OF STRATA (FEET)	IN-SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (LB/SQ FT)	ULTIMATE SETTLEMENT (FEET)
1	3.00	330.00	262.90	.000
2	8.50	754.25	306.90	.011

3. TIME-SETTLEMENT SUMMARY.

STRATA NO	ULT	(SETTLEMENT IN FEET AT SPECIFIED TIMES) .50 (YRS.)	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	25.00 (YRS.)	50.00 (YRS.)
1	.000	.000	.000	.000	.000	.000	.000
2	.011	.000	.000	.005	.011	.011	.011
TOTALS:	.011	.000	.000	.005	.011	.011	.011

POSITION: X= 80.0
****

2. SUMMARY OF ULTIMATE SETTLEMENTS.

STRATA NO.	MID-DEPTH OF STRATA (FEET)	IN-SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (LB/SQ FT)	ULTIMATE SETTLEMENT (FEET)
1	3.00	330.00	48.65	.000

2	8.50	754.25	135.70	.004

3. TIME-SETTLEMENT SUMMARY.

STRATA NO	ULT	.50 (YRS.)	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	25.00 (YRS.)	50.00 (YRS.)
		(SETTLEMENT IN FEET AT SPECIFIED TIMES)					
1	.000	.000	.000	.000	.000	.000	.000
2	.004	.000	.000	.002	.004	.004	.004
TOTALS:	.004	.000	.000	.002	.004	.004	.004

Input Data

Date: 23-May-01 Time: 3:41 pm

Title:

Units: ft sec

Water Description

Coeff. Of Permeability : 1.00E-03
Height Of Headwater Against Structure : 20.00
Change In Head (Between headwater and tailwater): 17.00
Flow Direction : Left
Coefficient Of Permeability (Layer 2) : 4.20E-02
Depth of Lower Soil Layer : 31.00

Fragment Data

FRAG NO.	FRAG TYPE	L (ft)	A (ft)	B (ft)	T (ft)	S1 (ft)	S2 (ft)
1	2				37.00	13.00	
2	2				37.00	13.00	

Intermediate Results for Two-Layered Flow

Date: 23-May-01 Time: 3:41 pm

Title:

EPSILON = 0.0

Q = 1.06E-02 (ft^2/sec)
K = 1.00E-03 (ft/sec)
Q/K = 1.06E+01 (ft/sec)
Total Head Loss = 17.00 (ft)

Frag No.	Frag Type	L (ft)	A (ft)	B (ft)	T (ft)	S1 (ft)	S2 (ft)	Form Factor	Head Loss (ft)
1	2				37.00	13.00		0.80	8.50
2	2				37.00	13.00		0.80	8.50

Exit Gradient = 0.405

EPSILON = 0.25

Q = 1.40E-02 (ft^2/sec)
K = 1.00E-03 (ft/sec)
Q/K = 1.40E+01 (ft/sec)
Total Head Loss = 17.00 (ft)

Frag No.	Frag Type	L (ft)	A (ft)	B (ft)	T (ft)	S1 (ft)	S2 (ft)	Form Factor	Head Loss (ft)
1	2				68.00	13.00		0.61	8.50
2	2				68.00	13.00		0.61	8.50

Exit Gradient = 0.413

EPSILON = 0.50

1/Q = 0.0000 (ft/sec)
Exit Gradient = 0.230

Analysis Results

Date: 23-May-01 Time: 3:41 pm

Title:

```
Epsilon           = 0.45
K                 = 1.00E-03 (ft/sec)
K2                = 4.20E-02 (ft/sec)
Q                 = 5.63E-02 (ft^2/sec)
Headwater height  = 20.00    (ft)
Tailwater height  = 3.00     (ft)
Total Head Loss   = 17.00    (ft)
Exit Gradient     = 0.281
```

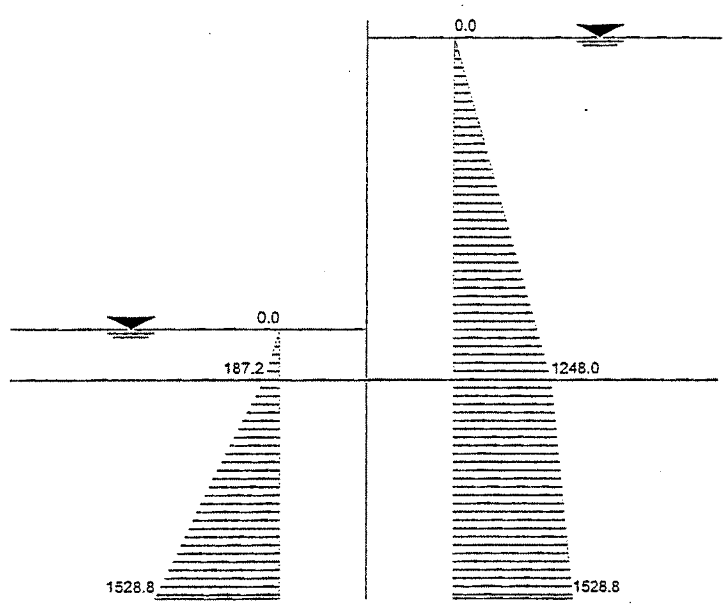
Fragment Data

Frag No.	Frag Type	L (ft)	A (ft)	B (ft)	T (ft)	S1 (ft)	S2 (ft)	Head Loss (ft)
1	2				37.00	13.00		8.50
2	2				37.00	13.00		8.50

Resultant Forces On Structure

```
Lateral Force Headwater Side = 30529.20   (lbs)
Uplift Force                 = 0.00       (lbs)
Lateral Force Tailwater Side = 11434.80   (lbs)
```

Plot of Water Pressures



Page 1

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CBEAR - Bearing Capacity Analysis of Shallow Foundations


Date : 6/20/2001 5:20:30 AM

*************************************************
* One Layer Soil System, Using Meyerhof (1963) *
*************************************************

* Foundation Geometry     Width = 5.50 (ft)    Length = ******

  Foundation Elevation: 2.00 (ft)

  Foundation Type :  Continuous

* Soil Data
  Left Side:  x-Coord.    Elevation  Right Side:  x-Coord.    Elevation
                (ft)        (ft)                    (ft)        (ft)
              -20.00       6.00                    20.00        6.00


  Friction Angle            Cohesion    Total Unit weight
      (deg)                   (psf)          (pcf)
         33.00                0.00          110.00


* Surcharge Description
  Surch.   Surface    Unit Weight        Surch.    Surface     Unit Weigh
t
    No.    Elevation      Total             No.    Elevation      Total
             (ft)         (pcf)                      (ft)         (pcf)
     1     *******        ***               2      *******        ***


* Water Table Description
  Water Table Elevation :  20.00 (ft)
  Unit Weight Of Water  :  62.40 (pcf)

* Applied Load Description
  Applied Load         : 20.00 (kips)
  x-Coord. Of Load     : 0.00 (ft)
  z-Coord. of Load     : 1.50 (ft)
  Angle of Inclination: 30.00 (deg)

* Effective Base Dimensions : Width = 5.50 (ft)    LENGTH = ******

             *** Summary Of Bearing Capacity Factors ***
```

srf11.out

Factors	FNC	FNQ	FNG	Bearing Capacity (Xt) (ksf)	
Bearing Cap.	38.638310	26.092010	26.165710	9.994181	
Shape - Conc.	1.000000	1.000000	1.000000	9.994181	Selecte
Shape - Ecc.	1.000000	1.000000	1.000000	9.994181	Selecte
Inclination	0.444444	0.444444	0.008264	2.947902	Selecte
Base Tilt	0.434942	0.456598	0.456598	1.346006	Selected
Ground Slope	1.000000	1.000000	1.000000	1.346006	Selected
Embedment	1.267894	1.133947	1.133947	1.526300	Selected
	FNC +	FNQ +	FNG	= Q	
Combined Effects of Factors	0.000000	1.511644	0.014656	1.526300	

Factor of Safety for Bearing Capacity = 0.42

APPENDIX C
COST ESTIMATE

INTRODUCTION

General

C1. This appendix outlines the development of, and contains the total first and annualized costs for the Recommended Plan for flood damage protection and ecosystem restoration along the banks of the South River in the Raritan River basin, particularly in the Townships of Sayreville and South River, in Middlesex County, NJ. Cost development for the various project elements of the recommend plan are discussed.

C2. The cost estimate for storm damage reduction is comprised of four (4) individual construction elements, namely (1) Levees and Floodwalls for the Eastern and Western Segments of the line of protection, (2) Interior Drainage Facilities (pump station, gravity drains and diversion pipes), (3) Flood Control Barrier (storm surge barrier with sector gate, bulkheads) and (4) Fish & Wildlife Facilities (wetlands mitigation). Ecosystem Restoration is presented as a separate cost estimate. The MCACES cost summary pages for both storm damage reduction and ecosystem restoration is displayed at the end of this cost appendix.

Basis of Cost

C3. Cost estimates are based on October 2001 price levels for labor, material, and equipment and 1980 topographic surveys. The quantities for the Recommended Plan have been developed from the detailed plans shown in the Main Body and Engineering & Design Appendix in this Feasibility Report, as well as detailed design data in the Engineering & Design Appendix.

Work Breakdown Structure

C4. The detailed cost estimate was compiled using MCACES Gold and patterned after the Civil Works Template as a model. At this feasibility stage the estimate uses the first 3 of 6 available six reporting levels available in the following format:

Level 1	Construction Element	One of five major account codes used to estimate the total project cost
Level 2	Sub Element/Segment	An individual segment of construction activity comprising one or more categories of work or features (cost accounts)
Level 3	Feature	A sub component of a major type of work (cost accounts)
Level 4-6	Sub Feature, Bid Item, And Assembly	Increasingly detailed levels of descriptions and estimating dependent on the information and design level developed for the Feasibility Report.

Project Description for Storm Damage Reduction

C5. The project area is located in the watershed of the South River in Middlesex County, New Jersey, in the Towns of Sayreville and South River. The Recommended Plan generally consists of one storm surge gate and pump station within a barrier crossing South River and levee/floodwall construction both east and west of the barrier. Improvements are designed to provide protection against storm surge up to a 500-year recurrence interval. The three elements of the project are designated as: the Eastern Segment, the River Segment, and the Western Segment. Protected areas are subject to interior flooding from surface runoff from rainfall, therefore interior drainage facilities are provided. The location of each of the elements and associated features are shown in Figures 1,2, 4a, 4b, and 7, of the Main Report and are described in the following sections. Wetland mitigation areas included as part of the project are shown in the Environmental Appendix.

C6. **Eastern Segment.** The Eastern Segment of the line of protection is located primarily in the Township of Sayreville. Top of protection is at elevation +21.5 ft. NGVD. The grade elevations along the entire line of protection range between +4.0 and +20.0 ft. NGVD, therefore the height of protection above grade ranges between 1.5 feet and 17.5 feet. The levee has a 10-ft. wide crest with side slopes of 2.3 ft. horizontal to 1.0 ft. vertical. A vinyl cutoff wall will provide additional seepage control. The floodwall reaches consist of continuous watertight vinyl sheet pile driven to elevation -10.0 NGVD, with two strut beams and a continuous concrete footing anchoring system, as well as continuous wale and concrete cap.

C7. The line of protection, with a total of 426 feet of floodwall and 6081 feet of levee, begins Station 0+00 at the northeastern end as a levee starting at a point approximately 250 feet west of the intersection of Anderson Court and Canal Street behind some newly constructed residential properties. There will be a maintenance vehicle access to the top of the levee at this point. The levee then extends in a northwesterly direction between the rear property lines of the residential development and the municipal sewage facility for approximately 500 feet where it meets the eastern bank of Washington Canal. The top of levee will be widened in this area to accommodate a vehicle turnaround. Due to space restrictions, the levee then transitions to a floodwall which runs southwest along the bank of the canal at the frontage of the sewage facility for approximately 300 feet where it turns almost due south for an additional 100 feet before transitioning back to levee for the remainder of the Eastern Segment. All levee south of the floodwall is located in an undeveloped area located between the Washington Canal and the South River to the west, and residential development to the east. From the floodwall, the levee runs in a southeasterly direction for approximately 450 feet then turns to a southwesterly course for 350 feet passing the eastern termination of Hinton Street. Another access ramp will be located at the end of Hinton Street. The levee makes another slight turn to the west and continues in a southwesterly direction for nearly 750 feet before turning south for another 600 feet. There will be another vehicle turnaround located in this segment. The levee turns to a southwesterly direction again and runs parallel to Weber Avenue at a 300 ft. offset for nearly 800 feet, then turns south and runs again parallel to Weber Avenue this time at a 450 ft. offset for approximately 2150 feet. There will be a turnaround located approximately at 1/3 of the length of this segment. The levee then turns southwest and continues for approximately 350 feet until it meets the eastern bank of the South River where it terminates against a bulkhead. An access ramp is to be located at this last change in direction in the levee. The last 200 feet of levee for closure to elevation +21.5 is located on the western side of the South River, on the other side of the River Segment, in the Township of South River. Once across the river, there is a bulkhead similar to that on the eastern side. The levee begins again and immediately turns to the south where it continues until it meets high ground alongside Veteran's Highway within 50 feet of the western abutment.

C8. **River Segment.** The line of protection crosses the river for approximately 320 feet in the form of a storm surge barrier and a tentatively sized 80 feet wide clear opening storm (sector) gate which lies collinear with the levee. A 1200 cfs pump station is to be located within the barrier between the South River west bank and the storm gate. Between the eastern side of the storm gate and the east bank of the South River, there will be control structures (gravity drains) with backflow prevention of a sufficient size to alleviate build-up of interior drainage when at a higher elevation than the tidal driven storm surge. Like the rest of the line of protection, the barrier and storm gate provide protection to an elevation of +21.5 ft. NGVD. For details of the River Segment, see Figures 7 through 11 of the Main Report.

C9. **Western Segment.** The Western Segment of the line of protection is located entirely within the Township of South River. As with the Eastern Segment, the top of protection is at elevation +21.5 ft. NGVD. The grades on the western side of the river are similar to those on the eastern side. Therefore, the height of protection also ranges from 1.5 feet to 17.5 feet above grade. Levee crest width is again 10 feet, and levee side slopes are 1V: 2.3H. The levees contain a vinyl cutoff wall and fabric reinforcement at grade to provide continued level of protection and reduce settlement in an area with underlying organic material. The two floodwall reaches again consist of continuous watertight vinyl sheet pile driven to elevation -10.0 NGVD, with two strut beams an a continuous concrete footing anchoring system, as well as continuous wale and concrete cap.

C10. The line of protection with a total of 4631 feet of levee and 1229 feet of floodwall begins at the northwestern corner of the protection layout as a levee. Station 0+00 is located at the southeast corner of an unpaved trailer lot off of Tices Corner Road. There will be vehicle access to the top of the levee from this lot. The levee runs southeast for approximately 600 feet through a wooded area until it is within 150 feet of the river bank where it turns to a southwesterly direction. The levee then continues along the river bank for an additional 400 feet where it becomes a floodwall due to space restrictions. There will be a vehicle turnaround provided at the end of the levee in this location. The floodwall is located at the riverbank. It parallels the river for approximately 900 feet as it bends to the southeast. The cross-section then reverts back to levee where space becomes available and continues to parallel the river for an additional 450 feet. There will be vehicle access provided in this segment. At this location, the levee turns slightly south. It runs in a southeasterly direction, no longer parallel to the river, for approximately 450 feet where it turns slightly further south and continues in a southerly direction for another 1250 feet. The levee then turns further south and continues in a southerly direction for approximately 350 feet where it ends and a floodwall begins to minimize impacts to the adjacent wetlands. Vehicle access to the levee will be provided at this end of the levee as well. As before, the floodwall runs directly adjacent to and parallel with the river for approximately 400 feet until in meets Veteran's Highway approximately 100 feet northeast of its intersection with Water Street. The final segment of the line of protection is a levee which extends from the end of the last floodwall segment directly adjacent to and parallel with Veteran's Highway on the north side for approximately 1150 feet where it terminates at high ground elevation +21.5 ft. NGVD. There will be a turnaround at the beginning of this segment and vehicle access at the end.

Formulation of Project First Costs for Storm Damage Reduction and Environmental Restoration

C11. **First Costs.** First costs include the charges arising from the construction of each individual construction element, as well as costs of contingencies, engineering during construction, construction management, real estate assessment, administration and processing (refer to the Real Estate Appendix for more detail).

A summary of the project first costs for the recommended plan of protection for storm damage protection/mitigation and environmental restoration is given in Tables C-1 and C-1A respectively. The first Cost estimates for the recommended plan are broken out by the Sub-feature level. Tables C-2 & C-2A show the fully funded costs for the recommended plans up to the Feature level and escalated to the mid point of construction, January 2008

C12. **Unit Costs.** Feasibility level unit costs were jointly developed by NYD and A/E consultants (URS Corp & Northern Ecological Associates), and are based on: historic actual costs of previous similar COE projects, quotes from equipment manufacturers, dealers, distributors, material suppliers, and construction contractors in the vicinity of the proposed project, standard cost estimating references such as R S Means Cost Data, and judgment based on experience.

C13. **Not applicable at this time**

C14. **Lump Sum Items.** Based on experience, certain items of costs such as mobilization and demobilization were assigned a lump sum cost due to the multiplicity of activities required to accomplish such items.

C15. **Contingencies.** General contingency factors (%) assigned to the various project/construction elements vary throughout this estimate increasing with the incompleteness of design detail for a particular element. They identify the uncertainty associated with an item of work or task, forecast the risk/cost relationship, and assign a value that would limit the cost risk to an acceptable degree of confidence.

- Land & Damages 15% - Detailed, but not final assessment for major real estate requirements.
- Storm Barrier Sector Gate 20% - Cost based on detailed design of similar structure and gate used elsewhere (New Orleans) with appropriate conservative revision on a cost/lf basis for size, location and time differentials.
- Storm Barrier Pump Station 15% - Detailed but not final design.
- Interior Drainage 15% - Cost based on detailed but not final design.
- Levees & Floodwalls 15% - Detailed but not final design.

- Fish & Wildlife Mitigation 20% - Detailed but not final design.

Estimates of Project Features for Storm Damage Reduction

C16. **Lands and Damages.** In order to construct the proposed flood damage reduction plan, the non-Federal sponsor will be required to provide lands and easements and rights-of-way. The extent and value of the lands required for project implementation are outlined in Appendix J – Real Estate.

C17. **Fish and Wildlife Mitigation**. Environmental impacts are addressed by mitigation plans which compensate for losses associated with project implementation. Fish and Wildlife mitigation measures are included in the Recommended Plan. The selected mitigation plan proposes to restore 5.0 acres of wetland Phragmites habitat to 3.3 acres of salt marsh and 1.7 acres of wetland shrub-scrub. In addition, upland disturbed habitat will be restored to create 6.1 acres of wetland shrub-scrub. When compared to the no-action alternative, the implementation of the selected mitigation plan will result in an increase of 19.1 average annual habitat units and 16.6 more functional capacity units. Fish and Wildlife issues associated with the project are fully outlined in the Draft Environmental Impact Statement.

C18. **Levees and Floodwalls.** Levees and floodwalls comprise the majority of the line of protection for the South River project, and represent one of the most significant construction features of the project.

C19. **Levees.** The estimate for the construction of the levees was approached from the viewpoint of heavy earthwork operations characterized by large dozers, loaders, and rollers. Productivity considerations were based on the relative placement area configuration of the embankments, compaction, placement criteria, and the distance of truck-delivered borrow from off-site and project stockpiles, access, haul roads, entrances, proximity to streams and construction easements.

C20. The inspection trenches were assumed to extend the full length of each levee with consideration given to intrusion of ground water into these trenches. A contingency was allocated for remediation of possible unsuitable material after proof-rolling the levee subgrade. It has been assumed that 10% of the excavated material from the inspection trench will be unsuitable for reuse and must be trucked away. However, the topsoil from stripping operations, as well as the balance of the excavated material from the inspection trench, can be reused as levee embankment fill or level topsoil and stockpiled near enough to the levees to generally not warrant trucking.

C21. Two levee cross-sections are utilized, depending on soil conditions along the alignment. Both sections include a 10-ft. level crest width, 1V on 2.3H side slopes, crest elevation of +21.5 ft. NGVD, and 5 inches topsoil and seeding.

C22. The first cross-section type, suitable for sandy soils, will be constructed with a core section composed of impervious soils to restrict seepage through and beneath the levee under surge conditions. The core section will be 10 feet wide and will extend from the top of the levee to a depth of approximately 5 feet below grade for the entire length of the levee. The impervious core will consist of uniform silts (<200 sieve) supplied from local borrow pits near Sayerville (within 20 miles of the site). For additional seepage control, a vinyl sheet pile cut-off wall continuous along the length of the levee will be installed from several feet above grade to more than 6 feet below grade. A drainage ditch is provided along the levee toe. Estimated length of sandy soil foundation cross-section levee is 7000LF.

C23. The second soil condition is soil containing underlying large quantities of organic material. This poorer foundation condition requires installation of a core consisting of two bolted-together lengths of continuous vinyl sheet pile. The upper length of sheet pile extends from the top of the levee at El. +21.5 to 5 ft. below existing grade, and is topped by a concrete cap flush with the top of the levee crest. The lower length of sheet pile starts 5 ft. above grade and extends to 10 ft. below the bottom of the organic soil layer. The bolted overlap section is 10 ft. in length, 5 ft. above grade and 5 ft. below grade. A 12-inch thick stone blanket at grade surrounded by geo textile will be constructed across the entire footprint of the levee, up to the drainage ditch. In this fashion seepage under the levee will be collected and directed to the drainage ditch along the toe of the levee in a controlled fashion. The stone blanket will consist of one-inch diameter clean stone supplied from local quarries (within 20 miles of the site). Estimated length of organic soil foundation cross-section levee is 4000LF. (Note that estimated lengths for the two cross-section types will be refined based on additional borings to be taken during the subsequent detailed design phase.)

C24. **Floodwalls.** The Eastern Segment contains 426 LF floodwall where space restrictions preclude use of a levee. The Western Segment has two floodwall reaches, totaling approximately 1229 lf. A watertight jointed vinyl sheet pile floodwall that is anchored by two strut beams connected to a bearing footing has been developed specifically for this project in order to meet all design criteria. A continuous 8" x 8" structural tube wale will be fixed at the back side of the wall. Angled struts, filled with reinforced concrete, will be joined to the wale at approximately 6 feet spacing along the floodwall. The struts will terminate in a continuous concrete footing below grade. This floodwall design is adequate for both sandy and organic soil conditions, although soil replacement will be included where organic soils are near the surface.

C25. Following installation of vinyl sheeting for the floodwalls, backhoes will excavate to an approximate El. –1.0 NGVD for the strut beam anchoring system. The excavated material will be removed to an adjacent location for drying and possible reuse as backfill. The precast concrete footing will be positioned after proper compacting of subgrade. The wales and strut beams will then be connected to the wall and precast footing. The excavated area will be backfilled and compacted to a minimum of 12" cover atop the continuous precast reinforced concrete footing. Compaction will be performed by hand-operated tamping machines to avoid damage to the anchoring system.

C26. **Storm Barrier System.** The storm surge tidal barrier crosses the South River, connecting with levees on both sides of the river. It contains three major components; the barrier walls, a sector gate, and an enclosed pump station. Other components include:

- Connecting bulkheads to levees on both the east and west sides of the river. Bulkheads are vinyl sheet pile with continuous concrete cap, continuous timber wale, and concrete dead man type tie-backs. Starting at each side of the tidal barrier, the bulkheads extend perpendicular to the levee centerline for the width of the levee cross-section, providing tie-off. Top elevation varies with that of the levee, and estimated embedment depth is –22 ft. NGVD.

- East and west timber guide walls for vessels at upstream and downstream sides of the gated opening
- One check dam, south of the enclosed pump station, to limit shoaling interference to the pumps. Reno mattresses line the sump bottom between the check dam and the pump station for erosion control.
- Control structures (gravity drains) with backflow prevention, located east of the sector gate along and within the storm barrier walls.

C27. Storm Barrier Walls. The tidal barrier walls consist of a double line of high-strength vinyl sheeting lined with reinforced concrete and structurally connected with steel beams for stability. Crest elevation is +21.5 ft. NGVD, to match the rest of the line of protection.

C28. Sector Gate . The steel sector gate is tentatively sized to provide an 80 ft. clear opening and a 34 ft. height to crest elevation +21.5 NGVD with a (-)12.5 ft. NGVD foundation pad elevation. This gate consists of two semi-circular halves, each of which rotates horizontally between open and closed positions. The pile supported gate structure includes an electric motor, opening and closing mechanism and controls. A sector gate was chosen due to a history of good operation under high sediment conditions. In addition, sector gates can be opened and closed under flow conditions, which could be experienced under a storm surge. Sector gates also provide maintenance advantages since they can be removed and replaced from the gate monolith in the wet, whereas other types of gates require coffer damming and dewatering for gate removal and maintenance.

C29. Two detailed sector gate designs were used to develop the cost for the sector gate for the South River Storm Damage Reduction Project. The cost for the first sector gate (56 ft. wide by 20 ft. high clear opening) for the Larouse Floodgate Project at Grand Isle, Louisiana, is based on the bid abstract for the 1983 constructed project. The cost for the second sector gate (125 ft. wide by 27.5 ft. high clear opening) for the Algiers Canal Hurricane Protection Project at New Orleans, Louisiana, is based on the CWE established in the project's Design Memorandum No. 1 dated March 2000. The sector gate for the South River Storm Damage Reduction Project is 80 ft. wide by 35.5 ft high clear opening.

C30. As shown in Table C-3, the costs for the two sample sector gates were used to develop the cost for the South River sector gate with pertinent adjustments made for location and inflation. By reviewing the detailed cost breakout for the two gates it was determined that the gate housing with the associated electrical and mechanical features represents approximately 30% to 40 % of the total gate cost and varies much less significantly than the ratio of the clear opening surface areas. Therefore, developing a cost for the South River sector gate based on cost/ sq. ft. of clear opening would be over estimating the South River gate cost given the large differentials in clear opening area, i.e. 3,440 sq. ft. for the Algiers Canal gate vs. 1,120 sq. ft. for the Larouse gate. A cost analysis based on cost/ linear ft. of clear opening was determined to be more representative of the gate costs at South River from the extrapolation of gate costs for the two sample gates. Based on the cost/ linear ft. of clear opening as shown in Table C-3 for the two gates, i.e. $101,865/ft. for the Larouse gate and$105,074/ft. for the Algiers gate

TABLE C-1

Total First Cost (Selected Plan)

South River Flood Control Feasibility Study

Account Code	Description	QTY	UOM	Unit Price		Amount	% Cont'g		Cont'g Amt		Total
	48" CMP - Interim drainage	300	LF	84.60	$	25,380	15.00%	$	3,800	$	29,200
	Precast concrete MH	5	EA	1500.00	$	7,500	15.00%	$	1,100	$	8,600
	Reinforced concrete	10	CY	540.00	$	5,400	15.00%	$	800	$	6,200
	60" RCP (in place of culvert)	930	LF	178.70	$	166,191	15.00%	$	24,900	$	191,100
	18" flap gate - inside culvert	2	EA	6078.50	$	12,157	15.00%	$	1,800	$	14,000
	36" flap gate -inside culvert	2	EA	10420.50	$	20,841	15.00%	$	3,100	$	23,900
	Crushed stone	723	CY	20.00	$	14,460	15.00%	$	2,200	$	16,700
	36" RCP	200	LF	81.10	$	16,220	15.00%	$	2,400	$	18,600
	36 " flap gate - outlet	2	EA	10420.50	$	20,841	15.00%	$	3,100	$	23,900
	36" sluice gate	2	EA	14477.50	$	28,955	15.00%	$	4,300	$	33,300
	36" X 36" trash rack	2	EA	739.00	$	1,478	15.00%	$	200	$	1,700
	Utility relocation	100	LF	100.00	$	10,000	15.00%	$	1,500	$	11,500
	Channel - vegetated biomat	1074	SY	5.70	$	6,122	15.00%	$	900	$	7,000
	West Segment - Minimum Facilities										
	1' X 24" DIP through floodwall	5	LF	107.60	$	538	15.00%	$	100	$	600
	2' X 60" DIP through floodwall	10	LF	839.70	$	8,397	15.00%	$	1,300	$	9,700
	Excavation & Hauling for pipe	27	CY	6.59	$	178	15.00%	$	-	$	200
	Backfill & Compaction	21	CY	3.71	$	78	15.00%	$	-	$	100
	Manhole frame & cover	11	EA	740.00	$	8,140	15.00%	$	1,200	$	9,300
	Concrete for inlet/outlet MH	214.5	CY	540.00	$	115,830	15.00%	$	17,400	$	133,200
	24" RCP	100	LF	40.60	$	4,060	15.00%	$	600	$	4,700
	24" Dia flap gates	2	EA	9868.00	$	19,736	15.00%	$	3,000	$	22,700
	24" sluice gate	2	EA	10420.50	$	20,841	15.00%	$	3,100	$	23,900
	24" X 24" trash rack	2	EA	475.00	$	950	15.00%	$	100	$	1,100
	60" RCP	700	LF	178.70	$	125,090	15.00%	$	18,800	$	143,900
	60" Dia flap gate	7	EA	12954.00	$	90,678	15.00%	$	13,600	$	104,300
	60" sluice gate	9	EA	36195.00	$	325,755	15.00%	$	48,900	$	374,700
	60" X 60" trash rack	9	EA	1520.00	$	13,680	15.00%	$	2,100	$	15,800
	Main Channel - Minimum Facility										
	Box Culvert	3000	SF	50.00	$	150,000	15.00%	$	22,500	$	172,500
	Flap Gates (5)	5	EA	57600.00	$	288,000	15.00%	$	43,200	$	331,200
	Sluice Gates (5)	5	EA	144000.00	$	720,000	15.00%	$	108,000	$	828,000
	Trash Racks	5	EA	5000.00	$	25,000	15.00%	$	3,800	$	28,800
	60" RCP	400	LF	178.70	$	71,480	15.00%	$	10,700	$	82,200
	60" Dia Flap gate	4	EA	12954.00	$	51,816	15.00%	$	7,800	$	59,600
	60" sluice gate	4	EA	36195.00	$	144,780	15.00%	$	21,700	$	166,500
	60" X 60" trash rack	4	EA	1520.00	$	6,080	15.00%	$	900	$	7,000
	Manhole Frame & Cover	4	EA	740.00	$	2,960	15.00%	$	400	$	3,400
	Concrete for inlet/outlet/MH	78	CY	540.00	$	42,120	15.00%	$	6,300	$	48,400
	SUBTOTAL				$	21,308,110		$	3,196,200	$	**24,504,310**
13	PUMPING PLANT - 1200CFS										
	Mob & Demob	1	LS	150,000	$	150,000	15.00%	$	22,500	$	172,500
	Dewatering	1	LS	100,000	$	100,000	15.00%	$	15,000	$	115,000
	Cofferdam	1	LS	65,000	$	65,000	15.00%	$	9,800	$	74,800
	Vinyl Sheeting	1	LS	150,000	$	150,000	15.00%	$	22,500	$	172,500
	Check Dam (130' X 20')	2600	SF	25	$	65,000	15.00%	$	9,800	$	74,800
	Reno Mattress	333	SY	45	$	15,000	15.00%	$	2,300	$	17,300
	Crane (30T)	1	LS	90,000	$	90,000	15.00%	$	13,500	$	103,500
	Misc. Building	1	LS	150,000	$	150,000	15.00%	$	22,500	$	172,500
	Trash Rack	1	LS	45,000	$	45,000	15.00%	$	6,800	$	51,800
	Steel	50000	LBS	2	$	92,000	15.00%	$	13,800	$	105,800
	Piles (105 @35'/EA)	3675	LF	28	$	102,000	15.00%	$	15,300	$	117,300
	Concrete (Wall 550CY + Floor 300CY)	850	CY	435	$	370,000	15.00%	$	55,500	$	425,500
	Pump Equipment	1	LS	1,800,000	$	1,800,000	15.00%	$	270,000	$	2,070,000
	Gates	1	LS	210,000	$	210,000	15.00%	$	31,500	$	241,500
	Formed Suction Intake (4)	4	EA	45,000	$	180,000	15.00%	$	27,000	$	207,000

TABLE C-1
Total First Cost (Selected Plan)

South River Flood Control Feasibility Study

Account Code	Description	QTY UOM	Unit Price		Amount	% Cont'g		Cont'g Amt		Total
	Tideflex flap gates	4 EA	18,750	$	75,000	15.00%	$	11,300	$	86,300
	SUBTOTAL			$	3,659,000		$	549,100	$	4,208,100
15	FLOODWAY CONTROL AND DIVERSION STRUCTURES									
	Barrier									
	Sheeting 180' X 35'	6300 SF	25	$	157,500	15.00%	$	23,600	$	181,100
	Backfill 35' X 35' x 26'	2000 CY	22	$	44,000	15.00%	$	6,600	$	50,600
	Paving	230 SY	7	$	1,610	15.00%	$	200	$	1,800
	Concrete	20 CY	450	$	9,000	15.00%	$	1,400	$	10,400
	Bulkhead	1 LS	315,000	$	315,000	15.00%	$	47,300	$	362,300
	Sector Gate 35' X 80'	1 LS		$	8,700,000	20.00%	$	1,740,000	$	10,440,000
	SUBTOTAL			$	9,227,110		$	1,819,100	$	11,046,210
	TOTAL CONSTRUCTION COST			$	36,581,820		$	6,042,100	$	42,623,920
01	LANDS AND DAMAGES									
	Acquire Permanent Levee Easements	25.3 AC	50,000	$	1,265,000	15.00%	$	189,800	$	1,454,800
	Severance Damage - Levee Easements	55 AC	19,091	$	1,050,000	15.00%	$	157,500	$	1,207,500
	Acquire Fee Simple interest for Mitigation	11 AC	10,100	$	111,100	15.00%	$	16,700	$	127,800
	Acquire Temporary Work Area Easements	9.7 AC	8,010	$	77,700	15.00%	$	11,700	$	89,400
	SUBTOTAL			$	2,503,800		$	375,700	$	2,879,500
	Administrative cost of acquisition	1 LS	370,000	$	370,000	15.00%	$	55,500	$	425,500
	TOTAL LANDS AND DAMAGES			$	2,873,800		$	431,200	$	3,305,000
30	ENGINEERING & DESIGN									
	Flood damage reduction			$	2,641,250	10.00%	$	264,100	$	2,905,400
	Mitigation			$	977,500	10.00%	$	97,800	$	1,075,300
	SUBTOTAL			$	3,618,750		$	361,900	$	3,980,650
31	CONSTRUCTION MANAGEMENT			$	2,970,000	15.00%	$	445,500	$	3,415,500
	TOTAL PROJECT FIRST COST			$	46,044,370		$	7,280,700	$	53,325,070

TABLE C-1A
Total First Cost

South River Environmental Restoration

Account Code	Description	QTY	UOM	Unit Price		Amount	% Cont'g		Cont'g Amt		Total
06	FISH AND WILDLIFE FACILITIES										
	Surveying	1	LS	182,100	$	182,100	20.00%	$	36,400	$	218,500
	Mobilization & Demobilization	1	LS	75,000	$	75,000	20.00%	$	15,000	$	90,000
	Site Access	1	LS	10,045,800	$	10,045,800	20.00%	$	2,009,200	$	12,055,000
	Site preparation	1	LS	6,415,500	$	6,415,500	20.00%	$	1,283,100	$	7,698,600
	Excavation for Marsh Creation	1	LS	6,988,900	$	6,988,900	20.00%	$	1,397,800	$	8,386,700
	Planting	1	LS	2,894,500	$	2,894,500	20.00%	$	578,900	$	3,473,400
	Erosion Control	1	LS	1,600,000	$	1,600,000	20.00%	$	320,000	$	1,920,000
	Adaptive Management	1	LS	1,000,000	$	1,000,000	0.00%			$	1,000,000
	Monitoring	1	LS	292,600	$	292,600	20.00%	$	58,500	$	351,100
	TOTAL CONSTRUCTION COST				$	29,494,400		$	5,698,900	$	35,193,300
01	LANDS AND DAMAGES										
	Acquiring Fee Simple interest to restore lost/degraded Phragmites wetlands	435.65	ACR	10,100	$	4,400,000	15.00%	$	660,000	$	5,060,000
	Administrative cost of acquisition	1	LS	660,000	$	660,000	NA	$	100,000	$	760,000
	SUBTOTAL				$	5,060,000		$	760,000	$	5,820,000
30	ENGINEERING & DESIGN										
	Engineering & Design	1	LS	2,520,000	$	2,520,000	10.00%	$	252,000	$	2,772,000
31	CONSTRUCTION MANAGEMENT				$	2,360,000	15.00%	$	354,000	$	2,714,000
	TOTAL PROJECT FIRST COST				$	39,434,400		$	7,064,900	$	46,499,300

Table C-2

*** TOTAL FEDERAL COST-SHARED SUMMARIES ***

This Estimate is based on the scope contained in the Feasibility Report dated April 2002

Project: South River Flood Control Project

Location: Raritan River Basin, NJ

District: New York
POC: P Harimohan

		Current MCACES Estimate Prepared: September 2002				..............Fully Funded Estimate.............				
		Effective Pricing Level: October 2001				Feature Mid Point:				
Acct. No.	Feature Description	Cost ($K)	Cont. ($K)	Cont. (%)	Total ($K)	%	Date	Cost ($K)	Cont. ($K)	Total ($K)
06	Fish & Wildlife	2,387.6	477.7	20%	$2,865	30.17%	Jan-08	3107.8	621.8	3,729.6
11	Levees & Floodwalls	21,308.1	3,196.2	15%	$24,504	30.17%	Jan-08	27735.8	4,160.3	31,896.1
13	Pumping Plant	3,659.0	549.1	15%	$4,208	30.17%	Jan-08	4762.8	714.7	5,477.5
15	Floodway Diversion Structures	9,227.1	1,819.1	20%	$11,046	30.17%	Jan-08	12010.5	2,367.8	14,378.3
	Total	36,581.8	6,042.1		42,623.9			47616.9	7,864.7	55,481.6
01---	Lands & Damages	2,873.8	431.2	15%	3,305.0	28.70%	Jan-06	3698.6	555.0	4,253.5
30---	Engineering & Design	3,618.8	361.9	10%	3,980.7	28.70%	Jan-06	4657.3	465.8	5,123.1
31---	Construction Management	2,970.0	445.5	15%	3,415.5	40.20%	Jan-08	4163.9	624.6	4,788.5
	Total Federal Cost Summary	46,044.4	7,280.7		53,325.1			60,136.7	9,510.0	69,646.8

Note: Inflation was developed using EC11-2-181 dtd 31 Mar 2001

Total Federal Costs($K): 45,270.4
Total Non-Federal Costs($K): 24,376.4

Table C-2A

*** TOTAL FEDERAL COST-SHARED SUMMARIES ***

This Estimate is based on the scope contained in the Feasibility Report dated April 2002

Project: Environmental Restoration

Location: Raritan River Basin, NJ

District: New York

POC: P Harimohan

		Current MCACES Estimate Prepared: September 2002				...............Fully Funded Estimate.............				
		Effective Pricing Level: October 2001				Feature Mid Point:				
Acct. No.	Feature Description	Cost ($K)	Cont. ($K)	Cont. (%)	Total ($K)	CWCCIS %	Date	Cost ($K)	Cont. ($K)	Total ($K)
06	Fish & Wildlife	29,494.4	5,698.9	19%	$35,193	30.17%	Jan-08	38392.9	7,418.3	45,811.1
	Total	29,494.4	5,698.9		35,193.3			38392.9	7,418.3	45,811.1
01---	Lands & Damages	5,060.0	760.0	15%	5,820.0	28.70%	Jan-06	6512.2	978.1	7,490.3
30---	Engineering & Design	2,520.0	252.0	10%	2,772.0	28.70%	Jan-06	3243.2	324.3	3,567.6
31---	Construction Management	2,360.0	354.0	15%	2,714.0	40.20%	Jan-08	3308.7	496.3	3,805.0
	Total Federal Cost Summary	39,434.4	7,064.9		46,499.3			51,457.0	9,217.0	60,674.1

Note: Inflation was developed using EC11-2-181 dtd 31 Mar 2001 (including location and inflation factors), the sector gate cost for South River is computed to be $8,700,000 or $108,500/ft.x80 ft. clear opening. This cost is based on a linear interpolation using the cost/ft. and height differentials of the two sample gates. This relationship applies due to the fact that the height differentials of the two sample gates and the South River gate are roughly proportional. If the South River gate height was substantially higher than the 35.5 ft. height, i.e. roughly 40 ft. or more, this relationship would not apply and a cost /sq. ft. analysis, not a cost/linear ft. would have been more suitable.

Table C-3 South River, N.J. Multipurpose Study
Storm Gate Cost - Based on Larouse Sector Gate, Grande Isle, La.
and Algiers Sector Gate, New Orleans, La.

	Larouse Gate	Algiers Gate
	(56' Wide X 20' High)	(125' Wide X 27.5' High)
Bid/CWE Amount (Pertinent Items)	$3,107,000 (1983 P.L.)	$10,730,000 (2000 P.L.)
Unit Price per linear foot	$55,482	$85,840
Time Adjustment (To 10/2001 P.L)	$29,405 (53%)	$1,717 (2%)
Location Adjustment (20%)	$16,978	$17,511
Adjusted Unit Price per linear foot	$101,865	$105,074
Estimated Cost of South River Gate		
South River 35.5 ft. high gate size (linear ft)		80
Price/ft. (Incl. 1.2 location and time adjustment to 2001)		$108,500**
South River Gate Cost		$8,700,000

** $108,500 is based on the adjusted increase of gate cost/linear ft. due to a higher gate; this adjustment is a linear interpolation using the cost and height differentials of the two sample gates,
i.e. $101,865 + ($105,074 - $101,865)x(15.5/7.5) = $108,500

The detailed design of the sector gate will be accomplished in the Preconstruction, Engineering & Design Phase (EDR Report).

C31. **Interior Drainage**. Work classified as Interior Drainage consists of drainage inlets, pipes and manholes, and sluice and flap gates necessary to permit drainage from areas behind levees and floodwalls to drain to the exterior side of the line of protection. This work will generally be done just prior, during, or concurrent with construction of the levees and floodwalls. Interior drainage design incorporated into the storm barrier across South River includes the pump station (see next paragraph) and 5 slide gate concrete chambers (each 10'x10') to prevent surge flow whereby gates could be opened only to allow interior water to drain out when surge levels are lower.

C32. Pump Station. A pump station, provided to alleviate any interior drainage accumulation behind the line of protection during gate closure, is enclosed within the storm barrier walls west of the sector gate. Included are three 400-cfs submersible propeller pumps. These are direct drive, diesel powered units with no electrical backup required, since electrical back up power is not readily available in the barrier area. The pump station chamber is pile-supported. Included in the pump station are a trash rack and rake, slide gates fronting the forced suction intake lines, pump motors and drive gears, an overhead crane for pump placement and servicing, decking and concrete masonry units (CMU) with steel truss roof super structures at the level of the pump motors, and outlet pipe.

C33. The storm surge barrier construction will include (a) the installation of timber piling for support of the pump chambers, sector gate structure and drainage outlet structures, (b) the installation of vinyl sheeting to act as a cofferdam for the construction of the pump station, sector gates and drainage structures, and (c) cast-in-place reinforced concrete wall interfacing the vinyl sheeting for the pump station and drainage structure.

C 34. **Drainage Swale Excavation.** This is excavation necessary to provide a paved ditch along the toe of the protected side of the levee to direct interior runoff to the outlet pipes and structures. It is assumed that most of the material from this excavation (90%) is suitable for further use. Approximately 10% must be hauled from the site and disposed of.

Estimates of Additional Costs

C35. **Engineering and Design**. Costs were developed for all activities associated with the engineering and design effort. These costs include the preparation of an Engineering Documentation Report (EDR) for interior drainage, gate design and wall design. Also included is pre-construction monitoring, plans and specifications, and engineering support through project construction.

C36. **Construction Management**. Costs were developed for all construction management activities from pre-award requirements through final contract closeout. This cost was based on approximately 8% of the direct construction cost based on previous experience with similar type construction projects.

C37. **Interest During Construction**. Interest during construction (IDC) is the cost of study (PED) and construction money invested before the beginning of the period of economic benefit. IDC costs have been added to the project cost to determine the investment costs. Average annual costs were determined based on investment costs which include IDC. Interest during construction was considered for a 48-month construction period at 6-1/8% after a PED phase of 24 months.

Annual Charges for Storm Damage Reduction

Period of Analysis

C38. It is estimated that the major features of the project consisting of levees, floodwalls, closure structures, storm gates, and pump stations would have a useful life expectancy of 50 years.

Interest and Amortization

C39. The interest rate used in converting investment costs to equivalent annual costs is the rate set by the Water Resources Council for the evaluation of Federal Government water resources projects. This rate has been set at 6-1/8% for FY2001.

C40. Amortization is the financial or economic process of recovering an investment in a project. For this project this period is 50 years. The amortization period is the period of time assumed or selected for economic recovery of the net investment in a project. When combined, interest and amortization become the capital recovery factor which, when applied to project costs, will result in the annual cost of the project investment.

C41. **Rehabilitation.** Because the recommended plan is a 500 year level of protection, design excedance and the major rehabilitation of project elements from design excedance are therefore negligible and not included.

Operation & Maintenance, and Replacement

C42. Charges attributed to the operation and maintenance (O&M) of the flood control project consist of annualized replacement costs, repair anticipated energy charges, and labor charges for the care and cleaning of project facilities at the storm barrier. Project components requiring routine care include; the storm gate, levees and floodwalls, interior drainage facilities including the pump station.

C43. The major mechanical equipment items within the storm gate and the interior drainage pump station have anticipated life expectancies of 25 to 30 years. The cost of periodic equipment replacement has been estimated, annualized over the 50-year period of analysis and incorporated into the interior drainage O&M charge. In addition, electric power requirements based on the anticipated frequency of pump station and storm gate operation have been added to the project annual operation charge.

Annual Costs

C44. **Annual Costs.** The annual charges include the annualized first cost with interest during construction, as well as annual operations and maintenance costs of the storm damage protection/mitigation and ecosystem restoration.

C45. A summary of annual costs is presented in Table C-4 & C-4A

TABLE C-4 - RECOMMENDED PLAN TOTAL ANNUAL COST South River, Raritan River, NJ Multipurpose Study LEVEE/FLOODWALL ELEVATION 21.5	
Total First Cost	$53,325,050
Interest During Construction (a)	$7,741,768
Total Investment Cost	$61,066,818
Annualized Investment Cost (b)	$3,942,106
Annual Levee/Floodwall Maintenance (c)	$34,000
Interior Drainage O&M	$18,250
Annual Equipment Replacement Cost	$88,500
Pump Station O&M	$28,750
Sector Gate O&M	$40,000
Mitigation Maintenance	$12,000
Subtotal O&M	$221,500
Total Annual Cost	$4,163,606

TABLE C-4A - RECOMMENDED PLAN TOTAL ANNUAL COST South River, Raritan River, NJ Multipurpose Study Environmental Restoration	
Total First Cost	$46,499,300
Interest During Construction (a)	$6,598,379
Total Investment Cost	$53,097,679
Annualized Investment Cost (b)	$3,427,667
Restoration O&M	$80,000
Total Annual Cost	$3,507,667

(a) For all funds expended from PED thru construction at i = 6 1/8%
(b) For 50-year period of analysis
(c) Based on $2.75/l.f.

National Environmental Restoration Plan (NER)

C46. **Basis of Cost For Selecting the NER Plan.** Costs for restoration activities were estimated as part of the planning phase for the purpose of determining Project feasibility, and to provide a means of comparing proposed restoration options. For each of the 16 restoration scenarios (*i.e.*, four Restoration Areas by four scales of restoration (25, 50, 75, and 100%)), implementation costs were calculated based on estimates of real estate, mobilization/demobilization, site access, construction, site preparation and excavation, disposal, planting, erosion and sediment control, and monitoring costs. The following describes the derivation of cost estimates used in the calculation of costs.

- Real estate acquisition costs were estimated based on a site assessment performed by the District.

- Surveying included the costs associated with surveying the area prior to commencement of restoration activities.

- Site access costs included consideration of the location of proposed restoration activities and the means of accessing these sites. Restoration Areas 1 – 3 are located on the Island, with no existing point of access, and will require special equipment to conduct restoration activities. Construction of a temporary bridge on the western side of the Island was determined to be the most cost-effective means of accessing the Island (Table C-6). Restoration in Area 4 is on the mainland and will not require special site access considerations. Site access costs also included the cost of road construction for movement within the wetland, including the crossing of tidal creeks. The number of small and large tidal creek crossings was based on the cover type map and a visual assessment of aerial photographs. Cost calculations for each restoration scenario were based on the number of creeks identified in that area.

- Site preparation included the costs associated with the removal of *Phragmites* and the restoration of wetland and upland forest/scrub-shrub habitats. The assumption was made that *Phragmites* removal will entail excavation and offsite disposal of 1 foot of thatch material over the entire Project area. Relative elevation differences between community types were based on the results of the *South River Plant Community Elevation Report*. Also, these costs included onsite hauling and grading activities associated with the restoration of wetland forest/scrub-shrub and upland forest/scrub-shrub habitat.

- Excavation included the costs associated with the restoration of low emergent marsh, intertidal mudflat, tidal creek, and tidal pond habitats, ditch improvements, and offsite hauling and disposal fees. Relative elevation differences between community types were used to estimate excavation depths. Offsite hauling and disposal fees will be applied to those scenarios for which there is more excavated material than will be used in the creation of wetland and upland forest/scrub-shrub habitats. In some scenarios, all the excavated material will be used onsite, and no offsite hauling and disposal costs will be applied to these scenarios. For these scenarios, onsite hauling costs will apply (see site preparation). Because excavated material is not projected to be of the correct size, density, and consistency for use as fill material for the flood control portion of the Project, excess material must be disposed of at an approved location.

- Planting included costs associated with establishing the targeted habitat types.

- Mobilization and demobilization costs were the lump sum costs associated with the initiation and cessation of activities at the site, including obtaining and transporting equipment, and the break down of temporary site features and equipment upon completion of the Project (*i.e.,* bridges, access roads, staging areas).

- Erosion and sediment control costs were estimated at 6% of total construction costs.

- The USACE standard for monitoring costs is 1% of the total Project cost.

C47. The timing of construction should be coordinated with the flood control portion of the Project. Restoration activities should be completed prior to construction of levees and floodwalls in areas where flood control and restoration activities overlap.

C48. Costs were subjected to independent QA/QC by the District's Engineering Department to ensure that line item cost estimates used in the calculation of costs were accurate based on the available data. In addition, data entry for costs, number of small and large creeks, and cost calculations, were subjected to internal QA/QC by the South River Team.

C49. **Basis of Cost For Constructing the NER Plan.**

A final construction cost breakdown for the NER Plan shows that approximately 379.3 acres of wetland *Phragmites* would be converted to the targeted habitat types for a total first cost of $44.2 million (Table C-1A). The average annual cost for the NER Plan would be $3.34 million per year during the 50-year Project life.

The District recognizes that there may be some cost differences associated with the actual construction of the NER Plan. For example, using more excavated material in the restoration of upland forest/scrub-shrub habitat could decrease or eliminate disposal costs. For modeling purposes, the depth of material needed to create upland islands was estimated at 4 ft above the wetland *Phragmites* elevation, but could be increased to accommodate more of the excavated material. In addition, cost savings could be achieved through concurrent implementation of the NER Plan with proposed flood control measures.

South River Flood Control
Storm Damage Protection and
Environmental Mitigation
Town of Sayerville
Middlesex County, NJ

Designed By: USA COE NY District/URS Corp
Estimated By: P.Harimohan

Prepared By: P. Harimohan
Checked by: JChew

Preparation Date: 04/19/02
Effective Date of Pricing: 10/01/01

Sales Tax: 0.00%

LABOR ID: SO[illegible] EQUIP ID: SOURIV Currency [illegible]LLARS CREW ID: SOURIV U[illegible] UP01EA

This estimate contains the total first cost of the Recommended Plan for flood damamge protection and ecosystem restoration along the banks of the South River in the Raritan River Basin, particularly in the Townships of Sayreville and South River in Middlesex County, NJ.

The cost estimate for storm damage reduction is comprised of four (4) individual construction elements, namely, (1) Levees & Floodwalls for the Eastern & Western Segments of the line of protection, (2) Interior Drainage Facilities (pump station , gravity drains, and diversion pipes, (3) Flood Control Barrier (storm surge barrier with sector gate, and bulkheads), and (4) Fish & Wildlife Facilities (wetlands mitigation). Ecosysytem Restoration is presented in a separate cost estimate. Costs are at October 2001 price level.

SUMMARY REPORTS — SUMMARY PAGE

DETAILED ESTIMATE — DETAIL PAGE

No Backup Reports...

* * * END TABLE OF CONTENTS * * *

Fri 06 Sep 2002
Eff. Date 10/01/01

Tri-Service Automated Cost Engineering System (TRACES)
PROJECT SOURIV: South River Flood Control - Storm Damage Protection and
Draft Feasibility CWE
** PROJECT OWNER SUMMARY - Contract (Rounded to 100's) **

TIME 08:58:48
SUMMARY PAGE 1

		QUANTY UOM	CONTRACT	CONTINGN	ESCALATN	TOTAL COST	UNIT
01	Lands and Damages		2,873,800	431,100	0	3,304,900	
06	Fish and Wildlife Facilities		2,387,500	477,500	0	2,865,000	
11	Levees and Floodwalls		21,307,900	3,196,200	0	24,504,100	
13	1200 CFS Pumping Plant		3,659,000	548,900	0	4,207,900	
15	Fldway Ctrl/Diversion Structure		9,227,000	1,819,100	0	11,046,100	
30	Planning, Engineering and Design		3,617,800	361,800	0	3,979,500	
31	Construction Management		2,970,000	445,500	0	3,415,500	
TOTAL	South River Flood Control		46,043,000	7,279,900	0	53,322,900	

LABOR ID: SO[illegible] EQUIP ID: SOURIV Currency [illegible]LARS CREW ID: SOURIV U[illegible] UP01EA

Tri-Service Automated Cost Engineering System (TRACES)
PROJECT SOURIV: South River Flood Control - Storm Damage Protection and Draft Feasibility CWE
** PROJECT OWNER SUMMARY - Feature (Rounded to 100's) **

	QUANTY UOM	CONTRACT	CONTINGN	ESCALATN	TOTAL COST	UNIT
01 Lands and Damages						
01_25 Acquiring Easements		2,873,800	431,100	0	3,304,900	
TOTAL Lands and Damages		2,873,800	431,100	0	3,304,900	
06 Fish and Wildlife Facilities						
06_02 Surveying		7,700	1,500	0	9,200	
06_03 Site Accessing		185,100	37,000	0	222,200	
06_04 Site Preparation		297,300	59,500	0	356,800	
06_05 Levee Improvements	7.00 ACR	620,900	124,200	0	745,100	106442
06_07 Excavation for Marsh Creation	9.51 ACR	879,800	176,000	0	1,055,700	111013
06_08 Planting	11.10 ACR	133,800	26,800	0	160,500	14460
06_10 Erosion & Sediment Control		133,900	26,800	0	160,700	
06_15 Monitoring		22,300	4,500	0	26,800	
06_20 Mobilization & Demobilization		106,800	21,400	0	128,100	
TOTAL Fish and Wildlife Facilities		2,387,500	477,500	0	2,865,000	
11 Levees and Floodwalls						
11_01 Mob/Demob		150,000	22,500	0	172,500	
11_05 Floodwalls	1655.00 LF	2,742,900	411,400	0	3,154,300	1905.94
11_10 Levees	10712 LF	15,344,500	2,301,700	0	17,646,200	1647.33
11_15 Interior Drainage		3,070,500	460,600	0	3,531,100	
TOTAL Levees and Floodwalls		21,307,900	3,196,200	0	24,504,100	
13 1200 CFS Pumping Plant						
13_10 1200CFS Pumping Plant		3,659,000	548,900	0	4,207,900	
TOTAL 1200 CFS Pumping Plant		3,659,000	548,900	0	4,207,900	
15 Fldway Ctrl/Diversion Structure						
15_05 Barriers		212,000	31,800	0	243,800	
15_10 Bulkhead		315,000	47,300	0	362,300	
15_15 Sector Gate		8,700,000	1,740,000	0	10,440,000	
TOTAL Fldway Ctrl/Diversion Structure		9,227,000	1,819,100	0	11,046,100	
30 Planning, Engineering and Design		3,617,800	361,800	0	3,979,500	
31 Construction Management		2,970,000	445,500	0	3,415,500	

Fri 06 Sep 2002 | Tri-Service Automated Cost Engineering System (TRACES) | TIME 08:58:48
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** PROJECT OWNER SUMMARY - Feature (Rounded to 100's) **

	QUANTY UOM	CONTRACT	CONTINGN	ESCALATN	TOTAL COST	UNIT
TOTAL South River Flood Control		46,043,000	7,279,900	0	53,322,900	

LABOR ID: SOU[illegible] EQUIP ID: SOURIV   Currency [illegible]LARS   CREW ID: SOURIV U[illegible] UP01EA

	QUANTY UOM	CONTRACT	CONTINGN	ESCALATN	TOTAL COST	UNIT
01 Lands and Damages						
01_25 Acquiring Easements		2,873,800	431,100	0	3,304,900	
TOTAL Lands and Damages		2,873,800	431,100	0	3,304,900	
06 Fish and Wildlife Facilities						
06_02 Surveying		7,700	1,500	0	9,200	
06_03 Site Accessing		185,100	37,000	0	222,200	
06_04 Site Preparation		297,300	59,500	0	356,800	
06_05 Levee Improvements	7.00 ACR	620,900	124,200	0	745,100	106442
06_07 Excavation for Marsh Creation	9.51 ACR	879,800	176,000	0	1,055,700	111013
06_08 Planting	11.10 ACR	133,800	26,800	0	160,500	14460
06_10 Erosion & Sediment Control		133,900	26,800	0	160,700	
06_15 Monitoring		22,300	4,500	0	26,800	
06_20 Mobilization & Demobilization		106,800	21,400	0	128,100	
TOTAL Fish and Wildlife Facilities		2,387,500	477,500	0	2,865,000	
11 Levees and Floodwalls						
11_01 Mob/Demob		150,000	22,500	0	172,500	
11_05 Floodwalls	1655.00 LF	2,742,900	411,400	0	3,154,300	1905.94
11_10 Levees	10712 LF	15,344,500	2,301,700	0	17,646,200	1647.33
11_15 Interior Drainage						
11_15.01 East Segment - Minimum Facility		422,900	63,400	0	486,300	
11_15.02 East Segment - 100CFS Diversion		411,400	61,700	0	473,200	
11_15.03 West Segment - Minimum Facility		734,000	110,100	0	844,000	
11_15.04 Main Channel - Minimum Facility		1,502,200	225,300	0	1,727,600	
TOTAL Interior Drainage		3,070,500	460,600	0	3,531,100	
TOTAL Levees and Floodwalls		21,307,900	3,196,200	0	24,504,100	
13 1200 CFS Pumping Plant						
13_10 1200CFS Pumping Plant		3,659,000	548,900	0	4,207,900	
TOTAL 1200 CFS Pumping Plant		3,659,000	548,900	0	4,207,900	
15 Fldway Ctrl/Diversion Structure						
15_05 Barriers		212,000	31,800	0	243,800	

Fri 06 Sep 2002
Eff. Date 10/01/01

Tri-Service Automated Cost Engineering System (TRACES)
PROJECT SOURIV: South River Flood Control - Storm Damage Protection and
Draft Feasibility CWE
** PROJECT OWNER SUMMARY - Sub Feat (Rounded to 100's) **

TIME 08:58:48
SUMMARY PAGE 5

	QUANTY UOM	CONTRACT	CONTINGN	ESCALATN	TOTAL COST	UNIT
15_10 Bulkhead		315,000	47,300	0	362,300	
15_15 Sector Gate		8,700,000	1,740,000	0	10,440,000	
TOTAL Fldway Ctrl/Diversion Structure		9,227,000	1,819,100	0	11,046,100	
30 Planning, Engineering and Design		3,617,800	361,800	0	3,979,500	
31 Construction Management		2,970,000	445,500	0	3,415,500	
TOTAL South River Flood Control		46,043,000	7,279,900	0	53,322,900	

LABOR ID: SO[illegible] EQUIP ID: SOURIV Currency [illegible]LLARS CREW ID: SOURIV U[illegible] UP01EA

South River Environmental
Restoration

Designed By: USA COE NY District/URS Corp
Estimated By: P.Harimohan

Prepared By: P. Harimohan
Checked by: John Chew

Preparation Date: 09/05/02
Effective Date of Pricing: 10/01/01
Est Construction Time: 1460 Days

Sales Tax: 0.00%

Currency [illegible]LARS

LABOR ID: SO[illegible] EQUIP ID: SOURIV

CREW ID: SOURIV U[illegible] UP01EA

This estimate contains the total first cost of the Recommended Plan for Ecosystem Restoration along the banks of the South River in the Raritan River Basin, particularly in the Townships of Sayreville and South River in Middlesex County, NJ. The work is assumed to be performed by a enviromental restoration general contractor. Costs at October 2001 price level and were developed by the A/E Northern Ecological Assocs as shown in the attached attached cost estimate back up. Various contingency percentages are assigned to the cost of each project feature consistent with its level of design and quantity development. Unit costs include overhead and profit.

LABOR ID: SO[illegible] EQUIP ID: SOURIV Currency [illegible]LLARS CREW ID: SOURIV U[illegible] UP01EA

SUMMARY REPORTS — SUMMARY PAGE

DETAILED ESTIMATE — DETAIL PAGE

No Backup Reports...

* * * END TABLE OF CONTENTS * * *

** CONTRACTOR SETTINGS **

		AMOUNT	PCT	PCT S	RISK	DIFF	SIZE	PERIOD	INVEST	ASSIST	SUBCON
BB Prime Contractor											
Prime Contractor's Field Overhead	P		0.00								
Prime's Home Office Expense	P		0.00								
Prime Contractor's Profit	P		10.00								
Prime Contractor's Bond	P		0.00								

Fri 06 Sep 2002
Eff. Date 10/01/01

Tri-Service Automated Cost Engineering System (TRACES)
PROJECT SOURI2: South River Environmental - Restoration

TIME 14:07:56

SUMMARY PAGE 1

** PROJECT OWNER SUMMARY - Contract (Rounded to 100's) **

	QUANTY UOM	CONTRACT	CONTINGN	ESCALATN	TOTAL COST	UNIT
01 Lands & Damages		5,060,100	760,000	0	5,820,100	
06 Fish & Wildlife		29,494,300	5,898,900	0	35,393,200	
30 Engineering & Design		2,520,000	252,000	0	2,772,000	
31 Construction Management		2,360,000	354,000	0	2,714,000	
TOTAL South River Environmental		39,434,400	7,264,900	0	46,699,200	

LABOR ID: SOU EQUIP ID: SOURIV Currency LLARS CREW ID: SOURIV U UP01EA

Fri 06 Sep 2002
Eff. Date 10/01/01

Tri-Service Automated Cost Engineering System (TRACES)
PROJECT SOURI2: South River Environmental - Restoration

TIME 14:07:56

SUMMARY PAGE 2

** PROJECT OWNER SUMMARY - Feature (Rounded to 100's) **

	QUANTY UOM	CONTRACT	CONTINGN	ESCALATN	TOTAL COST	UNIT
01 Lands & Damages						
01_05 Real Estate Acquisition Area 1/4		4,400,100	660,000	0	5,060,100	
01_06 Acquisition Administration Cost		660,000	100,000	0	760,000	
TOTAL Lands & Damages		5,060,100	760,000	0	5,820,100	
06 Fish & Wildlife						
06_02 Surveying		182,100	36,400	0	218,500	
06_03 Site Access		10,045,800	2,009,200	0	12,054,900	
06_04 Site Preparation		6,415,500	1,283,100	0	7,698,500	
06_05 Excavation for Marsh Creation		6,988,900	1,397,800	0	8,386,700	
06_06 Planting		2,894,500	578,900	0	3,473,400	
06_07 Mobilization & Demobilization		75,000	15,000	0	90,000	
06_08 Erosion & Sediment Control		1,600,000	320,000	0	1,920,000	
06_09 Monitoring		292,600	58,500	0	351,100	
06_10 Adaptive Management		1,000,000	200,000	0	1,200,000	
TOTAL Fish & Wildlife		29,494,300	5,898,900	0	35,393,200	
30 Engineering & Design						
30_01 Environmental Restoration E & D		2,520,000	252,000	0	2,772,000	
TOTAL Engineering & Design		2,520,000	252,000	0	2,772,000	
31 Construction Management						
31_01 Construction Management		2,360,000	354,000	0	2,714,000	
TOTAL Construction Management		2,360,000	354,000	0	2,714,000	
TOTAL South River Environmental		39,434,400	7,264,900	0	46,699,200	

LABOR ID: SOU EQUIP ID: SOURIV   Currency ...LLARS   CREW ID: SOURIV   U... UP01EA

** PROJECT OWNER SUMMARY - Sub Feat (Rounded to 100's) **

	QUANTY UOM	CONTRACT	CONTINGN	ESCALATN	TOTAL COST	UNIT
01 Lands & Damages						
01_05 Real Estate Acquisition Area 1/4		4,400,100	660,000	0	5,060,100	
01_06 Acquisition Administration Cost		660,000	100,000	0	760,000	
TOTAL Lands & Damages		5,060,100	760,000	0	5,820,100	
06 Fish & Wildlife						
06_02 Surveying		182,100	36,400	0	218,500	
TOTAL Surveying		182,100	36,400	0	218,500	
06_03 Site Access						
06_03.05 Site Accessing Area 1 to 4		10,045,800	2,009,200	0	12,054,900	
TOTAL Site Access		10,045,800	2,009,200	0	12,054,900	
06_04 Site Preparation						
06_04.05 Site Preparation Area 1 to 4		6,415,500	1,283,100	0	7,698,500	
TOTAL Site Preparation		6,415,500	1,283,100	0	7,698,500	
06_05 Excavation for Marsh Creation						
06_05.05 Excavation, Marsh Creation A1/A4		6,988,900	1,397,800	0	8,386,700	
TOTAL Excavation for Marsh Creation		6,988,900	1,397,800	0	8,386,700	
06_06 Planting						
06_06.05 Planting Area 1 to 4		2,894,500	578,900	0	3,473,400	
TOTAL Planting		2,894,500	578,900	0	3,473,400	
06_07 Mobilization & Demobilization						
06_07.01 Mobilization & Demobilization A1		75,000	15,000	0	90,000	
TOTAL Mobilization & Demobilization		75,000	15,000	0	90,000	

Fri 06 Sep 2002
Eff. Date 10/01/01

Tri-Service Automated Cost Engineering System (TRACES)
PROJECT SOURI2: South River Environmental - Restoration

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SUMMARY PAGE 4

** PROJECT OWNER SUMMARY - Sub Feat (Rounded to 100's) **

	QUANTY UOM	CONTRACT	CONTINGN	ESCALATN	TOTAL COST	UNIT
06_08 Erosion & Sediment Control						
06_08.05 Erosion & Sediment Control A1/A4		1,600,000	320,000	0	1,920,000	
TOTAL Erosion & Sediment Control		1,600,000	320,000	0	1,920,000	
06_09 Monitoring						
06_09.05 Monitoring Area 1 to Area 4		292,600	58,500	0	351,100	
TOTAL Monitoring		292,600	58,500	0	351,100	
06_10 Adaptive Management		1,000,000	200,000	0	1,200,000	
TOTAL Fish & Wildlife		29,494,300	5,898,900	0	35,393,200	
30 Engineering & Design						
30_01 Environmental Restoration E & D		2,520,000	252,000	0	2,772,000	
TOTAL Engineering & Design		2,520,000	252,000	0	2,772,000	
31 Construction Management						
31_01 Construction Management		2,360,000	354,000	0	2,714,000	
TOTAL Construction Management		2,360,000	354,000	0	2,714,000	
TOTAL South River Environmental		39,434,400	7,264,900	0	46,699,200	

LABOR ID: SOUF EQUIP ID: SOURIV Currency [illegible]LARS CREW ID: SOURIV U[illegible]: UP01EA

SOUTH RIVER RARITAN RIVER BASIN

HURRICANE AND STORM DAMAGE REDUCTION
AND
ECOSYSTEM RESTORATION

VOLUME 3

APPENDICES D THROUGH H

SEPTEMBER 2002

APPENDIX D

ENVIRONMENTAL COMPLIANCE AND COORDINATION

Appendix D

Federal register notices and distribution list

Responses to comments received on the draft integrated feasibility report and environmental impact statement

Section 404(b)1 guidelines evaluation

Coastal Zone Management Evaluation

Essential Fish Habitat Assessment

United State's Fish and Wildlife Service's final and draft 2(b) report

Pertinent correspondence

FEDERAL REGISTER NOTICES

AND

DISTRIBUTION LIST

[Federal Register: July 8, 1998 (Volume 63, Number 130)]
[Notices]
[Page 36888]
From the Federal Register Online via GPO Access [wais.access.gpo.gov]
[DOCID:fr08jy98-58]

DEPARTMENT OF DEFENSE

Department of the Army, **Corps of Engineers**

Intent To Prepare a Draft Environmental Impact Statement (DEIS) for the South River, Raritan River Basin, Combined Flood Control and Environmental Restoration Project, Middlesex County, New Jersey

AGENCY: U.S. Army **Corps of Engineers**, DoD.

ACTION: Notice of intent.

SUMMARY: The New York District of the U.S. Army **Corps of Engineers** (**Corps**) is preparing a Draft Environmental Impact Statement (DEIS) for **proposed** measures to provide flood control protection and environmental restoration in the South River, Raritan River Basin, New Jersey. For this Notice of Intent, the **Corps** is considering protection measures to reduce damages caused by flooding and coastal storms. The EIS will be prepared according to the U.S. Army **Corps** of **Engineers** procedures for implementing the National Environmental Policy Act of 1969, as amended, (NEPA), 42 U.S.C. 4332(2)(C), and consistent with the U.S. Army **Corps** of Engineer's policy to facilitate public understanding and scrutiny of agency proposals. This notice of intent is published as required by the President's Council on Environmental Quality **regulations** implementing the provisions of NEPA, 40 CFR Parts 1500-1508.

FOR FURTHER INFORMATION CONTACT: Questions regarding the action can be addressed to Mark H. Burlas, Project Environmental Manager, phone (212) 264-4663, U.S. Army **Corps of Engineers**, New York District, Planning Division, 26 Federal Plaza New York, New York 10278-0090.

SUPPLEMENTARY INFORMATION:

1. Authorization

This study is authorized by a U.S. House of Representatives resolution dated May 13, 1993. The reconnaissance report, completed in May 1995, identified a potential plan of improvement that consists of two levees, each approximately 10,000 feet long along opposite banks of the South River. The levees would protect the communities of South River and Sayerville from a 100-year flood.

For environmental restoration, we identified a plan of improvement to restore the quality of the salt marsh near the Washington Canal. The plan would involve the replacement of low quality vegetation in 250 acres of wetlands to restore an important habitat.

2. Location of the **Proposed** Action

This study area is located within the lower Raritan River Basin in Middlesex County, New Jersey. The South River is the first major tributary of the Raritan River, located approximately 8.3 miles upstream of the Raritan River's mouth at the Raritan Bay.

The South River is formed by the confluence of Matchaponix and Manalapan Brooks, just above Duhernal Lake, and flows northward from Duhernal Lake Dam for a distance of approximately seven miles, at which point it splits into the old South River and the Washington Canal. It flows through the Townships of East Brunswick and Old Bridge, and the Boroughs of South River and Sayerville.

3. Reasonable Alternative Actions

In addition to the ``No Action'' alternative, the flood control component of the feasibility study will evaluate alternatives such as buy-outs, storm gates and flood walls to avoid and minimize impacts to coastal wetlands, as well as various levee layouts and heights. The environmental restoration component will analyze alternatives to restore degraded coastal marshes and tidal ecosystems.

4. Significant Issues Requiring In-Depth Analysis

1. Coastal Wetlands Impacts; 2. Impacts to Aquatic Resources; 3. Archaeological and Cultural Resources Impacts; 4. Hydrology Impacts; 5. Economic Impacts.

5. Environmental Review and Consultation

Review will be conducted as outlined in the Council on Environmental Quality regulations dated November 29, 1983 (40 CFR Parts 1500-1508) and U.S. Army Corps of Engineer regulation ER 200-2-2 dated March 4, 1988.

6. Public Scoping Meeting

A public scoping meeting is tentatively scheduled for July 16, 1998, at the South River Public Library, (55 Appleby Avenue, South River, New Jersey 08816) from 5:30 p.m. to 8:00 p.m.

7. Estimated Date of DEIS Availability

February 2000.
Gregory D. Showalter,
Army Federal Register Liaison Officer.
[FR Doc. 98-18027 Filed 7-7-98; 8:45 am]
BILLING CODE 3710-06-M

[Federal Register: June 7, 2002 (Volume 67, Number 110)]
[Notices]
[Page 39366-39368]
From the Federal Register Online via GPO Access [wais.access.gpo.gov]
[DOCID:fr07jn02-60]

DEPARTMENT OF DEFENSE

Department of the Army, Corps of Engineers

Availability of the Draft Environmental Impact Statement for the South River, Raritan River Basin, Hurricane and Storm Damage Reduction and Ecosystem Restoration Study

AGENCY: Department of the Army, U.S. Army Corps of Engineers, DoD.

ACTION: Notice of availability.

SUMMARY: The New York District of the U.S. Army Corps of Engineers (Corps) has prepared a Draft Environmental Impact Statement (DEIS) for the South River, Raritan River Basin Raritan, Hurricane and Storm Damage Reduction and Ecosystem Restoration Study. The purpose of the study is to identify a plan that would protect the South River, Sayerville and Woodbridge communities from damages caused by hurricanes and storms, and restore degraded habitats in the South River. The DEIS was prepared to evaluate those alternatives identified in the Feasibility Report.

DATES: The DEIS will be available for public review when this announcement is published. The review period of the document will be until July 22, 2002. To request a copy of the DEIS please call (212) 264-4663.

FOR FURTHER INFORMATION CONTACT: For further information regarding the DEIS, please contact Mark Burlas, Project Wildlife Biologist, telephone (212) 264-4663, Planning Division, ATTN: CENAN-PL-EA, Corps of Engineers, New York District, 26 Federal Plaza, New York, New York, 10278-0090.

SUPPLEMENTARY INFORMATION: 1. The South River, Raritan River Basin, Hurricane and Storm Damage Reduction and Ecosystem Restoration Feasibility Study was authorized by resolution of the U.S. House of Representatives Committee on Public Works and Transportation and adopted May 13, 1993. The resolution states that: Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, that, the Secretary of the Army, acting through the Chief of Engineers, is requested to review the report of the Chief of Engineers, titled Basinwide Water Resources Development Report on the Raritan River Basin, New Jersey, published as House Document 53, Seventy-first Congress, Second Session, and other pertinent reports, to determine whether modifications of the recommendations contained therein are advisable at the present time in the interest of flood control and related purposes on the South River, New Jersey.

2. The South River, Raritan River Basin, Hurricane and Storm Damage Reduction and Ecosystem Restoration Feasibility Study has been

conducted by the Corps with the non-Federal project partner, the New Jersey Department of Environmental Protection (NJDEP). The study area initially included the entire South River basin. The South River is the first major tributary of the Raritan River, located approximately 8.3 miles upstream of the Raritan River's mouth at Raritan Bay. The South River is formed by the confluence of the Matchaponix and Manalapan Brooks, just above Duhernal Lake, and flows northward from Duhernal Lake a distance of approximately 7 miles, at which point it splits into two branches, the Old South River and the Washington Canal. Both branches flow northward into the Raritan River. The South River is tidally controlled from its mouth upstream to Duhernal Lake Dam; fluvial conditions prevail above the dam. Based on coordination with NJDEP, County and local governments, it was determined that there are no widespread flooding problems in the South River watershed upstream of the Duhernal Lake dam. Consequently, the study area was modified, focusing on river reaches below the dam, specifically flood-prone areas within the Boroughs of South River and Sayreville, the Township of Old Bridge, and the Historic Village of Old Bridge (located within the Township of East Brunswick). The downstream river reaches encompass virtually all the flood-prone structures in the watershed and the areas of greatest ecological degradation (and greatest potential for ecosystem restoration).

3. Periodic hurricanes and storms have caused severe flooding along the South River. Flood damages downstream of Duhernal Lake are primarily due to storm surges with additional damages associated with basin runoff. The communities repeatedly affected by storm surges are the Boroughs of South River and Sayreville, the Township of Old Bridge, and the Historic Village of Old Bridge in East Brunswick Township. There are approximately 1,247 structures (1,082 residential; 165 commercial) in the 100-year floodplains of these communities and 1,597 structures in the 500-year floodplains (1,399 residential; 198 commercial). Storm surges create the greatest damages in the study area occurring during hurricanes and northeasters that generate sustained onshore winds through multiple tidal cycles. For example, the northeaster of March 1993 (a 25-year event) resulted in approximately $17 million damage (2001 dollars) and closed the highway bridge connecting the Boroughs of South River and Sayreville.

4. The area under consideration for ecosystem restoration encompasses 1,278 acres along the Old South River and the Washington Canal and includes the 380-acre Clancy Island bounded by these waterways and by the Raritan River. Wetland plant communities account for 786 acres (61 percent) of the study area land cover. Uplands account for the remaining 492 acres, of which 234 acres are occupied by residential, commercial, and industrial development. These wetlands and uplands are ecologically degraded. Approximately 527 acres (41 percent of the study area) are dominated by monotypic stands of common reed (Phragmites australis). Other wetland communities are scattered around the site in a patchwork of fragmented parcels. The uplands are dominated by low quality scrub-shrub land cover. The current degraded ecological conditions appear to be the result of: (1) Construction and maintenance dredging associated with the Federal navigation channels in the South River,

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Washington Canal, and Raritan River and (2) clay excavation and industrial activity associated with the defunct Sayreville brick industry.

5. Plan formulation for hurricane and storm damage reduction along the South River considered a full range of structural and nonstructural

measures. Alternative plans that survived the initial screening of alternatives included: (1) A storm surge barrier at the confluences of the South River and Washington Canal with the raritan River, (2) multiple levee and floodwall configurations, and (3) buy-out of flood-prone properties. Further investigation determined that the storm surge barrier alternative at the confluence of the Washington Canal and the Raritan River was not economically feasible and that there would be significant adverse environmental effects on study area wetlands. It was also determined that acquisition of structures in the flood plains was not economically feasible. In contrast, preliminary analysis indicated that the levee and floodwall protection of flood-prone properties in the study area was found to be economically and technically feasible.

6. More detailed analysis indicated that levees and floodwalls along the eastern and western banks of the lower South River would be economically justified and would have minimal effects on study area wetlands. It was also determined that structural protection of upstream reaches would not be economically justified. A storm surge barrier (different location than previously described), located just downstream (north) of the Veterans Memorial Bridge, was subsequently evaluated in combination with levees/floodwalls in the lower reaches. The barrier was found to be an economically feasible means to protect upstream reaches. In addition, it would: (1) Minimize environmental impacts on wetlands, (2) avoid potential Hazardous Toxic Radioactive Waste (HTRW) sites upstream, and (3) preclude the need for nonstructural protection in upstream communities by providing comprehensive storm surge protection.

7. Economic analysis of the hurricane and storm reduction plans indicated that the levee/floodwall system with upstream storm surge barrier would result in the greatest net benefits. Subsequent optimization of this plan determined that a 500-year level of protection would provided the greatest net benefits. Consequently, the levee/floodwall system with upstream storm surge barriers providing a 500-year level of protection was designated as the National Economic Development (NED) plan and was selected as the recommended plan. Using a combination of levees, floodwalls, and a storm surge barriers, structural protection will extend to an elevation of +21.5 feet NGVD. The levees will extend 10,712 feet in length, and the floodwalls will extend 1,655 feet in length. The storm surge barrier will span the South River for a length of 320 feet and will have a clear opening of 80 feet. It is anticipated that the first costs of the selected hurricane and storm reduction plan will be approximately $62.5 million with average annual costs estimated at $4.3 million. With an average annual benefits estimated at $9.1 million, the average annual net benefits associated with the selected hurricane and storm reduction plan will be approximately $4.8 million. The selected hurrican and storm reduction plan is expected to have a benefit-cost ratio of 2.1 to one.

Even though the selected hurricane and storm damage reduction plan was specifically designed to avoid and minimize environmental impacts, there were some unavoidable impacts to the natural resources in the South River. Based on a Habitat Evaluation Procedures (HEP) study and an Evaluation of Planned Wetlands (EPW) assessment, the selected NED plan will result in a loss of 1.07 Average Annual Habitat Units (AAHUs) and 20.74 Functional Capacity Units (FCUs). Consequently, to offset these impacts it was determined that the mitigation goal will replace at least 100% of the combined loss of AAHUs summed across evaluation species and FCUs summed across wetland functions, and at least 50% (agreed upon by HEP Team) of the loss of AAHUs per evaluation species and FCSs lost per function, as a result of implementation of the selected hurricane and storm damage reduction measures.

8. To achieve the mitigation goal, a screening analysis was conducted to evaluate the feasibility of improving the available habitat on the proposed levee (e.g., plant shrubs to improve songbird habitat); improving the existing habitats (e.g., increase the density/cover of the vegetation by planting more shrubs and/or herbaceous species); and, converting one habitat/cover type to another more valuable habitat (e.g., covert areas of Phragmites to salt marsh or wetland scrub-shrub).

9. Based on an analysis of the acreages, costs, benefits, and incremental cost/output for each of these plans it was determined that Mitigation Alternative 2 had ecological outputs that were worth its associated costs. The selected mitigation plan will fulfill the mitigation goal and will involve the conversion of 11.1 acres of degraded wetland Phragmites and disturbed habitat to a combination of wetland scrub-shrub (7.8 acres) and salt marsh (3.3 acres). This plan is estimated to cost $2,865,300 and is included in the hurricane and storm damage reduction cost provided earlier.

10. Plan formulation for ecosystem restoration considered a wide variety of restoration measures to address opportunities associated with ecosystem restoration along the South River. Restoration goals and objectives were specified early in the plan formulation process. Restoring biodiversity and ecological functioning were established as the restoration goals; the restoration objectives included: restoring habitat for threatened and endangered species, increasing site biodiversity, increasing tidal flushing, reducing Phragmites, improving water quality, and stabilizing and protecting desirable wetland habitat. After a preliminary restoration screening process that the assessed ecological benefits and engineering constraints of eleven different alternatives, four priority habitats were chosen for ecological restoration of the study area: low emergent marsh, intertidal mudflat, wetland forest scrub-shrub, and open water (i.e., tidal creeks and tidal ponds). Using different proportions of each habitat, more than 250 potential mathematical combinations of these habitats were evaluated.

11. These combinations were then applied to four potential restoration areas delineated in the study area using four different scales of restoration for degraded acreage in each area: 25 percent, 50 percent, 75 percent, and 100 percent. Cost effectiveness and incremental cost analysis was applied to the resultant 40,000 potential restoration plans, resulting in identification of eight ``best buy'' restoration plans for the study area. These plans represent the most efficient means to achieve ecosystem restoration in the study area. Based upon the incremental analysis and the ability of the alternative plans to achieve the restoration planning goals and objectives, one of the Best Buy plans was selected as the National Ecosystem Restoration (NER) plan.

12. The NER plan will restore 100 percent of the 379 acres of degraded wetlands in the potential restoration areas. The NER plan will restore the following habitats: low emergent marsh (151 acres: 40 percent), wetland forest/scrub-shrub (170 acres: 45 percent; plus an additional 19 acres, or 5 percent, as upland forest/scrub-shrub), mudflat (19 acres: 5 percent), and open water (19

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acres: 5 percent). It is expected that implementation of the NER plan will cost approximately $50.6 million with an average annual cost of approximately $3.3 million.

13. The costs of project implementation for the hurricane and storm

damage reduction features and ecosystem restoration features will be shared by the Federal government and the non-Federal project partner (NJDEP) on a 65 percent/35 percent basis. All operations and maintenance costs will be borne by the non-Federal project partner. For the hurricane and storm damage reduction features, the project implementation costs will be shared as follows: $40,608,700 Federal and $21,866,200 non-Federal with annual O&M costs of $221,500 (non-Federal). This includes mitigation costs associated with the implementation of these features ($2,865,300 total with $1,862,400 Federal and $1,002,900 non-Federal). For the ecosystem restoration features, the project implementation costs $50,552,800 million will be shared with $32,859,300 Federal and $17,693,500 non-Federal with O&M costs of $80,000 (non-Federal).

14. Potential beneficial cumulative impacts to migratory waterfowl and songbirds are likely to result from implementation of the selected mitigation and ecosystem restoration plans. These plans, in conjunction with similar projects in the South River watershed, should increase the overall ecological value of the area. Specifically, the mitigation and restoration plans will add large areas of more desirable wetland communities and increase the study area's biodiversity (i.e., improve the areas composition and abundance of plant and animal species).

15. The construction and maintenance of both the hurricane and storm damage reduction measures and the ecosystem restoration measures will not negatively impact any Federally or state listed endangered or threatened species, areas of designated critical habitat, or essential fish habitat. By providing increased cover and opportunities for foraging and nesting, the selected plans will also improve habitat for the Federally listed threatened bald eagle thought to utilize habitats in the general vicinity, and for many of the State of New Jersey endangered and threatened species observed in the restoration area (e.g., black skimmer, northern harrier, peregine falcon, yellow-crowned night heron, osprey, black-crowned night heron, and American bittern).

16. In sum, the recommended plan will efficiently reduce hurricane and storm damages along the South River and improve the structure and function of degraded ecosystems in the study area. The non-Federal project partner, NJDEP, has indicated its support for the recommended plan and is willing to enter into a Project Cooperation Agreement with the Federal Government for the implementation of the plan. At this time, there are no known major areas of controversy or unresolved issues regarding the study and selected plan among agencies or the public interest.

Len Houston,
Chief, Environmental Analysis Branch.
[FR Doc. **02-14226 Filed** 6-6-02; 8:45 am]
BILLING CODE 3710-06-M

[Federal Register: [redacted]02 (Volume 67, Number 169)]
[Notices]
[Page 55823-55824]
From the Federal R[redacted] via GPO Access [wais.access.gpo.gov]
[DOCID:fr30au02-83[redacted]

DEPARTMENT OF DEF[redacted]

Department of the [redacted] Engineers

Comment Period Ext[redacted] Draft Environmental Impact Statement for the [redacted] Raritan River Basin, Hurricane and Storm Damage Reduction [redacted] Restoration Study, Middlesex County, NJ

AGENCY: Departmen[redacted] U.S. Army Corps of Engineers, DoD.

ACTION: Notice; [redacted] extension.

SUMMARY: By Federa[redacted]tice of June 7, 2002 (67 FR 39366) the New York District [redacted] Army Corps of Engineers (Corps) announced the availability [redacted]nvironmental

[[Page 55824]]

Impact Statement [redacted] South River, Raritan River Basin, Hurricane and Sto[redacted]ction and Ecosystem Restoration Study. The purpose of th[redacted] identify a plan that would protect local communities from d[redacted] by hurricanes and storms, and restore degraded ecosystem[redacted] function in the South River watershed.

In response to[redacted] increase the public notice comment period, the Corps [redacted]ropriate to extend the comment period for an additional 45 d[redacted]e 22 July 2002 date previously in effect. All intere[redacted] are notified that the comment period of this public notic[redacted]xtended until 5 September 2002.

DATES: Written co[redacted] be submitted on or before 5 September 2002.

ADDRESSES: Written[redacted]uld be submitted to Mark Burlas, Project Wildlife Biologist,[redacted]ivision, U.S. Army Corps of Engineers, New York District, [redacted]Plaza, New York, New York 10278-0090.

FOR FURTHER INFORM[redacted]: Mark Burlas, Project Wildlife Biologist, Planning[redacted] U.S. Army Corps of Engineers, New York District, 26 Federa[redacted] York, New York, 10278-0090 at (212) 264-4663.

Luz D. Ortiz,
Army Federal Regis[redacted]fficer.
[FR Doc. 02-22191 [redacted]; 8:45 am]
BILLING CODE 3710-[redacted]

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Section 2. **Agencies**

Section 3. **Easements, Utilities, Railroads**

Section 4. **Interested Parties**

Section 5. **Interested Public**

Section 6. **Property Owners**

1.0 ELECTED OFFICIALS

1.1 FEDERAL OFFICIALS

The Honorable Frank Pallone
US House of Representatives
6th Congressional District
420 Cannon Building
Washington, DC 20515

The Honorable Robert Menendez
US House of Representatives
13th Congressional District
2238 Rayburn Building
Washington, DC 20515

The Honorable Rush Holt
US House of Representatives
12th Congressional District
1630 Longworth Building
Washington, DC 20515

The Honorable Robert Torricelli
US Senate
113 Dirksen Senate Office Bldg
Washington, DC 20515

The Honorable John S. Corzine,
US Senate
One Gateway Center
11th Floor
Newark, NJ 07102

1.2 STATE OFFICIALS

Joseph Azzolina
NJ District 13 Assemblyman
One Arin Park Bldg., Suite 102
1715 Highway 35
Middletown, NJ 07748

Peter J. Barnes
NJ District 18 Assemblyman
1967 Route 27, Suite 20
Edison, NJ 08817

Senator Barbara Buona
NJ District 18
100 Plainfield Ave., Suite 1
Edison, NJ 08817

Upendra J. Chivukula
NJ District 17 Assemblyman
888 Easton Ave.
Somerset, NJ 08873

Patrick J. Diegnan
NJ District 18 Assemblyman
908 Oak Tree Ave., Unit P
South Plainfield, NJ 07080

Joseph V. Egan
NJ District 17 Assemblyman
100 Bayard St.
New Brunswick, NJ 08901

Arline M. Frisca
District 19 Assemblywoman
245 Main St
Woodbridge, NJ 07001

Jerry Green
NJ District 22 Assemblman
17 Watchung Ave.
Plainfield, NJ 07060

Linda R. Greenstein
NJ District 14 Assemblywoman
7 Centre Dr., Suite 2
Monroe, NJ 08831

Gary L. Guear
NJ District 14 Assemblyman
1700 Whitehorse-Hamilton Square Rd
Unit C-4
Hamilton, NJ 08690

Senator Peter Inverso
NJ District 14
3691A Nottingham Way
Hamilton Square, NJ 08690

Senator Joseph M. Kyrillos, Jr.
NJ District 13
1715 Highway 35, Suite 303
Middletown, NJ 07748

Governor James McGreevey
Office of the Governor, State Capitol
West State St.
Trenton, NJ 08625

Senator Bob Smith
NJ District 17
216 Stelton Rd., Suite E-5
Piscataway, NJ 08854

Linda Stender
District 22 Assemblywoman
1801 East Second St., 2nd Floor
Scotch Plains, NJ 07076

Senator Joseph Suliga
NJ District 22
22 North Wood Ave.
Linden, NJ 07036

Samuel D. Thompson
NJ District 13 Assemblyman
725 Highway 34
Matawan, NJ 07747

Senator Joseph F. Vitale
NJ District 19
87 Main St.
Woodbridge, NJ 07095

John S. Wisniewski
NJ District 19 Assemblyman
3145 Bordentown Ave., Suite B
Parlin, NJ 08859

1.3 COUNTY OFFICIALS

Freeholder Jane Z. Brady
County Office
1 John F. Kennedy Sq.
New Brunswick, NJ 08901

David B. Crabiel
Freeholder Director
Directors Office
1 John F. Kennedy Sq.
New Brunswick, NJ 08901

Freeholder Stephen J. Dalina
Deputy Director
Directors Office
1 John F. Kennedy Sq.
New Brunswick, NJ 08901

Freeholder Camille Fernicola
County Office
1 John F. Kennedy Sq.
New Brunswick, NJ 08901

Freeholder H. James Polos
County Office
1 John F. Kennedy Sq.
New Brunswick, NJ 08901

Freeholder John Pulomena
County Office
1 John F. Kennedy Sq.
New Brunswick, NJ 08901

Freeholder Christopher D. Rafano
County Office
1 John F. Kennedy Sq.
New Brunswick, NJ 08901

1.4 LOCAL OFFICIALS

Meryle Asaro
Town Council
One Jean Walling Civic Center
PO Box 1081
East Brunswick, NJ 08816

Phyllis Batko
Town Council
Sayreville Borough Hall
167 Main St.
Sayreville, NJ 08872

Edwin J. Brautman
Town Council
One Jean Walling Civic Center
PO Box 1081
East Brunswick, NJ 08816

Reginald Butler
Town Council
One Old Bridge Plaza
Old Bridge, NJ 08857

Mayor Barbara Cannon
One Old Bridge Plaza
Old Bridge, NJ 08857

Gerald Cucchiara
Town Council
One Old Bridge Plaza
Old Bridge, NJ 08857

Joann Dembinski
Town Council
48 Washington Street
P.O. Box 660
South River, NJ 08882

Saul W. Fink
Town Council
One Jean Walling Civic Center
PO Box 1081
East Brunswick, NJ 08816

Richard J. Greene
Town Council
One Old Bridge Plaza
Old Bridge, NJ 08857

Joseph G. Hoff
Town Council
One Old Bridge Plaza
Old Bridge, NJ 08857

Donald E. Klemp
Town Council
One Jean Walling Civic Center
PO Box 1081
East Brunswick, NJ 08816

Tele Koukourdelis
Town Council
48 Washington Street
P.O. Box 660
South River, NJ 08882

Arthur Londensky
Town Council
48 Washington Street
P.O. Box 660
South River, NJ 08882

Dennis M. Maher
Town Council
One Old Bridge Plaza
Old Bridge, NJ 08857

Frank Makransky
Town Council
Sayreville Borough Hall
167 Main St.
Sayreville, NJ 08872

Thomas Marcinczyk
Town Council
Sayreville Borough Hall
167 Main St.
Sayreville, NJ 08872

Georgette Marinaccio
Town Council
One Old Bridge Plaza
Old Bridge, NJ 08857

Gerald McAtee
Town Council
48 Washington Street
P.O. Box 660
South River, NJ 08882

John J. Melillo
Town Council
Sayreville Borough Hall
167 Main St.
Sayreville, NJ 08872

Mayor William P. Neary
One Jean Walling Civic Center
PO Box 1081
East Brunswick, NJ 08816

Mayor Kennedy O'Brien
Sayreville Borough Hall
167 Main St.
Sayreville, NJ 08872

Thomas Pollando
Town Council
Sayreville Borough Hall
167 Main St.
Sayreville, NJ 08872

Lawrence J. Redmond
Town Council
One Old Bridge Plaza
Old Bridge, NJ 08857

Rich Riechenbach
Town Council
48 Washington Street
P.O. Box 660
South River, NJ 08882

Jeffrey K. Simon
Town Council
One Jean Walling Civic Center
PO Box 1081
East Brunswick, NJ 08816

David A. Sliker
Town Council
48 Washington Street
P.O. Box 660
South River, NJ 08882

Roman N. Sohor
Town Council
One Old Bridge Plaza
Old Bridge, NJ 08857

Mayor Robert P. Szegeti
48 Washington Street
P.O. Box 660
South River, NJ 08882

Edward Testino
Town Council
One Old Bridge Plaza
Old Bridge, NJ 08857

Vincent Zarcaro
Town Council
Sayreville Borough Hall
167 Main St.
Sayreville, NJ 08872

2.0 AGENCIES

2.1 Federal Agencies

First Coast Guard District, Director
U.S. Coast Guard
Governors Island, Bldg. 135A
New York, NY 10040

Robert Dieterich
U.S. EPA Region II
Strategic Planning & Multimedia Programs
New York, NY 10007

Karen Greene
Habitat and Protected Resources Division
National Marine Fisheries Service
Sandy Hook Biological Laboratory
Highlands, NJ 07732

Gerad Hertel
U.S. Department of Agriculture
Forest Service
5 Radnor Corporate Ctr., Suite 200
Radnor, PA 19087

[illegible]ke Ludwig
National Marine Fisheries Service
U.S. Department of Commerce
212 Rogers Avenue
Milford, CT 06460

U.S. Maritime Administration
26 Federal Plaza
New York, NY 10278

Diane Rusanowski
National Marine Fisheries Service
U.S. Department of Commerce
212 Rogers Avenue
Milford, CT 06460

J. Sidoti Anton
Federal Energy Regulation Commission
19 West 34th Street, Suite 400

John Dunnigan, Director
Atlantic States Marine Fisheries Com.
1444 Eye Street, NW
6th Floor
Washington, DC 20005

Allen Jackson
U.S. Fish & Wildlife Service
927 N. Main Street
Bldg. D 1
Pleasantville, NJ 08232

Thomas Kane
Fed. Emergency Mgmt. Agency
Region 2
26 Federal Plaza
New York, NY 10278

Victoria Martinez
Federal Hwy. Administration
840 Bear Tavern Road
Suite 310
Trenton, NJ 08628

L. Grady Moore, District Chief
U.S. Geological Survey
425 Jordan Road
Troy, NY 12180
New York, NY 10278

Anthony Ward, Executive Coordinator
Military Ocean Terminal
Bayonne, NJ 07002

Clifford Day
U.S. Fish & Wildlife Svc.
927 N. Main Street
Bldg. D 1
Pleasantville, NJ 08232

Stanley Gorski
Habitat and Protected Resources Division
National Marine Fisheries Service
Sandy Hook Biological Laboratory
Highlands, NJ 07732

Robert Hargrove, Chief
U.S. EPA
Strategic Planning & Multimedia
Prgms. Branch
Region II
New York, NY 10007

Don Kilma, Director
Advisory Council on Historic Preservatior
The Old Post Office Bldg.
1100 Pennsylvania Ave., NW #809
Washington, DC 20004

Thomas McDowell
Robert McKeon
U.S. Fish & Wildlife Service
927 N. Main Street
Building D1
Pleasantville, NJ 08232

Joe Piccianio, Division Chief
Federal Emergency Mgmt.
Agency
Region 2
26 Federal Plaza
New York, NY 10278

Leigh Skaggs
Institute for Water Resources
7701 Telegraph Road, Casey Bldg
Alexandria, VA 22315

2.2 State Agencies

William Connolly, Jr.
State of New Jersey
P.O. Box 800
Trenton, NJ 08625

Ruth Ehinger, Bureau Chief
NJ DEP
501 E. State Street, CN401
Trenton, NJ 08625

Andrew Fekete
1035 Parkway Avenue
P.O. Box 600
Trenton, NJ 08625

Howard Golub, Acting Director
311 West 43rd Street
Suite 201
New York, NY 10036

Lonna R. Hooks
State House
CN300
Trenton, NJ 08625

Jane Kenny, Commissioner
101 S. Broad Street
CN800
Trenton, NJ 08625

James Mumman, Administrator
401 E. State Street
CN409
Trenton, NJ 08625

Frank McDonough, Director
State of New Jersey
P.O. Box 820
Trenton, NJ 08625

Bernie Moore, Administrator
NJ DEP
1510 Hooper Avenue
Toms River, NJ 09753

Lawrence Schmidt, Director
NJ DEP
P.O. Box 418
Trenton, NJ 98625

Joel Piccohilo
NJ DEP
P.O. Box 418
Trenton, NJ 98625

Robert Piel
NJ DEP
P.O. Box 401
Trenton, NJ 08625

William E. Ward, Chief
50 W. State Street
2nd Fl., CN229
Trenton, NJ 08625

Robert C. Shinn Jr.
NJ DEP
401 E. State Street, CN402
Trenton, NJ 08625

Herbert Simmens, Director
Dept. of the Treasury
33 W. State St., CN204
Trenton, NJ 08625

Chris Dolphin
NJ DEP
501 E. State Street, CN401
Trenton, NJ 08625

Wes Whaler
State of New Jersey
P.O. Box 5050
Woodbridge, NJ 07095

John Yencik
Dept. of Labor & Industry
P.O. Box V
Trenton, NJ 08625

2.3 COUNTY AGENCIES

Richard Fitamant
Edgeboro Landfill
P.O. Box 159
Sayreville, NJ 08872

Ralph Albanir, Director
Middlesex Co. Parks Dept.
1030 River Road
Piscataway, NJ 08854

Jay Cornell
CME Associates
3141 Bordentown Avenue
Parlin, NJ 08859

Barbara Quinlin
Middlesex Co. Utilities Authority
Main Street Extension
Sayreville, NJ 08872

William Kruse, Director
Middlesex Co. Planning &
Open Space
40 Livingston Avenue
New Brunswick, NJ 08903

Ray Naperkowski
Building Dept.
48 Washington Ave.
South River, NJ 08882

Rod Schmid, Director
Mosquito Exchange Commission
200 Parsonage Road
Edison, NJ 08837

John Reiser
County Road Dept.
P.O. Box 1248
New Brunswick, NJ 08903

George Ververdies, Director
Middlesex Co. Planning Bd.
40 Livingston Avenue
New Brunswick, NJ 08903

2.4 LOCAL AGENCIES

Elizabeth H. Kiss
Town Clerk
Borough of East Brunswick
East Brunswick, NJ 08816

[illegible]in Jolly
Municipal Building
[illegible] Main Street
Sayreville, NJ 08872

Nelson Iglesias
Engineering Dept.
Village of Old Bridge
1 Old Bridge Plaza
Old Bridge, NJ 08857

Richard Reichenbach
Engineering Dept.
Borough of South River
48 Washington Street
South River, NJ 08882

Charles Krlakowski
Sewage Authority
Borough of South River
[illegible] Whitehead Avenue
South River, NJ 08882

Lawrence Riccio
Borough of East Brunswick
25 Harts Lane
East Brunswick, NJ 08816

Albert Seaman
Borough Clerk
Borough of South River
33 Gordon Street
South River, NJ 08882

Gladys R. Rzepka
Borough Clerk
Borough of Sayreville
[illegible] Main Street
Sayreville, NJ 08872

Rosemary Saracino
Town Clerk
Village of Old Bridge
1 Old Bridge Plaza
Old Bridge, NJ 67876

3.0 EASMENTS, UTILITIES, RAILROADS

ıickey Bucci
PSG & E
80 Park Plaza
Newark, NJ 07102

Daniel Jacobs
Conrail Rail Road
405 Division Street
Elizabeth, NJ 07201

James A. Shissias
GPU Genco Energy
River Rd. Generating Station
Sayreville, NJ 08872

Dieter Wolf
AT&T
4260 US Hwy. 1
Monmouth Jct., NJ 08852

4.0 INTERESTED PARTIES

American Littoral Society
Sandy Hook
Building # 18
Highlands, NJ 07732

Asbury Park Press
Attn: Todd Bates
3601 Highway 66, PO Box 1550
Neptune, NJ 07754

Association of NJ Environmental Commissions
300 Mendham Rd., PO Box 157
Mendham, NJ 07945

Baymen's Protective Association
Attn: Dennis Kavanaugh
8 Bay Street
Rumson, NJ 07718

Blikshteyn Alexander & Marina
21 Dorchester Drive
East Brunswick, NJ 08816

Clean Action Ocean
PO Box 505
Highlands, NJ 07732

Dangelo Louis & Marina
409 McDowell Drive
Sayreville, NJ 08872

East Brunswick Library
2 Civic Center Drive
East Brunswick, NJ 08816

Garden State Audubon Council
c/o 325 South Shore Road
Absecon, NJ 08201

Goldberg Alexander & Marina
268 Palombi Court
East Brunswick, NJ 08816

Historic Village of Old Bridge Community Group, Inc.
Attn: Sharon Chodak
c/o 28 Kossman Street
East Brunswick, NJ 08816

Home News Tribune
Attn: Editor
PO Box 1049
East Brunswick, NJ 08816

Hudson River Foundation
40 West 20th Street, 9th Floor
New York, NY 10011

Jersey Shore Audubon Society
c/o 1916 Kenilworth Court
Toms River, NJ 08753

Manomet Bird Observatory
Kathrine Parsons, Ph.D.
PO Box 1770
Manomet, MA 02345

Middletown Township Env.
1 Kings Highway
Middletown, NJ 07748

Middletown Township
Parks & Recreation Department Commission
Leonardville Road
Leonardo, NJ

Monmouth County
Friends of Clearwater
PO Box 303
Redbank, NJ 07701

NJ Alliance for Action
PO Box 6438
Raritan Plaza II
Edison, NJ 08818

New Jersey Audubon Society
Headquarters & Lorrimer Sanctuary
PO Box 125, 790 Ewing Street
Franklin Lakes, NJ 07417

NJ Conservation Foundation
125 Weber Avenue
Morristown, NJ 07748

NJ Environmental Federation
Shore Office
808 Belmar Plaza
Belmar, NJ 07719

NJ Public Interest Research Group (NJPIRG)
119 Somerset Street
New Brunswick, NJ 08901

NJ Sea Grant Marine Advisory Service
c/o Institute of Marine & Coastal
Cook College, PO Box 231
New Brunswick, NJ 08903

NJ Water Environment Federation
44 Wesleyan Drive
Trenton, NJ 08690

Old Bridge Township Library
1 Old Bridge Plaza # 1
Old Bridge, NJ 08857

Sayreville Free Public Library
1050 Washington Road
Parlin, NJ 08859

Spector Leonid & Marina
300 Mendham Road
East Brunswick, NJ 08816

Trust for Public Land
NJ Field Office
1095 Mount Kemble Ave., 2nd Fl.
Morristown, NJ 07960

WNJB-Ch. 58, CNN777
Attn: William Jobes
25 S. Stockton Street
Trenton, NJ 08611

NJ Baykeeper
American Littoral Society
Sandy Hook, Bldg. # 18
Highlands, NJ 07732

River's End Marina
Attn: Mrs. Sullivan
John Street
Old Bridge, NJ 08857

South River Boat Club
Attn: Mr. Ken Wallace
Whitehead Avenue
South River, NJ 08882

The Home News & Tribune
Attn: Theresa Klink
P.O. Box 1049
East Brunswick, NJ 08816

WCTC (AM)/WMGQ (FM)
Attn: Bruce Johnson
P.O. Box 100, Broadcast Ctr.
New Brunswick, NJ 08903

WNJU-Ch. 47
Attn: Ricardo Alvarez
Industraial Avenue
Teterboro, NJ 07608

WVPH (FM) Radio
Attn: News Editor
100 Belmer Road
Piscataway, NJ 08854

Old Bridge Historic Pres. Com.
Attn: Richard Kujawinski
311 Amboy Road
Matawan, NJ 07747

Save Our Bay Foundation
Mercedes & Jim Kelly
50 Washington Avenue
Keansburg, NJ 07734

South River Library
55 Appleby Avenue
South River, NJ 08882

The Star-Ledger
Attn: Jim Willse, Editor
1 Star-Ledger Plaza
Newark, NJ 07102

WHSE-TV Ch. 68
Attn: Barry Diller
390 W. Market Street
Newark, NJ 07107

WRSU-FM Radio
Attn: Karen Krausse
126 College Avenue
New Brunswick, NJ 08903

5.0 INTERESTED PUBLIC

Ashok Mantri
78 Weber Avenue
Sayreville, NJ 08872

Michael P. Clancy
43 Virginia Street
South River, NJ 08882

Julia Miklaszewski
35 Charles Street
Old Bridge, NJ 08857

Laurence F. Gates
66 Weber Avenue
Sayreville, NJ 08872

S. Meloni
53 Kamm Avenue
South River, NJ 08882

John Falzone
114 Causeway Street
South River, NJ 08882

John S. Wisniewski
NJ District 18 Assemblyman
3145 Bordentown Avenue
Parlin, NJ 08859

Susan Luczu
42 River Road
East Brunswick, NJ 08816

John M. Fetsko
12 River Road
East Brunswick, NJ 08816

Sheila M. Sowa
35 Charles Street
Old Bridge, NJ 08857

6.0 PROPERTY OWNERS

(Includes South River, Sayreville, Old Bridge, and East Brunswick)

Louise Abeyta
Or Current Resident
33 Patton Dr.
Sayreville, NJ 08872

[illegible]. Garrucho & A. Taipina
Or Current Resident
[illegible] LeRoy Street
South River, NJ 08882

Sabry R. & Mary N. Abdel-Malak
Or Current Resident
2 Button Wood Drive
Old Bridge, NJ 08857

Victor & Belmira Abru
Or Current Resident
56 Levinson Avenue
South River, NJ 08882

Edward & Joyce Abrams
Or Current Resident
[illegible] June Street
South River, NJ 08882

Edward & Joyce Abrams
Or Current Resident
2 June Street
South River, NJ 08882

Laura Adomunas
Or Current Resident
7 Gavel Road
Sayreville, NJ 08872

[illegible] V. Adamca
Or Current Resident
[illegible] Main Street
South River, NJ 08882

Stanislawa Adamecwicz
Or Current Resident
35 Furman Avenue
Sayreville, NJ 08872

John J. & Lillian Albecker
Or Current Resident
14 North Street
Spotswood, NJ 08884

Emmanuel & Cathy Ann Agostini
Or Current Resident
77 Major Drive
Sayreville, NJ 08872

Alexander & Annamaria Ahapow
Or Current Resident
32 Eisenhower Dr.
Sayreville, NJ 08872

Allan G. & Barbara A. Alessi Jr.
Or Current Resident
39 Patton Dr.
Sayreville, NJ 08872

Joseph & Loretta Albin
Or Current Resident
[illegible] Mac Arthur Avenue
Sayreville, NJ 08872

Raimundo & Dalia Aleman
Or Current Resident
46 Major Drive
Sayreville, NJ 08872

Richard Mazyck Allen
Or Current Resident
82 Canal Street
Sayreville, NJ 08872

Jose & Maria Algaba
Or Current Resident
[illegible] E. Adison Avenue
Collingswood, NJ 08108

Cynthia T. Allen
Or Current Resident
15 Vandeventer Court
Sayreville, NJ 08872

Ludmilla Altuchow
Or Current Resident
PO Box 1463
Arlington, TX 76004

[illegible] M. & Rose A. Almeida
Or Current Resident
4 Levinson Avenue
South River, NJ 08882

Ayo & Tofe Alonge
Or Current Resident
43 Eisenhower Dr.
Sayreville, NJ 08872

Joseph & Carol Sue Ambrosio Jr.
Or Current Resident
4 Ciecko Court
Sayreville, NJ 08872

Oscar & Nancy G. Alvares
Or Current Resident
[illegible] Fort Lee Road
[illegible], NJ 07605

John & Sarah Amarescu
Or Current Resident
24 Major Drive
Sayreville, NJ 08872

Carroll P. Andres
Or Current Resident
8 Wildwood Road
Califon, NJ 07830

Mary Anderson
Or Current Resident
12 Eisenhower Dr.
Sayreville, NJ 08872

Joao C. Andre
Or Current Resident
6 Milton Avenue
South River, NJ 08882

Veronica Antone
Or Current Resident
29 William Street
Old Bridge, NJ 08857

Anna Anka
Or Current Resident
13 George Street
South River, NJ 08882

Dolph Anthony
Or Current Resident
64 Weber Avenue
Sayreville, NJ 08872

J & S. & M. Antoniszyn
Or Current Resident
17 Whitehead Avenue
South River, NJ 08882

Joseph & Michelle Antone
Or Current Resident
29 William Street
Old Bridge, NJ 08857

R.Antonio & Joy P. Antonio
Or Current Resident
90 Canal Street
Sayreville, NJ 08872

Ellen Applegate
Or Current Resident
72 Mac Arthur Avenue
Sayreville, NJ 08872

C. Robert & Jeanette C. Appleby
Or Current Resident
43 Main Street
South River, NJ 08882

Estate Edwina Applegate
Or Current Resident
347 Main Street
Sayreville, NJ 08872

Neil J. & Neusa Ardolino
Or Current Resident
22 Oak Tree Road
Sayreville, NJ 08872

Rosa Araujo
Or Current Resident
61 Jackson Street
South River, NJ 08882

Joseph & Helen Arciszewski
Or Current Resident
18-20 Water Street
South River, NJ 08882

George & Sharon Armhold
Or Current Resident
83 Miller Avenue
Sayreville, NJ 08872

James & Theresa Argiropoulas
Or Current Resident
85 Miller Avenue
Sayreville, NJ 08872

Edgar D. Armagost
Or Current Resident
5 Vandeventer Court
Sayreville, NJ 08872

Lindbergh & Evelyn M. Arzadon
Or Current Resident
8 Forden Court
Sayreville, NJ 08872

Stephanie L. & Christopher Armour
Or Current Resident
37 Kathryn Street
South River, NJ 08882

John A. Armour
Or Current Resident
25 Kathryn Street
South River, NJ 08882

Hristo Avramov
Or Current Resident
8-10 Washington Street
South River, NJ 08882

Victor Athanas & M.K. Kung
Or Current Resident
3916 Potomac Court
Charlotte, NC 28211

Joseph Aurigemma & K. Gragiulo
Or Current Resident
25 Major Drive
Sayreville, NJ 08872

Cynthia Bailey
Or Current Resident
98 Canal Street
Sayreville, NJ 08872

N & Milano P. Bailey
Or Current Resident
128 Franklin Blvd
Somerset, NJ 08873.

George W. & Florence A. Bailey
Or Current Resident
30 Washington Road
Sayreville, NJ 08872

Otis & Rosa Baker
Or Current Resident
11 Kathryn Street
South River, NJ 08882

Thomas E. & Susan L. Baist
Or Current Resident
39 Eisenhower Dr.
Sayreville, NJ 08872

Brian E. Bajkowski
Or Current Resident
9 Forden Court
Sayreville, NJ 08872

Anna Balabas
Or Current Resident
114 Weber Avenue
Sayreville, NJ 08872

Clyde Baker
Or Current Resident
47 David Street
Old Bridge, NJ 08857

Hal & Linda Baker
Or Current Resident
50 Major Drive
Sayreville, NJ 08872

William & Christina Bamsey
Or Current Resident
51 Major Drive
Sayreville, NJ 08872

Lysiuk Balkowski
Or Current Resident
64 Rubin Street
South River, NJ 08882

Mary Balwierczak
Or Current Resident
96 Pitman Avenue
Sayreville, NJ 08872

Ceferino & Jocelyn Baquilod
Or Current Resident
50 Canal Street
Sayreville, NJ 08872

Rose Banach
Or Current Resident
28 Water Street
South River, NJ 08882

Michael & Joyce Banjany
Or Current Resident
18 Major Drive
Sayreville, NJ 08872

John & Mary Ann Barcikowski
Or Current Resident
50-54 Augusta Street
South River, NJ 08882

Vasyl & Anastasia Barabanov
Or Current Resident
62-68 Augusta Street
South River, NJ 08882

Yenkel & Margarita Barbarosh
Or Current Resident
52 Vandeventer Court
Sayreville, NJ 08872

Joan R. Baron
Or Current Resident
22 Eisenhower Dr.
Sayreville, NJ 08872

Maureen A. Barge
Or Current Resident
61-63 Augusta Street
South River, NJ 08882

Carl & Lottie Baron
Or Current Resident
5 Reid Street
South River, NJ 08882

Robert J. & Carolyn G. Barszcz
Or Current Resident
20 Candle Lane
East Brunswick, NJ 08816

M & L. Barry
Or Current Resident
43 New Street
South River, NJ 08882

Michael L. & Lillian C. Barry
Or Current Resident
71 Price Place
South River, NJ 08882

John J. Bartkowicz
Or Current Resident
203 MacArthur Avenue
Sayreville, NJ 08872

Thomas Bartholomew
Or Current Resident
185 Whitehead Avenue
South River, NJ 08882

Robert Bartkowicz
Or Current Resident
3 Canal Street
Sayreville, NJ 08872

Charlotte & Theodore Batko
Or Current Resident
2 Marks Place
South River, NJ 08882

Louis John & Donna Marie Basile
Or Current Resident
21 Major Drive
Sayreville, NJ 08872

Frank, Sandra & Eliza Baszak
Or Current Resident
19 William Street
South River, NJ 08882

Catherine G. Beecham
Or Current Resident
14 Marshall Place
Sayreville, NJ 08872

[redacted] Bauzys
[redacted] Current Resident
[redacted] Henry Street
[redacted] River, NJ [redacted]82

Richard A. & Ellen M. Bednarz
Or Current Resident
85 Weber Avenue
Sayreville, NJ 08872

Alaska Bell
Or Current Resident
42 Kathryn Street
South River, NJ 08882

[redacted] Belenski
[redacted] Current Resident
[redacted] Scott Avenue
[redacted] Amboy, NJ [redacted]879

Cleveland Bell
Or Current Resident
51 Maple Street
South River, NJ 08882

Joseph & Pearl Bellan
Or Current Resident
30 Deerfield Road
Parlin, NJ 08859

[redacted] J. & Susan D. Bell
[redacted] Current Resident
[redacted] Eisenhower Dr.
[redacted], NJ 08872

Kevin D. & Brenda Bell
Or Current Resident
51 Maple Street
South River, NJ 08882

Dessel & Bagen Berg
Or Current Resident
4960 Bordentown Avenue
Old Bridge, NJ 08857

[redacted] & Marlene Bender
[redacted] Current Resident
[redacted]George Street
[redacted] River, NJ 08882

Charles E. & Lois Bentivenga
Or Current Resident
66 Mac Arthur Avenue
Sayreville, NJ 08872

Pauline Bielak
Or Current Resident
259 MacArthur Avenue
Sayreville, NJ 08872

[redacted] M. & Stephanie Bialkowski
[redacted] Current Resident
[redacted] William Street
[redacted] Bridge, NJ 08857

Leon Bielak
Or Current Resident
259 MacArthur Ave
Sayreville, NJ 08872

Roberta & Leola Binns
Or Current Resident
13 William Street
South River, NJ 08882

[redacted] J. Biggins
[redacted] Current Resident
[redacted] Armstrong Avenue
[redacted] River, NJ 08882

Walter Bilicki
Or Current Resident
27 Mac Arthur Avenue
Sayreville, NJ 08872

William E. & Marie A. Blanken
Or Current Resident
65 Mac Arthur Avenue
Sayreville, NJ 08872

[redacted] J. & Lorna B. Bishop
[redacted] Current Resident
[redacted] Oak Tree Road
[redacted], NJ 08872

Henry Bitale
Or Current Resident
2 Spring Street
Matawan, NJ 08882

Barbara Blodin
Or Current Resident
9 Ciecko Court
Sayreville, NJ 08872

[redacted] J. Blaska
[redacted] Current Resident
[redacted] Stephen Street
[redacted] River, NJ 08882

Edward F. & Rose Blaszka
Or Current Resident
PO Box 25
Sayreville, NJ 08872

Theodore Bochenski
Or Current Resident
145 Mac Arthur Avenue
Sayreville, NJ 08872

[redacted] H. & Eleanor Blondin
[redacted] Current Resident
[redacted] Patton Dr.
[redacted], NJ 08872

Douglas R. & Barglow Bobrowski
Or Current Resident
32 Reid Street
South River, NJ 08882

Olga Bohnyak
Or Current Resident
1 Levinson Avenue
South River, NJ 08882

J & J. Bodnar
Or Current Resident
19 June Street
South River, NJ 08882

Robert & Denise Bodnar
Or Current Resident
1 June Street
South River, NJ 08882

Gerald L. Bolinger
Or Current Resident
34 Kathryn Street
South River, NJ 08882

Mara Bojczuk
Or Current Resident
12 Elizabeth Street
South River, NJ 08882

Ronald & Janice Bolanowski
Or Current Resident
20 Washington Road
Sayreville, NJ 08872

D, V. & K. Bongiovi
Or Current Resident
5 Icker Avenue
South River, NJ 08882

Peter & Linda Bomm
Or Current Resident
3 Ciecko Court
Sayreville, NJ 08872

William R. & Mariann A. Bond
Or Current Resident
77 Armstrong Avenue
South River, NJ 08882

Colin E. Bonus
Or Current Resident
37 Leonardine Ave
South River, NJ 08882

Leon S. & Monica Bonkowski
Or Current Resident
93 Mac Arthur Avenue
Sayreville, NJ 08872

Alfred Bonus
Or Current Resident
59 Mac Arthur Avenue
Sayreville, NJ 08872

Casimir F. Borowinski
Or Current Resident
37 Furman Avenue
Sayreville, NJ 08872

Xavery & Ludmila Borisovets
Or Current Resident
28 Herman Street
South River, NJ 08882

Frank J. & Valarie L. Borow
Or Current Resident
545 Main Street
Sayreville, NJ 08872

Houston & Florine W. Boyd
Or Current Resident
69 Bishop Street
New Brunswick, NJ 08901

Alan R. & Jennie F. Borusovic
Or Current Resident
16 Baumer Road
Sayreville, NJ 08872

D. Bosques
Or Current Resident
38 Armstrong Street
South River, NJ 08882

John M. & Rita Brack Jr.
Or Current Resident
29 Vandeventer Court
Sayreville, NJ 08872

Eileen & Marinaccio Boykin
Or Current Resident
97 Prospect Street
South River, NJ 08882

Barbara A. Boyler
Or Current Resident
580 Marlboro Road
Old Bridge, NJ 08857

Veronica Brickman
Or Current Resident
185 Mac Arthur Avenue
Sayreville, NJ 08872

Betty Bradley
Or Current Resident
50 David Street
Old Bridge, NJ 08857

Betty Jean Bradley
Or Current Resident
PO Box 171
South River, NJ 08882

Linda Marie Brow
Or Current Resident
103 McCutcheon Avenue
Sayreville, NJ 08872

Vito & Rosaria Briscese
Or Current Resident
207 Whitehead Avenue
South River, NJ 08882

William & Dorothy Brooks
Or Current Resident
28 Marie Street
South River, NJ 08882

Jacquitter & Armour J. Brown
Or Current Resident
129 Whitehead Avenue
South River, NJ 08882

Thomas M. & Linda A. Brown
Or Current Resident
7 Eisenhower Dr.
Sayreville, NJ 08872

Alice M. Brown
Or Current Resident
3 Forden Court
Sayreville, NJ 08872

Wanda Brustowicz
Or Current Resident
7 Water Street
South River, NJ 08882

Bridgett Brown
Or Current Resident
3 Vandeventer Court
Sayreville, NJ 08872

Donald C. Brown & Deborah Gardner
Or Current Resident
12 Anderson Court
Sayreville, NJ 08872

Stephen & Rose Budney
Or Current Resident
52 Levinsonn Avenue
South River, NJ 08882

Parson & Joseph Bryant
Or Current Resident
9 Little Martin Avenue
South River, NJ 08816

Anthony Bryant & Cynthia Clark
Or Current Resident
94 Canal Stret
Sayreville, NJ 08872

Lester & Jeanette Bukowski
Or Current Resident
79 Miller Avenue
Sayreville, NJ 08872

Stephen J. & Kathryn Budney
Or Current Resident
14 Washington Street
South River, NJ 08882

Alex E. & Mary Ann Budny Jr.
Or Current Resident
24 Weber Avenue
Sayreville, NJ 08872

Robert L. & Gertrude Burke
Or Current Resident
3 Nimitz Place
Sayreville, NJ 08872

Robert D. & June M. Bull
Or Current Resident
11 Samuel Drive
South River, NJ 08882

Romeo Bunag & Salve
Or Current Resident
5 Connors Court
Sayreville, NJ 08872

M. Busto & J. Bustos
Or Current Resident
43 Major Drive
Sayreville, NJ 08872

Richard M.& Ignomirello Burnett
Or Current Resident
12 Washington Road
Sayreville, NJ 08872

Tayseer & Mervat Bustami
Or Current Resident
63 Major Drive
Sayreville, NJ 08872

Moses & Alberta Butts
Or Current Resident
53 Kathryn Street
South River, NJ 08882

Walter & Mary Butkiewicz
Or Current Resident
89 Standiford Avenue
Sayreville, NJ 08872

William C. Butler Jr.
Or Current Resident
391 Main Street
Sayreville, NJ 08872

Sidney Byrd, Jr.
Or Current Resident
17 Kathryn Street
South River, NJ 08882

Sergio & Ola Byczkowski
Or Current Resident
53 Armstrong Avenue
South River, NJ 08882

Sidney & Bridget L. Byrd III
Or Current Resident
12 Marie Street
South River, NJ 08882

Rocco & Wendy Cagno
Or Current Resident
35 George Street
South River, NJ 08882

Charles Jr. & Ann Byron
Or Current Resident
11 George Street
South River, NJ 08882

Manuel & Maria Silva Cacador
Or Current Resident
38 Water Street
South River, NJ 08882

Alexander & Angeline Cappitelli
Or Current Resident
73 Mac Arthur Avenue
Sayreville, NJ 08872

Grace Callahan
Or Current Resident
8 Henry Street
South River, NJ 08882

Philip G. & Joyce A. Cancilla
Or Current Resident
129 Mac Arthur Avenue
Sayreville, NJ 08872

Jose & Clara Carrasco
Or Current Resident
28 Kathryn Street
South River, NJ 08882

Gerald Carchio
Or Current Resident
3 Furman Avenue
Sayreville, NJ 08872

F & J. Harrison Carney
Or Current Resident
13 Anne Street
South River, NJ 08882

John J. & Eileen Casey
Or Current Resident
8 Marshall Place
Sayreville, NJ 08872

Percy W. & Elaine P. Carter
Or Current Resident
131 Whitehead Avenue
South River, NJ 08882

Mary Cartinella
Or Current Resident
7 Miklton Avenue
South River, NJ 08882

Thomas & Mary Ann Cassidy
Or Current Resident
11 Gavel Road
Sayreville, NJ 08872

Katherine Cashman
Or Current Resident
6 Anne Street
South River, NJ 08882

Mario & Maria A. Caspento
Or Current Resident
P.O. Box 86
Spotswood, NJ 08884

Richard F. Catena
Or Current Resident
53 William St
South River, NJ 08882

Thomas A. & Joanne M. Catalano
Or Current Resident
35 Vandeventer Court
Sayreville, NJ 08872

Anthony S. & Christi Catanese
Or Current Resident
28 Avenue J
Jamesburg, NJ 08831

Gerald C. & Carol Ann Cerulli
Or Current Resident
8 Vreeland Court
Sayreville, NJ 08872

G & G, Morris, A. & W. Ladyka, S. Celkupa
Or Current Resident
59 Levinson Avenue
South River, NJ 08882

Michael Cenci
Or Current Resident
23 Canal Street
Sayreville, NJ 08872

FA & ZA Chakra
Or Current Resident
39 Vandeventer Court
Sayreville, NJ 08872

Joseph & Mary Ann Steiner Chadwick
Or Current Resident
39 Foch Street
Sayreville, NJ 08872

J.F & M.A. Steiner Chadwick
Or Current Resident
39 Foch Street
Sayreville, NJ 08872

Louis & Christine Chaney
Or Current Resident
31 Eisenhower Dr.
Sayreville, NJ 08872

Arthur & Emily Chambers
Or Current Resident
10 Nimitz Place
Sayreville, NJ 08872

Charles F.C. & Shui Y.C. Chan
Or Current Resident
78 Major Drive
Sayreville, NJ 08872

Wai Hung & Mabel Chin
Or Current Resident
83 Canal Street
Sayreville, NJ 08872

Wei Xiong & Xiao Hui Chen
Or Current Resident
33 Major Drive
Sayreville, NJ 08872

San Tin Cheng & Mei Ying Ngai
Or Current Resident
74 Canal Street
Sayreville, NJ 08872

Stella Chitren
Or Current Resident
51-53 Mac Arthur Avenue
Sayreville, NJ 08872

Michael & Jill Chiofalo
Or Current Resident
95 Lark Drive
South River, NJ 08882

Elizabeth AKA E.J. Chionchio
Or Current Resident
457 Main Street
Sayreville, NJ 08872

Eddie & Susan Chow
Or Current Resident
22 Cherokee Road
East Brunswick, NJ 08816

Han Sen & Judith Chou
Or Current Resident
85 Canal Street
Sayreville, NJ 08872

Hao Sen & Linda Chou
Or Current Resident
236 Northstevens Avenue
South Amboy, NJ 08879

Yu Yan Chu
Or Current Resident
20 Major Drive
Sayreville, NJ 08872

Vita Christiano
Or Current Resident
116 Causeway
South River, NJ 08882

Leonard P. & L. Remo Chrzaszcz
Or Current Resident
37 Vandeventer Court
Sayreville, NJ 08872

Jose & Deborah Ann Americo
Or Current Resident
27 Adam Blvd.
Brooklyn, NY 11201

Kai Yuen & Ching Chu Chuna
Or Current Resident
12 Oak Tree Road
South Amboy, NJ 08879

Barbara & Joseph Chudkowski
Or Current Resident
2148 Batchelder Street
Sayreville, NJ 08872

Evelyn Church
Or Current Resident
8 Milton Avenue
South River, NJ 08882

Eugenia Z. & Stephen Chunco
Or Current Resident
41 William Street
Old Bridge, NJ 08857

John & Vanco, Elizabeth Chunco
Or Current Resident
52 David Street
Old Bridge, NJ 08857

Sean P. Clarke
Or Current Resident
89 Weber Avenue
Sayreville, NJ 08872

Edward & Anna Cichalski
Or Current Resident
171 Whitehead Avenue
South River, NJ 08882

Gilbert R. & Laura A. Clark
Or Current Resident
208 Pulaski Avenue
Sayreville, NJ 08872

Frances Cohn
Or Current Resident
206 Salem Ct., Apt 1
Princeton, NJ 08540

Shari Claude
Or Current Resident
80 Canal Street
Sayreville, NJ 08872

Jess & Joni, S. Gerardi Cohen
Or Current Resident
31 Heathrow Lane
Old Bridge, NJ 08857

George & Dawn Collins
Or Current Resident
25 Belmont Ave
South River, NJ 08882

Francis & Evenlyn Colalillo
Or Current Resident
37 Jackson Street
South River, NJ 08882

John G. & Kathy Collazo
Or Current Resident
41 Maple St
South River, NJ 08882

Arcadio & Judith Conlon
Or Current Resident
118 Weber Avenue
Sayreville, NJ 08872

Pearl Congleton
c/o B. Hansen
Or Current Resident
7 Dobson Road
Edison, NJ 08817

John F. & Sarah A. Conlon
Or Current Resident
30 Eisenhower Dr.
Sayreville, NJ 08872

Peter J. & Constance J. Conroy
Or Current Resident
13 Vreeland Court
Sayreville, NJ 08872

Dennis S.J. & Kathy Connelly
Or Current Resident
15 Canal Street
Sayreville, NJ 08872

Dorothy Connor
Or Current Resident
45 Maple Street
South River, NJ 08882

Manuel & Maria Lucia Costa
Or Current Resident
36 Levinson Avenue
South River, NJ 08882

Johnnie & Minnie Coons
Or Current Resident
34 Belmont Ave
South River, NJ 08882

Nancy Cooper
Or Current Resident
463 Main Street
Sayreville, NJ 08872

David L. & Irene F. Coyne
Or Current Resident
17 Patton Dr.
Sayreville, NJ 08872

Donald & Toni Costas
Or Current Resident
9 Hope Dr.
Sayreville, NJ 08872

William & Ruth Coyle
Or Current Resident
9 Tricorn Court
Sayreville, NJ 08872

Brian B. Crowe
Or Current Resident
86 Mac Arthur Avenue
Sayreville, NJ 08872

Walter & Ida Bell Crawford
Or Current Resident
PO Box 6
South River, NJ 08882

Lindia Creighton
Or Current Resident
42 Hinton Street
Sayreville, NJ 08872

Lina Cuffie
Or Current Resident
9 Brant Street
South River, NJ 08882

Joseph & Catherine Crowell
Or Current Resident
139 South Street
Cuthbert, GA 31740

Carlos & Iraida Cruz
Or Current Resident
4 Nimitz Place
Sayreville, NJ 08872

Gaetano & Susan Cusumano
Or Current Resident
7 Ciecko Court
Sayreville, NJ 08872

Samuel Currie
Or Current Resident
122 Weber Avenue
Sayreville, NJ 08872

Manuel J. & Maria Custodio
Or Current Resident
5 LeRoy Street
South River, NJ 08882

Zigmunt R. Czaplinski
Or Current Resident
5 Gavel Road
Sayreville, NJ 08872

Louis Cyktor, Jr.
Or Current Resident
P.O. Box 29
Woodbridge, NJ 07095

Curtis J. Cypra
Or Current Resident
7 Forden Court
Sayreville, NJ 08872

Antonio & Marie Da Silva
Or Current Resident
19 Oak Tree Road
Sayreville, NJ 08872

Florence Czernikowski
Or Current Resident
186 Pulaski Avenue
Sayreville, NJ 08872

Louis S. D'Angelo
Or Current Resident
125 Weber Avenue
Sayreville, NJ 08872

Lydia Davis
Or Current Resident
28 Armstrong Avenue
South River, NJ 08882

Genevieve Dabroski
Or Current Resident
25 Stephen Street
South River, NJ 08882

Glenn & Joyce Davis
Or Current Resident
15 Thomas Street
South River, NJ 08882

Anthony & Joyce De Gisi
Or Current Resident
18 Marshall Place
Sayreville, NJ 08872

John R. & Laurie Dawson
Or Current Resident
13 Bissett Place
South River, NJ 08882

Arelen & Albert De Bellis
Or Current Resident
2412 Derby Dr.
Fallston, MD 21047

Anthony & Irene De Palma
Or Current Resident
14 Barton Road
Old Bridge, NJ 08857

Victor & Walfida De Jesus
Or Current Resident
8 William Street
South River, NJ 08882

Joseph & Barbara De Oliveira
Or Current Resident
88 Weber Avenue
Sayreville, NJ 08872

James Wilson & Debra Decker
Or Current Resident
32 John Street
Old Bridge, NJ 08857

Paul A. & Kimberly Klitzk De Sarno
Or Current Resident
451 Main Street
Sayreville, NJ 08872

Michael Haroun & Deb Cameron
Or Current Resident
402-7 Cranbury Road
East Bruswick, NJ 08816

Dominick & Maryann Deleto
Or Current Resident
48 Canal Street
Sayreville, NJ 08872

William & Ann DeCorso
Or Current Resident
19 Thomas Street
South River, NJ 08882

Francis Del Duca
Or Current Resident
55 Charles Street
Old Bridge, NJ 08857

J. Dellas
Or Current Resident
238 Benner Street
Highland Park, NJ 08904

Daniel F. & Eileen Deleva
Or Current Resident
80 Major Drive
Sayreville, NJ 08872

A. DelGiudice & D. Tagliaferro
Or Current Resident
29 Major Drive
Sayreville, NJ 08872

Anthony & Michelle Demaio
Or Current Resident
19 Eisenhower Dr.
Sayreville, NJ 08872

Patrick A. Deltuvia
Or Current Resident
9 Marks Place
South River, NJ 08882

Thomas J. Jr. & Nancy F. Deltz
Or Current Resident
12 Lee Street
South River, NJ 08882

Jacqueline Dembowski
Or Current Resident
6 Vreeland Court
Sayerville, NJ 08872

Barbara DeMartino
Or Current Resident
23 Wahington Road
Sayreville, NJ 08872

Jeffrey & Joanne Dembinski
Or Current Resident
45 Wilson Avenue
South River, NJ 08882

John J. Derent
Or Current Resident
141 Washington Road
Sayreville, NJ 08872

Helen Demeter
Or Current Resident
100 Weber Avenue
Sayreville, NJ 08872

Mary Denniston
Or Current Resident
16 Marshall Place
Sayreville, NJ 08872

Anthony J. & Joann Di Matteo
Or Current Resident
14 Baumer Road
Sayreville, NJ 08872

Gary & Carolyn Derusso
Or Current Resident
96 Canal Street
Sayreville, NJ 08872

Edwin B. & Jasmin A. Deza
Or Current Resident
6 Vandeventer court
Sayreville, NJ 08872

Kiosnorides Diaz
Or Current Resident
440 Buckelew Avenue
Monroe, NJ 08831

Vincent & Sal Di Nuzzo
Or Current Resident
7 Bedle Road
Hazlet, NJ 07730

Diosnorides Diaz
Or Current Resident
5 Russell Avenue
South River, NJ 08882

Luis Diaz
Or Current Resident
5 Russell Avenue
South River, NJ 08882

Javier & Liza Diaz
Or Current Resident
40 Hinton Street
Sayreville, NJ 08872

Diosnorides Diaz
Or Current Resident
440 Buckelew Avenue
Monroe, NJ 08831

Richard Diorio
Or Current Resident
109 Water Street
South River, NJ 08882

Kathleen & Michael Dillon
Or Current Resident
60 Washington Road
Sayreville, NJ 08872

Stilianos Dimitrakis
Or Current Resident
87 Miller Avenue
Sayreville, NJ 08872

Kenneth & Candace Doctors
Or Current Resident
9 Buttonwood Drive
Old Bridge, NJ 08857

Lorraine Dipaolo
Or Current Resident
124 McCutcheon Avenue
Sayreville, NJ 08872

Tyrone M. & Pamela L. Dixon
Or Current Resident
33 Vandeventer Court
Sayreville, NJ 08872

J & M. Dominigues
Or Current Resident
17 Armstrong Avenue
South River, NJ 08882

William J. & Donna M. Dodds
Or Current Resident
10 Lee Street
South River, NJ 08882

Zigmunt S. & Mary Dombrowski
Or Current Resident
32 Weber Avenue
Sayreville, NJ 08872

Mary Donnamaria
Or Current Resident
6 Eisenhower Dr.
Sayreville, NJ 08872

John & Lisa Dominik
Or Current Resident
9 Milton Avenue
South River, NJ 08882

Michael J. & Laura A. Doney
Or Current Resident
17 Eisenhower Dr.
Sayreville, NJ 08872

David & Anita Dorffman
Or Current Resident
23 Dumas Road
Old Bridge, NJ 08857

Aida J. Doolittle
Or Current Resident
35 Belmont Ave
South River, NJ 08882

Pauline Dopeiralski
Or Current Resident
35 Reid Street
South River, NJ 08882

Oleh Dubiaha
Or Current Resident
16 Radcliffe Street
South River, NJ 08882

Roman & Elizabeth Drogomirecki
Or Current Resident
42 William Street
Old Bridge, NJ 08857

John Dubeckyj
Or Current Resident
45 Levinson Avenue
South River, NJ 08882

Ryszard & Teresa Dufrat
Or Current Resident
12 Ciecko Court
Sayreville, NJ 08872

Phyllis Dubman
Or Current Resident
11 Eisenhower Dr.
Sayreville, NJ 08872

Thomas R. & Mary Ann Duffy
Or Current Resident
4 Martin Avenue
South River, NJ 98882

Theodore E. & Karen Du[illegible] Or Current Resident [illegible] Herman Street South River, NJ 08882	[illegible] F. & Cecelia M. Dunn [illegible] Current Resident [illegible] Main Street Sayreville, NJ 08872	Terrance W. & Susan Dunyak Or Current Resident 52 Armstrong Avenue South River, NJ 08882
Walter J. & Susan Lee D[illegible] Or Current Resident 121 Weber Avenue Sayreville, NJ 08872	[illegible] C. & Jacqueline Durham [illegible] Current Resident [illegible] Furman Avenue Sayreville, NJ 08872	Stephen Jr. & Jacquel Duschock Or Current Resident 88 Price Place South River, NJ 08882
Anthony & Helen Dzerg[illegible] Or Current Resident 27 William St South River, NJ 08882	George Dusko Jr. [illegible] Current Resident [illegible] Mac Arthur Avenue Sayreville, NJ 08872	Debra Dustal Or Current Resident 16 Washington Street South River, NJ 08882
J. Marques & E. Morais Or Current Resident 10 LeRoy Street South River, NJ 08882	[illegible] & Alfreda Dzergoski [illegible] Current Resident [illegible] Furman Avenue Sayreville, NJ 08872	Antoinette & Walter Dzwil Or Current Resident 9 Elizabeth Street South River, NJ 08882
Ronald J. & Joan D. Edea Or Current Resident 15 Smith Street Sayreville, NJ 08872	[illegible] Eberle [illegible] Current Resident [illegible] Weber Avenue Sayreville, NJ 08872	Stella Eckert Or Current Resident 3 Wharian Court Yardville, NJ 08620
Joseph E. & Sharon L. Ei[illegible] Or Current Resident 34 Eisenhower Dr. Sayreville, NJ 08872	[illegible] & [illegible] Edwards [illegible] Current Resident [illegible] Drive Sayreville, NJ 08872	Robert T. & Janelle Ehrlich Or Current Resident 53 Major Drive Sayreville, NJ 08872
Paul R. & Doris Emmons Or Current Resident 69 Mac Arthur Avenue Sayreville, NJ 08872	[illegible]nald & Shirley G. Ellis [illegible] Current Resident [illegible] Anne Street South River, NJ 08882	Richard W. & Muriel Emmons Or Current Resident 2 Martin Avenue South River, NJ 08882
Deborah J. Eosso Or Current Resident 40 Eisenhower Dr. Sayreville, NJ 08872	[illegible]rles J. Engelhardt [illegible] Current Resident [illegible] Mac Arthur Avenue Sayreville, NJ 08872	Sharon E. English Or Current Resident 109 Washington Road Sayreville, NJ 08872
John Ol & Mary Jo Erdek Or Current Resident PO Box 3084 South Amboy, NJ 08879	William & Margaret M. Eppinger [illegible] Current Resident [illegible] Weber Avenue Sayreville, NJ 08872	James P. Eppinger Or Current Resident 11 Texas Road Jamesburg, NJ 08831

Steve Toth & F. Krimin
Or Current Resident
100 William Street
South River, NJ 08882

Rueben Evans
Or Current Resident
16 Marie Street
South River, NJ 08882

Milton T. & Maxine Evertz
Or Current Resident
63 Canal Street
Sayreville, NJ 08872

Joan M. Fabiyan
Or Current Resident
92 Mac Arthur Avenue
Sayreville, NJ 08872

I & D Maldonado & F. Kaminsky
Or Current Resident
65 Reid Street
South River, NJ 08882

Michael J. & Christine Fabiszeqski
Or Current Resident
441 Main Street
Sayreville, NJ 08872

John & Ann Faffara
Or Current Resident
3 Serviss Street
South River, NJ 08882

Jose R. & Eilyn Fabregas
Or Current Resident
54 Vandeventer Court
Sayreville, NJ 08872

Joao Carlos & Anna D.T. Facao
Or Current Resident
32 Stephen Street
South River, NJ 08882

Frank & Rita Fallon
Or Current Resident
26 Charles Street
Old Bridge, NJ 08857

Joseph S. & Marilyn J. Falcone
Or Current Resident
19 Patton Dr.
Sayreville, NJ 08872

Edward J. Sr. & Joan Fallivene
Or Current Resident
53 Mimii Road
Old Bridge, NJ 08857

John & Anne Fazekas
Or Current Resident
115 William Street
South River, NJ 08882

John & Jane Falzone
Or Current Resident
114 Causeway
South River, NJ 08882

Audrey Fanok
Or Current Resident
46 Weber Avenue
Sayreville, NJ 08872

Eleanor Felice
Or Current Resident
181 Whitehead Avenue
South River, NJ 08882

Gilbert & Nancy Febinger
Or Current Resident
11 William Street
South River, NJ 08882

Carolyn M. Fedor
Or Current Resident
5 Vreeland Court
Sayreville, NJ 08872

Philip J. Ferlitto III
Or Current Resident
37 Eisenhower Dr.
Sayreville, NJ 08872

Fannie L. Felton
Or Current Resident
23 Kathryn Street
South River, NJ 08882

Charles M. & Audrey H. Fenton
Or Current Resident
30 Water Street
South River, NJ 08882

Diane Ferrera
Or Current Resident
13 Forden Court
Sayreville, NJ 08872

Aurelio D. & Silvia Fernandes
Or Current Resident
17 Herman Street
South River, NJ 08882

Ashton F. & Nida S. Fernando
Or Current Resident
79 Major Drive
Sayreville, NJ 08872

Peter M. Ferro
Or Current Resident
154 Boehmhurst avenue
Sayreville, NJ 08872

Manuel N. & Rosa J. Ferro
Or Current Resident
12 Jackson Street
South River, NJ 08882

Maria Ferro
Or Current Resident
40 Jeffrie Avenue
South River, NJ 08882

Salvatore & Darlene Filannino
Or Current Resident
Weber Avenue
Sayreville, NJ 08872

Mary R. Fielek
Or Current Resident
539 Main Street
Sayreville, NJ 08872

Jose Figueroa
Or Current Resident
13 Martin Avenue
South River, NJ 08882

John D. & Ann Floersch
Or Current Resident
12 Nimitz Place
Sayreville, NJ 08872

Genevieve J. Fischer
Or Current Resident
43 Bissett Street
Sayreville, NJ 08872

Robert D. & Diane Fisher
Or Current Resident
25 Weber Avenue
Sayreville, NJ 08872

Frank & Julia A. Fodor
Or Current Resident
18 Samuel Drive
South River, NJ 08882

Aygmunt & Stefania Florczak
Or Current Resident
543 Main Street
Sayreville, NJ 08872

Edward & Linda M. Flynn
Or Current Resident
93 Miller Avenue
Sayreville, NJ 08872

Eugene & Emma R. Foster
Or Current Resident
9 Kathryn Street
South River, NJ 08882

Margaret Fogarty
Or Current Resident
169 Washington Road
Sayreville, NJ 08872

Andrew & Cynthia Fontana
Or Current Resident
5 Eastern Street
South River, NJ 08882

Robert B. & Kathleen Fozman
Or Current Resident
335 Washington Place
North Brunswick, NJ 08902

Bozena Pignataro Foster
Or Current Resident
15 Patton Dr.
Sayreville, NJ 08872

Peter J. & Kyung Ja Fox
Or Current Resident
8 Iroquois Drive
Parlin, NJ 08859

Janet Fross
Or Current Resident
126 McCutcheon Avenue
Sayreville, NJ 08872

Samuel & Stella Freeman
Or Current Resident
43 Weber Avenue
Sayreville, NJ 08872

Michael & Kimberly Savola Frobosilo
Or Current Resident
39 Furman Avenue
Sayreville, NJ 08872

Edward & Sylvia Gan
Or Current Resident
94 Standiford Avenue
Sayreville, NJ 08872

Mark J. & Lynne Gallager
Or Current Resident
5 Henry Street
South River, NJ 08882

Nicholas & Kim Gamba
Or Current Resident
45 Weber Avenue
Sayreville, NJ 08872

Florence Gardner
Or Current Resident
25 Levinson Avenue
South River, NJ 08882

Jose & Isalinda Gandarinho
Or Current Resident
12-14-16 Ferry Street
South River, NJ 08882

Donaly & Leona Garboski
Or Current Resident
36 Weber Avenue
Sayreville, NJ 08872

Vernon & Floreatha Gatling
Or Current Resident
13 Kathryn Street
South River, NJ 08882

Minnie Lee Gash
Or Current Resident
44 Causeway
South River, NJ 08882

Laurence F. Gates
Or Current Resident
66 Weber Avenue
Sayreville, NJ 08872

Richard & Irene Geipel
Or Current Resident
Charles Street
Old Bridge, NJ 08857

George Gavares
Or Current Resident
6 Parr Drive
Sayreville, NJ 08872

Marie W. & Stanely Jr. Gdula
Or Current Resident
117 McCutcheon Avenue
Sayreville, NJ 08872

Margaret Gerstaker
Or Current Resident
54 Reid Street
South River, NJ 08882

C & R. Geist
Or Current Resident
7 Pitt Road
East Brunswick, NJ 08816

Ernest Geresy
Or Current Resident
1 George Street
South River, NJ 08882

John & Ann Gildea
Or Current Resident
25 Oak Tree Road
Sayreville, NJ 08872

J & L. & M. Ghigliotti
Or Current Resident
43 Levinson Avenue
South River, NJ 08882

Maria & Georgio Giannakopoulos
Or Current Resident
129 Johnson Place
South River, NJ 08882

Jennie Glendenning
Or Current Resident
5 Marshall Place
Sayreville, NJ 08872

James & Joan Gillette
Or Current Resident
11 Locklin Court
Sayreville, NJ 08872

Rose Glade
Or Current Resident
26 Marshall Place
Sayreville, NJ 08872

Alexander L. Go & Grace Lee
Or Current Resident
10 Anderson Court
Sayreville, NJ 08872

Irvin & Mary Glover
Or Current Resident
30 Kathryn Street
South River, NJ 08882

Catherine Glover
Or Current Resident
3 Causeway
South River, NJ 08882

Helen E. & Applegate Golla
Or Current Resident
28 William Street
Old Bridge, NJ 08857

Shelly Goldman
Or Current Resident
49 Main Street
South River, NJ 08882

Adolph & Richard Golla
Or Current Resident
18 William Street
Old Bridge, NJ 08857

Samuel & Emma B. Gordon
Or Current Resident
33 Kathryn Street
South River, NJ 08882

Armenio & Maria Gomes
Or Current Resident
26 Obert Street
South River, NJ 08882

William A. & Sylvia Good
Or Current Resident
3 Eisenhower Dr.
Sayreville, NJ 08872

Joseph V. Gorrie
Or Current Resident
23 Mac Arthur Avenue
Sayreville, NJ 08872

Berdella Gorman
Or Current Resident
2 Bissett Street
Sayreville, NJ 08872

John & Nancy Gorman Jr.
Or Current Resident
74 Washington Road
Sayreville, NJ 08872

Edward Grabowski
Or Current Resident
106 McCutcheon Avenue
Sayreville, NJ 08872

Vincent J. & Jozefa H. Gostkowski
Or Current Resident
19 Pettit Avenue
South River, NJ 08882

William E. & Joanne B. Gottstine
Or Current Resident
91 River Road
Sayreville, NJ 08872

Charles A. & Wille Grace
Or Current Resident
Major Drive
Sayreville, NJ 08872

Vincent J. Graham
Or Current Resident
70A Dorchester Drive
Lakewood, NJ 08701

Barbara J. Green
Or Current Resident
5 Hope Dr.
Sayreville, NJ 08872

Daniel J. & Patricia Greene
Or Current Resident
3 Gavel Road
Sayreville, NJ 08872

Richard & Barbara Griggs
Or Current Resident
35 Stephen Street
South River, NJ 08882

Helen Grobelny
Or Current Resident
11 Lee Street
South River, NJ 08882

Theodore & Maureen Grossmann
Or Current Resident
88 Mac Arthur Avenue
Sayreville, NJ 08872

Luis M. & Sandra Guardiano
Or Current Resident
7 Anne Street
South River, NJ 08882

Steven K. & Donna M. Haasz
Or Current Resident
35 Kathryn Street
South River, NJ 08882

[redacted] & Mary Ann Grabowski
[redacted]rent Resident
[redacted]ber Avenue
[redacted]ville, NJ 08872

[redacted] & Nancy Miller Graer
[redacted]Current Resident
[redacted]Vandeventer Court
[redacted]eville, NJ 08872

[redacted] & Maureen L Grams, Jr.
[redacted]Current Resident
[redacted] Street
[redacted]Bridge, NJ 08857

[redacted] W. Green
[redacted]Current Resident
[redacted]ensler Avenue
[redacted]ville, NJ 08872

[redacted] & Arceliana Grego
[redacted]rrent Resident
[redacted]hitehead Avenue
[redacted] River, NJ 08882

[redacted]nce & Shirley Griggs
[redacted]Current Resident
[redacted]ton Dr.
[redacted]eville, NJ 08872

[redacted] Grooms & Robin Franklin
[redacted]Current Resident
[redacted]ecko Court
[redacted]eville, NJ 08872

[redacted] & Delores Grote
[redacted]Current Resident
[redacted] Street
[redacted]Bridge, NJ 08857

[redacted] M. & Barbara Guidice
[redacted]Current Resident
[redacted] Street
[redacted]ville, NJ 08872

Antonina Grabowski
Or Current Resident
96 Whitehead Avenue
South River, NJ 08882

Timothy J. & Lillian M. Graham
Or Current Resident
24 De Voe Street, Apt. C
South River, NJ 08882

Franklin & Lovina Grasparil
Or Current Resident
37 Major Drive
Sayreville, NJ 08872

Barry G. Greene
Or Current Resident
89 Miller Avenue
Sayreville, NJ 08872

Frank & Dorothy Grekoski
Or Current Resident
3 Marshall Place
Sayreville, NJ 08872

Catherine Grobelny
Or Current Resident
25 Washington Road
Sayreville, NJ 08872

Winifred Grossmann
Or Current Resident
96 Weber Avenue
Sayreville, NJ 08872

Dolores Grudziecka
Or Current Resident
4 Vandeventer Court
Sayreville, NJ 08872

Raymond Gulick & P. McMullen
Or Current Resident
1 Ciecko Court
Sayreville, NJ 08872

Paul Halas
Or Current Resident
Brainerd Drive
Cranbury, NJ 08512

Ibrahim M. Habib
Or Current Resident
7 Lenape Lane
East Brunswick, NJ 08816

Dennis & Helen Haklar
Or Current Resident
66 Hollywood Avenue
Somerset, NJ 08873

Vladimir & Wanda Halinski
Or Current Resident
31 Belmont Ave
South River, NJ 08882

John Halasz
Or Current Resident
51 Bissett Street
Sayreville, NJ 08872

George Halbert
Or Current Resident
45 William Street
Old Bridge, NJ 08857

Farouk & Amal Hanna
Or Current Resident
637 Ayres Avenue
North Plainfield, NJ 07063

John B. & Clara H. Hamilton
Or Current Resident
28 Washington Road
Sayreville, NJ 08872

Joseph & Olga Hanis
Or Current Resident
17 Martin Avenue
South River, NJ 08882

Joseph J. & Judith A. Harkay Sr.
Or Current Resident
20 Weber Avenue
Sayreville, NJ 08872

Sharon M. Hansell
Or Current Resident
6 Nimitz Place
Sayreville, NJ 08872

Erwin S. & Beverly Hapson
Or Current Resident
38 Eisenhower Dr.
Sayreville, NJ 08872

Emily Harris
Or Current Resident
10 Littyu Martin Avenue
South River, NJ 08882

Samira & Makram Harous
Or Current Resident
25 Marlin Road
Old Bridge, NJ 08857

Frances & Andrea Tucker Harrell
Or Current Resident
10 Vreeland Court
Sayreville, NJ 08872

George & Debra Hartrum
Or Current Resident
29 Maple Street
South River, NJ 08882

Clara Harris
Or Current Resident
P.O. Box 3443
Charlottesville, VA 22903

Rodney & Deborah L. Harris
Or Current Resident
15 Kathryn Street
South River, NJ 08882

Richard M. & Annette Haydock
Or Current Resident
16 Eisenhower Dr.
Sayreville, NJ 08872

Jennifer C. Hasey
Or Current Resident
127 Whitehead Avenue
South River, NJ 08882

Kenneth W. and Karen D. Jones Hauck
Or Current Resident
45 Cambridge Road
South River, NJ 08872

Justine Heffner
Or Current Resident
155 Mac Arthur Avenue
Sayreville, NJ 08872

Jennifer Hayek
Or Current Resident
115 Weber Avenue
Sayreville, NJ 08872

Herman Heatai
Or Current Resident
23 Oak Tree Road
Sayreville, NJ 08872

Clifford & Audrey Henderson
Or Current Resident
8 Ruth Street
Eaast Brunswick, NJ 08816

Edward S. & Delores N. Helpa
Or Current Resident
11 Seminole Street
Sayreville, NJ 08872

Gary Heluk
Or Current Resident
124 Whitehead Avenue
South River, NJ 08882

Alfredo Henriques
Or Current Resident
3 Elm Street
Newark, NJ 07105

Marvin & Donna Henderson Jr.
Or Current Resident
15 Major Drive
Sayreville, NJ 08872

Essasm, William & Merva Henein
Or Current Resident
3 George Street
South River, NJ 08882

Howard & Josephine Herzog
Or Current Resident
111 William Street
South River, NJ 08882

Richard & Kathleen Herban
Or Current Resident
9 Patton Dr.
Sayreville, NJ 08872

Jose & Rosa Hernadez
Or Current Resident
34 Reid Street
South River, NJ 08882

John & Margaret Higginbotham
Or Current Resident
26 Eisenhower Dr.
Sayreville, NJ 08872

Robert H. & Pauline H. Heyboer
Or Current Resident
36 Eisenhower Dr.
Sayreville, NJ 08872

Walter A. Hickman Jr.
Or Current Resident
249 Concord Street
Carlisle, MA 01741

Max & Carrie Hill
Or Current Resident
183 Witehead Avenue
South River, NJ 08882

Richard B. & Rubinia C. Hill
Or Current Resident
68 Mac Arthur Avenue
Sayreville, NJ 08872

Betty Lou Hill
Or Current Resident
8040 SW 20 Place
Davie, FL 33324

Andrew & Verna Himey
Or Current Resident
27 Charles Street
Old Bridge, NJ 08857

Ernest Jr. & Karen Hill
Or Current Resident
7 Henry Street
South River, NJ 08882

Richard Hills
Or Current Resident
16 Washington Street
South River, NJ 08882

Joseph F. & Christine D. Horn
Or Current Resident
PO Box 5323
Old Bridge, NJ 08857

Anthony & Lorraine Holobowski
Or Current Resident
112 Weber Avenue
Sayreville, NJ 08872

George & Frances Hordubay
Or Current Resident
93 Dutch Road
East Brunswick, NJ 08816

Ronald & Cammie L. Howard
Or Current Resident
7 Brant Street
South River, NJ 08882

I. Horowitz
Or Current Resident
P.O. Box 241
South River, NJ 08882

Richard M. & Mary Lynn Hover
Or Current Resident
9 Vreeland Court
Sayreville, NJ 08872

Elizabeth Huband
Or Current Resident
21 Eisenhower Dr.
Sayreville, NJ 08872

Thomas P. Howley
Or Current Resident
P.O. Box 132
South River, NJ 08882

Zhongyi Huang & Kam Fung Chan
Or Current Resident
70 Canal Street
Sayreville, NJ 08872

Tod T. & Sandra Hughes
Or Current Resident
8 Anderson Court
Sayreville, NJ 08872

George & Diane Hubert
Or Current Resident
36 Reid Street
South River, NJ 08882

Nellie H. Hufford
Or Current Resident
35 Eisenhower Dr.
Sayreville, NJ 08872

Mary, Agnes & Louise Iannotta
Or Current Resident
Reid Street
South River, NJ 08882

Dennis & Jerilyn Hutnick
Or Current Resident
103 Lark Drive
South River, NJ 08882

Joseph M. Hyland
Or Current Resident
43 Tice Avenue
South River, NJ 08882

Callixtus & Ida Ita
Or Current Resident
184 Kamm Avenue
South River, NJ 08882

George & Stella Ioannou
Or Current Resident
20 Levinson Avenue
South River, NJ 00082

Georgios Ioannou
Or Current Resident
20 Levinson Avenue
South River, NJ 08882

Sheila L. Jackson
Or Current Resident
22 Anne Street
South River, NJ 08882

Richard M. Izzo
Or Current Resident
13 Vandeventer Court
Sayreville, NJ 08872

Edward & Betty Jackowski
Or Current Resident
62 Washington Road
Sayreville, NJ 08872

John & Evelyn Jackson Jr.
Or Current Resident
105 MCCutcheon Avenue
Sayreville, NJ

Leslie A. Jackson
Or Current Resident
11 Bissett Place
South River, NJ 08882

Carrie Mae Jackson
Or Current Resident
11 Causeway
South River, NJ 08882

J & M. Domanow Jakimtschuk
Or Current Resident
182 South Moetz Drive
Milltown, NJ 08850

Samuel & Sarah Jacob
Or Current Resident
124 Weber Avenue
Sayreville, NJ 08872

Edgar & Valerie Jacque
Or Current Resident
88 Canal Street
Sayreville, NJ 08872

Anil Jani
Or Current Resident
21 Victorian Drive
Old Bridge, NJ 08857

Stanley Jakubczak
Or Current Resident
15 Markwood Dr.
Howell, NJ 07731

Agnes Janczylik
Or Current Resident
43 William Street
Old Bridge, NJ 08857

Anna Javorova
Or Current Resident
27 Water Street
South River, NJ 08882

Walter & Bernice Jannos
Or Current Resident
23 Charles Street
Old Bridge, NJ 08857

Steve & Lillian Janosko
Or Current Resident
67 Water Street
South River, NJ 08882

Laura Jensen
Or Current Resident
21 Thomas Street
South River, NJ 08882

Maria Jaworski
Or Current Resident
30 Herman Street
South River, NJ 08882

Joseph & Elizabeth Jelonek
Or Current Resident
4 Elizabeth Street
South River, NJ 08882

Glenn R. & Carol S. Johnson
Or Current Resident
61 Canal Street
Sayreville, NJ 08872

Elmer & Dorothy Jensen
Or Current Resident
37 Perry Street
South River, NJ 08882

George A. & Mary Johnson
Or Current Resident
98 E. Walnut Street
Metuchen, NJ 08840

Gregory & Charisse Hawkins
Or Current Resident
Major Drive
Sayreville, NJ 08872

Sophie Johnson
Or Current Resident
24 Chestnut Street
South River, NJ 08882

Russell & Mildred Johnson
Or Current Resident
11 Anne Street
South River, NJ 08882

Tommey & Daphne Thomas
Or Current Resident
95 Canal Street
Sayreville, NJ 08872

Kenneth W. & Mary Ann Jones
Or Current Resident
5 Eisenhower Dr.
Sayreville, NJ 08872

Charlotte C. Jones
Or Current Resident
10 Sandpiper Lane
Dayton, NJ 08810

Peter & Bertha Jozsa
Or Current Resident
18 Maple Street
South River, NJ 08882

Ramon Jordan
Or Current Resident
35 Armstrong Avenue
South River, NJ 08882

Mary B. Jordan
Or Current Resident
36 Kathryn Street
South River, NJ 08882

Julia Jurewicz
Or Current Resident
44 Levinson Avenue
South River, NJ 08882

Joseph J. & Evelyn E. Jucewicz
Or Current Resident
34 Stephen Street
South River, NJ 08882

Michael E. & Sharon K. Jurewicz
Or Current Resident
19 George Street
South River, NJ 08882

Stephen Kakos
Or Current Resident
104 Dolan Street
Sayreville, NJ 08872

Genevieve Kaczmarek
Or Current Resident
55 Washington Road
Sayreville, NJ 08872

Ronald S. & Carol A. Kadi
Or Current Resident
27 Major Drive
Sayreville, NJ 08872

Michael & Wanda Kaliczynski
Or Current Resident
61 Weber Avenue
Sayreville, NJ 08872

Ann Kalasin
Or Current Resident
82 Prentice Avenue
South River, NJ 08882

John & Laura Kalicki
Or Current Resident
22 Bright Street
South River, NJ 08882

Thomas A. & Theresa Kapes
Or Current Resident
2 Marshall Place
Sayreville, NJ 08872

Frank & Charlotte Kaminsky
Or Current Resident
24 George Street
South River, NJ 08882

Estelle Kanc
Or Current Resident
25 Marlon Pond Road
Hamilton Square, NJ 08690

Ronald & Karen Kecskes
Or Current Resident
42 Weber Avenue
Sayreville, NJ 08872

Dimitrios & Katherine Kappas
Or Current Resident
73-75 Whitehead Avenue
South River, NJ 08882

H. & KM Kasperowicz
Or Current Resident
459 Main Street
Sayreville, NJ 08872

Henry & Evelyn Kelch
Or Current Resident
177 Whitehead Avenue
South River, NJ 08882

Helen Keister
Or Current Resident
20 Marshall Place
Sayreville, NJ 08872

Henry & Evelyn Kelch
Or Current Resident
10 Elizabeth Street
South River, NJ 08882

Richard E. & Carol Kemple
Or Current Resident
Patton Dr.
Sayreville, NJ 08872

Alice A. Kelley
Or Current Resident
39 Maple Street
South River, NJ 08882

Theresa Kelly
Or Current Resident
235 Green Street
Woodbridge, NJ 07095

Paul Kern
Or Current Resident
8 LeRoy Street
South River, NJ 08882

William Kendrick
Or Current Resident
28 Clark Street
South River, NJ 08882

Michael H. Keppe III
Or Current Resident
11 Henry Street
South River, NJ 08882

Patrick J. & Maria E. Kipp
Or Current Resident
78 Mac Arthur Avenue
Sayreville, NJ 08872

S & O. & A. Khosla
Or Current Resident
9 Appletree Lane
East Brunswick, NJ 08816

Stanley J. Kielian
Or Current Resident
151 Mac Arthur Avenue
Sayreville, NJ 08872

R. & RE Gilbert Kita
Or Current Resident
5 Forden Court
Sayreville, NJ 08872

Matthew A. & Donna M. Kirchner
Or Current Resident
3 Hope Dr.
Sayreville, NJ 08872

Helen Kish
Or Current Resident
21 Herman Street
South River, NJ 08882

Joseph J. & Lucille Klock
Or Current Resident
6 John Street
Old Bridge, NJ 08857

Rose Klinsport
Or Current Resident
14 Nickel Avenue
Sayreville, NJ 08872

Joseph J. & Carey A. Kloc
Or Current Resident
31 Drummond Way
Jamesburg, NJ 08831

Michael T. & Mary Louise Knox
Or Current Resident
12 Samuel Drive
South River, NJ 08882

Karl & Elizabeth Klostreich
Or Current Resident
15 Maple Street
South River, NJ 08882

Veronica Klucznik
Or Current Resident
49 Kathryn Street
South River, NJ 08882

John Kohler & Susanna Sviatko
Or Current Resident
31 Canal Street
Sayreville, NJ 08872

Joseph & Suzanne Koch
Or Current Resident
1 Serviss Street
South River, NJ 08882

Stella & William Koenig
Or Current Resident
14 Elizabeth Street
South River, NJ 08882

Stanislaw & Marianna Kolacz
Or Current Resident
13 Reid Street
South River, NJ 08862

Cris & Eliazavet C. Kokino
Or Current Resident
51 Levinson Avenue
South River, NJ 08882

Cerasimos & Anastasia Kokinos
Or Current Resident
41 Mercer Street
South River, NJ 08882

Stella Kolodziejski
Or Current Resident
17 Stephen Street
South River, NJ 08882

Vana & Graciela Koldada
Or Current Resident
28 Edmund Road
Hollywood, Fla 33023

Rita Kolodziej
Or Current Resident
55 Furman Avenue
Sayreville, NJ 08872

Ralph J. & Diane Koneski Jr.
Or Current Resident
:7 Main Street
Sayreville, NJ 08872

Carol Komorowski
Or Current Resident
38 Kathryn Street
South River, NJ 08882

Jean Kondratyk
Or Current Resident
55 Jackson Street
South River, NJ 08882

Esther & Daniel D. Kopsco
Or Current Resident
10 Bright Street
Sayreville, NJ 08872

Elaine Konopka
Or Current Resident
97 Weber Avenue
Sayreville, NJ 08872

E. Kopanakis
Or Current Resident
238 Benner Street
Highland Park, NJ 08904

Joseph F. & Sharon L. Kosmo
Or Current Resident
333 Independence Blvd.
North Brunswick, NJ 08902

Sophie Kordowski
Or Current Resident
28 Eisenhower Dr.
Sayreville, NJ 08872

Feyzi & Saadet Korkusuz
Or Current Resident
46 Quaid Avenue
Sayreville, NJ 08872

Evangelos & Sofi Koukourdelis
Or Current Resident
25 Mercer Street
South River, NJ 08882

Donce & Vaslika Kostrevski
Or Current Resident
73 Armstrong Avenue
South Rivernj, NJ 08882

George & Haido Koukourdelis
Or Current Resident
25 Mageria Street
South River, NJ 08882

Linda & Restine, Susan Kovacs
Or Current Resident
15 Oak Tree Road
Sayreville, NJ 08872

K & A. Koukourdelis
Or Current Resident
43-45 Augusta Street
South River, NJ 08882

Anatol & Marlene Kous
Or Current Resident
26 John Street
Old Bridge, NJ 08857

Leon, III & Kathleen Krajewski
Or Current Resident
26 Calliope Road
Sayreville, NJ 08701

Susanne Koxiatek
Or Current Resident
9 Herman Street
South River, NJ 08882

Florence M. Krainski
Or Current Resident
51 Jernee Mill Road
Sayreville, NJ 08872

Richard & Lorraine Krause
Or Current Resident
132 Boehmhurst Avenue
Sayreville, NJ 08872

Leon Krajewski, IV
Or Current Resident
26 Calliope Road
Sayreville, NJ 08872

Richard A. & Lorraine F. Krause
Or Current Resident
132 Boehmhurst Avenue
Sayreville, NJ 08872

Dennis & Elizabeth Krilla
Or Current Resident
103 William St
South River, NJ 08882

E. & Sylvester A. & J. Krawczyk
Or Current Resident
29 Hillside Avenue
Sayreville, NJ 08872

Arlene & Joakim Krell
Or Current Resident
23 Clove Road
Little Falls, NJ 07424

Dorothy Krzyzkowski
Or Current Resident
58 Washington Road
Sayreville, NJ 08872

Frank & Helen Krimin
Or Current Resident
200 William Street
South River, NJ 08882

Florence M. Kruczynski
Or Current Resident
249 MacArthur Avenue
Sayreville, NJ 08872

Reverand Leonard Kuberski
Or Current Resident
1 Whitehead Avenue
South River, NJ 08882

Darren Kuback
Or Current Resident
42 Levinson Avenue
South River, NJ 08882

Leonard Kuberski
Or Current Resident
451 Whitehead Ave
South River, NJ 08882

Feliks D. & Goldie Kucharski
Or Current Resident
107 William Street
South River, NJ 08882

Mary Kucharski
Or Current Resident
133 Whitehead Avenue
South River, NJ 08882

Michael G. Kucharski
Or Current Resident
39 James Street
South River, NJ 08882

Helen M. Kugel
Or Current Resident
11 Marshall Place
Sayreville, NJ 08872

Martin & Theresa Kuczynski
Or Current Resident
127 Weber Avenue
Sayreville, NJ 08872

John A. Kuczynski
Or Current Resident
19 Weber Avenue
Sayreville, NJ 08872

Alexander & Mae Kulesa
Or Current Resident
84 Hillside Avenue
South River, NJ 08882

V. Jr. & Sherman, A. Kugler
Or Current Resident
22 Water Street
South River, NJ 08882

Mary Kulakovich
Or Current Resident
10 Serviss Street
South River, NJ 08882

Barry W. & Joyce Kupsch
Or Current Resident
7 Marshall Place
Sayreville, NJ 08872

Andrew W. & Dortothy D. Kulick
Or Current Resident
88 Standiford Avenue
Sayreville, NJ 08872

Miguel & Lourdes Kulik
Or Current Resident
23 Stephen Street
South River, NJ 08882

P. Kurczeski
Or Current Resident
19 Old Stage Road
Spotswood, NJ 08884

Glenn A. & Marlene Kupsch
Or Current Resident
15 Eisenhower Dr.
Sayreville, NJ 08872

Lee George & Phyllis Kupsch
Or Current Resident
13 Eisenhower Dr.
Sayreville, NJ 08872

W.S.C., L.L.C.
Or Current Resident
190 William Street
South River, NJ 08882

Matthew L. & Elizabeth Kurtz
Or Current Resident
58 Mac Arthur Avenue
Sayreville, NJ 08872

John C. & Rosemarie Kwitkowski
Or Current Resident
120 Pulaski Avenue
Sayreville, NJ 08872

John B. & Helen Lacko
Or Current Resident
5 Ciecko Court
Sayreville, NJ 08872

Helen & Salvatore La Grande
Or Current Resident
349 Main Street
Sayreville, NJ 08872

Maria E. Labordeta
Or Current Resident
7 Anderson Court
Sayreville, NJ 08872

Raymond Laffin
Or Current Resident
7 Main Street
South River, NJ 08882

Joel J. & Katia Mitton Lacoste
Or Current Resident
143 Mac Arthur Avenue
Sayreville, NJ 08872

Marjoire A. & Ronald E. Lado
Or Current Resident
33 Eisenhower Dr.
Sayreville, NJ 08872

Tony & Ping Yu Lam
Or Current Resident
Canal Street
Sayreville, NJ 08872

Robert W. & Patricia A. Lahrman
Or Current Resident
54 Mac Arthur Avenue
Sayreville, NJ 08872

Louis H. Lahrman Jr.
Or Current Resident
64 Mac Arthur Avenue
Sayreville, NJ 08872

Eleanor Lash
Or Current Resident
41 Armstrong Avenue
South River, NJ 08882

Norma D. Lamo
Or Current Resident
43 University Road
East Brunswick, NJ 08816

David & Wanda Larsen
Or Current Resident
57 Bordentown Avenue
Old Bridge, NJ 08857

Rose Ann Laughery
Or Current Resident
16 Ciecko Court
Sayreville, NJ 08872

Violet Lasko
Or Current Resident
51 Furman Avenue
Sayreville, NJ 08872

Lee L. & Vanni Lattimer
Or Current Resident
69 Canal Street
Sayreville, NJ 08872

Eugene & Elizabeth M. Layeski
Or Current Resident
105 Weber Avenue
Sayreville, NJ 08872

John & Judith Lauro
Or Current Resident
76 William Street
Old Bridge, NJ 08857

Calvin & Jeanette Lawrence
Or Current Resident
17 Major Drive
Sayreville, NJ 08872

John & Phylis Lee Lepucki
Or Current Resident
5 Serviss Street
South River, NJ 08882

Scott & Melissa Lebow
Or Current Resident
12 Vandeventer Court
Sayreville, NJ 08872

Charles & Eileen Lecorchick
Or Current Resident
60 Augusta Street
South River, NJ 08882

Arthur L. Lessler
Or Current Resident
540 Turnpike Road
South River, NJ 08882

Thomas Lepucki
Or Current Resident
5 Lee Street
South River, NJ 08882

Jolanta Lesniewska
Or Current Resident
92 Weber Avenue
Sayreville, NJ 08872

William T. & Claudia Lins
Or Current Resident
17 Oak Tree Road
Sayreville, NJ 08772

Stella Letts
Or Current Resident
67 Reid Street
South River, NJ 08882

H. Lichtman
Or Current Resident
6 William Street
South River, NJ 08882

Mary Lis
Or Current Resident
62 Mac Arthur Avenue
Sayreville, NJ 08872

Stanley N. & Margaret Lipinski
Or Current Resident
1 Herman Street
South River, NJ 08882

Mary Ann Lippin
Or Current Resident
10 Forden Court
Sayreville, NJ 08872

Arthur V. Livingston, III
Or Current Resident
681 Prospect Avenue
Little Silver, NJ 07739

Wladimiro & Maria Lischuk
Or Current Resident
68 Johnson Place
South River, NJ 08882

Richard & Alexina Liscio
Or Current Resident
5 Nimitz Place
Sayreville, NJ 08872

Angela Belfiore Loconte
Or Current Resident
Vreeland Court
Sayreville, NJ 08872

Jasmin Livingstone
Or Current Resident
7 Parr Drive
Sayreville, NJ 08872

Daniele S. & Maria R. Lo Conti
Or Current Resident
32 Belmont Ave
South River, NJ 08882

William Long
Or Current Resident
173 Willow St
East Brunswick, NJ 08816

Giovanni Belfiore Loconte
Or Current Resident
14 Colonial court
Woodbridge, NJ 07095

Ernest E. & Cordula Logan
Or Current Resident
191 Whitehead Avenue
South River, NJ 08882

William Lorfing
Or Current Resident
4 Eisenhower Dr.
Sayreville, NJ 08872

Minnie Longo
Or Current Resident
3 Lee Street
South River, NJ 08882

Irving & Jay Lopatin
Or Current Resident
7 Meadowlark Lane
East Bruswick, NJ 08816

Cyktor Louis, Jr.
Or Current Resident
PO Box 29
Woodbridge, NJ 07095

Yolanda & Lorraine Lotesto
Or Current Resident
58 Vandeventer Court
Sayreville, NJ 08872

Gregory I. & Susan G. Louis
Or Current Resident
13 Gavel Road
Sayreville, NJ 08872

Katherine Lubczynski
Or Current Resident
6 Martin Avenue
South River, NJ 08882

Mario & Judite Lourenco
Or Current Resident
37 William Street
South River, NJ 08882

Zeng Lung & Ming Quin Lu
Or Current Resident
19 Main Street
South River, NJ 08882

Joa & Julieta Lucas
Or Current Resident
45 Obert Street
South River, NJ 08882

Manual & Rosa Lucas
Or Current Resident
55 Weber Avenue
Sayreville, NJ 08872

Georgino Lucas
Or Current Resident
121 Fedeal Road
Englishtown, NJ 07726

Lillian M. Lukacs
Or Current Resident
48 Quaid Avenue
Sayreville, NJ 08872

Joel G. & Josephine Lugtu
Or Current Resident
81 Miller Avenue
Sayreville, NJ 08872

Margaret Lukacs
Or Current Resident
43 Belmont Ave
South River, NJ 08882

John & Josephine Lydersen
Or Current Resident
1 Vandeventer Court
Sayreville, NJ 08872

Pauline & Milton Luniewski
Or Current Resident
35 Jackswon Street
South River, NJ 08882

Peter F. Luster
Or Current Resident
93 River Road
Sayreville, NJ 08872

Michael & Helen Maclas
Or Current Resident
115 John Street
South River, NJ 08882

Elizabeth Lynch
Or Current Resident
15 Hope Dr.
Sayreville, NJ 08872

John R. Lynch & Kay Gee
Or Current Resident
52 Canal Street
Sayreville, NJ 08872

F. Michael & Kate Fay Maiolo
Or Current Resident
Vandeventer Court
Sayreville, NJ 08872

Cesar & Cristina Maderal
Or Current Resident
8 Memorial Way
Sayreville, NJ 08872

Eduardo & Nelly Magas
Or Current Resident
47 Kathryn Street
South River, NJ 08882

Sunday A. Mako
Or Current Resident
120 Weber Avenue
Sayreville, NJ 08872

Harris & Helen Major
Or Current Resident
41 Whitehead Avenue
South River, NJ 08882

Adrian & Susan Major
Or Current Resident
56 Mac Arthur Avenue
Sayreville, NJ 08872

Ronald & Nelida Malet
Or Current Resident
98 Mac Arthur Avenue
Sayreville, NJ 08872

Kamal Abdel & Nadia Malak
Or Current Resident
130 Weber Avenue
Sayreville, NJ 08872

Manuel & Gloria J. Males
Or Current Resident
84 Browns Lane
South River, NJ 08882

Mario & Alda Maltez
Or Current Resident
23 Whitehead Avenue
South River, NH 08882

Joseph & Helen Malkiewicz
Or Current Resident
56 William Street
Old Bridge, NJ 08857

Kevin & Kathleen A. Maloney
Or Current Resident
18 Armstrong Avenue
South River, NJ 08882

Frank & Grace Maniscalco
Or Current Resident
66 Canal Street
Sayreville, NJ 08872

Joseph & Frances Manfre
Or Current Resident
7 Patton Dr.
Sayreville, NJ 08872

Phillip Mangione
Or Current Resident
17B Thomas Street
South River, NJ 08882

Ashok & Sheela Mantri
Or Current Resident
78 Weber Avenue
Sayreville, NJ 08872

John F. & Felicia A. Manning
Or Current Resident
13 Hope Dr.
Sayreville, NJ 08872

Antonio & Rosa Mano
Or Current Resident
3 Milton Avenue
South River, NJ 08882

Anthony & Elizabeth J. Marano
Or Current Resident
27 Oak Tree Road
Sayreville, NJ 08872

Joseph & Angelo Manzo
Or Current Resident
P.O. Box 5
South River, NJ 08882

J. Sr. & J. Jr. Manzo
Or Current Resident
82 Prospect Street
So. River, NJ 08882

Susan Marcinkiewicz
Or Current Resident
12-14 Levinson Avenue
South River, NJ 08882

Jason Marcinczyk
Or Current Resident
56 Reid Street
South River, NJ 08882

John H. & Sharon Marcinczyk Jr.
Or Current Resident
41 Canal Street
Sayreville, NJ 08872

John Markowski
Or Current Resident
9 Lee Street
South River, NJ 08882

Salvatore A. & Lori Marconi Jr.
Or Current Resident
62 Canal Street
Sayreville, NJ 08872

Mark S. & Robin A. Margres
Or Current Resident
355 Main Street
Sayreville, NJ 08872

Peter & Ann Mary Marottoli
Or Current Resident
1 Patton Dr.
Sayreville, NJ 08872

Mindy H. Marks
Or Current Resident
14 Belmont Ave
South River, NJ 08882

Evelyn Markulic
Or Current Resident
101 Mac Arthur Avenue
Sayreville, NJ 08872

Alfonso & George Martinez
Or Current Resident
21 Belmont Ave
South River, NJ 08882

Jose & Rose Gregoria Marques
Or Current Resident
16 Reid Street
South River, NJ 08882

M. & Armour G. Martin
Or Current Resident
15 Martin Avenue
South River, NJ 08882

Anthony & Sophie Massaro
Or Current Resident
31 Stephen Street
South River, NJ 08882

Frank Martino
Or Current Resident
1 Brightwood Lane
Bedminster, NJ 07921

Richard Jr. & Michele Mascarello
Or Current Resident
18 Belmont Ave
South River, NJ 08882

John R. & Janet Matson
Or Current Resident
11 Oak Tree Road
Sayreville, NJ 08872

Joseph F. & Rita R. Matagrano
Or Current Resident
58 Creamer Dr.
Sayreville, NJ 08872

Michael & Donna Matrafajlo
Or Current Resident
114 Mc Cutcheon Avenue
Sayreville, NJ 08872

Nellie Matyas
Or Current Resident
11 June Street
South River, NJ 08882

Giovanni & Irene Mattiolia
Or Current Resident
6 Forden Court
Sayreville, NJ 08872

Jan & Elizieta Matusiak
Or Current Resident
26 Water Street
South River, NJ 08882

Keith Mayer
Or Current Resident
RD 1, Box 63
Jamesburg, NJ 08831

Joseph F. & Carol M. May
Or Current Resident
49 David Street
South River, NJ 08882

Andrew & Wanda Maydish
Or Current Resident
535 Main Street
Sayreville, NJ 08872

Mary Mazuroski
Or Current Resident
110 Dolan Street
Sayreville, NJ 08872

Juan P. & Ana Mazorra
Or Current Resident
209 Whitehead Avenue
South River, NJ 08882

Rose Mazur
Or Current Resident
122 McCutcheon Avenue
Sayreville, NJ 08872

Joseph P. & Daragh McAuley
Or Current Resident
60 Canal Street
Sayreville, NJ 08872

Frank & Marlene Mazzaroni
Or Current Resident
40 William Street
Old Bridge, NJ 08857

Regina Mc Hugh
Or Current Resident
131 Mac Arthur Avenue
Sayreville, NJ 08872

Erma Lee McCarty
Or Current Resident
9 Eisenhower Dr.
Sayreville, NJ 08872

Robert McBride
Or Current Resident
12 Anne Street
South River, NJ 08882

Thomas R. & Janet A. McCarthy
Or Current Resident
21 Hope Dr.
Sayreville, NJ 08872

John McCormack
Or Current Resident
) Pershing Avenue
Sayreville, NJ 08872

Alexander & Lois McCluskey
Or Current Resident
17 William Street
South River, NJ 08882

David & Beatrice McConnell
Or Current Resident
49 Harvey Circle
East Brunswick, NJ 08816

Regina McHugh
Or Current Resident
131 MacArthur Ave
Sayreville, NJ 08872

Dolores McCoy
Or Current Resident
50 Mac Arthur Avenue
Sayreville, NJ 08872

Philip R. & Cindy McCutcheon
Or Current Resident
18 Anne Avenue
South River, NJ 08882

Joseph Mecca
Or Current Resident
75 Major Drive
Sayreville, NJ 08872

James McLellan
Or Current Resident
530 Birch Bark Drive
Brick, NJ 08723

Michael & Rose McTiernan
Or Current Resident
14 Ciecko Court
Sayreville, NJ 08872

John E. Mehl
Or Current Resident
8 Ciecko Court
Sayreville, NJ 08872

Zenen & Marjorie Medina
Or Current Resident
14 William Street
South River, NJ 08882

Rizaldy Medoza & E. Mendoza
Or Current Resident
13 Major Drive
Sayreville, NJ 08872

Kenneth S. & Rosmar Melkowitz
Or Current Resident
11 Milton Avenue
South River, NJ 08882

Donald E. & Peggy Mehlhorn
Or Current Resident
4 Marshall Place
Sayreville, NJ 08872

Thomas & Donna Melee
Or Current Resident
11 Hope Dr.
Sayreville, NJ 08872

Gregory Meseeka
Or Current Resident
183 Mac Arthur Avenue
Sayreville, NJ 08872

Rafael A. & Rafael Mendez
Or Current Resident
48 Reid Street
South River, NJ 08882

Jose & Adriana Mendez
Or Current Resident
43 Patton Dr.
Sayreville, NJ 08872

Charles E. Metz
Or Current Resident
30 Levinson Avenue
South River, NJ 08882

Joseph Messina & Fortuna Guarino
Or Current Resident
14 Major Drive
Sayreville, NJ 08872

Dorothy Methner
Or Current Resident
93 Weber Avenue
Sayreville, NJ 08872

Jeanette W. Meyertons
Or Current Resident
17 Furman Street
Sayreville, NJ 08872

Gregory J. & Maria Metzger
Or Current Resident
41 Belmont Ave
South River, NJ 08882

John & Coleen Meyer
Or Current Resident
17 Gavel Road
Sayreville, NJ 08872

Vincet & Helen Michko
Or Current Resident
18 Eisenhower Dr.
Sayreville, NJ 08872

Robert B. & Susan D. Michaelson
Or Current Resident
39 Mitchell Avenue
East Brunswick, NJ 08816

Alfred F. & Stella Michalik
Or Current Resident
125 Mac Arthur Avenue
Sayreville, NJ 08872

Joseph & Esther Migliorato
Or Current Resident
Canal Street
Sayreville, NJ 08872

Jenny M. Mieszkuc
Or Current Resident
26 Kathryn Street
South River, NJ 08882

Charles & Jennie Mieszkuc
Or Current Resident
26 Kathryn Street
South River, NJ 08882

David & Hinlicky Miller
Or Current Resident
187 Whitehead Avenue
South River, NJ 08882

Julia Mihalichko
Or Current Resident
74 Augusta Street
South River, NJ 08882

Edward & Julia Miklaszewski
Or Current Resident
35 Charles Street
Old Bridge, NJ 08857

Ralph L. & Florease Minnis
Or Current Resident
44 Augusta Street
South River, NJ 08882

Jeneen M. Miller
Or Current Resident
18 Levinson Avenue
South River, NJ 08882

Velibor & Zivana Milojevic
Or Current Resident
207 Pond Road
Freehold, NJ 07728

Wayne L. & Wayne W. Misner
Or Current Resident
4 Downing Drive
East Brunswick, NJ 08816

Edward Miranowicz
Or Current Resident
37 Roosevelt Street
South River, NJ 08882

Mohammed S. Mirza
Or Current Resident
18 Washington Street
South River, NJ 08882

Richard Monek
Or Current Resident
20 Elm Street
Bayville, NJ 08721

Edwardo & Yolanda Molina
Or Current Resident
39 Wilmont Street
East Brunswick, NJ 08816

Thomas J. & Helen M. Monaco, Jr.
Or Current Resident
7 Oak Tree Road
Sayreville, NJ 08872

James J. Moran III
Or Current Resident
9 Marshall Place
Sayreville, NJ 08872

Courtney V. & Edga M. Moore
Or Current Resident
93 McCutcheon Avenue
Sayreville, NJ 08872

Henry J. Moore
Or Current Resident
P.O. Box 455
South River, NJ 08882

Kathleen Moroz
Or Current Resident
2 Anne Street
South River, NJ 08882

James & Juanita Morgan
Or Current Resident
16 Anne Street
South River, NJ 08882

Mary & Timothy Morgan
Or Current Resident
7 James Road
East Brunswick, NJ 08816

W. Richard & Ellen Mosulak
Or Current Resident
49 David Street
Old Bridge, NJ 08857

Hanna & Stanley R. Mosakowski
Or Current Resident
102 Jackson Street
South River, NJ 08882

Stephen J. Moss
Or Current Resident
638 Englishtown Road
Old Bridge, NJ 08857

Dorothy Mozdzen
Or Current Resident
28 Mac Arthur Avenue
Sayreville, NJ 08872

Antonio C. Moulton
Or Current Resident
9 Parr Drive
Sayreville, NJ 08872

Joseph F. & Beatrice T. Mozdzen
Or Current Resident
37 Patton Dr.
Sayreville, NJ 08872

Henry Mujiyono
Or Current Resident
Central venue
East Brunswick, NJ 08816

H. M. & E. Mozdzen
Or Current Resident
26 Mac Arthur Avenue
Sayreville, NJ 08872

Juliana Mueller
Or Current Resident
103 Mac Arthur Avenue
Sayreville, NJ 08872

Wilson & Louise Murray
Or Current Resident
44 Kathryn Street
South River, NJ 08882

Melissa Muller
Or Current Resident
P.O. Box 3442
Charlottsville, VA 22903

Wilson & Louise Murray
Or Current Resident
44 Kathryn Street
South River, NJ 08882

CG & RA Fazi Mustaciuolo
Or Current Resident
19 Vandeventer Court
Sayreville, NJ 08872

Kelrick P. & Fay E. Murray
Or Current Resident
87 Canal Street
Sayreville, NJ 08872

Patrick & Dolores Murray Sr.
Or Current Resident
4 Forden Court
Sayreville, NJ 08872

Rose Myzewski
Or Current Resident
P.O. Box 115
South River, NJ 08882

Mary Lagoda Mutilitis
Or Current Resident
51-53 Washington Road
Sayreville, NJ 08872

Mary Mutilitis
Or Current Resident
53 Washington Road
Sayreville, NJ 08872

Richard S. Nalepka
Or Current Resident
173 Mac Arthur Avenue
Sayreville, NJ 08872

J. Naeema
Or Current Resident
18 Washington Street
South River, NJ 08882

Paul Nagy
Or Current Resident
15 Armstrong avenue
South River, NJ 08882

Bozena J. & Gerald Nasce
Or Current Resident
54 David Street
Old Bridge, NJ 08857

Mary Nalepka
Or Current Resident
177 Mac Arthur Avenue
Sayreville, NJ 08872

Cecelia Naperkowski
Or Current Resident
27 Thomas Street
South River, NJ 08882

Doris C. Nelson
Or Current Resident
13 Patton Dr.
Sayreville, NJ 08872

Virginia Navickas
Or Current Resident
52 Mac Arthur Avenue
Sayreville, NJ 08872

Joseph & Donna Nawalany
Or Current Resident
127 Mac Arthur Avenue
Sayreville, NJ 08872

Joseph R. & Rita Nemisnki
Or Current Resident
188 Pulaski Avenue
Sayreville, NJ 08872

Judith M. Nelson
Or Current Resident
27 Eisenhower Dr.
Sayreville, NJ 08872

E.J. & J.R. Neminski
Or Current Resident
133 North Edward Street
Sayreville, NJ 08872

JW & AW Ng
Or Current Resident
67 Canal Street
Sayreville, NJ 08872

Giuseppi & Elida Nervegna
Or Current Resident
43 Jackson Street
South River, NJ 08882

Joao M. & Alzenda B. Neto
Or Current Resident
16 William Street
South River, NJ 08882

Thaddeus & Nancy Nieratko
Or Current Resident
Brookside Avenue
Sayreville, NJ 08872

James E. & Aida I. Nickens
Or Current Resident
7 Vandeventer Court
Sayreville, NJ 08872

Joseph Niedwich
Or Current Resident
13 John Street
Old Bridge, NJ 08857

John & Susan Norel
Or Current Resident
31 Patton Dr.
Sayreville, NJ 08872

Efsta & Konstantinos Nikolaou
Or Current Resident
48 Augusta Street
South River, NJ 08882

James & Marie Niotis
Or Current Resident
5 Charles Street
Old Bridge, NJ 08857

Arlene Novak
Or Current Resident
13 Henry Street
South River, NJ 08882

Alfred F. & Julia Novak
Or Current Resident
16 Nickel Avenue
Sayreville, NJ 08872

Lucy Novak
Or Current Resident
27 Patton Dr.
Sayreville, NJ 08872

James & Marie O'Neill
Or Current Resident
P.O. Box 280
Franklin Park, NJ 08823

Michael & Frances O'Connor
Or Current Resident
84 Weber Avenue
Sayreville, NJ 08872

Brian F. & Patricia Hanshaw O'Grady
Or Current Resident
7 Vreeland Court
Sayreville, NJ 08872

Santiago Ocasio & Deb Mayers
Or Current Resident
40 Major Drive
Sayreville, NJ 08872

Raymond P. & Mary E. O'Neill
Or Current Resident
8 Eisenhower Dr.
Sayreville, NJ 08872

Antonia O'Rourke
Or Current Resident
33 Cressida Drive
Old Bridge, NJ 08857

Frank & Arlene Okulewicz
Or Current Resident
9 LeRoy Street
South River, NJ 08882

Denise Ogle
Or Current Resident
88 Causeway
South River, NJ 08882

Nancyann M. Ogrosso
Or Current Resident
13 Furman Avenue
Sayreville, NJ 08872

Edward T. Olender
Or Current Resident
25 Patton Dr.
Sayreville, NJ 08872

Richard Olchaskey
Or Current Resident
220 First Street
South Amboy, NJ 08879

Frank & Marian Olchaskey
Or Current Resident
54 Weber Avenue
Sayreville, NJ 08872

Dagoberto & Leticia Olive
Or Current Resident
12 Major Drive
Sayreville, NJ 08872

Joseph J. & Joan M. Oleniak
Or Current Resident
66 Washington Road
Sayreville, NJ 08872

Kenneth & Mary Ann Oleskin
Or Current Resident
13 Ciecko Court
Sayreville, NJ 08872

Mark & Julie Orlando
Or Current Resident
14 Nimitz Place
Sayreville, NJ 08872

Jose M. & Aldina G. Oliveira
Or Current Resident
109 Whitehead Avenue
South River, NJ 08882

T. Olszewski
Or Current Resident
7 Pitt Road
East Brunswick, NJ 08816

Della Oshiro
Or Current Resident
Ciecko Court
Sayreville, NJ 08872

Robert J. & Joan Orlopp
Or Current Resident
1 Bright Street
Sayreville, NJ 08872

Rose Orsag
Or Current Resident
157 Prospect Street
South River, NJ 08882

Manuel & Celia C. Pacheco
Or Current Resident
32 Levinson Avenue
South River, NJ 08882

Ronald & Christine Osmond
Or Current Resident
43 Bordertown Avenue
Old Bridge, NJ 08857

Regina Osowski
Or Current Resident
64 Ferris Street
South River, NJ 08882

Vincet Paisal
Or Current Resident
216 South Broadway
South Amboy, NJ 08879

Michael & Catherine Pachkowski
Or Current Resident
34 Charles Street
Old Bridge, NJ 08857

Helen Padla
Or Current Resident
7 Hope Dr.
Sayreville, NJ 08872

Leona & Fred Palka
Or Current Resident
68 Washington Road
Sayreville, NJ 08872

Eugeniusz Pajkowski
Or Current Resident
26 Water Street
South River, NJ 08882

Michael & Jean Palazzolo
Or Current Resident
31 Water Street
South River, NJ 08882

Emanuel & Tina Papamanolis
Or Current Resident
12 Starkin Road
Milltown, NJ 08850

Eugene & Charlotte Palmer
Or Current Resident
25 Eisenhower Dr.
Sayreville, NJ 08872

Gary S. Panichella
Or Current Resident
17 Hwy Terrace
Edison, NJ 08817

Russell & Eleanor Parker
Or Current Resident
3 LeRoy Street
South River, NJ 08882

Robert & Brazyna Pasko
Or Current Resident
56 Vandeventer Court
Sayreville, NJ 08872

Patel
Or Current Resident
35 Major Drive
Sayreville, NJ 08872

Priya A. & Kumarninad M. Patel
Or Current Resident
21 Vandeventer Court
Sayreville, NJ 08872

Rameshbhai T. & Niranjan Patel
Or Current Resident
61 Whitehead Avenue
South River, NJ 08882

Richrd & Joyce Patterson
Or Current Resident
34 Water Street
South River, NJ 08882

Scott W. & Olaine T. Pelham
Or Current Resident
9 Furman Avenue
Sayreville, NJ 08872

Jennifer & Stanley Pawlowski
Or Current Resident
29 Herman Street
South River, NJ 08882

Palmer Lee Pearson
Or Current Resident
9 Levinson Avenue
South River, NJ 08882

Alcina & Americo Periera
Or Current Resident
7 LeRoy Street
South River, NJ 08882

Maria Pelka
Or Current Resident
440 Buckelew Avenue
Monroe, NJ 08831

Agostino & Olivia Pereira
Or Current Resident
25 Herman Street
South River, NJ 08882

Anna Peteet
Or Current Resident
.evinson Avenue
South River, NJ 08882

Vincent Petrie, Jr.
Or Current Resident
11 High Street
South River, NJ 08882

Daniel Phillips
Or Current Resident
5 Sugarbush Court
Jackson, NJ 08527

Stanley M. Pietrowicz
Or Current Resident
19 Elana Drive
Jackson, NJ 08527

Armando S.R. Pineda
Or Current Resident
59 Major Drive
Sayreville, NJ 08872

Kenneth & Christine Piscitelli
Or Current Resident
9 Canal Street
Sayreville, NJ 08872

Stella Pish
Or Current Resident
36 Herman Street
South River, NJ 08882

Joseph Podsiadlik
Or Current Resident
35 Levinson Avenue
South River, NJ 08882

Joseph J. Polgar
Or Current Resident
28 Idlewile Avenue
Sayreville, NJ 08872

Micheal D. & Maria D. Perini
Or Current Resident
3 Connors Court
Sayreville, NJ 08872

Philip & Robin Rhine Peter
Or Current Resident
31 Levinson Avenue
South River, NJ 08882

James J. & Regina A. Petroski
Or Current Resident
117 Weber Avenue
Sayreville, NJ 08872

Carmella Piccolo
Or Current Resident
18 Ciecko Court
Sayreville, NJ 08872

Peter & Emilie Pilecki
Or Current Resident
7 Reid Street
South Rier, NJ 08882

Jane H. Pinkowski
Or Current Resident
3 Bright Street
Sayreville, NJ 08872

D. Piscitelli
Or Current Resident
33 Thomas Street
South River, NJ 08882

Wieslaw & Alina Pitera
Or Current Resident
15 James Street
South River, NJ 08882

John C. & Theresa C. Polak
Or Current Resident
196 Amwell Road
Somerville, NJ 08876

Krishna Persad
Or Current Resident
55 Canal Street
Sayreville, NJ 08872

Robert & Marianne Petersen
Or Current Resident
13 Highland Avenue
South River, NJ 08882

Thomas J. & Debra A. Phair
Or Current Resident
100 Dolan Street
Sayreville, NJ 08872

Frank T. & Alicia M. Picone
Or Current Resident
4 Watt Street
South River, NJ 08882

Daniel F. & Ilda Pimental
Or Current Resident
44 Belmont Ave
South River, NJ 08882

Jose D. & Leonilde Pinto
Or Current Resident
90 Standiford Avenue
Sayreville, NJ 08872

Salvatore & Glenna Piscitelli
Or Current Resident
34 Levinson Avenue
South River, NJ 08882

Louise Plevina
Or Current Resident
52 Reid Street
South River, NJ 08882

Joseph J. Polgar
Or Current Resident
28 Idlewild Avenue
Sayreville, NJ 08882

William F. Polochak
Or Current Resident
Marshall Place
Sayreville, NJ 08872

Simone B. Porcaro
Or Current Resident
126 Weber Avenue
Sayreville, NJ 08872

Antonio & Feranda Pratas
Or Current Resident
54 Armstrong Avenue
South River, NJ 08882

Rosemarie Prusakowski
Or Current Resident
58 Dolan Street
Sayreville, NJ 08872

Helen Przygoda
Or Current Resident
37 Water Street
South River, NJ 08882

Eduardo & Patricia Pulido
Or Current Resident
128 Weber Avenue
Sayreville, NJ 08872

D. Scavone & R. Obusek
Or Current Resident
101 Millstone Rd
Englishtown, NJ 07726

Cosmos Radix & Marie Won
Or Current Resident
92 Canal Street
Sayreville, NJ 08872

Ahmed Ramandan
Or Current Resident
49 Major Drive
Sayreville, NJ 08872

O & E. Polgardi
c/o Otto's Liquor
Or Current Resident
49 Obert Street
South River, NJ 08882

Mary Poplowski
Or Current Resident
11 Snyder Avenue
Sayreville, NJ 08872

Benedict J. Porowski
Or Current Resident
Mac Arthur Avenue
Sayreville, NJ 08872

Allan J. & Yvette S. Pressman
Or Current Resident
20 Oak Tree Road
Sayreville, NJ 08872

Frances Przybylko
Or Current Resident
1540 Evelyn Avenue
North Brunswick, NJ 08902

E & T. Ptaszynski
Or Current Resident
36 Water Street
South River, NJ 08882

Edward J. & Marie A. Pytel
Or Current Resident
56 Dolan Street
Sayreville, NJ 08872

Christopher & Susan Raba
Or Current Resident
26 Washington Road
Sayreville, NJ 08872

Jesus & Mary Josephine Rafanan
Or Current Resident
73 Canal Street
Sayreville, NJ 08872

Joseph & Charlotte Pollack
Or Current Resident
26 Stephen Street
South River, NJ 08882

Terry E. & Bonnie Popowski
Or Current Resident
103 Weber Avenue
Sayreville, NJ 08872

Charles J. & Theresa Powell, Sr.
Or Current Resident
58 Levinson Avenue
South River, NJ 08882

Petro Prochliak
Or Current Resident
13 Maple Street
South River, NJ 08882

Candace & La Branche Przygoda
Or Current Resident
445 Main Street
Sayreville, NJ 08872

Johnnie L. & Denise C. Pugh
Or Current Resident
65 Canal Street
Sayreville, NJ 08872

Mary Ellen Quigley
Or Current Resident
11 Herman Street
South River, NJ 08882

Czeslan & Danuta Raczynski
Or Current Resident
104 Lark Drive
South River, NJ 08882

John F. Rakoski
Or Current Resident
95 Prospect Street
South River, NJ 08882

Raymond & Mariann Rayhon
Or Current Resident
Standiford Avenue
Sayreville, NJ 08872

Hector, Sonia & Olivo Ramirez
Or Current Resident
7 Canal Street
Sayreville, NJ 08872

Mary Rasmussen
Or Current Resident
2 Lee Street
South River, NJ 08882

Michael Reckage
Or Current Resident
38 Levinson Avenue
South River, NJ 08882

Michael & Mary I. Razzano, Sr.
Or Current Resident
1 Lee Street
South River, NJ 08882

Ronald W. Reba
Or Current Resident
41 Reid Street
South River, NJ 08882

William Reichenbach, Jr.
Or Current Resident
21 George Street
South River, NJ 08882

Viola Reckage
Or Current Resident
38 Levinson Avenue
South River, NJ 08882

Robert Reichenbach
Or Current Resident
4 William Street
South River, NJ 08882

Alan P. & Lori A. Reilly
Or Current Resident
24 Stephen Street
South River, NJ 08882

Gregory G. Reid
Or Current Resident
3 Washington Street
South River, NJ 08882

Stelvino Reigota
Or Current Resident
40 Levinson Avenue
South River, NJ 08882

Ana-Paula Goncalves Renkert
Or Current Resident
199 Mac Arthur Avenue
Sayreville, NJ 08872

Michele & R. Candelario Reis
Or Current Resident
2 Nimitz Place
Sayreville, NJ 08872

Edward R. & Rosa M. Rendon
Or Current Resident
41 Major Drive
Sayreville, NJ 08872

Santa Restivo
Or Current Resident
98 Weber Avenue
Sayreville, NJ 08872

Francis & Nancy Renner
Or Current Resident
10 Armstrong Avenue
South River, NJ 08882

Joseph C. & Janice R. Repetti
Or Current Resident
21 Oak Tree Road
Sayreville, NJ 08872

Armando & Ermelinda Ribau
Or Current Resident
72 Prospect Street
Newark, NJ 07105

Norma Rhoades
Or Current Resident
27 Vandeventer Court
Sayreville, NJ 08872

Albino C. & Maria L. Ribau
Or Current Resident
2 LeRoy Street
South River, NJ 0882

David & Kathryn Rizzo Jr.
Or Current Resident
12 Weber Avenue
Sayreville, NJ 08872

Adolfo & Ada Rivera
Or Current Resident
4 Conners Court
Sayreville, NJ 08872

Arnaldo & Maria C. Rivera
Or Current Resident
91 Canal Street
Sayreville, NJ 08872

Carolyn Robertson
Or Current Resident
39 William Street
South River, NJ 08882

Alfred F. & Thomas Moon Rizzuto
Or Current Resident
31 Vandeventer Court
Sayreville, NJ 08872

James & Anna Robertson
Or Current Resident
27 Kathryn Street
South River, NJ 08882

Joseph J. & Mary Rock
Or Current Resident
Levinson Avenue
South River, NJ 08882

Maria Rocha
Or Current Resident
34 Armstrong Avenue
South River, NJ 08882

Iria & Regina Rocha
Or Current Resident
19 Miller Street
South River, NJ 08882

Peter & Donna Roehsler
Or Current Resident
P.O. Box 161
South River, NJ 08882

F. & Costa, J. & M. Rodrigues
Or Current Resident
11 Jackson Street
South River, NJ 08882

Ivette Rodriguez
Or Current Resident
15 Herman Street
South River, NJ 08882

John Roj
Or Current Resident
20 Elizabeth Street
South River, NJ 08882

James C. Roes
Or Current Resident
5 Herman Street
South River, NJ 08882

Szczepan & Danuta Roguski
Or Current Resident
1 Hope Dr.
Sayreville, NJ 08872

Carlos & Edith Roman
Or Current Resident
17 Ciecko Court
Sayreville, NJ 08872

Robert Roj
Or Current Resident
31 Smith Street
Sayreville, NJ 08872

Thomas M. & Jodi A. Roland
Or Current Resident
1 Eisenhower Dr.
Sayreville, NJ 08872

William A. Rondeau Jr.
Or Current Resident
5 Patton Dr.
Sayreville, NJ 08872

Joan E. Romanowski
Or Current Resident
17 Hope Dr.
Sayreville, NJ 08872

Richard & Linda Romeo
Or Current Resident
10 Radcliffe Street
South River, NJ 08882

Milton & Grace Rose
Or Current Resident
15 George Street
South River, NJ 08882

Ezekial & Ruth B. Roper
Or Current Resident
72 Canal Street
Sayreville, NJ 08872

Julio, Mayra & Saeed Rosario
Or Current Resident
20 Marie Street
South River, NJ 08882

Cheryl Z. Rosenberg
Or Current Resident
20 Mershon Drive
Princton, NJ 08540

Willie & Charlotte Roseburgh
Or Current Resident
7 Major Drive
Sayreville, NJ 08872

Thomas C. & Leslie Roselli
Or Current Resident
22 Samuel Drive
South River, NJ 08882

Homer & Masie Rozier
Or Current Resident
21 Kathryn Street
South River, NJ 08882

Felix & Antoinette Rosinksi
Or Current Resident
60 Dolan Street
Sayreville, NJ 08872

Louis & Lena Rossi
Or Current Resident
63 Reid Street
South River, NJ 08882

Alfred E. & Sari M. Rudmann
Or Current Resident
41 Vandeventer Court
Sayreville, NJ 08872

Joseph & Rosemarie Rubino
Or Current Resident
31 Charles Street
Old Bridge, NJ 08857

Howard J. Rudd
Or Current Resident
2 Vandeventer Court
Sayreville, NJ 08872

Miguel Ruiz & Dorothy A.
Habenstein
Current Resident
, Canal Street
Sayreville, NJ 08872

George & Lydia Rug
Or Current Resident
31 Thomas Street
South River, NJ 08882

Robert Ruggiero
Or Current Resident
12 Forden Court
Sayreville, NJ 08872

Florence Rzigalinski
Or Current Resident
361 Main Street
Sayreville, NJ 08872

James M. & Lori A. Rusbarsky
Or Current Resident
10 Washington Road
Sayreville, NJ 08872

Thomas & Mary Ann Ryan
Or Current Resident
84 Mac Arthur Avenue
Sayreville, NJ 08872

Richard F. & Diane M. Sabo
Or Current Resident
64 Washington Road
Sayreville, NJ 08872

Maria Saavedra
Or Current Resident
31 Obert Street
South River, NJ 08882

Andrew & Carol Sabine
Or Current Resident
2 Ciecko Court
Sayreville, NJ 08872

Frederick & Claire Salamon
Or Current Resident
40 Charles Street
Old Bridge, NJ 08857

Florence Sack
Or Current Resident
8 Furman Avenue
Sayreville, NJ 08872

Andrew Sadowski
Or Current Resident
RR #1 Box 3-A
Old Bridge, NJ 08857

Josephine Samuel
Or Current Resident
97 Mac Arthur Avenue
Sayreville, NJ 08872

Robert F. & James Samuel
Or Current Resident
41 Furman Avenue
Sayreville, NJ 08872

David & Debra Samuel
Or Current Resident
99 Winkler Street
Sayreville, NJ 08872

Antonia M. & Augusta P. Santos
Or Current Resident
21 Essex Street
South River, NJ 08882

Emido & Maria Sancho
Or Current Resident
192 Johnson Place
South River, NJ 08882

M. Santiago & A. Rudolph
Or Current Resident
10 Ciecko Court
Sayreville, NJ 08872

Manuel M. & Maria E. Santos
Or Current Resident
89 William Street
South River, NJ 08882

Manuel Santos
Or Current Resident
33 Elizabeth Street
South River, NJ 08882

Joelson P. Santos
Or Current Resident
179 Whitehead Avenue
South River, NJ 08882

Joao & Rosa Sarabando
Or Current Resident
13 Fourth Street
South River, NJ 08882

Manuel & Rosinda Santos
Or Current Resident
10 Oak Tree Road
Sayreville, NJ 08872

Carlos & Maria A. Santos
Or Current Resident
39 Weber Avenue
Sayreville, NJ 08872

Donald Satorski
Or Current Resident
71 Mac Arthur Avenue
Sayreville, NJ 08872

Benjamin & Marie Saranglao, Jr.
Or Current Resident
19 Samuel Drive
South River, NJ 08882

Stillianos Sardis
Or Current Resident
78 Causeway
South River, NJ 08882

David G. & Evelyn J. Sauer
Current Resident
Oak Tree Road
Sayreville, NJ 08872

Donald F. & B. Satorski
Or Current Resident
53 Weber Avenue
Sayreville, NJ 08872

James Satorski
Or Current Resident
74 Macarthur Avenue
Sayreville, NJ 08872

John & Rosemarie Scala
Or Current Resident
440 Turnpike Road
South River, NJ 08882

Matthew J. Sautner
Or Current Resident
9 Vandeventer Court
Sayreville, NJ 08872

Helen Sawka
Or Current Resident
17 Canal Street
Sayreville, NJ 08872

Rudolph & Helen Scheffler
Or Current Resident
47 Bordentown Avenue
Old Bridge, NJ 08857

John & Marianne Scarola
Or Current Resident
78 Canal Street
Sayreville, NJ 08872

Micahel J. Scarpa
Or Current Resident
23 Vandeventer Court
Sayreville, NJ 08872

John C. & Doreen Schlottfeld
Or Current Resident
86 Canal Street
Sayreville, NJ 08872

Rudolph & Helen Scheffler
Or Current Resident
26 Wembley Drive
Mt. Laurel, NJ 08054

Lawrence F. & Theresa Scheid
Or Current Resident
9 Nimitz Place
Sayreville, NJ 08872

Igor & Klaudia Schtschors
Or Current Resident
31 Herman Street
South River, NJ 08882

Andrew & Elsie Schmidt
Or Current Resident
13 Florence Street
South River, NJ 08882

Mark & Helene Schrager
Or Current Resident
13 Dobson Rd
East Brunswick, NJ 08816

Samuel & Eileen Scott
Or Current Resident
49 Woodbridge Avenue
Highland Park, NJ 08904

John & Myrtle Schwolow
Or Current Resident
13 Marshall Place
Sayreville, NJ 08872

Walter & Shirley Scibek
Or Current Resident
11 Canal Street
Sayreville, NJ 08872

Cathleen & Nancy Sedlak
Or Current Resident
49 Furman Avenue
Sayreville, NJ 08872

H. Kenneth & Georgia A. Scott
Or Current Resident
14 Oak Tree Road
Sayreville, NJ 08872

Merton & Marylou Seaman
Or Current Resident
10 Marshall Place
Sayreville, NJ 08872

Ella Sengstack
Or Current Resident
80 William Street
Old Bridge, NJ 08857

Alberto & Maria Seixeiro
Or Current Resident
5 Grand Avenue
South River, NJ 08882

Maria Selevanov
Or Current Resident
47 Augusta Srtee
South River, NJ 08882

Babak K. & Silvana Seraji
Or Current Resident
43 Furman Avenue
Sayreville, NJ 08872

Irene Sengstack
Or Current Resident
82 William Street
Old Bridge, NJ 08857

Linda Senyszyn
Or Current Resident
104 Weber Avenue
Sayreville, NJ 08872

Anil & Shilpa Shah
Or Current Resident
4 Hinton Street
Sayreville, NJ 08872

Alfred J. & Alice S. Serra
Or Current Resident
13 Oak Tree Road
Sayreville, NJ 08872

Herman & Rosa Serrano
Or Current Resident
15 Gavel Road
Sayreville, NJ 08872

Rasheed I. Shaikh
Or Current Resident
16 Major Drive
Sayreville, NJ 08872

Harish & Hema Shah
Or Current Resident
23 Major Drive
Sayreville, NJ 08872

Frakash Shah & Nanda P. Shah
Or Current Resident
77 Canal Street
Sayreville, NJ 08872

Michael P. & Mary C. Sheenan
Or Current Resident
16 Oak Tree Road
Sayreville, NJ 08872

Herbert Shapiro
Or Current Resident
13 Thomas Street
South River, NJ 08882

William & Barbara Shaver Jr.
Or Current Resident
97 McCutcheon Avenue
Sayreville, NJ 08872

William C. & Betty Shields
Or Current Resident
2 Brant Street
South River, NJ 08882

Tony L. & Betty Sheperd
Or Current Resident
9 Anderson Court
Sayreville, NJ 08872

Johnson C. & Sharon M. Sherwood
Or Current Resident
24 Marshall Place
Sayreville, NJ 08872

Eric Shuler
Or Current Resident
59 Washington Road
Sayreville, NJ 08872

L.L.C. Shimon
Or Current Resident
217 Yorkshire Court
Old Bridge, NJ 08857

Kapildev J. & Hansak Shukla
Or Current Resident
55 Major Drive
Sayreville, NJ 08872

John Siarniak Jr.
Or Current Resident
37 Meadow Point Dr.
Brick, NJ 08723

Aloysius & Anna Shymanski
Or Current Resident
30 Charles Street
Old Bridge, NJ 08857

Edward & Mary Shymanski
Or Current Resident
15 John Street
Old Bridge, NJ 08857

Zlatan & Luba Sifovski
Or Current Resident
26 Grand Avenue
South River, NJ 08882

Marion Regelski Siatkowski
Or Current Resident
14 June Street
South River, NJ 08882

Zvonko Z. Sifovski
Or Current Resident
19 Levinson Avenue
South River, NJ 08882

Alenander & Nina Silwanowicz
Or Current Resident
156 Kamm Avenue
South River, NJ 08882

Richard Sigmund Jr.
Or Current Resident
21 Canal Street
Sayreville, NJ 08872

Dennis Silowka
Or Current Resident
10 Charles Street
Old Bridge, NJ 08857

Nigel Singh & Francine Singh
Or Current Resident
3 Anderson Court
Sayreville, NJ 08872

S. & J. Frikker Simon
Or Current Resident
25 Garfield Avenue
East Brunswick, NJ 08816

Alfed & Frances Singer
Or Current Resident
28 Weber Avenue
Sayreville, NJ 08872

Cheung Yim & Tak Kam Cheung
Or Current Resident
2 Major Drive
Sayreville, NJ 08872

Josephine & Anderson Sippel
Or Current Resident
23 Levinson Avenue
South River, NJ 08882

Helen & Messeka, G. & D Siry
Or Current Resident
27 Armstrong Avenue
South River, NJ 08882

David J. Siwulec
Or Current Resident
700 Jernee Mill Road
Sayreville, NJ 08872

Andrew J. Sivess
Or Current Resident
20-22 Armstrong Avenue
South River, NJ 08882

Andrew K. & Josephine K. Siwadlo
Or Current Resident
93 Standiford Avenue
Sayreville, NJ 08872

Mary Skwara
Or Current Resident
50 Weber Avenue
Sayreville, NJ 08872

Walter & Peggy A. Skiba
Or Current Resident
22 Marie Street
South River, NJ 08882

Frederick Skurka
Or Current Resident
187 Mac Arthur Avenue
Sayreville, NJ 08872

Mary Smierzynski
Or Current Resident
455 Main Street
Sayreville, NJ 08872

Gary Skwiat & Karen Kubicher
Or Current Resident
6 Ciecko Court
Sayreville, NJ 08872

Dean T. Sliker
Or Current Resident
1 Henry St
South River, NJ 08882

Robert & Patricia Smith
Or Current Resident
19 Water Street
South River, NJ 08882

Helen Smigalewski
Or Current Resident
21 Jernee Mill Road
Sayreville, NJ 08872

J. Smiglesky
Or Current Resident
33 Thomas Street
South River, NJ 08882

Marie Smith
Or Current Resident
6 Bissett Street
Sayreville, NJ 08872

Linda Yvette Smith
Or Current Resident
9 Major Drive
Sayreville, NJ 08872

Paul & David Smith
Or Current Resident
31 Quaid Street
Sayreville, NJ 08872

Joel Solomon
c/o Fashion Expl.
Or Current Resident
P.O. Box 355
South River, NJ 08882

Veronica Sobiranski
Or Current Resident
52 William Street
Old Bridge, NJ 08857

John & Carol Soke
Or Current Resident
39 Belmont Ave
South River, NJ 08882

Stanley P. & Annie Soroka
Or Current Resident
27 Levinson Avenue
South River, NJ 08882

Michael Sopchck
Or Current Resident
1 Nimitz Place
Sayreville, NJ 08872

Esther Sorensen
Or Current Resident
14 Eisenhower Dr.
Sayreville, NJ 08872

Alfreda & Annette Sowa
Or Current Resident
21 Bordertown Avenue
Old Bridge, NJ 08857

Peter & Sophia Sosulski
Or Current Resident
132 Weber Avenue
Sayreville, NJ 08872

Antonio Sousa
Or Current Resident
67 Major Drive
Sayreville, NJ 08872

Carmen F. & Christine O. Spezzi
Or Current Resident
[illegible]1 Weber Avenue
Sayreville, NJ 08872

Specialty Refractories, Inc.
Or Current Resident
405 Lexington Avenue
New York, NY 10174

David & Dolores Sperber
Or Current Resident
50 Brookside Avenue
Sayreville, NJ 08872

Charles L. & Laura A. Stark
Or Current Resident
9 George Street
South River, NJ 08882

Anthony J. Spitaleri
Or Current Resident
18 Ferry Street
South River, NJ 08882

Howard R. & Larnice Spruill
Or Current Resident
171 Chestnut Street
Avenel, NJ 07001

Carol Ann & Howarth, J. Staunch
Or Current Resident
29 Levinson Avenue
South River, NJ 08882

Helen Starzynski
Or Current Resident
82 Mac Arthur Avenue
Sayreville, NJ 08872

Frank Joseph & Stella P. Staskiak
Or Current Resident
73 Fanwood Dr.
Sayreville, NJ 08872

Mary Stelmaszek
Or Current Resident
18 Nickel Avenue
Sayreville, NJ 08872

Ronald T. & Lisa A. Steiner
Or Current Resident
14 John Street
Old Bridge, NJ 08857

Douglas & Angela P. Steiner
Or Current Resident
84 Canal Street
Sayreville, NJ 08872

Peter Stojcevski
Or Current Resident
57 Armstrong Avenue
South River, NJ 08882

Robert & Lula Mae Stembridge
Or Current Resident
54 Levinson Avenue
South River, NJ 08882

Benjamin Stevens
Or Current Resident
101 Weber Avenue
Sayreville, NJ 08872

Paul & Kathleen Stuart
Or Current Resident
12 Washington Street
South River, NJ 08882

Brian J. & Robin E. Storrs
Or Current Resident
86 Lark Drive
South River, NJ 08882

Jorge & Lillian Storti
Or Current Resident
13 Armstrong avenue
South River, NJ 08882

Thomas & Veronica Sullivan
Or Current Resident
5 John Street
Old Bridge, NJ 08857

Rose Ann Styles
Or Current Resident
58 William Street
Old Bridge, NJ 08857

George Sudnikovich
Or Current Resident
67 Augusta Street
South River, NJ 08882

Victoria Supak
Or Current Resident
29 Eisenhower Dr.
Sayreville, NJ 08872

Jacob Sumski
Or Current Resident
22 Schack Avenue
South River, NJ 08882

Hung-Chi & Shui-Wah Sung
Or Current Resident
48 Major Drive
Sayreville, NJ 08872

Walter Swenticky
Or Current Resident
69 Augusta Street
South River, NJ 08882

Edward & Violet Sutton
Or Current Resident
96 Mac Arthur Avenue
Sayreville, NJ 08872

Alice M. Swecanski
Or Current Resident
4 Serviss Street
South River, NJ 08882

Stanley R. & Lori Synarksi Jr.
Or Current Resident
15 Mac Arthur Avenue
Sayreville, NJ 08872

Marie Swider
Or Current Resident
54 Washington Road
Sayreville, NJ 08872

Mary Swider
Or Current Resident
118 Causeway
South River, NJ 08882

Joseph M. & Florence L. Syslo
Or Current Resident
16 Washington Road
Sayreville, NJ 08872

Raymond & Doris Syslo
Or Current Resident
52 Dolan Street
Sayreville, NJ 08872

Martin D. Syslo
Or Current Resident
50 Dolan Street
Sayreville, NJ 08872

Edward J. & Joan Szarejko
Or Current Resident
74 Weber Avenue
Sayreville, NJ 08872

Louis & Linda Szabo
Or Current Resident
15 Weber Avenue
Sayreville, NJ 08872

Joan Szarejko
Or Current Resident
74 Weber Avenue
Sayreville, NJ 08872

Mary & Joseph Szeliga
Or Current Resident
14 Furman Avenue
Sayreville, NJ 08872

James & Lorraine Szawaryn
Or Current Resident
129 Weber Avenue
Sayreville, NJ 08872

Robert & Linda E. Szegeti
Or Current Resident
10 Terry Avenue
South River, NH 08882

Michael T. Szkodny
Or Current Resident
14 Reid Street
South River, NJ 08882

Rodolphe J. & Donna J. Szilagyi
Or Current Resident
24376 Dietz Drive
Bonita Springs, FL 34135

Feliks & Euginia Szkiladz
Or Current Resident
58 Augusta Street
South River, NJ 08882

Anthony Talarico
Or Current Resident
112 East Main Street
Bergenfield, NJ 07621

Agnes & Edward Szymanski
Or Current Resident
25 Furman Avenue
Sayreville, NJ 08872

David Tabaczynski
Or Current Resident
45 Charles Street
Old Bridge, NJ 08857

Jeannette Targonski
Or Current Resident
99 Mac Arthur Avenue
Sayreville, NJ 08872

Eddie G. & Jacqueline B. Tan
Or Current Resident
5 Anderson Court
Sayreville, NJ 08872

Daniel E. & Ana Tarantini
Or Current Resident
20 Bissett Street
Sayreville, NJ 08872

John T. & Florence K. Tarnacki
Or Current Resident
251 MacArthur Avenue
Sayreville, NJ 08872

Chester & Clara Targonski
Or Current Resident
446 Main Street
Sayreville, NJ 08872

Guy Targonski
Or Current Resident
71 Weber Avenue
Sayreville, NJ 08872

Shiv & Rajesh Thapar
Or Current Resident
13 Tyska Avenue
Sayreville, NJ 08872

Fernando & Teresita Tendeiro
Or Current Resident
144 Whitehead Avenue
South River, NJ 08882

Ruth A. & Blair D. Terhune
Or Current Resident
11 Furman Avenue
Sayreville, NJ 08872

Gertrude Thomas
Or Current Resident
4 Marie Street
South River, NJ 08882

Richard & Joyce Thomas
Or Current Resident
20 Belmont Ave
South River, NJ 08882

Rosie Thomas
Or Current Resident
306 Central Avenue
Edison, NJ 08817

Theodore S. & Lynn Thorn
Or Current Resident
1 Anderson Court
Sayreville, NJ 08872

Norman G. & Beatrice Thomas
Or Current Resident
32 Belmont Ave
South River, NJ 08882

Richard & Jodie Thomas
Or Current Resident
25 Vandeventer Court
Sayreville, NJ 08872

Myrtle Toft
Or Current Resident
29 Patton Dr.
Sayreville, NJ 08872

Dante P. & Marilou Tinitigan
Or Current Resident
22-24 Washington Road
Sayreville, NJ 08872

Larry Todman & Diane M. Goulding
Or Current Resident
3 Parr Drive
Sayreville, NJ 08872

John & Robin Tonzola
Or Current Resident
10 Marie Street
South River, NJ 08882

Sophie Tolmachewich
Or Current Resident
7 Harman Street
South River, NJ 08882

Manuel & Maria Tome
Or Current Resident
10 William Street
South River, NJ 08882

Eladio & Evelyn S. Torres
Or Current Resident
9 Charles Street
Old Bridge, NJ 08857

Stacia Toreky
Or Current Resident
27 Jeffrie Avenue
South River, NJ 08882

Ariel & Theresa Torres
Or Current Resident
29 Water Street
South Rivernj, NJ 08882

Anthony J. and Irene Toto
Or Current Resident
19 Flagler Street
East Brunswick, NJ 08816

Cecelia Toth
Or Current Resident
133 Mac Arthur Avenue
Sayreville, NJ 08872

Gary F. & Genevieve A. Toth
Or Current Resident
9 John Street
Old Bridge, NJ 08857

Brian & Samantha Trainor
Or Current Resident
69 Major Drive
Sayreville, NJ 08872

Ann Marie Toto
Or Current Resident
109 Davis Lane
Red Bank, NJ 07701

John P. & Gayle Grankowski Tracy
Or Current Resident
113 Weber Avenue
Sayreville, NJ 08872

Mark S. Tresch
Or Current Resident
11 Nimitz Place
Sayreville, NJ 08872

Gordon J. & Brenda Treat
Or Current Resident
60 William Street
Old Bridge, NJ 08857

Frederick J. & Diana Trepesowsky
Or Current Resident
62 Dolan Street
Sayreville, NJ 08872

Edward L. Trygar
Or Current Resident
44 Ferry Street
South River, NJ 08882

Joseph F. & Patricia Tripod Jr.
Or Current Resident
6 Fisher Street
Sayreville, NJ 08872

Felix & Jennie Trojanowski
Or Current Resident
205 Whitehead Avenue
South River, NJ 08882

Phyllis A. & Scott Turner
Or Current Resident
8 Furman Avenue
Sayreville, NJ 08872

Joyce Tucker
Or Current Resident
19 Herman Street
South River, NJ 08882

Lawrence & Marie Tulanowski
Or Current Resident
44 Quaid Avenue
Sayreville, NJ 08872

George H. & Katherine Uhrig
Or Current Resident
94 Mac Arthur Avenue
Sayreville, NJ 08872

Vera & John H. Twardos
Or Current Resident
40 Mac Arthur Avenue
Sayreville, NJ 08872

Theodore J. & Barbara Tyskiewicz
Or Current Resident
111 Weber Avenue
Sayreville, NJ 08872

Arthur & Veronica Utter
Or Current Resident
38 Weber Avenue
Sayreville, NJ 08872

Anthony S. Ulcej
Or Current Resident
499 Main Street
Sayreville, NJ 08872

Edward & Jennifer Ureta
Or Current Resident
15 Samuel Drive
South River, NJ 08882

Ovidio & Mayra Valentin, Jr.
Or Current Resident
5 Oak Tree Road
Sayreville, NJ 08872

M. Vainqueur
Or Current Resident
15 Ciecko Court
Sayreville, NJ 08872

Freddy A. Vajda
Or Current Resident
67 Valley Forge Drive
East Brunswick, NJ 08816

Alexander J. Vass
Or Current Resident
23 Eisenhower Dr.
Sayreville, NJ 08872

Armindo & Maria Valoura
Or Current Resident
9 First Street
East Brunswick, NJ 08816

Evelyn Vargas
Or Current Resident
11 Anderson Court
Sayreville, NJ 08872

M. Verbitski
Or Current Resident
P.O. Box 241
South River, NJ 08882

Samuel & Noelia Vega
Or Current Resident
93 Canal Street
Sayreville, NJ 08872

Ismael & Nilsa Velez
Or Current Resident
4 Parr Drive
Sayreville, NJ 08872

Heriberto & Deidre L. Vidro Jr.
Or Current Resident
95 River Road
Sayreville, NJ 08872

Jane E. Verpent
Or Current Resident
37 William Street
South River, NJ 08882

Edward G. & Mariann C. Veverka
Or Current Resident
11 Vandeventer Court
Sayreville, NJ 08872

Joyce L. Vinson & Leroy Manley
Or Current Resident
97 Canal Street
Sayreville, NJ 08872

Robert & Deborah Vierschilling Jr.
Or Current Resident
7 Furman Avenue
Sayreville, NJ 08872

James & Maria Elena Villa
Or Current Resident
71 Major Drive
Sayreville, NJ 08872

Ddaniel & Margaret Volosin
Or Current Resident
9 Oak Tree Road
Sayreville, NJ 08872

Nicholas J. Vivona
Or Current Resident
42 Eisenhower Dr.
Sayreville, NJ 08872

Elizabeth Vlcej
Or Current Resident
126 Whitehead Avenue
South River, NJ 08882

Barry Vroeginday
Or Current Resident
4 Vandeventer Court
Sayreville, NJ 08872

Michael A. Vona
Or Current Resident
65 Weber Avenue
Sayreville, NJ 08872

Steve and Rose Vrable
Or Current Resident
54 Scott Avenue
South Amboy, NJ 08879

Ethel Mae Walker
Or Current Resident
4 Anne Street
South River, NJ 08882

Wladyslaw & Elizabeth Wajda
Or Current Resident
86 William Street
South River, NJ 08882

Stanley & Lorraine Walczak
Or Current Resident
32 Obert Street
South River, NJ 08882

Dawn marie Warren
Or Current Resident
529 Main Street
Sayreville, NJ 08872

Earl & Kathleen Walker
Or Current Resident
116 Weber Avenue
Sayreville, NJ 08872

Lydia & Miranowicz Wallach
Or Current Resident
92 Hillside Avenue
South River, NJ 08882

Harry & Mary V. Wasnak
Or Current Resident
21 Patton Dr.
Sayreville, NJ 08872

Margaret Warren
Or Current Resident
76 Mac Arthur Avenue
Sayreville, NJ 08872

Anthony & M. Vagnato Wasilewski
Or Current Resident
89 River Road
Sayreville, NJ 08872

Michael & Irene Wegh
Or Current Resident
11 LeRoy Street
South River, NJ 08882

Pearl Watkins & Ruby Green
Or Current Resident
11 Major Drive
Sayreville, NJ 08872

Thomas C. & Mary Ann Weber
Or Current Resident
123 Weber Avenue
Sayreville, NJ 08872

Ann Wilczewski
Or Current Resident
32 Herman Street
South River, NJ 08882

Edward & Joyce Weinheimer
Or Current Resident
299 Lambton Lane
Naples, FL 33942

Betty Lou Wilborn
Or Current Resident
20 Anne Street
South River, NJ 08882

Patricia A. Williams
Or Current Resident
19 Hope Dr.
Sayreville, NJ 08872

James R. & Patricia A. Williams
Or Current Resident
5003 Boredentown Avenue
Old Bridge, NJ 08857

Merilin Williams
Or Current Resident
1900 Wethersfield Drive
Florence, SC 29501

William & Rosa Rodgers
Or Current Resident
89 Canal Street
Sayreville, NJ 08872

David & Anne Williams
Or Current Resident
6 Memorial Way
Sayreville, NJ 08872

Barry & Evelyn Williams
Or Current Resident
46 Ryders Lane
East Bruswick, NJ 08816

Viola Wojciechowski
Or Current Resident
3 Kearny Drive
Milltown, NJ 08882

Royce R. & June Wingerter
Or Current Resident
53 David Street
Old Bridge, NJ 08857

Louis W. & Louis J. Wisniewski
Or Current Resident
46 Main Street
East Brunwick, NJ 08816

Harold & Mary Wolfe
Or Current Resident
1 Washington Road
Sayreville, NJ 08872

Theresa C. Wojton
Or Current Resident
33 Furman Avenue
Sayreville, NJ 08872

Genevieve Wolanin
Or Current Resident
14 Forden Court
Sayreville, NJ 08872

Linda Wood
Or Current Resident
124 Whitehead Avenue
South River, NJ 08882

Colvin T. & Sandra M. Wong
Or Current Resident
76 Canal Street
Sayreville, NJ 08872

Lap Man & Yuk Ping Wong
Or Current Resident
65 Major Drive
Sayreville, NJ 08872

Vera Worobey
Or Current Resident
24 Eisenhower Dr.
Sayreville, NJ 08872

Marlene A. & Charles Woods
Or Current Resident
71 Zaleski Dr.
Sayreville, NJ 08872

Camille Wornowicz
Or Current Resident
15 Nickel Avenue
Sayreville, NJ 08872

Theresa Wright
Or Current Resident
99 William Street
South River, NJ 08882

Carl Woronowicz
Or Current Resident
115 Mac Aarthur Avenue
Sayreville, NJ 08872

Luba Woydatt
Or Current Resident
22 Stephen Street
South River, NJ 08882

Frank Wybranski
Or Current Resident
32 Herman Street
South River, NJ 08882

Helen & Redding Wrobel
Or Current Resident
58 Armstrong Avenue
South River, NJ 08882

Mary Ann Wrobel
Or Current Resident
9 Henry Street
South River, NJ 08882

Michael & Denise Yahas
Or Current Resident
109 Stagecoach Road
Freehold, NJ 07728

Hui Heng & Jian Wen Xiao
Or Current Resident
42 Major Drive
Sayreville, NJ 08872

Ralph & Waide, Laur Yacovelli
Or Current Resident
39 Reid Street
South River, NJ 08882

Michael J. Yuaniak
Or Current Resident
46 Reid Street
South River, NJ 08882

Christine Yanda
Or Current Resident
47 Levinson Avenue
South River, NJ 08882

Ding-Hing & Pui-Chee Yu
Or Current Resident
71 Canal Street
Sayreville, NJ 08872

Anna Zach
Or Current Resident
465 Main Street
Sayreville, NJ 08872

Queenie Yue
Or Current Resident
6 Connors Court
Sayreville, NJ 08872

Walter & Aniela Zabicki
Or Current Resident
28 Yorkshire Place
Parlin, NJ 08859

Simon & Julia Zagata
Or Current Resident
95 McCutcheon Avenue
Sayreville, NJ 08872

Rory R. & Bonnie L. Zach
Or Current Resident
461 Main Street
Sayreville, NJ 08872

Raymond & Kathyrn Zaczek Jr.
Or Current Resident
131 Weber Avenue
Sayreville, NJ 08872

Adm & Danuta Zakamarek
Or Current Resident
12 Causeway
South River, NJ 08882

Julia Zajack
Or Current Resident
54 Dolan Street
Sayreville, NJ 08872

Jozef Zakamarek
Or Current Resident
35 Water Street
South River, NJ 08882

Mario M. and Maria F. Zargo
Or Current Resident
4 Maple Street
South River, NJ 08882

Joseph & Franca Zammit
Or Current Resident
59 Canal Street
Sayreville, NJ 08872

Romeo I. & Violeta C. Zamora
Or Current Resident
55 Major Drive
Sayreville, NJ 08872

Joseph F. & Josephine Ziemba
Or Current Resident
4 Bissett Street
Sayreville, NJ 08872

Kenneth & Theresa Zdep
Or Current Resident
119 Weber Avenue
Sayreville, NJ 08872

Gloria J. Zieliniski
Or Current Resident
43 Whitehead Avenue
South River, NJ 08882

Albert & Joyce Zofchak
Or Current Resident
6 Gulfstream Blvd.
Matawan, NJ 07747

Toni Zifovski
Or Current Resident
26 Grand Avenue
South River, NJ 08882

Joseph & Kathy Ziolkowski
Or Current Resident
44 Eisenhower Dr.
Sayreville, NJ 08872

Ivan Zuraulevic
Or Current Resident
8 Anne Street
South River, NJ 08882

Michael & Marie Zollinger
Or Current Resident
80 Weber Avenue
Sayreville, NJ 08872

Joseph & Nora Zonak
Or Current Resident
108 Weber Avenue
Sayreville, NJ 08872

30-34 Main Street Association
c/o Freund
Or Current Resident
32 Main Street
South River, NJ 08882

11 Russell Partnership
Or Current Resident
11 Russell Avenue
South River, NJ 08882

22 Acre Corps
c/o A. Safran
Or Current Resident
400 West End Avenue Apt. 4A
New York, NY 10024

Affordable Homes of NJ, Inc.
Or Current Resident
565 New Brunswick Avenue
Perth Amboy, NJ 08861

55 Acre Corporation
c/o A. Safran
Or Current Resident
400 West End Avenue Apt. 4A
New York, NY 08872

Administrator of Veterans Affairs
Or Current Resident
20 Washington Place
Sayreville, NJ 08872

Alltite Gasket Company
Or Current Resident
323 William Street
South River, NJ 08882

Allied Insulation Corporation
Or Current Resident
PO Box 143
Tennent, NJ 07763

Allied Interiors
Or Current Resident
235 McLean Blvd, Rte. 20 North
Paterson, NJ 07504

B & G. Vending Co., Inc.
Or Current Resident
61 Merrill Avenue
East Brunswick, NJ 08816

Andre Construction and Sons
Or Current Resident
10 Joseph Street
South River, NJ 08882

B & C Enterprises, L.L.C.
Or Current Resident
49 Water Street
South River, NJ 08882

C & A. Transport Company
Or Current Resident
27 William Street
South River, NJ 08882

Borough of South River
Or Current Resident
64-66 Main Street
South River, NJ 08882

Borough of South River
Or Current Resident
33 Gordon Street
South River, NJ 08882

Celotex Corporation
Or Current Resident
PO Box 31602
Tampa, FL 33631

C & J. Enterprises, Inc.
Or Current Resident
PO Box 663
South River, NJ 08882

Cavaco, Inc.
Or Current Resident
2 Ferry Street
South River, NJ 08882

Consolidated Rail Corporation
Or Current Resident
PO Box 8499
Philadelphia, PA 19101

Cifelli & Sons, Inc.
Or Current Resident
P.O. Box 538
South River, NJ 08882

Citicorp Mortgage, Inc.
Or Current Resident
15851 Clayton Road
Baldwin, MO 03011

Deerfield Equipment Co., Inc.
Or Current Resident
PO Box 161
Parlin, NJ 08859

D & A Investment Group, Inc.
Or Current Resident
11 Maurice Court
Kendall Park, NJ 08824

Daryl Graphics, Inc.
c/o N. Agra
Or Current Resident
5 Water Street
South River, NJ 08882

DZZ Properties, Inc.
Or Current Resident
45 Grove Street
South River, NJ 08882

Downwind Holdings
Or Current Resident
1 Milton Avenue
South River, NJ 08882

Dupont De Nemours
Or Current Resident
PO Box 1039
Wilmington, DE 19899

E.T.S., Inc.
Or Current Resident
12 Center Street
South River, NJ 08882

E & B. Hodges
Or Current Resident
3143 Bordentown Avenue
Parlin, NJ 08859

E I. DuPont Co. Prop. Tax Finance
Or Current Resident
PO Box 1039
Wilmington, DE 19899

Ecko Holding Company, L.L.C.
Or Current Resident
1 Martin Avenue
South River, NJ 08882

Easy River Group, Inc.
c/o Gussi
Or Current Resident
83 Paterson Street
New Brunswick, NJ 08903

EBB Tide Corp.
Or Current Resident
7 Main Street
South River, NJ 08882

F & T. Realty
Or Current Resident
11 Stephen Street
South River, NJ 08882

Elmwood Supply
Or Current Resident
485 River Drive
Garfield, NJ 07026

Emmess Apartments, Ltd
Or Current Resident
7800 River Road
North Bergen, NJ 07047

Forest View Industrial Park, Inc.
Or Current Resident
PO Box 1122
New Brunswick, NJ 08903

Farroy Associates
Or Current Resident
2 Colts Gate Lane
Colts Neck, NJ 07722

First Reformed Church
Or Current Resident
42 Thomas Street
South River, NJ 08882

Gillette Enterprises, Inc.
Or Current Resident
Locklin Court
Sayreville, NJ 08872

Halocarbon Products Crop.
Or Current Resident
887 Kinderkamack kRoad
River Edge, NJ 07661

Hess Brothers, Inc.
Or Current Resident
P.O. Box 198
Parlin, NJ 08859

Ind. Dev. & Leasing Corp
Or Current Resident
33 Cotter Lane
East Brunswick, NJ 08816

Jersey Cooperage Co.
Or Current Resident
20 River Road
Sayreville, NJ 08872

KGR Associates, LTD.
Or Current Resident
PO Box 134
Sayreville, NJ 08872

Lyons-Schepsco VFW Post 1451
Or Current Resident
31 Reid Street - PO Box 325
South River, NJ 08882

Marisat Inc.
Or Current Resident
Jernee Mill Road
Sayreville, NJ 08872

Middlesex County Utilities Auth.
Or Current Resident
PO Box B-1
Sayreville, NJ 08625

G.R. Wholesaler, Inc.
c/o R. Pan
Or Current Resident
122 Philip Drive
Rockaway, NJ 07866

God's Last Call Revival, Inc.
Or Current Resident
203 Whitehead Avenue
South River, NJ 08882

Hercules, Inc.
Or Current Resident
50 South Minnisink Avenue
Parlin, NJ 08859

Hillside Estates
Or Current Resident
200 Central Avenue
Mountainside, NJ 07092

Jernee Mill Associates, L.L.C.
Or Current Resident
PO Box 874
Matawan, NJ 07747

JVJ Associates
Or Current Resident
5 Fisher Street
Sayreville, NJ 08872

Kobran
c/o Felicia Village Apartments
Or Current Resident
1018 Stuyvesant Avenue
Irvingston, NJ 07111

M & C Realty Co.
Or Current Resident
3010 Bordentown Avenue
Parlin, NJ 08859

Martins, J. & Martins, R. & Martins
Or Current Resident
170 Whitehead Avenue
South River, NJ 08882

G.T. Realty Partnership
Or Current Resident
71 Weber Avenue
Sayreville, NJ 08872

Greenberg Management, L.L.C.
Or Current Resident
37 Main Street
P.O. Box 267
South River, NJ 08882

Hertma Investment, Inc.
Or Current Resident
60 Miko Road
P.O. Box 16
Edison, NJ 08817

I. S. T. Corp.
Or Current Resident
PO Box 170
Parlin, NJ 08859

Jersey Central P. & L. Co.
Or Current Resident
PO Box 16001
Reading, PA 19101

Kamosoulis, Konstantinos & Kat
Or Current Resident
PO Box 163
South River, NJ 08882

Lou Jean Enterprises, Inc.
Or Current Resident
46 Main Street
East Brunswick, NJ 08816

Mapei East Corp.
Or Current Resident
1501 Wall Street
Garland, TX 75041

MidAtlantic Bank, NA
c/o PNC Bank
Or Current Resident
505 Thornall Street, Suite 25
Edison, NJ 08837

Nat West Bank
c/o M. Bradley
Or Current Resident
19 Pleasant Street
Woburn, MA 01801

Modern Times Association
c/o L. Connor II
Or Current Resident
Jemee Mill Road
Sayreville, NJ 08872

N.W.R. Limited Corp.
c/o S. Phil
Or Current Resident
15 Griffin Street
East Brunswick, NJ 08816

Old Bridge Veterans
VFW Post 7508
Or Current Resident
17 Bordertown Avenue
Old Bridge, NJ 08857

North Jersey Energy Associates
Or Current Resident
350 Lincoln Place
Hingham, MA 02043

Ocwen Federal Bank
Or Current Resident
1675 Palm Beach Lakes Blvd
West Palm Beach, FL 33401

Pfizer Inc.
Or Current Resident
219 East 42nd Street
New York, NY 10017

P. M. Milano, Inc.
Or Current Resident
148 Main Street
South River, NJ 08882

Pardo, Agata & Slawomir
Or Current Resident
10 Glenside Court
East Brunswick, NJ 08816

Portuguese Venture, Inc.
Or Current Resident
25 Whitehead Avenue
South River, NJ 08882

Polish Army Vet. Assoc
Or Current Resident
452 Turnpike Road
South River, NJ 08882

Polish Falcons Nest 822 Inc.
Or Current Resident
45 Ferry Street
South River, NJ 08882

Pulse Savings Bank
Or Current Resident
6 Jackson Street
South River, NJ 08882

Professional Finishes, Inc.
Or Current Resident
92 Browns Lane
PO Box 241
South River, NJ 08882

Pulse Savings Bank
Or Current Resident
6 Jackson Street
South River, NJ 08882

Roundabout 11, Inc.
Or Current Resident
3143 Bordentown Avenue
Parlin, NJ 08859

Raritan River RR Co.
Tax Dept.
Or Current Resident
P.O. Box 8499
Philadelphia, PA 19101

Riverside Supply Company of
Sayreville
Or Current Resident
6 Washington Road
Sayreville, NJ 08872

Saybo, De Voe & De Voe, Esq.
Or Current Resident
90 Livingston Avenue
New Brunswick, NJ 08901

Rowack Chiropractic Center Cor
Or Current Resident
PO Box 6532
East Brunwick, NJ 08816

S & C Co., Inc.
c/o Piluso
Or Current Resident
123 Whitehead Avenue
South River, NJ 08882

Schott's Inc.
c/o B. Weinstein
Or Current Resident
99 Water Street
South River, NJ 08882

Sayreville Bridge Liquors, Inc.
Or Current Resident
32 Washington Road
Sayreville, NJ 08872

Sayreville Memorial Post 4699 VFW
Or Current Resident
Jemee Mill Road
Sayreville, NJ 08872

Sojka Living Trust
Or Current Resident
PO Box 54
Edison, NJ 08818

Sea Star Realty.
Or Current Resident
251 L. Marlboro Road
Old Bridge, NJ 08857

Secretary of Veterans Affairs
Or Current Resident
20 Washington Place
Newark, NJ 07102

South River Boat Club
Or Current Resident
ox 293
South River, NJ 08882

Sonalisa, Inc.
Or Current Resident
426 Metlars Lane
Piscataway, NJ 08854

South River Appliance, Inc.
Or Current Resident
45 Main Street
South River, NJ 08882

South River Pistol Club
Or Current Resident
PO Box 11
South River, NJ 08882

South River Contracting Co.
Or Current Resident
33 So. Wilson Ave
Milltown, NJ 08850

South River Moose Lodge 165
Or Current Resident
29 Reid Street
South River, NJ 08882

Sr.R. Parking Authority
c/o Schultz
Or Current Resident
P.O. Box 243
South River, NJ 08882

South River Storage, Inc.
Or Current Resident
634 East St. George Avenue
Linden, NJ 07036

Specialty Refractories, Inc.
Or Current Resident
405 Lexington Avenue
New York, NY 10174

St. Stephen's Catholic Church
Or Current Resident
20 William Street
South River, NJ 08882

St. Mary's Roman Catholic Church
Or Current Resident
30 Jackson Street
South River, NJ 08882

St. Stanislaus RC Church
Or Current Resident
225 Mac Arthur Avenue
Sayreville, NJ 08872

Superior Air Products, Co.
Or Current Resident
PO Box 956
Tyler, TX 75710

Sta-Seal, Inc.
Or Current Resident
PO Box 419
Kingston, NJ 08528

Sunshine Biscuit, Inc.
Or Current Resident
100 Woodbridge Center Drive
Woodbridge, NJ 07095

Transcontinental Gas Pipeline Corporation
Or Current Resident
P.O. Box 1396
Houston, TX 77251

Tatau Enterprises, Inc.
Or Current Resident
95 Whitehead Avenue
South River, NJ 08882

Thomas & Chadwick, Inc.
Or Current Resident
6 Washington Road
Sayreville, NJ 08872

V & L. Investments, Inc.
Or Current Resident
238 Rector Street
Perth Amboy, NJ 08861

True Light Pentecostal Faith Church
Or Current Resident
80 Causeway
South River, NJ 08882

U.S. Government Post Office
Or Current Resident
44-48 Obert Street
South River, NJ 08882

VJV Associates
Or Current Resident
441 Hobart Road
North Brunswick, NJ 08902

V. Keiser & H. & E. Litwinski
Or Current Resident
51 Augusta Street
South River, NJ 08882

Van Brunt & Sons, Inc.
Or Current Resident
Bordentown Avenue
Old Bridge, NJ 08857

Wa Wa, Inc.
Or Current Resident
Baltimore Turnpike
Wa Wa, PA 19063

Vosk, Stella & Orlowski
Or Current Resident
55 Armstrong Avenue
South River, NJ 08882

W.W. Henry Co.
Or Current Resident
313 W. Liberty Avenue
Lancaster, PA 17604

Westholme Partners
Or Current Resident
25115 W. Stanford Ave.
Valencia, CA 91355

WBSR, Inc.
Or Current Resident
19 Whitney Drive
Marlboro, NJ 08846

Yeshivoth Sheartith Hapletah, Corp.
c/o Halberstam
Or Current Resident
1431 50th Street
Brooklyn, NY 11219

Westholme Partners
c/o G. Maniscaclo
Or Current Resident
309 Main Street
Sayreville, NJ 08872

RESPONSES TO COMMENTS RECEIVED

ON THE

DRAFT INTEGRATED FEASIBILITY REPORT

AND

ENVIRONMENTAL IMPACT STATEMENT

Comment Letters Received on the Draft Integrated Feasibility Report and Environmental Impact Statement (Report).

Federal Agencies:

National Marine Fisheries Service, United States Department of Commerce, Habitat Conservation Division.

United States Environmental Protection Agency, Region II.

United States Department of the Interior, Office of Environmental Policy and Compliance.

United States Department of Health and Human Services, Centers for Disease Control and Prevention.

State Agencies:

State of New Jersey, Department of Environmental Protection, Office of Program Coordination.

Elected Officials:

James E. McGreevey, Governor, State of New Jersey

John S. Wisniewski, Assemblyman, 19th District, New Jersey General Assembly.

Environmental Groups:

NY/NJ Baykeeper

Edison Wetlands Association, Inc.

Private Citizens:

Leslie Senko

Lucille Kloc

Ted Bochenski

Ashok Mantri

Michael P. Clancy

John Falzone

S. Meloni

Louis J. Luczu

Marilyn Meloni

Susan Luczu

David Hoover

Laurence F. Gates

Public Meeting:

Summary of public meeting questions and answers.

Comment Letters Received on the Draft Integrated Feasibility Report and Environmental Impact Statement (Report).

Federal Agencies:

National Marine Fisheries Service, United States Department of Commerce, Habitat Conservation Division.

United States Environmental Protection Agency, Region II.

United States Department of the Interior, Office of Environmental Policy and Compliance.

United States Department of Health and Human Services, Centers for Disease Control and Prevention.

District response to National Marine Fisheries Service, United States Department of Commerce, Habitat Conservation Division:

District Response to NMFS Comment 1: The District appreciates that the NMFS does not oppose the project and is in full support of its implementation. The District would also like to extend its full appreciation and thanks to the NMFS for its participation throughout the feasibility phase.

District Response to NMFS Comment 2: The District does not agree that the EFH is incomplete. The DEIS – in particular the EFH assessment as discussed in Volume 3 – provides a satisfactory analysis that identified the impacts of the storm gate, levees and flood walls, and ecosystem restoration. Implementation of the stormgate, levees and floodwalls will result in minimal loss of river bed and saltmarsh. Furthermore, the District coordinated with your office to revise the original proposed flood control footprint to avoid and minimize impacts to wetlands.

Short-term adverse impacts to EFH will be limited during construction and are expected to have minimal direct (*e.g.*, contamination or physical disruption), indirect (*e.g.*, loss of prey, reduction in species' fecundity), or habitat-wide impacts, including individual, cumulative and synergistic. In fact, the construction of both the flood control (via mitigation) and ecosystem restoration components are expected to provide long-term benefits to EFH. Mitigation of the flood control component will convert uplands to wetlands and restore degraded wetlands, creating additional habitat improvements for aquatic resources. The ecosystem restoration component of the project will significantly, positively impact EFH through the conversion of a large area of dense *Phragmites* to a mosaic of intertidal, saltmarsh, mudflat and open water habitat. Biodiversity will be improved, as well as habitat quality (in term of wildlife values [HUs}and wetland functioning [FCUs]). Site-specific and habitat-wide benefits in terms if individual, cumulative and synergistic are also expected. Construction of the mitigation (to offset flood control impacts) and ecosystem restoration plans will augment similar habitat improvement efforts in the vicinity, such as the NJ Department of Transportation mitigation site located within the project area.

Accordingly, based on the EFH assessment (Volume 3) and above response, the District maintains that an adequate EFH analysis has been performed and requests that the NMFS submit their conservation recommendations.

District Response to NMFS Comment 3: The District agrees and will add an anadromous fish monitoring component to ensure that the storm gate does not adversely affect the movement of anadromous fish. The District looks forward to working with the NMFS and the NJ Department of Environmental Protection regarding this monitoring effort.

District Response to NMFS Comment 4: At this time the District does not agree that there is a need to limit the time when the storm surge barrier can be constructed. We look forward to discussing this matter further. The results of the anadromous fish monitoring component should provide us with the information that we need to make the appropriate decision.

District Response to NMFS Comment 5: The frequency of events per year that the pump will be operational is dependent upon the number of storms that would occur in a given year that would necessitate the closure of the storm surge barrier. The duration of time that the pumps will be running will coincide with the length of the storm and the tidal cycle. To minimize the cost to operate the pumps, the gate will open at the onset or just after the beginning of the ebb tide. Opening the gate at this time will permit the water stored behind the gate to discharge with the out-going tide instead of having to operate the pumps. If the storm continues to last when the flood tide begins the storm gate will be closed again and the pumps will be turned on. This opening and closing of the gate will repeat until the storm event passes and the tide returns to normal.

The pumps will be turned off when the gate is in the open position. The storm surge barrier pump station has four intakes. Each intake contains two slide gates (for a total of eight slide gates) which are eight feet wide by eight feet high. The screen size is ½ inch mesh. The velocity of the water at the trash racks, which are a distance of 10 feet from the intakes, is approximately one foot per second. The gates will operate on a two year tidal event (approximately every two years) and up to a period of 48 hours depending on the severity of the event.

District Response to NMFS Comment 6: The District looks forward to continued coordination with the NMFS during the next phase of the project. In addition, we expect to continue our coordination even after construction has been completed.

Mary

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Habitat Conservation Division
James J. Howard Marine
Sciences Laboratory
74 Magruder Road
Highlands, New Jersey 07732

RCVD 9/18
MAB

July 22, 2002

Mr. Len Houston, Chief
Environmental Analysis Branch
New York District
US Army Corps of Engineers
26 Federal Plaza
New York, NY 10278-0900

ATTN: Mark Burlas

Dear Mr. Houston:

We have reviewed the following documents relating to the Army Corps of Engineers' (ACOE) South River, Rartian River Basin Hurricane and Storm Damage Reduction and Ecosystem Restoration project: the draft Integrated Feasibility Report and Environmental Impact Statement, the Impact Assessment and Mitigation Analysis Report and the South River Ecosystem Restoration Plan. The proposed project involves the construction of levees as well as a storm surge barrier and gate across the South River in Middlesex County, New Jersey. Compensatory mitigation is proposed to offset unavoidable impacts and an ecosystem restoration project is included as a separate project component. We have been working with ACOE staff on this project for several years and have only a few comments to offer to ensure compliance with the requirements of the Magnuson Stevens Act (MSA) and to minimize impacts to resources of concern to NMFS. We do not oppose the proposed project, and we support fully the ACOE's ecosystem restoration efforts.

Essential Fish Habitat (EFH)

We received a partial EFH assessment from the ACOE on January 19, 2001. As discussed with ACOE staff and the ACOE's contractor, Northern Ecological Associates at the Habitat Evaluation Procedure team meeting held on January 31, 2001, and in our letter dated February 9, 2001, the assessment did not fully address all of the potential impacts of the project on EFH, and is not complete. In our previous letter, we requested that the ACOE provide us with a complete EFH assessment that addresses both the immediate and long term impacts of the levees, stormgate and ecosystem restoration, as well as the temporary impacts that may occur during project construction. We have not yet received a complete EFH assessment, and the needed information is not contained within the documents mentioned above. As a result, the ACOE has not yet completed the EFH consultation process as required by section 305 (b)(2) the MSA. Once we receive a complete EFH assessment, we will provide conservation recommendations as appropriate.

Fish and Wildlife Coordination Act

Anadromous fish such as alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*) and American shad (*Alosa sapidissima*) use South River and its tributaries as spawning, nursery and forage habitat. Although we generally do not support the placement of structures across waterways, particularly in areas such as the South River which supports anadromous fish migration and spawning, the information provided by the ACOE has demonstrated that the proposed storm surge gate will remain open except under limited flood conditions. As a result, the ACOE does not anticipate that impacts to anadromous fish migration will result from the operation of the storm surge barrier. To confirm this determination, we recommend that the ACOE, in consultation with New Jersey Department of Environmental Protection's Division of Fish and Wildlife, develop a monitoring plan to evaluate the pre and post construction passage of anadromous fish through the storm surge gate. If fish migration is affected adversely, a remedial plan should be developed.

The construction of the storm surge barrier, as well as the ecosystem restoration and mitigation projects could increase turbidity in the South River and the Washington Canal temporarily. These turbidity increases could degrade the water quality and impede migration and spawning of anadromous fish. As a result, we recommend that in-water work within the South River and Washington Canal, such as the construction of the storm surge barrier be prohibited from April 1 to June 30 to minimize impacts to anadromous fish. Best management practices to reduce turbidity and the release of sediments into the waterways during project construction should also be used.

In addition, the proposed storm surge barrier and gate will include a pump station to alleviate any interior drainage behind the gates when the gates are closed. Page 108 of the DEIS states that fish trapped on the upstream side of the storm surge barrier when the gate is closed may be killed if they are drawn through the pump intake during its operation. The DEIS does not provide sufficient detail to evaluate the impacts of the operation of the pumps on fishery resources. We request that additional information including the number of intakes, the intake size, screen sizes on the intakes, the velocity of the water entering the intakes and the expected periods of operation be provided so that we may assess the impacts of the intake on resources of concern to us, and make recommendations to reduce impacts if appropriate.

Lastly, as mentioned above, the proposed project includes both an the ecosystem restoration plan and compensatory mitigation which are in the conceptual stages. We request that the ACOE continue coordination as the final designs for the restoration and mitigation are developed so that we may assist the ACOE in developing plans which will maximize the benefits to fishery resources.

Thank you for the opportunity to comment on this project. We look forward to continued coordination and to the completion of the EFH consultation process so that this project may move forward

If your would like to discuss this matter further, please contact Karen Greene at 732 872-3023.

Sincerely,

Stanley W. Gorski
Field Offices Supervisor

kmg:southriv.eis.wpd/071802
cf: RO - Chiarella
NOAA - Office of Policy Coordination, S. Kokkinakis

MAR-29-02 FRI 01:45 PM P. 02

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Habitat Conservation Division
James J. Howard Marine
Sciences Laboratory
74 Magruder Road
Highlands, New Jersey 07732

February 9, 2001

Mr. Joseph Vietri, Deputy Chief
Planning Division
New York District
US Army Corps of Engineers
26 Federal Plaza
New York, NY 10278-0900

ATTN: Josephine Axt and Mark Burlas

Dear Mr. Vietri:

Reference is made to your letter dated January 19, 2001 concerning the essential fish habitat (EFH) assessment for the Raritan River Basin Flood Control and Ecosystem Restoration Feasibility Study for South River and Sayerville, New Jersey. As discussed with Ms. Axt and the ACOE's contractor, Northern Ecological Associates at the Habitat Evaluation Procedure team meeting held on January 31, 2001, the assessment does not fully address all of the potential impacts of the project on EFH. In order to comply with the requirements of the Magnuson Stevens Act (MSA), the EFH assessment must address the direct (e.g., contamination or physical disruption), indirect (e.g., loss of prey, reduction in species' fecundity), site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions of the project. This should include both the immediate and long term impacts of the levees, stormgate and ecosystem restoration, as well as the impacts that may occur during construction.

It is important to note that the MSA seeks to protect the habitat of federally managed species and their food sources. Consequently, the absence of a species during a particular sampling event does not mean that the area is not EFH. If an area is designated by one of the regional federal fisheries management councils or by the NMFS as EFH, and the habitat parameters of that area, such as depth, salinities and bottom type fit the description of EFH as defined in the fisheries management plans, the area is EFH regardless of any sampling information.

Although some of the needed information is included in the document provided with your January 19, 2001 letter, additional information is needed before the EFH assessment can be considered complete. We have provided a marked up copy of the assessment to your staff and to the contractor to assist them in making revisions to the assessment. Once we receive a revised assessment, we will provide conservation recommendations as appropriate. We look forward to continued coordination on this project. If your would like to discuss this matter further, please contact Karen Greene at 732 872-3023.

Sincerely,

Stanley W. Gorski
Field Offices Supervisor

cf: RO - Chiarella

District response to Environmental Protection Agency, Region II:

District response to EPA comment #1: The District's selected mitigation plan will result in a 1:1 creation to impact ratio. The proposed storm protection project will create 3.3 acres of emergent/herbaceous wetland and the selected mitigation plan will convert 6.1 acres of upland disturbed area to wetland scrub-shrub. Therefore, the project's wetland impacts of 9.4 acres will be offset by the creation of 9.4 acres of wetland habitat. It should be noted as well that, in contrast to EPA's statement to the contrary, the restoration component of the South River project serves in no way as mitigation for the hurricane and storm damage reduction component of the project.

District response to EPA comment #2: The District used the Evaluation of Planned Wetlands (EPW) method, in conjunction with the HEP method, to provide a more robust assessment of impacts to wetlands through an assessment of wetland functions and values. Similar to WET, the information collected using the EPW method provides a numeric index (*i.e.*, functional capacity index [FCI]) that is useful in baseline and impact assessments to evaluate proposed actions that potentially result in a change in either wetland quantity or quality, and to evaluate the relative value of wetlands identified in mitigation plans.

EPW provides a quantitative assessment of the relative value of wetlands through a final numerical output that is technically defensible, replicable, and can be applied consistently in a variety of different wetland types. Based on the wetland type, the EPW assessment method uses seven to 20 elements to evaluate six major wetland functions (*i.e.*, shoreline bank erosion control, sediment stabilization, water quality, wildlife, fish, and uniqueness/heritage). Element scores are combined and weighted to produce an FCI value from 0.0 to 1.0 for each wetland function. Size of the wetland is multiplied by the FCI value to produce a wetland Functional Capacity Unit (FCU), which represents the wetlands capacity to perform each wetland function. The FCUs are used as the quantitative basis for wetland comparisons.

Based on an exhaustive field effort to quantitatively measure the existing wetland elements in the project area and a thorough calculation of FCI values, the District was able to select a mitigation plan that fulfilled the goal to replace at least 100% of the combined loss of FCUs (summed across wetland functions), and at least 50% of the loss of FCUs lost per function, as a result of implementation of the Selected Plan. Specifically, the selected mitigation plan will result in a combined total gain of 8.0 FCUs (139%) and will replace >100% of all the wetland functions, except sediment stabilization (88% replacement).

District response to EPA comment #3: The District appreciates the support of EPA for the ecosystem restoration component of the South River project and plans to work closely with all interested parties in ensuring the success of the restoration. In the next and final planning and design phase, the District has budgeted funds for a comprehensive hydrodynamic model. More comprehensive hydrology and hydraulic studies are needed to accurately design the restoration management measures for the site-specific conditions and then assess their ramifications on the site's existing hydrology.

During the design process, particular emphasis will be placed on the particular inundation requirements of certain habitat types. In this phase, the conceptual plan presented in the Report will be expanded and finalized with additional detail regarding grading, planting, Phragmites eradication, and monitoring.

District response to EPA comment #4: The District is committed to complying with all applicable air conformity rules and regulations. Toward that end, the District is currently preparing a scope of work for detailed, comprehensive, quantitative emission estimates in order to quantify emissions from all aspects of the South River project. The results of this scope of work will be coordinated with the appropriate agencies, receive a formal public review, and be included in the Record of Decision for the South River Project. The notice to proceed for this scope of work will be issued as soon as the Preconstruction, Engineering, and Design phase is initiated (Fall 2002) for the South River project and funds become available.

In the meantime, preliminary emission estimates have been made based on emission estimates generated from similar activities for the Environmental Impact Statement for the proposed Meadowlands Mills Project (Environmental Impact Statement for the Department of the Army, Application Number 95-07440-RS by Empire, LTD, 2002). Emissions were estimated based on a comparison of the relative sizes of the two projects for the associated activity.

For example, both projects specify transferring fill material from off-site locations to the project sites. Thus, NOx emissions for the proposed South River Project were estimated as:

Meadowlands Mills Project:	2,300,000 cubic yards fill
South River Project:	107,800 cubic yards fill
Ratio	= (107,800 cubic yards)/(2,300,000 cubic yards)
	= 0.047

Meadowlands Mills NOx Emissions	= 28.3 tons/year
South River Project NOx Emissions	= (28.3 tons/year)(0.047)
	= 1.33 tons/year

Emissions from wetlands construction activities and construction employee commuting were estimated similarly. Emission estimates from levee construction activities were estimated based on comparison with fill operation emission estimates for the Meadowlands Mills Project. A summary of the total estimated emissions from the proposed South River Project are provided in Table 1; the Report has been revised to include detailed emission calculations for each activity, as well as the summary Table 1.

For the purposes of these preliminary estimates, the direct emissions were those emissions generated from levee construction activities and from the mitigation and restoration activities, and the indirect emissions were those emissions occurring during construction activities from transport of fill material to the site from off-site locations and from construction workers commuting to the site, and future emissions generated from the pump station.

District response to EPA comment #5: A conformity demonstration is required for each pollutant where the total direct and indirect emissions from the Federal action exceed the corresponding de minimis level. The proposed South River Project is located in an ozone and CO nonattainment area. For ozone nonattainment areas, the de minimis levels apply to both volatile organic compound (VOC) and oxides of nitrogen (NOx) emissions, which are both considered ozone precursors. The de minimis levels as prescribed by 40 CFR 93.158 that would apply to the South River Project are:

VOC:	25 tons/year
NOx:	25 tons/year
CO:	100 tons/year

As provided in Table 1, the preliminary projected total direct and indirect VOC and CO emissions from the proposed project are estimated to be below the de minimis threshold levels. The preliminary projected total direct and indirect NOx emissions appear to exceed the de minimis threshold of 25 tons per year. Although the General Conformity requirements do not appear to apply to VOC and CO emissions, as indicated above, the District will conduct a detailed quantitative analysis – in close coordination with EPA and the New Jersey Department of Environmental Protection – to more precisely quantify all emissions from the South River Project and to determine conformity accordingly. Upon completion of the revised emission estimates, a Draft General Conformity Determination will be prepared and submitted for review.

As specified in 40 CFR 93.158, conformity is demonstrated by meeting any of the following:

- The action is specifically identified in the State Implementation Plan (SIP);
- The emissions from the action along with all other emissions in the area would not exceed the emission budget specified in the SIP;
- For ozone (VOC or NOx), the total emissions are fully offset through a revision of the SIP or a similarly enforceable measure (such as use of emission reduction credits) that effects emission reductions equal to the emissions from the action.

Section VI.A. of the New Jersey SIP addresses General Conformity. The SIP specifically identifies only one Federal action for General Conformity – McGuire Air Force Base. Therefore, the proposed South River Project is not specifically identified in the SIP. However, the SIP does state that:

> ". . . several federal agencies have consulted the NJDEP regarding actions they were considering, and the emission budgets they must meet. In general, the project emission increases and decreases resulting from these

projects have been more than adequately covered by the emission growth projected in the SIP." [1]

Projected emissions in the SIP include emissions from On-Road and Non-Road emission sources. Table 24 in the SIP budgets allows for 178.73 tons per day of NOx emissions for the year 2005 for On-Road Sources. By comparison, NOx emissions for the proposed South River Project are estimated at 0.01 tons per day from On-Road sources (transportation of fill material to the site and construction employee commuting).

Appendix II of the SIP provides emission inventory projections including projections for Non-Road emission sources. Attachment IIK of Appendix II provides detailed NOx emission projections by county for the various categories of Non-Road emission sources. The projected NOx emissions from Construction and Mining Equipment Non-Road Sources (SCC 2270002003 - 2270002081) for Middlesex County in 2005 is 9.44 tons per day. By comparison, NOx emissions from the construction activities for the proposed South River Project are estimated at 0.16 tons per day.

The total direct and indirect NOx emissions from the proposed South River Project represent approximately 0.005% of the On-Road emission sources budget and 1.6% of the Non-Road emission sources budget in the New Jersey SIP for 2005. Thus, per the provisions of 40 CFR 93.158, the Corps will explore with the NJDEP the potential that the NOx emissions from the proposed South River Project are adequately covered by the emissions projected in the SIP.

A conformity determination may also be required if emissions from a Federal action are deemed to be regionally significant. An action is considered to be regionally significant if the total emissions of a pollutant represent 10 percent or more of the total emissions inventory in a nonattainment or maintenance area. As shown in Table 1, the total direct and indirect NOx, VOC and CO emissions are preliminarily estimated to represent much less than 10% of the total emissions inventory for the area. Therefore, the activities associated with the proposed South River Project are not expected to be regionally significant.

Upon completion of the proposed South River Project, emissions will be generated from intermittent operation of the pump(s) that will be in the pump house. The size of the pump(s) for the pump station has not been specified at this time. Therefore, emission estimates could not be made for the pump(s). However, operation of the pump station will not occur until after construction activities are completed. Thus, emissions from the construction activities represent the maximum annual emissions from the South River Project.

Due to the anticipated size and use of the pump house, potential emissions from the pump(s) are expected to be below Major Facility threshold levels. Thus the facility

[1] State Implementation Plan (SIP) Revision for the Attainment and Maintenance of the Ozone National Ambient Air Quality Standard (NAAQS), New Jersey 1996 Actual Emission Inventory and Rate of Progress (ROP) Plan for 2002, 2005 and 2007, December 31, 2000.

will be considered as an area source. The pump(s) will conform with the SIP by complying with the appropriate applicable requirements for significant and/or insignificant source operations identified in N.J.A.C. 7:27-8, N.J.A.C. 7:27-16, and N.J.A.C. 7:27-19.

Overall, as previously noted, the discussion and conclusions above will be revisited when the current preliminary estimates of air emissions associated with the South River project are revised with more accurate and comprehensive air emission estimates in the next project phase (Preconstruction, Engineering and Design). At this point, the Corps has established an approximate timeline for demonstrating conformity:

- conduct detailed emissions analyses (Dec 2002 – Jan 2003)
- assess emissions results (Feb 2003)
- evaluate conformity options (Feb 2003)
- conduct detailed mitigation assessment (Mar 2003)
- formal agency/public review of proposed mitigation and draft General Conformity Determination (Apr 2003)
- respond to agency/public comments (May 2003)
- publish final General Conformity Determination and summarize process/results/mitigation in ROD (May 2003)

The Corps will conduct this process in close consultation with the USEPA and the NJDEP.

As necessary, in addition to pursuing mitigation alternatives like emission offsets, emission credits, emission reduction technologies, and operational modifications to reduce emissions, the Corps is aware that conformity can be demonstrated if the emissions from the action along with all other emissions in the area would not exceed the emission budget specified in the SIP. For example, the preliminary NOx emissions from the project represent an insignificant portion of the emissions budgeted in the New Jersey SIP for 2005, so the potential exists for direct and indirect NOx emissions from the project to demonstrate conformity with the SIP. Once detailed information is available, the Corps will explore this option with the NJDEP.

TABLE 1
SUMMARY OF PROJECTED AIR EMISSIONS FROM SOUTH RIVER, RARITAN RIVER BASIN HURRICANE AND STORM DAMAGE REDUCTION AND ECOSYSTEM RESTORATION PROJECT

	NOx		VOC		CO	
	ton/year	ton/day	ton/year	ton/day	ton/year	ton/day
DIRECT (Construction activities)						
Levee Construction	1.32	0.008	0.13	0.001	0.65	0.004
Wetlands Construction	46.05	0.15	3.62	0.012	28.6	0.092
TOTAL CONSTRUCTION		0.155		0.012		0.095
NJSIP[1]		9.44		1.27		3.43
Percent of SIP		1.64%		0.97%		2.78%
INDIRECT (Transporation)						
Transport of Fill Material	1.33	0.004	0.22	0.0006	1.03	0.003
Employee Commuting	1.80	0.005	1.40	0.0038	10.20	0.028
TOTAL TRANSPORATION		0.01		0.0044		0.03
NJSIP[2]		178.73		94.59		747.36
Percent of SIP		0.005%		0.005%		0.004%
TOTAL PROJECT EMISSIONS	50.49	0.164	5.37	0.017	40.5	0.126
DEMINIMIS LEVELS	25		25		100	
NJSIP[3]		511.51		578.11		2148.89
PERCENT OF SIP		0.032%		0.003%		0.006%

[1]State Implementation Plan (SIP) Revision for the Attainment and Maintenance of the Ozone National Ambient Air Quality Standard (NAAQS), New Jersey 1996 Actual Emission Inventory and Rate of Progress (ROP) Plan for 2002, 2005 and 2007, Appendix II: Inventory Projects for 1999, 2002, 2005 and 2007, Attachments IIJ, IIK and IIL, Projected emissions for Middlesex County for 2005 for Non-road Sources, Construction and Mining Equipment (SCC 2270002003 - 2270002081).

[2]State Implementation Plan (SIP) Revision for the Attainment and Maintenance of the Ozone National Ambient Air Quality Standard (NAAQS), New Jersey 1996 Actual Emission Inventory and Rate of Progress (ROP) Plan for 2002, 2005 and 2007, Tables 23 - 25, Project Inventories for On-Road Sources, New Jersey portion of New York MPO.

[3]State Implementation Plan (SIP) Revision for the Attainment and Maintenance of the Ozone National Ambient Air Quality Standard (NAAQS), New Jersey 1996 Actual Emission Inventory and Rate of Progress (ROP) Plan for 2002, 2005 and 2007, Tables 26 - 28, Project Inventories for All Emission Sources, New Jersey portion of New York MPO.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
290 BROADWAY
NEW YORK, NY 10007-1866

AUG 23 2002

Mr. Mark H. Burlas
Project Environmental Manager
U.S. Army Corps of Engineers
New York District - Planning Division
26 Federal Plaza
New York, New York 10278-0090

Rating: EC-2

Dear Mr. Burlas:

The Environmental Protection Agency (EPA) has reviewed the draft environmental impact statement (EIS) (CEQ#020239) for the South River, Raritan Basin, Combined Flood Control and Environmental Restoration Project, located in Middlesex County, New Jersey. This review was conducted in accordance with Section 309 of the Clean Air Act, as amended (42 U.S.C. 7609, PL 91-604 12 (a), 84 Stat. 1709), and the National Environmental Policy Act.

The proposed project entails the construction of storm protection structures in the Boroughs of South River and Sayreville, and the Township of Old Bridge, Middlesex County, New Jersey. Specifically, the proposal would entail the construction of 10,712 feet of levees and 1,644 feet of flood walls along the eastern and western banks of the lower South River, and the installation of a storm surge barrier. The proposed project is designed to provide flood protection to the adjacent properties from a 500-year storm event. Additionally, the proposed project also includes an ecosystem restoration plan (NER) in the vicinity of the project. This plan would restore 379.3 acres of Phragmites dominated wetlands to 171 acres of forested and scrub-shrub wetlands, 152 acres of low emergent marsh, 19 acres of mud flats, 19 acres of open water, and 19 acres of upland forest and scrub-shrub. Based on our review of the draft EIS, EPA offers the following comments.

The proposed storm protection project would impact 9.41 acres of wetlands, and convert an additional 3.29 acres to drainage swales within the vicinity of the proposed structures. While it appears that the proposed wetland impacts for the flood control aspect of project have been minimized to the greatest extent practicable, EPA does not believe that mitigation is sufficient to compensate for the proposed impacts. Notwithstanding the restoration proposed under the NER, which the draft EIS emphasizes is intended to mitigate for the flood control project, the mitigation proposed for the flood control project, if successfully completed, would result in the net loss of 6.6 acres of wetlands. Currently, the mitigation plan has proposed 11.1 acres of mitigation which would require the conversion of 3.3 acres of Phragmites marsh to Spartina marsh, the conversion of 1.7 acres of Phragmites marsh to scrub-shrub wetlands, and the creation of 6.1 acres of scrub-shrub wetlands from uplands. While we agree that this mitigation will likely offset the habitat losses associated with the project, we must note, as indicated in regard to previous Corps proposals, that EPA does not consider a Habitat Evaluation Procedure (HEP) analysis alone to be adequate to assess functions and values associated with proposed wetland impacts. As such, EPA recommends, at a minimum, that the Corps use a WET analysis in conjunction with the HEP in order to more fully properly characterize the functional values of wetlands that are proposed to be impacted. Using data from both the HEP and WET, mitigation ratios can then be developed using best professional judgment. Under no circumstances, however, do we recommend that the mitigation ratio fall below a 1:1 creation to impact ratio, or a 3:1 enhancement to impact ratio as is the case with the current mitigation proposal. Additionally, any proposed mitigation ratio must be evaluated in light of the proposed mitigation plan, and the plan's likelihood of success. Currently, the draft EIS provides only a brief conceptual mitigation plan with little or no information on how the mitigation plan would be carried out. Consequently, with out a detailed proposal in the final EIS, it is difficult to determine whether the mitigation proposal would be successful and if the mitigation ratios are acceptable.

With regard to NER aspect of the project, EPA supports the restoration concept outlined in the draft EIS. However, as with the mitigation for the flood control project, we do not believe that the draft EIS has provided sufficient detail to enable EPA us to assess the potential success of the NER. For example, the plan did not identify the duration of the flooding and drainage periods necessary to achieve the intended communities, or the sizing of the proposed channels necessary to achieve the desired flooding regime. As such, we would recommend that a more sophisticated hydrological model be developed in support of this proposal. More over, we also recommend that the final EIS include more detail regarding the grading, planting, Phragmites eradication, and monitoring plans proposed for the NER.

In Section 7.1.8 of the draft EIS, the document states "construction, operation and maintenance... would not have a significant impact on air quality, and it is assumed that emissions from construction equipment were included in the development of New Jersey's Air Quality Implementation Plan." Indeed, emissions from the construction, operation and maintenance may not have significant impacts on air quality. However, given the size of the project, EPA requests that the final EIS quantify emissions from all aspects of the project. Without a quantitative analysis, the project-related air quality impacts cannot be assessed. The draft EIS also assumes that emissions from the project-related construction equipment were included in the New Jersey Air Quality Implementation Plan. This assumption may not be entirely accurate. As such, we strongly recommend that the final EIS cite the specific location in the New Jersey Air Quality Implementation Plan where the emissions from the proposed project have been considered.

Additionally, both Section 7.1.8 and Section 7.2.8 state "Temporary, short term air quality impacts associated with heavy construction equipment and operation of the pump station may occur. However, controls and the limited duration of emissions will miniminze these potentially adverse effects. It is anticipated that construction vehicles will be land-based and subject to state emission standards when inspected by the New Jersey Department of Motor Vehicles." EPA believes the information cited above is inadequate to determine if the proposed project would lead to significant air quality impacts. As such, EPA strongly recommends that the USACE quantify all project related emissions per 40 CFR Parts 51, and 93 and include these emission estimates in the final EIS. Moreover, quantified project-related direct and indirect emissions should be compared to the requirements of 40 CFR Part 93 to determine general conformity applicability. EPA also recommends that the USACE cite any specific exemptions claimed under general conformity as well as any controls, mitigation, and emission offset measures.

With regard to construction vehicle emissions, all project related-emissions from these vehicles should be included in the general conformity determination. Given that these vehicles are an integral piece of the Federal action, emissions should be quantitatively expressed and included in the general conformity determination in the final EIS. Moreover, please note that there is no exemption in general conformity for vehicles that are "subject to state emission standards when expected." As such, this statement should not be included in the final EIS.

The proposed project is located in the New Jersey Coastal Plain Aquifer System, which was designated by EPA as a Sole-Source Aquifer on June 24, 1988 (citation 53 F.R. 23791). Therefore, our review was conducted in accordance with Section 1424(e) of the Safe Drinking Water Act (SDWA). Based on the information provided, the project satisfies the requirements of Section 1424(e), and EPA does not anticipate that the proposed project would significantly impact ground water resources.

In summary, EPA has rated this EIS as EC-2, indicating that we have environmental concerns regarding wetland and air quality impacts, and request that additional information be included in the final EIS to address these concerns.

Thank you for the opportunity to comment. Should you have any questions concerning this letter, please contact Mark Westrate of my staff at (212) 637-3789.

Sincerely yours,

Robert W. Hargrove, Chief
Strategic Planning and Multi-Media Programs Branch

District response to the United States Department of the Interior, Office of Environmental Policy and Compliance:

District Response to DOI Comment 1: The District appreciates that the DOI supports the implementation of the project and recognizes that it will increase the area's biodiversity and overall ecological value. The District would also like to extend its full appreciation and thanks to the Fish and Wildlife Service for its participation throughout the feasibility phase.

District Response to DOI Comment 2: The District's mitigation goal was to replace at least 100% of the combined loss of AAHUs (summed across evaluation species) and at least 50% of the loss of AAHUs per evaluation species. Although the replacement of every AAHU lost per species was preferred, it was determined that trade-offs between evaluation species may be necessary. The decision of which AAHUs are replaced and/or traded was based on the interagency HEP Team's consideration of all mitigation alternatives, and a thorough analysis to ensure the selected plan was cost-effective and incrementally justified.

The selected mitigation plan will result in a total gain of 9.15 HUs (189%) across all evaluation species. Although the clapper rail and marsh wren do not achieve 100% replacement of their HUs, the black duck HUs will more than double in number (255%) and the yellow warbler HUs will achieve an increase of 1.5 times their original number (153%). Similarly, the eastern cottontail and American woodcock will benefit significantly from the selected mitigation plan (*i.e.*, 749% increase in cottontail HUs and 250% increase in woodcock HUs). In addition, while the difference of AAHUs in Year 2055 between the No-Action Plan and the Selected Plan with Mitigation is -0.99 for the clapper rail and -0.32 for the marsh wren, the combined total of AAHUs across all evaluation species is +17.57. Based on the results of the HEP study and their original mitigation goal, the District does not believe that additional mitigation is warranted.

United States Department of the Interior

OFFICE OF THE SECRETARY
Office of Environmental Policy and Compliance
408 Atlantic Avenue - Room 142
Boston, Massachusetts 02210-3334

July 22, 2002

ER 02/496

Colonel John O'Dowd
District Engineer, New York District
U.S. Army Corps of Engineers
26 Federal Plaza
New York, New York 10278-0090

Dear Colonel O'Dowd:

The Department of the Interior (Department) has reviewed the Draft Integrated Feasibility Report and Draft Environmental Impact Statement for the South River, Raritan River Basin, Hurricane and Storm Damage Reduction and Ecosystem Restoration Study, Monmouth County, New Jersey (DEIS). The subject DEIS addresses proposed flood control along the South River by the use of levees, floodwalls, and an upstream surge barrier. Also proposed is an ecosystem restoration project for the same area. The following comments are provided pursuant to the National Environmental Policy Act of 1969 (83 Stat. 852; 42 U.S.C. 4321 *et seq.*).

GENERAL COMMENTS

The Department generally concurs with the Corps' recommended plan and notes that the majority of concerns and recommendations from the U.S. Fish and Wildlife Service (FWS) have been addressed. The ecosystem restoration plan should improve the structure and function of degraded ecosystems in the South River area. Beneficial cumulative impacts to migratory waterfowl and songbirds are likely to result from implementation of this project, and the mitigation and restoration plans will add large areas of more desirable wetland communities, and increase the area's biodiversity and overall ecological value.

SPECIFIC COMMENTS

In the Draft Fish and Wildlife Coordination Act Section 2(b) Report (U.S. Fish and Wildlife Service, 2002), FWS recommended that additional conversion of disturbed areas to wetland be considered for the mitigation portion of the flood control project. This would benefit the marsh wren (*Cistothorus palustris*), which is a declining species in New Jersey, and the clapper rail (*Rallus longirostris*). The Corps responded that it did not agree with this recommendation based on the Habitat Evaluation

Procedures (HEP) (U.S. Fish and Wildlife Service, 1980) method that was used to quantify project impacts. Using "habitat units," the HEP analysis showed that 51 percent of clapper rail habitat will be replaced and 64 percent of marsh wren habitat will be replaced by the selected mitigation plan, resulting in an overall loss of habitat for these two evaluation species. Although FWS still has concerns regarding the loss of habitat for these two species and requests that the Corps reconsider this issue with respect to the flood control project, we also realize the substantial beneficial effects that almost 400 acres of wetland enhancement/restoration will have to the fish and wildlife resources of the area from the Corps restoration project.

CONCLUSION

The Department is generally supportive of the project and commends the Corps for its ecosystem restoration initiatives, but recommends re-addressing the above concern of the FWS in the Final Feasibility Report and Environmental Impact Statement.

If you have any questions regarding these comments pertaining to fish and wildlife resources or require further assistance on fish and wildlife issues related to the proposed project, including federally listed threatened or endangered species, please contact the FWS at the following address:

Supervisor
U.S. Fish and Wildlife Service
New Jersey Field Office
927 N. Main Street, Building D
Pleasantville, New Jersey 08232
(609) 646-9310

Thank you for the opportunity to provide these comments.

Sincerely,

Andrew L. Raddant
Regional Environmental Officer

LITERATURE CITED

Urquhart, K. 2002. Assessment of the South River Flood Control and Ecosystem Restoration Project, Middlesex County, New Jersey. Draft Fish and Wildlife Coordination Act Section 2(b) Report, U.S. Department of the Interior, Fish and Wildlife Service, New Jersey Field Office, Pleasantville, New Jersey. 15 pp. + appendices.

U.S. Fish and Wildlife Service. 1980. Habitat Evaluation Procedures. ESM 102. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. 135 pp.

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

Centers for Disease Control and Prevention

July 16, 2002

Mr. Mark H. Burlas
Senior Wildlife Biologist
CENAN-PL-EA
26 Federal Plaza
New York, New York 10278-0090

Dear Mr. Burlas:

We have completed our review of the Draft Integrated Feasibility Report(DFR), which contains the Draft Environmental Impact Statement (DEIS) and supporting appendices for the proposed South River, Raritan River Basin, Hurricane and Storm Damage Reduction and Ecosystem Restoration Study. We are responding on behalf of the U.S. Public Health Service, Department of Health and Human Services (DHHS).

Our primary potential concerns are environmental health impacts to human populations. Based our review, we believe that this DFR/DEIS project will provide very beneficial future protection to human populations from hurricanes and floods when implemented. We have no comments to offer at this time. Thank you for the opportunity to review and comment on this document.

Please send us a copy of any future environmental impact statements which may indicate potential public health impact and are developed under the National Environmental Policy Act (NEPA).

Sincerely,

for Paul Joe, DO, MPH
Medical Officer
National Center for Environmental Health (F16)
Centers for Disease Control & Prevention

Comment Letters Received on the Draft Integrated Feasibility Report and Environmental Impact Statement (Report).

State Agencies:

State of New Jersey, Department of Environmental Protection, Office of Program Coordination.

District response to State of New Jersey, Department of Environmental Protection, Office of Program Coordination:

District response to NJDEP comment #1: The Corps has received a letter of support (September 2002) from the New Jersey State Department of Environmental Protection and the Corps has and continues to support strong interagency participation in all aspects of the South River project.

District response to NJDEP comment #2: In coordination with NJDEP's Land Use Regulation Program office, the District was instructed to conduct a wetland function and values assessment for the South River Project. Specifically, in an email message to Stacie Grove of Northern Ecological Associates, Inc. dated March 2, 2000, Chris Dolphin of the NJDEP stated that *"We will be requesting that the Evaluation for Planned Wetlands [EPW] method prepared by Environmental Concern Inc. be used to assess the wetlands to be impacted and to compare the mitigation proposal to the wetlands impacted."* As part of the process, the NJDEP participated in a pilot study on site and provided their opinion regarding the final technical approach for the South River study. In particular, Chris Dolphin stated in an email message to Stacie Grove dated August 9, 2002, that *"For EPW, we here at the Program prefer Scenario 2"*.

The purpose of this assessment was to ensure adequate mitigation for wetland impacts. Based on the results of the EPW study and a thorough evaluation of FCUs, the District has developed a mitigation plan that accounts for the replacement of wetland functions and values to the maximum extent possible.

District response to NJDEP technical comment #1: The District is committed to complying with all applicable air conformity rules and regulations. Toward that end, the District is currently preparing a scope of work for detailed, comprehensive, quantitative emission estimates in order to quantify emissions from all aspects of the South River project. The results of this scope of work will be coordinated with the appropriate agencies, receive a formal public review, and be included in the Record of Decision for the South River Project. The notice to proceed for this scope of work will be issued as soon as the Preconstruction, Engineering, and Design phase is initiated (Fall 2002) for the South River project and funds become available.

A summary of the preliminary emission estimates of total direct and indirect emissions from the proposed South River Project, including emissions from construction employees commuting to and from the construction site, is provided in Table 1 (the Report has been revised to include detailed emission calculations for each activity, as well as the summary Table 1). Based on these preliminary estimates, potential direct and indirect NOx emissions will likely exceed the de minimis level of 25 tons per year. Preliminary estimates of potential direct and indirect VOC and CO emissions are estimated to be below the de minimis levels.

The NJDEP noted in their comments that air emissions associated with the proposed project have not been included in the development of New Jersey's Air Quality

Implementation Plan. The proposed South River Project is not specifically identified in the SIP and therefore would not demonstrate conformity per the provisions of 40 CFR 93.158(a)(1). However, per the provisions of 40 CFR 93.158(a)(5)(i)(A), conformity may also be demonstrated if:

> "The total direct and indirect emissions from the action (or portion thereof) is determined and documented by the State agency primarily responsible for the applicable SIP to result in a level of emissions, which together with all other emissions in the nonattainment (or maintenance) area, would not exceed an emission budgets specified in the applicable SIP."

The total direct and indirect NOx emissions from the proposed South River Project appear to represent an insignificant portion of the emissions budgeted in the New Jersey SIP for 2005, accounting for approximately 0.005% of the On-Road emission sources budget and 1.6% of the Non-Road emission sources. Thus, the NOx emissions from the proposed South River Project appear to be adequately covered by the emissions projected in the SIP. Therefore, the total direct and indirect emissions associated with the construction activities associated with the proposed South River Project may demonstrate conformity per the provisions of 40 CFR 93.158(a)(5)(i)(A).

Although the General Conformity requirements do not appear to apply to VOC and CO emissions, as indicated above, the District will conduct a detailed quantitative analysis – in close coordination with EPA and the New Jersey Department of Environmental Protection – to more precisely quantify all emissions from the South River Project and to determine conformity accordingly. Upon completion of the revised emission estimates, a Draft General Conformity Determination will be prepared and submitted for review, and all of the results and conclusions will be included in the Record of Decision after the appropriate formal agency review period.

A conformity determination may also be required if emissions from a Federal action are deemed to be regionally significant. An action is considered to be regionally significant if the total emissions of a pollutant represent 10 percent or more of the total emissions inventory in a nonattainment or maintenance area. As shown in Table 1, the total direct and indirect NOx, VOC and CO emissions are preliminarily estimated to represent much less than 10% of the total emissions inventory for the area. Therefore, the activities associated with the proposed South River Project are not expected to be regionally significant.

Upon completion of the proposed South River Project, emissions will be generated from intermittent operation of the pump(s) that will be in the pump house. The size of the pump(s) for the pump station has not been specified at this time. Therefore, emission estimates could not be made for the pump(s). However, operation of the pump station will not occur until after construction activities are completed. Thus, emissions from the construction activities represent the maximum annual emissions from the South River Project.

Due to the anticipated size and use of the pump house, potential emissions from the pump(s) are expected to be below Major Facility threshold levels. Thus the facility will be considered as an area source. The pump(s) will conform with the SIP by complying with the appropriate applicable requirements for significant and/or insignificant source operations identified in N.J.A.C. 7:27-8, N.J.A.C. 7:27-16, and N.J.A.C. 7:27-19.

TABLE 1
SUMMARY OF PROJECTED AIR EMISSIONS FROM SOUTH RIVER, RARITAN RIVER BASIN HURRICANE AND STORM DAMAGE REDUCTION AND ECOSYSTEM RESTORATION PROJECT

	NOx		VOC		CO	
	ton/year	ton/day	ton/year	ton/day	ton/year	ton/day
DIRECT (Construction activities)						
Levee Construction	1.32	0.008	0.13	0.001	0.65	0.004
Wetlands Construction	46.05	0.15	3.62	0.012	28.6	0.092
TOTAL CONSTRUCTION		0.155		0.012		0.095
NJSIP[1]		9.44		1.27		3.43
Percent of SIP		1.64%		0.97%		2.78%
INDIRECT (Transporation)						
Transport of Fill Material	1.33	0.004	0.22	0.0006	1.03	0.003
Employee Commuting	1.80	0.005	1.40	0.0038	10.20	0.028
TOTAL TRANSPORATION		0.01		0.0044		0.03
NJSIP[2]		178.73		94.59		747.36
Percent of SIP		0.005%		0.005%		0.004%
TOTAL PROJECT EMISSIONS	50.49	0.164	5.37	0.017	40.5	0.126
DEMINIMIS LEVELS	25		25		100	
NJSIP[3]		511.51		578.11		2148.89
PERCENT OF SIP		0.032%		0.003%		0.006%

[1]State Implementation Plan (SIP) Revision for the Attainment and Maintenance of the Ozone National Ambient Air Quality Standard (NAAQS), New Jersey 1996 Actual Emission Inventory and Rate of Progress (ROP) Plan for 2002, 2005 and 2007, Appendix II: Inventory Projects for 1999, 2002, 2005 and 2007, Attachments IIJ, IIK and IIL, Projected emissions for Middlesex County for 2005 for Non-road Sources, Construction and Mining Equipment (SCC 2270002003 - 2270002081).

[2]State Implementation Plan (SIP) Revision for the Attainment and Maintenance of the Ozone National Ambient Air Quality Standard (NAAQS), New Jersey 1996 Actual Emission Inventory and Rate of Progress (ROP) Plan for 2002, 2005 and 2007, Tables 23 - 25, Project Inventories for On-Road Sources, New Jersey portion of New York MPO.

[3]State Implementation Plan (SIP) Revision for the Attainment and Maintenance of the Ozone National Ambient Air Quality Standard (NAAQS), New Jersey 1996 Actual Emission Inventory and Rate of Progress (ROP) Plan for 2002, 2005 and 2007, Tables 26 - 28, Project Inventories for All Emission Sources, New Jersey portion of New York MPO.

District response to NJDEP technical comment #2: Per the National Marine Fisheries Service's letter dated 22 July 2002, it is recommended that the District refrain from construction activities during the period 1 April through 30 June. This more recent letter from the National Marine Fisheries Service updates their outdated recommendation. Please coordinate information supporting a prohibition of construction activities between 1 September and 30 November with the District's Environmental Analysis Branch for future consideration.

District response to NJDEP technical comment #3: The Project will directly impact two Green Acre areas, including Varga Park and Recreation Area and an unnamed parcel located in the southeastern portion of the Project Area near the Sayreville/South River Bridge (see attached Figure). Although the District has specifically aligned the levee/floodwall footprint to minimize impacts to these two areas, due to their proximity to the South River and adjacent residential/developed areas it was impossible to avoid them. Consequently, the District will coordinate with the NJDEP and NJ State House Commission to obtain the necessary permits and approvals to traverse these areas.

District response to NJDEP technical comment #4: Only a handful of samples exceeded the Non Residential Direct Contact Soil Cleanup Criteria (NRDCSCC), and elevated levels of arsenic greater than the NJDEP's threshold for NRDCSCC are not unusual for geologic formations in that part of New Jersey (NJAC 7:26D, February 3, 1992). Since the project area in general and the island in particular are downstream of heavily industrial/urbanized areas, elevated levels of certain constituents are not unexpected.

However, the Corps concurs in general with NJDEP's comments regarding the movement of material proposed for the restoration areas on the island. In the Preconstruction, Engineering and Design phase, the Corps has budgeted funds to comprehensively collect soil samples, in a systematic gridwork pattern, and analyze them for targeted potential contaminants. Upon review of the laboratory analyses, the selected restoration plan will be modified to take into account any levels of contamination. The Corps looks forward to working closely with NJDEP in this effort, and will not recommend any restoration design plan that fails to adequately address NJDEP's HTRW concerns.

District response to NJDEP technical comment #5: Although several species of concern have been seen foraging in the project area, there have been no observations of nesting activity in the area of direct impacts (*i.e.*, the levee/floodwall footprint). In fact, the levee/floodwall alignment has been specifically sited to avoid a heron roost and great horned owl nest. Therefore, construction activities will not directly impact any species of concern.

The District does acknowledge that some species of concern may be temporarily impacted during implementation of the Project. Specifically, increased noise and heavy machinery activity could cause displacement of individuals during construction activities, and wetland-dependent species may be temporarily displaced by the habitat alterations that would occur due to construction activities. However, the District believes that these temporary impacts are far outweighed by the benefits to species of concern anticipated from the creation of habitats associated with the Project's mitigation and restoration activities.

District response to NJDEP technical comment #6: The Corps agrees that additional detailed evaluations are necessary to adequately minimize impacts to surface water quality during construction. During the next and final planning phase (the Preconstruction, Engineering and Design phase), after the Corps finalizes the details of its hurricane and storm damage reduction and ecosystem restoration measures, comprehensive evaluations will be conducted. At this time, the Corps will list the type and function of all selected erosion and sediment control measures to be implemented. The Corps is committed to minimizing surface water quality impacts, and this information is critical for certain permits the Corps must acquire prior to construction. The Corps has currently budgeted more than $3 million for erosion and sediment control for the ecosystem restoration component of the project alone.

District response to NJDEP technical comment #7: The 9.41 acres of wetland impact presented in the IFR/DEIS does account for wetland areas located on the landward side of the levee/floodwall. Therefore, indirect impacts associated with a change in wetland hydrology have been included in the District's impact assessment. Similarly, the total area of wetland impacts includes the infrastructure necessary to support the proposed Project.

Wetland areas impacted by the construction of temporary access roads and/or equipment parking areas have not yet been identified and are not included in the total acreage of wetland impacts. However, these areas will be restored to their original vegetative cover following construction activities. Therefore, there will be no permanent conversion of wetland cover type or hydrology.

District response to NJDEP technical comment #8: Visual impacts associated with the levee and floodwall will be minimized to the maximum extent possible without interfering with the overall integrity of their form and function. Specifically, the landward side of the levee will be planted with shrubs and native grasses in order to create a more visually appealing area and to improve the diversity and abundance of bird and mammal species. Similarly, the 20-foot retention ditch located on the landward side of the floodwall will function as an emergent wetland area and will support a variety of wetland plants and animals.

Public access to the river will only be restricted during construction activities. Once construction is complete, the public will be able to easily and safely access the waterfront. In addition there will be additional recreational opportunity such as walking, running, or biking along the top of the levee.

District response to NJDEP technical comment #9: Local noise ordinances governing maximum permissible sound levels and construction periods permitting elevated sound levels will be adhered to throughout the project. The primary noise-sensitive receptors in the Project area include residential homes that are located at least 100 feet from the construction area on the east side of the Washington Canal. Although construction activities will be located closer to structures on the western side of the river, this area is highly developed and primarily consists of local businesses and roads.

The District does not anticipate the need to mitigate impacts associated with localized, temporary, increased noise levels. Although minor short-term impacts on noise levels will result from the construction phase, these noises will be dissipated by distance and/or masked by the high background levels of traffic and community activity. Site preparation (generally two weeks prior to construction), construction activities, and the necessary heavy equipment are likely to produce noise levels in the 70 to 90 dBA range 50 feet from the source.

District response to NJDEP technical comment #10: The loss in average annual habitat units for the clapper rail and marsh wren are the result of a large acreage of low quality habitat (379.3 acres of *Phragmites australis*; habitat suitability index (HSI, from 0 – 1) of .55 for the clapper rail and .47 for the marsh wren) being converted to a smaller amount of high quality habitat (151.7 acres of tidal salt marsh; HSI of .92 for the clapper rail and .83 for the marsh wren). The value of the tidal salt marsh for both the clapper rail and marsh wren is further augmented by the physical interconnectedness and proximity of 19 acres of mudflat and 19 acres of open water. Since the HEP models used in the cost effectiveness and incremental cost analysis multiply quantity x quality to arrive at habitat units, the models lack the sophistication to capture the reality of how the habitats are interspersed on the landscape and how they interact and interrelate. For example, the models do not completely capture the difference between five acres of Phragmites in a monotypic clump and five acres of Phragmites intermixed among tidal salt marsh and mud flat.

The goal of the selected National Ecosystem Restoration (NER) plan is to maximize biodiversity and ecological functioning in the South River watershed, and that is what it does; the HEP species were tools to quantify this goal. Although modifications to the NER plan can be made in the Preconstruction, Engineering and Design (PED) phase – and the Corps welcomes sustained and detailed involvement by NJDEP in the PED phase – national Corps guidance on the matter is very clear: no mitigation measures will be conducted as the result of restoration activities.

District response to NJDEP technical comment #11: In the case of South River, the Phase II cultural investigations, if necessary, are being conducted in the Preconstruction, Engineering, and Design (PED) phase. In the PED phase, Phase I cultural investigations will also be completed for the ecosystem restoration portion of the project. Section 7.2.7 has been revised to correctly indicate that, as the project is currently designed, project impacts to the Washington Canal are possible, not definite. The first sentence of the last paragraph under Section 7.2.7 has been revised to: "The proposed construction within the APE will have no impact on significant cultural resources as long as work is conducted according to the recommendations in the Phase I cultural investigation feasibility report (Panamerican 2001)."

District response to NJDEP technical comment #12: The hurricane and storm damage protection component of the project is formulated and designed to protect existing structures in the floodplain. As a nationwide policy rule, the Corps does not evaluate the potential of development in a study area after a project is in place. As part of the final project the non-Federal sponsor (State of New Jersey Department of Environmental Protection) is to provide a floodplain management plan.

District response to NJDEP technical comment #13: Required baseline information on such habitats exists in part; the monitoring plan will supplement the necessary additional information for similar habitats in the region.

District response to NJDEP technical comment #14: Concur.

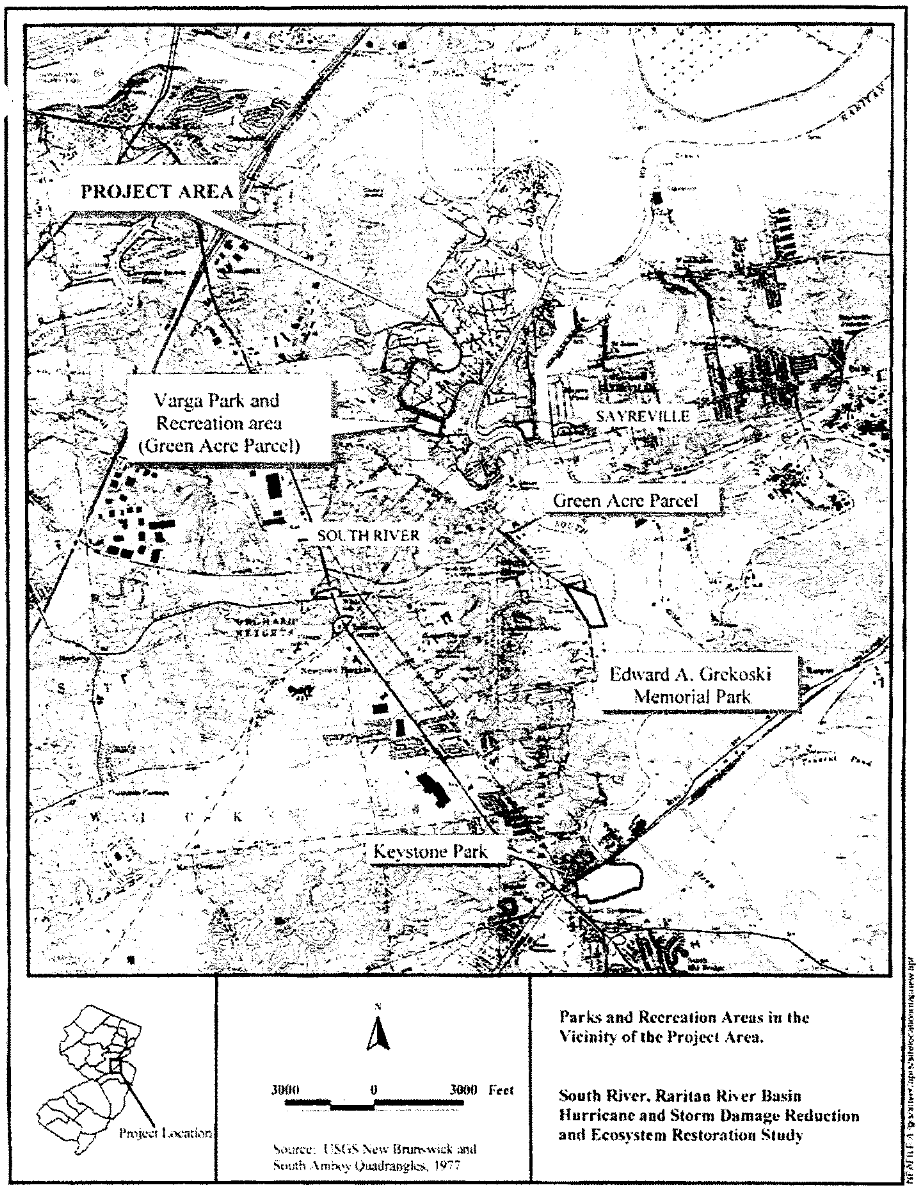
District response to NJDEP technical comment #15: Concur.

District response to NJDEP technical comment #16: Concur.

District response to NJDEP technical comment #17 regarding Ecosystem Restoration Plan report: Section 4.2.1: the "dredged material" in this case is simply the material removed from other parts of the island; it is not dredged material from a waterway or other open water area. Section 4.2.2 – 4.2.4: concur. Section 5.2, page 25: the draft Report notes that boating activities will be temporarily disrupted due to construction activities; the impacts from the access road will be minimized along with all other construction activities, and the area will be restored to its original vegetative cover following construction activities. Section 5.2, page 26: concur.

District response to NJDEP technical comment #18: Concur.

District response to NJDEP technical comment #19 regarding Impact Assessment and Mitigation Analysis Report: The intent of the IFR/EIS is to provide a detailed summary of the engineering, environmental, and economic issues that the District considered during the development of their selected NED, NER, and mitigation plans. Due to the numerous technical studies conducted by the District and the volume of supporting information, it would be impossible to include all the details within the IFR/EIS. Therefore, the District has included references to the original documents, reports, and studies so that the more detailed information can be easily located, if necessary. The original Mitigation Alternative 2 was reduced in size because the mitigation goals (*i.e.*, number of AAHUs and FCUs) established by the interagency team (USFWS, NJDEP, NMFS, and USACE) were greatly exceeded. Therefore, in order to develop a more economical plan that still fulfilled the original mitigation goals, the District reduced the size of the selected plan. Based on this reduction, there is no net loss of wetland functions and values.



Parks and Recreation Areas in the Vicinity of the Project Area.

South River, Raritan River Basin Hurricane and Storm Damage Reduction and Ecosystem Restoration Study

State of New Jersey

s E. McGreevey
Governor

Department of Environmental Protection

Bradley M. Campt
Commissioner

September 5, 2002

Len Houston
Chief, Environmental Analysis Branch
Department of the Army
New York District, Corps of Engineers
Jacob K. Javits Federal Building
New York, NY 10278-0090

RE: South River, Raritan River Basin
Hurricane & Storm Damage Reduction and Ecosystem Restoration

Dear Mr. Houston:

The Office of Program Coordination of the New Jersey Department of Environmental Protection has completed its review of the Draft Integrated Feasibility Report and Environmental Impact Statement (IFR/EIS; April 2002) prepared for the above referenced projects. This review was undertaken pursuant to the requirements of the National Environmental Policy Act. The Draft IFR/EIS evaluated the following two projects:

- Hurricane and Storm Damage Reduction: construction of floodwalls, levees, and a tidal storm surge barrier along the South River and Washington Canal.
- Ecosystem Restoration: restoration of 379 acres of existing wetlands currently dominated by *Phragmites australis*.

The Executive Summary (page xiii) and Section 9.2 (page 128) of the Draft IFR/EIS note that the Department is the non-Federal partner for the proposed projects. The Department continues to support the proposed flood control and ecosystem restoration projects. However, at this time, it does have a number of concerns regarding the projects. In particular, the Department is concerned with the parameters used to design the flood control project, such that it believes the proposed project may be "over-designed" for potential flooding conditions in the project area. The use of these same parameters in the design of the ecosystem restoration plan may also be problematical.

Thus, at the present time, the Department believes additional staff-level coordination is needed with the USACE on the design and evaluation of alternatives for both projects before it can be fully supportive of a "selected plan". The Department requests that interagency committees be established to evaluate the proposed projects and their potential alternatives, future monitoring and maintenance activities, etc., prior to the development of the Final IFR/EIS by the USACE.

When evaluating the need for mitigation of wetlands impacts, the Department's Land Use Regulation Program does not use Functional Capacity Units or Average Annual Habit Units. The Department will assess the direct acreage of wetlands lost, and require mitigation at a ratio of 2:1 for any created wetlands, and a minimum ratio of 3:1 for enhanced wetlands.

The Department's concerns with the design of the flood control project may be transmitted to the USACE by the Department's Engineering and Construction group under separate cover.

Technical comments on the Draft IFR/EIS are included as Attachment #1.

Please note that the following permits/approvals may be required for the proposed projects:

- CZM Consistency Determination
- Clean Air Act Conformity
- Water Quality Certificate
- Waterfront Development Permit
- Stream Encroachment Permit
- Riparian Instruments (tidelands)
- Section 106 consultation

Thank you for providing the Department the opportunity to review the Draft IFR/EIS for these projects. If you have any questions, I may be contacted at 609-292-2662.

Sincerely,

Lawrence Schmidt
Director
Office of Program Coordination

c. John Moyle, Engineering and Construction
Clark Gilman, Engineering and Construction
Robert McDowell, Fish and Game
Robert Piel, Land Use Regulation
Dorothy Guzzo, Historic Preservation

Attachment #1

Technical Comments: South River Hurricane & Storm Damage and Ecosystem Restoration

(1) Air Quality: the Draft IFR/EIS does not include a quantitative analysis of the total direct and indirect air emissions associated with the proposed projects. Therefore, it is not known if these emissions exceed the following *de minimis* levels for air quality nonattainment areas (see 40 CFR 93.153(b) et seq.):

- VOCs and NOx - 25 tons per year (severe NAA)
- CO - 100 tons per year (all NAA)

Direct emissions include emissions from construction employees' commuting vehicles. If a quantitative analysis of project-associated air emissions show the levels to be below the above-referenced values, but account for 10 per cent or more of the nonattainment (or maintenance) area's total emissions of that pollutant, the project will be defined as a regionally significant action.

In addition (and contrary to the statement made in Section 7.1.8, page 109 of the Draft IFR/EIS), the air emissions associated with the proposed projects have not been included in the development of New Jersey's Air Quality Implementation Plan.

(2) Anadromous Fish: the South River has documented usage by river herring and shad. In order to protect these species during migration and/or spawning, construction activities should not be conducted from April 1 through June 30 and from September 1 through November 30. These periods of prohibited work are consistent with those identified by the National Marine Fisheries Service (see Appendix D, Pertinent Correspondence, September 2, 1998 letter from Stanley W. Gorski, NMFS).

(3) Section 3.10, page 44: please add a figure that identifies the location of the parks and recreation areas discussed. It appears that construction of the levee/floodwall will occur within the boundaries of some of these parks. Since these parks are subject to NJ Green Acres encumbrances, approval to impact them will be required from the Commissioner of the Department and the NJ State House Commission. In addition, these impacts to the parks should be reflected in Section 7.1.10 (page 110) of the Draft IFR/EIS.

(4) Section 3.12, page 45: notes that studies conducted for the Draft IFR/EIS found elevated levels of a number of hazardous/toxic substances in the proposed ecosystem restoration area (Clancy Island), and elevated arsenic levels at one location (SB-1-2) in the area of levee construction. However, Sections 7.1.12 (page 111) and 7.2.12 (page 119) simply state that "no HTRW issues are anticipated during project implementation". Given the potential movement and reuse of project soils (see Comment #17), and the goal of the ecosystem restoration project to improve the quality of fish and wildlife habitat (and thus potentially

increasing exposure to these contaminants), the potential short and long-term impacts of the observed elevated levels of hazardous/toxic substances should be evaluated in greater detail.

(5) T/E Species, Section 3.6.3.2, page 40: notes that a number of State T/E species have been observed in the project area, including black skimmer, northern harrier, peregrine falcon, yellow-crowned night heron, osprey, black-crowned night heron, and American bittern. In addition, yellow-crowned night herons have recently been observed nesting near the South River (see attached newspaper article). However, the Avoidance and Minimization Plan (January 2002; Section 4.2, page 11) notes that the levees /floodwalls were located so as to avoid a heron roost site and a great horned owl nest. Thus, the conclusions of the Draft IFR/EIS (Section 7.1.6.3, page 108 and Section 7.2.6.3, page 117) that construction and operation of the proposed projects will not adversely impact any State T/E species should be reevaluated in more detail.

(6) Section 7.1.3, page 104: additional detailed discussions/evaluations of potential construction impacts to surface water quality are needed, particularly concerning the movement of large quantities of soil/sediments and plant materials and the resulting potential for increased turbidity in the South River and Washington Canal. The soil erosion and sediment control measures proposed for use should be identified and their effectiveness discussed.

(7) Section 7.1.6.1, page 105: notes that construction of the flood control project will impact 9.41 acres of wetlands. Does this wetland acreage include areas impacted as a result of the construction of stormwater management infrastructure (pipes, culverts, outfalls)? In addition, any wetlands located landward of the flood control structures that could be adversely impacted by changes in hydrology should be included in the total acreage of impacted wetlands.

(8) Section 7.1.11, page 111: concludes that, since the project area is substantially developed, construction of the levee/floodwall will not have an adverse visual/aesthetic impact. However, construction of the levee/floodwall will introduce a new visual element along the South River and Washington Canal, and possibly result in less public access to these waters. These potential adverse impacts (including visual/aesthetic impacts to cultural and historical resources) should be evaluated in greater detail.

(9) Section 7.1.9, page 110: please identify any noise-sensitive receptors in the project area that could be adversely impacted by construction noise, and develop measures to mitigate any such impacts.

(10) Tables 35 and 36, page 115: show that implementation of the proposed restoration plan would result in the net loss of Clapper Rail (-55.9 AAHUs) and Marsh Wren habitat (-44.2 AAHUs), and wetlands Sediment Stabilization function (-47.4 FCUs). The potential impacts of these losses are not discussed in the Draft IFR/EIS. To compensate (in part) for the loss of Clapper Rail and Marsh Wren habitat, the USFWS has recommended in its Draft 2b Report (April 2002) that an additional 3 acres of wetlands be created as part of the levee/floodwall mitigation project.

(11) Section 7.2.7, page 117: states that Washington Canal is potentially eligible for placement on the National/State Registers of Historic Places. Further, the Draft IFR/EIS concludes that the canal will be impacted by the proposed ecosystem restoration project, and states that additional Phase II investigations are needed. Archaeological investigations of the ecosystem restoration area are also needed. A determination of the status of Washington Canal and the required Phase II investigations should be completed before the preparation of the Final IFR/EIS for this project.

In addition, the final paragraph of this section of the Draft IFR/EIS states "The proposed construction within the APE will have no impact on significant cultural resources ..." This conclusion is not consistent with earlier statements regarding potential impacts to Washington Canal.

(12) Section 7.7, page 122: would construction of the proposed levee/floodwall encourage additional development activities in the project area? If so, the Draft IFR/EIS should evaluate the potential impacts of such development.

(13) Section 8.6, page 126: when evaluating the success of the proposed ecosystem restoration plan, various monitoring activities of the restoration project will be evaluated against "similar habitats in the region". Does the required baseline information on such habitats currently exist, or will the monitoring plan also require additional studies of such habitats to acquire this information?

(14) Levee/Floodwall Landscaping: the Department recommends that native warm seasonal grasses and the deciduous shrub and tree species identified in "Landscaping for Birds on New Jersey's Barrier Islands" (see attached) be planted on the levee/floodwall. These plants would provide additional food and shelter for wildlife, are more drought, salt, and disease resistant, and will require less maintenance once established.

(15) *Phragmites* Treatment Plan: the Department agrees with the plan to use "Rodeo" or a similar product, and further recommends that

- A soybean-based surfactant be used.
- *Phragmites* should be sprayed between August 15 and October 15 (but before the first frost), with September 15 being the approximate optimal date. If spraying occurs during these dates, fixed wing aircraft could be used. The Phragmites should be subsequently burned during January-February.
- Removal of the *Phragmites* may reveal microtopographical conditions that will have to be modified to ensure elimination of this plant.

(16) Herbivore Waterfowl Control: in addition to fencing, other actions may be needed to prevent waterfowl from flying into the mitigation and restoration sites.

(17) South River Ecosystem Restoration Plan (October 2001):

- Section 4.2.1, page 19 - states that dredged material can be used to restore various habitats. Please explain in greater detail and identify potential sources for this dredged material. Note that if dredging and/or beneficial use of dredged material is associated with the proposed project, additional Departmental permits may be required.
- Sections 4.2.2-4.2.4, pages 20/21 - note that excavated material could be used as part of the ecosystem restoration project; see Comment #4.
- Section 5.2, page 25 - notes that a temporary bridge and access road to Clancy Island will be needed. However, the Draft IFR/EIS does not evaluate the potential impacts of the construction and use of these structures.
- Section 5.2, page 26 - to avoid adversely impacting restoration areas, the levees/floodwalls should be constructed first in areas where the two activities overlap.

(18) USFWS Draft 2b report (April 2002): the Department agrees with and supports the various recommendations made by the USFWS in this report (see Section VII, page 18).

(19) Impact Assessment and Mitigation Analysis report (April 2002), page S-3: for the proposed flood control project wetlands mitigation plan, notes that "only 80% of the total combined FCUs lost would be replaced by mitigation". However, specific wetlands elements are to be further "optimized" to obtain 100% replacement of lost wetlands functions. These "optimizations" should be discussed in detail in the Final IFR/EIS and wetlands mitigation plan to ensure no net loss of wetlands functions. Since the original Mitigation Alternative 2 plan was reduced in size (see section 4.6.1, page 69), it may be appropriate to increase the size of the final selected mitigation plan to ensure no net loss of wetlands functions.

Threatened bird sighted

Courtesy of James Faczak

■ A yellowed-crowned night heron photographed near the South River, where three nests were discovered and some young birds were found.

Yellow-crowned night herons seen nesting near the South River

HNT 7-22-02

By JOHN YOCCA
STAFF WRITER

SOUTH RIVER: Curious about a lanky, long-billed bird that visited her back yard, a friend asked Leslie Senko, an avid birder, to name it..

Senko knew the long-legged avian that dropped by the home near the South River was a heron of some kind. When the bird slowly turned and looked at her through the window, the borough woman checked her guide and identified it as a yellow-crowned night heron.

Senko called in Cheesequake State Park naturalist James Faczak, who took pictures, discovered three nests in the area and found some young birds, evidence that the herons are reproducing.

"This is really exciting," said Senko, who shares with few people the whereabouts of the herons, fearful that they may be disturbed. "They are really special birds."

Al Ivany, a spokesman for the New Jersey Division of Fish and Wildlife, said the yellow-crowned night heron is on the state's threatened species list. The state tries to protect areas where threatened species are found, he said.

The yellow-crowned night heron is usually about 21 inches tall with a blue-gray neck, chest, back and belly. It has a yellow crown and black head with a patch of white that flows from the eyes. The food it eats consists primarily of crustaceans but also includes small fish, reptiles, amphibians, eels, insects and mollusks. Faczak said he found pale-blue egg shells and fiddler crabs near the nests.

Senko said the birds are creating a small colony behind some homes. It's significant that they are reproducing, given their threatened status, she said.

To protect the birds, she immediately began making calls to state wildlife officials and environmental

See **Bird**, Page **B2**

BIRD

■ From Page B1

organizations, including the New Jersey Audubon Society and the Edison Wetlands Association.

Robert Spiegel, executive director of Edison Wetlands, said he was glad to hear that threatened species are returning to the area. However, he was concerned that a plan by the Army Corps of Engineers to install earthen levees and concrete walls along the South River to control flooding may threaten wildlife and force the birds to migrate somewhere else.

"We're seeing more species like the herons come back to the area," he said. "Now we just have to work to protect the area."

John Yocca: (732) 565-7256; e-mail jyocca@thnt.com

Contributing: Staff Writer Jennifer Micale.

Landscaping for Birds on New Jersey's Barrier Islands

New Jersey has been called the "crossroads of migration" because millions of birds migrate along our coast each spring and fall. Homeowners residing in this crucial habitat can play a vital role in helping to provide food and sheltering greenways for these weary travelers.

If you have visited Island Beach State Park, you have seen a remnant of the thick forests of cedar, bayberry, holly, sumac, and beach plum than once lined our entire coast. Unfortunately, that greenery has virtually disappeared from our shoreline in the last fifty or a hundred years. Landscaping to help restore some of that habitat is not that difficult, and the payoff to wildlife and the environment is immeasurable. Backyard by backyard, beach community by beach community, it is imperative that we plant for wildlife: that we put back some of what once was there so that we can help insure the success of future generations of migrant birds.

Designing A Landscape for Birds

Try to keep in mind the basic needs of migrating birds for food, water, and shelter as you create a plan to enhance you property. On a barrier island, if we focus on the needs of migrants first, the habitat improvement will benefit all birds. Resident birds, such as the mockingbird and the mourning dove, will build their nests in the same trees and shrubs you provide for the migrants. For small yards this may mean taking some areas out of lawn or gravel and pulling together existing plantings with additional landscap ing to create larger areas of suitable habitat.

To maximize the improved habitat, work first along your property boundaries. You can start by planning a vegetative hedge to help break the wind and protect less tolerant plant which should be sited toward the interior of your property. Begin by visualizing where trees and shrubs can be planted and hold off on plant selection until a design is in place. Which plants you should select depend on your proximity to the ocean and their tolerance of its strong, salt-bearing winds. As you draw up a plan, keep in mind that it is best tc landscape with small and medium height trees because they will have greater resistance to winds than taller species. (Al species listed below are appropriate; the taller varieties will grower shorter near the shore.)

Now as you walk around your yard, look for areas where yo might incorporate individual trees into a landscape border, or areas that are not otherwise used by your family. You can visualize where you might add additional individual trees and shrubs by placing flower pots on 10 ft. centers for small trees and additional markers on 4-6 ft. centers for shrubs. With the markers in place, lay a garden hose on the ground and adjust it to your liking taking into consideration foot traffic flow and the ultimate potential growth of your plantings. Delineate the edge with a shovel or lawn edger.

By converting some lawn areas into vegetative borders, you are taking an important step in improving your property for birds. Manicured lawns provide virtually no wildlife value (especially at the shore where worms are seldom present) and are expensive in terms of time, resources, and energy. Lawns also have a negative impact on the environment when fertilizer, herbicides, and pesticides are applied. Finally, in the sandy, porous, impoverished soil that is typical of barrier islands, maintaining green lawns strains our water resources.

If you are converting areas that have been landscaped with stone to shrubs and trees, you are taking an important step to help wildlife. Stone mulch has no wildlife value. Most stone lawns were put down in a effort to reduce maintenance, but you will discover that after the first few seasons of initial watering, shrubs and trees also require very little maintenance. In addition to their value to wildlife, these areas provide a cooling, quieting, soothing backdrop to the bright and intense beach environment.

Selecting the Plants

Most of the trees and shrubs suitable for planting on a barrier island are native plants adapted to the harsh, dı acidic conditions of the island environment. These plant also have very high wildlife value; both local nesters an migrant birds have depended on them in the past for frı nuts, seeds, and shelter. When making your selection, gi the highest priority to trees and shrubs that provide foo sources for migrants such as red cedar, bayberry, holly, arrowwood, and sumac. Be sure to include a mix of ever- green trees and shrubs in your plan to provide birds she tered roosting and resting places, protection from harsh weather, cover for nesting, and hiding places from preda

The plants listed below are grouped into two main categ according to their ability to withstand exposure to salt-laden winds. If you live on the ocean front or in a very exposed situation, choose plants from the first category. If you live in a more sheltered situation, a block or more in from the shore, you can landscape with plants from either category.

When purchasing trees and shrubs, choose plants that are balled and burlapped or container grown with healtl disease-free bark and leaves.

Preparing the Site

Due to nature of the shore's sandy soil, it is more effecti remove the surface weeds, mulch, and improve the soil i each planting hole rather than cultivate the whole bed. Eliminate weeds or turf in your newly defined border by spraying the vegetation with a glyphosate-based herbici (such as RoundUp or KleenUp). Proper application follo label directions should kill the ground cover and not lea any harmful residual effects in the soil. An alternate me is to lay down a thick layer of newspaper or a sheet of d landscape fabric which in combination with mulch will the turf and help conserve moisture. If you are converti from a mulch of stone to vegetation, be sure to discard old plastic on which chemicals may have built up over t Cover the area with a 3-4" layer of wood chips or shred bark. Cut holes through the mulch when you are ready plant. Add wet peat moss, and compost or sterlized top and some slow release fertilizer to each planting hole b setting your shrub or tree in place. In future seasons a small doses of fertilizer in the fall, early spring and la spring because organic matter and nutrients tend to le out of the coarse, porous, sandy soil of the barrier islan

New shrubs and trees will need to be watered well during the first growing season or two, and after that in times of 'rought or excessive heat and wind. .our plants should receive haif an inch of water twice a week. Set up several coffee cans and time how long it takes for your sprinkler to provide half an inch of water to the planting area. Base your future watering on that amount of time, adjusting for rainfall and extreme weather conditions. If you are using a soaker hose or drip irrigation, water twice a week until the soil is moist 6"-8" down.

Spreading The Word

Since larger, contiguous areas of vegetation provide better shelter and cover, you may want to talk to your neighbors about joining in an effort to re-landscape. Your individual sanctuary efforts will be far more effective if your neighbors enhance their yards also. Your neighborhood can become an oasis of greenery enjoyed by birds and humans alike.

Evergreen Shrubs & Trec for Seaside Condition

American Holly, Ilex opa
Eastern Red Cedar, Juniperus virgiai
Inkberry, Ilex glab
Japanese Black Pine, Pinus thunbergii [non-nati\
Juniper cultivars, Juniperus chinens
J. communis [non-nativ

Deciduous Shrubs & Tree for Seaside Condition

Beach Plum, Prunus maritin
Black Cherry, Prunus serotii
Common Waxmyrtle, Myrica cerife
Northern Bayberry, Myrica pennsylvani
Rugosa Rose, Rosa rugosa [non-nativ
Shadbush, Amelanchier canadens
Virginia Creeper, Parthenocissus quinquefolia (vin
Winged Sumac, Rhus copallir

Evergreen Shrubs & Tree for Sheltered Condition

Pitch Pine, Pinus rigic
Virginia Pine, Pinus virginiar
Holly cultivars, Ilex crenata, I. cornuta [non-nativ

Deciduous Shrubs Trees for Sheltere Condition

Arrowwood, Viburnum dentatu
Cotoneaster, Cotoneaster spp. [non-nativ
Crab Apple, Malus sp
Gray Birch, Betula populifol
Hackberry, Celtis occidental
Hawthorn, Crataegus sp
Highbush Blueberry, Vaccinium canadens
Pyracantha, Pyracantha coccinea [non-nativ
Red Maple, Acer rubru
Red Mulberry, Morus rub
Sassafras, Sassafras albidu
Scrub Oak, Quercus ilicifol
Sour Gum, Nyssa sylvati
Sweet Gum, Liquidamber styraciflı
Winterberry Holly, Ilex verticilla

= provides food: berries, fruit, seec
nuts, and catki

This and many other exciting projects are funded through NJ's Endangered Wildlife Conservation Fund on your State Income Tax and Conserve Wildlife license plates. For more information, or to make a direct donation, please write the Division of Fish, Game and Wildlife's Endangered & Nongame Species Program at P.O. Box 400, Trenton, NJ 08625-0400 for more informaiton.

Sources For More Information:

John V. Dennis. *The Wildlife Gardener.* Knopf: New York, 1988.

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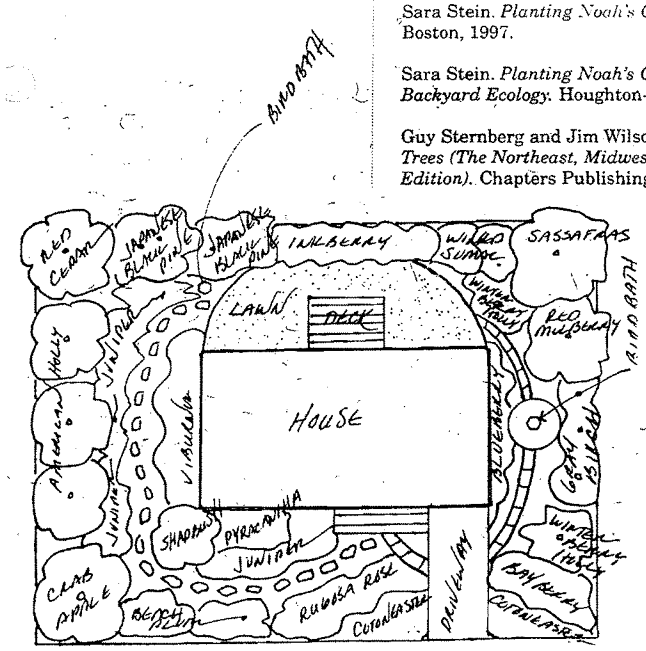

Comment Letters Received on the Draft Integrated Feasibility Report and Environmental Impact Statement (Report).

Elected Officials:

James E. McGreevey, Governor, State of New Jersey

John S. Wisniewski, Assemblyman, 19th District, New Jersey General Assembly.

State of New Jersey
OFFICE OF THE GOVERNOR
PO BOX 001
TRENTON NJ 08625-0001

JAMES E. MCGREEVEY
Governor

June 5, 2002

Mr. Len Houston
Chief, Environmental Analysis
Department of the Army
NY District Corps of Engineers
Jacob K. Javits Federal Building
New York, New York 10278

Dear Mr. Houston:

Thank you for forwarding a copy of the Draft Integrated Feasibility Report to my office. Your thoughtful consideration in sending it is appreciated.

Through transmission of this letter to Bradley Campbell, Commissioner of the Department of Environmental Protection, I am requesting that he review the information set forth in your correspondence with all due attention and consideration to determine the best course of action. You may contact Commissioner Campbell directly at 401 East State Street (7[th] floor), Post Office Box 402, Trenton, New Jersey 08625-0402 or call 609-292-2885.

Again, thank you for writing.

With all good wishes,

James E. McGreevey

cc: Bradley Campbell

District response to John S. Wisniewski, Assemblyman, 19th District, New Jersey General Assembly.

District response to general comment: The Corps appreciates your careful consideration of the South River project and, as indicated in your letter, will address the specifics of each of your three general concerns in the next phase of the project (Preconstruction, Engineering, and Design).

NEW JERSEY GENERAL ASSEMBLY

ASSISTANT MAJORITY LEADER
JOHN S. WISNIEWSKI
ASSEMBLYMAN, 19TH DISTRICT
PART OF MIDDLESEX
3145 BORDENTOWN AVENUE
SUITE B
PARLIN, NJ 08859-1164
(732) 316-1885
FAX (732) 316-1890
Email: AsmWisniewski@njleg.state.nj.us

COMMITTEES
CHAIRMAN,
TRANSPORTATION
TELECOMMUNICATIONS
AND UTILITIES
REGULATED PROFESSIONS A
INDEPENDENT AUTHORITIE

COMMISSIONS
CHAIRMAN,
FIRE SAFETY COMMISSION

September 4, 2002

Joseph Redican, Project Engineer
United States Army Corps of Engineers
New York District - Planning Division
26 Federal Plaza
New York, NY 10278-0900

Re: Comments on "The Hurricane and Storm Drainage and Ecosystem Restoration Plan"

Dear Mr. Redican:

Thank you for coming to Sayreville to present information on the plan proposed by the Army Corps of Engineers to mediate flooding of the South River. It was a useful meeting where residents and local officials could voice their concerns about the project.

As a result of the meeting, I would like to submit comments which address some of the concerns raised by the public that attended the meeting.

1. **Flood Concerns in the Old Bridge Section of Sayreville:** As addressed at the meeting last night, it appears as though the Old Bridge Section of Sayreville is affected by flood waters. As you indicated, this may be a municipal drainage problem which lies outside the scope of your project. However, if the Army Corps is attempting to re-mediate flooding, it would be prudent to examine all areas where flooding is a problem. If the problem in this section is indeed with the municipality's drainage system, it is my hope that your plan would include a way to coordinate flood alleviation efforts with the municipality. However, I submit that this is not simply a municipal problem and does lie within the scope of this project.

2. **Maintenance of the Project, Post-Construction:** At present, the project does not appear

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to indicate exactly who would be responsible for maintenance of the levee system and storm gate post-construction. Some mention was made of the system being run by the State of New Jersey, the County of Middlesex or possibility the municipalities of South River and Sayreville. This is an important detail which should be worked out before construction begins. Funding for maintenance and operations is better organized at a federal or state level.

3. **Land Usage:** In this preliminary study, it appears as though the actual ramifications on land usage and zoning in Sayreville have not yet been determined. A more detailed and factual report of which areas of land will be affected, i.e., houses which must be condemned, new land which may become available, and new flood risk status for existing land is a vital component of the next phase of study.

These comments represent components which should be included in the next phase of the storm plan. The plan should pass on to the next phase, but before advancing further than that, should include these suggestions.

Thank you for educating us on the specifics of this project and for the opportunity to submit comments on this proposal. If you have any questions, or I can be of assistance in this or any matter, please do not hesitate to contact me.

Very truly yours,

John S. Wisniewski
Assemblyman, 19th District

JSW:cm

cc: Congressman Frank Pallone
Mayor O'Brien and Members of the Sayreville Borough Council

Carol Kadi
27 Major Dr.
Sayreville, NJ 08872
732-257-8854

Mr. & Mrs. Joe Kloc
6 John St.
Old Bridge, NJ 08857
732-254-6959

Alfred & Frances Singer
28 Weber Ave.
Sayreville, NJ 08872
732-254-4524

Elaine Konopka
97 Weber Ave.
Sayreville, NJ 08872
732-257-3634

Joe Nawalany
127 MacArthur Ave.
Sayreville, NJ 08872
732-238-4882

Edna Cornell
9 Pulaski Ave.
Sayreville, NJ 08872
732-254-3601

Kathleen Makowski
52 Creamer Dr.
Sayreville, NJ 08872
732-651-0740

Donna Nawalany
127 MacArthur Ave.
Sayreville, NJ 08872
732-254-0592

Ed & Arlene Strek
58 Nickel Ave.
Sayreville, NJ 08872
732-238-2052

Della Oshiro
11 Ciecko Ct.
Sayreville, NJ 08872
732-238-9243

Frank Olchaskey
54 Weber Ave.
Sayreville, NJ 08872
732-254-5980

Ken Piscitelli
9 Canal St.
Sayreville, NJ 08872

Kamal Malak
130 Weber Ave.
Sayreville, NJ 08872
732-390-4539

Joanne Martino
97 Weber Ave.
Sayreville, NJ 08872
732-257-3634

Theresa Strek
140 McCutcheon Ave.
Sayreville, NJ 08872
732-257-4362

Eleanor Eppinger
6 Grand Ave.
South River, NJ 08882
732-257-7521

John Straczynski
188 Main St.
Sayreville, NJ 08872
732-254-1673

Zigmunt Dombrowski
32 Weber Ave.
Sayreville, NJ 08872
732-254-1934

Jay Cornell
31 Tyska Ave.
Sayreville, NJ 08872
732-727-8000

MaryAnn Oleskin
13 Ciecko Ct.
Sayreville, NJ 08872
732-238-5990

Joseph Tirelli
249 - 9th Street
Sayreville, NJ 08872
732-727-3766

Phyllis Batko
5 Glynn Ct.
Parlin, NJ 08859
732-257-5668

John Felek
12 River Rd.
East Brunswick, NJ 08816
732-254-0548

Rosalind McBride
48 Richards Dr.
Parlin, NJ 08859

Alexander Go
10 Anderson Ct.
Sayreville, NJ 08872

Joan Szarejko
74 Weber Ave.
Sayreville, NJ 08872
732-257-1978

M. Zollinger
80 Weber Ave.
Sayreville, NJ 08872
732-257-7990

Stanley Golembieski
151 Boehmhurst Ave.
Sayreville, NJ 08872
732-254-5526

Caryn Muskees
4 Karwatt Ct.
Sayreville, NJ 08872
732-721-8319

Ellen Bednarz
85 Weber Ave.
Sayreville, NJ 08872
732-238-7882

John Tracy
113 Weber Ave.
Sayreville, NJ 08872

Roeshler Family
1 Jernee Mill Rd.
Sayreville, NJ 08872
732-254-1176

Alex Previdi
167 Main St.
Sayreville, NJ 08872

Local Officials

Mayor Kennedy O'Brien
Council President Frank Makransky
Councilman Thomas V. Pollando
Councilperson Phyllis Batko
Councilman Vincent Zacaro, Jr.
Councilman Thomas Marcinczyk
Zoning Board Member Donald Newton

Comment Letters Received on the Draft Integrated Feasibility Report and Environmental Impact Statement (Report).

Environmental Groups:

NY/NJ Baykeeper

Edison Wetlands Association, Inc.

District response to NY/NJ Baykeeper:

District response to Baykeeper comment #1: in Section 7.1.6.2, the Report does note that the selected hurricane and storm damage reduction measures would temporarily or permanently affect birds in the study area. The District is cognizant of the area's value to a wide variety of avian species, made every effort during the planning stages to avoid and minimize the impacts of the hurricane and storm damage reduction measures (*e.g.*, altering the path of part of the west bank levee system to avoid an existing owl nest), and designed a mitigation plan based on the technique of Habitat Evaluation Procedures (HEP) to specifically compensate for estimated impacts. As the District finalizes its construction schedule and order of implementation, it will continue to carefully evaluate how best to minimize unavoidable adverse impacts resulting from construction activities, taking into account breeding seasons, migration patterns, and critical habitat areas.

District response to Baykeeper comment #2: the hurricane and storm damage reduction and ecosystem restoration project was not designed to improve and increase the amount of habitat for anadromous fish species. The hurricane and storm damage reduction measures were designed to protect the area from tidal flooding and the ecosystem restoration measures were designed to improve biodiversity and increase ecological functioning. Implementation of the overall project will cause temporary, localized negative impacts to fish in association with construction activities, but the overall effect of the project will be to increase tidal creek, mud flat, and salt marsh habitat – areas heavily used by anadromous fish for spawning, refugia, and forage.

District response to Baykeeper comment #3: the impacts to wetlands from the hurricane and storm damage reduction measures will be fully mitigated, as described in the Report. The ecosystem restoration measures will restore hundreds of acres of wetlands. The District has budgeted funds for use in the next and final planning and design phase to fully assess the effects on wetland hydrology and functioning of regular, periodic closing of the stormgate. A hydrodynamic model will be used to model the effects and develop any resulting design changes.

District response to Baykeeper comment #4: visual impacts associated with the levee and floodwall will be minimized to the maximum extent possible without interfering with the overall integrity of their form and function. Specifically, the landward side of the levee will be planted with shrubs and native grasses in order to create a more visually appealing area and to improve the diversity and abundance o f bird and mammal species. Similarly, the 20-foot retention ditch located on the landward side of the floodwall will function as an emergent wetland area and will support a variety of wetland plants and animals.

Public access to the river will only be restricted during construction activities. Once construction is complete, the public will be able to use easily and safely access the waterfront. In addition there will be additional recreational opportunity such as walking, running, or biking along the top of the levee.

District response to Baykeeper comment #5: The District greatly appreciates the support of Baykeeper for the ecosystem restoration component of the South River project and plans to work closely with all interested parties in ensuring the success of the restoration. However, in regards to your recommendation of land acquisition as part of a proactive conservation strategy, the Corps authority for ecosystem restoration does not extend to acquiring lands to preclude development. The State of New Jersey, as non-Federal Sponsor, will be responsible to provide the South River project with all the lands, easements, rights-of-way, relocations and disposal areas that the District determines is necessary for the construction, operation, maintenance, repair and (if necessary) rehabilitation of the project. In determining what lands are so required, the District can only consider those lands that are, in fact, necessary for the purposes set forth above. The project's current Real Estate Plan calls for the acquisition of permanent Levee easements for the right-of-way for the levee/floodwall system (with temporary work area easements of 18 months' duration immediately adjacent thereto to facilitate construction) and acquisition of fee simple interest (outright purchase) for the 11acres of environmental mitigation between the levee and the Washington Canal in Sayreville, as well as the approximately 400 acres of ecosystem restoration areas in Sayreville and the approximately 60 acres of ecosystem restoration area in South River. In accordance with Public Law 91-646 (as amended), all affected landowners, whether private or public, will receive just compensation that is no less than the appraised fair market value of the interest(s) acquired from them.

While it may be desirable from an overall environmental point of view for the State of New Jersey or another public or quasi-public entity to obtain, for example, all the lands (both wetlands and uplands) between the levee/floodwall alignment and the Washington Canal in Sayreville, only the land discussed above has been determined to be required for this project. We respectfully suggest to Baykeeper that it follow up its concerns (regarding acquisition of real property or interests in real property outside the South River project limits) directly with the NJDEP and/or Middlesex County and/or the Borough of Sayreville and the Sayreville Economic Development Corporation.

District response to Baykeeper comment #6: The District will examine closely the monitoring protocol developed by the New York/New Jersey Harbor Estuary Program before the District's monitoring plan is finalized in the next study phase, prior to completion of plans and specifications. The District appreciates Baykeeper's supplying of the information, and will investigate the possibility of expanding the monitoring period. Corps guidance currently limits cost-shared monitoring to five years after construction, but the Corps is pursuing other avenues to extend the monitoring period (*e.g.*, academic institutions, non-governmental organizations, etc.).

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Building 18, Sandy Hook • Highlands, New Jersey 07732 • Tel: (732) 291-0176 • Fax (732) 291-7727
www.nynjbaykeeper.org • email: nynjbay@keeper.org

August 5, 2002

VIA FACSIMILE AND U.S. MAIL
Mark Burlas
U.S. Army Corps of Engineers
26 Federal Plaza
New York, New York 10278-0090

RE: South River, Raritan River Basin, Hurricane & Storm Damage Reduction and Ecosystem Restoration Project

Dear Mr. Burlas:

Please accept the following comments on the above-captioned restoration project from the NY/NJ Baykeeper. The Baykeeper is an organization with a mission to protect the environmental resources of the Hudson Raritan Estuary.

Hurricane and Storm Damage Reduction Plan

As noted in the ecosystem restoration plan, "birds in the study area would be temporarily or permanently affected by implementation of the project." This is of particular concern given the fact that the project area contains breeding populations of the state threatened yellow-crowned night heron and habitat for several other threatened and endangered species including: Henslow's sparrow, pied-billed grebe, American bittern, black skimmer, northern harrier, black-crowned night heron, peregrine falcon and osprey, and is located along a major migratory bird flyway. To every extent practical, the Army Corp of Engineers (ACOE) and their consultant should make every effort to reduce impacts to the study area resulting from equipment use and storage. The ACOE should schedule construction around breeding seasons and migration. Whenever practical work crews should keep their distance from critical habitat areas

Although the project is designed to improve and increase the amount of habitat for anadromous fish species, we are concerned that the project, especially the proposed tidal barrier, will have substantial impacts to these species, specifically alewife, blueback herring and American shad which use the South River and its tributaries as spawning nursery and forage habitat. We are also concerned about the potential impacts to wetlands in the project area, including changes in wetlands hydrology resulting from the construction of a tidal barrier, pump, and levee system.

Baykeeper also requests the ACOE mitigate for the loss of both visual and physical access to the South River that will occur through the construction of the 21.5 foot levee and floodwall height.

Provisions should be made to ensure that waterfront public access sites are in place and easily accessible once the project is completed.

Ecosystem Restoration Plan

Baykeeper supports and praises the ACOE restoration plan in its creation of significant woodland habitat in addition to marshland. Wetland forests with mature canopies are critical to many wildlife species and are relatively rare in the South River area. Baykeeper supports the conversion of wetland phragmites areas to a variety of habitats including wetland forest, upland forests and mudflats, which ultimately increases the ecological benefits of the project. Baykeeper recommends that the ACOE work with the state Green Acres program and non-profit organizations to acquire all lands, both wetlands and uplands, within the flood levees and floodwalls as a critical proactive conservation strategy. This area should be permanently protected so as not to allow future development within these floodwater areas. The ACOE should be wary of restricting development in this area without adequately compensating landowners, as this may subject the ACOE to a "takings" claim. This is especially true in the uplands within the floodwall and levee areas. This may open up potential litigation by landowners substantially delaying the project.

Finally acquisition of these areas will permanently add critical upland habitat and therefore provide a greater buffer to the restoration/enhancement area. Baykeeper would like to work with the ACOE to develop an acquisition strategy for these properties.

Restoration Monitoring Plan

The ACOE proposes a five (5) year monitoring plan with monitoring of the restoration/enhancement areas every other year. It has been our experience with restoration projects that major changes usually take place after the first 5 years. Success or failure of the plantings cannot be measured adequately in the 5 year time period. Baykeeper recommends that the ACOE follow the monitoring protocol developed by the New York/New Jersey Harbor Estuary Program and continue the monitoring for an additional three to five years following the conclusion of the initial five-year monitoring period. (See attached NY/NJ HEP Salt Marsh Monitoring Protocol)

I look forward to working with you on this project. If you have any questions feel free to contact me at (732) 291-0176.

Sincerely,

Megan Callus

Megan Callus
Conservation Associate

I. Salt Marsh Monitoring Protocol

Draft of the Tidal Wetlands Restoration Recommended Monitoring Protocol

These guidelines were developed by Andrew Bergen, NYC Parks/Natural Resources Group (NRG), and revised by the NYS DOS Division of Coastal Resources, with input from the HEP Habitat Workgroup.

1. Principal Parties Involved

A. Responsible Party (RP): The party responsible for carrying out all mandated restoration requirements will be referred to as the Responsible Party (RP). Restoration activities include the development and implementation of a monitoring protocol to assess the progress of the ongoing restoration and to evaluate the success or failure of the restoration at the conclusion of the monitoring period (a period $\geq$ 5 years is recommended).

B. Designer: The Designer in the employ of the RP designs the restoration and, in collaboration with the Ecologist, integrates into the site plan all monitoring specifications, including:
a. Location of transects
b. Location of quadrats
c. Location of permanent photo points
d. Code for identifying all transects, quadrats, and photo points

C. Ecologist: The Ecologist in the employ of the RP assists the Designer in planning and implementing a site-specific monitoring protocol. In collaboration with the Designer, the Ecologist carries out all phases of the monitoring from the design through completion of the project. Should the site be part of Superfund or other mandated remediation, the monitoring plan must include appropriate assays assessing the reduction of those priority pollutants of concern.

D. Contractor: The Contractor(s) in the employ of the RP construct(s) the restoration and is (are) responsible, along with the Designer and Ecologist, for maintaining transects, quadrats, and permanent photo points for monitoring efforts. When a Contractor is not required for restoration, all site manipulation and maintenance activities are generally the responsibility of the RP.

E. Regulator: The Regulator(s) in the employ of the city, state, or federal government is (are) responsible for approving restoration designs and monitoring protocols and for obtaining any required permits for restoration activities. The Regulator also determines when the restoration is complete by assessing all aspects of the project.

F. Volunteers: Volunteers may be involved in conducting monitoring activities. They may require training and are usually supervised by and/or report to the RP.

Note: The Designer and the Ecologist may be the same person, and this person may also be the RP. The RP is generally responsible for ensuring fulfillment of all monitoring requirements, including those of the

Designer, Ecologist, Contractor(s), and Volunteers as specified in the work plan, and is responsible for reporting as specified to the Regulator(s) when applicable.

2. Purpose of Monitoring

The purpose of monitoring is to assess the success or failure of the salt marsh restoration. Success is defined as the establishment of the desired salt marsh habitat.

A. Salt marsh habitat is defined by accepted standards of salt marsh function:
  a. Primary productivity
  b. Vegetation development
  c. Soil properties
  d. Colonization by benthic invertebrates
  e. Utilization by macrofauna

B. Five years of monitoring is the minimum required to determine the above functional standards and maintain the site in case of damage by geese, wrack, ice, and debris.

3. Monitoring Protocol Design

It is recommended that all salt marsh restoration project transects, 1.0 m^2 quadrats, and fixed-point photo stations be planned and located according to the guidelines described below. A comprehensive work plan should always be written by the RP for any restoration project undertaken, including any site-specific modifications to the recommended monitoring protocol, where necessary and appropriate. All monitoring parameters and activities, whether the recommended protocol below or some other appropriate protocol, should be clearly articulated and documented in the comprehensive work plan in a manner similar to, and at a level of detail equal to, the guidelines below. All transects, 1.0 m^2 quadrats, and fixed-point photo stations should be assigned location codes, and this information should be documented on the official site map and in the work plan for the restoration project.

All monitoring, except where noted below, should be conducted at the restoration project site and at an appropriate reference site. This reference site will consist of, at a minimum, ***a single control transect (including 3 quadrats)***, and must be located contiguous with or nearby the restoration site, and similar in morphology and vegetation zones (*i.e.*, compare restored high marsh with nearby unrestored "natural" high marsh; restored low marsh creek bank with nearby unrestored "natural" low marsh creek bank). An additional requirement of the reference site is that all major vegetation zones of the restoration site must be matched at the reference site. Therefore, additional transects at the reference site may be needed to provide control data for all applicable vegetation zones or morphological features.

The purpose of the reference site is to help discern background environmental effects from the effects attributable to the restoration project. For example, vegetation parameters at a restoration site must be compared with the same parameters at a nearby reference site to determine whether an observed loss of vegetation is a restoration failure or is the result of a natural event, such as a hurricane or winter storm that has similarly affected all the marshes in the area.

Salt Marsh Monitoring Protocol

A. Transects: *A minimum of 3 transects*, evenly spaced across the site, should be used for all restoration projects. For large sites, transects should be evenly spaced, and although an absolute minimum of three transects is required, a larger number of transects is recommended based on the acreage to be covered and the number and type of vegetation zones present. Transects should run perpendicular to the main channel and/or parallel with the elevation gradient, across the restoration site approximately from the seaward edge of the *Spartina alterniflora* zone (*i.e.*, encompassing traditional areas of occurrence for *Geukensia demissa* and/or *Fucus spp.*) to the mean high water mark. Transect locations should be permanently marked at the upland and seaward ends using stakes that are sturdy and will be easily located.

During monitoring visits, a tape measure should be used to mark the transect line, starting at the upland end. Hook the tape measure onto the upland stake and walk toward the seaward transect end. To minimize trampling of the site, do not walk directly to the seaward transect end. Rather, walk diagonally from the upland marker toward some point a short distance away from the actual seaward marker, but in line with the marker, to either the right or left. When you are in line with the seaward marker, walk to it and wrap the measuring tape around the stake, making sure it is taut. This forms a transect line between the upland and seaward stakes. This procedure should be repeated for all pairs of upland/seaward transect ends at the restoration site.

Noteworthy features occurring along each transect should be recorded relative to the distance marked on the tape measure. It is imperative that a notation be made stating that the upland marker is being used as zero distance, and that the same end be consistently used as zero distance for all transect monitoring at a restoration site.

B. Quadrats: Quadrats (1.0 m^2) should be placed along the transects at a *minimum of three different elevations* (*i.e.*, a minimum of three quadrats) between the seaward edge of the *Spartina alterniflora* zone and the mean high water mark, including, as applicable, all vegetation zones present. Within a single vegetation zone (*e.g.*, low marsh *Spartina alterniflora* zone), quadrats must be located *at least 3.0 meters apart* along the length of the transect. Quadrats will be placed randomly anywhere within an area 2.0 meters to either side of the measuring tape transect line. A stake, bar, length of PVC pipe, or other item 4.0 meters in length, carried or placed on the ground with 2.0 meters length extending on either side of the centerline, can be used to demarcate this area during monitoring visits. Placement of quadrats can be accomplished by walking in a zigzag pattern back and forth across the demarcated area along the entire length of the transect line, dropping quadrats randomly (with the exception of deliberate inclusion of all vegetation zones present and/or deliberate placement of quadrats >3.0 meters apart within a single vegetation zone). After placement, the location of quadrats in terms of the distance marked on the tape measure where they were placed should be recorded, *e.g.*, distance from zero of the upper corner and distance from zero of the lower corner of the quadrat (such as: 4.3m - 5.3m). This should be done for all quadrats along all transects at the restoration site.

C. Permanent Fixed-Point Photo Stations: The permanent transect marker stakes (seaward end and upland end) should also be used as permanent photo stations for photographic monitoring. Photographs should be taken facing the seaward transect marker from the upland transect marker and facing the upland transect marker from the seaward marker. This should be done for all pairs of transect ends at the restoration site. Also, a location that provides an overview photograph or photographs of the entire restoration site should be identified and consistently used for the duration of photomonitoring. All photographs should be taken at low tide (avoiding spring tide and full moon periods) and should be labeled with the location code, direction of view, date, time, and tide, if ambiguous. All photographs should be in the form of prints no smaller than 4" x 6" and must be in color.

D. Video Monitoring: Use of video monitoring is encouraged to supplement photomonitoring and provide additional qualitative information that cannot be provided by standard photographs. This includes close-up images of vegetation, benthic epifauna, and substrates. Panoramic filming of the site is also encouraged. The restoration site should be walked by the video monitor, using the transect lines as guides. Cards may be filmed, or voice may be used, to give the required information, such as location code, date, time of day, direction of view, and tide. At each transect end, the location code and direction of view should be identified. Close-up views should be filmed of all vegetation zones occurring along the transects.

4. Pre-Restoration Monitoring Activities

On sites where *planting is planned*, a complete set of color photographs should be taken, including all permanent fixed-point stations (transect ends and elevated overview), upon completion of the design phase and prior to any construction activities. Photographs should also be taken at the reference site.

On sites where some marsh habitat already exists, (*e.g.*, formerly connected marshes, grid ditched marshes) and *no planting is planned*, all parameters described below under ***Post-Manipulation Monitoring: Annual for Five Years*** should be monitored once prior to the restoration at both the restoration site and the reference site. At a minimum, all parameters should be monitored once during the last week of August prior to the restoration. May and/or December parameters specified below can be included in the pre-restoration monitoring during the year prior to the restoration at the discretion of the RP or other overseeing entity.

5. Post-Manipulation Monitoring: Four to Five Weeks Post-Planting/Manipulation

A. The restoration site should be walked by the RP, the Ecologist, and/or the Regulator(s) four to five weeks post-planting/manipulation to assess compliance with submitted work plans.

B. Permanent fixed-point photo stations: A set of color photographs should be taken at this time at all permanent fixed-point photo stations articulated above, for the restoration site and the reference site. All photographs should be taken at low tide (avoiding spring tide and full moon periods) and should be labeled with the location code, direction of view, date, time, and tide, if ambiguous. All photographs should be in the form of prints no smaller than 4" x 6" and must be in color.

C. The Regulator(s), the RP, or some other overseeing entity should determine, based on the four to five week post-manipulation assessment, whether any additional work is required to achieve work plan compliance.

6. Post-Manipulation Monitoring: Annual for Five Years

A.Vegetation: The vegetation parameters found below should be monitored for the restored, reference, and existing vegetation at the site. Parameters should be monitored once annually in the last week of August or first three weeks of September. All quadrats should also be assessed once before planting. All results should be submitted to the Regulator.

- a. **Percent cover:** Percent coverage of each m^2 quadrat is assessed annually. Each m^2 quadrat is scored from 0 - 1.0 by assessing visually the percentage of the m^2 quadrat covered by the basal and areal portions of vegetation.
- b. **Stem density/m^2 quadrats:** Vigor of individual quadrats is measured at the various elevations monitored. All stems in each m^2 quadrat are counted annually. Stems identified as late summer cohorts and dead are not counted.
- c. **Flower density/m^2 quadrat:** Vigor and potential of seed to act as a colonizer of marsh beyond the extent of the restoration site is measured. All flowers in each m^2 quadrat are counted annually.
- d. **Plant height:** Heights of six plants are measured in cm within each m^2 quadrat. Plants from each corner of the quadrat and from two points in the center of each quadrat are randomly selected and measured annually.
- e. **Basal area of plants:** Vigor of the individual plants in the first two years after planting is measured. The cross section of the base of six plants in each m^2 quadrat should be measured in cm annually.
- f. **Rhizome spread of plants:** Lateral, rhizomonous spread of individual plants in the first two years after planting is measured. Emergent rhizomes are measured in cm from the parent plants in each m^2 quadrat annually.
- g. **Signs of disease or pests:** Disease and pests, such as rust or goose or muskrat predation, should be assessed and recorded for each m^2 quadrat.
- h. **Vegetation Zones:** Walk along the measuring tape that demarcates the transect line, starting at the seaward transect end, noting the distance marked on the tape at the transition between vegetation zones and the dominant species composition of these zones.

B. Fixed-Point Photo Stations: Color photographs should be taken from all designated locations once annually for 5 years at the time of vegetation monitoring, for both the restoration site and the reference site. The permanent transect marker stakes (seaward end and upland end) should be used as photo stations for the photographic monitoring. Photographs should be taken facing the seaward marker from the upland marker, and facing the upland marker from the seaward marker. This should be done for all pairs of transect ends at the restoration site. Also, an overview photograph or photographs of the entire restoration site should be consistently used in all photomonitoring. Photographs should be taken at low tide (avoid spring tide and full moon periods) and should be labeled with the location code, direction of view, date, time, and tide condition. All photographs should be in the form of prints no smaller than 4" x 6" and must be in color.

Video monitoring, if used, should also occur at the time of vegetation monitoring, annually for 5 years.

C. Soil Properties: The following parameters should be monitored once annually for 5 years, at the time of vegetation monitoring (during the last week of August or the first three weeks of September, at low tide, avoiding spring tide and full moon periods). All soil property parameters should be measured twice in all quadrats placed along the transect line.

a. Soil organic matter: Sediment cores (2 per quadrat) should be sampled to 10 cm depth using a cylindrical push corer ~5 cm in diameter. Soil organic matter from marsh substrates may be measured by loss on combustion. Samples for this procedure are dried, weighed, combusted at 500 degrees Celsius for ~8 hours, and weighed again.

b. Soil salinity: The salinity of the soil may be determined in the field using a refractometer. Pore water from a small soil sample is squeezed onto the lens of the refractometer, and the resulting salinity reading is recorded as "soil salinity." Pore waters with high concentrations of suspended solids may require rudimentary filtration in the field. In these cases, squeeze pore water through filter paper before testing.

D. Benthic Invertebrates: The parameters below should be monitored in all m^2 quadrats for 5 years annually for the restored, reference, and existing vegetation at the site. All quadrats should also be assessed once before planting. All results should be submitted to the Regulator(s).

a. Ribbed mussels: All live and dead ribbed mussels (*Geukensia demissa*) should be counted in each m^2 quadrat. Six mussels (or fewer, as appropriate) should be measured lengthwise in each m^2 quadrat. March is the best time of year to find and measure ribbed mussels.

b. Fiddler crab burrows: All fiddler crab (*Uca spp.*) burrows should be counted in each m^2 quadrat. The presence of live fiddler crabs should also be recorded, where applicable. March is the best time of year to assess fiddler crab burrows.

c. Other benthic invertebrates: The presence of additional species observed *(e.g., Melampus bidentata)* and the number of individuals (when practical) should be recorded both within quadrats and along the length of the transect line.

E. Macrofauna: The parameters below (except ***Other Macrofauna***) should be monitored for the restored sites *once monthly in May and August* for 5 years. *Monitoring of bird species will not generally be required for the reference site*, unless the specific goals of the restoration project target these parameters. In this case, at minimum, the monitoring protocol below should be conducted at both the reference site and the restored site. The RP or some other overseeing entity may design additional monitoring plans for bird species.

Birds should be observed from an obscured location on the upland side of the restoration site, unless site-specific characteristics require otherwise. Where this is the case, a location should be identified that will minimize disturbance to bird species at the site when the monitor approaches. In every case, the location must be documented, assigned a location code, and must be accessible in future monitors. During bird observation, the monitor should record sightings as described below for a 1-2 hour period between low and mid-tide. Time of day and tidal condition must be recorded on all observation sheets, as well as the location code and direction of view from the chosen viewing station.

a. **Saltwater-fish-feeding birds:** Presence, duration of stay, general location, and activity should be recorded for wading birds, *e.g.*, great egret (*Ardea alba*), snowy egret (*Egretta thula*), tricolor heron (*Egretta tricolor*), black-crowned night heron (*Nycticorax nycticorax*), and other appropriate species, if observed.

b. **Benthic-invertebrate-feeding birds:** Presence, general location, duration of stay, and activity should be recorded for wading birds, *e.g.*, little blue heron (*Egretta caerulea*), yellow-crowned night heron (*Nyctanassa violacea*), and other appropriate species, if observed.

c. **Winter waterfowl:** If resources are available and the goals of the restoration are compatible, waterfowl species can be monitored ***once annually in December.*** Species, abundance, general location, activities, and duration of stay should be recorded.

d. **Other bird species:** Sightings of additional birds should be recorded, including species, abundance, general activities, location, and duration of stay.

e. **Other macrofauna:** The presence of, or reasonable evidence of the presence of, any other macrofauna (small mammals, horseshoe crabs, terrapin) at the site, observed ***during any site visit,*** should be recorded.

7. Monitoring Report Requirements

Annual monitoring reports should be written and submitted to the Regulator(s), when applicable, and/or some other pre-designated central repository, beginning after the first post-planting or post-manipulation growing season. All data and photographs, labeled as described above, should be included, as well as a brief summary of the collected data. All length measurements should be reported using the metric system.

8. Recommended Monitoring After Five Years

It is recommended that photomonitoring for all restoration sites continue for an additional three to five years following the conclusion of the initial five-year monitoring period. Photomonitoring during years five to ten should occur at a minimum of once annually during the last week of August or the first three weeks of September, and consist of the same site overview and photographs as described above at all of the same permanent transect photo stations used during the initial monitoring period. The additional three to five years of photomonitoring records should be labeled, stored, and distributed in the same manner as during the initial five-year monitoring period.

District response to Edison Wetlands Association, Inc.:

District response to Edison Wetlands Association, Inc. comment #1 – Land Acquisition: The State of New Jersey, as non-Federal Sponsor, will be responsible to provide the South River project with all the lands, easements, rights-of-way, relocations and disposal areas that the District determines is necessary for the construction, operation, maintenance, repair and (if necessary) rehabilitation of the project. In determining what lands are so required, the District can only consider those lands that are, in fact, necessary for the purposes set forth above. The project's current Real Estate Plan calls for the acquisition of permanent Levee easements for the right-of-way for the levee/floodwall system (with temporary work area easements of 18 months' duration immediately adjacent thereto to facilitate construction) and acquisition of fee simple interest (outright purchase) for the 11acres of environmental mitigation between the levee and the Washington Canal in Sayreville, as well as the approximately 400 acres of ecosystem restoration areas in Sayreville and the approximately 60 acres of ecosystem restoration area in South River. In accordance with Public Law 91-646 (as amended), all affected landowners, whether private or public, will receive just compensation that is no less than the appraised fair market value of the interest(s) acquired from them.

In regards to the recommendation of land acquisition as part of a proactive conservation strategy, the Corps authority for ecosystem restoration does not extend to acquiring lands to preclude development. While it may be desirable from an overall environmental point of view for the State of New Jersey or another public or quasi-public entity to obtain, for example, all the lands (both wetlands and uplands) between the levee/floodwall alignment and the Washington Canal in Sayreville, only the land discussed above has been determined to be required for this project. We respectfully suggest to Edison Wetlands Association, Inc. that it follow up its concerns (regarding acquisition of real property or interests in real property outside the South River project limits) directly with the NJDEP and/or Middlesex County and/or the Borough of Sayreville and the Sayreville Economic Development Corporation.

District response to Edison Wetlands Association, Inc. comment #2 – Site Characterization: Concur.

District response to Edison Wetlands Association, Inc. comment #3 – Design Implementation: The District is cognizant of the area's current value to a wide variety of plant and animal species, and will continue to make every effort – as design plans are finalized and construction schedule and logistics are determined – to reduce and minimize the impacts to the area from trucks and equipment during plan implementation. The District wholeheartedly agrees with Edison Wetland Association's assessment that certain impacts can be lessened through creative planning and close attention to unique, site-specific characteristics. The District appreciates and values Edison Wetland Association's recommendations; the District will take them into consideration as it determines how best to minimize unavoidable adverse impacts resulting from construction activities. As much as practicable, the District is committed to scheduling construction to avoid disrupting breeding seasons, migration patterns, and critical habitat areas.

District response to Edison Wetlands Association, Inc. comment #4 – Monitoring: The District recognizes that restoration projects can undergo significant alterations more than five years after construction is completed. Although the District is currently investigating the possibility of expanding the monitoring period, Corps guidance limits cost-shared monitoring to five years after construction. In other words, the use of monitoring in conjunction with adaptive management (*i.e.*, spending up to three percent of the total ecosystem restoration cost on major necessary changes in the field – for example, regarding, replanting, etc.) is limited to within the first five years, but the District is pursuing other avenues to extend an organized, comprehensive, non-cost-shared monitoring period (*e.g.*, collaborating with academic institutions, non-governmental organizations, etc.).

Edison Wetla[illegible]ssociation, Inc.
4055 W[illegible] Avenue
Edison, New Je[illegible]08837-3308
Telephone 732-661-1660 FAX 732-661-9640
www.ediso[illegible]la[illegible]s.org • ra[illegible]an1@aol.com
A 5[illegible]ion

August 5, 2002

VIA FACSIMILE AND U.S. MAIL
Mark Burlas
U.S. Army Corps of Engineers
26 Federal Plaza
New York, New York 10278-0090

RE: South River, Raritan River Basin, Hurricane & Storm Damage Reduction and Ecosystem Restoration Project

Dear Mr. Burlas:

I am writing to submit my comments regarding the South River Flood Control Project. I have divided them up in the 3 areas. They are as follows:

1. **Land Acquisition**
2. **Site characterization**
3. **Design Implementation**
4. **Monitoring**

<u>1. Land Acquisitions</u>:

The Army Corps of Engineers needs to acquire all lands either by direct purchase or by acquisition of easements that are within the flood levees and floodwalls. This includes the wetlands and upland areas. I suggest this for several reasons:

- If the Army Corps does not acquire these lands, the land owner may in the future try to develop them and in doing so put potential buyers in substantial and imminent risk and danger due to flood waters.
- By not allowing development of these areas and not compensating landowners amounts to a taking of land by the ACOE. This is especially true in the uplands within the floodwall and levee areas. This may open up potential litigation by landowners substantially delaying the project.
- By acquiring the property or easements, the ACOE will ensure that the flood control project will not have to be modified by future development within the flood hazard areas.
- Acquisition of these areas will permanently add critical upland habitat to the restoration/enhancement area.

Preservation of these lands or purchase of the easements can be done through several mechanisms:

- The Army Corps of Engineers can directly negotiate with landowners and offer them fair market value for the purchase of the land or easements.
- The ACOE, South River Township, NJ DEP Green Acres Program and other non-profits such as the NY/ NJ Baykeeper can work together to develop an acquisition strategy for the properties.
- The Army Corps can partner with a land conservancy or other non-profit organization such as the NY/NJ Baykeepers and utilize their expertise with land acquisition and preservation.

2. Site Characterization:

The EPA has identified impacts to the study area from Kin-Buc Landfill Superfund Site[1]. Since the Raritan River is impacted from hundreds of industrial sites, formerly used defense sites, old landfills and other contaminated areas, its is reasonable to assume that the area identified by the ACOE for restoration and enhancement may also have been impacted. Additionally, there may be containers of chemicals in the study area as result of Hurricane Floyd. Thousands of drums, pails and containers were recovered from the Raritan River and its tributaries as result of that storm. EWA and the Raritan River Keeper have found drums after the cleanup operation was halted and the possibility exists that more may be located in remote places in the study area.

The severity of the impacts cannot be quantified at this time. Detailed laboratory analysis of sediments for pollutants need to be conducted by the Army Corps of Engineers for several reasons. Potential chemical contamination of the restoration/enhancement area might:

- Pose a risk to ACOE personal and their contractors who will be working in the area and require personal protective equipment (PPE) to be worn.
- Impact the success of plantings in the restoration/enhancements areas.
- Resuspend contaminants during excavation of sediments especially in mud flats.
- Pose a risk to the community by volatilizing contaminants during site work.

The Army Corps of Engineers must conduct a Preliminary Assessment (PA) of the study area and a more detailed Phase II to either confirm the presents or absence of chemical contamination.

3. Design Implementation:

The ACOE must pay special attention to design planning and implementation. To the extent practical, the ACOE and their consultants should make every effort to reduce impacts to the study area from trucks, equipment and work scheduling. It has been the Edison Wetlands Associations experience that some impacts can be mitigated through creative planning and

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[1] See Record of Decision, Kin-Buc Landfill, Operable Unit 2, 09/28/92

attention to the unique variations that are inherent in all sensitive ecological areas. Some ideas the ACOE should consider are the following:

- Access roads should, where practical, be put in the same areas where the levees are to be constructed. The work could begin at the farthest areas and could work backwards minimizing the need to bring in addition fill or road stabilization.
- Turnarounds in the work areas should be kept to a minimum as they increase surface cover areas in the work area.
- Work should be done at times that will not interrupt bird migration or during reproductive cycles.
- Whenever practical work crews should keep their distance from critical habitat that already exists in the area.

4.Monitoring:

The ACOE proposes a five (5) year monitoring plan with monitoring of the restoration/enhancement areas every other year. It has been the EWA's experience with restoration/enhancement projects that major changes usually take place after the first 5 years. Success or failure of the plantings cannot be measured adequately in the 5 year time period. The EWA recommends that the ACOE extend the monitoring period to include monitoring in years seven (7) and nine (9).

These are the four (4) areas where I see deficiencies in the proposed plan. I would appreciate the ACOE consideration of the concerns and ideas I have raised. If you have any questions or need clarification of the above items, please feel free top contact me.

I look forward to working in the spirit of cooperation to the extent possible with ACOE on this project. I see many potential benefits that this plan can bring to the South River and the Raritan River provided the ACOE work with the stakeholders on the Raritan River/South River on the planning and implementation of the proposal.

Sincerely,

Robert Spiegel

Robert Spiegel
Executive Director

Cc: Congressman Frank Pallone
Brad Campbell, NJ DEP Commisioner
William Schultz, Raritan River Keeper
Andrew Willner, NY/NJ Baykeeper

Comment Letters Received on the Draft Integrated Feasibility Report and Environmental Impact Statement (Report).

Private Citizens:

Leslie Senko

Lucille Kloc

Ted Bochenski
Ashok Mantri

Michael P. Clancy

John Falzone

S. Meloni

Louis J. Luczu

Marilyn Meloni

Susan Luczu

David Hoover

Laurence F. Gates

District response to private citizens:

District response to Leslie Senko:

District response to comment #1: Ecological value for the ecosystem restoration portion of the project was assigned and computed for each habitat type (*e.g.*, *Phragmites australis*, low emergent marsh, open water, etc.) using the Habitat Evaluation Procedure (HEP), a well-established tool developed by the US Fish and Wildlife Service for assessing habitat value. The choice of certain species to use in HEP models – in this case American black duck, clapper rail, marsh wren, yellow warbler, eastern cottontail and American woodcock – should not be construed as evidence that the ecological benefits calculated from the models are for those species exclusively. Rather, the different species are indicative of different guilds, and represent broad benefits that will accrue to all species that utilize that habitat. The Evaluation for Planned Wetlands technique, developed by Environmental Concern, Inc. in the early 1990s, was also used to quantify wetland functions and values.

District response to comment #2: Although clapper rail, marsh wren, and yellow warbler will all benefit from the ecosystem restoration component of the South River project, construction activities will entail adverse short-term disturbances. The District is cognizant of the area's value to a wide variety of avian species, made every effort during the planning stages to avoid and minimize the impacts of the hurricane and storm damage reduction measures (*e.g.*, altering the path of part of the west bank levee system to avoid an existing owl nest), and designed a mitigation plan based on the technique of Habitat Evaluation Procedures to specifically compensate for estimated impacts. As the District finalizes its construction schedule and order of implementation, it will continue to carefully evaluate how best to minimize unavoidable adverse impacts resulting from construction activities, taking into account breeding seasons, migration patterns, and critical habitat areas. Implementation of the overall project will cause temporary, localized negative impacts to shellfish and crabs in association with construction activities, but the overall effect of the project will be to increase tidal creek, mud flat, and salt marsh habitat – areas heavily used by such species for refuge and forage.

District response to comment #3: Although the water and soil salinities in the restoration areas are not high enough to guarantee successful conversion of *Phragmites australis* (*Phragmites*) to salt marsh habitat, there are several management strategies that have been used successfully for restoring or creating salt marsh habitat from *Phragmites*-dominated habitat. Some effective management strategies include reintroducing flooding and saline conditions by removing tidal restrictions, lowering the marsh surface, increasing tidal flushing, and establishing the proper slopes for salt marsh establishment. The aforementioned management strategies coupled with adaptive management strategies such as herbicide treatment and excavation to remove *Phragmites* culms should be sufficient to control and remove *Phragmites* from the restoration area. The herbicide Rodeo© is approved for use in aquatic environments and is widely used to control invasive plant species; it is a post-emergent, nonselective herbicide, containing the active ingredient isopropylamine salt of glyphosate (N-(phosphonomethyl) glycine).

The encroachment of invasive plant species have degraded and stressed plant communities in the Project area. As a result, natural brackish and salt marsh communities have been converted to monotypic stands of *Phragmites*, which do not support as diverse an assemblage of wildlife species. High value, ecologically vital salt marsh communities are therefore relatively rare in the vicinity of the Project area. The District has not finished construction on any tidal salt marsh restoration projects, so our success rate in this field remains to be determined. However, the Corps is both conducting research on and planning/implementing restoration projects around the country (see http://www.usace.army.mil and http://www.wes.army.mil/el/homepage).

District response to comment #4: The District apologized at the 19 July 2002 public meeting in South River for the lack of Reports available for public review at the designated libraries. The dearth of reports was unintentional, and is by no means indicative of the Corps commitment to public outreach and involvement. By the following week the District had placed copies of the Report in all designated local libraries. In order to compensate for this indefensible oversight, the District extended the formal comment period by 45 days, providing ample opportunity for the public to review the Report and submit comments.

District response to Lucille Kloc:

During the detailed evaluation of the storm surge barrier at the Bordentown Avenue Bridge, the Corps evaluated the potential effects of the water coming downstream from Duhernal Lake Dam. To be incorporated into this structure will be pumps and valves to carry the water through the barrier when it is closed. The condition of the river behind the barrier when closed during a storm event will lower water levels and provide benefits all the way to Duhernal Lake Dam then without the project.

Dredging of the river will not lower water levels alone without the barrier and is not cost effective with the gate in place. We will continue to evaluate this option with the State of New Jersey in the next phase to determine if the state is willing to contribute funding for this added cost if it is both beneficial and not harmful to the environment. The Corps can also investigate environmentally beneficial effects of dredging under its Hudson-Raritan Estuary study, if additional Federal funds are received.

District response to Ted Bochenski:

Thank you for your proposal of an elevated roadway to serve as a levee and alleviate traffic to Route 9N. Unfortunately, our study was for the limited purpose of reducing flood damage and the additional cost for providing it is not justified.

District response to Ashok Mantri:

The planning stage for the feasibility phase is scheduled to be over in the next month. The next phase is the Pre-Construction Engineering and Design (PED) Phase where the plans will be revised to a greater detail. At this time the levee heights are 21.5 NGVD (approx. 16 feet high in some places) and is located on the canal side of the paper street that exists there. (approx. 500 ft from homes)

District response to Michael P. Clancy:

Consideration was given to the storm water run-off from South River streets through the pump into the South River. Additional analysis in the next phase will look at this in greater detail to ensure interior flooding will be minimized to the extent possible.

District response to John Falzone:

You will be sent a copy of the final integrated feasibility report and environmental impact statement. There are no impacts to the causeeway in Sayreville.

District response to S. Meloni:

The Federal funding for the project is appropriated on a yearly basis.

District response to Louis Luczu:

Flooding along the South River downstream of Duhernal Lake is due to the tide. Dredging of the South River would not alleviate this situation. Analysis was done to determine pumps and openings that are needed to be in place when the tide gates are closed so water levels behind it do not induce flooding. In the next phase the project this will again be updated.

District response to Marilyn Meloni:

Ok.

District response to Susan Luczu:

Corps engineering analyses and hydrologic modeling have not indicated any increased risk to the Historic Village of Old Bridge as a result of the implementation of the hurricane and storm damage reduction measures.

District response to David Hoover:

Meeting held with Assemblyman on September 4th.

District response to Laurence F. Gates:

At this time the levee heights are 21.5 NGVD (approx. 16 ft high along Weber Avenue). In the next phase this height may be lowered due to a more detailed analysis. The levee is located along the canal side of the paper street in Sayreville behind Weber

Avenue (approx. 500 ft from homes). The house would be out of the 500-year floodplain.

Please fill out the comment card and leave in the box on the reception desk or mail in your comments

SOUTH RIVER, NEW JERSEY
HURRICANE AND STORM DAMAGE REDUCTION AND ECOSYSTEM RESTORATION STUDY
PUBLIC MEETING - COMMENT CARD

am (Please check one): __ Landowner __ Agency Representative __ Interest Group Member
__ Legislator X Concerned Citizen __ Recreational User

Name: Leslie Seako [illegible]
Address: 44 [illegible] Avenue SR [illegible]
E-mail address: ______
Affiliation: ______
Phone: 732-967-[illegible]
Yes, please add me to the mailing list x

Comment: Concerns: how value assigned : computed for acreage to Eco-Sys Res [illegible] [comment 1] disturbance to clapper rail, marsh wren yellow warbler - threat of permanent displacement of some species smothering of shellfish crabs etc. Rodeo herbicide (how choice made to "[illegible]" some species of birds over others as Eco-System modified [illegible] of feasibility if removing Phragmites document [illegible] rate for these types of Eco-System projects - understand [illegible] Fact [illegible] Report not available @ [illegible] [comment 2] [comment 1] [comment 3] [comment 4]

Please fill out the comment card and leave in the box on the reception desk or mail in your comments

SOUTH RIVER, NEW JERSEY
URRICANE AND STORM DAMAGE REDUCTION AND ECOSYSTEM RESTORATION STUDY
PUBLIC MEETING - COMMENT CARD

am (Please check one): X Landowner __ Agency Representative __ Interest Group Member
__ Legislator X Concerned Citizen __ Recreational User

Name: LUCILLE KLOC (MRS. JOSEPH) Affiliation: ______
Address: 6 JOHN STREET OLD BRIDGE, NJ Phone: 732-254-6959
E-mail address: LUKLOC @aol.com 08857 Yes, please add me to the mailing list X

Comment: LETTER ENCLOSED
OUR SMALL SECTION OF (SAYREVILLE + OLD BRIDGE AREA)
IS NOT WELL RECOGNIZED

SOME CONCERNED RESIDENTS OF THIS AREA ATTENDED
THE JULY 19, 2002 (AND OTHER MEETINGS REGARDING THIS
MATTER) A LETTER IS ENCLOSED ABOUT OUR
FEELINGS.

0278-0090
Biologist
gineers

July 23, 2002

Mark H Burlas, Project Biologist
U.S. Army Corps of Engineers
New York District
26 Federal Plaza
New York, New York 10278-0090

Dear Mark H Burlas, Project Biologist:

My neighbors, my husband and I attended the meeting at South River, NJ Knights of Columbus on July 19, 2002. So far, it has been the most productive and promising meeting in the many years of your program.

I enjoy the herons and other egrets and wildlife on the river, and I believe there are few people who have a love of the land and enjoy this more than I do. I am not protesting your willingness to preserve it. However, it was disheartening to learn that in your eyes, we, as humans, are less valuable or so it seemed by your presentation. I also understand that in order to get funding, the ecology aspect must be considered. I can live with that, but after so many years of seeing my neighbors being flooded because of a problem that seems to be so easily remedied, the political aspects are frustrating.

I say "easily remedied" because we live right on the South River's edge and in our 43 years here, we have never had flooding in our house. I attribute that to "good planning."

The "NOR-EASTER" of December 1992 was as close as we have ever been to getting water, so I am now worried that if your project is not well planned we, too, will become victims.

Our section, from the Bordentown Avenue Bridge to your proposed gates has become so shallow that I fear it will not hold the excess water from the upstream drainage without dredging. While your gates are designed to keep the ocean from coming in on us, the river continues to drain in that direction and when conditions are right, we will have flooding problems.

We have lost about 30 feet of our original property because of the meandering of the South River, so I am sure this pattern follows along its entire pathway. Please, in your studies, consider the prospect of dredging this section. The silt and debris are there and we are living with it. I am sure that moving it from the main channel of the river to the banks will not do any harm to the environment.

I am grateful that some effort is being made, and especially grateful for the effort of Peter Blum who seems to be so dedicated to this project.

Thank you for allowing me to express my opinion.

Sincerely,

Lucille Kloc (Mrs Joseph)

Lucille Kloc, (Mrs. Joseph)
6 John Street
Old Bridge, NJ 08857
732- 254-6959

c: Hon. Frank Pallone
Kennedy O Brien, Mayor, Sayreville
John Yocca, Home News Tribune
Tom Haydon, Star Ledger

145 Mac Arthur Ave.
Sayreville, NJ 08872
June 25, 2002

Dept. of the Army
New York District, Corps of Engineers
Jacob K. Javits Federal Building
New York, NY 10278-0090

Attn: Len Houston

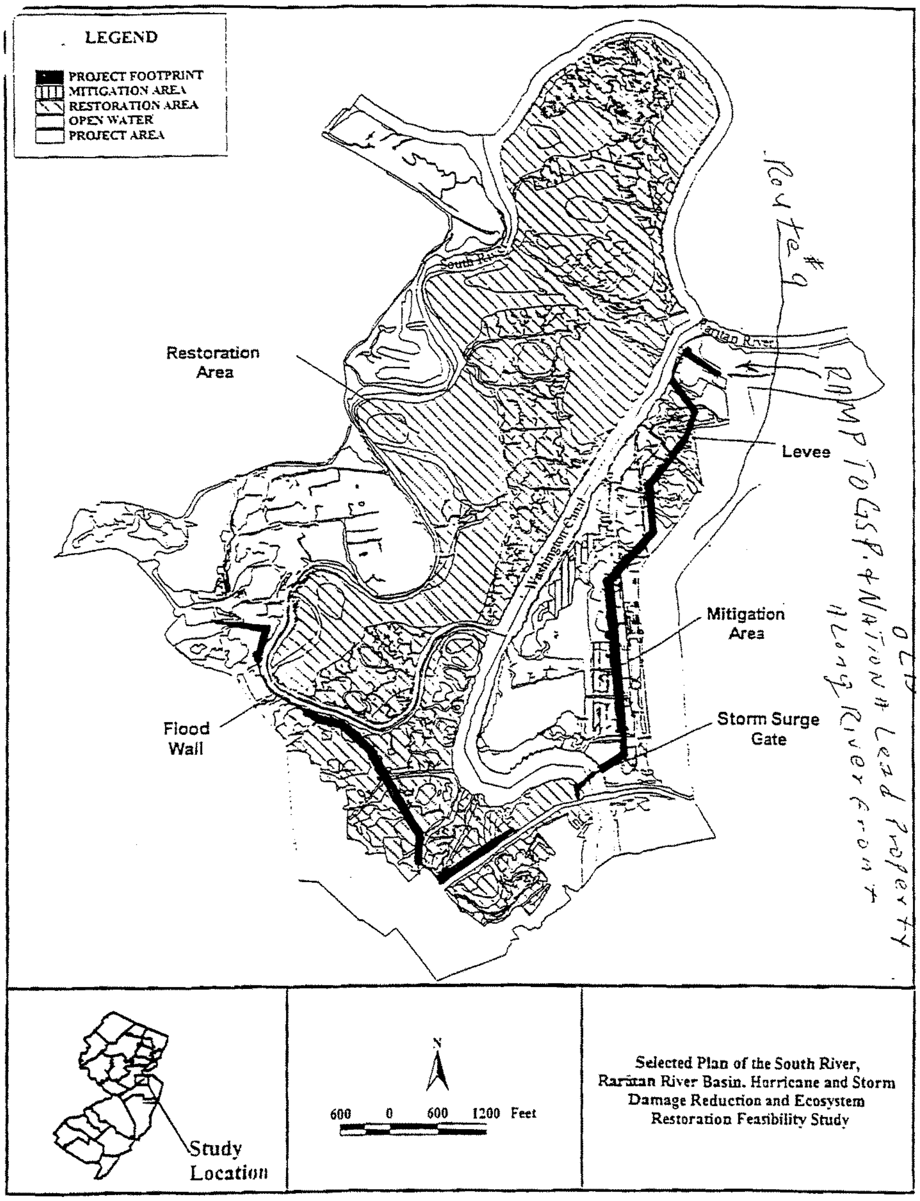
Dear Mr. Houston:

A golden opportunity to correct two problems at one time, presents itself here. If an elevated roadway is constructed along the bank of the river, it will serve as a levee and eleviate traffic in the area. It can run from Route 9 and continue under the Veteran's Bridge into Old Bridge (Bordentown Ave.). Another route between these areas is badly needed.

Thank you for taking the time to read my comments.

Yours truly,

Ted Bochenski



Selected Plan of the South River, Raritan River Basin, Hurricane and Storm Damage Reduction and Ecosystem Restoration Feasibility Study

Please fill out the comment card and leave in the box on the reception desk or mail in your comments

SOUTH RIVER, NEW JERSEY
HURRICANE AND STORM DAMAGE REDUCTION AND ECOSYSTEM RESTORATION STUDY
PUBLIC MEETING - COMMENT CARD

I am (Please check one): ✓ Landowner __ Agency Representative __ Interest Group Member
__ Legislator ✓ Concerned Citizen ✓ Recreational User

Name: LORETTA FETSKO Affiliation: Historic Village OB/EB
Address: 12 RIVER ROAD EB NJ 08816 Phone: 732-254-0548
E-mail address: BecauseHel@AOL.com Yes, please add me to the mailing list ____

Comment:

Please fill out the comment card and leave in the box on the reception desk or mail in your comments

SOUTH RIVER, NEW JERSEY
HURRICANE AND STORM DAMAGE REDUCTION AND ECOSYSTEM RESTORATION STUDY
PUBLIC MEETING - COMMENT CARD

I am (Please check one): ✓ Landowner __ Agency Representative __ Interest Group Member
__ Legislator __ Concerned Citizen __ Recreational User

Name: ASHOK MANTRI Affiliation:
Address: 78 Weber Ave Sayreville NJ Phone: 732 390 7328
E-mail address: Yes, please add me to the mailing list ✓

Comment: I would like to know TIME FRAME
After your planning stage is over
How long it takes number of years
to complete the project.
Is Fund is available ?
(2) My property is facing Washington
Canal Right on Weber Street
How far Levy is ? and how high ?

5-6-9 (3)

Please fill out the comment card and leave in the box on the reception desk or mail in your comments

SOUTH RIVER, NEW JERSEY
HURRICANE AND STORM DAMAGE REDUCTION AND ECOSYSTEM RESTORATION STUDY
PUBLIC MEETING - COMMENT CARD

I am (Please check one): X Landowner __ Agency Representative __ Interest Group Member
__ Legislator X Concerned Citizen __ Recreational User

Name: Michael P Clancy
Address: 43 Virginia St. South River
E-mail address:
Affiliation:
Phone:
Yes, please add me to the mailing list X

Comment: Consideration has to be given to storm water runoff from South River streets through pump houses into the South River. High tide directly impacts pumping capabilities, and if the river levels stay high, flooding will occur throughout the town, not along the River. Adjustments to riverfront pump houses must be considered.
- Speakers were well spoken, and prepared to handle the many questions directed at them.
- Cost of project is too expensive (municipal share) for the local towns.

Please fill out the comment card and leave in the box on the reception desk or mail in your comments

SOUTH RIVER, NEW JERSEY
HURRICANE AND STORM DAMAGE REDUCTION AND ECOSYSTEM RESTORATION STUDY
PUBLIC MEETING - COMMENT CARD

I am (Please check one): ✓ Landowner __ Agency Representative __ Interest Group Member
__ Legislator __ Concerned Citizen __ Recreational User

Name: JOHN FALZONE
Address: 114 CAUSEWAY ST. SO. RIVER
E-mail address: JOHN_FALZONE@HOTMAIL.COM
Affiliation:
Phone: 732-254-8513
Yes, please add me to the mailing list ✓

Comment: 1) CAN I GET COPY OF FEASABILITY REPORT
WHAT IS THE IMPACT OF THIS ON THE CAUSEWAY THAT RUNS PARALLEL TO THE VETERAN'S BRIDGE TO SAYREVILLE

Please fill out the comment card and leave in the box on the reception desk or mail in your comments

SOUTH RIVER, NEW JERSEY
HURRICANE AND STORM DAMAGE REDUCTION AND ECOSYSTEM RESTORATION STUDY
PUBLIC MEETING - COMMENT CARD

I am (Please check one): ✓ Landowner __ Agency Representative __ Interest Group Member
__ Legislator __ Concerned Citizen __ Recreational User

Name: S. Melini
Address: 53- Kamm Ave
E-mail address:
Affiliation:
Phone:
Yes, please add me to the mailing list X

Comment: Is the money in place for this project –

Please fill out the comment card and leave in the box on the reception desk or mail in your comments

SOUTH RIVER, NEW JERSEY
HURRICANE AND STORM DAMAGE REDUCTION AND ECOSYSTEM RESTORATION STUDY
PUBLIC MEETING - COMMENT CARD

I am (Please check one): ✓ Landowner __ Agency Representative __ Interest Group Member
__ Legislator __ Concerned Citizen __ Recreational User

Name: Louis J Luczu
Address: 42 River Road E.B. 08816
E-mail address: The.Magician@att.net
Affiliation: HVOBCG
Phone: 732 651 0267
Yes, please add me to the mailing list ____

Comment: Concerned about the South end of the South River flooding due to floodgates. At high tide the water comes up in our yard now. It will only get worse as there is practically NO Channel [illegible] the River End Marina!

Please fill out the comment card and leave in the box on the reception desk or mail in your comments

SOUTH RIVER, NEW JERSEY
HURRICANE AND STORM DAMAGE REDUCTION AND ECOSYSTEM RESTORATION STUDY
PUBLIC MEETING - COMMENT CARD

I am (Please check one): X Landowner __ Legislator __ Agency Representative X Concerned Citizen __ Interest Group Member __ Recreational User

Name: MARILYN MELONI
Affiliation: TAXPAYER
Address: 53 KAMM AVE SO RIVER N.J. 08882
Phone: 732-257-8958
E-mail address: ELBER53@AOL.COM
Yes, please add me to the mailing list Y

Comment: LONG OVERDUE!

Please fill out the comment card and leave in the box on the reception desk or mail in your comments

SOUTH RIVER, NEW JERSEY
HURRICANE AND STORM DAMAGE REDUCTION AND ECOSYSTEM RESTORATION STUDY
PUBLIC MEETING - COMMENT CARD

I am (Please check one): ✓ Landowner __ Legislator __ Agency Representative __ Concerned Citizen __ Interest Group Member __ Recreational User

Name: Susan Luczu
Affiliation: Historic Village of OB Community Group
Address: 42 RIVER RD EAST BRUNSWICK NJ 08816
Phone: 732-257-6424
E-mail address: SLUCZU@mycomcast.com
Yes, please add me to the mailing list ✓

Comment: As a homeowner on the River Bank in EAST BRUNSWICK we are concerned about the effect of any plans to construct Levees OR a flood gate system. We are looking for assurances that the Historic Village of OLD BRIDGE will not be [illegible] flooded, Damaged or otherwise effected as a result of this plan.

Please fill out the comment card and leave in the box on the reception desk or mail in your comments

SOUTH RIVER, NEW JERSEY
HURRICANE AND STORM DAMAGE REDUCTION AND ECOSYSTEM RESTORATION STUDY
PUBLIC MEETING - COMMENT CARD

I am (Please check one): __ Landowner __ Agency Representative __ Interest Group Member
✓ Legislator __ Concerned Citizen __ Recreational User

Name: David Hoover representative of
Address: 3145 Bordentown Ave
E-mail address: dhoover@ njleg.org
Affiliation:
Phone: 732 - 316 - 1885
Yes, please add me to the mailing list ✓

Comment: Assemblyman Wisniewski would request a town hall meeting in Sayreville for project

Please fill out the comment card and leave in the box on the reception desk or mail in your comments

SOUTH RIVER, NEW JERSEY
HURRICANE AND STORM DAMAGE REDUCTION AND ECOSYSTEM RESTORATION STUDY
PUBLIC MEETING - COMMENT CARD

I am (Please check one): ✓ Landowner __ Agency Representative __ Interest Group Member
__ Legislator __ Concerned Citizen __ Recreational User

Name: SHEILA M. SOWA
Address: 35 CHARLES ST. OLD BRIDGE NJ 08857
E-mail address: smsowa@aol.com
Affiliation:
Phone: 732-254-7610
Yes, please add me to the mailing list ✓

Comment:

Please fill out the comment card and leave in the box on the reception desk or mail in your comments

SOUTH RIVER, NEW JERSEY
HURRICANE AND STORM DAMAGE REDUCTION AND ECOSYSTEM RESTORATION STUDY
PUBLIC MEETING - COMMENT CARD

I am (Please check one): X Landowner __ Agency Representative __ Interest Group Member
__ Legislator __ Concerned Citizen __ Recreational User

Name: LAURENCE F. GATES Affiliation: ______
Address: 66 WEBER AVE SAYREVILLE NJ. Phone: 732-238-9027
E-mail address: laurence_gates@KinderMorgan.com Yes, please add me to the mailing list X

Comment:

① How High will Levee/Walls Be on Sayreville Side?
② How close will it be to Residential Prop. in Sayreville Along Weber Ave.?
③ Would House be out of Flood Plain?

Comment Letters Received on the Draft Integrated Feasibility Report and Environmental Impact Statement (Report).

Public Meeting:

Summary of public meeting questions and answers.

SUMMARY OF PUBLIC MEETING COMMENTS

HURRICANE AND STORM DAMAGE REDUCTION AND ECOSYSTEM RESTORATION STUDY SOUTH RIVER, NEW JERSEY

The following provides a summary of the public's questions and comments as well as the District's responses recorded during the public meeting held on July 19, 2002. Comments were obtained from a tape recording of the meeting and have been sorted into three sections: engineering design/planning, funding, and environmental issues. Portions of the tape were inaudible and, therefore, certain comments could not be transcribed.

ENVIRONMENTAL ISSUES

Question: How long will it be before marshlands revert back to pre-project cover types?
Response: *If we do it right they won't. That's the whole point of determining elevations between various cover types.*

Question: Can you define cover type?
Response: *Cover type and habitat are being used interchangeably. Cover type is simply habitat characterized by the vegetation within an area.*

Question: Are areas on the inside of the levee going to be subject to conservation easements?
Response: *Yes, restoration areas will have conservation easements, but areas that aren't mitigation areas on the inside of the levee will not. However, part of the process will be to acquire easements from landowners to avoid losing benefits and money associated with the project.*

Question: In your documentation in your report it indicates that there are a significant number of threatened or endangered species that use this area as breeding habitat. How will those species, as well as most other wildlife be impacted by the project?
Response: *I don't think we said there were any documented cases of endangered or threatened species using it as breeding habitat, but the way we are going to implement the project won't be enough to curtail their breeding efforts. We are not going to canvas the area with construction. Additionally, in obtaining our permits we will have to follow strict guidelines and make sure precautions are made to protect wildlife.*

Question: You talked about potential disturbances to historical sites, what do you mean by that?
Response: *The reason it is a potential disturbance is because structures are usually buried and you don't know where they are.*

Question: Did you bring copies of the report with you?

Response: *No, all you have to do is provide your name and address and it will be sent to you.*

Question: Can I get a copy of the real estate plan?
Response: *It is an appendix of the report and will be available in one of the municipal buildings or libraries.*

Question: Do Corps projects have to adhere to state regulations?
Response: *We meet all state permits.*

Comment: I don't think the presentation tells the people how the project is going to benefit them.
Response: *In other words, you want to know how it is going to alleviate the flood damages and how much less water you are going to get. I will try to explain those more general issues in the next few weeks.*

Comment: If you are going to come into the community and ask for feedback from the residents show us what you have done, what you have looked at, what you are recommending. The presentation of the study you are bringing to the public is not what the public has questions about.
Response: *We are trying to generate questions.*

Comment: The reports are not available at any of the libraries for public review and there was no one helpful at the number on your flyer. Make all reports available and not just the EIS and the feasibility reports.
Response: *We will get copies of the reports and appendices to the 3 libraries and the 3 municipal buildings.*

Comment: It seems like this is a statewide problem and instead of little groups of projects, the project should be in one area so that you can take the whole picture into consideration.

Comment: A lot of people are not interested in this project or affected by it because no one is here.

Comment: I want to say thank you for doing something.

Comment: I think this is a great plan.

Comment: I suggest you open a website to allow citizens to participate in this process instead of coming to meetings once a year. Also, it would save paper by electronically making reports available.

Comment: You are doing all this remediation but as the river fills up water gets shallower and warmer, and kills out all the stuff you want to bring back.

Comment: The project is long overdue!

ENGINEERING DESIGN/PLANNING

Question: Is the stormgate going to be a remote-controlled operation?
Response: *It is going to be triggered by something on the dam. There will also be a back-up if this trigger fails.*

Question: What will be the average closure of the gate if you know there is a tidal event occurring?
Response: *The duration for specific events is listed in one of the appendices of the reports. I do not have that information with me.*

Question: When will the stormgate be operated?
Response: *It will be operated 24 hours a day, seven days a week, and 365 days a year by the state of New Jersey.*

Question: I have heard that the gates could close for up to two hours before an event and stay closed for up to two hours after an event. Is this true, and what about the boats that can't get through because of closed gates?
Response: *Yes, that is true. I would hope that the boating crowd would come to these meetings so that they are aware of the triggers and know to pay attention to the radio. We will give them the best warning we can.*

Question: Why not place a stormgate on the canal of the Raritan River?
Response: *The gate must be tied into high ground and at that location high ground is not high enough. Also, diversion channels would have to be built to maintain water flows within the area.*

Question: Will the stormgate normally be down?
Response: *No, it's usually open. The gate is only closed during storm events.*

Question: If they release water from the dam upstream, what is going to happen to us in terms of flooding?
Response: *A pump house will control rainwater levels.*

Question: Who is going to maintain the pump?
Response: *The state of New Jersey will coordinate with the local municipality, involved agencies, and citizens to come up with an operation plan.*

Question: Are the pumps automatic?
Response: *Yes, once the water level reaches a certain height they will be activated.*

Question: Is the floodwall going to protect the whole project area?
Response: *Yes.*

Question: What power source is used to open and close the levee?
Response: *It will be a diesel generator.*

Comment: I do not agree that dredging will not help. I have lived here 83 years. They used to dredge the river and there was no flooding. Why was there no flooding then?

Response: *In order to accomplish this project and alleviate the flood problem they must do the levees, dredging will not help. Flooding is attributed to tidal fluctuations; no matter how deep we dug the river, water height would remain the same because more water from the ocean would be coming in. The only way to prevent flooding is to build something higher.*

Question: Why can't they take the material that's been washed into the river and use it to fill the estuary so the river drains easier?

Response: *The plan was designed so as not to move or bring in a lot of material. Analyses have not been done to address the sediment issue. We (the Corps) are unaware if the factors that cause the sediment have stopped or are ongoing. The issue has not been addressed because it is not a navigation issue.*

Question: Over the past 100 years there have been a lot of changes to the river. Why at one point could barges travel up and down the river and now they can't? Obviously dredging used to work. What are the reasons for the river clogging?

Response: *There has been a lot of development in the area over the past 100 years. Also, sea level has risen.*

Question: In the past 5 years why were houses allowed to be built along the river and now you are saying this project has to be done?

Response: *Nobody is going to force you to do this. The town must agree and sign a contract for the whole thing.*

Comment: We would rather see the river dredged than the estuary repaired.

FUNDING

Question: How is the state going to pay for the project?

Response: *There is money set aside in the state's budget for flood control and shore protection projects.*

Question: How is each town going to come up with 1 million dollars for the project?

Response: *Each town is not going to pay the same amount. It will be based on the benefits accrued to each town. Also, the amount would be paid over a period of years.*

Question: How do your formulas account for future costs?

Response: *There is money set aside for adaptive management for the first 5 years.*

SECTION 404(B)(1) GUIDELINES EVALUATION

DRAFT SECTION 404(b)(1) GUIDELINES EVALUATION

HURRICANE AND STORM DAMAGE REDUCTION AND ECOSYSTEM RESTORATION STUDY
RARITAN RIVER BASIN, SOUTH RIVER, NEW JERSEY

INTRODUCTION

This document presents the Section 404(b)(1) guidelines evaluation for the construction of a storm surge barrier within the South River channel, placement of levees/floodwalls along the South River shorelines, and construction activities associated with the restoration of a 379.3 acre ecosystem restoration site. The evaluation is based on the regulations presented in 40 CFR 230: Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material. The regulations implement sections 404(b) and 401(1) of the Clean Water Act, which govern disposal of dredged and fill material inside the territorial sea baseline [§230.2(b)].

DRAFT 404(b)(1) EVALUATION

The following Section 404(b)(1) evaluation is presented in a format consistent with typical evaluations in the New York/New Jersey Harbor area and addresses all required elements of the evaluation.

I. Study Description

a. Location – The South River is a tributary to the Raritan River and is located in Middlesex County, New Jersey. The Study area is concentrated within the communities of Sayreville and South River. The South River drains an area of approximately 342 square kilometers and is formed primarily by the confluence of Manalapan and Matchaponix Brooks.

b. General Description – The proposed selected hurricane and storm damage reduction plan involves the construction of two earthen levees/floodwalls along the South River and Washington Canal channels and abutting residential/commercial areas. One levee, to be placed along the western edge of the South River, will be approximately 5,750 feet long and will extend northward from the Route 535 Bridge to the South River landfill. A second levee, to be located along the eastern edge of the Washington Canal, will be approximately 6,000 feet long and will extend northward from the Route 535 Bridge. In addition, a storm surge barrier across the South River channel will be placed just north of the Route 535 Bridge.

The proposed ecosystem restoration plan will involve the conversion of 379.3 acres of *Phragmites*-dominated wetland to 151.7 acres of low emergent marsh, 170.7 acres of wetland forest/scrub-shrub, 19.0 acres of mudflat, 9.5 acres of tidal creek, 9.5 acres of tidal pond, and 19.0 acres of upland forest/scrub-shrub habitat.

c. Authority and Purpose – The Hurricane and Storm Damage Reduction and Ecosystem Restoration Study was authorized by a United States House of Representatives Committee on Public Works and Transportation resolution dated May 13, 1993, to provide hurricane and storm damage reduction along the entire length of the South River.

d. General Description of Fill Material – Construction of the storm surge barrier and earthen levees will require the placement of stone, sand, and timber pilings. In addition, construction associated with the ecosystem restoration plan will involve the addition of fill material to create certain targeted plant communities.

(1) General Characteristics of Material – The storm surge barrier will consist of timber sheet pile trunk section oriented perpendicular to the river on both sides of the stream bank. The storm surge barrier will be placed immediately downstream of Route 535. During tidal flooding events, the storm surge barrier would be closed to prevent flooding of East Brunswick, Old Bridge, and adjacent communities.

The levees will consist primarily of compacted earth fill. Such fill is expected to be comprised of clay-loam or other clay containing soils as described by the Middlesex County Soil Survey.

Floodwalls will be constructed of concrete material.

Implementation of the ecosystem restoration plan will require the excavation and movement of material within the area. In addition, some material will be removed from the site and some may be brought to the site. The placement of fill material will be limited to the restored wetland and upland forest/scrub-shrub areas where "clean fill" may be required to promote the successful establishment of the target plant communities (*i.e.*, desirable plant species).

(2) Quantity of Material – While the exact amount of material in cubic feet is yet to be determined, the selected hurricane and storm damage reduction plan is expected to directly and indirectly impact approximately 25.9 acres, and the ecosystem restoration plan will restore approximately 380 acres. The exact amount of fill material will be determined during the design and specifications phase of the Study.

(3) Source of Material – Sources of fill material may include on-site and off-site substrate dependent upon the composition of soils at the site-

specific locations. Rocks and concrete material will be obtained from commercial sources proximal to the Study area.

e. Proposed Discharge Site Description –

(1) Location – The Study area is described in I (a), above.

(2) Size – The size of the storm surge barrier and levees/floodwalls are described in I (b), above.

(3) Type of Sites/Habitat – The selected hurricane and storm damage reduction plan will result in the following cover type impacts:

Salt Marsh -	0.63 acres
Wetland *Phragmites* -	5.59 acres
Wetland *Phragmites*/Scrub-shrub -	0.74 acres
Wetland Scrub-shrub -	0.32 acres
Wetland Forest -	0.12 acres
Wetland Herbaceous -	0.27 acres
Wetland Herbaceous/Scrub-shrub -	0.88 acres
Mudflat -	0.44 acres
Open water -	0.43 acres
Upland *Phragmites*/Scrub-shrub -	0.35 acres
Upland Forest -	1.43 acres
Upland Forest/Scrub-shrub -	5.83 acres
Upland Grass -	1.42 acres
Upland Herbaceous -	1.22 acres
Upland Herbaceous/Scrub-shrub -	1.63 acres
Upland Scrub-shrub -	2.06 acres
Disturbed –	2.00 acres
Developed -	0.55 acres

The selected ecosystem restoration plan will result in the conversion of 379.3 acres of wetland *Phragmites* to the following cover types:

Salt Marsh -	151.70 acres
Wetland Forest/Scrub-shrub	170.70 acres
Mudflat -	19.00 acres
Tidal Creek -	9.50 acres
Tidal Pond -	9.50 acres
Upland Forest/Scrub-shrub -	19.00 acres

(4) Time and Duration of Disposal – The selected plans will be constructed in increments over a four-year period. Construction of the first element is projected to begin in Year 2006.

f. Disposal Method – Construction equipment such as bulldozers, backhoes, and dump trucks will be used.

II. Factual Determinations

a. Physical Substrate Determination –

(1) Substrate Elevation and Slope – Levees will be constructed with a 1:2.3 slope. Floodwalls will have straight vertical rises.

The selected ecosystem restoration plan will alter the existing topography to promote the successful establishment of the targeted plant communities. The following elevations were estimated in the South River Study area and will be refined during the Plans and Specifications phase:

Low Emergent Marsh	
• Low emergent marsh	0.36 feet
• Interior *Phragmites*	2.46 feet
Tidal Creek and Permanently Flooded Tidal Pond	
• Tidal creek	-2.28 feet
• Tidal Pond	-3.90 feet
• Interior *Phragmites*	2.46 feet
Intertidal Mudflat	
• Intertidal mudflat	-1.41 feet
• Interior *Phragmites*	2.46 feet
Wetland Forest Scrub/Shrub	
• Wetland *Phragmites* scrub/shrub	2.94 feet
• Interior *Phragmites*	2.46 feet
Upland Forest Scrub/Shrub	
• Vegetated upland	5.25 feet
• Interior *Phragmites*	2.46 feet

(2) Sediment Type – Sediments similar to those present in the area will be used.

(3) Dredged Material Movement – Impacts to wetlands and streams will occur as a result of fill activities.

(4) Physical Effects on Benthos – Some benthic invertebrates may be buried or smothered by fill material. However, long-term adverse effects are not anticipated. Post-restoration monitoring of the recovery of benthic communities will be conducted in areas where salt marsh and mudflat will be created.

(5) Other Effects – No additional major impacts are anticipated.

(6) Actions Taken to Minimize Impacts – The selected hurricane and storm damage reduction plan was specifically designed to fill only areas necessary.

b. Water Circulation, Fluctuations, and Salinity Determinations –

(1) Water Quality –

(a) Salinity – Not Applicable (N/A).

(b) Water Chemistry – No impacts are anticipated.

(c) Clarity – Temporary increases in suspended sediment during construction of the storm surge barrier and other near-stream activities including the ecosystem restoration activities are expected. No long-term impacts are anticipated.

(d) Color – Minor, temporary changes are possible due to the generation of suspended solids during storm surge barrier construction and ecosystem restoration activities.

(e) Odor – Not measurable.

(f) Taste – N/A.

(g) Dissolved Gas Levels – Potential short-term localized decrease in dissolved oxygen could occur if organic material is suspended into the water column.

(h) Nutrients – Potential short-term increase.

(i) Eutrophication – N/A.

(j) Other – N/A.

(2) Current Pattern and Circulation –

(a) Current Pattern and Flow – The storm surge barrier would close during a flooding event to control tidal flow (upstream) and prevent the tidal flooding of adjacent communities. Normal flow would continue when the surge barrier is open.

(b) Velocity – The storm surge barrier would close during a flooding event to decrease upstream tidal flow velocity and prevent the tidal flooding of adjacent communities. Normal velocity would continue when the surge barrier is open.

(c) Stratification – N/A.

(3) Normal Water Level Fluctuations – The storm surge barrier would only operate during extreme storm events in which flooding could occur. Normal water level fluctuations will not be impacted by the proposed Study.

(4) Salinity Gradients – No impacts are anticipated.

(5) Actions Taken to Minimize Impacts – No long-term adverse impacts to the overall water quality, water circulation, fluctuations, and salinity determinations are anticipated; therefore, no mitigative measures are required.

c. Suspended Particulate/Turbidity Determination –

(1) Expected Changes – Short-term, localized increases in suspended particulate matter and turbidity are expected during implementation of the proposed storm surge barrier and ecosystem restoration plan.

(2) Effects on Chemical and Physical Properties of the Water Column –

(a) Light Penetration – Sediment dominated by coarse textured soil material will settle rapidly out of the water column. Minor, temporary impacts are anticipated.

(b) Dissolved Oxygen – Possible short-term affects due to in-stream disturbance of particulates.

(c) Toxic Metals and Organics – No adverse effects are anticipated.

(d) Pathogens – N/A.

(e) Aesthetics – The ecosystem restoration activities will permanently improve the overall aesthetic character of the Study area. Floodwalls and levees will be constructed and landscaped in a manner considered to be generally pleasing to the public.

(f) Others as Appropriate – N/A.

(3) Effects on Biota –

(a) Primary Production, Photosynthesis – Potential short-term disruption. No major impacts.

(b) Suspension/Filter Feeders – Short-term insignificant effects.

(c) Sight Feeders – Fishes and motile invertebrates are generally capable of avoiding areas of degraded water quality. Short-term effects to fish mobility during severe storm conditions will be experienced when the surge barrier is closed to prevent upstream flooding.

(4) Action to Minimize Impacts – In-stream construction activities have been reduced from the original plans such that only the minimum amount of construction will occur in or near the stream. In addition, implementation of the selected ecosystem restoration plan will have long-term beneficial impacts on the biota.

d. Contaminant Determination – Testing of materials to be used for construction will be made prior to the initiation of the selected hurricane and storm damage reduction and ecosystem restoration plans. Only clean material will be used.

e. Aquatic Ecosystems and Organisms Determination –

(1) Effects on Plankton/Nekton - Nekton that do not leave the Study area might experience short-term impact if their gills become blocked or irritated by suspended sediment. However, the storm surge barrier may create long-term benefits such as additional habitat and protection for nekton, and sessile aquatic vegetation and invertebrates.

(2) Effects on Benthos – Some benthic species and some embryonic/juvenile nekton may be buried during storm surge barrier construction and/or implementation of the ecosystem restoration plan. However, the storm surge barrier may create long-term benefits such as additional habitat and protection for benthic organisms.

(3) Effects on Aquatic Food Web – Short-term impact to food availability is expected, however no long-term adverse effects are anticipated. Long-term benefits may result from the creation of additional habitat and the protection of nekton, and sessile aquatic vegetation and invertebrates, thus increasing the area's overall productivity.

(4) Effects on Special Aquatic Sites –

(a) Sanctuaries and Refuges – N/A.

(b) Wetlands – Approximately 9.4 acres of wetlands will be impacted due to fill activities and removal of vegetation associated with the hurricane and storm damage reduction plan. An additional 379.3 acres of wetland area dominated by *Phragmites* will be restored to a more ecologically diverse wetland ecosystem.

(c) Mud Flat – The hurricane and storm damage reduction plan will not affect any mudflat areas. The ecosystem restoration plan will create an additional 19 acres of mudflat habitat and 19 acres of tidal creeks/ponds.

(d) Vegetated Shallows – N/A.

(e) Bay Shoreline – N/A

(f) Riffle and Pool Complexes – N/A.

(5) Threatened and Endangered Species – No Federal or State endangered or threatened species will be adversely affected by the proposed Study. However, several species of special interest (*e.g.*, northern harrier, black duck, bald eagles, osprey, and American bittern) may benefit from the selected ecosystem restoration plan.

(6) Other Wildlife – Short-term impact to food availability is expected, however no long-term adverse impacts are anticipated.

(7) Actions to Minimize Impacts – N/A.

f. Proposed Disposal Site Determination –

(1) Mixing Zone Determination – N/A.

(2) Determination of Compliance with Applicable Water Quality Standards – State water quality standards should not be exceeded by the proposed action.

(3) Potential Effects on Human Use Characteristic –

(a) Municipal and Private Water Supply – N/A

(b) Recreational and Commercial Fisheries – No major recreational or commercial fisheries are located within the Study area.

(c) Water-Related Recreation – Short-term degradation of quality of experience due to turbidity. Boating activities within the Study area will experience short-term impact during time of construction. However, long-term beneficial impacts will be realized by the restoration of the 379.3 acre site.

(d) Parks, National and Historical Monuments, National Seashores, Wilderness Areas, Research Sites, and Similar Preserves – Phase one cultural work still needs to be carried out at the proposed restoration island and mitigation site. The Washington Canal will be impacted and will need to be assessed in terms of the National Register of Historic Places. If there are changes to the selected plans footprint, additional assessments may be needed.

g. Determination of Cumulative Effects on the Aquatic Ecosystem – None anticipated. Construction of storm surge barrier will provide additional habitat for nekton, and sessile aquatic vegetation and invertebrates. Similarly, the ecosystem restoration plan will improve the overall habitat quality of the South River area.

h. Determination of Secondary Effects on the Aquatic Ecosystem – No major impacts are anticipated.

III. Findings of Compliance or Noncompliance

a. No significant adaptations of the guidelines were made relative to this evaluation.

b. Numerous alternatives to the alleviation of the flooding problem in the Study area were considered. However, none of these were practicable under the jurisdiction of Section 404(b)(1) guidelines.

c. The proposed Study does not appear to violate applicable state water quality standards or effluent standards.

d. Placement of material associated with the proposed Study will not violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.

e. The proposed Study will have no significant adverse impact on endangered species or their critical habitats (Endangered Species Act of 1973).

f. The proposed Study will have no impact on marine sanctuaries designated by the Marine Protection, Research, and Sanctuaries Act of 1972.

g. The proposed Study will not result in significant adverse effects on human health and welfare, including municipal and private water supplies, recreational and commercial fishing, plankton, fish, shellfish, wildlife, and special aquatic sites. Significant adverse effects on aquatic ecosystem diversity productivity and stability, and recreational, aesthetic and economic values will not occur.

h. Appropriate steps to minimize potential adverse impacts of the discharge on aquatic systems include good engineering practices.

i. On the basis of the guidelines, the proposed construction site for the proposed Study is specified as complying with the requirements of these guidelines.

IV. Conclusions

Based on the above evaluation, the proposed action is determined to be in compliance with the Section 404(b)(1) Guidelines, subject to appropriate and reasonable conditions, to be determined on a case-by-case basis, to protect the public interest.

COASTAL ZONE MANAGEMENT EVALUATION

NEW JERSEY COASTAL ZONE MANAGEMENT EVALUATION

RARITAN RIVER BASIN, SOUTH RIVER, NEW JERSEY HURRICANE AND STORM DAMAGE REDUCTION AND ECOSYSTEM RESTORATION STUDY

INTRODUCTION

The Coastal Zone Management Act (CZMA) of 1972 (16 U.S.C. §§1451-1464) was enacted by Congress in an effort to balance the often competing demands of growth and development with the protection of coastal resources. Its stated purpose is to "...preserve, protect, and develop where possible, to restore or enhance the resources of the nation's coastal zone...". The Act established the framework for achieving this balance by encouraging the states to develop coastal zone management programs, consistent with minimum federal standards, designed to regulate land use activities that could impact coastal resources. The Coastal Zone Act Reauthorization Act Amendments of 1990 further strengthened the act by requiring the state programs to focus more on controlling land use activities and the cumulative effects of activities within designated coastal zones.

The State of New Jersey administers its federally approved coastal zone program through the Department of Environmental Protection, Division of Coastal Resources (NJDCR). Pursuant to the federal CZMA, New Jersey has defined its coastal zone boundaries and developed policies to be utilized to evaluate projects within the designated coastal zone, as set forth in New Jersey's Rules on Coastal Zone Management (CZM) (N.J.A.C. 7:7, 7:7E, dated July 18, 1994 and addendum to 7:7E-5 and 7:7E-8.7, dated August 19, 1996). The Waterfront Development Law (N.J.S.A. 12:5-3) and related requirements (N.J.A.C. 7:7-23) provide the authority for issuance of permits for, among other activities, the placement or construction of structures, pilings, or other obstructions in any tidal waterway. New Jersey's Rules on Coastal Zone Management (Rules) are employed by the State's Land Use Regulation Program in the review of permit applications and coastal decision making; they address issues of location, use, and resources. New Jersey's Rules provide for a balance between economic development and coastal resource protection, recognizing that coastal management involves explicit consideration of a broad range of concerns, in contrast to other resource management programs that have a more limited scope of concern.

The proposed Study is located within the coastal zone of New Jersey. New Jersey DCR has designated 48 Special Areas, types of coastal areas that merit focused attention and special management rule, to better monitor the areas covered by the Rules of the CZM. These Special Areas are divided into: Special Water Areas (N.J.A.C. 7:7E-3.2 through 3.15), Special Water's Edge Areas (N.J.A.C. 7:7E-3.16 through 3.32), Special Land Areas (N.J.A.C. 7:7E-3.33 through 3.35), and Coastwide Special Areas (N.J.A.C. 7:7E-3.36 through 3.48).

The proposed Study would be consistent with CZM standards set by NJDCR for Special Water Areas. Specifically, the Study would follow all guidelines set forth in N.J.A.C. 7:7E-3.15 Intertidal and Subtidal Shallows.

The proposed South River Study would be consistent with CZM standards set by NJDCR for Special Water's Edge Areas. Specifically, placement of the storm surge barrier and levees/floodwalls, as well as the ecosystem restoration activities, in the South River Study area would prevent further erosion of existing topography and protect the adjacent land from flooding. All adverse impacts to wetlands in the South River Study area, as a result of the proposed Study, would be mitigated.

Special Land Areas' standards set forth by the NJDCR would not be applicable to the proposed South River Study.

The proposed South River Study would be consistent with CZM standards set by NJDCR for Coastwide Special Areas. The proposed South River Study would enhance public open space for recreational and aesthetic use.

DISCUSSION OF NEW JERSEY COASTAL ZONE MANAGEMENT POLICIES APPLICABLE TO THE PROPOSED STUDY

The following section identifies the New Jersey CZM policies that are applicable to the proposed South River Study, and provides a discussion of the Study issues relevant to each.

SUBCHAPTER 3 - SPECIAL AREAS

7:7E-3.2 SHELLFISH HABITAT

This policy generally limits disturbance of shellfish habitat.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study will cause a short-term, temporary increase in sedimentation. However, due to the diurnal tidal fluctuation of the Study area, sedimentation and turbidity impacts would be minimal and no adverse impacts are expected as a result of the proposed South River Study.

7:7E-3.3 SURF CLAM AREAS

This policy prohibits development that would destroy or contaminate surf clam areas.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study area is not located in a surf clam area; therefore, this policy is not applicable.

7:7E-3.4 PRIME FISHING AREAS

This policy prohibits sand or gravel submarine mining in prime fishing areas.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study does not involve submarine mining; therefore, this policy is not applicable.

7:7E-3.5 FINFISH MIGRATORY PATHWAYS

This policy prohibits development such as dams, dikes, spillways, channelization, tide gates, and intake pipes that would create physical barriers to migratory fish. Development that would lower water quality so as to interfere with fish movement is also prohibited.

Hurricane and Storm Damage Reduction – The proposed hurricane and storm damage reduction activities would result in the construction of a storm surge barrier in the South River Channel. The surge barrier would remain open throughout the year, except during severe storm events, and therefore would not hinder the migration of finfish in the South River.

Ecosystem Restoration – The proposed ecosystem restoration activities will not create physical barriers to migratory fish.

7:7E-3.6 SUBMERGED VEGETATION HABITAT

This policy prohibits or restricts permanent significant impacts to submerged vegetation habitats unless compensation/mitigation efforts are enacted.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – There are no areas of submerged vegetation habitat located in the proposed South River Study area; therefore, this policy is not applicable.

7:7E-3.7 NAVIGATION CHANNELS

This policy prohibits construction that would extend into a navigation channel that would result in the loss of navigability.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – During construction of the hurricane and storm damage reduction and ecosystem restoration activities, navigation in the South River Channel and Washington Canal might be temporarily restricted/limited due to the presence of construction equipment and temporary bridges. However, the proposed South River Study will have no significant long-term loss of navigability in any waterways in the proposed South River Study area.

7:7E-3.8 CANALS

This policy prohibits actions that would interfere with boat traffic in canals used for navigation.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – During construction of the hurricane and storm damage reduction and ecosystem restoration activities, navigation in the South River Channel and Washington Canal might be temporarily restricted/limited due to the presence of construction equipment and temporary bridges. However, the proposed South River Study will not permanently interfere with boat traffic in canals used for navigation.

7:7E-3.9 INLETS

This policy prohibits filling and discourages submerged infrastructure in coastal inlets.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study area is not located in an inlet as defined by the NJDEP; therefore, this policy is not applicable.

7:7E-3.10 MARINA MOORINGS

This policy prohibits non-water dependent development in marina mooring areas.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study would not involve development in any marina mooring areas; therefore, this policy is not applicable.

7:7E-3.11 PORTS

This policy prohibits actions that would interfere with port uses.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study area is not located in a significant shipping port; therefore, this policy is not applicable.

7:7E-3.12 SUBMERGED INFRASTRUCTURE ROUTES

This policy prohibits any activity that would increase the likelihood of submerged infrastructure damage, or interfere with maintenance operations.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – There are no submerged infrastructures in the proposed South River Study area; therefore, this policy is not applicable.

7:7E-3.13 SHIPWRECKS AND ARTIFICIAL REEFS

This policy restricts the use of special areas with shipwrecks and artificial reefs that would adversely affect the usefulness of the area as a fisheries resource. Also, construction of new or expanded artificial reefs by the deposition of weighted non-toxic material is conditionally acceptable provided that (1) it is demonstrated that the material will not wash ashore and interfere with either navigation or commercial fishing operations; and (2) placement of material and management of the habitat is coordinated with the NJDEP Division of Fish, Game, and Wildlife.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study area does not contain any known shipwrecks or artificial reefs, and new reefs will not be constructed; therefore, this policy is not applicable.

7:7E-3.14 WET BORROW PITS

This policy restricts the use and filling of wet borrow pits.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study area does not contain any known wet borrow pits; therefore, this policy is not applicable.

7:7E-3.15 INTERTIDAL AND SUBTIDAL SHALLOWS

This policy discourages disturbance of shallow water areas (*i.e.*, permanently or twice daily submerged areas from the spring high tide to a depth of four feet below mean low water).

Hurricane and Storm Damage Reduction – The proposed hurricane and storm damage reduction activities involve acceptable hurricane and storm damage reduction measures including the creation of levee/floodwall structures to protect erosion hazard areas; therefore, the proposed hurricane and storm damage reduction activities would be consistent with this policy.

Ecosystem Restoration – The proposed ecosystem restoration activities will not occur in erosion hazard areas; therefore, this policy is not applicable.

7:7E-3.20 BARRIER ISLAND CORRIDOR

This policy restricts new development on barrier islands.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study area does not contain a barrier island; therefore, this policy is not applicable.

7:7E-3.21 BAY ISLANDS

This policy restricts development on bay islands.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study area does not contain any bay islands; therefore, this policy is not applicable.

7:7E-3.22 BEACHES

This policy restricts development on beach areas.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study area does not contain any beaches; therefore, this policy is not applicable.

7:7E-3.23 FILLED WATER'S EDGE

This policy seeks to promote water dependent uses at areas along the waterfront that have been previously filled.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The South River Study would protect adjacent buildings and enhance the overall aesthetic and recreational value of the South River wetland complex, thus promoting water dependent uses along the waterfront. The proposed South River Study would be consistent with this policy.

7:7E-3.24 EXISTING LAGOON EDGES

This policy restricts development at lagoon edges because of potential water quality problems.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study area does not include any lagoon edges; therefore, this policy is not applicable.

7:7E-3.25 FLOOD HAZARD AREAS

This policy is designed to restrict development in flood hazard areas and ensure that the waterfront is not pre-empted by uses that could function equally well at inland locations. The goal of this rule is to reduce losses of life and property resulting from unwise development of flood hazard areas, and allow uses compatible with periodic flooding.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study would involve construction of hurricane and storm damage reduction measures, thereby protecting life and property near the South River Channel and Washington Canal. In addition, ecosystem restoration activities will ensure better tidal flow throughout the South River Study area. The proposed South River Study would be consistent with this policy.

7:7E-3.26 (RESERVED)

7:7E-3.27 WETLANDS

This policy restricts disturbance in wetland areas and requires mitigation if wetlands are destroyed or disturbed.

Hurricane and Storm Damage Reduction – The proposed hurricane and storm damage reduction activities would directly impact 9.4 acres of wetlands. Construction of the proposed hurricane and storm damage reduction activities would comply with all applicable permit requirements, including any required post-construction mitigation and monitoring. Therefore, the proposed hurricane and storm damage reduction activities would be consistent with this policy.

Ecosystem Restoration – The proposed ecosystem restoration activities would convert 379.3 acres of wetland *Phragmites* to a diverse coastal complex of interspersed salt marsh, wetland forest/scrub-shrub, mudflat, tidal creeks and ponds, and upland forest/scrub-shrub habitats. Construction of the ecosystem restoration activities would comply with all applicable permit requirements, including any required post-construction monitoring. Therefore, the proposed ecosystem restoration activities would be consistent with this policy.

7:7E-3.28 WETLAND BUFFERS

This policy restricts development in wetland buffer areas in order to protect wetlands.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – Construction of the hurricane and storm damage reduction and ecosystem restoration activities would include wetland buffer areas. However, construction activities would comply with all applicable permit requirements, including any required post-construction monitoring/mitigation. Therefore, the proposed South River Study would be consistent with this policy.

7:7E-3.29 (RESERVED)

7:7E-3.30 (RESERVED)

7:7E-3.31 COASTAL BLUFFS

This policy restricts development on coastal bluffs.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study will not impact any coastal bluffs; therefore, this policy is not applicable.

7:7E-3.32 INTERMITTENT STREAM CORRIDORS

This policy restricts actions in intermittent stream corridors.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study will not directly impact any intermittent stream corridors; therefore, this policy is not applicable.

7:7E-3.33 FARMLAND CONSERVATION AREAS

This policy seeks to preserve large parcels of land used for farming.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – There are no farmland conservation areas located within the proposed South River Study area; therefore, this policy is not applicable.

7:7E-3.34 STEEP SLOPES

This policy seeks to preserve steep slopes by restricting development in such areas.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – There are no steep slopes in the proposed South River Study area; therefore, this policy is not applicable.

7:7E -3.35 (RESERVED)

7:7E-3.36 HISTORIC AND ARCHAEOLOGICAL RESOURCES

This policy protects the value of historic and archaeological resources and may require cultural resource surveys and other protective measures.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study is taking protective measures to preserve historical and archeological resources. Therefore, the proposed South River Study would be consistent with this policy.

7:7E-3.37 SPECIMEN TREES

This policy seeks to protect specimen trees.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study will not impact any specimen trees; therefore, this policy is not applicable.

7:7E-3.38 ENDANGERED OR THREATENED WILDLIFE OR VEGETATION SPECIES HABITATS

This policy restricts development in endangered or threatened wildlife or vegetation species habitat areas.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – Federally listed threatened species occurring in the vicinity of the proposed South River Study area include: bald eagle (*Haliaeetus leucocephalus*), swamp pink (*Helionas bullata*), and bog turtle (*Clemmys muhlenbergii*). State listed threatened species observed in the proposed South River Study area include: American bittern (*Botarus lentiginosus*), yellow-crowned night heron (*Nyctanassa violacea*), osprey (*Pandion haliaetus*), and black-crowned night heron (*Nycticorax nycticorax*). State listed endangered species observed in the proposed South River Study area include: black skimmer (*Rynchops niger*), northern harrier (*Circus cyaneus*), and peregrine falcon (*Falco peregrinus*). In addition, state listed endangered species occurring in the vicinity of the proposed South River Study area include: Henslow's sparrow (*Ammodramus henslowii*), pied-billed grebe (*Podilymbus podiceps*), and bog turtle.

The proposed South River Study will comply with all applicable permit requirements and ensure that no endangered or threatened wildlife or vegetation species or habitats are impacted during construction. In addition, the proposed ecosystem restoration activities would enhance biodiversity and significantly improve the existing habitat for estuarine plants and wildlife; therefore, the proposed South River Study would be consistent with this policy.

7:7E-3.39 CRITICAL WILDLIFE HABITATS

This policy discourages development that would adversely affect critical wildlife habitat.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study would not impact any areas of critical wildlife habitat as designated by the NJDEP or USFWS; therefore, this policy is not applicable.

7:7E-3.40 PUBLIC OPEN SPACE

This policy encourages new public open spaces and discourages development that might adversely affect existing public open space.

Hurricane and Storm Damage Reduction – The proposed hurricane and storm damage reduction activities would create structures to protect public open space from storm surges, floods, and erosion. The proposed hurricane and storm damage reduction activities would be consistent with this policy.

Ecosystem Restoration – The proposed ecosystem restoration activities would improve the aesthetic value of the existing public open space by converting approximately 380 acres of wetland *Phragmites* into a diverse coastal complex of interspersed salt marsh, wetland forest/scrub-shrub, mudflats, tidal creeks and ponds, and upland forest/scrub-shrub habitats. The proposed ecosystem restoration activities would be consistent with this policy.

7:7E-3.41 SPECIAL HAZARD AREAS

This policy discourages development in hazard areas.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study area does not contain any special hazard areas; therefore, this policy is not applicable.

7:7E-3.42 EXCLUDED FEDERAL LANDS

Federal lands are beyond the jurisdiction of the New Jersey Coastal Zone. New Jersey has the authority to review activities on Federal lands if impacts may occur in New Jersey's Coastal Zone.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study would not involve any disturbance to Federal land; therefore, this policy is not applicable.

7:7E-3.43 SPECIAL URBAN AREAS

This policy seeks to encourage development that would help to restore the economic and social viability of certain municipalities that receive state aid.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study would not involve a Special Urban Area; therefore, this policy is not applicable.

7:7E-3.44 PINELANDS NATIONAL RESERVE AND PINELANDS PROTECTION AREA

This policy allows the Pinelands Commission to serve as the reviewing agency for actions within the Pinelands National Reserve.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study is not located within the Pinelands National Reserve; therefore, this policy is not applicable.

7:7E-3.45 HACKENSACK MEADOWLANDS DISTRICT

This policy allows the Hackensack Meadowlands Development Commission to serve as the reviewing agency for actions within the Hackensack Meadowlands District.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study is not located within the Hackensack Meadowlands District; therefore, this policy is not applicable.

7:7E-3.46 WILD AND SCENIC RIVER CORRIDORS

This policy recognizes the outstanding value of certain rivers in New Jersey by restricting development to compatible uses.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study will not impact a wild and scenic river corridor; therefore, this policy is not applicable.

7:7E-3.47 GEODETIC CONTROL REFERENCE MARKS

This policy discourages disturbance of geodetic control reference marks.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study will not disturb any geodetic control reference marks; therefore, this policy is not applicable.

7:7E-3.48 HUDSON RIVER WATERFRONT AREA

This policy restricts development along the Hudson River Waterfront and requires development, maintenance, and management of a section of the Hudson Waterfront Walkway coincident with the shoreline of the development property.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study is not located within the Hudson River Waterfront Area; therefore, this policy is not applicable.

SUBCHAPTER 3A - STANDARDS FOR BEACH AND DUNE ACTIVITIES

7:7E-3A.1 STANDARDS APPLICABLE TO ROUTINE BEACH MAINTENANCE

Hurricane and Storm Damage Reduction & Ecosystem Restoration – Initial or routine beach maintenance is not part of the proposed South River Study; therefore, this policy is not applicable.

7:7E-3A.2 STANDARDS APPLICABLE TO EMERGENCY POST-STORM BEACH RESTORATION

Hurricane and Storm Damage Reduction & Ecosystem Restoration – Emergency post-storm beach ecosystem restoration is not part of the proposed South River Study; therefore, this policy is not applicable.

7:7E-3A.3 STANDARDS APPLICABLE TO DUNE CREATION AND MAINTENANCE

Hurricane and Storm Damage Reduction & Ecosystem Restoration – Dune creation and maintenance are not part of the proposed South River Study; therefore, this policy is not applicable.

7:7E-3A.4 STANDARDS APPLICABLE TO THE CONSTRUCTION OF BOARDWALKS

Hurricane and Storm Damage Reduction & Ecosystem Restoration – Boardwalks will not be constructed as part of the proposed South River Study; therefore, this policy is not applicable.

SUBCHAPTER 3B - WETLAND MITIGATION PROPOSALS

7-7E-3B.1 MITIGATION PROPOSAL REQUIREMENTS

This section details the requirements of a wetland mitigation proposal.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – Wetland mitigation efforts in the proposed South River Study area will conform to the mitigation proposal requirements listed in this policy. The USACE does not mitigate for ecosystem restoration activities. Therefore, the proposed hurricane and storm damage reduction portion of the South River Study would be consistent with this policy.

SUBCHAPTER 3C - IMPACT ASSESSMENT FOR ENDANGERED AND THREATENED WILDLIFE SPECIES

This section details the performance and reporting standards for impact assessments for endangered and threatened wildlife species.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – No impacts to endangered and threatened wildlife species are anticipated. However, if a species is identified in the Study area prior to implementation of the proposed hurricane and storm damage reduction measures and/or ecosystem restoration activities a habitat/impact assessment will be conducted. The assessment will conform to the performance and reporting standards identified within this policy.

SUBCHAPTER 4 - GENERAL WATER AREAS

7:7E-4.2 Acceptability Conditions for Uses

This section defines the important uses of general water areas and sets conditions or standards of acceptability for certain uses. Only those standards applicable to the proposed South River Study area are listed:

(j) Standards relevant to filling:

Hurricane and Storm Damage Reduction – Filling would be necessary for construction in the proposed South River Study area. There is a demonstrated need for the construction of hurricane and storm damage reduction measures that cannot be satisfied by existing facilities. Therefore, the minimum practicable area will be filled, and wetland mitigation measures will take place as necessary.

Ecosystem Restoration - Fill will be required to convert 189.7 acres of the wetland *Phragmites* into 170.7 acres of wetland forest/scrub-shrub habitat and 19.0 acres of upland forest/scrub-shrub habitat. Any fill activities associated with the proposed ecosystem restoration activities would be consistent with this policy.

SUBCHAPTER 5 - GENERAL LAND AREAS

This rule defines the acceptability of development in general land areas.

Hurricane and Storm Damage Reduction – The proposed hurricane and storm damage reduction activities are considered a linear development as defined in N.J.A.C. 7:7E-6.1. The requirements of this subchapter do not apply to linear developments; therefore, this policy is not applicable.

Ecosystem Restoration – The proposed ecosystem restoration activities will comply with all applicable permit requirements and improve the existing land areas; therefore, the proposed ecosystem restoration activities would be consistent with this policy.

SUBCHAPTER 6 - GENERAL LOCATION RULES

7:7E-6.1 Location of Linear Development

This rule sets conditions for acceptability of linear development (*e.g.,* roads, walkways, pipelines).

Hurricane and Storm Damage Reduction – The proposed hurricane and storm damage reduction activities involve the construction of approximately 10,488 feet of levee, 1,378 feet of floodwall, 275 feet of bulkhead, and a storm surge barrier. Construction of hurricane and storm damage reduction measures will meet all permit requirements. The proposed hurricane and storm damage reduction activities would be consistent with this policy.

Ecosystem Restoration – The proposed ecosystem restoration activities are not considered a linear development; therefore this policy is not applicable.

7:7E-6.2 BASIC LOCATION

This rule states that the NJDEP may reject or conditionally approve a Study for safety, protection of certain property, or preservation of the environment.

Hurricane and Storm Damage Reduction – The proposed hurricane and storm damage reduction activities involve promoting public safety and welfare and protecting public and private property, through construction of hurricane and storm damage reduction measures. Alternatives and design analysis, in coordination with the NJDEP, have ensured that the proposed hurricane and storm damage reduction activities would be consistent with this policy.

Ecosystem Restoration - The ecosystem restoration activities involve the creation of beneficial habitats for the existing plants and wildlife. Ecosystem restoration design planning included NJDEP input to ensure that the proposed ecosystem restoration activities would be consistent with this policy.

7:7E-6.3 SECONDARY IMPACTS

This rule sets the requirements for the secondary impact analysis.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – Additional development is not expected as a result of the proposed South River Study; therefore, this policy is not applicable.

SUBCHAPTER 7 - USE RULES

7:7E-7.2 HOUSING USE

These rules set standards for housing construction in the coastal area.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study does not involve housing construction; therefore, this policy is not applicable.

7:7E-7.3 RESORT RECREATIONAL USE

This rule sets standards for resort and recreational uses in the coastal area.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study does not involve resort recreational uses; therefore, this policy is not applicable.

7:7E-7.3A MARINA DEVELOPMENT

This rule sets standards for marina development in the coastal area.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study does not involve marina development; therefore, this policy is not applicable.

7:7E-7.4 ENERGY USE

This rule sets standards for energy uses in the coastal areas.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study does not involve construction activities that would require long-term energy use. Although the pump station would require energy for operation, it would only be operated during times of use (*i.e.*, storm events). Therefore, this policy is not applicable.

7:7E-7.5 TRANSPORTATION USE

This rule sets standards for roads, public transportation, footpaths and parking facilities in the coastal area.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study does not involve construction of roads, public transportation, footpaths, or parking facilities. Hurricane and storm damage reduction and ecosystem restoration activities will be accomplished using the existing local roads as the means for site access, additional roads will not be constructed; therefore, the proposed South River Study would be consistent with this policy.

7:7E-7.6 PUBLIC FACILITY USE

This rule sets standards for public facilities (*e.g.*, solid waste facilities) in the coastal area.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study does not involve construction of any public facilities; therefore, this policy is not applicable.

7:7E-7.7 INDUSTRY USE

This rule sets standards for industrial uses in the coastal area.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study does not involve construction of industrial facilities; therefore, this policy is not applicable.

7:7E-7.8 MINING USE

This rule sets standards for mining in the coastal area.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study does not involve mining; therefore, this policy is not applicable.

7:7E-7.9 PORT USE

This rule sets standards for port uses and port-related development.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study does not involve use of a port; therefore, this policy is not applicable.

7:7E-7.10 COMMERCIAL FACILITY USE

This rule sets standards for commercial facilities such as hotels, and other retail services in the coastal zone.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study does not involve construction of commercial facilities; therefore, this policy is not applicable.

7:7E-7.11 COASTAL ENGINEERING

This section sets standards to protect the shoreline, maintain dunes, and provide beach nourishment. Only those standards applicable to the proposed South River Study are listed:

(e) Standards relevant to structural shore protection:

Hurricane and Storm Damage Reduction – The construction of hurricane and storm damage reduction measures, including levees and floodwalls, to prevent tidal waters from reaching erodible material is acceptable if it meets certain conditions. The proposed South River Study will comply with the conditions identified in this policy; therefore, the proposed hurricane and storm damage reduction activities would be consistent with this policy.

Ecosystem Restoration – The proposed ecosystem restoration activities do not involve the protection of shoreline, maintenance of dunes, or beach nourishment; therefore, this policy is not applicable.

7:7E-7.12 DREDGED MATERIAL DISPOSAL ON LAND

This rule sets standards for disposal of dredged materials.

Hurricane and Storm Damage Reduction – The construction of the proposed hurricane and storm damage reduction measures will not involve the disposal of dredged material; therefore, this policy is not applicable.

Ecosystem Restoration – The proposed ecosystem restoration activities will involve the excavation of materials to lower the elevation of 189.6 acres of the existing wetland *Phragmites*. Disposal of dredged material associated with the proposed South River Study will comply with the conditions identified in this policy; therefore, the proposed ecosystem restoration activities would be consistent with this policy.

7:7E-7.13 NATIONAL DEFENSE FACILITY USE

This rule sets standards for the location of defense facilities in the coastal zone.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study does not involve location of a defense facility; therefore, this policy is not applicable.

7:7E-7.14 HIGH RISE STRUCTURES

This rule sets standards for high rise structures in the coastal zone.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study does not involve construction of high rise structures; therefore, this policy is not applicable.

SUBCHAPTER 8 - RESOURCE RULES

7:7E-8.2 MARINE FISH AND FISHERIES

This rule sets standards of acceptability so as to cause minimal feasible interference with the reproductive and migratory patterns of estuarine and marine species of finfish and shellfish.

Hurricane and Storm Damage Reduction – The construction of the proposed storm surge barrier will have a short-term impact on shellfish and finfish within the proposed South River Study area. Impacts to both shellfish and finfish species would be minimal and temporary; therefore, the South River Study would be consistent with this policy.

Ecosystem Restoration – The proposed ecosystem restoration activities may temporarily disrupt the migratory patterns and/or reproductive behavior of some estuarine species. However, the long-term effects of the ecosystem restoration activities will be beneficial for finfish and shellfish species in the South River. The South River Study would be consistent with this policy.

7:7E-8.3 (RESERVED)

7:7E 8.4 WATER QUALITY

This rule sets standards for coastal development to limit effects on water quality.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – Short-term water quality impacts resulting from an increase in sedimentation and turbidity during construction activities would be localized in the vicinity of the proposed South River Study area. Long-term water quality in the proposed South River Study area is expected to be comparable to pre-construction quality. Ecosystem restoration activities may improve localized water clarity by the filtering action of the restored tidal salt marsh; therefore, the proposed South River Study would be consistent with this policy.

7:7E-8.5 SURFACE WATER USE

This rule sets standards for coastal development so as to limit effects on surface water.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed Study will not adversely affect the long-term use or classification of surface water in the South River. The proposed South River Study would be consistent with this policy.

7:7E-8.6 GROUNDWATER USE

This rule sets standards for coastal development so as to limit effects on groundwater supplies.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study will not impact or affect groundwater; therefore, this policy is not applicable.

7:7E-8.7 STORMWATER MANAGEMENT

This rule sets standards for coastal development so as to limit effects of stormwater runoff.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study is designed to improve storm water management by protecting the area from flooding during periods of high tide and storm surge events. Therefore, the proposed South River Study will be consistent with this policy.

7:7E-8.8 VEGETATION

This rule sets standards for coastal development while protecting native vegetation.

Hurricane and Storm Damage Reduction – The construction of the proposed hurricane and storm damage reduction measures will directly impact 25.9 acres of upland and wetland vegetation. Construction of the proposed hurricane and storm damage reduction activities would comply with all applicable permit requirements, including any required post-construction mitigation and monitoring. Therefore, the proposed hurricane and storm damage reduction activities would be consistent with this policy.

Ecosystem Restoration – The proposed ecosystem restoration activities would replace 379.3 acres of wetland *Phragmites* with native species (local varieties) adapted to the hydrological conditions present in tidal salt marsh, tidal creeks and ponds, wetland forest/scrub-shrub, and upland forest scrub-shrub. Construction of the ecosystem restoration activities would comply with all applicable permit requirements, including any required post-construction monitoring, and would result in increased species diversity in the South River Study area. Therefore, the proposed ecosystem restoration activities would be consistent with this policy.

7:7E-8.9 (RESERVED)

7:7E-8.10 AIR QUALITY

This rule sets standards for coastal development with requirements that projects must meet applicable air quality standards.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study is not anticipated to increase air emissions above existing levels. The proposed South River Study would be consistent with this policy.

7:7E-8.11 PUBLIC ACCESS TO THE WATERFRONT

This rule requires that coastal development adjacent to the waterfront provide perpendicular and linear access to the waterfront to the extent practicable, including both visual and physical access.

Hurricane and Storm Damage Reduction – At present, there are no areas of waterfront access for vehicles (*i.e.*, boat ramps), but there are several footpaths to the river/canal. Installation of fencing around the construction area will temporarily impact public access to waterfront activities on the east bank. However, no long-term impacts are expected. The proposed hurricane and storm damage reduction activities would be consistent with this policy.

Ecosystem Restoration – The proposed ecosystem restoration activities will have no impacts on public access to waterfront activities; therefore, this policy does not apply.

7:7E -8.12 SCENIC RESOURCES AND DESIGN

This rule sets standards that new coastal development be visually compatible with its surroundings.

Hurricane and Storm Damage Reduction – Visual impacts associated with the proposed hurricane and storm damage reduction measures would include temporary impacts during construction activities. In addition, the Study would result in a restricted view of the river.

However, the levee will be planted with shrubs to enhance the wildlife viewing opportunities and the mitigation area would provide a more scenic wetland setting (*i.e.*, salt marsh habitat). Therefore, the hurricane and storm damage reduction activities would be consistent with this policy.

Ecosystem Restoration – Ecosystem restoration activities would enhance plant and wildlife resources resulting in an increase in the aesthetic value of the South River Study area. Therefore, the ecosystem restoration activities would be consistent with this policy.

7:7E-8.13 BUFFERS AND COMPATIBILITY OF USES

This rule sets standards for adequate buffers between compatible land uses.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study is compatible with adjacent land uses; therefore, the South River Study would be consistent with this policy.

7:7E-8.14 TRAFFIC

This rule sets standards that restrict coastal development that would disturb traffic systems.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study will make every effort possible to mitigate temporary impacts on vehicular traffic during construction activities. For safety reasons, foot traffic in the proposed South River Study area would be prohibited and boat traffic of the South River Channel and Washington Canal would also be limited during construction periods. The proposed South River Study is compatible with current vehicular traffic systems, and therefore, would be consistent with this policy.

7:7E-8.15 THROUGH 8.20 (RESERVED)

7:7E-8.21 SUBSURFACE SEWAGE DISPOSAL SYSTEMS

This rule sets standards for subsurface sewage disposal systems in the coastal zone.

Hurricane and Storm Damage Reduction & Ecosystem Restoration – The proposed South River Study does not involve a subsurface sewage disposal system; therefore, this policy is not applicable.

ESSENTIAL FISH HABITAT ASSESSMENT

(819)

EFH ASSESSMENT WORKSHEET

ACTION: Hurricane and Storm Damage Reduction and Ecosystem Restoration, South River, NJ
DATE: April 3, 2001

Step 1. Use the species list from the EFH web site or other EFH documentation to determine if EFH occurs in the vicinity of the proposed action. If EFH is present make a preliminary determination of impact

1. INITIAL CONSIDERATIONS			
EFH Designations	Y	N	Species
Is action located in or adjacent to EFH?	x		
Is EFH designated for eggs?	x		See Table 1
Is EFH designated for larvae?	x		See Table 1
Is EFH designated for juveniles?	x		See Table 1
Is EFH designated for adults?	x		See Table 1
Is there HAPC at or near project site?		x	Checked with NMFS
Does action have the potential to adversely affect EFH of species or life stages checked above to any degree?	x		If no, consultation is not required. If yes, complete form - consultation is required.

Step 2. In order to assess impacts, it is critical to know the habitat characteristics of the site before the activity is undertaken.

2. SITE CHARACTERISTICS	
Site Characteristics	Description
Is the site intertidal/sub-tidal/ water column?	Storm surge barrier: water column, sub-tidal Levee: intertidal, water column Restoration area: all three
What are the sediment characteristics?	Storm surge barrier: no information, but probably silt/clay Levee: variable Restoration area: silt/clay with organic matter
Is there HAPC at the site, if so what type, size, characteristics?	No HAPC at construction site or in marsh
What is typical salinity and temperature regime?	Salinity variable by stage of tide, season, amount of freshwater runoff, and location in river; temperature varies by season. Storm surge barrier/levee: annual salinity range in river 0-18 ppt,; 0.3 ppt at low tide to 15.6 ppt at high tide in May and September, 2000. Temperatures

	range 5 – 28°C. Restoration area: average salinity at several locations (various tides) was 1-4.1 ppt in April, 1.7-5.6 in June, and 2.3-6.3 in September, 2000 (see attached figure); minimum and maximum values were 0.1-8.1 in April, 0.1-12.4 in June, and 6.5-15.3 in September. Average temperatures ranged from 11.5 – 12.1°C in April, 22.3 – 22.9°C in June, and 20.6 – 22.7°C in September, 2000.
What is the normal frequency of site disturbance?	Storm surge barrier/levee: infrequent flooding during storm surges. Restoration area: infrequent flooding during storm surges.
What is the area of impact (work footprint & far afield)?	Storm surge barrier: approximately 0.4 acres of river bed habitat and 0.04 acres of wetland and salt marsh habitat. Levee: approximately 21.3 acres of upland and wetland habitat, 0.7 acres of salt marsh, 0.5 acres of mud flat, and 0.3 acres of river bed habitat. Restoration area: 50-300 acres of *Phragmites*-dominated wetland.

Step 3. This section is used to evaluate the consequences of the proposed action on habitat functions and values as well as the vulnerability of the EFH species and their life stages. This step is critical in identifying the EFH species listed in Step 1 that will be adversely impacted based upon the habitat characteristics identified in Step 2 and the nature of the impacts described within this step. The Guide to EFH Species on the EFH web site should be consulted during the evaluation to determine the ecological parameters/preferences associated with each species listed.

3. ASSESSMENT OF IMPACTS

Impacts	Y	N	Description
Nature and duration of activity(s)			Storm surge barrier/levee: temporary, localized disturbance to bottom substrate during construction (1 week); during operation, surge barrier would be closed only during flood tide during extreme storm surges when water level reaches +5 ft NGVD to prevent flooding above bridge; water will be pumped from upstream to downstream side of surge barrier when it is closed. Restoration: 6-12 months of site preparation and planting (tidal ditches, mud flat, wetland scrub-shrub and salt marsh); 3 years of monitoring.
Will benthic community be disturbed?	x x		Storm surge barrier/levee: minimal disturbance during construction; no lasting effects, except for the permanent loss of 32,000 sq ft of river bed and 31,300 sq ft of low emergent marsh for base of storm surge barrier and levee. Restoration: short-term disturbance in areas selected for channel modification or new channels; best management practices will be followed to ensure that there are no lasting effects.
Will SAV be impacted?		x	No SAV in South River.
Will sediments be altered and/or sedimentation rates change?	 x	x	Storm surge barrier/levee: sediments may build up on either side of sill, but there will be no significant long-term impact. No change in sedimentation rate. Restoration: limited on-site movement of tidal creek and/or river sediment; sedimentation rate in marsh could potentially increase when river flow through marsh increases/improves.
Will turbidity increase?	x x		Storm surge barrier/levee: temporary, short-term increase in suspended sediments during construction. Restoration: increased turbidity during site preparation and/or until vegetation is established.
Will water depth change?	 x	x	Storm surge barrier/levee: USACE hydrodynamic model indicates that the depth of the South River will not change significantly. Restoration area: the depth of water on the marsh will increase when the area is excavated to a lower elevation to promote the establishment of saltmarsh vegetation.

Will contaminants be released into sediments or water column?		x	Based on a HTRW report prepared by the USACE, sediments in the project area and in the restoration area are free of contaminants.
Will tidal flow, currents or wave patterns be altered?	x x		Storm surge barrier/levee: tidal/river flow will be interrupted at the surge barrier during storm events to prevent upstream flooding. No change in currents or wave patterns. Restoration area: increased tidal flow throughout restoration area. No change in currents or wave patterns.
Will ambient salinity or temperature regime change?	x x		Storm surge barrier/levee: possible reduction in salinity above bridge when surge barrier is closed during flood tide; no change in temperature. Restoration area: increased salinity in the marsh during high tides; no change in temperature.
Will water quality be altered?	 x	x	Storm surge barrier/levee: no. Restoration area: unknown at this time, but increased tidal flow on the interior of the marsh should increase DO, especially during low tide.
Will functions of EFH be impacted for:			If yes, list Species, Life Stage and Habitat Type to be Impacted
Spawning		x x	Only two EFH species could potentially spawn in South River: winter flounder and windowpane. Other EFH species either require salinities >20 ppt to spawn or spawn offshore in deeper water. Storm surge barrier/levee: A few adult winter flounder may occupy project area near storm surge barrier or restoration area during high tide (if salinity >15 ppt) during spawning season and deposit eggs on bottom, but eggs exposed to salinities <5 ppt at low tide would not survive. Because spawning conditions in the South River are already very poor, storm surge barrier construction and operation will not adversely affect spawning habitat. Adult windowpane tolerate salinities as low as 5 ppt and produce pelagic eggs, but do not spawn at temperatures >15°C, thus any spawning in South River would be limited to spring and fall, but only during high tide. Closing of storm surge barrier during flood tide would prevent adults from occupying upper portion of river and spawning there, but only during storm events. Restoration area: Restoration will improve tidal flow into marsh habitat during high tide, but because salinity will remain <15 ppt most of the time and temperature will be >15°C during the summer, winter flounder will not spawn in the restored marsh any more than they do at present. Windowpane spawning in the spring and fall will not be affected.
Nursery	 x	x x	Storm surge barrier: no significant negative impacts on EFH larvae or juveniles. Levee: Loss of low emergent marsh along river bank would cause loss of nursery habitat for juveniles of EFH species that occupy project area, *i.e.*, winter flounder, windowpane, bluefish, butterfish, and summer flounder (Table 1). No affect on larvae. Restoration area: long-term benefits for juvenile bluefish due to creation of new and improved habitat for forage fish; temporary displacement of EFH species (*e.g.* juvenile bluefish) and their prey from construction area to nearby unaffected areas during initial restoration activities. No affect on larvae. Construction impacts will be minimized by using best management practices.
Forage	 x	x x	Storm surge barrier: no significant negative impacts. Levee: loss of low emergent marsh along river bank would cause forage fish that are prey for juvenile bluefish and juvenile and adult summer flounder to permanently re-locate to other areas. Loss of benthic invertebrate food resources would have same effect on juvenile and adult winter flounder and windowpane. Butterfish are planktivores and would not be affected. Restoration area: long-term benefits for juvenile bluefish due to

			creation of new and improved habitat for forage fish.
Shelter		x	Storm surge barrier: no negative impacts since river bottom does not currently provide shelter for EFH species. Surge barrier may actually create a small amount of new shelter.
	x		Levee: loss of low emergent marsh along river bank could cause loss of shelter for juvenile EFH species in project area.
		x	Restoration area: long-term creation of additional shelter (emergent marsh vegetation) for forage fish and EFH species; short-term displacement of EFH species and forage fish from construction area to nearby unaffected areas during initial restoration activities. Construction impacts will be minimized by using best management practices.
Will impacts be temporary or permanent?			Storm surge barrier: temporary impacts during construction (increased turbidity, disturbance of benthic community) and operation (reduced salinity on up-stream side of surge barrier, interrupted river flow); some permanent loss of bottom habitat as a result of construction. Levee: some permanent loss of bottom habitat and marsh as a result of construction, with possible negative impacts on nursery, forage, and shelter for EFH species. Restoration area: temporary construction impacts during construction, but long-term beneficial impacts.
Will compensatory mitigation be used?	x		Replacement of wildlife habitat value (HU's) and wetland functions and values (FCU's); in addition, best management practices will help minimize impact.

Step 4. This section provides the federal action agency's determination on the degree of impact to EFH from the pr posed action. The EFH determination also dictates the type of EFH consultation that will be required with NMFS.

4. DETERMINATION OF IMPACT		
	√	EFH Determination
Overall degree of adverse effects on EFH (not including compensatory mitigation) will be: (check the appropriate statement)	x	No more than minimal adverse effect on EFH - there is no need for further assessment. This worksheet is sufficient for consultation.
		Adverse effect on EFH is not substantial - use contents of this form to develop written assessment.
		Adverse effect on EFH is substantial - a written assessment and methods to avoid or minimize impacts must be provided expanding upon the impacts revealed in this form. Typically, this degree of impact will require an expanded consultation.

UNITED STATES FISH AND WILDLIFE SERVICE'S

FINAL 2(B) REPORT

(825)

Responses to the USFWS 2b Report Comments

1. Contact the Service to obtain current information of federally listed threatened and endangered species if the project is not implemented within the 180 days.

   The Corps concurs with this recommendation and will continue to coordinate with the appropriate Federal agencies regarding the occurrences of threatened and endangered species in the Project area.

2. Contact the New Jersey Natural Heritage Program for updated information on State-listed and federal candidate species in the project area if the project is not implemented within 180 days. Contact the Service if the NHP data search reveals new information regarding any federal candidate species in the project area.

   The Corps concurs with this recommendation and will continue to coordinate with the appropriate state and federal agencies regarding the occurrences of threatened and endangered species in the Project area.

3. Implement the mitigation plan for flood control project concurrently with construction of flood control features to minimize short-term adverse impacts to fish and wildlife.

   The Corps concurs with this recommendation and will coordinate construction activities to the maximum extent possible.

4. Evaluate additional conversion of the existing disturbed area to salt marsh. Implementation of both the flood control project and the ERP will result in a loss of HUs for the clapper rail and marsh wren. Marsh wren populations are declining in New Jersey. Additional conversion of disturbed areas to wetland will benefit both clapper rail and marsh wren.

   The District's mitigation goal was to replace at least 100% of the combined loss of AAHUs (summed across evaluation species) and at least 50% of the loss of AAHUs per evaluation species. Although the replacement of every AAHU lost per species was preferred, it was determined that trade-offs between evaluation species may be necessary. The decision of which AAHUs are replaced and/or traded was based on the interagency HEP Team's consideration of all mitigation alternatives, and a thorough analysis to ensure the selected plan was cost-effective and incrementally justified.

   Although the clapper rail and marsh wren do not achieve 100% replacement of their HUs, the black duck HUs will more than double in number (255%) and the yellow warbler HUs will achieve an increase of 1.5 times their original number (153%). Similarly, the eastern cottontail and American woodcock will benefit significantly from the selected mitigation plan (i.e., 749% increase in cottontail HUs and 250% increase in woodcock HUs). In addition, while the difference of AAHUs in Year 2055 between the No-Action Plan and the Selected Plan with Mitigation is -0.99 for the clapper rail and -0.32 for the marsh wren, the combined total of AAHUs across all evaluation species is +17.57. Based on the results of the HEP study and their original mitigation goal, the District does not believe that additional mitigation is warranted

Additionally, the selected mitigation plan for the flood control project would result in a net loss of wetland acreage (9.4 acres of wetland fill *vs.* 6.1 acres of restored disturbed areas). The remaining 5.0 acres of mitigation is considered to be enhancement, and although the habitat quality is improved by the enhancement, it does not add wetland acreage. To benefit clapper rail and marsh wren and to achieve no net loss of wetlands, the Service recommends additional conversion of approximately 3 acres of the existing disturbed area to emergent salt marsh.

The District's selected mitigation plan will result in a 1:1 creation to impact ratio. The proposed storm protection project will convert 3.3 acres of upland habitat to emergent wetland and the selected mitigation plan will convert 6.1 acres of upland disturbed area to wetland scrub-shrub. Therefore, the project's wetland impacts of 9.4 acres will be offset by the creation of 9.4 acres of wetland habitat. Consequently, the District does not believe that additional mitigation is warranted

5. Conduct long-term monitoring as proposed. The Service concurs with the proposed monitoring plan for both the flood control mitigation and the ERP. We also support the Corps' interest in conducting long-term post-construction monitoring, and encourage this effort to ensure that *Phragmites* does not re-invade, that the correct hydrology has been established, and that the fish and wildlife habitat values gained are maintained over the life of the project. Remedial measure should be implemented if necessary to correct deficiencies in the results of the mitigation or restoration efforts (*e.g.*, re-invasion by *Phragmites*). Any corrective measure should be coordinated with the Service and the NJDFW. The Service requests copies of the monitoring reports.

The Corps plans on monitoring at 1, 3, and 5 years post-construction and notes that if monitoring identifies any deficiencies, as defined by performance criteria for each vegetative cover type, funding will be available for remedial measures. The Corps proposes to coordinate with the Service and NJDFW during the development of the monitoring plan. In addition, the Corps will provide the Service and the NJDFW with copies of the monitoring reports/results and coordinate any corrective measures. The Corps is interested in working with academic institutions to continue monitoring over the life of the project.

FISH AND WILDLIFE COORDINATION ACT
SECTION 2(b) REPORT

ASSESSMENT OF THE SOUTH RIVER FLOOD CONTROL AND ECOSYSTEM RESTORATION PROJECT
MIDDLESEX COUNTY, NEW JERSEY

Prepared by:

U.S. Fish and Wildlife Service
Ecological Services, Region 5
New Jersey Field Office
Pleasantville, New Jersey 08232

August 2002

United States Department of the Interior

FISH AND WILDLIFE SERVICE
New Jersey Field Office
Ecological Services
927 North Main Street, Building D
Pleasantville, New Jersey 08232
Tel: 609/646 9310
Fax: 609/646 0352
http://njfieldoffice.fws.gov

AUG 23 ...2

Colonel John O'Dowd
District Engineer, New York District
U.S. Army Corps of Engineers
26 Federal Plaza
New York, New York 10278-0090

Dear Colonel O'Dowd:

This is the final report of the U.S. Fish and Wildlife Service (Service) regarding anticipated impacts on fish and wildlife resources from the U.S. Army Corps of Engineers (Corps) proposed Raritan River Basin, South River Flood Control and Ecosystem Restoration Project, Towns of South River and Sayreville, Middlesex County, New Jersey. This report is entitled *Assessment of the South River Flood Control and Ecosystem Restoration Project, Middlesex County, New Jersey* and was prepared pursuant to Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 *et seq.*) (FWCA). This report is provided in accordance with our Fiscal Year-1998 scope-of-work agreement and is based on plans and information provided by the Corps.

Except for an occasional transient bald eagle (*Haliaeetus leucocephalus*), no other federally listed or proposed endangered or threatened flora or fauna under Service jurisdiction are known to occur within the project area. Copies of the federal and State threatened and endangered species lists are included in Appendices A and B, respectively.

A copy of the draft report was forwarded to the New Jersey Division of Fish and Wildlife (NJDFW) for review. The NJDFW expressed concurrence with the draft FWCA report by letter dated April 30, 2002. A copy of the NJDFW letter is included in Appendix C.

The Service commends the Corps restoration efforts in the South River project area, which would convert 380 acres of common reed-dominated marsh to productive salt marsh.

If you have any questions regarding this report, please contact John Staples of my staff at (609) 646-9310, extension18.

Sincerely,

Clifford G. Day
Supervisor

Enclosure

FISH AND WILDLIFE COORDINATION ACT SECTION 2(b) REPORT

ASSESSMENT OF THE SOUTH RIVER FLOOD CONTROL AND ECOSYSTEM RESTORATION PROJECT MIDDLESEX COUNTY, NEW JERSEY

Prepared for:

U.S. Army Corps of Engineers
New York District
New York, New York
10278-0090

Prepared by:

U.S. Fish and Wildlife Service
Ecological Services, Region 5
New Jersey Field Office
Pleasantville, New Jersey 08232

Preparers: Kathy Urquhart, John C. Staples
Assistant Project Leader: John C. Staples
Project Leader: Clifford G. Day

August 2002

EXECUTIVE SUMMARY

The New York District, U.S. Army Corps of Engineers (Corps) was authorized to conduct a feasibility study to evaluate federal participation in flood control improvements along the South River located in the Towns of South River and Sayreville, Middlesex County, New Jersey. A second component of the project is to restore degraded wetlands within the project area (ecosystem restoration component).

This Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 *et seq.*) report constitutes an evaluation of both the flood control and ecosystem restoration components of the proposed project. This report is based on current project plans and the results of fish and wildlife studies in the project area. The focus of the Service throughout the study has been to ensure avoidance and minimization of adverse environmental effects of the selected plan, and to ensure inclusion of appropriate and practicable measures to compensate for any unavoidable adverse impacts. The information presented in this report documents the fish and wildlife resources in the project area, provides an assessment of the effects of the proposed project on fish and wildlife resources, and provides recommendations regarding proposed plans for mitigation of project-related adverse impacts and for ecosystem restoration.

In accordance with the National Environmental Policy Act (83 Stat. 852; 42 U.S.C. 4321 *et seq.*) requirements to assess impacts of the proposed project, the Corps cooperated with an interagency advisory team (Team) that included members from the National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (Service), and the New Jersey Department of Environmental Protection's Land Use Regulation Program (LURP). The Team agreed to use the Habitat Evaluation Procedures (HEP) (U.S. Fish and Wildlife Service, 1980) method to quantify the South River Flood Control and Ecosystem Restoration Project (Project) impacts (beneficial and adverse) in terms of wildlife Habitat Units (HUs), and to identify the amount of mitigation necessary to offset adverse impacts associated with the flood control component of the project. In addition, the Team agreed to use the Evaluation for Planned Wetlands (EPW) method (Bartoldus *et al.*, 1994) as a tool to provide an assessment of impacts to wetlands through an analysis of wetland functions and values in terms of wetland Functional Capacity Units (FCUs). The EPW method was used in conjunction with HEP to assist with mitigation efforts necessary to offset adverse impacts associated with the flood control project. The purpose of the Ecosystem Restoration Project (ERP) is to identify several potential restoration plans that will restore biodiversity and ecological functions in the project area, while satisfying federal, regional, State, and local interests, and remaining consistent with the federal objective for National Ecosystem Restoration (USACE ER 1165-2-501 and EP 1165-2-502).

The HEP and EPW methods were used to evaluate the benefits of 11 alternative restoration plans for the ERP. The 11 alternatives were compared against one another and against the no-action alternative for 6 evaluation species selected: American black duck (*Anas rubripes*), clapper rail (*Rallus longirostris*), marsh wren (*Cistothorus palustris*), yellow warbler (*Dendroica petechia*), eastern cottontail (*Sylvilagus floridanus*), and American woodcock (*Scolopax minor*).

The Corps-selected ERP would involve the conversion of 100 percent of the wetland common reed (*Phragmites australis*) cover type in the project area (379.4 acres) to 151.7 acres of low emergent marsh, 170.6 acres of wetland forest/scrub-shrub, 19.0 acres of mudflat, 19.1 acres of open water (9.5 acres of tidal creek and 9.5 acres of tidal pond), and 19.0 acres of upland forest/scrub-shrub. The final benefits analysis indicated that implementation of the recommended ERP would result in a gain of HUs for four of the HEP evaluation species (black duck, yellow warbler, American woodcock, eastern cottontail) as compared to the no-action plan over the 50-year project life. For two of the species evaluated, clapper rail and marsh wren, the ERP will result in a loss of HUs due to the species' higher affinity to common reed. An overall increase in wetland functional benefits, as determined by the EPW assessment, will result from the ERP, with a loss shown only for the sediment stabilization function.

Approximately 9.4 acres of wetland would be filled to create levees for the flood control project. Based on the results of the HEP, the selected project plan for the flood control project and associated habitat impacts and conversions will result in a loss of HUs for three evaluation species (clapper rail, marsh wren, and yellow warbler) and a gain in HUs for three species (black duck, American woodcock, eastern cottontail). Implementation of the selected project plan will result in the loss of FCUs for six of the wetland functions measured. The uniqueness / heritage function has the highest FCU loss (5.26), followed by sediment stabilization (4.69), water quality (4.54), shoreline bank (2.75), fish (2.24), and wildlife (1.26).

The Corps-selected mitigation plan for the flood control project will convert 3.3 acres of existing wetland *Phragmites australis* (*Phragmites*) cover type to salt marsh, 1.7 acres of *Phragmites* to wetland scrub-shrub, and 6.1 acres of disturbed area (previously existing sidecast dredge material) to wetland scrub-shrub, for a total of 11.1 acres. In addition, the landward side of the levee will be planted with shrubs as well as grass species. The mitigation goal of >50 percent replacement of HUs for each evaluation species and >50 percent replacement of FCUs for each function would be met by this mitigation plan. However, implementation of both the flood control project and the ERP will actually result in a loss of HUs for two species, clapper rail and marsh wren. Conversion of a greater amount of disturbed areas to wetland in association with the flood control project would benefit these species. In addition, the selected mitigation plan for the flood control project would not achieve the goal of "no net loss of wetlands" (9.4 acres of wetland fill *vs.* 6.1 acres of restored disturbed areas). The remaining 5.0 acres of mitigation is considered as enhancement of existing wetlands. For these reasons, the Service recommends additional conversion of approximately 3 acres of disturbed area to salt marsh to benefit clapper rail and marsh wren.

The Service concurs with the proposed monitoring plan for both the mitigation and the ERP. We also support the Corps' interest in conducting long-term post-construction monitoring, and encourage this effort to ensure that *Phragmites* does not re-invade, that the correct hydrology has been established, and that the fish and wildlife habitat values gained are maintained over the life of the project.

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APPENDICES

I. INTRODUCTION

This constitutes the U.S. Fish and Wildlife Service's (Service) Fish and Wildlife Coordination Act (48 Stat. 401; 16 U.S.C. 661 *et seq.*) (FWCA), Section 2(b) report describing the fish and wildlife resources and supporting ecosystems in the area of the proposed Raritan River Basin, South River Flood Control and Ecosystem Restoration Project. This report is provided in accordance with a Fiscal Year-1998 scope-of-work agreement between the New York District, U.S. Army Corps of Engineers (Corps) and the Service's New Jersey Field Office. This FWCA report provides: an evaluation of both the flood control and ecosystem restoration components of the proposed project; existing information on fish and wildlife resources, based on field investigations; an assessment of the effects of the proposed project on fish and wildlife; and recommendations to mitigate adverse effects of the project on those resources. To be assessed are the direct impacts to the vegetative cover types located in the proposed levee footprint, potential impacts to the aquatic ecosystem resulting from construction of a flood gate, and indirect impacts to the ecosystem that may result from construction of the proposed flood control structures. Consultation is also provided pursuant to Section 7 of the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*) (ESA). The project area is in the watershed of South River, located in the Towns of South River and Sayreville, Middlesex County, New Jersey (Figure 1).

The Service requests that no part of this report be used out of context, and if the report is reproduced, it should appear in its entirety. Furthermore, any data, opinions, figures, recommendations, or conclusions excerpted from this report should be properly cited and include the page number from which the information was taken. This report should be cited as follows:

> U.S. Fish and Wildlife Service. 2002. Assessment of the South River Flood Control and Ecosystem Restoration Project, Middlesex County, New Jersey. Fish and Wildlife Coordination Act Section 2(b) Report, U.S. Department of the Interior, Fish and Wildlife Service, New Jersey Field Office, Pleasantville, New Jersey. 21 pp. + appendices.

Questions or comments regarding this report are welcomed by the Service. Written inquiries should be addressed to:

Supervisor
New Jersey Field Office, Ecological Services
U.S. Fish and Wildlife Service
927 North Main Street, Building D
Pleasantville, New Jersey 08232

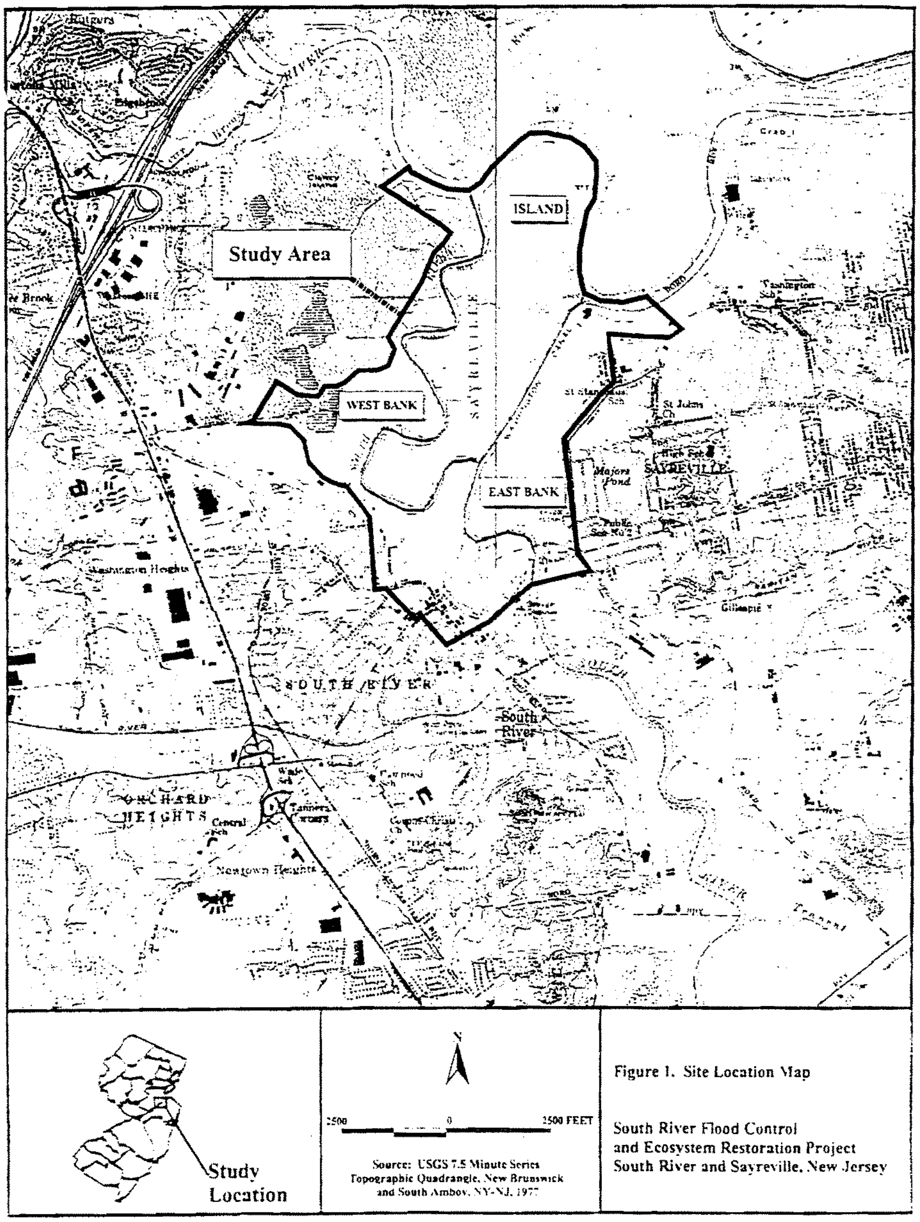


Figure 1. Site Location Map

South River Flood Control
and Ecosystem Restoration Project
South River and Sayreville, New Jersey

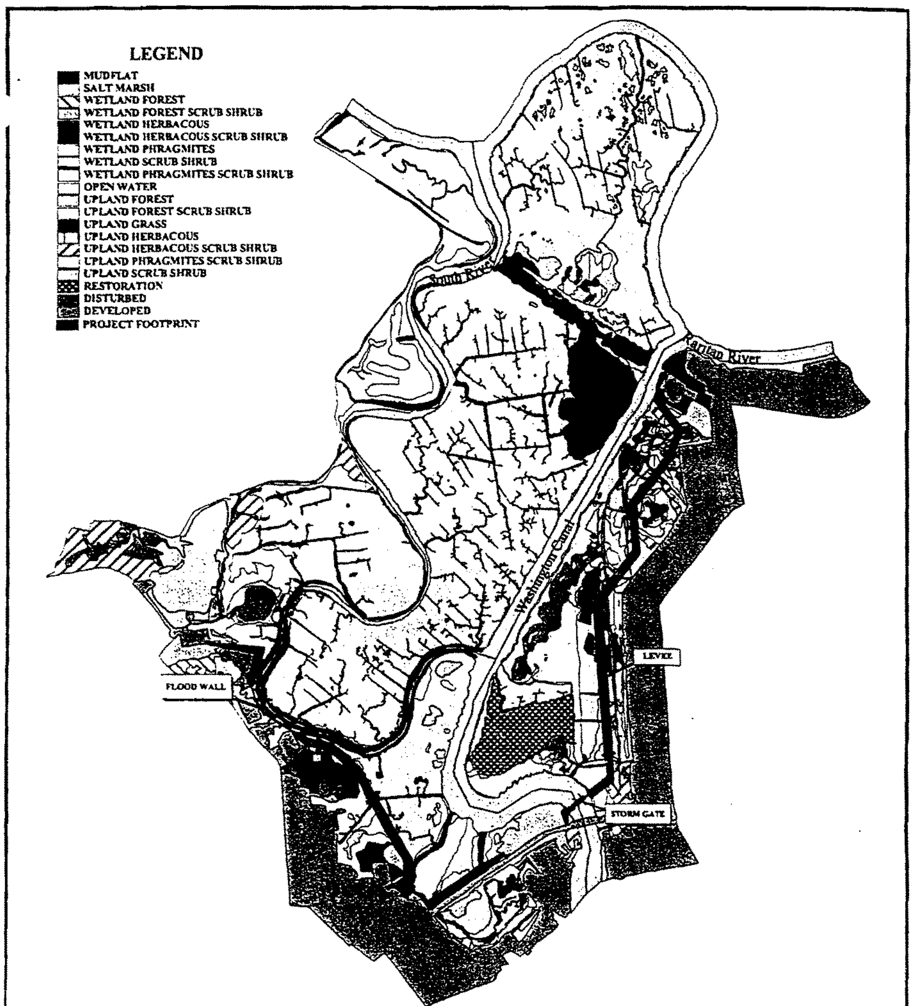
2

II. DESCRIPTION OF THE PROPOSED PROJECT

The Corps is conducting a feasibility study to evaluate solutions to the property damage associated with flooding along the South River in Middlesex County, New Jersey. The New Jersey Department of Environmental Protection (NJDEP) is the non-Federal sponsor for the South River feasibility study. The study was authorized by resolution of the U.S. House of Representatives Committee on Public Works and Transportation and adopted on May 13, 1993.

The selected plan for the flood control portion of the project consists of two components (Figure 2). The first component involves the construction of two earthen levees and a floodwall along the South River and Washington Canal channels and abutting residential and commercial areas. One levee, to be placed along the western edge of the South River Channel, will be approximately 5,750 feet long and will extend northward from the South River/Route 535 bridge to the South River landfill. A second levee, to be located along the eastern edge of the Washington Canal channel, will be approximately 6,000 feet long and will extend northward from the South River/Route 535 bridge. The floodwall will be 1,378 feet long and placed adjacent to a southeast portion of the South River. The second component involves placement of a flood gate across the South River channel just north of the South River/Route 535 bridge. The proposed project area encompasses approximately 1,196 acres, of which 785 acres consists of wetlands. Approximately 9.4 acres of wetland will be filled for levees, and the remaining wetland acres will be impacted by occasional flooding. The selected mitigation plan consists of converting 3.3 acres of common reed (*Phragmites australis*) (*Phragmites*) to salt marsh, 1.7 acres of *Phragmites* to wetland scrub/shrub for a total of 5 acres of enhancement. Wetland creation would occur on 6.1 acres of disturbed area (previously existing sidecast dredge material), which would become wetland scrub/shrub. The total of wetland enhancement and creation would equal 11.1 acres of compensatory mitigation for the 9.4 acres filled for levee construction with the recommended plan.

A separate component of the project is intended to evaluate several potential restoration alternatives designed to restore significant ecological components of the South River watershed. The purpose of the Ecosystem Restoration Project (ERP) is to restore biodiversity and ecological functions in the South River Flood Control and ERP area while satisfying federal, regional, State, and local interests. Although the flood control portion of the proposed project is also located in the South River area, the ecosystem restoration portion will not be used as compensatory mitigation for impacts associated with the flood control portion of the project. The area considered for restoration activities is approximately 380 acres of marsh, which is currently dominated by *Phragmites*. The ERP will use a combination of management practices, which include: restoring tidal flushing; lowering the marsh surface through excavation and removal of thatch material; using herbicides, burning, cutting, or mowing to eradicate *Phragmites* effectively in the project area; ensuring successful establishment of the targeted communities; and limiting further colonization by *Phragmites*.



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600 0 600 1200 Feet

Figure 2. Flood Control Features

South River Flood Control and Ecosystem Restoration Project South River and Sayreville, New Jersey

III. METHODS

The information and findings presented in this report are based on the review of proposed project plans and other information provided by the Corps, including the South River, Raritan River Basin Multipurpose Feasibility Study, the South River, Raritan River Basin Multipurpose Reconnaissance Study (May 1995), the Final Project Scoping Document (June 1998), Draft Impact Assessment and Mitigation Analysis (August 2001), and the South River Ecosystem Restoration Project report (June 2001). The content of this report is also based on a review of Service files and material and site visits conducted by Service personnel.

The field investigation discussed in this report includes a Habitat Evaluations Procedures (HEP) study of fish and wildlife resources in the South River study area for both the flood control and ecosystem restoration components of the project. The purpose of the HEP study was to assess the value of the wetlands and uplands of the South River project area for targeted wildlife species and to assess the effects of the proposed projects on those species. This study was conducted in accordance with standard HEP methodology (U.S. Fish and Wildlife Service, 1980). The HEP study was conducted by Northern Ecological Associates, Inc. (NEA) based upon recommendations made by the HEP team, consisting of representatives from the Corps, the Service, the National Marine Fisheries Service, NJDEP and NEA. Briefly, HEP is used to assess habitat quality and quantity by multiplying a Habitat Suitability Index (HSI) by acreage to derive a Habitat Unit (HU) for individual species. The number of HUs gained or lost over time can be annualized (expressed as Average Annual Habitat Units [AAHU]) to provide relative comparisons of future with- and without-project conditions for a given evaluation species. A detailed discussion of the methods, results, and conclusions for the flood control and ecosystem restoration studies have been documented in separate reports (U.S. Army Corps of Engineers, 2001a; 2001b), and are not repeated here.

To summarize, the evaluation species selected for the HEP study included: black duck (*Anas rubripes*), used to evaluate estuarine vegetated wetlands; clapper rail (*Rallus longirostris*), used to evaluate estuarine emergent and scrub/shrub wetlands; marsh wren (*Cistothorus palustris*), used to evaluate estuarine and palustrine emergent and scrub/shrub wetlands; American woodcock (*Scolopax minor*), used to evaluate upland herbaceous, scrub/shrub and forested wetlands; yellow warbler (*Dendroica petechia*), used to assess deciduous shrub upland and deciduous scrub/shrub wetland; and eastern cottontail (*Sylvilagus floridanus*), which was selected to represent species using a variety of forested, scrub/shrub, and mixed cover types. The results of the HEP analysis were used in the development of an array of mitigation plans intended to offset identified detrimental impacts to wildlife habitats and communities from the flood control project, and to identify potential options for the ecosystem restoration component of the project.

To supplement the HEP, the Evaluation for Planned Wetlands (EPW) (Bartoldus *et al.*, 1994) assessment method was used to characterize and assess project impacts to other wetland values. The EPW provides a technique for determining a wetland's capacity to perform certain wetland functions by evaluating elements of six major wetland functions: shoreline bank erosion control, sediment stabilization, water quality, wildlife (general habitat values), fish (general habitat values), and uniqueness/heritage (*e.g.*, rarity, historical significance, park or sanctuary, habitat for endangered species, scientific value). The EPW analysis produces a numeric index to evaluate wetland functional benefits in terms of Functional Capacity Units (FCUs). The FCUs are used as a quantitative basis for wetland comparisons. The EPW method was designed to be used in conjunction with the HEP methodology to provide a more effective assessment of the quality of wetlands through an assessment of wetland functions and values in addition to wildlife habitat values.

IV. EXISTING CONDITIONS

A. PHYSICAL CHARACTERISTICS

The South River is located within the lower Raritan River basin in Middlesex County, New Jersey, and is the first major tributary of the Raritan River. The South River is formed by the confluence of Matchaponix and Manalapan Brooks, just upstream of Duhernal Lake, and flows northward from the Duhernal Lake Dam for a distance of approximately 7 miles. The South River flows through the townships of East Brunswick and Old Bridge, and the boroughs of South River and Sayreville, at which point it splits into two branches: South River and Washington Canal. Both branches continue their flow northward until they reach the Raritan River. The South River is tidally influenced from its mouth upstream to the Duhernal Lake Dam.

Long-term commercial and industrial activities in and around the South River Project area have led to the loss and degradation of the area's natural resources, resulting in a corresponding reduction in plant, animal, and habitat diversity and abundance. In addition, development-related factors have affected the project area through filling, channelization for mosquito control, introduction and encroachment of invasive plant species, and decreased water quality. The degradation and stress to plant communities in the project area have resulted in the conversion of natural brackish and salt marsh to monotypic stands of *Phragmites*, which do not support as diverse an assemblage of wildlife. As a result of disturbance and subsequent *Phragmites* invasion, diverse salt marsh communities are relatively rare in the project area. The overall study area encompasses approximately 1,276 acres. A total of 19 cover types, including 10 wetland/aquatic cover types, and nine non-wetland cover types, were identified within the South River flood protection component of the project area. Wetland plant communities account for 785 acres (61 percent) of the land cover. Of the vegetated cover types, wetland *Phragmites* dominates the site, comprising approximately 527 acres (41 percent) of the study area. Uplands account for the remaining 491 acres (39 percent), of which 234 (18 percent) acres are occupied by residential, commercial, and industrial development. Approximately 115 homes are located within the 100-year flood plain and 96 homes within the 10-year flood plain.

B. VEGETATION

As part of the interagency HEP study team, the Corps prepared detailed maps of the vegetative cover types within the project area. The draft HEP report prepared by the U.S. Army Corps of Engineers (2001a) provides a thorough description of the extent of various cover types identified in the study area. Major cover types are summarized below.

1. Wetlands

Four general wetland types, including estuarine, palustrine, riverine, and lacustrine (Cowardin *et al.*, 1979) are identified on the National Wetlands Inventory maps of the study area. Wetlands and deepwater sites within the project area include the South River and its tributaries and their adjacent wetlands, all of which are located in the Raritan River Basin. The U.S. Environmental Protection Agency (1994) has designated all tidally influenced estuarine wetlands within the boundaries of the Raritan Bay Estuary as priority wetlands, which are considered to be the most important and vulnerable wetlands in the State. Estuarine wetland systems consist of tidal, brackish waters and contiguous wetlands regularly or occasionally flushed with salt water (U.S. Army Corps of Engineers, 1995). Estuarine wetlands identified within the South River project area are classified as intertidal-emergent, intertidal-open water, and a combination of intertidal broad-leaved deciduous scrub/shrub and intertidal emergent wetlands. Intertidal emergent marsh is dominated either by smooth cordgrass (*Spartina alterniflora*) or saltmeadow cordgrass (*S. patens*), which represent the most salt-tolerant communities, or by *Phragmites*. The majority of the wetland areas located at the mouth of South River and the island between South River and Washington Canal consist of estuarine intertidal emergent wetlands dominated by *Phragmites*, with areas of smooth cordgrass, saltmeadow cordgrass, and spike grass (*Distichlis spicata*). Approximately 33 acres are disturbed by sidecast dredge material and remain sparsely vegetated.

Palustrine wetlands in the project area include all nontidal and tidally influenced freshwater (<0.5 ppt. salinity) wetlands. Considerable differences in vegetation types exist among palustrine wetlands due to hydrology, water chemistry, soils, and human disturbance (Tiner, 1987). Palustrine wetlands along the western shore at the mouth of the South River are classified primarily as palustrine open water areas with some broad-leaved scrub/shrub, broad-leaved forested, or a combination of both.

Riverine wetlands are restricted to the South River's freshwater channel from Duhernal Lake to the point downstream where salinity is consistently less that 0.5 ppt. These wetlands occur from the bank to deeper water, are not dominated by persistent vegetation and are classified as riverine tidal open water.

Approximately 142 acres of open water exist in the project area and consist of sparsely vegetated to unvegetated river and man-made canal channels and ditches. The major channels throughout the area have been historically dredged; however, dredging of either the South River or Washington Canal channels have not occurred for at least 50 years. Bank vegetation is dominated by dense stands of *Phragmites* and isolated areas of smooth cordgrass. Most ditches have steep banks, silt/mud substrate, and flow only intermittently. Vegetation along the ditches is typically comprised of *Phragmites*, groundsel tree (*Baccharis halimifolia*), arrow-wood (*Viburnum dentatum*), and switchgrass (*Panicum virgatum*).

2. Uplands

A variety of upland cover types exist on the site, including *Phragmites* transitional areas, forest, scrub/shrub, herbaceous, grass, disturbed, and developed areas. Forest vegetation consists of oak (*Quercus spp.*), black cherry (*Prunus serotina*), and tree of heaven (*Ailanthus altissima*). Scrub/shrub vegetation consists of dense shrubs and some taller trees along the narrow drainage, including marsh elder (*Iva frutescens*), groundsel tree, northern bayberry (*Myrica pensylvanica*), gray birch (*Betula populifolia*), and multiflora rose (*Rosa multiflora*). Herbaceous species include goldenrod (*Solidago spp.*), aster (*Aster spp.*), and common ragweed (*Ambrosia artemisiifolia*).

C. WILDLIFE

Habitats for terrestrial wildlife species are restricted due to the highly developed condition of the area. Remaining habitats are limited to existing open marshes, upland and wetland scrub-shrub and forest fragments. A total of 48 bird species, 8 mammal species, 2 reptile species, and 1 species of amphibian were recorded by NEA (1999).

1. Mammals

Mammalian species recorded in upland habitats by NEA (1999) included eastern cottontail (*Sylvilagus floridanus*), white-tailed deer (*Odocoileus virginianus*), Norway rat (*Rattus norvegicus*), house mouse (*Mus musculus*), northern red-backed vole (*Clethrionomys gapperi*), masked shrew (*Sorex cinereus*), and red fox (*Vulpes vulpes*). Muskrat (*Ondatra zibethicus*) were observed in emergent wetland areas.

2. Birds

The most abundant species observed included marsh wren, red-winged blackbird (*Agelaius phoeniceus*), and swamp sparrow (*Melospiza melodia*), which were associated with wetland areas. American tree sparrow (*Spizella arborea*), American goldfinch (*Carduelis tristis*), and yellow-rumped warbler (*Dendroica coronata*) were also abundant in the project area. The State-listed northern harrier (*Circus cyaneus*) was seen hunting over the project area during the NEA (1999) surveys. Five of the HEP evaluation species are breeding birds. The New Jersey Division of Fish and Wildlife (NJDFW) (2002) rates the populations of black duck, clapper rail, woodcock, and yellow warbler as "stable." Marsh wren populations are rated as "decreasing" in New Jersey.

3. Reptiles and Amphibians

Reptiles and amphibians recorded during NEA's (1999) survey include Fowler's toad (*Bufo woodhousii fowleri*), snapping turtle (*Chelydra serpentina*), and diamondback terrapin (*Malaclemys terrapin*), in project area wetlands.

4. Fish

A total of 1,089 fish comprising 17 species were sampled from 26 sample sites in the project area by NEA (1998). White perch (*Morone americana*) was the dominant species, followed by Atlantic menhaden (*Brevoortia tyrannus*), inland silverside (*Menidia beryllina*), and mummichog (*Fundulus heteroclitus*). Several invertebrates, including blue crabs (*Callinectes sapidus*), fiddler crabs (*Uca* spp.), and jellyfish were also sampled in the project area.

V. ENDANGERED AND THREATENED SPECIES

Endangered and threatened species and their habitats are afforded protection under Section 7(a)(2) of the ESA, which requires every federal agency, in consultation with the Service, to ensure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. An assessment of potential direct, indirect, and cumulative impacts is required for all federal actions that may affect listed species. Lists of federally listed and candidate species in New Jersey are included in Appendix A.

A review of Service records indicates that there are no known federally listed or proposed threatened or endangered species within the South River project area. However, occasional transients of the federally listed (threatened) bald eagle (*Haliaeetus leucocephalus*) pass through this area during both spring and fall migrations.

If additional information on federally listed or proposed species becomes available or project plans change, the above determinations may be reconsidered. Information on federally listed species and candidate species for federal listing is updated continually, and new species may be added to the list of threatened and endangered plants and animals. Therefore, if the selected plan is not implemented within 180 days, the Service recommends that the Corps contact the Service to obtain current information.

Except for an occasional northern harrier, no State-listed species are known to occur in the project area. A list of State-listed species is included in Appendix B. The New Jersey Natural Heritage Program (NHP) provides the most up-to-date data source for federal candidate species in the State, as well as maintaining information on State-listed species. If the project is not implemented within 180 days, the NHP should be contacted to ensure that information regarding State-listed species and any federal candidate species is up to date. The NHP is available at the following address:

Natural Heritage Program
Division of Parks and Forestry
CN 404
Trenton, New Jersey 08625

Should the NHP data search reveal the presence of any candidate species in the project area, the Service should be contacted to ensure that these species are not adversely affected by project activities.

VI. PROJECT IMPACTS AND RECOMMENDED MITIGATIVE MEASURES

A. FLOOD CONTROL PROJECT

1. Service Mitigation Policy

The Service's views and recommendations on this project are guided by its Mitigation Policy (Federal Register, Vol. 46, No. 15, January 23, 1981). This policy reflects the goal that the most important fish and wildlife resources should receive priority in mitigation planning. The term "mitigation" is defined as: (a) avoiding a negative impact altogether by not taking a certain action or parts of an action; (b) minimizing negative impacts by limiting the degree or magnitude of the action and its implementation; (c) rectifying the negative impact by repairing, rehabilitating, or restoring the affected environment; (d) reducing or eliminating negative impacts over time; and (e) compensating for negative impacts by replacing or providing substitute resources or habitats.

The Service's recommendations are also guided by Executive Order 11988 and 11990 (Federal Register, Vol. 42, No. 100, May 24, 1977). Executive Order 11988 states that "each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by floodplains . . . ." Flood protection by levees, channel modification, and detention basins offer structural methods of flood control. Non-structural methods, including floodplain protection and preservation, should be examined as alternatives to structural flood control pursuant to Executive Order 11988.

Executive Order 11990 states that "each agency shall provide leadership and shall take action to minimize destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities for...providing Federally undertaken, financed, or assisted construction and improvements...." Pursuant to Executive Order 11990, federal projects shall avoid undertaking or providing assistance for new construction located in wetlands unless there are no practicable alternatives and the proposed action includes all practicable measures to minimize loss of, or adverse impacts to, wetlands.

In accordance with the Mitigation Policy and the above-mentioned Executive Orders, the Service generally promotes non-structural alternatives such as floodplain acquisition and restoration, zoning restrictions, flood proofing, and early flood warning systems for flood protection in preference to structural solutions. Only floodplain reclamation offers permanent flood control. The current flooding in the South River project area is the direct result of a long history of unwise development in the floodplain. Flooding will continue to cause property damage, and the aquatic and terrestrial ecosystems will continue to suffer adverse effects, as long as floodplain development continues.

An evaluation of the social and economic considerations that led to the selection of the current plan over non-structural alternatives, such as floodplain acquisition, is beyond the purview of the Service or the scope of this report. The Service's focus throughout the current phase of the study has been on ensuring that the adverse environmental effects of the selected plan are minimized and that measures to compensate for any unavoidable impacts are included in the proposed plan.

2. Service Position on the use of HEP and EPW

The Service views both HEP and EPW as tools to assist in making decisions regarding the functions and values of wetlands and uplands within the study area. When implemented properly, these tools can assist biologists in evaluating potential impacts to target species that may occur from the proposed project. However, the use of these methods does not preclude the use of best professional judgement in assessing project impacts and evaluating compensatory mitigation. Mitigation often involves compensating for wetland functions or values other than the wildlife-related values assessable via HEP. The use of the EPW method may provide additional benefits in evaluating project impacts and mitigation requirements; however, Service staff have found the EPW methodology to be somewhat subjective, requiring discretionary estimates of broad indicators of wetland functions.

3. Project Impacts

Direct impacts to 9.4 acres of wetlands will result from the fill material required for construction of the levees. Levee construction will also impact 16.5 acres of uplands. Dredging activities to remove existing *Phragmites* areas will have temporary impacts to water quality including increased turbidity and a decrease of dissolved oxygen levels from suspended solids. Short-term disturbances to aquatic and terrestrial organisms will occur during construction. Construction of levees and installation of a flood gate on South River will result in additional adverse impacts on wetlands by preventing tidal waters from reaching areas landward of the structures, and by increasing the amount and duration of flood waters on the interior wetlands. The resulting changes in hydrology may alter the marsh; since both the mitigation site and the restoration site are located within the levees, such changes might affect mitigation and restoration efforts adversely.

Based on the results of the HEP, the selected project plan for the flood control project (before mitigation) will result in a loss of HUs over the no-action alternative for three of the six evaluation species. Over the project life, AAHUs would decrease for clapper rail (-3.18), marsh wren (-2.13), and yellow warbler (-5.49). A gain in AAHUs would be seen for black duck (+0.57), American woodcock (+3.25), and eastern cottontail (+5.91) (U.S. Army Corps of Engineers, 2002a). Based on the results of the EPW, the selected project plan (before mitigation) will result in a loss for all functions measured. The uniqueness/heritage function has the highest FCU loss (-5.62), followed by sediment stabilization (-4.69), water quality (-4.54), shoreline bank (-2.75), fish (-2.24), and wildlife (-1.26).

4. Mitigation Goal

Using HEP and EPW methodology and protocols, the Corps' mitigation goal was to develop an array of alternative mitigation actions that will, either individually or together, replace all of the HUs lost through time (AAHUs), and replace all of the FCUs at the time of their loss. The Corps defined "all" as the sum of AAHUs of each evaluation species, and the sum of FCUs of each function. Although the Corps preferred replacement of every HU lost per evaluation species and every FCU lost per function, the Corps expected trade-offs between the evaluation species' HUs and the FCUs for the different wetland functions in order to ensure that the selected mitigation plan is cost-effective and incrementally justified. As a benchmark, the Corps determined that at least 50 percent of the total HUs lost per evaluation species, and at least 50 percent of the FCUs lost per function, would be replaced (U.S. Army Corps of Engineers, 2001a).

Although HEP results are expressed in HUs, and annualized as AAHUs, for each evaluation species, the Service cautions that combining HUs for different species yields a meaningless sum. Due to the variation in habitat requirements for different species, adding HUs across species can result in habitat values being double-counted or canceled out. Rather, HUs or AAHUs should always be expressed as a unit for a given species. Similarly, adding FCUs from dissimilar functions would not yield a meaningful number or account for critical functions that may constitute limiting factors. The Service does agree with the overall goal, which is to select the mitigation plan that best compensates for lost habitat values for each of the evaluation species and each of the wetland functions. We also acknowledge that some trade-offs may be justifiable, depending on the regional importance of given evaluation species or the critical nature of a given wetland function. The HEP and EPW results remain as useful tools to gauge relative gains and losses for individual species and individual wetland functions, respectively.

As noted above, the Corps also used percentage loss or gain in HUs by species, and percentage loss or gain in FCUs by function, for relative comparison among plans. Percentages lost or gained may provide a useful gauge in assessing mitigative goals for individual species, but some caution is warranted in comparing percentage lost or gained among different species since usable area and before-project habitat suitability may differ considerably, as can regional importance.

5. Potential Mitigation Areas

a. Offsite Mitigation

A total of eight offsite areas were evaluated as potential mitigation sites. All were excluded because of their low potential for ecological improvement, acquisition issues, significant costs, and distance from the impact area (U.S. Army Corps of Engineers, 2001a).

b. Onsite Mitigation

Based on the results of the HEP and EPW impact assessments, mitigation options were evaluated in terms of their ability to fulfill the mitigation goal. Three potential mitigation options were identified to compensate for unavoidable adverse impacts from the South River flood control project:

- improvement / enhancement of the available habitat on the levees;
- improvement / enhancement of existing habitats; and,
- conversion of one habitat or cover type to another more valuable habitat or cover type.

Finally, cost-effective mitigative options were identified that would fulfill the mitigation goal of replacing at least 50 percent of lost HUs over time for evaluation species and at least 50 percent of the FCUs lost per function.

6. Selected Mitigation Plan

All mitigation activities are proposed for the East Bank area of the project site, adjacent to the New Jersey Department of Transportation mitigation site (Figure 3). The selected mitigation plan for the flood control project would include 5 acres of wetland enhancement and 6.1 acres of wetland creation. Specifically, the selected plan would convert 5.0 acres of *Phragmites* to 3.3 acres of salt marsh and 1.7 acres to wetland shrub/scrub. An additional 6.1 acres of disturbed areas would be converted to 6.1 acres of wetland scrub/shrub. The total 11.1 acres of compensatory mitigation would cost $1.47 million. Gains in HUs greater than 100 percent of the HUs lost would be realized for four evaluation species: American black duck (254 percent), yellow warbler (155 percent), eastern cottontail (749 percent), and American woodcock (250 percent). Additionally, gains in HUs greater than 50 percent but less than 100 percent of the loss would be realized for the clapper rail (51 percent) and marsh wren (64 percent).

The replacement of FCUs for each function would also be met by the selected mitigation plan. Gains in total FCUs greater than 100 percent of the FCUs lost would be realized for five of the six wetland functions; shoreline bank (102 percent), water quality (110 percent), wildlife (641 percent), fish (118 percent), and uniqueness/heritage (116 percent). The shoreline stabilization function would realize an 88 percent gain in FCUs over those lost.

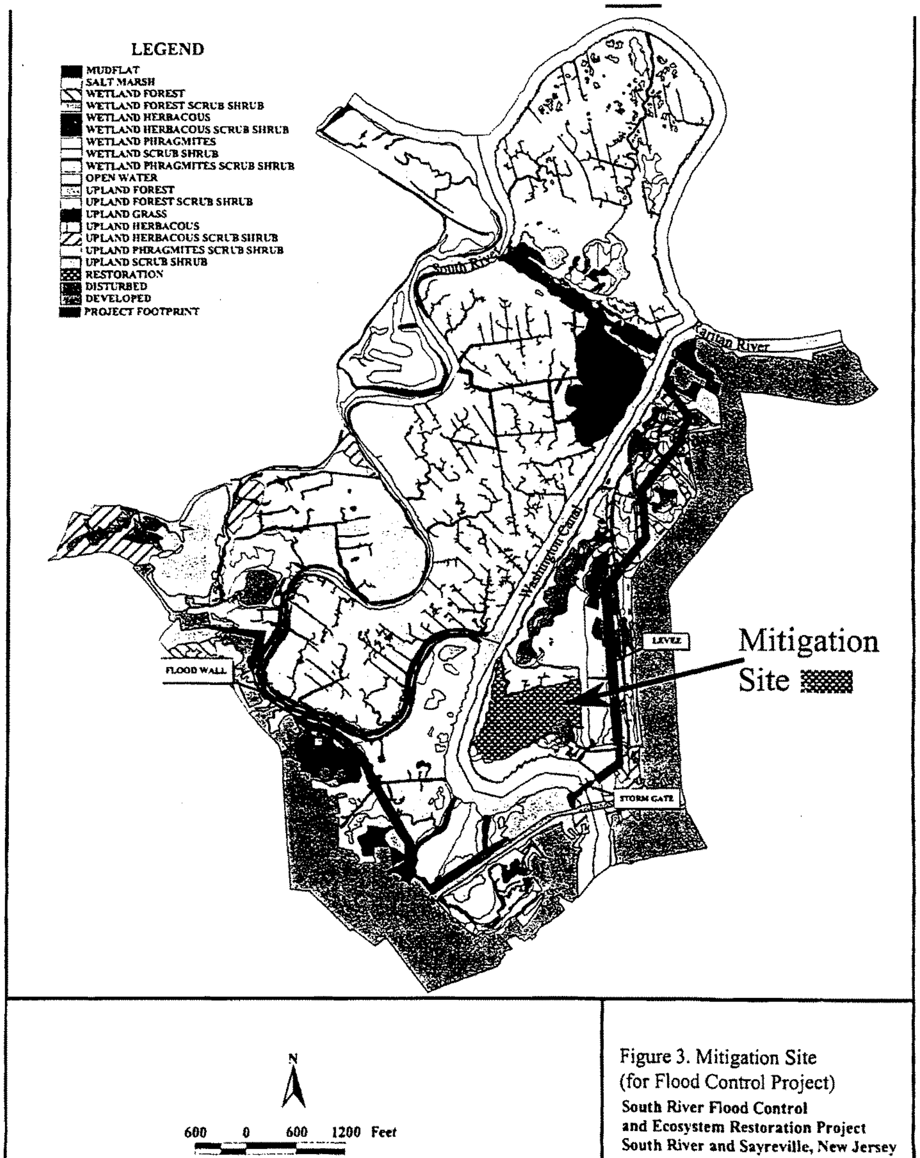

Figure 3. Mitigation Site
(for Flood Control Project)
**South River Flood Control
and Ecosystem Restoration Project
South River and Sayreville, New Jersey**

7. Service Recommendations

The Service generally concurs with selection of the recommended on-site mitigation plan over other alternatives; however, additional measures would further minimize or compensate for adverse impacts to the evaluation species and wetland functions and values. To ensure that habitat value losses for the evaluation species are short-term and minimal, the Service recommends implementing the proposed mitigation concurrently with construction of flood control features.

Implementation of the project, with mitigation included, will result in the loss of HUs for two evaluation species, clapper rail and marsh wren. As stated in the Draft Impact Assessment and Mitigation Analysis (U.S. Army Corps of Engineers, 2001a), the greatest benefit to clapper rail, without having a negative effect on other species, would be from conversion of disturbed areas to wetland. Marsh wren habitat would also be improved by increasing the aerial coverage of emergent herbaceous vegetation. Therefore, both species would benefit from a greater amount of disturbed area being converted to wetland habitat. Since the marsh wren is rated by the NJDFW (2002) as decreasing in the State, the Service recommends additional consideration for this species.

To ensure that the AAHUs and FCUs are maintained as predicted over the life of the project, long-term monitoring is necessary. The Service has reviewed the Corps (2001a) proposed monitoring plan and generally concurs. If post-construction monitoring indicates re-invasion of *Phragmites,* improper hydrology (from flood gates or other factors), or loss of target plant communities, remedial actions should be implemented. The Service and the New Jersey Division of Fish and Wildlife should be contacted for technical assistance and coordination if monitoring reveals any need for remedial measures. The Service requests copies of the monitoring reports.

B. ECOSYSTEM RESTORATION PROJECT

1. Project Benefits

Although the flood control portion of the proposed project is also located in the South River area, the Corps (2001b) has determined that the ecosystem restoration portion of the project will not be used as compensatory mitigation for impacts associated with the flood control portion of the project. The two actions are regarded as independent.

The area considered for restoration is approximately 380 acres, and includes the South River Project Area Island (Island) and an undeveloped marsh located adjacent to the western end of the Sayreville/South River bridge. The overall restoration area is bounded by the Washington Canal to the east, the South River to the west and south, and the Raritan River to the north (Figure 4).

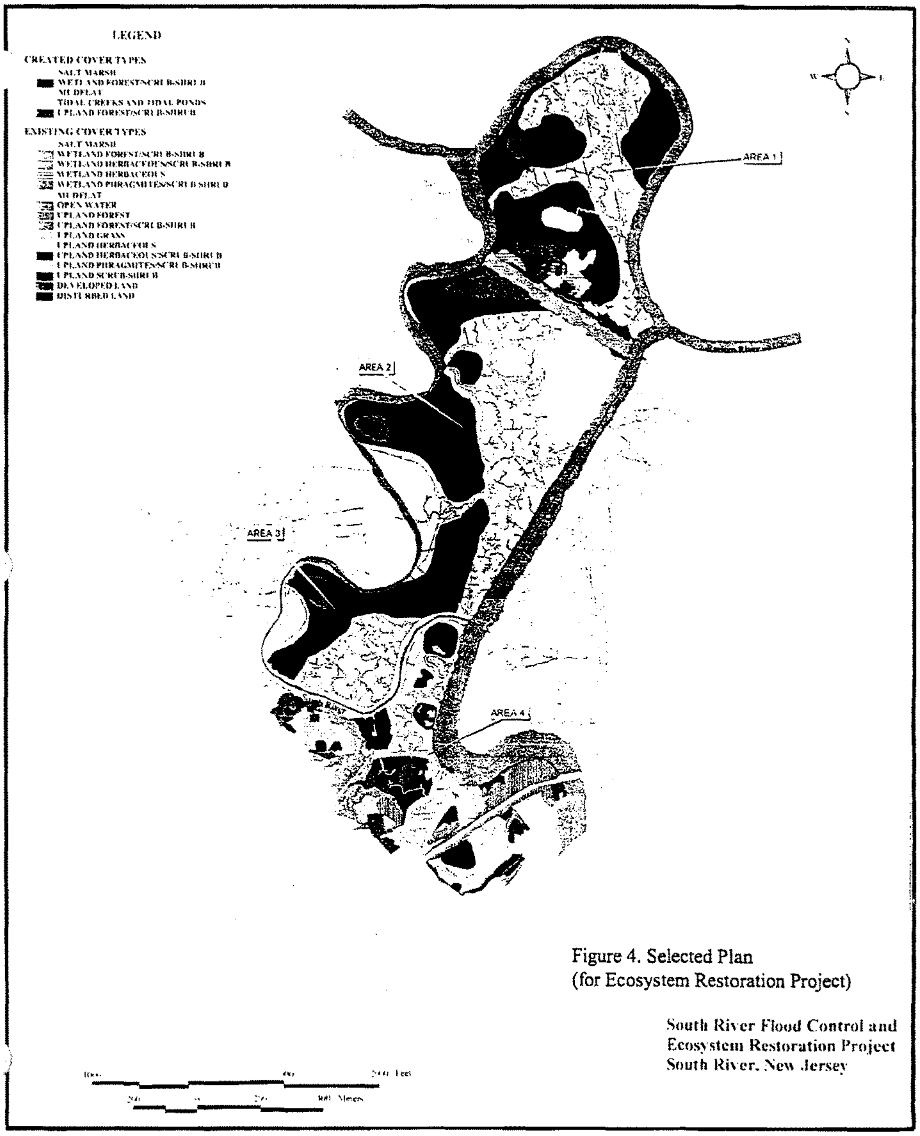

Figure 4. Selected Plan
(for Ecosystem Restoration Project)

South River Flood Control and Ecosystem Restoration Project South River, New Jersey

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Although *Phragmites*-dominated marshes do provide some important ecological benefits, such as water quality improvement and habitat for some bird species, widespread dominance of *Phragmites* results in the loss of other important wetland habitats, such as those provided by low and high emergent salt marshes and intertidal mudflats (Roman *et al.* 1984; Cross and Fleming, 1989; Sinicrope *et al.* 1990; U.S. Army Corps of Engineers, 1999a, b). *Phragmites*, because of its colonizing properties, is often characterized as an aggressive, invasive, nuisance wetland species (Chambers *et al.* 1998; Ailstock, 2000). Unlike dense monotypic stands of *Phragmites*, an ecosystem with an array of wetland plant species and community types supports a diverse collection of birds, mammals, reptiles, and amphibians (U.S. Army Corps of Engineers, 2000a). Restoration of tidal salt marsh is feasible and would increase wildlife use of the area. Tidal salt marsh was once abundant but is currently scarce along the Raritan River. Tidal saltwater marshes can support diverse and thriving communities that provide spawning and nursery habitats for commercially valuable anadromous fish and shellfish, as well as many species of waterfowl that nest and/or use the marsh as a migratory stopover. Ecological benefits include increasing habitat biodiversity, restoring under-represented wetland habitats, increasing tidal flushing of wetlands, and improving water quality. As a result, ecosystem restoration of the South River's *Phragmites*-dominated marsh would provide a significant contribution to the local and regional ecology of the New York metropolitan area.

The Corps-selected ecosystem restoration plan would involve conversion of all of the wetland *Phragmites* cover type in the project area (379.3 acres) to 151.7 acres of low emergent marsh, 170.6 acres of wetland forest/scrub-shrub, 19.1 acres of mudflat, 19.1 acres of open water (9.55 acres tidal creek and 9.55 acres tidal pond), and 19.0 acres of upland forest/scrub-shrub. The final benefits analysis indicated that implementation of the ERP would result in a gain of AAHUs (ecological benefits) over the No-Action plan for black duck (+44.86), eastern cottontail (+153.54), American woodcock (+92.21) and yellow warbler (+108.82), but would result in a loss of AAHUs for clapper rail (-55.91) and marsh wren (-44.15). There would be an overall increase of a total of 116.2 FCUs for shoreline bank erosion control (+75.3), water quality (+10.9), wildlife (+29.8), and tidal fish (+47.6), with a loss only for the sediment stabilization function (-47.4). This loss is explained by the loss of the stabilizing value provided by the extensive root system of the existing *Phragmites* cover type.

2. Service Recommendations

As noted for the flood control portion of the project, the Service generally concurs with the proposed monitoring plan. The Service commends the Corps' efforts to restore 380 acres of *Phragmites*-dominated marsh to a functioning salt marsh ecosystem with diverse low and high marsh emergent and scrub/shrub plant communities that will benefit many species of fish and wildlife, particularly migratory waterfowl and shore birds. Monitoring is necessary to ensure the long-term success of these restoration efforts. The Service requests copies of the monitoring reports and recommends that the Corps coordinate with this office and the New Jersey Division of Fish and Wildlife if monitoring indicates a need for remedial actions.

VII. CONCLUSIONS AND SUMMARY OF RECOMMENDATIONS

The Service concludes that adverse impacts to fish and wildlife from the proposed flood control project would be minor, primarily due to the currently degraded conditions of the project site. Implementation of the ERP and wetland mitigation plan should improve fish and wildlife habitats by reducing the *Phragmites* monoculture and restoring a more diverse wetland ecosystem. The Corps must be commended for the restoration component (ERP), which would convert 380 acres of *Phragmites* monoculture into a diverse salt marsh ecosystem. Such restoration projects within the New York / New Jersey metropolitan area can achieve substantial benefits to fish and wildlife resources. The Service looks forward to working with the Corps on future restoration projects.

The goal of the Service throughout project planning has been to ensure avoidance or minimization of adverse environmental effects from the selected flood control plan and that appropriate mitigative measures are incorporated. The recommendations discussed in the text above are intended for that purpose. These recommendations are summarized below with comments on the Service's draft FWCA report noted in brackets. The NJDFW's comment letter of April 30, 2002 is provided in Appendix C.

1. Contact the Service to obtain current information on federally listed threatened and endangered species if the project is not implemented within 180 days. [The Corps (2002b) concurs with this recommendation.]

2. Contact the New Jersey Natural Heritage Program for updated information on State-listed and federal candidate species in the project area if the project is not implemented within 180 days. Contact the Service if the NHP data search reveals new information regarding any federal candidate species in the project area. [The Corps (2002b) concurs with this recommendation.]

3. Implement the mitigation plan for the flood control project concurrently with construction of flood control features to minimize short-term adverse impacts to fish and wildlife. [The Corps (2002b) concurs with this recommendation.]

4. Evaluate additional conversion of the existing disturbed area to salt marsh. Implementation of both the flood control project and the ERP will result in a loss of HUs for the clapper rail and marsh wren. Marsh wren populations are declining in New Jersey. Additional conversion of disturbed areas to wetland will benefit both clapper rail and marsh wren. Additionally, the selected mitigation plan for the flood control project would result in a net loss of wetland acreage (9.4 acres of wetland fill *vs.* 6.1 acres of restored disturbed areas). The remaining 5.0 acres of mitigation is considered to be enhancement, and although the habitat quality is improved by the enhancement, it does not add wetland acreage. To benefit clapper rail and marsh wren and to achieve no net loss of

wetlands, the Service recommends additional conversion of approximately 3 acres of the existing disturbed area to emergent salt marsh.

[The NJDFW concurs with the recommendation. The Corps (2002b) contends that project impacts are fully mitigated since the total AAHUs added across evaluation species exceed the loss from project implementation, and AAHUs replaced for each species exceed 50 percent. The Service maintains that adding AAHUs across species makes no sense biologically, but acknowledges that trade-offs among evaluation species are often necessary in project planning. Of the evaluation species, only clapper rail and marsh wren would receive less than 100 percent replacement of AAHUs lost to flood control features; the other evaluation species gain in AAHUs. Since marsh wren is ranked as decreasing in the State, the Service continues to recommend considering additional conversion of the disturbed area to salt marsh if economically feasible. Additional rehabilitation of the disturbed area would also benefit clapper rail. Consistent with the Department of Interior letter of July 22, 2002, we wish to add that in the broad context of the entire project, habitat losses resulting from flood control features are small compared to the overall fish and wildlife benefits of the restoration component (380 acres of common reed converted to tidal marsh).

5. Conduct long-term monitoring as proposed. The Service concurs with the proposed monitoring plan for both the flood control mitigation and the ERP. We also support the Corps' interest in conducting long-term post-construction monitoring, and encourage this effort to ensure that *Phragmites* does not re-invade, that the correct hydrology has been established, and that the fish and wildlife habitat values gained are maintained over the life of the project. Remedial measures should be implemented if necessary to correct deficiencies in the results of the mitigation or restoration efforts (*e.g.*, re-invasion by *Phragmites*). Any corrective measures should be coordinated with the Service and the NJDFW. The Service requests copies of the monitoring reports. [The NJDFW concurs with the proposed monitoring plan and the Service's recommendations. The Corps (2002b) clarifies that it would monitor at 1, 3, and 5 years post-construction and notes that if monitoring identifies any deficiencies, as defined by performance criteria for each vegetative cover type, funding will be available for remedial measures. The Corps proposes to provide the Service and NJDFW with copies of the monitoring reports and coordinate on any corrective measures. The Corps expresses an interest in working with academic institutions to continue monitoring over the life of the project.]

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APPENDIX A

Federally listed endangered and threatened species
and candidate species in New Jersey

FEDERALLY LISTED ENDANGERED AND THREATENED SPECIES IN NEW JERSEY

An **ENDANGERED** species is any species that is in danger of extinction throughout all or a significant portion of its range.

A **THREATENED** species is any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

	COMMON NAME	SCIENTIFIC NAME	STATUS
FISHES	**Shortnose sturgeon***	*Acipenser brevirostrum*	E
REPTILES	**Bog turtle**	*Clemmys muhlenbergii*	T
	Atlantic Ridley turtle*	*Lepidochelys kempii*	E
	Green turtle*	*Chelonia mydas*	T
	Hawksbill turtle*	*Eretmochelys imbricata*	E
	Leatherback turtle*	*Dermochelys coriacea*	E
	Loggerhead turtle*	*Caretta caretta*	T
BIRDS	**Bald eagle**	*Haliaeetus leucocephalus*	T
	Piping plover	*Charadrius melodus*	T
	Roseate tern	*Sterna dougallii dougallii*	E
MAMMALS	**Eastern cougar**	*Felis concolor couguar*	E+
	Indiana bat	*Myotis sodalis*	E
	Gray wolf	*Canis lupus*	E+
	Delmarva fox squirrel	*Sciurus niger cinereus*	E+
	Blue whale*	*Balaenoptera musculus*	E
	Finback whale*	*Balaenoptera physalus*	E
	Humpback whale*	*Megaptera novaeangliae*	E
	Right whale*	*Balaena glacialis*	E
	Sei whale*	*Balaenoptera borealis*	E
	Sperm whale*	*Physeter macrocephalus*	E

	COMMON NAME	SCIENTIFIC NAME	STATUS
INVERTEBRATES	Dwarf wedgemussel	*Alasmidonta heterodon*	E
	Northeastern beach tiger beetle	*Cicindela dorsalis dorsalis*	T
	Mitchell satyr butterfly	*Neonympha m. mitchellii*	E+
	American burying beetle	*Nicrophorus americanus*	E+
PLANTS	Small whorled pogonia	*Isotria medeoloides*	T
	Swamp pink	*Helonias bullata*	T
	Knieskern's beaked-rush	*Rhynchospora knieskernii*	T
	American chaffseed	*Schwalbea americana*	E
	Sensitive joint-vetch	*Aeschynomene virginica*	T
	Seabeach amaranth	*Amaranthus pumilus*	T

STATUS:			
E	endangered species	PE	proposed endangered
T	threatened species	PT	proposed threatened
+	presumed extirpated**		

* Except for sea turtle nesting habitat, principal responsibility for these species is vested with the National Marine Fisheries Service.

** Current records indicate the species does not presently occur in New Jersey, although the species did occur in the State historically.

Note: for a complete listing of Endangered and Threatened Wildlife and Plants, refer to 50 CFR 17.11 and 17.12.

For further information, please contact:

U.S. Fish and Wildlife Service
New Jersey Field Office
927 N. Main Street, Building D
Pleasantville, New Jersey 08232
Phone: (609) 646-9310
Fax: (609) 646-0352

Revised 12/06/00

FEDERAL CANDIDATE SPECIES IN NEW JERSEY

CANDIDATE SPECIES are species that appear to warrant consideration for addition to the federal List of Endangered and Threatened Wildlife and Plants. Although these species receive no substantive or procedural protection under the Endangered Species Act, the U.S. Fish and Wildlife Service encourages federal agencies and other planners to give consideration to these species in the environmental planning process.

SPECIES	SCIENTIFIC NAME
Bog asphodel	*Narthecium americanum*
Hirst's panic grass	*Panicum hirstii*

Note: For complete listings of taxa under review as candidate species, refer to Federal Register *Vol. 64, No. 205, October 25, 1999 (Endangered and Threatened Wildlife and Plants; Review of Plant and Animal Taxa that are Candidates for Listing as Endangered or Threatened Species).*

Revised 11/99

APPENDIX B

State-listed endangered and threatened species in New Jersey

8/21/01

ENDANGERED AND THREATENED WILDLIFE OF NEW JERSEY

Endangered Species are those whose prospects for survival in New Jersey are in immediate danger because of a loss or change in habitat, over-exploitation, predation, competition, disease, disturbance, or contamination. Assistance is needed to prevent future extinction in New Jersey.

Threatened Species are those who may become endangered if conditions surrounding them begin to or continue to deteriorate.

BIRDS

Endangered

Pied-billed grebe, *Podilymbus podiceps**
American bittern, *Botaurus lentiginosus**
Bald eagle, *Haliaeetus leucocephalus*[BR]**
Northern harrier, *Circus cyaneus**
Northern goshawk, *Accipiter gentilis**
Red-shouldered hawk, *Buteo lineatus*[BR]
Peregrine falcon, *Falco peregrinus*
Piping plover, *Charadrius melodus***
Upland sandpiper, *Bartramia longicauda*
Roseate tern, *Sterna dougallii***
Least tern, *Sterna antillarum*
Black skimmer, *Rynchops niger*[BR]
Short-eared owl, *Asio flammeus**
Sedge wren, *Cistothorus platensis*
Loggerhead shrike, *Lanius ludovicianus*
Vesper sparrow, *Pooecetes gramineus*[BR]
Henslow's sparrow, *Ammodramus henslowii*

Threatened

Black-crowned night heron, *Nycticorax nycticorax**
Yellow-crowned night heron, *Nyctanassa violaceus*
Bald eagle, *Haliaeetus leucocephalus*[NB]**
Red knot, *Calidris canutus*
Osprey, *Pandion haliaetus**
Cooper's hawk, *Accipiter cooperii*
Red-shouldered hawk, *Buteo lineatus*[NB]
Black rail, *Laterallus jamaicensis*
Long-eared owl, *Asio otus*
Barred owl, *Strix varia*
Red-headed woodpecker, *Melanerpes erythrocephalus*
Black skimmer, *Rynchops niger*[NB]
Savannah sparrow, *Passerculus sandwichensis**
Grasshopper sparrow, *Ammodramus savannarum**
Bobolink, *Dolichonyx oryzivorus*
Vesper sparrow, *Pooecetes gramineus*[NB]

* Only breeding population considered endangered or threatened.
** Federally endangered or threatened.
[BR] Breeding population only.
[NB] Non-breeding population only.

REPTILES

Endangered

Bog turtle, *Clemmys muhlenbergi*
Atlantic hawksbill, *Eretmochelys imbricata***
Atlantic loggerhead, *Caretta caretta***
Atlantic ridley, *Lepidochelys kempi***
Atlantic leatherback, *Dermochelys coriacea***
Corn snake, *Elaphe g. guttata*
Timber rattlesnake, *Crotalus h. horridus*

Threatened

Wood turtle, *Clemmys insculpta*
Atlantic green turtle, *Chelonia mydas***
Northern pine snake, *Pituophis m. melanoleucus*

**Federally endangered or threatened

www.njfishandwildlife.com

8/21/01

AMPHIBIANS

Endangered

Tremblay's salamander, *Ambystoma tremblayi*
Blue-spotted salamander, *Ambystoma laterale*
Eastern tiger salamander, *Ambystoma t. tigrinum*
Pine Barrens treefrog, *Hyla andersonii*
Southern gray treefrog, *Hyla chrysoscelis*

Threatened

Long-tailed salamander, *Eurycea longicauda*
Eastern mud salamander, *Pseudotriton montanus*

MAMMALS

Endangered

Indiana bat, *Myotis sodalis***
Bobcat, *Lynx rufus*
Eastern woodrat, *Neotoma floridana*
Sperm whale, *Physeter macrocephalus***
Fin whale, *Balaenoptera physalus***
Sei whale, *Balaenoptera borealis***
Blue whale, *Balaenoptera musculus***
Humpback whale, *Megaptera novaeangliae***
Black right whale, *Balaena glacialis***

INVERTEBRATES

Threatened

Mitchell's satyr, *Neonympha m. mitchellii***
Northeastern beach tiger beetle, *Cicindela d. dorsalis*
American burying beetle, *Nicrophorus americanus***
Dwarf wedge mussel, *Alasmidonta heterodon***

**Federally endangered

FISH

Endangered

Shortnose sturgeon, *Acipenser brevirostrum***

List revisions:	March 29, 1979
	January 17, 1984
	May 6, 1985
	July 20, 1987
	June 3, 1991
	July 19, 1999

The lists of New Jersey's endangered and nongame wildlife species are maintained by the DEP's Division of Fish and Wildlife's Endangered and Nongame Species Program. These lists are used to determine protection and management actions necessary to ensure the survival of the state's endangered and nongame wildlife. This work is made possible through voluntary contributions received through Check-off donations to the Endangered Wildlife Conservation Fund on the New Jersey State Income Tax Form, the sale of Conserve Wildlife License Plates, and donations. For more information about the Endangered and Nongame Species Program or to report a sighting of endangered or threatened wildlife, contact: Endangered and Nongame Sp cies Program, PO Box 400, Trenton, NJ 08625, or call (609) 292-9400.

www.njfishandwildlife.com

APPENDIX C

Coordination with the New Jersey Division of Fish and Wildlife

State of New Jersey
Department of Environmental Protection

James E. McGreevey
Governor

Bradley M. Campbell
Commissioner

Division of Fish and Wildlife
Robert McDowell, Director
PO Box 400
Trenton, NJ 08625-0400
www.njfishandwildlife.com

April 30, 2002

Clifford G. Day, Administrator
U.S. Fish and Wildlife Service
927 N. Main St.: Bldg. D
Pleasantville, NJ 08232

Dear Mr. Day:

This serves to inform you that the Division of Fish and Wildlife [DFW] concurs with the *Draft Fish and Wildlife 2 (b) Coordination Act Report; Assessment of the South River Flood Control and Ecosystem Restoration Project, Middlesex County, New Jersey.* This constitutes the USFWS's draft report on fish and wildlife impacts that can be expected to result from the ACOE's proposed project for South River.

We agree with the service's recommendation to change three (3) acres of existing disturbed area to emergent salt marsh to benefit Clapper Rail and the Marsh Wren. We also agree with the monitoring plan for the mitigation plan and the ERP.

We hope this information is of service to you.

Sincerely,

Robert McDowell, Director
Division of Fish and Wildlife

c. A. Didun, OER
J. Staples, USFWS
D. Wilkinson, OER

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United States Department of the Interior

FISH AND WILDLIFE SERVICE
New Jersey Field Office
Ecological Services
927 North Main Street, Building D
Pleasantville, New Jersey 08232
Tel: 609/646 9310
Fax: 609/646 0352
http://njfieldoffice.fws.gov

In Reply Refer to:

FP-01/23

April 12, 2002

Robert McDowell, Director
New Jersey Division of Fish and Wildlife
CN 400
Trenton, New Jersey 08625

Dear Mr. McDowell:

Enclosed is the U.S. Fish and Wildlife Service's (Service) Draft Fish and Wildlife Coordination Act Report entitled, "Assessment of the South River Flood Control and Ecosystem Restoration Project, Middlesex County, New Jersey." This constitutes the Service's draft report on fish and wildlife impacts that can be expected to result from the Army Corps of Engineers (Corps) proposed plan. This report has been prepared pursuant to Section 2 (b) of the Fish and Wildlife Coordination Act (48 Stat. 401; as amended; 16 U.S.C. 661 *et seq.*) and is for inclusion in the Corps forth-coming Feasibility Report.

The Service's report contains an assessment of the proposed flood control and restoration projects and recommendations for protection of fish and wildlife resources. Please provide a letter of comment including indication of concurrence, or lack thereof, within 20 days from the date of this letter. If there are any questions concerning this report, please contact John Staples or Kathy Urquhart of my staff at (609) 646-9310, extensions 18 and 45, respectively. Thank you for your assistance in this matter.

Sincerely,

Clifford G. Day
Supervisor

Enclosure

UNITED STATES FISH AND WILDLIFE SERVICE'S DRAFT 2(B) REPORT

(873)

South River, Raritan River Basin
Hurricane and Storm Damage Reduction and Ecosystem Restoration Study

The District Response to the U.S. Fish and Wildlife Service draft 2b Report

1. The District Response to Service Recommendation 1: The District Concurs.

2. The District Response to Service Recommendation 2: The District Concurs.

3. The District Response to Service Recommendation 3: The District Concurs.

4. The District Response to Service Recommendation 4: The Districts does not agree that additional mitigation is needed. The selected mitigation meets the mitigation goal for the replacement of at least 100% of the combined loss of Average Annual Habitat Units (AAHUs) summed across evaluation species and FCUs summed across wetland functions, and at least 50% of the loss of AAHUs per evaluation species and FCUs lost per function. To achieve this goal, mitigation of impacted habitats, will involve planting shrubs on the levee and the conversion of wetland *Phragmites* to salt marsh and wetland-scrub-shrub, and the conversion of upland disturbed areas to wetland-scrub-shrub on the East Bank of the study area as described below.

With implementation of the selected hurricane and storm damage reduction measures the mitigation goal of replacement of at least 100% of the combined AAHUs for all evaluation species and at least 50% of the AAHUs for each evaluation species is met. The combined AAHUs lost due to implementation of the selected plan was determined to be 1.07, and implementation of the selected mitigation plan results in a gain of 17.57 AAHUs at year 2055 when compared to the No-Action alternative. In addition, the replacement of FCUs for each wetland function would also be met by the selected mitigation plan. Gains in total FCUs greater than 100% would be realized for all wetland functions.

5. The Corps appreciates the support of the FWS in ensuring that proper post-construction monitoring is done at the ecosystem restoration site. The Corps is committed to conducting three years of monitoring during the course of five years (*i.e.*, at 1, 3, and 5 years post-construction). Adaptive management will be in force, so that if monitoring uncovers any deficiencies in project performance – as defined by specific performance criteria for each cover type – funding will be available to correct the problem (*e.g.*, incorrect elevation for cover type, Phragmites encroachment). In addition, the Corps is interested in working with academic institutions and non-profit groups to establish regular and sustained monitoring over the course of the project life (50 years). Corrective measures will be coordinated with the FWS and the New Jersey Department of Fish and Wildlife. Copies of the monitoring reports will be provided to the FWS.

DRAFT
FISH AND WILDLIFE COORDINATION ACT
SECTION 2(b) REPORT

ASSESSMENT OF THE SOUTH RIVER FLOOD CONTROL AND ECOSYSTEM RESTORATION PROJECT
MIDDLESEX COUNTY, NEW JERSEY

Prepared by:

U.S. Fish and Wildlife Service
Ecological Services, Region 5
New Jersey Field Office
Pleasantville, New Jersey 08232

April 2002

United States Department of the Interior

FISH AND WILDLIFE SERVICE
New Jersey Field Office
Ecological Services
927 North Main Street, Building D
Pleasantville, New Jersey 08232
Tel: 609/646 9310
Fax: 609/646 0352
http://njfieldoffice.fws.gov

In Reply Refer to:

FP-01/23

April 12, 2002

Colonel John O'Dowd
District Engineer, New York District
U.S. Army Corps of Engineers
26 Federal Plaza
New York, New York 10278-0090

Dear Colonel O'Dowd:

This is the draft report of the U.S. Fish and Wildlife Service (Service) regarding anticipated impacts on fish and wildlife resources from the U.S. Army Corps of Engineers (Corps) proposed Raritan River Basin, South River Flood Control and Ecosystem Restoration Project, Towns of South River and Sayreville, Middlesex County, New Jersey. The draft report is entitled *Assessment of the South River Flood Control and Ecosystem Restoration Project, Middlesex County, New Jersey.* This report was prepared pursuant to Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 *et seq.*) (FWCA). This report is provided in accordance with our Fiscal Year-1998 scope-of-work agreement and is based on plans and information provided by the Corps.

Except for an occasional transient bald eagle (*Haliaeetus leucocephalus*), no other federally listed or proposed endangered or threatened flora or fauna under Service jurisdiction are known to occur within the project area.

A copy of this draft report was forwarded to the New Jersey Division of Fish and Wildlife (NJDFW) for concurrence. The Service is currently awaiting NJDFW's response to this draft report.

The Service commends the Corps restoration efforts in the South River project area, which would convert 380 acres of common reed-dominated marsh to productive salt marsh.

If you have any questions regarding this report, please contact John Staples or Kathy Urquhart of my staff at (609) 646-9310, extensions 18 and 45, respectively.

Sincerely,

Clifford G. Day
Supervisor

Enclosure

DRAFT
FISH AND WILDLIFE COORDINATION ACT
SECTION 2(b) REPORT

ASSESSMENT OF THE SOUTH RIVER FLOOD CONTROL AND ECOSYSTEM RESTORATION PROJECT MIDDLESEX COUNTY, NEW JERSEY

Prepared for:

U.S. Army Corps of Engineers
New York District
New York, New York
10278-0090

Prepared by:

U.S. Fish and Wildlife Service
Ecological Services, Region 5
New Jersey Field Office
Pleasantville, New Jersey 08232

Preparer: Kathy Urquhart
Assistant Project Leader: John C. Staples
Project Leader: Clifford G. Day

April 2002

EXECUTIVE SUMMARY

The New York District, U.S. Army Corps of Engineers (Corps) was authorized to conduct a feasibility study to evaluate federal participation in flood control improvements along the South River located in the Towns of South River and Sayreville, Middlesex County, New Jersey. A second component of the project is to restore degraded wetlands within the project area (ecosystem restoration component).

This draft Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 *et seq.*) report constitutes a preliminary evaluation of both the flood control and ecosystem restoration components of the proposed project. This report is based on current project plans and the results of fish and wildlife studies in the project area. The focus of the Service throughout the current phase of study has been to ensure avoidance and minimization of adverse environmental effects of the selected plan, and to ensure inclusion of appropriate and practicable measures to compensate for any unavoidable adverse impacts. The information presented in this report documents the fish and wildlife resources in the project area, provides an assessment of the effects of the proposed project on fish and wildlife resources, and provides recommendations regarding proposed plans for mitigation of project-related adverse impacts and for ecosystem restoration.

In accordance with the National Environmental Policy Act (83 Stat. 852; 42 U.S.C. 4321 *et seq.*) requirements to assess impacts of the proposed project, the Corps cooperated with an interagency advisory team (Team) that included members from the National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (Service), and the New Jersey Department of Environmental Protection's Land Use Regulation Program (LURP). The Team agreed to use the Habitat Evaluation Procedures (HEP) (U.S. Fish and Wildlife Service, 1980) method to quantify the South River Flood Control and Ecosystem Restoration Project (Project) impacts (beneficial and adverse) in terms of wildlife Habitat Units (HUs), and to identify the amount of mitigation necessary to offset adverse impacts associated with the flood control component of the project. In addition, the Team agreed to use the Evaluation for Planned Wetlands (EPW) method (Bartoldus *et al.*, 1994) as a tool to provide an assessment of impacts to wetlands through an analysis of wetland functions and values in terms of wetland Functional Capacity Units (FCUs). The EPW method was used in conjunction with HEP to assist with mitigation efforts necessary to offset adverse impacts associated with the flood control project. The purpose of the Ecosystem Restoration Project (ERP) is to identify several potential restoration plans that will restore biodiversity and ecological functions in the project area, while satisfying federal, regional, State, and local interests, and remaining consistent with the federal objective for National Ecosystem Restoration (USACE ER 1165-2-501 and EP 1165-2-502).

The HEP and EPW methods were used to evaluate the benefits of 11 alternative restoration plans for the ERP. The 11 alternatives were compared against one another and against the no-action alternative for 6 evaluation species selected: American Black Duck (*Anas rubripes*), Clapper Rail (*Rallus longirostris*), Marsh Wren (*Cistothorus palustris*), Yellow Warbler (*Dendroica petechia*), Eastern cottontail (*Sylvilagus floridanus*), and American Woodcock (*Scolopax minor*).

The Corps selected ERP would involve the conversion of 100 percent of the wetland common reed (*Phragmites australis*) cover type in the project area (379.4 acres) to 151.7 acres of low emergent marsh, 170.6 acres of wetland forest/scrub-shrub, 19.0 acres of mudflat, 19.1 acres of open water (9.5 acres of tidal creek and 9.5 acres of tidal pond), and 19.0 acres of upland forest/scrub-shrub. The final benefits analysis indicated that implementation of the recommended ERP would result in a gain of HUs for four of the HEP evaluation species (Black Duck, Yellow Warbler, American Woodcock, Eastern cottontail) as compared to the no-action plan over the 50-year project life. For two of the species evaluated, clapper rail and marsh wren, the ERP will result in a loss of HUs due to the species' higher affinity to common reed. An overall increase in wetland functional benefits, as determined by the EPW assessment, will result from the ERP, with a loss shown only for the sediment stabilization function.

Approximately 9.4 acres of wetland would be filled to create levees for the flood control project. Based on the results of the HEP, the selected project plan for the flood control project and associated habitat impacts and conversions will result in a loss of HUs for three evaluation species (Clapper Rail, Marsh Wren, and Yellow Warbler) and a gain in HUs for three species (Black Duck, American Woodcock, Eastern cottontail). Implementation of the selected project plan will result in the loss of FCUs for six of the wetland functions measured. The uniqueness / heritage function has the highest FCU loss (5.26), followed by sediment stabilization (4.69), water quality (4.54), shoreline bank (2.75), fish (2.24), and wildlife (1.26).

The Corps selected mitigation plan for the flood control project will convert 3.3 acres of existing wetland *Phragmites australis* (*Phragmites*) cover type to salt marsh, 1.7 acres of *Phragmites* to wetland scrub-shrub, and 6.1 acres of disturbed area (previously existing sidecast dredge material) to wetland scrub-shrub, for a total of 11.1 acres. In addition, the landward side of the levee will be planted with shrubs as well as grass species. The mitigation goal of >50 percent replacement of HUs for each evaluation species and >50 percent replacement of FCUs for each function would be met by this mitigation plan. However, implementation of both the flood control project and the ERP will actually result in a loss of HUs for two species, Clapper Rail and Marsh Wren. Conversion of a greater amount of disturbed areas to wetland in association with the flood control project would benefit these species. In addition, the selected mitigation plan for the flood control project would not achieve the goal of "no net loss of wetlands" (9.4 acres of wetland fill *vs.* 6.1 acres of restored disturbed areas). The remaining 5.0 acres of mitigation is considered as enhancement of existing wetlands. For these reasons, the Service recommends additional conversion of approximately 3 acres of disturbed area to salt marsh to benefit Clapper Rail and Marsh Wren.

The Service concurs with the proposed monitoring plan for both the mitigation and the ERP. We also support the Corps interest in conducting long-term post-construction monitoring, and encourage this effort to ensure that *Phragmites* does not re-invade, that the correct hydrology has been established, and that the fish and wildlife habitat values gained are maintained over the life of the project.

TABLE OF CONTENTS

LIST OF FIGURES

APPENDICES

I. INTRODUCTION

This constitutes the U.S. Fish and Wildlife Service's (Service) draft Fish and Wildlife Coordination Act (48 Stat. 401; 16 U.S.C. 661 *et seq.*) (FWCA), Section 2(b) report describing the fish and wildlife resources and supporting ecosystems in the area of the proposed Raritan River Basin, South River Flood Control and Ecosystem Restoration Project. This report is provided in accordance with a Fiscal Year-1998 scope-of-work agreement between the New York District, U.S. Army Corps of Engineers (Corps) and the Service's New Jersey Field Office. This FWCA report provides: an evaluation of both the flood control and ecosystem restoration components of the proposed project; existing information on fish and wildlife resources, based on field investigations; an assessment of the effects of the proposed project on fish and wildlife; and recommendations to mitigate adverse effects of the project on those resources. To be assessed are the direct impacts to the vegetative cover types located in the proposed levee footprint, potential impacts to the aquatic ecosystem resulting from construction of a flood gate, and indirect impacts to the ecosystem that may result from construction of the proposed flood control structures. Consultation is also provided pursuant to Section 7 of the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*) (ESA). The project area is in the watershed of South River, located in the Towns of South River and Sayreville, Middlesex County, New Jersey (Figure 1).

The Service requests that no part of this report be used out of context, and if the report is reproduced, it should appear in its entirety. Furthermore, any data, opinions, figures, recommendations, or conclusions excerpted from this report should be properly cited and include the page number from which the information was taken. This report should be cited as follows:

> Urquhart, K. 2002. Assessment of the South River Flood Control and Ecosystem Restoration Project, Middlesex County, New Jersey. Draft Fish and Wildlife Coordination Act Section 2(b) Report, U.S. Department of the Interior, Fish and Wildlife Service, New Jersey Field Office, Pleasantville, New Jersey. 15 pp. + appendices.

Questions or comments regarding this report are welcomed by the Service. Written inquiries should be addressed to:

Supervisor
New Jersey Field Office, Ecological Services
U.S. Fish and Wildlife Service
927 North Main Street, Building D
Pleasantville, New Jersey 08232

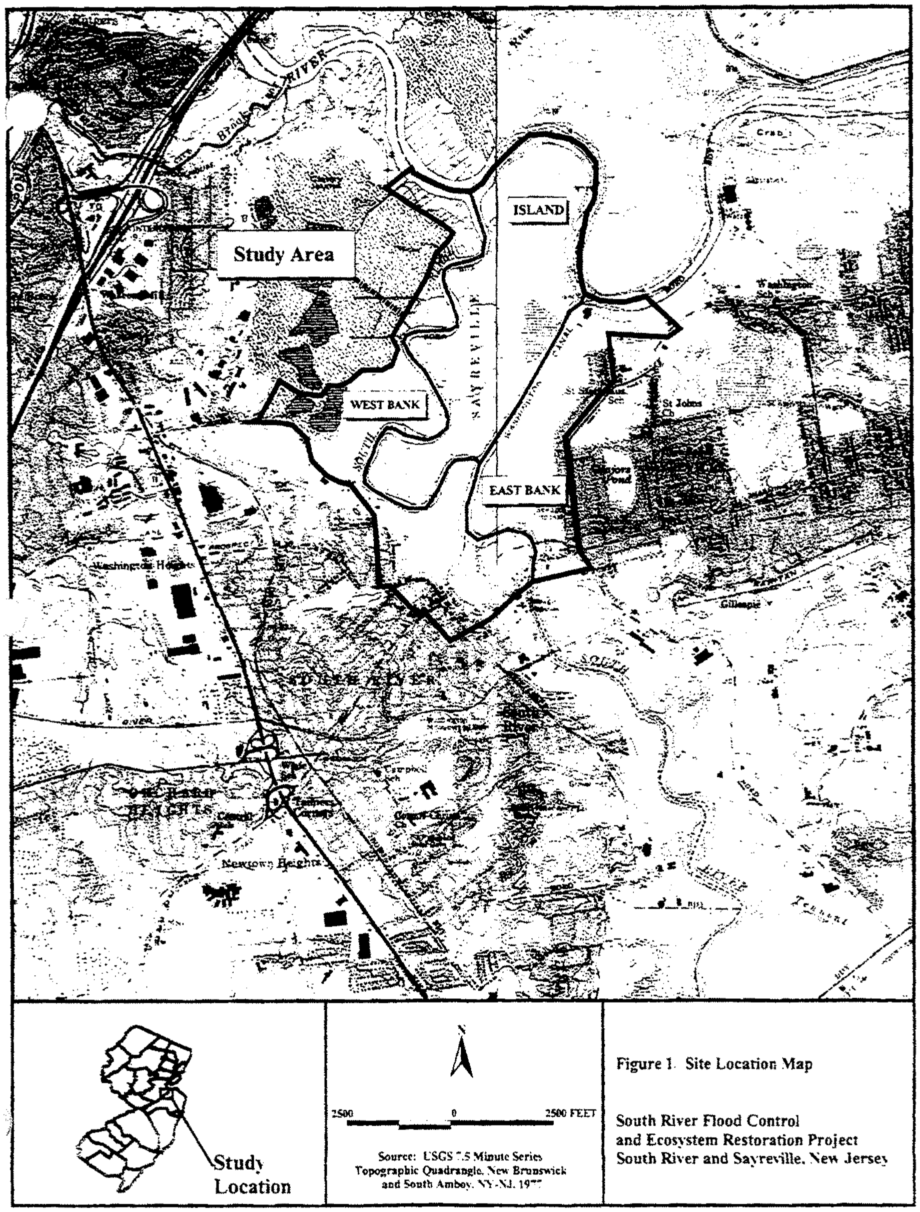

Figure 1. Site Location Map

South River Flood Control and Ecosystem Restoration Project South River and Sayreville, New Jersey

II. DESCRIPTION OF THE PROPOSED PROJECT

The Corps is conducting a feasibility study to evaluate solutions to the property damage associated with flooding along the South River in Middlesex County, New Jersey. The New Jersey Department of Environmental Protection (NJDEP) is the non-Federal sponsor for the South River feasibility study. The study was authorized by resolution of the U.S. House of Representatives Committee on Public Works and Transportation and adopted on May 13, 1993.

The selected plan for the flood control portion of the project consists of two components (Figure 2). The first component involves the construction of two earthen levees and a floodwall along the South River and Washington Canal channels and abutting residential and commercial areas. One levee, to be placed along the western edge of the South River Channel, will be approximately 5,750 feet long and will extend northward from the South River/Route 535 bridge to the South River landfill. A second levee, to be located along the eastern edge of the Washington Canal channel, will be approximately 6,000 feet long and will extend northward from the South River/Route 535 bridge. The floodwall will be 1,378 feet long and placed adjacent to a southeast portion of the South River. The second component involves placement of a flood gate across the South River channel just north of the South River/Route 535 bridge. The proposed project area encompasses approximately 1,196 acres, of which 785 acres consists of wetlands. Approximately 9.4 acres of wetland will be filled for levees, and the remaining wetland acres will be impacted by occasional flooding. The selected mitigation plan consists of converting 3.3 acres of common reed (*Phragmites australis*) (*Phragmites*) to salt marsh, 1.7 acres of *Phragmites* to wetland scrub/shrub for a total of 5 acres of enhancement. Wetland creation would occur on 6.1 acres of disturbed area (previously existing sidecast dredge material), which would become wetland scrub/shrub. The total of wetland enhancement and creation would equal 11.1 acres of compensatory mitigation for the 9.4 acres filled for levee construction with the recommended plan.

A separate component of the project is intended to evaluate several potential restoration alternatives designed to restore significant ecological components of the South River watershed. The purpose of the Ecosystem Restoration Project (ERP) is to restore biodiversity and ecological functions in the South River Flood Control and ERP area while satisfying federal, regional, State, and local interests. Although the flood control portion of the proposed project is also located in the South River area, the ecosystem restoration portion will not be used as compensatory mitigation for impacts associated with the flood control portion of the project. The area considered for restoration activities is approximately 380 acres of marsh, which is currently dominated by *Phragmites*. The ERP will use a combination of management practices, which include: restoring tidal flushing; lowering the marsh surface through excavation and removal of thatch material; using herbicides, burning, cutting, or mowing to eradicate *Phragmites* effectively in the project area; ensuring successful establishment of the targeted communities; and limiting further colonization by *Phragmites*.

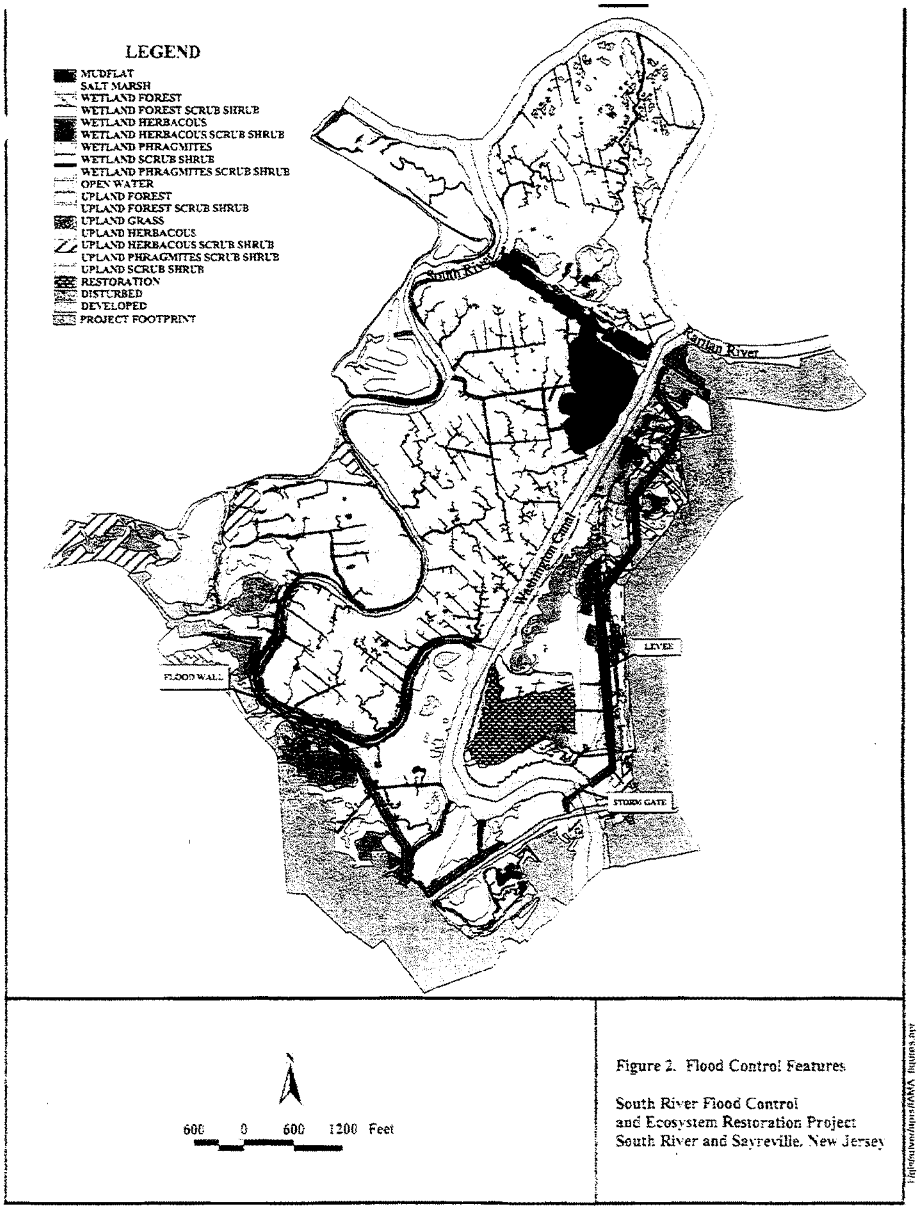

Figure 2. Flood Control Features

South River Flood Control
and Ecosystem Restoration Project
South River and Sayreville, New Jersey

III. METHODS

The information and findings presented in this report are based on the review of proposed project plans and other information provided by the Corps, including the South River, Raritan River Basin Multipurpose Feasibility Study, the South River, Raritan River Basin Multipurpose Reconnaissance Study (May 1995), the Final Project Scoping Document (June 1998), Draft Impact Assessment and Mitigation Analysis (August 2001), and the South River Ecosystem Restoration Project report (June 2001). The content of this report is also based on a review of Service files and material and site visits conducted by Service personnel.

The field investigation discussed in this report includes a Habitat Evaluations Procedures (HEP) study of fish and wildlife resources in the South River study area for both the flood control and ecosystem restoration components of the project. The purpose of the HEP study was to assess the value of the wetlands and uplands of the South River project area for targeted wildlife species and to assess the effects of the proposed projects on those species. This study was conducted in accordance with standard HEP methodology (U.S. Fish and Wildlife Service, 1980). The HEP study was conducted by Northern Ecological Associates, Inc. (NEA) based upon recommendations made by the HEP team, consisting of representatives from the Corps, the Service, the National Marine Fisheries Service, NJDEP and NEA. Briefly, HEP is used to assess habitat quality and quantity by multiplying a Habitat Suitability Index (HSI) by acreage to derive a Habitat Unit (HU) for individual species. The number of HU's gained or lost over time can be annualized (expressed as Average Annual Habitat Units [AAHU]) to provide relative comparisons of future with and without project conditions for a given evaluation species. A detailed discussion of the methods, results, and conclusions for the flood control and ecosystem restoration studies have been documented in separate reports (U.S. Army Corps of Engineers, 2001a; 2001b), and will not be repeated here.

To summarize, the evaluation species selected for the HEP study included: Black Duck (*Anas rubripes*), used to evaluate estuarine vegetated wetlands; Clapper Rail (*Rallus longirostris*), used to evaluate estuarine emergent and scrub/shrub wetlands; Marsh Wren (*Cistothorus palustris*), used to evaluate estuarine and palustrine emergent and scrub/shrub wetlands; American Woodcock (*Scolopax minor*), used to evaluate upland herbaceous, scrub/shrub and forested wetlands; Yellow Warbler (*Dendroica petechia*), used to assess deciduous shrub upland and deciduous scrub/shrub wetland; and eastern cottontail (*Sylvilagus floridanus*), which was selected to represent species using a variety of forested, scrub/shrub, and mixed cover types. The results of the HEP analysis were used in the development of an array of mitigation plans intended to offset identified detrimental impacts to wildlife habitats and communities from the flood control project, and to identify potential options for the ecosystem restoration component of the project.

To supplement the HEP, the Evaluation for Planned Wetlands (EPW) (Bartoldus *et al.*, 1994) assessment method was used to characterize and assess project impacts to other wetland values. The EPW provides a technique for determining a wetland's capacity to perform certain wetland functions by evaluating elements of six major wetland functions: shoreline bank erosion control, sediment stabilization, water quality, wildlife (general habitat values), fish (general habitat values), and uniqueness/heritage (*e.g.*, rarity, historical significance, park or sanctuary, habitat for endangered species, scientific value). The EPW analysis produces a numeric index to evaluate wetland functional benefits in terms of Functional Capacity Units (FCUs). The FCUs are used as a quantitative basis for wetland comparisons. The EPW method was designed to be used in conjunction with the HEP methodology to provide a more effective assessment of the quality of wetlands through an assessment of wetland functions and values in addition to wildlife habitat values.

IV. EXISTING CONDITIONS

A. PHYSICAL CHARACTERISTICS

The South River is located within the lower Raritan River basin in Middlesex County, New Jersey, and is the first major tributary of the Raritan River. The South River is formed by the confluence of Matchaponix and Manalapan Brooks, just upstream of Duhernal Lake, and flows northward from the Duhernal Lake Dam for a distance of approximately 7 miles. The South River flows through the townships of East Brunswick and Old Bridge, and the boroughs of South River and Sayreville, at which point it splits into two branches: South River and Washington Canal. Both branches continue their flow northward until they reach the Raritan River. The South River is tidally influenced from its mouth upstream to the Duhernal Lake Dam.

Long-term commercial and industrial activities in and around the South River Project area have led to the loss and degradation of the area's natural resources, resulting in a corresponding reduction in plant, animal, and habitat diversity and abundance. In addition, development-related factors have affected the project area through filling, channelization for mosquito control, introduction and encroachment of invasive plant species, and decreased water quality. The degradation and stress to plant communities in the project area have resulted in the conversion of natural brackish and salt marsh to monotypic stands of *Phragmites*, which do not support so diverse an assemblage of wildlife. As a result of disturbance and subsequent *Phragmites* invasion, diverse salt marsh communities are relatively rare in the project area. The overall study area encompasses approximately 1,276 acres. A total of 19 cover types, including 10 wetland/aquatic cover types, and nine non-wetland cover types, were identified within the South River flood protection component of the project area. Wetland plant communities account for 785 acres (61 percent) of the land cover. Of the vegetated cover types, wetland *Phragmites* dominates the site, comprising approximately 527 acres (41 percent) of the study area. Uplands account for the remaining 491 acres (39 percent), of which 234 (18 percent) acres are occupied by residential, commercial, and industrial development. Approximately 115 homes are located within the 100-year flood plain and 96 homes within the 10-year flood plain.

B. VEGETATION

As part of the interagency HEP study team, the Corps prepared detailed maps of the vegetative cover types within the project area. The draft HEP report prepared by the U.S. Army Corps of Engineers (2001a) provides a thorough description of the extent of various cover types identified in the study area. Major cover types are summarized below.

1. Wetlands

Four general wetland types, including estuarine, palustrine, riverine, and lacustrine (Cowardin *et al.*, 1979) are identified on the National Wetlands Inventory maps of the study area. Wetlands and deepwater sites within the project area include the South River and its tributaries and their adjacent wetlands, all of which are located in the Raritan River Basin. The U.S. Environmental Protection Agency (1994) has designated all tidally influenced estuarine wetlands within the boundaries of the Raritan Bay Estuary as priority wetlands, which are considered to be the most important and vulnerable wetlands in the State. Estuarine wetland systems consist of tidal, brackish waters and contiguous wetlands regularly or occasionally flushed with salt water (U.S. Army Corps of Engineers, 1995). Estuarine wetlands identified within the South River project area are classified as intertidal-emergent, intertidal-open water, and a combination of intertidal broad-leaved deciduous scrub/shrub and intertidal emergent wetlands. Intertidal emergent marsh is dominated either by smooth cordgrass (*Spartina alterniflora*) or saltmeadow cordgrass (*S. patens*), which represent the most salt-tolerant communities, or by *Phragmites*. The majority of the wetland areas located at the mouth of South River and the island between South River and Washington Canal consist of estuarine intertidal emergent wetlands dominated by *Phragmites*, with areas of smooth cordgrass, saltmeadow cordgrass, and spike grass (*Distichlis spicata*). Approximately 33 acres are disturbed by sidecast dredge material and remain sparsely vegetated.

Palustrine wetlands in the project area include all nontidal and tidally influenced freshwater (<0.5 ppt. salinity) wetlands. Considerable differences in vegetation types exist among palustrine wetlands due to hydrology, water chemistry, soils, and human disturbance (Tiner, 1987). Palustrine wetlands along the western shore at the mouth of the South River are classified primarily as palustrine open water areas with some broad-leaved scrub/shrub, broad-leaved forested, or a combination of both.

Riverine wetlands are restricted to the South River's freshwater channel from Duhernal Lake to the point downstream where salinity is consistently less that 0.5 ppt. These wetlands occur from the bank to deeper water, are not dominated by persistent vegetation and are classified as riverine tidal open water.

Approximately 142 acres of open water exist in the project area and consist of sparsely vegetated to unvegetated river and man-made canal channels and ditches. The major channels throughout the area have been historically dredged; however, dredging of either the South River or Washington Canal channels have not occurred for at least 50 years. Bank vegetation is dominated by dense stands of *Phragmites* and isolated areas of smooth cordgrass. Most ditches have steep banks, silt/mud substrate, and only flow intermittently. Vegetation along the ditches is typically comprised of *Phragmites*, groundsel tree (*Baccharis halimifolia*), arrowwood (*Viburnum dentatum*), and switchgrass (*Panicum virgatum*).

2. Uplands

A variety of upland cover types exist on the site, including *Phragmites* transitional areas, forest, scrub/shrub, herbaceous, grass, disturbed, and developed areas. Forest vegetation consists of oak (*Quercus spp.*), black cherry (*Prunus serotina*), and tree of heaven (*Ailanthus altissima*). Scrub/shrub vegetation consists of dense shrubs and some taller trees along the narrow drainage, including marsh elder (*Iva frutescens*), groundsel tree, northern bayberry (*Myruca pensylvanica*), gray birch (*Betula populifolia*), and multiflora rose (*Rosa multiflora*). Herbaceous species include goldenrod (*Solidago spp.*), aster (*Aster spp.*), and common ragweed (*Ambrosia artemisiifolia*).

C. WILDLIFE

Habitats for terrestrial wildlife species are restricted due to the highly developed condition of the area. Remaining habitats are limited to existing open marshes, upland and wetland scrub-shrub and forest fragments. A total of 48 bird species, 8 mammal species, 2 reptile species, and 1 species of amphibian were recorded by NEA (1999).

1. Mammals

Mammalian species recorded in upland habitats by NEA (1999) included Eastern cottontail (*Sylvilagus floridanus*), white-tailed deer (*Odocoileus virginianus*), Norway rat (*Rattus norvegicus*), house mouse (*Mus musculus*), northern red-backed vole (*Clethrionomys gapperi*), masked shrew (*Sorex cinereous*), and red fox (*Vulpes vulpes*). Muskrat (*Ondatra zibethicus*) were observed in emergent wetland areas.

2. Birds

The most abundant species observed included Marsh Wren, Red-Winged Blackbird (*Agelaius phoeniceus*), and Swamp Sparrow (*Melospiza melodia*), which were associated with wetland areas. American Tree Sparrow (*Spizella arborea*), American Goldfinch (*Carduelis tristis*), and Yellow-Rumped Warbler (*Dendroica coronata*) were also abundant in the project area. The State-listed Northern Harrier (*Circus cyaneus*) was seen hunting over the project area during the NEA (1999) surveys. Five of the HEP evaluation species are breeding birds. The New Jersey Division of Fish and Wildlife (NJDFW) (2002) rates the populations of Black Duck, Clapper Rail, Woodcock, and Yellow Warbler as "stable." Marsh Wren populations are rated as "decreasing" in New Jersey.

3. Reptiles and Amphibians

Reptiles and amphibians recorded during NEA's (1999) survey include Fowler's toad (*Bufo woodhousii fowleri*), snapping turtle (*Chelydra serpentina*), and diamondback terrapin (*Malaclemys terrapin*), in project area wetlands.

4. Fish

A total of 1,089 fish comprising 17 species were sampled from 26 sample sites in the project area by NEA (1998). White perch (*Morone americana*) was the dominant species, followed by Atlantic menhaden (*Brevoortia tryannus*), inland silverside (*Menidia beryllina*), and mummichog (*Fundulus heteroclitus*). Several invertebrates, including blue crabs (*Callinectes sapidus*), fiddler crabs (*Uca* spp.), and jellyfish were also sampled in the project area.

V. ENDANGERED AND THREATENED SPECIES

Endangered and threatened species and their habitats are afforded protection under Section 7(a)(2) of the ESA, which requires every federal agency, in consultation with the Service, to ensure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. An assessment of potential direct, indirect, and cumulative impacts is required for all federal actions that may affect listed species. Lists of federally listed and candidate species in New Jersey are included in Appendix A.

A review of Service records indicates that there are no known federally listed or proposed threatened or endangered species within the South River project area. However, occasional transients of the federally listed (threatened) Bald Eagle (*Haliaeetus leucocephalus*) pass through this area during both spring and fall migrations.

If additional information on federally listed or proposed species becomes available or project plans change, the above determinations may be reconsidered. Information on federally listed species and candidate species for federal listing is updated continually, and new species may be added to the list of threatened and endangered plants and animals. Therefore, if the selected plan is not implemented within 180 days, the Service recommends that the Corps contact the Service to obtain current information.

Except for an occasional Northern Harrier, no State-listed species are known to occur in the project area. A list of State-listed species is included in Appendix B. The New Jersey Natural Heritage Program (NHP) provides the most up-to-date data source for federal candidate species in the State, as well as maintaining information on State-listed species. If the project is not implemented within 180 days, the NHP should be contacted to ensure that information regarding State-listed species and any federal candidate species is up to date. The NHP is available at the following address:

Natural Heritage Program
Division of Parks and Forestry
CN 404
Trenton, New Jersey 08625

Should the NHP data search reveal the presence of any candidate species in the project area, the Service should be contacted to ensure that these species are not adversely affected by project activities.

VI. PROJECT IMPACTS AND RECOMMENDED MITIGATIVE MEASURES

A. FLOOD CONTROL PROJECT

1. Service Mitigation Policy

The Service's views and recommendations on this project are guided by its Mitigation Policy (Federal Register, Vol. 46, No. 15, January 23, 1981). This policy reflects the goal that the most important fish and wildlife resources should receive priority in mitigation planning. The term "mitigation" is defined as: (a) avoiding a negative impact altogether by not taking a certain action or parts of an action; (b) minimizing negative impacts by limiting the degree or magnitude of the action and its implementation; (c) rectifying the negative impact by repairing, rehabilitating, or restoring the affected environment; (d) reducing or eliminating negative impacts over time; and, (e) compensating for negative impacts by replacing or providing substitute resources or habitats.

The Service's recommendations are also guided by Executive Order 11988 and 11990 (Federal Register, Vol. 42, No. 100, May 24, 1977). Executive Order 11988 states that "each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by floodplains . . . ." Flood protection by levees, channel modification, and detention basins offer structural methods of flood control. Non-structural methods, including floodplain protection and preservation, should be examined as alternatives to structural flood control pursuant to Executive Order 11988.

Executive Order 11990 states that "each agency shall provide leadership and shall take action to minimize destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities for . . . . providing federally undertaken, financed, or assisted construction and improvements." Pursuant to Executive Order 11990, federal projects shall avoid undertaking or providing assistance for new construction located in wetlands unless there are no practicable alternatives and the proposed action includes all practicable measures to minimize loss of, or adverse impacts to, wetlands.

In accordance with the Mitigation Policy and the above-mentioned Executive Orders, the Service generally promotes non-structural alternatives such as floodplain acquisition and restoration, zoning restrictions, flood proofing, and early flood warning systems for flood protection in preference to structural solutions. Only floodplain reclamation offers permanent flood control. The current flooding in the South River project area is the direct result of a long history of unwise development in the floodplain. Flooding will continue to cause property damage, and the aquatic and terrestrial ecosystems will continue to suffer adverse effects, as long as floodplain development continues.

An evaluation of the social and economic considerations that led to the selection of the current plan over non-structural alternatives, such as floodplain acquisition, is beyond the purview of the Service or the scope of this report. The Service's focus throughout the current phase of the study has been on ensuring that the adverse environmental effects of the selected plan are minimized and that measures to compensate for any unavoidable impacts are included in the proposed plan.

2. Service Position on the use of HEP and EPW

The Service views both HEP and EPW as tools to assist in making decisions regarding the functions and values of wetlands and uplands within the study area. When implemented properly, these tools can assist biologists in evaluating potential impacts to target species that may occur from the proposed project. However, the use of these methods does not preclude the use of best professional judgement in assessing project impacts and evaluating compensatory mitigation. Mitigation often involves compensating for wetland functions or values other than the wildlife-related values assessable via HEP. The use of the EPW method may provide additional benefits in evaluating project impacts and mitigation requirements; however, Service staff have found the EPW methodology to be somewhat subjective, requiring discretionary estimates of broad indicators of wetland functions.

3. Project Impacts

Direct impacts to 9.4 acres of wetlands will result from the fill material required for construction of the levees. Levee construction will also impact 16.5 acres of uplands. Dredging activities to remove existing *Phragmites* areas will have temporary impacts to water quality including increased turbidity and a decrease of dissolved oxygen levels from suspended solids. Short-term disturbances to aquatic and terrestrial organisms will occur during construction. Construction of levees and installation of a flood gate on South River will result in additional adverse impacts on wetlands by preventing tidal waters from reaching areas landward of the structures, and by increasing the amount and duration of flood waters on the interior wetlands. The resulting changes in hydrology may alter the marsh; since both the mitigation site and the restoration site are located within the levees, such changes might affect mitigation and restoration efforts adversely.

Based on the results of the HEP, the selected project plan for the flood control project (before mitigation) will result in a loss of HUs over the no-action alternative for three of the six evaluation species. Over the project life, AAHUs would decrease for Clapper Rail (-3.18), Marsh Wren (-2.13), and Yellow Warbler (-5.49). A gain in AAHUs would be seen for Black Duck (+0.57), American Woodcock (+3.25), and Eastern cottontail (+5.91). Based on the results of the EPW, the selected project plan (before mitigation) will result in a loss for all functions measured. The uniqueness/heritage function has the highest FCU loss (-5.62), followed by sediment stabilization (-4.69), water quality (-4.54), shoreline bank (-2.75), fish (-2.24), and wildlife (-1.26).

4. Mitigation Goal

Using HEP and EPW methodology and protocols, the Corps' mitigation goal was to develop an array of alternative mitigation actions that will, either individually or together replace all of the HUs lost through time (AAHUs), and replace all of the FCUs at the time of their loss. The Corps defined "all" as the sum of AAHUs of each evaluation species, and the sum of FCUs of each function. Although the Corps preferred replacement of every HU lost per evaluation species and every FCU lost per function, the Corps expected trade-offs between the evaluation species' HUs and the FCUs for the different wetland functions in order to ensure that the selected mitigation plan is cost-effective and incrementally justified. As a benchmark, the Corps determined that at least 50 percent of the total HUs lost per evaluation species, and at least 50 percent of the FCUs lost per function, would be replaced (U.S. Army Corps of Engineers, 2001a).

Although HEP results are expressed in HUs, and annualized as AAHUs, for each evaluation species, the Service cautions that combining HUs for different species yields a meaningless sum. Due to the variation in habitat requirements for different species, adding HUs across species can result in habitat values being double-counted or canceled out. Rather, HUs or AAHUs should always be expressed as a unit for a given species. Similarly, adding FCUs from dissimilar functions would not yield a meaningful number or account for critical functions that may constitute limiting factors. The Service does agree with the overall goal, which is to select the mitigation plan that best compensates for lost habitat values for each of the evaluation species and each of the wetland functions. We also acknowledge that some trade-offs may be justifiable, depending on the regional importance of given evaluation species or the critical nature of a given wetland function. The HEP and EPW results remain as useful tools to gauge relative gains and losses for individual species and individual wetland functions, respectively.

As noted above, the Corps also used percentage loss or gain in HUs by species, and percentage loss or gain in FCUs by function, for relative comparison among plans. Percentages lost or gained may provide a useful gauge in assessing mitigative goals for individual species, but some caution is warranted in comparing percentage lost or gained among different species since usable area and before-project habitat suitability may differ considerably, as can regional importance.

5. Potential Mitigation Areas

a. Offsite Mitigation

A total of eight offsite areas were evaluated as potential mitigation sites. All were excluded because of their low potential for ecological improvement, acquisition issues, significant costs, and distance from the impact area (U.S. Army Corps of Engineers, 2001a).

b. Onsite Mitigation

Based on the results of the HEP and EPW impact assessments, mitigation options were evaluated in terms of their ability to fulfill the mitigation goal. Three potential mitigation options were identified to compensate for unavoidable adverse impacts from the South River flood control project:

- improvement / enhancement of the available habitat on the levees;
- improvement / enhancement of existing habitats; and,
- conversion of one habitat or cover type to another more valuable habitat or cover type.

Finally, cost-effective mitigative options were identified that would fulfill the mitigation goal of replacing at least 50 percent of lost HUs over time for evaluation species and at least 50 percent of the FCUs lost per function.

6. Selected Mitigation Plan

All mitigation activities are proposed for the East Bank area of the project site, adjacent to the New Jersey Department of Transportation mitigation site (Figure 3). The selected mitigation plan for the flood control project would include 5 acres of wetland enhancement and 6.1 acres of wetland creation. Specifically, the selected plan would convert 5.0 acres of *Phragmites* to 3.3 acres of salt marsh and 1.7 acres to wetland shrub/scrub. An additional 6.1 acres of disturbed areas would be converted to 6.1 acres of wetland scrub/shrub. The total 11.1 acres of compensatory mitigation would cost $1.47 million. Gains in HUs greater than 100 percent of the HUs lost would be realized for four evaluation species: American Black Duck (254 percent), Yellow Warbler (155 percent), eastern cottontail (749 percent), and American Woodcock (250 percent). Additionally, gains in HUs greater than 50 percent but less than 100 percent of the loss would be realized for the Clapper Rail (51 percent) and Marsh Wren (64 percent).

The replacement of FCUs for each function would also be met by the selected mitigation plan. Gains in total FCUs greater than 100 percent of the FCUs lost would be realized for five of the six wetland functions; shoreline bank (102 percent), water quality (110 percent), wildlife (641 percent), fish (118 percent), and uniqueness/heritage (116 percent). The shoreline stabilization function would realize an 88 percent gain in FCUs over those lost.

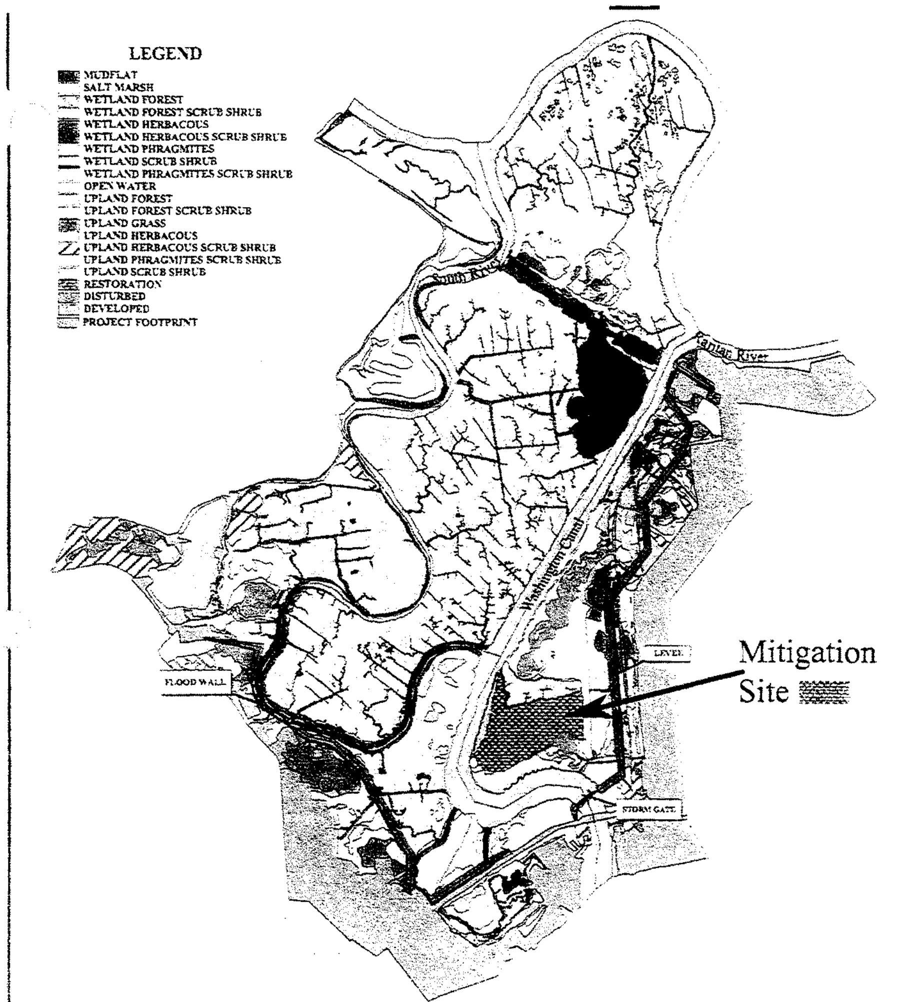

Figure 3. Mitigation Site
(for Flood Control Project)
South River Flood Control
and Ecosystem Restoration Project
South River and Sayreville, New Jersey

7. Service Recommendations

The Service generally concurs with selection of the recommended on-site mitigation plan over other alternatives; however, additional measures would further minimize or compensate for adverse impacts to the evaluation species and wetland functions and values. To ensure that habitat value losses for the evaluation species are short-term and minimal, the Service recommends implementing the proposed mitigation concurrently with construction of flood control features.

Implementation of the project, with mitigation included, will result in the loss of HUs for two evaluation species, Clapper Rail and Marsh Wren. As stated in the Draft Impact Assessment and Mitigation Analysis (U.S. Army Corps of Engineers, 2001a), the greatest benefit to Clapper Rail, without having a negative effect on other species, would be from conversion of disturbed areas to wetland. Marsh Wren habitat would also be improved by increasing the aerial coverage of emergent herbaceous vegetation. Therefore, both species would benefit from a greater amount of disturbed area being converted to wetland habitat. Since the Marsh Wren is rated by the NJDFW (2002) as decreasing in the State, the Service recommends additional consideration for this species.

To ensure that the AAHUs and FCUs are maintained as predicted over the life of the project, long-term monitoring is necessary. The Service has reviewed the Corps (2001a) proposed monitoring plan and generally concurs. If post-construction monitoring indicates re-invasion of *Phragmites,* improper hydology (from flood gates or other factors), or loss of target plant communities, remedial actions should be implemented. The Service and the New Jersey Division of Fish and Wildlife should be contacted for technical assistance and coordination if monitoring reveals any need for remedial measures. The Service requests copies of the monitoring reports.

B. ECOSYSTEM RESTORATION PROJECT

1. Project Benefits

Although the flood control portion of the proposed project is also located in the South River area, the Corps (2001b) has determined that the ecosystem restoration portion of the project will not be used as compensatory mitigation for impacts associated with the flood control portion of the project. The two actions are regarded as independent.

The area considered for restoration is approximately 380 acres, and includes the South River Project Area Island (Island) and an undeveloped marsh located adjacent to the western end of the Sayreville/South River bridge. The overall restoration area is bounded by the Washington Canal to the east, the South River to the west and south, and the Raritan River to the north (Figure 4).

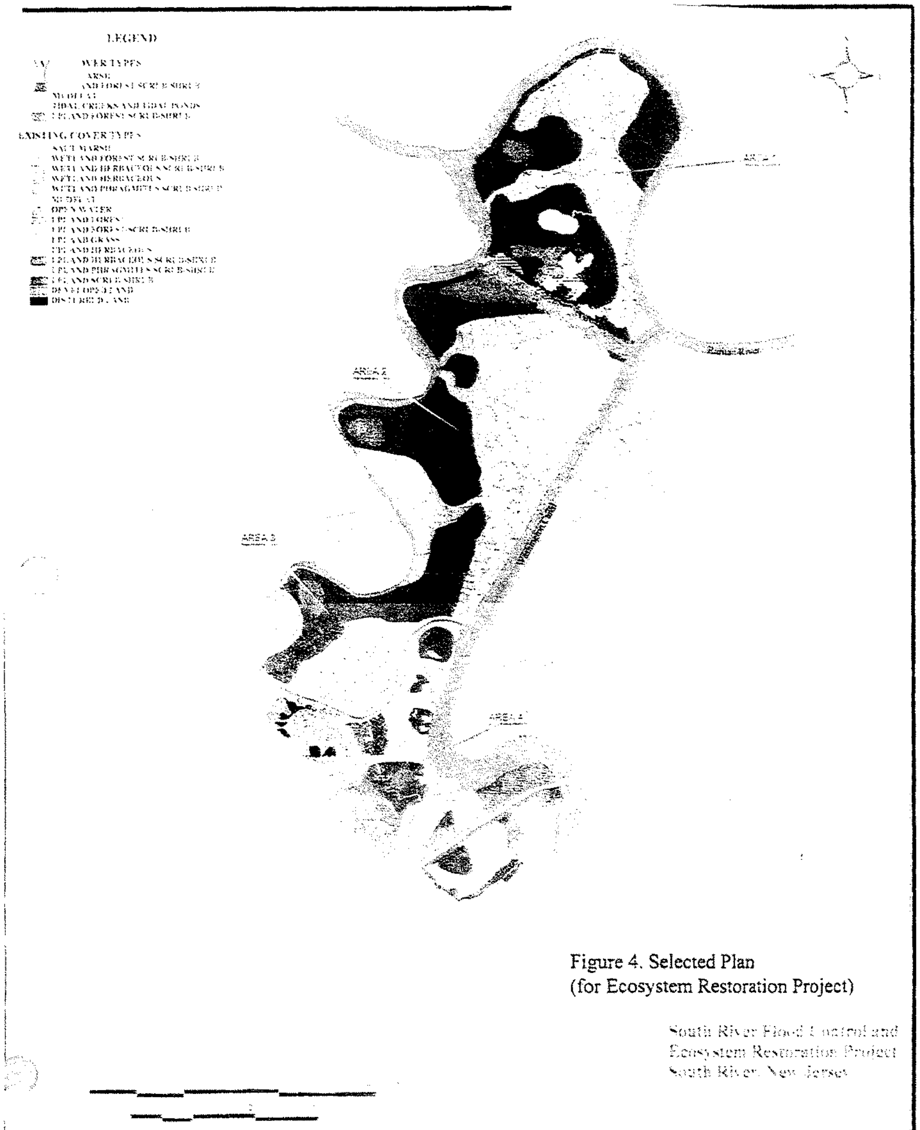

Figure 4. Selected Plan
(for Ecosystem Restoration Project)

South River Flood Control and
Ecosystem Restoration Project
South River, New Jersey

Although *Phragmites*-dominated marshes do provide some important ecological benefits such as water quality improvement and habitat for some bird species, widespread dominance of *Phragmites* results in the loss of other important wetland habitats, such as those provided by low and high emergent salt marshes and intertidal mudflats (Roman *et al.* 1984; Cross and Fleming, 1989; Sinicrope *et al.* 1990; U.S. Army Corps of Engineers, 1999a, b). *Phragmites*, because of its colonizing properties, is often characterized as an aggressive, invasive, nuisance wetland species (Chambers *et al.* 1998; Ailstock, 2000). Unlike dense monotypic stands of *Phragmites*, an ecosystem with an array of wetland plant species and community types supports a more diverse collection of birds, mammals, reptiles, and amphibians (U.S. Army Corps of Engineers, 2000a). Restoration of tidal salt marsh is feasible and would increase wildlife use of the area. Tidal salt marsh was once abundant, but is currently scarce along the Raritan River. Tidal saltwater marshes can support diverse and thriving communities that provide spawning and nursery habitats for commercially valuable anadromous fish and shellfish, as well as many species of waterfowl that nest and/or use the marsh as a migratory stopover. Ecological benefits include increasing habitat biodiversity, restoring under-represented wetland habitats, increasing tidal flushing of wetlands, and improving water quality. As a result, ecosystem restoration of the South River's *Phragmites*-dominated marsh would provide a significant contribution to the local and regional ecology of the New York metropolitan area.

The Corps selected ecosystem restoration plan would involve conversion of all of the wetland *Phragmites* cover type in the project area (379.3 acres) to 151.7 acres of low emergent marsh, 170.6 acres of wetland forest/scrub-shrub, 19.1 acres of mudflat, 19.1 acres of open water (9.55 acres tidal creek and 9.55 acres tidal pond), and 19.0 acres of upland forest/scrub-shrub. The final benefits analysis indicated that implementation of the ERP would result in a gain of AAHU's (ecological benefits) over the No-Action plan for Black Duck (+44.86), Eastern cottontail (+153.54), American Woodcock (+92.21) and Yellow Warbler (+108.82), but would result in a loss of AAHU's for Clapper Rail (-55.91) and Marsh Wren (-44.15). There would be an overall increase of a total of 116.2 FCUs for shoreline bank erosion control (+75.3), water quality (+10.9), wildlife (+29.8), and tidal fish (+47.6), with a loss only for the sediment stabilization function (-47.4). This loss is explained by the loss of the stabilizing value provided by the extensive root system of the existing *Phragmites* cover type.

2. Service Recommendations

As noted for the flood control portion of the project, the Service generally concurs with the proposed monitoring plan. The Service commends the Corps' efforts to restore 380 acres of *Phragmites*-dominated marsh to a functioning salt marsh ecosystem with diverse low and high marsh emergent and scrub/shrub plant communities that will benefit many species of fish and wildlife, particularly migratory waterfowl and shore birds. Monitoring is necessary to ensure the long-term success of these restoration efforts. The Service requests copies of the monitoring reports and recommends that the Corps coordinate with this office and the New Jersey Division of Fish and Wildlife if monitoring indicates a need for remedial actions.

VII. CONCLUSIONS AND SUMMARY OF RECOMMENDATIONS

The Service concludes that the proposed flood control project will result in minor adverse impacts to fish and wildlife resources, primarily due to the currently degraded conditions at the project site. Implementation of the ERP and wetland mitigation plan should improve fish and wildlife habitats by reducing the *Phragmites* monoculture and restoring a more diverse wetland ecosystem.

The goal of the Service throughout project planning has been to ensure avoidance or minimization of adverse environmental effects from the selected plan and that appropriate mitigative measures are incorporated into the final plan. The recommendations contained in this report contribute toward that end. The Service recommends the following:

1. Contact the Service to obtain current information on federally listed threatened and endangered species if the project is not implemented within 180 days.

2. Contact the New Jersey Natural Heritage Program for updated information on State-listed and federal candidate species in the project area if the project is not implemented within 180 days. Contact the Service if the NHP data search reveals new information regarding any federal candidate species in the project area.

3. Implement the mitigation plan for the flood control project concurrently with construction of flood control features to minimize short-term adverse impacts to fish and wildlife.

4. Evaluate additional conversion of the existing disturbed area to salt marsh. Implementation of both the flood control project and the ERP will result in a loss of HUs for the Clapper Rail and Marsh Wren. Marsh Wren populations are declining in New Jersey. Additional conversion of disturbed areas to wetland will benefit both Clapper Rail and Marsh Wren. Additionally, the selected mitigation plan for the flood control project would result in a net loss of wetland acreage (9.4 acres of wetland fill *vs.* 6.1 acres of restored disturbed areas). The remaining 5.0 acres of mitigation is considered to be enhancement, and although the habitat quality is improved by the enhancement, it does not add wetland acreage. To benefit Clapper Rail and Marsh Wren and to achieve no net loss of wetlands, the Service recommends additional conversion of approximately 3 acres of the existing disturbed area to emergent salt marsh.

5. Conduct long-term monitoring as proposed. The Service concurs with the proposed monitoring plan for both the flood control mitigation and the ERP. We also support the Corps' interest in conducting long-term post-construction monitoring, and encourage this effort to ensure that *Phragmites* does not re-invade, that the correct hydrology has been established, and that the fish and wildlife habitat values gained

are maintained over the life of the project. Remedial measures should be implemented if necessary to correct deficiencies in the results of the mitigation or restoration efforts (*e.g.*, re-invasion by *Phragmites*). Any corrective measures should be coordinated with the Service and the NJDFW. The Service requests copies of the monitoring reports.

VIII. LITERATURE CITED

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APPENDIX A

Federally listed endangered and threatened species
and candidate species in New Jersey

FEDERALLY LISTED ENDANGERED AND THREATENED SPECIES IN NEW JERSEY

An **ENDANGERED** species is any species that is in danger of extinction throughout all or a significant portion of its range.

A **THREATENED** species is any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

	COMMON NAME	SCIENTIFIC NAME	STATUS
FISHES	**Shortnose sturgeon***	*Acipenser brevirostrum*	E
REPTILES	**Bog turtle**	*Clemmys muhlenbergii*	T
	Atlantic Ridley turtle*	*Lepidochelys kempii*	E
	Green turtle*	*Chelonia mydas*	T
	Hawksbill turtle*	*Eretmochelys imbricata*	E
	Leatherback turtle*	*Dermochelys coriacea*	E
	Loggerhead turtle*	*Caretta caretta*	T
BIRDS	**Bald eagle**	*Haliaeetus leucocephalus*	T
	Piping plover	*Charadrius melodus*	T
	Roseate tern	*Sterna dougallii dougallii*	E
MAMMALS	**Eastern cougar**	*Felis concolor couguar*	E+
	Indiana bat	*Myotis sodalis*	E
	Gray wolf	*Canis lupus*	E+
	Delmarva fox squirrel	*Sciurus niger cinereus*	E+
	Blue whale*	*Balaenoptera musculus*	E
	Finback whale*	*Balaenoptera physalus*	E
	Humpback whale*	*Megaptera novaeangliae*	E
	Right whale*	*Balaena glacialis*	E
	Sei whale*	*Balaenoptera borealis*	E
	Sperm whale*	*Physeter macrocephalus*	E

	COMMON NAME	SCIENTIFIC NAME	STATUS
INVERTEBRATES	**Dwarf wedgemussel**	*Alasmidonta heterodon*	E
	Northeastern beach tiger beetle	*Cicindela dorsalis dorsalis*	T
	Mitchell saytr butterfly	*Neonympha m. mitchellii*	E+
	American burying beetle	*Nicrophorus americanus*	E+
PLANTS	**Small whorled pogonia**	*Isotria medeoloides*	T
	Swamp pink	*Helonias bullata*	T
	Knieskern's beaked-rush	*Rhynchospora knieskernii*	T
	American chaffseed	*Schwalbea americana*	E
	Sensitive joint-vetch	*Aeschynomene virginica*	T
	Seabeach amaranth	*Amaranthus pumilus*	T

STATUS:			
E	endangered species	PE	proposed endangered
T	threatened species	PT	proposed threatened
+	presumed extirpated**		

* Except for sea turtle nesting habitat, principal responsibility for these species is vested with the National Marine Fisheries Service.

** Current records indicate the species does not presently occur in New Jersey, although the species did occur in the State historically.

Note: for a complete listing of Endangered and Threatened Wildlife and Plants, refer to 50 CFR 17.11 and 17.12.

For further information, please contact:

U.S. Fish and Wildlife Service
New Jersey Field Office
927 N. Main Street, Building D
Pleasantville, New Jersey 08232
Phone: (609) 646-9310
Fax: (609) 646-0352

Revised 12/06/00

FEDERAL CANDIDATE SPECIES IN NEW JERSEY

CANDIDATE SPECIES are species that appear to warrant consideration for addition to the federal List of Endangered and Threatened Wildlife and Plants. Although these species receive no substantive or procedural protection under the Endangered Species Act, the U.S. Fish and Wildlife Service encourages federal agencies and other planners to give consideration to these species in the environmental planning process.

SPECIES	SCIENTIFIC NAME
Bog asphodel	*Narthecium americanum*
Hirst's panic grass	*Panicum hirstii*

Note: *For complete listings of taxa under review as candidate species, refer to* Federal Register *Vol. 64, No. 205, October 25, 1999 (Endangered and Threatened Wildlife and Plants; Review of Plant and Animal Taxa that are Candidates for Listing as Endangered or Threatened Species).*

Revised 11/99

APPENDIX B

State-listed endangered and threatened species in New Jersey

8/21/01

ENDANGERED AND THREATENED WILDLIFE OF NEW JERSEY

Endangered Species are those whose prospects for survival in New Jersey are in immediate danger because of a loss or change in habitat, over-exploitation, predation, competition, disease, disturbance, or contamination. Assistance is needed to prevent future extinction in New Jersey.

Threatened Species are those who may become endangered if conditions surrounding them begin to or continue to deteriorate.

BIRDS

Endangered

Pied-billed grebe, *Podilymbus podiceps**
American bittern, *Botaurus lentiginosus**
Bald eagle, *Haliaeetus leucocephalus*[BR]**
Northern harrier, *Circus cyaneus**
Northern goshawk, *Accipiter gentilis**
Red-shouldered hawk, *Buteo lineatus*[BR]
Peregrine falcon, *Falco peregrinus*
Piping plover, *Charadrius melodus***
Upland sandpiper, *Bartramia longicauda*
Roseate tern, *Sterna dougallii***
Least tern, *Sterna antillarum*
Black skimmer, *Rynchops niger*[BR]
Short-eared owl, *Asio flammeus**
Sedge wren, *Cistothorus platensis*
Loggerhead shrike, *Lanius ludovicianus*
Vesper sparrow, *Pooecetes gramineus*[BR]
Henslow's sparrow, *Ammodramus henslowii*

Threatened

Black-crowned night heron, *Nycticorax nycticorax**
Yellow-crowned night heron, *Nyctanassa violaceus*
Bald eagle, *Haliaeetus leucocephalus*[NB]**
Red knot, *Calidris canutus*
Osprey, *Pandion haliaetus**
Cooper's hawk, *Accipiter cooperii*
Red-shouldered hawk, *Buteo lineatus*[NB]
Black rail, *Laterallus jamaicensis*
Long-eared owl, *Asio otus*
Barred owl, *Strix varia*
Red-headed woodpecker, *Melanerpes erythrocephalus*
Black skimmer, *Rynchops niger*[NB]
Savannah sparrow, *Passerculus sandwichensis**
Grasshopper sparrow, *Ammodramus savannarum**
Bobolink, *Dolichonyx oryzivorus*
Vesper sparrow, *Pooecetes gramineus*[NB]

* Only breeding population considered endangered or threatened.
** Federally endangered or threatened.
[BR] Breeding population only.
[NB] Non-breeding population only.

REPTILES

Endangered

Bog turtle, *Clemmys muhlenbergi*
Atlantic hawksbill, *Eretmochelys imbricata***
Atlantic loggerhead, *Caretta caretta***
Atlantic ridley, *Lepidochelys kempi***
Atlantic leatherback, *Dermochelys coriacea***
Corn snake, *Elaphe g. guttata*
Timber rattlesnake, *Crotalus h. horridus*

Threatened

Wood turtle, *Clemmys insculpta*
Atlantic green turtle, *Chelonia mydas***
Northern pine snake, *Pituophis m. melanoleucus*

**Federally endangered or threatened

www.njfishandwildlife.com

8/21/01

AMPHIBIANS

Endangered

Tremblay's salamander, *Ambystoma tremblayi*
Blue-spotted salamander, *Ambystoma laterale*
Eastern tiger salamander, *Ambystoma t. tigrinum*
Pine Barrens treefrog, *Hyla andersonii*
Southern gray treefrog, *Hyla chrysoscelis*

Threatened

Long-tailed salamander, *Eurycea longicauda*
Eastern mud salamander, *Pseudotriton montanus*

MAMMALS

Endangered

Indiana bat, *Myotis sodalis***
Bobcat, *Lynx rufus*
Eastern woodrat, *Neotoma floridana*
Sperm whale, *Physeter macrocephalus***
Fin whale, *Balaenoptera physalus***
Sei whale, *Balaenoptera borealis***
Blue whale, *Balaenoptera musculus***
Humpback whale, *Megaptera novaeangliae***
Black right whale, *Balaena glacialis***

INVERTEBRATES

Threatened

Mitchell's satyr, *Neonympha m. mitchellii***
Northeastern beach tiger beetle, *Cicindela d. dorsalis*
American burying beetle, *Nicrophorus americanus***
Dwarf wedge mussel, *Alasmidonta heterodon***

**Federally endangered

FISH

Endangered

Shortnose sturgeon, *Acipenser brevirostrum***

List revisions:	March 29, 1979
	January 17, 1984
	May 6, 1985
	July 20, 1987
	June 3, 1991
	July 19, 1999

The lists of New Jersey's endangered and nongame wildlife species are maintained by the DEP's Division of Fish and Wildlife's Endangered and Nongame Species Program. These lists are used to determine protection and management actions necessary to ensure the survival of the state's endangered and nongame wildlife. This work is made possible through voluntary contributions received through Check-off donations to the Endangered Wildlife Conservation Fund on the New Jersey State Income Tax Form, the sale of Conserve Wildlife License Plates, and donations. For more information about the Endangered and Nongame Species Program or to report a sighting of endangered or threatened wildlife, contact: Endangered and Nongame Species Program, PO Box 400, Trenton, NJ 08625, or call (609) 292-9400.

www.njfishandwildlife.com

APPENDIX C

Coordination with the New Jersey Division of Fish and Wildlife

United States Department of the Interior

FISH AND WILDLIFE SERVICE
New Jersey Field Office
Ecological Services
927 North Main Street, Building D
Pleasantville, New Jersey 08232
Tel: 609/646 9310
Fax: 609/646 0352
http://njfieldoffice.fws.gov

In Reply Refer to:

FP-01/23

April 12, 2002

Robert McDowell, Director
New Jersey Division of Fish and Wildlife
CN 400
Trenton, New Jersey 08625

Dear Mr. McDowell:

Enclosed is the U.S. Fish and Wildlife Service's (Service) Draft Fish and Wildlife Coordination Act Report entitled, "Assessment of the South River Flood Control and Ecosystem Restoration Project, Middlesex County, New Jersey." This constitutes the Service's draft report on fish and wildlife impacts that can be expected to result from the Army Corps of Engineers (Corps) proposed plan. This report has been prepared pursuant to Section 2 (b) of the Fish and Wildlife Coordination Act (48 Stat. 401; as amended; 16 U.S.C. 661 *et seq.*) and is for inclusion in the Corps forth-coming Feasibility Report.

The Service's report contains an assessment of the proposed flood control and restoration projects and recommendations for protection of fish and wildlife resources. Please provide a letter of comment including indication of concurrence, or lack thereof, within 20 days from the date of this letter. If there are any questions concerning this report, please contact John Staples or Kathy Urquhart of my staff at (609) 646-9310, extensions 18 and 45, respectively. Thank you for your assistance in this matter.

Sincerely,

Clifford G. Day
Supervisor

Enclosure

PERTINENT CORRESPONDENCE

- **U.S. Fish and Wildlife Services (USFWS)**
- **New Jersey Department of Environmental Protection (NJDEP)**
- **National Marine Fisheries Services (NMFS)**
- **U.S. Environmental Protection Agency (USEPA)**
- **Miscellaneous**

U.S. FISH AND WILDLIFE SERVICE

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, N.Y. 10278–0090

REPLY TO
ATTENTION OF

December 17, 1998

Environmental Analysis Branch
Environmental Assessment Section

Mr. Clifford G. Day
Supervisor, New Jersey Field Office
U.S. Fish and Wildlife Service
Ecological Services, Region 5
927 North Main Street, Building D1
Pleasantville, New Jersey 08323

Re: Raritan River Basin, South River, New Jersey
Combined Flood Control and Environmental Restoration Project

Dear Mr. Day:

The U.S. Army Corps of Engineers, New York District (District) would like to initiate informal consultation with the U.S. Fish and Wildlife Service (Service) pursuant to Section 7 of the Endangered Species Act. A project scoping document is attached that briefly identifies possible solutions to reduce damages caused by flooding, the existing biological, ecological and cultural resources, and potential impacts that may be associated with possible solutions. The District intends to use the Habitat Evaluation Procedure (HEP) to assess impacts of the proposed project. An invitation to participate on the interagency HEP team will be forthcoming in the near future.

If you have any questions or would like additional information regarding the project, please contact Mark Burlas of my staff at either 212-264-4663 or e-mail at mark.h.burlas@nan02.usace.army.mil or fax at 212-264-6040. The District looks forward to working with the Service on this project.

Sincerely,

Frank Santomauro, P.E.
Chief, Planning Division

Attachment
Copy Furnished:
Mr. Bernard Moore, NJDEP

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
927 N. Main Street (Bldg. D1)
Pleasantville, New Jersey 08232
Tel: 609-646-9310
Fax: 609-646-0352

IN REPLY REFER TO:
ES-98/280

January 20, 1999

Frank Santomauro, Chief - Planning Division
U.S. Army Corps of Engineers, New York District
Jacob K. Javits Federal Building
New York, New York 10278-0090

Reference: Threatened and endangered species review for the proposed Combined Flood Control and Environmental Restoration Project, Raritan River Basin, South River, Middlesex County, New Jersey

The U.S. Fish and Wildlife Service (Service) has reviewed the proposed project(s) pursuant to Section 7 of the Endangered Species Act (ESA) (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*) to ensure the protection of federally listed and proposed endangered and threatened species. The following comments do not address all Service concerns for fish and wildlife and do not preclude separate review and comment afforded by other applicable environmental legislation.

Endangered species and their habitats are protected by Section 7(a)(2) of the ESA, which requires every federal agency, in consultation with the Service, to ensure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. An assessment of potential direct, indirect, and cumulative impacts is required for all federal actions that may affect listed species.

Potentially suitable habitat for the following federally listed or proposed endangered or threatened species occurs on or in the vicinity of the proposed project site(s):

Swamp pink (*Helonias bullata*)

To assist you in determining the potential impacts of the proposed project(s) on the above species, information regarding the species and its habitat is enclosed. If any such habitat will be disturbed, or if materials will be discharged into or upstream of such habitat, a survey of the project area(s) must be conducted by a qualified biologist to determine the species presence or absence. If the survey documents a federally listed or proposed species within the project area(s), an assessment of potential project impacts must also be completed. Project construction or implementation must not commence until the survey results and assessment of impacts have been forwarded to this office to determine if further consultation under Section 7 of the ESA is required. If you have any questions or require further assistance regarding threatened or endangered species, please contact this office.

Reviewing Biologist: Lisa P. Arroyo

Authorizing Supervisor: [signature]

Enclosures

Sect 7 (es-surv.ltr) rev. 5/6/98

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, N.Y. 10278-0090

REPLY TO ATTENTION OF

May 21, 1999

Environmental Analysis Branch
Environmental Assessment Section

Mr. Clifford G. Day
U.S. Fish and Wildlife Service
Ecological Services, Region 5
New Jersey Field Office
Pleasantville, New Jersey 08232

Re: South River, Raritan River Basin
Multi-Purpose Feasibility Study

Dear Mr. Day:

The U.S. Army Corps of Engineers, New York District (District) has initiated a multi-purpose feasibility study to identify a solution to reduce flood damages caused by tidal inundation and develop alternatives to ecologically restore degraded habitats. A project scoping document is attached that briefly identifies possible solutions, the existing biological, ecological and cultural resources, and potential impacts that may be associated with possible solutions.

The District intends to use the Habitat Evaluation Procedure (HEP) to assess impacts of the flood control component and to identify habitat unit outputs of ecological restoration alternatives. The HEP provides a quantitative assessment of relative value of wildlife habitats through a final numerical output that is technically defensible, replicable, and can be applied consistently in a variety of different habitat types. The HEP is based on combining a measure of habitat quantity with an index of habitat quality to determine habitat unit values. The underlying assumption of a HEP is that the habitat for a given wildlife species can be described by a Habitat Suitability Index (HSI) model.

To initiate the implementation of the HEP, the District would like to extend an invitation to your agency to participate on the interagency HEP team. The HEP involves obligatory attendance at many technical meetings that can last for most of a day; membership also includes significant coordination, fieldwork, and review and comment to HEP meeting minutes and technical documents. Accordingly, your decision to participate should reflect an obligation to allocate the essential amount of personnel time to accomplish each element of the HEP. A kick-off meeting to begin the HEP is scheduled for June 30, 1999 at Sandy Hook, New Jersey (see the attached meeting agenda).

The District would like to request written confirmation regarding your decision to participate on the interagency HEP team. In addition, I would appreciate your contacting Mark Burlas of my staff to inform him if you are planning to attend the HEP meeting. If you have any questions or would like additional information regarding the project, Mr. Burlas can be reached via telephone at 212-264-4663, e-mail at mark.h.burlas@nan02.usace.army.mil or fax at 212-264-6040. The District looks forward to working with the USFWS on this project.

Sincerely,

Frank Santomauro, P.E.
Chief, Planning Division

Attachments
Copy Furnished:
Mr. Bernard Moore, P.E.; NJDEP

USACE South River, New Jersey Project
Habitat Evaluation Procedures Meeting Agenda
National Marine Fisheries Service
James J. Howard Marine Science Laboratory
74 Magruder Road
June 30, 1999, 9:30 AM
Sandy Hook, New Jersey

I. **Project Overview**
- Present project purpose and objectives.
- Present potential solutions
- Update of scoping meeting results/comments.

II. **Presentation of Environmental Data**
- Review draft cover type map.
- Review draft wetland map.
- Address comments/questions.

III. **Preliminary Assessment of Natural Resources**
- Identify and discuss natural resources in the project area.
- Identify potential threatened/endangered species concerns.
- Identify potential environmental impacts (direct and indirect).
- Discuss state and federal regulatory issues/concerns.

IV. **Discussion of Habitat Evaluation Procedures (HEP)**
- Overview of HEP and its use for impact assessment/mitigation.
- Identify project-specific goals/objectives for HEP.
- Discuss membership and responsibilities (i.e., meetings, document review, etc.) of the HEP team.
- Initiate formulation of species selection criteria.

V. **Meeting Summary**
- Review the group/individual task assignments.
- Develop a schedule for completion and review of the various tasks.
- Schedule future group meetings and/or conference calls.

Lunch Break

VI. **Project Area Site Visit**
- Familiarize the group with the project area/boundaries.
- Visit areas of potential impact and/or concern.
- Update task assignments if necessary.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
927 North Main Street (Bldg. D1)
Pleasantville, New Jersey 08232

FP-99/029

June 21, 1999

Frank Santomauro, P.E.
Chief, Planning Division
New York District
U.S. Army Corps of Engineers
26 Federal Plaza
New York, New York 10278-0090

Dear Mr. Santomauro:

This responds to the U.S. Army Corps of Engineers (Corps) letter dated May 21, 1999, in which the Corps requested U.S. Fish and Wildlife Service participation in the Habitat Evaluation Procedures (HEP) study for the South River, Raritan River Basin Multi-Purpose Feasibility Study (Feasibility Study). The Feasibility Study would evaluate alternatives to prevent or reduce flooding of low-lying residential and commercial areas bordering the South River as well as evaluate the feasibility of restoring 250 acres of degraded coastal marsh bordering the Washington Canal and the South River. The study area is located along the South River in Middlesex County, New Jersey.

The Service intends to participate in the HEP study and attend the June 30, 1999 HEP study kickoff meeting at Sandy Hook, New Jersey. The Service looks forward to working with the Corps on both the HEP study and the Feasibility Study. Should you have any questions regarding these comments, please contact me or have your staff contact Thomas McDowell of my staff at (609) 646-9310.

Sincerely,

Clifford G. Day
Supervisor

CENAN-PL-FF 28 June 1999

MEMORANDUM FOR: Chief, Environmental Analysis Branch

SUBJECT: South River, Raritan River Basin, NJ Feasibility Study

1. Enclosed is a letter dated 21 June 1999, regarding the initial HEP Team meeting on 30 June 1999 for the above subject study.

2. At this time please provide a summary on the procedures that will be followed for the mitigation and restoration. I feel it is necessary at this time so we may circumvent any problems in the future.

3. The point of contact for this matter is Joseph Redican, Project Planner, at x5538.

EUGENE BRICKMAN, P.G.
Chief, Plan Formulation Branch

Enclosure

Burlas, Mark H NAN02

From: Robin Dingle [rdingle@neamaine.com]
Sent: Wednesday, March 22, 2000 4.32 PM
To: Burlas - Mark (E-mail)
Subject: FW: Swamp Pink

Mark - FYI

Subject: Re: Swamp Pink
Author: Tom McDowell at 5HA-NJFO
Date: 03/16/2000 3:13 PM

Robin,

You seem to have it correct. I am not worried about swamp pink and will say this in our FWCA reports.

Tom

______________________________ Reply Separator

Subject: Swamp Pink
Author: Robin Dingle <rdingle@neamaine.com> at FWS
Date: 03/15/2000 2:11 PM

Tom,

Mark Burlas and I were discussing the survey requirements for swamp pink in the Union Beach and South River project areas. It is my understanding that the swamp pink is not a concern for either project. Based on our previous discussions, it was determined that the South River levees are no longer proposed in the Old Bridge area and that the project is not likely to impact potential habitat. In addition, the Union Beach project area does not provide suitable and/or potential habitat.

Would you please let me know if there is any other requirements necessary for the swamp pink or if I have misunderstood our discussions.

Sincerely,
Robin Dingle

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, N.Y. 10278-0090

REPLY TO ATTENTION OF

November 8, 2000

Planning Division

Mr. Richard Kropp, P.E.
Director, Land Use Regulation Program
New Jersey Department of Environmental Protection
501 East State Street
P.O. Box 439
Trenton, New Jersey 08625-0439

Mr. Clifford G. Day
Supervisor, New Jersey Field Office
U.S. Fish and Wildlife Service
927 North Main Street, Building D
Pleasantville, New Jersey 08232

Mr. Stanley Gorski
National Marine and Fisheries Service
Habitat Conservation Division
James J. Howard Marine Sciences Laboratory
74 Magruder Road
Highlands, New Jersey 07732

Re: Raritan Bay – Sandy Hook Bay
Hurricane and Storm Damage Reduction Feasibility Study
Union Beach, New Jersey

Raritan River Basin
Flood Control and Ecosystem Restoration Feasibility Study
South River and Sayerville, New Jersey

Dear Mr. Kropp, Mr. Day and Mr. Gorski:

On behalf of the U.S. Army Corps of Engineers (USACE), New York District (District), I would like to take this opportunity to express my appreciation to the New Jersey Department of Environmental Protection (NJDEP), Land Use Regulation Program (LURP), the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) for your active participation in the ongoing Habitat Evaluation Procedure (HEP) and Evaluation of Planned Wetlands (EPW) analyses for the subject studies. In addition, I would also like to reaffirm our interagency team's commitment to the utilization of these evaluation tools for the subject studies.

As you are aware, the HEP and EPW have been agreed upon by our agencies as the assessment techniques to use to determine impacts. The units of measure to quantify impacts, which is the comparison of the No-Action alternative to the with project without mitigation alternative, are habitat units (HUs) and functional capacity units (FCUs). In order to compare impacts and mitigation strategies, USACE Regulations require the use of the same unit(s) of measure that were used to establish the impacts. Accordingly, the compensatory mitigation strategy is to identify alternative mitigation plans that would replace the HUs and FCUs that would be lost due to the implementation of the selected plan for each study area, which have yet to be identified. With regards to the South River/Sayerville study, the HU and FCU outputs of the ecosystem restoration component are considered independent and separate from compensatory mitigation to offset impacts caused by the implementation of the study's flood control component.

The USACE recognizes the importance of forming an interagency team early in the planning process to initiate a dialog to reach technical agreements and subsequent recommendations with regards to impacts and compensatory mitigation. As the lead Federal agency, recommendations from all interagency teams are subject to review and acceptance by USACE higher authority. The District believes in and welcomes a seamless government approach and is positive that common ground can be reached and built upon, should a divergence occur with regards to our respective institutional regulations and policies. I believe that our agencies via the HEP and EPW are heading in a unified direction.

Finally, the District looks forward to continued Federal and State partnerships and is confident that we can mutually agree with a plan that protects the Union Beach, South River and Sayerville communities from damages caused by hurricanes and floods, as well as restore the ecosystem that is associated with the South River. At this time, I am looking to reconfirm that HEP and EPW are the evaluation tools to determine impacts and develop recommendations for compensatory mitigation to replace the values and functions of the affected ecological and biological resources. If you have any questions, contact Mark Burlas of my staff at 212-264-4663.

Sincerely,

Frank Santomauro, P.E.
Chief, Planning Division

Copy Furnished:
Mr. Bernard Moore, P.E.; NJDEP

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Ecological Services
927 North Main Street (Bldg. D1)
Pleasantville, New Jersey 08232

Tel: 609-646-9310
FAX: 609-646-0352

IN REPLY REFER TO:

FP-00/065

December 19, 2000

Frank Santomauro, P.E.
Chief, Planning Division
New York District
U.S. Army Corps of Engineers
26 Federal Plaza
New York, New York 10278-0090

Re: Raritan Bay / Sandy Hook Bay Hurricane and Storm Damage Reduction Feasibility Study
Union Beach, New Jersey

Raritan River Basin Flood Control and Ecosystem Restoration Feasibility Study, South River and Sayerville, New Jersey

Dear Mr. Santomauro:

This responds to your letter of November 8, 2000, in which the U.S. Army Corps of Engineers, New York District (Corps) requested confirmation from the U.S. Fish and Wildlife Service (Service) that Habitat Evaluation Procedures (HEP) and Evaluation for Planned Wetlands (EPW) are suitable techniques for assessing impacts to wetlands associated with the referenced planning projects. Specifically, the Corps plans to use these two assessment methodologies as a tool for determining compensatory mitigation requirements for wetland impacts associated with the flood control components and to assess the benefits of the ecosystem restoration component.

I would like to take this opportunity to thank you and your staff for valuing Service participation in the Corps planning process. Additionally, I continue to find the working relationship between our agencies at the staff level to be professional, respectful, and productive. The maintenance of this good working relationship is a high priority for me and my staff.

AUTHORITY

The following comments provide technical assistance only and do not constitute comments by the Service as afforded by the Fish and Wildlife Coordination Act (48 Stat. 401; 16 U.S.C. 661 *et seq.*), nor do they preclude comment on any forthcoming environmental documents pursuant to the National Environmental Policy Act of 1969 as amended (83 Stat. 852; 42 U.S.C. 4321 *et seq.*).

SERVICE POSITION ON THE USE OF HEP AND EPW

The Service supports the Corps efforts to characterize wetland and upland functions and values in the two project areas using HEP and EPW. However, the use of both HEP and EPW does not preclude the use of best professional judgement in assessing project impacts and evaluating compensatory mitigation. The Service views both HEP and EPW as tools to assist in making decisions regarding the functions and values of wetlands and uplands within the study areas.

The HEP process, when implemented properly, can be a valuable tool to assist biologists in evaluating potential impacts to target species that would occur from the proposed projects. However, compensatory wetland mitigation often involves compensating for wetland functions and values other than the wildlife-related values assessable via HEP. The Service is uncertain whether the EPW study will provide additional insight into the functions or values of wetlands within the two study areas and aid in determining compensatory mitigation. Service staff participated in an on-site field trial of EPW and found the methodology to be subjective, requiring on-site estimates of broad indicators of wetland functions. The Service understands that the use of EPW was requested by the New Jersey Department of Environmental Protection.

HIGHER LEVEL OVERSIGHT

As you are aware, the HEP process is directed by a HEP team, which makes technical decisions, preferably via consensus, throughout the HEP study. The HEP team currently consists of two representatives of the Corps, and one representative each from the Service, the National Marine Fisheries Service, and the New Jersey Department of Environmental Protection's Land Use Regulation Program. The Corps Consultant, Northern Ecological Associates, provides valuable input to the HEP team regarding technical matters. Professional judgement in the field is required to conduct a meaningful HEP; therefore, the team concept is a critical component of the HEP process. Without support from the HEP team, any modifications to the HEP study and subsequent conclusions based on those modifications are not defensible.

In the November 8 letter, the Corps states that "...recommendations from all interagency teams are subject to review and acceptance by USACE [U.S. Army Corps of Engineers] higher authority." We interpret your November 8 letter to imply that higher level review may discount the recommendations of the HEP team. I am certain that you will agree such intervention is nonproductive to long-term trust and cooperation between our agencies. Such intervention does not promote the "seamless government approach" mentioned in your November 8 letter. We need to look for ways to build bridges and not walls to promote interagency conditions.

As you are aware, higher authority intervention previously occurred with regard to the Corps Raritan Bay and Sandy Hook Bay combined Flood Control and Shoreline Protection study at Port Monmouth, New Jersey. The interagency HEP team assembled for the Port Monmouth project was in near complete agreement on the results of the HEP study and necessary compensatory mitigation. However, higher level objections within the Corps invalidated the significant time and effort of the HEP team and devalued its efforts. Fortunately, the current HEP team members have continued to work very well together on the referenced projects. The incentive to cooperatively participate in such studies could become strained should such higher level objections within the Corps continue to occur after interagency consensus is reached at the District and Field Office level.

Should you have any questions regarding these comments, please contact me or have your staff contact Thomas McDowell of my staff at (609) 646-9310, extension 18.

Sincerely,

Clifford G. Day
Supervisor

Mela

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Ecological Services
927 North Main Street (Bldg. D1)
Pleasantville, New Jersey 08232

Tel: 609-646-9310
FAX: 609-646-0352

IN REPLY REFER TO:

FP-00/064

December 20, 2000

Frank Santomauro, P.E.
Chief, Planning Division
New York District
U.S. Army Corps of Engineers
26 Federal Plaza
New York, New York 10278-0090

Re: South River Restoration Screening Report
Flood Control and Ecosystem Restoration Project
South River, New Jersey

Dear Mr. Santomauro:

This responds to a request made by Josephine Axt, Ph.D. of your staff for the U.S. Fish and Wildlife Service (Service) to review and provide comments on the referenced document. The referenced screening report provides a description of potential restoration goals and identifies general strategies for meeting each goal. The Service fully supports the U.S. Army Corps of Engineers (Corps) efforts to restore habitats in the South River watershed. Since additional planning will occur prior to on-the-ground implementation of any restoration option discussed in the report, the Service requests continued involvement.

AUTHORITY

The following comments provide technical assistance only and do not constitute comments by the Service as afforded by the Fish and Wildlife Coordination Act (48 Stat. 401; 16 U.S.C. 661 *et seq.*), nor do they preclude comment on any forthcoming environmental documents pursuant to the National Environmental Policy Act of 1969 as amended (83 Stat. 852; 42 U.S.C. 4321 *et seq.*).

~~S~~PECIFIC COMMENTS

ne document is generally well written and thorough; however, the Service has identified some recommended changes to improve the document. These recommendations are listed below by page and paragraph number.

Pg. 1 Include an explanation of why ecosystem restoration options in the South River watershed are being evaluated.

Pg. 2, Par. 1 Add a statement to clarify that this proposed environmental restoration project is *not* compensatory mitigation for any proposed impacts associated with the Flood Control project discussed in this paragraph.

Pg. 2, Par. 2 Discuss how mosquito ditching has affected wetland hydrology and associated vegetation communities in the project area.

Pg. 6, Par. 2 This paragraph discussed impacts to wetlands associated with years of industrial activities. The Service recommends including a discussion regarding direct impacts (e.g., ditching, dredging, filling).

Pg. 22, Par 1 - Why the Corps views large areas of salt pan as being undesirable is unclear. These communities are a natural component of salt marsh systems and should be retained to provide habitat diversity.

Pg. 25, Par. 1 The citation "Zeff, 1999" does not appear in the literature cited section of the report.

Pg. 25, Par. 3 The Corps plans to construct broad and shallow channels through emergent marsh. Channels that would mimic natural channels, in regard to morphologic features such as sinuosity, slope, and width to depth ratio, would be more appropriate. Such natural channels are generally not broad and shallow. Such an appropriately constructed channel should remain stable and provide habitat for aquatic species, as well as transmit water to and from adjacent wetlands.

Pg. 26. Par. 2 Again, as stated above, it is unclear that low to moderate slopes of stream banks are appropriate or natural. The Service recommends surveying tidal creeks in the area to determine appropriate morphology.

Pg. 27, Par. 3 Examine the feasibility of constructing mud flats by filling open water rather than excavating existing wetlands. Specifically, it may be feasible to fill some areas of the historic South River channel near Clancy Island while maintaining the historic channel's integrity. The historic channel's size could be reduced because it does not discharge the same volume it historically did because flow is now diverted to the Washington Canal. It may be possible to fill some areas of the historic South River channel while compensating for the loss of open water by constructing tidal creeks within Clancy Island.

Pg. 34 The Corps discusses the feasibility of creating either upland or wetland forest / scrub-shrub communities via the disposal of dredged material generated from wetlands restoration activities. Such communities may provide wading bird nesting habitat. The Service views this dredged material disposal / habitat enhancement option as potentially viable; however, the Service recommends that the Corps minimize the area of wetland impacts and focus any impacts on low-quality wetlands or wetlands with the least probability of being successfully restored. We understand that uplands currently exist on Clancy Island, as well as at the fringe of other wetlands within the study area; therefore, disposal of excess material on existing uplands may be feasible. The Corps should also demonstrate that any functions and values lost as a result of creating uplands from wetlands have been compensated for by other components of the ecosystem restoration project.

Pg. 38, Par. 2 The point of this paragraph is not clear. The paragraph appears to assert that Durhernal Lake Dam on the South River did not cause the demise of anadromous fish in the South River; however, such an assertion is not justified within this paragraph. If anadromous fish are adversely affected by factors other than the dam, those factors should be identified along with potential corrective measures.

Pg. 40 The Corps discusses the potential of constructing permanently flooded tidal ponds as a habitat enhancement technique. However, from review of the document, the advantage of constructing tidal ponds rather than tidal creeks remains unclear. Tidal creeks would provide a more natural tidal marsh feature.

Pg. 43 The Corps discusses the option of creating a recreational park with dredged material. However, there is no discussion regarding what cover type would be filled with dredged material in order to construct the park. Additionally, construction of a recreational park is generally not considered ecosystem restoration.

Pg. 40 The difference between pans and tidal ponds should be identified, both from a structural and ecological perspective. Additionally, any proposals to eliminate large areas of wetlands by excavating ponds and disposing of dredged material by creating uplands from wetlands would not be desirable. Finally, the ecological benefits of constructing tidal ponds rather than tidal creeks should be explained.

Pg. 48 The Corps has ranked ecosystem restoration techniques for the study area. The Service is generally in agreement with the ranking technique employed and would encourage implementation of most of these techniques at appropriate sites within the study area. The Service notes, however, that construction of a fish ladder ranked low compared to other ecosystem restoration options. As discussed above, we recommend reevaluating the apparent conclusion that Durhernal Lake Dam was not the major contributor to the loss of anadromous fish from the South River system. If that conclusion were modified, fish ladder construction may rank higher as a potential ecosystem restoration technique.

Please continue to keep the Service involved in the South River flood control and ecosystem restoration project. The Service is especially interested in assisting the Corps with more detailed ecosystem restoration planning. Should you have any questions regarding these comments, please contact me or have your staff contact Thomas McDowell of my staff at (609) 646-9310, extension 45.

Sincerely,

Clifford G. Day
Supervisor

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

(939)

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, N.Y. 10278-0090

REPLY TO ATTENTION OF

July 8, 1998

Flood Control &
Navigation Section

Mr. Chris Jones
Section Chief, Land Use Regulation Program
New Jersey Department of Environmental Protection
501 East State Street
Trenton, New Jersey 08625-0600

Dear Mr. Jones:

I would like to thank you for meeting with members of my staff on June 22, 1998, at your offices in Trenton, New Jersey to discuss the South River, Raritan River Basin, Multi-Purpose Study. I have enclosed for your information a copy of our Memorandum For Record, dated June 29, 1998, which summarizes discussions held at the meeting.

We look forward to continued coordination with you and your staff, and would appreciate any comments you may have concerning this study. If you have any questions regarding this matter, please contact me or Mr. Joseph Redican, Project Planner, Flood Control and Navigation Section at (212) 264-5538.

Sincerely,

Frank Santomauro, P.E.
Chief, Planning Division

Encls

Copies Furnished:
Bernard J. Moore, New Jersey Department of Environmental Protection

CENAN-PL-FF

29 July 1998

MEMORANDUM FOR RECORD

SUBJECT: South River, Raritan River Basin - Meeting with the New Jersey Department of Environmental Protection

1. A meeting was held on 22 June 1998 at the office of the New Jersey Department of Environmental Protection in Trenton, New Jersey, to hold a pre-application meeting and discuss the current status of the South River Study. The following personnel were present at the meeting:

Name	**Office**	**Title**	**Phone Number**
Joseph H. Redican	USACE	Study Manager	212-264-5538
Robert Greco	USACE	Eng. Technical Manager	212-264-9080
Bob Alpern	USACE	Chief, H&H	212-264-9083
Walter Scott	USACE	Hydraulic Engineer	212-264-9083
Heather Bittner	USACE	Oceanographer	212-264-0248
Mark Burlas	USACE	Wildlife Biologist	212-264-4663
Chris Jones	NJDEP	Section Chief, Land Use Reg	609-633-6754

2. The Corps initiated this pre-application with the NJDEP to familiarize the Land Use Regulation Section with the flood control and environmental restoration components of the study. The Corps was looking to provide the State with information regarding the current formulation process and any input or direction they had regarding the alternatives. The Corps was also seeking to receive input from the State of New Jersey before any detailed analysis were completed so time and funds would not be wasted.

3. I stated that the current study is for both environmental restoration and flood control. I then began with a brief overview of the study and what were the results and purpose of the reconnaissance phase. I then began to describe the Corps process for formulation of alternatives and what alternatives we are currently evaluating. I stated that the current study is both a flood control and environmental restoration study.

4. I stated that the feasibility study will be recommending a combination of a flood control alternative and an environmental restoration alternative realizing savings in construction of the restoration component. There will be cost-savings due to the fact that the mitigation area and restoration area will be in the same vicinity and supervision and mob/demob costs will be less.

5. Mark Burlas then began to describe the purposes and function of the storm barrier plan and the potential environmental impacts it may have. He stated that the storm barrier will only be closed during times of excessive high tides and the mean-high-tide will still be maintained. It was noted that the barrier would both directly and

indirectly impact wetlands. This would be further evaluated during the formulation process.

6. Chris Jones stated that he is concerned with the direct and indirect wetland impacts from the barrier and would like to see the evaluation of an array of high and low tides with the current modeling and a comparison of the with and with-out project conditions. He would also look for the Corps to try and avoid and minimize the impacts. He noted that even though the wetland areas are of lower value in this area it is still a wetland.

7. If the storm barrier alternative is chosen then the Corps may need to perform a water quality analysis. This is dependent on the change of water elevations, if any, with the barrier in place. The hydraulic data may be available to negate the need for a water quality analysis.

8. Bob Alpern then stated that the Corps is currently evaluating the necessity of the pump station with the storm barrier, as there may be sufficient storage area behind the storm barrier. This will greatly decrease the current cost estimates for this alternative and lessen the direct wetland impacts.

9. I then began to discuss in more detail the levee alternatives for the project area. I stated that our investigations have indicated that there are no feasible structural alternatives for reaches 1,2 & 5. The Corps has evaluated the best case structural alternative for the areas and they were not justified.

10. Mark Burlas and Walter Scott then began to describe the levee alignments that were recommended in the reconnaissance study. Walter Scott then added that we have updated the costs for these levees and the wetland impacts. He also showed the proposal for laid back levees along both reaches.

11. Bob Alpern then stated that in the State of Florida there have been projects where levees have been constructed along riverbanks and pump stations maintain the wetlands by controlling the levels of water behind them. Mark Burlas stated that in the area of levee reach 4 the wetlands are of poor quality and if the levels of water can be maintained then this would enhance the quality of the wetland. This idea has not been used in New York District but may be a viable option for this area. Mr. Burlas agreed with this assumption.

12. Chris Jones stated that his agency is only concerned over the direct and indirect impacts of the levees and would rather see the wetlands left naturally then having to be maintained. The associated operation and maintenance will also continue to have an associated cost with the state and locals.

13. The Corps then stated that we will concentrate on set back levees and prepare a summary table that shows the potential levee layouts with the wetlands directly and indirectly impacted. The associated costs would also be shown in this summary table.

14. Chris Jones then stated that the project falls under several different statutes, which include Freshwater Wetlands Act of 1988, Tidal Wetland Act of 1970, Flood Hazard Area Control Act, and Waterfront Development Act of 1980. He stated that if the project area is included on Tidal Wetland Maps of 1980 maps then it falls under this act.

15. The Corps will request that the NJDEP research these maps and inform us if they are included under Wetlands Act of 1970.

16. The meeting concluded with the Corps stating that a summary table will be prepared and submitted to the NJDEP for review. The Corps also requested that additional meetings be held so that an effective and acceptable plan be formulated,

17. The point of contact for this matter is the undersigned at (212) 264-5538.

Joseph H. Redican
Study Manager
Flood Control & Navigation Section

CF:
Blum/Brickman
Alpern/Greco/Scott
Bittner/Burlas
Jones/Moore - NJDEP

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, N.Y. 10278-0090

REPLY TO
ATTENTION OF

December 17, 1998

Environmental Analysis Branch
Environmental Assessment Section

Ms. Ruth Ehinger
Chief, Bureau of Coastal Regulations
New Jersey Department of Environmental Protection
501 East State Street
P.O. Box 439
Trenton, New Jersey 08625-0439

Re: Raritan River Basin, South River, New Jersey
Combined Flood Control and Environmental Restoration Project

Dear Ms. Ehinger:

The U.S. Army Corps of Engineers, New York District (District) would like to initiate informal consultation with the New Jersey Department of Environmental Protection (NJDEP) concerning the possible effect to State-listed threatened and endangered species at or adjacent to the project area. I believe that early coordination with your office regarding this matter will facilitate the appropriate effort needed to fully address this Coastal Zone Management policy

A project scoping document is attached that briefly identifies possible solutions to reduce damages caused by flooding, the existing biological, ecological and cultural resources, and potential impacts that may be associated with possible solutions. The District intends to use the Habitat Evaluation Procedure (HEP) to assess impacts of the proposed project. An invitation to participate on the interagency HEP team will be forthcoming in the near future.

If you have any questions or would like additional information regarding the project, please contact Mark Burlas of my staff at either 212-264-4663 or e-mail at mark.h.burlas@nan02.usace.army.mil or fax at 212-264-6040. The District looks forward to working with your office on this project.

Sincerely,

Frank Santomauro, P.E.
Chief, Planning Division

Attachment
Copy Furnished:
Mr. Bernard Moore, NJDEP

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, N.Y. 10278-0090

REPLY TO ATTENTION OF

December 17, 1998

Environmental Analysis Branch
Environmental Assessment Section

Mr. Kurt Kalb
Section Chief, Bureau of Coastal Regulations
New Jersey Department of Environmental Protection
501 East State Street
P.O. Box 439
Trenton, New Jersey 08625-0439

Re: Raritan Bay and Sandy Hook Bay
Combined Flood Control and Shore Protection Project
Union Beach, Monmouth County, New Jersey

Dear Mr. Kalb:

The U.S. Army Corps of Engineers, New York District (District) would like to take this opportunity to thank you for deciding to participate on the subject project's interagency Habitat Evaluation Procedures (HEP) team. The District looks forward to working with your office on this project.

At the HEP "kick-off" meeting, there was a discussion concerning the possible effect to State-listed threatened and endangered species at or adjacent to the project area. Accordingly, the District would like to initiate consultation with your office concerning State-listed threatened and endangered species. I believe that early coordination with your office regarding this matter will facilitate the appropriate effort needed to fully address this Coastal Zone Management policy.

If you have any questions or desire additional information, please contact Mark Burlas from my office at 212-264-4663.

Sincerely,

Frank Santomauro, P.E.
Chief, Planning Division

Copy Furnished
Mr. Bernard Moore, NJDEP

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, N.Y. 10278-0090

REPLY TO ATTENTION OF

March 15, 1995

Environmental Analysis Branch
Environmental Assessment Section

Mr. James Hall
Assistant Commissioner for Natural and Historic Resources
Deputy Chief Historic Preservation Officer
Historic Preservation Office
New Jersey Department of Environmental Protection
CN 404
Trenton, New Jersey 08625

Attention: Mr. Jonathan Gell

Dear Mr. Hall,

The U.S. Army Corps of Engineers, New York District (Corps), is studying the feasibility of implementing a flood control project along the South River from its confluence with the Raritan River to Duhernal Lake, in the Townships of East Brunswick and Old Bridge and the Boroughs of Sayreville, South River and Spotswood, Middlesex County, New Jersey. Proposed plans consist of several configurations of levees, flood gates and limited stream channel changes.

The attached cultural resource reconnaissance report is largely based on an earlier Corps project, the Lower Raritan River Multipurpose Study, the cultural resource component of which was conducted by Louis Berger & Associates, Inc. The Lower Raritan work was reviewed by your office in 1982 and comments were issued at that time (Attachment 2).

On the basis of current project plans and pending review by your office, the Corps is of the opinion that the area is sensitive for both prehistoric and historic resources. Further historical research and archaeological testing is recommended to determine the eligibility of sites present in the areas of project impact. Please provide us with section 106 comments as pursuant to 36 CFR 800.5.

If you or your staff require additional information or have any questions, please contact Lynn Rakos, Project Archaeologist, (212) 264-4663. Thank you for your assistance.

Sincerely,

Stuart Piken, P.E.
Chief, Planning Division

Attachments

HENN

State of New Jersey

Christine Todd Whitman
Governor

Department of Environmental Protection
Division of Parks and Forestry
Historic Preservation Office
CN-404
Trenton, N.J. 08625-0404
TEL: (609) 292-2023
FAX: (609) 984-0578

Robert C. Shinn, Jr.
Commissioner

HPO-H95-157
August 17, 1995

Mr. Stuart Piken, P.E.
Chief, Planning Division
Department of the Army New York District
Corps of Engineers
Jacob K. Javits Federal Building
New York, NY 10278-0090

Subject: Middlesex County, East Brunswick, Old Bridge, Sayreville, South River, Spotswood
Flood control project along the South River from its confluence with the Raritan River to Duhernal Lake

Attn: Lynn Rakos, Project Archaeologist

Dear Mr. Seebode:

Thank you for having provided the opportunity to review the results from the cultural resource reconnaissance for the South River Flood Control Project. I concur that on the basis of the identification of the numerous historic and prehistoric resources within the area of potential project impact that additional historical research and archaeological testing should be undertaken to determine eligibility of resources within the project impact zone.

I look forward to the results of this work and to our further consultation pursuant to Section 106. Thank you once again for having provided this opportunity for review and comment. If you have any questions, please contact Deborah Fimbel, current staff archaeologist for this project.

Sincerely,

Dorothy P. Guzzo

Dorothy Guzzo
Deputy State Historic
Preservation Officer

DG:DF
C:\WD\pw\106\951029

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DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, N.Y. 10278-0090

REPLY TO ATTENTION OF

May 21, 1999

Environmental Analysis Branch
Environmental Assessment Section

Ms. Ruth Ehinger
Manager, Bureau of Coastal Regulations
New Jersey Department of Environmental Protection
501 East State Street
P.O. Box 439
Trenton, New Jersey 08625-0439

Re: South River, Raritan River Basin
Multi-Purpose Feasibility Study

Dear Ms. Ehinger:

The U.S. Army Corps of Engineers, New York District (District) has initiated a multi-purpose feasibility study to identify a solution to reduce flood damages caused by tidal inundation and develop alternatives to ecologically restore degraded habitats. A project scoping document is attached that briefly identifies possible solutions, the existing biological, ecological and cultural resources, and potential impacts that may be associated with possible solutions.

The District intends to use the Habitat Evaluation Procedure (HEP) to assess impacts of the flood control component and to identify habitat unit outputs of ecological restoration alternatives. The HEP provides a quantitative assessment of relative value of wildlife habitats through a final numerical output that is technically defensible, replicable, and can be applied consistently in a variety of different habitat types. The HEP is based on combining a measure of habitat quantity with an index of habitat quality to determine habitat unit values. The underlying assumption of a HEP is that the habitat for a given wildlife species can be described by a Habitat Suitability Index (HSI) model.

To initiate the implementation of the HEP, the District would like to extend an invitation to your agency to participate on the interagency HEP team. The HEP involves obligatory attendance at many technical meetings that can last for most of a day; membership also includes significant coordination, fieldwork, and review and comment to HEP meeting minutes and technical documents. Accordingly, your decision to participate should reflect an obligation to allocate the essential amount of personnel time to accomplish each element of the HEP.

A kick-off meeting to begin the HEP is scheduled for June 30, 1999 at Sandy Hook, New Jersey (see the attached meeting agenda).

The District would like to request written confirmation regarding your decision to participate on the interagency HEP team. In addition, I would appreciate your contacting Mark Burlas of my staff to inform him if you are planning to attend the HEP meeting. If you have any questions or would like additional information regarding the project, Mr. Burlas can be reached via telephone at 212-264-4663, e-mail at mark.h.burlas@nan02.usace.army.mil or fax at 212-264-6040. The District looks forward to working with the NJDEP, Bureau of Coastal Regulations on this project.

Sincerely,

Frank Santomauro, P.E.
Chief, Planning Division

Attachments
Copy Furnished:
Mr. Bernard Moore, P.E.; NJDEP

USACE South River, New Jersey Project
Habitat Evaluation Procedures Meeting Agenda
National Marine Fisheries Service
James J. Howard Marine Science Laboratory
74 Magruder Road
June 30, 1999, 9:30 AM
Sandy Hook, New Jersey

I. **Project Overview**
- Present project purpose and objectives.
- Present potential solutions
- Update of scoping meeting results/comments.

II. **Presentation of Environmental Data**
- Review draft cover type map.
- Review draft wetland map.
- Address comments/questions.

III. **Preliminary Assessment of Natural Resources**
- Identify and discuss natural resources in the project area.
- Identify potential threatened/endangered species concerns.
- Identify potential environmental impacts (direct and indirect).
- Discuss state and federal regulatory issues/concerns.

IV. **Discussion of Habitat Evaluation Procedures (HEP)**
- Overview of HEP and its use for impact assessment/mitigation.
- Identify project-specific goals/objectives for HEP.
- Discuss membership and responsibilities (i.e., meetings, document review, etc.) of the HEP team.
- Initiate formulation of species selection criteria.

V. **Meeting Summary**
- Review the group/individual task assignments.
- Develop a schedule for completion and review of the various tasks.
- Schedule future group meetings and/or conference calls.

Lunch Break

VI. **Project Area Site Visit**
- Familiarize the group with the project area/boundaries.
- Visit areas of potential impact and/or concern.
- Update task assignments if necessary.

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, N.Y. 10278-0090

REPLY TO ATTENTION OF

May 21, 1999

Environmental Analysis Branch
Environmental Assessment Section

Mr. Robert McDowell
Director, Division of Fish, Game and Wildlife
New Jersey Department of Environmental Protection
501 East State Street
CN 400
Trenton, New Jersey 08625-0400

Re: South River, Raritan River Basin
Multi-Purpose Feasibility Study

Dear Mr. McDowell:

The U.S. Army Corps of Engineers, New York District (District) has initiated a multi-purpose feasibility study to identify a solution to reduce flood damages caused by tidal inundation and develop alternatives to ecologically restore degraded habitats. A project scoping document is attached that briefly identifies possible solutions, the existing biological, ecological and cultural resources, and potential impacts that may be associated with possible solutions.

The District intends to use the Habitat Evaluation Procedure (HEP) to assess impacts of the flood control component and to identify habitat unit outputs of ecological restoration alternatives. The HEP provides a quantitative assessment of relative value of wildlife habitats through a final numerical output that is technically defensible, replicable, and can be applied consistently in a variety of different habitat types. The HEP is based on combining a measure of habitat quantity with an index of habitat quality to determine habitat unit values. The underlying assumption of a HEP is that the habitat for a given wildlife species can be described by a Habitat Suitability Index (HSI) model.

To initiate the implementation of the HEP, the District would like to extend an invitation to your agency to participate on the interagency HEP team. The HEP involves obligatory attendance at many technical meetings that can last for most of a day; membership also includes significant coordination, fieldwork, and review and comment to HEP meeting minutes and technical documents. Accordingly, your decision to participate should reflect an obligation to allocate the essential amount of personnel time to accomplish each element of the HEP.

A kick-off meeting to begin the HEP is scheduled for June 30, 1999 at Sandy Hook, New Jersey (see the attached meeting agenda).

The District would like to request written confirmation regarding your decision to participate on the interagency HEP team. In addition, I would appreciate your contacting Mark Burlas of my staff to inform him if you are planning to attend the HEP meeting. If you have any questions or would like additional information regarding the project, Mr. Burlas can be reached via telephone at 212-264-4663, e-mail at mark.h.burlas@nan02.usace.army.mil or fax at 212-264-6040. The District looks forward to working with the NJDEP, Division of Fish, Game and Wildlife on this project.

Sincerely,

Frank Santomauro, P.E.
Chief, Planning Division

Attachments
Copy Furnished:
Mr. Bernard Moore, P.E.; NJDEP

USACE South River, New Jersey Project
Habitat Evaluation Procedures Meeting Agenda
National Marine Fisheries Service
James J. Howard Marine Science Laboratory
74 Magruder Road
June 30, 1999, 9:30 AM
Sandy Hook, New Jersey

I. Project Overview
- Present project purpose and objectives.
- Present potential solutions
- Update of scoping meeting results/comments.

II. **Presentation of Environmental Data**
- Review draft cover type map.
- Review draft wetland map.
- Address comments/questions.

III. **Preliminary Assessment of Natural Resources**
- Identify and discuss natural resources in the project area.
- Identify potential threatened/endangered species concerns.
- Identify potential environmental impacts (direct and indirect).
- Discuss state and federal regulatory issues/concerns.

IV. **Discussion of Habitat Evaluation Procedures (HEP)**
- Overview of HEP and its use for impact assessment/mitigation.
- Identify project-specific goals/objectives for HEP.
- Discuss membership and responsibilities (i.e., meetings, document review, etc.) of the HEP team.
- Initiate formulation of species selection criteria.

V. **Meeting Summary**
- Review the group/individual task assignments.
- Develop a schedule for completion and review of the various tasks.
- Schedule future group meetings and/or conference calls.

Lunch Break

VI. **Project Area Site Visit**
- Familiarize the group with the project area/boundaries.
- Visit areas of potential impact and/or concern.
- Update task assignments if necessary.

State of New Jersey
Department of Environmental Protection

Christine Todd Whitman
Governor

Robert C. Shinn, Jr.
Commissioner

Division of Fish, Game and Wildlife
Robert McDowell, Director
P.O. Box 400
Trenton, NJ 08625-0400
www.nj.us/dep/fgw

June 25, 1999

Department of the Army
New York District, Corps of Engineers
Jacob K. Javits Federal Building
New York, NY 10278-0090
Attn.: Frank Santomauro, P.E.

Dear Mr. Santomauro:

Reference is made to your letter of May 21, 1999 inviting the Division of Fish, Game and Wildlife [DFGW] to participate in a Habitat Evaluation Procedure [HEP] study for the South River Multi-Purpose Feasibility Study. Please know that Division staff is fully committed at this time and we cannot participate in the proposed HEP. However, as always, we will provide whatever other assistance / recommendations we can relative to fish and wildlife interests and resources.

The DFGW notes with interest that the project plans have not changed since we had provided input on this project at a meeting in Sandy Hook [NMFS] on November 20, 1997. At that time, the DFGW as well as the USFWS recommended a redesign of the project to move levees inland or out of the marshes and to consider partial buy-outs of some flood-prone areas either as a way to move levees or to eliminate problem structures. It is somewhat discouraging to note that recommended measures to avoid and / or minimize impacts to existing natural resources have not been incorporated into the current scoping document. Further, it would appear that such alternatives to the project scope are needed in order to provide better options on which to evaluate a HEP analysis.

We hope this information is of service to you. If you have need of any additional information, feel free to contact Andrew Didun [609-984-2413] of my staff.

Sincerely,

Robert McDowell, Director
Division of Fish, Game and Wildlife

c. A. Didun
D. Wilkinson
M. Burlas, ACOE
USFWS, Pleasantville

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, N.Y. 10278-0090

REPLY TO ATTENTION OF

MHS
Burlas/4663

August 6, 1999

Environmental Assessment Section
Environmental Analysis Branch

Mr. Robert McDowell
Director, Division of Fish, Game and Wildlife
New Jersey Department of Environmental Protection
P.O. Box 400
Trenton, New Jersey 07863

Re: South River, Raritan River Basin
South River, New Jersey
Flood Control and Environmental Restoration Study

Dear Mr. McDowell:

The U.S. Army Corps of Engineers, New York District (District) would like to thank you for the opportunity to respond to your attached June 25, 1999 letter. The District regrets that your office can not actively participate in the HEP analysis for the subject project. However, we will provide Mr. Didun of your office with a copy of the minutes of each HEP team meeting, and components of the HEP report and environmental restoration report as they become available. Your comments are welcome.

The District notes your concern regarding measures to avoid and minimize impacts to wetlands. We are pleased to inform you that numerous alternatives have been developed that demonstrates avoidance and minimization of wetland impacts. We are currently in the process of selecting alternatives to study in detail. For your information, attached is a map that shows a revised conceptual plan that is currently being evaluated and is subject to further review by the District. This map was provided to the agencies that attended the initial HEP team meeting. Accordingly, my office will coordinate with representatives from the NJDEP, Land Use Regulation Program the plans to be studied in detail to facilitate concurrence that avoidance and minimization of wetland impacts has been achieved.

If you have any questions, please contact Mr. Mark Burlas of my staff at either 212-264-4663 or email (mark.h.burlas@nan02.usace.army.mil) or fax (212-264-0640).

Sincerely,

HENN MHS
HOOK
VIETRI
SANTOMAURO

Frank Santomauro, P.E.
Chief, Planning Division

Attachments
Copy Furnished:
Mr. Bernard Moore, P.E.; NJDEP

NEA
NORTHERN ECOLOGICAL ASSOCIATES, INC.
ENVIRONMENTAL SCIENTISTS & PLANNERS

February 17, 2000

Office of Land Management
Natural Heritage Program
P.O. Box 404
22 South Clinton Avenue
Trenton, NJ 08625-0404

RE: Natural Heritage database information request – South River, NJ Flood Protection and Environmental Restoration Project

Dear Sir or Madam:

Northern Ecological Associates, Inc. (NEA) has been contracted by the U.S. Army Corps of Engineers (USACE) to assist in environmental surveys, documentation, and permitting for a proposed Flood Protection and Environmental Restoration project in South River, NJ. Pursuant to Section 7 of the Endangered Species Act, NEA is requesting information regarding rare, threatened, endangered, or special concern animal, plant, and natural communities and/or significant wildlife habitats within a two-mile radius of the South River Project area. The Project area encompasses approximately 800 acres in the vicinity of the South River and Washington Canal channels, as indicated on the enclosed location figure. Also enclosed is the required Natural Heritage Database Request Form.

Your written concurrence with this project would be greatly appreciated. If you have any questions regarding this request, please do not hesitate to call me at (207) 879-9496.

Sincerely,
Northern Ecological Associates, Inc.

Stacie L. Grove

Stacie Grove
Environmental Scientist

Enclosure

cc: M. Burlas (USACE)
R. Dingle (NEA)

451 Presumpscot Street • Portland, Maine 04103 • (207) 879-9496 • fax (207) 879-9481 • www.nea-enviro.com • nea@neamaine.com

Natural Heritage Data Request Form

This form is used to request a search of the Natural Heritage Database for records of rare or endangered species and natural communities on or near a project site. The Natural Heritage Program provides the information in order to assist the requestor in preserving habitat for rare and endangered species and natural communities.

To initiate a search, please provide:

A) A letter explaining the project; B) A copy of a USGS quad map(s) delineating the bounds of the project site; C) A completed data request form.

Send completed request to:

Office of Natural Lands Management
Natural Heritage Program
PO Box 404
22 South Clinton Avenue
Trenton, NJ 08625-0404.

NAME STACIE L. GROVE

AGENCY NORTHERN ECOLOGICAL ASSOCIATES, INC.

ADDRESS 451 PRESUMPSCOT ST., PORTLAND, ME 04103

PHONE 207-879-9496

PROJECT OR SITE NAME
USACOE - SOUTH RIVER FLOOD PROTECTION AND ENVIRONMENTAL RESTORATION PROJECT

County (check those that apply):

Atlantic ___ Bergen ___ Burlington ___ Camden ___ Cape May ___ Cumberland ___

Essex ___ Gloucester ___ Hudson ___ Hunterdon ___ Mercer ___ Middlesex X Monmouth ___

Morris ___ Ocean ___ Passaic ___ Salem ___ Somerset ___ Sussex ___ Union ___ Warren ___

USGS QUAD(S): Any material supplied by the Office of Natural Lands Management will not be published without crediting the Natural Heritage Database as the source of the material. It is understood that there will be a charge of $20.00 per hour for the services requested. An invoice will
NEW BRUNSWICK AND SOUTH AMBOY

be sent with the request response and payment should be made by check or money order payable to "Office of Natural Lands Management."

Date Needed 2/29/00 3/6/00 SLF Signature Stacie L. Fiore

FOR OFFICE USE ONLY

DATE RECEIVED ____________________

Item Code: REG _____ ST _____ RTC _____ NC _____

REGEO _____ STEO _____ RTCEO _____ NCEO _____

Hrs: __________

Project Code: ____________________ Inv. #: __________

DPF-225 9/98

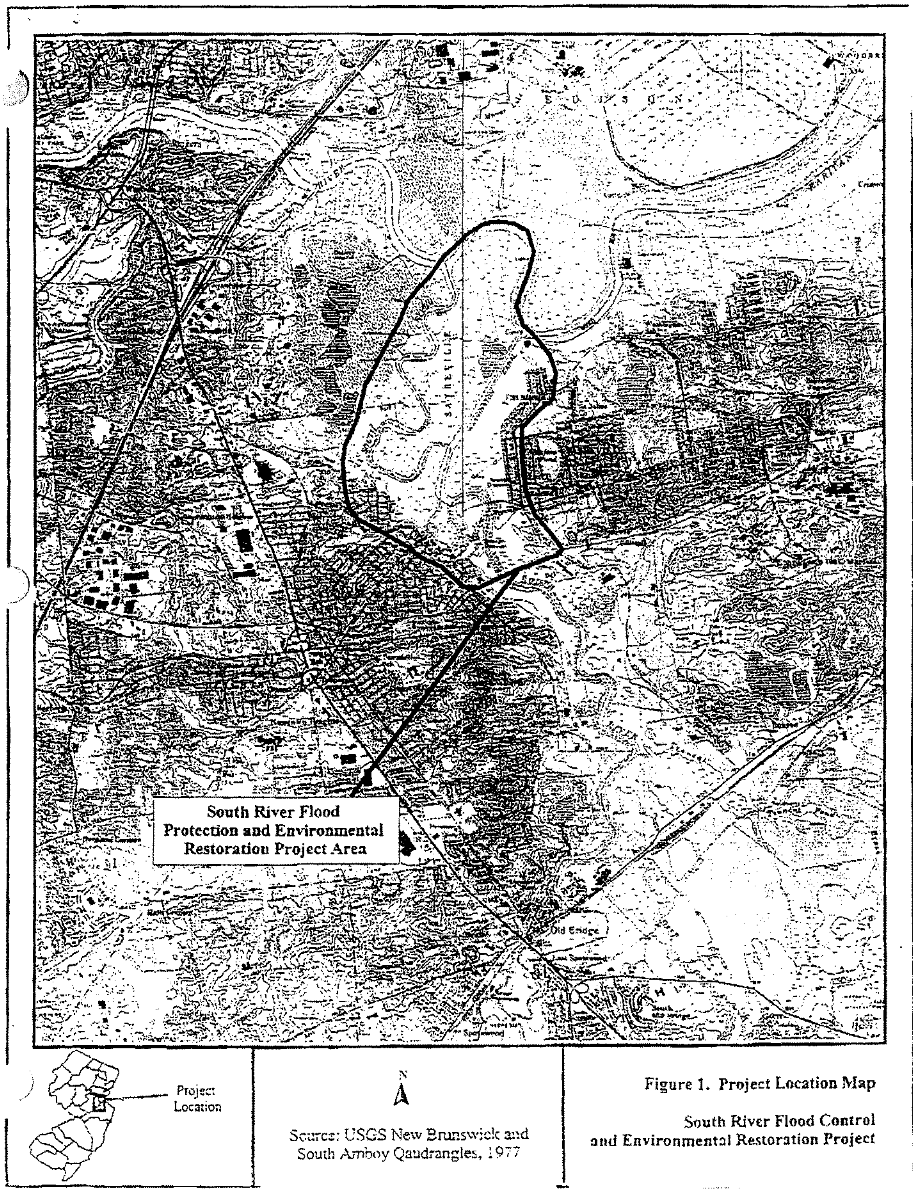

Figure 1. Project Location Map

South River Flood Control and Environmental Restoration Project

NEA ENVIRONMENTAL SCIENTISTS & PLANNERS
NORTHERN ECOLOGICAL ASSOCIATES, INC.

July 12, 2000

DEP – Division of Parks and Forestry
Office of Natural Lands Management
Natural Heritage Program
PO Box 404
Trenton, NJ 08625-0404

To whom it may concern;

Northern Ecological Associates, Inc. (NEA) has been contracted by the New York District, U.S. Army Corps of Engineers (USACE) to prepare an Environmental Impact Statement (EIS) for the South River Flood Control and Environmental Restoration Project.

As part of the EIS process, a number of ecological surveys have been conducted in the South River Project area (Figure 1). The USACE and NEA would like to take this opportunity to inform you of several state-listed/special concern species that have been directly observed by NEA field crews and confirmed by our staff ornithologist in the general Project area:

- Black skimmer (*Rynchops niger*)
- Yellow-crowned night heron (*Nyctanassa violacea*)
- Northern harrier (*Circus cyaneus*)

A single adult black-skimmer was observed foraging above the Washington canal, between Areas 2 and 5 (Figure 2). Multiple observations were documented between 7 am and 5 pm, from May 22nd – 25th, 2000. No evidence of breeding and/or nesting was observed. A photograph is available, although the quality is poor.

Adult yellow-crowned night heron were observed foraging along salt marsh (*Spartina alterniflora*) communities and mudflats of the South River Channel in Areas 3 and 4 (Figure 2). Numerous observations were also documented in these areas between 7 am and 5 pm, from May 23rd – 28th, 2000. Three unique adult individuals have been confirmed. While several heron and egret species (black-crowned night heron [*Nycticorax nycticora]*), great-blue heron [*Ardea herodia]*), great egret [*Casmerodius albus]*, and snowy egret [*Egretta thula]*) have been observed foraging and roosting in the Project area, no evidence of breeding and/or nesting has been observed in the Project area for any of these species.

451 Presumpscot Street • Portland, Maine 04103 • (207) 879-9496 • fax (207) 879-9481 • www.nea-enviro.com • nea@neamaine.com

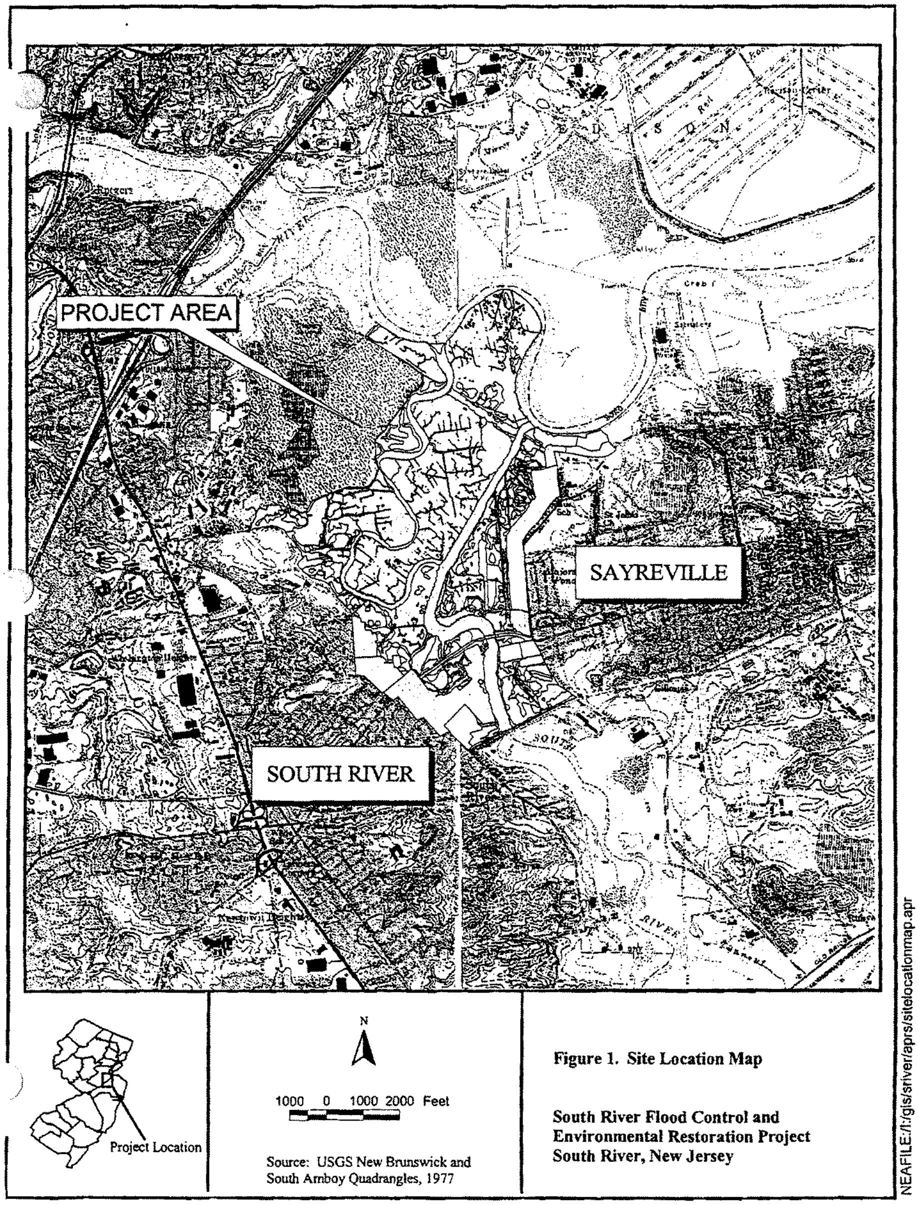

Figure 1. Site Location Map

South River Flood Control and Environmental Restoration Project South River, New Jersey

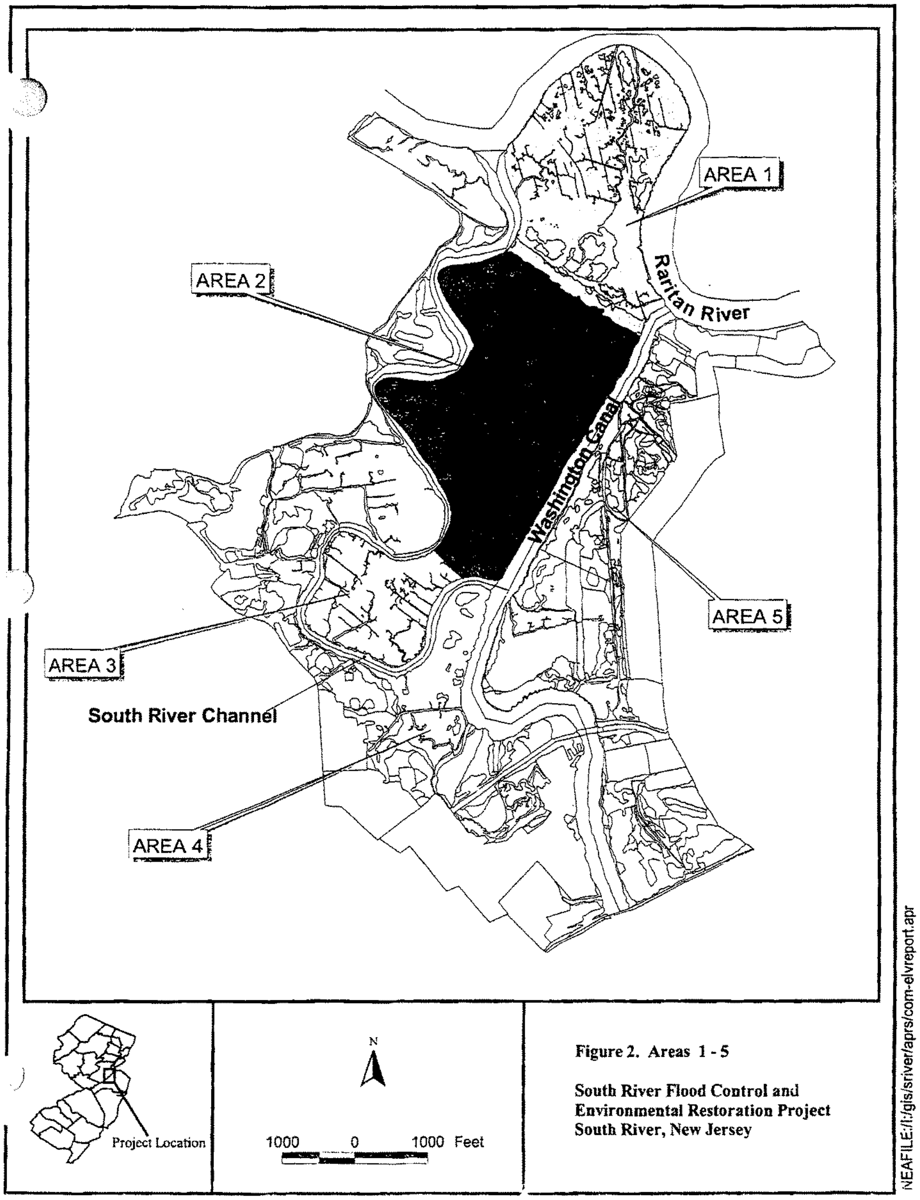

Figure 2. Areas 1 - 5

South River Flood Control and Environmental Restoration Project South River, New Jersey

Northern harrier(s) have been observed during several field visits to the Project area. A single adult male was observed circling above the South River Island in Areas 1, 2 and 3 (Figure 2), during field sampling in June 1998. In March 2000, during field sampling efforts, two harriers (sex not confirmed) were observed foraging above the island in Areas 1 and 2 and hovering along the edges of Washington Canal between Areas 2 and 5. In May 2000, a northern harrier (sex not confirmed) was again observed circling above the South River Island and over Areas 1 and 5. No direct evidence of breeding and/or nesting was observed.

Please do not hesitate to contact me at (207) 879-9496 if you have any questions regarding these accounts.

Sincerely,
Northern Ecological Associates, Inc.

Stacie L. Grove
Environmental Scientist/Field Manager

Attachments

Cc: Mark Burlas (USACE)
Josephine Axt (USACE)
Robin Dingle (NEA)
Project File: CE400, DO83-1

NEA

State of New Jersey

C...istine Todd Whitman
Governor

Department of Environmental Protection
Division of Parks & Forestry
Historic Preservation Office
PO Box 404
Trenton, NJ 08625-0404
TEL: (609)292-2023
FAX: (609)984-0578

Robert C. Shinn, Jr.
Commissioner

HPO-A2001-129
106/01-0167
January 11, 2001

Received 1/18/01

Joseph Vietri, Assistant Chief
Planning Division
Department of the Army
New York District, Corps of Engineers
Jacob K. Javits Federal Building
New York, N.Y. 10278-0090

ATTN: John Killeen

South River Flood Control and Ecosystem Restoration Project
Middlesex County, Boroughs of Sayreville and South River
Review of the Phase I Cultural Resource Survey for the project

Dear Mr. Vietri:

Thank you for having provided the opportunity to review the draft project report, Phase I Cultural Resource Survey for the South River Flood Control and Ecosystem Restoration Project, Boroughs of Sayreville and South River, Middlesex County prepared by Panamerican Consultants, Inc. in September 2000. The report is well organized and portions (e.g. the Background Research) well prepared. However, additional information and in some instances additional archaeological testing will need to be conducted prior to completion of 800.4 and 800.5 of the 36 CFR 800. My specific comments follow.

1) The Office concurs with the need to conduct survey and research for Wetland Restoration Areas 1, 2, 3, 4, 5, 6, and 8 and the Washington Canal, as recommended on page 6-3 of the draft report.

2) Assessment of visual effects to historic properties is not discussed in the report. If there are no effects to architectural properties because the nature of the project and/or the distance from historic and potentially historic properties, there needs to be a statement and short narrative in the report explaining this.

3) Similar to the above, the project itself, relative to its potential to impact archaeological properties needs to be better described. While a 100-foot wide corridor was presented in the survey report as the study area, probability testing was limited to only one transect throughout the corridor. Staff discussion with John Killeen indicated, however, that the actual impact area may be closer to 20 feet with the remainder generally being covered with mounded fill. The assessment of the need for additional testing (see below), needs to analyzed and discussed in relation to the actual potential for project impacts to archaeological resources.

4) Very generally, there appears to be only limited connection between the information gleaned as the result of background research and the actual testing strategy. The testing strategy in areas of known resources (most notably the remains associated with Sayre and Fisher and the other industrial remains associated with or resulting from brick manufacturing along South River) needs to first take into account the potential significance of the brick industries as a whole, their anticipated associated physical remains, what has been learned about the industry in New Jersey and elsewhere, and what questions remain.

Only when this context is understood can the potential significance of more discrete units (the sites and their individual element) be understood, a testing strategy be determined, and archaeological remains evaluated. Probability testing alone is more appropriate for areas where nothing is known or culture bearing land surfaces are accessible. However, many areas ultimately proved inaccessible (e.g. 61 % of the area along the western levee), and detailed information exists for other areas about the location of potential physical remains.

For areas where cultural material was identified, either through testing or historic research, Phase II consideration of cultural resource potential is necessary. This will need to include(depending on the circumstance) some combination of:
a) further development of the context for assessment and appropriate testing strategy discussed above;
b) refinement of actual Area of Potential Effects (see # 3 above);
c) analysis of the flown aerials for the Area of Potential Effects. Because many of these industries existed well into the twentieth century, flown aerials may provide useful information;
d) remote sensing survey for inaccessible areas where resources are known to have existed; and
e) additional (Phase II) testing including opening larger and/or deeper units to determine the presence and significance of archaeological remains.

5) Views on the project should be solicited from organizations such as Middlesex County Cultural and Heritage Commission, Sayreville Historical Society and South River Historic Society.

6) Smithsonian numbers for all archaeological sites identified should be obtained from the New Jersey State Museum and provided in the project report. Relative to this

comment, the project team should re-check the NJHPO guidelines to ensure that they are fully addressed.

7) The repository for artifact curation should be identified in the survey report. Again, this is one of the elements in the HPO report guidelines.

8) Either deep testing or a rationale for failure to test should be provided for Area B in the East Levee/Floodwall footprint in the vicinity of E48 (see page 6-2 of the draft report).

Thank you again for providing this opportunity for review and Consultation. I look forward to further consultation on this project. If you have any questions, please do not hesitate to contact Deborah Fimbel, staff reviewer for this project, at 609-984-6019.

Sincerely,

Dorothy P. Guzzo
Deputy State Historic
Preservation Officer

DPG:DRF

January 22, 2001

Mr. Chris Dolphin
New Jersey Department of Environmental Protection
501 E. State Street, Station Plaza 5
Trenton, NJ 08625

Re: Draft Avoidance and Minimization Plan for the South River Flood Control and Ecosystem Restoration Project

Dear Chris:

Please find enclosed a copy of the Draft Avoidance and Minimization Plan for the South River Flood Control and Ecosystem Restoration Project for your review.

NEA is coordinating with the USACE regarding the Economic section of the report. Upon receipt of additional information, NEA will revise the report accordingly.

If you require any additional information please do not hesitate to call me at (207) 879-9496. NEA looks forward to providing continued support on the South River Project.

Sincerely,
Northern Ecological Associates, Inc.

Stacie Grove
Environmental Scientist

Stacie Grove

From:	Stacie Grove
Sent:	Monday, April 02, 2001 3:14 PM
To:	Chris Dolphin (E-mail)
Cc:	Mark Burlas (E-mail 2); Robin Dingle
Subject:	S. River direct impacts

Chris,

Thank you for your input on the proposed South River project footprint. The footprint has been revised to incorporate your suggestions.

A figure and memo describing the direct wetland impacts based on the revised footprint was sent to you today via Fed-Ex.

Please review the documents and contact me if you have any questions or comments.

Thanks.

Stacie

Tracking:

Recipient	Delivery
Chris Dolphin (E-mail)	
Mark Burlas (E-mail 2)	
Robin Dingle	Delivered: 4/2/01 3:14 PM

LETTER OF TRANSMITTAL

Date: 04/02/01

To: Chris Dolphin
Subject: Revised South River Direct Wetland Impacts
From: Stacie Grove, NEA
CC: Mark Burlas (USACE)
Josephine Axt (USACE)
Robin Dingle (NEA)

Chris,

Thank you for your input regarding revisions to the proposed footprint (alternative 2 – optimized) for the South River Flood Protection and Ecosystem Restoration Project.

The footprint has been revised to incorporate your suggestions (see attached figure). Footprint revisions resulted in a reduction in 0.23 acres, for a total of 9.23 acres of direct wetland impacts under the currently proposed footprint design. The impacts include only direct impacts based on year 2000 cover type acreages.

The slight increase in wetland impacts in the West Bank study area is a result of engineering modifications needed to tie the footprint into a higher topographic elevation and to avoid private property and sensitive ecological areas (*i.e.*, forested wetland, great-horned owl nest). See the northern end of the West Bank footprint on the attached figure.

	Alternative 2 (optimized)		**Revised Alternative 2 (optimized)**	
	East Bank	West Bank	East Bank	West Bank
Wetland impacts	5.51	3.95	4.93	4.30
Combined wetland impacts (EB + WB)	9.46		9.23	

Modeling for tides, ponding areas, pools, etc. is in progress. You will receive the results as soon as work is completed.

Please do not hesitate to contact Robin Dingle or I if you have any questions or comments.

Stacie Grove

Stacie Grove

From:	Stacie Grove
Sent:	Thursday, April 19, 2001 7:57 AM
To:	Chris Dolphin (E-mail)
Cc:	Mark Burlas (E-mail 2); Robin Dingle
Subject:	South River Avoidance and Minimization

Chris,

Have you recieved the packet containing the revised South River footprint and summary of impacts?

Please let me know if the packet was received and if the revised footprint meets NJDEP avoidance and minimization criteria.

Dont' hesitate to give me a call if you have any questions or concerns.

Thank you.

Stacie L. Grove
Environmental Scientist

Northern Ecological Associates, Inc.
451 Presumpscot Street
Portland, ME 04103
(207) 879 - 9496
Fax: (207) 879 - 9481

Tracking:	Recipient	Delivery
	Chris Dolphin (E-mail)	
	Mark Burlas (E-mail 2)	
	Robin Dingle	Delivered: 4/19/01 7:57 AM

1

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, N.Y. 10278-0090

REPLY TO ATTENTION OF

April 30, 2001

Environmental Assessment Section
Environmental Analysis Branch

Cultural Resources

Ms. Dorothy P. Guzzo
Deputy State Historic Preservation Officer
Historic Preservation Office
New Jersey Department of Environmental Protection
CN 404
Trenton, New Jersey 08625-0404

Attention: Deborah Fimbel

Dear Ms. Guzzo:

The U.S. Army Corps of Engineers, New York District (Corps), is pleased to furnish you with a camera-ready copy of the final Phase I cultural resources investigation report for the South River Flood Control and Ecosystem Restoration Project, Boroughs of Sayreville and South River, Middlesex County, New Jersey (Attachment 1). The flood control project construction is not expected to impact any significant cultural resource. No further cultural resource investigations are recommended for the flood control portion of the project area. The ecosystem restoration portion of the project will likely, however, impact the historic Washington Canal and Phase II investigation of that structure has been recommended. Finally, subsurface investigation of the wetland area in which the ecosystem restoration will take place has uncovered four natural strata and should be investigated further for possible prehistoric remains. We will continue to coordinate with your office throughout the course of this project.

We appreciate Section 106 comments that you have provided regarding the enclosed report. Thank you for your assistance in the Section 106 process. If you or your staff require additional information or have any questions, please contact John Killeen, Project Archaeologist at (212) 264-0473.

Sincerely,

Jenine Gallo
Team Leader, Environmental Review

Attachment

Cf: J. Redican

Stacie Grove

..om:	Stacie Grove
..nt:	Tuesday, June 12, 2001 3:51 PM
.o:	Chris Dolphin (E-mail)
Cc:	Mark Burlas (E-mail 2); Robin Dingle
Subject:	South River Footprint

Chris,

The USACE is awaiting word from NJDEP regarding the revised South River footprint (sent to you on April 2, 2001).

Would you please provide a letter to the USACE indicating that the revised footprint meets NJDEP avoidance and minimization criteria? This project is on a very fast track within the USACE and this issue needs to be finalized as soon as possible. If you are unable to send a letter sometime this week, would you please let us know when you anticipate that you will have the time to complete this task.

Don;' hesitate to give me a call if you have any questions or concerns.

Thank you.

Stacie L. Grove
Environmental Scientist

Northern Ecological Associates, Inc.
451 Presumpscot Street
Portland, ME 04103
(207) 879 - 9496
Fax: (207) 879 - 9481

Tracking:

Recipient	Delivery
Chris Dolphin (E-mail)	
Mark Burlas (E-mail 2)	
Robin Dingle	Delivered: 6/12/01 3:51 PM

Stacie Grove

m:	Stacie Grove
ıt:	Thursday, June 28, 2001 7:33 AM
To:	Chris Dolphin (E-mail)
Cc:	Mark Burlas (E-mail 2); Robin Dingle
Subject:	S. River footprint

Chris,

We have not received any response regarding our requests for comments from the NJDEP on the revised South River footprint. Therefore, to avoid further delays, we are proceeding with the Impact Assessment and Mitigation Analysis based on the revised footprint that was sent to you on April 2, 2001.

The USACE still needs verification indicating that the footprint meets NJDEP criteria. Please provide a letter to the USACE (similar to that provided for the Union Beach project) as soon as possible.

Dont' hesitate to give me a call if you have any questions or concerns.

Thank you.

Stacie L. Grove
Environmental Scientist

Northern Ecological Associates, Inc.
451 Presumpscot Street
Portland, ME 04103
(207) 879 - 9496
Fax: (207) 879 - 9481

Tracking:

Recipient	Delivery
Chris Dolphin (E-mail)	
Mark Burlas (E-mail 2)	
Robin Dingle	Delivered: 6/28/01 7:33 AM

Stacie Grove

From: Stacie Grove
Sent: Friday, July 27, 2001 2:28 PM
To: Chris Dolphin (E-mail)
Subject: reminder

Chris,

We have not received any response to our requests for comments from the NJDEP on the revised South River footprint. Therefore, the footprint that was sent to you for review and comment on April 2, 2001, is now considered final.

Please provide a letter to the USACE indicating that the footprint meets NJDEP criteria as soon as possible.

Thank you.

Stacie L. Grove
Environmental Scientist

Northern Ecological Associates, Inc.
451 Presumpscot Street
Portland, ME 04103
(207) 879 - 9496
Fax: (207) 879 - 9481

NATIONAL MARINE FISHERIES SERVICES

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Habitat Conservation Division
James J. Howard Marine
Sciences Laboratory
74 Magruder Road
Highlands, New Jersey 07732

MFR:
RCVD 11/9/98
AHG

September 2, 1998

Mr. Frank Santomauro, P.E.
Chief, Planning Division
Department of the Army
New York District, Corps of Engineers
26 Federal Plaza
New York, NY 10278-0900

Dear Mr. Santomauro:

We have reviewed the Scoping Document for the Raritan River Basin South River, New Jersey Flood Control and Environmental Restoration Project. We understand that the scoping document provides only general information and that project plans are still in development. We offer the following comments to aid in your planning effort.

The South River and its tributaries provide spawning, nursery and forage habitat for anadromous river herring such as alewife (Alosa pseudoharengus), blueback herring (Alosa aestivalis) and American shad (Alosa sapidissima). Little data is available on the use of the Washington Canal by these species, but anadromous fishes likely use it to access the upper reaches of South River. One of the flood control options mentioned in the scoping document is the construction of a tidal barrier, pump station and diversion channel across South River. This would prevent the passage of fish and eliminate spawning in the South River watershed. Over the past several years, great strides have been made in restoring anadromous fish runs in New Jersey. As water quality improves and blockages are removed, fish are returning to their historic spawning grounds. We oppose strongly any project which would eliminate the passage of anadromous fish to their spawning grounds.

In addition, between South River and the Washington Canal are tidal wetlands that provide valuable habitat for fish and wildlife. We support the Corps in their environmental restoration goals for this area. However, the wetlands fill and changes in wetlands hydrology resulting from the construction of a tidal barrier, pump and levee system will degrade the wetlands the Corps seeks to restore.

The conceptual plan presented in the scoping document also includes the construction of levees and flood walls, bridge replacement, road raising and lining portions of the shoreline with crushed stone. Without site specific information about the habitat of the areas affected, a full review of the impacts is not possible. However, any work in the water should be prohibited from April 1 to June 30 and September 1 to November 30 of any given year to minimize impacts to anadromous fish migrating to and from the upstream spawning ground. Also, any work in or along the banks of the South River should be evaluated to determine the impacts to spawning and resting habitat for anadromous fishes.

The document discusses several non-structural solutions to provide storm damage protection for the project area. We support strongly the use of these methods. We oppose the construction of any obstruction across South River or the Washington Canal. Additional information is necessary for a full evaluation of the impacts of the proposed levees. We look forward to continued coordination with your office on this project. If you would like to discuss this matter further, please contact Ms. Karen Greene at 732 872-3023.

Sincerely,

Stanley W. Gorski
Field Offices Supervisor

cc: EPA - Region II
FWS - Pleasantville
NJDEP - Land Use

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, N.Y. 10278-0090

REPLY TO ATTENTION OF

December 17, 1998

Burlas/4663

Environmental Analysis Branch
Environmental Assessment Section

Mr. Stanley W. Gorski
National Marine Fisheries Service
Habitat Conservation Division
James J. Howard Marine Sciences Laboratory
74 Magruder Road
Highlands, New Jersey 07732

Re: Raritan River Basin, South River, New Jersey
Combined Flood Control and Environmental Restoration Project

Dear Mr. Gorski:

The U.S. Army Corps of Engineers, New York District (District) would like to initiate informal consultation with the National Marine Fisheries Service (NMFS) pursuant to Section 7 of the Endangered Species Act. A project scoping document is attached that briefly identifies possible solutions to reduce damages caused by flooding, the existing biological, ecological and cultural resources, and potential impacts that may be associated with possible solutions. The District intends to use the Habitat Evaluation Procedure (HEP) to assess impacts of the proposed project. An invitation to participate on the interagency HEP team will be forthcoming in the near future.

If you have any questions or would like additional information regarding the project, please contact Mark Burlas of my staff at either 212-264-4663 or e-mail at mark.h.burlas@nan02.usace.army.mil or fax at 212-264-6040. The District looks forward to working with the NMFS on this project.

Sincerely,

HENN
HOOK
SANTOMAURO

Frank Santomauro, P.E.
Chief, Planning Division

Attachment
Copy Furnished:
Mr. Bernard Moore, NJDEP

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Habitat Conservation Division
James J. Howard Marine
Sciences Laboratory
74 Magruder Road
Highlands, New Jersey 07732

MTK: REC'D. 1/25/99 MHB

January 14, 1999

Mr. Frank Santomauro, Chief
Planning Division
New York District
U.S. Army Corps of Engineers
26 Federal Plaza
New York, NY 10278-0900

ATTN: Mark Burlas

Dear Mr. Santomauro:

Reference is made to your December 17, 1998 letter initiating informal consultation pursuant to Section 7 of the Endangered Species Act for the Raritan River Basin, South River, New Jersey Combined Flood Control and Environmental Restoration Project. No endangered or threatened species under the jurisdiction of the National Marine Fisheries Service (NMFS) are in the project area. Further consultation under Section 7 of the Endangered Species Act will not be necessary. However, should project plans change, or should new information become available which modifies the basis for this determination, consultation should be reinitiated.

We have reviewed the scoping document and provided your office with comments in our letter dated September 2, 1998. Our comments focused primarily on the project impacts to South River, the Washington Canal and adjacent wetlands. We are concerned that the proposed project, especially the proposed tidal barrier will have substantial impacts to anadromous fish such as alewife (Alosa pseudoharengus), blueback herring (Alosa aestivalis) and American shad (Alosa sapidissima) which use South River and its tributaries as spawning, nursery and forage habitat. We are also concerned about the potential impacts to the wetlands in the project area including wetlands fill and changes in wetlands hydrology resulting from the construction of a tidal barrier, pump and levee system.

We look forward to continued coordination with your office on this project as part of the Habitat Evaluation Procedure team, and through the NEPA process. If you would like to discuss this matter further, please contact Ms. Karen Greene at (732) 872-3023.

Sincerely,

Stanley W. Gorski
Field Offices Supervisor

kmg:soriver.hep
cc: Milford - Haley

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, N.Y. 10278-0090

REPLY TO ATTENTION OF

May 21, 1999

Environmental Analysis Branch
Environmental Assessment Section

Mr. Stanley W. Gorski
National Marine Fisheries Service
Habitat Conservation Division
James J. Howard Marine Sciences Laboratory
74 Magruder Road
Highlands, New Jersey 07732

Re: South River, Raritan River Basin
Multi-Purpose Feasibility Study

Dear Mr. Gorski:

The U.S. Army Corps of Engineers, New York District (District) has initiated a multi-purpose feasibility study to identify a solution to reduce flood damages caused by tidal inundation and develop alternatives to ecologically restore degraded habitats. A project scoping document is attached that briefly identifies possible solutions, the existing biological, ecological and cultural resources, and potential impacts that may be associated with possible solutions.

The District intends to use the Habitat Evaluation Procedure (HEP) to assess impacts of the flood control component and to identify habitat unit outputs of ecological restoration alternatives. The HEP provides a quantitative assessment of relative value of wildlife habitats through a final numerical output that is technically defensible, replicable, and can be applied consistently in a variety of different habitat types. The HEP is based on combining a measure of habitat quantity with an index of habitat quality to determine habitat unit values. The underlying assumption of a HEP is that the habitat for a given wildlife species can be described by a Habitat Suitability Index (HSI) model.

To initiate the implementation of the HEP, the District would like to extend an invitation to your agency to participate on the interagency HEP team. The HEP involves obligatory attendance at many technical meetings that can last for most of a day; membership also includes significant coordination, fieldwork, and review and comment to HEP meeting minutes and technical documents. Accordingly, your decision to participate should reflect an obligation to allocate the essential amount of personnel time to accomplish each element of the HEP.

A kick-off meeting to begin the HEP is scheduled for June 30, 1999 at Sandy Hook, New Jersey (see the attached meeting agenda).

The District would like to request written confirmation regarding your decision to participate on the interagency HEP team. In addition, I would appreciate your contacting Mark Burlas of my staff to inform him if you are planning to attend the HEP meeting. If you have any questions or would like additional information regarding the project, Mr. Burlas can be reached via telephone at 212-264-4663, e-mail at mark.h.burlas@nan02.usace.army.mil or fax at 212-264-6040. The District looks forward to working with the NMFS on this project.

Sincerely,

Frank Santomauro, P.E.
Chief, Planning Division

Attachments
Copy Furnished:
Mr. Bernard Moore, P.E.; NJDEP

USACE South River, New Jersey Project
Habitat Evaluation Procedures Meeting Agenda
National Marine Fisheries Service
James J. Howard Marine Science Laboratory
74 Magruder Road
June 30, 1999, 9:30 AM
Sandy Hook, New Jersey

I. **Project Overview**
- Present project purpose and objectives.
- Present potential solutions
- Update of scoping meeting results/comments.

II. **Presentation of Environmental Data**
- Review draft cover type map.
- Review draft wetland map.
- Address comments/questions.

III. **Preliminary Assessment of Natural Resources**
- Identify and discuss natural resources in the project area.
- Identify potential threatened/endangered species concerns.
- Identify potential environmental impacts (direct and indirect).
- Discuss state and federal regulatory issues/concerns.

IV. **Discussion of Habitat Evaluation Procedures (HEP)**
- Overview of HEP and its use for impact assessment/mitigation.
- Identify project-specific goals/objectives for HEP.
- Discuss membership and responsibilities (i.e., meetings, document review, etc.) of the HEP team.
- Initiate formulation of species selection criteria.

V. **Meeting Summary**
- Review the group/individual task assignments.
- Develop a schedule for completion and review of the various tasks.
- Schedule future group meetings and/or conference calls.

Lunch Break

VI. **Project Area Site Visit**
- Familiarize the group with the project area/boundaries.
- Visit areas of potential impact and/or concern.
- Update task assignments if necessary.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Habitat Conservation Division
James J. Howard Marine
Sciences Laboratory
74 Magruder Road
Highlands, New Jersey 07732

June 17, 1999

Mr. Frank Santomauro, Chief
Planning Division
New York District
U.S. Army Corps of Engineers
26 Federal Plaza
New York, NY 10278-0900

ATTN: Mark Burlas

Dear Mr. Santomauro:

Thank you for your recent invitation for NMFS to participate on the interagency Habitat Evaluation Procedure (HEP) team for the South River, Raritan River Basin Multi-purpose Feasibility Study. We look forward to working with your staff on this project as part of the Habitat Evaluation Procedure team.

We have provided some initial comments in our letter dated January 14, 1999, and have participated in some initial interagency meetings on the project. As you are aware, the project area provides habitat for many fish species, including anadromous fish such as alewife (Alosa pseudoharengus), blueback herring (Alosa aestivalis) and American shad (Alosa sapidissima) which use South River and its tributaries as spawning, nursery and forage habitat. In addition, the mixing zone of the Raritan River has been designated as essential fish habitat (EFH) under 1996 amendments to the Magnuson Stevens Act (MSA) for a number of species including red hake (Urophycis chuss), winter flounder (Pseudopleuronectes americanus), summer flounder (Paralichthys dentatus), windowpane flounder (Scophthalmus aquosus), black sea bass (Centropristis striata) and Atlantic butterfish (Peprilus triacanthus). The freshwater portion of the Hudson-Raritan Estuary has also has been designated as EFH for summer flounder larvae. Other species for which EFH is proposed in the project area, but for which the designations have not been finalized include bluefish (Pomatomus saltatrix) and Atlantic herring (Clupea harengus). As a member of the HEP team, and through the NEPA process, we will work with your staff to insure that the EFH requirements of the MSA are met.

We look forward to continued coordination on this project. If you would like to discuss this matter further, please contact Ms. Karen Greene at (732) 872-3023.

Sincerely,

Stanley W. Gorski
Field Offices Supervisor

kmg:srhep.hep

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, N.Y. 10278-0090

REPLY TO
ATTENTION OF

November 4, 1999

Environmental Analysis Branch
Environmental Assessment Section

Mr. Stanley W. Gorski
National Marine Fisheries Service
Habitat Conservation Division
James J. Howard Marine Sciences Laboratory
74 Magruder Road
Highlands, New Jersey 07732

Re: Raritan River Basin
South River, New Jersey
Flood Control and Environmental Restoration Project

Dear Mr. Gorski:

The U.S. Army Corps of Engineers, New York District (District) would like to initiate Essential Fish Habitat (EFH) consultation with the National Marine Fisheries Service (NMFS) pursuant to sections 303 and 305 of the Magnuson-Stevens Fishery Conservation and Management Act for the referenced project. Attached is a map of the project area.

If you have any questions or need additional information, please contact Mark Burlas from my office at 212-264-4663. The District looks forward to continuing to work with your office on these projects.

Sincerely,

Frank Santomauro, P.E.
Chief, Planning Division

Attachments
Copy Furnished:
Mr. Bernard Moore, P.E.; NJDEP

SOURCE:

U.S.G.S. 7.5 Minute Series
South Amboy, NJ-NY
Photo Revised 1981

New Brunswick, NJ
Photo Revised 1981

SCALE:

1" = 3,125'

N

FIGURE 1

SITE LOCATION MAP - SOUTH RIVER

Scoping Document
Raritan Bay and Sandy Hook Bay
South River, New Jersey
Flood Control and Shoreline Protection Project

NEW JERSEY

Project Area

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, N.Y. 10278-0090

REPLY TO ATTENTION OF

November 8, 2000

Planning Division

Mr. Richard Kropp, P.E.
Director, Land Use Regulation Program
New Jersey Department of Environmental Protection
501 East State Street
P.O. Box 439
Trenton, New Jersey 08625-0439

Mr. Clifford G. Day
Supervisor, New Jersey Field Office
U.S. Fish and Wildlife Service
927 North Main Street, Building D
Pleasantville, New Jersey 08232

Mr. Stanley Gorski
National Marine and Fisheries Service
Habitat Conservation Division
James J. Howard Marine Sciences Laboratory
74 Magruder Road
Highlands, New Jersey 07732

Re: Raritan Bay – Sandy Hook Bay
Hurricane and Storm Damage Reduction Feasibility Study
Union Beach, New Jersey

Raritan River Basin
Flood Control and Ecosystem Restoration Feasibility Study
South River and Sayerville, New Jersey

Dear Mr. Kropp, Mr. Day and Mr. Gorski:

On behalf of the U.S. Army Corps of Engineers (USACE), New York District (District), I would like to take this opportunity to express my appreciation to the New Jersey Department of Environmental Protection (NJDEP), Land Use Regulation Program (LURP), the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) for your active participation in the ongoing Habitat Evaluation Procedure (HEP) and Evaluation of Planned Wetlands (EPW) analyses for the subject studies. In addition, I would also like to reaffirm our interagency team's commitment to the utilization of these evaluation tools for the subject studies.

As you are aware, the HEP and EPW have been agreed upon by our agencies as the assessment techniques to use to determine impacts. The units of measure to quantify impacts, which is the comparison of the No-Action alternative to the with project without mitigation alternative, are habitat units (HUs) and functional capacity units (FCUs). In order to compare impacts and mitigation strategies, USACE Regulations require the use of the same unit(s) of measure that were used to establish the impacts. Accordingly, the compensatory mitigation strategy is to identify alternative mitigation plans that would replace the HUs and FCUs that would be lost due to the implementation of the selected plan for each study area, which have yet to be identified. With regards to the South River/Sayerville study, the HU and FCU outputs of the ecosystem restoration component are considered independent and separate from compensatory mitigation to offset impacts caused by the implementation of the study's flood control component.

The USACE recognizes the importance of forming an interagency team early in the planning process to initiate a dialog to reach technical agreements and subsequent recommendations with regards to impacts and compensatory mitigation. As the lead Federal agency, recommendations from all interagency teams are subject to review and acceptance by USACE higher authority. The District believes in and welcomes a seamless government approach and is positive that common ground can be reached and built upon, should a divergence occur with regards to our respective institutional regulations and policies. I believe that our agencies via the HEP and EPW are heading in a unified direction.

Finally, the District looks forward to continued Federal and State partnerships and is confident that we can mutually agree with a plan that protects the Union Beach, South River and Sayerville communities from damages caused by hurricanes and floods, as well as restore the ecosystem that is associated with the South River. At this time, I am looking to reconfirm that HEP and EPW are the evaluation tools to determine impacts and develop recommendations for compensatory mitigation to replace the values and functions of the affected ecological and biological resources. If you have any questions, contact Mark Burlas of my staff at 212-264-4663.

Sincerely,

Frank Santomauro, P.E.
Chief, Planning Division

Copy Furnished:
Mr. Bernard Moore, P.E.; NJDEP

Axt, Josephine R NAN02

From:	Karen Greene [Karen.Greene@noaa.gov]
Sent:	Thursday, November 16, 2000 1:04 PM
To:	Axt, Josephine R NAN02
Cc:	Chris Dolphin; Burlas, Mark H NAN02; Tom McDowell; 'rdingle@neamaine.com'; 'sgrove@neamaine.com'; Redican, Joseph H NAN02; Houston, Leonard NAN02; 'David Miller'
Subject:	Re: Restoration Meeting

I'll do my best to look at the report before you go, and get you comments. As far as creating islands within the restoration area, they would not be habitat for our resources, but we do not outright oppose them. They must be designed to enhance the overall value of the site, of a limited size and the remaining enhancement must compensate for the loss of wetlands area.

"Axt, Josephine R NAN02" wrote:
>
> Hello HEP team,
>
> I wanted to let you all know that Mark and I are going to Portland (Nov 30
> and Dec 1) for an intensive meeting with NEA to brainstorm and construct and
> evaluate different preliminary ecosystem restoration plans for the South
> River project. This meeting will initiate the process that will eventually
> culminate in NEA's preparation of a draft Ecosystem Restoration Plan report
> (although obviously this meeting isn't the beginning of the process, in the
> sense that NEA and the Corps have been defining goals and
> objectives/gathering info/analyzing results/discussing and screening
> restoration alternatives/etc. for a couple years now).
>
> I don't anticipate that the busy schedules you all have will allow your
> attendance at the meeting, but you are all more than welcome to come (not
> that I can offer that the Corps will pick up the tab for any of your
> time/travel/trouble...). The Corps has always been and continues to be very
> receptive to feedback and input from other agencies in its development of
> the ecosystem restoration plan for South River. A draft meeting agenda is
> attached.
>
> Thanks,
> Josephine
>
> P.S. Chris, Tom and Karen - it was hoped that any
> concerns/comments/questions regarding the Restoration Screening Report would
> be raised with me/Mark prior to this meeting. Also, as I've discussed with
> Chris and Tom, the Corps is considering using excavated material from the
> island to create a scrub/shrub forested wetland and/or upland or two on the

> island. It really is imperative that we know before this meeting if
either
> of your respective agencies would veto that outright. Neither one of
you
> felt that it couldn't be considered, and said you'd check into it.
Please
> let me know!
>
> <<ERP Meeting Agenda 11.16.00.doc>>
>
> Josephine R. Axt, Ph.D.
> CENAN-PL-ES
> Room 2142
> 26 Federal Plaza
> New York, NY 10278-0090
> phone: 212-264-5119
> fax: 212-264-0961
>
> Name: ERP Meeting Agenda
11.16.00.doc
> ERP Meeting Agenda 11.16.00.doc Type: Winword File
(application/msword)
> Encoding: x-uuencode

Axt, Josephine R NAN02

From: Karen Greene [Karen.Greene@noaa.gov]
Sent: Thursday, December 07, 2000 2:32 PM
To: Axt, Josephine R NAN02
Subject: Re: South River Restoration report

I knew you guys were not proposign to fill fish habitat. it was meant as a generic comment on the report. About the letter of support, who should we send it to? Should it just say we are supportive of the ACOE's project and look forward to workng with the ACOE as the project progresses?

"Axt, Josephine R NAN02" wrote:
>
> Karen,
>
> I appreciate the time you took to so carefully review the South River
> Restoration Screening Report. We will definitely keep your comments
in mind
> as we move forward in the process of designing the Ecosystem
Restoration
> Plan. To clarify, we have no interest or intent to convert low
emergent
> marsh to scrub/shrub forested wetland or upland. The only areas where
we
> would consider creating scrub/shrub forested wetland or upland are
areas
> dominated by Phrag (and data from our tide data collection efforts and
plant
> community/elevation analyses indicates that the Phrag at South River
is not
> functioning as fishery habitat).
>
> Ultimately, as I said on the phone a few weeks ago, the Corps would
> appreciate any letter of support NMFS could provide to the restoration
> portion of the project - the Corps Ecosystem Restoration Plan for
South
> River will be available around the end of January 2001. The ERP will
lay
> out more clearly how, what, where, why, and how much for the
restoration
> alternatives (in addition to recommending certain restoration plans).
>
> Thanks again,
> Josephine
>
> -----Original Message-----
> From: Karen Greene [mailto:Karen.Greene@noaa.gov]
> Sent: Monday, December 04, 2000 10:59 AM
> To: Axt, Josephine R NAN02
> Subject: South River Restoration report
>
> Overall, it looks good to me. I have a few comments though.
>
> Page 12 - common methods of implementation for salt marshes should
also
mention excavating from uplands as a method.

> Page 18 mentions spraying an buring to remove phrag. As a nd FYI,
there

> have been concerns voiced by citizens and environmental groups over
the
> use of Rodeo in South Jersey for the PSE&G restoration projects. We
> should keep this is mind if it is to be used here. There may be some
> public comments on this issue. Also, burning will probably not be
> permitted near populated areas.
>
> Page 20 Create brackish marsh. This section confuses me a bit. The
> difference between a salt marsh and a brackish marsh should be more
> clearly identified - what are the salinity differences? As it is
> written, I was asking myself, "How is this different from a salt
> marsh?" It seems a duplication effort.
>
> Page 23, the reverse side is blank and it pushes page 24 to wrong side
> of the paper. I'm not sure that's clear, but anyhow, check the page
> numbering.
>
> Page 26. How likely is SAV to be found in the project area? Is it a
> valid performance standard for South River?
>
> page 29 Atlantic White Cedar Habitat. Why is this an option at all?
Is
> it feasible in the project area? It seems like we are padding the
list
> of options.
>
> Page 38, Fish ladder construction. If pursued in the future, we must
> also look above th dam to determine if the habitat above is suitable
for
> restoration - water quality, food sources ect. The Philly Corps did
> this type of study as part of the Barnegat Bay Recon study. Also,
> sampling should be done in the spring. If is not clear from the doc

> that was when it was done. Lastly, FWS' Regional office has experts in
> fish ladder design. They should be contacted if a ladder is ever
> proposed.
>
> page 42, Create a walkway- this section should note that the
> construction of a walkway would result in adverse impacts to fish and
> wildlife, and that the common method of installation involves fill.
> compliance with 404 b 1 guidelines and mitigation would be required.
> Succesful establishment would place the walkway in areas where it
would
> cause the most harm to fish and wildlfe.
>
> page 43, create a park with dredge material. This would also result
in
> fill. It is non-water depended and would require an alternatives
> analysis, compliance with 404 b 1 guidelines and mitigation.
>
> page 46 NJDEP Division of Coastal Resources, I think this is their old
> name, unless they changed it back recently. I think it is still the
> Land Use Regulation Element. This should be checked.
>
> Page 49 - There are two of them.
>
> Page 52 - more detail shoudl be included on how the flood control
> project could affect the site. Also, if affected, the area may be
> needed for mitigation for the flood control project. Also, NMFS would
be very concerned about the conversion of low marh to uplands or to
forested wetlands. We cannotnot endorse any loss of fish habitat.
> While diversity is nice, we cannot agree to it at the expense of
fishery
> resources.

>
> Page 54 - Option 4. Has there been any sampling of the sediments on
> Clancy Island for contaminants?

> Page 55- Option 5 Filling the canal would result in the loss of open
> water. How much should be quantified.
>
> PAge 60 Option 6 - dredged material can be used to create
> forest/scrub-shrub along as along as it does not involve filling
fishery
> habitat. Other issues with dredging involve time of year restriction,
> sediment testing and the identification of a suitable disposal site.
>
> page 65 Create forest/scrub-shrub - wetland impacts may not
> necessarily be offset be the creation of nesting habitat for birds.
> Impacts to fish habitat (low marshes & open water) can not be offset
by
> creating bird habitat. We need to keep the functions and values in
> mind.
>
> That's all. Those are my very picky comments. Thanks

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, N.Y. 10278-0090

REPLY TO ATTENTION OF

January 19, 2001

Environmental Analysis Branch

Mr. Stanley Gorski
National Marinè and Fisheries Service
Habitat Conservation Division
James J. Howard Marine Sciences Laboratory
74 Magruder Road
Highlands, New Jersey 07732

Re: Raritan River Basin
Flood Control and Ecosystem Restoration Feasibility Study
South River and Sayerville, New Jersey

Dear Mr. Gorsky:

The U.S. Army Corps of Engineers, New York District (District) is pleased to submit the Essential Fish Habitat (EFH) assessment for the subject project to the National Marine and Fisheries Service (NMFS) for review and comment pursuant to the 1996 Magnuson-Stevens Act.

The EFH assessment identified only two EFH-designated species, winter flounder (*Pseudopleuronectes americanus)* and bluefish (*Pomatomus saltatrix*) to occur in the study area. The restoration of the marsh ecosystem is expected to have an immediate and long-term benefit on EFH, particularly for bluefish, since ecosystem restoration is expected to improve the extent and quality of juvenile nursery habitat for this species.

The construction and operation of the proposed storm gate is not expected to have any significant short- and/or long-term adverse impact on either of these species. Therefore, the implementation of the proposed storm gate would not contribute to either any existing or proposed action that may have a significant long-term adverse impact on EFH in the study area.

The District, based on the enclosed EFH assessment, has concluded that ecosystem restoration will provide immediate and long-term benefits for EFH for bluefish and that the construction and operation of the proposed storm gate is expected to have no more than minimal short-term adverse effect on EFH. Accordingly, the District does not have any recommendations because there is no need for further assessment.

At this time, I am looking for comment by your agency to verify the conclusions of the EFH assessment. We look forward to continue to work closely with you on this project. If you have any questions or need additional information, please contact Mark Burlas or Josephine Axt of my staff at 212-264-4663.

Sincerely,

Joseph Vietri
Deputy Chief, Planning Division

Attachment
Copy Furnished:
Mr. Bernard Moore, P.E.; NJDEP

Axt, Josephine R NAN02

From:	Karen Greene [Karen.Greene@noaa.gov]
Sent:	Monday, February 05, 2001 10:34 AM
To:	Axt, Josephine R NAN02; Brad Schaeffer; Chris Dolphin; Mark burlas; Sarah Watts; Stacie Grove; 'tom_mcdowell@fws.gov'
Subject:	south river and upland islands

I was just going back through my note from the Meadowlands Interagency Mitigation Advisory Committee meeting to find the background information on upland islands. I misspoke the other day about the percentages. The percent upland islands agreed to by NMFS, FWS, the ACOE, NJDEP and HMDC is no more than 5 percent, not 10. I have not found all of the notes on this decision, but there was a great deal of discussion about it. If I can't find all of the documentation, maybe tom can look to see if Pete Benjamin left his notes. Or I'll chenck with the other MIMAC members. Sorry for the mistake and the trouble it may cause, but NMFS will have to recommmend no more than 5 percent upland islands.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Habitat Conservation Division
James J. Howard Marine
Sciences Laboratory
74 Magruder Road
Highlands, New Jersey 07732

February 9, 2001

Mr. Joseph Vietri, Deputy Chief
Planning Division
New York District
US Army Corps of Engineers
26 Federal Plaza
New York, NY 10278-0900

ATTN: Josephine Axt and Mark Burlas

Dear Mr. Vietri:

Reference is made to your letter dated January 19, 2001 concerning the essential fish habitat (EFH) assessment for the Raritan River Basin Flood Control and Ecosystem Restoration Feasibility Study for South River and Sayerville, New Jersey. As discussed with Ms. Axt and the ACOE's contractor, Northern Ecological Associates at the Habitat Evaluation Procedure team meeting held on January 31, 2001, the assessment does not fully address all of the potential impacts of the project on EFH. In order to comply with the requirements of the Magnuson Stevens Act (MSA), the EFH assessment must address the direct (e.g., contamination or physical disruption), indirect (e.g., loss of prey, reduction in species' fecundity), site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions of the project. This should include both the immediate and long term impacts of the levees, stormgate and ecosystem restoration, as well as the impacts that may occur during construction.

It is important to note that the MSA seeks to protect the habitat of federally managed species and their food sources. Consequently, the absence of a species during a particular sampling event does not mean that the area is not EFH. If an area is designated by one of the regional federal fisheries management councils or by the NMFS as EFH, and the habitat parameters of that area, such as depth, salinities and bottom type fit the description of EFH as defined in the fisheries management plans, the area is EFH regardless of any sampling information.

Although some of the needed information is included in the document provided with your January 19, 2001 letter, additional information is needed before the EFH assessment can be considered complete. We have provided a marked up copy of the assessment to your staff and to the contractor to assist them in making revisions to the assessment. Once we receive a revised assessment, we will provide conservation recommendations as appropriate. We look forward to continued coordination on this project. If your would like to discuss this matter further, please contact Karen Greene at 732 872-3023.

Sincerely,

Stanley W. Gorski
Field Offices Supervisor

cf: RO - Chiarella

Axt, Josephine R NAN02

From:	Karen Greene [Karen.Greene@noaa.gov]
Sent:	Wednesday, April 18, 2001 12:11 PM
To:	Sarah Watts; Robin Dingle; mark.h.burlas@nan02.usace.army.mil; Josephine Axt
Subject:	South River ERP

I have just a few very minor comments. Most importantly, everyone did a great job on this. I can't believe all the different combinations you guys had to look at. The document is also well written and comprehensive.

My minor comments are:

Page 21: In addition to American shad, there is a confirmed spawning run of alewife in the South River at the dam.

page 28: Ther elevations listed for the various types of habitat appear different from the benchmarks on the previous page.

page 29: EFH - I have a recommended some changes to the second paragraph under 3.6. In the first sentence, it should be state that the NEFMC and the Mid-Atlantic Fisheries Management Councils have designated EFH for 15 federally managed species in the vicinity of the South River project area. Not NMFS

As some background, the councils designate the EFH (except for highly migratory species and sharks for which NMFS did the designations), the Secretary of Commerce has the authority to approve or disapprove the designations. NMFS role in the council's designations was to provide information, source documents on the species life histories, survey data etc to assisst the councils. On behalf of the Secretary of Commerce, NMFS also reviewed and commented on the designations, but the desingations themselves are a product of the various councils.

Also, please change the second sentence as follows: "In order to verify the presence/absence of EFH for these species in the project area......"

That's it. Overall, its a great document so far. Please call if you have any questions.

Axt, Josephine R NAN02

From: Karen Greene [Karen.Greene@noaa.gov]
Sent: Thursday, July 05, 2001 10:54 AM
To: Axt, Josephine R NAN02; Robin Dingle; Sarah Watts
Subject: South River Restoration Plan

Sorry for the delay. I read the report and have no addtional comments other than "Holy Cow!" I did not realize that the plan proposes to restore all of the areas. If completed, this will be a wonderful project for fish and wildlife. Good job.

U.S. ENVIRONMENTAL PROTECTION AGENCY

(1003)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
290 BROADWAY
NEW YORK, NY 10007-1866

RCVD 9/8/98 WHB

SEP 02 1998

Mark Burlas
Project Biologist
U.S. Army Corps of Engineers
CENAN-PL-EA
26 Federal Plaza
New York, New York 10278-090

Dear Mr. Burlas:

The Environmental Protection Agency (EPA) has reviewed the scoping documents for the Environmental Impact Statements (EIS) being prepared for the Raritan River Basin, South River Flood Control and Environmental Restoration Project located in Middlesex County, New Jersey and the Raritan Bay and Sandy Hook Bay, Union Beach Flood Control and Shoreline Protection Project located in Monmouth County, New Jersey.

The South River Feasibility Study has been initiated to evaluate structural and non-structural solutions that provide storm damage protection that could also be implemented independently or in combination. Structural alternatives include levees, floodwalls, and tidal barriers. Non-structural flood control alternatives include zoning, flood proofing of buildings, a flood warning system, and a buy-out plan.

The Union Beach project is intended to provide protection against beach erosion and wave damage along the Raritan Bay Shore, as well as inundation and storm damage in the Raritan Bay-Sandy Hook Bay area. Alternatives being considered include the construction of a 3500 foot dune, and 19,000 feet of levees and floodwalls. Given that the submitted scoping documents are rather general, we would like to offer some broad suggestions and comments that are applicable to both projects.

The scoping documents discuss the potential cumulative impacts associated with the implementation of the proposed projects and include many of the topics we typically recommend for inclusion in such an analysis. However, EPA is concerned that the Army Corps of Engineers (ACE) is looking at cumulative impacts on a project-by-project basis, and not in a comprehensive analysis. The ACE is involved with many beach nourishment and erosion and flood control projects along the coasts of New York and New Jersey. In order to fully evaluate the impacts of these projects, we need to understand not only how the proposed actions might affect the natural resources directly or indirectly, but also what more remote disturbances the proposed actions might have on the ecosystem. Toward this end, EPA sent a letter to the ACE on August 13, 1998, requesting that they perform a comprehensive cumulative impact analysis for their projects located along the New York and New Jersey coastlines.

Additionally, EPA believes that non-structural alternatives for the projects, such as home/business flood proofing, and property "buy-outs", appear to have been dismissed too quickly. Both of these methods often yield higher benefit-to-cost ratios than structural methods, and have fewer negative environmental impacts. These types of non-structural alternatives are currently being utilized in the Passaic River Basin and in the City of Rahway. We also recommend that the draft EISs thoroughly evaluate combinations of structural and non-structural alternatives in order to minimize adverse environmental impacts. The feasibility of these types of alternatives must be thoroughly considered in order to satisfy the 404 (b)(1) Guidelines of the Clean Water Act.

EPA also believes that the Corps should consider using floodwalls as opposed to levees in wetland areas. Floodwalls typically have narrower "footprints" than levees and would help minimize impacts to wetlands. We also believe the linear extent of levees should be minimized, and the configurations of levees and flood walls should be designed to avoid bisecting large wetlands. This would also help minimize indirect (e.g., hydrological) impacts to wetland areas.

Finally, we suggest that the draft EISs include a discussion justifying the chosen level of protection, the 100-year storm event. The discussion should include the costs and environmental impacts of this level of protection as compared to lower levels, such as the 50-year and 75-year storm event. In addition, the South River document states that about 3100 structures occur within the 100-year floodplain. The severity of flooding (e.g., basement versus first floor) for these structures should be estimated for various storm frequencies (50, 75, and 100-year storms). Similar analyses should be performed for the Union Beach Project.

Thank you for the opportunity to comment. Should you have any questions concerning this letter, please contact Mark Westrate of my staff at (212) 637-3789.

Sincerely yours,

Robert W. Hargrove, Chief
Strategic Planning and Multi-Media Programs Branch

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, N.Y. 10278-0090

REPLY TO
ATTENTION OF

May 21, 1999

Environmental Analysis Branch
Environmental Assessment Section

Mr. Robert W. Hargrove
Chief, Strategic Planning and Multi-Media Programs Branch
U.S. Environmental Protection Agency
Region 2
290 Broadway
New York, New York 10278-0900

Re: South River, Raritan River Basin
Multi-Purpose Feasibility Study

Dear Mr. Hargrove:

The U.S. Army Corps of Engineers, New York District (District) has initiated a multi-purpose feasibility study to identify a solution to reduce flood damages caused by tidal inundation and develop alternatives to ecologically restore degraded habitats. A project scoping document is attached that briefly identifies possible solutions, the existing biological, ecological and cultural resources, and potential impacts that may be associated with possible solutions.

The District intends to use the Habitat Evaluation Procedure (HEP) to assess impacts of the flood control component and to identify habitat unit outputs of ecological restoration alternatives. The HEP provides a quantitative assessment of relative value of wildlife habitats through a final numerical output that is technically defensible, replicable, and can be applied consistently in a variety of different habitat types. The HEP is based on combining a measure of habitat quantity with an index of habitat quality to determine habitat unit values. The underlying assumption of a HEP is that the habitat for a given wildlife species can be described by a Habitat Suitability Index (HSI) model.

To initiate the implementation of the HEP, the District would like to extend an invitation to your agency to participate on the interagency HEP team. The HEP involves obligatory attendance at many technical meetings that can last for most of a day; membership also includes significant coordination, fieldwork, and review and comment to HEP meeting minutes and technical documents. Accordingly, your decision to participate should reflect an obligation to allocate the essential amount of personnel time to accomplish each element of the HEP.

A kick-off meeting to begin the HEP is scheduled for June 30, 1999 at Sandy Hook, New Jersey (see the attached meeting agenda).

The District would like to request written confirmation regarding your decision to participate on the interagency HEP team. In addition, I would appreciate your contacting Mark Burlas of my staff to inform him if you are planning to attend the HEP meeting. If you have any questions or would like additional information regarding the project, Mr. Burlas can be reached via telephone at 212-264-4663, e-mail at mark.h.burlas@nan02.usace.army.mil or fax at 212-264-6040. The District looks forward to working with the USEPA on this project.

Sincerely,

Frank Santomauro, P.E.
Chief, Planning Division

Attachments
Copy Furnished:
Mr. Bernard Moore, P.E.; NJDEP

USACE South River, New Jersey Project
Habitat Evaluation Procedures Meeting Agenda
National Marine Fisheries Service
James J. Howard Marine Science Laboratory
74 Magruder Road
June 30, 1999, 9:30 AM
Sandy Hook, New Jersey

I. Project Overview
- Present project purpose and objectives.
- Present potential solutions
- Update of scoping meeting results/comments.

II. Presentation of Environmental Data
- Review draft cover type map.
- Review draft wetland map.
- Address comments/questions.

III. Preliminary Assessment of Natural Resources
- Identify and discuss natural resources in the project area.
- Identify potential threatened/endangered species concerns.
- Identify potential environmental impacts (direct and indirect).
- Discuss state and federal regulatory issues/concerns.

IV. Discussion of Habitat Evaluation Procedures (HEP)
- Overview of HEP and its use for impact assessment/mitigation.
- Identify project-specific goals/objectives for HEP.
- Discuss membership and responsibilities (i.e., meetings, document review, etc.) of the HEP team.
- Initiate formulation of species selection criteria.

V. Meeting Summary
- Review the group/individual task assignments.
- Develop a schedule for completion and review of the various tasks.
- Schedule future group meetings and/or conference calls.

Lunch Break

VI. Project Area Site Visit
- Familiarize the group with the project area/boundaries.
- Visit areas of potential impact and/or concern.
- Update task assignments if necessary.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
290 BROADWAY
NEW YORK, NY 10007-1866

JUN 0 9 1999

Frank Santomauro, P.E.
Chief, Planning Division
Department of the Army
New York District, Corps of Engineers
Jacob J. Javits Federal Building
New York, New York 10278-0090

Dear Mr. Santomauro:

Thank you for inviting the Environmental Protection Agency (EPA) to join the interagency Habitat Evaluation Procedure (HEP) team for the South River, Raritan River Basin Multi-Purpose Feasibility Study. Participation in the HEP team would require obligatory attendance at technical meetings, coordination, fieldwork, and reviewing and commenting on HEP team meeting minutes and technical documents.

Unfortunately, EPA does not have the resources that would be necessary to adequately participate in the HEP team being formed for this project. However, pursuant to our responsibilities under Section 309 of the Clean Air Act, we would be pleased to review any environmental review documents, including the HEP reports, issued for the project in accordance with the National Environmental Policy Act.

If you have any questions concerning this letter, please contact Mark Westrate of my staff at (212) 637-3789.

Sincerely yours,

Robert W. Hargrove, Chief
Strategic Planning and Multi-Media Programs Branch

MISCELLANEOUS

U.S. Army Corps of Engineers
New York District
Environmental Analysis Branch

FAX TRANSMITTAL

From: Mark Burlas   Date: 12/7/99

FAX No.: 212-264-0961

Phone: 212-264-4663

To: Tom McDowell

Organization: FWS

FAX No.: 609-646-0352

Phone:

No. of pages including form: 2

Comments: Tom -

I could not find a response from your agency. I must have misplaced it. Could you fax me a copy at 212-264-0961.

Thanks.

M[illegible]

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, N.Y. 10278-0090

REPLY TO ATTENTION OF

December 17, 1998

Environmental Analysis Branch
Environmental Assessment Section

Mr. Clifford G. Day
Supervisor, New Jersey Field Office
U.S. Fish and Wildlife Service
Ecological Services, Region 5
927 North Main Street, Building D1
Pleasantville, New Jersey 08323

Re: Raritan River Basin, South River, New Jersey
Combined Flood Control and Environmental Restoration Project

Dear Mr. Day:

The U.S. Army Corps of Engineers, New York District (District) would like to initiate informal consultation with the U.S. Fish and Wildlife Service (Service) pursuant to Section 7 of the Endangered Species Act. A project scoping document is attached that briefly identifies possible solutions to reduce damages caused by flooding, the existing biological, ecological and cultural resources, and potential impacts that may be associated with possible solutions. The District intends to use the Habitat Evaluation Procedure (HEP) to assess impacts of the proposed project. An invitation to participate on the interagency HEP team will be forthcoming in the near future.

If you have any questions or would like additional information regarding the project, please contact Mark Burlas of my staff at either 212-264-4663 or e-mail at mark.h.burlas@nan02.usace.army.mil or fax at 212-264-6040. The District looks forward to working with the Service on this project.

Sincerely,

Frank Santomauro, P.E.
Chief, Planning Division

Attachment
Copy Furnished:
Mr. Bernard Moore, NJDEP

U.S. Fish and Wildlife Service
New Jersey Field Office

Field Notes

An activity report of field operations - May 1999

From the Supervisor's Chair...

By: Clifford G. Day

The theme of this issue of Field Notes is *interconnections*; articles focus on the ongoing, but changing, relationships taking place between the various components of our environment. Interconnections are described in ecology via the dynamic relationships between living organisms and their environment. These relationships can be observed in ecosystems through naturally occurring phenomena as well as by the consequences of human intervention.

Anthropocentric interconnections are observed on-the-ground; their resulting changes may be positive, indicating a connective relationship between humans and wild living things, or negative, pointing to a disconnective relationship. Recognizing the importance of environmental interconnections and taking proactive approaches can yield positive, long-term gains - *for people and wildlife!* Human intervention that attempts to achieve and maintain a healthy, natural ecosystem can develop into a long-term interconnection. Examples of such interconnections can result from sound land-use planning efforts such as watershed management, landscape ecology, and/or ecosystem management. The State of New Jersey's Development and Redevelopment Plan is one proactive approach for guiding responsible land-use planning. Also noteworthy is the State's Open Space funding initiative to protect an additional one million acres of natural areas from development. On the federal level, proceeds from Duck Stamp Sales purchased millions of acres for wildlife. The establishment and enforcement of environmental laws provide other gauges of society's responsiveness to interconections. The failure to impose and enforce meaningful consequences for bad land-use decisions promotes more bad land-use decisions - a poor legacy for future generations.

Disregard for the consequences of environmental interconnections is evident as short-term gains that drive the exploitation of natural resources. The consequences of these disconnections yielded threatened and endangered species, ecosystem fragmentation, loss of wetlands, degradation of water quality, declining native wildlife populations, loss of wildlife habitat and corridors from suburban sprawl, invasive exotic species, human-generated contaminants in naturally functioning ecosystems, and disconnection between humans and the natural world. It is especially sad to see the disconnection between youth and nature, particularly among many urban and suburban youth who are more apt at identifying corporate logos than native wild species.

Society's decisions will continue to affect fish and wildlife resources and their supporting ecosystems. We must advance an integrated management approach to fish and wildlife and other natural resources conservation in recognition of the interconnections occurring in the natural world. We can accomplish this through education, science, interdependent land-use planning, land acquisition and conservation easement programs, enforcement of environmental laws, conscientious environmental decisions in consideration of future generations, and by exercising sound judgement. In addition to sustaining and safeguarding fish and wildlife resources, our understanding of and actions in behalf of environmental interconnections will greatly influence the quality of life. The following articles address the U.S. Fish and Wildlife Service's (Service) awareness of environmental interconnections from the New Jersey Field Office's (NJFO) perspective.

The Federal Duck Stamp, one of the most successful conservation ventures in existence today.

A positive interconnection *- for people and wildlife!*

Interconnections

Fish, wildlife, people and the Service

By: Steve Atzert
Refuge Manager, Forsythe National Wildlife Refuge

I think the Service does not relate well to the public, and many people do not connect with us because we "only care about fish and wildlife."

The mission of the Service is "...working with others to conserve, protect, and enhance fish and wildlife and their habitats for the continuing benefit of the American people." The mission statement stresses two important interconnections: the Service must work with others, and the Service's allegiance is to the American people.

All too often Service employees stop reading the mission statement after the word "habitats." Sometimes I hear the term "save the dirt" as an encapsulation of the Service's mission. That phrase addresses "conserve, protect, and enhance fish and wildlife and their habitat," but it does not address "the continuing benefit of the American people." I think this lack of focus on our ultimate employer diminishes support for our work. I think the Service does not relate well to the public, and many people do not connect with us because we "only care about fish and wildlife." To many, fish and wildlife are like "ice cream and cake," not essential to most people's daily lives. Most people focus on "meat and potato" or "bread and butter" issues, such as the economy.

An article by Costanza *et al.*, published in Nature, "The Value of the World's Ecosystem Services and Natural Capital," addresses the value of goods and services the ecosystem provides. The authors evaluated 17 different services, valuing the items at about $33 trillion. The authors found that most of the biosphere's economic value is not fully "captured" in commercial markets, so natural goods and services are often ignored in policy decisions. Wrote Costanza, "This neglect may ultimately compromise the sustainability of humans in the biosphere. The economies of the Earth would grind to a halt without the services of ecological life-support systems, so in a sense their total value to the economy is infinite."

Karl-Henrik Robert, of Sweden, developed *The Natural Step*, a good tool for placing the Service's work into people's economic understanding. *The Natural Step* is based on four principles: nothing disappears, everything disperses, biological and economic value is in concentration and structure, and green cells are the only net producers of concentration and structure.

The Natural Step has four system conditions: 1. Material from the earth's crust must not be allowed to systematically increase in nature; 2. Persistent substances produced by society must not systematically increase in nature; 3. The physical basis for the earth's productive, natural cycles and biological diversity must not be systematically deteriorated; and 4. There must be fair and efficient use of resources in meeting human needs.

When we discuss "systems conditions" and think "systems" it shows our growing understanding of interconnections. As the Service continues its mission for the benefit of all Americans, it is important we do not lose sight of the many interconnections between fish, wildlife, and people.

A Partnership Grows in the Great Swamp

by: Bill Koch, Refuge Manager, Great Swamp National Wildlife Refuge, *and* Louise Jensen, Project Leader, Morris Land Conservancy

New Jersey Field Office
927 North Main Street, Building D-1
Pleasantville, New Jersey 08232
(609) 646-9310 Fax: (609) 646-0352
e-mail: R5ES_NJFO@fws.gov

As pressures on the watershed and the Refuge grow, the surrounding communities must recognize the area's complex interconnections and share responsibility for protecting it.

The whole is greater than the sum of its parts. And this holds true in the Great Swamp. During the past year the Service and Morris Land Conservancy created a broader perspective of the Great Swamp... a "whole" picture. A cornerstone of this partnership is the development of a Science and Technology Center (Center) which will link environmental organizations and initiatives throughout the watershed.

The Great Swamp National Wildlife Refuge's wet landscape is unusual, trapped at the lower end of a watershed and in a nearly enclosed basin. The watershed is within an hour of New York City and Philadelphia, an area with more than 20 million people. The ridges lining the basin are valuable real estate - both Morris and Somerset Counties are among the nation's 10 wealthiest counties. Nearly 30 years ago, a jetport proposal threatened to destroy the Swamp; today residential development and water quality issues threaten the Swamp's survival.

As pressures on the watershed and the Refuge grow, the surrounding communities must recognize the area's complex interconnections and share responsibility for protecting it. The Refuge is habitat for protected species such as the bog turtle and blue-spotted salamander, and the surrounding land generates drinking water for hundreds of thousands of people. As one partner stated during the Center's planning process, "We can't manage from behind a fence any longer." Only by working together with an integrated approach can the Great Swamp be saved.

The Service plays a leading role, working to build stewardship throughout the watershed communities. The function relates well with the Service's ecosystem approach and recent Congressional legislation encouraging public involvement in the National Wildlife Refuge System. The effort's focus is on developing a facility to meet community and Service needs. From these efforts grew a core planning group, the cornerstone for the Great Swamp Partnership.

The Partnership helped set the Center's conceptual plan. By assessing current and past watershed initiatives, the Partnership discovered the pressing need for a coordinated and sustained approach to evaluating watershed and Refuge health. The partners agreed on the following mutual goals for the Center: sponsor continuous health studies for the watershed and Refuge; store, interpret, and distribute data; and develop outreach programs to help residents, civic leaders, and professionals get the tools and resources needed to make wise decisions about the watershed and Refuge.

At the October 10, 1998 Great Swamp National Wildlife Refuge open house, Anthony Leger, Assistant Regional Director for Wildlife and Refuges, referred to the Great Swamp Partnership as "one of the most creative partnerships the Service is participating in nationwide." And the effort is growing. Resource groups developed conceptual plans for programs, exhibits and buildings. Morris Land Conservancy is developing a presentation and final concept plan for the Service. By building on past successes, the Partnership plans to bring a healthy Great Swamp ecosystem into the 21st century.

Both Rachel Carson and Aldo Leopold understood the importance of interconnections well before our time. Their two most famous books, Leopold's A Sand County Almanac and Carson's Silent Spring focus on interconnections. Although no longer with us, this "interview" provides, through their own words, a small look into their deep and great understanding of our natural world. As we enter the 21st century, their words remain a strong portent of our need to respect our planet's complex biology.

Carson and Leopold Discuss Interconnections

An "interview" with Rachel Carson and Aldo Leopold

Ocean waves break along New Jersey's marshy seashore, the flowing water caressing timeworn sands. Topping a small rise, the Earth quickly sprouts into a mix of pinelands and farms. Wispy smoke from a farmhouse chimney quickly fades about the deep blue sky and puffy white clouds. In such a setting both Carson and Leopold seem relaxed, but at the same time anxious to tell one last story. And so we begin.

So why is it so important people recognize interconnections?
"The history of life on earth has been a history of interaction between living things and their surroundings," answers Carson. Leopold stops puffing on his pipe to add, "Civilization is not, as they [historians] often assume, the enslavement of a stable and constant earth. It is a state of *mutual and interdependent cooperation* between human animals, other animals, plants, and soils which may be disrupted at any moment by the failure of any of them." He pauses, then continues, "These wild things, I admit, had little human value until mechanization assured us of a good breakfast, and until science disclosed the drama of where they come from and how they live."

If history is full of these interconnections, then why don't people understand their value and what ignoring them could mean?
Carson addresses this question. "There is still very limited awareness of the nature of the threat. This is an era of specialists, each of whom sees his own problem and is unaware of or intolerant of the larger frame into which the right to make a dollar at whatever cost is seldom challenged."

Then do ecologists, those who study connections, have a leg up on everyone else, especially when they integrate cost into an issue?
Leopold smiles and shakes his head from side to side. "The emergence of ecology has placed the economic biologist in a peculiar dilemma: with one hand he points out the accumulated findings of his search for utility, or lack of utility, in this or that species; with the other he lifts the veil from a biota so complex, so conditioned by interwoven cooperations and competitions, that no man can say where utility begins and ends."

Some people think that society will be better off if we can identify and actively manage and regulate these interconnections. What do you think?
Carson slowly shakes her head to disagree, "The 'control of nature' is a phrase conceived in arrogance, born of the Neanderthal age of biology and philosophy, when it was supposed that nature exists for the convenience of man." She softens and continues, "Only by taking account of such life forces and by cautiously seeking to guide them into channels favorable to ourselves can we hope to achieve a reasonable accommodation..."

In terms of future development and our growing understanding of interconnection what final thoughts do you have?
This time Leopold begins. "There can be no doubt that a society rooted in the soil is more stable than one rooted in pavements. Stability seems to vary inversely to the mental distance from fields and woods." Carson adds one last comment, "Future generations are unlikely to condone our lack of prudent concern for the integrity of the natural world that supports all life"

Very true. Thank you both

The Consequences of "Disconnection"

By: Daniel Russell, Fish and Wildlife Biologist, Environmental Contaminants Specialist

The success of human society is partly based on the principle that we are all connected to one another. This belief forces us to realize individual actions may have far-reaching consequences on society, spreading like ripples on a pond. In recent times, scientists have come to understand that this concept of interconnections also applies to the natural world around us. By learning of "food webs" and "ecosystems," we begin to understand that plants, fish, and wildlife depend on one another and that disruption of their complex strands of "relatedness" can have cascading adverse impacts. In the last several decades our knowledge of interconnections enabled us to see that these disruptions can also be caused by human actions, and that the consequences could return to haunt us.

Today, we face a variety of problems associated with these negative consequences. From determining the environmental fate of pesticides to understanding the link between land-use decisions and the threat to biodiversity, it becomes clear that understanding interconnections is critical to restoring imperiled resources. However, learning the mechanics of interconnections is only part of the solution. We must also learn and overcome the reason why resources become jeopardized in the first place.

As society doggedly pursues the goal of "improved quality of life," a standard often raised, we continue to remove and insulate ourselves against the natural world. We have "disconnected" from our own ecology and it is precisely this disconnection that allows us to act without considering the consequences. Examples abound that demonstrate our rapidly deteriorating understanding of our place in the natural world. Many people today work in buildings where fresh air cannot intrude. We think nothing of driving in climate-controlled vehicles for trivial tasks, even when the destination is right around the corner. The link between what food the land provides and the end-product we finally eat is increasingly blurred as people rely on "fast-food" and mall-like grocery stores. Intimate knowledge of local flora and fauna has been replaced by television shows on exotic, high-profile species. At the close of the 20th century, people commonly spend entire days without setting foot on *terra firma.* Given all this, it is no surprise we continue to fragment and cover our remaining wild spaces, squander resources at an alarming rate, and use our water, air, and land to receive the waste generated by our consumptive lifestyle.

Solving the problems arising from our disconnection requires more than technical expertise. It also requires belief in a simple philosophy: humankind is not separate from nature, but rather an integral part of it -- interconnected to all other components of our surrounding ecosystems. The challenge for those of us working to protect our natural resources is difficult. Not only must we learn the complex interconnections of ecosystems, but we should also be harbingers of a more holistic approach to humankind's place on the earth. Service programs, such as "Earth Stewards," a program reaching out to future generations, and "Partners for Fish and Wildlife," a habitat enhancement and restoration effort, attempt to promote and foster this philosophy. While society may never revert to its agrarian or hunter/gatherer roots, it is not too late to change our way of thinking and "re-connect" with the environment around us. Aldo Leopold, the father of conservation, told us that "The land is one organism." We must not forget we are part of that whole.

In the last several decades our knowledge of interconnections enabled us to see that these disruptions can also be caused by human actions, and that the consequences could return to haunt us.

Earth Stewards

Interconnections between students and professionals

By: Edward G. Henry
Outreach Specialist

While many environmental programs teach students about the natural world, few create the interactions with resource professionals that are an integral part of Earth Stewards.

Earth Stewards is a partnership between the Service, the National Fish and Wildlife Foundation, local schools, and communities to introduce students to wildlife, their habitats, and people's relationship with them. Students, and through them teachers, parents, and communities, learn about the importance of stewardship and how society's decisions affect fish and wildlife resources.

New Jersey's Earth Stewards is among the nation's most successful. The NJFO sponsors two program sites, an elementary school in Atlantic County and a high school in Ocean County. Both programs use field trips, habitat enhancement, guest speakers, the internet, and customized lessons to provide students a learning experience that goes beyond the classroom.

Among the most successful characteristics of Earth Stewards' are the interconnections fostered between students and resource professionals. While many environmental programs teach students about the natural world, few create the interactions with resource professionals that are an integral part of Earth Stewards. When biologists, community planners, and naturalists take the time to work with Earth Stewards students, the interconnections result in unique educational and work experiences. When students see adults with a passion for their work, it provides them new opportunities to explore their own feelings about a subject.

For example, NJFO personnel working with the Smithville Elementary School helped prepare and implement the enhancement of a drainage ditch into a pond ecosystem. At Pinelands Regional High School resource professionals from the Service and from other organizations introduced students to a variety of subjects and career paths. The Ocean County Parks Department provided a set of aerial maps for local land-use patterns studied by Earth Stewards classes. For one student, a field trip to a estuarine reserve blossomed into a summer internship and possible career path. For both schools, students once unfamiliar with the environment now show interest in natural resource careers.

The expertise provided by resource professionals complements many aspects of the Earth Stewards program. Since Earth Stewards is cross-curricular, the various skills associated with any natural resource field blend with other school activities. For example, the Service's Junior Duck Stamp Program, a chance for students to express their interest in migratory birds through art, provides a different approach for fish and wildlife appreciation. Students learn the importance of math, English, art, and history in relation to resource management. Some students will become resource professionals, hopefully sharing their experience with generations to come. The interconnections between today's resource professionals and tomorrow's students make this program work. With its value firmly entrenched among students, educators, and the community, Earth Stewards is a rising star in the education of New Jersey's students.

How Cows Can Protect a Threatened Species

Interconnections Between Bog Turtles and Cattle

By: Lisa P. Arroyo, Fish and Wildlife Biologist, Endangered Species Specialist and Jason Tesauro, Assistant Biologist, New Jersey Endangered and Nongame Species Program


Although many interconnections exist throughout the natural world, some appear more peculiar than others. In New Jersey, biologists discovered an interesting interconnection between bog turtles (*Clemmys muhlenbergii*) and cattle: bog turtle habitat is created and maintained by cattle grazing.

Bog turtles are distinguished from other turtles by their small size (3 - 4.5 inches in length), light brown to black shell, and a large, conspicuous yellowish-orange blotch on each side of the head. Bog turtles live in wetland habitats with soft, mucky soil that is saturated by groundwater discharge. Low growing vegetation, such as grasses, hummock-forming sedges, rushes, and mosses, are typical of bog turtle habitats, allowing optimal sunlight penetration into the ground-level habitat. When these wetlands are left undisturbed, natural succession allows shrubs and trees to grow, ultimately transforming the open marsh habitat into an unsuitable shady swamp. Loss of this mid-successional habitat due to natural succession and human impacts led to the federal listing of the bog turtle as a threatened species on November 4, 1997.

Prior to European settlement, bog turtle habitats were created and maintained by natural fire, beaver flooding, and grazing by wild herbivores.[1] As these natural forces were reduced, cattle grazing became the primary force in the creation and maintenance of bog turtle habitats. Today, cattle continue to play an integral role in maintaining suitable bog turtle habitats. When low numbers of cattle are present in early successional wetlands, their grazing activities suppress the growth of trees and shrubs. Light grazing also increases plant diversity, inhibiting fast-growing species from dominating the wetland.[2] In addition, cattle footprints enhance bog turtle habitats by producing hummocks that bog turtles use for egg-laying.

Historically, New Jersey was a large dairy producer. Today, many of the former dairy regions continue to support active bog turtle populations. Funded by the U.S. Fish and Wildlife Service since 1995, the New Jersey Endangered and Nongame Species Program has conducted bog turtle surveys and discovered that 80 percent of historic and active bog turtle populations in New Jersey occur in active or recently abandoned cattle pastures. (To date, the bog turtle surveys have been focused in northern and central New Jersey; future efforts will also include southern New Jersey.) This bog turtle-cattle relationship is also apparent in other states supporting bog turtle populations. Maryland, Virginia, North Carolina, and Georgia reported that light grazing occurs on more than 50 percent of existing bog turtle sites.[3,4]

Unfortunately, many cattle pastures have been abandoned in New Jersey, allowing natural succession and the invasion of exotic plant species to alter the habitat. Although the relationship between bog turtles and cattle may appear peculiar to us, the preservation of this interconnection is critical to the long-term survival of the threatened bog turtle.

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3. Smith, S.A. 1994. Report on the status of the bog turtle (*Clemmys muhlenbergii*) in Maryland. Unpublished report submitted to the U.S. Fish and Wildlife Service 1825 Virginia St. Annapolis, MD 21401.

4.Tyron, B.W. and D.W. Herman. 1991 Status, conversion, and management of bog turtle, *Clemmys muhlenbergii*, in the southeastern United States. In Beaman, K.R., F. Caporaso, S. McKeown. and M.D. Graff, eds. Proceedings of the First International Symposium on Turtles and Tortoises: Conservation and Captive Husbandry, 36-53. Chapman University. Orange, California.

Interconnections Through Time -

Superfund Cleanup at Great Swamp National Wildlife Refuge

By: Billy J. Umstead[1]
Chief, Environmental & Facility Compliance

The interconnection between this dumping activity and its effect on wildlife is a part of the story of the Refuge's creation.

When considering contaminants in our environment, one might ask in surprise, "why is there a five acre Superfund Site in the middle of the well-established Great Swamp National Wildlife Refuge near Morristown, New Jersey?" The answer stretches back in time, when industry was king and the environment a mere afterthought. The Site was present when the Service established Great Swamp National Wildlife Refuge in 1968. The hazardous waste, mainly asbestos, accumulated as a manufacturing company used the area as a landfill for 50 years. The interconnection between this dumping activity and its effect on wildlife is a part of the story of the Refuge's creation.

In the 1960s the New York/New Jersey Port Authority proposed to fill the entire swamp and build a new airport. The contaminated landfill would disappear beneath a sea of concrete runways. However, opposition was strong; local citizens led the successful charge to preserve the swamp as a quiet, serene National Wildlife Refuge rather than a loud, busy jetport. The Refuge was a success. In 1968, Congress designated the Refuge's eastern half a Wilderness Area, the first east of the Mississippi. Cam Cavanaugh, in the book, "Saving the Great Swamp," retells this story of "people power." However, by saving the Swamp, the landfill remained uncovered. New research uncovered the dangers of asbestos and the Great Swamp had a new problem to address. The same dynamic people who saved the swamp 35 years ago continued their activism, working closely with the Service in the Superfund Site cleanup.

The Service began its investigation of this contaminated site in 1991. Teamwork helped assess many alternatives ranging from excavation and removing the entire landfill to a combination of capping and limited removal. Local groups and concerned individuals added their input and concerns. The U.S. EPA selected capping, removal, and proper disposal of contaminants. The solution included a two-foot clean soil cap over the site and a buried plastic screen to prevent small animals from burrowing into the landfill. Workers removed 1,300 tons of contaminated materials. The remediated site reopened to the public in November 1998.

The Superfund Site cleanup is one example highlighting how the Service works with partners and local communities to restore contaminated land and make it safe for people and wildlife. It is also an example of how environmental activities that occurred long ago influences the current and future environment. Time, at least on a human scale, does not heal all of the Earth's wounds. Events displaced by many years will continue to be a source of interconnections we can only guess at today.

1. Billy Umstead is the Chief of the Service's Office for Environmental and Facility Compliance. His office writes policy and assures Service facilities comply with environmental laws. His office is also responsible for the remediation of contaminated sites at all Service facilities.

Suburban Sprawl, Land Preservation, and Quality of Life

By: Thomas L. McDowell
Fish and Wildlife Biologist

These [Service] protected lands demand no sewer, water, roads, or schools yet provide numerous, services such as clean water, fish and wildlife habitat, and recreational opportunities.

New Jersey annually loses about 10,000 acres of rural land to development. Much of this "lost" land becomes piecemeal development and results in a condition known as suburban sprawl. "Sprawl" is defined in Webster's New Collegiate Dictionary as "to develop irregularly...to spread out carelessly or awkwardly." Sprawl leads to more difficult commutes, increased infrastructure (roads, water, sewer), increased property taxes, the need for more schools and other public services, degraded inner cities, a diminished sense of community, a loss of rural landscapes, and increased air and water pollution. In short, sprawl taxes our ability to enjoy life.

Despite these problems some municipalities continue to pursue ratables in an effort to reduce property taxes; however, this strategy rarely proves fruitful. For example, according to the State of New Jersey, during the 1980s, the average property tax bill doubled, despite record ratable construction such as commercial buildings and homes.

It is encouraging that New Jersey's citizens have taken action to combat suburban sprawl. Last year, voters approved the Governor's proposal to establish a stable funding source for the preservation of an additional one million acres of rural land. Additionally, both the State and counties have become more involved with conservation easements. Since rural land requires fewer services (e.g., sewer, water, schools), its preservation is a long-term investment in the environmental and financial quality of life.

The Service has no direct means to regulate suburban sprawl, but we help maintain a high quality of life for New Jersey's citizens through the purchase of lands for National Wildlife Refuges. The Service's effort to purchase and preserve land can reduce sprawl and short circuit the ratables chase. For example, New Jersey's five Refuges currently protect about 66,000 acres of land and the Service hopes to purchase, from willing sellers, an additional 26,000 acres. These protected lands demand no sewer, water, roads, or schools yet provide numerous services such as clean water, fish and wildlife habitat, and recreational opportunities.

While the Service purchases ecologically valuable land for the Refuge System, legally, we can only purchase lands providing habitats for federally listed species or within Refuge acquisition boundaries. Areas such as the Hackensack Meadowlands, critically important to migratory birds and fish, remain unprotected and under imminent threat from proposed development. Many of these developments could be redirected to decaying urban centers.

Although land preservation is not the only solution, it is the Service's most effective tool to slow sprawl and protect environmentally sensitive areas. The Service, to help ensure a high quality of life in New Jersey, promotes land preservation efforts and encourages other opportunities, such as conservation easements, for controlling suburban sprawl.

Silent Spring: Revisited?

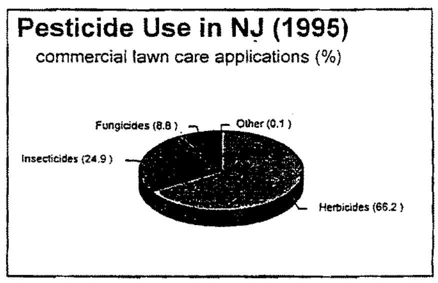
Interconnections in our backyard

By: Mark Eberle, Fish and Wildlife Biologist

If you are like most suburbanites, you want your home surrounded by a grass lawn. Not just any lawn, but a well-manicured, lush green lawn free from weeds, insects, and other pests yet supporting suburban wildlife. However, have you ever thought about the "price" of having such a lawn? Not in dollars, but in impacts to our natural environment resulting from the maintenance of this "green" lawn. In 1995 alone, licensed applicators applied 374,991 lbs. of pesticides to New Jersey's lawns, with herbicides accounting for approximately two-thirds of all use (see graph). The counties showing the greatest use of pesticides were Morris (14.2%), Monmouth (13.4%), Bergen (11.4%), and Middlesex (10.1%). These amounts do not include pesticide use by individual homeowners; therefore, they are conservative measures of the pesticide volume potentially impacting New Jersey's fish and wildlife resources. What are the interconnections between this pesticide use and our wildlife? One documented example occurred after improper insecticide use at a New Jersey condominium complex and resulted in a large-scale fish kill at two local ponds. In another case, the improper use of a common insecticide on an office complex lawn resulted in the death of two immature mallard ducks.[1]

Many scientific studies show detrimental effects to fish and wildlife from commonly used pesticides. A 1988 Service study showed that recommended application rates of chlorpyrifos, an insecticide commonly used in New Jersey, harmed nontarget species, including birds, fish, and invertebrates.[2] A 1987 study by the New York State Department of Environmental Conservation cited a case where 14 red wing blackbirds died from poisoning associated with home lawn applications of isofenphos.[3]

With considerable scientific evidence demonstrating the detrimental effect of lawn care products on our environment, why do people still use them? Some homeowners want to increase property value, aesthetics, or have a place to recreate, while others are unaware of the environmental damage these products can cause. No matter what the reason, the best way to promote a change in people's lawn-care habits is through education and by using more sensitive alternatives. If you must use pesticides, use them sparingly and carefully follow the directions for applying and handling these chemicals. Some ways to reduce pesticide use on your lawn include: keep your lawn small enough to allow manual weeding, use a grass mixture appropriate to your soil and climate, or try alternatives to a lawn. One alternative to a "green" lawn is a native wildflower meadow. Other options include growing a vegetable or butterfly garden, establishing a mini-orchard, or creating a wildlife-attracting pond.[4]



In 1962, Rachel Carson, a U.S. Fish and Wildlife Service employee, opened our eyes to the dangers of pesticides with her book Silent Spring -- in light of our current "green" lawn syndrome, maybe it is time we revisit this profound work.

[1]Brown, C. 1998. Personal Communication. New Jersey Department of Environmental Protection. Pesticide Control Program. Trenton. New Jersey.
[2]Odenkirchen, E.W., and R. Eisler. 1988. Chlorpyrifos hazards to fish, wildlife, & invertebrates: a synoptic rev. USFWS. Biol. Rpt 85 (1.13). 34 pp.
[3]Stone, W.B., and P.B. Gradoni. 1987. Poisoning of birds by cholinesterase inhibitor pesticides. NY State Dept. of Environmental Protection. 15 pp.
[4]Tufts, C. 1988. The backyard naturalist. National Wildlife Federation. 79 pp.

APPENDIX E

ECONOMICS

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INTRODUCTION

Purpose

This appendix presents the economic analysis used in the determination of the economic viability for federal participation in the South River, New Jersey Hurricane and Storm Damage Reduction and Ecosystem Restoration Study. Benefits were calculated for the plan that was anticipated to be the most effective with respect to local support, survivability, and flood protection criteria. Alternatives were screened for relative cost-effectiveness based on the level of without project damages, and preliminary estimates of benefits and costs.

Benefit Types

Benefits to be derived from the plan of improvement include:

1. Reduced inundation damage to structures and contents
2. Reduced public emergency costs
3. Reduced Federal Insurance Administrative costs
4. Ecosystem Restoration

Conditions

This appendix presents a description of the method used to develop damages and benefit-to-cost ratios, and is in accordance to ER 1105-2-100 and ER 1105-2-205. Benefits and costs are expressed as average annual values at the current Federal discount rate of 6 1/8% and project life of 50 years. The project base year (the year in which significant benefits will accrue from project construction) is 2010. All benefits are expressed in October 2001 price levels unless stated otherwise.

DESCRIPTION OF STUDY AREA

The study area is located within the lower Raritan River Basin in Middlesex County, New Jersey. The South River is the first major tributary of the Raritan River, located approximately 8.3 miles upstream of the Raritan River's mouth at Raritan Bay. The South River is formed by the confluence of the Matchaponix and Manalapan Brooks, just above Duhernal Lake, and flows northward from Duhernal Lake a distance of approximately 7 miles, at which point it splits into two branches, the Old South River and the Washington Canal. Both branches flow northward into the Raritan River. The South River is tidally controlled from its mouth upstream to Duhernal Lake Dam. Fluvial conditions prevail above the dam.

The study area encompasses four municipalities: Sayreville Borough, South River Borough, East Brunswick Township and Old Bridge Township. The majority of the structures affected in the study area lies within Sayreville and South River Boroughs. The historic Village of Old Bridge in East Brunswick, and the western part of Old Bridge Township fronting South River are also included in this study.

Sayreville Borough

Community Profile

Sayreville Borough is a suburban municipality located in central Middlesex County. The Borough can be characterized as a single-family home neighborhood. The Borough's population in 1990 is 34,988, an increased of 17 percent from 1980 as shown in Table 1[1]. The Borough's 1989 median household income was higher than the State and slightly higher than the County as shown in Table 2. The Borough's median housing value was slightly lower than that of the County and the State based on 1990 Census data. Sayreville experienced an increase in housing construction during the mid-1980's, due in large part to multi-family housing construction.[2]

Historically, Sayreville Borough has had a strong industrial and commercial economic base. Because of the resources in its soil, Sayreville became a brick building industry between 1850 and 1950. Industrial growth in this century was more diversified. The Borough is home to such major industries as E.I. Dupont, Hercules, Inc. and New Jersey Steel. While the Borough began as an industrial center in the 19th century, in the mid and latter parts of the 20th century the Borough became a bedroom community, with a 1990 population to job ratio of 4.93. This is well above the average ratio for Middlesex County, but is characteristic of some of the surrounding municipalities as shown in Table 3.[3] Sayreville residents are employed in a variety of industries as shown in Table 4[4]. The industry employing the highest percentage of Borough residents is manufacturing (21 percent), followed by retail trade (17 percent), finance/insurance/real estate (10 percent), education services (6 percent) and health services (6 percent). Manufacturing is a large employer because the region has traditionally been a manufacturing center. The Woodbridge Mall and assorted retail stores on Route 9 and 35 provide a large number of retail trade employment opportunities for Borough residents, while public, private and secondary schools in the area provide a large number of jobs in education services. The greatest increases in employment for Borough residents occurred in other professional services (127 percent), finance/insurance/real estate (83 percent), construction (77 percent), and wholesale trade (72 percent) as shown in Table 4. Service employment increases are likely due to commercial development in the area.

TABLE 1. POPULATION

Year	1970	1980	1990	2000	2010	2020
Middlesex County	583,813	595,893	671,811	722,573	778,933	823,162
Sayreville Borough	32,508	29,969	34,998	39,193	45,584	49,906
South River Borough	15,428	14,361	13,692	13,834	14,253	14,617
East Brunswick Township	34,166	37,711	43,548	45,935	47,841	49,514
Old Bridge Township	48,715	51,515	56,493	62,032	69,573	75,570

[1] U.S. Bureau of the Census, 1970, 1980, 1990; Middlesex County Planning Department, 2000, 2010, 2020.
[2] Heyer, Gruel & Talley, PA, 1998 Master Plan Borough of Sayreville Middlesex County, New Jersey, p. II-2.
[3] U.S. Bureau of the Census, 1990; N.J. Department of Labor. Note that Census 2000 data are not currently available.
[4] U.S. Bureau of the Census, 1980 and 1990.

TABLE 2. MEDIAN HOUSEHOLD INCOME			
Year	1979	1989	Percent Change (1979-1989)
New Jersey	$19,800	$40,927	106.7%
Middlesex County	$25,023	$45,623	82.3%
Sayreville Borough	$24,683	$46,057	86.6%
South River Borough	$20,989	$37,998	81.0%
Old Bridge Township	$23,222	$47,482	104.5%
East Brunswick Township	$30,498	$58,709	92.7%
South Amboy City	$18,544	$37,933	104.5%
Edison Township	$25,206	$50,075	98.7%
Woodbridge Township	$24,054	$45,516	89.2%

Table 3. POPULATION TO JOB RATIOS			
	1990 Population	1990 Covered Employment	Population To Jobs
Middlesex County	671,780	299,530	2.24
Monmouth County	553,124	170,419	3.25
Sayreville Borough	34,986	7,093	4.93
South River Borough	13,692	1,975	6.93
Old Bridge Township	56,475	6,279	8.99
East Brunswick Township	43,548	22,107	1.97
South Amboy City	7,863	2,585	3.04
Edison Township	88,680	62,935	1.41
Perth Amboy City	41,967	11,872	3.53
Woodbridge Township	93,086	41,669	2.23

TABLE 4. EMPLOYMENT TRENDS

Industry	SAYREVILLE BOROUGH Employment 1979	Employment 1989	% Change 79-89	MIDDLESEX COUNTY Employment 1979	Employment 1989	% Change 79-89
Agriculture/Mining	69	87	26.09%	1,934	2,779	43.69%
Construction	590	1,046	77.29%	11,919	18,893	58.51%
Manufacturing	4,799	3,835	-20.09%	84,979	69,634	-18.06%
Transportation	772	1,454	88.34%	16,439	20,809	26.58%
Communications/Utilities	604	791	30.96%	9,241	13,237	43.24%
Wholesale Trade	687	1,182	72.05%	15,569	22,464	44.29%
Retail Trade	2,211	3,222	45.73%	44,864	54,630	21.77%
Finance/Ins./R. Estate	1,034	1,897	83.46%	17,108	33,651	96.70%
Bus & Repair Services	773	982	27.04%	15,398	18,788	22.02%
Personal & Rec. Services	372	463	24.46%	7,233	11,459	58.43%
Health Services	719	1,172	63.00%	16,072	24,949	55.23%
Education Services	987	1,191	20.67%	27,464	30,230	10.07%
Other prof. Services	440	999	127.05%	10,433	25,946	148.69%
Public administration	582	816	40.21%	11,913	13,040	9.46%
Total	14,639	19,137	30.73%	290,566	360,509	24.07%

Land Use

Sayreville Borough contains a unique mix of older suburban residential development; strong industrial base and highway commercial corridors that in recent decades have been supplemented by large planned unit residential developments. The Borough's development continues to be influenced by its strategic regional location, vacant land and infrastructure availability. The predominant land use in the Borough is residential land that comprises 2,667 acres, or 22.2 percent of the land area of the Borough. Privately owned land constitutes 2,333 acres, or 19.5 percent of the land area and public and semi-public uses, including parks and open space, compromise 2,160 acres, or 18 percent of the Borough's land area. Industrial uses account for 1,317 acres or 11.0 percent of the Borough's land area. Commercial land use accounts for 578 acres, or 4.8 percent of the Borough's land area. It should be noted that almost 14 percent of the Borough's land area is water.

The future development potential of the Borough is based on development of approved projects not yet built and future development of vacant land. The combination of approved projects and development of vacant lands produces the build-out potential of the Borough. Redevelopment of underutilized existing, primarily nonresidential, sites are identified as potential redevelopment areas. Approximately 224 acres of privately owned vacant land over two acres in size is zoned residential and could produce 984 units. An additional 524 acres are zoned for residential and nonresidential uses. An estimated 1,550 housing units could be built on these parcels. The nonresidential portion could result in 1,352,538 square feet of commercial and industrial space. Over 1,170 acres of vacant land is zoned for commercial and industrial uses. A maximum of 24,996,992 square feet of new commercial and industrial space could be developed under the current zoning ordinance.[5]

Transportation

The Borough of Sayreville is well served by a variety of transportation facilities. The Garden State Parkway, Routes 9 and 35 traverse the Borough. Local and express bus service is provided from Sayreville to New York City and local points. Rail and air transportation are easily accessible from the Borough. New Jersey Transit and Academy Transit provide bus service throughout the Borough, and two routes directly to New York City. New Jersey Transit's North Jersey Coast Line provides train service to Newark, New York and Hoboken. This line extends from New York/Newark south through Union, Middlesex and Monmouth counties to the northern border of Ocean County at Bay Head. The average weekday total boarding at the South Amboy Station was 1,114 commuters in 1990.[6]

South River Borough

Community Profile

South River Borough is located on the westerly bank of the South River. Residential development is the major developed land use in South River Borough. Historically, single-family residential development overtook industrial development as the dominant form of land use at the turn of the century. Multi-family dwelling units and apartment complexes have been constructed to meet the changing demographic characteristics and economic needs of the Borough's residents. The 1990 population to job ratio of 6.93 is well above the average ratio for Middlesex County, but is characteristic of some of the surrounding municipalities as shown in Table 3. Commercially, South River is primarily a "Needle Trade" borough producing fine ladies clothing, embroidery, lace, etc. other trades; sand and gravel, adhesives, road materials, aluminum recovery works, and a number of general construction contractors of considerable size. The Central Business District caters to father-son types of retail.

The Borough's population in 1990 was 13,692, a decrease of 5 percent from 1980 as shown in Table 1. The Borough's 1989 median household income was lower than the State and County as shown in Table 2. The Borough's median housing value was 15 percent lower than that of the County.[7] South River residents are employed in a variety of industries as shown in Table 5. The industry employing the highest percentage of Borough residents is manufacturing (26 percent), followed by services (24 percent), retail trade (16 percent), construction (12 percent) and finance/insurance/real estate (6 percent).

[5] Heyer, Gruel & Talley, PA, op. cit., p. III-8 to III-11.
[6] Ibid., p. IV-19.
[7] Sheehan Consulting Group, Borough of South River 1997 Master Plan Update, April 1997, p. 56.

TABLE 5. POPULATION BY INDUSTRY[8]					
Industry	South River	East Brunswick	Old Bridge Twp	Middlesex County	New Jersey
Agriculture	21	141	199	2,297	38,208
Forestry/Fisheries	0	4	7	82	1,953
Mining	0	15	14	400	5,066
Construction	840	1,072	2,003	18,893	231,328
Manufacturing	1,779	4,096	5,034	69,634	653,436
Transportation/Comm.	537	1,969	3,409	34,046	332,879
Wholesale Trade	290	1,477	1,931	22,464	207,413
Retail Trade	1,116	3,521	4,708	54,630	587,969
Finance/Ins./R. Estate	420	2,334	4,002	33,651	346,037
Services	1,622	8,736	8,518	111,372	1,283,940
Public administration	269	648	1,229	13,040	180,469
Total	6,894	24,013	31,054	360,509	3,868,698

Land Use

The Borough of South River is approximately 2.75 square miles, or 1,812 acres in land. In addition, the Borough consists of claims to approximately 64 acres in water rights pertaining to the South River (located along the municipality's eastern boundary) and approximately 0.21 acres of Riparian Grants contained therein. The landmass of the Borough is comprised of an assortment of land use categories, specifically: residential, commercial, industrial, public, quasi-public, rights-of-ways, and vacant land. This community is predominately residential with a mature suburban character.[9]

The Borough is 86 percent developed. The predominant land use in the Borough is residential land that comprises 666 acres, or 37.8 percent of the land area of the Borough. Privately owned land constitutes 247 acres, or 13.7 percent of the land area and public and semi-public uses, including parks and open space, compromise 410 acres, or 6.3 percent of the Borough's land area. Industrial uses account for 93acres or 5.2 percent of the Borough's land area. Commercial land use accounts for 83 acres, or 4.6 percent of the Borough's land area.[10]

The future development potential of the Borough is based on development of approved projects not yet built and future development of vacant land. The Planning Board does not propose any radical land use concepts that would dramatically change the character of the community. Current land development patterns are encouraged to be maintained, while redevelopment is urged along the perimeter of the Downtown Business District and along the riverfront. The remaining few vacant tracts of land is encouraged to be developed in a manner that will be beneficially compatible with the surrounding area.[11]

[8] U.S. Bureau of the Census, 1990.
[9] Ibid., p. 13.
[10] Ibid., p. 22.
[11] Ibid., p. 127.

Transportation[12]

There are no major regional roadways that traverse through the Borough. However, this does not preclude South River from having adequate regional access. The Borough is directly impacted by State Route 18, located a short distance from the Borough's western boundary. This thoroughfare is a principal north to south arterial roadway serving central New Jersey that provides direct linkage to the New Jersey Turnpike, which lies a mile to the north. Access to Route 18 from South River is accomplished through the use of several county routes and local streets in nearby East Brunswick Township. The Garden State Parkway and State Route 9 are located approximately five miles east of the Borough and are readily accessible via several county routes through the adjoining municipality of Sayreville. New Jersey Transit and Suburban Transit provide local and regional bus transportation. Local bus transportation is accessible within South River and includes a designated point of transfer on Main Street between Obert Street and Ferry Street. Regional bus transportation is not directly accessible within South River itself, but is readily accessible via the East Brunswick Transportation Center. This facility is located at the corner of Tice Lane and Old Bridge Turnpike, which is adjacent to the municipal boundary at the north end of the Borough. Regional bus service is considered readily accessible to South River residents. There are two passenger rail lines available to residents of South River that are located some distance outside of the municipal boundaries. The New Jersey Transit North Jersey Coast Line lies east of South River with the closest available train station located in South Amboy. The New Jersey Transit Northeast Corridor Line lies west of South River with the closest available train station located in New Brunswick. Each station is accessible through regional bus transportation services.

Village of Old Bridge, East Brunswick Township

Community Profile[13]

East Brunswick Township is one of the fastest growing suburban areas in Middlesex County. Located inland south of the Raritan River, it runs parallel to the South River on its easterly and southern side and is bordered by the Farrington Lake on its westerly side. People of Scotch, Dutch, and German origin settled the area in the 17th century. The growth of industry in 19th century East Brunswick was facilitated by the abundance of raw materials, proximity to large markets as well as relatively inexpensive transportation to the markets of New York and Philadelphia. Currently, it is encouraging industrial parks which cater to light industry and more sophisticated post-industrial concerns, such as computer, electronics, and publishing firms. The Township's population in 1990 is 43,548, an increased of 15 percent from 1980 as shown in Table 1. The Township's 1989 median household income was higher than the State and highest in the County as shown in Table 2. East Brunswick Township residents are employed in a variety of industries as shown in Table 5. The industry employing the highest percentage of Borough residents is services (36 percent), followed by manufacturing (17 percent), retail trade (15 percent), finance/insurance/real estate (10 percent), and transportation/communication (9 percent).

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[12] Ibid., p. 87-102.

[13] East Brunswick Historical Society.

The Historic Village of Old Bridge is located in southeastern East Brunswick Township. It is bordered on two sides, east and south, by the South River, by the Chestnut Hill Cemetery on the north and by Route 18 and Old Bridge Turnpike on the west. Old Bridge Village is listed as a historic district on the New Jersey State, September 1975, and on the National Register, June 1977.

Land Use
The Historic District Master Plan restricts commercial activity to historically established areas of use. It confines commercial activities and uses to local or neighborhood-oriented services, sales, and offices. No new industrial uses are permitted, and will seek to terminate all present industrial activities. The residential community consists of single-family homes built on lots averaging 4,500 sq. ft. The general density of residences in the district should not be increased.[14]

Transportation
New Jersey Transit and Suburban Transit provide local and regional bus transportation. The New Jersey Transit North Jersey Coast Line runs though Old Bridge Village but the closest available train station is located in South Amboy.

Old Bridge Township

Community Profile
Old Bridge is a developing community situated between the Gateway Region, with its tourism, culture and other urban amenities, and the Shore Region, with its beach and boardwalk and other amusements. The Township retains ample farmland and green space, including the beachfront, a state park and 15 municipal parks, and vacant land is available for continued growth. Initially, the Township was made up of farms and the population grew slowly. After 1950, the building boom started and the farms gave way to developments. This growth in population has not been accompanied by a concomitant growth of the economic base, and today Old Bridge is a predominantly residential community with a very low employment base. The 1990 population to job ratio is 8.99. The highest in Middlesex County, but is characteristic of some of the surrounding municipalities as shown in Table 3. The Township's population in 1990 is 56,493, an increased of 10 percent from 1980 as shown in Table 1. The Township's 1989 median household income was higher than the State and the third highest in the County as shown in Table 2. Old Bridge Township residents are employed in a variety of industries as shown in Table 5. The industry employing the highest percentage of Borough residents is services (27 percent), followed by manufacturing (16 percent), retail trade (15 percent), finance/insurance/real estate (13 percent), and transportation/communication (11 percent).

[14] Township of East Brunswick, NJ, Master Plan, Historic District Amendment, September 1977.

Land Use[15]

Old Bridge has a land area of 39.1 square miles, or approximately 25,152 acres. In 1975, about $^{1}/_{3}$ of the Township was considered developed, with approximately 13 percent in fields and 50 percent in forest or woodlands. In 1982, it was estimated that approximately 2,0000 acres were occupied with single family housing, 2,300 with multi-family housing, 400 with commercial and 675 with industrial uses. In addition, 8,500 acres were dedicated open space, including the Cheesequake State Park, Runyan and Duhernal watersheds, school grounds, flood plains and public utility lands. At present, there are over 4,000 acres of land under farmland assessment in Old Bridge, or 17 percent of its area. The pattern of land uses in Old Bridge is somewhat sprawled, with development strung along roads in the less developed portions of the Township, and concentrated in the northwest, central and northeastern sections. Historically, the Township has developed as roads pushed out from the west, with the older sections of town built along Routes 35, 34, and 516.

The new land use plan will focus on the development of a new town center, near the Old Bridge Municipal Complex. A variety of housing types within walking distance of stores shops, and recreational facilities are projected in the area of Cottrell and Matawan Roads. Upgrading of existing neighborhoods is proposed by the plan through capital improvements such as sidewalks and street trees. Under the plan, an additional 5,200-7,200 new housing units could be built over the next 20-30 years. The plan could also generate up to 3 million square feet of new commercial space, of which roughly 85 percent will be space for office, research and development, 14 percent retail and professional services, and less than two percent manufacturing/warehousing. This could translate roughly into an additional 15,600 jobs.

Transportation[16]

Old Bridge Township is crossed by Route 9, running north to south, and by Route 18, running northwest to southwest. The Garden State Parkway, which traverses the Cheesequake State Park, accesses the Laurence Harbor and Morristown areas. Other major components of the ground transportation network include Routes 34, 35, 527, and 516. Several mass transit operators work in Old Bridge, and although most services are in the form of commuter lines to Newark, Jersey City, and New York City, many offer local service as well. There are no rail stations currently operating within the Township. Rail service must be obtained through South Amboy.

DESCRIPTION OF THE PROBLEM

The South River Basin area, which is prone to imminent and catastrophic flooding, is located in northeastern New Jersey and is a highly urbanized, densely populated area. The South River Basin has experienced tidal flooding, which continues to threaten human life, safety, well-being, and causes significant economic damages due to repeated flooding of structures and infrastructure facilities located within the floodplain.

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[15] Hintz/Nelessen Associates, P.C., Old Bridge Township, Middlesex County, New Jersey, Master Plan, 1997, p. 52, 104-107.
[16] Ibid., p. 94 – 96.

Past storms impacting the area include the March 1962 Northeaster, May 1968 tidal event, Hurricane Doria (1971), 11 December 1992 Northeaster, and most recently the March 1993 Northeaster. The Northeaster storms are capable of producing unusually high tides. These storms can cause a multitude of problems, such as damages to roads and bridges; damage or destruction to public facilities, utility lines and sewers; and the damage to homes and commercial properties. The occurrence of such events endangers the health, safety and welfare of the people who live and work in the South River Basin. These problems have resulted in extensive financial losses to residents and businesses in the community.

A brief description of the flooding and damages in the past is listed below[17]:

- March 1962: Damages from this storm were estimated to be in excess of $4.2 million (FY 2001 dollars). A tidal event, this storm caused severe physical damage to residential, commercial, and industrial properties in South River and Sayreville. Motor vehicle traffic over the South River became impassable due to flooding of the Causeway Bridge.
- May 1968: Estimated to be a 20-year storm, flooding occurred as a result of tidal backwater flooding. Damages were estimated at $8.8 million (FY 2001 dollars), with significant structural damage to over 80 dwellings and 20 commercial buildings.
- August and September 1971: Hurricane Doria caused minor flooding in the area with estimated damages of $1.4 million (FY 2001 dollars) in South River, Sayreville, and Spotswood. The flooding was fluvial in nature as a result of over eight inches of rain.
- April 1984: A fluvial event, the storm caused minor flooding above Duhernal Lake, with no cost estimates for the damages available.
- December 1992 and March 1993: These two storms together are regarded as the worst on record for the region. Flooding occurred as a result of a northeaster storm combined with unusual high tides (over four feet above normal). Over 200 people were evacuated from the flood areas, which in South River was estimated to be 25% of the Borough. Estimated damages, as compiled by the Middlesex County Office of Emergency Management immediately after the storm, were estimated to be $7.8 million in South River, $6.6 million in Old Bridge, and $2.2 million in Sayreville (FY 2001 dollars). These damage estimates generally emphasize damages to structures and contents, which often do not become apparent until weeks or even months after the floodwaters subside. The bridge over South River, connecting the Boroughs of South River and Sayreville, was closed for several days and rail movement was also shutdown. The flood from the March 1993 storm is considered to be a 25-year event.

[17] U.S. Army Corps of Engineers, New York District, South River Raritan River Basin, New Jersey, Multipurpose Reconnaissance Study, May 1995, p. 10-13.

WITHOUT PROJECT FUTURE CONDITIONS

General

In order to develop plans, which would be responsive to both the immediate and future needs of the flood-prone communities and the overall goals of the region, it is necessary to describe the future conditions which would exist in the absence of a Federal project. The most probable future for the flood-prone areas within the basin assumes a basically stable level of development. This is so, because residential, commercial and industrial users generally require specialized structures, which have remained in these particular areas for a significant period in the past due to desirable features of the areas, such as low transportation costs caused by easy access and close proximity to New York City. Since floodplain regulations minimize new construction in areas which are subject to damage by the 100-year flood, it was considered that future reallocations of new residential, commercial, and industrial uses are not likely. If the areas are considered to remain a viable segment of the respective communities in the future, the most probable future is expected to be one of a stable, almost fully developed floodplain with relatively few new developments. Accordingly, the future without project condition includes the threat of severe and frequent flooding with threats and impacts stated above.

Reach Designation

The South River Basin study area has been divided into five economic reaches; these reaches were selected based on jurisdictional boundaries. The five reaches are defined as follows (see Figures 1 & 2):

Reach 1: Right bank of the South River in the East Spotswood Area (Old Bridge Township). This Reach contains 27 residential structures within the 100-year floodplain. This Reach contains 2 commercial structures and 64 residential structures within the 500-year floodplain.

Reach 2: Left bank of the South River in the Historic Village of Old Bridge (East Brunswick Township) area just downstream of Reach 1. This Reach contains 10 commercial structures and 65 residential structures within the 100-year floodplain. This Reach contains 16 commercial structures and 109 residential structures within the 500-year floodplain.

Reach 3: Left bank of the South River in the Borough of South River. Reach 3 was sub-divided into Reach 3A north of the Veteran Memorial Bridge (41 commercial and 166 residential structures) and Reach 3B South of the bridge (86 commercial and 367 residential structures) within the 100-year floodplain. Reach 3A has 48 commercial and 212 residential structures and Reach 3B has104 commercial and 505 residential structures within the 500-year floodplain.

Reach 4: Right bank of the South River and the Washington Canal in the Borough of Sayreville, across from reach 3. Reach 4 was sub-divided into Reach 4A north of the Veteran Memorial Bridge (9 commercial and 342 residential structures) and Reach 4B South of the bridge (17 commercial and 58 residential structures) within the 100-year floodplain. Reach 4A has 9 commercial and 367 residential structures and Reach 4B has 17 commercial and 85 residential structures within the 500-year floodplain.

Reach 5: Right bank of South River just downstream from Reach 2 (Old Bridge Township). This Reach contains 2 commercial structures and 57 residential structures within the 100-year and 500-year floodplain.

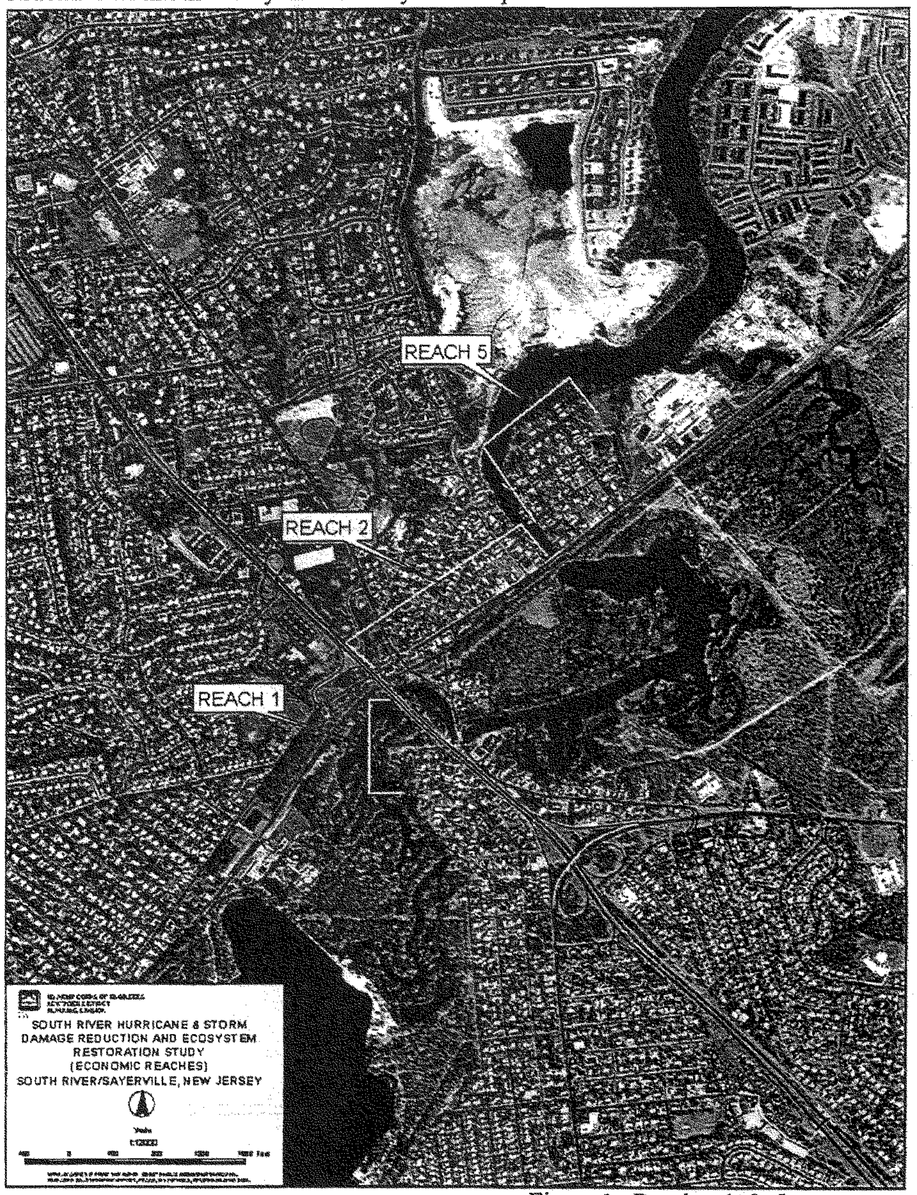

Figure 1. Reaches 1, 2, 5

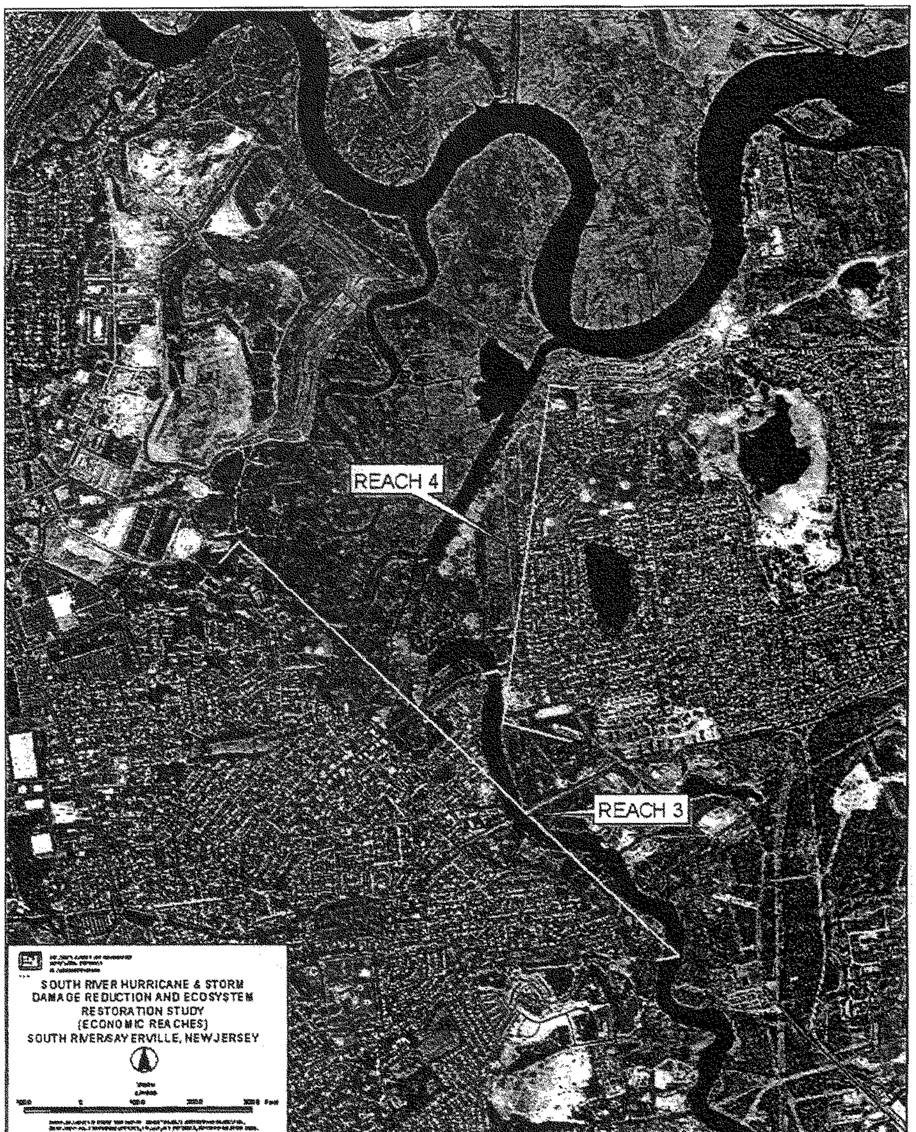

Figure 2. Reaches 3 and 4

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FLOOD DAMAGE

General

The analysis of flood damage utilized the following steps:

- Inventory flood plain development
- Estimate depreciated replacement costs
- Assign general damage functions
- Assign evaluation reaches
- Calculate aggregate stage vs. damage relationships

The flood damage calculations were performed using Microsoft Excel with Palisade's @ Risk for Excel add-in. This program adds Monte Carlo simulation capabilities and incorporates uncertainty inputs to calculate expected damage values. The following areas of uncertainty were incorporated into the calculation of flood damage:

- stage-frequency for each flood event
- first floor elevation
- structure size
- depreciated structure and contents value

The stage-frequency relationships incorporate the standard deviations listed in Tables 6-9. Based on EM 110-2-1619 Table 6-5, the first floor elevation standard deviation is approximately 0.6 foot when using topographic mapping using 2-ft. contour intervals. The variation in structure value was estimated with a triangular distribution with a plus/minus 22% difference from the most likely value. The structure size incorporated a standard deviation based upon the structure inventory.

Inventory Method

The structure database was generated through a survey of the structures adjacent to the project area. The structure data was obtained through an on-site survey of the area using topographic mapping with a scale of 1 inch = 200 feet with a 2-foot contour interval. The inventory was limited to categorizing structures by type and elevation, and identifying the typical structure value. Structure value is calculated based on RS Means Square Foot Costs manual.

The technique used to produce an inventory of all of the structures within the 500 yr. floodplain is the Mark I Eyeball Method. Later, as a check on the adequacy of that Mark I Eyeball Method as applied in this particular instance, a sample of the structures was inventoried using actual physical measurements. The result is, in effect, two samples of the relevant population, one sample taken using the Mark I Eyeball Method and the other taken using actual measurements.

The means of the two samples differ. The statistical question is whether the difference between the two samples is small enough to have been caused by sampling variability or the difference is so large that it is not likely to occur unless the methods systematically

produce different results (*i.e.*, the difference cannot be explained by sampling variability alone).
To answer this question, the difference in means test should be applied. Let us designate the two samples e (for the sample generated by the Mark I Eyeball Method) and m (for the sample generated by the physical measurement method). Let us also set the level of significance at 5%. That is to say that if the probability of getting a difference between the means of the two samples as big as the difference in the means of these two particular samples is greater than 5%, we will conclude that the observed difference in the means could be the product of sampling variability, but if the probability of getting a difference between the means of the two samples as big as the observed difference in the means of these two particular samples is less than 5%, we will conclude that the observed difference in the means is probably not the product of sampling variability. If the observed difference in the means is probably not the product of sampling variability, it probably is due to the methods being systematically different. To state this in terms of testable hypotheses, we would write:

$$H_0 : \mu_e = \mu_m$$
$$H_A : \mu_e \neq \mu_m$$

where μ_e refers to the population mean found by the Mark I Eyeball Method of inventory and μ_m refers to the population mean found by actual physical measurements method of inventory. Given the sample size, the relevant test statistic would be:

$$t_{obs.} = \left| \frac{\bar{x}_e - \bar{x}_m}{SE_{(\bar{x}_e - \bar{x}_m)}} \right|$$

where

$$SE_{(\bar{x}_e - \bar{x}_m)} = \sqrt{\left(\frac{\left[\sum x_e^2 - \frac{\left(\sum x_e\right)^2}{n_e} \right] + \left[\sum x_m^2 - \frac{\left(\sum x_m\right)^2}{n_m} \right]}{[n_e + n_m - 2]} \right) \left(\frac{[n_e + n_m]}{[n_e n_m]} \right)}$$

The test criterion is that if $t_{obs.} > t_{critical}$ reject H_0. If H_0 cannot be rejected, we can conclude, with 95% certainty, that there is no systematic difference between the results of the two inventory methods.

$$t_{obs.} = \left| \frac{1092 - 1153}{356} \right| \qquad t_{obs.} = 0.17 \qquad t_{critical} = 1.96\text{, for 95\% certainty}$$

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H_0 cannot be rejected because $t_{obs.} < t_{critical}$. Therefore, we conclude, with 95% certainty, that there is no systematic difference between the results of the two inventory methods and the Mark I Eyeball Method will be used.

Description of Damage Functions

Sea level rise is a factor in contributing to tidal flooding. Based on NOAA tide gauge readings at Sandy Hook, sea level rise has been increasing at an average of 0.014 foot per year and will result in an approximately 0.826 foot increase in tidal stages from 2001 to the end of project life in year 2059. The hydrologic data provided for various storm exceedance probabilities for the analysis are shown in Tables 6 – 9.

Table 6 - Water Surface Elevation

Reaches 3 and 4 Year 2000

Exceedance Probability	Without Project Conditions Water Surface Elevation	Standard Deviation
0.500	6.9	0.43
0.200	8.7	0.63
0.100	10.1	1.33
0.040	11.9	1.58
0.020	13.3	2.13
0.010	14.7	3.14
0.005	16.1	3.46
0.002	18.0	2.77

Table 7 - Water Surface Elevation

Reaches 1,2 and 5 Year 2000

Exceedance Probability	Without Project Conditions Water Surface Elevation	Standard Deviation
0.500	7.2	0.41
0.200	9.0	0.85
0.100	10.4	1.29
0.040	12.2	1.66
0.020	13.6	2.28
0.010	15.0	3.48
0.005	16.4	3.34
0.002	18.3	2.64

Table 8- Water Surface Elevation

Reaches 3 and 4 Year 2059

Exceedance Probability	Without Project Conditions Water Surface Elevation	Standard Deviation
0.500	7.7	0.43
0.200	9.5	0.62
0.100	10.9	1.33
0.040	12.7	1.57
0.020	14.1	2.13
0.010	15.5	3.14
0.005	16.9	3.46
0.002	18.8	2.77

Table 9- Water Surface Elevation

Reaches 1,2, and 5 Year 2059

Exceedance Probability	Without Project Conditions Water Surface Elevation	Standard Deviation
0.500	8.0	0.41
0.200	9.8	0.85
0.100	11.2	1.29
0.040	13.1	1.66
0.020	14.5	2.28
0.010	15.9	3.48
0.005	17.3	3.34
0.002	19.1	2.64

Generalized FEMA damage functions for structure and contents damages were applied to the residential and non-residential structures. Public emergency damages were calibrated as a percentage of structure value based on local FEMA damage reports. The damage functions reflect damages as a percent of structural value over a full range of water depths and were applied on a structure-by-structure basis to determine damages at one-tenth-of a foot increments of flood stage. Similarly, depth damage functions developed by Natural Resource Conservation Services were applied to calculate automobile damages.

Damage Verification

On-site interviews were conducted in the study area. However, so much time has passed between the most significant flood event in 1992 and the interviews, that memories had faded and as a consequence the kind of numeric information necessary to perform the calibration of the stage damage function was not generated.

The issue is the extent to which the apparent difference between the District's damage estimate and the information included in a newspaper article written in the immediate aftermath of the storm event in question can be reconciled. The article appeared in the *Central New Jersey Home News* on December 16, 1992. The only sentence in the article that attaches numbers to damages in the relevant municipalities reads, "Other heavily hit municipalities in the county were South River, with $6.1 million in estimated damages; Carteret, $4.2 million; Old Bridge, about $5.2 million; Sayreville, $1.7 million; and South Amboy, $4.5 million." Of these municipalities, only South River, Old Bridge, and Sayreville are relevant to this report. The damages mentioned in those municipalities summed to $13.0 million.

In order to render this December 1992 estimate comparable to the other estimates of dollar amounts in the report, the appropriate index from *RS Means Square Foot Costs 2002* was used to convert the $13.0 million to the October 2001 price level. The result of this calculation is to adjust the $13.0 million to $16.6 million. This is in contrast to the damages calculated by the District for the Boroughs of South River and Sayreville, and Old Bridge Township, which totaled $30 million.

There are a number of obstacles to the correlation of the damage estimates in the *Home News* article with the District's damage estimates. The principle obstacle lies in the fact that it is impossible to know what is being compared to what. This is because the article is silent as to the geographic areas within the municipalities over which damages were estimated, the types of damage included, and the necessarily preliminary nature of the estimates given the proximity in time to the storm event. Moreover, there were subsequent articles in the *Home News* that indicated damages to foundation of homes along Weber Avenue in Sayreville, NJ in the range of $25,000 to $35,000 in December 1992 prices, which translate to $32,000 to $45,000 in October 2001 prices. This tends to substantiate the District's analysis.

In light of the deficiencies in the information offered in the *Home News* article December 16, 1992, a diligent effort was made to re-check the sources of information consulted in the course of previous efforts to generate a basis for adjusting the FEMA curves away from their standard positions. Among those sources were the archives of the *Home News*, FEMA flood insurance claims records (both Region II and the Washington D.C. offices were consulted), the local chapter of the Red Cross, the Middlesex County and local Emergency Management officials, and the offices of the Mayor and Business Manager of the Borough of South River. In addition to those sources, the search for information was expanded to include the archives of the *New York Times* and *The Star Ledger* (the only New Jersey newspaper with state-wide circulation). None of these sources yielded any reference to a dollar amount of damages in the relevant area other than the preliminary estimate in an article in the December 16, 1992 *Home News* article that was noted above. Evidence was found that indicates that damage estimates were rising days after the storm, as opportunities for more careful and thorough assessments arose. For instance, the lead story on the front page of *The Star Ledger* for December 15, 1992 carries the headline, "Storm Damage Estimates Skyrocketing." Although the *Star Ledger* article gives dollar estimates for some areas, there is no specific mention of a dollar estimate of damages in South River or any of the other relevant municipalities. In light of the foregoing, it does not appear that there is any credible information available at this juncture on which a deviation of the FEMA curves from their standard positions can be based. Therefore, this study used standard FEMA depth damage curves because there is no credible evidence supporting a deviation from the standard curves was uncovered by the District investigation.

EXTENT AND SCOPE OF ALTERNATIVES

General

The analysis compares alternatives to provide tidal flood protection against a storm with a 1% chance of being exceeded in any year (a 100-year storm). Based on modeling for tidal flooding and modeling performed on the fluvial component of the flooding, it was determined that the tidal flooding dominated from the mouth of the South River to the Duhernal Lake Dam. In the initial analysis the flood stage associated with such a probability is 13.5 ft. NGVD, with a ± 2.0 ft. standard deviation. In order to ensure that a structural solution may reliably protect against a 100-year flood (13.5 ft. NGVD), the top of any structural measures has been set at 15.5 ft. NGVD to account for risk and uncertainties in the tidal stage frequency curves. As the study progressed, additional modeling was performed and new stage frequency relationships were developed. In the current analysis the flood stage associated with a 100-year storm event is 14.7 ft. NGVD, with a ± 3.1 ft. standard deviation and a 0.7 ft. sea level rise. In order to ensure that a structural solution may reliably protect against a 100-year flood (14.7 ft. NGVD), the top of any structural measures has been set at 18.5 ft NGVD to account for risk and uncertainties in the tidal stage frequency curves.

The non-structural measure analyzed was the buy-out plan for structures located within the 100-year floodplain. The structural hurricane storm damage reduction measures analyzed were levees and a storm surge barrier. Three alternatives were then selected for detail analysis. These plans were: Plan 1- Storm surge barrier with levees in the lower reaches (Reaches 3B and 4B); Plan 2- Levees in all reaches (Reaches 1-5); Plan-3 Levees in Reaches 3 and 4. All alternatives were analyzed at a 100-year storm event. After identifying the preferred alternatives for further analysis, various levels of protection will be considered for each alternative to identify the most cost-effective alternative. A description of the physical levees and storm surge barrier is found in Appendix A Hydrology, Hydraulics & Design.

Screening of Alternatives

Nonstructural measures were given full consideration in plan formulation. Given the number, age, condition, and location of flood-prone structures in the study area, nonstructural measures were screened out early in plan formulation as a stand-alone alternative. Some nonstructural measures were carried forward as potential complements to structural protection. These non-structural alternatives (in the Historic Village of Old Bridge) were being considered to work in conjunction with the "levees/floodwalls only" option for protection in reaches 3 and 4. As the plans were further formulated it was determined that the "levee/floodwall and storm surge barrier (at the Bridge)" was more cost effective than the "levees/floodwalls only" option. This option now also included additional benefits that were realized for the Historic Village of Old Bridge, were non-structural alternatives were to be evaluated, but no longer required. For reaches 3 and 4, non-structural measures for lower levels of protection were not feasible as a stand-alone element or in combination with a structural plan, as the topography and alignment of homes were not conducive for this. Lower levels of non-structural improvements would not eliminate the need for structural flood protection for higher levels of protection and the costs for the structural component would be similar to the current plan.

Alternative Plans 1- 3 were screened based on structure and content damage and the existing hydrologic conditions. Damage functions at one-foot increments were used for the analysis. Table 10 summarizes the average annual costs and benefits of the alternative flood damage reduction plans. As indicated in this table, Plan 1 (storm surge barrier with levees for Reaches 3B and 4B) has the highest net benefits. It must be noted that the screening of alternatives used a 6 3/8% discount rate, as it was the prevailing discount rate at the time of analysis.

TABLE 10
AVERAGE ANNUAL COSTS AND BENEFITS OF
FLOOD DAMAGE REDUCTION ALTERNATIVES
(100-year Storm Event; 6 3/8% discount rate, October 2000 price levels)

Alternative	Annual Cost	Annual Benefit	Net Benefits	BCR
Plan 1 (Storm surge barrier with levees in Reaches 3B and 4B)	$2,865,000	$3,319,000	$454,000	1.2
Plan 2 (Levees in all reaches, Reaches 1-5)	$3,752,000	$3,319,000	($433,000)	0.9
Plan 3 (Levees in Reach 3 and 4)	$2,919,000	$2,930,000	$11,000	1.0

AVERAGE ANNUAL DAMAGES

General

Plan 1 (Storm surge barrier with levees in Reaches 3B and 4B) was analyzed for storm events with 50-year, 100-year, 200-year, and 500-year recurrence intervals. Updated hydrology and hydraulic data were applied subsequent to Plan 1 being selected for optimization. The damage functions that were based on one-foot increments were refined to one-tenth of a foot increments for damage analyses.

The storm damages were broken down into three categories: structure and content damage, public emergency costs and infrastructure damage, and automobile damage. The size of the database spreadsheet necessitated that the commercial/municipal and residential structure/content damages to be consolidated into one output when performing risk analysis. Tables 11-31 show the expected annual damages under existing conditions for year 2000. Tables 32-52 show expected annual damages under without project conditions for year 2059. The future 2059 without-project damage estimates include the effect of sea level rise.

TABLE 11.

SOUTH RIVER - REACH I YEAR 2000
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

RESIDENTIAL + COMMERCIAL

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$2,566,522		$5,133	$144,936
		0.002		$2,566,522		
18.32	0.002		$2,566,522		$6,377	$139,803
		0.003		$2,125,830		
16.44	0.005		$1,685,139		$7,269	$133,426
		0.005		$1,453,888		
15.04	0.01		$1,222,638		$10,258	$126,156
		0.01		$1,025,779		
13.63	0.02		$828,921		$13,750	$115,898
		0.02		$687,512		
12.23	0.04		$546,102		$25,339	$102,148
		0.06		$422,322		
10.38	0.1		$298,542		$24,086	$76,809
		0.1		$240,856		
9	0.2		$183,171		$36,944	$52,723
		0.3		$123,145		
7.18	0.5		$63,119		$15,780	$15,780
		0.5		$31,559		
	1		$0			

Table 12.

SOUTH RIVER - REACH I YEAR 2000
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

EMERGENCY

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$35,350		$71	$2,230
		0.002		$35,350		
18.32	0.002		$35,350		$89	$2,159
		0.003		$29,504		
16.44	0.005		$23,657		$102	$2,070
		0.005		$20,423		
15.04	0.01		$17,188		$145	$1,968
		0.01		$14,494		
13.63	0.02		$11,799		$197	$1,823
		0.02		$9,832		
12.23	0.04		$7,865		$366	$1,627
		0.06		$6,097		
10.38	0.1		$4,328		$355	$1,261
		0.1		$3,550		
9	0.2		$2,773		$600	$906
		0.3		$1,999		
7.18	0.5		$1,225		$306	$306
		0.5		$612		
	1		$0			

TABLE 13.

SOUTH RIVER - REACH 1 YEAR 2000
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

AUTO

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$60,418		$121	$3,213
		0.002		$60,418		
18.32	0.002		$60,418		$152	$3,092
		0.003		$50,824		
16.44	0.005		$41,229		$187	$2,939
		0.005		$37,488		
15.04	0.01		$33,747		$297	$2,752
		0.01		$29,678		
13.63	0.02		$25,609		$415	$2,455
		0.02		$20,733		
12.23	0.04		$15,857		$700	$2,040
		0.06		$11,668		
10.38	0.1		$7,479		$553	$1,340
		0.1		$5,530		
9	0.2		$3,582		$631	$787
		0.3		$2,104		
7.18	0.5		$625		$156	$156
		0.5		$313		
	1		$0			

Table 14.

SOUTH RIVER - REACH 2 YEAR 2000
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

RESIDENTIAL + COMMERCIAL

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$6,809,176		$13,618	$237,355
		0.002		$6,809,176		
18.32	0.002		$6,809,176		$17,068	$223,737
		0.003		$5,689,195		
16.44	0.005		$4,569,213		$19,669	$206,669
		0.005		$3,933,714		
15.04	0.01		$3,298,214		$27,399	$187,001
		0.01		$2,739,859		
13.63	0.02		$2,181,504		$35,235	$159,602
		0.02		$1,761,749		
12.23	0.04		$1,341,994		$56,085	$124,367
		0.06		$934,757		
10.38	0.1		$527,520		$36,807	$68,282
		0.1		$368,070		
9	0.2		$208,620		$31,361	$31,475
		0.3		$104,537		
7.18	0.5		$454		$113	$113
		0.5		$227		
	1		$0			

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Table 15.

SOUTH RIVER - REACH 2 YEAR 2000
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

EMERGENCY

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$91,043		$182	$3,459
		0.002		$91,043		
18.32	0.002		$91,043		$228	$3,277
		0.003		$76,158		
16.44	0.005		$61,273		$265	$3,049
		0.005		$52,996		
15.04	0.01		$44,719		$373	$2,784
		0.01		$37,307		
13.63	0.02		$29,895		$490	$2,411
		0.02		$24,523		
12.23	0.04		$19,151		$818	$1,920
		0.06		$13,633		
10.38	0.1		$8,115		$579	$1,102
		0.1		$5,789		
9	0.2		$3,463		$521	$523
		0.3		$1,736		
7.18	0.5		$9		$2	$2
		0.5		$5		
	1		$0			

Table 16.

SOUTH RIVER - REACH 2 YEAR 2000
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

AUTO

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$141,942		$284	$5,659
		0.002		$141,942		
18.32	0.002		$141,942		$386	$5,375
		0.003		$128,756		
16.44	0.005		$115,570		$535	$4,989
		0.005		$107,068		
15.04	0.01		$98,566		$842	$4,453
		0.01		$84,223		
13.63	0.02		$69,879		$1,107	$3,611
		0.02		$55,370		
12.23	0.04		$40,862		$1,574	$2,504
		0.06		$26,231		
10.38	0.1		$11,600		$668	$930
		0.1		$6,675		
9	0.2		$1,750		$263	$263
		0.3		$875		
7.18	0.5		$0		$0	$0
		0.5		$0		
	1		$0			

Table 17.

SOUTH RIVER - REACH 5 YEAR 2000
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

RESIDENTIAL + COMMERCIAL

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$4,008,240		$8,016	$150,235
		0.002		$4,008,240		
18.32	0.002		$4,008,240		$10,486	$142,219
		0.003		$3,495,256		
16.44	0.005		$2,982,272		$13,056	$131,733
		0.005		$2,611,148		
15.04	0.01		$2,240,024		$18,822	$118,677
		0.01		$1,882,192		
13.63	0.02		$1,524,360		$23,890	$99,855
		0.02		$1,194,510		
12.23	0.04		$864,659		$35,235	$75,965
		0.06		$587,242		
10.38	0.1		$309,826		$20,936	$40,731
		0.1		$209,359		
9	0.2		$108,893		$17,632	$19,795
		0.3		$58,772		
7.18	0.5		$8,652		$2,163	$2,163
		0.5		$4,326		
	1		$0			

Table 18.

SOUTH RIVER - REACHES 5
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

EMERGENCY

STAGE	PROBABILITY	DIFFERENCE DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE AVERAGE OF DAMAGES	AVERAGE EXPECTED ANNUAL DAMAGE INTERVAL	CUMUL- EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$53,851		$108	$2,307
		0.002		$53,851		
18.32	0.002		$53,851		$141	$2,199
		0.003		$46,892		
16.44	0.005		$39,932		$176	$2,058
		0.005		$35,238		
15.04	0.01		$30,544		$262	$1,882
		0.01		$26,246		
13.63	0.02		$21,947		$353	$1,620
		0.02		$17,639		
12.23	0.04		$13,331		$556	$1,267
		0.06		$9,266		
10.38	0.1		$5,201		$357	$711
		0.1		$3,565		
9	0.2		$1,929		$314	$354
		0.3		$1,046		
7.18	0.5		$162		$41	$41
		0.5		$81		
	1		$0			

Table 19.

SOUTH RIVER - REACH 5 YEAR 2000
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

AUTO

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$94,400		$189	$6,229
		0.002		$94,400		
18.32	0.002		$94,400		$278	$6,040
		0.003		$92,794		
16.44	0.005		$91,187		$430	$5,761
		0.005		$86,065		
15.04	0.01		$80,942		$714	$5,331
		0.01		$71,421		
13.63	0.02		$61,900		$1,056	$4,617
		0.02		$52,787		
12.23	0.04		$43,675		$1,826	$3,561
		0.06		$30,436		
10.38	0.1		$17,197		$1,079	$1,735
		0.1		$10,786		
9	0.2		$4,375		$656	$656
		0.3		$2,188		
7.18	0.5		$0		$0	$0
		0.5		$0		
	1		$0			

Table 20.

SOUTH RIVER - REACH 3A YEAR 2000
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

RESIDENTIAL + COMMERCIAL

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$14,670,845		$29,342	$620,098
		0.002		$14,670,845		
17.97	0.002		$14,670,845		$37,093	$590,756
		0.003		$12,364,304		
16.11	0.005		$10,057,763		$69,068	$553,663
		0.008		$8,633,524		
14.71	0.01		$7,209,285		$59,752	$484,595
		0.01		$5,975,224		
13.32	0.02		$4,741,164		$74,291	$424,843
		0.02		$3,714,551		
11.92	0.04		$2,687,938		$147,485	$350,552
		0.08		$1,843,566		
10.09	0.1		$999,194		$115,116	$203,066
		0.16		$719,473		
8.71	0.2		$439,752		$87,950	$87,950
		0.4		$219,876		
6.89	0.5		$0		$0	$0
		0.5		$0		
	1		$0			

Table 21.

SOUTH RIVER - REACH 3A YEAR 2000
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

EMERGENCY

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$193,653		$387	$6,564
		0.002		$193,653		
17.97	0.002		$193,653		$492	$6,176
		0.003		$163,924		
16.11	0.005		$134,195		$930	$5,684
		0.008		$116,217		
14.71	0.01		$98,238		$822	$4,755
		0.01		$82,195		
13.32	0.02		$66,153		$1,050	$3,933
		0.02		$52,523		
11.92	0.04		$38,893		$2,145	$2,882
		0.08		$26,817		
10.09	0.1		$14,740		$737	$737
		0.1		$7,370		
8.71	0.2		$0		$0	$0
		0.4		$0		
6.89	0.5		$0		$0	$0
		0.5		$0		
	1		$0			

Table 22.[18]

SOUTH RIVER - REACH 3A YEAR 2000
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

AUTO

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		3,541,110		7,082	495,059
		0.002		3,541,110		
17.97	0.002		3,541,110		10,548	487,977
		0.003		3,515,959		
16.11	0.005		3,490,809		27,671	477,429
		0.008		3,458,933		
14.71	0.01		3,427,057		33,927	449,758
		0.01		3,392,729		
13.32	0.02		3,358,401		65,031	415,830
		0.02		3,251,527		
11.92	0.04		3,144,653		186,606	350,800
		0.08		2,332,577		
10.09	0.1		1,520,500		93,659	164,194
		0.1		936,588		
8.71	0.2		352,675		70,535	70,535
		0.4		176,338		
6.89	0.5		0		0	0
		0.5		0		
	1		0			

[18] Laffin Chevrolet Auto Dealership is located in Reach 3A

Table 23.

SOUTH RIVER - REACH 3B YEAR 2000
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

RESIDENTIAL + COMMERCIAL

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$42,613,137		$85,226	$3,923,032
		0.002		$42,613,137		
17.97	0.002		$42,613,137		$111,261	$3,837,806
		0.003		$37,086,950		
16.11	0.005		$31,560,763		$223,086	$3,726,545
		0.008		$27,885,774		
14.71	0.01		$24,210,785		$211,130	$3,503,459
		0.01		$21,112,956		
13.32	0.02		$18,015,127		$307,000	$3,292,329
		0.02		$15,349,990		
11.92	0.04		$12,684,854		$774,251	$2,985,330
		0.08		$9,678,135		
10.09	0.1		$6,671,416		$844,459	$2,211,079
		0.16		$5,277,866		
8.71	0.2		$3,884,316		$1,038,977	$1,366,620
		0.4		$2,597,444		
6.89	0.5		$1,310,572		$327,643	$327,643
		0.5		$655,286		
	1		$0			

Table 24.

SOUTH RIVER - REACH 3B YEAR 2000
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

EMERGENCY

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$550,475		$1,101	$50,390
		0.002		$550,475		
17.97	0.002		$550,475		$1,438	$49,289
		0.003		$479,422		
16.11	0.005		$408,369		$2,895	$47,851
		0.008		$361,910		
14.71	0.01		$315,450		$2,762	$44,955
		0.01		$276,169		
13.32	0.02		$236,888		$4,069	$42,194
		0.02		$203,445		
11.92	0.04		$170,001		$10,472	$38,125
		0.08		$130,901		
10.09	0.1		$91,800		$7,366	$27,653
		0.1		$73,658		
8.71	0.2		$55,515		$15,185	$20,287
		0.4		$37,962		
6.89	0.5		$20,408		$5,102	$5,102
		0.5		$10,204		
	1		$0			

Table 25.

SOUTH RIVER - REACH 3B YEAR 2000
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

AUTO

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
~	0		740,603		1,481	58,965
		0.002		740,603		
17.97	0.002		740,603		1,989	57,484
		0.003		663,004		
16.11	0.005		585,405		2,621	55,495
		0.005		524,241		
14.71	0.01		463,077		4,095	52,874
		0.01		409,505		
13.32	0.02		355,934		6,119	48,779
		0.02		305,936		
11.92	0.04		255,937		12,172	42,660
		0.06		202,871		
10.09	0.1		149,805		11,339	30,488
		0.1		113,389		
8.71	0.2		76,972		14,397	19,149
		0.3		47,990		
6.89	0.5		19,008		4,752	4,752
		0.5		9,504		
	1		0			

Table 26.

SOUTH RIVER - REACH 4A YEAR 2000
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

RESIDENTIAL + COMMERCIAL

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
~	0		$25,679,981		$51,360	$1,597,429
		0.002		$25,679,981		
17.97	0.002		$25,679,981		$68,473	$1,546,069
		0.003		$22,824,399		
16.11	0.005		$19,968,818		$88,590	$1,477,596
		0.005		$17,718,037		
14.71	0.01		$15,467,256		$132,854	$1,389,006
		0.01		$13,285,445		
13.32	0.02		$11,103,634		$184,779	$1,256,151
		0.02		$9,238,955		
11.92	0.04		$7,374,277		$327,991	$1,071,372
		0.06		$5,466,514		
10.09	0.1		$3,558,750		$276,475	$743,382
		0.1		$2,764,748		
8.71	0.2		$1,970,747		$359,848	$466,907
		0.3		$1,199,492		
6.89	0.5		$428,237		$107,059	$107,059
		0.5		$214,118		
	1		$0			

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Table 27.

SOUTH RIVER - REACH 4A YEAR 2000
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

EMERGENCY

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$339,855		$680	$22,470
		0.002		$339,855		
17.97	0.002		$339,855		$906	$21,790
		0.003		$301,972		
16.11	0.005		$264,089		$1,171	$20,884
		0.005		$234,271		
14.71	0.01		$204,452		$1,762	$19,713
		0.01		$176,246		
13.32	0.02		$148,040		$2,481	$17,950
		0.02		$124,047		
11.92	0.04		$100,053		$4,517	$15,469
		0.06		$75,290		
10.09	0.1		$50,528		$3,974	$10,952
		0.1		$39,739		
8.71	0.2		$28,949		$5,331	$6,978
		0.3		$17,769		
6.89	0.5		$6,589		$1,647	$1,647
		0.5		$3,295		
	1		$0			

Table 28.

SOUTH RIVER - REACH 4A YEAR 2000
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

AUTO

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		556,903		1,114	51,593
		0.002		556,903		
17.97	0.002		556,903		1,571	50,480
		0.003		523,722		
16.11	0.005		490,542		3,641	48,908
		0.008		455,142		
14.71	0.01		419,741		3,739	45,267
		0.01		373,939		
13.32	0.02		328,137		5,651	41,528
		0.02		282,569		
11.92	0.04		237,001		14,066	35,876
		0.08		175,824		
10.09	0.1		114,646		8,327	21,811
		0.1		83,270		
8.71	0.2		51,892		11,758	13,483
		0.4		29,396		
6.89	0.5		6,900		1,725	1,725
		0.5		3,450		
	1		0			

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Table 29.

SOUTH RIVER - REACH 4B YEAR 2000
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

RESIDENTIAL + COMMERCIAL

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
–	0		$5,827,374		$11,655	$417,893
		0.002		$5,827,374		
17.97	0.002		$5,827,374		$15,261	$406,238
		0.003		$5,086,897		
16.11	0.005		$4,346,421		$19,190	$390,977
		0.005		$3,838,022		
14.71	0.01		$3,329,623		$28,899	$371,787
		0.01		$2,889,864		
13.32	0.02		$2,450,104		$42,172	$342,889
		0.02		$2,108,602		
11.92	0.04		$1,767,099		$83,616	$300,717
		0.06		$1,393,599		
10.09	0.1		$1,020,098		$78,541	$217,101
		0.1		$785,413		
8.71	0.2		$550,727		$103,590	$138,559
		0.3		$345,301		
6.89	0.5		$139,876		$34,969	$34,969
		0.5		$69,938		
	1		$0			

Table 30.

SOUTH RIVER - REACH 4B YEAR 2000
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

EMERGENCY

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
–	0		$75,531		$151	$7,998
		0.002		$75,531		
17.97	0.002		$75,531		$198	$7,847
		0.003		$66,080		
16.11	0.005		$56,628		$252	$7,649
		0.005		$50,373		
14.71	0.01		$44,118		$384	$7,397
		0.01		$38,394		
13.32	0.02		$32,670		$563	$7,013
		0.02		$28,146		
11.92	0.04		$23,622		$1,137	$6,450
		0.06		$18,947		
10.09	0.1		$14,272		$1,097	$5,313
		0.1		$10,969		
8.71	0.2		$7,666		$2,300	$4,216
		0.3		$7,666		
6.89	0.5		$7,666		$1,917	$1,917
		0.5		$3,833		
	1		$0			

Table 31.

SOUTH RIVER - REACH 4B YEAR 2000
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

AUTO

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		124,331		249	5,904
		0.002		124,331		
17.97	0.002		124,331		333	5,655
		0.003		110,858		
16.11	0.005		97,386		441	5,322
		0.005		88,215		
14.71	0.01		79,044		693	4,881
		0.01		69,261		
13.32	0.02		59,477		984	4,189
		0.02		49,194		
11.92	0.04		38,911		1,605	3,205
		0.06		26,743		
10.09	0.1		14,575		907	1,600
		0.1		9,066		
8.71	0.2		3,557		594	694
		0.3		1,979		
6.89	0.5		400		100	100
		0.5		200		
	1		0			

Table 32.

SOUTH RIVER - REACH 1 YEAR 2059
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

RESIDENTIAL + COMMERCIAL

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$2,993,831		$5,988	$203,518
		0.002		$2,993,831		
19.15	0.002		$2,993,831		$7,462	$197,530
		0.003		$2,487,188		
17.27	0.005		$1,980,545		$8,658	$190,069
		0.005		$1,731,521		
15.87	0.01		$1,482,497		$12,674	$181,411
		0.01		$1,267,449		
14.46	0.02		$1,052,400		$17,412	$168,737
		0.02		$870,584		
13.06	0.04		$688,767		$32,520	$151,325
		0.06		$542,007		
11.21	0.1		$395,248		$32,579	$118,804
		0.1		$325,792		
9.83	0.2		$256,335		$56,366	$86,225
		0.3		$187,886		
8.01	0.5		$119,437		$29,859	$29,859
		0.5		$59,719		
	1		$0			

Table 33.

SOUTH RIVER - REACH 1 YEAR 2059
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

EMERGENCY

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$40,828		$82	$3,036
		0.002		$40,828		
19.15	0.002		$40,828		$103	$2,955
		0.003		$34,167		
17.27	0.005		$27,506		$121	$2,852
		0.005		$24,197		
15.87	0.01		$20,889		$179	$2,731
		0.01		$17,888		
14.46	0.02		$14,887		$247	$2,552
		0.02		$12,363		
13.06	0.04		$9,839		$465	$2,305
		0.06		$7,751		
11.21	0.1		$5,664		$471	$1,840
		0.1		$4,711		
9.83	0.2		$3,758		$866	$1,369
		0.3		$2,886		
8.01	0.5		$2,013		$503	$503
		0.5		$1,006		
	1		$0			

Table 34.

SOUTH RIVER - REACH 1 YEAR 2059
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

AUTO

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$73,288		$147	$4,846
		0.002		$73,288		
19.15	0.002		$73,288		$181	$4,700
		0.003		$60,210		
17.27	0.005		$47,132		$214	$4,519
		0.005		$42,749		
15.87	0.01		$38,366		$336	$4,305
		0.01		$33,636		
14.46	0.02		$28,905		$500	$3,969
		0.02		$25,014		
13.06	0.04		$21,123		$955	$3,469
		0.06		$15,924		
11.21	0.1		$10,725		$843	$2,513
		0.1		$8,430		
9.83	0.2		$6,134		$1,201	$1,670
		0.3		$4,005		
8.01	0.5		$1,875		$469	$469
		0.5		$938		
	1		$0			

Table 35.

SOUTH RIVER - REACH 2 YEAR 2059
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

RESIDENTIAL + COMMERCIAL

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$7,860,661		$15,721	$365,900
		0.002		$7,860,661		
19.15	0.002		$7,860,661		$19,959	$350,179
		0.003		$6,653,039		
17.27	0.005		$5,445,418		$23,562	$330,220
		0.005		$4,712,316		
15.87	0.01		$3,979,214		$34,000	$306,658
		0.01		$3,399,969		
14.46	0.02		$2,820,724		$46,083	$272,659
		0.02		$2,304,155		
13.06	0.04		$1,787,585		$78,849	$226,575
		0.06		$1,314,158		
11.21	0.1		$840,730		$60,667	$147,726
		0.1		$606,674		
9.83	0.2		$372,618		$67,580	$87,059
		0.3		$225,266		
8.01	0.5		$77,915		$19,479	$19,479
		0.5		$38,957		
	1		$0			

Table 36.

SOUTH RIVER - REACH 2 YEAR 2059
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

EMERGENCY

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$104,435		$209	$5,348
		0.002		$104,435		
19.15	0.002		$104,435		$266	$5,139
		0.003		$88,676		
17.27	0.005		$72,916		$316	$4,873
		0.005		$63,289		
15.87	0.01		$53,662		$460	$4,556
		0.01		$46,015		
14.46	0.02		$38,368		$631	$4,096
		0.02		$31,575		
13.06	0.04		$24,781		$1,121	$3,465
		0.06		$18,684		
11.21	0.1		$12,586		$925	$2,344
		0.1		$9,254		
9.83	0.2		$5,922		$1,087	$1,418
		0.3		$3,623		
8.01	0.5		$1,325		$331	$331
		0.5		$662		
	1		$0			

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Table 37.

SOUTH RIVER - REACH 2 YEAR 2059
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

AUTO

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$159,073		$318	$8,417
		0.002		$159,073		
19.15	0.002		$159,073		$423	$8,099
		0.003		$140,944		
17.27	0.005		$122,814		$579	$7,676
		0.005		$115,844		
15.87	0.01		$108,873		$979	$7,097
		0.01		$97,950		
14.46	0.02		$87,026		$1,450	$6,117
		0.02		$72,492		
13.06	0.04		$57,958		$2,357	$4,668
		0.06		$39,284		
11.21	0.1		$20,610		$1,350	$2,310
		0.1		$13,505		
9.83	0.2		$6,400		$960	$960
		0.3		$3,200		
8.01	0.5		$0		$0	$0
		0.5		$0		
	1		$0			

Table 38.

SOUTH RIVER - REACH 5 YEAR 2059
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

RESIDENTIAL + COMMERCIAL

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$4,454,629		$8,909	$221,462
		0.002		$4,454,629		
19.15	0.002		$4,454,629		$11,783	$212,553
		0.003		$3,927,546		
17.27	0.005		$3,400,463		$15,175	$200,770
		0.005		$3,034,965		
15.87	0.01		$2,669,468		$22,968	$185,595
		0.01		$2,296,830		
14.46	0.02		$1,924,193		$31,724	$162,627
		0.02		$1,586,221		
13.06	0.04		$1,248,248		$53,553	$130,903
		0.06		$892,545		
11.21	0.1		$536,842		$37,455	$77,350
		0.1		$374,545		
9.83	0.2		$212,249		$34,859	$39,895
		0.3		$116,197		
8.01	0.5		$20,145		$5,036	$5,036
		0.5		$10,073		
	1		$0			

Table 39.

SOUTH RIVER - REACH 5 YEAR 2059
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

EMERGENCY

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
–	0		$59,983		$120	$3,354
		0.002		$59,983		
19.15	0.002		$59,983		$158	$3,234
		0.003		$52,783		
17.27	0.005		$45,582		$204	$3,075
		0.005		$40,730		
15.87	0.01		$35,878		$312	$2,872
		0.01		$31,234		
14.46	0.02		$26,591		$453	$2,559
		0.02		$22,646		
13.06	0.04		$18,700		$819	$2,106
		0.06		$13,650		
11.21	0.1		$8,599		$615	$1,287
		0.1		$6,147		
9.83	0.2		$3,696		$599	$673
		0.3		$1,996		
8.01	0.5		$296		$74	$74
		0.5		$148		
	1		$0			

Table 40.

SOUTH RIVER - REACH 5 YEAR 2059
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

AUTO

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
–	0		$94,400		$189	$9,142
		0.002		$94,400		
19.15	0.002		$94,400		$282	$8,953
		0.003		$93,990		
17.27	0.005		$93,579		$456	$8,671
		0.005		$91,278		
15.87	0.01		$88,977		$806	$8,215
		0.01		$80,617		
14.46	0.02		$72,257		$1,277	$7,408
		0.02		$63,828		
13.06	0.04		$55,398		$2,404	$6,132
		0.06		$40,073		
11.21	0.1		$24,749		$1,860	$3,727
		0.1		$18,599		
9.83	0.2		$12,450		$1,868	$1,868
		0.3		$6,225		
8.01	0.5		$0		$0	$0
		0.5		$0		
	1		$0			

Table 41.

SOUTH RIVER - REACH 3A YEAR 2059
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

RESIDENTIAL + COMMERCIAL

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$16,736,215		$33,472	$992,706
		0.002		$16,736,215		
18.79	0.002		$16,736,215		$43,119	$959,233
		0.003		$14,373,062		
16.93	0.005		$12,009,909		$83,241	$916,114
		0.008		$10,405,163		
15.53	0.01		$8,800,418		$74,326	$832,873
		0.01		$7,432,644		
14.14	0.02		$6,064,870		$98,656	$758,546
		0.02		$4,932,807		
12.74	0.04		$3,800,744		$219,797	$659,890
		0.08		$2,747,458		
10.91	0.1		$1,694,172		$194,171	$440,093
		0.16		$1,213,570		
9.53	0.2		$732,969		$190,740	$245,922
		0.4		$476,849		
7.71	0.5		$220,730		$55,182	$55,182
		0.5		$110,365		
	1		$0			

Table 42.

SOUTH RIVER - REACH 3A YEAR 2059
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

EMERGENCY

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$219,763		$440	$10,415
		0.002		$219,763		
18.79	0.002		$219,763		$569	$9,975
		0.003		$189,780		
16.93	0.005		$159,797		$1,112	$9,406
		0.008		$139,045		
15.53	0.01		$118,293		$1,009	$8,294
		0.01		$100,909		
14.14	0.02		$83,526		$1,373	$7,285
		0.02		$68,645		
12.74	0.04		$53,764		$3,160	$5,912
		0.08		$39,497		
10.91	0.1		$25,229		$1,261	$2,752
		0.1		$12,615		
9.53	0.2		$0		$662	$1,490
		0.4		$1,656		
7.71	0.5		$3,312		$828	$828
		0.5		$1,656		
	1		$0			

Table 43.

SOUTH RIVER - REACH 3A YEAR 2059
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

AUTO

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$3,558,866		$7,118	$698,928
		0.002		$3,558,866		
18.79	0.002		$3,558,866		$10,604	$691,810
		0.003		$3,534,562		
16.93	0.005		$3,510,259		$27,904	$681,206
		0.008		$3,487,986		
15.53	0.01		$3,465,713		$34,328	$653,303
		0.01		$3,432,806		
14.14	0.02		$3,399,899		$67,256	$618,975
		0.02		$3,362,776		
12.74	0.04		$3,325,653		$206,709	$551,719
		0.08		$2,583,863		
10.91	0.1		$1,842,073		$142,685	$345,010
		0.1		$1,426,849		
9.53	0.2		$1,011,625		$202,325	$202,325
		0.4		$505,813		
7.71	0.5		$0		$0	$0
		0.5		$0		
	1		$0			

Table 44.

SOUTH RIVER - REACH 3B YEAR 2059
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

RESIDENTIAL + COMMERCIAL

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$47,794,377		$95,589	$5,441,415
		0.002		$47,794,377		
18.79	0.002		$47,794,377		$126,030	$5,345,827
		0.003		$42,010,153		
16.93	0.005		$36,225,929		$258,618	$5,219,796
		0.008		$32,327,220		
15.53	0.01		$28,428,510		$248,760	$4,961,178
		0.01		$24,875,960		
14.14	0.02		$21,323,409		$369,857	$4,712,419
		0.02		$18,492,846		
12.74	0.04		$15,662,283		$1,000,922	$4,342,562
		0.08		$12,511,524		
10.91	0.1		$9,360,764		$1,195,841	$3,341,640
		0.16		$7,474,004		
9.53	0.2		$5,587,243		$1,574,493	$2,145,799
		0.4		$3,936,233		
7.71	0.5		$2,285,224		$571,306	$571,306
		0.5		$1,142,612		
	1		$0			

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Table 45.

SOUTH RIVER - REACH 3B YEAR 2059
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

EMERGENCY

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
~	0		$617,061		$1,234	$68,932
		0.002		$617,061		
18.79	0.002		$617,061		$1,629	$67,698
		0.003		$542,844		
16.93	0.005		$468,627		$3,350	$66,070
		0.008		$418,753		
15.53	0.01		$368,879		$3,237	$62,720
		0.01		$323,736		
14.14	0.02		$278,593		$4,861	$59,482
		0.02		$243,068		
12.74	0.04		$207,543		$13,394	$54,621
		0.08		$167,419		
10.91	0.1		$127,295		$10,274	$41,227
		0.1		$102,744		
9.53	0.2		$78,193		$22,445	$30,953
		0.4		$56,113		
7.71	0.5		$34,032		$8,508	$8,508
		0.5		$17,016		
	1		$0			

Table 46.

SOUTH RIVER - REACH 3B YEAR 2059
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

AUTO

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
~	0		$801,714		$1,603	$84,057
		0.002		$801,714		
18.79	0.002		$801,714		$2,177	$82,454
		0.003		$725,707		
16.93	0.005		$649,699		$2,951	$80,277
		0.005		$590,284		
15.53	0.01		$530,869		$4,748	$77,325
		0.01		$474,774		
14.14	0.02		$418,678		$7,285	$72,578
		0.02		$364,262		
12.74	0.04		$309,846		$15,105	$65,292
		0.06		$251,754		
10.91	0.1		$193,663		$15,515	$50,187
		0.1		$155,153		
9.53	0.2		$116,644		$23,937	$34,672
		0.3		$79,791		
7.71	0.5		$42,938		$10,735	$10,735
		0.5		$21,469		
	1		$0			

Table 47.

SOUTH RIVER - REACH 4A YEAR 2059
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

RESIDENTIAL + COMMERCIAL

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$28,001,529		$56,003	**$2,323,079**
		0.002		$28,001,529		
18.79	0.002		$28,001,529		$75,637	$2,267,076
		0.003		$25,212,279		
16.93	0.005		$22,423,028		$101,085	$2,191,439
		0.005		$20,217,082		
15.53	0.01		$18,011,137		$157,849	$2,090,353
		0.01		$15,784,936		
14.14	0.02		$13,558,735		$230,000	$1,932,504
		0.02		$11,499,979		
12.74	0.04		$9,441,224		$441,719	$1,702,504
		0.06		$7,361,990		
10.91	0.1		$5,282,756		$407,542	$1,260,785
		0.1		$4,075,423		
9.53	0.2		$2,868,089		$588,849	$853,243
		0.3		$1,962,831		
7.71	0.5		$1,057,573		$264,393	$264,393
		0.5		$528,787		
	1		$0			

Table 48.

SOUTH RIVER - REACH 4A YEAR 2059
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

EMERGENCY

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$370,253		$741	**$32,565**
		0.002		$370,253		
18.79	0.002		$370,253		$999	$31,824
		0.003		$333,079		
16.93	0.005		$295,904		$1,334	$30,825
		0.005		$266,740		
15.53	0.01		$237,576		$2,089	$29,491
		0.01		$208,892		
14.14	0.02		$180,208		$3,072	$27,402
		0.02		$153,621		
12.74	0.04		$127,034		$6,017	$24,330
		0.06		$100,283		
10.91	0.1		$73,531		$5,721	$18,313
		0.1		$57,208		
9.53	0.2		$40,884		$8,555	$12,592
		0.3		$28,516		
7.71	0.5		$16,149		$4,037	$4,037
		0.5		$8,074		
	1		$0			

Table 49.

SOUTH RIVER - REACH 4A YEAR 2059
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

AUTO

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$570,599		$1,141	$77,295
		0.002		$570,599		
18.79	0.002		$570,599		$1,633	$76,154
		0.003		$544,319		
16.93	0.005		$518,040		$3,910	$74,521
		0.008		$488,812		
15.53	0.01		$459,585		$4,235	$70,611
		0.01		$423,508		
14.14	0.02		$387,431		$6,765	$66,376
		0.02		$338,265		
12.74	0.04		$289,099		$18,328	$59,610
		0.08		$229,097		
10.91	0.1		$169,095		$12,703	$41,283
		0.1		$127,028		
9.53	0.2		$84,961		$22,142	$28,580
		0.4		$55,356		
7.71	0.5		$25,750		$6,438	$6,438
		0.5		$12,875		
	1		$0			

Table 50.

SOUTH RIVER - REACH 4B YEAR 2059
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

RESIDENTIAL + COMMERCIAL

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$6,484,602		$12,969	$588,745
		0.002		$6,484,602		
18.79	0.002		$6,484,602		$17,281	$575,776
		0.003		$5,760,359		
16.93	0.005		$5,036,116		$22,218	$558,495
		0.005		$4,443,619		
15.53	0.01		$3,851,122		$34,002	$536,277
		0.01		$3,400,181		
14.14	0.02		$2,949,240		$50,971	$502,275
		0.02		$2,548,566		
12.74	0.04		$2,147,891		$106,902	$451,303
		0.06		$1,781,702		
10.91	0.1		$1,415,513		$107,625	$344,401
		0.1		$1,076,246		
9.53	0.2		$736,980		$157,883	$236,777
		0.3		$526,277		
7.71	0.5		$315,574		$78,894	$78,894
		0.5		$157,787		
	1		$0			

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Table 51.

SOUTH RIVER - REACH 4B YEAR 2059
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

EMERGENCY

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$83,985		$168	$10,320
		0.002		$83,985		
18.79	0.002		$83,985		$224	$10,152
		0.003		$74,738		
16.93	0.005		$65,491		$289	$9,928
		0.005		$57,890		
15.53	0.01		$50,289		$448	$9,638
		0.01		$44,830		
14.14	0 02		$39,371		$681	$9,190
		0.02		$34,035		
12.74	0.04		$28,699		$1,443	$8,509
		0.06		$24,050		
10.91	0.1		$19,402		$1,478	$7,066
		0.1		$14,781		
9.53	0.2		$10,160		$3,048	$5,588
		0.3		$10,160		
7.71	0.5		$10,160		$2,540	$2,540
		0.5		$5,080		
	1		$0			

Table 52.

SOUTH RIVER - REACH 4B YEAR 2059
EXPECTED ANNUAL STORM DAMAGE COMPUTATIONS

AUTO

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$133,822		$268	$8,825
		0.002		$133,822		
18.79	0.002		$133,822		$365	$8,557
		0.003		$121,578		
16.93	0.005		$109,333		$498	$8,193
		0.005		$99,622		
15.53	0.01		$89,911		$801	$7,694
		0.01		$80,147		
14.14	0.02		$70,383		$1,213	$6,893
		0.02		$60,665		
12 74	0.04		$50,947		$2,229	$5,680
		0.06		$37,149		
10.91	0.1		$23,352		$1,618	$3,451
		0.1		$16,184		
9.53	0.2		$9,016		$1,532	$1,832
		0.3		$5,108		
7.71	0.5		$1,200		$300	$300
		0.5		$600		
	1		$0			

Risk Analysis

In order to perform risk analysis, the summations of expected annual damage for each probability in each table (Tables 11-52) were selected as @Risk outputs. For example, in Table 52, the "table cell" containing the summation of expected annual damages up to the 0.002 probability, ($8,557) was selected as an @Risk output. Tables 53-60 show the risk incorporated expected annual damages for existing without-project conditions (year 2000) and the future without-project conditions (year 2059). All damage figures shown in Tables 53-60 are expected annual damages and represents the interval calculation up to the exceedance probability shown for each row of the table. For example, the total annual damages of $2,214,211 shown to be associated with a 0.200-exceedance probability in Table 53 are not damages from a 0.200 exceedance event (5-year flood). Rather the damages shown are the summation of expected annual damages up to the 0.200 exceedance event.

Table 53

Structures - Without Project Conditions Year 2000
Summation of Average Annual Damages

Exceedance Probability	Reach 1	Reach 2	Reach 5	Reach 3A	Reach 3B	Reach 4A	Reach 4B	Total Annual Damages
0.500	$ 16,378	$ 1,566	$ 2,388	$ 17,128	$ 354,326	$ 140,227	$ 41,914	$ 573,926
0.200	$ 54,144	$ 37,437	$ 22,227	$ 128,382	$ 1,422,648	$ 528,056	$ 150,438	$ 2,343,333
0.100	$ 78,861	$ 78,423	$ 46,271	$ 270,544	$ 2,324,463	$ 835,838	$ 230,008	$ 3,864,409
0.040	$ 105,419	$ 138,198	$ 84,924	$ 447,881	$ 3,132,125	$ 1,193,923	$ 315,935	$ 5,418,405
0.020	$ 120,648	$ 176,880	$ 110,323	$ 531,275	$ 3,451,105	$ 1,386,848	$ 360,518	$ 6,137,597
0.010	$ 132,760	$ 208,377	$ 129,890	$ 596,780	$ 3,672,708	$ 1,522,038	$ 391,693	$ 6,654,246
0.005	$ 141,307	$ 230,595	$ 142,937	$ 671,177	$ 3,905,365	$ 1,609,459	$ 412,199	$ 7,113,040
0.002	$ 148,035	$ 248,104	$ 152,880	$ 709,393	$ 4,018,514	$ 1,676,196	$ 427,823	$ 7,380,945
SPF	$ 153,122	$ 261,347	$ 160,306	$ 738,959	$ 4,103,581	$ 1,726,344	$ 439,460	$ 7,583,119

Table 54

Automobile - Without Project Conditions Year 2000
Summation of Average Annual Damages

Exceedance Probability	Reach 1	Reach 2	Reach 5	Reach 3A	Reach 3B	Reach 4A	Reach 4B	Total Annual Damages
0.500	$ 199	$ -	$ 2	$ 53	$ 5,535	$ 2,351	$ 127	$ 8,266
0.200	$ 942	$ 483	$ 944	$ 87,969	$ 21,430	$ 15,545	$ 900	$ 128,212
0.100	$ 1,593	$ 1,448	$ 2,266	$ 186,689	$ 33,566	$ 25,027	$ 2,013	$ 252,601
0.040	$ 2,401	$ 3,321	$ 4,223	$ 357,169	$ 46,768	$ 40,217	$ 3,806	$ 457,904
0.020	$ 2,853	$ 4,507	$ 5,296	$ 416,142	$ 53,457	$ 46,133	$ 4,854	$ 533,243
0.010	$ 3,189	$ 5,354	$ 5,968	$ 448,409	$ 57,932	$ 49,942	$ 5,585	$ 576,378
0.005	$ 3,418	$ 5,899	$ 6,355	$ 475,434	$ 60,708	$ 53,494	$ 6,042	$ 611,350
0.002	$ 3,599	$ 6,308	$ 6,622	$ 486,212	$ 62,756	$ 55,040	$ 6,383	$ 626,919
SPF	$ 3,736	$ 6,611	$ 6,812	$ 493,637	$ 64,279	$ 56,161	$ 6,638	$ 637,874

Table 55

Public Emergency - Without Project Conditions   Year 2000

Summation of Average Annual Damages

Exceedance Probability	Reach 1	Reach 2	Reach 5	Reach 3A	Reach 3B	Reach 4A	Reach 4B	Total Annual Damages
0.500	$ 306	$ 28	$ 41	$ 256	$ 5,412	$ 2,143	$ 1,935	$ 10,121
0.200	$ 917	$ 607	$ 382	$ 461	$ 20,901	$ 7,844	$ 4,258	$ 35,370
0.100	$ 1,284	$ 1,236	$ 776	$ 1,403	$ 28,709	$ 12,203	$ 5,353	$ 50,964
0.040	$ 1,667	$ 2,094	$ 1,362	$ 3,930	$ 39,563	$ 17,099	$ 6,514	$ 72,229
0.020	$ 1,884	$ 2,630	$ 1,726	$ 5,086	$ 43,779	$ 19,689	$ 7,106	$ 81,900
0.010	$ 2,053	$ 3,056	$ 1,997	$ 5,973	$ 46,687	$ 21,489	$ 7,514	$ 88,769
0.005	$ 2,172	$ 3,355	$ 2,175	$ 6,964	$ 49,719	$ 22,649	$ 7,782	$ 94,814
0.002	$ 2,264	$ 3,589	$ 2,310	$ 7,467	$ 51,188	$ 23,533	$ 7,984	$ 98,334
SPF	$ 2,334	$ 3,765	$ 2,410	$ 7,856	$ 52,291	$ 24,195	$ 8,134	$ 100,985

Table 56

Total -Without Project Conditions   Year 2000

Summation of Average Annual Damages

Exceedance Probability	Reach 1	Reach 2	Reach 5	Reach 3A	Reach 3B	Reach 4A	Reach 4B	Total Annual Damages
0.500	$ 16,883	$ 1,594	$ 2,431	$ 17,437	$ 365,273	$ 144,720	$ 43,975	$ 592,314
0.200	$ 56,003	$ 38,527	$ 23,553	$ 216,813	$ 1,464,979	$ 551,445	$ 155,596	$ 2,506,914
0.100	$ 81,738	$ 81,107	$ 49,312	$ 458,637	$ 2,386,737	$ 873,069	$ 237,374	$ 4,167,974
0.040	$ 109,487	$ 143,613	$ 90,509	$ 808,979	$ 3,218,456	$ 1,251,239	$ 326,254	$ 5,948,538
0.020	$ 125,385	$ 184,018	$ 117,345	$ 952,504	$ 3,548,341	$ 1,452,670	$ 372,478	$ 6,752,740
0.010	$ 138,002	$ 216,787	$ 137,855	$ 1,051,162	$ 3,777,326	$ 1,593,469	$ 404,792	$ 7,319,393
0.005	$ 146,897	$ 239,849	$ 151,467	$ 1,153,575	$ 4,015,792	$ 1,685,602	$ 426,023	$ 7,819,205
0.002	$ 153,898	$ 258,000	$ 161,812	$ 1,203,072	$ 4,132,458	$ 1,754,769	$ 442,189	$ 8,106,199
SPF	$ 159,192	$ 271,723	$ 169,528	$ 1,240,452	$ 4,220,152	$ 1,806,699	$ 454,232	$ 8,321,979

Table 57

Structures - Without Project Conditions Year 2059
Summation of Average Annual Damages

Exceedance Probability	Reach 1	Reach 2	Reach 5	Reach 3A	Reach 3B	Reach 4A	Reach 4B	Total Annual Damages
0.500	$ 28,051	$ 17,992	$ 6,796	$ 54,138	$ 572,517	$ 262,214	$ 77,824	$ 1,019,533
0.200	$ 82,389	$ 89,058	$ 45,559	$ 260,312	$ 2,131,411	$ 851,801	$ 246,700	$ 3,707,230
0.100	$ 114,893	$ 152,803	$ 84,885	$ 481,140	$ 3,344,061	$ 1,264,521	$ 355,821	$ 5,798,124
0.040	$ 148,152	$ 233,312	$ 137,534	$ 722,549	$ 4,366,596	$ 1,708,777	$ 462,849	$ 7,779,769
0.020	$ 166,678	$ 281,675	$ 168,950	$ 829,012	$ 4,751,513	$ 1,938,875	$ 515,025	$ 8,651,728
0.010	$ 180,907	$ 319,002	$ 191,658	$ 909,628	$ 5,013,725	$ 2,094,931	$ 550,462	$ 9,260,313
0.005	$ 190,797	$ 344,723	$ 206,395	$ 997,710	$ 5,285,788	$ 2,192,100	$ 573,641	$ 9,791,153
0.002	$ 198,647	$ 364,981	$ 217,549	$ 1,041,089	$ 5,415,168	$ 2,264,207	$ 591,045	$ 10,092,686
SPF	$ 204,605	$ 380,294	$ 225,830	$ 1,074,019	$ 5,511,364	$ 2,317,890	$ 603,847	$ 10,317,848

Table 58

Automobile - Without Project Conditions Year 2059
Summation of Average Annual Damages

Exceedance Probability	Reach 1	Reach 2	Reach 5	Reach 3A	Reach 3B	Reach 4A	Reach 4B	Total Annual Damages
0.500	$ 492	$ 18	$ 141	$ 7,552	$ 11,103	$ 6,638	$ 327	$ 26,271
0.200	$ 1,774	$ 1,327	$ 2,222	$ 218,575	$ 36,531	$ 30,140	$ 2,069	$ 292,638
0.100	$ 2,724	$ 3,135	$ 4,416	$ 375,215	$ 53,046	$ 43,846	$ 3,908	$ 486,290
0.040	$ 3,781	$ 5,806	$ 7,022	$ 584,442	$ 69,215	$ 63,394	$ 6,292	$ 739,952
0.020	$ 4,340	$ 7,297	$ 8,302	$ 649,752	$ 76,986	$ 70,364	$ 7,551	$ 824,594
0.010	$ 4,735	$ 8,282	$ 9,051	$ 684,058	$ 82,091	$ 74,559	$ 8,395	$ 871,171
0.005	$ 4,998	$ 8,892	$ 9,466	$ 712,226	$ 85,241	$ 78,399	$ 8,916	$ 908,138
0.002	$ 5,204	$ 9,342	$ 9,743	$ 723,226	$ 87,503	$ 80,042	$ 9,293	$ 924,352
SPF	$ 5,359	$ 9,672	$ 9,938	$ 730,715	$ 89,155	$ 81,209	$ 9,569	$ 935,616

Table 59

Public Emergency - Without Project Conditions Year 2059

Summation of Average Annual Damages

Exceedance Probability	Reach 1	Reach 2	Reach 5	Reach 3A	Reach 3B	Reach 4A	Reach 4B	Total Annual Damages
0.500	$ 473	$ 306	$ 111	$ 809	$ 8,472	$ 3,949	$ 2,826	$ 16,945
0.200	$ 1,312	$ 1,433	$ 119	$ 1,454	$ 30,606	$ 12,486	$ 6,215	$ 53,626
0.100	$ 1,787	$ 2,384	$ 782	$ 2,860	$ 40,976	$ 18,239	$ 7,710	$ 74,738
0.040	$ 2,265	$ 3,524	$ 1,441	$ 6,269	$ 54,626	$ 24,256	$ 9,148	$ 101,529
0.020	$ 2,528	$ 4,189	$ 2,276	$ 7,733	$ 59,689	$ 27,325	$ 9,840	$ 113,580
0.010	$ 2,727	$ 4,694	$ 2,726	$ 8,818	$ 63,115	$ 29,393	$ 10,305	$ 121,777
0.005	$ 2,864	$ 5,039	$ 3,034	$ 9,989	$ 66,662	$ 30,678	$ 10,606	$ 128,873
0.002	$ 2,971	$ 5,307	$ 3,234	$ 10,562	$ 68,344	$ 31,631	$ 10,833	$ 132,882
SPF	$ 3,052	$ 5,511	$ 3,346	$ 10,996	$ 69,591	$ 32,340	$ 10,999	$ 135,835

Table 60

Total -Without Project Conditions Year 2059

Summation of Average Annual Damages

Exceedance Probability	Reach 1	Reach 2	Reach 5	Reach 3A	Reach 3B	Reach 4A	Reach 4B	Total Annual Damages
0.500	$ 29,016	$ 18,316	$ 7,048	$ 62,499	$ 592,091	$ 272,801	$ 80,977	$ 1,062,748
0.200	$ 85,475	$ 91,818	$ 47,900	$ 480,341	$ 2,198,549	$ 894,426	$ 254,984	$ 4,053,494
0.100	$ 119,404	$ 158,322	$ 90,084	$ 859,214	$ 3,438,082	$ 1,326,606	$ 367,440	$ 6,359,152
0.040	$ 154,199	$ 242,642	$ 145,998	$ 1,313,260	$ 4,490,437	$ 1,796,426	$ 478,289	$ 8,621,250
0.020	$ 173,547	$ 293,161	$ 179,529	$ 1,486,498	$ 4,888,188	$ 2,036,564	$ 532,416	$ 9,589,902
0.010	$ 188,369	$ 331,978	$ 203,435	$ 1,602,504	$ 5,158,931	$ 2,198,883	$ 569,162	$ 10,253,262
0.005	$ 198,659	$ 358,653	$ 218,894	$ 1,719,925	$ 5,437,691	$ 2,301,177	$ 593,163	$ 10,828,164
0.002	$ 206,821	$ 379,630	$ 230,526	$ 1,774,877	$ 5,571,015	$ 2,375,880	$ 611,171	$ 11,149,920
SPF	$ 213,017	$ 395,476	$ 239,114	$ 1,815,730	$ 5,670,109	$ 2,431,438	$ 624,415	$ 11,389,299

Damages in years 2010 (base year) through 2058 were interpolated and discounted and the 50 years (2010-2059) were amortized at a discount rate of 6.125 percent to calculate the average annual damages. Tables 61-64 show the summary of the average annual damages for the 50-year period of economic analysis from 2010 to 2059.

Table 61

Structures - Without Project Conditions

Summation of Average Annual Damages

Exceedance Probability	Reach 1	Reach 2	Reach 5	Reach 3A	Reach 3B	Reach 4A	Reach 4B	Total Annual Damages
0.500	$22,343	$8,644	$4,408	$33,907	$468,766	$190,277	$56,645	$784,989
0.200	$69,606	$61,782	$33,569	$192,319	$1,811,030	$660,370	$189,801	$3,018,478
0.100	$99,006	$114,840	$65,517	$378,482	$2,900,195	$1,010,589	$281,346	$4,849,974
0.040	$130,038	$187,089	$112,487	$592,055	$3,848,654	$1,403,173	$375,726	$6,649,222
0.020	$147,602	$232,255	$141,998	$690,362	$4,215,196	$1,610,854	$423,306	$7,461,574
0.010	$161,356	$268,159	$164,099	$766,302	$4,467,632	$1,754,238	$456,143	$8,037,928
0.005	$170,997	$293,226	$178,664	$851,073	$4,731,288	$1,845,405	$477,688	$8,548,342
0.002	$178,614	$312,977	$189,730	$893,823	$4,858,266	$1,914,146	$493,997	$8,841,553
SPF	$184,383	$327,910	$197,975	$926,631	$4,953,274	$1,965,592	$506,079	$9,061,842

Table 62

Automobile - Without Project Conditions

Summation of Average Annual Damages

Exceedance Probability	Reach 1	Reach 2	Reach 5	Reach 3A	Reach 3B	Reach 4A	Reach 4B	Total Annual Damages
0.500	$335	$7	$61	$3,244	$8,240	$4,118	$210	$16,217
0.200	$1,356	$873	$1,548	$148,869	$29,161	$21,537	$1,381	$204,724
0.100	$2,172	$2,253	$3,319	$279,483	$43,901	$32,737	$2,791	$366,656
0.040	$3,135	$4,580	$5,672	$475,643	$59,174	$49,682	$4,823	$602,706
0.020	$3,660	$5,969	$6,898	$540,922	$66,731	$56,014	$5,955	$686,150
0.010	$4,042	$6,927	$7,643	$576,031	$71,748	$59,970	$6,730	$733,093
0.005	$4,299	$7,532	$8,066	$605,197	$74,854	$63,630	$7,212	$770,792
0.002	$4,502	$7,984	$8,354	$616,730	$77,117	$65,211	$7,567	$787,466
SPF	$4,654	$8,317	$8,558	$624,638	$78,788	$66,347	$7,829	$799,133

Table 63

Public Emergency - Without Project Conditions

Summation of Average Annual Damages

Exceedance Probability	Reach 1	Reach 2	Reach 5	Reach 3A	Reach 3B	Reach 4A	Reach 4B	Total Annual Damages
0.500	$396	$147	$73	$507	$7,044	$2,884	$2,298	$13,349
0.200	$1,143	$997	$343	$911	$26,307	$9,741	$5,055	$44,496
0.100	$1,577	$1,800	$913	$2,118	$35,681	$14,662	$34,796	$91,546
0.040	$2,023	$2,830	$1,615	$5,165	$48,388	$20,006	$7,583	$87,610
0.020	$2,273	$3,453	$2,227	$6,522	$53,223	$22,786	$8,215	$98,700
0.010	$2,466	$3,939	$2,609	$7,548	$56,529	$24,690	$8,644	$106,426
0.005	$2,599	$4,276	$2,865	$8,676	$59,965	$25,899	$8,926	$113,206
0.002	$2,703	$4,539	$3,045	$9,240	$61,615	$26,808	$9,137	$117,088
SPF	$2,782	$4,738	$3,163	$9,672	$62,847	$27,488	$9,294	$119,983

Table 64

Total -Without Project Conditions

Summation of Average Annual Damages

Exceedance Probability	Reach 1	Reach 2	Reach 5	Reach 3A	Reach 3B	Reach 4A	Reach 4B	Total Annual Damages
0.500	$23,074	$8,799	$4,542	$37,657	$484,050	$197,278	$59,151	$814,553
0.200	$72,105	$63,652	$35,459	$342,099	$1,866,497	$691,647	$196,237	$3,267,698
0.100	$102,754	$118,893	$69,748	$660,083	$2,979,777	$1,057,988	$318,934	$5,308,177
0.040	$135,197	$194,499	$119,773	$1,072,863	$3,956,214	$1,472,860	$388,132	$7,339,538
0.020	$153,535	$241,678	$151,123	$1,237,807	$4,335,150	$1,689,654	$437,476	$8,246,423
0.010	$167,863	$279,025	$174,352	$1,349,882	$4,595,910	$1,838,899	$471,517	$8,877,447
0.005	$177,895	$305,035	$189,595	$1,464,946	$4,866,108	$1,934,934	$493,826	$9,432,339
0.002	$185,818	$325,499	$201,130	$1,519,794	$4,996,999	$2,006,165	$510,702	$9,746,106
SPF	$191,820	$340,965	$209,696	$1,560,939	$5,094,909	$2,059,427	$523,202	$9,980,957

INTERIOR DRAINAGE DAMAGES

General

Rainfall runoffs in the interior of the protected area may also cause damages. Interior stage vs. frequency data was analyzed for three locations, (1) West Segment - area behind the levee in Reach 3A; (2) East Segment - area behind the levee in Reach 4A; and (3)

Main Channel Segment - area upstream of the storm surge barrier at Veteran Memorial Bridge, Reaches 1, 2, 5, 3B, 4B, 5.

The selected flood damage reduction plan created two small drainage areas, one area (0.69 acres) in the Borough of South River behind the West Segment levee and one area (0.54 acres) in the Borough of Sayreville behind the East Segment levee. The drainage area behind the storm surge barrier consisted of the entire South River Basin (~135 square miles). Plan formulation for interior drainage facilities consisted of a three-part process. First, the minimum facility plans were identified. Second, the costs and benefits of alternative interior drainage plans were estimated. Benefits are based on reduction of residual flood damages (i.e., those that remain under the minimum-facility condition). Finally, an optimum drainage alternative was selected based on an NED economic analysis.

Historical data indicate limited correlation between rainfall/runoff events and tidal flooding events. It was concluded that: (1) limited runoff would coincide with severe storm surge and (2) significant storm surge would coincide with only moderately severe rainfall. Data suggest that the majority of interior runoff events would coincide with a storm surge level less than or equal to a 2-year storm and that the majority of significant storm surge events are likely to coincide with runoff equivalent to a 2-year event or less.

Therefore, the analysis was conducted for events with five (5) recurrence intervals: the 2-yr, 10-yr, 50-yr, 100-yr, and 500-yr frequency events. In order to develop a stage-frequency relationship, the interior events were routed against exterior tidal margins. For the most likely flooding scenarios, the five interior storm events were routed against a 2-yr exterior tide, and a 2-yr interior storm event was routed against the five exterior events. The highest water surface elevation of corresponding coincidental frequencies (e.g., 2-yr interior and 10-yr exterior, or 10-yr interior and 2-yr exterior) was identified as the most damaging flood level for the coincidental frequency. The analysis was performed for both current and expected future conditions, including sea level rise.

Uncertainty was incorporated into the analysis by establishing lower and upper coincidental frequency bounds: the interior storm events were routed against a normal exterior tidal condition (the lower bound), and the interior events were routed against a 10-yr external tide and the 10-yr interior event against the five exterior tidal conditions (the upper bound).

Minimum Facilities

The minimum facilities are the starting point from which additional interior drainage facilities are compared. The minimum facilities should provide interior flood relief such that during low exterior stages (gravity conditions) the local storm drainage system functions essentially as it did without flood protection in place, up to that of the local storm sewer design. For this project, minimum facilities represent the minimum drainage required such that no induced flooding occurs during the low exterior stages. Refer to Appendix H Interior Drainage for a more in-depth discussion.

Interior Drainage Alternatives

West Segment – Pump station alternatives were primarily considered for the West Segment interior area due to the steep slope of the drainage area and relatively small ponding area. Pump capacities from 50cfs to 150cfs were analyzed as alternatives to the minimum facilities.

East Segment – Pumping and diversion alternatives were considered for the East Segment interior drainage area. Pump station alternatives from 40cfs to 100cfs were considered, alone and in conjunction with diversion. A Diversion of 100cfs of upper drainage area runoff was analyzed.

Main Channel – Pumping alternatives of 1,000cfs to 1,600cfs were considered for the South River storm surge barrier.

Identification of the Interior Drainage Plan

Flood damage analyses were performed on the West Segment, East Segment, and the Main Channel based on the interior water surface elevations for minimum facility design and the alternatives. The analysis is identical to the without-project analysis except that interior stage frequencies were used. For illustrative purpose, Table 65 is a snapshot of one iteration of the risk simulations for the interior drainage expected annual damage calculations for the West Segment. Cumulative functions were used for the various stage-frequency relationships and @Risk outputs were obtained for the summation of expected annual damage for each probability to account for risk and uncertainty. Average annual damages were calculated for the minimum facility design and each alternative and are summarized in Table 66 by interior drainage segments.

Table 65. Sample @Risk Calculation

SOUTH RIVER - REACH 3A
WEST SEGMENT INTERIOR DRAINAGE
AVERAGE ANNUAL STORM DAMAGE COMPUTATIONS
RESIDENTIAL + COMMERCIAL

STAGE	PROBABILITY	DIFFERENCE IN PROBABILITIES	DAMAGES	AVERAGE OF DAMAGES	EXPECTED ANNUAL DAMAGE INTERVAL	EXPECTED ANNUAL DAMAGE SUMMATION
-	0		$419,063		$838	$41,057
		0.002		$419,063		
8.68	0.002		$419,063		$1,151	$40,219
		0.003		$383,805		
8.27	0.005		$348,547		$2,722	$39,068
		0.008		$340,242		
8.14	0.01		$331,938		$3,236	$36,346
		0.01		$323,633		
8.09	0.02		$315,329		$5,361	$33,109
		0.02		$268,029		
7.76	0.04		$220,730		$15,136	$27,749
		0.08		$189,197		
7.59	0.1		$157,664		$12,613	$12,613
		0.16		$78,832		
6.53	0.2		$0		$0	$0
		0.4		$0		
5.96	0.5		$0		$0	$0
		0.5		$0		
	1		$0			

TABLE 66[19]
INTERIOR DRAINAGE
Summary of all Alternative Plans Damages
JAN 2000 PRICE LEVEL, 6 1/8 % INT., 50YEARS

West Segment

Plan	Description	Annual Residual Damages
Min Fac	Minimum Facility	$209,100
Alt 3.1	50 cfs pump	$151,700
Alt 3.2	100cfs pump	$121,200
Alt 3.3	150cfs pump	$103,300

East Segment

Plan	Description	Annual Residual Damages
Min Fac	Minimum Facility	$168,400
Alt 4.1	40cfs pump	$132,000
Alt 4.2	100cfs pump	$100,500
Alt 4.3	100 cfs Diversion	$119,400
Alt 4.4	100cfs div/40cfs pump	$95,800
Alt 4.5	100cfs div/100cfs pump	$71,600

Main Gate

Plan	Description	Annual Residual Damages
Min Fac		$902,250
Alt M1	1000 cfs pump station	$399,950
Alt M2	1200 cfs pump station	$326,250
Alt M3	1400 cfs pump station	$302,900
Alt M4	1600 cfs pump station	$258,600

Costs were developed for each interior drainage alternative and they were incrementally compared to their minimum facility design. The optimum plan is defined as the plan that maximizes the net excess benefits over cost. Based on the evaluation process, a 100-cfs diversion of upper drainage area flow is recommended for the East Segment line-of-protection. Minimum facilities are recommended for the West Segment line-of-protection. A 1,200-cfs pumping station is recommended for the main channel line-of-protection. Table 67 summarizes the plan costs, annual damages.

[19] Jan 2000 prices were the price levels used at the time of the optimization of interior drainage analysis

TABLE 67
INTERIOR DRAINAGE
Summary of all Alternative Plans Costs & Damages
JAN 2000 PRICE LEVEL, 6 1/8 % INT., 50YEARS

West Segment

Plan	Description	FIRST CONSTRUCTION COST (Incremental)[1]	FIRST LAND COST [2]	OPERATION &MAINTENANCE (Annual)[3]	TOTAL ANNUAL COST	Equivalent Annual Damage	Annual Damage Reduction	Annual Net Benefit
Min Fac	Minimum Facility	$1,029,700	$0	$8,450	$74,950	$209,100	$0	$0
Alt 3.1	50 cfs pump	$702,400	$0	$30,000	$150,250	$151,700	$57,400	($17,900)
Alt 3.2	100cfs pump	$1,404,700	$0	$35,000	$200,650	$121,200	$87,900	($37,800)
Alt 3.3	150cfs pump	$2,107,100	$0	$40,000	$250,950	$103,300	$105,800	($70,200)

East Segment

Plan	Description	FIRST CONSTRUCTION COST (Incremental)[1]	FIRST LAND COST [2]	OPERATION &MAINTENANCE (Annual)[3]	TOTAL ANNUAL COST	Equivalent Annual Damage	Annual Damage Reduction	Annual Net Benefit
Min Fac	Minimum Facility	$596,600	$13,200	$4,800	$44,000	$168,400	$0	$0
Alt 4.1	40cfs pump	$638,500	$0	$30,000	$115,200	$132,000	$36,400	($34,800)
Alt 4.2	100cfs pump	$1,404,700	$0	$35,000	$169,700	$100,500	$67,900	($57,800)
Alt 4.3	100cfs diversion	$577,200	$9,600	$2,750	$84,650	$119,400	$49,000	$8,350
Alt 4.4	100cfs div/40cfs pump	$1,215,740	$9,600	$32,750	$155,850	$95,800	$72,600	($39,250)
Alt 4.5	100cfs div/100cfs pump	$1,981,940	$9,600	$37,750	$210,250	$71,600	$96,800	($69,450)

Main Gate

Plan	Description	FIRST CONSTRUCTION COST (Incremental)[1]	FIRST LAND COST [2]	OPERATION &MAINTENANCE (Annual)[3]	TOTAL ANNUAL COST	Equivalent Annual Damage	Annual Damage Reduction	Annual Net Benefit
Min Fac		$2,107,600	$0	$19,250	$155,050	$902,250	$0	$0
Alt M1	1000 cfs pump station	$3,657,350	$0	$23,000	$414,150	$399,950	$502,300	$243,200
Alt M2	1200 cfs pump station	$4,078,750	$0	$25,400	$443,725	$326,250	$576,000	$287,325
Alt M3	1400 cfs pump station	$4,558,900	$0	$28,750	$478,100	$302,900	$599,350	$276,300
Alt M4	1600 cfs pump station	$5,235,700	$0	$32,500	$525,550	$258,600	$643,650	$273,150

[1] First cost includes 15% Engineering & Design, 7% Administration &15% Contingency. Pumps: First cost includes 7% Engineering & Design, 7% Administration & 12% Contingency.
[2] First Land Cost includes 5% Survey & Appraisal, &10% Contingency
[3] The replacement of flap/sluice gate/trash rack/pumps will occur every 25 years.
Note: Jan 2000 prices were the price levels used at the time of the optimization of interior drainage analysis. Updating to Oct 2001 price levels does not change the plan selection.

Tables 68-71 show the summary of the average annual damages for the 50-year period of economic analysis from 2010 to 2059.

Table 68. Residual Interior Damages

Structures

Exceedance Probability	R1	R2	R5	R3A	R3B	R4A	R4B	Total Annual Damages
0.500	$ -	$ -	$ -	$ 14,649	$ 21,022	$ 28,384	$ 404	$ 64,460
0.200	$ 127	$ -	$ 33	$ 52,762	$ 75,798	$ 68,510	$ 2,111	$ 199,341
0.100	$ 1,374	$ 33	$ 248	$ 90,480	$154,569	$ 89,075	$ 6,705	$ 342,524
0.040	$ 3,175	$ 386	$ 570	$118,250	$226,868	$106,170	$ 12,609	$ 468,028
0.020	$ 4,149	$ 872	$ 843	$126,431	$253,231	$113,605	$ 15,791	$ 514,922
0.010	$ 4,834	$ 1,395	$ 1,123	$131,089	$271,463	$118,186	$ 18,058	$ 546,148
0.005	$ 5,239	$ 1,766	$ 1,328	$135,073	$288,412	$120,758	$ 19,391	$ 571,966
0.002	$ 5,534	$ 2,095	$ 1,516	$136,856	$296,136	$122,651	$ 20,382	$ 585,169
SPF	$ 5,756	$ 2,367	$ 1,675	$138,210	$302,005	$124,087	$ 21,137	$ 595,239

Table 69. Residual Interior Damages

Automobile

Exceedance Probability	R1	R2	R5	R3A	R3B	R4A	R4B	Total Annual Damages
0.500	$ -	$ -	$ -	$ -	$ 12	$ -	$ -	$ 12
0.200	$ -	$ -	$ -	$ 3,760	$ 73	$ 21	$ -	$ 3,853
0.100	$ 11	$ -	$ -	$ 22,207	$ 574	$ 139	$ 10	$ 22,941
0.040	$ 30	$ -	$ 1	$ 51,882	$ 1,326	$ 362	$ 26	$ 53,628
0.020	$ 45	$ 2	$ 8	$ 61,020	$ 1,775	$ 458	$ 40	$ 63,348
0.010	$ 57	$ 7	$ 20	$ 66,416	$ 2,115	$ 531	$ 56	$ 69,201
0.005	$ 64	$ 12	$ 29	$ 71,077	$ 2,318	$ 603	$ 67	$ 74,171
0.002	$ 70	$ 17	$ 39	$ 73,188	$ 2,471	$ 639	$ 77	$ 76,502
SPF	$ 75	$ 22	$ 47	$ 74,798	$ 2,590	$ 668	$ 85	$ 78,285

Table 70. Residual Interior Damages

Public Emergency

Exceedance Probability	R1	R2	R5	R3A	R3B	R4A	R4B	Total Annual Damages
0.500	$ -	$ -	$ -	$ 131	$ 326	$ 471	$ -	$ 927
0.200	$ 2	$ -	$ 0	$ 394	$ 1,190	$ 1,125	$ 34	$ 2,747
0.100	$ 26	$ 1	$ 5	$ 645	$ 1,955	$ 1,451	$ 75	$ 4,159
0.040	$ 60	$ 7	$ 11	$ 1,060	$ 3,060	$ 1,717	$ 134	$ 6,048
0.020	$ 77	$ 15	$ 15	$ 1,182	$ 3,454	$ 1,832	$ 209	$ 6,783
0.010	$ 89	$ 24	$ 20	$ 1,251	$ 3,721	$ 1,903	$ 248	$ 7,256
0.005	$ 95	$ 29	$ 23	$ 1,310	$ 3,966	$ 1,942	$ 276	$ 7,642
0.002	$ 100	$ 34	$ 27	$ 1,336	$ 4,077	$ 1,971	$ 293	$ 7,837
SPF	$ 103	$ 39	$ 29	$ 1,356	$ 4,160	$ 1,992	$ 302	$ 7,983

Table 71. Residual Interior Damages

Total

Exceedance Probability	R1	R2	R5	R3A	R3B	R4A	R4B	Total Annual Damages
0.500	$ -	$ -	$ -	$ 14,780	$ 21,360	$ 28,855	$ 404	$ 65,399
0.200	$ 129	$ -	$ 33	$ 56,915	$ 77,062	$ 69,656	$ 2,146	$ 205,941
0.100	$ 1,411	$ 34	$ 252	$113,333	$157,097	$ 90,666	$ 6,790	$ 369,624
0.040	$ 3,266	$ 393	$ 581	$171,192	$231,254	$108,249	$ 12,769	$ 527,704
0.020	$ 4,271	$ 889	$ 865	$188,633	$258,459	$115,895	$ 16,040	$ 585,053
0.010	$ 4,980	$ 1,426	$ 1,163	$198,756	$277,298	$120,620	$ 18,362	$ 622,605
0.005	$ 5,398	$ 1,807	$ 1,381	$207,460	$294,696	$123,303	$ 19,734	$ 653,779
0.002	$ 5,704	$ 2,146	$ 1,582	$211,380	$302,683	$125,260	$ 20,753	$ 669,508
SPF	$ 5,935	$ 2,429	$ 1,752	$214,364	$308,755	$126,748	$ 21,524	$ 681,507

IDENTIFICATION OF THE NED PLAN

Costs

The final structural design elevations were raised to account for sea-level rise. A discussion of cost calculations for the storm surge barrier and the levees is found in the Hydrology, Hydraulics, and Design Appendix. Table 72 summarizes the costs for the 50-year, 100-year, 200-year, and 500-year design elevations. The design costs listed in Table 72 are used only as a comparison to determine the selection of alternatives. Once the NED plan is selected, a detailed cost analysis will be calculated for that specific plan.

Table 72. Storm Surge Barrier and Levees, Costs of Alternative Plans		
Storm Event	Levee Height NGVD (ft.)	Design[20] Costs
50-year	16.0	$ 3,169,667
100-year	18.5	$ 3,446,114
200-year	20.5	$ 3,729,987
500-year	21.5	$ 3,922,122

Benefits

With the project in place, the storm surge barrier and levees will prevent damages that were attributable to that storm event in the without-project conditions. The average annual damages prevented for the 50-year, 100-year, 200-year, and 500-year level of protection were compared to their respective design costs in Table 73. It is noted that plans that provide at least a 100-year level of protection will also provide benefits from savings in flood insurance administration costs. Federal Emergency Management Agency (FEMA) records indicate that there are 206 flood insurance policies in the affected floodplain. The cost savings is $135 per policy for a total of $27,810. The 500-year level of protection is anticipated to produce the greatest average annual net benefits and was consequently selected as the NED plan.

Table 73. Optimization of Plan 1

Exceedance Probability	Damages Prevented	Minus[21] Residual Interior Damage	Reduced Flood Insurance Admin. Cost	Total Damages Prevented	Annual Costs	Annual Net Benefits	BCR
0.500	$814,554	$681,507	$0	$133,046			
0.200	$3,267,698	$681,507	$0	$2,586,190			
0.100	$5,308,177	$681,507	$0	$4,626,670			
0.040	$7,339,539	$681,507	$0	$6,658,031			
0.020	$8,246,423	$681,507	$0	$7,564,916	$3,169,667	$4,395,249	2.39
0.010	$8,877,446	$681,507	$27,810	$8,223,749	$3,446,114	$4,777,635	2.39
0.005	$9,432,339	$681,507	$27,810	$8,778,642	$3,729,987	$5,048,655	2.35
0.002	$9,746,106	$681,507	$27,810	$9,092,409	$3,922,122	$5,170,287	2.32

Subsequent to the plan selection the final cost estimate for the NED plan was calculated to be $4,163,606. The average annual damages prevented are $9,092,409, and average annual net benefits are $ 4,928,803. The Benefit-Cost Ratio is 2.2.

[20] Design Costs were updated to October 2001 price levels for formulation analysis.
[21] Due to the limited correlation between interior and exterior events, the interior damages are essentially independent from the exterior exceedance frequency. Therefore, the residual interior damages are constant.

ECOSYSTEM RESTORATION

General

The USACE Institute for Water Resources (IWR) has developed decision support software known as the IWR-PLAN for use in formulating and comparing alternative restoration and/or mitigation plans. This software was developed based on the methodology presented in "Cost Effectiveness Analysis for Environmental Planning: Nine EASY Steps" (USACE 1994). Cost-effectiveness and incremental cost analyses (CE/ICA) allow the comparison of monetary costs with non-monetary outputs, or benefits. These analyses are conducted in a stepwise process, comparing alternative plans with successive levels of output, identifying those plans that meet the CE/ICA criteria, and eliminating those plans that do not. Although CE/ICA do not result in identification of one "best" plan, they provide the user with a series of cost-effective and "best buy" plans that are the least expensive for different levels of output (cost-effective plans) and provide the greatest increases in output for the least increases in cost ("best buy" plans). CE/ICA provide the user with the information necessary to make more informed decisions regarding ecosystem restoration (USACE 1995). This approach was used to combine and analyze conceptual restoration plans within the South River project area.

Sections 5.1 through 5.3 describe the process used to determine outputs and costs, and to develop conceptual restoration plans. Output was measured in terms of ecological units (*i.e.*, Average Annual Habitat Unit, AAHU) gained through implementation of each conceptual restoration plan, and costs were calculated based on the specific features of each plan. Section 5.4 summarizes the CE/ICA process that occurs within the IWR-PLAN software, and Section 5.5 discusses the IWR-PLAN's selected "best buy" conceptual restoration plans for the South River project.

Description of HEP Outputs

For this Ecosystem Restoration Plan (ERP), the USFWS's Habitat Evaluation Procedure (HEP) was used to assess the outputs of alternative conceptual restoration plans by calculating the output of each plan in terms of AAHUs, and comparing each plan to existing and future (no-action) conditions. For the calculation of AAHUs for the ERP, the assumption was made that plans would attain their full potential number of AAHUs in the first year. After the National Ecosystem Restoration (NER) plan was selected, the USACE fine-tuned the number of AAHUs acquired over the 50-year life of the ERP.

Habitat Suitability Index (HSI) values were calculated for each cover/habitat type according to the six species selected for the HEP evaluation in the South River Project area: American black duck, clapper rail (*Rallus longirostris*), marsh wren (*Cistothorus palustris*), yellow warbler (*Dendroica petechia*), eastern cottontail (*Sylvilagus floridanus*), and American woodcock (USACE 2001c). Based on the goals and objectives of the ERP and the results of the Restoration Screening Report (RSR), restoration options for the South River Project area include the restoration of four targeted habitat types: low emergent marsh, mudflat, wetland forest/scrub-shrub (including a small percentage of upland forest/scrub-shrub), and open water (tidal creek and tidal pond habitat). Calculations of ecological outputs and costs for the open water component were based on the assumption that half of the total open water area will be used for the restoration of tidal creek habitat, and half will be used for the restoration of tidal pond habitat. Similarly, as a subset of wetland forest/scrub-shrub habitat, it was assumed that the restoration of upland forest/scrub-shrub habitat would never exceed 5% of the total restoration area, as agreed upon by the interagency HEP Team.

All combinations of the targeted habitat types were evaluated at 10 scales of percent area (5%, 10%, 15%, 20%, 30%, 40%, 50%, 60%, 70%, and 80%), creating a total of 10,000 combinations of the various habitat type ratios (ratio combinations). To ensure compliance with the goal of increasing biodiversity, the analysis was limited to a minimum of 5% (rather than 0%) and a maximum of 50% of each habitat type considered for each restoration option except for salt marsh, because of it's designation as a priority wetland in New Jersey. Combinations that did not add up to 100% were eliminated, leaving 167 restoration ratio combinations.

The ratio combinations were examined within each proposed restoration area (Figure 3. Areas 1 – 4) at four scales of restoration, 100%, 75%, 50%, and 25% of the total acreage of wetland *Phragmites* within each area, creating 16 restoration scenarios for the Project area. Each restoration scenario was assigned a unique identification number based on the restoration area and the scale of restoration. For example, Scenario 1a would indicate restoring 100% of Area 1, and Scenario 3c would indicate restoring 50% of Area 3. Table 74 presents the number of acres restored and the unique identifier for each restoration scenario.

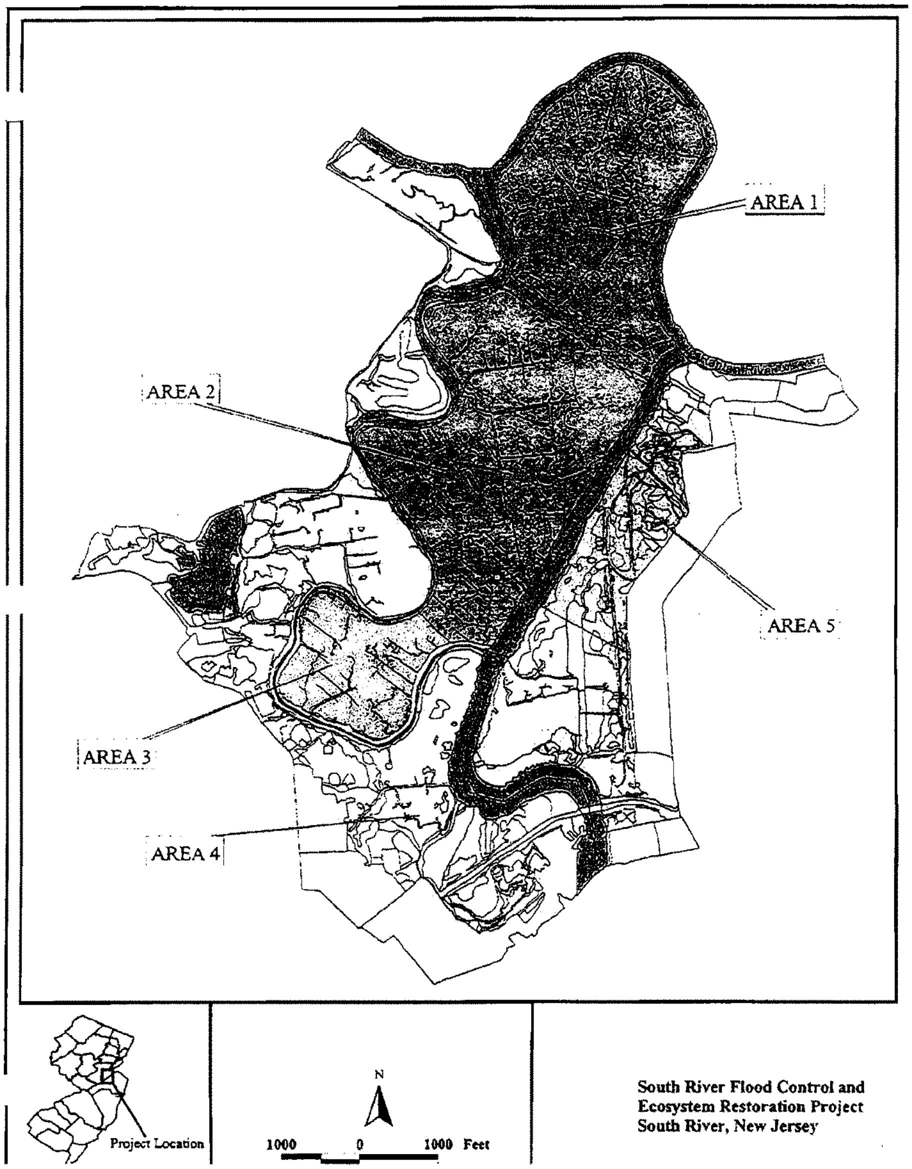

Figure 3. Potential Restoration Areas

Table 74. Number of Acres Restored for each Restoration Scenario at each Restoration Area.

	Acres Restored – Restoration Scenario			
Area	100% (a)	75% (b)	50% (c)	25% (d)
1	116.5 – 1a	87.4 – 1b	58.3 – 1c	29.1 – 1d
2	163.8 – 2a	122.9 – 2b	81.9 – 2c	41.0 – 2d
3	53.0 – 3a	39.8 – 3b	26.5 – 3c	13.3 – 3d
4	46.0 – 4a	34.5 – 4b	23.0 – 4c	11.5 – 4d

The 167 ratio combinations were applied to all 16 restoration scenarios, and the ecological outputs were calculated in terms of AAHUs based on a 50-year project life. The process that was used to identify the ecological outputs (AAHUs) of each ratio combination for each restoration scenario is outlined below.

1) Calculate the acreages for all 16 restoration scenarios based on the percent of each habitat type identified in the 167 ratio combinations, resulting in 167 habitat type acreage combinations for each restoration scenario.
2) Multiply the HSI values for the targeted habitat types by the acreages to calculate the number of habitat units (HUs) for each of the six evaluation species.
3) Add the HUs for all six species together to obtain total HUs attributable to restoration for each ratio combination for each Restoration Area.
4) Subtract the number of HUs of wetland *Phragmites* (HSI for wetland *Phragmites* multiplied by the number of acres proposed for restoration) from the total number of HUs attributable to restoration to obtain the net gain or loss in HUs due to the conversion.
5) The difference (net gain or loss) in HUs was used to calculate the number of AAHUs for all 167 ratio combinations for each restoration scenario based on the calculation presented in the HEP Manual (USFWS 1980)
6) Eliminate the ratio combinations for which implementation would result in negative AAHUs (*i.e.*, no net gain in ecological output) from further analysis, resulting in 131 ratio combinations for Areas 1 – 3, and 145 ratio combinations for Area 4.

The processes involved in calculating the outputs were checked for QA/QC by the team. QA/QC included verification of HSI variable calculations, data entry, and calculations of AAHUs.

Description of Costs

Implementation costs for each restoration scenario were calculated based on estimates of real estate, mobilization/demobilization, site access, construction, site preparation and excavation, disposal, planting, erosion and sediment control, and monitoring costs. A contingency cost of 20% was included to account for uncertainty in the final design and/or implementation of the selected NER Plan. These costs were estimated as part of the planning phase for the purpose of determining Project feasibility, and to provide a means of comparing proposed restoration options. The following describes the derivation of cost estimates used in the calculation of costs.

- Real estate acquisition costs were estimated based on a site assessment performed by the District.

- Surveying included the costs associated with completing a land survey of the area prior to commencement of restoration activities.

- Site access costs accounted for the location of proposed restoration activities and the means of accessing these sites. Restoration Areas 1 – 3 are located on the Island, with no existing point of access, and will require special equipment to conduct restoration activities. Construction of a temporary bridge on the western side of the Island was determined to be the most cost-effective means of accessing the Island. Restoration Area 4 is on the mainland and will not require special site access considerations. Site access costs also included the cost of road construction for movement within the wetland, including the crossing of tidal creeks. The number of small and large tidal creek crossings was based on the cover type map and a visual assessment of aerial photographs. Cost calculations for each restoration scenario were based on the number of creeks identified in Table 75.

Table 75. Estimated Number of Creeks Crossed for each Restoration Scenario at each Restoration Area.

	Number of Small Creeks				**Number of Large Creeks**			
Area	100% - a	75% - b	50% - c	25% - d	100% - a	75% - b	50% - c	25% - d
1	20	15	10	5	4	3	2	1
2	28	21	14	7	12	9	6	3
3	16	12	8	4	4	3	2	1
4	4	3	2	1	4	3	2	1

-

- Site preparation included the costs associated with the removal of *Phragmites* and the restoration of wetland and upland forest/scrub-shrub habitats. The assumption was made that *Phragmites* removal will entail excavation of thatch material, extending down 1 foot from the ground surface and including the rhizomes and other root material, in all low emergent marsh, mudflat, and open water areas. Relative elevation differences between community types were based on the results of the *Plant Community Elevation Report* (USACE 2000c). Also, site preparation costs included onsite hauling and grading activities associated with the restoration of wetland forest/scrub-shrub and upland forest/scrub-shrub habitat. The assumption was made that the forested habitats will be restored using the material excavated during the restoration of the other habitat types. The excavated material containing *Phragmites* thatch will be used as fill material in upland forest/scrub-shrub areas, and the excess material will be disposed of offsite. Excavated material that is free of *Phragmites* thatch will be used to cap the wetland forest and upland forest/scrub-shrub areas. For some scenarios, fill material from offsite sources will be needed in the absence of enough excavated material.

- Excavation included the costs associated with the restoration of low emergent marsh, intertidal mudflat, tidal creek, and tidal pond habitats, ditch improvements, and offsite hauling and disposal fees. Relative elevation differences between community types (USACE 2000c) were used to estimate excavation depths. Offsite hauling and disposal fees will be applied to those scenarios for which there is more excavated material than will be necessary for the creation of wetland and upland forest/scrub-shrub habitats. In some scenarios, all the excavated material will be used onsite, and no offsite hauling and disposal costs will be applied to these scenarios. For these scenarios, onsite-hauling costs will apply (see site preparation). Because excavated material is not of the correct size, density, and consistency for use as fill material for the flood control portion of the , excess material must be disposed of at an approved offsite location.

- Planting included costs associated with establishing the targeted habitat types, such as obtaining source material, planting, and fertilizing.

- Mobilization and demobilization costs were the lump sum costs associated with the initiation and cessation of activities at the site, including obtaining and transporting equipment, and the removal of temporary site features and equipment upon completion of the (*i.e.,* bridges, access roads, staging areas).

- Erosion and sediment control costs were estimated at 6% of total construction costs.

- The USACE standard for monitoring costs is 1% of the total cost.

The timing of construction should be coordinated with the flood control portion of the . Restoration activities should be completed prior to construction of levees and floodwalls in areas where flood control and restoration activities overlap.

Costs were subjected to independent QA/QC by the District's Engineering Department to ensure that line-item cost estimates used in the calculation of restoration costs were accurate based on the available data. In addition, data entry for costs, number of small and large creeks (Table 75), and cost calculations were subjected to an internal QA/QC by the Team.

Development of Conceptual Restoration Plans

The ratio combinations for each restoration scenario that resulted in a positive ecological output were combined with costs specific to each Restoration Area, creating over 2,150 conceptual restoration plans. Costs were annualized, creating average annual costs (AAC) to facilitate comparison with AAHUs based on a 50-year life and a constant discount rate of 6.125%. Prior to entering these plans into the IWR-PLAN, a preliminary cost-effectiveness analyses was conducted using Excel spreadsheets, in accordance with the IWR's Evaluation of Environmental Investments Procedures Manual Interim: Cost Effectiveness and Incremental Cost Analyses (USACE 1995).

Based on the ecological outputs and estimated costs for each conceptual restoration plan, a preliminary cost-effectiveness analysis was conducted to eliminate those plans that were not cost-effective. This analysis was performed by sorting all the conceptual restoration plans at each Restoration Area in order of increasing output, and eliminating conceptual restoration plans that cost more for a given level of output, or produced less output for greater cost. Preliminary cost-effectiveness analysis reduced the number of conceptual restoration plans at each Restoration Area from between 131 and 145 to between one and five per restoration scenario, thereby creating a total of 63 cost-effective conceptual restoration plans for the South River ERP (Tables 76 – 79). The preliminary cost-effectiveness analysis underwent internal QA/QC to ensure accuracy in the preliminary screening process.

Table 76. Restoration Area 1: Summary of Cost-Effective Conceptual Restoration Plans.

Ratio Number	Percent Low Emergent Marsh	Percent Mudflat	Percent Wetland Forest/ Scrub-Shrub	Percent Upland Forest/ Scrub-Shrub	Percent Open Water (Tidal Creek & Tidal Pond)	Total Cost	Average Annual Cost (AAC)	Average Annual Habitat Units (AAHU)	Average Cost (Total Cost/ AAHU)
Scenario 100% (1a)									
1	80%	5%	8%	2%	5%	$18,099,508	$1,208,847	103.4	$175,044
9	70%	5%	16%	4%	5%	$16,367,522	$1,093,170	102.5	$159,683
24	60%	5%	25%	5%	5%	$14,698,490	$ 981,697	101.5	$144,813
42	50%	5%	35%	5%	5%	$13,114,026	$ 875,872	100.9	$129,971
64	40%	5%	45%	5%	5%	$11,512,609	$ 768,915	100.2	$114,896
Scenario 75% (1b)									
1	80%	5%	8%	2%	5%	$13,668,126	$ 912,880	77.6	$176,136
9	70%	5%	16%	4%	5%	$12,369,545	$ 826,149	76.8	$161,062
24	60%	5%	25%	5%	5%	$11,109,333	$ 741,981	76.0	$146,175
42	50%	5%	35%	5%	5%	$ 9,921,396	$ 662,640	75.7	$131,062
64	40%	5%	45%	5%	5%	$ 8,731,818	$ 583,189	75.2	$116,115
Scenario 50% (1c)									
1	80%	5%	8%	2%	5%	$ 9,172,146	$ 612,598	51.9	$176,727
9	70%	5%	16%	4%	5%	$ 8,309,839	$ 555,006	51.2	$162,302
24	60%	5%	25%	5%	5%	$ 7,481,547	$ 499,685	50.8	$147,275
42	50%	5%	35%	5%	5%	$ 6,673,181	$ 445,695	50.4	$132,404
64	40%	5%	45%	5%	5%	$ 5,880,130	$ 392,728	50.1	$117,368
Scenario 25% (1d)									
1	80%	5%	8%	2%	5%	$ 4,739,123	$ 316,521	25.8	$183,687
9	70%	5%	16%	4%	5%	$ 4,307,356	$ 287,684	25.6	$168,256
24	60%	5%	25%	5%	5%	$ 3,892,390	$ 259,969	25.4	$153,244
42	50%	5%	35%	5%	5%	$ 3,495,864	$ 233,485	25.2	$138,725
64	40%	5%	45%	5%	5%	$ 3,099,338	$ 207,002	25.1	$123,480

Table 77. Restoration Area 2: Summary of Cost-Effective Conceptual Restoration Plans.

Ratio Number	Percent Low Emergent Marsh	Percent Mudflat	Percent Wetland Forest/ Scrub-Shrub	Percent Upland Forest/ Scrub-Shrub	Percent Open Water (Tidal Creek & Tidal Pond)	Total Cost	Average Annual Cost (AAC)	Average Annual Habitat Units (AAHU)	Average Cost (Total Cost/ AAHU)
Scenario 100% (2a)									
1	80%	5%	8%	2%	5%	$25,390,044	$1,695,775	145.5	$174,502
9	70%	5%	16%	4%	5%	$22,960,090	$1,533,481	144.0	$159,445
24	60%	5%	25%	5%	5%	$20,619,319	$1,377,143	142.7	$144,494
42	50%	5%	35%	5%	5%	$18,375,257	$1,227,264	141.7	$129,677
64	40%	5%	45%	5%	5%	$16,132,834	$1,077,495	140.8	$114,580
Scenario 75% (2b)									
1	80%	5%	8%	2%	5%	$19,080,520	$1,274,368	109.3	$174,570
9	70%	5%	16%	4%	5%	$17,251,180	$1,152,189	108.0	$159,733
24	60%	5%	25%	5%	5%	$15,493,962	$1,034,826	107.0	$144,803
42	50%	5%	35%	5%	5%	$13,812,145	$ 922,499	106.3	$129,936
64	40%	5%	45%	5%	5%	$12,130,328	$ 810,172	105.6	$114,871
Scenario 50% (2c)									
1	80%	5%	8%	2%	5%	$12,821,920	$ 856,363	72.7	$176,368
9	70%	5%	16%	4%	5%	$11,596,214	$ 774,499	71.9	$161,283
24	60%	5%	25%	5%	5%	$10,425,828	$ 696,330	71.3	$146,225
42	50%	5%	35%	5%	5%	$ 9,319,930	$ 622,469	71.0	$131,267
64	40%	5%	45%	5%	5%	$ 8,198,719	$ 547,584	70.6	$116,129
Scenario 25% (2d)									
1	80%	5%	8%	2%	5%	$ 6,512,397	$ 434,956	36.5	$178,422
9	70%	5%	16%	4%	5%	$ 5,902,617	$ 394,230	36.1	$163,507
24	60%	5%	25%	5%	5%	$ 5,315,784	$ 355,036	35.6	$149,320
42	50%	5%	35%	5%	5%	$ 4,755,178	$ 317,593	35.4	$134,327
64	40%	5%	45%	5%	5%	$ 4,194,573	$ 280,151	35.2	$119,164

Table 78. Restoration Area 3: Summary of Cost-Effective Conceptual Restoration Plans.

Ratio Number	Percent Low Emergent Marsh	Percent Mudflat	Percent Wetland Forest/ Scrub-Shrub	Percent Upland Forest/ Scrub-Shrub	Percent Open Water (Tidal Creek & Tidal Pond)	Total Cost	Average Annual Cost (AAC)	Average Annual Habitat Units (AAHU)	Average Cost (Total Cost/ AAHU)
Scenario 100% (3a)									
1	80%	5%	8%	2%	5%	$8,421,875	$562,488	47.1	$178,808
9	70%	5%	16%	4%	5%	$7,635,722	$509,982	46.5	$164,209
24	60%	5%	25%	5%	5%	$6,875,796	$459,227	46.2	$148,827
42	50%	5%	35%	5%	5%	$6,151,111	$410,826	45.9	$134,011
64	40%	5%	45%	5%	5%	$5,426,426	$362,425	45.6	$119,001
Scenario 75% (3b)									
1	80%	5%	8%	2%	5%	$6,365,243	$425,128	35.3	$180,319
9	70%	5%	16%	4%	5%	$5,769,137	$385,315	34.9	$165,305
24	60%	5%	25%	5%	5%	$5,211,290	$348,057	34.6	$150,615
42	50%	5%	35%	5%	5%	$4,664,358	$311,528	34.4	$135,592
64	40%	5%	45%	5%	5%	$4,117,426	$274,999	34.2	$120,393
Scenario 50% (3c)									
1	80%	5%	8%	2%	5%	$4,306,971	$287,658	23.6	$182,499
9	70%	5%	16%	4%	5%	$3,916,224	$261,561	23.4	$167,360
24	60%	5%	25%	5%	5%	$3,533,111	$235,973	23.1	$152,949
42	50%	5%	35%	5%	5%	$3,179,245	$212,339	23.0	$138,228
64	40%	5%	45%	5%	5%	$2,808,426	$187,572	22.8	$123,177
Scenario 25% (3d)									
1	80%	5%	8%	2%	5%	$2,305,922	$154,010	11.8	$195,417
9	70%	5%	16%	4%	5%	$2,114,236	$141,208	11.5	$183,847
24	60%	5%	25%	5%	5%	$1,925,829	$128,624	11.5	$167,463
64	40%	5%	45%	5%	5%	$1,556,650	$103,967	11.4	$136,548

Table 79. Restoration Area 4: Summary of Cost-Effective Conceptual Restoration Plans.

Ratio Number	Percent Low Emergent Marsh	Percent Mudflat	Percent Wetland Forest/ Scrub-Shrub	Percent Upland Forest/ Scrub-Shrub	Percent Open Water (Tidal Creek & Tidal Pond)	Total Cost	Average Annual Cost (AAC)	Average Annual Habitat Units (AAHU)	Average Cost (Total Cost/ AAHU)
Scenario 100% (4a)									
64	40%	5%	45%	5%	5%	$4,577,549	$305,730	48.3	$ 94,773
Scenario 75% (4b)									
64	40%	5%	45%	5%	5%	$3,449,018	$230,356	36.2	$ 95,277
Scenario 50% (4c)									
64	40%	5%	45%	5%	5%	$2,377,711	$158,805	24.2	$ 98,253
Scenario 25% (4d)									
64	40%	5%	45%	5%	5%	$1,249,181	$ 83,431	12.1	$103,238

Cost Effectiveness and Incremental Cost Analyses

All 63 conceptual restoration plans that remained after the preliminary cost-effectiveness analysis were entered into the IWR-PLAN for CE/ICA. Specifically, 20 conceptual restoration plans for both Restoration Areas 1 and 2, 19 conceptual restoration plans for Restoration Area 3, and four for Restoration Area 4 were entered into the IWR-PLAN. All the conceptual restoration plans within a Restoration Area were considered non-combinable, while all combinations of conceptual restoration plans between Restoration Areas were combinable. In calculating the costs and outputs of combined conceptual restoration plans, costs were not always additive. Cost adjustments were applied within the IWR-PLAN based on the following assumptions:

- If construction was proposed in multiple Restoration Areas, mobilization and demobilization costs were applied only once; and,
- If construction was proposed in Restoration Areas 1 and 2, temporary bridge costs were applied only once.

Considering these restrictions and cost adjustments, all combinations of the conceptual restoration plans were examined, creating 40,000 actual combinations. Eight "best buy" conceptual restoration plans, including the No-Action plan, were identified within the IWR-PLAN (Table 80).

Table 80. "Best Buy" Conceptual Restoration Plans Selected by Cost-Effectiveness and Incremental Cost Analyses.*

Plan	Description	Acres Low Emergent Marsh	Acres Mudflat	Acres Wetland Forest/ Scrub-Shrub	Acres Upland Forest/ Scrub-Shrub	Acres Open Water (Tidal Creek & Tidal Pond)	Total Acres Restored	Average Annual Habitat Units (AAHU)	Total Cost	Average Annual Cost (AAC)	Incremental Cost/Output (Change in AAC/Change in AAHU)
1	No-Action	0	0	0	0	0	0	0	$0	$0	$0
2	100% of Area 4	18.4	2.3	20.7	2.3	2.3	46	48.3	$4,577,549	$305,730	$6,330
3	100% of Areas 1 & 4, 75% of Area 2	114.1	14.3	128.4	14.3	14.3	285.4	254.1	$27,970,486	$1,868,120	$7,592
4	100% of Areas 1, 2 & 4	130.5	16.3	146.8	16.3	16.3	326.3	289.3	$31,972,992	$2,135,443	$7,594
5	100% of all Areas	151.7	19	170.7	19	19	379.3	334.9	$37,324,418	$2,492,859	$7,838
6	100% of all Areas	217.2	19	110.1	14.1	19	379.3	339.6	$46,581,628	$3,111,139	$131,549
7	100% of all Areas	238.4	19	90.4	12.4	19	379.3	341.1	$49,577,077	$3,311,202	$133,375
8	100% of all Areas	285	19	47.4	9	19	379.3	344.3	$56,163,976	$3,751,134	$137,479

* Includes all the combinations between all the restoration areas.

The Team performed QA/QC on data entry of all costs and outputs into the IWR-PLAN. In addition, the District held a working session with IWR to review the development of outputs and costs, conceptual restoration plans, and CE/ICA used in the ERP. IWR and the USACE approved the methodology used throughout the ERP process. IWR's comments on the preliminary draft have been incorporated into this document.

Results and Discussion

The IWR-PLAN results are summarized below in Table 81.

Table 81. IWR-PLAN

Plan	Total Acres Restored	Average Annual Habitat Units	Total Cumulative Habitat Units	Average Annual Cost	Total Cost	Incremental Cost/ Output
1	0	0	0	$0	$0	$0
2	46	48.3	2,415	$305,730	$4,577,549	$6,330
3	285.4	254.1	12,705	$1,868,120	$27,970,486	$7,592
4	326.3	289.3	14,465	$2,135,443	$31,972,992	$7,594
5	379.3	334.9	16,745	$2,492,859	$37,324,418	$7,838
6	379.3	339.6	16,980	$3,111,139	$46,581,628	$131,549
7	379.3	341.1	17,055	$3,311,202	$49,577,077	$133,375
8	379.3	344.3	17,215	$3,751,134	$56,163,976	$137,479

Implementation of Plan 2 instead of the No-Action plan would convert 46.0 acres of wetland *Phragmites* into the targeted habitat types at a cost of approximately $4.6 million and a gain of 48.3 AAHUs per year, or 2,415 total cumulative HUs during the 50-year life. Although this plan has the lowest AAC, total cost, and incremental cost/output of all the "best buy" plans, all restoration activity occurs in Area 4 and none of the Island would be converted if this plan were selected.

Plan 3 is equivalent to Plan 2 plus the conversion of almost 240 acres of the wetland *Phragmites* on the Island to the targeted habitat types. Implementation of Plan 3 instead of Plan 2 results in a large gain in AAHUs, from 48.3 to 254.1 per year, or 12,705 total cumulative HUs during the 50-year life, at an additional cost of $23.4 million. The incremental cost/output increases from $6,330 to $7,592.

In comparison to Plan 3, Plan 4 results in an additional 40.9 acres of restoration, 35.2 AAHUs, and 1,760 total cumulative HUs during the 50-year life, at an additional total cost of $4 million. The incremental cost/output for Plan 4 ($7,594) is only slightly higher than for Plan 3 ($7,592).

Plan 5 converts all of the wetland *Phragmites* (379.3 acres) in the four Restoration Areas to the targeted habitat types. If this plan were implemented instead of Plan 4, an additional 45.6 AAHUs of output would be gained, resulting in a total of 334.9 AAHUs each year, or 16,745 cumulative HUs, during the 50-year life, at an added cost of $5.3 million. The incremental cost/output increases marginally, by $244, with Plan 5 versus Plan 4.

Plans 6 through 8 vary in their ratio combinations of the target restoration cover types, but all would restore the entire area of wetland *Phragmites* in Restoration Areas 1 – 4. Selection of any of these Plans instead of Plan 5 would not increase the number of acres restored, but would result in some increase in AAHUs during the life and variable increases in cost, ranging from an additional $9.3 million to $18.9 million. As presented in the graph below, there is a break point between Plans 5 and 6 where incremental cost/output increases by $123,711, indicating that selection of Plans 6 through 8 is not recommended.

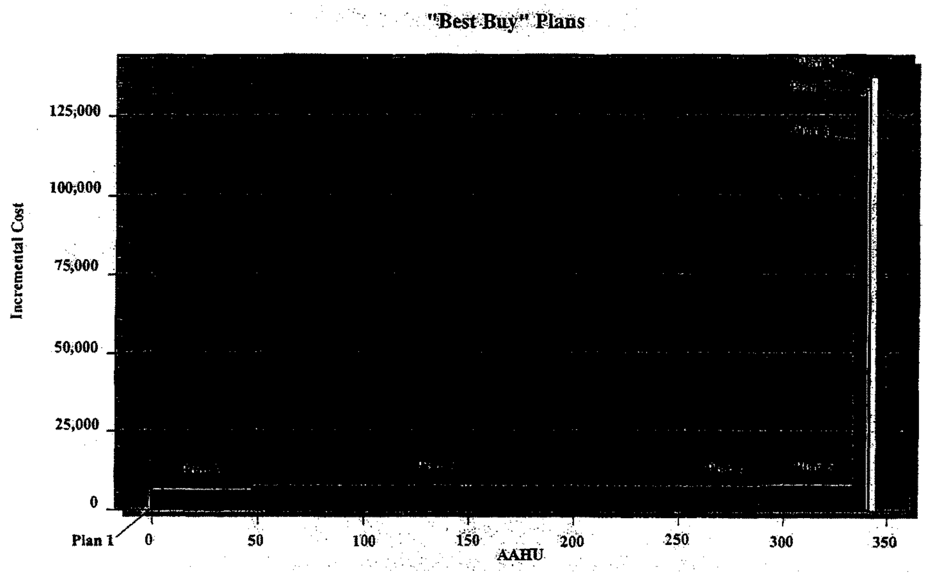

Figure 4. "Best Buy" Plans

APPENDIX F
STUDY CORRESPONDENCE

(1101)

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Habitat Conservation Division
James J. Howard Marine
Sciences Laboratory
74 Magruder Road
Highlands, New Jersey 07732

MFR:
RCVD 11/9/98
MHB

September 2, 1998

Mr. Frank Santomauro, P.E.
Chief, Planning Division
Department of the Army
New York District, Corps of Engineers
26 Federal Plaza
New York, NY 10278-0900

Dear Mr. Santomauro:

We have reviewed the Scoping Document for the Raritan River Basin South River, New Jersey ›d Control and Environmental Restoration Project. We understand that the scoping document provides only general information and that project plans are still in development. We offer the following comments to aid in your planning effort.

The South River and its tributaries provide spawning, nursery and forage habitat for anadromous river herring such as alewife (Alosa pseudoharengus), blueback herring (Alosa aestivalis) and American shad (Alosa sapidissima). Little data is available on the use of the Washington Canal by these species, but anadromous fishes likely use it to access the upper reaches of South River. One of the flood control options mentioned in the scoping document is the construction of a tidal barrier, pump station and diversion channel across South River. This would prevent the passage of fish and eliminate spawning in the South River watershed. Over the past several years, great strides have been made in restoring anadromous fish runs in New Jersey. As water quality improves and blockages are removed, fish are returning to their historic spawning grounds. We oppose strongly any project which would eliminate the passage of anadromous fish to their spawning grounds.

In addition, between South River and the Washington Canal are tidal wetlands that provide valuable habitat for fish and wildlife. We support the Corps in their environmental restoration goals for this area. However, the wetlands fill and changes in wetlands hydrology resulting from the construction of a tidal barrier, pump and levee system will degrade the wetlands the Corps ks to restore.

The conceptual plan presented in the scoping document also includes the construction of levees and flood walls, bridge replacement, road raising and lining portions of the shoreline with crushed stone. Without site specific information about the habitat of the areas affected, a full review of impacts is not possible. However, any work in the water should be prohibited from April 1 to June 30 and September 1 to November 30 of any given year to minimize impacts to anadromous fish migrating to and from the upstream spawning ground. Also, any work in or along the banks of the South River should be evaluated to determine the impacts to spawning and resting habitat for anadromous fishes.

The document discusses several non-structural solutions to provide storm damage protection for the project area. We support strongly the use of these methods. We oppose the construction of any obstruction across South River or the Washington Canal. Additional information is necessary for a full evaluation of the impacts of the proposed levees. We look forward to continued coordination with your office on this project. If you would like to discuss this matter further, please contact Ms. Karen Greene at 732 872-3023.

Sincerely,

Stanley W. Gorski
Field Offices Supervisor

cc: EPA - Region II
FWS - Pleasantville
NJDEP - Land Use

Joe

HISTORIC VILLAGE OF OLD BRIDGE COMMUNITY GROUP
28 Kossman Street
East Brunswick, New Jersey 08816

March 6, 1999

US Army Corps of Engineers
c/o Col. Bill Pearce
New York District
26 Federal Plaza
New York, New York 10278-0090

Dear Col. Pearce:

We would like to take this opportunity to commend your staff on a job well done. On January 28, 1999, a public meeting was initiated by the Historic Village of Old Bridge Community Group to discuss the South River Flood Control and Environmental Restoration Project. The meeting was attended by both Mr. Joseph Redican and Mr. Peter Blum of the US Army Corps of Engineers.

The residents of the area left this meeting with a sense that their voices were finally heard with regard to this project. Mr. Blum and Mr. Redican discussed these sensitive issues with the utmost of professionalism and knowledge. They were courteous and willing to listen to the concerns and suggestions of the residents. Their ability to deal one on one in an enthusiastic and competent manner is a valuable asset to your program.

Our thanks again to you and your staff for their time and the courtesies shown to us. We look forward to working with them in the future. Keep up the good work.

Sincerely,

Karen Scott, Chairperson
Historic Village River Preservation Committee
6 Squire Street
East Brunswick, NJ 08816
(732) 238-3969

KS/kaw

Brickman

State of New Jersey
Department of Environmental Protection

Christine Todd Whitman
Governor

Robert C. Shinn, Jr.
Commissioner

March 18, 1999

Frank Santomauro, P.E.
Chief, Planning Division
New York District Corps of Engineers
26 Federal Plaza
New York, NY 10278

Dear Mr. Santomauro:

I have reviewed the South River, Raritan River Basin, Flood Control and Ecosystem Restoration "P-7" Plan Formulation Document and support your recommendations as outlined in the document.

I concur with the recommendation for detailed evaluations of structural measures in reaches three and four, while evaluation non-structural alternative in reaches one, two and five. I also agree with your recommendation to proceed in evaluating an ecosystem restoration alternative for the island located between the Old South River and the Washington Canal. The New Jersey Department of Environmental Protection intends to continue to participate fully in partnership with the Corps.

We believe that it is in the best interest of the State of New Jersey and the Boroughs of East Brunswick, South River and Sayreville that project authorization be provided by Congress as soon as possible. Please be assured of our interest and support in this matter and our desire to get this project to completion.

Sincerely,

Bernard J. Moore
Administrator

State of New Jersey

Department of Environmental Protection

Christine Todd Whitman
Governor

Robert C. Shinn, Jr.
Commissioner

Natural and Historic Resources
Division of Engineering and Construction

April 15, 1999

Mr. Frank Santomauro, P. E.
Deputy District Engineer
New York Dist. Corps of Engineers
26 Federal Plaza
New York, NY 10278

Dear Mr. Santomauro:

This is in follow-up to my March 18, 1999 letter of support for your Plan Formulation (P-7) Report for the South River Feasibility Study. This letter provides the State of New Jersey's preferred course of action for the remaining engineering and design effort for the South River study.

The original Project Study Plan (PSP) required that the feasibility report include expanded engineering detail to allow us to bypass the traditional Design Memorandum (DM) stage and proceed directly to plans and specifications. I request that your modify the PSP to:

- Streamline the feasibility report without expanding the engineering
- Expedite the completed feasibility report to Congress for earliest possible project authorization
- Upon feasibility completion, enter into a cost-shared Pre-construction Engineering and Design (PED) phase to document the expanded engineering detail in a DM and proceed with plans and specifications

Based on my support of the proposed P-7 report levee systems and my experience with similar Corps levee system projects, the separate DM is needed to insure adequate documentation of the levee designs and the associated complex interior drainage works.

This course of action will expedite project authorization and ultimately save both time and money. We also believe that it is in the best interest of the State of New Jersey and the Boroughs of East Brunswick, South River and Sayreville that project authorization be provided by Congress as soon as possible. Please be assured of our interest and support in this matter and our desire to get this project to completion.

Sincerely,

Bernard J. Moore
Administrator

APR 21, 1999
By
Original given to Plan Formulation Branch

Phone
(732) 255-0770

1510 Hooper Avenue, Toms River, NJ 08753

Fax
(732) 255-0774

State of New Jersey
Department of Environmental Protection

Christine Todd Whitman
·rnor

Robert C. Shinn, Jr.
Commissioner

Division of Fish, Game and Wildlife
Robert McDowell, Director
P.O. Box 400
Trenton, NJ 08625-0400
www.nj.us/dep/fgw

June 25, 1999

Department of the Army
New York District, Corps of Engineers
Jacob K. Javits Federal Building
New York, NY 10278-0090
Attn.: Frank Santomauro, P.E.

Dear Mr. Santomauro:

Reference is made to your letter of May 21, 1999 inviting the Division of Fish, Game and Wildlife [DFGW] to participate in a Habitat Evaluation Procedure [HEP] study for the South River Multi-Purpose Feasibility Study. Please know that Division staff is fully committed at this time and we cannot participate in the proposed HEP. However, as always, we will provide whatever other assistance / recommendations we can relative to fish and wildlife interests and resources.

The DFGW notes with interest that the project plans have not changed since we had provided input on this project at a meeting in Sandy Hook [NMFS] on November 20, 1997. At that time, the DFGW as well as the USFWS recommended a redesign of the project to move levees inland or out of the marshes and to consider partial buy-outs of some flood-prone areas either as a way to move levees or to eliminate problem structures. It is somewhat discouraging to note that recommended measures to avoid and / or minimize impacts to existing natural resources have not been incorporated into the current scoping document. Further, it would appear that such alternatives to the project scope are needed in order to provide better options on which to evaluate a HEP analysis.

We hope this information is of service to you. If you have need of any additional information, feel free to contact Andrew Didun [609-984-2413] of my staff.

Sincerely,

Robert McDowell, Director
Division of Fish, Game and Wildlife

c. A. Didun
D. Wilkinson
M. Burlas, ACOE
USFWS, Pleasantville

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Ecological Services
927 North Main Street (Bldg. D1)
Pleasantville, New Jersey 08232

Tel: 609-646-9310
FAX: 609-646-0352

IN REPLY REFER TO:

FP-00/065

December 19, 2000

Frank Santomauro, P.E.
Chief, Planning Division
New York District
U.S. Army Corps of Engineers
26 Federal Plaza
New York, New York 10278-0090

Re: Raritan Bay / Sandy Hook Bay Hurricane and Storm Damage Reduction Feasibility Study
Union Beach, New Jersey

Raritan River Basin Flood Control and Ecosystem Restoration Feasibility Study, South River and Sayerville, New Jersey

Dear Mr. Santomauro:

This responds to your letter of November 8, 2000, in which the U.S. Army Corps of Engineers, New York District (Corps) requested confirmation from the U.S. Fish and Wildlife Service (Service) that Habitat Evaluation Procedures (HEP) and Evaluation for Planned Wetlands (EPW) are suitable techniques for assessing impacts to wetlands associated with the referenced planning projects. Specifically, the Corps plans to use these two assessment methodologies as a tool for determining compensatory mitigation requirements for wetland impacts associated with the flood control components and to assess the benefits of the ecosystem restoration component.

I would like to take this opportunity to thank you and your staff for valuing Service participation in the Corps planning process. Additionally, I continue to find the working relationship between our agencies at the staff level to be professional, respectful, and productive. The maintenance of this good working relationship is a high priority for me and my staff.

AUTHORITY

The following comments provide technical assistance only and do not constitute comments by the Service as afforded by the Fish and Wildlife Coordination Act (48 Stat. 401; 16 U.S.C. 661 *et seq.*), nor do they preclude comment on any forthcoming environmental documents pursuant to the National Environmental Policy Act of 1969 as amended (83 Stat. 852; 42 U.S.C. 4321 *et seq.*).

SERVICE POSITION ON THE USE OF HEP AND EPW

The Service supports the Corps efforts to characterize wetland and upland functions and values in the two project areas using HEP and EPW. However, the use of both HEP and EPW does not preclude the use of best professional judgement in assessing project impacts and evaluating compensatory mitigation. The Service views both HEP and EPW as tools to assist in making decisions regarding the functions and values of wetlands and uplands within the study areas.

The HEP process, when implemented properly, can be a valuable tool to assist biologists in evaluating potential impacts to target species that would occur from the proposed projects. However, compensatory wetland mitigation often involves compensating for wetland functions and values other than the wildlife-related values assessable via HEP. The Service is uncertain whether the EPW study will provide additional insight into the functions or values of wetlands within the two study areas and aid in determining compensatory mitigation. Service staff participated in an on-site field trial of EPW and found the methodology to be subjective, requiring on-site estimates of broad indicators of wetland functions. The Service understands that the use of EPW was requested by the New Jersey Department of Environmental Protection.

HIGHER LEVEL OVERSIGHT

As you are aware, the HEP process is directed by a HEP team, which makes technical decisions, preferably via consensus, throughout the HEP study. The HEP team currently consists of two representatives of the Corps, and one representative each from the Service, the National Marine Fisheries Service, and the New Jersey Department of Environmental Protection's Land Use Regulation Program. The Corps Consultant, Northern Ecological Associates, provides valuable input to the HEP team regarding technical matters. Professional judgement in the field is required to conduct a meaningful HEP; therefore, the team concept is a critical component of the HEP process. Without support from the HEP team, any modifications to the HEP study and subsequent conclusions based on those modifications are not defensible.

In the November 8 letter, the Corps states that "...recommendations from all interagency teams are subject to review and acceptance by USACE [U.S. Army Corps of Engineers] higher authority." We interpret your November 8 letter to imply that higher level review may discount the recommendations of the HEP team. I am certain that you will agree such intervention is nonproductive to long-term trust and cooperation between our agencies. Such intervention does not promote the "seamless government approach" mentioned in your November 8 letter. We need to look for ways to build bridges and not walls to promote interagency conditions.

As you are aware, higher authority intervention previously occurred with regard to the Corps Raritan Bay and Sandy Hook Bay combined Flood Control and Shoreline Protection study at Port Monmouth, New Jersey. The interagency HEP team assembled for the Port Monmouth project was in near complete agreement on the results of the HEP study and necessary compensatory mitigation. However, higher level objections within the Corps invalidated the significant time and effort of the HEP team and devalued its efforts. Fortunately, the current HEP team members have continued to work very well together on the referenced projects. The incentive to cooperatively participate in such studies could become strained should such higher level objections within the Corps continue to occur after interagency consensus is reached at the District and Field Office level.

Should you have any questions regarding these comments, please contact me or have your staff contact Thomas McDowell of my staff at (609) 646-9310, extension 18.

Sincerely,

Clifford G. Day
Supervisor

Blum

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Ecological Services
927 North Main Street (Bldg. D1)
Pleasantville, New Jersey 08232

Tel: 609-646-9310
FAX: 609-646-0352

IN REPLY REFER TO:

FP-00/064

December 20, 2000

Frank Santomauro, P.E.
Chief, Planning Division
New York District
U.S. Army Corps of Engineers
26 Federal Plaza
New York, New York 10278-0090

Re: South River Restoration Screening Report
Flood Control and Ecosystem Restoration Project
South River, New Jersey

Dear Mr. Santomauro:

This responds to a request made by Josephine Axt, Ph.D. of your staff for the U.S. Fish and Wildlife Service (Service) to review and provide comments on the referenced document. The referenced screening report provides a description of potential restoration goals and identifies general strategies for meeting each goal. The Service fully supports the U.S. Army Corps of Engineers (Corps) efforts to restore habitats in the South River watershed. Since additional planning will occur prior to on-the-ground implementation of any restoration option discussed in the report, the Service requests continued involvement.

AUTHORITY

The following comments provide technical assistance only and do not constitute comments by the Service as afforded by the Fish and Wildlife Coordination Act (48 Stat. 401; 16 U.S.C. 661 *et seq.*), nor do they preclude comment on any forthcoming environmental documents pursuant to the National Environmental Policy Act of 1969 as amended (83 Stat. 852; 42 U.S.C. 4321 *et seq.*).

SPECIFIC COMMENTS

The document is generally well written and thorough; however, the Service has identified some recommended changes to improve the document. These recommendations are listed below by page and paragraph number.

Pg. 1 Include an explanation of why ecosystem restoration options in the South River watershed are being evaluated.

Pg. 2, Par. 1 Add a statement to clarify that this proposed environmental restoration project is *not* compensatory mitigation for any proposed impacts associated with the Flood Control project discussed in this paragraph.

Pg. 2, Par. 2 Discuss how mosquito ditching has affected wetland hydrology and associated vegetation communities in the project area.

Pg. 6, Par. 2 This paragraph discussed impacts to wetlands associated with years of industrial activities. The Service recommends including a discussion regarding direct impacts (e.g., ditching, dredging, filling).

Pg. 22, Par 1 - Why the Corps views large areas of salt pan as being undesirable is unclear. These communities are a natural component of salt marsh systems and should be retained to provide habitat diversity.

Pg. 25, Par. 1 The citation "Zeff, 1999" does not appear in the literature cited section of the report.

Pg. 25, Par. 3 The Corps plans to construct broad and shallow channels through emergent marsh. Channels that would mimic natural channels, in regard to morphologic features such as sinuosity, slope, and width to depth ratio, would be more appropriate. Such natural channels are generally not broad and shallow. Such an appropriately constructed channel should remain stable and provide habitat for aquatic species, as well as transmit water to and from adjacent wetlands.

Pg. 26, Par. 2 Again, as stated above, it is unclear that low to moderate slopes of stream banks are appropriate or natural. The Service recommends surveying tidal creeks in the area to determine appropriate morphology.

Pg. 27, Par. 3 Examine the feasibility of constructing mud flats by filling open water rather than excavating existing wetlands. Specifically, it may be feasible to fill some areas of the historic South River channel near Clancy Island while maintaining the historic channel's integrity. The historic channel's size could be reduced because it does not discharge the same volume it historically did because flow is now diverted to the Washington Canal. It may be possible to fill some areas of the historic South River channel while compensating for the loss of open water by constructing tidal creeks within Clancy Island.

Pg. 34 The Corps discusses the feasibility of creating either upland or wetland forest / scrub-shrub communities via the disposal of dredged material generated from wetlands restoration activities. Such communities may provide wading bird nesting habitat. The Service views this dredged material disposal / habitat enhancement option as potentially viable; however, the Service recommends that the Corps minimize the area of wetland impacts and focus any impacts on low-quality wetlands or wetlands with the least probability of being successfully restored. We understand that uplands currently exist on Clancy Island, as well as at the fringe of other wetlands within the study area; therefore, disposal of excess material on existing uplands may be feasible. The Corps should also demonstrate that any functions and values lost as a result of creating uplands from wetlands have been compensated for by other components of the ecosystem restoration project.

Pg. 38, Par. 2 The point of this paragraph is not clear. The paragraph appears to assert that Durhernal Lake Dam on the South River did not cause the demise of anadromous fish in the South River; however, such an assertion is not justified within this paragraph. If anadromous fish are adversely affected by factors other than the dam, those factors should be identified along with potential corrective measures.

Pg. 40 The Corps discusses the potential of constructing permanently flooded tidal ponds as a habitat enhancement technique. However, from review of the document, the advantage of constructing tidal ponds rather than tidal creeks remains unclear. Tidal creeks would provide a more natural tidal marsh feature.

Pg. 43 The Corps discusses the option of creating a recreational park with dredged material. However, there is no discussion regarding what cover type would be filled with dredged material in order to construct the park. Additionally, construction of a recreational park is generally not considered ecosystem restoration.

Pg. 40 The difference between pans and tidal ponds should be identified, both from a structural and ecological perspective. Additionally, any proposals to eliminate large areas of wetlands by excavating ponds and disposing of dredged material by creating uplands from wetlands would not be desirable. Finally, the ecological benefits of constructing tidal ponds rather than tidal creeks should be explained.

Pg. 48 The Corps has ranked ecosystem restoration techniques for the study area. The Service is generally in agreement with the ranking technique employed and would encourage implementation of most of these techniques at appropriate sites within the study area. The Service notes, however, that construction of a fish ladder ranked low compared to other ecosystem restoration options. As discussed above, we recommend reevaluating the apparent conclusion that Durhernal Lake Dam was not the major contributor to the loss of anadromous fish from the South River system. If that conclusion were modified, fish ladder construction may rank higher as a potential ecosystem restoration technique.

Please continue to keep the Service involved in the South River flood control and ecosystem restoration project. The Service is especially interested in assisting the Corps with more detailed ecosystem restoration planning. Should you have any questions regarding these comments, please contact me or have your staff contact Thomas McDowell of my staff at (609) 646-9310, extension 45.

Sincerely,

Clifford G. Day
Supervisor

State of New Jersey
Department of Environmental Protection

_D T. DiFrancesco
Acting Governor

Robert C. Shinn, Jr.
Commissioner

Natural and Historic Resources
Division of Engineering and Construction

June 5, 2001

Mr. Frank Santomauro, P.E.
Chief, Planning Division
New York District, Corps of Engineers
26 Federal Plaza
New York, New York 10278

Dear Mr. Santomauro:

This letter is in response to your letter dated March 29, 2001 regarding the draft Environmental Restoration Plan and subsequent meeting to be held on April 10, 2001 to discuss the South River, Raritan River Basin, Flood Control and Environmental Restoration Feasibility Study.

As you are aware, we have been looking to reschedule the original meeting and are coordinating with your staff on a new meeting date. At this time I would like to reiterate that the New Jersey Department of Environmental Protection supports the flood control portion of the study that provides a 500-year level of protection for the Boroughs of South River, Sayreville and East Brunswick. We request that the Corps does not proceed on evaluating higher levels of protection, as we feel that any larger project will not be implementable. In regards to the environmental restoration component of the study, we agree with the process that has been undertaken to produce the Environmental Restoration Plan and would like to discuss this further, at a date to be determined, to discuss the final recommendation and provide our recommendations and support.

We will continue to work with you and your staff to produce a draft feasibility report this summer so that project authorization may be provided by Congress as soon as possible. Please be assured of our interest and support in this matter and our desire to get this project to completion.

Sincerely,

Bernard J. Moore
Administrator

Phone
(732) 255-0770

1510 Hooper Avenue, Toms River, NJ 08753

Fax
(732) 255-0774

State of New Jersey
Department of Environmental Protection

..s E. McGreevey
Governor

Bradley M. Campbell
Commissioner

Natural and Historic Resources
Division of Engineering and Construction

April 17, 2002

Mr. Frank Santomauro, P.E.
Chief, Planning Division
New York District, Corps of Engineers
26 Federal Plaza
New York, New York 10278

Dear Mr. Santomauro:

This letter is in follow up to the Alternative Formulation Briefing and my subsequent review of the preliminary draft report for the South River, Raritan River Basin Hurricane and Storm Damage Reduction and Ecosystem Restoration Feasibility Study. At this time I would like to reiterate that the New Jersey Department of Environmental Protection supports the recommendations of the draft report for hurricane and storm damage reduction and ecosystem restoration in the South River Basin.

We will continue to work with you and your staff to produce the final draft feasibility report this summer so that project authorization may be provided by Congress as soon as possible.

Please be assured of our interest and support in this matter and our desire to get this project to completion.

Sincerely,

Bernard J. Moore
Administrator

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Phone (732) 255-0770 **1510 Hooper Avenue, Toms River, NJ 08753** **Fax** (732) 255-0774

State of New Jersey

James E. McGreevey
Governor

Department of Environmental Protection
Natural and Historic Resources
Division of Engineering & Construction

Bradley M. Campbell
Commissioner

SEP 26 2002

Mr. Frank Santomauro, P.E.
Chief, Planning Division
New York District, Corps of Engineers
26 Federal Plaza
New York, New York 10278

Dear Mr. Santomauro:

This letter is in follow up to our coordination of the South River, Raritan River Basin Hurricane and Storm Damage Reduction and Ecosystem Restoration Feasibility Study. At this time I would like to reiterate that the New Jersey Department of Environmental Protection supports the recommendations that were documented in the draft report and will be included in the final report for hurricane and storm damage reduction and ecosystem restoration in the South River Basin.

We will continue to work with you and your staff to finalize the Project Management Plan for the Pre-Construction, Engineering and Design Phase and execute the Design Agreement so we may initiate the design phase of the project. Please be assured of our interest and support in this matter and our desire to get this project to completion.

Should you have any further questions, please contact me at (609) 984-0859.

Sincerely,

John H. Moyle, P.E.
Acting Administrator
Division of Engineering and Construction

E-Mail Address: DamSafety@dep.state.nj.us
Internet Address: www.state.nj.us/dep/nhr/engineering/damsafety
Mailing Address: 501 East State Street, P.O. Box 419, Trenton, NJ 08625

APPENDIX G
REAL ESTATE

U.S. Army Corps of Engineers

REAL ESTATE PLAN

South River, Raritan River Basin, New Jersey
Storm Damage Reduction and Ecosystem Restoration Project

Prepared by:

Department of the Army
New York District
Corps of Engineers

Real Estate Division

September 2002

REAL ESTATE PLAN

South River, Raritan River Basin, New Jersey
Storm Damage Reduction and Ecosystem Restoration Project

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Map 1 – General Project Vicinity
Map 2 – Project Area and Alignment
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Map 4 – Overall Project with Ownership Lot lines

Preamble

A. **Introduction**: South River, the first major tributary of the Raritan River, is located approximately 8.3 miles upstream of the Raritan River's mouth at Raritan Bay. The South River is subject to frequent and severe flooding, which poses a threat to this highly urbanized and densely populated area. Since 1960, there have been six major flood events (March '62, May '68, September '71, April '84, December '92, and March '93). The most current flood event, in March 1993, is regarded as the worst on record.

In May 1995, a Multiple Reconnaissance Study was prepared identifying the flooding problems along the South River. The study discussed several alternatives to remediate the flooding problems. These included a tidal barrier plan and multiple levee schemes. The 2002 Feasibility Study recommends a levee plan including a storm surge barrier crossing South River, which meets all the conditions for Federal interest, and also includes an environmental restoration plan. The proposed project will provide a 500-year level of flood protection in the communities of Sayreville and South River, New Jersey.

B. **Authorization**: The present study was authorized by a resolution of the US House of Representatives, Committee on Public Works and Transportation and adopted 13 May 1993.

C. **Designation**: South River, Raritan River Basin, New Jersey Storm Damage Reduction and Ecosystem Restoration Project.

D. **Location**: The Project area is located within the lower Raritan River Basin in Middlesex County, New Jersey (see Figure 1), approximately 30 miles southwest of New York City and 25 miles northeast of Trenton, the State capital. The South River is the first major tributary of the Raritan River, and is located approximately 8.3 miles upstream of the Raritan River's mouth at Raritan Bay. The South River is formed by the confluence of the Matchaponix and Manalapan Brooks, just above Duhernal Lake, and flows northward from Duhernal Lake a distance of approximately 7 miles, at which point it splits into two branches, the Old South River and the Washington Canal. Both branches flow northward into the Raritan River. The South River is tidally controlled from its mouth upstream to Duhernal Lake Dam. Fluvial conditions prevail above the dam.

D. **Non-Federal Sponsor**: The non-Federal sponsor for this Project is the State of New Jersey, Department of Environmental Protection ("NJDEP" or the "Sponsor").

E. **Cost-Sharing**: The Government will be responsible for **65%** of the Total Project Costs ("TPC"); the non-Federal Sponsor will be responsible for the remaining **35%**.

1. **Statement of Purpose**: The purpose of this Real Estate Plan is to present the overall plan describing the minimum real estate requirements for the construction, operation, maintenance, repair and rehabilitation of the South River, Raritan River Basin Storm Damage Reduction and Ecosystem Restoration Project.

2. **Project Purpose and Features**:

A. Periodic storms have caused severe flooding along the South River. Flooding upstream of Duhernal lake is fluvial. Flood damages downstream of Duhernal Lake are tidally dominated with additional damages associated with basin runoff. The Middlesex County Boroughs of South River and Sayreville are repeatedly affected by storm tidal surges. Tidal flooding typically occurs during hurricanes and "northeasters" when sustained offshore winds push storm surges inland up tidal channels. In addition to damages from storm inundation, storm surges often block existing storm water drainage outlets, resulting in additional flood damages.

B. The Plan of Improvement calls for construction of two levee/floodwall segments, each approximately 6,000 feet long, along opposite banks of the South River (the "Eastern alignment" and "Western alignment"). The levee/floodwall alignment will protect the communities of South River and Sayreville from a 500-year flood event. In addition, a storm surge barrier will be placed across the South River which will tie into the levee and floodwall system on both sides of the river to form a continuous blockage from storm tides insurgence into flood prone low lying areas of South River and Sayreville. In addition, the Environmental Restoration Plan of Improvement is to restore the quality of the degraded salt marsh near the Washington Canal. The plan would involve the replacement of low quality vegetation in 380 acres of wetlands to restore an important habitat. Details are as follows:

Eastern alignment: The eastern portion of the line of protection is located mostly within the Township of Sayreville. The top of protection is at +21.5 NGVD. The existing grade elevations along the entire line of protection excluding the segment that crosses the South River range between +4.0 and +20.0 NGVD. Therefore, the height of protection ranges between 1.5 feet and 17.5 feet.

The line of protection, with a total of **426 feet of floodwall** and **6,081 feet of levee**, begins at the northeastern end as a levee starting at a point approximately 250 feet west of the intersection of Anderson Court and Canal Street behind some newly constructed residential properties. There will be maintenance vehicle access to the top of the levee at this point. The levee then extends in a northwesterly direction between the rear property lines of the residential development and the municipal sewage facility for approximately 500 feet, where it meets the eastern bank of the Washington Canal. The top of the levee will be widened in this area to accommodate a vehicle turnaround. Due to space restrictions, the levee then transitions to a floodwall, which runs southwest along the bank of the canal at the frontage of the sewage facility for approximately 300 feet, where it turns south for an additional 100 feet before switching back to levee for the remainder of its length. The remainder of the 10 foot-wide crested and 1 on 2.5

side-sloped levee is located in an undeveloped area located between the Washington Canal and the South River to the west, and residential development to the east. From the floodwall, the levee runs in a southeasterly direction for approximately 450 feet, and then turns to a southwesterly course for 350 feet, passing the eastern termination at Hinton Street. Another access ramp will be located at the end of Hinton Street. The levee makes another slight turn to the west and continues in a southwesterly direction for nearly 750 feet before turning south for another 600 feet. There will be another vehicle turnaround located in this segment. The levee turns to a southwesterly direction again and runs parallel to Weber Avenue at a 300 feet offset for nearly 800 feet, then turns south and runs again parallel to Weber Avenue, this time at a 450 foot offset for approximately 2,150 feet. There will be a turnaround located approximately at one third (1/3) of the length of this segment. The levee then turns southwest and continues for approximately 350 feet until it meets the eastern bank of the South River where it terminates against a bulkhead, which is essentially the east side of a storm surge barrier. A maintenance access ramp is to be located at this last change in direction in the levee. The last 200 feet of levee for closure to elevation +21.5 is located on the western side of the South River in the Township of South River. Once across the river, there is a bulkhead similar to that on the eastern side. The levee begins again and immediately turns to the south where it continues until it meets high ground alongside Veteran's Highway within 50 feet of the western bridge abutment.

Storm Surge Barrier Alignment: The line of protection continues across the river for 320 feet in the form of a storm surge barrier and a tentatively sized 80-foot wide clear opening storm gate, which lies collinear with the levee. A pump station is to be located within the barrier between the South River west bank and the storm gate. Between the eastern side of the storm gate and the east bank of the South River, there will be gravity drains with backflow prevention of a sufficient size to alleviate build-up of interior drainage. Like the rest of the line of protection, the barrier and storm gate provide protection to an elevation of +21.5 NGVD.

Western Alignment: The western portion of the line of protection is located entirely within the Township of South River. As with the eastern segment, the top of protection is located at +21.5 NGVD. The grades on the western side of the river are similar to those on the eastern side. Therefore, the height of protection also ranges from 1.5 feet to 17.5 feet NGVD. The line of protection, with a total of **4,631 feet of levee** and **1,229 feet of floodwall**, begins at the northwestern corner as a levee starting at a point located at the southeast corner of an unpaved trailer lot off of Tices Corner Road. There will be maintenance vehicle access to the top of the levee from this lot. The levee runs southeast for approximately 600 feet through a wooded area until it is within 150 feet of the riverbank, where it turns to a southwesterly direction. The 10 foot wide crest width with a 1 on 2.5 side slope levee then continues along the river bank for an additional 400 feet, where the levee transitions to a floodwall due to space restrictions. There will be a vehicle turnaround provided at the end of the levee in this location. The floodwall is located at the riverbank. It parallels the river for approximately 900 feet as it bends to the southeast. The cross-section then reverts back to levee where space becomes available and continues to parallel the river for an additional 450 feet. There will be vehicle access provided in this segment. At this location, the levee turns slightly southward and continues in a southeasterly direction, no longer parallel to the river, for approximately 450 feet where it turns slightly further south and continues on for another 1,250 feet. The levee then turns further south and continues in a southerly direction for approximately 350 feet, where it ends and a floodwall begins, to minimize impacts to the adjacent wetlands. Vehicle access to the levee will be provided at this end of the levee as well. As before, the floodwall runs directly adjacent to and parallel with the river for 400 feet until it meets Veteran's Highway approximately 100 feet northeast of its intersection with Water Street. The final segment of the line of protection is a levee, which extends from the end of the last floodwall segment directly adjacent to and parallel with Veteran's Highway on the north side for approximately 1,150 feet, where it terminates at high ground at elevation +21.5 NGVD. There will be a turnaround at the beginning of this segment and vehicle access at the end.

Construction of the proposed levee system will require approximately **320,000 cubic yards** of earthen material. The Contractor will obtain this material from existing, Project-approved, commercial sources within a 50-mile radius of the Project area. The Project does **NOT** require acquisition of real property interests for borrow or disposal areas.

C. Required Lands, Easements, Rights-of-Way, Relocations and Disposal Areas (LERRD) – The estimated total acreage required for the Project is approximately **536.65 acres**, consisting of approximately **25.30 acres of permanent easements** with **55.0 acres of severance damages** (Flood Protection Levee Easements) for the levee/floodwall alignment, **9.70 acres of temporary work area easements** to support construction of the levee/floodwall system, and **446.65 acres of Fee Simple acquisition (435.59 acres** for the environmental restoration feature and **11.06 acres** for environmental mitigation).

<u>Preliminary Ownership Information</u>: With respect to the Environmental Restoration and Mitigation areas, there are approximately 28 affected tracts (lots) and 5 affected ownerships, as follows:

Borough of Sayreville, 20 lots, approx. 402 acres
Borough of South River, 3 lots, approx. 20 acres
Middlesex County, 1 lot, approx. 5 acres
Veterans of Foreign Wars, 1 lot, approx. 10 acres
Saint Mary's Church, 3 lots, approx. 8 acres

With respect to the Levee and Floodwall alignment, there are approximately 24 affected lots and 7affected ownerships, as follows:

Borough of Sayreville -- 3 lots
Borough of South River -- 3 lots
Middlesex County -- 8 lots
Polish Veterans' Association -- 4 lots
Veterans of Foreign Wars -- 2 lots
Saint Mary's Church -- 3 lots
Unknown owner -- 1 lot

A summary of the acreage needed for the Project and the uses thereof is as follows:

	Acres
Fee Simple	446.65 (see note below)
Permanent (Perpetual) Easements	
Flood Protection Levee Easements	25.30 (see note below)
Severance Damages	55.00
Sub-total:	80.30
Temporary Easements	
Temporary work area easements	9.70 (see note below)
Total:	**536.65 acres**

D. Appraisal Information – The highest and best use of the land is as follows: Wetlands (public use/parklands), residential and commercial.

A summary of real estate costs, using a January 2001 valuation (Gross Appraisal) is as follows:

Lands and Damages

a. Fee Simple	446.65 acres		$4,475,450
b. Permanent Easements	25.30 acres		$1,265,000
b. Temporary Easements	9.70 acres		$ 77,600
c. Severance Damages	55.00 acres		$1,050,000
		Sub total	$6,868,050
		(Rounded to:	**$6,900,000**
d. Administrative Costs (15% of Lands and Damages)			$1,035,000
e. Contingencies (15% of Lands and Damages and Admin Costs):			$1,190,250
Total Real Estate Costs:			$9,125,250
(Rounded to:			**$9,125,000**)

Appraisal Information Note: The Project Appraiser noted an "overlap" of approximately 2.02 acres in the reported acreage of the permanent Levee Easement area, and approximately 0.86 acre in the reported acreage of the temporary Work Area Easement area.

The Project Appraiser further noted a discrepancy between the total acreage (approx. 446.65 acres) required in fee for the Environmental Restoration component of the Project and the acreage for these lands (approx. 459.37 acres) as reported by the local taxing authority. These latter discrepancies are attributable to cumulative errors in the taxing authority's estimates of acreage of the taxed parcels within its jurisdiction, as well as erosion/accretion of land in Environmental Restoration Areas 1, 2 and 3, which areas comprise an artificial island bounded by the Raritan River to the north, Washington Canal to the east, and the South River to the south and west.

These apparent discrepancies will be reconciled either by physical surveys that will be taken during the Project's Pre-Construction Engineering and Design ("PED") phase, or by surveys taken by the acquiring non-Federal Sponsor prior to acquisition in the Project's Construction phase.

3. **Non-Federal Sponsor Owned Lands**: The Project will construct tide barrier gates across the South River, a Federal Navigable waterway whose bottom is owned by the State of New Jersey. The Sponsor does not own any other lands required for the construction, operation or maintenance of the Project.

4. **Estates**: There are three "standard estates" to be provided by the non-Federal Sponsor: Fee Simple ("Standard Estate" No. 1); Flood Protection Levee Easement ("Standard Estate" No. 9); and Temporary Work Area Easement (5 years' duration) ("Standard Estate" No. 15). The complete text of these estates is included in **Exhibit "A."**

5. **Existing Federal Projects**: There are two Federal navigation projects in the study area: (a) the Washington Canal and South River and (b) the Raritan River. These projects are described below:

a. *The Washington Canal and South River*: This navigation project connects communities along the South River with the Raritan River. Private interests constructed the Washington Canal in the 1830's by widening and deepening a large pre-existing tidal channel. The Canal and the South River navigation channel were federalized in 1871. The authorized project is a 12-foot deep, 100-foot wide channel in the Washington Canal for a distance of 0.8 miles upstream of the Raritan River and then a 12-foot deep, 150-foot wide channel in the South River to Old Bridge. The total length of the Canal is 5.2 miles. In 1929, when the last improvements to the project were authorized, the channel was used to transport brick, hollow tile, sand, clay, crushed stone, and coal to/from New York Harbor. The last Corps involvement was for maintenance dredging in the early 1940s. The 1941 contract documents specified that dredged material should be transported and disposed of in designated disposal areas with disposal of dredged material to aid the improvement or betterment of the land. Historically, such disposal sites were in close proximity of the actual dredging location, often within open shallow water or wetlands. Currently, small recreation vessels are the sole users of the Washington Canal and South River; there is currently no commercial traffic.

(b) *The Raritan River*: This Federal navigation project along the Raritan River main stem includes channel depths up to 25 feet deep with various associated widths, turning basins and navigation features from the Great Beds light at the turn in the New York and New Jersey Channel to the Raritan Arsenal. The channel continues with a 15-foot depth to the Washington Canal, with a subsequent 10-foot depth upstream beyond New Brunswick to the terminus of the Delaware and Raritan Canal.

6. **Federally-Owned Lands**: There are no known Federal Government owned lands within the Project area.

7. **Navigational Servitude**: South River is a Federal Navigation channel, and the Project will construct tide barrier gates across the Federal channel.

8. **Project Maps**: Project maps are attached hereto as **Maps 1, 2, 3** and **4. Map #1** shows the general area of the Townships of Sayreville and South River; **Map #2** depicts the general Project; **Map # 3** depicts the Mitigation areas; **Map #4** depicts the overall Project (including the Levee/Floodwall alignment and tide barrier gates, the four Environmental Restoration areas and the Environmental Mitigation areas) together with the lot lines for the affected properties and a table of affected properties.

9. **Induced Flooding**: No induced flooding is anticipated as a result of this Project.

10. **Baseline Cost Estimate**: A baseline cost estimate, in M/CACES format, is attached hereto as **Exhibit "B."**

11. **Compliance with Public Law 91-646:** No persons, farms or businesses will be displaced for this project. Therefore, relocation assistance pursuant to Title II of Public Law 91-646, as amended, will not be required.

12. **Mineral and Timber Activities**: There are no present or anticipated mineral extraction or timber harvesting activities in the Project area and vicinity.

13. **Assessment of the Non-Federal Sponsor's Land Acquisition Experience and Ability**: The non-Federal Sponsor is aware of the requirements of Public Law 91-646 and of the requirement to maintain records of expenses in order to document its requests for credit for LERRD provided in accordance with the Project Cooperation Agreement. An "*Assessment of the non-Federal Sponsor's Real Estate Acquisition*

Capability" is attached hereto as **Exhibit "C".** The New Jersey Department of Environmental Protection (NJDEP) is the non-Federal Sponsor and has the legal and professional capability and experience to acquire and provide the LERRD for the construction, operation and maintenance of the project. NJDEP has condemnation authority and quick-take capability but it is not anticipated that these actions will be required for this project. NJDEP has successfully acquired the LERRD for other Corps projects of comparable magnitude, including the Keansburg, NJ and the Sea Bright to Manasquan Inlet, NJ Projects.

14. **Zoning**: Application or enactment of zoning ordinances is not anticipated for the Project.

15. **Acquisition Schedules**: A Table of Real Estate Acquisition Milestones and Schedule is attached hereto as **Exhibit "D"**.

16. **Facility/Utility Relocations**: There are no anticipated facility or utility relocations.

17. **Hazardous, Toxic or Radiological Waste ("HTRW")**: As stated in **Section 3.12** of the Project's *Integrated Feasibility Report and Environmental Impact Statement*, there are no known contaminants or HTRW problems associated with the LERRD required for construction, operation and maintenance of the Project.

18. **Project Support**: Local officials, landowners and other residents in the Project area are supportive of this Project.

19. **Notification to Non-Federal Sponsor**: Based on its past sponsorship of other Corps water resource (Civil Works) projects and ongoing discussions during the Project's Feasibility phase, the non-Federal Sponsor is aware of the risks of acquiring LERRD required for the Project prior to the signing of the Project Cooperation Agreement ("PCA"). Formal written notification of the risks of such acquisition, in accordance with paragraph 12-31 of Chapter 5 of the Corps of Engineers Real Estate Handbook, ER 405-1-12, will be forwarded to the non-Federal Sponsor during the Project's Preconstruction Engineering and Design ("PED") phase.

20. **Historical Sites**: There are no known historical buildings, structures or artifacts in the project area.

21. **Recommendations**: This report has been prepared in accordance with the Corps of Engineers Regulation ER 405-1-12. It is recommended that this report be approved.

Noreen D. Dresser

Noreen D. Dresser
~~Acting~~ Chief, Real Estate Division

REAL ESTATE PLAN

South River, Raritan River Basin, New Jersey
Storm Damage Reduction and Ecosystem Restoration Project

EXHIBIT "A" - ESTATES

South River, Raritan River Basin, New Jersey
Storm Damage Reduction and Ecosystem Restoration Project

Estates

1. Fee Simple (**Standard Estate No. 1**):

"The fee simple title to the land described in Schedule A (Tract No. __), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines."

2. Perpetual Flood Protection Levee Easement (**Standard Estate No.9**):

"A perpetual and assignable right and easement in (the land described in Schedule A) (Tract Nos.____, ___ and ___) to construct, maintain, repair, operate, patrol and replace a flood protection levee, including all appurtenances thereto, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines."

3. Temporary Work Area Easement (**Standard Estate No. 15**) of Eighteen (18) Months' Duration:

"A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tract Nos. ____ , ____, and ____), for a period not to exceed _____________ , beginning with the date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a (work area), including the right to (move, store, and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the _______________ Project, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines."

REAL ESTATE PLAN

South River, Raritan River Basin, New Jersey Storm Damage Reduction and Ecosystem Restoration Project

EXHIBIT "B" – BASELINE COST ESTIMATES in M/CACES Format

Exhibit B - Chart of Accounts
for
South River, Raritan River Basin, New Jersey Storm Damage Reduction Ecosystem Restoration Project
(Prepared by CENAN-RE-A)

	TOTAL PROJECT COSTS	non-Federal	Federal	Project Cost
01	LANDS AND DAMAGES	$7,700,000	$234,750	7,934,750
	Contingencies (15%)			1,190,250
	TOTAL, Lands and Damages			**9,125,000**
01A	**PROJECT PLANNING**	**0**	**65,000**	
01A10	REAL ESTATE SUPPLEMENT/PLAN		50,000	
01A20	PRELIMINARY RE ACQUISITION MAPS		15,000	
01A30	PHYSICAL TAKINGS ANALYSIS		0	
01A40	PRELIMINARY ATTORNEY'S OPINION OF COMPENSABILITY		0	
01A50	ALL OTHER RE ANALYSES/DOCUMENTS		0	
01B	**ACQUISITIONS**	**625,000**	**40,000**	
01B10	BY GOVERNMENT			
01B20	BY LOCAL SPONSOR (LS)	625,000		
01B30	BY GOVT ON BEHALF OF LS			
01B40	REVIEW OF LS		40,000	
01C	**CONDEMNATIONS**	**0**	**0**	
01C10	BY GOVERNMENT			
01C20	BY LS			
01C30	BY GOVT ON BEHALF OF LS			
01C40	REVIEW OF LS			
01D	**INLEASING**	**0**	**0**	
01D10	BY GOVERNMENT			
01D20	BY LS			
01D30	BY GOVT ON BEHALF OF LS			
01D40	REVIEW OF LS			
01E	**APPRAISAL**	**175,000**	**35,000**	
01E10	BY GOVT (IN HOUSE)			
01E20	BY GOVT (CONTRACT)			
01E30	BY LS	175,000		
01E40	BY GOVT ON BEHALF OF LS			
01E50	REVIEW OF LS		35,000	
01F	**PL 91-646 ASSISTANCE**	**0**	**0**	
01F10	BY GOVERNMENT			
01F20	BY LS			
01F30	BY GOVT ON BEHALF OF LS			
01F40	REVIEW OF LS			

Exhibit B - Chart of Accounts
for
South River, Raritan River Basin, New Jersey Storm Damage Reduction Ecosystem Restoration Project
(Prepared by CENAN-RE-A)

01G	**TEMPORARY PERMITS/LICENSES/RIGHTS-OF-ENTRY**	**0**	**0**	
01G10	BY GOVERNMENT			
01G20	BY LS	0		
01G30	BY GOVT ON BEHALF OF LS			
01G40	REVIEW OF LS		0	
01G50	OTHER			
01G60	DAMAGE CLAIMS			
01H	**AUDITS**	**0**	**0**	
01H10	BY GOVERNMENT			
01H20	BY LS			
01H30	BY GOVT ON BEHALF OF LS			
01H40	REVIEW OF LS			
01J	**ENCROACHMENTS AND TRESPASS**	**0**	**0**	
01J10	BY GOVERNMENT			
01J20	BY LS			
01J30	BY GOVT ON BEHALF OF LS			
01J40	REVIEW OF LS			
01K	**DISPOSALS**	**0**	**0**	
01K10	BY GOVERNMENT			
01K20	BY LS			
01K30	BY GOVT ON BEHALF OF LS			
01K40	REVIEW OF LS			
01N00	**FACILITY/UTILITY RELOCATIONS**	**0**	**0**	
01Q00	**RESERVED FOR FUTURE HQUSACE USE**	**0**	**0**	
01R	**REAL ESTATE PAYMENTS**	**6,900,000**	**67,750**	
01R1	**LAND PAYMENTS**	5,850,000	40,750	
01R1A	BY GOVERNMENT			
01R1B	BY LS	5,850,000		
01R1C	BY GOVT ON BEHALF OF LS			
01R1D	REVIEW OF LS		40,750	
01R2	**PL 91-646 ASSISTANCE PAYMENTS**	0	0	
01R2A	BY GOVERNMENT			
01R2B	BY LS			
01R2C	BY GOVT ON BEHALF OF LS			
01R2D	REVIEW OF LS			

Exhibit B - Chart of Accounts
for
South River, Raritan River Basin, New Jersey Storm Damage Reduction Ecosystem Restoration Project
(Prepared by CENAN-RE-A)

01R3	**DAMAGE PAYMENTS**	1,050,000	0	
01R3A	BY GOVERNMENT			
01R3B	BY LS	1,050,000		
01R3C	BY GOVT ON BEHALF OF LS			
01R3D	REVIEW OF LS		0	
01R9	**OTHER**			
01T	**LERRD CREDITING**	**0**	**27,000**	
01T10	LAND PAYMENTS		22,000	
01T20	ADMINISTRATIVE COSTS		5,000	
01T30	PL 91-646 ASSISTANCE			
01T40	ALL OTHER			

REAL ESTATE PLAN

South River, Raritan River Basin, New Jersey Storm Damage Reduction and Ecosystem Restoration Project

EXHIBIT "C" – Assessment of Non-Federal Sponsor's Real Estate Acquisition Capability

South River, Raritan River Basin, New Jersey
Storm Damage Reduction and Ecosystem Restoration Project

Assessment of Non-Federal Sponsor's Real Estate Acquisition Capability

I. Legal Authority:

a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes? YES
b. Does the sponsor have the power of eminent domain for this project? YES
c. Does the sponsor have "quick-take" authority for this project? YES
d. Are any of the lands/interests in the land required for the project located outside the sponsor's political boundary? NO
e. Are any of the lands/interests in the land required for the project owned by an entity whose property the sponsor cannot condemn? NO

II. Human Resources Requirements:

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P.L. 91-646, as amended? NO
b. If the answer to IIa is YES, has a reasonable plan been developed to provide such training? N/A
c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? YES
d. Is the sponsor's projected in-house staffing level sufficient considering its other work load, if any, and the project schedule? YES
e. Can the sponsor obtain contractor support, if required, in a timely fashion? YES
f. Will the sponsor likely request USACE assistance in acquiring real estate? NO

III. Other Project Variables:

a. Will the sponsor's staff be located within reasonable proximity to the project site? YES
b. Has the sponsor approved the project/real estate schedule / milestones? YES

Exhibit "C"

IV. Overall Assessment:

a. Has the sponsor performed satisfactorily on other USACE projects? YES
b. With regard to this project, the sponsor is anticipated to be: highly capable/ fully capable/ moderately capable/ marginally capable/ insufficiently capable. HIGHLY CAPABLE

V. Coodination:

a. Has this assessment been coordinated with the sponsor? YES
b. Does the sponsor concur with this assessment? YES

Prepared by:

Stanley H. Nuremburg,
Realty Specialist

Reviewed and Approved by:

Noreen D. Dresser
Chief, Real Estate Division

Exhibit "C"

2

REAL ESTATE PLAN

South River, Raritan River Basin, New Jersey Storm Damage Reduction and Ecosystem Restoration Project

EXHIBIT "D" – Real Estate Acquisition Milestones and Schedules

EXHIBIT D - SCHEDULE OF ACQUISITION
South River, Raritan River Basin, New Jersey
Storm Damage Reduction & Ecosystem Restoration Project

ID	Task Name	Duration	Start	Finish
1	**Start real Estate Acquisition**	**590d**	**9/1/05**	**12/5/07**
2	Signed PCA Obtained by NAN	0d	9/1/05	9/1/05
3	**Obtain LERRD**	**410d**	**9/1/05**	**3/28/07**
4	(NAN-RE) Formal Transmittal of Final ROW drawings to A	0d	9/1/05	9/1/05
5	(LS) Prepare Mapping and Legal description	30d	9/1/05	10/12/05
6	(NAN-RE) Review Mapping and Legal description	10d	10/13/05	10/26/05
7	(LS) Obtain title Evidence	30d	10/27/05	12/7/05
8	(NAN-RE) Review Title Evidence	15d	12/8/05	12/28/05
9	(LS) Obtain Tract Appraisal	120d	12/29/05	6/14/06
10	(NAN-RE) Review Tract Appraisal	20d	6/15/06	7/12/06
11	(LS) Conduct Negotiations	60d	7/13/06	10/4/06
12	(NAN-RE) Review Counteroffers	10d	10/5/06	10/18/06
13	(LS) Perform Closings	45d	10/19/06	12/20/06
14	(NAN-RE) Review Closings	10d	12/21/06	1/3/07
15	(LS) Submit Authorization for Entry to Construct	10d	1/4/07	1/17/07
16	(NAN) Review Authorization for Entry to Construct	10d	1/18/07	1/31/07
17	(NAN-OC) Review Authorization for Entry to Construct by	15d	2/1/07	2/21/07
18	(NAN-RE) Certify LER for Construction	15d	2/22/07	3/14/07
19	(NAN-RE) Delivery of Certification prior to Construction Aw	10d	3/15/07	3/28/07
20	Construction Award Date	0d	3/28/07	3/28/07
21	**(LS) Prepare and Submit Credit Requests**	**180d**	**3/29/07**	**12/5/07**
22	(NAN-RE) Review and approve Credit to LS	180d	3/29/07	12/5/07
23	(NAN-RE) Establish Value for Creditable LERRD to PM	180d	3/29/07	12/5/07

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REAL ESTATE PLAN

South River, Raritan River Basin, New Jersey
Storm Damage Reduction and Ecosystem Restoration Project

MAPS

Figures 1, 2, 3 & 4

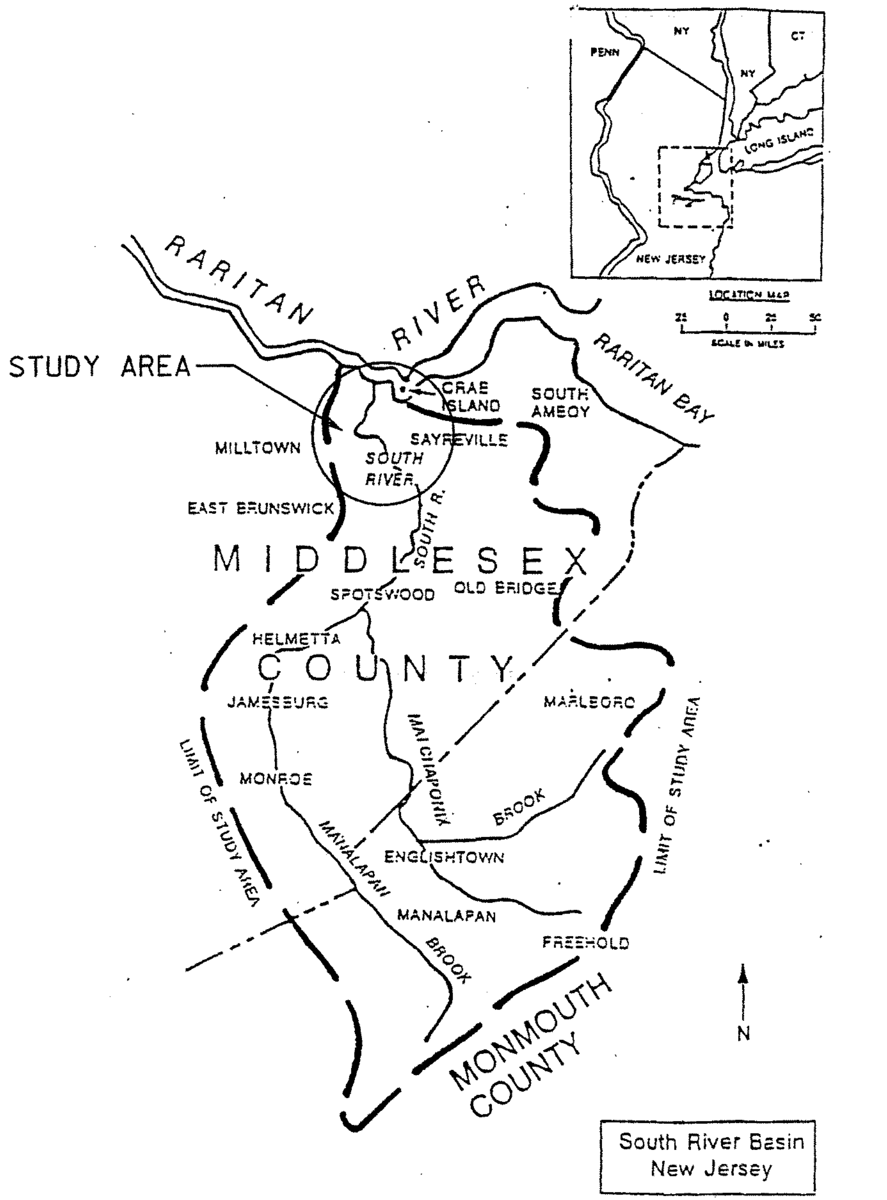
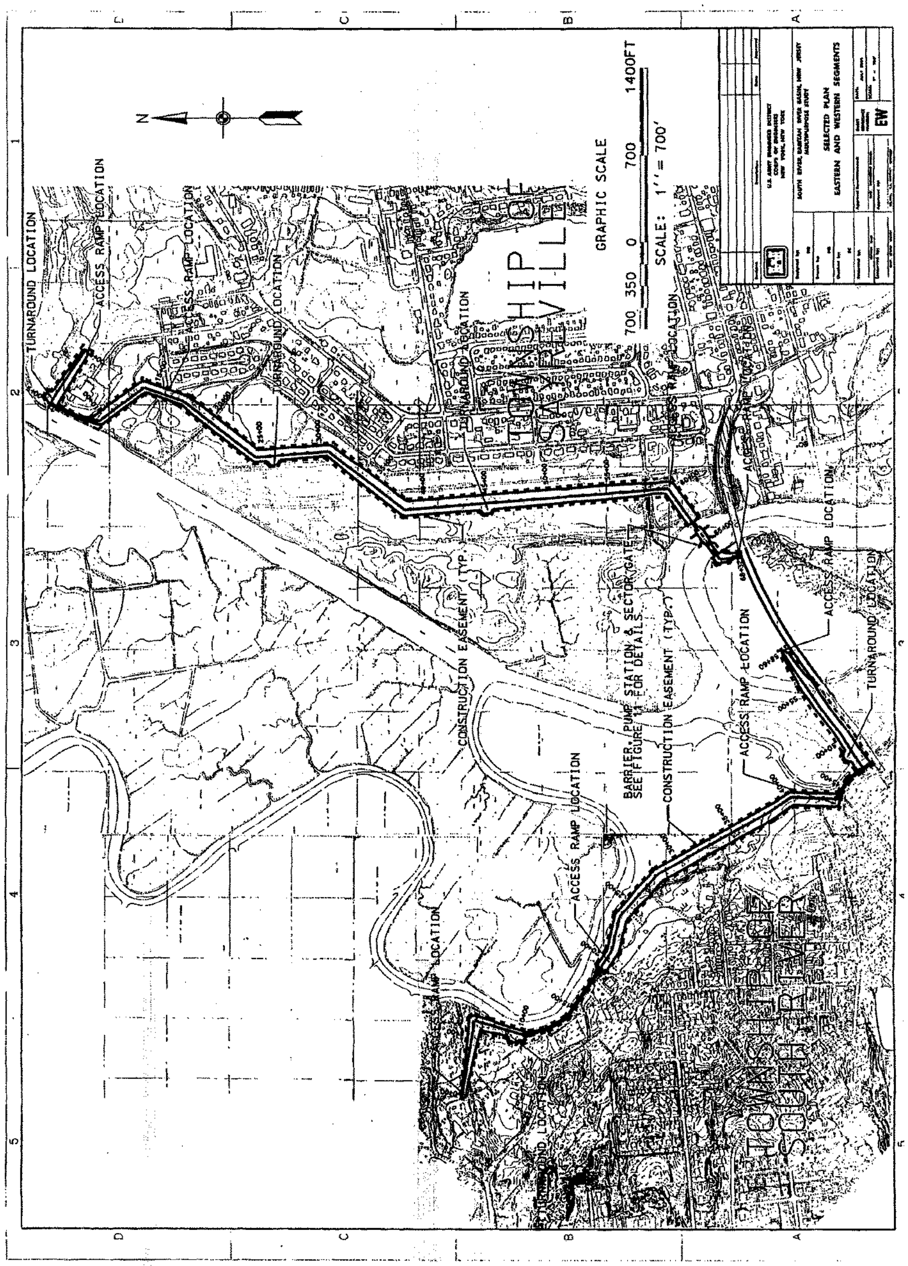
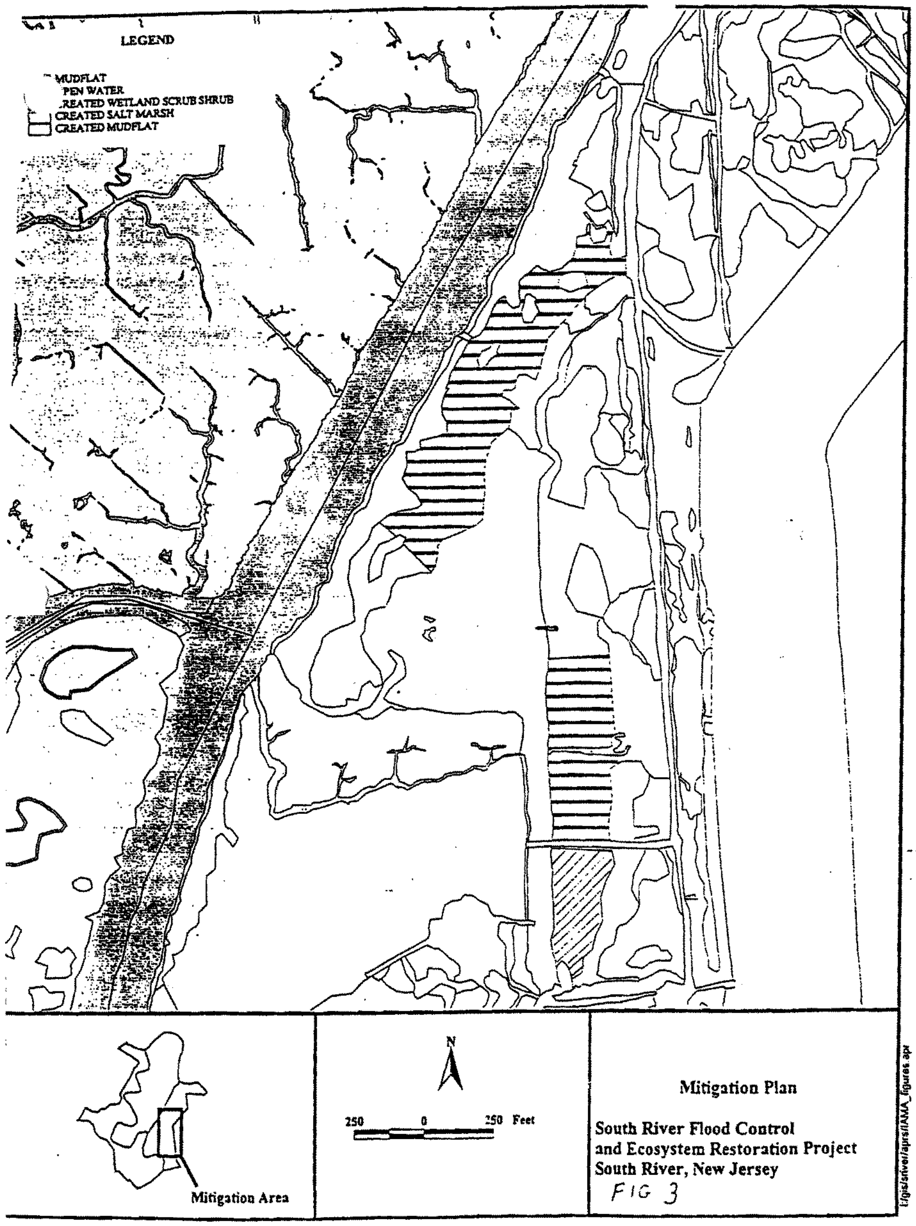


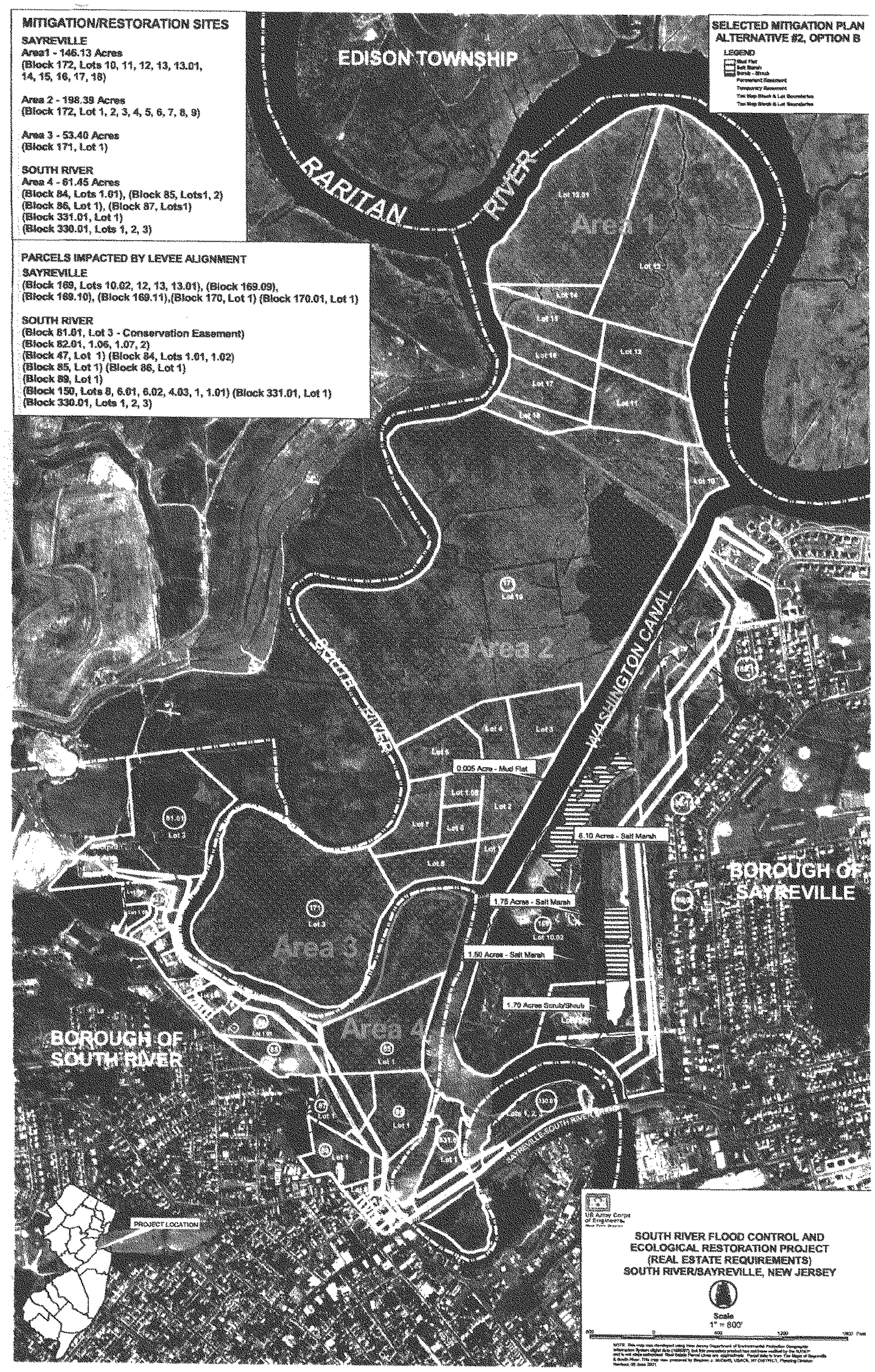
Figure 1 - Watershed/Study Area Location Map

MAP # 1



TURNAROUND LOCATION
ACCESS RAMP LOCATION
CONSTRUCTION EASEMENT (TYP.)
BARRIER, PUMP STATION & SECTOR GATE SEE FIGURE 11 FOR DETAILS.
CONSTRUCTION EASEMENT (TYP.)
GRAPHIC SCALE
700 350 0 700 1400FT
SCALE: 1'' = 700'
SELECTED PLAN
EASTERN AND WESTERN SEGMENTS
EW


LEGEND
MUDFLAT
PEN WATER
.REATED WETLAND SCRUB SHRUB
CREATED SALT MARSH
CREATED MUDFLAT
Mitigation Area
N
250 0 250 Feet
Mitigation Plan
South River Flood Control
and Ecosystem Restoration Project
South River, New Jersey
FIG 3


MITIGATION/RESTORATION SITES
SAYREVILLE
Area1 - 146.13 Acres
(Block 172, Lots 10, 11, 12, 13, 13.01, 14, 15, 16, 17, 18)
Area 2 - 198.39 Acres
(Block 172, Lot 1, 2, 3, 4, 5, 6, 7, 8, 9)
Area 3 - 53.40 Acres
(Block 171, Lot 1)
SOUTH RIVER
Area 4 - 61.45 Acres
(Block 84, Lots 1.01), (Block 85, Lots1, 2)
(Block 86, Lot 1), (Block 87, Lots1)
(Block 331.01, Lot 1)
(Block 330.01, Lots 1, 2, 3)
PARCELS IMPACTED BY LEVEE ALIGNMENT
SAYREVILLE
(Block 169, Lots 10.02, 12, 13, 13.01), (Block 169.09),
(Block 169.10), (Block 169.11),(Block 170, Lot 1) (Block 170.01, Lot 1)
SOUTH RIVER
(Block 81.01, Lot 3 - Conservation Easement)
(Block 82.01, 1.06, 1.07, 2)
(Block 47, Lot 1) (Block 84, Lots 1.01, 1.02)
(Block 85, Lot 1) (Block 86, Lot 1)
(Block 89, Lot 1)
(Block 150, Lots 8, 6.01, 6.02, 4.03, 1, 1.01) (Block 331.01, Lot 1)
(Block 330.01, Lots 1, 2, 3)
SELECTED MITIGATION PLAN
ALTERNATIVE #2, OPTION B
EDISON TOWNSHIP
RARITAN RIVER
SOUTH RIVER
WASHINGTON CANAL
Area 1
Area 2
Area 3
Area 4
0.005 Acre - Mud Flat
8.10 Acres - Salt Marsh
1.75 Acres - Salt Marsh
1.50 Acres - Salt Marsh
1.70 Acres Scrub/Shrub
BOROUGH OF SAYREVILLE
BOROUGH OF SOUTH RIVER
PROJECT LOCATION
US Army Corps of Engineers
SOUTH RIVER FLOOD CONTROL AND
ECOLOGICAL RESTORATION PROJECT
(REAL ESTATE REQUIREMENTS)
SOUTH RIVER/SAYREVILLE, NEW JERSEY
Scale
1" = 800'

US Army Corps
of Engineers
New York District

SOUTH RIVER, RARITAN RIVER BASIN

HURRICANE & STORM DAMAGE REDUCTION AND ECOSYSTEM RESTORATION

DRAFT INTEGRATED FEASIBILITY REPORT & ENVIRONMENTAL IMPACT STATEMENT

Appendix H

Interior Drainage

DRAFT

April 2002

SOUTH RIVER, NEW JERSEY

DRAFT INTEGRATED FEASIBILITY STUDY AND EIS

APPENDIX H - INTERIOR DRAINAGE

Table of Contents

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Figure *Page*

Appendix H

SubAppendix H1 – Detailed Formulation Plans

INTRODUCTION

Scope

H1. Interior drainage facilities are required to safely store and discharge storm water runoff that collects on the protected side of the levees, floodwalls, and storm surge barrier associated with the storm damage reduction project. This Appendix describes the interior drainage facilities for the South River Hurricane and Storm Damage Reduction Project and documents how these facilities were developed to manage interior runoff.

Study Location

H2. The South River flows north through the Townships of East Brunswick and Old Bridge, and the Boroughs of South River and Sayreville, and then splits into two branches, the South River and the Washington Canal, both of which flow into the Raritan River. The area of the South River watershed is approximately 135 square miles. Principal tributaries to the South River include Manalapan Brook, Matchaponix Brook, and Cedar Brook, which are upstream of Duhernal Lake, and Deep Run and Tennent Brook, which are downstream of the Lake. The study area is shown in Figures H-1 and H-1a.

H3. Land use in the watershed is a combination of: (1) urban land uses primarily in the Boroughs of Sayreville and South River, and the Township of Old Bridge, (2) limited suburban developments around the Boroughs, and (3) rural land uses.

Source of Flooding

H4. Periodic storms have caused severe flooding along the South River. Flooding upstream of Duhernal Lake is fluvial. Flooding downstream is primarily the result of storm surge backwater flooding from the Raritan River. The communities repeatedly affected by the storm surges are the Boroughs of South River and Sayreville, and the

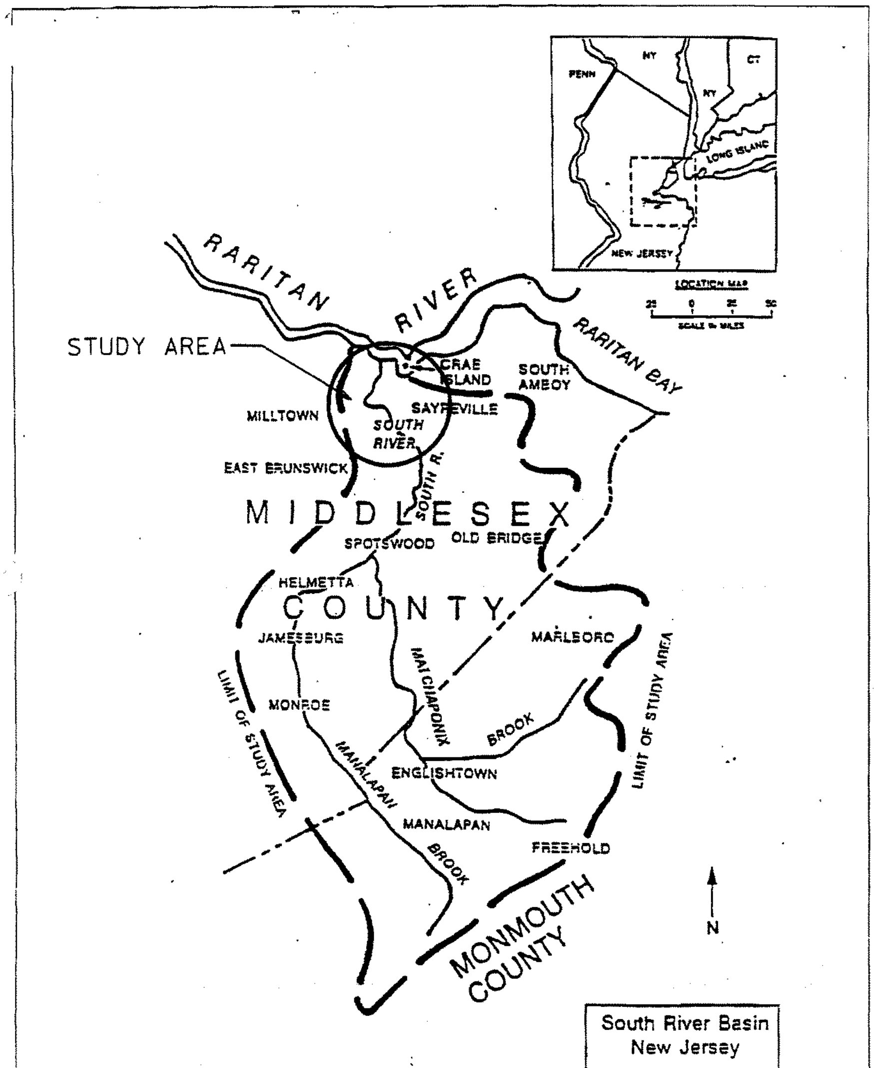


Figure H-1 **Watershed/Study Area Location Map**

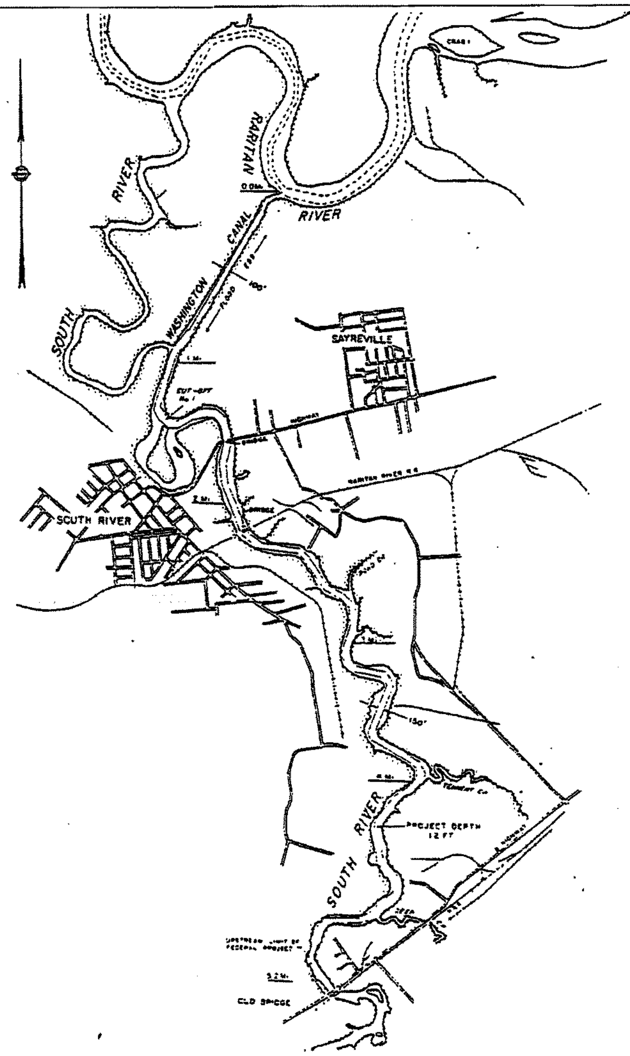


Figure H-1a Washington Canal & South River Project Area Map

Townships of Old Bridge and East Brunswick. There are approximately 1,000 structures in the 100-year floodplains of these communities. Flooding typically occurs during hurricanes and northeasters when sustained onshore winds push storm surges inland up tidal channels.

H5. In the Boroughs of South River and Sayreville, water surface elevations in excess of 4.5 feet above mean sea level (MSL), which can occur several times a year, inundate developed areas and cause significant flood damages. In addition to damages resulting from storm surge inundation, storm surges often block existing stormwater drainage outlets, indirectly resulting in additional flood damages. The tidal area below the Duhernal Lake dam encompasses virtually all the damages associated with flooding in the basin.

General

H6. Areas protected from exterior storm surges by the line-of-protection are subject to interior flooding from storm water runoff. Thus, interior drainage facilities are required to safely store and discharge the runoff to limit interior residual flooding. The interior areas are studied to determine the specific nature of flooding and to formulate drainage alternatives to maximize National Economic Development (NED) benefits.

H7. In accordance with the Army Corps of Engineers Engineering Manual (EM) 1110-2-1413, *Hydrologic Analysis of Interior Areas*, the interior drainage facilities are evaluated separately from the line-of-protection. First, a minimum facility plan is identified. The minimum facility plan is considered the smallest plan that can be implemented as part of the line-of-protection. It is the starting point from which additional interior facilities planning commences. Next, the benefits accrued from alternative interior drainage plans are attributable to the reduction in the residual flood damages which may have remained under the minimum facility condition. Finally, an optimum drainage alternative is selected based on meeting NED objectives.

H8. The interior drainage facilities must be formulated to maximize NED benefits while meeting NED objectives to provide a complete, effective, efficient, and acceptable plan of protection.

- Completeness is defined in Engineering Regulation (ER) 1105-2-100 as,

  The extent to which the alternative plans provide and account for all necessary investments or other actions to ensure the realization of the planning objectives, including actions by other Federal and non-Federal entities.

- Effectiveness is defined as,

  The extent to which the alternative plans contribute to achieve the planning objectives.

- Efficiency is defined as,

  The extent to which an alternative plan is the most cost-effective means of achieving the objectives.

- Acceptability is defined as,

  The extent to which the alternative plans are acceptable in terms of applicable laws, regulations, and public policies.

PROPOSED PROTECTION PLAN

General

H9. The selected storm damage protection system includes a line-of-protection consisting of levees, floodwalls, and storm surge barriers, plus interior drainage facilities. The system will extend from the confluence of the Washington Canal and the Raritan River to Veteran's Memorial Bridge, across the river, and along the bank of the South River. The recommended line-of-protection, shown in Figure H-2, provides a 500-year level of protection. Each of the major plan components - the East Segment, West Segment, and the Main Channel – are described in the following paragraphs.

East Segment

H10. The eastern portion of the line-of-protection is located mostly within the Borough of Sayreville, as shown in Figure H-2. The top of protection is at 21.5 feet NGVD. The grade elevations along the entire line-of-protection, excluding the segment that crosses the South River, range between 4.0 and 20.0 feet NGVD. Therefore, the height of protection ranges between 1.5 and 17.5 feet. All levee sections have a 10-foot wide top, with embankment side slopes ranging from 1:2.3 to 1:2.5. Typical levee and floodwall cross-sections are shown in Figures I-3 and I-4, respectively.

H11. The line-of-protection begins at the northeastern end at a point approximately 250 feet west of the intersection of Anderson Court and Canal Street behind some newly constructed residential properties. There will be maintenance vehicle access to the top of the levee at this point. The levee then extends in a northwesterly direction between the rear property lines of the residential development and the municipal sewage pumping facility for approximately 500 feet where it meets the eastern bank of the Washington Canal. The top of the levee will be widened in this area to accommodate a vehicle turnaround. The levee then becomes a floodwall due to space restrictions, which runs

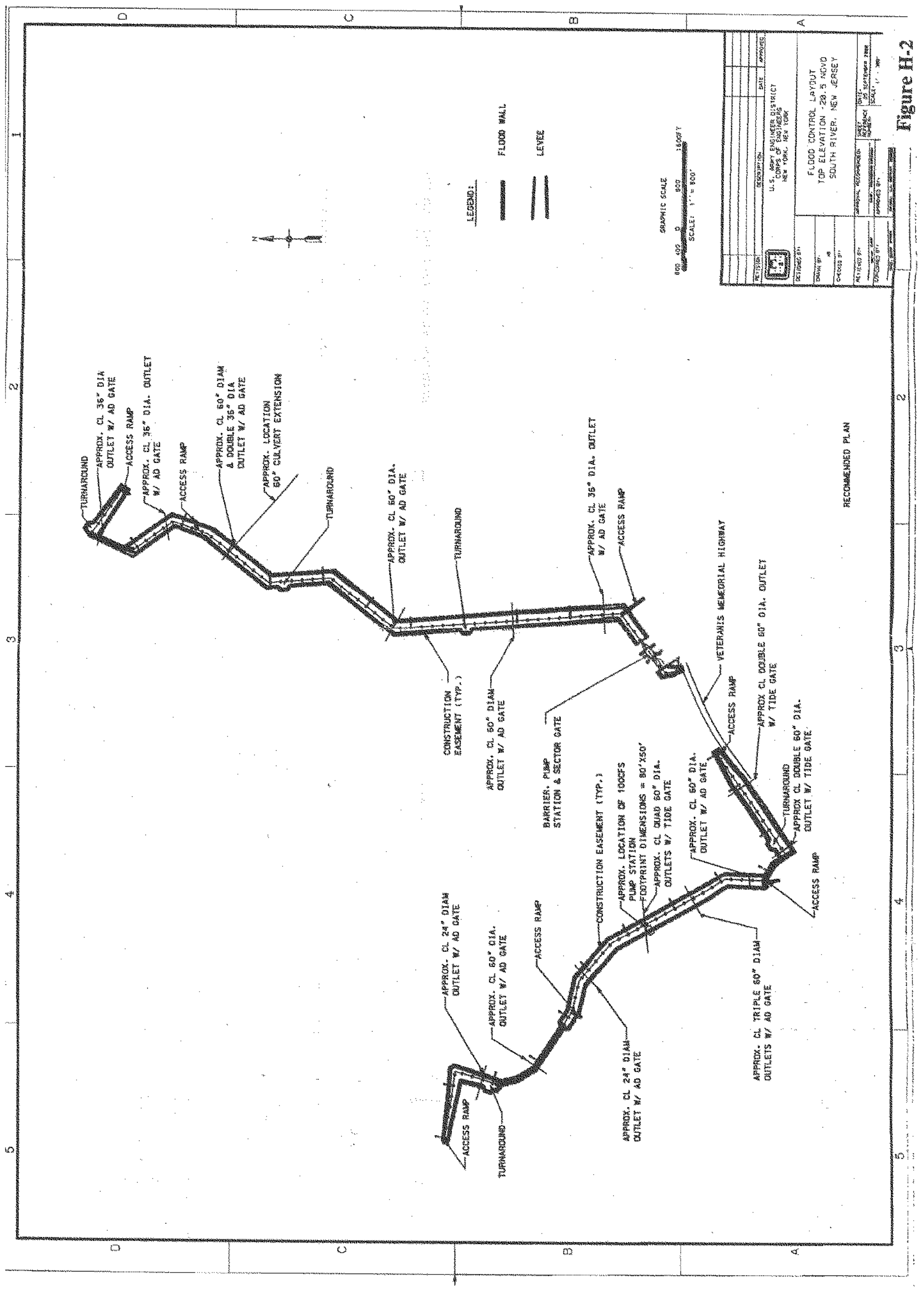


Figure H-2
FLOOD CONTROL LAYOUT
TOP ELEVATION 28.5 NGVD
SOUTH RIVER, NEW JERSEY
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
NEW YORK, NEW YORK
LEGEND:
FLOOD WALL
LEVEE
GRAPHIC SCALE
RECOMMENDED PLAN
TURNAROUND
APPROX. CL 36" DIA OUTLET W/ AD GATE
ACCESS RAMP
APPROX. CL 36" DIA. OUTLET W/ AD GATE
APPROX. CL 60" DIAM & DOUBLE 36" DIA OUTLET W/ AD GATE
APPROX. LOCATION 60" CULVERT EXTENSION
APPROX. CL 60" DIA. OUTLET W/ AD GATE
APPROX. CL 36" DIA. OUTLET W/ AD GATE
VETERANS MEMORIAL HIGHWAY
APPROX CL DOUBLE 60" DIA. OUTLET W/ TIDE GATE
CONSTRUCTION EASEMENT (TYP.)
APPROX. CL 60" DIAM OUTLET W/ AD GATE
BARRIER, PUMP STATION & SECTOR GATE
APPROX. LOCATION OF 100CFS PUMP STATION FOOTPRINT DIMENSIONS = 50'X50'
APPROX. CL QUAD 60" DIA. OUTLETS W/ TIDE GATE
APPROX. CL 60" DIA. OUTLET W/ AD GATE
APPROX CL DOUBLE 60" DIA. OUTLET W/ TIDE GATE
APPROX. CL TRIPLE 60" DIAM OUTLETS W/ AD GATE
APPROX. CL 24" DIAM OUTLET W/ AD GATE
APPROX. CL 60" DIA. OUTLET W/ AD GATE

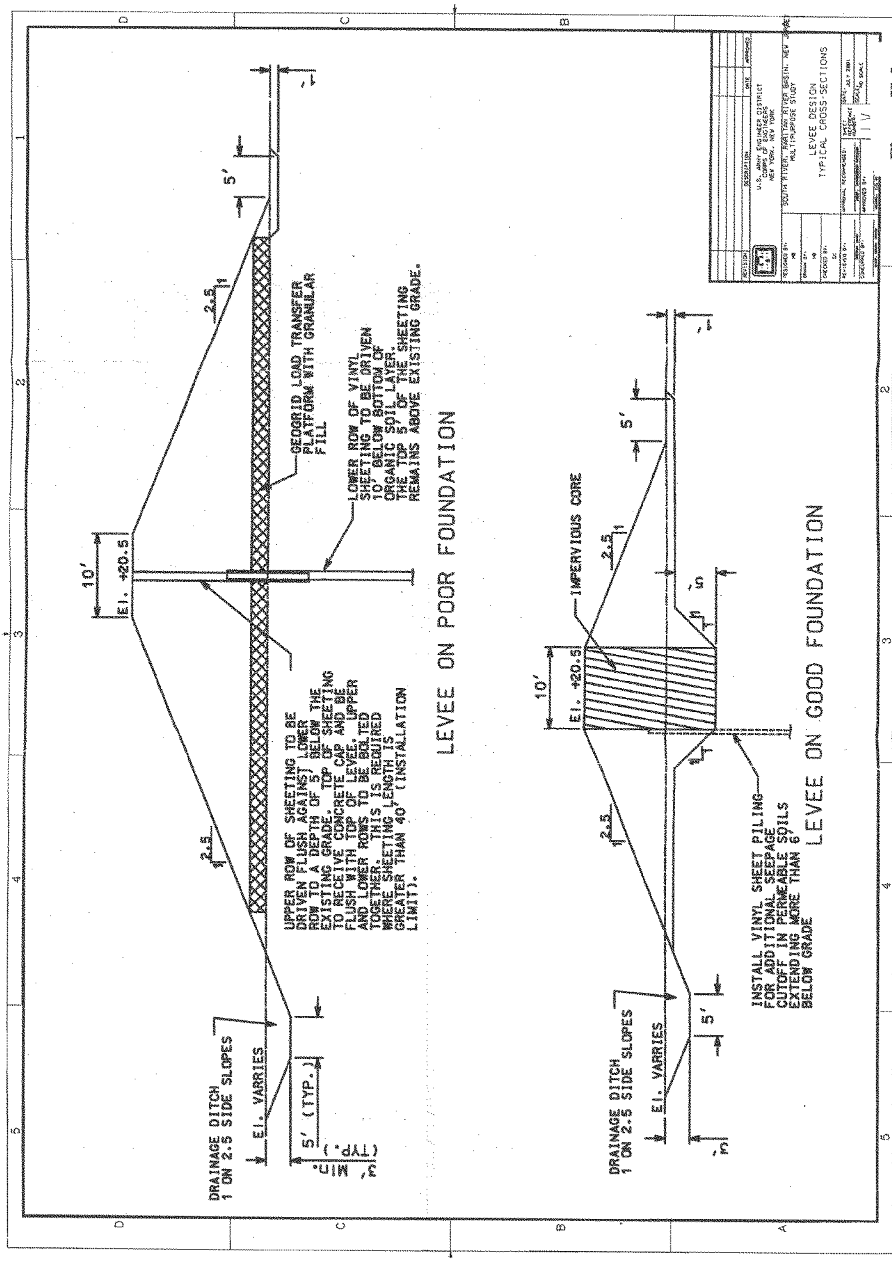

LEVEE ON POOR FOUNDATION
10'
El. +20.5
2.5
1
GEOGRID LOAD TRANSFER PLATFORM WITH GRANULAR FILL
LOWER ROW OF VINYL SHEETING TO BE DRIVEN 10' BELOW BOTTOM OF ORGANIC SOIL LAYER. THE TOP 5' OF THE SHEETING REMAINS ABOVE EXISTING GRADE.
UPPER ROW OF SHEETING TO BE DRIVEN FLUSH AGAINST LOWER ROW TO A DEPTH OF 5' BELOW THE EXISTING GRADE. TOP OF SHEETING TO RECEIVE CONCRETE CAP AND BE FLUSH WITH TOP OF LEVEE. UPPER AND LOWER ROWS TO BE BOLTED TOGETHER. THIS IS REQUIRED WHERE SHEETING LENGTH IS GREATER THAN 40' (INSTALLATION LIMIT).
DRAINAGE DITCH 1 ON 2.5 SIDE SLOPES
El. VARRIES
5' (TYP.)
3' MIN. (TYP.)
5'
LEVEE ON GOOD FOUNDATION
IMPERVIOUS CORE
INSTALL VINYL SHEET PILING FOR ADDITIONAL SEEPAGE CUTOFF IN PERMEABLE SOILS EXTENDING MORE THAN 6' BELOW GRADE
U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS NEW YORK, NEW YORK
SOUTH RIVER, RARITAN RIVER BASIN, NEW JERSEY MULTIPURPOSE STUDY
LEVEE DESIGN
TYPICAL CROSS-SECTIONS

Figure H-3

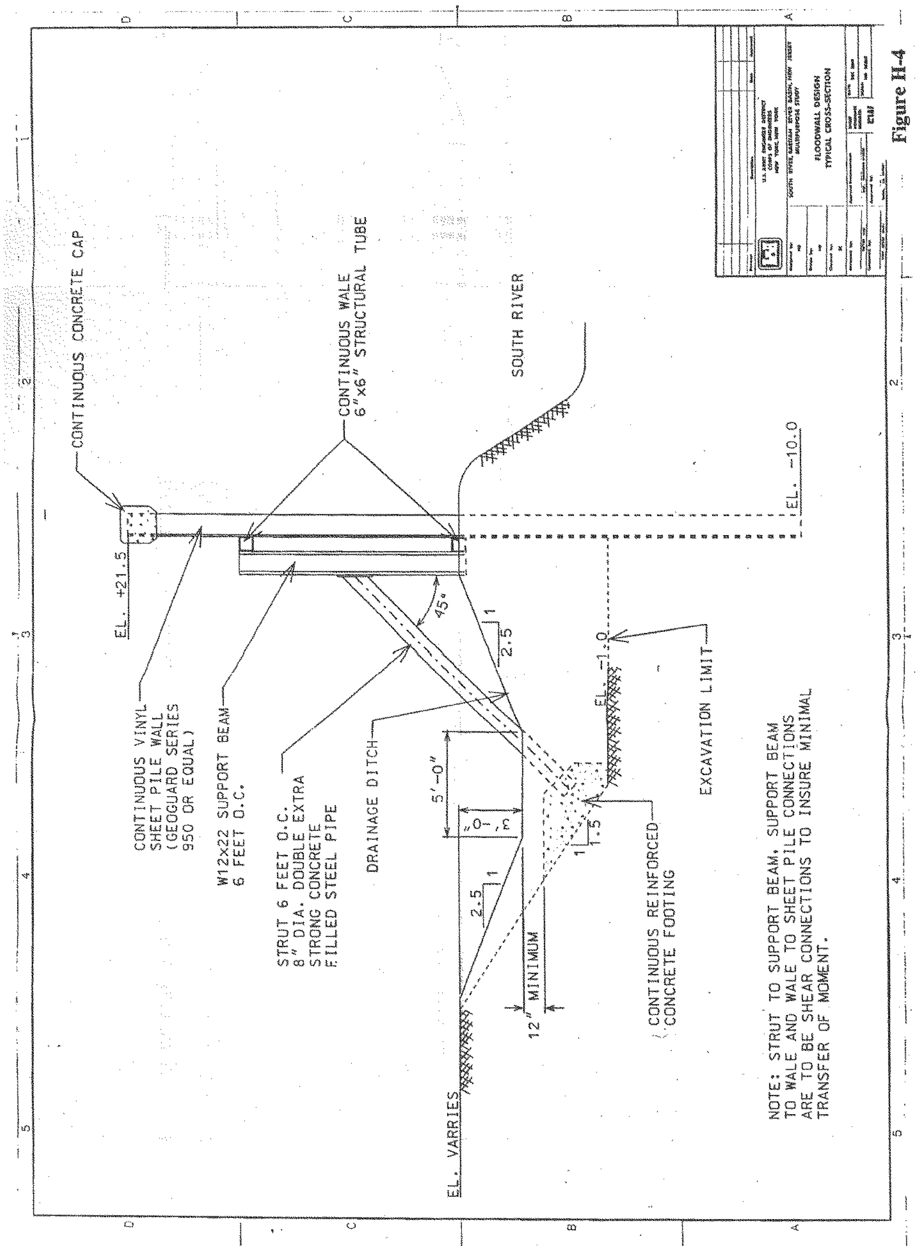

CONTINUOUS CONCRETE CAP
CONTINUOUS WALE 6"x6" STRUCTURAL TUBE
SOUTH RIVER
EL. -10.0
EL. +21.5
CONTINUOUS VINYL SHEET PILE WALL (GEOGUARD SERIES 950 OR EQUAL)
W12x22 SUPPORT BEAM 6 FEET O.C.
STRUT 6 FEET O.C. 8" DIA. DOUBLE EXTRA STRONG CONCRETE FILLED STEEL PIPE
DRAINAGE DITCH
45°
2.5
1
EL. -1.0
EXCAVATION LIMIT
5'-0"
3'-0"
1.5
1
2.5
1
12" MINIMUM
CONTINUOUS REINFORCED CONCRETE FOOTING
NOTE: STRUT TO SUPPORT BEAM, SUPPORT BEAM TO WALE AND WALE TO SHEET PILE CONNECTIONS ARE TO BE SHEAR CONNECTIONS TO INSURE MINIMAL TRANSFER OF MOMENT.
EL. VARRIES
FLOODWALL DESIGN
TYPICAL CROSS-SECTION

Figure H-4

southwest along the bank of the canal at the frontage of the sewage facility for approximately 300 feet where it turns south for an additional 100 feet before switching back to levee for the remainder of its length. The remainder of the levee is located in an undeveloped area located between the Washington Canal to the west and residential development to the east. At this point, the levee runs in a southeasterly direction for approximately 450 feet then turns to a southwesterly course for 350 feet, passing the eastern termination of Hinton Street. Another access ramp will be located at the end of Hinton Street. The levee makes another slight turn to the west and continues in a southwesterly direction for nearly 750 feet before turning south for another 600 feet. There will be another turnaround located in this segment. The levee turns to a southwesterly direction again and runs parallel to Weber Avenue at a 300 feet offset for nearly 800 feet, then turns south and again runs parallel to Weber Avenue this time at a 450 feet offset for approximately 2,150 feet. There will be a turnaround located approximately at the one-third point of this segment. The levee then turns southwest and continues for approximately 350 feet until it meets the eastern bank of the South River where it terminates against the east side of the storm surge barrier bulkhead. An access ramp is to be located at this last change in direction in the levee. Once across the river, the levee begins again from the west side of the storm surge barrier bulkhead and immediately turns to the south where it continues until it meets high ground alongside Veteran's Highway (Main Street) within 50 feet of the western abutment.

West Segment

H12. The western portion of the line-of-protection is located entirely within the Borough of South River, as shown in FIGURE H-2. As with the eastern segment, the top of protection is located at 21.5 feet NGVD. The grades on the western side of the river are similar to those on the eastern side. Therefore, the height of protection also ranges from 0.5 to 16.5 feet. All levee sections have a 10-foot wide top, with embankment side slopes ranging from 1:2.3 to 1:2.5.

H13. The line-of-protection begins at the northwestern corner at a point located at the southeast corner of an unpaved trailer lot off of Tices Corner Road. There will be vehicle access to the top of the levee from this lot. The levee runs east for approximately 600 feet through a wooded area until it is within 150 feet of the riverbank where it turns to a southerly direction. The levee then continues along the riverbank for an additional 400 feet where it becomes a floodwall due to space restrictions. There will be a turnaround provided at the end of the levee in this location. The floodwall, located at the riverbank, parallels the river for approximately 900 feet as it bends to the southeast. The line-of-protection then reverts back to levee where space becomes available and continues to parallel the river for an additional 450 feet. There will be vehicle access provided in this segment. At this location, the levee turns slightly south. It runs in a southeasterly direction, no longer parallel to the river, for approximately 450 feet, then continues for another 1,250 feet in a south-southeasterly direction. The levee then turns further south and proceeds in a southerly direction for approximately 350 feet where it ends and a floodwall begins. Vehicle access to the levee will be provided at this end of the levee as well.

H14. As before, the floodwall runs directly adjacent to and parallel with the river for 400 feet until it meets Veteran's Highway, approximately 100 feet northeast of its intersection with Water Street. The final segment of the line-of-protection is a levee which extends from the end of the last floodwall segment directly adjacent to and parallel with Veteran's Highway on the north side proceeds for approximately 1,150 feet, finally terminating at high ground at elevation 21.5 feet NGVD. There will be a turnaround at the beginning of this segment and vehicle access at the end.

Main Channel

H15. The line-of-protection continues across the river, north of Veteran Memorial Bridge, in the form of a storm barrier and storm gate, which lie collinear with the levee. The structure will be made of reinforced concrete with hinged steel sector gates. When open, the gates will provide an 80-foot wide opening. The gates are used in pairs, meeting at the center when in the 'closed' position and rotating into recesses in the concrete walls for the 'open' position. Sector gates are normally used in areas subject to tidal inundation where the gates may be subjected to reversal of heads. The gates can be opened and closed under head. The gates swing apart and water flows through the center opening between the gates. The storm barrier is shown in FIGURE H-5. The sector gate is shown in Figure I-6.

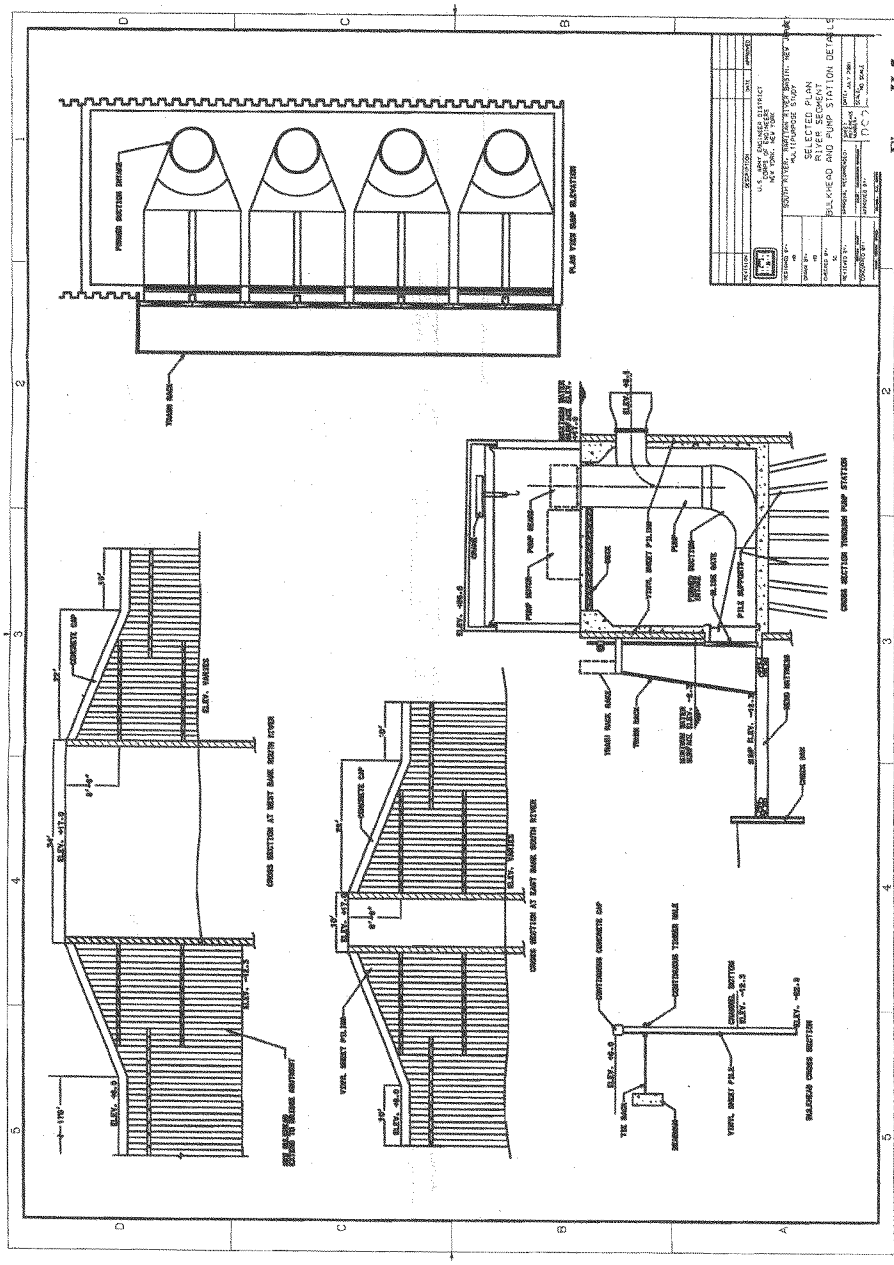


Figure H-5

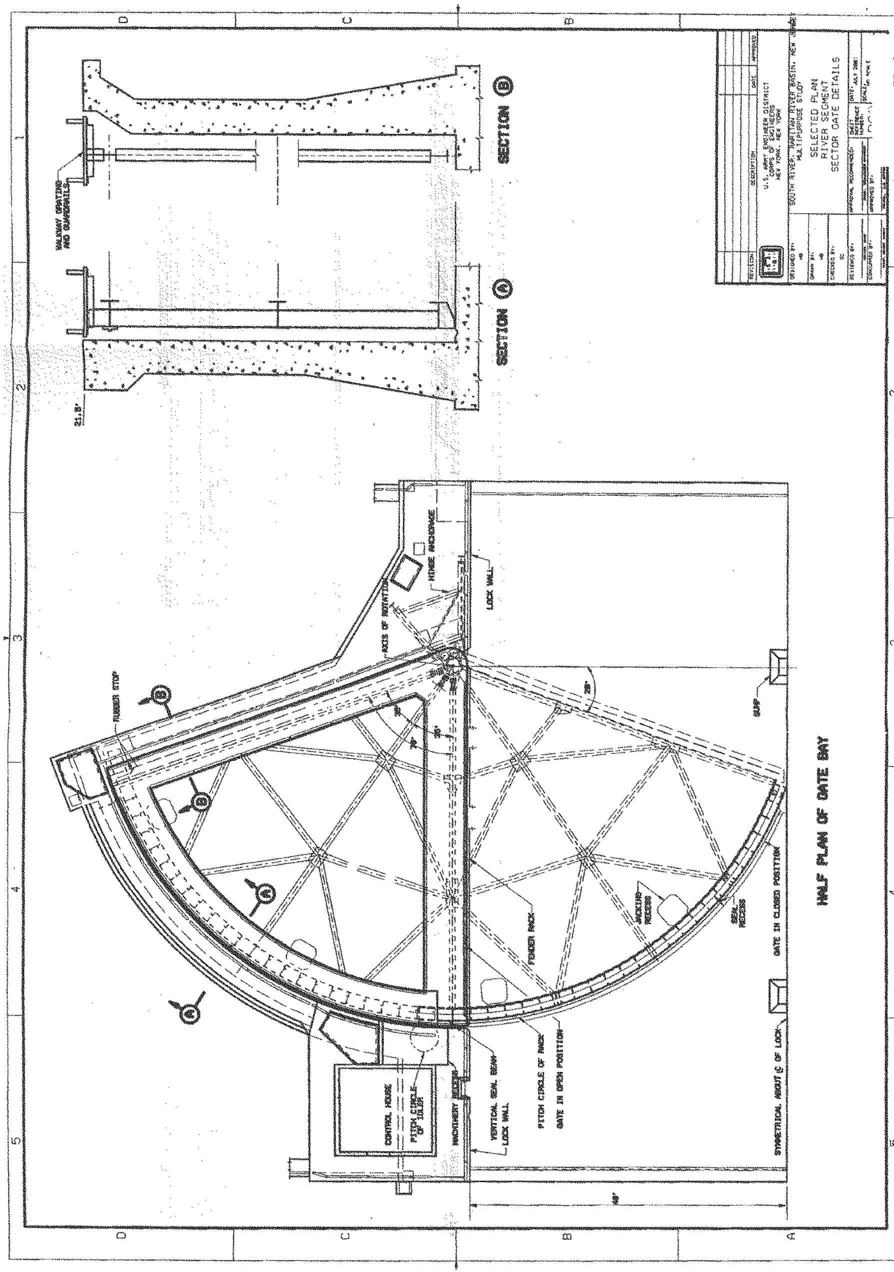

SECTION (A)
SECTION (B)
WALKWAY GRATING AND GUARDRAILS
RUBBER STOP
AXIS OF ROTATION
HINGE ANCHORAGE
LOCK WALL
SUMP
FENDER RACK
JACKING RECESS
SEAL RECESS
GATE IN CLOSED POSITION
PITCH CIRCLE OF RACK
GATE IN OPEN POSITION
VERTICAL SEAL BEAM
MACHINERY RECESS
CONTROL HOUSE
PITCH CIRCLE OF IDLER
SYMMETRICAL ABOUT ℄ OF LOCK
HALF PLAN OF GATE BAY
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
NEW YORK, NEW YORK
SELECTED PLAN
RIVER SEGMENT
SECTOR GATE DETAILS

Figure H-6

DESCRIPTION OF PROTECTED AREAS

General

H16. For purposes of this project, an "interior drainage area" is a distinct land area that drains to a primary detention location behind the proposed line-of-protection. Three areas have been identified for the current study: the East Segment, located in the Borough of Sayreville; the West Segment, located in the Borough of South River; and the Main Channel of the South River, located behind the storm surge barrier. In some cases, the otherwise distinct interior areas could become combined during rare storm events due to high ponding depths on the South River main channel.

Location

H17. For the hurricane and storm damage reduction plan formulation, the South River Basin study area was divided into five reaches, as shown in Figures H-7 and H-8. The five reaches are defined as they pertain to the protected areas as follows:

Main Channel

Reach 1: Right bank of the South River in Old Bridge Township.

Reach 2: Left bank of the South River in the Historic Village of Old Bridge immediately downstream of Reach 1.

Reach 3, Subreach 3B: Left bank of the South River in the Borough of South River, South of Veteran's Highway.

Reach 4, Subreach 4B: Right bank of the South River and the Washington Canal in the Sayreville area, across from Reach 3, South of Veteran's Highway.

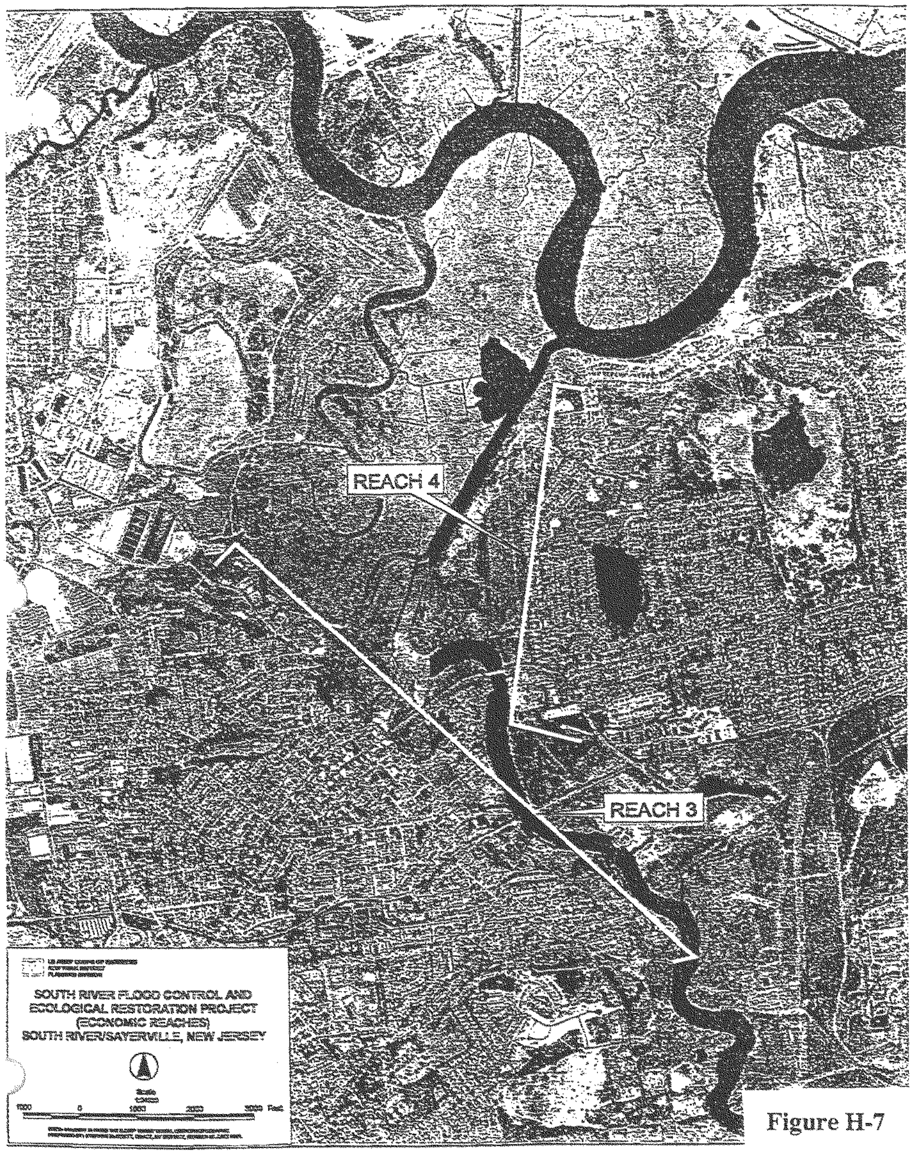

REACH 4
REACH 3
SOUTH RIVER FLOOD CONTROL AND
ECOLOGICAL RESTORATION PROJECT
(ECONOMIC REACHES)
SOUTH RIVER/SAYERVILLE, NEW JERSEY
Scale
0
Feet

Figure H-7

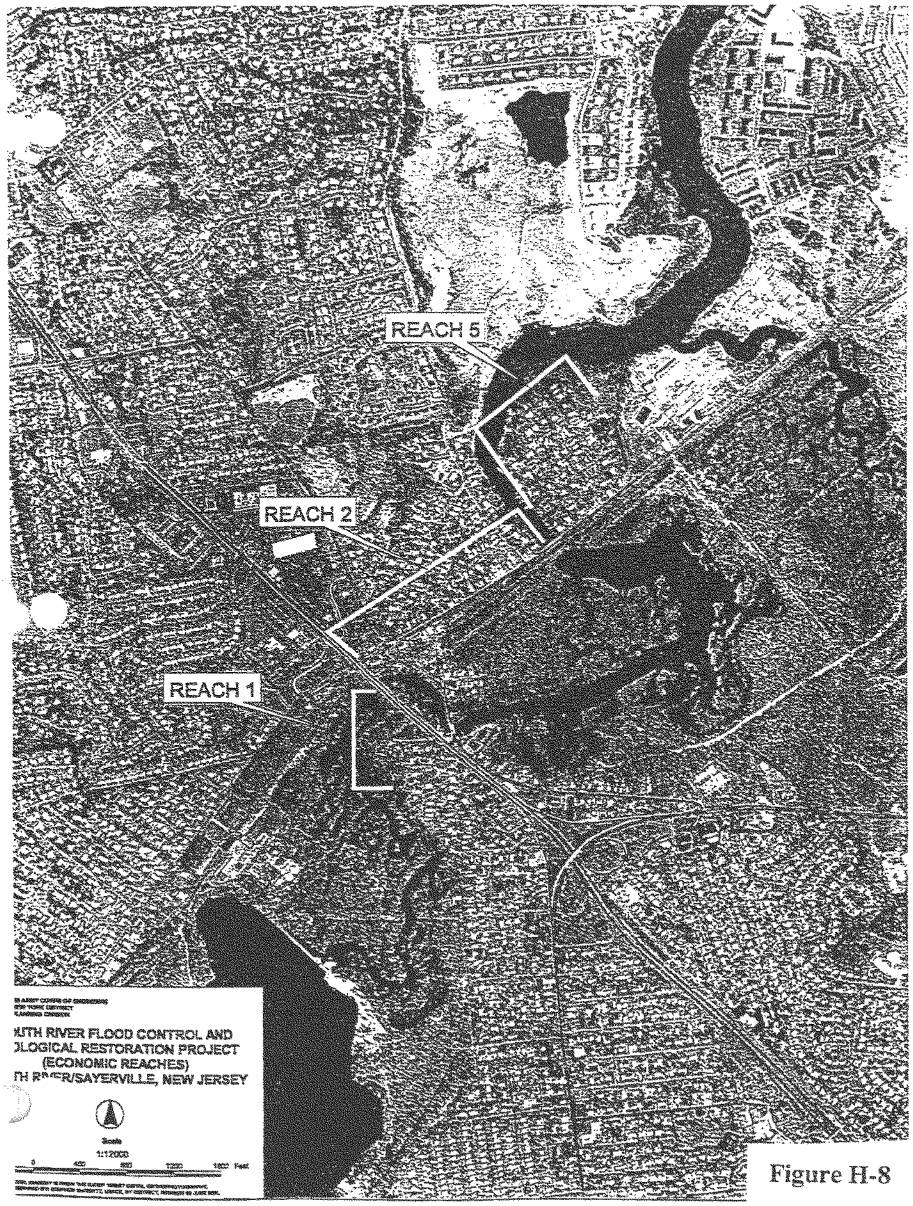

REACH 5
REACH 2
REACH 1
UTH RIVER FLOOD CONTROL AND
LOGICAL RESTORATION PROJECT
(ECONOMIC REACHES)
TH R/SAYERVILLE, NEW JERSEY
Scale
1:12000
0
400
800
1200
1600 Feet

Figure H-8

Reach 5: Right bank of South River just downstream from Old Bridge (Reach 2).

East Segment

Reach 4, Sub-reach 4A: In the Borough of Sayreville, north of Veteran's Highway.

West Segment

Reach 3, Sub-reach 3A: In the Borough of South River, north of Veteran's Highway.

DESIGN PROCEDURE

General

H18. A combination levee/floodwall and storm gate system was determined to be the most feasible means of flood protection for the South River Basin. Levees and floodwalls adjacent to the Boroughs of South River and Sayreville, in conjunction with a storm barrier and gate across the river north of Veterans' Memorial Bridge, eliminate the need for additional levees upstream of the bridge. The levee/floodwall and storm gate system creates two small interior drainage areas, one in the Borough of South River behind the West Segment levee and one in the Borough of Sayreville behind the East Segment levee. The drainage area behind the storm gate consists of the entire South River Basin. Due to the considerable differences in the drainage area sizes (East Segment – 0.54 square miles; West Segment – 0.69 square miles; Main Channel - ~135 square miles), two different approaches were used to analyze the interior drainage facilities.

H19. As described in EM 1110-2-1413, procedures for formulating and evaluating flood loss reduction measures for interior drainage areas are similar to planning procedures used in other types of investigations. The complexity of the process is dependent upon the nature of the study area, flood hazard, damage potential, and environmental and social factors. A comprehensive array of alternatives is formulated and evaluated through an iterative process until a final array of plans is developed. Data necessary to conduct the investigation includes basin hydrology, stage-frequency curves, hydraulic parameters of plan components, and estimated residual damages. Using this data, with- and without-project benefits can be determined in order to identify the plan which maximizes NED benefits.

Interior Flood Control Simulation Models

General

H20. Two mathematical models were used to simulate the hydrologic response of the interior drainage areas and the operation of the interior drainage facilities. The first model, developed by the Corps' Hydrologic Engineering Center (HEC), is the Interior Flood Hydrology Package (HEC-IFH), Version 2.1.

H21. The analysis assumes that the sector gate on the South River will be operated in response to both interior and exterior water surface elevations. This requires a more flexible model than HEC-IFH. The second model is a Lotus123© spreadsheet that was originally developed by the New York District to evaluate flood gate alternatives for the Pompton Lakes Dam and was modified to evaluate South River's Main Channel interior drainage system.

HEC-IFH Model

H22. HEC-IFH is a computer program designed to route floods through interior drainage facilities to adjacent rivers or estuaries accounting for variable tailwater conditions. This program was utilized to simulate the surface runoff response of the interior basins to precipitation while taking into account both the hydrologic and hydraulic components of these basins. The program was used exclusively for the analysis of the East and West Segments' interior drainage areas.

Lotus123© Model

H23. A Lotus123© spreadsheet was programmed to evaluate South River's Main Channel interior drainage system, in which gate operation is governed by both interior elevations and downstream water surface levels or trends. The spreadsheet modeled pumping station, storm gate, and gravity outlet impacts on the main river outflow.

Overview

H24. In the Lotus123© (hereafter referred to as Lotus) spreadsheet, outflow can be from a pumping station, the main storm gate, and/or gravity outlets. The stage-storage relationship of the interior drainage area is based on available topographic mapping. The downstream storm surge elevation versus time relationship is selected by the user. After defining the upstream and downstream conditions, outflow over time is computed by running the model's macro. The Lotus macro is a series of instructions that speeds up repetitive or complex tasks. This macro performs the level pool routing method to route the selected frequency inflow through the interior drainage area, accounting for changes in the exterior water levels, and operation of the sector gates.

H25. The storm gate is modeled as a submerged weir, with a resultant flow that changes over time based upon the depth of water in the reservoir (behind the gate) and the depth of the downstream tide. The gate is open at any point for which the differential head between the interior area and the tide is greater than or equal to 0.5 feet. The invert elevation of this 80-foot wide gate is set at -14 feet NGVD.

H26. For pumping stations, the model has been designed such that the pump will function at maximum capacity at any time for which the gate is closed. The pumping rate does not vary with head; it is strictly either in the 'on' or 'off' position, and is not staged in any way.

H27. For gravity outflow, only positive flow is allowed. Furthermore, gravity outflow is allowed only when there is positive outflow through the gate.

Calculations

H28. **Gate.** The model used the following submerged weir equation to model flow through the gate:

$$Q_s = \{1-(H_2/H_1)^{1.5}\}^{.385} \times Q$$

where Q_s is the discharge over the submerged weir, H_2 is the depth of water above the weir crest on the downstream side of the weir, H_1 is the depth of water over the weir crest on the upstream side of the weir, and Q is the unsubmerged discharge, computed as:

$$Q=CLH^{1.5}$$

Here, Q equals the flow over the top of the weir, C is the discharge coefficient, L is the effective length of the weir crest, and H is the total head above the weir crest.

H29. **Pump.** The pumps were modeled to operate at full capacity at any time for which the gate is closed, and to cease operation completely at any time for which this criteria is not met. Because the simulated pumping rate is not a function of differential head between the interior reservoir elevation and the exterior surge elevation, some error is introduced into the model. This was not a significant source of error because the pump curve associated with the proposed line-of-protection is flat, that is, the pumping rate does not increase appreciably with decreasing head. The equations used to model pump operation are adequate representations of this system.

H30. **Gravity Outlets.** The model incorporated an orifice equation to model flow through the proposed gravity outlets:

$$Q=CA[2g(h_1-h_2)]^{0.5}$$

where Q equals the discharge through the outlet, C is the discharge coefficient, A is the area of the orifice, g is the acceleration due to gravity, h_1 is the distance from the surface to the center of the orifice opening inside the interior drainage system, and h_2 is the distance from the surface to the center of the orifice opening outside of the interior drainage system.

Flow occurs where the head differential is greater than zero since the outlets will be installed with a backflow valve, preventing negative flow conditions in the pipe.

Verification

H31. The Lotus model was evaluated prior to the interior drainage analysis. The submerged weir equation was compared with Manning's equation and the performance of the gravity outlets was verified by comparing output from the Lotus model with output from XP Software's Stormwater & Wastewater Management Model (XP-SWMM) Version 7.5. Because XP-SWMM could not model real time controls, only the reservoir and the gravity outlets were modeled. The gravity outlets were modeled as side-outlet orifices.

H32. General agreement between the results from both approaches was observed. These results indicate that the equations used in the Lotus model are adequate for routing flows through the interior drainage area.

Basis of Design

Hydrologic Analysis of Interior Areas

H33. The HEC-1 (Flood Hydrograph Package) model developed for the main South River watershed is described in the Hydrology, Hydraulics, and Design Appendix. HEC-IFH runoff models were developed for the smaller, East and West Segments' interior drainage watersheds. Basic input parameters developed for the hydrologic models include: surface area, rainfall generated for a series hypothetical storm events (2 to 500-year return periods), runoff curve numbers, and time of concentration (T_c).

Hydraulic Analysis

East and West Segments

H34. Proposed outlet structures such as culverts and pipes through floodwalls or levees integral to the project line-of-protection were analyzed within HEC-IFH using inlet and outlet control analyses as described in Federal Highway Administration's Hydraulic Design Series No. 5 "*Hydraulic Design of Highway Culverts*" (HDS-5).

H35. The StormCAD® computer program was used to analyze the design capacities of the proposed diversion alternatives for incorporation into the HEC-IFH model.

Main Channel

H36. The Lotus model was used for the Main Channel hydraulic analysis.

Selection of Analysis Methods

H37. The analysis presented herein is based on the concepts and guidelines contained in EM 1110-2-1413 "*Hydrologic Analysis of Interior Areas*", dated 15 Jan 1987.

Correlation Analysis

General

H38. The proposed storm damage reduction features will trap local drainage behind the line-of-protection. In order to release the interior runoff to the South River, outlet pipes with flap valves and sluice gates to control backflow will be provided along the line-of-protection. The sector gate, which provides the line-of-protection within the South River main channel, will be operated to discharge when storm surge levels are below interior flood levels. Since the gravity structures can not discharge runoff against high tailwater stages, it was important to develop an understanding of the relationship between the precipitation events creating significant interior runoff and storm events creating high exterior stages that block the gravity outlets.

H39. A review of historical precipitation and tide data was performed in order to quantify any correlation between the amount of precipitation and peak surge level during storms, and to identify tailwater conditions for use in the analysis.

Raritan Bay Tides

H40. Tides in Raritan Bay affecting the Raritan River are semi-diurnal and have a mean range of 5.6 feet. Tide ranges for points in the project area are summarized in Table I-1. The maximum-recorded storm surge elevation at Sandy Hook was observed on December 11, 1992, when the reported water level was 8.69 feet NGVD. The second highest water level at Sandy Hook was 8.56 feet NGVD on September 12, 1960.

Table H-1
Tidal Datum

Elevation of Datums	Elevations in Feet					
	Sayreville		Old Bridge		Sandy Hook	
	MLLW	NGVD	MLLW	NGVD	MLLW	NGVD
Mean Higher High Water (MHHW)	5.95	3.58	6.20	3.90	6.33	2.14
Mean High Water (MHW)	5.60	3.23	5.85	3.55	5.99	1.80
Mean Tide Level (MTL)	2.92	0.55	3.05	0.75	3.66	-0.53
NGVD	2.37	0.00	2.30	0.00	4.19	0.00
Mean Low Water (MLW)	0.23	-2.14	0.24	-2.06	1.33	-2.86
Mean Lower Low Water (MLLW)	0.00	-2.37	0.00	-2.30	0.00	-4.19

Source: NOAA

Review of Historic Storms

H41. Precipitation and tidal data for approximately 67 years of record were obtained and reviewed. Using this data, an assessment was made of the dependence between significant precipitation and tidal events. The following paragraphs describe the review and assessment in more detail.

H42. Peak river discharge and peak ocean elevation data were obtained for major coastal storms and major river (fluvial) floods from the September 1938 hurricane flood to the present. These events included (but were not limited to) the aforementioned hurricane flood, the September 1944 hurricane flood, Hurricane Donna (September 1960), the March 1962 Nor'Easter, the August 1971 ("Hurricane Doria") flood, the flood of November 1977, Hurricanes David (September 1979), Gloria (September 1985) and Hugo (September 1989), the Halloween '91 Nor'Easter, the December '92 Nor'Easter (tidal flood of record in the study area) and the October '96 Nor'Easter.

H43. Peak river discharge data was obtained for three USGS gaged basins in the study area: the Raritan River at Bound Brook, NJ; Lawrence Brook at Farrington Dam, NJ; and the South River at Old Bridge NJ. Peak ocean elevation data was obtained for the two tide gages, Perth Amboy NJ, and Sandy Hook NJ, respectively, at and close to, the mouth of the Raritan River. The data is shown in Table H-2.

Data Analysis

H44. The peak flow and surge data was transformed to common (base 10) logarithms. Peak flow data from each of the three stream gages was correlated with peak ocean surge data from both tide gages to produce 3 x 2 = 6 correlations, or data sets, of river and ocean peak data. Coincidence, or timing, was not considered in this analysis but looked at separately within the August 1971 ("Hurricane Doria") flood and the December '92 Nor'Easter, the two historic floods used in the calibration of the South River hydrologic and hydraulic models (HEC-1 and HEC-RAS, respectively).

Table H-2
Fluvial Tidal Correlation – Peak Elevations vs. Peak Flow

Storm Date	Peak Elev. (NGVD)		Peak Discharges (CFS)			Storm Date	Peak Elev. (NGVD)		Peak Discharges (CFS)		
	A	B	C	D	E		A	B	C	D	E
24 SEP 1882	ND	ND	47840	ND	ND	14 JUL 1975	3.49	ND	27100	1330	1790
06 FEB 1896	ND	ND	54740	ND	ND	21 JUL 1975	3.72	ND	24300	3560	4920
10 OCT 1903	ND	ND	32100	ND	ND	26 SEP 1975	4.27	ND	23900	1940	1940
17 JUL 1927	ND	ND	ND	ND	1720	23 MAR 1977	4.05	ND	26300	1280	1040
06 JUL 1928	ND	ND	ND	ND	1900	08 NOV 1977	6.00	6.91	19000	3160	900
21 SEP 1938	5.90	6.60	31000	ND	2660	26 JAN 1978	5.21	ND	30000	3000	1430
14 SEP 1944	7.70	7.40	ND	4250	2220	25 JAN 1979	5.86	ND	34600	3320	1870
19 JUL 1945	ND	ND	12500	3200	ND	24 MAY 1979	4.57	NC	18800	1230	1430
03 JUN 1946	ND	ND	24800	2320	1280	04 AUG 1979	4.44	ND	E 3200	E 400	E 90
23 JUL 1946	ND	ND	14900	2430	1050	06 SEP 1979	5.91	ND	12300	E 940	1180
21 AUG 1948	ND	ND	ND	3030	ND	20 DEC 1979	ND	5.52	D 860	D 100	D 20
31 DEC 1948	ND	ND	30600	2060	940	25 OCT 1980	ND	7.04	E 3680	E 390	D 30
25 NOV 1950	7.20	9.50	20200	780	690	15 NOV 1981	ND	5.44	D 120	D 30	D 50
02 JUN 1952	3.06	ND	15200	2360	930	18 MAR 1983	ND	5.79	14000	790	950
6-7 NOV 1953	7.90	ND	D 410	E 430	ND	16 APR 1983	4.78	ND	28100	1300	750
31 AUG 1954	6.40	ND	E 4380	E 270	D 30	29 MAR 1984	7.14	7.92	E 8470	2570	E 460
13 AUG 1955	4.16	ND	27300	2650	1450	30 MAY 1984	4.67	ND	24200	3820	1040
19 AUG 1955	4.36	ND	30800	ND	570	07 JUL 1984	3.98	ND	28600	1350	630
14-16 OCT 1955	6.20	7.70	26700	1040	660	12 FEB 1985	ND	7.00	E 9220	1260	E 230
20 MAR 1958	6.20	ND	D 2070	750	E 250	27 SEP 1985	7.05	ND	14100	1260	540
:4 JUL 1959	3.26	ND	ND	1750	1610	05 NOV 1985	ND	6.38	D 2240	E 320	D 70
12 SEP 1960	8.60	10.00	19200	2430	1400	17 APR 1986	4.14	ND	20100	2710	990
13 APR 1961	6.90	ND	14400	1500	790	01 JAN 1987	7.10	7.20	D 1120	1670	E 440
23 OCT 1961	5.90	ND	D 220	E 120	D 20	20 JAN 1988	ND	5.87	E 5000	E 640	E 170
6-8 MAR 1962	7.80	ND	19500	1620	850	22 OCT 1988	ND	5.86	3160	ND	240
23 JAN 1966	ND	8.42	D 250	190	D 0.3	05 JUL 1989	4.58	ND	ND	ND	1600
07 MAR 1967	4.26	ND	29300	1910	1510	19 SEP 1989	5.39	ND	23500	ND	4360
24 MAY 1967	ND	6.05	D 690	D 80	D 20	19 OCT 1989	ND	6.62	17900	ND	900
30 MAY 1968	3.76	ND	27800	4180	1750	09 AUG 1991	ND	5.60	E 3420	ND	450
10 JUN 1968	ND	5.86	18000	2230	900	19 AUG 1991	4.60	ND	E 4950	ND	ND
12 NOV 1968	ND	8.45	E 2590	760	E 210	31 OCT 1991	7.03	7.25	D 170	ND	ND
26 DEC 1969	ND	7.04	D 1160	E 570	D 50	06 JAN 1992	5.71	ND	E 1220	ND	ND
03 APR 1970	4.80	ND	29600	1380	780	26 SEP 1992	5.69	ND	D 470	ND	ND
05 FEB 1971	ND	7.95	E 12000	1380	480	10 DEC 1992	8.70	10.10	20000	ND	1270
28 AUG 1971	3.99	4.68	46100	4210	2920	12-13 MAR 1993	7.13	ND	D 1530	ND	ND
13 SEP 1971	3.82	4.22	21400	2490	480	03 MAR 1994	ND	7.24	D 840	ND	ND
19 FEB 1972	ND	7.50	E 3170	1190	E 230	24 DEC 1994	5.11	ND	E 1350	ND	ND
23 JUN1972	4.87	ND	26900	1350	1580	08 JAN 1996	6.03	ND	E 1160	ND	ND
01 FEB 1973	4.04	ND	28000	1940	2710	19-21 JAN 1996	5.14	ND	32700	ND	ND
12 FEB 1973	ND	5.42	D 1580	E 360	D 50	19-20 OCT 1996	6.61	ND	40700	ND	ND
21 DEC 1973	3.76	ND	31000	2680	1720						

COLUMN HEADING LEGEND:

A SANDY HOOK, NJ
B PERTH AMBOY, NJ / RARITAN ARSENAL, NJ
C RARITAN RIVER BELOW CALCO DAM AT BOUND BROOK, NJ
D SOUTH RIVER AT OLD BRIDGE, NJ
E LAWRENCE BROOK AT FARRINGTON DAM

FLOW/ELEV. LEGEND:

D MEAN DAILY FLOW
E ESTIMATED FLOW
ND NO DATA

H45. Within each of the six correlations, or data sets, two best-fit lines were computed :

- River peak flow as the "y" value, the ordinate, the dependent variable, assumed to have all the error, which cannot be observed and must therefore be predicted, with peak ocean elevation as the "x" value, the abscissa, the independent variable, assumed to be completely without error, which can always be observed.
- The inverse of the above: Peak ocean elevation as the "y" value, the ordinate, the dependent variable, assumed to have all the error, which cannot be observed and must therefore be predicted, with river peak flow as the "x" value, the abscissa, the independent variable, assumed to be completely without error, which can always be observed.

H46. The two lines cross at the average value of the common (base 10) logarithms of the river peak flows and peak ocean elevations. The average of the two lines was determined by computing the average of their slopes and then plotting a line of this average slope through the intersection of the two best-fit lines. This was done because both the peak ocean elevation and river peak flow data contain some uncertainty. Neither should be assumed to be error-free. Also, for some historic storms, peak ocean elevation is available but not river peak flow. The reverse is true for other historic storms. Therefore, neither quantity can always be observed for the historic storms considered, and neither should be considered as the dependent or independent variable.

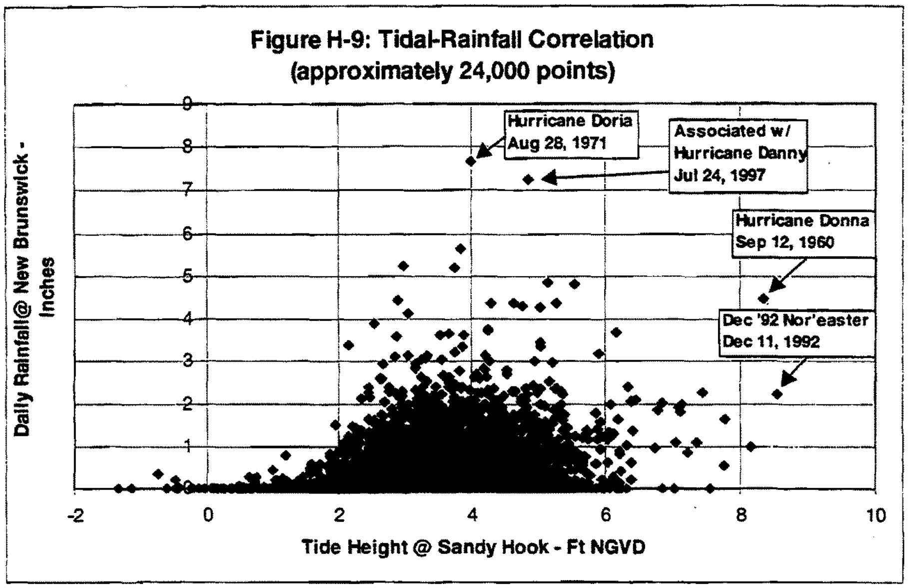
H47. The results of the correlations are shown in Table H-3. The correlations show a weak inverse relationship between river and ocean flooding for the lower Raritan River basin and the Atlantic Ocean at the mouth of the Raritan River. The correlation is weak because the correlation coefficients are all less than 0.5000. The correlation coefficient is a measure of the extent to which the variation of the value of the dependent variable is explained by the relationship between the independent and dependent variable (the best-fit line). It is also a measure of how well the dependent variable is predicted from the independent variable by the best-fit line. The relationship is inverse because, for the best-fit lines and their average, ocean elevation decreases as river peak flow increases, and vice versa. This inverse relationship is shown by the negative values of the correlation coefficients. High ocean peak elevation with low river peak flow is exemplified by the September 1960 (Hurricane Donna) storm, the March 1962 Nor'Easter, and the December 1992 Nor'Easter. High river peak flow with low ocean peak elevation is exemplified by the September 1944, August 1971 (Hurricane Doria) and November 1977 floods.

Table H-3
Results of Fluvial – Tidal Correlation

Number Of Data Points	Variable "y" (fluvial)	Correlation Coefficient "r"	Mean Log		y as Dependent Variable		x as Dependent Variable	
			X	Y	Slope M	y Intercept "b"	Slope m	y Intercept "b"
Fluvial – tidal correlations with Sandy Hook, NJ peak stages (ft, NGVD) as tidal. (Variable "x")								
39	South R.At Old Bridge, NJ	-0.2350	0.7122	3.2028	-0.6233	3.6467	-0.0886	0.9959
49	Raritan R At Bound Brook, NJ	-0.3901	0.7217	4.0218	-2.2696	5.6596	-0.0688	0.9994
40	Lawrence Brk At Farrington Dam, NJ	-0.2029	0.7026	3.0416	-0.5523	3.4296	-0.0746	0.9294
Fluvial – tidal correlations with Perth Amboy / Raritan Arsenal, NJ peak stages (ft, NGVD) as tidal. (Variable "x")								
24	South R At Old Bridge, NJ	+0.4872	0.86	2.80	3.6739	-0.2419	0.0646	0.6612
29	Raritan R At Bound Brook, NJ	+0.3114	0.84	3.62	2.8825	1.1749	0.0336	0.7229
26	Lawrence Brook At Farrington Dam, NJ	+0.4928	0.84	2.55	3.8208	-0.6771	0.0636	0.6796

H48. In a separate analysis, hourly water surface elevations were obtained from the gage at Sandy Hook for the time period from Jan 1933 to Feb 2000. These data were reduced to obtain daily high tide records for that time period. (It should be noted that since these are hourly readings and not peak values, the actual peak values may have been slightly higher.) Daily rainfall data for the same time period was also obtained from the New Brunswick precipitation gage. These data were combined, and after cleaning the data for unpaired data points and other suspect data, approximately 24,000 data pairs were assembled. This data is plotted in Figure H-9.

H49. As can be seen in Figure H-9, most of the higher tide events occurred with little rainfall, and most high rainfall events occurred with normal tides.



Summary of Findings

H50. This analysis supports the conclusion that there is, at best, a weak correlation between rainfall and tidal surge. Although the numbers show little correlation, it is understood that the storms that typically produce tidal surges, *i.e.*, hurricanes and northeasters, also can produce significant rainfall. And many of the high rainfall events are accompanied by some degree of storm surge.

Recommended Analysis Approach

H51. Due to the limited correlation between rainfall/runoff events and tidal flooding events, it is considered most likely that only limited runoff will coincide with severe storm surge and significant storm surge will coincide with only moderately severe rainfall. Historical data indicate that the majority of interior runoff events will coincide with a storm surge level less than or equal to a 2-year storm. Similarly, the majority of significant storm surge events are likely to coincide with runoff equivalent to a 2-year event or less.

H52. The analysis was conducted for events with five (5) recurrence intervals: the 2-year, 10-year, 50-year, 100-year, and 500-year frequency events. In order to develop a stage-frequency relationship, the interior events were routed against exterior tidal marigrams. For the most likely or expected flooding scenarios, the five interior storm events were routed against a 2-year exterior tide, and a 2-year interior storm event was routed against the five exterior events. The highest water surface elevation (WSEL) of corresponding coincidental frequencies (e.g., 2-year interior and 10-year exterior, or 10-year interior and 2-year exterior) was identified as the most damaging flood level for the coincidental frequency (as shown in Table H-4). The analysis was performed for both the current and expected future conditions, including sea level rise.

Table H-4
Recommended Analysis Approach
Combination of Interior and Exterior Conditions Analyzed

Interior Flow	Exterior Stage	Time Condition	Peak Int. WSEL	Peak Ext. WSEL	Interior Flow	Exterior Stage	Time	Peak Int. WSEL	Peak Ext. WSEL	Max WS	Risk Condition
2yr	Normal	Current	Model Output	3.6	N/a			Model Output		Greatest WSEL for the Frequency Comb.	Lower Bound
10yr	Normal	Current		3.6	N/a						Lower Bound
50yr	Normal	Current		3.6	N/a						Lower Bound
100yr	Normal	Current		3.6	N/a						Lower Bound
500yr	Normal	Current		3.6	N/a						Lower Bound
2yr	2yr	Current		5.8	2yr	2yr	Current		5.8		Expected (2yr)
10yr	2yr	Current		5.8	2yr	10yr	Current		9.0		Expected (10yr)
50yr	2yr	Current		5.8	2yr	50yr	Current		12.3		Expected (50yr)
100yr	2yr	Current		5.8	2yr	100yr	Current		13.6		Expected(100yr)
500yr	2yr	Current		5.8	2yr	500yr	Current		16.9		Expected(500yr)
2yr	2yr	Current		5.8	2yr	2yr	Current		5.8		Upper Bound
10yr	10yr	Current		9.0	10yr	10yr	Current		9.0		Upper Bound
50yr	10yr	Current		9.0	10yr	50yr	Current		12.3		Upper Bound
100yr	10yr	Current		9.0	10yr	100yr	Current		13.6		Upper Bound
500yr	10yr	Current		9.0	10yr	500yr	Current		16.9		Upper Bound
2yr	Normal	Future	Model Output	4.4	N/A			Model Output		Greatest WSEL for the Frequency Comb.	Lower Bound
10yr	Normal	Future		4.4	N/A						Lower Bound
50yr	Normal	Future		4.4	N/A						Lower Bound
100yr	Normal	Future		4.4	N/A						Lower Bound
500yr	Normal	Future		4.4	N/A						Lower Bound
2yr	2yr	Future		6.6	2yr	2yr	Future		6.6		Expected(2yr)
10yr	2yr	Future		6.6	2yr	10yr	Future		9.8		Expected(10yr)
50yr	2yr	Future		6.6	2yr	50yr	Future		13.1		Expected(50yr)
100yr	2yr	Future		6.6	2yr	100yr	Future		14.4		Expected(100yr)
500yr	2yr	Future		6.6	2yr	500yr	Future		17.7		Expected(500yr)
2yr	2yr	Future		6.6	2yr	2yr	Future		6.6		Upper Bound
10yr	10yr	Future		9.8	10yr	10yr	Future		9.8		Upper Bound
50yr	10yr	Future		9.8	10yr	50yr	Future		13.1		Upper Bound
100yr	10yr	Future		9.8	10yr	100yr	Future		14.4		Upper Bound
500yr	10yr	Future		9.8	10yr	500yr	Future		17.7		Upper Bound

H53. Uncertainty was incorporated into the analysis by establishing lower and upper coincidental frequency bounds: the interior storm events were routed against a normal exterior tidal condition (the lower bound), and the interior events were routed against a 10-year external tide and the 10-year interior event against the five exterior tidal conditions (the upper bound).

HYPOTHETICAL STORM SURGE DATA

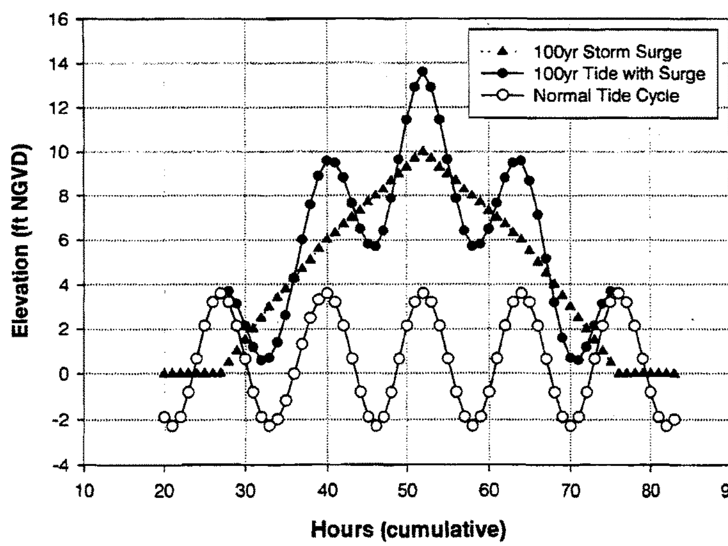
H54. The tides and storm surges used to develop the storm surge marigrams for exterior peak stages are shown in Table H-5. The tide and surge components are shown graphically in Figure H-10.

Table H-5
Exterior Peak Stage-Frequency Data

Frequency	Elevation*				
	Current Tide Height	Future Tide Height	Storm Surge	Current Peak Exterior Elevation	Future Peak Exterior Elevation
2-year	3.6	4.3	3.3	6.9	7.6
10-year	3.6	4.3	6.5	10.1	10.8
50-year	3.6	4.3	9.7	13.3	14.0
100-year	3.6	4.3	11.1	14.7	15.4
500-year	3.6	4.3	14.4	18.0	18.7

*all elevations in Feet NGVD

Figure H-10
Storm Surge and Tide Components



H55. As shown in Table H-4, the interior storm events were routed against a 2-year exterior storm surge, and a 2-year interior storm event was routed against the five exterior events to establish the expected interior stage-frequency curve. For the East and West Segment levees, the timing of peak precipitation was assumed coincidental with peak exterior storm surges. For the Main Channel storm gate, peak river flow was assumed coincidental with peak exterior storm surges. While the Main Channel condition may not be the most likely scenario, it was considered the most conservative assumption for this analysis. The analysis was performed for both current conditions and expected future conditions including sea level rise (see the Sea Level Rise section).

H56. The relationship between rainfall/runoff (including river flow) and storm surge is highly uncertain and may have a significant impact on interior stages. Thus, uncertainty was incorporated into the analysis by routing the interior storm events against a normal exterior tidal condition, and routing the interior events against a 10-year external storm surge, and the 10-year interior event against the five exterior storm surge conditions, as shown in Table H-4. This methodology established an upper and a lower bound of occurrences. The three conditions: lower bound, expected (or design) and upper bound were then incorporated into the economic analysis using a cumulative distribution.

SEA LEVEL RISE

H57. Sea level rise has been found to be a factor contributing to increased flood elevations. Firm geologic evidence exists indicating that the eustatic (*i.e.*, global average) sea level has been rising for the last 15,000 years (National Research Council (1987)). Meanwhile, numerous researchers believe that the recent rises in the atmospheric level of "greenhouse gasses" will contribute to an acceleration in the sea level rise in the near future.

H58. Guidance from the Coastal Engineering Research Center (CERC) indicates that the most appropriate sea level rise values would be found in the report by the National Research Council entitled *Responding to Changes in Sea Level* (NRC, 1987). This NRC report emphasizes the uncertainty inherent in measuring or predicting eustatic sea level rise, and that appropriate coastal engineering practices must account for this uncertainty with engineering flexibility. The report also emphasizes the spatial variability of relative sea level rise rates. The report states that the eustatic sea level rise over the last century has been 4.8 in. (2.4 in. over a 50-yr period). The report further details that the range of the "predominant change" is between 2.0 and 9.8 in. (over a 50-yr period). Higher values of sea level rise for future years were also presented: 3.9 in. between 1987 and 2012, 27.6 in. (+/- 25%) between 1987 and 2075, and 39.4 in. (+/-50%) between 1987 and 2100. The second of these values is from a study by the Board on Atmospheric Sciences and Climate. The higher sea level rise predicted in future periods is a result of predicting an acceleration in the sea level rise, an assumption which that the NRC report indicates is largely speculative. Finally, the report generalizes that data does not explicitly support alarmingly high predictions of sea level rise and the above values predicted to 2075 and 2100 may fall under this description.

H59. The value of eustatic sea level rise that is most prevalent in the NRC report is 0.047 in/yr, or 2.4 in. over a 50-yr period. The report goes on to indicate that the predominant change is a rising sea level with rates ranging from 0.039 to 0.20 in/yr, or 2.0 to 9.8 in. in a 50-yr period. The subsidence at New York City (Battery Park) is estimated to be 0.059 in/yr, or 3.0 in. in a 50-yr period. The NRC report estimates historical land subsidence at

Sandy Hook, New Jersey to be 0.059 in/yr higher than that in New York City. This value combined with the above value results in a Sandy Hook subsidence value of 0.118 in/yr, or 5.9 in. over 50 years. Therefore, the relative sea level rise over a 50-yr period is predicted to be 8.3 in. at Sandy Hook, or approximately 0.014 feet per year. This figure was used in the analysis to determine future tidal elevations.

HYPOTHETICAL RAINFALL DATA

H60. A 48-hour duration hypothetical storm was modeled so that the basin-wide HEC-1 model would be accurate for watersheds with times of concentration between 24 and 48 hours. The Raritan River, at its USGS gage at Bound Brook, NJ, has a time of concentration of 21.4 hours. Its time of concentration increases to 24 hours and greater, but not more than 48 hours, as it flows downstream to the study area (South River) and then to its mouth (Raritan Bay). The South River, at its USGS gage at Old Bridge, NJ, has a time of concentration of 25.2 hours. Its time of concentration increases as it flows downstream to its mouth, but to less than 48 hours.

H61. The development of the hypothetical rainfall data is described in the Hydrology, Hydraulics and Design Appendix. The hypothetical point rainfall data used in the HEC-IFH models is given in Table H-6.

Table H-6
Hypothetical Rainfall Data

Duration		Rainfall Depth (in.) for each Hypothetical Event						
		1 yr	2 yrs	5 yrs	10 yrs	50 yrs	100 yrs	500 yrs
5	Minutes	0.33	0.42	0.50	0.55	0.70	0.77	0.91
15	Minutes	0.65	0.80	1.00	1.13	1.49	1.64	2.02
1	Hour	1.19	1.40	1.80	2.15	2.78	3.10	3.72
2	Hours	1.48	1.78	2.30	2.70	3.50	3.80	4.66
3	Hours	1.63	1.95	2.65	3.00	3.85	4.30	5.23
6	Hours	1.95	2.40	3.20	3.60	4.70	5.20	6.31
12	Hours	2.30	2.90	3.76	4.30	5.65	6.30	7.65
24	Hours	2.70	3.30	4.35	5.10	6.70	7.35	9.00
48	Hours	3.11	3.81	5.30	5.83	7.78	8.53	10.44

DELINEATION OF DRAINAGE AREAS

Delineation Methods

H62. For purposes of this analysis, an "interior drainage area" or sub-basin is a distinct land area, which drains to one primary detention location behind the proposed line-of-protection. The interior drainage basin created behind the line-of-protection in the Borough of Sayreville was divided into two subbasins in order to conduct a diversion alternative analysis. The basin areas and hydraulic paths used to develop the hydrologic models are shown in Figure H-11.

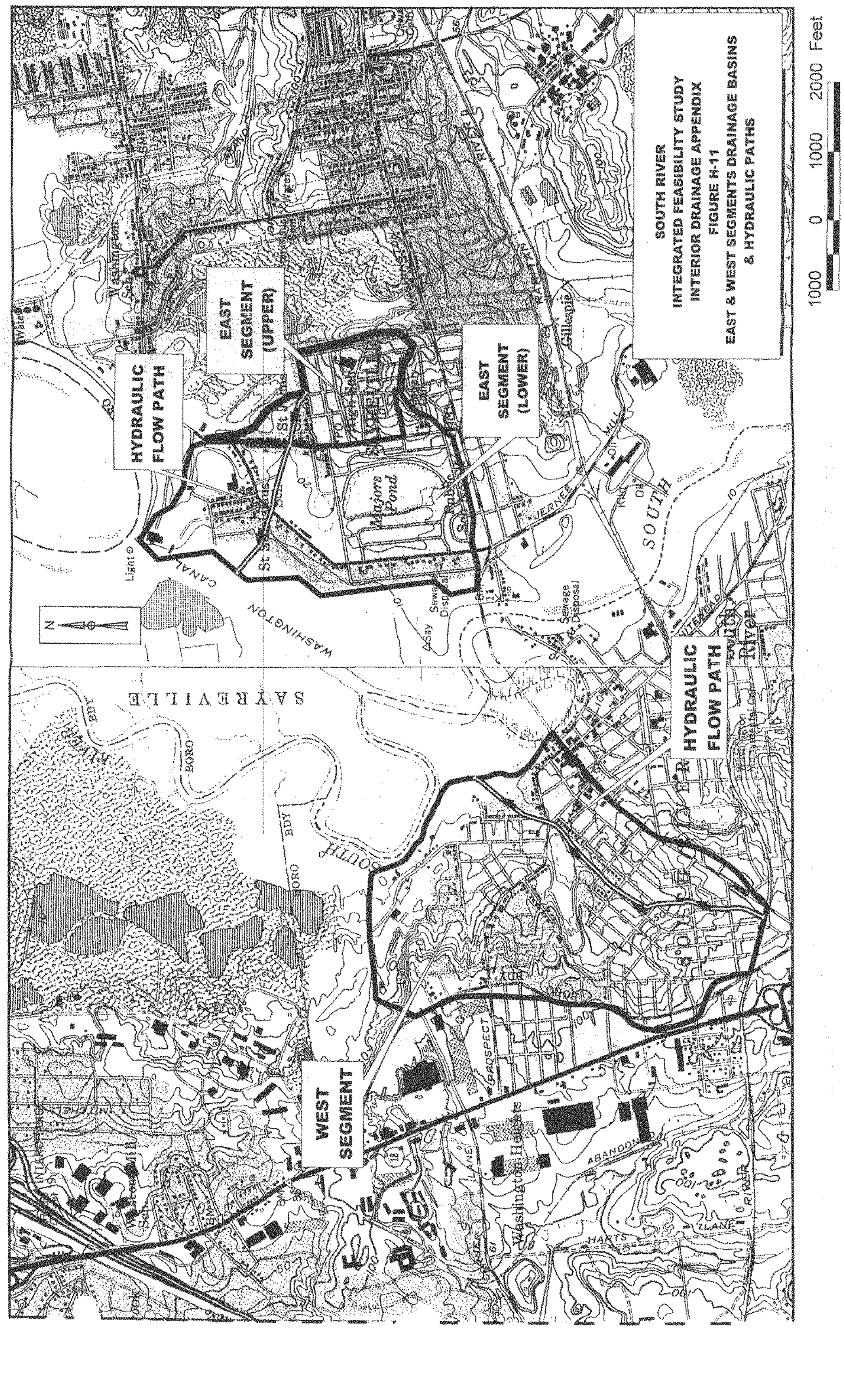
Existing Drainage Systems

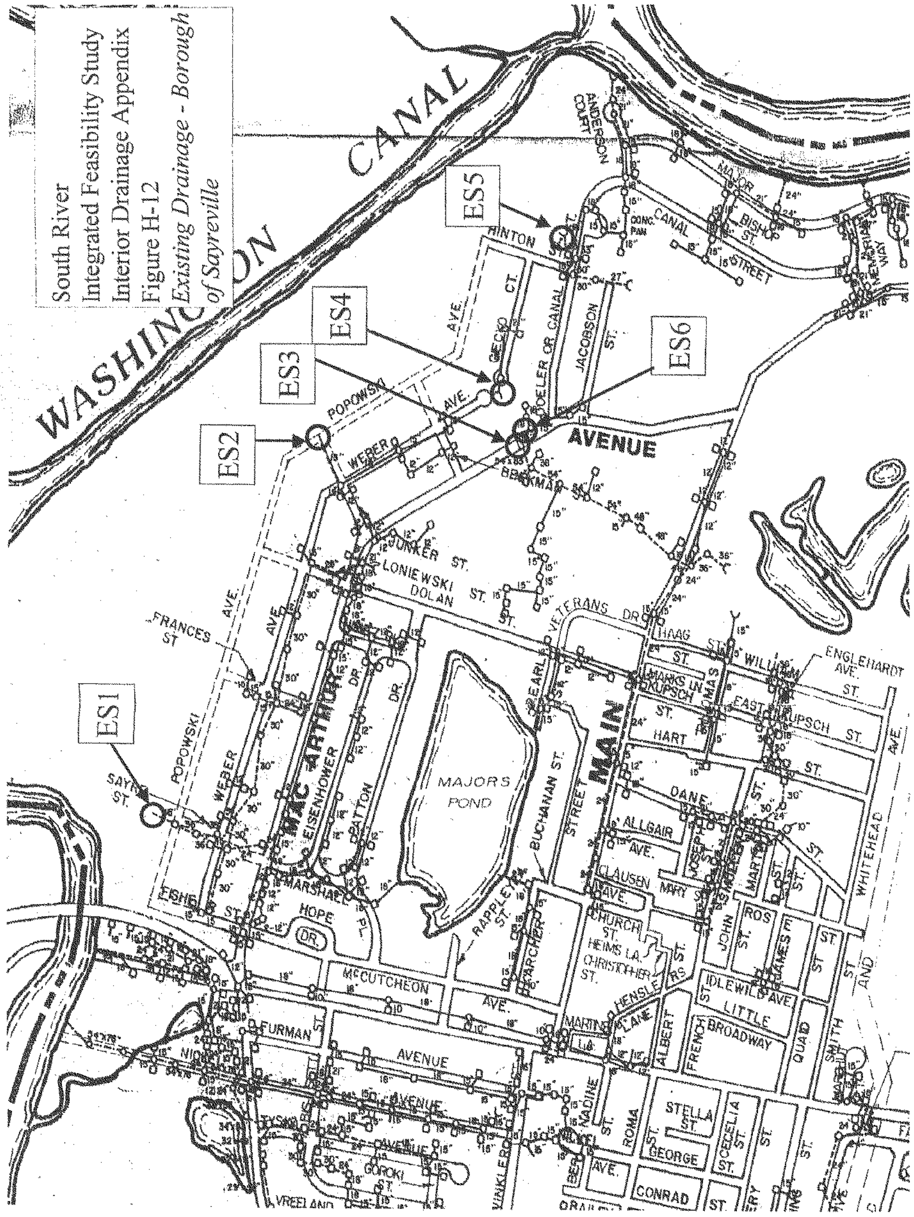
H63. Existing drainage systems consisting of catch basins, manholes and storm sewer pipes currently serve the South River and Sayreville interior drainage areas. Unfortunately, no storm sewer network map is available for the Borough of South River. In Sayreville, these pipes range in size from 12" to 48" diameter. Table H-7 provides a summary of the existing outlets by basins. Figures I-12 and I-12a show the approximate locations of the South River and Sayreville outlets.

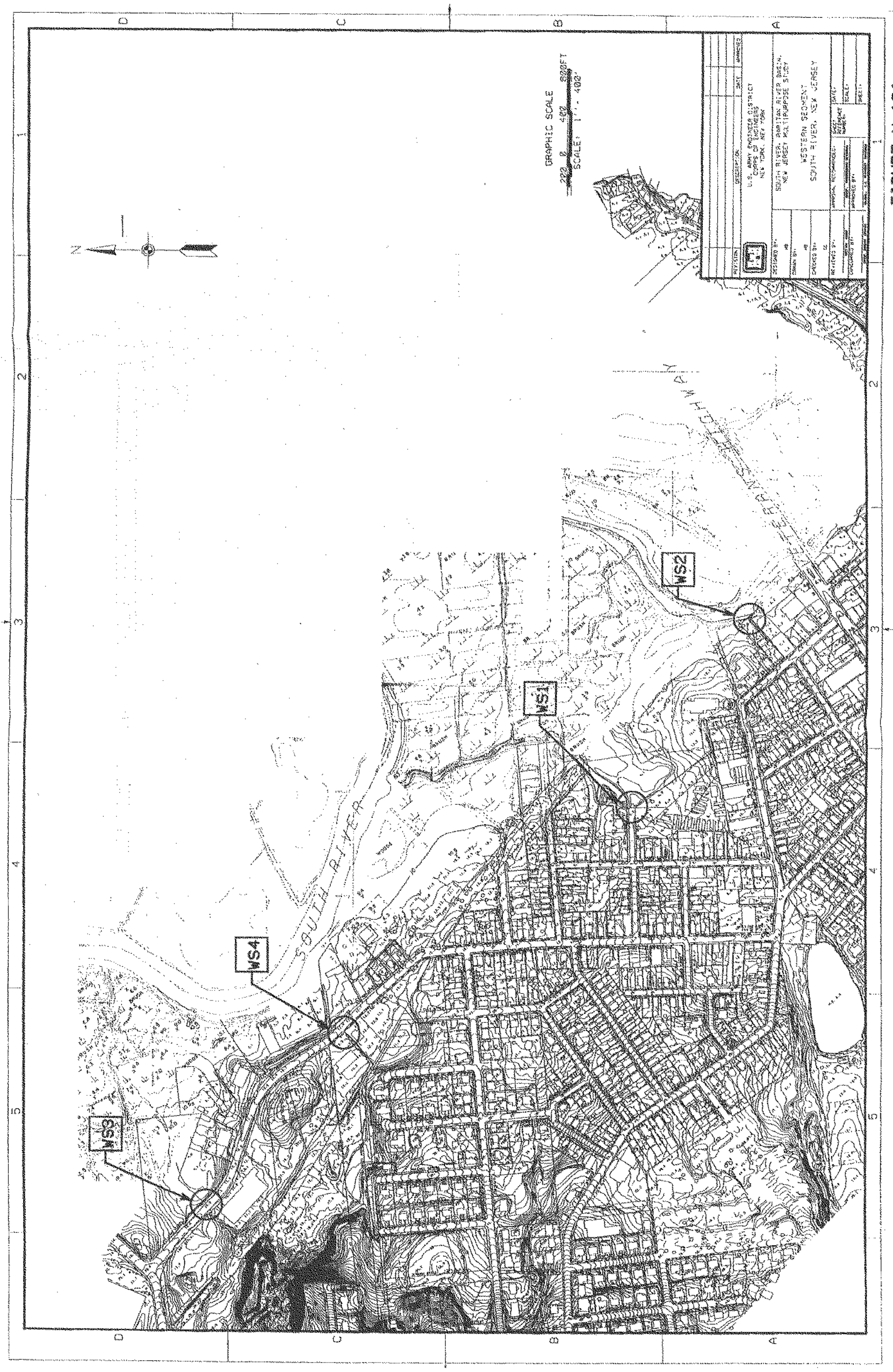
Table H-7
South River and Sayreville
Existing Gravity Outlets (East and West Segment Drainage Areas)

Basin	Outfall Designation	Outfall Location	Type	Size	Existing Inv. El.(1) (ft NGVD)
East	ES1	End of Sayre Street	DIP	3x24"	8.0(2)
	ES2	End of Junker Street	RCP	15"	8.0
	ES3	MacArthur Avenue	BOX	54"x83"	1.0
	ES4	End of Ciecko Street	RCP	15"	2.0
	ES5	Corner of Hinton St. and Canal St.	RCP	36"	2.1
	ES6	MacArthur Avenue	RCP	18"	2.0
West	WS1	End of Maple Avenue	RCP	60"	1.0
	WS2	Intersection of Reed St. and George St.	RCP	24"	0.5
	WS3	Underroad culvert (drains to ditch)	RCP	24"	12.0
	WS4	Underroad culvert (drains to ditch)	RCP	24"	8.0

(1) Existing inverts are approximated.
(2) The existing ES1 outfall includes a pump station as part of the NJDEP mitigation project.


SOUTH RIVER
INTEGRATED FEASIBILITY STUDY
INTERIOR DRAINAGE APPENDIX
FIGURE H-11
EAST & WEST SEGMENTS DRAINAGE BASINS
& HYDRAULIC PATHS
1000 0 1000 2000 Feet
HYDRAULIC FLOW PATH
EAST SEGMENT (UPPER)
EAST SEGMENT (LOWER)
Majors Pond
WASHINGTON CANAL
SAYREVILLE
HYDRAULIC FLOW PATH
WEST SEGMENT
Washington Heights


South River
Integrated Feasibility Study
Interior Drainage Appendix
Figure H-12
Existing Drainage - Borough of Sayreville
WASHINGTON CANAL
ES1
ES2
ES3
ES4
ES5
ES6
AVENUE
MAC ARTHUR
MAIN
MAJORS POND
POPOWSKI
WEBER
EISENHOWER
PATTON
BUCHANAN ST.
LONIEWSKI
DOLAN
VETERANS DR.
HOPE
FURMAN
McCUTCHEON
WHITEHEAD
HINTON
JACOBSON
CANAL
STREET
MAJOR
BISHOP
FRANCES ST
SAYRE ST.
ENGLEHARDT AVE.
HART
DANE
ALLGAIR AVE.
CLAUSEN
MARSHALL
CHURCH ST.
CHRISTOPHER ST.
IDLEWILD AVE.
LITTLE BROADWAY
QUAID
SMITH
ALBERT
FRENCH
STELLA ST.
GEORGE
CONRAD
ROMA
NADINE
GORDKI ST.
VREELAND


WS1
WS2
WS3
WS4
SOUTH RIVER
GRAPHIC SCALE
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
NEW YORK, NEW YORK
WESTERN SEGMENT
SOUTH RIVER, NEW JERSEY

DEVELOPMENT OF INTERIOR RUNOFF HYDROGRAPHS

General Description

H64. Hydrologic models were developed to estimate flood runoff hydrographs of the interior drainage areas using HEC-IFH for the areas behind the levee/floodwalls, and HEC-1 for the remainder of the South River basin. For the East and West Segments, runoff hydrographs were computed in HEC-IFH using drainage area size, percent of the drainage as impervious, infiltration losses, and Clark's unit hydrograph.

HEC-IFH Runoff Hydrographs

Precipitation Loss Data

H65. Land surface interception, depression storage, and infiltration are referred to as precipitation losses. Interception and depression storage are intended to represent the surface storage of water by trees or grass, local depressions in the ground surface, in cracks and crevices in parking lots and roofs, or in areas where water is not free to move as overland flow. Infiltration represents the movement of water to areas beneath the land surface. For the HEC-IFH model, precipitation losses were accounted for using the percent impervious factor and the initial-uniform loss method.

H66. For the initial-uniform loss method, and initial loss (inches) and a constant loss rate (inches per hour) were specified, as shown in Table H-8. All rainfall is lost until the volume of initial loss is satisfied. After the initial loss is satisfied, rainfall is lost at the constant rate.

Table H-8 Precipitation Loss Data		
Storm Event	**Initial Loss (inches)**	**Uniform Loss (in/hr)**
1-year	1.00	0.2460
2-year	1.00	0.2260
10-year	1.00	0.2600
50-year	1.00	0.2486
100-year	1.00	0.2410
150-year	1.00	0.2290
500-year	1.00	0.2180
Average*	**1.00**	**0.2380**
*used in HEC-IFH model		

Clark Unit Hydrograph Computation

H67. Three empirical methods for developing unit hydrographs are available within the HEC-IFH program. The Clark method was used in this analysis. The Clark method requires three parameters to calculate the unit hydrograph: T_c, the time of concentration for the basin; *R*, a storage coefficient; and a time-area curve. The time-area curve defines the cumulative area of the watershed contributing runoff to the sub-basin outlets as a function of time (expressed as a function of T_c). The HEC-IFH Clark Unit Hydrograph computation parameters for the East and West Segments are shown in Table H-9.

Table H-9 Summary of Hydrologic Data – East and West Segments							
Subbasin		**Area**		**% Impervious**	**Tc (hr)**	**Storage Coeff.**
		Acres	**Square Miles**			
East	Combined	346	0.54	36.7	0.52	0.57
East	Upper*	77	0.12	40.5	0.39	0.44
	Lower*	269	0.42	41.8	0.56	0.58
West		435	0.68	34.8	0.44	0.49
*East Segment was divided into Upper/Lower drainage areas for the diversion alternative analysis.						

Inflow Hydrographs

H68. Based on hydrologic and routing data generated from HEC-IFH, inflow hydrographs were developed for the East Segment and West Segment. Summaries of the peak inflows for the two segments are shown in Table H-10.

Table H-10
East and West Segment Peak Inflow (cfs)

Rainfall Event	East	West
2-year	422	591
10-year	655	911
50-year	908	1,276
100-year	964	1,340
500-year	1,179	1,640

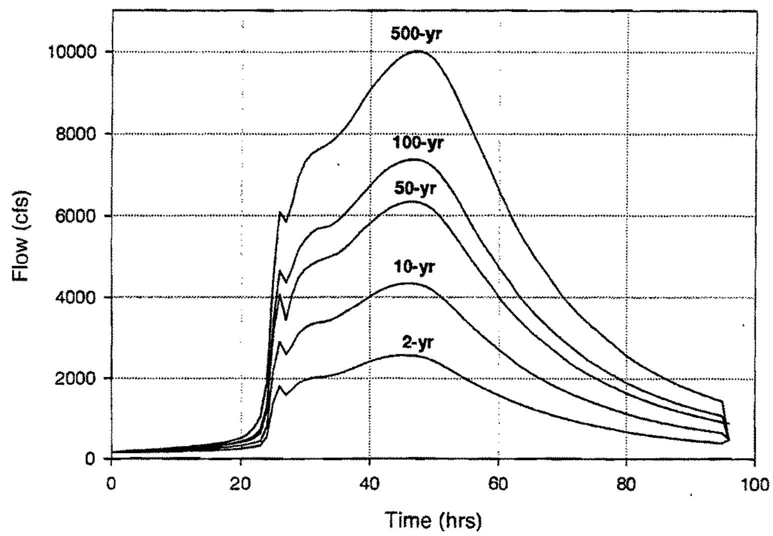
Main Channel Runoff Hydrograph

H69. The HEC-1 model for the Main Channel included the remainder of the South River watershed. This model is discussed in detail in the Hydrology, Hydraulics, and Design Appendix. Inflow hydrographs were developed for the basin for the different hypothetical storms using the HEC-1 program. A summary of peak inflows for all storm events analyzed is presented in Table H-11. The inflow hydrographs for the Main Channel are shown in Figure H-13.

Table H-11
South River Basin Peak Inflow

Storm Event	Inflow (cfs)
2-year	2,570
10-year	4,350
50-year	6,500
100-year	7,380
500-year	10,000

Figure H-13
South River Main Channel Flood Hydrographs



Interior Drainage Hydraulics

General

H70. In addition to the development of hydrologic data, the analysis of interior drainage facilities required additional input describing the physical and operational characteristics of the various alternatives. Input requirements consisted of potential storage volumes, and diversion and pumping rates. For the East and West Segment levees the HEC-IFH software package was utilized to evaluate the effectiveness of proposed interior drainage alternatives by routing interior fluvial flood events through the available storage at the line-of-protection. The criteria used to provide input to make these evaluations is described below.

Minimum Head

H71. The minimum head to open the flap valves for gravity outlet operation through the levees and floodwalls was assumed to be 0.2 feet. Two tenths of a foot is a standard head loss for pipes with flap valves up to 48" in diameter. Head loses up to 0.3 feet are possible for pipes 60" or larger equipped with flap valves. However, for this analysis, 0.2 feet was considered a reasonable estimate to account for the range of pipe sizes considered. The minimum head to open the flap valves for the box culverts in the storm surge barrier was assumed to be 0.25 feet.

Storm Surge Duration

H72. The interior drainage facilities were modeled with the storm surge causing one peak high tide, as shown in Figure H-10. While storms with longer surge durations are possible, multiple peak conditions have a significantly lower probability of occurring. A preliminary sensitivity analysis was conducted to determine is further study was needed to evaluate the affects of multiple exterior peaks. The results of the preliminary analysis indicated that multiple exterior peak high tides did not significantly impact the interior water surface elevations.

Starting Interior Water Surface Elevation

H73. For the East and West Segments, due to the presence of ground water at approximately 1.0 feet NGVD, a starting interior WSEL of 2.0 feet NGVD was considered in the analysis. Due to the tidal influence of South River, the starting water surface elevation for the Main Channel was the existing tide elevation.

Elevation/Storage Relationships

H74. In order to evaluate the storage capacity at the line-of-protection, elevation-storage relationships were developed. Using project mapping and commencing with the lowest elevation at the proposed ponding site behind the line-of-protection and the storm gate, the planimetric area enveloped by a particular elevation was estimated. For consecutive elevations, the HEC-IFH program uses the average end-area method to compute the volume. The program then sums the volumes between elevations to generate an overall elevation-volume relationship for a particular ponding site. Table H-12 summarizes the storage area relationship of the three ponding areas.

Table H-12
Storage Area of Ponding Sites
(As Surface Area)

Elevation (ft NGVD)	Area (acres)		
	Storm surge barrier	East Segment	West Segment
0.1[1]	-	0.1[2]	0.1[2]
2	-	0.2	0.2
4	25.97	9.4	1.9
6	43.01	25.7	6.5
8	51.54	65.5	22.1
10	65.36	91.1	42.9
12	74.57		68.8
14	87.49		88.1
16	101.34		
18	117.50		
20	144.69		
22	184.73		
24	237.76		
26	301.31		

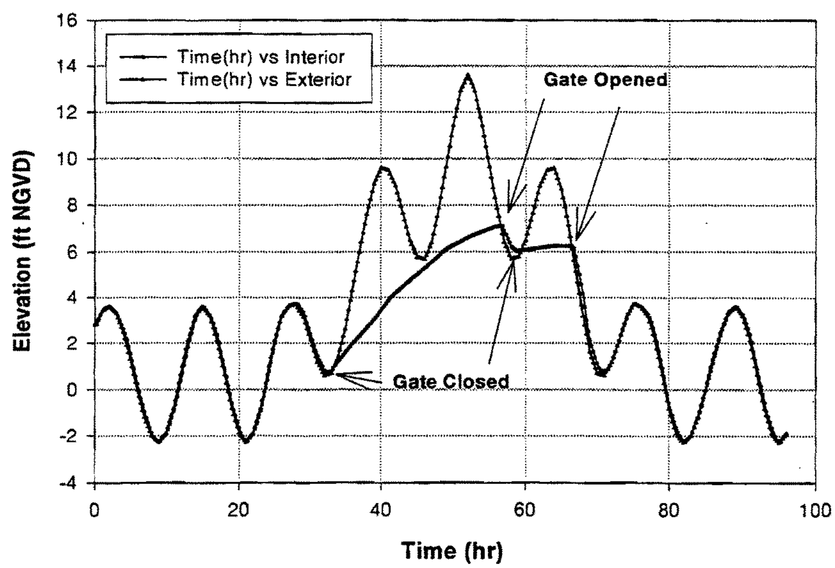
[1]Modeling required storage to commence at the outlet pipe invert.
[2]Minimal additional storage is available in toe drains and outlet sumps.

Storm Gate Operation

H75. The Main Channel storm damage reduction system will be manually activated through the use of an alerting system. At a "yellow" alert, signifying that although the critical water surface elevations have not yet been reached they are impending, preparation will be made to close the storm gates (or sector gates). At a "red" alert, signifying that the critical water surface elevations have been reached and that the implementation of the storm damage redcution plan is required, the storm gates will be closed. A "red" alert would typically be signaled at the start of the flood tide following the first higher than normal low tide. The first higher than normal low tide would indicate the arrival of the rising limb of the storm surge, as shown in Figure H-14.

H76. The storm gates will remain closed during the storm surge until it has been determined that the combined tide and surge is receding and the head differential between the interior and exterior water surface elevations is equal or greater than 0.5 feet, as shown in Figure H-14 for the 2-year interior vs. 100-year exterior condition. This will enable the gate to be opened as necessary to allow discharge during periods of low astronomic tide, reducing the need for additional drainage outlets.

Figure H-14
Storm Gate Operation
(2yr Interior vs. 100yr Exterior; 1,200 cfs Pump)



Pump Station Configuration

H77. The pump stations for the interior drainage areas were configured using the criteria in Table H-13.

Table H-13 Pumping Station Criteria		
Total Station Capacity	**Number of Pumps**	**Design Capacity per Pump**
East and West Segment		
200 cfs or less	2	1/2 total
>200 cfs but <450 cfs	3	1/3 total
Main Channel		
All	4	1/4 total

Pump-on/Pump-off Elevations

East and West Segments

H78. The pump-on elevation for the lead pump was selected based on the gravity outlet invert and the first significant damage elevation. Based on preliminary without-project annual damage estimates, the first significant damage was estimated for each segment. Maximum pump-on elevation providing full station capacity (all pumps running) was set at least ½ foot below the first significant damage elevation. After determining the lead pump-on elevation, additional pumps were started at ½-foot intervals. Pump-off elevations are set to one foot below the lead pump's pump-on elevation. Table H-14 summarizes the pump on/off elevations for the East and West Segments.

Table H-14 East and West Segments – Pump On/Off Elevations (feet NGVD)				
Segment	**First Significant Damage**	**First Pump On**	**Second Pump On**	**Pumps Off**
East	5.0	4.0	4.5	3.0
West	7.0	5.0	5.5	4.0

Main Channel

H79. For the main river pump station, all pumps were modeled to operate simultaneously, that is, all pumps will have the same start and stop elevations. The actual staggered operation of the pumps will be refined in the next phase of the project.

H80. For modeling purposes, the operating scenario called for the main channel storm gate to be closed at low tide during the approach of the tidal surge to maximize interior storage. Following that general operating scenario, pumping commences once the gates are closed and the interior WSEL reaches –2.0 feet NGVD.

Pump Cycle Time – East and West Segments

H81. Pumps are expected to have a minimum cycle time of six minutes, *i.e.*, 10 starts/hour. To achieve this cycle time, an adequate volume of surface runoff from the interior drainage area must be stored and available whenever the pumping operation is initiated. The storage volume in cubic feet required between the lead pump-on and pump-off elevations is 90 times the pump capacity based on the following equation:

$$V=[(6 \text{ min x } 60 \text{ sec}) \text{ x } Q_{pump}] / 4$$

where V is the volume in cubic feet and Q_{pump} is the pump discharge rate in cubic feet per second.

H82. Where adequate storage volumes are not provided by ditches or ponding areas, additional excavation may be required or the cycle time reduced to four minutes, which is the minimum operating cycle time under the most critical flow conditions, per EM 1110-2-3102, *General Principles of Pumping Station Design and Layout.* Under this condition, the required storage volume could be reduced using the above relationship, considering 4 minutes in lieu of 6 minutes cycle time.

H83. As shown in Table H-15, the stage versus storage curve for the West Segment interior area provides adequate storage for stable flood routings. No additional excavation or adjustment in the West Segment is required. Likewise, there is ample storage in the Main River for the pumps at the tide gate.

Table H-15
Natural Pond Storage – West Segment

Elevation (ft NGVD)	Storage (cf)	Storage Required (cf)	
		50 cfs pump	100 cfs pump
2.0	8,500	4,500	9,000
3.0	56,300	4,500	9,000
4.0	104,500	4,500	9,000
5.0	235,200	4,500	9,000
6.0	470,500	4,500	9,000

ECONOMIC CRITERIA

Conditions

H84. The analysis of benefits and costs for formulation of the interior drainage plans was conducted using a discount rate of 6-1/8 (6.125) % over a 50-year project life.

Costs

General

H85. Interior drainage facility costs are based on incremental improvements and are additive to features integral to the line-of-protection (*i.e.,* the minimum facilities). These costs consist of first construction costs, real estate costs, and annual operation and maintenance (O&M) expenses. Each of these is described below.

First Construction Costs

H86. First construction costs assigned to interior drainage facilities include primary and secondary outlets, intake structures and gates associated with the outlet, pond excavation, diversion pipes, and pump stations. Interior drainage costs do not include major line-of-protection costs, but rather are limited to project features that may be altered by the interior drainage design. First costs for items were estimated based on prevailing unit costs. First costs include: (1) for structures other than pumps, Engineering and Design (15%), Supervision and Administration (7%), and Contingency (15%); (2) for pump stations, Engineering and Design (7%), Supervision and Administration (7%), and Contingency (12%). First land costs include Survey, Appraisal and Administration (5%), and Contingency (10%).

Real Estate Costs

H87. Real estate acquisitions associated with interior drainage facilities are based on the purchase of a permanent drainage easement where interior features are required (drainage ditch, diversion pipe easement, ponds, etc.). The preliminary real estate unit costs are as follows:

Parkland (per acre)
Fee acquisition $20,000
Temporary easement.........$3,000
Flowage easement.............$8,000

Real estate acquisition costs include an adjustment to the base value of the land for surveying, appraisal, and administration (5%), and contingencies (10%).

Operation and Maintenance

H88. Annual charges attributed to the operation and maintenance (O&M) of interior drainage facilities consist of labor charges for the care and cleaning of pond areas, outlets and pump stations, as well as anticipated energy charges and annualized replacement costs. Operation of the main storm gate is considered part of the line-of-protection.

Replacement Costs

H89. Replacement costs for flap gates, trash racks, and sluice gates were assumed to occur every 25 years. The replacement costs were estimated by multiplying the cost of the components by the present worth. The following present worth factor was used: $1 / (1 + DR)^{25}$. The resultant cost was annualized and included in the O&M costs.

Cost Estimate Assumptions

H90. The following assumptions were made when developing the interior drainage facilities' estimated costs:

- Mobilization/Demobilization, dewatering: Construction of the minimum facilities is assumed to occur simultaneously with the line-of-protection construction; therefore, mobilization, demobilization, and dewatering costs are not required as part of the interior drainage costs.

- Toe ditch construction: Toe ditch construction costs are assumed to be part of the line-of-protection costs.

- Outlet riprap is not required due to the concrete apron in the typical outlet (see the typical gravity outlet figures).

- Outlet ditches will be vegetated; no riprap is expected to be required.

- A trench sled would be used during construction of the diversion alternative for the East Segment due to the shallow excavation depth, minimizing the need for sheeting.

Benefits

General

H91. Benefits due to the reduction of interior flooding are summarized for each interior drainage facility listed in subsequent sections. The benefits for interior drainage facilities are calculated as the difference between minimum facility residual damages and residual damages associated with the interior drainage plan alternative being evaluated.

Residual Flood Damages

H92. As described in the Benefits Appendix, the expected damage to structures and vehicles, as well as expected emergency costs, were calculated for various depths of interior or residual flooding, that is, flooding which occurs as a result of the line-of-protection preventing runoff. The residual damages with the minimum facility plan represent the starting point from which additional interior facilities planning commences. The benefits accrued from alternative interior drainage plans are attributable to the reduction in the residual flood damages which may have remained under the minimum facility condition.

Residual Annual Damages

H93. Residual damages were calculated using risk based simulation techniques. The damage analysis assumed that there will be no significant coincidence between the residual interior flooding from rainfall and residual flooding from storms exceeding the line-of-protection. In accordance with EM 1110-2-1413, interior damage was calculated for a full range of interior flood events up to and including the 500-year storm.

PLAN FORMULATION

Minimum Facilities Analysis

General

H94. The minimum facilities are the starting point from which additional interior drainage facilities are compared. The minimum facilities should provide interior flood relief such that during low exterior stages the local storm drainage system functions essentially as it did without flood protection in place, up to that of the local storm sewer design. For this project, minimum facilities represent the minimum drainage required such that no induced flooding occurs during low exterior stages.

H95. The determination of interior facilities was conducted using guidance from EM 1110-2-1413. The strategy outlined under this guidance follows the premise that interior facilities will be planned and evaluated separately from the line-of-protection, and should provide adequate drainage at least equal to that of the existing infrastructure. This initial plan represents the minimum interior facilities required to implement the line-of-protection plan. In order to minimize the environmental impact of these facilities, the outlet pipes discharge to existing drainage ditches where possible.

Results of Minimum Facilities Analysis

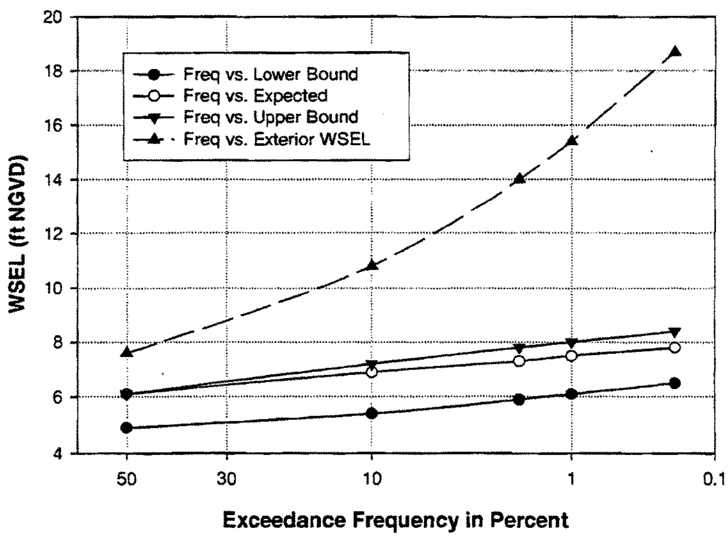
East Segment

H96. The minimum facilities for the East Segment line-of-protection, shown in Table H-16, consist of 4 primary and 2 secondary outlets. An additional 18-inch outlet has been added to provide tidal flushing of the wetland area located behind the line-of-protection between stations 41+00 and 52+00. A comparison of the existing conditions and minimum facilities impact on interior water surface elevations (WSELs) is shown in Figure H-15.

Table H-16 East Segment Minimum Facilities					
Outlet	Location (Approximate Station)	Size	Interior Invert(1) (ft NGVD)	Exterior Invert(1) (ft NGVD)	Tie to Existing Drainage Sys. (Yes/No)
Primary	6+00	36" RCP	0.1	0.0	Yes
Secondary	13+20	36" RCP	5.1	5.0	Yes
Primary	20+00	60" RCP	2.1	2.0	Yes
Primary	38+20	60" RCP(2)	0.1	0.0	No
Primary	49+30	60" RCP(2)	0.1	0.0	No
Secondary	49+50	18" RCP(3)	0.1	0.0	No
Secondary	58+00	36" RCP(4)	5.1	5.0	Yes

Notes:
(1) Estimated invert elevation.
(2) Requires ditch construction.
(3) Required for environmental purposes; no flap gate installed.
(4) Downstream of NJDOT Mitigation Site pump station.

Figure H-15
East Segment Interior WSEL Comparison
(Minimum Facility is 3x60" and 3x36" Outlets;
Shown with Future Sea Level)



West Segment

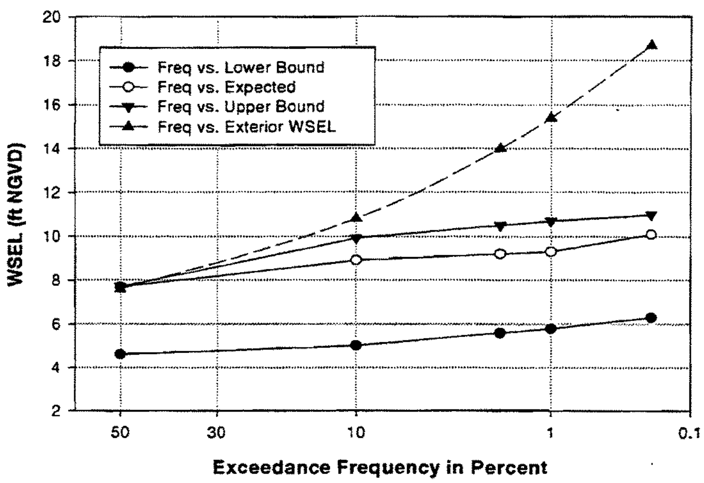
H97. The minimum facilities for the West Segment line-of-protection, shown in Table H-17, consist of 8 primary and 3 secondary outlets. Two of the outlets located station 36+00 do not have flap gates installed. This will allow tidal flushing of the wetlands behind the line-of-protection. A comparison of the existing conditions and minimum facilities impact on interior water surface elevations (WSELs) is shown in Figure H-16.

Table H-17
West Segment Minimum Facilities

Outlet	Location (Approximate Station)	Size	Interior Invert(1) (ft NGVD)	Exterior Invert(1) (ft NGVD)	Tie to Existing Drainage Sys. (Yes/No)
Secondary	11+00	24" RCP	0.1	0.0	No
Primary	15+00	60" RCP	0.1	0.0	No
Secondary	24+50	24" RCP	0.1	0.0	No
Primary	32+00	60" RCP 60" RCP 60" RCP	0.1	0.0	Yes
Primary	36+00	60" RCP 60" RCP(2) 60" RCP(2)	0.1	0.0	Yes
Secondary	44+00	60" RCP	0.1	0.0	Yes

Notes:
(1) Estimated invert elevations.
(2) No flap gates installed to allow for tidal flushing.

Figure H-16
West Segment Interior WSEL Comparison
(Minimum Facility is 9x60" and 2x24" Outlets;
Shown with Future Sea Level)

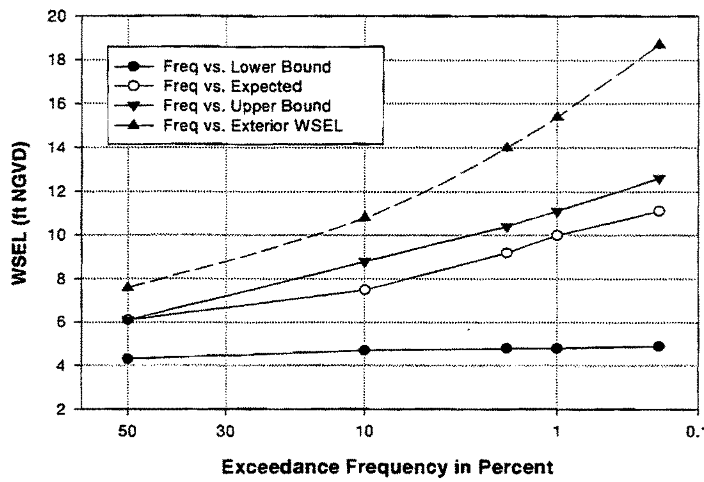


Main Channel

H98. In addition to the sector gates, the minimum facilities for the main channel include five 10-foot wide by 10-foot high culverts through the storm surge barrier on the right bank of the channel. A comparison of the existing conditions and minimum facilities impact on WSELs is shown in Figure H-17.

H99. Four culvert extensions were included in the minimum facilities costs but were not considered in the minimum facilities analysis. Four, approximately 60" pipe culverts with flap gates drain the wetland area just south of Veteran's Memorial Highway in the Borough of South River. These culverts will be extended through the West Segment levee section that parallels the highway at approximate levee stations 48+00 and 55+00, and fashioned with sluice gates, flap gates, and trash racks. Field visits indicated that some backflow through the existing flap gates currently occurs, providing limited flushing of the wetlands south of the highway. The installation of new flap gates on the culvert extensions could eliminate this limited flushing. Therefore, this component of the interior drainage facilities will need further analysis in the next phase of the project to determine if a means for providing limited flushing of the wetlands area (e.g., one or more 18" or 24" flow through outlets with sluice gates) should be included in the project.

Figure H-17
Main Channel Segment Interior WSEL Comparison
(Minimum Facility is Five 10ftx10ft Culverts;
Shown with Future Sea Level)



Summary

H100. Table H-18 provides a summary of the project minimum facility conditions.

Table H-18 Summary of Minimum Facility Conditions			
Sub-Basin	Construction Cost(1)	Annual Cost(2)	Expected Annual Residual Damages
East Segment	$606,800	$44,000	$168,400
West Segment	$1,029,700	$74,950	$209,100
Main Channel(3)	$2,107,600	$155,350	$902,250

(1) Includes E&D, S&A, contingency, and land costs.
(2) Includes Operation and Maintenance costs.
(3) Gravity outlet costs only.

Analysis of Alternative Plans

General

H101. The minimum facility plan was the starting point from which additional interior facilities planning commenced. The benefits accrued from alternative plans are attributable to the reduction in the residual flooding and damages which may have remained under the minimum facility condition. For an alternative plan to be justified, it must be implementable and reasonably maximize benefits versus the additional cost required for its construction, operation and maintenance. Plan alternatives examined include the use of pump stations and the diversion of upland runoff. Excavated ponds were not analyzed due to the impacts on freshwater wetlands. The following is a general description of various plan alternatives that were considered during the development of interior drainage facilities.

Pumping Plan

H102. Pumping plans incorporate the use of pump stations in conjunction with the minimum facility features developed for each interior area. Pump stations were considered as a means of reducing residual flood heights within interior storage areas through the mechanical displacement of accumulated surface runoff from the interior watershed. To determine how efficiently a pump station reduces flooding, the resultant reduction in residual flood damages is compared to the initial and annual costs of developing and operating the pump station.

H103. The costs of pumping alternatives are additive to the minimum facility cost. The construction of a pump station creates additional capital or first project costs and also increases annual maintenance and operation costs. Capital expenditures affected by the addition of pump stations include mechanical equipment and associated housing. In addition, the establishment of pump stations also increases the cost of project operation and maintenance, specifically in the area of power consumption and equipment operation, maintenance and replacement.

Diversion Plan

H104. Diversion plans include diversion of runoff from upland areas directly through the line-of-protection, bypassing natural storage areas. Diversion was considered as a means of reducing residual flood heights within interior storage areas through a reduction in the accumulated runoff entering the storage areas. To determine how efficiently a diversion plan reduces flooding, the resultant reduction in residual flood damages is compared to the initial and annual costs of constructing the diversion channel or pipeline.

H105. As with pumping alternatives, the costs of diversion alternatives are additive to the minimum facility cost. Capital expenditures affected by the addition of diversion pipes or channels primarily include excavation and construction of the diversion facilities. Additional O&M costs include maintenance of the manholes, and inspecting and clearing the pipe.

Interior Drainage Alternatives

East Segment Alternatives

H106. Pumping and diversion alternatives were considered for the East Segment interior drainage area. Pump station alternatives from 40cfs to 200 cfs were considered, alone and in conjunction with diversion. Diversion of 100cfs and 200cfs of upper drainage area runoff were analyzed.

H107. The interior drainage alternatives for East Segment are summarized in Table H-19.

West Segment Alternatives

H108. Pump station alternatives were primarily considered for the West Segment interior area due to the steep slope of the drainage area and relatively small ponding area. Pump capacities from (50cfs to 150cfs) were analyzed as alternatives to the minimum facilities.

H109. The pumping alternatives for West Segment are summarized in Table H-19.

Main Channel Alternatives

H110. Pumping alternatives of 1,000 cfs to 1,600 cfs were considered for the South River main storm gate. The pumping alternatives for the main river are also summarized in Table H-19.

Optimum Plan

H111. The optimum plan is defined as the plan that maximizes the net excess benefits over cost. As outlined within the description of minimum facility, the planning and development of interior drainage facilities is performed independently from the line-of-protection. Each interior drainage area is analyzed individually to determine the optimum alternative. Within each interior drainage area, the economics for a series of alternate facilities were evaluated and compared to determine which contributes the highest level of net excess benefits to the project. The optimum interior drainage alternative for each sub-basin is presented in Table H-20.

Table H-19
Summary of Interior Drainage Alternatives

Plan	Description	First Construction Cost(1) (Incremental)	First Land Cost(2)	Operation & Maintenance (Annual)(3)	Total Annual Cost	Equivalent Annual Damage	Annual Damage Reduction	Annual Net Benefit
East Segment								
MinFac	Minimum Facility	$593,600	$13,200	$4,800	$44,000	$168,400	$0	$0
Alt 4.1	40cfs pump	$638,500	$0	$30,000	$115,200	$132,000	$36,400	($34,830)
Alt 4.2	100cfs pump	$1,404,700	$0	$35,000	$169,700	$100,500	$67,900	($57,800)
Alt 4.3	100cfs diversion	$577,200	$9,600	$2,750	$84,650	$119,400	$49,000	**$8,300**
Alt 4.4	100cfs div & 40cfs pump	$1,215,740	$9,600	$32,750	$155,850	$95,800	$72,600	($39,260)
Alt 4.5	100cfs div & 100cfs pump	$1,981,940	$9,600	$37,750	$210,250	$71,600	$96,800	($69,430)
West Segment								
MinFac	Minimum Facility	$1,029,700	$0	$8,450	$74,950	$209,100	$0	**$0**
Alt 3.1	50 cfs pump	$702,400	$0	$30,000	$150,250	$151,700	$57,400	($17,900)
Alt 3.2	100 cfs pump	$1,404,700	$0	$35,000	$200,650	$121,200	$87,900	($37,800)
Alt 3.3	150 cfs pump	$2,107,100	$0	$40,000	$250,950	$103,300	$105,800	($70,200)
Main Gate								
MinFac	Minimum Facility	$2,107,600	$0	$19,250	$155,350	$902,250	$0	$0
Alt M1	1,000 cfs pump	$3,657,350	$0	$23,000	$414,450	$399,950	$502,300	$243,200
Alt M2	1,200 cfs pump	$4,078,750	$0	$25,400	$444,025	$326,250	$576,000	**$287,300**
Alt M3	1,400 cfs pump	$4,558,900	$0	$28,750	$478,400	$302,900	$599,350	$276,300
Alt M4	1,600 cfs pump	$5,235,700	$0	$32,500	$525,850	$258,600	$643,700	$273,200

(1) Minimum Facilities and Diversion First Cost includes Engineering and Design (15%), Supervision and Administration (7%), and Contingency (15%). For pumps, First Cost includes Engineering and Design (7%), Supervision and Administration (7%), and Contingency (12%).
(2) First Land Cost includes 5% Survey, Appraisal & Admin, and 10% Contingency.
(3) The replacement of flap/sluice gate/trash rack/pumps will occur every 25 years; Discount Rate = 6-1/8%; Project Life = 50 years.

Table H-20 Optimum Interior Drainage Plan Summary				
Basin	**Description**	**First Construction Cost(2)**	**Total Annual Cost(3)**	**Residual Annual Damages(3)**
East Segment	100 cfs Diversion(1)	$1,193,600	$84,650	$119,400
West Segment	Minimum Facility	$1,029,700	$74,950	$209,100
Main Gate	1,200cfs Pump Station(1)	$6,186,340	$444,000	$326,250

(1) Includes Minimum Facilities
(2) Includes E&D (15%), S&A (7%), and Contingency (15%), except pump stations (7%; 7%; 12%); and land costs.
(3) Annual Costs and Residual Damages are based on a discount rate of 6-1/8% and a 50-year project life; Annual Costs include Operation and Maintenance, and Replacement.

Selected Interior Plans

H112. As described above, alternative interior drainage plans were formulated to provide safe and reliable protection from interior flooding. Due consideration was given to evaluating only feasible alternatives, that is, alternatives that are implementable and provide equitable protection to properties within the line-of-protection. Selection of a recommended plan thus focused on economics, that is, providing the optimum reduction in damages for the cost of protection.

H113. Using these criteria, a 100 cfs diversion of upper drainage area flow was selected for recommendation for the East Segment line-of-protection, minimum facilities were selected for recommendation for the West Segment line-of-protection, while a 1,200 cfs pumping station was selected for recommendation for the Main Channel line-of-protection. Table H-21 summarizes the selected plan costs and annual damages. Figure H-18 presents stage-frequency curves for each of the selected interior plans. Typical outlet structures for the Selected Plan are presented in Figures I-19 through I-22.

H114. The selected interior drainage plan is shown in Figures H-22a through H-33.

Figure H-18
Selected Plans Int/Ext WSEL Comparision
(Design Interior WSEL)

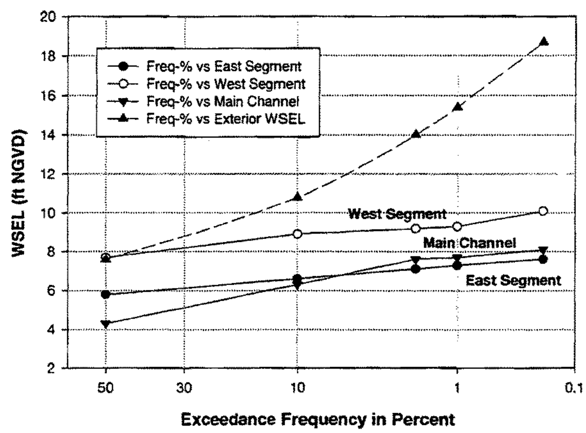


Table H-21
Selected Interior Drainage Plan Summary

Basin	Facility	Number of Gravity Outlets & Size	Total Pump Station Size	First Construction Cost*	Land Cost	O&M Cost	Annual Cost	Annual Residual Damages	Significant Damage Elevation (ft NGVD)	Street Flooding Elevation (ft NGVD)
East Segment	100 cfs Diversion	930ft 60" dia. diversion pipe; 5@36" dia. 3@60" dia. 1@18" dia.	N/A	$1,193,600	$22,800	$7,550	$84,650	$119,400	5.0	4.5
West Segment	Minimum Facilities	2@24" dia. 9@60" dia.	N/A	$1,029,700	$0	$8,450	$74,950	$209,100	7.0	6.5
Main Channel	1,200cfs Pump Station	5@10'x10' box culverts; 4@60" dia.	1,200 cfs	$6,186,340	$0	$44,600	$444,000	$326,250	5.0	4.5
TOTAL				**$8,409,640**	**$22,800**	**$60,600**	**$603,600**	**$654,750**		

*includes Minimum Facilities

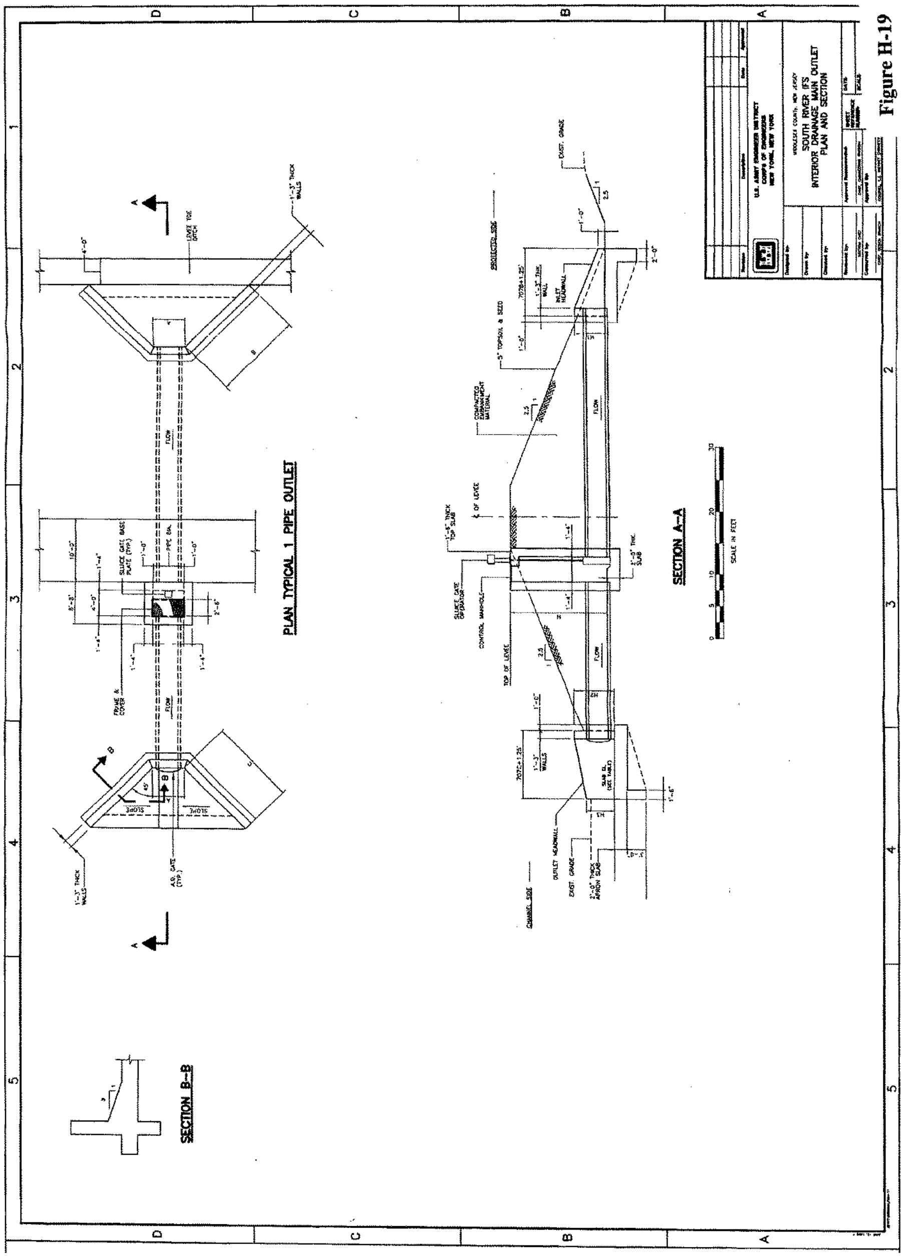

PLAN TYPICAL 1 PIPE OUTLET
SECTION A-A
SECTION B-B
SCALE IN FEET
SOUTH RIVER IFS
INTERIOR DRAINAGE MAIN OUTLET
PLAN AND SECTION

Figure H-19

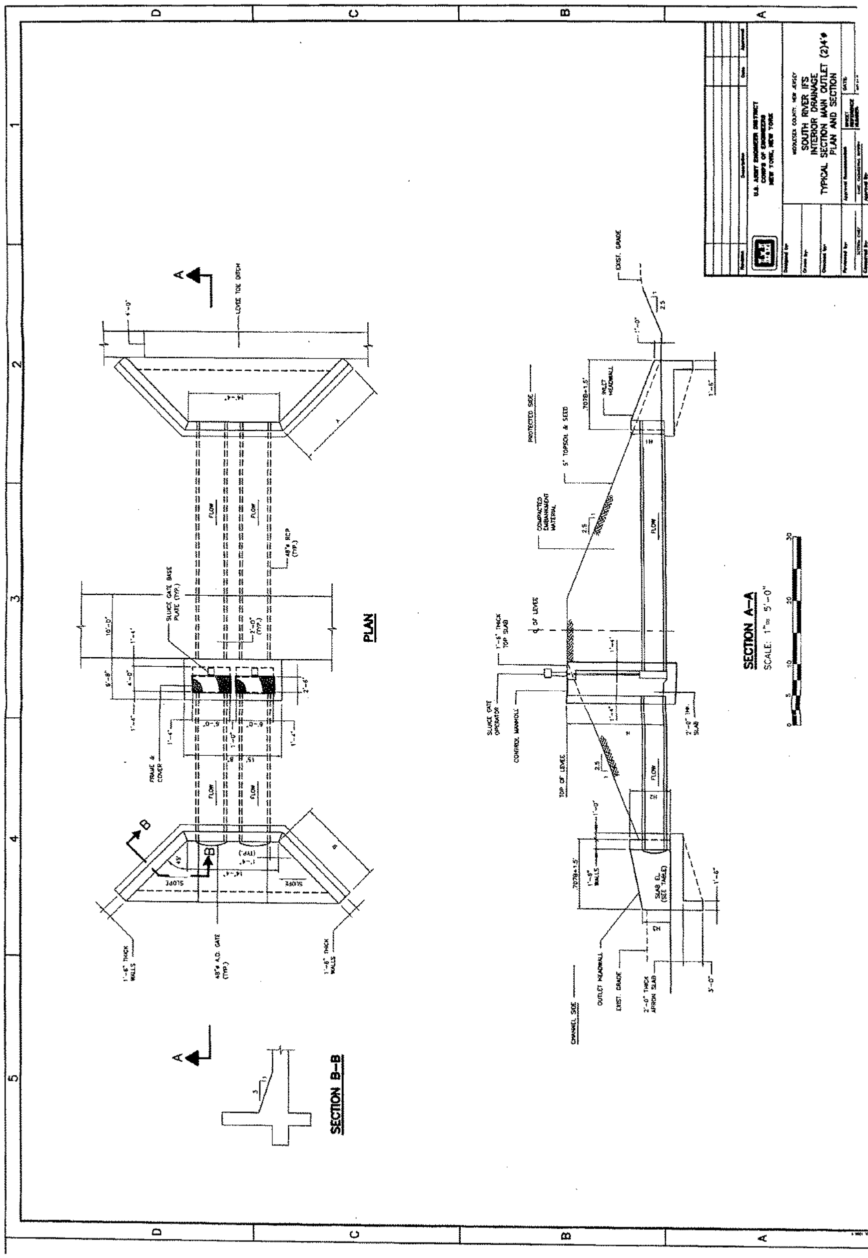

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
NEW YORK, NEW YORK
MIDDLESEX COUNTY, NEW JERSEY
SOUTH RIVER IFS
INTERIOR DRAINAGE
TYPICAL SECTION MAIN OUTLET (2)4'⌀
PLAN AND SECTION
PLAN
SECTION A–A
SCALE: 1"= 5'-0"
SECTION B–B
FLOW
PROTECTED SIDE
CHANNEL SIDE
EXIST. GRADE
OUTLET HEADWALL
INLET HEADWALL
TOP OF LEVEE
CONTROL MANHOLE
SLUICE GATE OPERATOR
LEVEE TOE DITCH

Figure H-20

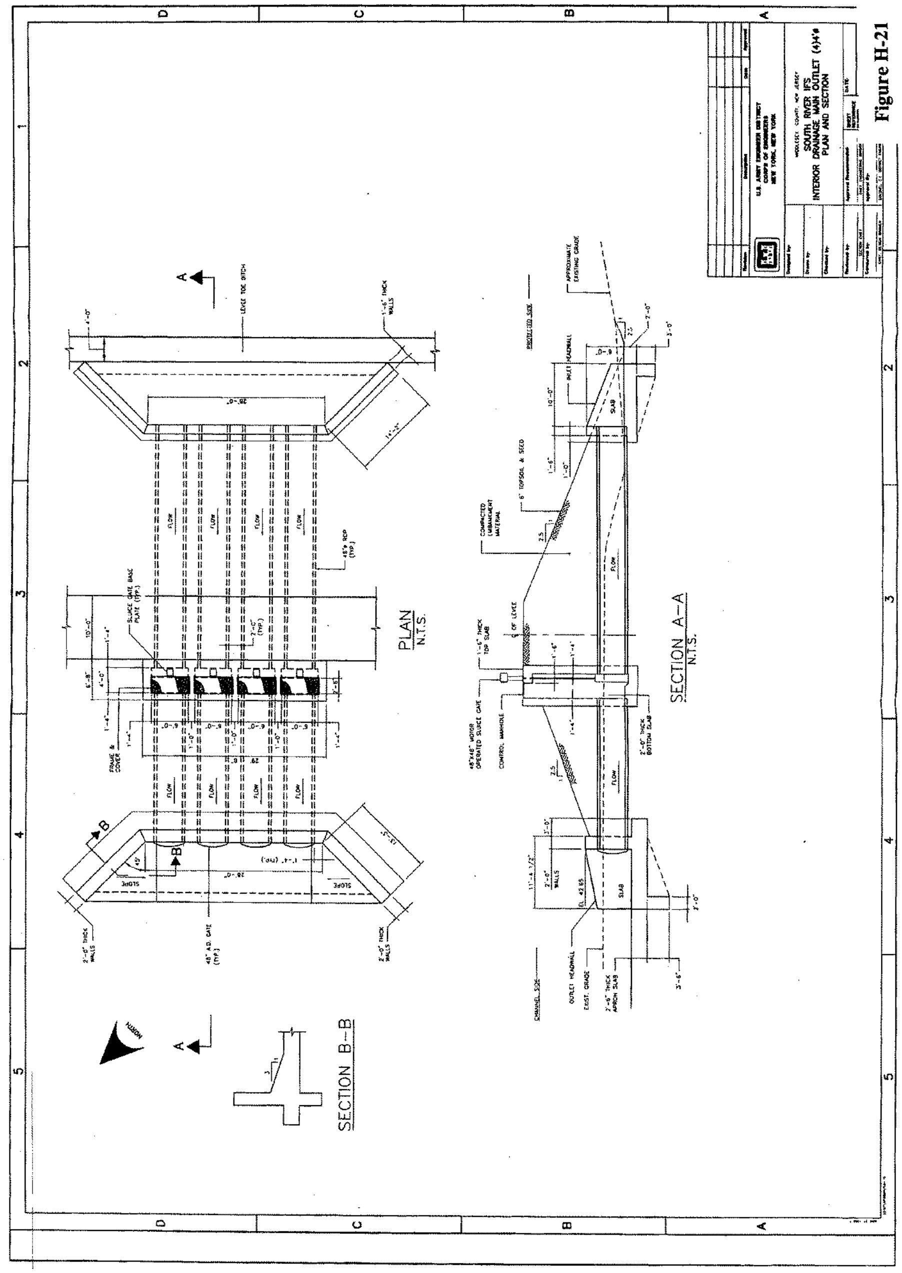

PLAN
N.T.S.
SECTION A–A
N.T.S.
SECTION B–B
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
NEW YORK, NEW YORK
SOUTH RIVER IFS
INTERIOR DRAINAGE MAIN OUTLET
PLAN AND SECTION

Figure H-21

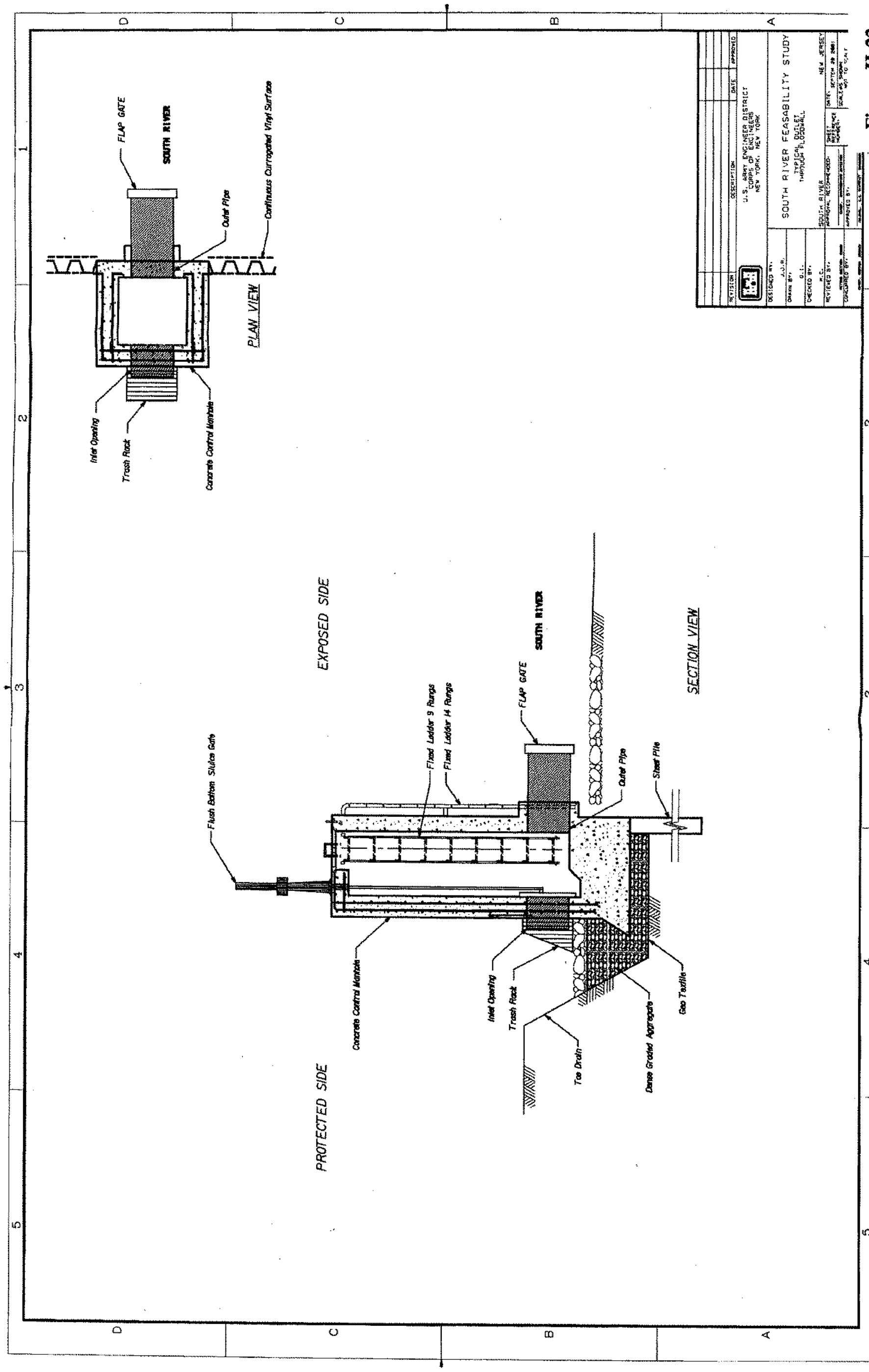

FLAP GATE
SOUTH RIVER
Outlet Pipe
Continuous Corrugated Vinyl Surface
Inlet Opening
Trash Rack
Concrete Control Manhole
PLAN VIEW
EXPOSED SIDE
PROTECTED SIDE
Flush Bottom Sluice Gate
Fixed Ladder 9 Rungs
Fixed Ladder 14 Rungs
FLAP GATE
SOUTH RIVER
Outlet Pipe
Steel Pile
Concrete Control Manhole
Inlet Opening
Trash Rack
Toe Drain
Dense Graded Aggregate
Geo Textile
SECTION VIEW
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
NEW YORK, NEW YORK
SOUTH RIVER FEASABILITY STUDY
TYPICAL OUTLET
THROUGH FLOODWALL
SOUTH RIVER
NEW JERSEY

Figure H-22

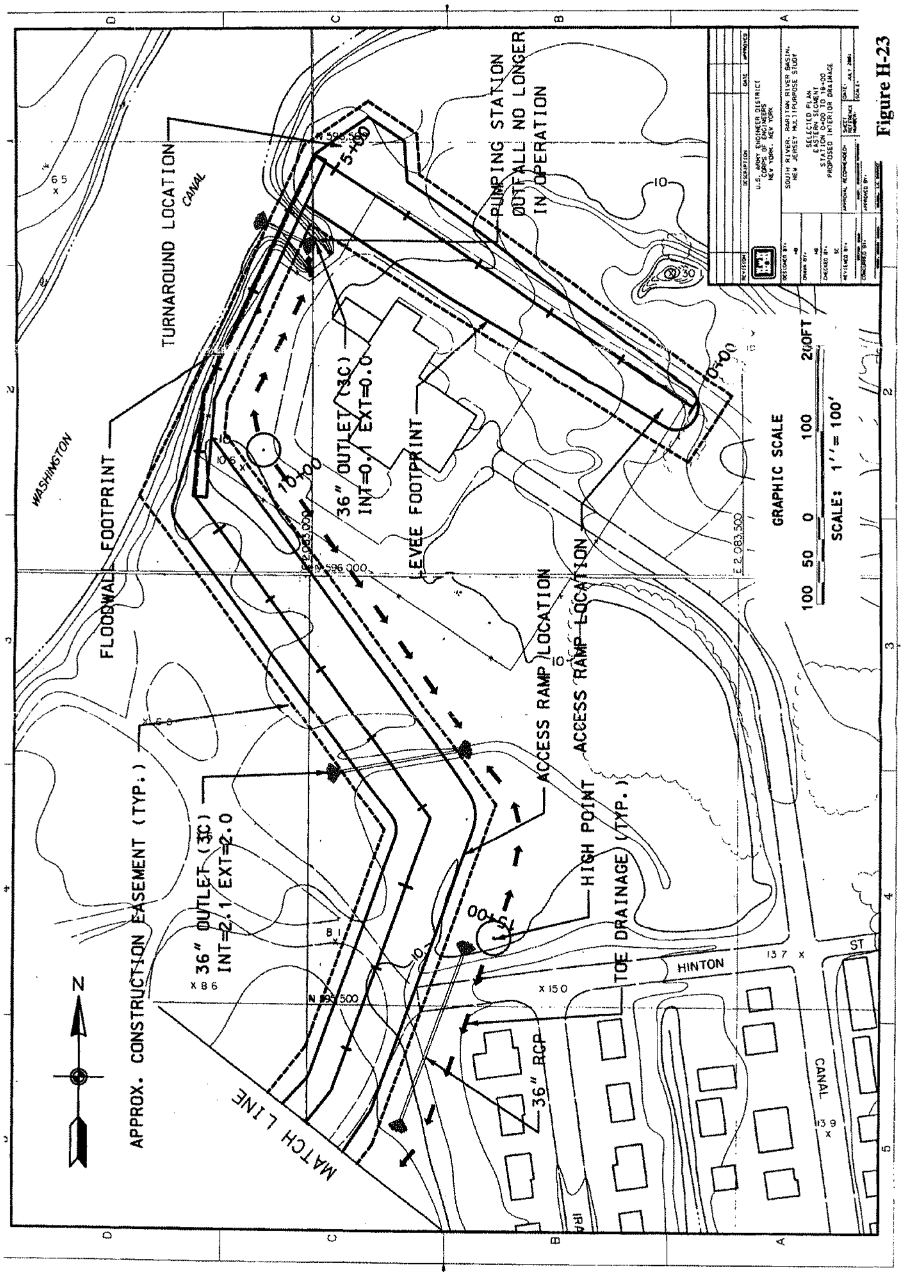

TURNAROUND LOCATION
PUMPING STATION
OUTFALL NO LONGER
IN OPERATION
FLOODWALL FOOTPRINT
LEVEE FOOTPRINT
36" OUTLET (3C)
INT=0.1 EXT=0.0
ACCESS RAMP LOCATION
HIGH POINT
TOE DRAINAGE (TYP.)
APPROX. CONSTRUCTION EASEMENT (TYP.)
36" OUTLET (3C)
INT=2.1 EXT=2.0
36" RCP
MATCH LINE
WASHINGTON
CANAL
HINTON
ST
GRAPHIC SCALE
100 50 0 100 200FT
SCALE: 1'' = 100'
N

Figure H-23

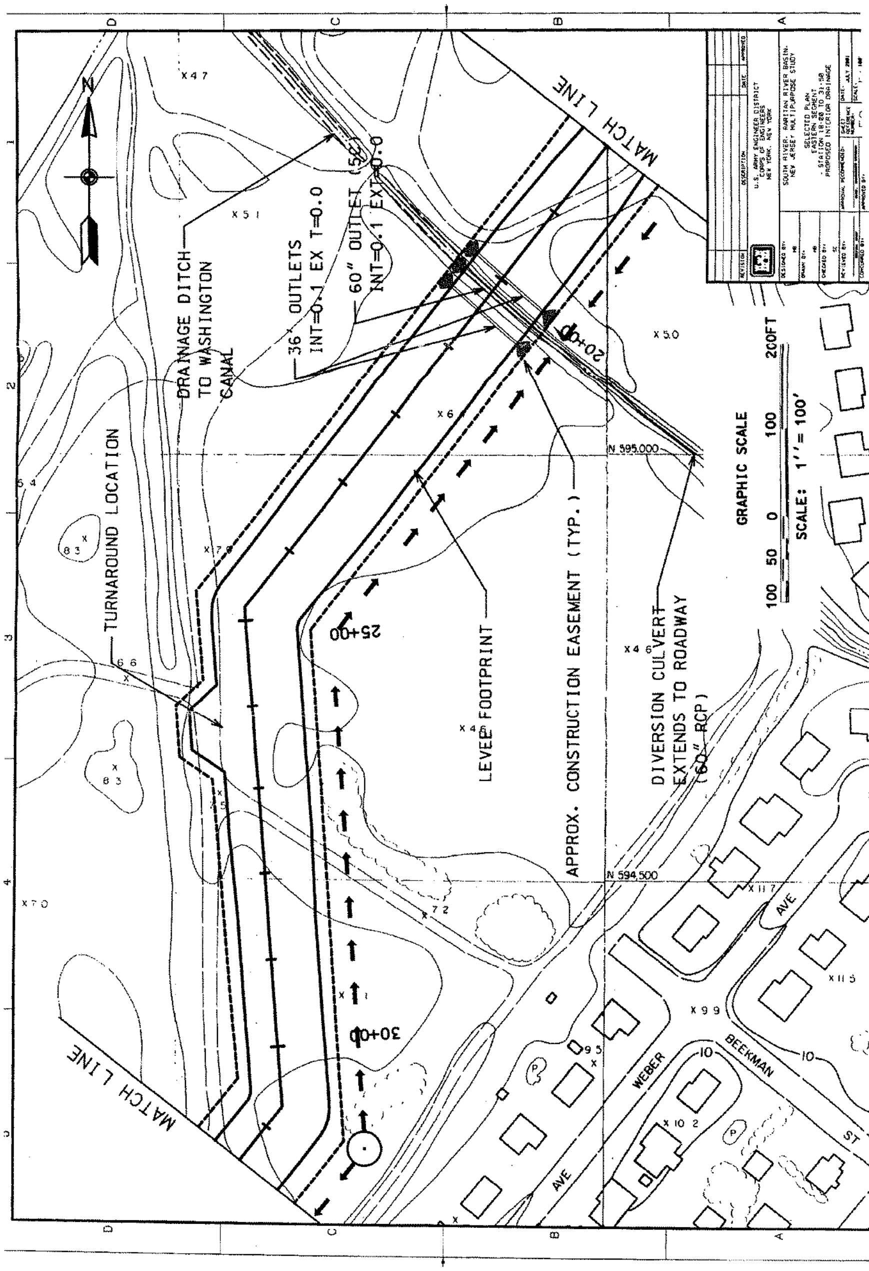

MATCH LINE
TURNAROUND LOCATION
DRAINAGE DITCH TO WASHINGTON CANAL
36" OUTLETS INT=0.1 EX T=0.0
60" OUTLET (5) INT=0.1 EXT=0.0
20+00
25+00
30+00
LEVEE FOOTPRINT
APPROX. CONSTRUCTION EASEMENT (TYP.)
DIVERSION CULVERT EXTENDS TO ROADWAY (60" RCP)
N 595,000
N 594,500
GRAPHIC SCALE
100 50 0 100 200FT
SCALE: 1''=100'
WEBER AVE
BEEKMAN ST
MATCH LINE

Figure H-24

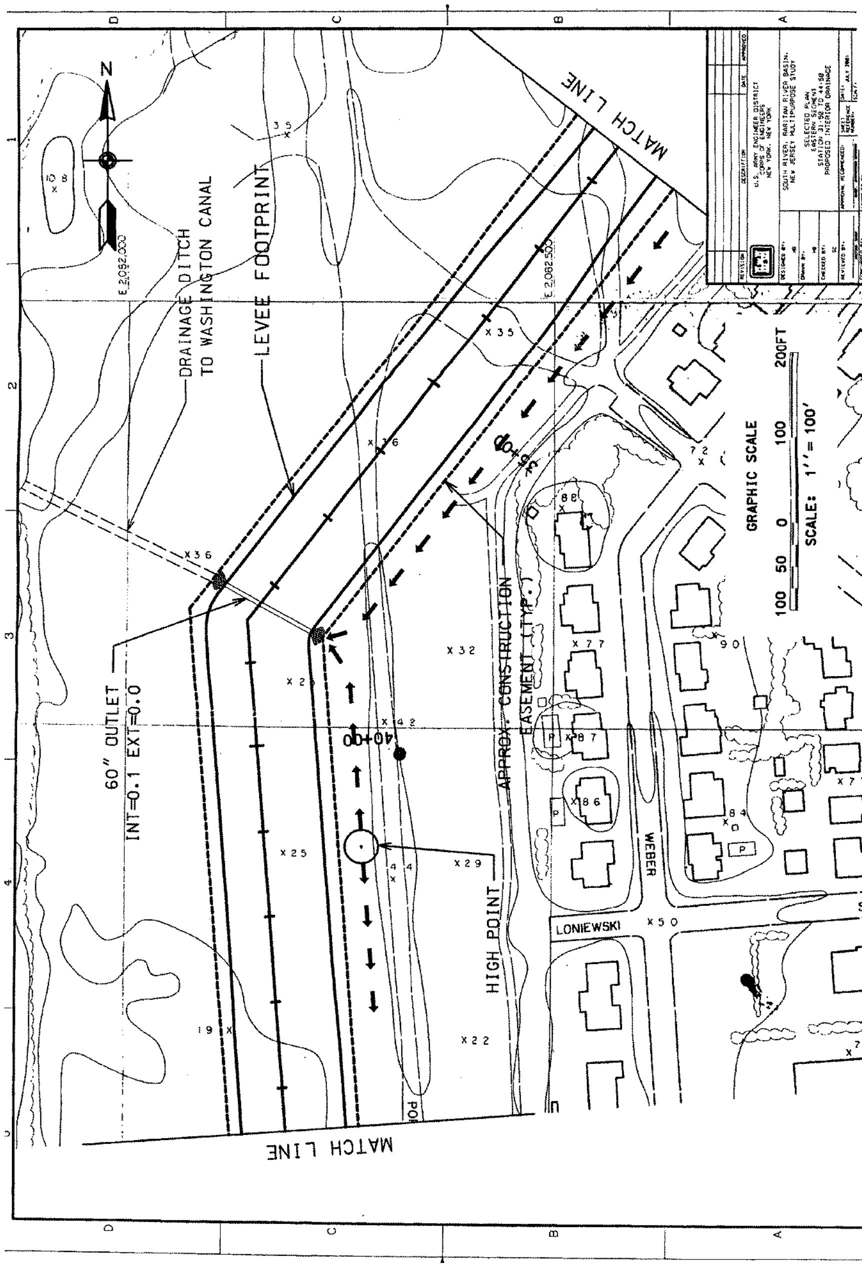

N
MATCH LINE
DRAINAGE DITCH
TO WASHINGTON CANAL
LEVEE FOOTPRINT
35+00
40+00
60" OUTLET
INT=0.1 EXT=0.0
HIGH POINT
APPROX. CONSTRUCTION
EASEMENT (TYP.)
WEBER
LONIEWSKI
ST
GRAPHIC SCALE
100 50 0 100 200FT
SCALE: 1'' = 100'
MATCH LINE

Figure H-25

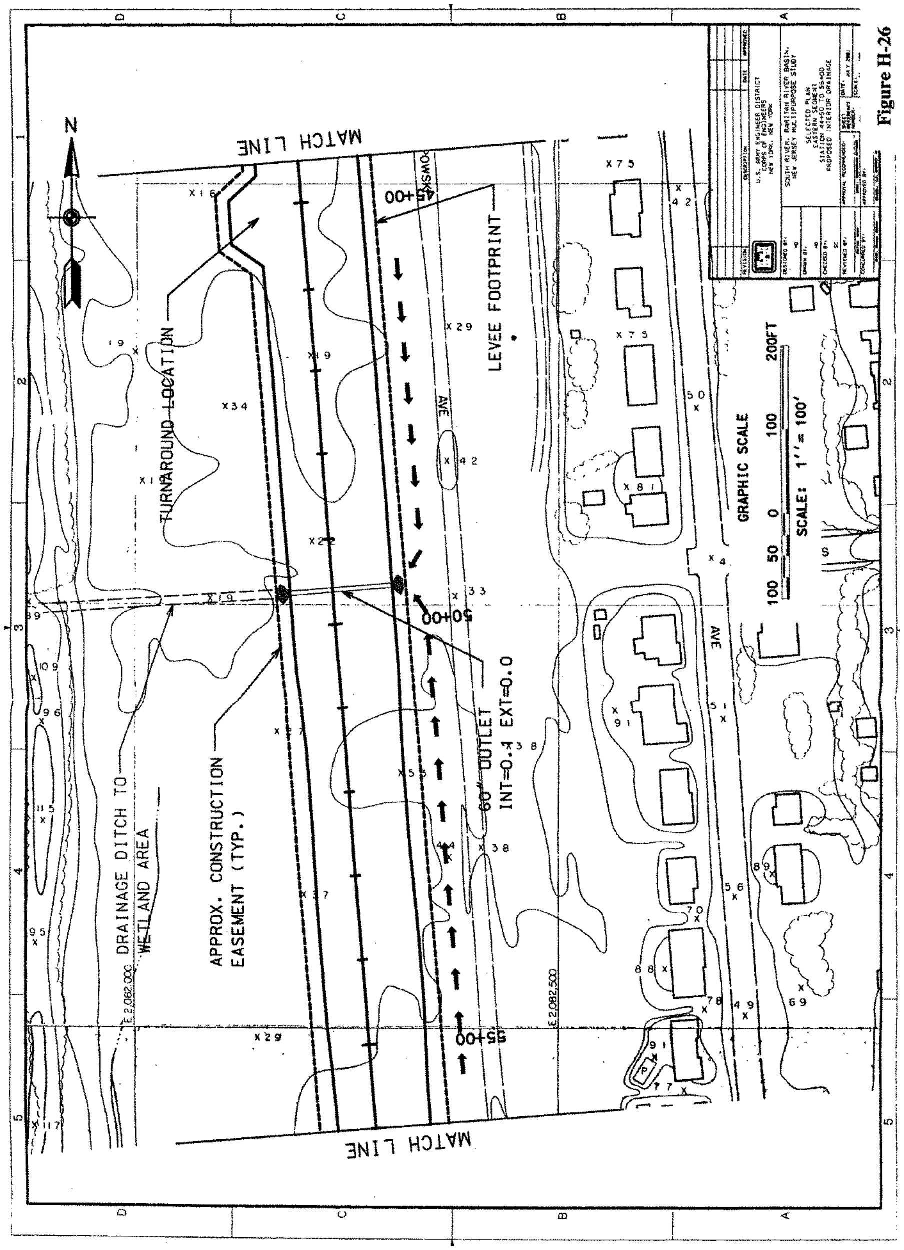

MATCH LINE
N
TURNAROUND LOCATION
LEVEE FOOTPRINT
45+00
50+00
55+00
60" OUTLET
INT=0.4 EXT=0.0
DRAINAGE DITCH TO
WETLAND AREA
APPROX. CONSTRUCTION
EASEMENT (TYP.)
AVE
GRAPHIC SCALE
100 50 0 100 200FT
SCALE: 1''= 100'
MATCH LINE

Figure H-26

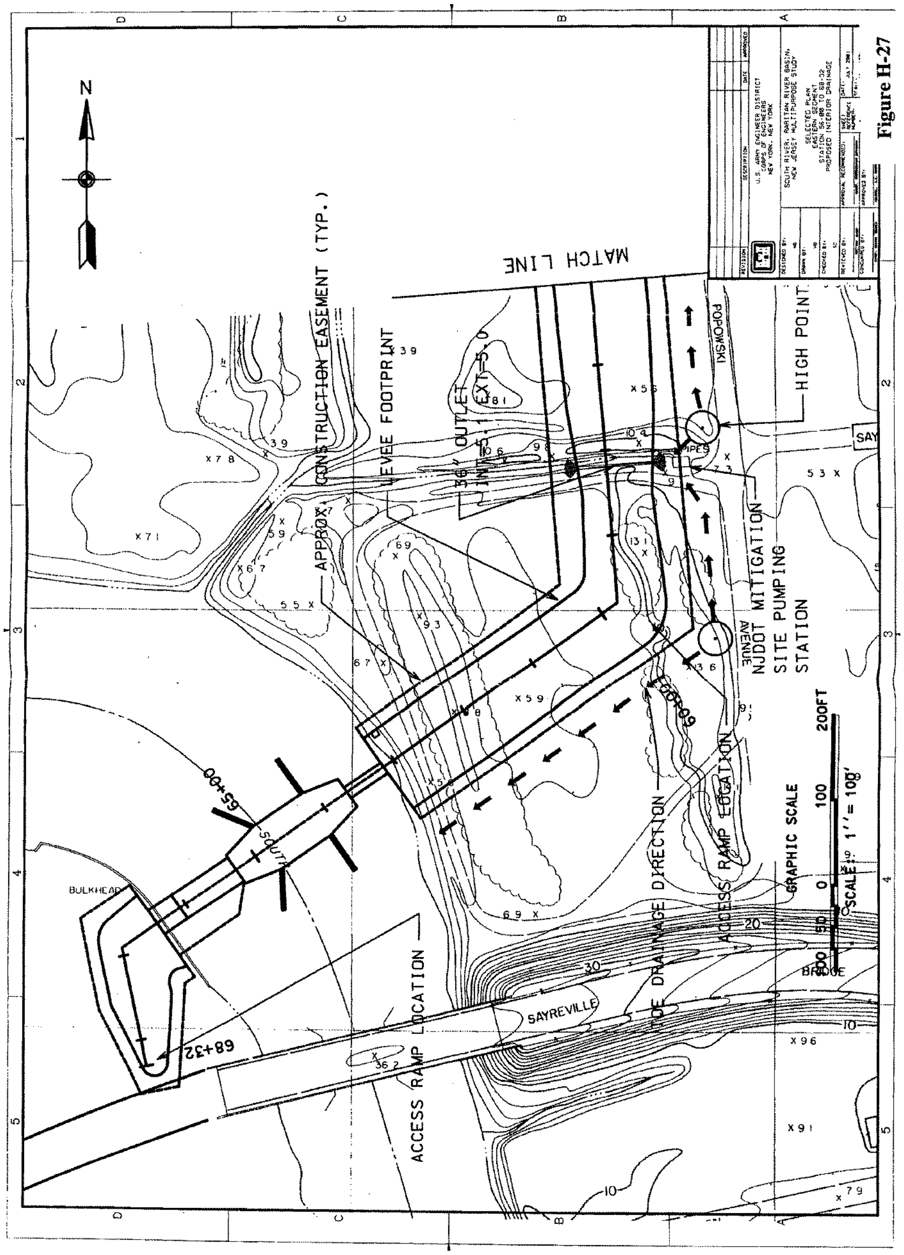

MATCH LINE
N
APPROX. CONSTRUCTION EASEMENT (TYP.)
LEVEE FOOTPRINT
36" OUTLET
HIGH POINT
NJDOT MITIGATION
SITE PUMPING
STATION
POPOWSKI
AVENUE
TOE DRAINAGE DIRECTION
ACCESS RAMP LOCATION
ACCESS RAMP LOCATION
GRAPHIC SCALE
SCALE: 1'' = 100'
200FT
BULKHEAD
SAYREVILLE
BRIDGE
65+00
68+32
60+00

Figure H-27

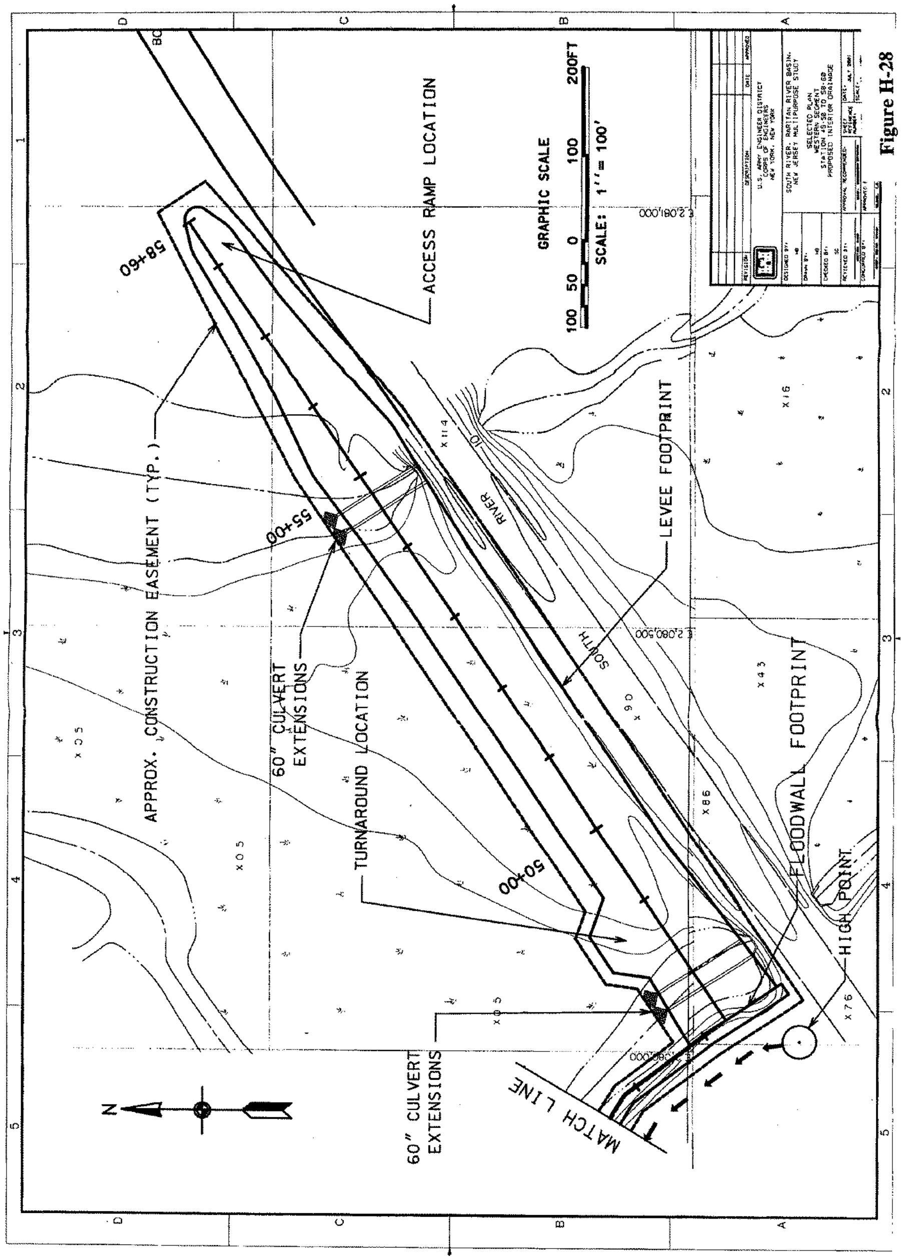
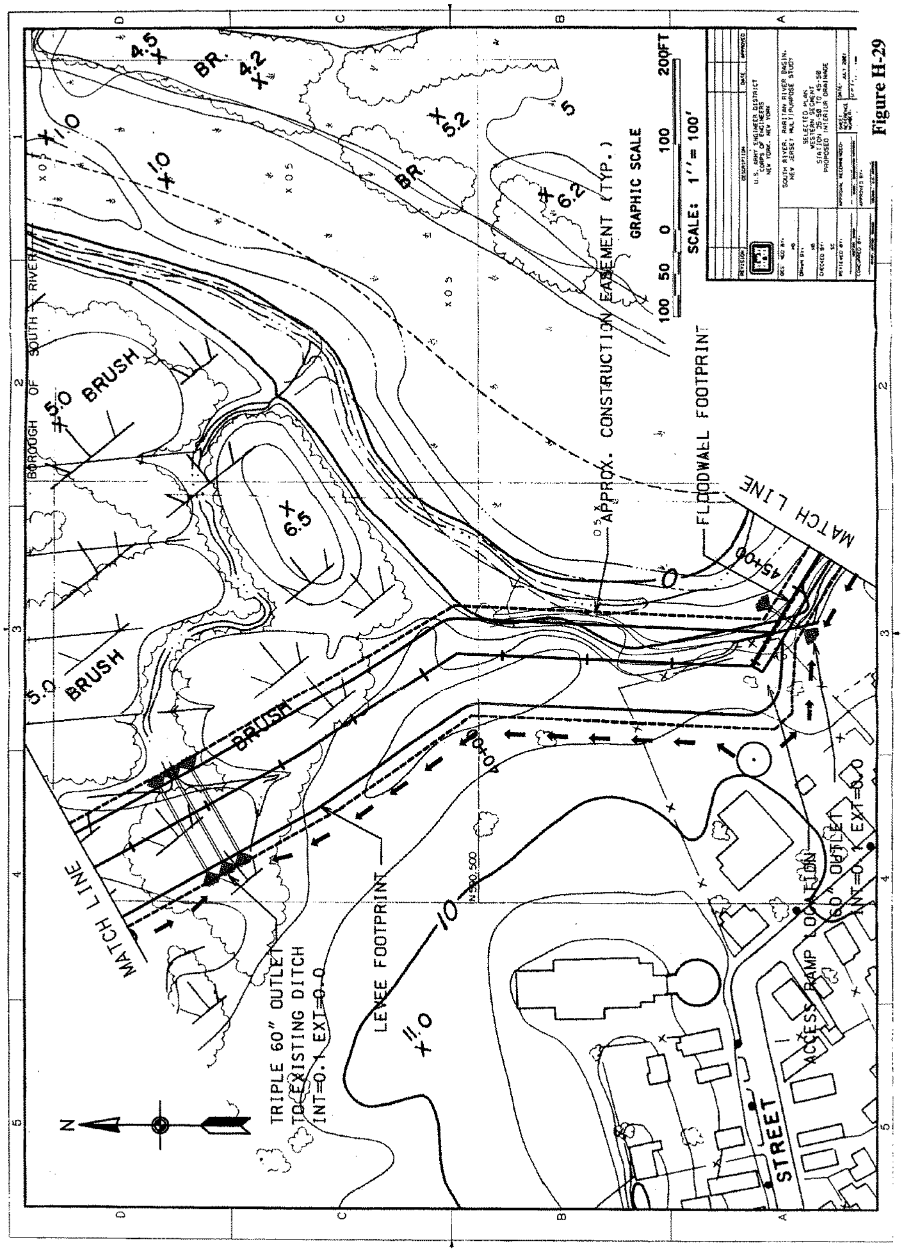

ACCESS RAMP LOCATION
GRAPHIC SCALE
100 50 0 100 200FT
SCALE: 1'' = 100'
58+60
55+00
50+00
APPROX. CONSTRUCTION EASEMENT (TYP.)
60" CULVERT EXTENSIONS
TURNAROUND LOCATION
LEVEE FOOTPRINT
SOUTH RIVER
FLOODWALL FOOTPRINT
HIGH POINT
60" CULVERT EXTENSIONS
MATCH LINE
N

Figure H-28


BOROUGH OF SOUTH RIVER
BRUSH
BRUSH
BRUSH
BR.
BR.
APPROX. CONSTRUCTION EASEMENT (TYP.)
FLOODWALL FOOTPRINT
LEVEE FOOTPRINT
MATCH LINE
MATCH LINE
TRIPLE 60" OUTLET
TO EXISTING DITCH
INT=0.1 EXT=0.0
60" OUTLET
INT=0.1 EXT=0.0
ACCESS RAMP LOCATION
STREET
GRAPHIC SCALE
100 50 0 100 200FT
SCALE: 1'' = 100'
45+00
40+00
N
Figure H-29

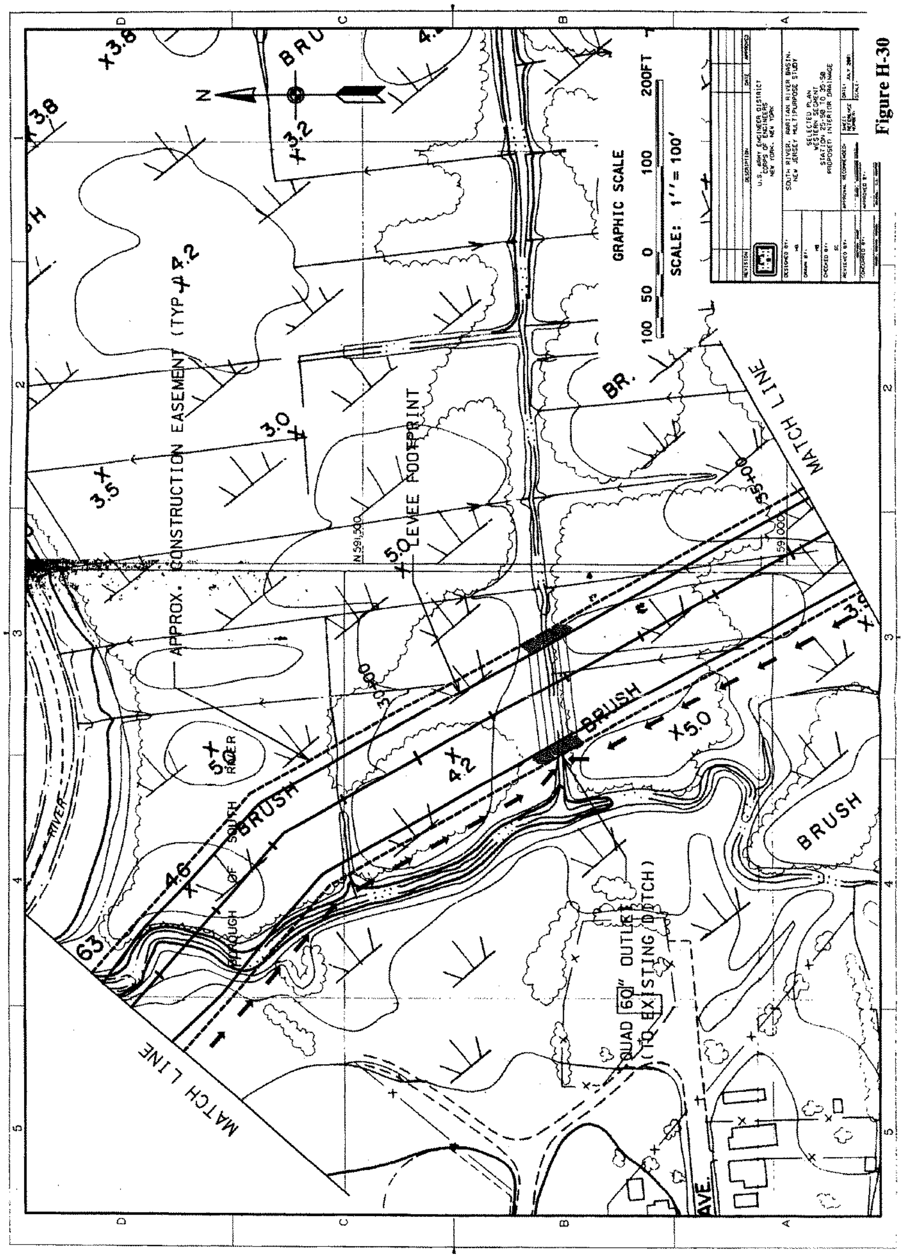

APPROX. CONSTRUCTION EASEMENT (TYP.)
LEVEE FOOTPRINT
MATCH LINE
MATCH LINE
BRUSH
BRUSH
BRUSH
SOUTH RIVER
GRAPHIC SCALE
100 50 0 100 200FT
SCALE: 1'' = 100'
QUAD 60" OUTLET
(TO EXISTING DITCH)
30+00
35+00
AVE.

Figure H-30

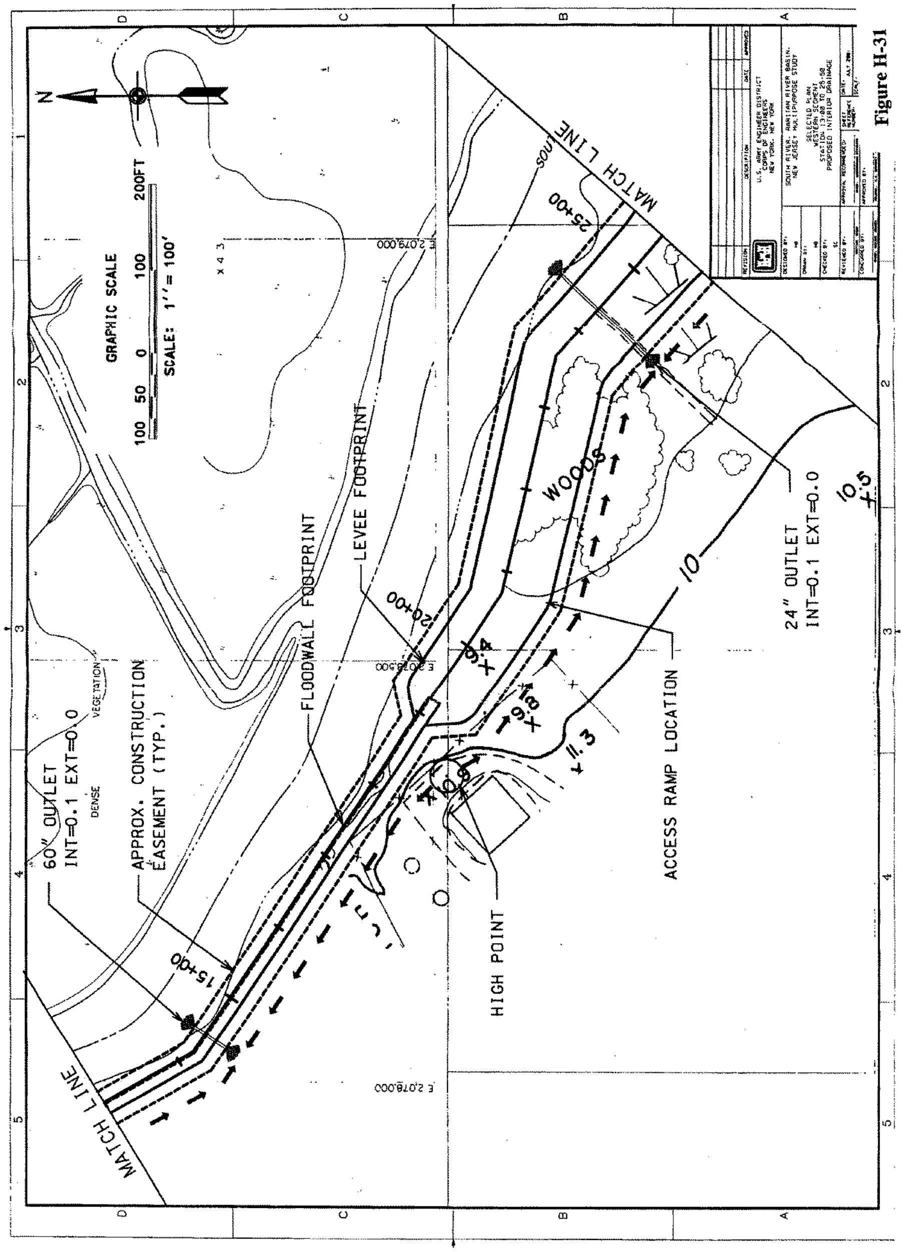
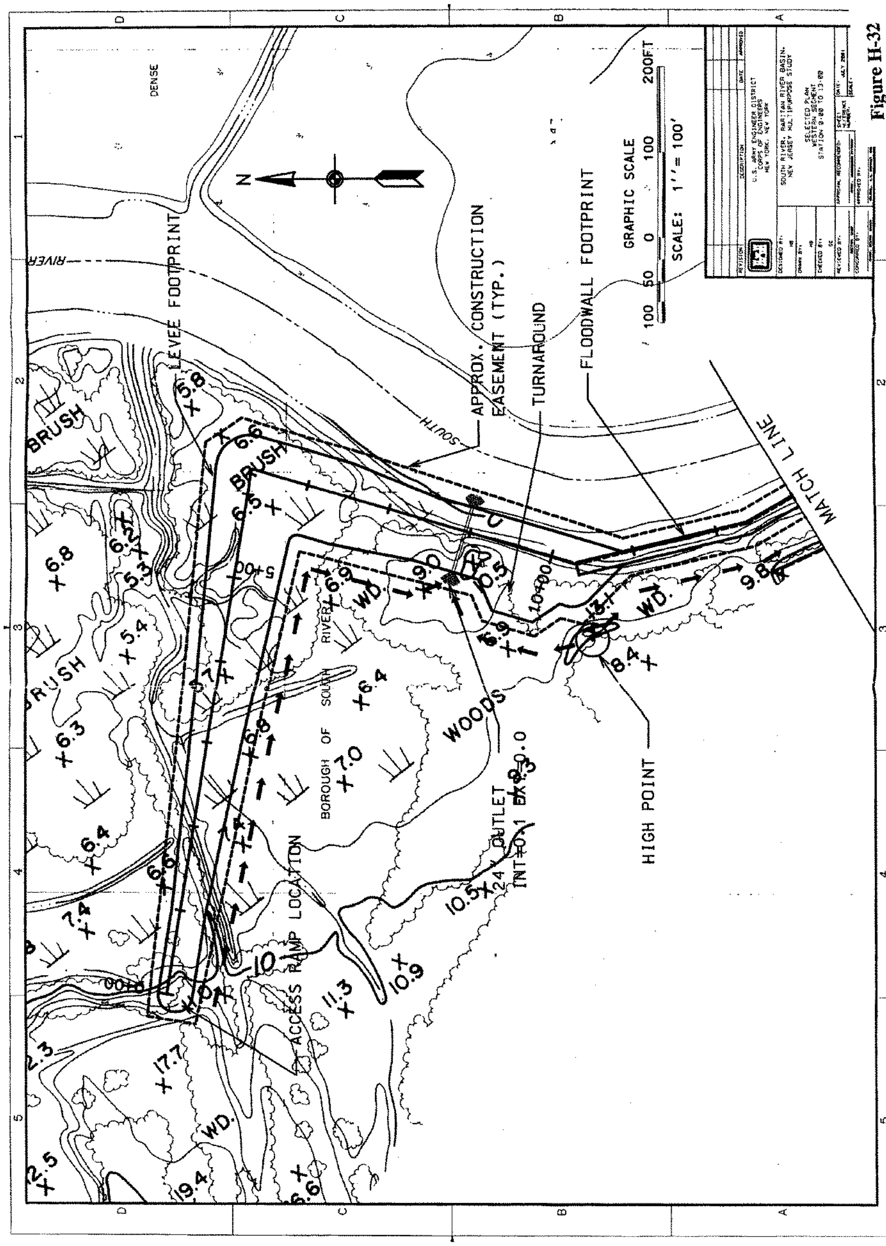

MATCH LINE
GRAPHIC SCALE
100 50 0 100 200FT
SCALE: 1'' = 100'
60" OUTLET
INT=0.1 EXT=0.0
APPROX. CONSTRUCTION
EASEMENT (TYP.)
FLOODWALL FOOTPRINT
LEVEE FOOTPRINT
15+00
20+00
25+00
WOODS
HIGH POINT
ACCESS RAMP LOCATION
24" OUTLET
INT=0.1 EXT=0.0
MATCH LINE

Figure H-31



LEVEE FOOTPRINT
APPROX. CONSTRUCTION
EASEMENT (TYP.)
TURNAROUND
FLOODWALL FOOTPRINT
GRAPHIC SCALE
100 50 0 100 200FT
SCALE: 1'' = 100'
MATCH LINE
HIGH POINT
ACCESS RAMP LOCATION
BOROUGH OF SOUTH RIVER
WOODS
BRUSH
DENSE
SOUTH
RIVER
WD.
OUTLET
N

Figure H-32

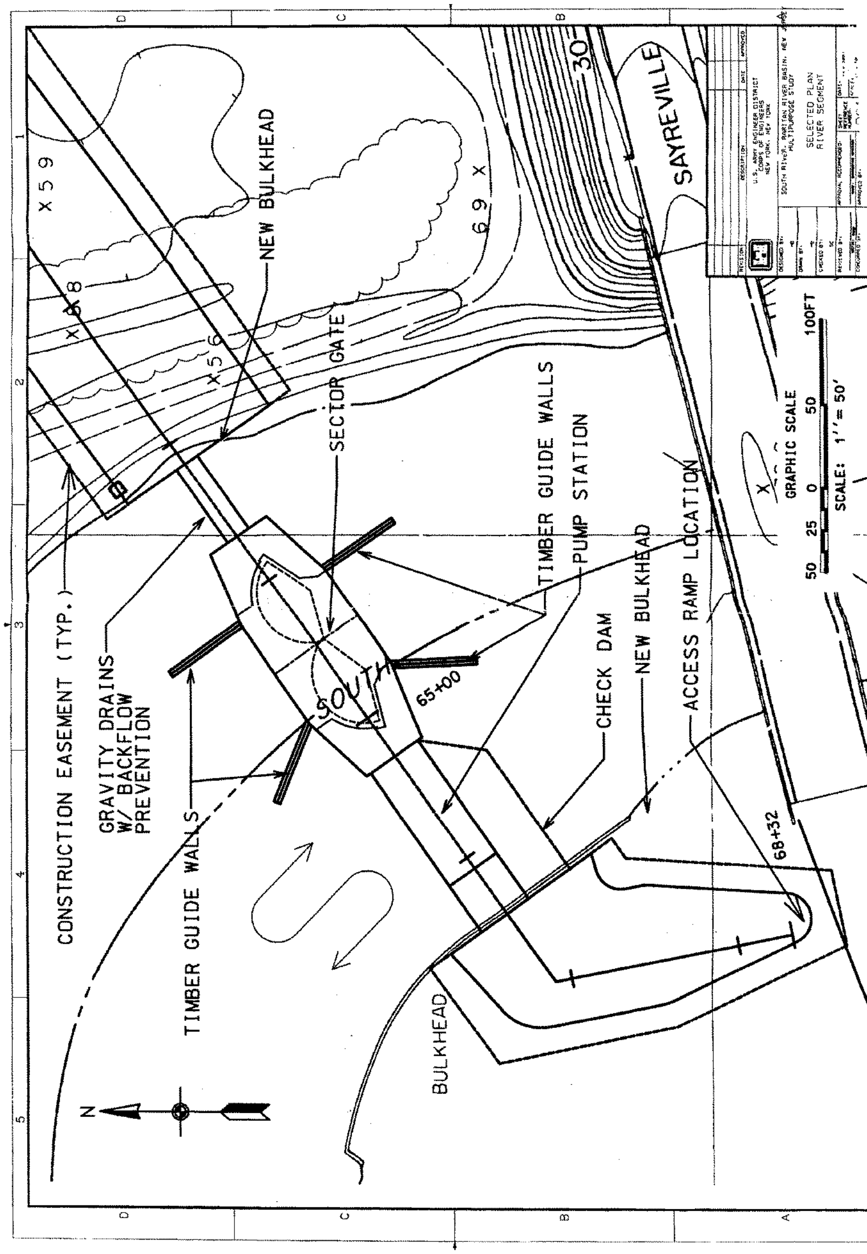

NEW BULKHEAD
SECTOR GATE
TIMBER GUIDE WALLS
PUMP STATION
CHECK DAM
NEW BULKHEAD
ACCESS RAMP LOCATION
CONSTRUCTION EASEMENT (TYP.)
GRAVITY DRAINS
W/ BACKFLOW
PREVENTION
TIMBER GUIDE WALLS
BULKHEAD
SOUTH
65+00
68+32
SAYREVILLE
30
GRAPHIC SCALE
50 25 0 50 100FT
SCALE: 1'' = 50'
SELECTED PLAN
RIVER SEGMENT
N

Figure H-33

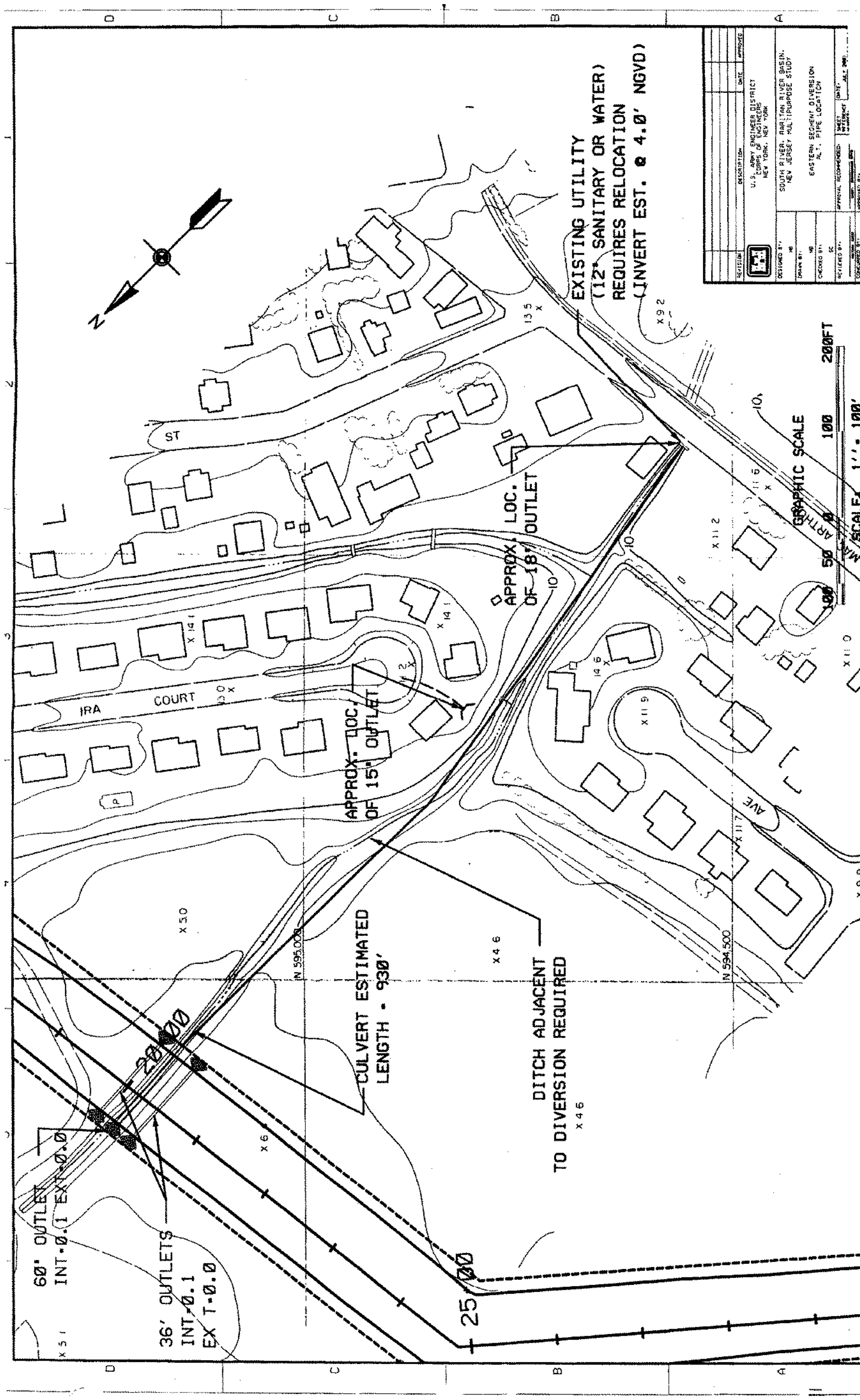
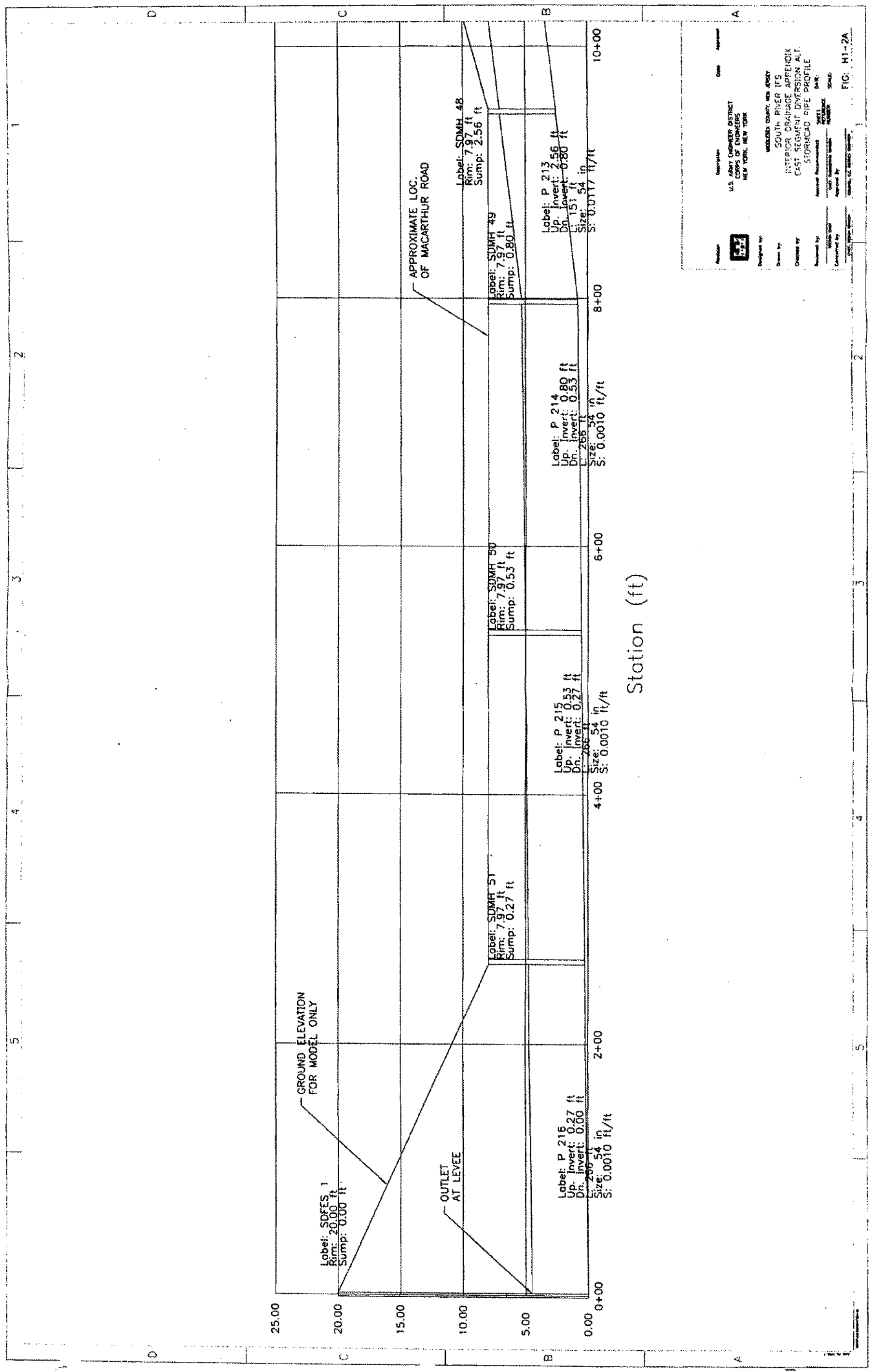
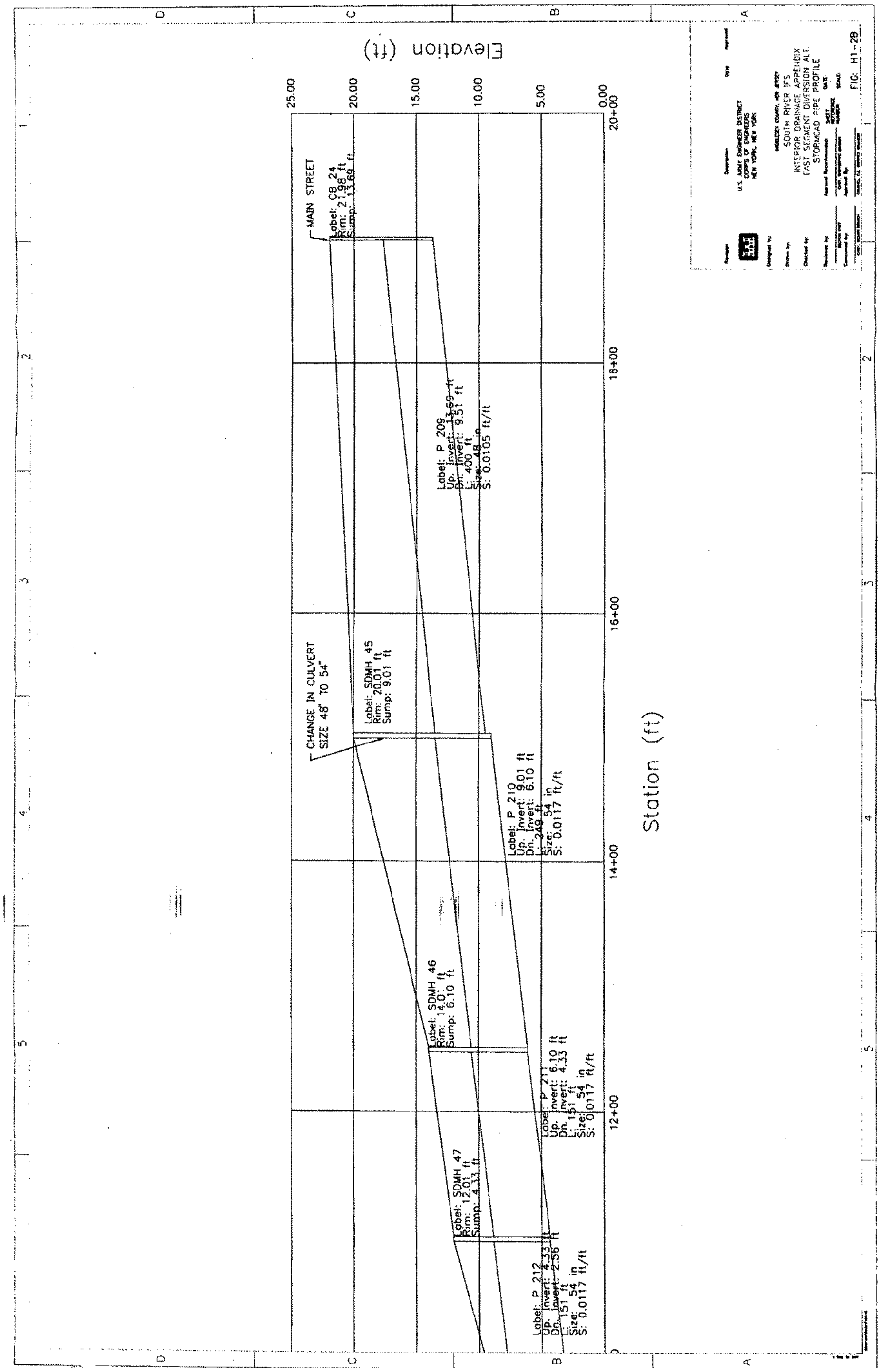

EXISTING UTILITY
(12" SANITARY OR WATER)
REQUIRES RELOCATION
(INVERT EST. @ 4.0' NGVD)
APPROX. LOC.
OF 18' OUTLET
APPROX. LOC.
OF 15' OUTLET
IRA
COURT
ST
AVE
GRAPHIC SCALE
SCALE: 1''= 100'
CULVERT ESTIMATED
LENGTH - 930'
DITCH ADJACENT
TO DIVERSION REQUIRED
60' OUTLET
36' OUTLETS
INT-0.1
EX T-0.0
N 595,000
N 594,500
25+00
20+00

Figure H1-1


Label: SDFES 1
Rim: 20.00 ft
Sump: 0.00 ft
GROUND ELEVATION FOR MODEL ONLY
OUTLET AT LEVEE
Label: P 216
Up. Invert: 0.27 ft
Dn. Invert: 0.00 ft
L: 268 ft
Size: 54 in
S: 0.0010 ft/ft
Label: SDMH 51
Rim: 7.97 ft
Sump: 0.27 ft
Label: P 215
Up. Invert: 0.53 ft
Dn. Invert: 0.27 ft
L: 266 ft
Size: 54 in
S: 0.0010 ft/ft
Label: SDMH 50
Rim: 7.97 ft
Sump: 0.53 ft
Label: P 214
Up. Invert: 0.80 ft
Dn. Invert: 0.53 ft
L: 266 ft
Size: 54 in
S: 0.0010 ft/ft
Label: SDMH 49
Rim: 7.97 ft
Sump: 0.80 ft
APPROXIMATE LOC. OF MACARTHUR ROAD
Label: P 213
Up. Invert: 2.56 ft
Dn. Invert: 0.80 ft
L: 151 ft
Size: 54 in
S: 0.0117 ft/ft
Label: SDMH 48
Rim: 7.97 ft
Sump: 2.56 ft
25.00
20.00
15.00
10.00
5.00
0.00
0+00
2+00
4+00
6+00
8+00
10+00
Station (ft)
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
NEW YORK, NEW YORK
MIDDLESEX COUNTY, NEW JERSEY
SOUTH RIVER IFS
INTERIOR DRAINAGE APPENDIX
EAST SEGMENT DIVERSION ALT.
STORMCAD PIPE PROFILE
FIG: H1-2A


Elevation (ft)
25.00
20.00
15.00
10.00
5.00
0.00
20+00
18+00
16+00
14+00
12+00
Station (ft)
MAIN STREET
Label: CB 24
Rim: 21.98 ft
Sump: 13.69 ft
Label: P 209
Up. Invert: 13.59 ft
Dn. Invert: 9.51 ft
L: 400 ft
Size: 48 in
S: 0.0105 ft/ft
CHANGE IN CULVERT SIZE 48" TO 54"
Label: SDMH 45
Rim: 20.01 ft
Sump: 9.01 ft
Label: P 210
Up. Invert: 9.01 ft
Dn. Invert: 6.10 ft
L: 249 ft
Size: 54 in
S: 0.0117 ft/ft
Label: SDMH 46
Rim: 14.01 ft
Sump: 6.10 ft
Label: P 211
Up. Invert: 6.10 ft
Dn. Invert: 4.33 ft
L: 151 ft
Size: 54 in
S: 0.0117 ft/ft
Label: SDMH 47
Rim: 12.01 ft
Sump: 4.33 ft
Label: P 212
Up. Invert: 4.33 ft
Dn. Invert: 2.56 ft
L: 151 ft
Size: 54 in
S: 0.0117 ft/ft
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
NEW YORK, NEW YORK
SOUTH RIVER IFS
INTERIOR DRAINAGE APPENDIX
EAST SEGMENT DIVERSION ALT.
STORMCAD PIPE PROFILE
FIG: H1-28

SUBAPPENDIX H1 – DETAILED FORMULATION PLANS

Introduction

H115. This subappendix includes detailed discussion of the plan formulation for each interior drainage area.

East Segment

General

H116. The interior drainage area behind the East Segment line-of-protection is located along the right (east) bank of the South River and the Washington Canal in the Borough of Sayreville, from Veterans Memorial Bridge north of the Raritan River. The area extends east beyond Main Street approximately 3 blocks. The interior drainage area comprises approximately 0.54 square miles (346 acres) of developed urban land, with minimal wetlands. The elevations of the lowest buildings are approximately 7 feet NGVD while Weber Avenue starts to flood at about elevation 4.5 feet NGVD.

H117. Review of the maps and the field investigation revealed that drainage systems consisting of catch basins, manholes, and storm drainage pipes serve the Sayreville interior drainage area. There are 5 existing storm outfalls within the East Segment drainage area. Table H1-1 provides a summary of the existing storm drainage outlets.

Table H1-1
Sayreville Existing Gravity Outlets

Basin	Outfall Designation	Outfall Location	Type	Approx. Size	Existing Inv. El.[1] (ft NGVD)
East	ES1	End of Sayre Street	DIP	3x24"	8.0[2]
	ES2	End of Junker Street	RCP	15"	8.0
	ES3	MacArthur Avenue	BOX	54"x83"	1.0
	ES4	End of Ciecko Street	RCP	15"	2.0
	ES5	Corner of Hinton St. and Canal St.	RCP	36"	2.1
	ES6	MacArthur Avenue	RCP	18"	2.0

(1) Existing inverts are approximated.
(2) The existing ES1 outfall includes a pump station as part of the NJDEP mitigation project.

H118. In addition to the minimum facility, one diversion alternative, two pumping alternatives, and two combined diversion/pumping alternatives were analyzed. These are described in subsequent paragraphs.

Minimum Facility

H119. Minimum facility for the East Segment has primary and secondary outlets as noted in Table H1-2. Both the primary and secondary outlets are being provided with a sluice gate and trash rack. The outlets will also be provided with flap gates to prevent tidal surges from entering the protected area. Ditches will be constructed along the landward side of the levee/floodwall to direct runoff toward either the primary or secondary outlet. The starting pond elevation was set to approximately 2 feet. The East Segment interior drainage minimum facilities are shown in Table H1-2.

Table H1-2
East Segment Minimum Facilities

Outlet	Location (Approximate Station)	Size	Interior Invert(1) (ft NGVD)	Exterior Invert(1) (ft NGVD)	Tie to Existing Drainage Sys. (Yes/No)
Primary	6+00	36" RCP	0.1	0.0	Yes
Secondary	13+20	36" RCP	5.1	5.0	Yes
Primary	20+00	60" RCP	2.1	2.0	Yes
Primary	38+20	60" RCP(2)	0.1	0.0	No
Primary	49+30	60" RCP(2)	0.1	0.0	No
Secondary	49+50	18" RCP(3)	0.1	0.0	No
Secondary	58+00	36" RCP(4)	5.1	5.0	Yes

Notes:
(1) Estimated invert elevation.
(2) Requires ditch construction.
(3) Installed for environmental purposes.
(4) Downstream of NJDOT Mitigation Site pump station.

Diversion Alternative

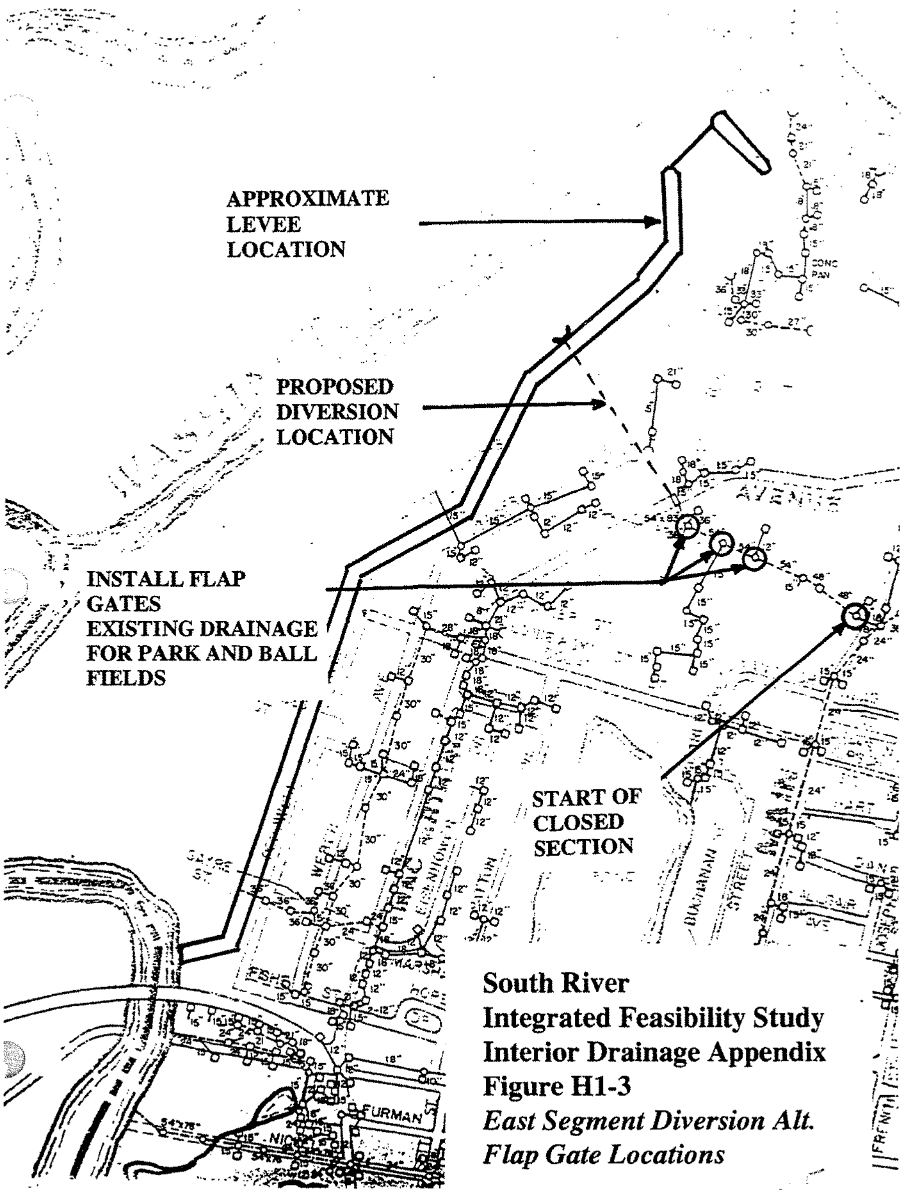
H120. A HEC-IFH model was developed using the minimum facility works in combination with one diversion alternative. The diversion alternative was based on a maximum diversion of 100cfs from the upper drainage area. This was determined to be the maximum capacity of the existing storm drainage system, which would be included in the alternative.

H121. A StormCAD® model was developed using existing storm sewer dimensions to determine the feasibility of diversion and the maximum diversion flow from the upper drainage area. Based on existing topography, an outlet invert of 0.0 feet NGVD was required to provide 0.1% slope from MacArthur Road to the levee in order to provide 2.5ft of cover above the culvert under the roadway (note: the existing ditch invert is approximately 2.0 feet NGVD). Construction of the culvert extension with an outlet invert of 0.0 feet NGVD will likely require the construction of a drainage ditch from the outlet to the South River. Table H1-3 shows the input parameters for the StormCAD® model.

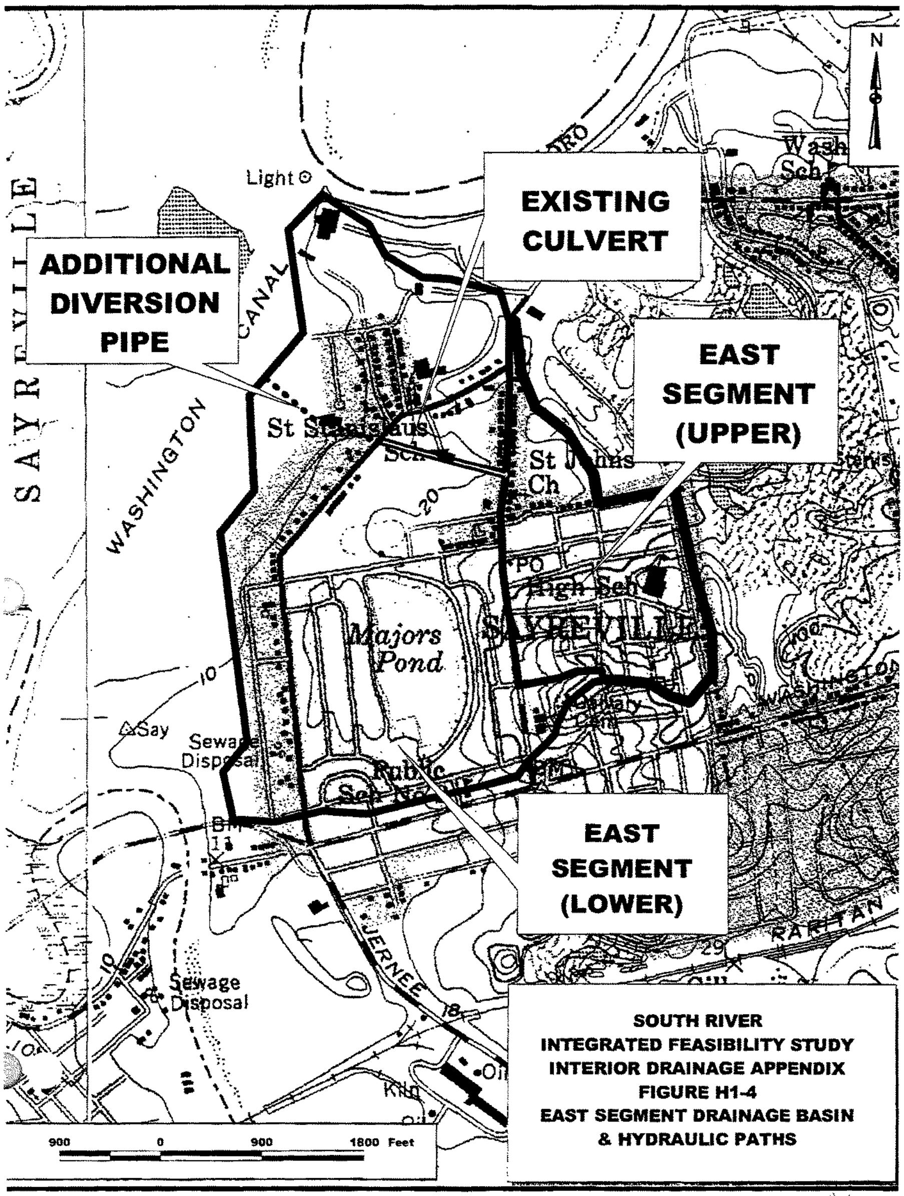
Table H1-3
StormCAD® Model Input Parameters

Description	Value*
Slope: Main Street to MacArthur Road	1.17%
Slope: MacArthur Road to Levee Outlet	0.1%
Main Street Inlet Sump	15.0 feet NGVD
Culvert Invert at MacArthur Road	0.8 feet NGVD
Outlet Invert at Levee	0.0 feet NGVD
Pipe Culvert Size: 48"	400 ft
Pipe Culvert Size: 54"	1600 ft
Manholes	7
*Dimensions approximated.	

H122. From the StormCAD® analysis it was determined that approximately 100 cfs was the maximum diversion possible from the upper drainage area based on a 2-year exterior storm surge. Conceptual plans for the diversion alternative are shown in Figures H1-1 through H1-3.



South River
Integrated Feasibility Study
Interior Drainage Appendix
Figure H1-3
East Segment Diversion Alt.
Flap Gate Locations


ADDITIONAL DIVERSION PIPE
EXISTING CULVERT
EAST SEGMENT (UPPER)
EAST SEGMENT (LOWER)
SAYREVILLE
WASHINGTON
CANAL
Light
St Stanislaus Sch
St Johns Ch
Majors Pond
High Sch
Sewage Disposal
RARITAN
JERNEE
Kiln
N
900 0 900 1800 Feet
SOUTH RIVER
INTEGRATED FEASIBILITY STUDY
INTERIOR DRAINAGE APPENDIX
FIGURE H1-4
EAST SEGMENT DRAINAGE BASIN
& HYDRAULIC PATHS

Pumping Alternatives

H123. HEC-IFH models were also developed using the minimum facility works in combination with two pump station alternatives. The pump station alternatives were based on a total station capacity of 40 and 100 cfs, each consisting of two pumps of equal capacity. The first pump-on was set at 4 feet NGVD and the second one at 4.5 feet NGVD with both pump-off elevations at 3 feet NGVD.

Diversion/Pumping Alternatives

H124. Both pump station alternatives were evaluated in combination with the 100 cfs diversion.

Hydraulic Analysis

H125. The results of the HEC-IFH analysis for the minimum facilities and each alternative are shown in Tables H1-4 through H1-9.

Optimum Plan

H126. As shown in Table H1-10, the 100 cfs diversion plan is the optimum interior drainage plan for the East Segment.

1248

Table H1-4
East Segment – Minimum Facilities Analysis Results

Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Min Fac.	Risk Condition
2yr	Normal	Current	NORTIDE	4.5	3.6							4.5	Lower
10yr	Normal	Current		5.2	3.6							5.2	Lower
50yr	Normal	Current		5.7	3.6							5.7	Lower
100yr	Normal	Current		5.9	3.6							5.9	Lower
500yr	Normal	Current		6.4	3.6							6.4	Lower
2yr	2yr	Current	SR2YEAR	6.1	6.9	2yr	2yr	Current		6.1	6.9	6.1	Expected
10yr	2yr	Current		6.7	6.9	2yr	10yr	Current	210CUR	6.4	10.1	6.7	Expected
50yr	2yr	Current		7.0	6.9	2yr	50yr	Current	250CUR	6.5	13.3	7.0	Expected
100yr	2yr	Current		7.2	6.9	2yr	100yr	Current	2100CUR	7.0	14.7	7.2	Expected
500yr	2yr	Current		7.5	6.9	2yr	500yr	Current	2500CUR	7.1	18.0	7.5	Expected
2yr	2yr	Current	2AND10YR	6.1	6.9	2yr	2yr	Current		6.1	6.9	6.1	Upper
10yr	10yr	Current		7.1	10.1	10yr	10yr	Current	1010CUR	7.1	10.1	7.1	Upper
50yr	10yr	Current		7.7	10.1	10yr	50yr	Current	1050CUR	7.3	13.3	7.7	Upper
100yr	10yr	Current		7.9	10.1	10yr	100yr	Current	10100CUR	7.4	14.7	7.9	Upper
500yr	10yr	Current		8.3	10.1	10yr	500yr	Current	10500CUR	7.9	18.0	8.3	Upper
2yr	Normal	Future	FUTNORM	4.9	4.3							4.9	Lower
10yr	Normal	Future		5.4	4.3							5.4	Lower
50yr	Normal	Future		5.9	4.3							5.9	Lower
100yr	Normal	Future		6.1	4.3							6.1	Lower
500yr	Normal	Future		6.5	4.3							6.5	Lower
2yr	2yr	Future	FUT2YEAR	6.1	7.6	2yr	2yr	Future		6.1	7.6	6.1	Expected
10yr	2yr	Future		6.9	7.6	2yr	10yr	Future	210FUT	6.4	10.8	6.9	Expected
50yr	2yr	Future		7.3	7.6	2yr	50yr	Future	250FUT	6.9	14.0	7.3	Expected
100yr	2yr	Future		7.5	7.6	2yr	100yr	Future	2100FUT	7.1	15.4	7.5	Expected
500yr	2yr	Future		7.8	7.6	2yr	500yr	Future	2500FUT	7.1	18.7	7.8	Expected
2yr	2yr	Future	FUT210YR	6.1	7.6	2yr	2yr	Future		6.1	7.6	6.1	Upper
10yr	10yr	Future		7.2	10.8	10yr	10yr	Future	1010FUT	7.2	10.8	7.2	Upper
50yr	10yr	Future		7.8	10.8	10yr	50yr	Future	1050FUT	7.4	14.0	7.8	Upper
100yr	10yr	Future		8.0	10.8	10yr	100yr	Future	10100FUT	7.9	15.4	8.0	Upper
500yr	10yr	Future		8.4	10.8	10yr	500yr	Future	10500FUT	8.0	18.7	8.4	Upper

Table III-5
East Segment – 100cfs Diversion Analysis Results

Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Min Fac.	Max WS	Change	Risk Condition
2yr	Normal	Current	NORTIDE	4.2	3.6							4.5	4.2	-0.3	Lower
10yr	Normal	Current		4.8	3.6							5.2	4.8	-0.4	Lower
50yr	Normal	Current		5.4	3.6							5.7	5.4	-0.3	Lower
100yr	Normal	Current		5.6	3.6							5.9	5.6	-0.3	Lower
500yr	Normal	Current		6.1	3.6							6.4	6.1	-0.3	Lower
2yr	2yr	Current	SR2YEAR	5.7	6.9	2yr	2yr	Current		5.7	6.9	6.1	5.7	-0.4	Expected
10yr	2yr	Current		6.5	6.9	2yr	10yr	Current	210CUR	6.0	10.1	6.7	6.5	-0.2	Expected
50yr	2yr	Current		6.9	6.9	2yr	50yr	Current	250CUR	6.1	13.3	7.0	6.9	-0.1	Expected
100yr	2yr	Current		7.0	6.9	2yr	100yr	Current	2100CUR	6.2	14.7	7.2	7.0	-0.2	Expected
500yr	2yr	Current		7.3	6.9	2yr	500yr	Current	2500CUR	6.2	18.0	7.5	7.3	-0.2	Expected
2yr	2yr	Current	2AND10YR	5.7	6.9	2yr	2yr	Current		5.7	6.9	6.1	5.7	-0.4	Upper
10yr	10yr	Current		6.8	10.1	10yr	10yr	Current	1010CUR	6.8	10.1	7.1	6.8	-0.3	Upper
50yr	10yr	Current		7.4	10.1	10yr	50yr	Current	1050CUR	6.9	13.3	7.7	7.4	-0.3	Upper
100yr	10yr	Current		7.6	10.1	10yr	100yr	Current	10100CUR	6.9	14.7	7.9	7.6	-0.3	Upper
500yr	10yr	Current		8.1	10.1	10yr	500yr	Current	10500CUR	7.1	18.0	8.3	8.1	-0.2	Upper
2yr	Normal	Future	FUTNORM	4.7	4.3							4.9	4.7	-0.2	Lower
10yr	Normal	Future		5.2	4.3							5.4	5.2	-0.2	Lower
50yr	Normal	Future		5.7	4.3							5.9	5.7	-0.2	Lower
100yr	Normal	Future		5.8	4.3							6.1	5.8	-0.3	Lower
500yr	Normal	Future		6.3	4.3							6.5	6.3	-0.2	Lower
2yr	2yr	Future	FUT2YEAR	5.8	7.6	2yr	2yr	Future		5.8	7.6	6.1	5.8	-0.3	Expected
10yr	2yr	Future		6.6	7.6	2yr	10yr	Future	210FUT	6.0	10.8	6.9	6.6	-0.3	Expected
50yr	2yr	Future		7.1	7.6	2yr	50yr	Future	250FUT	6.2	14.0	7.3	7.1	-0.2	Expected
100yr	2yr	Future		7.3	7.6	2yr	100yr	Future	2100FUT	6.2	15.4	7.5	7.3	-0.2	Expected
500yr	2yr	Future		7.6	7.6	2yr	500yr	Future	2500FUT	6.2	18.7	7.8	7.6	-0.2	Expected
2yr	2yr	Future	FUT210YR	5.8	7.6	2yr	2yr	Future		5.8	7.6	6.1	5.8	-0.3	Upper
10yr	10yr	Future		6.9	10.8	10yr	10yr	Future	1010FUT	6.9	10.8	7.2	6.9	-0.3	Upper
50yr	10yr	Future		7.5	10.8	10yr	50yr	Future	1050FUT	6.9	14.0	7.8	7.5	-0.3	Upper
100yr	10yr	Future		7.7	10.8	10yr	100yr	Future	10100FUT	7.1	15.4	8.0	7.7	-0.3	Upper
500yr	10yr	Future		8.2	10.8	10yr	500yr	Future	10500FUT	7.1	18.7	8.4	8.2	-0.2	Upper

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Table H1-6
East Segment – 40cfs Pump Station Analysis Results

Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Min Fac.	Max WS	Change	Risk Condition
2yr	Normal	Current	NORTIDE	4.5	3.6							4.5	4.5	0.0	Lower
10yr	Normal	Current		5.1	3.6							5.2	5.1	-0.1	Lower
50yr	Normal	Current		5.6	3.6							5.7	5.6	-0.1	Lower
100yr	Normal	Current		5.8	3.6							5.9	5.8	-0.1	Lower
500yr	Normal	Current		6.3	3.6							6.4	6.3	-0.1	Lower
2yr	2yr	Current	SR2YEAR	5.8	6.9	2yr	2yr	Current		5.8	6.9	6.1	5.8	-0.3	Expected
10yr	2yr	Current		6.7	6.9	2yr	10yr	Current	210CUR	6.0	10.1	6.7	6.7	0.0	Expected
50yr	2yr	Current		7.0	6.9	2yr	50yr	Current	250CUR	6.0	13.3	7.0	7.0	0.0	Expected
100yr	2yr	Current		7.1	6.9	2yr	100yr	Current	2100CUR	6.0	14.7	7.2	7.1	-0.1	Expected
500yr	2yr	Current		7.4	6.9	2yr	500yr	Current	2500CUR	6.0	18.0	7.5	7.4	-0.1	Expected
2yr	2yr	Current	2AND10YR	5.8	6.9	2yr	2yr	Current		5.8	6.9	6.1	5.8	-0.3	Upper
10yr	10yr	Current		6.8	10.1	10yr	10yr	Current	1010CUR	6.8	10.1	7.1	6.8	-0.3	Upper
50yr	10yr	Current		7.4	10.1	10yr	50yr	Current	1050CUR	6.9	13.3	7.7	7.4	-0.3	Upper
100yr	10yr	Current		7.7	10.1	10yr	100yr	Current	10100CUR	6.9	14.7	7.9	7.7	-0.2	Upper
500yr	10yr	Current		8.1	10.1	10yr	500yr	Current	10500CUR	6.9	18.0	8.3	8.1	-0.2	Upper
2yr	Normal	Future	FUTNORM	4.9	4.3							4.9	4.9	0.0	Lower
10yr	Normal	Future		5.4	4.3							5.4	5.4	0.0	Lower
50yr	Normal	Future		5.9	4.3							5.9	5.9	0.0	Lower
100yr	Normal	Future		6.1	4.3							6.1	6.1	0.0	Lower
500yr	Normal	Future		6.5	4.3							6.5	6.5	0.0	Lower
2yr	2yr	Future	FUT2YEAR	5.8	7.6	2yr	2yr	Future		5.8	7.6	6.1	5.8	-0.3	Expected
10yr	2yr	Future		6.7	7.6	2yr	10yr	Future	210FUT	6.0	10.8	6.9	6.7	-0.2	Expected
50yr	2yr	Future		7.2	7.6	2yr	50yr	Future	250FUT	6.0	14.0	7.3	7.2	-0.1	Expected
100yr	2yr	Future		7.4	7.6	2yr	100yr	Future	2100FUT	6.0	15.4	7.5	7.4	-0.1	Expected
500yr	2yr	Future		7.7	7.6	2yr	500yr	Future	2500FUT	6.0	18.7	7.8	7.7	-0.1	Expected
2yr	2yr	Future	FUT210YR	5.8	7.6	2yr	2yr	Future		5.8	7.6	6.1	5.8	-0.3	Upper
10yr	10yr	Future		6.9	10.8	10yr	10yr	Future	1010FUT	6.9	10.8	7.2	6.9	-0.3	Upper
50yr	10yr	Future		7.4	10.8	10yr	50yr	Future	1050FUT	6.9	14.0	7.8	7.4	-0.4	Upper
100yr	10yr	Future		7.7	10.8	10yr	100yr	Future	10100FUT	6.9	15.4	8.0	7.7	-0.3	Upper
500yr	10yr	Future		8.2	10.8	10yr	500yr	Future	10500FUT	6.9	18.7	8.4	8.2	-0.2	Upper

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Table H1-7
East Segment – 100cfs Pump Station Analysis Results

Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Min Fac.	Max WS	Change	Risk Condition
2yr	Normal	Current	NORTIDE	4.5	3.6							4.5	4.5	0.0	Lower
10yr	Normal	Current		5.1	3.6							5.2	5.1	-0.1	Lower
50yr	Normal	Current		5.6	3.6							5.7	5.6	-0.1	Lower
100yr	Normal	Current		5.8	3.6							5.9	5.8	-0.1	Lower
500yr	Normal	Current		6.3	3.6							6.4	6.3	-0.1	Lower
2yr	2yr	Current	SR2YEAR	5.4	6.9	2yr	2yr	Current		5.4	6.9	6.1	5.4	-0.7	Expected
10yr	2yr	Current		6.4	6.9	2yr	10yr	Current	210CUR	5.6	10.1	6.7	6.4	-0.3	Expected
50yr	2yr	Current		6.9	6.9	2yr	50yr	Current	250CUR	5.6	13.3	7.0	6.9	-0.1	Expected
100yr	2yr	Current		7.0	6.9	2yr	100yr	Current	2100CUR	5.5	14.7	7.2	7.0	-0.2	Expected
500yr	2yr	Current		7.3	6.9	2yr	500yr	Current	2500CUR	5.5	18.0	7.5	7.3	-0.2	Expected
2yr	2yr	Current	2AND10YR	5.4	6.9	2yr	2yr	Current		5.4	6.9	6.1	5.4	-0.7	Upper
10yr	10yr	Current		6.5	10.1	10yr	10yr	Current	1010CUR	6.5	10.1	7.1	6.5	-0.6	Upper
50yr	10yr	Current		7.0	10.1	10yr	50yr	Current	1050CUR	6.4	13.3	7.7	7.0	-0.7	Upper
100yr	10yr	Current		7.3	10.1	10yr	100yr	Current	10100CUR	6.4	14.7	7.9	7.3	-0.6	Upper
500yr	10yr	Current		7.8	10.1	10yr	500yr	Current	10500CUR	6.3	18.0	8.3	7.8	-0.5	Upper
2yr	Normal	Future	FUTNORM	4.8	4.3							4.9	4.8	-0.1	Lower
10yr	Normal	Future		5.4	4.3							5.4	5.4	0.0	Lower
50yr	Normal	Future		5.9	4.3							5.9	5.9	0.0	Lower
100yr	Normal	Future		6.1	4.3							6.1	6.1	0.0	Lower
500yr	Normal	Future		6.5	4.3							6.5	6.5	0.0	Lower
2yr	2yr	Future	FUT2YEAR	5.5	7.6	2yr	2yr	Future		5.5	7.6	6.1	5.5	-0.6	Expected
10yr	2yr	Future		6.4	7.6	2yr	10yr	Future	210FUT	5.6	10.8	6.9	6.4	-0.5	Expected
50yr	2yr	Future		7.0	7.6	2yr	50yr	Future	250FUT	5.5	14.0	7.3	7.0	-0.3	Expected
100yr	2yr	Future		7.2	7.6	2yr	100yr	Future	2100FUT	5.5	15.4	7.5	7.2	-0.3	Expected
500yr	2yr	Future		7.6	7.6	2yr	500yr	Future	2500FUT	5.5	18.7	7.8	7.6	-0.2	Expected
2yr	2yr	Future	FUT210YR	5.5	7.6	2yr	2yr	Future		5.5	7.6	6.1	5.5	-0.6	Upper
10yr	10yr	Future		6.4	10.8	10yr	10yr	Future	1010FUT	6.4	10.8	7.2	6.4	-0.8	Upper
50yr	10yr	Future		7.0	10.8	10yr	50yr	Future	1050FUT	6.3	14.0	7.8	7.0	-0.8	Upper
100yr	10yr	Future		7.2	10.8	10yr	100yr	Future	10100FUT	6.3	15.4	8.0	7.2	-0.8	Upper
500yr	10yr	Future		7.8	10.8	10yr	500yr	Future	10500FUT	6.4	18.7	8.4	7.8	-0.6	Upper

Table H1-8
East Segment – 100cfs Diversion & 40cfs Pump Station Analysis Results

Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Min Fac.	Max WS	Change	Risk Condition
2yr	Normal	Current	NORTIDE	4.2	3.6							4.5	4.2	-0.3	Lower
10yr	Normal	Current		4.8	3.6							5.2	4.8	-0.4	Lower
50yr	Normal	Current		5.4	3.6							5.7	5.4	-0.3	Lower
100yr	Normal	Current		5.6	3.6							5.9	5.6	-0.3	Lower
500yr	Normal	Current		6.1	3.6							6.4	6.1	-0.3	Lower
2yr	2yr	Current	SR2YEAR	5.4	6.9	2yr	2yr	Current		5.4	6.9	6.1	5.4	-0.7	Expected
10yr	2yr	Current		6.4	6.9	2yr	10yr	Current	210CUR	5.6	10.1	6.7	6.4	-0.3	Expected
50yr	2yr	Current		6.8	6.9	2yr	50yr	Current	250CUR	5.6	13.3	7.0	6.8	-0.2	Expected
100yr	2yr	Current		6.9	6.9	2yr	100yr	Current	2100CUR	5.6	14.7	7.2	6.9	-0.3	Expected
500yr	2yr	Current		7.2	6.9	2yr	500yr	Current	2500CUR	5.6	18.0	7.5	7.2	-0.3	Expected
2yr	2yr	Current	2AND10YR	5.4	6.9	2yr	2yr	Current		5.4	6.9	6.1	5.4	-0.7	Upper
10yr	10yr	Current		6.5	10.1	10yr	10yr	Current	1010CUR	6.5	10.1	7.1	6.5	-0.6	Upper
50yr	10yr	Current		7.1	10.1	10yr	50yr	Current	1050CUR	6.5	13.3	7.7	7.1	-0.6	Upper
100yr	10yr	Current		7.3	10.1	10yr	100yr	Current	10100CUR	6.5	14.7	7.9	7.3	-0.6	Upper
500yr	10yr	Current		7.8	10.1	10yr	500yr	Current	10500CUR	6.5	18.0	8.3	7.8	-0.5	Upper
2yr	Normal	Future	FUTNORM	4.6	4.3							4.9	4.6	-0.3	Lower
10yr	Normal	Future		5.1	4.3							5.4	5.1	-0.3	Lower
50yr	Normal	Future		5.6	4.3							5.9	5.6	-0.3	Lower
100yr	Normal	Future		5.7	4.3							6.1	5.7	-0.4	Lower
500yr	Normal	Future		6.2	4.3							6.5	6.2	-0.3	Lower
2yr	2yr	Future	FUT2YEAR	5.4	7.6	2yr	2yr	Future		5.4	7.6	6.1	5.4	-0.7	Expected
10yr	2yr	Future		6.4	7.6	2yr	10yr	Future	210FUT	5.6	10.8	6.9	6.4	-0.5	Expected
50yr	2yr	Future		7.0	7.6	2yr	50yr	Future	250FUT	5.6	14.0	7.3	7.0	-0.3	Expected
100yr	2yr	Future		7.2	7.6	2yr	100yr	Future	2100FUT	5.6	15.4	7.5	7.2	-0.3	Expected
500yr	2yr	Future		7.5	7.6	2yr	500yr	Future	2500FUT	5.6	18.7	7.8	7.5	-0.3	Expected
2yr	2yr	Future	FUT210YR	5.4	7.6	2yr	2yr	Future		5.4	7.6	6.1	5.4	-0.7	Upper
10yr	10yr	Future		6.5	10.8	10yr	10yr	Future	1010FUT	6.5	10.8	7.2	6.5	-0.7	Upper
50yr	10yr	Future		7.1	10.8	10yr	50yr	Future	1050FUT	6.5	14.0	7.8	7.1	-0.7	Upper
100yr	10yr	Future		7.4	10.8	10yr	100yr	Future	10100FUT	6.5	15.4	8.0	7.4	-0.6	Upper
500yr	10yr	Future		7.9	10.8	10yr	500yr	Future	10500FUT	6.5	18.7	8.4	7.9	-0.5	Upper

Table H1-9
East Segment – 100cfs Diversion & 100cfs Pump Station Analysis Results

Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Min Fac.	Max WS	Change	Risk Condition
2yr	Normal	Current	NORTIDE	4.1	3.6							4.5	4.1	-0.4	Lower
10yr	Normal	Current		4.6	3.6							5.2	4.6	-0.6	Lower
50yr	Normal	Current		5.2	3.6							5.7	5.2	-0.5	Lower
100yr	Normal	Current		5.4	3.6							5.9	5.4	-0.5	Lower
500yr	Normal	Current		5.8	3.6							6.4	5.8	-0.6	Lower
2yr	2yr	Current	SR2YEAR	5.1	6.9	2yr	2yr	Current		5.1	6.9	6.1	5.1	-1.0	Expected
10yr	2yr	Current		6.0	6.9	2yr	10yr	Current	210CUR	5.2	10.1	6.7	6.0	-0.7	Expected
50yr	2yr	Current		6.7	6.9	2yr	50yr	Current	250CUR	5.2	13.3	7.0	6.7	-0.3	Expected
100yr	2yr	Current		6.8	6.9	2yr	100yr	Current	2100CUR	5.2	14.7	7.2	6.8	-0.4	Expected
500yr	2yr	Current		7.1	6.9	2yr	500yr	Current	2500CUR	5.2	18.0	7.5	7.1	-0.4	Expected
2yr	2yr	Current	2AND10YR	5.1	6.9	2yr	2yr	Current		5.1	6.9	6.1	5.1	-1.0	Upper
10yr	10yr	Current		6.1	10.1	10yr	10yr	Current	1010CUR	6.1	10.1	7.1	6.1	-1.0	Upper
50yr	10yr	Current		6.7	10.1	10yr	50yr	Current	1050CUR	6.1	13.3	7.7	6.7	-1.0	Upper
100yr	10yr	Current		7.0	10.1	10yr	100yr	Current	10100CUR	6.0	14.7	7.9	7.0	-0.9	Upper
500yr	10yr	Current		7.5	10.1	10yr	500yr	Current	10500CUR	6.0	18.0	8.3	7.5	-0.8	Upper
2yr	Normal	Future	FUTNORM	4.6	4.3							4.9	4.6	-0.3	Lower
10yr	Normal	Future		4.9	4.3							5.4	4.9	-0.5	Lower
50yr	Normal	Future		5.4	4.3							5.9	5.4	-0.5	Lower
100yr	Normal	Future		5.6	4.3							6.1	5.6	-0.5	Lower
500yr	Normal	Future		6.0	4.3							6.5	6.0	-0.5	Lower
2yr	2yr	Future	FUT2YEAR	5.1	7.6	2yr	2yr	Future		5.1	7.6	6.1	5.1	-1.0	Expected
10yr	2yr	Future		6.1	7.6	2yr	10yr	Future	210FUT	5.2	10.8	6.9	6.1	-0.8	Expected
50yr	2yr	Future		6.7	7.6	2yr	50yr	Future	250FUT	5.2	14.0	7.3	6.7	-0.6	Expected
100yr	2yr	Future		7.0	7.6	2yr	100yr	Future	2100FUT	5.2	15.4	7.5	7.0	-0.5	Expected
500yr	2yr	Future		7.4	7.6	2yr	500yr	Future	2500FUT	5.2	18.7	7.8	7.4	-0.4	Expected
2yr	2yr	Future	FUT210YR	5.1	7.6	2yr	2yr	Future		5.1	7.6	6.1	5.1	-1.0	Upper
10yr	10yr	Future		6.1	10.8	10yr	10yr	Future	1010FUT	6.1	10.8	7.2	6.1	-1.1	Upper
50yr	10yr	Future		6.6	10.8	10yr	50yr	Future	1050FUT	6.0	14.0	7.8	6.6	-1.2	Upper
100yr	10yr	Future		6.9	10.8	10yr	100yr	Future	10100FUT	6.0	15.4	8.0	6.9	-1.1	Upper
500yr	10yr	Future		7.4	10.8	10yr	500yr	Future	10500FUT	6.0	18.7	8.4	7.4	-1.0	Upper

Table H1-10
East Segment – Plan Comparison

Plan	Description	FIRST CONSTRUCTION COST (Incremental)(1)	FIRST LAND COST (2)	OPERATION &MAINTENANCE (Annual; Incremental))	INCREMENTAL ANNUAL COST	TOTAL ANNUAL COST	Equivalent Annual Damage	Annual Damage Reduction	Annual Net Benefit
	Minimum Facility	$593,600	$13,200	$4,800	$44,000	$44,000	$168,400	$0	$0
Alt 1	100cfs Diversion	$577,200	$9,600	$2,750	$40,650	$84,650	$119,400	$49,000	**$8,300**
Alt 2	40cfs Pump Station	$638,500	$0	$30,000	$71,200	$115,200	$132,000	$36,400	($34,830)
Alt 3	100cfs Pump Station	$1,404,700	$0	$35,000	$125,700	$169,700	$100,500	$67,900	($57,800)
Alt 4	100cfs Div&40cfs Pump	$1,215,740	$9,600	$32,750	$111,850	$155,850	$95,800	$72,600	($39,260)
Alt 5	100cfs Div & 100cfs Pump	$1,981,940	$9,600	$37,750	$166,250	$210,250	$71,600	$96,800	($69,430)

(1) First cost includes 15% Engineering & Design, 7% Administration &15% Contingencies (1.403 Construction Factor). Pumps: First cost includes 7% Engineering & Design, 7% Administration &12% Contingencies (1.277 Construction Factor).
(2) First Land Cost includes 5% Survey & Appraisal, &10% Contingencies

West Segment

General

H127. The interior drainage area behind the West Segment line-of-protection is located along the left (west) bank of the South River in the Borough of South River, from Veterans Memorial Bridge northwest to the intersection of William Street and Brick Plant Road. The interior drainage area comprises approximately 0.68 square miles (435 acres) of developed urban land, with minimal wetlands. Reid Street starts to flood at about elevation 6.5 feet NGVD.

H128. Review of the maps and the field investigation revealed that drainage systems consisting of catch basins, manholes, and storm drainage pipes serve the South River interior drainage area. There are 2 existing storm outfalls within the West Segment drainage area. Table H1-11 provides a summary of the existing storm drainage outlets.

Table H1-11
South River Existing Gravity Outlets

Basin	Outfall Designation	Outfall Location	Type	Approx. Size	Existing Inv. El.(1) (ft NGVD)
West	WS1	End of Maple Avenue	RCP	60"	1.0
	WS2	Intersection of Reed St. and George St.	RCP	24"	0.5
	WS3	Underroad culvert (drains to ditch)	RCP	24"	12.0
	WS4	Underroad culvert (drains to ditch).	RCP	24"	8.0

(1) Existing inverts are approximated.

H129. In addition to the minimum facility, three pumping alternatives were analyzed. These are described in subsequent paragraphs.

Minimum Facility

H130. Minimum facility for the West Segment has primary and secondary outlets as noted in Table H1-12. Both the primary and secondary outlets are being provided with a sluice gate and trash rack. The outlets will also be provided with flap gates to prevent tidal surges from entering the protected area. Ditches will be constructed along the landward side of the levee/floodwall to direct runoff toward either the primary or secondary outlet. The starting pond elevation was set to approximately 2 feet. The West Segment minimum facilities are listed in Table H1-12.

Table H1-12
West Segment Minimum Facilities

Outlet	Location (Approximate Station)	Size	Interior Invert(1) (ft NGVD)	Exterior Invert(1) (ft NGVD)	Tie to Existing Drainage Sys. (Yes/No)
Secondary	11+00	24" RCP	0.1	0.0	No
Primary	15+00	60" RCP	0.1	0.0	No
Secondary	24+50	24" RCP	0.1	0.0	No
Primary	32+00	4 X 60" RCP	0.1	0.0	Yes
Primary	36+00	3 X 60" RCP	0.1	0.0	Yes
Secondary	44+00	60" RCP	0.1	0.0	Yes

Notes:
(1) Estimated invert elevations.

Pumping Alternatives

H131. HEC-IFH models were developed using the minimum facility works in combination with three pump station alternatives. The pump station alternatives were based on a total station capacity of 50, 100, and 150 cfs, each consisting of two pumps of equal capacity. The first pump-on was set at 5 feet NGVD and the second one at 5.5 feet NGVD with both pump-off elevations at 4 feet NGVD.

Hydraulic Analysis

H132. The results of the HEC-IFH analysis for each alternative are shown in Tables H1-13 through H1-16.

Optimum Plan

H133. As shown in Table H1-17, the minimum facilities plan is the optimum plan for the West Segment.

Table III-13
West Segment – Minimum Facilities Analysis Results

Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Min Fac.	Risk Condition
2yr	Normal	Current	NORTIDE	3.9	3.6							3.9	Lower
10yr	Normal	Current		4.6	3.6							4.6	Lower
50yr	Normal	Current		5.4	3.6							5.4	Lower
100yr	Normal	Current		5.5	3.6							5.5	Lower
500yr	Normal	Current		6.1	3.6							6.1	Lower
2yr	2yr	Current	SR2YEAR	7.0	6.9	2yr	2yr	Current		7.0	6.9	7.0	Expected
10yr	2yr	Current		7.2	6.9	2yr	10yr	Current	210CUR	8.9	10.7	8.9	Expected
50yr	2yr	Current		7.6	6.9	2yr	50yr	Current	250CUR	9.2	13.3	9.2	Expected
100yr	2yr	Current		7.7	6.9	2yr	100yr	Current	2100CUR	9.2	14.7	9.2	Expected
500yr	2yr	Current		8.0	6.9	2yr	500yr	Current	2500CUR	9.8	18.0	9.8	Expected
2yr	2yr	Current	2AND10YR	7.0	6.9	2yr	2yr	Current		7.0	6.9	7.0	Upper
10yr	10yr	Current		9.7	10.1	10yr	10yr	Current	1010CUR	9.7	10.7	9.7	Upper
50yr	10yr	Current		10.1	10.1	10yr	50yr	Current	1050CUR	10.2	13.3	10.2	Upper
100yr	10yr	Current		10.3	10.1	10yr	100yr	Current	10100CUR	10.3	14.7	10.3	Upper
500yr	10yr	Current		10.5	10.1	10yr	500yr	Current	10500CUR	10.5	18.0	10.5	Upper
2yr	Normal	Future	FUTNORM	4.6	4.3							4.6	Lower
10yr	Normal	Future		5.0	4.3							5.0	Lower
50yr	Normal	Future		5.6	4.3							5.6	Lower
100yr	Normal	Future		5.8	4.3							5.8	Lower
500yr	Normal	Future		6.3	4.3							6.3	Lower
2yr	2yr	Future	FUT2YEAR	7.7	7.6	2yr	2yr	Future		7.7	7.6	7.7	Expected
10yr	2yr	Future		7.9	7.6	2yr	10yr	Future	210FUT	8.9	10.8	8.9	Expected
50yr	2yr	Future		8.2	7.6	2yr	50yr	Future	250FUT	9.2	14.0	9.2	Expected
100yr	2yr	Future		8.3	7.6	2yr	100yr	Future	2100FUT	9.3	15.4	9.3	Expected
500yr	2yr	Future		8.6	7.6	2yr	500yr	Future	2500FUT	10.1	18.7	10.1	Expected
2yr	2yr	Future	FUT210YR	7.7	7.6	2yr	2yr	Future		7.7	7.6	7.7	Upper
10yr	10yr	Future		9.9	10.8	10yr	10yr	Future	1010FUT	9.9	10.8	9.9	Upper
50yr	10yr	Future		10.5	10.8	10yr	50yr	Future	1050FUT	10.3	14.0	10.5	Upper
100yr	10yr	Future		10.7	10.8	10yr	100yr	Future	10100FUT	10.3	15.4	10.7	Upper
500yr	10yr	Future		11.0	10.8	10yr	500yr	Future	10500FUT	10.7	18.7	11.0	Upper

Table H1-14
West Segment - 50cfs Pump Station Analysis Results

Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Min. Fac.	Max WS	Change	Risk Condition
2yr	Normal	Current	NORTIDE	3.9	3.6							3.9	3.9	0.0	Lower
10yr	Normal	Current		4.6	3.6							4.6	4.6	0.0	Lower
50yr	Normal	Current		5.3	3.6							5.4	5.3	0.0	Lower
100yr	Normal	Current		5.5	3.6							5.5	5.5	0.0	Lower
500yr	Normal	Current		6.0	3.6							6.1	6.0	-0.1	Lower
2yr	2yr	Current	SR2YEAR	7.0	6.9	2yr	2yr	Current		7.0	6.9	7.0	7.0	0.0	Expected
10yr	2yr	Current		7.2	6.9	2yr	10yr	Current	210CUR	8.4	10.1	8.9	8.4	-0.5	Expected
50yr	2yr	Current		7.5	6.9	2yr	50yr	Current	250CUR	8.3	13.3	9.2	8.3	-0.9	Expected
100yr	2yr	Current		7.6	6.9	2yr	100yr	Current	2100CUR	8.3	14.7	9.2	8.3	-0.9	Expected
500yr	2yr	Current		8.0	6.9	2yr	500yr	Current	2500CUR	8.4	18.0	9.8	8.4	-1.4	Expected
2yr	2yr	Current	2AND10YR	7.0	6.9	2yr	2yr	Current		7.0	6.9	7.0	7.0	0.0	Upper
10yr	10yr	Current		9.5	10.1	10yr	10yr	Current	1010CUR	9.5	10.1	9.7	9.5	-0.2	Upper
50yr	10yr	Current		10.0	10.1	10yr	50yr	Current	1050CUR	9.6	13.3	10.2	10.0	-0.2	Upper
100yr	10yr	Current		10.1	10.1	10yr	100yr	Current	10100CUR	9.6	14.7	10.3	10.1	-0.2	Upper
500yr	10yr	Current		10.4	10.1	10yr	500yr	Current	10500CUR	9.6	18.0	10.5	10.4	-0.1	Upper
2yr	Normal	Future	FUTNORM	4.6	4.3							4.6	4.6	0.0	Lower
10yr	Normal	Future		5.0	4.3							5.0	5.0	0.0	Lower
50yr	Normal	Future		5.6	4.3							5.6	5.6	-0.1	Lower
100yr	Normal	Future		5.7	4.3							5.8	5.7	-0.1	Lower
500yr	Normal	Future		6.2	4.3							6.3	6.2	-0.1	Lower
2yr	2yr	Future	FUT2YEAR	7.7	7.6	2yr	2yr	Future		7.7	7.6	7.7	7.7	0.0	Expected
10yr	2yr	Future		7.8	7.6	2yr	10yr	Future	210FUT	8.4	10.8	8.9	8.4	-0.5	Expected
50yr	2yr	Future		8.1	7.6	2yr	50yr	Future	250FUT	8.3	14.0	9.2	8.3	-0.9	Expected
100yr	2yr	Future		8.2	7.6	2yr	100yr	Future	2100FUT	8.4	15.4	9.3	8.4	-0.9	Expected
500yr	2yr	Future		8.5	7.6	2yr	500yr	Future	2500FUT	8.4	18.7	10.1	8.5	-1.6	Expected
2yr	2yr	Future	FUT210YR	7.7	7.6	2yr	2yr	Future		7.7	7.6	7.7	7.7	0.0	Upper
10yr	10yr	Future		9.5	10.8	10yr	10yr	Future	1010FUT	9.5	10.8	9.9	9.5	-0.4	Upper
50yr	10yr	Future		10.2	10.8	10yr	50yr	Future	1050FUT	9.6	14.0	10.5	10.2	-0.3	Upper
100yr	10yr	Future		10.5	10.8	10yr	100yr	Future	10100FUT	9.6	15.4	10.7	10.5	-0.2	Upper
500yr	10yr	Future		10.8	10.8	10yr	500yr	Future	10500FUT	9.7	18.7	11.0	10.8	-0.2	Upper

Table H1-15
West Segment – 100cfs Pump Station Analysis Results

Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Min Fac.	Max WS	Change	Risk Condition
2yr	Normal	Current	NORTIDE	3.9	3.6							3.9	3.9	0.0	Lower
10yr	Normal	Current		4.6	3.6							4.6	4.6	0.0	Lower
50yr	Normal	Current		5.3	3.6							5.4	5.3	-0.1	Lower
100yr	Normal	Current		5.5	3.6							5.5	5.5	-0.1	Lower
500yr	Normal	Current		6.0	3.6							6.1	6.0	-0.2	Lower
2yr	2yr	Current	SR2YEAR	7.0	6.9	2yr	2yr	Current		7.0	6.9	7.0	7.0	0.0	Expected
10yr	2yr	Current		7.1	6.9	2yr	10yr	Current	210CUR	8.0	10.1	8.9	8.0	-0.9	Expected
50yr	2yr	Current		7.5	6.9	2yr	50yr	Current	250CUR	8.0	13.3	9.2	8.0	-1.2	Expected
100yr	2yr	Current		7.6	6.9	2yr	100yr	Current	2100CUR	8.0	14.7	9.2	8.0	-1.2	Expected
500yr	2yr	Current		7.9	6.9	2yr	500yr	Current	2500CUR	8.0	18.0	9.8	8.0	-1.9	Expected
2yr	2yr	Current	2AND10YR	7.0	6.9	2yr	2yr	Current		7.0	6.9	7.0	7.0	0.0	Upper
10yr	10yr	Current		9.2	10.1	10yr	10yr	Current	1010CUR	9.2	10.1	9.7	9.2	-0.5	Upper
50yr	10yr	Current		9.9	10.1	10yr	50yr	Current	1050CUR	9.2	13.3	10.2	9.9	-0.3	Upper
100yr	10yr	Current		10.0	10.1	10yr	100yr	Current	10100CUR	9.2	14.7	10.3	10.0	-0.3	Upper
500yr	10yr	Current		10.3	10.1	10yr	500yr	Current	10500CUR	9.2	18.0	10.5	10.3	-0.2	Upper
2yr	Normal	Future	FUTNORM	4.6	4.3							4.6	4.6	0.0	Lower
10yr	Normal	Future		5.0	4.3							5.0	5.0	0.0	Lower
50yr	Normal	Future		5.5	4.3							5.6	5.5	-0.1	Lower
100yr	Normal	Future		5.6	4.3							5.8	5.6	-0.1	Lower
500yr	Normal	Future		6.1	4.3							6.3	6.1	-0.1	Lower
2yr	2yr	Future	FUT2YEAR	7.7	7.6	2yr	2yr	Future		7.7	7.6	7.7	7.7	0.0	Expected
10yr	2yr	Future		7.8	7.6	2yr	10yr	Future	210FUT	7.9	10.8	8.9	7.9	-1.0	Expected
50yr	2yr	Future		8.1	7.6	2yr	50yr	Future	250FUT	8.0	14.0	9.2	8.1	-1.1	Expected
100yr	2yr	Future		8.2	7.6	2yr	100yr	Future	2100FUT	8.0	15.4	9.3	8.2	-1.1	Expected
500yr	2yr	Future		8.5	7.6	2yr	500yr	Future	2500FUT	8.0	18.7	10.1	8.5	-1.6	Expected
2yr	2yr	Future	FUT210YR	7.7	7.6	2yr	2yr	Future		7.7	7.6	7.7	7.7	0.0	Upper
10yr	10yr	Future		9.1	10.8	10yr	10yr	Future	1010FUT	9.1	10.8	9.9	9.1	-0.8	Upper
50yr	10yr	Future		10.0	10.8	10yr	50yr	Future	1050FUT	9.2	14.0	10.5	10.0	-0.5	Upper
100yr	10yr	Future		10.3	10.8	10yr	100yr	Future	10100FUT	9.2	15.4	10.7	10.3	-0.4	Upper
500yr	10yr	Future		10.7	10.8	10yr	500yr	Future	10500FUT	9.2	18.7	11.0	10.7	-0.3	Upper

Table H1-16
West Segment – 150cfs Pump Station Analysis Results

Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Min Fac.	Max WS	Change	Risk Condition
2yr	Normal	Current	NORTIDE	3.9	3.6							3.9	3.9	0.0	Lower
10yr	Normal	Current		4.6	3.6							4.6	4.6	0.0	Lower
50yr	Normal	Current		5.2	3.6							5.4	5.2	-0.1	Lower
100yr	Normal	Current		5.4	3.6							5.5	5.4	-0.1	Lower
500yr	Normal	Current		5.9	3.6							6.1	5.9	-0.2	Lower
2yr	2yr	Current	SR2YEAR	7.0	6.9	2yr	2yr	Current		7.0	6.9	7.0	7.0	0.0	Expected
10yr	2yr	Current		7.1	6.9	2yr	10yr	Current	210CUR	7.7	10.1	8.9	7.7	-1.2	Expected
50yr	2yr	Current		7.4	6.9	2yr	50yr	Current	250CUR	7.7	13.3	9.2	7.7	-1.5	Expected
100yr	2yr	Current		7.5	6.9	2yr	100yr	Current	2100CUR	7.7	14.7	9.2	7.7	-1.5	Expected
500yr	2yr	Current		7.8	6.9	2yr	500yr	Current	2500CUR	7.7	18.0	9.8	7.8	-2.0	Expected
2yr	2yr	Current	2AND10YR	7.0	6.9	2yr	2yr	Current		7.0	6.9	7.0	7.0	0.0	Upper
10yr	10yr	Current		8.9	10.1	10yr	10yr	Current	1010CUR	8.9	10.1	9.7	8.9	-0.8	Upper
50yr	10yr	Current		9.7	10.1	10yr	50yr	Current	1050CUR	8.9	13.3	10.2	9.7	-0.5	Upper
100yr	10yr	Current		9.9	10.1	10yr	100yr	Current	10100CUR	8.9	14.7	10.3	9.9	-0.4	Upper
500yr	10yr	Current		10.2	10.1	10yr	500yr	Current	10500CUR	8.9	18.0	10.5	10.2	-0.3	Upper
2yr	Normal	Future	FUTNORM	4.6	4.3							4.6	4.6	0.0	Lower
10yr	Normal	Future		5.0	4.3							5.0	5.0	0.0	Lower
50yr	Normal	Future		5.5	4.3							5.6	5.5	-0.1	Lower
100yr	Normal	Future		5.6	4.3							5.8	5.6	-0.2	Lower
500yr	Normal	Future		6.1	4.3							6.3	6.1	-0.2	Lower
2yr	2yr	Future	FUT2YEAR	7.6	7.6	2yr	2yr	Future		7.6	7.6	7.7	7.6	-0.1	Expected
10yr	2yr	Future		7.7	7.6	2yr	10yr	Future	210FUT	7.7	10.8	8.9	7.7	-1.2	Expected
50yr	2yr	Future		8.0	7.6	2yr	50yr	Future	250FUT	7.7	14.0	9.2	8.0	-1.2	Expected
100yr	2yr	Future		8.1	7.6	2yr	100yr	Future	2100FUT	7.7	15.4	9.3	8.1	-1.2	Expected
500yr	2yr	Future		8.4	7.6	2yr	500yr	Future	2500FUT	7.7	18.7	10.1	8.4	-1.7	Expected
2yr	2yr	Future	FUT210YR	7.6	7.6	2yr	2yr	Future		7.6	7.6	7.7	7.6	-0.1	Upper
10yr	10yr	Future		8.9	10.8	10yr	10yr	Future	1010FUT	8.9	10.8	9.9	8.9	-1.0	Upper
50yr	10yr	Future		9.7	10.8	10yr	50yr	Future	1050FUT	8.9	14.0	10.5	9.7	-0.8	Upper
100yr	10yr	Future		10.0	10.8	10yr	100yr	Future	10100FUT	8.9	15.4	10.7	10.0	-0.7	Upper
500yr	10yr	Future		10.6	10.8	10yr	500yr	Future	10500FUT	8.9	18.7	11.0	10.6	-0.4	Upper

Table H1-17
West Segment – Plan Comparison

Plan	Description	FIRST CONSTRUCTION COST (Incremental)(1)	FIRST LAND COST (2)	OPERATION &MAINTENANCE (Annual; Incremental))	INCREMENTAL ANNUAL COST	TOTAL ANNUAL COST	Equivalent Annual Damage	Annual Damage Reduction	Annual Net Benefit
	Minimum Facility	$1,029,700	$0	$8,450	$74,950	$74,950	$209,100	$0	$0
Alt 1	50cfs Pump Station	$702,400	$0	$30,000	$75,300	$150,250	$151,700	$57,400	($17,900)
Alt 2	100cfs Pump Station	$1,404,700	$0	$35,000	$125,700	$200,650	$121,200	$87,900	($37,800)
Alt 3	150cfs Pump Station	$2,107,100	$0	$40,000	$176,000	$250,950	$103,300	$105,800	($70,200)

(1) First cost includes 15% Engineering & Design, 7% Administration &15% Contingencies (1.403 Construction Factor). Pumps: First cost includes 7% Engineering & Design, 7% Administration &12% Contingencies (1.277 Construction Factor).
(2) First Land Cost includes 5% Survey & Appraisal, &10% Contingencies

Main Channel

General

H134. The interior drainage area behind the Main Channel storm surge barrier line-of-protection includes the remainder of the South River Basin – approximately 129 square miles. The primary damage center within this drainage area is Reach 3B, located just south of Veteran's Memorial Bridge along the left (west) bank of the river.

H135. In addition to the minimum facility, five pumping alternatives were analyzed. These are described in subsequent paragraphs.

Minimum Facility

H136. Minimum facility for the Main Channel storm surge barrier includes the 80-foot wide storm gate and five 10-foot wide by 10-foot high box culverts. The box culverts are being provided with a sluice gate and trash rack. The outlets will also be provided with flap gates to prevent tidal surges from entering the protected area.

Pumping Alternatives

H137. Lotus models were developed using the minimum facility works in combination with five pump station alternatives. The pump station alternatives were based on a total station capacity of: 1,200 cfs; 1,400 cfs; and 1,600 cfs, each consisting of four pumps of equal capacity.

Hydraulic Analysis

H138. The results of the interior drainage analysis for each alternative are shown in Tables H1-18 through H1-22.

Optimum Plan

H139. As shown in Table H1-23, the 1,200cfs pump station alternative is the optimum plan for the Main Channel.

Table H1-18
Main Channel - Minimum Facilities

Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Min Fac.	Risk Condition
2yr	Normal	Current	NORTIDE	3.8	3.6							3.8	Lower
10yr	Normal	Current		4.1	3.6							4.1	Lower
50yr	Normal	Current		4.1	3.6							4.1	Lower
100yr	Normal	Current		4.1	3.6							4.1	Lower
500yr	Normal	Current		4.3	3.6							4.3	Lower
2yr	2yr	Current	SR2YEAR	5.7	6.9	2yr	2yr	Current		5.7	6.9	5.7	Expected
10yr	2yr	Current		6.8	6.9	2yr	10yr	Current	210CUR	7.1	10.1	7.1	Expected
50yr	2yr	Current		7.3	6.9	2yr	50yr	Current	250CUR	8.7	13.3	8.7	Expected
100yr	2yr	Current		7.3	6.9	2yr	100yr	Current	2100CUR	9.5	14.7	9.5	Expected
500yr	2yr	Current		7.4	6.9	2yr	500yr	Current	2500CUR	10.5	18.0	10.5	Expected
2yr	2yr	Current	2AND10YR	5.7	6.9	2yr	2yr	Current		5.7	6.9	5.7	Upper
10yr	10yr	Current		8.4	10.1	10yr	10yr	Current	1010CUR	8.4	10.1	8.4	Upper
50yr	10yr	Current		9.5	10.1	10yr	50yr	Current	1050CUR	9.9	13.3	9.9	Upper
100yr	10yr	Current		9.7	10.1	10yr	100yr	Current	10100CUR	10.7	14.7	10.7	Upper
500yr	10yr	Current		10.3	10.1	10yr	500yr	Current	10500CUR	12.4	18.0	12.4	Upper
2yr	Normal	Future	FUTNORM	4.3	4.3							4.3	Lower
10yr	Normal	Future		4.7	4.3							4.7	Lower
50yr	Normal	Future		4.8	4.3							4.8	Lower
100yr	Normal	Future		4.8	4.3							4.8	Lower
500yr	Normal	Future		4.9	4.3							4.9	Lower
2yr	2yr	Future	FUT2YEAR	6.1	7.6	2yr	2yr	Future		6.1	7.6	6.1	Expected
10yr	2yr	Future		7.2	7.6	2yr	10yr	Future	210FUT	7.5	10.8	7.5	Expected
50yr	2yr	Future		7.9	7.6	2yr	50yr	Future	250FUT	9.2	14.0	9.2	Expected
100yr	2yr	Future		8.0	7.6	2yr	100yr	Future	2100FUT	10.0	15.4	10.0	Expected
500yr	2yr	Future		8.1	7.6	2yr	500yr	Future	2500FUT	11.1	18.7	11.1	Expected
2yr	2yr	Future	FUT210YR	6.1	7.6	2yr	2yr	Future		6.1	7.6	6.1	Upper
10yr	10yr	Future		8.8	10.8	10yr	10yr	Future	1010FUT	8.8	10.8	8.8	Upper
50yr	10yr	Future		9.9	10.8	10yr	50yr	Future	1050FUT	10.4	14.0	10.4	Upper
100yr	10yr	Future		10.1	10.8	10yr	100yr	Future	10100FUT	11.1	15.4	11.1	Upper
500yr	10yr	Future		10.9	10.8	10yr	500yr	Future	10500FUT	12.6	18.7	12.6	Upper

Table III-19
Main Channel – 1,000cfs Pump Station Analysis Results

Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Min Fac.	Max WS	Change	Risk Condition
2yr	Normal	Current	NORTIDE	3.6	3.6							3.8	3.6	-0.2	Lower
10yr	Normal	Current		4.0	3.6							4.1	4.0	-0.1	Lower
50yr	Normal	Current		4.1	3.6							4.1	4.1	0.0	Lower
100yr	Normal	Current		4.1	3.6							4.1	4.1	0.0	Lower
500yr	Normal	Current		4.3	3.6							4.3	4.3	0.0	Lower
2yr	2yr	Current	SR2YEAR	4.4	6.9	2yr	2yr	Current		4.4	6.9	5.7	4.4	-1.3	Expected
10yr	2yr	Current		6.3	6.9	2yr	10yr	Current	210CUR	6.0	10.1	7.1	6.3	-0.8	Expected
50yr	2yr	Current		7.1	6.9	2yr	50yr	Current	250CUR	7.6	13.3	8.7	7.6	-1.1	Expected
100yr	2yr	Current		7.3	6.9	2yr	100yr	Current	2100CUR	7.9	14.7	9.5	7.9	-1.6	Expected
500yr	2yr	Current		7.4	6.9	2yr	500yr	Current	2500CUR	8.7	18.0	10.5	8.7	-1.8	Expected
2yr	2yr	Current	2AND10YR	4.4	6.9	2yr	2yr	Current		4.4	6.9	5.7	4.4	-1.3	Upper
10yr	10yr	Current		7.7	10.1	10yr	10yr	Current	1010CUR	7.7	10.1	8.4	7.7	-0.7	Upper
50yr	10yr	Current		9.0	10.1	10yr	50yr	Current	1050CUR	9.2	13.3	9.9	9.2	-0.7	Upper
100yr	10yr	Current		9.3	10.1	10yr	100yr	Current	10100CUR	10.1	14.7	10.7	10.1	-0.6	Upper
500yr	10yr	Current		10.2	10.1	10yr	500yr	Current	10500CUR	11.4	18.0	12.4	11.4	-1.0	Upper
2yr	Normal	Future	FUTNORM	4.3	4.3							4.3	4.3	0.0	Lower
10yr	Normal	Future		4.6	4.3							4.7	4.6	-0.1	Lower
50yr	Normal	Future		4.8	4.3							4.8	4.8	0.0	Lower
100yr	Normal	Future		4.8	4.3							4.8	4.8	0.0	Lower
500yr	Normal	Future		4.9	4.3							4.9	4.9	0.0	Lower
2yr	2yr	Future	FUT2YEAR	4.8	7.6	2yr	2yr	Future		4.8	7.6	6.1	4.8	-1.3	Expected
10yr	2yr	Future		6.6	7.6	2yr	10yr	Future	210FUT	6.4	10.8	7.5	6.6	-0.9	Expected
50yr	2yr	Future		7.7	7.6	2yr	50yr	Future	250FUT	8.0	14.0	9.2	8.0	-1.3	Expected
100yr	2yr	Future		7.9	7.6	2yr	100yr	Future	2100FUT	8.1	15.4	10.0	8.1	-1.9	Expected
500yr	2yr	Future		8.1	7.6	2yr	500yr	Future	2500FUT	8.9	18.7	11.1	8.9	-2.2	Expected
2yr	2yr	Future	FUT210YR	4.8	7.6	2yr	2yr	Future		4.8	7.6	6.1	4.8	-1.3	Upper
10yr	10yr	Future		8.1	10.8	10yr	10yr	Future	1010FUT	8.1	10.8	8.8	8.1	-0.7	Upper
50yr	10yr	Future		9.5	10.8	10yr	50yr	Future	1050FUT	9.8	14.0	10.4	9.8	-0.6	Upper
100yr	10yr	Future		9.8	10.8	10yr	100yr	Future	10100FUT	10.5	15.4	11.1	10.5	-0.7	Upper
500yr	10yr	Future		10.7	10.8	10yr	500yr	Future	10500FUT	11.6	18.7	12.6	11.6	-1.0	Upper

Table H1-20
Main Channel – 1,200cfs Pump Station Analysis Results

Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Min Fac.	Max WS	Change	Risk Condition
2yr	Normal	Current	NORTIDE	3.6	3.6							3.8	3.6	-0.2	Lower
10yr	Normal	Current		4.0	3.6							4.1	4.0	-0.1	Lower
50yr	Normal	Current		4.1	3.6							4.1	4.1	0.0	Lower
100yr	Normal	Current		4.1	3.6							4.1	4.1	0.0	Lower
500yr	Normal	Current		4.3	3.6							4.3	4.3	0.0	Lower
2yr	2yr	Current	SR2YEAR	4.1	6.9	2yr	2yr	Current		4.1	6.9	5.7	4.1	-1.6	Expected
10yr	2yr	Current		6.1	6.9	2yr	10yr	Current	210CUR	5.7	10.1	7.1	6.1	-1.0	Expected
50yr	2yr	Current		7.1	6.9	2yr	50yr	Current	250CUR	7.1	13.3	8.7	7.1	-1.6	Expected
100yr	2yr	Current		7.3	6.9	2yr	100yr	Current	2100CUR	7.3	14.7	9.5	7.3	-2.2	Expected
500yr	2yr	Current		7.4	6.9	2yr	500yr	Current	2500CUR	8.0	18.0	10.5	8.0	-2.5	Expected
2yr	2yr	Current	2AND10YR	4.1	6.9	2yr	2yr	Current		4.1	6.9	5.7	4.1	-1.6	Upper
10yr	10yr	Current		7.5	10.1	10yr	10yr	Current	1010CUR	7.5	10.1	8.4	7.5	-0.9	Upper
50yr	10yr	Current		9.0	10.1	10yr	50yr	Current	1050CUR	9.1	13.3	9.9	9.1	-0.9	Upper
100yr	10yr	Current		9.3	10.1	10yr	100yr	Current	10100CUR	9.9	14.7	10.7	9.9	-0.7	Upper
500yr	10yr	Current		10.1	10.1	10yr	500yr	Current	10500CUR	11.2	18.0	12.4	11.2	-1.2	Upper
2yr	Normal	Future	FUTNORM	4.3	4.3							4.3	4.3	0.0	Lower
10yr	Normal	Future		4.5	4.3							4.7	4.5	-0.2	Lower
50yr	Normal	Future		4.8	4.3							4.8	4.8	0.0	Lower
100yr	Normal	Future		4.8	4.3							4.8	4.8	0.0	Lower
500yr	Normal	Future		4.9	4.3							4.9	4.9	0.0	Lower
2yr	2yr	Future	FUT2YEAR	4.5	7.6	2yr	2yr	Future		4.5	7.6	6.1	4.5	-1.6	Expected
10yr	2yr	Future		6.4	7.6	2yr	10yr	Future	210FUT	6.2	10.8	7.5	6.4	-1.1	Expected
50yr	2yr	Future		7.6	7.6	2yr	50yr	Future	250FUT	7.4	14.0	9.2	7.6	-1.6	Expected
100yr	2yr	Future		7.8	7.6	2yr	100yr	Future	2100FUT	7.8	15.4	10.0	7.8	-2.2	Expected
500yr	2yr	Future		8.1	7.6	2yr	500yr	Future	2500FUT	8.2	18.7	11.1	8.2	-2.9	Expected
2yr	2yr	Future	FUT210YR	4.5	7.6	2yr	2yr	Future		4.5	7.6	6.1	4.5	-1.6	Upper
10yr	10yr	Future		8.0	10.8	10yr	10yr	Future	1010FUT	8.0	10.8	8.8	8.0	-0.8	Upper
50yr	10yr	Future		9.4	10.8	10yr	50yr	Future	1050FUT	9.6	14.0	10.4	9.6	-0.8	Upper
100yr	10yr	Future		9.7	10.8	10yr	100yr	Future	10100FUT	10.4	15.4	11.1	10.4	-0.8	Upper
500yr	10yr	Future		10.6	10.8	10yr	500yr	Future	10500FUT	11.4	18.7	12.6	11.4	-1.2	Upper

Table HI-21
Main Channel - 1,400cfs Pump Station Analysis Results

Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Min Fac.	Max WS	Change	Risk Condition
2yr	Normal	Current	NORTIDE	3.6	3.6							3.8	3.6	-0.2	Lower
10yr	Normal	Current		3.9	3.6							4.1	3.9	-0.2	Lower
50yr	Normal	Current		4.1	3.6							4.1	4.1	0.0	Lower
100yr	Normal	Current		4.1	3.6							4.1	4.1	0.0	Lower
500yr	Normal	Current		4.3	3.6							4.3	4.3	0.0	Lower
2yr	2yr	Current	SR2YEAR	3.7	6.9	2yr	2yr	Current		3.7	6.9	5.7	3.7	-1.9	Expected
10yr	2yr	Current		6.0	6.9	2yr	10yr	Current	210CUR	5.4	10.1	7.1	6.0	-1.1	Expected
50yr	2yr	Current		7.0	6.9	2yr	50yr	Current	250CUR	6.5	13.3	8.7	7.0	-1.7	Expected
100yr	2yr	Current		7.2	6.9	2yr	100yr	Current	2100CUR	6.8	14.7	9.5	7.2	-2.4	Expected
500yr	2yr	Current		7.4	6.9	2yr	500yr	Current	2500CUR	7.1	18.0	10.5	7.4	-3.1	Expected
2yr	2yr	Current	2AND10YR	3.7	6.9	2yr	2yr	Current		3.7	6.9	5.7	3.7	-1.9	Upper
10yr	10yr	Current		7.3	10.1	10yr	10yr	Current	1010CUR	7.3	10.1	8.4	7.3	-1.1	Upper
50yr	10yr	Current		8.9	10.1	10yr	50yr	Current	1050CUR	8.9	13.3	9.9	8.9	-1.1	Upper
100yr	10yr	Current		9.2	10.1	10yr	100yr	Current	10100CUR	9.7	14.7	10.7	9.7	-0.9	Upper
500yr	10yr	Current		10.1	10.1	10yr	500yr	Current	10500CUR	10.8	18.0	12.4	10.8	-1.6	Upper
2yr	Normal	Future	FUTNORM	4.3	4.3							4.3	4.3	0.0	Lower
10yr	Normal	Future		4.4	4.3							4.7	4.4	-0.3	Lower
50yr	Normal	Future		4.8	4.3							4.8	4.8	0.0	Lower
100yr	Normal	Future		4.8	4.3							4.8	4.8	0.0	Lower
500yr	Normal	Future		4.9	4.3							4.9	4.9	0.0	Lower
2yr	2yr	Future	FUT2YEAR	4.3	7.6	2yr	2yr	Future		4.3	7.6	6.1	4.3	-1.8	Expected
10yr	2yr	Future		6.3	7.6	2yr	10yr	Future	210FUT	5.8	10.8	7.5	6.3	-1.2	Expected
50yr	2yr	Future		7.6	7.6	2yr	50yr	Future	250FUT	6.7	14.0	9.2	7.6	-1.6	Expected
100yr	2yr	Future		7.7	7.6	2yr	100yr	Future	2100FUT	7.0	15.4	10.0	7.7	-2.3	Expected
500yr	2yr	Future		8.1	7.6	2yr	500yr	Future	2500FUT	7.4	18.7	11.1	8.1	-3.0	Expected
2yr	2yr	Future	FUT210YR	4.3	7.6	2yr	2yr	Future		4.3	7.6	6.1	4.3	-1.8	Upper
10yr	10yr	Future		7.8	10.8	10yr	10yr	Future	1010FUT	7.8	10.8	8.8	7.8	-1.0	Upper
50yr	10yr	Future		9.3	10.8	10yr	50yr	Future	1050FUT	9.4	14.0	10.4	9.4	-1.0	Upper
100yr	10yr	Future		9.6	10.8	10yr	100yr	Future	10100FUT	10.2	15.4	11.1	10.2	-0.9	Upper
500yr	10yr	Future		10.5	10.8	10yr	500yr	Future	10500FUT	11.0	18.7	12.6	11.0	-1.6	Upper

Table H1-22
Main Channel – 1,600cfs Pump Station Analysis Results

Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Interior Flow	Exterior Stage	Time Condition	Exterior Module	Peak Int. WSEL	Peak Ext. WSEL	Min Fac.	Max WS	Change	Risk Condition
2yr	Normal	Current	NORTIDE	3.6	3.6							3.8	3.6	-0.2	Lower
10yr	Normal	Current		3.8	3.6							4.1	3.8	-0.3	Lower
50yr	Normal	Current		4.1	3.6							4.1	4.1	0.0	Lower
100yr	Normal	Current		4.1	3.6							4.1	4.1	0.0	Lower
500yr	Normal	Current		4.3	3.6							4.3	4.3	0.0	Lower
2yr	2yr	Current	SR2YEAR	3.6	6.9	2yr	2yr	Current		3.6	6.9	5.7	3.6	-2.1	Expected
10yr	2yr	Current		5.8	6.9	2yr	10yr	Current	210CUR	4.9	10.1	7.1	5.8	-1.3	Expected
50yr	2yr	Current		7.0	6.9	2yr	50yr	Current	250CUR	5.8	13.3	8.7	7.0	-1.7	Expected
100yr	2yr	Current		7.2	6.9	2yr	100yr	Current	2100CUR	6.0	14.7	9.5	7.2	-2.4	Expected
500yr	2yr	Current		7.4	6.9	2yr	500yr	Current	2500CUR	6.3	18.0	10.5	7.4	-3.1	Expected
2yr	2yr	Current	2AND10YR	3.6	6.9	2yr	2yr	Current		3.6	6.9	5.7	3.6	-2.1	Upper
10yr	10yr	Current		7.2	10.1	10yr	10yr	Current	1010CUR	7.2	10.1	8.4	7.2	-1.2	Upper
50yr	10yr	Current		8.8	10.1	10yr	50yr	Current	1050CUR	8.8	13.3	9.9	8.8	-1.2	Upper
100yr	10yr	Current		9.1	10.1	10yr	100yr	Current	10100CUR	9.6	14.7	10.7	9.6	-1.1	Upper
500yr	10yr	Current		10.0	10.1	10yr	500yr	Current	10500CUR	10.5	18.0	12.4	10.5	-1.9	Upper
2yr	Normal	Future	FUTNORM	4.3	4.3							4.3	4.3	0.0	Lower
10yr	Normal	Future		4.3	4.3							4.7	4.3	-0.4	Lower
50yr	Normal	Future		4.8	4.3							4.8	4.8	0.0	Lower
100yr	Normal	Future		4.8	4.3							4.8	4.8	0.0	Lower
500yr	Normal	Future		4.9	4.3							4.9	4.9	0.0	Lower
2yr	2yr	Future	FUT2YEAR	4.3	7.6	2yr	2yr	Future		4.3	7.6	6.1	4.3	-1.8	Expected
10yr	2yr	Future		6.1	7.6	2yr	10yr	Future	210FUT	5.4	10.8	7.5	6.1	-1.4	Expected
50yr	2yr	Future		7.6	7.6	2yr	50yr	Future	250FUT	6.1	14.0	9.2	7.6	-1.7	Expected
100yr	2yr	Future		7.7	7.6	2yr	100yr	Future	2100FUT	6.2	15.4	10.0	7.7	-2.3	Expected
500yr	2yr	Future		8.1	7.6	2yr	500yr	Future	2500FUT	6.6	18.7	11.1	8.1	-3.0	Expected
2yr	2yr	Future	FUT210YR	4.3	7.6	2yr	2yr	Future		4.3	7.6	6.1	4.3	-1.8	Upper
10yr	10yr	Future		7.6	10.8	10yr	10yr	Future	1010FUT	7.6	10.8	8.8	7.6	-1.2	Upper
50yr	10yr	Future		9.2	10.8	10yr	50yr	Future	1050FUT	9.3	14.0	10.4	9.3	-1.1	Upper
100yr	10yr	Future		9.5	10.8	10yr	100yr	Future	10100FUT	10.1	15.4	11.1	10.1	-1.1	Upper
500yr	10yr	Future		10.4	10.8	10yr	500yr	Future	10500FUT	10.7	18.7	12.6	10.7	-1.9	Upper

Table H1-23
Main Channel - Plan Comparison

Plan	Description	FIRST CONSTRUCTION COST (Incremental)(1)	FIRST LAND COST (2)	OPERATION &MAINTENANCE (Annual; Incremental))	INCREMENTAL ANNUAL COST	TOTAL ANNUAL COST	Equivalent Annual Damage	Annual Damage Reduction	Annual Net Benefit
Minimum Facility		$2,107,600	$0	$19,250	$155,350	$155,350	$902,250	$0	$0
Alt 1	1,000cfs Pump Station	$3,657,350	$0	$23,000	$259,100	$414,150	$399,950	$502,300	$243,200
Alt 2	1,200cfs Pump Station	$4,078,750	$0	$25,400	$288,700	$444,025	$326,250	$576,000	**$287,300**
Alt 3	1,400cfs Pump Station	$4,558,900	$0	$28,750	$323,050	$478,400	$302,900	$599,350	$276,300
Alt 4	1,600cfs Pump Station	$5,235,700	$0	$32,500	$370,500	$525,850	$258,550	$643,700	$273,200

(1) First cost includes 15% Engineering & Design, 7% Administration &15% Contingencies (1.403 Construction Factor). Pumps: First cost includes 7% Engineering & Design, 7% Administration &12% Contingencies (1.277 Construction Factor).
(2) First Land Cost includes 5% Survey & Appraisal, &10% Contingencies

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Honorable Nancy Pelosi
Speaker of the House
of Representatives
U.S. Capitol Building, Room H-232
Washington, D.C. 20515-0001

HOUSE DOCUMENT NUMBER 111-35

Dear Madam Speaker:

Per the request of the Chairman, Committee on Transportation and Infrastructure, I am resubmitting, herewith the following three Executive Communications: EC 10240 (South River, Raritan River Basin, New Jersey) and EC 10241 (General Reevaluation Report (GRR) to determine whether an extension of the Dallas Floodway, Trinity River project would be warranted) and EC 10242 (a feasibility report to document the development of a project for the Illinois River between Henry and Naples with particular reference to the non-Federal Peoria River Front Development project). I am enclosing all documents that were transmitted with the original correspondence.

Very truly yours,

John Paul Woodley, Jr.
John Paul Woodley, Jr.
Assistant Secretary of the Army
(Civil Works)

Enclosures

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Honorable Nancy Pelosi
Speaker of the House
of Representatives
U.S. Capitol Building, Room H-232
Washington, D.C. 20515-0001

2008 DEC 15 AM 11:26

Dear Madam Speaker:

In partial response to a resolution by the House Committee on Public Works and Transportation, adopted May 13, 1993, the U.S. Army Corps of Engineers (Corps) prepared a feasibility report to document the development of a project for the South River, Raritan River Basin, New Jersey. The proposal is described in the report of the Chief of Engineers dated July 22, 2003, which includes other pertinent reports and comments. The views of the State of New Jersey, the Department of the Interior, and the Environmental Protection Agency are set forth in the enclosed communications. The project includes both hurricane and storm damage reduction (HSDR) and ecosystem restoration (ER) components and was authorized in Section 1001 (34) of the Water Resources Development Act of 2007.

The HSDR features consist of a levee and floodwall system, a storm surge barrier across the South River, and a pumping station with associated facilities to control the interior drainage. The project would provide protection to the communities of South River, Sayreville, East Brunswick and Old Bridge, New Jersey from hurricanes and storm surges with a 0.2 percent chance of occurring in any given year. It includes approximately 10,700 feet of levees and 1,650 feet of floodwalls. A storm surge barrier with an 80-foot wide sector gate opening would span the 320-foot-wide South River in the area immediately downstream of the Veterans Memorial Bridge. The inclusion of the storm surge barrier would provide a comprehensive protection system and reduce adverse impacts on wetlands. A pumping station and box culverts would prevent interior flooding when the storm surge barrier is closed. In addition, diversion pipes and gravity outlets that pass through the levees and the floodwall would be included to provide for the natural hydrology during non-flood situations. Compensatory mitigation that would convert about 11 acres of *Phragmites* degraded wetlands to a combination of higher value wetland scrub-shrub and salt marsh habitats would replace habitat impacted by project construction. *Phragmites* is an invasive plant that colonizes disturbed areas in such density as to displace more desirable wetland species.

Average annual HSDR benefits are estimated at $12,097,000 and average annual costs are estimated at $4,487,000, based on the fiscal year 2007 discount rate of 4.875 percent and a 50-year period of economic analysis. The equivalent annual net benefits are $7,610,000, and the resulting benefit-cost ratio is 2.7. The selected HSDR alternative is the national economic development (NED) plan.

The ER features include the restoration of approximately 379 acres of wetlands to increase biodiversity and ecological functions degraded by severe *Phragmites* infestation. The restoration areas are located principally on Clancy Island between the Washington Canal, the South River, and the Raritan River, and on the west bank of the South River adjacent to the Veterans Memorial Bridge. Significant features of the restoration plan would include: controlling *Phragmites* by excavation, burning, spraying, or other measures; excavation of soil material to establish salt marsh hydrology favorable to *Spartina* and poorly suited for *Phragmites*; enlarging and increasing the sinuosity of existing channels, creating more natural channel morphology and increasing tidal flushing on the marsh surface; developing low emergent marsh habitat to transition between a large expanse of mudflat habitat and wetland forest/scrub-shrub habitat, and planting native vegetation to speed restoration and prevent re-establishment of *Phragmites*. The plan would restore 152 acres of low emergent marsh, 170 acres of wetland forest/scrub-shrub, 19 acres of upland forest/scrub-shrub, 19 acres of mudflats, and 19 acres of open water. These habitats would support a wide variety of significant fish and wildlife species.

The Corps employed cost effectiveness and incremental analysis techniques to identify the appropriate measures providing for the restoration of significant marine tidal wetland habitats. They closely considered eight environmental restoration alternatives including the no-action alternative. Plans were formulated using three habitat-based models. The project is expected to restore approximately 379 acres of marine tidal wetland habitats and increases the net habitat by 335 units annually over the without-project condition. The total first cost for restoration would be about $62,050,000. The selected ER alternative is the national ecosystem restoration (NER) plan.

The plan recommended by the Chief of Engineers is a combination of the NED plan and the NER plan. Based on October 2007 price levels, the Corps estimates that the initial construction costs of the project are approximately $132,316,000; HSDR features are estimated to be about $70,266,000 and ER features are estimated to be about $62,050,000. Based on the cost sharing principles specified by the Water Resources Development Act (WRDA) of 1986, as amended by Section 210 of WRDA 1996, 65 percent ($86,005,000) of the project first costs for both HSDR features and ER features would be Federal, and 35 percent ($46,311,000) would be non-Federal. The HSDR and ER features are separable elements that could be constructed and would provide the estimated HSDR and ER benefits independently.

The non-Federal sponsor is the New Jersey Department of Environmental Protection. All costs for the operation, maintenance, replacement and rehabilitation of the project will be the responsibility of the State of New Jersey. The non-Federal sponsor will also be required to develop and adopt a comprehensive floodplain management plan for the project area.

The Administration review of this project concluded that the authorized HSDR project would be eligible to compete for funding through the normal budget process at the appropriate time, considering national priorities and the availability of funds. However, the proposed ER plan does not represent an appropriate level of investment from the national perspective and is not consistent with the policy and programs of the President.

The Office of Management and Budget (OMB) advises that there is no objection to the submission of the report to Congress. A copy of its December 3, 2008 letter is enclosed. I am providing a copy of this transmittal and the OMB letter to the House Subcommittees on Energy and Water Development, and Water Resources and Environment.

Very truly yours,

John Paul Woodley, Jr.

John Paul Woodley, Jr.
Assistant Secretary of the Army
(Civil Works)

Enclosures

6 Enclosures

1. Report of the Chief of Engineers, Jul 22, 2003
2. State of New Jersey Letter Mar 07, 2003
3. EPA Letter Jan 28, 2003
4. DOI Letter, Mar 04, 2003
5. OMB Letter, Dec 3, 2008
6. South River, Raritan River Basin, New Jersey - Hurricane and Storm Damage Reduction and Ecosystem Restoration, September 2002

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20310-2600

REPLY TO
ATTENTION OF

CECW-PM (1105-21-10a)

22 JUL 2003

SUBJECT: South River, Raritan River Basin, New Jersey

THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress my report on hurricane and storm damage reduction and ecosystem restoration along the South River in Middlesex County, New Jersey. It is accompanied by the report of the district and division engineers. These reports are in response to a resolution by the Committee on Public Works and Transportation of the House of Representatives adopted 13 May 1993. The resolution requested a review of existing reports on the Raritan River Basin, New Jersey, to determine whether any modifications of the recommendations contained therein are advisable at the present time in the interest of flood control and related purposes on the South River, New Jersey. Pre-construction engineering and design (PED) activities for this proposed project will be continued under the resolution cited above.

2. The reporting officers recommended implementation of a combined plan that provides both hurricane and storm damage reduction (HSDR) and environmental restoration features.

a. The HSDR features consist of a levee and floodwall system along the eastern and western banks of the lower South River with an upstream storm surge barrier across the South River, located just downstream of the Veterans Memorial Bridge. The proposed project would provide a high level of protection from hurricane and storm damages to the communities of South River, Sayreville, East Brunswick and Old Bridge, New Jersey. The annual probability of coastal storm damages would be reduced from a 1-in-2 to a 1-in-500 chance in any year. The proposed project includes approximately 10,700 feet of levees and approximately 1,650 feet of floodwalls. The storm surge barrier will span the South River for a length of 320 feet and will have a clear opening of 80 feet. The inclusion of the storm surge barrier would provide a comprehensive protection system to the area and reduce adverse impacts on wetlands. To prevent induced flooding in the areas protected by the levees and floodwalls, facilities including diversion pipes and gravity outlets are included in the levees and floodwalls. A 1,200 cfs pumping station and box culverts are included with the storm surge barrier to prevent flooding caused by the back up of the South River flows when the storm surge barrier is closed. Even though the selected hurricane and storm damage reduction plan was specifically designed to avoid and minimize environmental impacts, there would be some unavoidable impacts to the natural resources, which

Encl 1

would be offset by providing mitigation. The selected mitigation plan would involve the conversion of 11.1 acres of *Phragmites* degraded wetlands to a combination of wetland scrub-shrub (7.8 acres) and salt marsh (3.3 acres) habitats.

b. The recommended plan also includes restoration of approximately 379 acres of wetlands degraded by severe *Phragmites* colonization to increase biodiversity and ecological functions. These areas are located principally on Clancy Island between the Washington Canal, the South River, and the Raritan River, and on the west bank of the South River adjacent to the Veterans Memorial Bridge. Significant features of the restoration plan include: controlling *Phragmites* by excavation, burning, spraying, or other measures; excavation of soil material to establish salt marsh hydrology favorable to *Spartina* and poorly suited for *Phragmites*; enlarging and increasing the sinuosity of existing channels, creating more natural channel morphology and increasing tidal flushing on the marsh surface; developing low emergent marsh habitat to transition between a large expanse of mudflat habitat and wetland forest/scrub-shrub habitat, and planting native vegetation to speed restoration and prevent re-establishment of *Phragmites*. The plan will restore the following habitats: low emergent marsh (152 acres: 40 percent), wetland forest/scrub-shrub (170 acres: 45 percent; plus an additional 19 acres, or 5 percent, as upland forest/scrub-shrub), mudflat (19 acres: 5 percent), and open water (19 acres: 5 percent).

3. Based on October 2002 price levels, the first cost of the project is $103,268,000: hurricane and storm damage reduction features are estimated to be $55,172,000 and ecosystem restoration features are estimated to be $48,096,000. Based on the cost sharing principles specified by the Water Resources Development Act (WRDA) of 1986, as amended by Section 210 of WRDA 1996, 65 percent ($67,124,000) of the project first costs for both HSDR features and ecosystem restoration features would be Federal and 35 percent ($36,144,000) would be non-Federal. The non-Federal sponsor would also be responsible for all costs related to operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) of the completed project. Of the non-Federal share, the total cash contribution required would be $26,721,000. The balance of the non-Federal share would consist of $9,423,000 for the estimated creditable value for lands, easements, rights-of-way, relocations, and suitable disposal/borrow areas (LERRD).

4. Based on a discount rate of 5.875 percent and a 50-year period of economic analysis, average annual hurricane and storm damage reduction benefits are estimated at $9,161,000 and average annual costs are estimated at $4,139,000. The equivalent annual net benefits are $5,022,000, and the resulting benefit-to-cost ratio is 2.2 to 1. Annual OMRR&R costs for the hurricane and storm damage features are estimated at $221,000. The total first cost of restoration of 379 acres of degraded wetlands would result in an increase in the habitat value of the area of 335 average annual habitat units (AAHU). To ensure that an efficient environmental restoration plan was recommended, cost effectiveness and incremental analysis techniques were used to evaluate alternative restoration plans. The cost of the recommended environmental restoration features is justified by the restoration of about 335 AAHU and provides for achieving habitat increases in the most cost-effective manner. These restored habitats are considered especially valuable due to

X

scarcity and dependence of certain species on these resources. Average annual costs are estimated at $3,486,000, or approximately $10,400 per AAHU. Annual OMRR&R costs for the ecosystem restoration features are estimated at $78,800. The recommended plan is a combination of the national economic development (NED) plan and the national ecosystem restoration (NER) plan.

5. Washington level review indicates that the plan developed is technically sound, economically justified, and socially and environmentally acceptable. The plan conforms to essential elements of the U.S. Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies and complies with other administration and legislative policies and guidelines. Also, the views of interested parties, including Federal, State, and local agencies have been considered.

6. I concur with findings, conclusions, and recommendations of the reporting officers. Accordingly, I recommend construction of this project for hurricane and storm damage reduction and ecosystem restoration in accordance with the reporting officers' recommended NED and NER plan with such modifications as in the discretion of the Chief of Engineers may be advisable. Also, this recommendation is subject to the non-Federal sponsor agreeing to comply with all applicable Federal laws and policies and other requirements including but not limited to:

a. Provide all lands, easements, rights-of-way, relocations, and disposal/borrow areas (LERRD) uncontaminated with hazardous and toxic wastes.

b. Provide an additional cash contribution if the value of LERRD contributions toward total project costs is less than 35 percent, so that the total share equals 35 percent.

c. Provide all improvements required on lands, easements, and rights-of-way to enable the proper disposal of dredged or excavated material associated with the construction, operation, and maintenance of the project. Such improvements may include, but are not necessarily limited to, retaining dikes, wasteweirs, bulkheads, embankments, monitoring features, stilling basins, and dewatering pumps and pipes.

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

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

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

g. Keep, and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the Project for a minimum of three years after completion of the accounting for which such books, records, documents, and other evidence is required, and, in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations (CFR) Section 33.20.

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

i. Assume complete financial responsibility, as between the Federal Government and the non-Federal project partner for all necessary cleanup and response costs of any CERCLA-regulated materials located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be necessary for the construction, operation, or maintenance of the Project.

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

k. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way, required for the construction, operation, and maintenance of the Project, including those necessary for relocations, borrow materials, and dredged or excavated material disposal, and inform all affected persons of applicable benefits, policies, and procedures in connection with said act.

l. Comply with all applicable Federal and State laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army" and all applicable Federal labor standards and requirements, including but not limited to 40 U.S.C. 3141-3148 and 40 U.S.C. 3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a *et seq.*), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 *et seq.*) and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c)).

m. Provide the non-Federal share of that portion of the costs of mitigation and data recovery activities associated with historic preservation, that are in excess of 1 percent of the total amount authorized to be appropriated for the Project, in accordance with the cost sharing provisions of the agreement.

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

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

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

q. Enter into an agreement, which provides, prior to construction, 25 percent of preconstruction, engineering and design costs for HSDR features and 25 percent for ecosystem restoration features.

r. Provide, during the first year of construction, any additional funds needed to cover the non-Federal share of PED costs.

CECW-PM
SUBJECT: South River, Raritan River Basin, New Jersey

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

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

u. Do not use Federal funds to meet the non-Federal sponsor's share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds is authorized.

7. The recommendation contained herein reflects the information available at this time and current departmental policies governing formulation of individual projects. It does not reflect program and budgeting priorities inherent in the formulation of a national civil works construction program nor the perspective of higher review levels within the executive branch. Consequently, the recommendation may be modified before it is transmitted to Congress as a proposal for authorization and implementation funding. However, prior to transmittal to Congress, the sponsor, the State of New Jersey Department of Environmental Protection; interested Federal agencies; and other parties will be advised of any significant modifications and will be afforded an opportunity to comment further.

ROBERT B. FLOWERS
Lieutenant General, U.S. Army
Chief of Engineers

State of New Jersey
Department of Environmental Protection
PO Box 402
Trenton, NJ 08625-0402

James E. McGreevey
Governor

Bradley M. Campbell
Commissioner
Tel. # (609) 292-2885
Fax # (609) 292-7695

March 7, 2003

Mr. James F. Johnson
Chief, Planning and Policy Division
US Army Corps of Engineers
Washington, DC 20314-1000

Dear Mr. Johnson:

Governor James E. McGreevey has asked me to respond on his behalf to your January 15, 2003 letter concerning the South River, Raritan River Basin Hurricane and Storm Damage Reduction and Ecosystem Restoration Feasibility Study.

The Department of Environmental Protection's (DEP) Offices of Natural and Historic Resources and Land Use met with staff from the New York District on January 30, 2003 to reach consensus on the direction of this project. The DEP agrees that we share the common goal to maximize the value of the project to reduce flood damages, while protecting and restoring the environment in a cost-effective manner.

In the Project Management Plan for the Pre-Construction, Engineering and Design Phase (PED), DEP will look to fully participate in a Value Engineering (VE) study and evaluate means for cost savings and refinement of the recommended plans for hurricane and storm damage reduction and enhanced ecosystem restoration. DEP is particularly interested in the hydrodynamic modeling for the tide surges and their correlation to historic readings, and a sustainable ecosystem restoration plan that removes substrate that would encourage non-desirable plants and invertebrates.

As agreed at the meeting, the Corps will address all concerns related to design, construction and environmental impacts during the PED phase to the satisfaction of the DEP. With this understanding, final processing of the Corps' integrated feasibility report / environmental impact statement and preparation of the Record of Decision is acceptable to the DEP.

The specific agreements which correspond to the points raised during the January 30 meeting are as follows:

- The hydraulic design the levees and floodwalls will be refined during PED, through use of a value engineering effort and the reevaluation and updating of hydraulic information. The levee design for the 500-year flood will most likely be scaled back, accordingly. Additionally, should the Department select a project smaller than the recommended plan, the same cost-sharing proportion as the recommended plan (65% Federal – 35% non-Federal) would be considered.

ENCL 2

- Mitigation requirements for wetland impacts will be refined during PED. Since the levee footprint will likely be scaled back, adverse impacts to wetlands would likely decrease. The project delivery team will coordinate mitigation requirements. If additional mitigation above the Federal limit are considered it could be included as "project betterment" at non-Federal cost.

- Sufficient information to evaluate potential contaminated sediments within the recommended ecosystem restoration project will be collected early during PED.

- General Conformity provisions of the Clean-Air Act will be addressed prior to preparation of the Record of Decision.

- The ecosystem restoration project design will be refined during PED, with emphasis on sub-surface conditions and the overall value of ecological benefits vs. restoration costs. The sizing and scale of the plan will also be refined with Department input and coordination.

- Impacts to local parkland subject to the conversion provisions of the State's Green Acres program will be addressed during PED. The requirement of prior approval by the State along with appropriate compensation for Green Acres parkland impacts will be fully addressed. The Federal vs. non-Federal responsibilities in resolving the parkland issues will be coordinated during PED.

- Phase I and Phase II cultural resources investigations will be completed during PED.

- Construction "windows" to avoid impacts to anadromous fish will be established during PED.

DEP will continue to work with the Corps to finalize the Project Management Plan for the Pre-Construction, Engineering and Design Phase and execute the Design Agreement so we may initiate the design phase of the project. Please be assured of our interest and support and our desire to move forward with the project.

If you have questions, please call Marc A. Matsil, Assistant Commissioner, at (609) 292-3541. We look forward to collaborating with you on this project

Sincerely

Bradley M. Campbell
Commissioner

c: Eugene Brickman, USACE
Marc A. Matsil, DEP

PC

State of New Jersey
OFFICE OF THE GOVERNOR
PO BOX 001
TRENTON NJ 08625-0001

JAMES E. MCGREEVEY
Governor

January 23, 2003

Mr. James F. Johnson
Chief, Planning & Policy Division (Civil Works)
US Army Corps of Engineers
Washington, D.C. 20314-1000

Dear Mr. Johnson:

Thank you for your recent correspondence. I appreciate you taking the time to share your thoughts with me.

Through transmission of this letter to Commissioner Bradley M. Campbell, I am requesting that he expedite a review of the information set forth in your letter with all due attention and consideration. Should you wish to contact Commissioner Campbell directly, he may be reached at the Department of Environmental Protection, 401 East State Street (7th floor), Post Office Box 402, Trenton, New Jersey 08625-0402 or by calling (609) 292-2885.

Again, thank you for writing. It is only through the continued concern and commitment of individuals such as yourself that we may hope to provide a better quality of life to all the residents of New Jersey.

With all good wishes,

James E. McGreevey

James E. McGreevey

cc: Bradley M. Campbell

08/27/2003 21:18 2122646840 PAGE 02

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
290 BROADWAY
NEW YORK, NY 10007-1866

JAN 28 2003

Mark H. Burlas
Project Environmental Manager
U.S. Army Corps of Engineers
New York District - Planning Division
26 Federal Plaza
New York, New York 10278-0090

Dear Mr. Burlas:

The Environmental Protection Agency (EPA) has reviewed the final environmental impact statement (EIS) (CEQ#020447) for the South River, Raritan Basin, Combined Flood Control and Environmental Restoration Project, located in Middlesex County, New Jersey. This review was conducted in accordance with Section 309 of the Clean Air Act, as amended (42 U.S.C. 7609, PL 91-604 12 (a), 84 Stat. 1709), and the National Environmental Policy Act (NEPA).

The proposed project entails the construction of a storm protection structure, in the Boroughs of South River and Sayreville, and the Township of Old Bridge, Middlesex County, New Jersey. Specifically, the proposal includes the construction of 10,712 feet of levees and 1,644 feet of floodwalls along the eastern and western banks of the lower South River, and the installation of a storm surge barrier. The project is designed to provide flood protection to the adjacent properties from a 500 year storm. The proposed activities would impact 9.41 acres of waters of the United States, and convert an additional 3.29 acres to drainage swales within the vicinity of the proposed structures. To compensate for these impacts, the USACE has proposed 11.1 acres of mitigation, which would require the conversion of 3.3 acres of Phragmites marsh to Spartina marsh, the conversion of 1.7 acres of Phragmites marsh to scrub-shrub wetlands, and the creation of 6.1 acres of scrub-shrub wetlands from uplands. The USACE arrived at this ratio after conducting a Habitat Evaluation Procedure (HEP) and an Evaluation of Planned Wetlands (EPW) analysis of the proposed impacts. In addition to the proposed flood control structures, the USACE has also proposed to implement an ecosystem restoration plan (NER) in the vicinity of the project, which would restore 379.3 acres of Phragmites dominated wetlands to 171 acres of forested and scrub-shrub wetlands, 152 acres of low emergent marsh, 19 acres of mud flat, 19 acres of open water, and 19 acres of upland forest and scrub-shrub. Based on our review of the final EIS, EPA offers the following comments.

In our August 23, 2002 comment letter on the draft EIS, we rated the document as EC-2, indicating that we had environmental concerns regarding wetland and air quality impacts, and requested that the final EIS include additional information to address our concerns. While some of the requested information was provided in the final EIS, particularly the information pertaining to air quality, the final EIS does not include the majority of the information we requested to address our wetlands concerns. However, it is EPA's understanding that some of the information we requested will not be available until later in the USACE's planning process. With this in mind, and given that the air quality analysis is still in its preliminary stages, EPA recommends that the USACE consider tiering off of the current final EIS with a subsequent NEPA document when more detailed information is available in the project's evolution, pursuant

Received Time Aug. 28. 7:55AM Prin Time Aug. 28. 7:59AM

ENCL #3

to 40 CFR 1508.28. Specifically, EPA believes it would be appropriate to tier off the current EIS with a subsequent NEPA document when details of the wetlands mitigation plan become available and the general conformity determination has been completed. With this in mind, the remainder of this letter will outline the information we believe should be included in a future NEPA document to address our concerns.

With regard to air quality, our comment letter on the draft EIS requested that project related direct and indirect air emissions per 40 CFR Parts 51, and 93, be quantified and compared to the requirements of 40 CFR Part 93 to determine general conformity applicability. As a follow-up to our August 23, 2002 comment letter, EPA and the USACE had several discussions about the general conformity requirements and the information EPA needed to be included in the final EIS. EPA is pleased to note that the final EIS includes the agreed upon "rough" emission estimates. Based upon these estimates, the initial calculations indicate that the proposed project would emit approximately 50.5 tons/year of NOx, well above the de minimus threshold of 25 tons/year. As such, the final EIS provides a table outlining the proposed schedule the USACE intends to follow in order to demonstrate conformity for the project. EPA believes the schedule in the final EIS, if followed closely, would allow the USACE to ensure conformity in the timeframe given. However, to ensure compliance with Section 176(c) of the Clean Air Act, the USACE must commit in the Record of Decision (ROD) to follow the proposed steps outlined in the schedule and not to proceed to construction until conformity can be demonstrated. Moreover, EPA suggests including the conformity determination in a subsequent NEPA document and running the public comment periods concurrently. EPA would also like to offer its assistance in reviewing draft analyses and other pertinent documents as they become available throughout the conformity process.

With regard to the proposed project's wetlands impacts, the final EIS provided only the final HEP and EPW values used to determine the mitigation for the project. Based on this information, it appears that the proposed mitigation plan will replace the functions and values of the unavoidable wetland losses. However, the analysis used to determine these values are not presented in the final EIS. Moreover, the document provided only a brief conceptual plan with little or no information as to how the proposed mitigation would be carried out. As such, it is difficult to fully assess adequacy of the proposed mitigation plan. In a related matter, the final EIS concludes that the selected mitigation plan will result in a 1:1 creation to impact ratio; we disagree. To reach this conclusion, the document appears to have characterized the conversion of wetlands to drainage swales as the creation of emergent /herbaceous wetlands. We consider this conversion an impact that requires mitigation rather than a source of mitigation itself. Consequently, EPA recommends the proposed mitigation plan be expanded to achieve the stated goal of a 1:1 creation to impact ratio.

With regard to the NER, we support the restoration concept proposed under this plan. However, as with the mitigation plan for the flood control project, the document did not provide sufficient detail to enable us to access the potential success for the NER. The USACE indicated in its response to EPA's comments on the draft EIS that such details would be developed in the future. As such, this response supports our recommendation that a subsequent NEPA document be prepared in order to provide the public and interested agencies the opportunity to review the information necessary to adequately assess the USACE's NER plan.

In conclusion, EPA remains concerned about project's air quality and wetland impacts. As such, EPA recommends that the USACE commit in the Record of Decision (ROD) to preparing a subsequent NEPA document which would include the project's General Conformity Determination and the requested information regarding our wetland concerns. This would also allow the public an opportunity to review the mitigation plan once specific details are available to determine the plan's likelihood for success. Alternatively, the ROD could include a commitment to provide this information prior to the initiation of the action.

Thank you for the opportunity to comment. Should you have any questions concerning this letter, please contact Mark Westrate of my staff at (212) 637-3789.

Sincerely yours,

Grace Musumeci for

Robert W. Hargrove, Chief
Strategic Planning and Multi-Media Programs Branch

ROD - has comments from agencies appended to it

NJDEP -
NMFS -
EPA -

United States Department of the Interior

OFFICE OF THE SECRETARY
Washington, D.C. 20240

MAR 4 2003

ER 03/68

Mr. James F. Johnson
Chief, Planning and Policy Division
Directorate of Civil Works
U.S. Army Corps of Engineers
CECW-P (SA)
7701 Telegraph Road
Alexandria, VA 22315-3860

Dear Mr. Johnson:

The U.S. Department of the Interior has reviewed the Chief of Engineers Proposed Report and the Report of the District Engineer on South River, Raritan River Basin, Middlesex County, New Jersey.

On the draft report, the Fish and Wildlife Service had a concern that the mitigation for the project's storm damage component fell short by 2 to 3 acres of wetland enhancement. However, the Corps' commitment to convert close to 400 acres of low quality Phragmites-dominated wetlands to Spartina marsh, with the project's restoration component, outweighs this concern.

Therefore, we have no comments to offer, and do not object to the proposed project. Thank you for the opportunity to review these materials.

Sincerely,

for Willie R. Taylor
Director
Office of Environmental Policy
and Compliance

ENCL #4

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

December 3, 2008

The Honorable John P. Woodley, Jr.
Assistant Secretary of the Army (Civil Works)
108 Army Pentagon
Washington, D.C. 20310-0108

Dear Mr. Woodley:

The Office of Management and Budget (OMB) has completed its review of the Army Corps of Engineers' South River, Raritan River Basin, Hurricane and Storm Damage Reduction and Ecosystem Restoration Projects.

Our review concluded that your recommendation for the Hurricane and Storm Damage Reduction work is consistent with the policy and programs of the President; however, the proposed separable element to provide environmental restoration in this area does not represent an appropriate level of investment from the national perspective. OMB advises that there is no objection to the submission of the report to Congress. However, when doing so, please indicate that the environmental restoration separable element is not consistent with the policy and programs of the President.

Sincerely,

Richard A. Mertens
Deputy Associate Director
Energy, Science and Water

ENCL 5

NOTICE

South River, New Jersey

Since Congress has authorized the project, the Army Corps of Engineers does not request that the report be printed. If there are any questions about this, please call (Wes Coleman) at Corps Headquarters. You can reach Mr. Coleman at (202) 761-5782.

SOUTH RIVER, RARITAN RIVER BASIN HURRICANE & STORM DAMAGE REDUCTION AND ECOSYSTEM RESTORATION

111th Congress, 1st Session – – – – – – – – – – – – House Document 111–35

SOUTH RIVER, RARITAN RIVER BASIN HURRICANE & STORM DAMAGE REDUCTION AND ECOSYSTEM RESTORATION

COMMUNICATION

FROM

THE ASSISTANT SECRETARY OF THE ARMY (CIVIL WORKS), THE DEPARTMENT OF THE ARMY

TRANSMITTING

THE INTEGRATED FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT STATEMENT FOR THE SOUTH RIVER, RARITAN RIVER BASIN HURRICANE AND STORM DAMAGE REDUCTION AND ECOSYSTEM RESTORATION

APRIL 23, 2009.—Referred to the Committee on Transportation and Infrastructure and ordered to be printed

U.S. GOVERNMENT PRINTING OFFICE

48–819 WASHINGTON : 2009