SOUTH SHORE OF STATEN ISLAND, NEW YORK
COASTAL STORM RISK MANAGEMENT

INTERIM FEASIBILITY STUDY
FOR
FORT WADSWORTH TO OAKWOOD BEACH

DRAFT MAIN REPORT

US Army Corps of Engineers
New York District

JUNE 2015

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EXECUTIVE SUMMARY

Introduction

ES1. The Coastal Storm Risk Management Study for the South Shore Staten Island, New York is in the Feasibility Phase. This report is identified as an Interim Feasibility Report because it is only partially responsive to the authority. This report addresses the most critical and vulnerable portion of the authorized study area from Fort Wadsworth to Oakwood Beach. The remainder of the authorized study area from Great Kills to Tottenville is being evaluated separately and is currently under coordination with the New York State Department of Environmental Conservation (NYSDEC) and New York City (NYC).

Hurricane Sandy

ES2. Staten Island, specifically the area from Fort Wadsworth to Oakwood Beach was heavily impacted by Hurricane Sandy (October 29-30, 2012). Hurricane Sandy was one of the largest Atlantic hurricanes to reach the United States on record, and resulted in great devastation along the Atlantic coast, particularly in the New York Metropolitan Area. Sixty (60) New Yorkers died, including 23 in Staten Island and 14 in the study area alone.

ES3. Hurricane Sandy generated record storm surges in the study area. During Sandy a nearby NOAA tidal gage, The Battery, New York, peaked at 12.4 feet National Geodetic Vertical Datum of 1929 (NGVD 1929), exceeding the previous record by over four feet. High water marks and storm tide gauges deployed by the United States Geological Survey (USGS) show that the water level in the study area, excluding wave fluctuations, peaked at approximately 13.6 ft. NGVD 1929.

ES4. The damage in the study area, and the loss of life during Hurricane Sandy was particularly devastating because of the unique nature of the area. The shorefront area along the study area contains high ground features at elevation +10 ft NGVD, along which Father Capodanno Blvd is located. Landward of this high ground, the terrain slopes down to much lower elevation areas where the existing communities are located, before sloping back up to high ground, effectively creating a bowl. Under relatively minor storm events (less than a 10-year return period), water does not crest these high ground features. During Hurricane Sandy, these shorefront features were completely submerged and the communities behind these areas flooded by rapidly rising, high velocity, life-threatening flood waters, in some areas to depths as great as 8 feet.

Recommendations

ES5. This report identifies a recommended plan for managing the risk of coastal storm damages, and describes the steps taken to identify the recommend plan. The recommended plan is the NED (National Economic Development) Plan that provides a line of protection as the first line of defense against severe coastal surge flooding and wave forces, and reduces the risk of storm damage with a still water elevation (tide plus storm surge) of 15.6 ft. NGVD 1929. This water height is about 2 feet higher than the peak water levels during Hurricane Sandy. The project is designed to function under a storm with an annual chance of exceedance of 0.3 % (300 year event) under current sea level conditions. The project provides risk management against ocean surge from a Hurricane Sandy-like event over the 50-year period of analysis even when taking into account an intermediate rate of sea level rise of 1.1 ft.

ES6. The NED plan also includes interior drainage features that include the acquisition and preservation of open space, pond excavation, construction of tide gates and gate chambers along the Line of Protection, road raisings, and other interior drainage features.

ES7. The Recommended Plan advances a number of post-Sandy initiatives, including the principles of the North Atlantic Coast Comprehensive Study. The following highlight the positive attributes of the Recommended Plan.

- The NED Plan is a resilient, sustainable, and a robust solution that has been optimized to a high surge and wave level that would only be seen during rare coastal storm events even when considering sea-level rise.
- The selected alignment of the NED Plan includes setback features, located significantly landward of the existing beach and on higher ground, which adds resiliency and sustainability to the system by allowing the existing beach to respond naturally during (beach erosion) and after storm events (beach recovery) and in response to sea level changes.
- The NED plan adds resiliency to the system since it will still dissipate wave energy even after the system's design parameters are exceeded.
- The NED Plan has the ability to defend against back to back high intensity storms because of the low expected structural damage to the buried seawall under design conditions (in contrast to beach berm and dune system that would likely suffer significant erosion).
- The NED Plan provides a complete solution that incorporates project features to address flooding not only due to coastal storm surge, but also due to precipitation
- The NED Plan integrates programs being implemented by New York State, New York City to provide a comprehensive, integrated solution to coastal storm risk management.
- The NED Plan embraces the concepts of preservation of natural storage and use of natural and nature based features for storm damage reduction, and advances the principles of Executive Order 11988, and the Federal Flood Risk Management Standard.
- The NED plan integrates with the existing, and planned recreational use of the area, and the plan features preserve and enhance the high recreational use of the area.
- The NED plan incorporates strategies for resiliency and sustainability through adaptation measures.

ES8. Overall, the recommended plan serves as model coastal storm risk management project that advances the principles identified in the North Atlantic Coast Comprehensive Study, and the principles of the Hurricane Sandy Rebuilding Task Force.

ES9. The following identifies the major steps undertaken in developing the recommended plan, and specifics of the recommended (NED) Plan.

Study Authorization

ES10. The study was authorized by a resolution of the U.S. House of Representatives Committee on Public Works and Transportation and adopted May 13, 1993. The resolution states that:

> *"The Secretary of the Army, acting through the Chief of Engineers, is requested to review the report of the Chief of Engineers, on the Staten Island Coast from Fort Wadsworth to Arthur Kill, New York, published as House Document 181, Eighty-ninth Congress, First Session, and other pertinent reports, to determine whether modifications of the recommendations contained therein are advisable at the present time, in the interest of beach erosion control, storm damage reduction and related purposes on the South Shore of Staten Island, New York, particularly in and adjacent to the communities of New Dorp Beach, Oakwood Beach, and Annadale Beach, New York."*

Problems and Opportunities

ES11. The study area represents a flood-prone, high risk area because of its low-lying topography. Flooding has been a problem in this area since the introduction of residential development.

ES12. As a result of Hurricane Sandy (October 29-30, 2012), residences, businesses and cars were heavily damaged and whole blocks of homes were removed from their foundations (NHC, 2013). The resulting damages to the properties and loss of life exemplify the critical need for improvements to coastal storm risk management in the region.

Plan Formulation

ES13. The goal of this project is to reduce the current coastal flooding in the Study Area.

In support of this goal, the planning objectives are to:

1. Manage the risk of damages from hurricane and storm surge flooding for the study area.
2. Manage the risk to local residents' life and safety.

ES14. Structural and non-structural coastal storm risk management measures were considered as part of the solution to address the planning objectives herein. The management measures resemble those typically seen in tidally influenced environments along the North Atlantic Coastline. Each measure was reviewed against the local conditions of the study area to locate its most feasible location and configuration. As a result several Alternatives were a combination of complimentary measures that together provides a solution to the flooding problems. These Alternatives were evaluated based on selection criteria that included reduction of risks to life and safety, economic performance, implementation constraints and construction feasibility, environmental impacts, government agency and public acceptance.

ES15. Applying these selection criteria, the following most viable alternatives, including the No-Action Plan, were further analyzed to determine the plan that resulted in the highest Net Benefits as compared with the No-Action Plan:

- No-Action Plan - no additional federal actions would be taken to provide for coastal storm risk management. It provides the base against which project benefits are measured. This plan would be implemented if project costs for coastal storm risk management plan were to exceed project benefits, thus indicating that risk management measures are not in the Federal interest. For the Study Area the without-project damages are estimated to be over **$34 million (**includes coastal inundation and interior flood damages) annually based on a 50 year period of analysis and a FY15 Federal Discount Rate of 3.375%.

- Alternative #1 - includes a combination of beach fill and seawalls, new floodwalls and raising of the existing levees near Oakwood Beach.

- Alternative #2 - includes road raising along the entire beachfront reach, a buried seawall/armored levee, levees and floodwalls.

- Alternative #3 – includes road raising of about 75% of the beachfront reach, raising the existing promenade, a buried seawall/armored levee, levees and floodwalls.

- Alternative #4 - includes floodwalls, levees and a buried seawall/armored levee (with raised promenade).

ES16. Nonstructural measures to provide an equivalent level of protection were also considered, but would cost about 8 times more than Alternatives 1-4, and, therefore not cost effect and were not considered for further comparison.

Tentatively Selected Plan

ES17. Alternative #4 was identified as the Tentatively Selected Line of Protection (LOP) Plan, and includes the following risk management features:

- Buried seawall/Armored Levee (with a raised promenade from Fort Wadsworth to Oakwood Beach, and
- Levees and a floodwall near Oakwood Beach

ES18. In addition, interior drainage measures and alternatives were formulated to address the interior flooding conditions that would result with implementation of the Tentatively Selected

LOP Plan. The formulation process used similar selection criteria; however, the No-Action Plan was replaced with the Minimum Facility Plan, which is the USACE minimum requirement.

National Economic Development (NED) Plan

ES19. The NED Plan represents the optimized design of the TSP. The NED Plan provides a robust coastal storm risk management system that is sustainable in the event of back-to-back storm events, and is also resilient and readily adaptable to sea level change. The Plan also provides for overall environmental enhancement through the removal of *Phragmites* in interior ponds in order to provide the needed storage capacity, and planting of native freshwater wetland plants with greater wildlife habitat value. The following Plan Descriptions, Figure, and Table present a more detailed description of the project make-up.

General Plan Description:
ES20. The Line of Protection consists of a buried seawall/armored levee along a majority of the reach (approximately 80%) serving as the first line of defense against severe coastal surge flooding and wave forces. The NED Plan is designed to manage and reduce the risk of storm damage due to waves, erosion and flooding for coastal storms with a total still water elevation (tide plus storm surge) of 15.6 NGVD 1929, which is about 2 feet higher than the peak water levels experienced during Hurricane Sandy. The design storm has an annual chance of exceedance of 0.3 % (300 year event) under current sea level conditions. Figure 1 shows an aerial overview of the Study Area along with the coastal storm risk management measures to be provided by the NED Plan.

ES21. The Line of Protection plan generally consists of three typical structures, with a total length of 5.5 miles, and a still water design level of 15.6 feet NGVD 1929:

- **Shoreline Reaches A-1 and A-2: Earthen Levee (3,700 ft.),** with crest elevation of 18 feet and crest width that ranges from 10 to 15 feet. The levee terminates into high ground northwest of Hylan Boulevard. A road closure structure at Hylan Boulevard will be deployed only during rare coastal storm events to prevent the flanking of tidal surge waters to the project area.

- **Shoreline Reach A-3: Vertical Floodwall (1,800 ft.),** consists of H-pile supported T-shaped concrete floodwall with top of wall elevations of 20.5 ft.; a reinforced concrete floodwall is provided where a confined footprint is needed to minimize impacts to the Oakwood Beach wastewater treatment plant (WWTP). A fronting tidal wetland will attenuate the wave forces and preserve the functionality of the tidal creek through a tide gate to the freshwater wetlands that serve as part of the project’s interior drainage.

- **Shoreline Reach A-4: Buried Seawall (22,700 ft.),** consists of a buried seawall with crest elevations of 20.5 feet NGVD 1929 with a 10 to 18-foot wide crest and 1.5:1 side slopes. A 10 to 18-foot wide scour apron is incorporated into the seaside structure toe. The seaward face and/or the landward and seaward faces of the above-grade portions of the structure are covered with excavated material to support native beach vegetation. The material cover is used to visually integrate the buried seawall with surrounding topography. A functionally equivalent raised promenade atop the buried seawall is provided from Oakwood Beach to Miller Field (approximately 1.75 mile), while an approximately 2.5 mile long, 38-ft wide pile supported functional equivalent boardwalk is provided between Miller Field and Ft. Wadsworth.

ES22. The Interior Drainage Plans include the acquisition and preservation of open space, pond excavation, construction of tide gates and gate chambers along the Line of Protection, road raisings, and other minor interior drainage measures necessary to meet the Minimum Facility Plan or supplement a selected Alternative with higher Net Benefits.

NED Plan Costs and Benefits

ES23. The estimated first cost of construction of the project is approximately $528.4 million (July, 2014 price levels). Taking into account the estimated inflation costs of $50.5 million through the midpoint of construction the total project cost, is estimated to be $578,926,000. The total annualized cost, which includes the annualized cost of the construction over the 50 year period of analysis, Interest during Construction (IDC) and Operations and Maintenance, is $24,011,000. With the annual storm risk management benefits of $27,732,000, the Net Project Benefits are $3,721,000, which gives a Project Benefit to Cost Ratio (BCR) of 1.2.

ES24. The Total Project Cost of the coastal storm risk management project will be cost-shared 65% by the Federal Government and 35% by the non-Federal Sponsors, Table ES 1 shows the cost sharing of the Total Project Cost. The non-federal share may be paid through a combination of cash, credits for Lands, Easements, Rights-of-way, and Relocations and in-kind services. The non-federal Sponsor is also responsible for conducting the Operation and Maintenance of the project (estimated to be $555,000 annually), which is not included in the Total Project Cost.

Table ES 1-NED Plan Total Project Cost*

Federal (65%)	$376,302,000
Non-Federal (35%)	$202,624,000
Total	$578,926,000

* Estimate based on July, 2014 price levels, includes escalation to estimated midpoint of construction.

Residual Flooding

ES25. The NED Plan is estimated to reduce damages by about $27.7 million annually. This includes risk management from ocean surges from a Hurricane Sandy-like event over the 50 year period of analysis taking into account Sea Level Change. However, it will not eliminate all flood related damages in the Study Area. For example, if a 1% annual-chance-event (also known as the 100-year storm) was to occur after the project was implemented, there would still be 461 structures within the study area that would experience some level of flooding from interior run-off flooding. That is compared to the 4,682 structures that would experience some level of coastal flooding during a 1% annual-chance-event in the without-project condition. More regular storm events, such as the 20% annual-chance-event (also known as the 5-year storm) will continue to cause low level damages from interior run-off in some parts of the Study Area even with the project in place.

ES26. In the very rare occurrence that coastal stillwater levels exceed the 15.6 feet NGVD 1929 design level of the project (approximately a 0.3% annual-chance-event or about the 300 year storm), the ocean surge could breach the line of protection inundating the study area to the level of surge. Therefore it is extremely important that residents follow New York City evacuation orders and protocol to help decrease risks to life safety in the event of a severe coastal storm event.

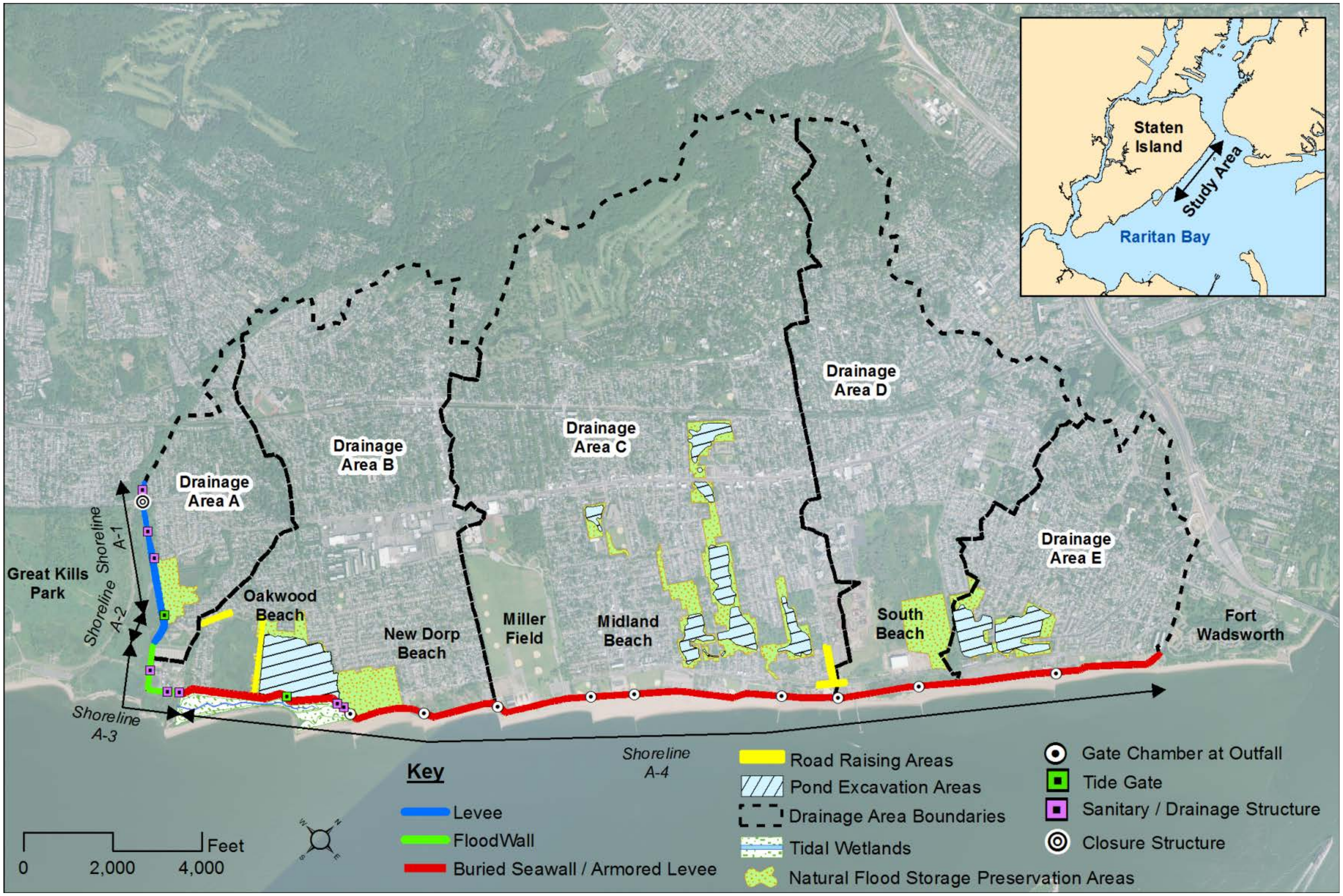

Figure 1 - Overview of NED Plan

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PERTINENT DATA

DESCRIPTION

The National Economic Development (NED) Plan provides for coastal storm risk management in the form of a Line of Protection consisting of levees, floodwalls and a buried seawall/armored levee (with raised promenade) supplemented by interior drainage improvements including excavated ponds, road raisings and new tide gates and other gate chamber and culvert structures.

GENERAL DATA

South Shore of Staten Island study area .... 3 sq. miles
Structures Impacted by a 100-year Flood Event..4,682*
*Floodwater above lowest adjacent grade of structure during the 100 year event at base year

DATUMS

This Interim Feasibility Study has been prepared with references to the National Geodetic Vertical Datum of 1929 (NGVD 1929). The project datum will be updated to the North American Vertical Datum of 1988 beyond the Feasibility phase. The conversion from NGVD 1929 to NAVD 1988 in New York City is accomplished by subtracting 1.1 feet from the original NGVD 1929 elevation value, or in other words NGVD 1929 - 1.1 ft. = NAVD 1988 in NYC.

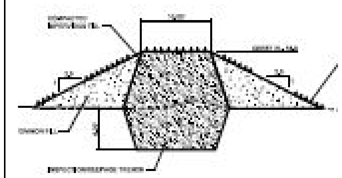
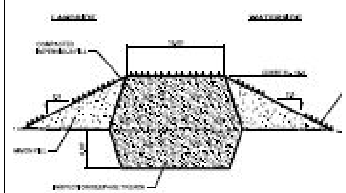
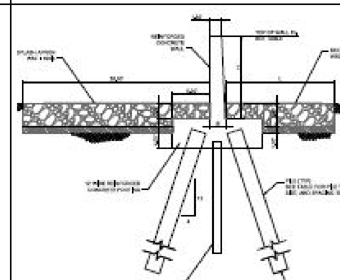
LINE OF PROTECTION

The plan is split into four engineering reaches based on differing design sections and is presented in Table ES 2.

INTERIOR DRAINAGE IMPROVEMENT ELEMENTS

The Interior Drainage management measures in the NED Plan are presented by Drainage Area in Table ES 2.

Detailed drawings for the NED Plan are included in Section 14. The Draft Engineering and Design Appendix and Interior Drainage Appendix of this interim study provide a full narrative on the formulation, evaluation, comparison, and tentative selection process.

Table ES 2 - NED Plan Storm Risk Management Measures								
Line of Protection								
Reach	**Type**	**Length**	**Crest Elevation**	**Depth**	**Slope**	**Materials**	**Typical Section View**	**Features**
A-1	Levee	2,800 lf.	18 ft. NGVD 1929 or 16.9 ft. NAVD 1988	10 ft. wide at crest	2.5:1.0 (H:V)	compacted impervious fill		The compact impervious fill will extend at least 6 feet below the existing grade to prevent seepage, a closure structure will be constructed along Hylan Boulevard.
A-2	Levee	600 lf.	18 ft. NGVD 1929 or 16.9 ft. NAVD 1988	15 ft. wide at crest	2.5:1.0 (H:V)	compacted impervious fill		The compact impervious fill will extend at least 6 feet below the existing grade to prevent seepage.
A-3	Floodwall	1,800 lf.	20.5 ft. NGVD 1929 or 19.4 ft. NAVD 1988	1.5 ft. wide at crest	vertical	reinforced concrete T-Wall on piles		A vertical steel sheet pile wall will be included below the wall to prevent seepage.

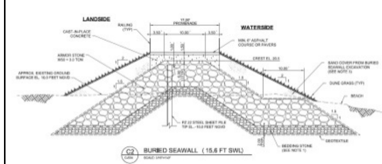
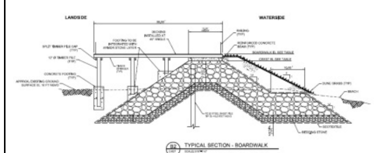
<table>
<tr><th colspan="9">Table ES 2 - NED Plan Storm Risk Management Measures</th></tr>
<tr><td>A-4</td><td>Buried Seawall / Armored Levee/tidal wetland</td><td>9,300 lf.</td><td>20.5 ft. NGVD 1929 or 19.4 ft. NAVD 1988</td><td>10 ft. wide at crest</td><td>1.5:1.0 (H:V)</td><td>3-ton armor stone</td><td></td><td>A vertical steel sheet pile wall will be incorporated to prevent seepage. A 17 ft. wide promenade will be constructed on top of the crest of the buried seawall/armored levee. Tidal wetland will help attenuate wave energy and reduce erosion. It also provides biological habitat value.</td></tr>
<tr><td>A-4</td><td>Buried Seawall / Armored Levee</td><td>13,400 lf.</td><td>20.5 ft. NGVD 1929 or 19.4 ft. NAVD 1988</td><td>10 ft. wide at crest</td><td>1.5:1.0 (H:V)</td><td>3-ton armor stone</td><td></td><td>A vertical steel sheet pile wall will be incorporated to prevent seepage. A 38 ft. wide pile supported boardwalk will be constructed on top of the crest of the buried seawall/armored levee.</td></tr>
<tr><th colspan="9">Interior Drainage</th></tr>
<tr><th colspan="2">Interior Drainage Area</th><th>Natural Storage</th><th>Excavated Pond</th><th colspan="2">Tide Gate</th><th>Outlets</th><th colspan="2">Road Raising</th></tr>
<tr><td colspan="2">Area A</td><td>17.19 acres</td><td>X</td><td colspan="2">22.75 ft. by 18 ft. NGVD 1929 (or 16.9 ft. NAVD 1988) by 16 ft. (LxHxD) with 3 @ 5 ft. by 5 ft. sluice gates, wingwalls, and pre-engineered bridge</td><td>2 new sluice gate structures (2 ft. by 2ft.) & 2 intermediate pipe outlets with flap gates</td><td colspan="2">X</td></tr>
</table>

Table ES 2 - NED Plan Storm Risk Management Measures					
Area B	86.41acres	1 Pond (46 acres) with 94,200 c.y. of excavation to 2.75 ft and NGVD 1929 (1.3ft. NAVD 1988)	22.75 ft. by 20.5 ft. NGVD 1929 (or 19.4 ft. NAVD 1988) by 16 ft. (LxHxD) with 3 @ 5 ft. by 5 ft. sluice gates, wingwalls, and pre-engineered bridge	New gate chambers at Ebbits St., New Dorp Ln., Tysens Ln. outfalls	1,730 lf. by 30 ft. of Kissam Ave. to 7.1 ft. NGVD 1929 (6 ft. NAVD 1988). An average raising height of 3 ft. 630 lf. by 60 ft. of Mill Rd. to 7.1 ft. NGVD 1929 (6 ft. NAVD 88). An average raising height of 1 ft.
Area C	120.44 acres	7 Ponds (100.51 acres), 377,200 c.y. of excavation to an invert of 2 ft. NGVD 1929 (0.9 ft. NAVD 1988)	X	New gate chambers at Greely Ave., Midland Ave., Naughton Ave., Seaview Ave. outfalls	820 lf. by 90 ft. of Seaview Ave to 10 ft. NGVD 1929 (8.9 ft. NAVD 1988). An average raising height of 1 ft. 300 lf. by 60 ft. of Father Capodanno Blvd. to 10 ft. NGVD 1929 (8.9 ft. NAVD 1988). An average raising height of 1 ft.
Area D	30.76 acres	X	X	New gate chamber at Quintard Street outfall	X
Area E	46.7 acres	2 Ponds (34 acres), 222,720 c.y. of excavation to an invert of 2 ft. NGVD 1929 (0.9 ft. NAVD 1988)	X	New gate chambers at Sand Lane, Quincy Ave. outfall	X
	Additional Measures Not Part of Minimum Facility Plan				

REAL ESTATE REQUIREMENTS

Six types of Standard Estate easements are required for the Coastal Storm Risk Management project. They are as follows:

- *Flowage Easements*[1] – Portions of land to be subjected to permanent inundation and portions to be subjected to occasional flooding. Flowage easements will be required where excavation of ponding areas will increase frequency and duration of flooding.
- *Flood Protection Levee Easement* – Portions of land required for the construction, operation and maintenance of the Line of Protection.
- *Restrictive Easement* – Portions of land restricted from any future development. This is essential to the effectiveness of ponding areas.
- *Temporary Work Area Easement* – Portions of land required for staging/work area purposes. The required temporary work areas are typically adjacent to land to be acquired for construction of the Line of Protection
- *Pipeline Easement* - required for the construction, operation and maintenance of an underground storm water drainage structure.
- *Road Easement* - required for the construction of an access road to provide access to sewer manhole.

Flowage Easements..112.08 acres[2]
Flood Protection Levee Easements..87.62 acres[3]
Restrictive Easements...143.84 acres
Temporary Work Area Easements... 62.62 acres
Pipeline Easement... 0.09 acres
Road Easements.. 1.14 acres

[1] Flowage easements are required in the optimization of the National Economic Development Plan to store interior flooding during high intensity precipitation storm events
[2] Pending final Physical Takings Analysis regarding the use of standard flowage easements for the 10 ponds within Interior Drainage Areas B, C and E as identified in Table 10 of the Interior Drainage Appendix (Appendix II).
[3] Real Estate Easement acreages based on the Real Estate Plan dated May 2015. Real Estate acreages and values in this Interim Report are subject to change pending Federal review and coordination

OPERATIONS AND MAINTENANCE

The Operations and Maintenance (O&M) responsibilities as part of the NED Plan include an annual survey of the Line of Protection, replacement of sand cover and dune grass along the buried seawall/armored levee, the operation and maintenance of the tide gates, gate chambers and intermediate outlets; the mowing and maintenance of the ponds; and the replacement of all gate structures at a 25 year interval.

Total O&M Annual Cost $555,000/year

ECONOMICS

First Project Cost*...$528.4 million
Total Project Cost (fully funded to mid-point of construction)……………..$ 578.9 million
Total Annual Cost**...$24.0 million
Total Annual Benefits ....$27.7 million
Net Benefits ....$3.7 million
Benefit to Cost Ratio...1.2
Base Year..2019
Damage Model Used.. HEC-FDA 1.2.5a

* Estimates based on May, 2015 price levels

** Annualized over the 50 year period of analysis using the Federal Discount rate of 3.375%

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1. INTRODUCTION

1. This Interim Feasibility Report (IFR) investigates the feasibility of alternative plans to address problems and opportunities associated with coastal storm risk management along the South Shore of Staten Island, New York (NY). This IFR has been prepared by the New York District (District) of the U.S. Army Corps of Engineers (USACE) in accordance with the subject authority. The non-Federal sponsor for this study is the New York State Department of Environmental Conservation (NYSDEC) who subsequently entered into a partnering agreement with the New York City Department of Environmental Protection (NYCDEP) and the New York City Department of Parks and Recreation (NYCDPR). New York City (NYC) is the local partner for this study. This report is identified as an Interim Feasibility Report because it is only partially responsive to the authority (see full Study Authorization below). This interim study investigates the feasibility of alternative plans to address problems and opportunities associated with coastal storm risk management along the South Shore of Staten Island, New York (NY) from Fort Wadsworth to Oakwood Beach.Its interim intent is to address the portion of the study area most vulnerable to storm damage as made evident by Hurricane Sandy (October 29-30, 2012).

1.1 Study Authority

2. The study was authorized by a resolution of the U.S. House of Representatives Committee on Public Works and Transportation and adopted May 13, 1993. The resolution states that:

> "*The Secretary of the Army, acting through the Chief of Engineers, is requested to review the report of the Chief of Engineers, on the Staten Island Coast from Fort Wadsworth to Arthur Kill, New York, published as House Document 181, Eighty-ninth Congress, First Session, and other pertinent reports, to determine whether modifications of the recommendations contained therein are advisable at the present time, in the interest of beach erosion control, storm damage reduction and related purposes on the South Shore of Staten Island, New York, particularly in and adjacent to the communities of New Dorp Beach, Oakwood Beach, and Annadale Beach, New York.*"

3. Formal requests for a new reconnaissance study were made by former Governor Mario Cuomo to the District Engineer in letters dated January 4, 1993 and June 24, 1993.

4. The Interim Feasibility study has been prepared in compliance with the applicable requirements of the Disaster Relief Appropriations Act of 2013 (Public Law 113-2). Under the Investigations Section of PL113-2 the Law includes the authorization of $20 million to conduct a comprehensive flood risk study along the North Atlantic Coast, evaluate the performance of existing USACE projects damaged by Hurricane Sandy, and identify and provide recommendations for new projects and improvements to existing

projects. In line with the objectives set forth in PL 113-2, this interim report demonstrates that the project is economically justified, technically feasible, and environmentally acceptable, and that it incorporates resiliency, sustainability, and consistency with the North Atlantic Coast Comprehensive Study (NACCS). PL 113-2 also provides the authority for 100% Federal funding for the completion of costal storm risk reduction feasibility studies that were underway as of October 29-30, 2012 (Hurricane Sandy) such as this interim study.

1.2 Additional Study Guidelines

5. Plan selections for the South Shore of Staten Island feasibility assessment were originally identified prior to Hurricane Sandy; however, post-Sandy changes to previously existing physical constraints and the preliminary release of an updated coastal flood study have been incorporated into this post-Hurricane Sandy feasibility assessment.

6. The post-Hurricane Sandy project approach identified four concerns and four solutions resulting in: (1) an interim study area that addresses the most critical and vulnerable portion of the authorized study area, deferring the Great Kills to Tottenville reach to a second phase; (2) a sensitivity analysis to identify the net benefits before and after Hurricane Sandy rebuilding efforts; (3) using the stage-frequency curves from FEMA's forthcoming New York City (NYC) coastal Flood Insurance Study (FIS); and (4) deferring certain data analyses requirements in the Environmental Impact Statement until the Pre-construction Engineering and Design (PED) phase of the project.

7. In addition, in accordance with the current USACE (Post-Katrina) engineering guidance on floodwalls, the design section along the perimeter of the Waste Water Treatment Plan (WWTP) at Oakwood Beach was changed from an I-Type floodwall to a T-Type concrete floodwall supported on concrete piles.

1.3 Study Purpose and Scope

8. The purpose of the South Shore of Staten Island Coastal Storm Risk Management Interim Feasibility Study is to evaluate the feasibility of Federal participation in implementing solutions to problems and opportunities associated with storm damage and erosion control in the study area. More specifically, the study:

- Identifies problems associated with periodic flooding from coastal storms,
- Identifies opportunities to incorporate new coastal storm risk management measures to avoid future loss of life and damage to property,
- Evaluates the technical, economic, environmental, and institutional feasibility of Federal action to address flooding problems.

9. The Study investigated the feasibility of Federal action to address coastal storm risk management and other associated opportunities along the South Shore of Staten Island, consistent with Federal water resources policies and practices, including those outlined in

the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G, 1983), the USACE *Planning Guidance Notebook* (ER 1105-2-100, 22 April 2000), the USACE *Planning Risk Analysis for Flood Damage Reduction Studies* (ER 1105-2-101, 3 April 2006), and *Procedures for Implementing NEPA* (ER 200-2-2, 4 March 1988).

10. Throughout this investigation, the USACE has worked closely with the non-Federal sponsor (NYSDEC) and local partner (NYCDEP and NYCDPR) to (1) describe the range of potential Federal participation in coastal storm risk management on the South Shore of Staten Island, and (2) explain the roles and responsibilities of USACE and the non-Federal partners in project planning and implementation. Furthermore, there has been extensive coordination with local stakeholders through formal and informal meetings. Future implementation of a Federal coastal storm risk management project in the study area would require support from non-Federal interests and a commitment to working with USACE to address storm damage along the South Shore of Staten Island.

1.4 Study Area

11. The interim study area is located on the eastern side of the south shoreline of Staten Island, NY and encompasses a reach approximately 5.5 miles long from Fort Wadsworth to Oakwood Beach (Figure 2). The principal neighborhoods along the study reach from east to west are South Beach, Midland Beach, New Dorp Beach, and Oakwood Beach. The study limit is bound inland by natural high ground approximately one mile from the shoreline. The study area lies within the political boundary of the 11th Congressional District of New York. The relevant features and characteristics of the study area are described in more detail in Section 3.

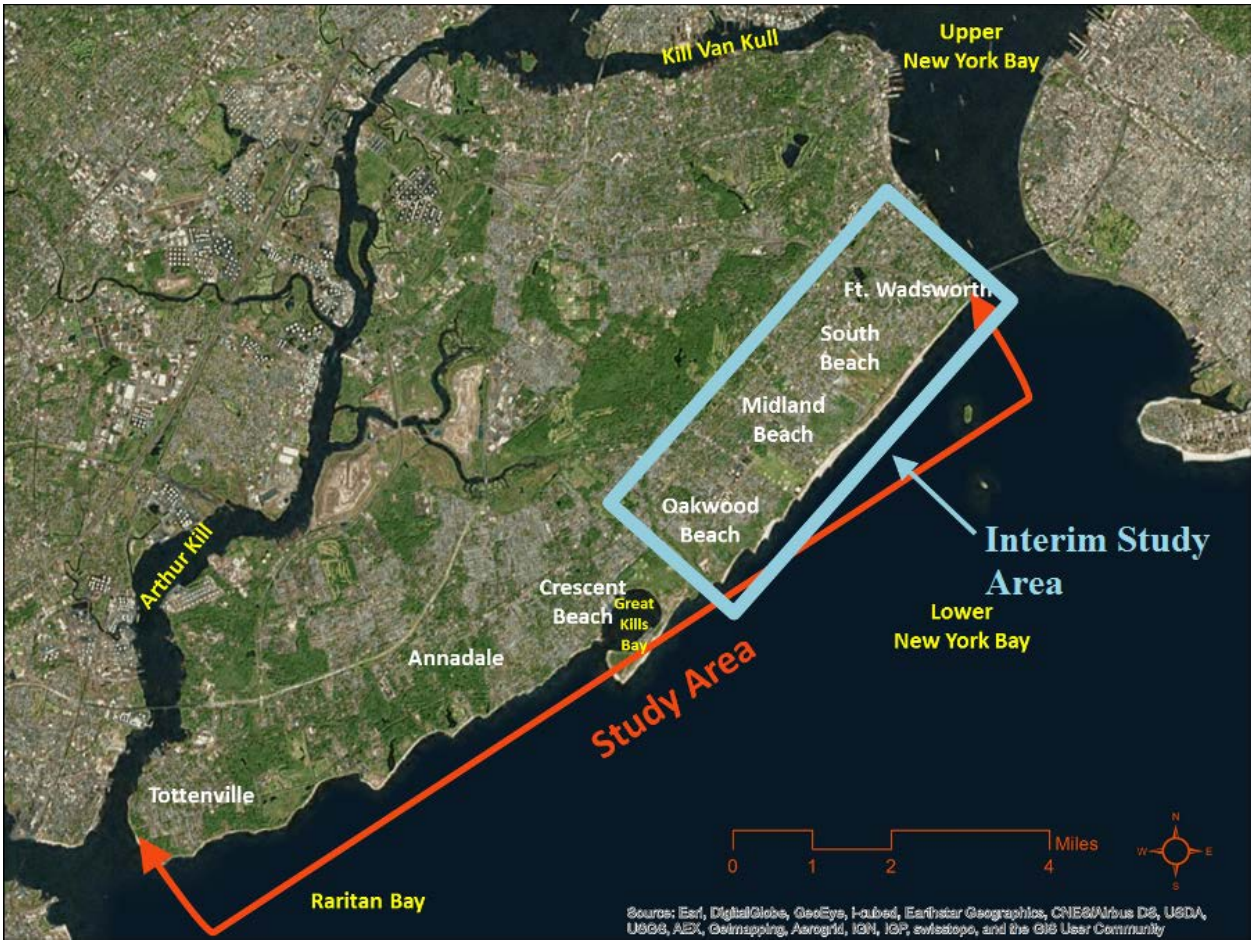

Figure 2 - Interim Study Area

1.5 Report Organization

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

13. Section 2 of this interim study provides a summary of Federal and local participation in previous studies or projects within the bounds of the study area.

14. Section 3 of this interim study reviews the existing site conditions pertinent to quantifying the “with” and “without” project consequences.

15. Section 4 reviews the “without” project conditions along the interim study area.

16. Section 5 identifies the storm damage problems, opportunities and constraints along the interim study area.

17. Section 6 provides an overview of the step-by-step process leading up to the identification of the NED Plan.

18. Section 7 describes the components of the NED Plan.

19. Section 8 provides review of the economic feasibility of the NED Plan.

20. Section 9 highlights the requirements of PL 113-2 as applicable to this interim feasibility study.

21. Section 10 reviews the implementation process, schedule and the cost-sharing agreement.

22. Section 11 includes information on the public review process.

23. Section 12 contains the outcome of this interim feasibility study recommended by the District Engineer.

24. Section 13 lists the sources referenced throughout the report.

25. Section 14 contains the Drawing sheets referenced in the report.

2. PRIOR STUDIES AND PROJECTS

2.1 Prior Studies

2.1.1 History of Federal Participation

26. In an application dated January 6, 1959, a cooperative beach erosion control study was initiated by the State of New York acting through the Long Island State Park Commission. The application requested a study of the Atlantic Coast of Nassau County, New York, between Jones Inlet and East Rockaway Inlet; Atlantic Coast of New York City, between East Rockaway Inlet and Norton Point; and Staten Island, New York, between Fort Wadsworth and Arthur Kill. The Chief of Engineers approved the application on March 23, 1959, in accordance with Section 2 of Public Law 520 (River and Harbor Act of 1930).

27. In response to severe damage to coastal and tidal areas of the eastern and southeastern United States from the hurricanes of August 31, 1954 and September 11, 1954 in New England, New York and New Jersey and the damages caused by other hurricanes in the past, a hurricane study was authorized by Public Law 71, 84th Congress, 1st Session on June 15, 1955. A combined report covering the cooperative beach erosion control study and the hurricane survey was approved by the Chief of Engineers on December 7, 1960.

28. A previous federal project, spanning from Fort Wadsworth to Arthur Kill, Staten Island, New York, was authorized by the Flood Control Act of October 27, 1965. Design modifications to the authorized project were developed in a realignment feasibility study dated September 1969. Following a review of the realignment feasibility report concerning the plan of improvement extending eastward to Fort Wadsworth, the Chief of Engineers, on April 7, 1970, directed the extension plan to be incorporated in the project design. This authorized and modified project was not constructed due to a lack of non-federal financing as discussed below.

2.1.2 Previously Authorized Federal Project

29. The federal project authorized in House Document No. 181, 89th Congress, 1st Session provided combined shore and hurricane protection between Fort Wadsworth and Oakwood Beaches. The recommended protective works included beach fill with dunes, groins, levees, floodwalls, and interior drainage facilities including pumping stations and relocations. Preconstruction planning for the project was initiated in January 1966 and was brought to 60 percent of completion.

30. The Draft Environmental Impact Statement was completed in March 1976 and the General Design Memorandum for Fort Wadsworth to Oakwood Beach was completed in June 1976. Further work was suspended at the request of local authorities. In a letter

dated October 3, 1977, the New York State Department of Environmental Conservation (NYSDEC) requested to defer their decision on project partnership because of the fiscal problems of New York City.

31. The portion of the plan addressed by the 1976 GDM extended from Great Kills Park to Fort Wadsworth. The plan of improvement from Oakwood Beach to Graham Beach was comprised of 24,000 feet of levee and 11,200 feet of beach fill. From Graham Beach to Fort Wadsworth, the plan was developed in accordance with the City's recommendation, and included 13,000 feet of levee.

32. The plan called for six pumping stations with pump capacities ranging from 135 to 540 c.f.s. designed to discharge interior drainage outside of the Line of Protection improvements. The three pumping stations at the eastern end of the project area between Graham Beach and Fort Wadsworth were to be located just north of the concrete I-wall on the landward side of the promenade and boardwalk. In addition, drainage ditches along the protected side of the wall, draining into major storm sewers, were recommended for interior runoff in areas of the improvement where runoff is not handled by existing storm lines.

2.1.3 Reconnaissance Study of June 1995

33. During the reconnaissance level investigation, federal interest was evaluated for the shoreline from Fort Wadsworth to Oakwood Beach and Annadale Beach. Several flood control and coastal storm risk management alternatives were investigated based on local needs and preferences, comparative costs, and implementation constraints. In addition to an alternative providing a level of coastal storm risk management equivalent or slightly higher than a 100 year event as authorized in 1976, alternatives providing lower levels of coastal storm risk management were also investigated. The reconnaissance level analysis indicated that there was federal interest in continued study.

2.2 Prior Projects

34. Since 1935, two Federal projects and two State/City project have been completed along the study area. Three of these were beach fill projects and are shown in Table 1. The fourth project was constructed in 1999 near the Oakwood Beach Waste Water Treatment Plant (WWTP) and is described at the bottom of this section. The beach fill projects contributed to a total of 2,880,000 cubic yards of fill placed along 15,600 feet (50%) of the shoreline.

35. From 1936 to 1937, the federal government built six timber and rock groins, constructed a timber bulkhead, and placed an estimated 1,000,000 cubic yards of hydraulic fill at South Beach. The total cost of the construction was approximately $1,000,000.

36. The State and City placed about 1,880,000 cubic yards of fill between New Creek and Miller Field in 1955 at a cost of about $745,000. The cost of additional work

performed by private interests is not known, but it is estimated to be several hundred thousand dollars. The material, which consists of medium grained sand, was placed along the shore and has helped it remain stable. The beaches provide a measure of risk management against tidal flooding as well as a recreational area. Two concrete storm sewer outfalls that extend through the fill have acted as groins, helping to further stabilize the beach.

Table 1: Reported Fill Volumes Placed Since 1935

Location	Fill Quantity (cu. Yd.)	Project Length (ft.)	Year	Work Performed By
South Beach	1,000,000	7,500	1937	U.S. Government
Midland Beach	1,880,000	8,100	1955	State and City
Total	**2,880,000**	**15,600**	-	-

37. As part of other post-Sandy efforts, NYC initiated short term dune improvements as part of its Special Initiative for Rebuilding and Resiliency (SIRR) that included beach nourishment and dune construction along the study area in attempt to decrease future losses from coastal storm events. This program was completed in October 2013. Location and quantities of beach fill are unavailable.

38. The U.S. Army Corps of Engineers (USACE) constructed a project in 1999 as part of the Section 103 Continued Authorities Program (CAP) to manage risk in the Oakwood Beach area from Bay flooding. The project consisted of two earthen levee segments, one tide gate structure, underground storm water storage, and road raising. The first levee segment, located south of the treatment plant and east of Oakwood Creek running parallel to the creek, had a top elevation of 10 feet NGVD 1929. The second levee segment, located north of the treatment plant and running approximately northward and westward, was a raised road system with a top elevation varying between 7.9 ft. NGVD 1929 to 8.4 ft. NGVD 1929. The project also consists of: (1) a new tide gate; (2) the raising of an access road at the northwestern area of the treatment plant property; and (3) underground storm runoff storage. The project was based on a 10-year period of analysis and provides risk management against a 15-year coastal storm (6.7% chance of occurring in any given year). An overview map of the project area and a photograph of the levee from 2001 are presented in Figure 3 and Figure 4, respectively.

Figure 3 - Section 103 (CAP) Project - Overview Map[4]

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[4] The NED plan removes the existing Section 103 tide gate at Oakwood Beach and deactivates the Federal project.

Figure 4 - Section 103 (CAP) Project - Levee

39. After Hurricane Sandy (October 29-30, 2012) USACE awarded two repair contracts authorized under the Flood Control and Coastal Emergencies Act, PL 84-99 (USACE, OAKWOOD BEACH, STATEN ISLAND, NY, Repair of Previously Constructed Projects, 2003) that we completed in Fall 2013 to repair the levee and tide gate from damages inflicted by Hurricane Sandy. Many of the alternatives considered in this study would replace this Section 103 tide gate with a larger scale solution. Upon completion of a larger project the Section 103 project will be deactivated.

3. EXISTING CONDITIONS

3.1 Physical Setting

40. The study area consists of approximately 5.5 miles of coastline in the Borough of Staten Island, New York City, New York, extending along the Lower New York Bay and Raritan Bay. The approximate west and east limits (i.e. along the south shoreline) of the study area are Oakwood Beach and the easternmost point of land within Fort Wadsworth at the Narrows. Across from Staten Island's western shore is the New Jersey shoreline at the southern shore of Raritan Bay, which extends from the community of South Amboy to the Sandy Hook peninsula. East of Staten Island is Brooklyn on the Narrows, Coney Island on the Lower New York Bay, and Rockaway Point on the Atlantic Ocean. The approach to Lower New York Bay from deep water in the ocean is through a 6-mile wide opening between Sandy Hook, New Jersey and Rockaway Point, New York.

41. The overall study area lies within the borough of Staten Island, County of Richmond, within the limits of the City of New York. The reach evaluated in the Interim Feasibility Study includes the area from Fort Wadsworth to Oakwood Beach.

3.1.1 Geology

42. The Staten Island study area lies within the Atlantic Coastal Plain province which extends along the eastern margin of the United States (USACE, 1964). The surface of the plain slopes gently in a southeast direction toward the Atlantic Ocean and merges into the tidal marshes, shallow bays and barrier beaches at the shore. The plain continues offshore beneath the waters of the ocean for about a distance of 100 miles to the edge of the continental shelf, where at a depth of approximately 100 fathoms, it is bounded by a steep escarpment. At this point the ocean bottom drops abruptly to far greater depths. A submarine valley of the Hudson River crosses the continental shelf in the Lower New York Bay waters, located to the southeast of the study area. This valley is more than 100 feet below the surface and varies in width from 2 to 10 miles.

3.1.2 Topography

43. The study area terrain ranges from high bluffs at its east end, to low-lying areas in much of the center and west end. The west end is fronted by low narrow beaches intersected by several creeks. The east end generally has a wide low beach intersected by several drainage structures contained within groins. Behind the east end beaches are low-lying residential areas, containing many structures susceptible to significant flooding. The shoreline is irregular because of the downdrift offsets at groins and headlands.

3.1.3 Climate

44. The warmest month in the Borough of Staten Island is July, when the average high temperature is 86º Fahrenheit, and the average low temperature is 67º Fahrenheit. The coolest month is January, when the average high is 39º Fahrenheit, and the average

low temperature is 24º Fahrenheit. The average monthly rainfall in the Borough of Staten Island is 4.05”. Precipitation does not show great seasonal variation, although the average monthly rainfall is generally higher over the warmer months (4.27”) than over the cooler months (3.83”). July is generally the wettest individual month and February the driest month, with average precipitation of 4.64’ and 3.11” respectively.

3.2 Existing Coastal Conditions

3.2.1 Physical Characteristics

45. *Topographic Survey*: Topographic surveys conducted by Rogers Surveying in 2000 and 2001 are the most recent topographic survey data for the project area. Post-Hurricane Sandy LIDAR was collected by the USACE Joint Airborne LiDAR Bathymetry Technical Center of Expertise (JALBTCX) on November 16, 2012.

46. The project area was surveyed on the following dates:

- October 27, 2000 - Oakwood Beach,
- July 1, 2001 - Fort Wadsworth to Oakwood Beach,
- November 16, 2012 - LIDAR over entire Project Area (Fort Wadsworth to Oakwood Beach).

47. *Bathymetric Survey*: Beach profile surveys were performed in February 2000 for the entire Project Area. Additional bathymetric data from NOAA Navigation Chart 12402 “New York Lower Bay was used to supplement the beach profile surveys and characterize the offshore bathymetry.

3.2.2 Physical Coastal Processes

48. Physical processes are those mechanisms occurring in the coastal zone which result in the movement of waters, wind, and littoral material. These processes shape the coastline. A thorough understanding of these processes coupled with predictive capabilities is necessary for a comprehensive and long term approach to coastal storm risk management.

49. *Wind:* Measured wind speeds and direction have been recorded at the Ambrose Light Station (ALSN6) located approximately 16 miles offshore of the South Shore of Staten Island and is well situated to measure wind speeds over open water. Data from this location indicates that the prevailing direction from which wind occurs is from the west to northwest, from which 25% of wind blows. The most severe wind often occurs from the east to northeast directions. The maximum storm wind velocity recorded near the study area was 78 mph at Long Branch, New Jersey located south of Sandy Hook.

50. *Waves:* The wave climate in the study area is comprised of a mixture swell waves that propagate from the New York Bight into Lower New York Harbor and locally generated sea waves generated by local wind conditions. A wave hindcast and wave

transformation study of the waves in study area was performed by the Coastal Engineering Research Center (CERC) in support of the Dredged Material Management Plan for New York Harbor ((CERC), 1988). The results of the wave transformation study provide the basis for the design wave conditions. A summary of the nearshore wave characteristics for the study are presented in Table 2.

Table 2:Nearshore Wave Conditions

Return Period (yr.)	Peak Wave Period [s]	Sig. Wave Height [ft.]
2	5.4	5.8
5	8.3	6.5
10	9.7	7.1
25	11.3	7.5
50	12.3	7.9
100	13.2	8.4
200	14.5	9.0
500	16.0	9.7

51. *Tides:* Tides along the Project Area are semi-diurnal and have a mean range varying of 4.6 feet[5] at Fort Wadsworth. Tidal datum relationships at Fort Wadsworth are presented in Table 3.

Table 3: Nearshore Wave Conditions	
Tidal Datum	**ft., NGVD 1929**
Mean Higher High Water (MHHW)	3.5
Mean High Water (MHW)	3.2
North American Vertical Datum of 1988	1.1
Mean Tide Level (MTL)	0.9
National Geodetic Vertical Datum of 1929	0.0
Mean Low Water (MLW)	-1.4
Mean Lower Low Water (MLLW)	-1.6

*Tidal datum based on NOAA's VDATUM 1983-2001 Epoch

52. *Sea Level Change*: By definition, sea level change is the change in the mean level of the ocean. Eustatic sea level change is an increase or decrease in global average sea level brought about by an increase or decrease to the volume of the world's oceans (thermal expansion). Relative sea level change takes into consideration the eustatic changes in sea level as well as local land movements of subsidence or lifting. Historic information and local MSL trends used for the Study Area are provided by the

[5] All datums are presented in NGVD29. All post-Feasibility datums will be presented in NAVD88

NOAA/NOS Center for Operational Oceanographic Products and Services (CO-OPS) using the tidal gauge at Sandy Hook, New Jersey. The historic sea level change rate (1935-2013) is an increase of approximately 0.013 feet/year or about 1.3 feet/century.

53. Recent climate research has documented observed global warming for the 20th century and has predicted either continued or accelerated global warming for the 21st century and possibly beyond (IPCC 2013). One impact of continued or accelerated climate warming is continued or accelerated rise of eustatic sea level due to continued thermal expansion of ocean waters and increased volume due to the melting of the Greenland and Antarctic ice masses (IPCC, 2013). A significant increase in relative sea level could result extensive shoreline erosion and dune erosion. Higher relative sea level elevates flood levels which may result in smaller, more frequent storms that could result in dune erosion and flooding equivalent to larger, less frequent storms.

54. The current guidance (ETL 1100-2-1 dated 30 Jun 2014 and ER 1100-2-8162 dated 31 Dec 2013) from USACE states that proposed alternatives should be formulated and evaluated for a range of possible future local relative sea level change rates. The relative sea level change rates shall consider as a minimum a low rate based on an extrapolation of the historic rate, and intermediate (Curve 1) and high (Curve III) rates which include future acceleration of the eustatic sea level change rate. These rates of change for this interim study correspond to an increase in sea levels of 0.7 ft., 1.1 ft., and 2.6 ft. over 50 years for the low, medium and high rates. The historic rate, 0.7 ft., is being used as the basis of design for the coastal structures in accordance with current USACE planning guidance (ER 1105-2-100). However, a sensitivity analysis is also to be performed for medium and high SLC rates to determine the effects because on the plan selection of potential changes in sea level. If the plan is sensitive to sea level change, considerations for the adaptability of the project have been incorporated into the plan selection. SLC and the adaptability of the NED Plan to medium and high rates of SLC are discussed in Sections 4.2 and 0, respectively.

55. *Storm Surges:* Two types of storms are of primary significance along the study area: (1) tropical storms which typically impact the New York area from July to October, and (2) extratropical storms which are primarily winter storms occurring from October to March. These storms are often referred to as "nor'easters" because of the predominate direction from which the winds originate. Storm surge is water that is pushed toward the shore by the force of the winds, the decrease in astronomical area pressure during major storms, and other localized effects such as wave setup, where water levels rise at the shoreline when the motion of driven waters is arrested by a coastal landmass.

56. Hurricane Sandy generated record storm surges in the study area. During Sandy the maximum water level at The Battery, NY peaked at 12.4 feet NGVD 1929, exceeding the previous record by over four feet. High water marks and storm tide gauges deployed by the USGS show that maximum water levels in the study area, excluding wave

fluctuations, peaked at approximately 13.6 feet NGVD 1929. This resulted in 14 deaths (Figure 5) in the study area alone and thousands of buildings damaged or destroyed.

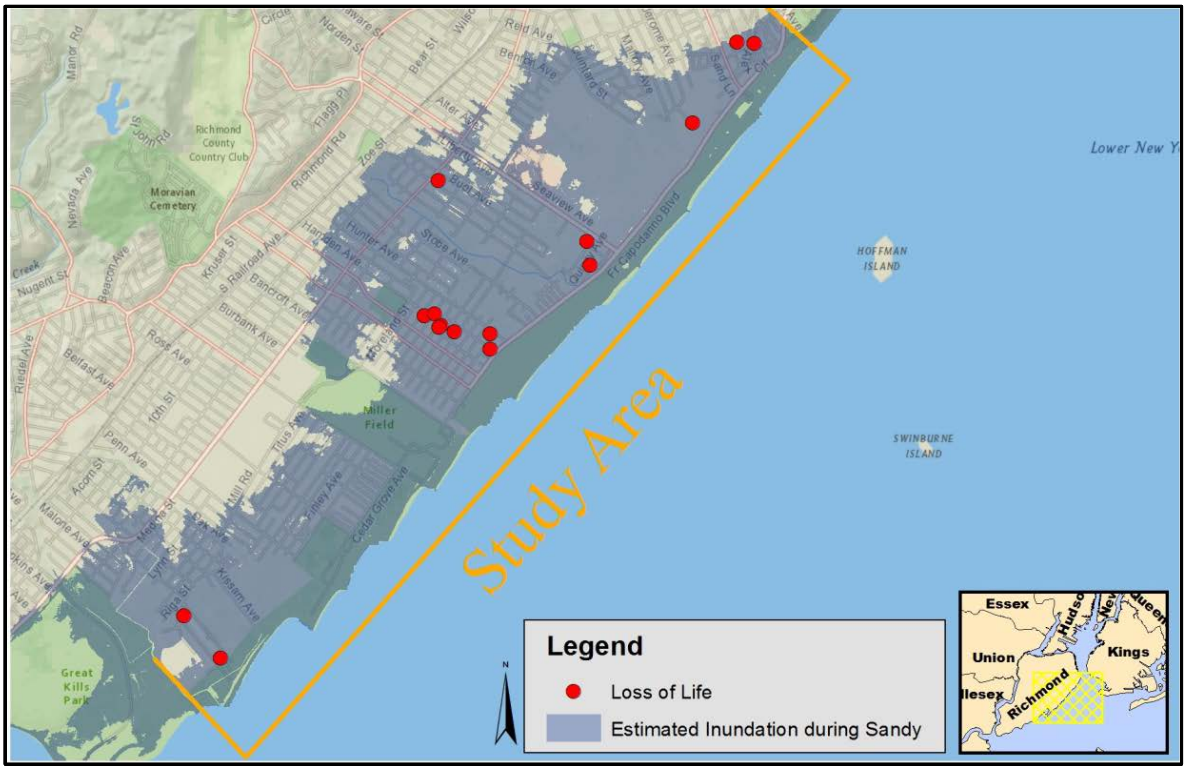

Figure 5 - Hurricane Sandy Loss of Life Map

57. The frequency-of-occurrence relationships for the total still water level elevations for the study area were obtained from FEMA's forthcoming New York City coastal Flood Insurance Study (FIS). Table 4 presents the preliminary values from the FEMA FIS at a location in the center of Lower New York Harbor just offshore of the study area.

Table 4: Stillwater Elevations for Project Area (FEMA)	
Return Period (yr.)	**ft., NGVD 1929**
2	5.3
5	7.2
10	8.5
25	10.0
50	11.3
100	12.6
200	14.0
500	15.9

58. *Currents:* Tidal currents along the study area are generally weak and do not exceed 1.0 knot. In addition, because the shape of Lower New York Bay helps restrict waves incident to the south shore from highly oblique waves, longshore wave-driven currents are limited.

3.2.3 Beach Profile Characteristics

59. The Project Area terrain ranges from high bluffs (Fort Wadsworth) to low-lying areas in much of the center. Most of the Project Area generally has a wide low beach intersected by several drainage structures contained within groins. Behind the beaches are low-lying residential areas, containing many structures susceptible to significant flooding.

The shoreline in the Project area consists entirely of city-owned beaches and lands of the Gateway National Recreation Area (NRA) owned by the Federal government and administered by the National Park Service (NPS), at the northeast end of the Project area, Miller Field (a former Army airfield, currently a park with athletic fields) in the New Dorp Beach area, and NYC's Great Kills Park (an undeveloped natural area) southwest of Oakwood Beach. A long boardwalk and hard-surface promenade walkway extends approximately 2.75 miles along the beach from South Beach to Midland Beach, ending at Miller Field. In addition to these public parks and recreation areas, landward of the beaches are low-lying, densely developed, primarily residential properties, as well as commercial properties located primarily along Hylan Boulevard. In addition, the Project area contains several large, undeveloped tidal and freshwater wetlands. The Oakwood Beach WWTP is located approximately 0.25 mile from the shore in Oakwood Beach, along Oakwood Creek (USACE 2015). Staten Island contains approximately 5,300 acres of floodplain, including surface waters (NYSHCR 2013).

The shoreline is irregular because of the downdrift offsets at groins. Figure 6 depicts an overview of general beach locations along the Project Area.

Figure 6 - Project Reach Beaches

60. The beachfront located between Fort Wadsworth (east end of Study Area) to South Beach area has a beach width of approximately 240 ft. The footprint of the existing boardwalk/promenade represents an additional beach width of approximately 40 feet. A low berm height, approximately elevation 10 ft. NGVD 1929, limits storm protection to the developed area of South Beach that has many very low-lying structures exposed to flooding.

61. The beachfront in the vicinity of Midland Beach has the widest beach at approximately 360 ft. wide, fronting the boardwalk/promenade. The beach berm is at approximately elevation 10 ft. NGVD 1929. The Midland Beach area, like South Beach, is a well-developed community and has some very low-lying structures exposed to flooding.

62. The beachfront in the New Dorp Beach area has a progressively narrower beach compared to Midland Beach. The average beach width is 240 ft. and the beach berm elevation is approximately 9 ft. NGVD 1929. There is no boardwalk or promenade in this area.

63. The Oakwood Beach beachfront has widths ranging from very narrow to considerable wide. Immediately downdrift of the bulkhead/groin at the eastern limit of

the Oakwood Beach, the beach is very narrow and backed by a rubble mound embankment. Further west, the beach widens and a vegetated dune up to approximately 16 ft. NGVD 1929. The average berm height in the Oakwood Beach area is at elevation 8 ft. NGVD 1929 and the average beach width is 117 ft. The upland areas are characterized by low-lying wetlands and a few low-lying developments.

3.2.4 Historical Shoreline Change

64. Historical data on shoreline changes for the project area cover the time period 1836-1994 (Smith et al., 1995) based on topographic sheets and aerial photographs obtained from the National Oceanic and Atmospheric Administration (NOAA). Additional shoreline analysis was performed based on comparisons of beach profiles surveyed in March 1961, February 1995, and February 2000.

65. Based on an analysis of the shoreline changes since 1836, the beachfront along the study area can be generally classified as having been subject to mild erosion. Fill mechanically placed has resulted in incidents of shoreline advance. The mean high water shoreline data from historic maps, aerial photographs, and surveys were used to conduct a shoreline analysis. The results indicated that the rate of erosion over most large areas of the shoreline is low. Most areas have averaged less than one foot of shoreline loss annually during the most recent period of analysis. Historic fill projects may have impacted shoreline loss rates in this area.

66. Despite the overall mild shoreline changes, certain areas have experienced dramatic change as the shoreline reaches equilibrium adjacent to newly constructed coastal structures. The effect has been the development of headland-like features, with dramatic embayments. An example is Oakwood Beach, where the shoreline immediately west of coastal structures is greatly offset. Areas such as Fort Wadsworth have experienced minimal change, as they lie adjacent to land masses featuring elevated headlands consisting of more rocky material, helping to naturally strengthen the land against erosional forces.

Recent shoreline changes were analyzed by comparing aerial imagery from the spring of 2004 and spring of 2014 that were published by Google Earth. This analysis was performed to reaffirm the historical shoreline trends and sediment budget. The wet/dry line on the aerial photography was selected as the baseline shoreline for 2004 and 2014. Reach average shoreline change rates along South Beach, Midland Beach, and New Dorp range between -1 ft/yr to -3.5 ft/yr. These shoreline change rates are similar to the historical sediment budget described below. Evaluation of volume changes for the project area was performed using the 1961 and 2000 profile surveys. Volume change computations show agreement with the shoreline location response. Within the 39 year period from 1961 to 2000, the beaches east of Great Kills Park showed mild erosion with the exception of Midland Beach which showed accretion. Refer to the Engineering & Design Appendix of this report for additional information on shoreline analysis.

3.2.5 Existing Coastal Storm Risk Management Structures

67. The most dominant structures east of Oakwood Beach are groins for outfall structures. Groins are generally very effective at trapping sand and the armored layer serves to protect the outfall pipe or conduit. There have been at least three prior projects that included the construction of groins. In 1936-37, the federal government built 6 timber and rock groins, constructed a timber bulkhead, and placed an estimated 1,000,000 cubic yards of hydraulic fill at South Beach. In 1955 the New York State and New York City placed about 1,880,000 cubic yards of fill between New Creek and Miller Field. Two concrete storm sewer outfalls that extend through the fill have acted as groins, helping to further stabilize the beach. Since then, the City of New York has constructed a significant number of outfalls structures to discharge stormwater runoff from streets and residential/commercial properties. There are 18 total groin-like structures within the study area. **F**igure 7 shows the locations of major storm sewer outfalls along the study area.

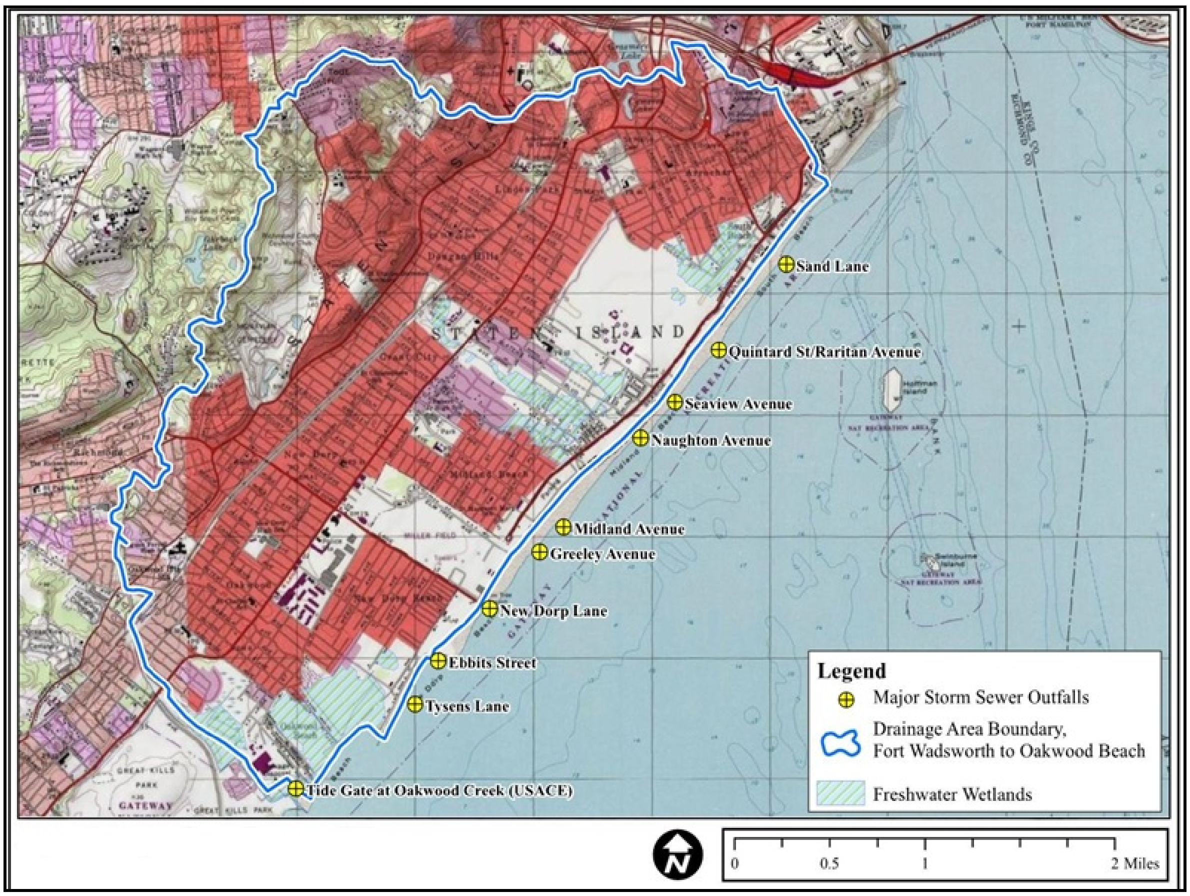

Figure 7 – Existing Storm Sewer Outfalls

68. In addition, the U.S. Army Corps of Engineers (USACE) constructed a project in 1999 to protect the Oakwood Beach area from Bay flooding. The project consists of two earthen levee segments, one tide gate structure, underground storm water storage, and road

raising. The first levee segment, located south of the treatment plant and east of Oakwood Creek running parallel to the creek, has a top elevation of 10 feet NGVD 1929. The second levee segment, located north of the treatment plant and running approximately northward and westward, is a raised road system with a top elevation varying between 7.9 ft. NGVD 1929 to 8.4 ft. NGVD 1929. This project also consists of: (1) a new tide gate; (2) the raising of an access road at the northwestern area of the treatment plant property; and (3) underground storm runoff storage—all within the project area. The project is based on a 10 year economic life and protects against a 15-year storm (6.7% chance of occurring in any given year).

Further, the The State of New York is currently executing the NY Rising Buyout and Acquisition Program for property owners whose homes were substantially damaged by Hurricane Sandy or by other designated storms. The program offers homeowners located in low-lying, high-risk flood areas (as identified by the State of New York) located in Staten Island an opportunity to sell their home to the State of New York. The program offers homeowners up to 100% of the property's pre-storm market value, funded in full or in part by Federal funds. The property bought out would be maintained as coastal buffer zones, which provides Federal restrictions for permanent improvements. The State of New York has currently bought out the Oakwood Beach section within the study area which will be preserved for open space.

3.3 Socio-Economic Conditions

3.3.1 Population and Housing

69. Richmond County (Staten Island) is the most rapidly developing borough in the City of New York. According to the year 2010 Census, the population of the Borough of Staten Island was 468,730, between 2000 and 2010, the population of Staten Island grew by 5.6 % (25030). Multi-person households represent 69.1% of all households within the Borough of Staten Island (compared to 54.5% for New York City).

70. The population of the study area is estimated to be over 30,000. Population data and projections can be found in Table 5 and population data by census tract can be found in Table 6. Figure 8 provides a Census Tract Map for the Study Area.

71. The New York City Department of City Planning has divided the city into 59 community districts, and the study area is covered by Staten Island Community Districts 2 and 3. Community District 2 covers the study area from Fort Wadsworth to New Dorp Beach, while Community District 3 covers Oakwood Beach to Tottenville.

Table 5: Population And Projection Of Future Population Richmond County And Surrounding Area

	Census 1980	Census 1990	Census 2000	Census 2010	2015	2020	2025	2030
New York State *●	17,558,072	17,990,455	18,976,457	19,651,127	20,136,000	20,896,000	21,656,000	22,416,000
New York City *+	7,071,639	7,322,564	8,008,278	8,175,136	8,406,000	8,637,000	8,868,000	9,100,000
Staten Island * +	352,121	378,977	443,728	468,730	489,600	510400	531,200	552,000
Community Districts 2 & 3 ◆	213,377	240,900	279,979	292,212	--	--	--	--

* *Census data from US Census Bureau website*

● *Population projections from US Census Bureau website*

◆ *Population Division, NYC Department of City Planning website*

\+ *Population projections from New York Metropolitan Transportation Council (NYMTC) website*

-- *Information Unavailable*

Table 6: Estimated Study Area Population

2010 Census Tract No. (west to east)	Approx. Percent In Study Area	2010 Census Tract Population	Approximate Population in Study Area
128.04	0.85	4,259	3,620
112.02	0.95	6,428	6,107
122	0.15	3,813	572
114.02	0.45	3,450	1,553
114.01	0.5	3,067	1,534
112.01	1	5,758	5,758
96.02	0.25	3,461	865
70	0.95	8,525	8,099
74	0.5	4,693	2,347
		Total:	***30,455***

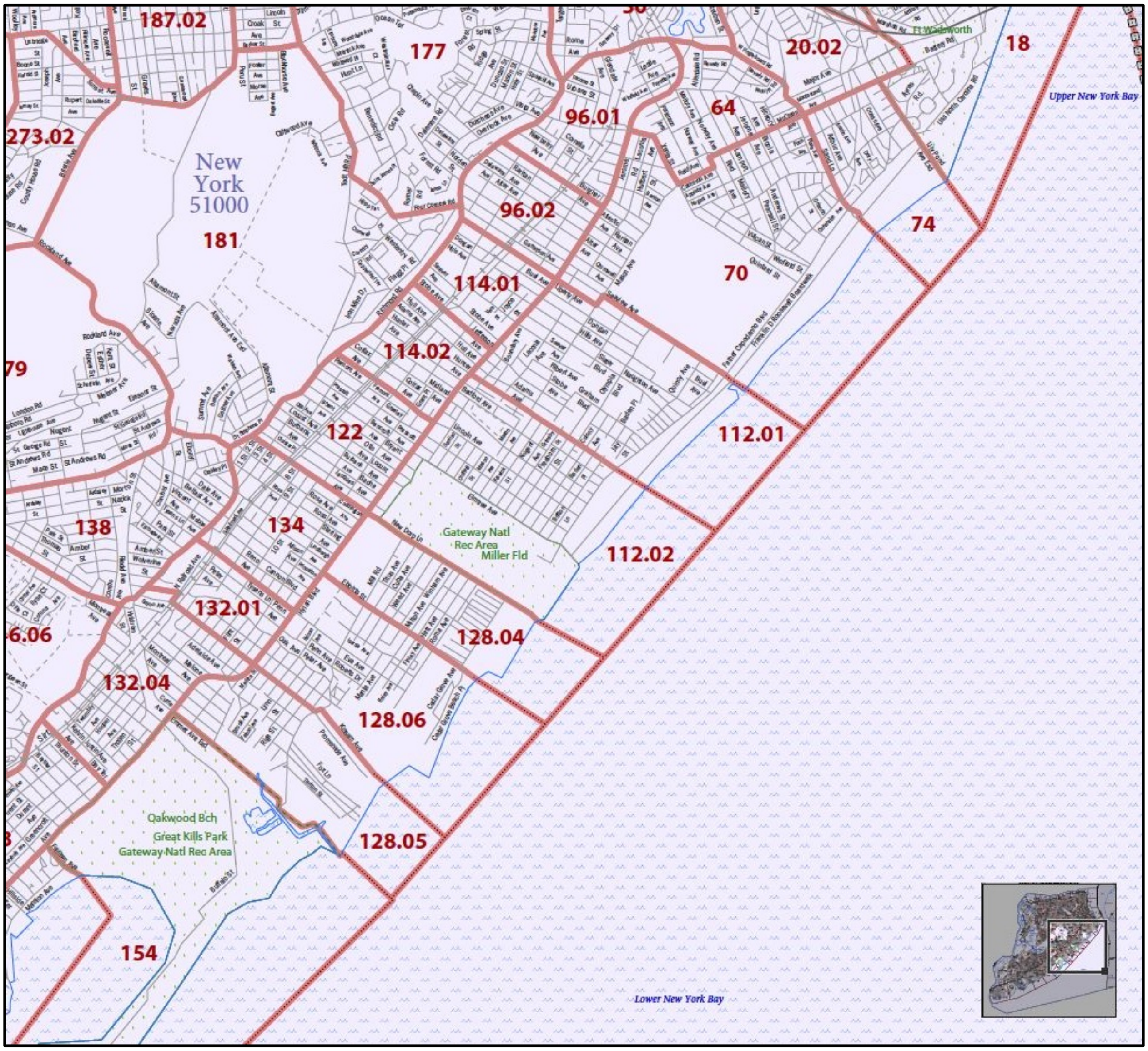

Figure 8 - Census Tract Map

3.3.2 Economy

72. Between 2008 and 2012, the average number of households in Staten Island was 163,675. The median household income was $73,496. Approximately 11.3 percent of the population was below the poverty level (USCB 2010).

3.4 Development

3.4.1 Borough Land Use

73. The Borough of Staten Island represents 25.4% of the land area of New York City, covering roughly 63.2 square miles. The majority of land within the study area has

been used for residential development, ranging from small cottages to expensive homes. The remaining lands within the study area are characterized by commercial development (concentrated primarily along Hylan Boulevard), wetlands, forests, ponds, creeks, meadows and beaches. Developed parks with large parking areas and shore-parallel boardwalks also line the beachfront. Coastal structures include revetments to protect uplands and groins containing drainage outlets.

74. Approximately 75% of the study area shoreline is publicly held land, consisting of City and federal parks. The study shoreline consists entirely of city beaches and the Gateway National Recreation Area.

75. A summary of land use in Community Districts 2 and 3 is presented in Table 7, along with the land use for the whole of Staten Island, for comparison. Although District 3 extends to the west well beyond the limits of the study area, its overall land use distribution is reasonably representative of the land use within the Study Area. The most significant land use in Community Districts 2 and 3 is 1-and 2- Family Residential Housing. Vacant land and open space/recreational areas make up the next largest land use percentage.

Table 7: Land Use Summary, Staten Island

Land Use Category	Community District 2	Community District 3	Staten Island Overall
1-and 2- Family Residential	30%	42%	33%
Multi-Family Residential	3%	2%	3%
Mixed Res./Commercial	0%	0%	1%
Commercial/Office	4%	2%	3%
Industrial	6%	3%	3%
Transportation/Utility	10%	5%	8%
Institutions	14%	9%	10%
Open Space/Recreation	15%	11%	20%
Parking Facilities	0%	0%	1%
Vacant Land	16%	24%	17%
Miscellaneous	2%	2%	1%

Source: Community District Needs, Staten Island, Fiscal Year 2002/2003, NYC Dept. of City Planning

76. Within the study area, there are over 7,300 structures and over 30,000 people. Of these structures approximately 4,600 (over 63%) lie within the 1% ACE floodplains.

3.4.2 Floodplain Management

77. There is evident pressure on continued development within the floodplain because of population increase and the replacement of small homes with larger homes and residential complexes. The development in the floodplain typically results in fill in the floodplain which overtime may exacerbate the flooding levels. To combat the

consequences of floodplain development, the Staten Island Bluebelt Program has been acquiring local property for the preservation of wetlands and introduction of new natural storage areas for stormwater conveyance. The Staten Island Bluebelt Program was introduced to incorporate Best Management Practices (BMPs) and other plans and actions to provide stormwater management, and to decrease flood hazards and increase water quality (NYCDEP, Final Generic Environmental Impact Statement, Staten Island Bluebelt Drainage Plans for Mid-Island Watersheds, 2014). Under the Mid-Island Bluebelt Program that encompasses the study area, NYCDEP proposed to acquire approximately 200 acres of natural storage (NYCDEP, Notice of Final Scope of Work for the Mid-Island Bluebelt Drainage Plans Environmental Impact Statement, 2010).

3.5 Biological Resources

78. The environmental setting of the island is characterized by residential and commercial development, wetlands, forests, ponds, creeks, meadows, and a narrow beach within the thirteen mile study limits of the southern Staten Island shore.

3.5.1 Wetlands:

79. Wetland boundaries were field delineated in 2003 and verified in 2009 as part of the District's planning for this Project (USACE 2009). The purpose of the delineation was to determine the presence and extent of areas within the Study Area that meet the criteria for wetland identification and other Waters of the United States, as established by USACE guidelines. Areas identified and delineated are potentially jurisdictional and regulated pursuant to Section 404 of the Clean Water Act (CWA). In addition, NYSDEC regulates freshwater wetlands greater than 12.4 acres under the New York State Environmental Conservation Law, Article 24 (Freshwater Wetlands) and also regulates tidal wetlands under Article 25 (Tidal Wetlands).

80. A total of 1,099 acres were surveyed in the Project area. In 2003, a total of 18 wetlands were identified and delineated. In 2009, the boundaries of the 18 previously identified wetlands were verified or updated and 12 additional wetlands were identified in an expanded survey area. A total of 30 wetlands occur within the Project survey limits. The majority of these wetlands are well defined emergent wetlands dominated by common reed. A total of approximately 300 acres of wetlands were found to be present in the Project area (USACE 2009). The Project area contains both tidal wetlands and freshwater wetlands, as explained below.

81. Tidal wetlands are the areas where the land meets the sea. These areas are periodically flooded by seawater during high or spring tides or, are affected by the cyclic changes in water levels caused by the tidal cycle. Salt marshes and mud flats are some typical types of tidal wetlands found along the south shore of Staten Island. Tidal wetlands are classified by the amount of water covering the area at high and low tides and the type of vegetation. New York State uses specific categories and codes to describe and represent different types of coastal, tidal and fresh water wetlands. Within the

Project area, tidal wetlands are only found in the Oakwood Beach area (Drainage Area A and Drainage Area B).

82. Freshwater wetlands include inland marshes and wet meadows dominated by herbaceous plants, swamps dominated by shrubs, and wooded swamps dominated by trees. Within the Project area, freshwater wetlands are found in the Oakwood Beach area (Drainage Area A and Drainage Area B), New Creek area (Drainage Area C), and South Beach area (Drainage Area D and Drainage Area E). Figure 9 presents an overlay of the wetland areas for the entire study area.

Figure 9 – Tidal & Freshwater Wetlands Overview

3.5.2 Upland Vegetative Cover:

83. Staten Island lies within the Eastern Deciduous Forest biome. Upland vegetation in the Project area includes maintained lawns and planted trees and shrubs, such as mulberry, associated with the boardwalk, promenade, and recreational parks adjacent to the beach at South Beach, Midland Beach, and Miller Field. Dominant vegetation commonly found along the coastal areas includes American beachgrass (*Ammophila breviligulata*), seaside goldenrod (*Solidago sempervirens*) sandbur (*Cenchrus* spp.), and beachheather (*Hudsonia* spp.) (NYCDEP 2013). Mulberry trees (*Morus rubra*) are also a prevalent native tree species in the uplands.

3.5.3 Bay Fisheries:

84. The bay is an important resource for both commercial and recreational fisheries. During 1991, this area accounted for 112.5 million live pounds of commercial shellfish and finfish valued at $23.5 million dollars (Blevins, 1992). Menhaden, American shad, blueback herring, summer flounder, butterfish, white perch, northern puffer, American eel, horseshoe crab, blue crab, American lobster, hard clam, and soft clam are the primary commercial species (Figley and McCloy, 1988). Popular recreational fisheries include weakfish, bluefish, winter flounder, summer flounder, striped bass, spot, tautog, and scup (Woodhead, 1991). In 2011, a migratory finfish survey (USACE 2013) was conducted to investigate timing and spatial distribution of seasonal movements of migratory fish in the New York/New Jersey Harbor. A total of 58 species were collected. The analysis of the 2011 data is consistent with previous studies that migratory finfish use the New York/New Jersey Harbor during spring and fall migration periods (USACE 2013).

3.5.4 Birds:

85. The coastal habitats of Lower Bay and Raritan Bay include tidal flats and sub tidal bottoms which provide important habitat for various bird species. Previous investigations (Andrle and Carroll, 1988; USFWS, 1992a; National Audubon Society, 1995, NYSDEC 2004) have listed 67 waterfowl and shorebird species; and 84 upland bird species as either observed or expected to occur within the project area (USFWS, 1995). Of the 151 species), 60 utilize the south shore of Staten Island area as a breeding site. Another 34 species are listed as either possibly or probably using the project area for nesting purposes. Feral wild turkeys are also found in the project area.

3.5.5 Amphibians and Reptiles:

86. A number of amphibians and reptiles still reside on Staten Island despite the extensive level of development. Due to the presence of open areas with an abundance of beach grass growing along the beach, large numbers of amphibians and reptiles live along these beach areas. Examples include the diamond-backed turtle (*Malaclemys t. terrapin*) at Great Kills Harbor and Cookes Point and Dekay's and Garter Snakes (*Storeria dekayi* and *Thamnophis S. sirtalis* respectively) in and around the Midland Beach area. Green frog, *Rana ciamitants* and Fowler's Toad, (*Bufo woodbousii fowlere*) have been found at Grand Avenue, above and below Hylan Blvd. NYCDEP 2013).

3.5.6 Mammals:

87. Mammals are still numerous throughout Staten Island due to the presence of open areas. The most common mammals present are the small mammals that do not need large areas of cover, as well as white tailed deer. Large areas of cover are not as extensive before man-made development occurred, and so the larger mammals are no longer present in Staten Island. This type of cover is found only on the park's acreage on the island, but the parks and their facilities are so well used that the larger mammals are also crowded out of these areas.

3.5.7 Threatened and Endangered Species:

88. The Draft EIS identifies the Piping Plover and Rufa Red Knot as the only federally protected species with potential to occur in the project area. No critical habitat has been identified or proposed for the piping plover. FWS has indicated that it will announce in 2015 whether critical habitat will be designated for the Rufa Red Knot. The EIS also lists additional State Species of concern that potentially could occur in the Project area, including the Osprey, Coopers Hawk, Northern Harrier, and Peregrine Falcon. Plant species of concern that have been observed in the project area include the Slender Blue Iris, Turks-caps-Lily, Royal fern, Slender Bue flag, Cinnamon fern, Spinulose Wood fern. The EIS also identifies other plant species of concern with the potential to occur.

89. The draft EIS also lists marine species such as the endangered leatherback (*Dermochelys coriacea*) and Atlantic ridley (*Lepidochelys kempii*) sea turtles, the threatened loggerhead sea turtle (*Caretta caretta*), and the endangered sei (*Balanoptera borealis*), humpback (*Megaptera novaeangliae*), and sperm (*Physeter catodon*) whales may also be present in the Raritan Bay/Lower Bay Complex (USFWS, 1995), but outside the immediate project area. These species are under the jurisdiction of the National Marine Fisheries Service.

3.6 Cultural and Historic Resources

90. As a federal agency the USACE has certain responsibilities for the identification, protection and preservation of cultural resources that may be located within the Area of Potential Effect (APE) associated with the proposed South Shore of Staten Island project. Present statutes and regulations governing the identification, protection and preservation of these resources include the National Historic Preservation Act of 1966 (NHPA), as amended; 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, August 2004); 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).

91. Most of the project’s APE has been subject to cultural resource surveys by USACE or by others. A reconnaissance report was prepared for this study in 1995 which was a summary of cultural resources work conducted to date in the project vicinity, a brief overview of historic map research and recommendations for further work (Rakos 1995). This work summarized and updated a previous study undertaken for the project (Lipson, et al. 1978.). USACE conducted archaeological investigations at Oakwood Beach and identified a Native American site (Rakos 1996). This site was later destroyed by a private development project. A Phase I survey of the entire south shore of Staten Island project area was completed for USACE in 2005 (Panamerican Consultants. Inc., 2005). This work included archaeological testing and an historic architectural survey. The resulting report recommended further archaeological investigations in selected locations along the proposed project alignment and interior drainage features. The only historic structures noted in the APE are at Miller Field. All District cultural resources studies were coordinated with the New York State Historic Preservation Office (SHPO).

92. No Native American resources were identified along the proposed alignment. However, the shoreline was determined sensitive for deeply buried sites (Panamerican 2005). The potential for deeply buried sites was corroborated by a geomorphological study conducted for the USACE's New York and New Jersey Harbor Navigation Project (Geoarchaeological Research Associates 2014). While this study's APE was offshore, it suggested that the south shore of Staten Island is moderately sensitive for now inundated or deeply buried shoreline sites. Work recommended along the LOP included the excavation of deep borings in selected locations to test for the presence of early landforms buried under marsh or organic soils. The 2005 report indicated that the need for borings is contingent on the construction technique proposed. If open trenching is proposed then borings are recommended however if pile driving is the proposed construction method then no borings will be excavated. Borings will serve to determine if any significant resources or sensitive landforms are present. If such resources are identified then construction impacts will be determined and mitigation measures developed. There is a moderate potential to encounter significant archaeological deposits.

93. USACE is working with the National Park Service (NPS) Gateway National Recreation Area (GNRA) regarding impacts to the Miller Army Airfield Historic District. This NRHP-listed resource is immediately adjacent to the proposed project. The historic district consists of the Hangar No. 38, which is a seaplane hangar constructed by the United States Army in 1920, and its concrete apron. Additions to the building were added in the 1930s by the Works Progress Administration. The Elm Tree Light is also included in the District. This structure was built in 1939 by the Coast Guard to replace earlier aids to navigation including a large elm tree that stood in the 18th century and served as a guide to mariners (Wren and Greenwood NPS 1976; Unrau and Powell 1981). The proposed project will sever the connection of Hangar No. 38, a seaplane hangar, from the sea thereby having an adverse effect on the setting of this historic district.

94. Adjacent to, but not included in, the Miller Army Airfield Historic District is a 1943 concrete fire control tower. It was built to serve as a "base end station" which aided location of offshore targets through triangulation and worked in concert with stations at Fort Wadsworth on Staten Island and Fort Hamilton in Brooklyn (Historic Miller Field 2007). This structure is also owned by the NPS but was not addressed in their April 2014 Final General Management Plan/Environmental Impact Statement (GMP/EIS). This structure was not included in the NRHP Nomination Form as a contributing element to the Miller Army Airfield Historic District (Wren and Greenwood NPS 1976). The 2005 District report indicated that due to the structure's lack of integrity it was neither an individually eligible resource nor a contributing element to the historic district however the report recommended further study. Construction of the proposed NED alignment will require that the fire tower be demolished. USACE will also evaluate the NRHP-eligibility of the tower and will continue to work with the NPS to minimize and/or mitigate for impacts to the Miller Army Airfield Historic District.

95. The Fort Wadsworth National Register Historic District, also a GNRA property, lies immediately adjacent to the northern terminus of the LOP and within the project's APE. The property contains nationally significant historic structures representing military history and coastal defense systems from the late 18th-century through the Cold War. The contributing structures to the historic district are largely sited to the north and east of the APE in locations that provided commanding view of the Narrows and Upper Bay, the entryway to New York Harbor, which the defenses were designed to protect. No significant adverse effects to this district are anticipated.

96. Several proposed segments of the proposed LOP have shifted landward since the 2005 survey including those at New Dorp Beach and Oakwood Beach. The closure gate structure proposed at Hylan Boulevard is a new element to the project. All uninvestigated features and alignments will be surveyed for cultural resources. The bungalow community at Cedar Grove was determined NRHP-eligible and was going to be removed by NYCDPR. The historic district was destroyed by Hurricane Sandy. No cultural resources work will be undertaken at Cedar Grove by USACE.

97. Archaeological testing of high ground adjacent to proposed ponding areas and pump stations as part of the project's interior drainage needs was recommended in the 2005 cultural resources report. Since that time the Corps has largely limited all interior drainage features to those areas included in the NYCDEP Blue Belt program. More detailed archaeological studies were undertaken in association with the Bluebelt (Historical Perspectives 2011a, 2011b and 2011c) Program. USACE will use the cultural resources recommendations provided for the Bluebelt Program on any overlapping project actions. Interior drainage features not included in the Bluebelt Program will be subject to a cultural resources survey by USACE.

98. USACE has drafted a Programmatic Agreement (PA) which stipulates the actions will be undertaken as the project proceeds with regard to cultural resources. The PA will

be used to ensure that USACE satisfies its responsibilities under Section 106 of the NHPA and other applicable laws and regulations. The draft PA will be provided to the SHPO, Advisory Council on Historic Preservation, the National Park Service, the Delaware Nation, and the Delaware Tribe of Indians and the Stockbridge-Munsee Community Mohican Band of Indians for their review and participation. A list of potential interested parties has been developed. The Staten Island Historical Society, Staten Island Museum, Staten Island Historian, Preservation League of Staten Island and the Harbor Defense Museum of Fort Hamilton were reached out to directly by the USACE. The draft PA is available for public review in the Draft EIS and will serve as the USACE's Section 106 public coordination. The final PA will incorporate comments received on the draft document, as appropriate.

3.7 Recreation

99. The study area contains both City-owned and Federally-owned parklands. Recreational opportunities include the Gateway NRA which extends approximately 7 miles in length along the shore. The Gateway National Recreation Area (GNRA) contains several beaches with associated boardwalks and promenades, and includes additional recreational opportunities at Miller Field and Fort Wadsworth. Figure 10 shows the Gateway National Recreation Area.

Figure 10 - Gateway National Recreation Area (Staten Island Unit)

100. Fort Wadsworth to Oakwood beach: The shoreline from Fort Wadsworth to Oakwood Beach consists entirely of city beaches and various segments of the Gateway National Recreation Area (GNRA). Located at the eastern boundary of the study area, Fort Wadsworth is Federal land, and is the location of a visitor center operated by the National Park Service.

101. West of Fort Wadsworth, the South Beach Wetlands occupy nearly 175 acres in the community of South Beach (this includes state delineated wetland NA-7). The park was once part of a wide tidal meadow, and small creeks flowed through this meadow. However, over time, many creeks were slowly polluted. The South Beach Wetlands are part of a growing trend of preservation along Staten Island's south shore. Efforts in nearby areas to restore original channel networks have been undertaken, emphasizing flood mitigation and natural filtration of pollutants.

102. Midland Beach was vested to the City of New York in 1935. As part of President Franklin Delano Roosevelt's Work's Progress Administration (WPA), the site underwent major renovations. Midland Beach is now a segment of Staten Island's Franklin Delano Roosevelt Boardwalk and Beach, supporting baseball fields, handball and shuffleboard courts, playgrounds, bocce ball courts, checker-tables, a skateboard park, a roller hockey rink, and a long pier for year-round fishing. The Franklin Delano Roosevelt Boardwalk and Beach is a 64.45 acre recreation area extending 2.5 miles west from Ocean Avenue to Miller Field. The wooden boardwalk transitions to a paved, at-grade asphalt roadway or promenade at Sea View Avenue and continues southwesterly along the shoreline to Miller Field.

103. The New York City Department of Parks and Recreation has estimated that average attendance has been increasing at Midland Beach and South Beach. They have observed a ten year average of approximately 250,000 to 300,000 visitors per year, with roughly 350,000 visitors in the year 2001. Though the number of beach visitors declined in 2013 because of damages to local infrastructure, the Parks Department recorded an annual increase of 40% from 2013 to 2014. The Parks Department statistics cited that over 450,000 people visited Midland and South Beach in 2014.

104. Miller Field is located just west of Midland Beach. It is a former Federal airfield that is now part of the Gateway National Recreation Area. The 144-acre field extends approximately 1,700 feet along the shoreline from the end of Father Capodanno Boulevard west to New Dorp Lane, and roughly 3,700 feet north to the New Dorp High School property. While the grounds themselves are now open to the public, the two vacant aircraft hangars and one lookout tower on the property, closed prior to Hurricane Sandy due to potential structural concerns, remain inaccessible to the public.

105. Other facilities include a ranger station (operated by the National Park Service), an outdoor skating rink, and a community garden.

106. Great Kills Park lies just west of the study area. It is part of the GNRA created by an Act of Congress in 1972 in order to bring parks and recreational facilities to people in densely populated urban areas.

3.8 Hazardous, Toxic, and Radioactive Waste (HTRW)

107. An assessment of documented Hazardous, Toxic, and Radioactive Waste (HTRW) sites in the Project area was conducted by reviewing recent state and Federal data sources. No HTRW sites or New York State-listed Inactive Hazardous Waste Disposal Sites have been identified within the Project area (USEPA 2014b).

108. In support of this Project, USACE also conducted a Phase I Environmental Site Assessment on available parcels of land along the coast to identify any recognized environmental conditions (REC) that may have an adverse environmental impact upon the subject properties (USACE 2003b). USACE conducted a thorough historical and municipal records search (Federal, State, and local), reviewed database listings, and conducted a site reconnaissance of the Project area. The findings of that investigation indicate that contaminated soils, surface water, and groundwater may be present throughout the Project area caused by known or potential historical fill, miscellaneous dumping activities, and past or present operations within or surrounding the properties and drainage areas of the study area. Findings also revealed that known or unknown active or abandoned underground storm sewer, sanitary sewer, and natural gas conduit may exist throughout all properties of the study area. In addition, record sources and previous site investigations have revealed that abandoned storm sewer and sanitary conduit extends into the Lower New York Bay, Great Kills Harbor, and the Raritan Bay from the southeastern shoreline (USACE 2003b).

109. Additionally, in conjunction with preparing the Bluebelt GEIS, Phase I and Phase II Environmental Site Assessments were conducted to reveal the potential for contamination at interior flood control sites (NYCDEP 2013). As noted previously, drainage areas are divided into sub-drainage areas A, B, C, D and E.

110. A discussion of the potentially applicable results of those assessments follows.

3.8.1 Oakwood Beach (Drainage Areas A and B)

- Drainage Area B: historical uses and the regulatory databases have indicated the need for site testing to identify any potential impacts on soil and groundwater conditions; and
- Shoreline: historical uses and the regulatory databases have indicated the need for site testing to identify any potential impacts on soil and groundwater conditions (NYCDEP 2013).

3.8.2 New Creek (Drainage Area C)

- Drainage Area C: historical uses, site observations, and the regulatory databases have indicated the need for site testing to identify any potential impacts on soil and groundwater conditions; several of the sites have either a moderate or high potential for site contamination; and
- Shoreline: historical uses and the regulatory databases have indicated the need for site testing to identify any potential impacts on soil and groundwater conditions (NYCDEP 2013).

3.8.3 South Beach (Drainage Areas D and E)

- Drainage Area E: Phase II testing associated with the Bluebelt GEIS has identified a high potential for soil and groundwater contamination; and
- Shoreline: historical uses and the regulatory databases have indicated a moderate potential for soil and groundwater contamination (NYCDEP 2013).

111. In addition to these studies, there has been recent discovery of the presence of radiological contamination in a portion of the Great Kills National Park, adjacent to NYC Parks property and the tie-off to the proposed LOP which may also extend under the Oakwood Beach Wastewater Treatment Plant. In 2010, sections of Great Kills Park were closed to visitation due to health and safety concerns following the discovery of radium. This section of the park remains closed today. These radium sources, found buried more than a foot below the ground's surface, have been removed; however, since then, additional areas exhibiting above-background radiation readings have been identified within the footprint of the historical landfill at this Great Kills National Park site. Investigation into the extent of the radium contamination is ongoing; based on the current limited information it is believed that the radium came from discarded medical treatment sources brought to the landfill site with the waste fill material. The extent of the wastefill material along the park's southeastern boundary has not yet been fully delineated. Radium present in the disposed items has likely leaked over time, resulting in contamination of the soil directly surrounding the sources. To ensure public safety, the NPS initiated a wider investigation into the extent of radium at the site in the form of a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, or Superfund) process in 2010. The goals of this CERCLA process are to determine the nature and extent of the contamination evaluate and select an option for cleanup, and return the park to a condition unencumbered by contamination. As they are identified, the sources of radium are removed from the site for proper storage and disposal at an out-of state facility. As of 2010 when the CERCLA process was initiated, the NPS (with technical assistance from the USACE) had removed radioactive sources and surrounding contaminated soil from the five locations with the highest radiation readings. The radiation at these sites averaged 4.12 milliroentgens per hour (mR/h) and dropped to 0.46 mR/h 3 feet away. Background radiation for this area is 0.02 mR/h (NPS 2014). The NPS will retain USACE Environmental to perform further investigation on its behalf starting

in early summer 2015. The NPS is currently further investigating the footprint of the former landfill area. The current steps for the CERCLA project are:

- Remedial Investigation 2015-2017;
- Feasibility Study 2018;
- Proposed Plan;
- Record of Decision;
- Remedial Design/Remedial Action.

112. USACE is coordinating with the NPS to have the Project area investigated first with the goal to ensure that, prior to construction of the recommended coastal storm risk management plan, either no contamination exists in the project construction footprint or all contamination has been removed from the project footprint by the responsible party. Additional information regarding the on-going assessment at Great Kills may be found at http://www.nps.gov/gate/learn/management/environmental-investigations.htm.

3.9 Transportation and Other Infrastructure

113. Several important transportation links pass through the study area and are connected to transport links of greater regional importance. The most significant roads in the study area are the main thoroughfares that run parallel to the shoreline, notably Hylan Boulevard, which runs through the northern part of the study area for its entire length. This road is an important local artery for commuter and commercial traffic, linking all the shoreline neighborhoods and communities with the Verrazano Narrows Bridge. Father Capodanno Boulevard, which runs along the shore for much of the study area, is another significant local artery for commuter traffic, and also provides access to many of the recreational facilities in the study area.

114. Staten Island itself is accessed by road via several bridges and highways of Interstate standard. These routes do not pass through the study area, but the potential effect of traffic disruption because of the flooding of local feeder roads should not be dismissed. The most significant of these highways is the Staten Island Expressway (I-278), which connects Staten Island with New Jersey via the Goethals Bridge, and then Staten Island with Brooklyn via the Verrazano Narrows Bridge. The Korean War Veterans' Highway (R-440) connects Staten Island with New Jersey via the Outerbridge Crossing.

115. The Staten Island Railway passes through the northern part of the study area. Passenger services are operated by the New York City Metropolitan Transportation Authority (MTA), and form an important service for commuters and other local residents. Outside the study area the Staten Island Railway connects at its northern terminus with the Staten Island Ferry, which connects Staten Island directly to Manhattan, and is one of the most important and well-known public transportation links in the City of New York. The NYC MTA also operates a network of bus services throughout the island, with many passing through the study area.

4. FUTURE WITHOUT-PROJECT CONDITIONS

4.1 General

116. The without-project future conditions for the South Shore of Staten Island have been identified as follows:

- Continued flooding during severe future storm events.
- Continued wave impacts and mild erosion of unprotected bay front shorelines.
- Continued development and fill of low-lying storage areas.

117. It is expected that future storms will continue to cause damages in the study area. Although coastal storm risk management from small storm events is provided by local topographic features and landforms, future large storm events will cause extensive damages to the study area. Since no major changes by the local government to the shorefront are expected, the existing level of coastal storm risk management will decline as sea level increases and severe storm surges become more frequent.

118. It is also assumed that the beach profile and layout shape will be maintained over the long term and that beach alignments will not significantly alter current conditions.

4.2 Sea Level Change

119. Storm Tide inundation is expected to increase over time, in direct relation to the anticipated rise in sea level. Based on long-term trends measured at the Sandy Hook Gage, an increase of 0.013 feet per year is anticipated, resulting in a baseline increase of 0.7 feet over the 50-year period of analysis for the project. As a result of the increase in sea level, more frequent and higher stages of flooding will result in the later years of the 50-yr period-of-analysis. As described in Section 8.6, there is also the potential for accelerated sea level rise in the future.

4.3 Development

120. It is expected that continued development will occur in the floodplain, subject to local floodplain management ordinances. Small residences will continue to be displaced by larger new homes and townhouses, and vacant areas will come under increasing pressure to be developed as the local population continues to increase.

121. The rapid rate of development that is being experienced in the study area, particularly in shorefront neighborhoods, coincides with an increasing amount of fill in the floodplain as new construction is elevated above the base flood elevation. Much of the currently vacant land in the study area is under considerable development pressure, with some areas already zoned for residential development. The combination of new development and fill will reduce the natural storage available to attenuate flood depths

from interior runoff. Consequently, increases in interior flood stages are expected to accompany continued development and fill in the floodplain. A more detailed discussion on the interior drainage issues is presented in the Interior Drainage Appendix.

122. In addition to the loss of natural flood storage areas, the inventory of properties vulnerable to flood damage will increase as the low-lying areas continue to be developed. Because the buildings will be constructed to be consistant with current floodplain regulations, a conservative assumption, the future year damage analysis has not included the increased inventory estimated with future development.

123. The NYCDEP's Staten Island Bluebelt Program incorporates plans and actions to provide stormwater management to decrease flood hazards and increase water quality both inside and outside the study area. One of the mitigating activities important to the level of development within the study area is the acquisition of local property for the preservation of wetlands and introduction of new natural storage areas for stormwater conveyance. Approximately 200 acres of the study area is already owned by the NYCDEP Bluebelt Program (NYCDEP, Final Generic Environmental Impact Statement, Staten Island Bluebelt Drainage Plans for Mid-Island Watersheds, 2014). The current planning timeline for implementing the Bluebelt program extends well beyond the schedule for constructing the Fort Wadsworth to Oakwood project shoreline reach and is subject to local funding.

124. Two new ocean outfalls are proposed in the future drainage plans developed by the City of New York as part of the Staten Island Bluebelt program. The new outfall in the Midland Beach area drains BMP NC-10 and will pass under Father Capodanno Blvd. between Jefferson Ave. and Hunter Ave. The new ocean outfall in South Beach is at Mc Laughlin Street. The previously planned new outfall in Oakwood Beach is no longer required because the State's buy-out plan makes the outfall unnecessary.

4.4 Project Base Year

125. The base year is the year that a potential project may be completed. The base year was assumed to be 2019 for the Fort Wadsworth to Oakwood Beach project reach.

5. PROBLEMS AND OPPORTUNITIES

5.1 Description of the Problem

126. Historically, lands along the South Shore of Staten Island have been susceptible to tidal inundation during extratropical storms, nor'easters, and hurricanes with severe damage to life and property caused by wave action, erosion, storm surges and rising interior stormwater runoff trapped landward of the Bay. Areas between Fort Wadsworth to Oakwood Beach are most susceptible to high velocity overtopping flood waters when the storm surge from the Raritan Bay rise above Father Capodanno Boulevard or other local topographic features as was the case during Hurricane Sandy. The greatest threat of damages to property and loss of life is due to coastal surges.

5.2 Causes of Flooding and Historic Storm Damage

5.2.1 Causes of Flooding

127. Flooding in this area can result from either high storm surges from the Bay or high interior ponding from precipitation runoff that cannot be discharged to the Bay. The study area is protected from storm surge until floodwaters rise above Father Capodanno Boulevard, or other local topographic features such as dunes or levees (approximate crest elevations at 10 feet NGVD 1929, which is typically overtopped during a 10 year coastal storm event or above). These existing coastal barriers block storm surge from entering the study area during some storm events but after the wave heights or surge level rise above its crest, the bowl-like, large low-lying inland area becomes rapidly filled with floodwater.

128. Throughout the project reach, more frequent localized interior flooding has been reported because of high pools of precipitation run-off trapped landward of the existing coastal barrier. The interior flood levels begin to rise rapidly when the storm stormwater outfalls are blocked by high tides or storm surges. Even during high tides the runoff is unable to flow to the Bay. Interior flooding may also occur when the intensity of the precipitation is such that the outflow of runoff is restricted by the capacity of the storm drainage system. Either situation results in flooding on the landward side of the existing high ground and is distinguishable from storm surge flooding discussed in the previous paragraph.

5.2.2 Historic Storm Damage

129. Some of the most damaging storms that have affected Staten Island include:

- Hurricane of November 1950
- Extratropical Storm of November 6-7, 1953
- Hurricanes of August 31 and September 11, 1954
- Hurricane Donna (September 12, 1960)
- Nor'easter of March 6-8, 1962
- Storm of January 23, 1966
- Storm of November 8, 1977
- Nor'easter of December 11-12, 1992
- Hurricane Sandy (October 29-30, 2012)

130. While these storms may be the most notable of those that have impacted the study area, many more storms have affected Staten Island's south shore. For example, in the thirty years prior to 1962, no less than ninety hurricanes, tropical storms or extratropical storms significantly impacted the New York City area (USACE, 1964). The following description of storm events summarizes three of the most destructive flood hazard events recorded along the South Shore of Staten Island.

5.2.2.1 Hurricane Donna (September 1960)

131. Prior to Hurricane Donna, a park development at South Beach was completed between Miller Field and Fort Wadsworth, which included an artificially filled beach and promenade. In addition, Seaside Boulevard (Father Capodanno Boulevard) was raised from Miller Field to the vicinity of Burgher Avenue (approximately half of the distance to Fort Wadsworth). This work was very effective in protecting the many dwellings that are located on the extensive marshland, inshore of the beach. During Hurricane Donna, however, tidewaters and waves broke through under the boardwalk and across the old road, at the point where the new boulevard ended. Foam-capped breakers reportedly soared 50 feet or more in the air between South Beach and Midland Beach. The beach was also breached at Sand Lane to the east and around the end of the boardwalk near Fort Wadsworth, inundating Seaside Boulevard up to a depth of 3 feet.

132. In the community of Oakwood Beach, tide gates at a wastewater treatment plant flume at the south end of a protective sand dike failed to operate and tidewater began to flow into the streets. As the tide and wave action increased, the dike was flanked at the breach near the center. Twenty-five families were forced to leave the area when their homes were inundated.

133. In New Dorp Beach, the grounds of the Seaside Nursing Home were flooded up to the steps of the main building, but damages were confined to clean-up operations. The streets of the residential area were flooded about 500 feet inland. From the Ocean Edge Colony, along New Dorp Lane to Cedar Grove Beach, residents and Fire Department

crews reportedly pumped water from the streets. Cedar Grove Avenue was impassable due to flooding.

134. Miller Field suffered damage when tidewater entered through the former New Dorp Avenue gate and flooded grounds, hangars and some buildings at the southeast end of the field. Hurricane Donna caused approximately $3.3 billion in damages (adjusted to 2010 price levels) and directly caused 50 deaths (Eric S. Blake E. J., 2011).

5.2.2.2 December 1992 Nor'easter

135. During this storm, flood levels ranged from 8.4 to 10.6 feet NGVD 1929 between Fort Wadsworth and Miller Field. Nearly 2,000 structures within this area had ground elevations at or below the average elevation of floodwaters recorded during this event. Also, the December 1992 storm caused the partial collapse of 22 bungalows at Cedar Grove Beach.

136. At Oakwood Beach the artificial dune system, located on New York City property, was breached in the 1992 storm. This occurred at Kissam Avenue, creating a breach in the dune up to 175 yards wide. In addition, prior to the completion of the USACE project in 1999, the Oakwood Beach area was open on its western flank to the low lands around the sewage treatment plant and Great Kills Park. Large areas along Fox Lane and Kissam Avenue were flooded with depths up to 5 feet. Remedial action removed debris in the watercourse, repaired the sewer system and reconstructed the dune. As previously described, a short-term plan of protection was implemented under the Corps of Engineers Continuing Authority Program to protect Oakwood Beach residents from inundation from the western flanked area in 1999.

137. As a result of this storm, 225 flood claims totaling almost $2 million (in 1992 price levels) were paid out from the National Flood Insurance Program (NFIP). Ten individuals lost their lives as a result of the storm (Eric S. Blake E. J., 2011).

5.2.2.3 Hurricane Sandy (October 2012)

138. On 29 October 2012, Hurricane Sandy made landfall approximately five miles south of Atlantic City, NJ, where it collided with a blast of arctic air from the north, creating conditions for an extraordinary and historic storm along the East Coast with the worst coastal impacts centered on the northern New Jersey, New York City, and the Long Island coastline. Hurricane Sandy's unusual track and extraordinary size generated record storm surges and offshore wave heights in the New York Bight. The maximum water level at The Battery, NY peaked at 12.4 feet NGVD 1929, exceeding the previous record by over 4 feet.

139. The south shore of Staten Island was one of the hardest hit areas. High water marks and storm tide gauges deployed by the USGS show that maximum water levels, excluding wave fluctuations, reached 13.6 feet NGVD 1929 in the Study Area during Sandy (USGS, 2013). An overview of the extent of flooding in the Study Area is shown

in Figure 11. Storm surge and waves devastated low-lying neighborhoods. At Kissam Avenue (Oakwood Beach) many homes were swept off of their foundations or flattened (Figure 12). Floodwaters rose rapidly in many neighborhoods once storm surge elevations exceeded the elevation of Father Capodanno Boulevard. The water was trapped in some areas for several days because of the bowl-like topography. Figure 13 shows the damage to homes located along Cedar Grove Avenue (New Dorp Beach) that are located 700 feet landward of the shoreline. In the same area, approximately 40 residential structures located close to the beach at Cedar Grove Beach Place were completely destroyed. Local recreational features experienced dismantling or destruction from the high surge and wave action such as the Franklin D. Roosevelt (FDR) Boardwalk, which was originally constructed in 1935 and stretches from Fort Wadsworth to Miller Field.

140. Preliminary estimates for the damages in the U.S from Sandy are upwards of $50 Billion, making it the second costliest storm in U.S. history since 1900[6] (Eric S. Blake E. J., 2011). The storm caused 147 direct deaths, twenty-four of which were residents of Staten Island, fourteen of which were in the Study Area.

[6] Not including historic price adjustments

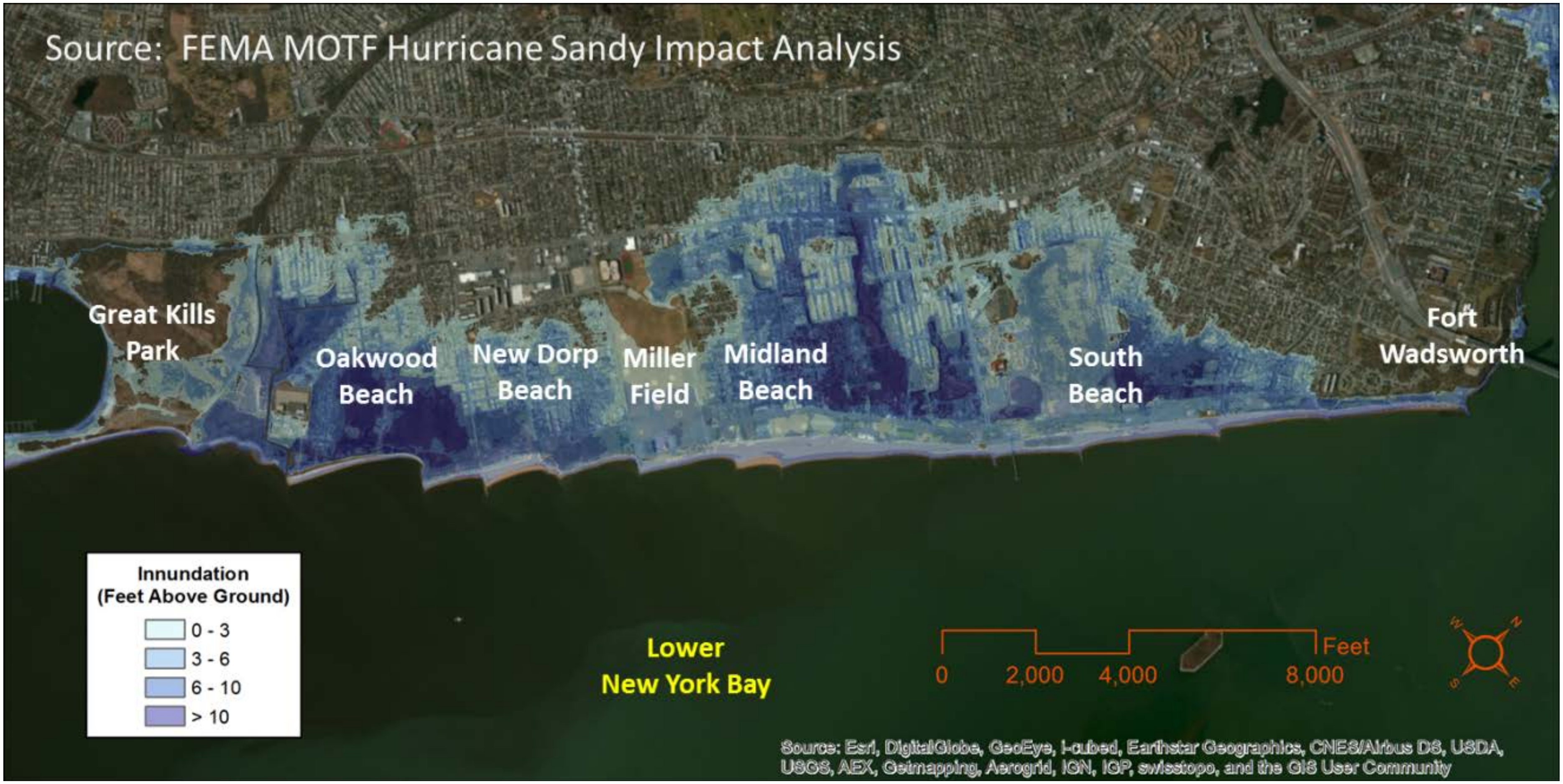

Figure 11 - Hurricane Sandy Flood Inundation

Figure 12 – Typical Hurricane Sandy Damage

Figure 13 – Typical Hurricane Sandy Damage

5.3 Modeling of Storm Damage Conditions

5.3.1 General and Conditions

141. The following steps were taken in the preliminary analysis of predicted inundation damage:

- Assign economic reaches,
- Inventory floodplain development,
- Estimate depreciated replacement cost,
- Assign generalized damage functions,
- Calculate aggregated stage vs. damage relationships.

142. Flood damage calculations were performed using Version 1.2.5a of the Hydrologic Engineering Center's Next Generation Flood Damage Analysis computer program (HEC-FDA, October 2010). Prior studies indicated that there was no limited risk of direct wave or erosion damages to residential and commercial structures in the study area. HEC-FDA was found to be a suitable program to quantify the damages because the damages are essentially limited to storm surge inundation. This program applies Monte Carlo simulation to calculate values of expected damage while explicitly accounting for uncertainty in the input data. HEC-FDA models were prepared for existing without-project and with-project conditions for each evaluated alternative coastal storm risk management plan.

143. Estimates of damages are based on July 2014 price levels and a 50-year period of analysis, and reflect the economic condition of Staten Island as of July 2014. Damages have been annualized over the 50-year analysis period using the fiscal year 2015 discount rate of 3.375%.

5.3.2 Economic Reaches

144. In order to identify unique characteristics within the study area, the project reach was subdivided into Economic Reaches.

145. Economic reach selection was determined by criteria such as the potential coastal storm risk management measure limits to facilitate an equitable comparison between alternatives. Wherever possible, boundaries of Economic reaches and Interior Drainage areas were made to be coincident to simplify the HEC-FDA stage vs. damage model.

146. Figure 14 depicts an Economic Reach overlay on the Drainage Areas and aerial image. Structure counts per economic reach are provided in Table 8.

Figure 14- Economic Reach Overview

Table 8: Overview Of Economic Reaches And Structures In Study Area				
Economic Reach in HEC-FDA	**Economic Reach Description**	**Number of Structures**		
		Res.	**Non-Res.**	**Total**
FWOB-1	*Fairlawn Ave. to Buffalo St.*	18	4	22
FWOB-2	*Buffalo St. to Tysens La*	949	51	1,000
FWOB-3	*Tysens La. to New Dorp Lane*	1,276	57	1,333
FWOB-4	*New Dorp Lane - Delaware Ave*	3,340	320	3,660
FWOB-5	*Delaware Ave. to Andrew St*	794	25	819
FWOB-6	*Andrew St. to Sand Lane*	234	12	246
FWOB-7	*Sand Lane to USS Iowa Circle*	253	33	286
FWOB-TP	*Oakwood Beach Waste Water Treatment Plant*	0	1	1
	Total:	***6,804***	***503***	***7,367***

5.3.3 Inventory Methodology

147. To accomplish the damage analysis, the development of a structural database was needed to assist in predicting flood damages. The structural data base was generated through "windshield survey" of the area and topographic mapping with a 2-foot contour interval. A "windshield survey" involves recording a myriad of characteristics for each structure by visual inspections from public roads and sidewalks without the need to enter on private property. Table 9 presents the physical characteristics captured for the building inventory.

Table 9: Physical Characteristics Obtained From Building			
1)	Structure ID	10)	Setback from Shoreline
2)	Map Number	11)	Midpoint from Shoreline
3)	Type	12)	Owner
4)	Usage	13)	Quality of Construction
5)	Size	14)	Condition
6)	Story	15)	Ground Elevation (NGVD 1929) *
7)	Basement Type	16)	Main Floor Opening
8)	Number of Garage Openings	17)	Low Opening
9)	Exterior Construction	18)	Reach

** Ground Elevations collected in NAVD 1988 and converted to NGVD1929.*

148. The data collected was used to categorize the structure population into groups with common physical features. Data pertaining to structure usage, condition, size and number of stories assisted in the structure value analysis. For each building, data was also gathered pertaining to its damage potential including ground and main floor elevations, lowest opening, construction material, basement, and proximity to the shorefront.

5.3.4 Post-Hurricane Sandy Depreciated Structure Values

149. The value of each building in the floodplain was originally calculated using standard building cost estimating procedures from the Marshall & Swift Valuation Service. This analysis combines the physical characteristics obtained in the inventory with standard unit prices per square foot. Depreciation was then calculated based on the observed quality and condition of each structure.

150. The inventory of structures contributing to storm damages was revised to reflect post-Sandy conditions via a review of publicly available aerial photographs and other pertinent information and via a field survey of a randomly selected sample of structures for the purposes of developing an overall update factor.

151. From the study of recent aerial photographs 61 buildings were identified which had been destroyed by Hurricane Sandy or demolished for other reasons and not rebuilt. These structures were deleted from the inventory database. Information from State and City agencies was also used to identify a significant number of structures which are in the process of being acquired and demolished for mitigation purposes in the Oakwood Beach section of the study area. In total 188 structures were identified as subject to acquisition programs as of December 26, 2013 and were also deleted from the inventory database. The field survey also aimed to identify any structures damaged during Sandy which have subsequently been elevated or for which applications for elevations have been submitted;

however, no recently elevated structures were observed during the field survey, and pertinent information from agencies implementing and administering building elevations was not available.

152. The sample set of structures for the field survey was developed by randomly selecting 25 ‘seed’ structures and then adding the next 19 structures in the sequential list following each seed to generate clusters of 20 structures totaling 500. The sample set was adjusted to ensure that there were no overlaps between clusters and that no clusters were split between geographically distant areas. During the review of aerial photographs 25 additional structures were identified as having been constructed since the previous inventory value update in 2009 and these were added to the field survey list.

153. Section 308 of the Water Resources Development Act of 1990 excludes certain structures built after July 1, 1991 from flood damage analyses. Applicable structures are those in the 1% Annual Chance Exceedance Floodplain which have main floor elevations below the contemporary Base Flood Elevation (BFE). Of the 24 structures identified as constructed since the 2009 update, two were identified as having main floors approximately one foot below the contemporary BFE, of which one is a residence and the other is an indoor sports facility. In both cases it is possible that the actual elevation meet the BFE requirement given the uncertainty in map and inventory elevations. Adjusting or removing these two structures would have a negligible effect on the results of the damage analyses.

154. On completion of the field survey, depreciated structure replacement values at a July 2014 price level were calculated for all surveyed structures using RS Means Square Foot Costs 2014. Structure values from the 2009 inventory were compared to the values calculated at the July 2014 price level to compute an overall value update factor of 1.21. This factor was then applied to all structures in the revised inventory which were not included in the field survey.

155. The total post-Sandy depreciated replacement value of all structures within the study area is just under $3.2 billion. A summary of structure values by economic reach can be found in Table 10.

Table 10: Estimated Structure Depreciated Replacement Value By Economic Reach

Price Level: July 2014

Economic Reach	Number of Structures	Total Depreciated Structure Replacement Value
FWOB-1	22	$11,287,000
FWOB-2	1,000	$375,885,000
FWOB-3	1,333	$591,704,000
FWOB-4	3,660	$1,633,719,000
FWOB-5	819	$346,969,000
FWOB-6	246	$77,037,000
FWOB-7	286	$120,150,000
FWOB-TP	1	N/A*
Total, All Reaches	***7,367***	***$3,156,811,000***

*See section 5.3.6 Inundation Damage Function

5.3.5 Stage-Frequency Data

156. Stillwater elevations for the Project Area were obtained from the forthcoming FEMA Flood Insurance Study (FIS) results as shown in Table 11. The coastal study project area for the modeling study includes New Jersey, New York City, Westchester County, NY, and the banks of the tidal portion of the Hudson River. A region wide storm surge modeling study was performed by FEMA (2011) using the Advanced Circulation Model for Oceanic, Coastal and Estuarine Waters (ADCIRC) which was dynamically coupled to the unstructured numerical wave model Simulating Waves Nearshore (unSWAN). Synthetic tropical and extra-tropical storms were generated based on parametric models and historical data. The numerical modeling results from the synthetic storms are used to determine still water frequency of occurrence relationships. The model results were extracted offshore of the Project Area in the center of Lower New York Harbor (74°4’57.48”W, 40°30’9.74”). When evaluating the Alternatives, the future year water surface elevations include the historic rate of sea level change, a 0.7 foot increase over the lifetime of the project. After the selection of the Alternative, intermediate and high sea-level change projections are also considered as part of the sensitivity testing of the selected alternative.

Table 11 - Summary of Stage Vs. Frequency Data, 50-yr Period of Analysis		
RETURN PERIOD (YEARS)	ELEVATION, EXISTING (FT NGVD 1929)	ELEVATION, FUTURE YEAR (FT NGVD 1929)
2	5.3	6.0
5	7.2	7.9
10	8.5	9.2
25	10.0	10.7
50	11.3	12.0
100	12.6	13.3
200	14.0	14.7
500	15.9	16.6

Stillwater elevations obtained from FEMA (2013)

5.3.6 Inundation-Damage Functions

157. Based on the type, usage and size of each structure inventoried, damage was calculated relative to the main floor elevation of the structure. Using structure and ground elevation data, these depths vs. damage relationships were converted to corresponding stage (NGVD 1929) vs. damage relationships. Damages for individual structures with exception of the Oakwood Beach WWTP at various stages were aggregated according to structure type (residential, apartment, commercial, etc.) and location (reach). Stage vs. damage plots by reach is presented in the Draft Benefits Appendix.

158. Generalized Depth-Percent Damage functions were applied to structures for calculation of inundation damage. A combination of two separately developed sets of damage functions were used to reflect the damage relationships in the study area:

- USACE damage function for residential structures with and without basement, and
- Passaic River Basin (PRB) Study damage functions

159. For the Oakwood Beach Wastewater Treatment Plant, a custom damage function relating actual dollar damages directly to a range of flood depths was developed, based on historical flooding information (including flooding from Hurricane Sandy) and vulnerability assessments provided by the New York City Department of Environmental Protections. This approach did not require depreciated structure values to be computed for the plant and associated structures.

5.3.7 Wave and Erosion Damages

160. Historically, the shoreline has not experienced significant beach erosion during storm events. Crest elevations of the existing coastal barrier averages between 9 and 10 ft. NGVD 1929. Significant damage from waves greater than the 3 ft. (FEMA, Atlantic Ocean and Gulf of Mexico Coastal Guidelines Update, 2007) will generally occur landward of the beach only when the stillwater elevations are at least 13 ft, which is greater than the 100 yr. storm event. Because Hurricane Sandy destroyed most of the structures potentially exposed to waves (i.e., the Cedar Grove bungalows), there are a negligible amount of insurable structures subjected to damaging wave heights. Wave damages in the study area would therefore be small and limited to events greater than Hurricane Sandy.

5.4 <u>Opportunities</u>

5.4.1 Coastal Storm Risk Management

161. The primary opportunity presented in this study is the potential for introducing management measures to reduce future damages to property and to decrease risks to life safety. Currently, there are many properties within the study area are at risk from coastal storm-induced flooding. The future will likely see higher sea levels and increased erosion of existing natural protective features, which may give rise to even higher magnitude and even more frequent damages to the study area.

162. Storms can cause economically quantifiable damage to structures (both residential and non-residential), hinder the activities of local businesses, and disrupt local road transport. In addition to the damages to property from such storm events, high coastal flood levels present a significant risk to public health and life-safety. If new coastal storm risk management measures can be incorporated, then damage to property and loss of life may be effectively reduced and even avoided.

5.4.2 Recreation

163. The numerous parks, beaches, and other leisure amenities present in the study area are among the most important recreational facilities, not just in the Borough of Staten Island, but also in the City of New York. They form a very important set of assets to the Borough of Staten Island, the City of New York, and to the region in general. Failure to invest in appropriate protective measures will result in increased flooding restricting the use of these facilities, and ultimately their complete loss. Such restriction or loss of use of these facilities through storm damage or erosion would have a detrimental effect both on the local economy and the quality of life. This study provides an opportunity to maintain and preserve the study area's many existing parks and other recreational facilities such as the partially restored (post-Sandy) FDR boardwalk and promenade, which is aligned along the shorefront for well over half of the project reach.

5.4.3 Wetlands Preservation

164. Approximately 300 acres of wetlands have been field delineated in the Project area (USACE 2009). Some of these wetlands are under considerable development pressure, with some areas already zoned for residential development, and the construction of new homes near the fringes of existing development each year.

165. This study represents an opportunity to preserve and maintain the currently existing wetlands in the study area. The benefits from the effort to preserve these areas are evident on consideration of the recognized functions and values of freshwater wetlands:

- Natural flood storage: Wetlands can manage flood risk by acting as storage areas; they can attenuate floodwaters for prolonged periods following precipitation events. This function may be considered the principal practical reason for the preservation of the study area's wetlands.
- Wildlife habitat: Wetlands provide habitat for a diverse range of wildlife, including both resident and migratory species and, potentially, threatened or endangered species.
- Recreation: Depending on the extent and nature of individual wetland areas, wetlands and associated watercourses can provide recreational opportunities from bird watching and fishing, to canoeing and boating.
- Educational and scientific value: Managed and accessible wetlands can function as "outdoor classrooms" for the education of local schoolchildren, or as a location for scientific study or research
- Water quality: Wetlands can prevent or reduce the degradation of local water quality by retaining sediment and various pollutants. Wetlands may also act as a filter to prevent excess nutrients from entering aquifers or surface water resources.
- Groundwater recharge: In some cases, freshwater wetlands may be a source of recharge to local aquifers.
- Visual and aesthetic value: The aesthetic appeal of wetlands may vary, and is a largely subjective quality, but some landscapes may be enhanced by their presence.

166. Although less extensive in this study area than freshwater wetlands, tidal salt marshes are potentially of value and worthy of preservation, since they may provide a rich wildlife habitat, form buffer zones capable of reducing erosion, and act as natural filtration systems, improving water quality by absorbing fertilizers, pesticides, heavy metals, and other contaminants.

6. IDENTIFICATION AND OPTIMIZATION OF THE TENTATIVELY SELECTED PLAN

167. The efforts leading up to the tentative selection of the plan for this feasibility study included plan formulation, evaluation, and comparison and were spread out over the course of 14 years between the feasibility study, initiated in 2000, and this interim Feasibility Report (2015). The Line of Protection and Interior Drainage Plan formulation and evaluation processes were completed in 2002. A comparison of the Line of Protection Alternatives and the tentative selection of the plan were completed in 2005 as was a comparison and tentative selection of the Interior Drainage Plans. A revised detailed cost-benefit comparison and consequently a change in the tentative plan selection for the Interior Drainage occurred in 2010 along with the optimization of the Tentatively Selected Line of Protection Plan after a few years of funding delays.

168. After Hurricane Sandy (October 29-30, 2012) a post-Sandy updated Interior Drainage Plan comparison and a optimization of the Tentatively Selected Line of Protection Plan were performed for this interim feasibility study to account for the changed conditions in the study area. This section discusses the formulation, evaluation, comparison, tentative selection process as they originally occurred along with a narrative on the impacts of the post-Sandy updates and the NED Plan optimization process.

6.1 Plan Formulation and Evaluation Criteria

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

- **Completeness** is defined as *"the extent to which a given alternative plan provides and accounts for all necessary investments of other actions to ensure the realization of the planned effects. This may require relating the plan to other types of public or private plans if the other plans are crucial to realization of the contributions of the objective."*

- **Effectiveness** is defined as *"the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities."*

- **Efficiency** is defined as *"the extent to which an alternative plan is the most cost effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment."*

- **Acceptability** is defined as *"the workability and viability of the alternative plan with respect to acceptance by State and local entities, and the public, and compatibility with existing laws, regulations, and public policies."*

6.1.1 Planning Objectives

170. Planning objectives were identified based on the needs and opportunities, as well as existing physical and environmental conditions in the project area. Accordingly, the following general and specific objectives have been identified:

6.1.1.1 General Objectives

- Meet the specified needs and concerns of the general public within the study area.
- Be flexible to accommodate changing economic, social and environmental patterns and changing technologies.

6.1.1.2 Specific Objectives

- Manage the risk of damages from hurricane and storm surge flooding along the study area.
- Manage the risk to local residents' life and safety.

6.1.1.3 Sponsor's Objectives

- The non-Federal Sponsor, in compliance with New York City's Special Initiative for Rebuilding and Resiliency (SIRR), plans to support projects with projects that afford a risk management level equivalent to the 100-year coastal storm event plus an additional three feet of freeboard.
- The non-Federal sponsor is expected to seek FEMA accreditation under the Code of Federal Regulations (CFR) 44-65.10 in order to incorporate the significance of the risk management measures into the effective Flood Insurance Rate Maps (FIRMS).

6.1.2 Planning Constraints

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

6.1.2.1 General Constraints.

The plan must:

1. Be able to be implemented with respect to financial and institutional capabilities and public consensus;
2. Comply with USACE environmental operating procedures.

6.1.2.2 Physical Technical Constraints:

1. Plans shall represent sound, safe, and acceptable engineering solutions taking into account the overall littoral system effects;
2. Plans shall be designed to be low-maintenance;
3. Plans should avoid and minimize impacts to environmental resources with the potential for enhancement;
4. Plans shall not affect access to beach;
5. Plans shall take into consideration aesthetics and viewshed.
6. Plans shall be in compliance with USACE regulations;

6.1.2.3 Economic Constraints:

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

6.1.2.4 Environmental Constraint:

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

6.1.2.5 Regional and Social Constraints:

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

6.1.2.6 Institutional Constraints:

1. Plans must be consistent with existing federal, state, and local laws;
2. Plans must be locally supported and signed by local authorities in the form of a Project Partnership Agreement and guarantee for all items of local cooperation including possible cost sharing;
3. Local interests must agree to provide public access to the shore in accordance with Federal and state guidelines and laws;
4. The plan must have broad overall support in the region and state.

6.1.2.7 Planning Constraints Specific to the Study

1. Where possible, plans will utilize the properties and easements available through the City, State, and Federal Government, or properties previously approved by NYC for acquisition under the Bluebelt Program. This will avoid delays associated with the Sponsor's land acquisition review process.

2. The impacts to beach erosion as a result of the implementation of the project must be considered during plan formulation and selection.

6.1.2.8 Planning Considerations Specific to the Study

1. Develop a plan consistent with and complementary to the New York City Bluebelt Program and recreational use of the area.

6.2 Formulation and Evaluation of Line of Protection Alternative Plans

172. Two categories of management measures were examined in the Line of Protection plan formulation: structural measures and nonstructural measures. Structural measures consist of structures designed to control, divert, or exclude the flow of water from the flood-prone areas to the extent necessary to reduce damages to property, hazards to life or public health, and general economic losses. These may include levees, floodwalls, seawalls or constructed beaches. Nonstructural measures are those activities that can be undertaken to move what is being damaged out of harm's way, rather than attempting to alter the movement of water. Generally nonstructural measures include a variety of techniques, including land-use controls to limit future development in the flood hazard areas, acquisition or relocation of flood-prone development, flood warning systems, evacuation planning and retrofit of existing structures. For this study, non-structural measures that are effective in reducing the risk to life and property include building elevations or acquisitions, and hurricane evacuation plan/storm warning system.

6.2.1 Viable Coastal Storm Risk Management Measures

6.2.1.1 Structural

173. *Floodwalls and Levees*: Floodwalls and levees are intended to provide flood risk management against coastal and riverine flooding in the absence of waves. These structures can be cost-effective measures against tidal flooding when placed landward of direct wave exposure. Used in this manner, floodwalls and levees provide flood risk management to interior structures. Although floodwalls and levees provide a cost-effective means to manage the risk of flooding in low-lying areas, runoff trapped behind the structure may cause flood related damages because the structure may not allow for the interior drainage area to discharge local stormwater runoff. Raising existing roads and thoroughfares can also act as a levee-like risk management measure and prevent tidal storm surges from entering low-lying areas.

174. *Beach Fill*: Beach fill involves the placement of sand on an eroding shoreline to restore its form and to provide adequate coastal storm risk management. A beach fill design typically includes a berm backed by a dune, and both elements combine to prevent erosion, wave attack and inundation damages to leeward areas. Compared to floodwalls and levees, beach nourishment represents a "soft," more natural method for reducing storm damages. Beach nourishment requires a long-term commitment to offset long-term

shoreline erosion, and may be costly along highly eroded shorelines. Federal participation in periodic nourishment would be limited to a period of 50 years from completion of project construction.

175. *Beach Erosion Control Structures:* Structures such as groins are used to retard beach erosion, increase the longevity of beach fill, and maintain a wide beach for risk management purposes and recreation. Groins placed at the ends of a beach nourishment project would reduce erosion rates and would minimize the potential impact of sand migration into any nearby tidal wetlands. These structures would reduce erosion and long-term renourishment requirements. Shorelines may already have adequate erosion control structures in place.

176. *Shore Stabilization*: Shore stabilization measures offer both flooding and erosion control for shorefront structures, and reduce flooding of low-lying interior areas. Structure types include bulkheads, seawalls, and revetments. Shore stabilization measures limit landward movement of the shoreline and minimize overtopping floodwaters. In combination with beach nourishment in highly erosive areas, or without beach nourishment for relatively stable shorelines, these structures can provide long-term storm coastal storm risk management. Costs can be high, depending on the extent and severity of existing shoreline problems.

6.2.1.2 Nonstructural

177. *Acquisition*: Permanent evacuation of existing areas subject to erosion and/or inundation involves the acquisition of this land and its structures either by purchase or by exercising the powers of eminent domain. Following this action, all development in these areas is either demolished or relocated.

178. *Zoning:* Through proper land use regulation, floodplains can be managed to ensure that their use is compatible with the severity of the flood hazard. Several means of regulation are available, including zoning ordinances, subdivision regulations, and building and housing codes. Although such controls can be effective in reducing future potential losses in other, less developed areas, in this case it would not be effective in mitigating the existing hazard. It should be noted that zoning is a local issue and is not within the jurisdiction of the Federal government. However, any Federal project will have a floodplain management plan component which includes requirements on the use of flood prone lands.

179. *Retrofit/Floodproofing*: Floodproofing is a body of techniques for reducing the risk of flood damages through modifications both to structures and their contents. It involves keeping water out, as well as reducing the effects of water entry. Such modifications can be applied by an individual or as part of a collective action, either when buildings are under construction or by retrofitting existing structures. Retrofits, including physically elevating structures, can significantly reduce damages, but still requires that residents be evacuated during a flood.

180. *Hurricane Evacuation Plan/Storm Warning System:* The process of notifying local residents of impending hurricanes can be divided into flood forecasting, warning, and preparedness planning. Forecasting and warning is primarily a program of the National Weather Service (NWS). Along the Study Area, preparedness planning and specific evacuation orders and warnings are sent out by New York City Office of Emergency Management (NYC OEM).

181. Table 12 presents a preliminary evaluation of the life-safety issues, economics, engineering feasibility and environmental impact for each Alternative determined which of the Alternatives should be considered for a detailed comparison and which should be eliminated from further consideration based on planning objectives.

Table 12: How Line of Protection Measures Address Planning Objectives

	Measure	Objective 1: Reduce risk of damages	Objective 2: Reduce risk to life and safety
Structural Measures	Double Sheet Pile Seawall	Reduces wave propagation and can prevent storm surge from inundating the study area.	Reduces the flood depth landward of the Line of Protection, preventing potential harm to people.
	Buried Seawall/Armored Levee		
	Levee		
	Floodwall		
	Raised road, ground surface, and asphalt areas		
	Beach Fill dune with fronting berm		
Nonstructural Measures	Acquisition	Removes structures from flood waters, preventing potential damage.	Removes people from potential harm.
	Retrofit/Flood Proofing	Elevates or waterproofs structures, preventing potential damage.	Buildings still need to be evacuated; does not reduce risk to life and safety.
	Zoning	Does not reduce risk to existing structures but it could reduce risks to damages to future development	Does not reduce existing risk to life and safety.
	Hurricane Evacuation Plan/ Storm Warning System	Minor	Evacuation orders and alerts communicate which critical facilities and citizens should evacuate at a point well in advance of the storm making landfall.

182. Based on the examination of previous studies, new concepts, and public suggestions these management measures were formulated into an array of Alternative Plans (herein called Alternatives). These Alternatives include several combinations of the flood risk management measures but also varying lengths of project implementation in order to cover a wide range of planning solutions. For example, in Table 13, Alternatives that only addressed a partial project reach from Fort Wadsworth to Miller Field begin with a FM designation whereas Preliminary Alternatives for the full project reach from Fort Wadsworth to Oakwood Beach begin with a FO designation.

183. A preliminary evaluation of the life-safety issues, economics, technical feasibility, environmental impact, and social consequences for each Alternative determined which of the Alternatives should be considered for a detailed comparison and which should be eliminated from further consideration. The array of Alternative solutions, constraint and evaluations are provided in Table 13.

Table 13: Evaluation of Alternatives					
Alternative	**Description**	**Benefits**	**Constraints**	**Preliminary BCR**	**Evaluation**
No-Action Plan	A no-action plan means that no additional federal actions would be taken to provide for coastal storm risk management.	• N/A	• N/A	N/A	Provides the base against which project benefits are measured.
FM1	Seawall (Fort Wadsworth to Miller Field Only)	• Access routes remain open during flood events • No significant environmental impacts identified • No private property would be directly impacted	• Miller Field to Oakwood Beach remains unprotected • Possible public safety problems	2.4	Lower net benefits compared to the Alternative covering full project reach (FO1): **Screened out**
FM2	Floodproofing: 25yr Floodplain (Fort Wadsworth to Miller Field Only)	• No hard structure to impede view of bay • Lots for any acquired structures would become open space • No wetland disturbance • No additional maintenance requirements	• Miller Field to Oakwood Beach remains unprotected • Access routes would not remain open during flood event • No coastal risk reduction outside of 25yr floodplain • Not cost-justified based on storm risk management benefits	0.2	Not economically feasible: **Screened out**

Table 13: Evaluation of Alternatives					
Alternative	**Description**	**Benefits**	**Constraints**	**Preliminary BCR**	**Evaluation**
FM3	Acquisition: 10yr Floodplain (Fort Wadsworth to Miller Field Only)	• Additional open space created • Would permanently eliminate potential for future losses to level of coastal storm risk management • May permanently eliminate need for future emergency response and recovery resources • No wetland disturbance	• Miller Field to Oakwood Beach remains unprotected • Decreased tax base • No coastal storm risk management outside of 10yr floodplain • Access routes would not remain open during flood event • Not cost-justified based on storm risk management benefits	0.1	Not economically feasible: **Screened out**

Table 13: Evaluation of Alternatives					
Alternative	**Description**	**Benefits**	**Constraints**	**Preliminary BCR**	**Evaluation**
FM4	Road Raising (Fort Wadsworth to Miller Field Only)	• Views of the Bay from the road are not blocked • Doesn't create potential public safety issues (as opposed to seawall alternative) • Access routes remain open during flood event • No wetland disturbance	• 49 structures require raising • Miller Field to Oakwood Beach remains unprotected • Major traffic delays may result during construction • Additional costs incurred for relocation of utilities • Creates additional interior drainage cost for handling runoff between the road and the shoreline	2.3	Lower net benefits compared to Alternative covering full project reach (FO3): **Screened out**
FO1	Seawall, beach fill and beach berm system.	• Access routes remain open during flood events • No private property would be directly impacted • Increased beach area may provide recreation opportunities	• Bay bottom shoreline disturbance • High fill quantities • Requires continued beach renourishment	1.8	**Further Development and Evaluation**

Table 13: Evaluation of Alternatives					
Alternative	**Description**	**Benefits**	**Constraints**	**Preliminary BCR**	**Evaluation**
FO2	Levee, Floodwall, Sheetpile Seawall, buried seawall and double sheetpile Seawall	• Access routes remain open during flood events • No significant environmental impacts identified • No private property would be directly impacted	• Possible public safety issues with the wall isolating the beach and boardwalk	2.2	Alternate variation available with higher BCR. See FO2A
FO2A	Levee, Floodwall, Buried Seawall/Armored Levee (with Raised boardwalk replacement)	• Access routes remain open during flood events • No significant environmental impacts identified • No private property would be directly impacted	• Replace existing boardwalk with functional equivalent.	2.8	**Further Development and Evaluation**
FO3	Raise Road, Buried Seawall/Armored Levees, Earthen, Levee, Floodwall	• Access routes remain open during flood events • No private property would be directly impacted • No significant environmental impacts • Does not create potential public safety issues	• 49 structures require raising • Major traffic delays may result during construction • Additional costs incurred for relocation of utilities • Creates additional interior drainage cost for handling runoff between the road and the shoreline	2.7	**Further Development and Evaluation**

Table 13: Evaluation of Alternatives					
Alternative	**Description**	**Benefits**	**Constraints**	**Preliminary BCR**	**Evaluation**
FO3A	Raised Road, Raised Boardwalk, Buried Seawall/Armored Levee, Floodwall	• Access routes remain open during flood events • No private property would be directly impacted • No significant environmental impacts • Does not create potential public safety issues	• 49 structures require raising • Major traffic delays may result during construction • Additional costs incurred for relocation of utilities • Creates additional interior drainage cost for handling runoff between the road and the shoreline	2.7	**Further Development and Evaluation**
FO3B	Road median Floodwall, Raised Road, Raised Boardwalk, Buried Seawall/Armored Levee	• Access routes remain open during flood events • No private property would be directly impacted • No significant environmental impacts • Does not create potential public safety issues	• 49 structures require raising • Major traffic delays may result during construction • Additional costs incurred for relocation of utilities • Creates additional interior drainage cost for handling runoff between the road and the shoreline	2.1	Not incrementally economical compared to FO3A: **Screened out**

Table 13: Evaluation of Alternatives					
Alternative	**Description**	**Benefits**	**Constraints**	**Preliminary BCR**	**Evaluation**
FO4	Floodproofing: 25yr Floodplain	• No wetland disturbance • No hard structure to impede view of bay • Lots for any acquired structures would become open space • No additional maintenance requirements	• Access routes would not remain open during flood event • No coastal storm risk management outside of 25yr floodplain • Not economically justified based on storm risk management benefits	0.2	Not economically feasible: **Screened out**
FO5	Acquisition: 10yr Floodplain	• No wetland disturbance • Creation of open space • Would permanently eliminate potential for future losses to level of risk management • May permanently eliminate need for future emergency response and recovery resources	• Decreased tax base • No coastal storm risk management outside of 10yr floodplain • Access routes would not remain open during flood event • Not cost-justified based on storm risk management benefits	0.2	Not economically feasible: **Screened out**

Table 13: Evaluation of Alternatives					
Alternative	**Description**	**Benefits**	**Constraints**	**Preliminary BCR**	**Evaluation**
FO6	Acquisition: Wave Zone	• No wetland disturbance • Creation of open space • Would permanently eliminate potential for future losses to level of risk management • Permanently eliminates need for future emergency response and recovery resources	• Only provides coastal storm risk management for structures susceptible to wave effects • Lower tax base • No risk management outside of wave zone • Access routes would not remain open during flood event • Not cost justified based on storm risk management benefits	0.5	Not economically feasible: **Screened out**

6.3 Comparison of Line of Protection Alternatives and Tentatively Selected Plan

184. Four Alternatives were selected from the formulated array of measures and Alternatives as a result of the evaluation process. Table 14 provides a brief description of each of the final four Alternatives. Only the alternatives that provided a systems approach for a project that implements coastal storm risk management for the hydraulic reach from Fort Wadsworth to Oakwood Beach was selected for more detailed analysis.

Table 14: List of Line of Protection Alternatives

Alternative	Description
No-Action Plan	A no-action plan means that no additional federal actions would be taken to provide for coastal storm risk management.
Alternative #1	Alternative #1, (formerly FO1), included a combination of beach dune and berm fill system, seawalls, new floodwalls, and raising of the existing levees near Oakwood Beach.
Alternative #2	Alternative #2, (formerly FO3), included road raising, a buried seawall/armored levee, levees and floodwalls. This alternative focused on raising the road along the entire beachfront reach.
Alternative #3	Alternative #3, (formerly FO3A), included a combination of road raising, promenade raising, a buried seawall/armored levee, levees and floodwalls. This alternative focused on a road raising for 75% of the beachfront reach and includes a raised promenade along the remaining beachfront reach.
Alternative #4	Alternative #4, (formerly FO2A), included varying lengths of floodwalls, levees and a buried seawall/armored levee (with a boardwalk replacement).

6.3.1 Design of Alternatives for Comparison

185. Each of the four Alternatives was designed to provide the same level of coastal storm risk management against a consistent stillwater level in order to afford a sound and fair basis for comparison of project costs and benefits. Other than the stillwater design level, the existing topography, wetlands, buildings, roadways and drainage patterns and other existing constraints had to be considered in the design and alignment of each Line of Protection Alternative. The specifications for the Alternative design sections were informed by an engineering analysis on existing and proposed geotechnical and structural conditions. The feasibility of special measures, such as intake and outlet structures, inlet channels, and gates, were examined on a case-by-case basis.

6.3.1.1 Equivalent Level of Risk Management

186. Levels of risk management may be described in terms of the design storm frequency or the design reliability, which considers possible variations or uncertainty in design storm conditions. The four Line of Protection alternatives were designed to the 1% chance of occurrence in any given year, which is often referred to as the 100-year storm.

The stage-frequency data utilized to determine the stillwater levels during a 100-yr storm event was estimated based on ADCIRC model results (1998) from the Coastal Research and Development Lab at the USACE Waterways Experiment Station. The stillwater design level, without wave setup, associated with the 100-yr storm was 11.8 ft. NGVD 1929. The Alternative Design Plans were created with consideration of wave setup and sea level change. Alternative crest designs accounted for a shoreline wave setup of 2.0 ft. added to storm surge elevations (0.5 to 1.0 ft. for levee tieback areas) for the 100 year storm event. A 0.7 ft. height allowance was also added to the design to account for future mean sea level change.

187. The design crest elevation for each management measure in the Alternative Plans is summarized in Table 15.

Table 15: Preliminary Design Crest Elevations

Structural Alternative Component	Feet NGVD 1929
Road raising	15.0
Buried seawall/armored levee	17.0
Beach dune	17.0
Dune reinforcement (tieback)	18.0
Levee/floodwall (tieback) within 1,000 ft. from shoreline	15.0
Levee/floodwall (tieback) 1,000 to 2,000 ft. from shoreline	14.0
Levee/floodwall (tieback) more than 1,000 ft. from shoreline	13.0

6.3.1.2 Description of Alternative Designs

ALTERNATIVE #1

Figure 15 - Plan View Alternative 1

188. Alternative 1 includes a dune and a protective fronting beach berm, seawalls, dune and Beach Reinforcement along the shorefront as well as a new floodwall and reconstruction of and existing levee near Oakwood Beach as depicted in Figure 15.

189. *Beach Dune and Berm Fill:* The beach was designed to have a wide berm area backed by a higher dune. The beach and dune were designed for storm surges, storm recession (storm induced erosion), and wave overtopping for the 100 year return period storm. The minimum dune crest required was calculated to be 17.0 ft. NGVD 1929, with a crest width of 40 ft. The dune's fronting berm was 11.0 ft. NGVD 1929, with a berm

width of 75 ft. At Oakwood Beach, existing dune reinforcement was required. The dune crest was set slightly higher, at an elevation of 18.0 ft. NGVD 1929 because the fronting berm is narrower and lower to fit within the existing shoreline to preclude a nonessential beach nourishment feature. The crest width of 40 ft. remained the same. The initial quantity of beach fill for the dune and berm system was estimated to be over 3.2 million cubic yards with the renourishment quantity calculated as 650,000 cubic yards of fill per operation (10-year nourishment cycle) or 65,000 cubic yards per year.

190. Figure 16 presents a typical section of the dune and berm design in this Alternative.

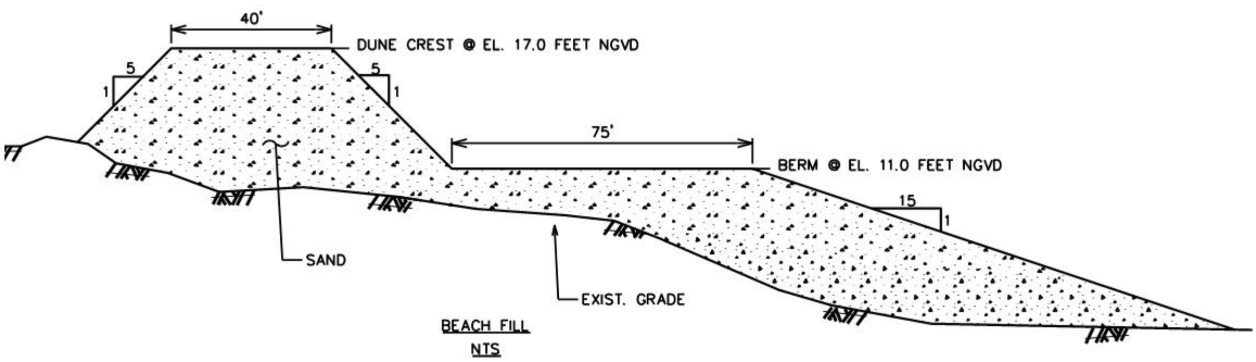

Figure 16 - Alternative Beach Fill Typical Section

191. The relatively large offsets in the existing shoreline positions at groins and outfalls underscores the potential for dramatic shoreline changes in the project area. Increasing the beach width would reduce the effective length of the existing groins and outfall structures resulting in an increase in alongshore sediment transport around these structures. This could make it very difficult to maintain the design shoreline, requiring substantial quantities of advanced beach fill and future renourishment operations. To mitigate against this natural phenomenon, this Alternative would also include two 400 ft. groin structures. With the proposed groins and the existing outfalls acting as groins, it is anticipated that the beach fill would be contained without adverse shoaling impacts to the outfalls or to Oakwood Creek.

192. *Seawalls:* This Alternative would also incorporate 400 lf. of buried seawall/armored levee to tie into high ground on the east end of the project reach. Figure 17 presents a typical section for the seawall design in this Alternative.

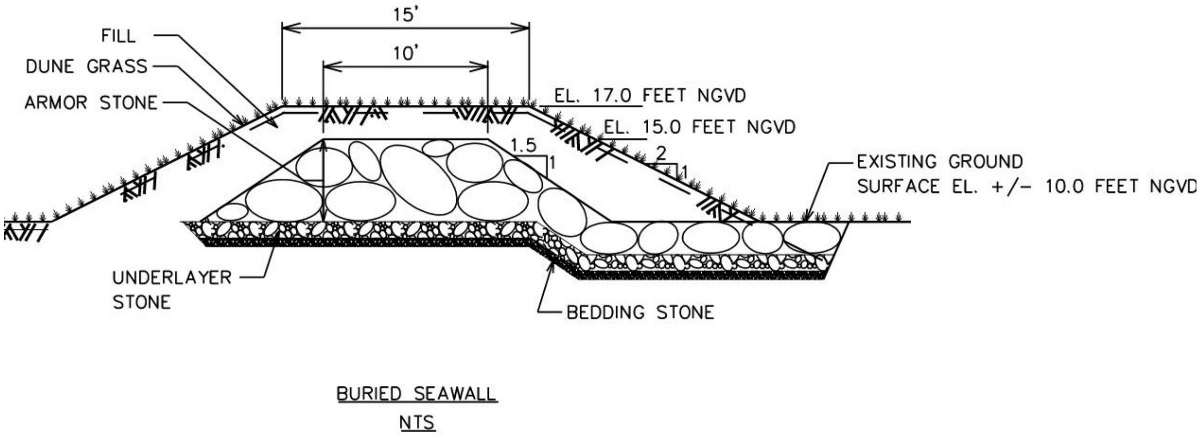

Figure 17 - Alternative Buried Seawall Armored Levee Typical Section

193. In two areas along the berm and dune system there are space restrictions that require two stretches of double lined structurally connected steel sheeting, separated by 10 to 15 feet. of fill and a designed cap with a crest of +17.0 ft. NGVD . The lengths of the seawalls are 170 lf. and 550 lf. A cross-section of the double-lined steel sheetpile seawall used in lieu of the dune and berm system is shown in Figure 21.

194. *Levees and Floodwall:* From the Waste Water Treatment Plan, moving westerly along the shore and northerly near the mouth of Oakwood Creek, the Line of Protection in this Alternative included the following:

- 650 feet of concrete encased cantilever steel sheet floodwall at an elevation of +14.0 feet NGVD 1929 along the Treatment Plant embankment
- A 700 linear foot raising of the existing levee (currently at elevation +10.0 feet NGVD 1929) along the Oakwood Beach Wastewater Treatment Plant to an elevation of +15.0 feet NGVD 1929
- 2,830 linear feet of new levee north of the Treatment Plant at an elevation of +13.0 feet NGVD 1929, with a tide gate structure across Oakwood Creek. This levee ties into existing high ground.

195. Figure 18 and Figure 19 present typical design sections for the levee and floodwall sections.

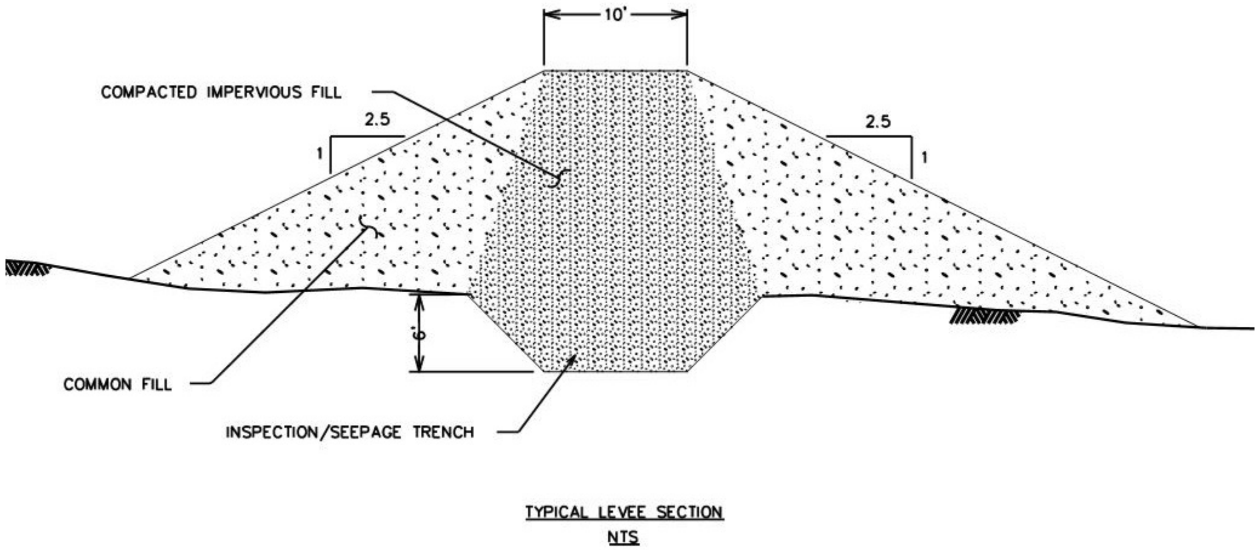

Figure 18 - Alternative Levee Typical Section

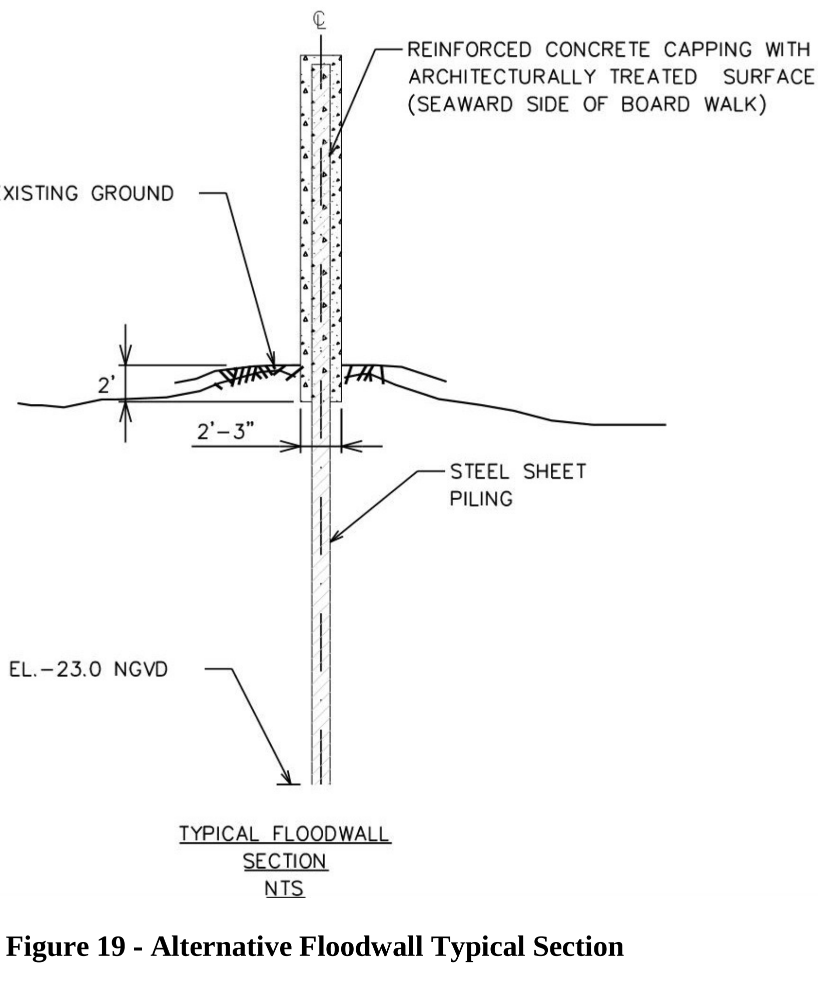

Figure 19 - Alternative Floodwall Typical Section

ALTERNATIVE #2

Figure 20 - Plan View Alternative 2 and 3

196. As depicted in Figure 20 Alternative 2 includes:

- Road Raising along the entire length of Father Capodanno Boulevard,
- Buried Seawall/Armored levee from Miller Field to Oakwood Beach,
- Dune Reinforcement, Levees and Floodwall at Oakwood Beach

197. *Road Raising:* With this alternative Father Capodanno Boulevard (with an average existing elevation of +10.0 feet NGVD 1929) would be raised by roughly 5 feet to an elevation of +15.0 feet NGVD 1929, for a distance of approximately 14,000 feet.

Two vehicular turnarounds feeding off Father Capodanno Boulevard, as well as approximately 49 adjacent structures, two bus shelters, and one monument would also be raised to maintain road access.

198. The plan included fill, new pavement, and sidewalks, plus necessary manhole and valve box raising, catch basin raising, light and power pole raising, tree, and hydrant raising. A temporary bypass constructed just south of Father Capodanno Boulevard would have to be utilized in sections between major intersecting thoroughfares while the road raising is accomplished in sections.

199. *Buried Seawall/Armored Levee:* Average existing elevations along the shoreline at the Line of Protection range from +7.0 to +10.0 feet NGVD 1929. Starting at the termination of Fr. Capodanno Boulevard (near Miller Field) and continuing in a westerly direction, this alternative consisted of 6,800 feet of buried stone seawall/armored levee with a crest elevation of +17.0 feet NGVD 1929 and would terminate at the existing dune at the eastern end of Oakwood Beach. The seawall reach would have a short 170 foot section of double sheet pile wall (a double line of structurally connected structurally connected cantilevered steel sheet piling separated by 10 to 15 feet of fill) with a designed cap and a crest elevation of +17.0 feet NGVD 1929. This short section of double sheet pile wall was necessitated by space restrictions, which preclude the use of a buried seawall. Typical design sections for the buried seawall/armored levee and sheet pile seawall are presented in Figure 17 and Figure 21, respectively.

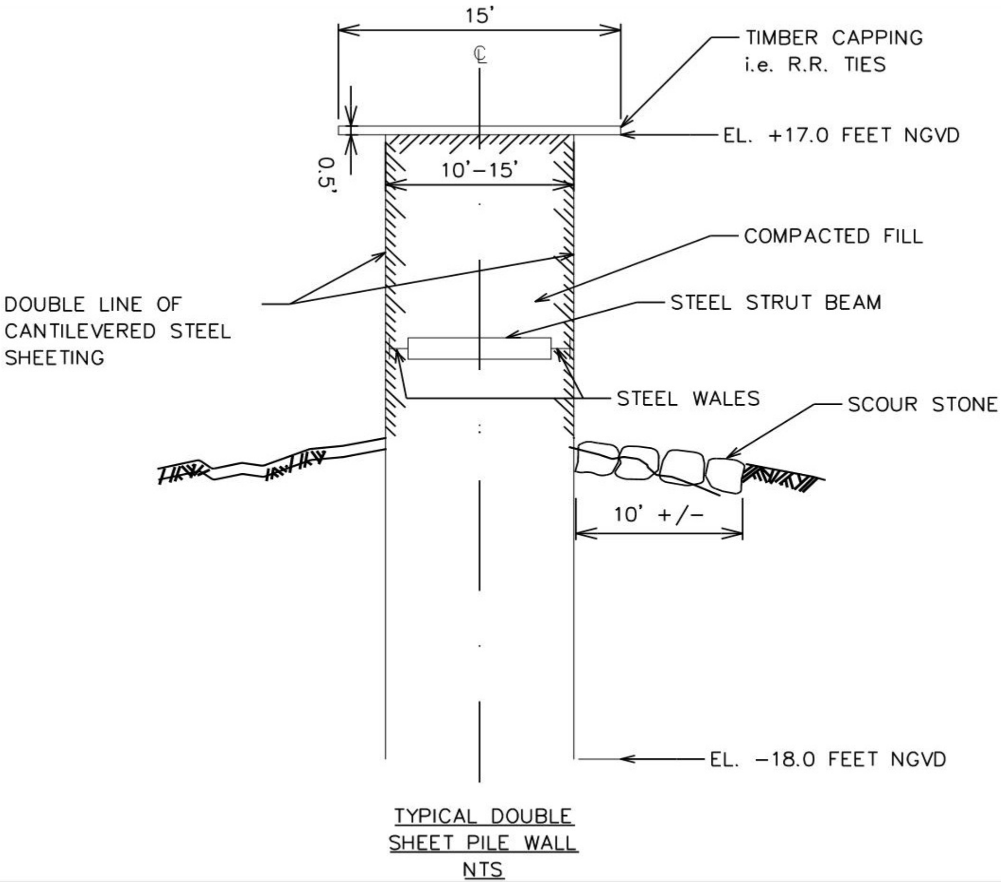

Figure 21 - Alternative Sheet Pile Seawall Typical Section

200. *Dune Reinforcement, Levees and Floodwall*: From the eastern end of Oakwood Beach and northerly near the mouth of Oakwood Creek, the tieback included the following:

- 1,920 feet of dune reinforcement to an elevation of +18.0 feet NGVD 1929
- 700 feet of new levee, plus 700 feet of raising the existing levee, and 60 feet of raising the abutment walls and providing a new parapet wall at the existing tide gate chamber (currently at a maximum elevation of +11.0 feet NGVD 1929) at the Oakwood Beach Wastewater Treatment Plant vicinity—all to an elevation of +15.0 feet NGVD 1929
- 650 feet of sheet pile floodwall, generally at an elevation of +14.0 feet NGVD 1929 tying into 600 feet of high ground at the Treatment Plant at elevation +14.0 feet NGVD 1929, or higher.
- 2,830 feet of levee north of the Treatment Plant at an elevation of +13.0 feet NGVD 1929, with a tide gate structure across Oakwood Creek. This levee ties into existing high ground at elevation +13.0 feet NGVD 1929.

201. Typical design sections of the levees and floodwalls are presented above in Figure 18 and Figure 19, respectively.

ALTERNATIVE #3

202. Alternative 3 is a slight variation of Alternative #2 and includes:

- A partial road raising along Father Capodanno Boulevard,
- Raising of existing promenade,
- Buried Seawall/Armored Levee from Miller Field to Oakwood Beach, and
- Levees and floodwall at Oakwood Beach

203. *Road Raising and Raised Promenade*: This alternative would be the same as the road raising of Alternative #2, except that the existing promenade (5,700 feet) would be raised in place of Father Capodanno Boulevard along the western end of the Alternative 2 road raising plan. Under this alternative, the promenade (at an average existing elevation of +10.0 feet NGVD 1929) would be raised to elevation +17.0 feet NGVD 1929.

204. *Buried Seawall/Armored Levee*: This section is identical to the layout described for Alternative #2. Typical design sections for the buried seawall/armored levee and sheet pile seawall are presented in Figure 17 and Figure 21, respectively.

205. *Dune Reinforcement, Levees and Floodwall Levees and Floodwall*: This section is identical to the layout described for Alternative #2. Typical design sections of the levees and floodwalls are presented above in Figure 18 and Figure 19, respectively.

ALTERNATIVE #4

Figure 22 - Plan View Alternative 4

206. As presented in Figure 22, Alternative 4 includes the following:

- Buried seawall/armored levee with a raised promenade
- Sheet pile seawall
- Levees and floodwall at Oakwood Beach

207. *Buried Seawall/Armored Levee*: This alignment would begin at the eastern end of the study area limits with 400 feet of buried stone seawall with a crest elevation of +17.0 feet NGVD 1929. A typical design section is presented above in Figure 17.

208. *Sheet Pile Seawall*: This alternative then continued in a generally westerly direction with 7,100 feet of concrete encased cantilevered steel sheet pile seawall, which

would directly front the boardwalk. The seawall crest elevation was designed at an elevation of +17.5 feet NGVD 1929 and would match the wooden boardwalk deck elevation. Fronting the seawall, to enhance the appearance of the concrete encasement, would be a dune grass capped section of sand fill with a crest elevation of +13.0 feet NGVD 1929 and its seaward face reinforced with geoweb and erosion control matting. A typical design section of the sheet pile seawall is presented above in Figure 21.

209. Eight pedestrian ramps from the boardwalk deck onto the beach would have to be removed and replaced to accommodate the seawall. In addition, approximately three double leaf swing gates would be required along the seawall alignment to provide access to the beach for maintenance vehicles at existing access points. At the western end of the boardwalk the seawall would tie into the raised promenade described below.

210. *Buried Seawall/Armored Levee with Raised Promenade*: The buried seawall/armored levee plan alignment would begin at the termination of the existing boardwalk (near the east end of Miller field). For the reach fronting Miller Field, average existing elevations along the shoreline at the line of protection range from +10.0 to +12.0 feet NGVD 1929. Continuing in a westerly direction, fronting Miller Field, the alignment consisted of 1,760 feet of buried stone seawall with a paved walkway and/or bicycle path crest and with a crest elevation of +17.0 feet NGVD 1929 to New Dorp Lane.

211. The plan alignment then continued with 170 feet of double lined structurally connected steel sheeting, separated by 10 to 15 feet of fill with a designed cap at elevation +17.0 feet NGVD 1929. This short section of double sheet pile wall was necessitated by space restrictions, which precluded the use of a buried seawall.

212. The alignment continued westerly for 4,800 feet again using a buried seawall (with a raised promenade to replace the existing promenade) section with a crest elevation of +17.0 feet NGVD 1929. The buried seawall/armored levee would terminate at the existing dune at the eastern end of Oakwood Beach.

213. *Dune Reinforcement, Levees and Floodwall Levees and Floodwall*: This section is identical to the layout described for Alternative #2. Typical design sections of the levees and floodwalls are presented above in Figure 18 and Figure 19, respectively.

6.3.2 Risks Inherent to the Alternatives

214. Alternative #1 included a combination of a berm and dune system (with periodic re-nourishment) and buried seawalls acting as a line of protection from future coastal storm events. In order to meet the Corps reliability standards for defending against a 100 year stillwater design level a relatively high quantity of beach fill was required (over 3.2 million cubic yards). This type of beach expansion, however, may also disrupt the present balance and stability of the existing beach-front. The historical shoreline change analysis indicates that the shoreline in the project area has been relatively stable over the last 40 years. However, the relatively large offset in the shoreline positions at groins and

outfalls underscores the potential for dramatic shoreline changes in the project area. These shore-perpendicular structures help hold the shoreline in place, and it appears that the shoreline has reached a state of equilibrium. Increasing the beach width would bring the shoreline out of balance resulting in an increase in alongshore sediment transport. This could make it very difficult to maintain the design shoreline, requiring substantial quantities of advanced beachfill and future renourishment operations not considered in the cost analysis. These increased erosion rates may lead to an increase in vulnerability to flood damages throughout the course of the erosion/renourishment cycle. Beyond the uncertainty in shoreline change there are also concerns that the beach and dune may not maintain their design dimensions when exposed to multiple design storm events.

215. Alternatives #2 and #3 featured road raising along Father Capodanno Boulevard. Alternative #2 included raising the entire roadway (14,000 feet) and Alternative #3 included raising a portion of the roadway along with a 5,700 foot promenade raising in place of the remaining length of the roadway.

216. Father Capodanno Boulevard is a busy arterial thoroughfare between the residential areas of Midland Beach and South Beach, providing access to two hospitals (Staten Island University Hospital and South Beach Psychiatric Hospital), and ultimately connecting to the Verrazano Narrows Bridge. The thoroughfare is important for commuters and local residents, and also provides access to the recreational amenities in this project reach.

217. In addition to traffic disruptions due to the road raising of Father Capodanno Boulevard, utilities under the road would also need to be relocated, and grading and structure setbacks would need to be adjusted to tie into the elevated roadway. Due to the complexity of coordinating with numerous property owners and utilities relocations, there is a high level of risk and the potential for cost increases associated with Alternatives #2 and #3.

218. Alternative #4 features a floodwall, levees and a buried seawall/armored levee (with a raised promenade). The modification improves the overall aesthetics of the project, includes the replacement of existing promenade facilities, and does not incorporate the disadvantages of pursuing road raising components. It also avoids the placement of 3.2 million cubic yards of sand required by Alternative 1, and the need for subsequent renourishment. As discussed above, placing this volume of sand would likely cause significant changes to the shoreline that currently appears to be in equilibrium, making it difficult to maintain the design shoreline. Alternative # 4 can better withstand multiple storms than Alternative #1, This is particularly significant given the loss of life that occurred in the project area during Hurricane Sandy.

6.3.3 Pre-Hurricane Sandy Economic Comparison of Line of Protection Alternatives and Identification of the Tentatively Selected Plan

219. Federal participation in a project requires a demonstration of economic feasibility, which is established by determining whether the annual benefits to the NED exceed the annual economic costs. Benefits are determined from the results of a detailed investigation of the economic impacts of flooding. Annual charges are based on the application of economic principles to all the costs of designing, constructing, operating, and maintaining the project.

220. Table 16 and Table 17 provide a comparison of the 4 alternative plans considered during the pre-Sandy Formulation, and identifies Alternative 4 as the Tentatively Selected Alternative with the highest Net Benefits and highest BCR. Alternative 4 includes the following risk management features:Buried seawall/Armored Levee (with a raised promenade from Fort Wadsworth to Oakwood Beach, and levees and a floodwall near Oakwood Beach

Table 16: Identification of Tentatively Selected Plan

Line of Protection Plan	Alternative #1 Beach Fill	Alternative #2 Road Raising (Full)	Alternative #3 Road Raising (Partial)	**Alternative #4 Buried Seawall/ Armored Levee**
Annual Benefits	$11,388,000	$11,388,000	$11,388,000	$11,388,000
Annual Costs	$4,974,000	$4,466,000	$5,340,000	$4,068,000
Net Benefits	$6,414,000	$6,922,000	$6,048,000	$7,320,000
Benefit to Cost Ratio (BCR)	2.3	2.5	2.1	2.8
Tentatively Selected Plan				☐

2003 price level updated to 2015 by Index, 3.375% Federal Discount rate, 50 year period of analysis

Table 17: Comparison of Final Four Line of Protection Alternatives						
Plan	**Total First Cost**	**Annual Renourishment + O&M Costs**	**Equivalent Annual Cost***	**With Project Equivalent Annual Damages***	**Annual Damage Reduction Benefits***	**Comparison**
No Action Plan	$0	$0	$0	$13.1 million	$0	Provides the base against which project benefits are measured.
Alternative #1	$90.1 million	$1.1 million	$5.0 million	$1.7 million	$11.4 million	This plan requires placing 3.2 million cy of sand to provide the design profile needed to protect against high storm surge. This profile could be difficult to maintain, and the project area vulnerable to flood damages over the course of the erosion/ renourishment cycle, particularly when exposed to multiple design storm events.
Alternative #2	$99.3 million	$148 thousand	$4.6 million	$1.7 million	$11.4 million	Although this alternative had comparable annual costs to Alternative 4, there were concerns about the escalation of costs because of unknown utility relocations. The alternative also created risk to life safety as the construction would cause significant congestion, which could inhibit quick access to two local hospitals.
Alternative #3	$119.4 million	$148 thousand	$5.5 million	$1.7 million	$11.4 million	This plan was the least economic and had the same cost escalation and life safety concerns as Alternative 2.
Alternative #4	$90.3 million	$148 thousand	$4.2 million	$1.7 million	$11.4 million	This alternative had the lowest estimated cost and included a robust design that would defend well against surge and wave action.

* 2003 price level updated to 2015 by Index, 3.375% Federal Discount rate, 50 year period of analysis

6.4 Post-Hurricane Sandy Updates and Optimization of Line of Protection

6.4.1 Post Sandy Updates

221. The Tentatively Selected Line of Protection Alternative was originally identified prior to Hurricane Sandy (October 29-30, 2012). The optimization process to identify the NED Plan, however, incorporates several post-Hurricane Sandy analyses and design changes. They are:

- Use of updated stage frequency curves from FEMA's forthcoming coastal Flood Insurance Study for New York City for updated stillwater design levels and for a revised damage analysis in HEC-FDA
- Changes in plan alignment and design section types based post-Sandy site conditions, and
- A recent update in technical guidance related to I-Type floodwall design

222. The post-Sandy hydraulic analyses performed for this interim feasibility study and the stillwater designs used in the optimization of the Line of Protection for the identification of the NED Plan incorporated the most up-to-date data. FEMA released preliminary coastal flooding data after Hurricane Sandy in efforts to aid with recovery and rebuilding. The forthcoming Flood Insurance Study that was released as preliminary information in 2012 updated the surge and wave hazard information along the NJ coastline and New York City, eventually terminating at the Troy Dam in Albany, NY. The coastal hazards from the forthcoming study have generally increased in the Raritan Bay area. The three design stillwater heights for the NED Plan selection were based on and analyzed with the preliminary FEMA coastal hazard information. The updated stage-frequency values generally show an increase in stages compared to the ADCIRC model results (1998) from the Coastal Research and Development Lab at the USACE Waterways Experiment Station (also known as the DMMP study). Figure 23 presents a comparison of the stage-frequency data.

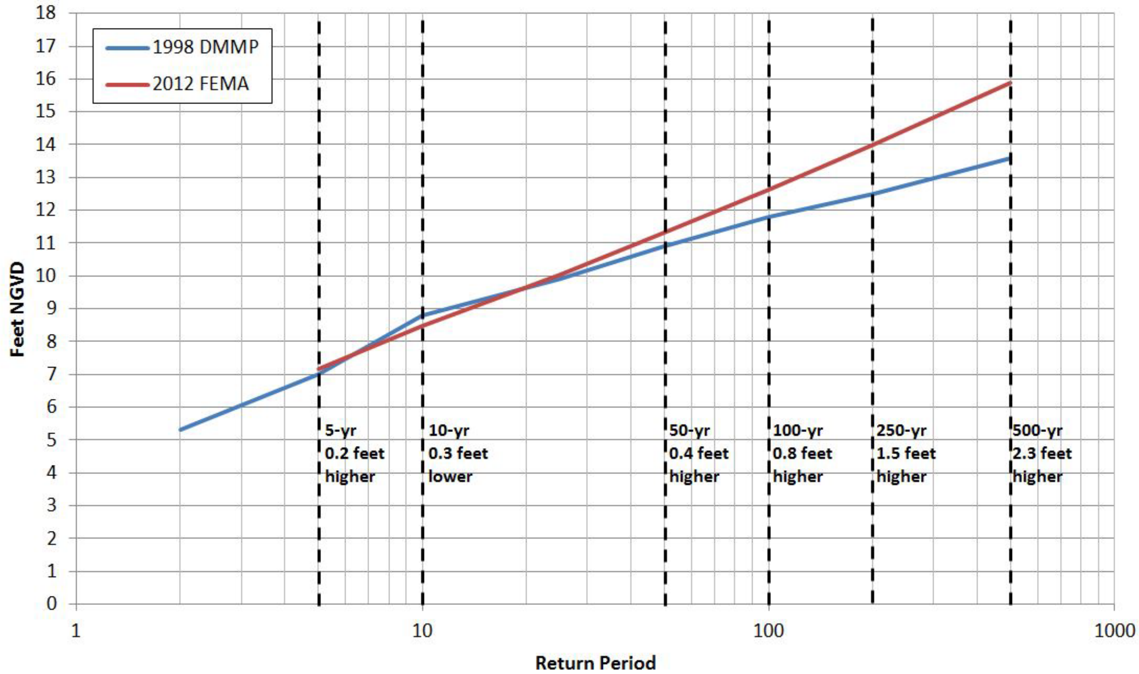

Figure 23 - Comparison of Stage-Frequency Data Updates

223. For the plan optimization, the revised stage frequency data was utilized for the "with" and "without"-project damage analyses performed in HEC-FDA. It is predicted that the revised stages would not affect the earlier tentative plan selection. If anything the increase in water levels would actually bolster the tentative plan selection of Alternative #4 because of the relatively linear cost increases incurred by increasing the buried seawall/armored levee design height whereas the road raising plans and beach berm/dune plan would start to become impractical and prohibitively expensive. Raising the roadway to meet the revised water surface elevation would include significant grading and elevation of bisecting roadways along with increase utility relocations. These expensive cost increases and constructability concerns would render the two road raising options impractical at the higher elevation. The large scale beach berm and dune and beach fill would experience a similar spike in costs for a different reason. The berm and beach fill would start reaching and covering the outfalls; therefore an extension of every outfall in the study area would be required. The extension would be an additional cost added to the material scale up cost.

224. The alignment of the Line of Protection used in the optimization process (see Section 7.1.1) accounts for a landward shift near Oakwood Beach and New Dorp Beach. Hurricane Sandy destroyed the bungalows along Cedar Grove, allowing for new efficiencies in plan alignment. With the homes near the shore demolished, a larger distance between the coast and the first row of homes exists. By using the new alignment the design effectively reduces the minimum design crest/top of wall elevations, reduces the length of the Line of Protection footprint and ultimately lowers the estimated construction cost of the Line of Protection because was are not breaching directly on the

structure. Similarly, because of the damage and demolition of structures along the beach, the updated design eliminates the necessity of utilizing sheet pile seawall sections and replaces it with one consistent buried stone seawall/armored levee design.

225. In addition, the design section along the perimeter of the Waste Water Treatment Plan (WWTP) at Oakwood Beach was changed from an I-Type floodwall to a T-Type concrete floodwall supported on concrete piles utilizing current USACE engineering guidance. The T-Type floodwall design in the Oakwood beach area is more robust than the original design and therefore more costly; however, implementing a management measure with a thin footprint is necessitated by physical site constraints along the perimeter of the Oakwood Beach Waste Water Treatment Plant.

6.5 Identification and Tentative Selection of Interior Drainage Alternatives

226. The formulation of Interior Drainage management measures was conducted using the guidance from Engineer Manual 1110-2-1413 (Hydrologic Analysis of Interior Areas). The strategy outlined under this guidance follows the premise that interior drainage management measures are planned and evaluated separately from the Line of Protection, and should provide adequate drainage at least equal to that of the existing local storm drainage infrastructure during low exterior stages without the Line of Protection in place.

227. For the interior drainage analysis the areas landward of the Line of Protection were subdivided into five Interior Drainage Areas, separated by high ground. The Areas run from Southwest to Northeast and are named Area A, Area B, Area C, Area D, and Area E. Figure 24 depicts an overview of the Interior Drainage Areas.

6.5.1 Interior Drainage Criteria - Minimum Facility Concept

228. As stated in U.S. Army Corps of Engineers EM 1110-2-1413, "Hydrologic Analysis of Interior Areas", the design Minimum Facility should provide interior flood relief such that during low exterior stages (at gravity conditions for normal astronomic tide) the local storm drainage system (typical 10-year design storm) functions essentially as it would without project in place.

229. The Minimum Facility is intended to ensure that the existing drainage system performs the same with and without the project put in place as to avoid induced flood damages. Additional interior drainage facilities may be designed to further reduce interior water levels beyond the minimum facilities. These additional interior facilities must be incrementally justified.

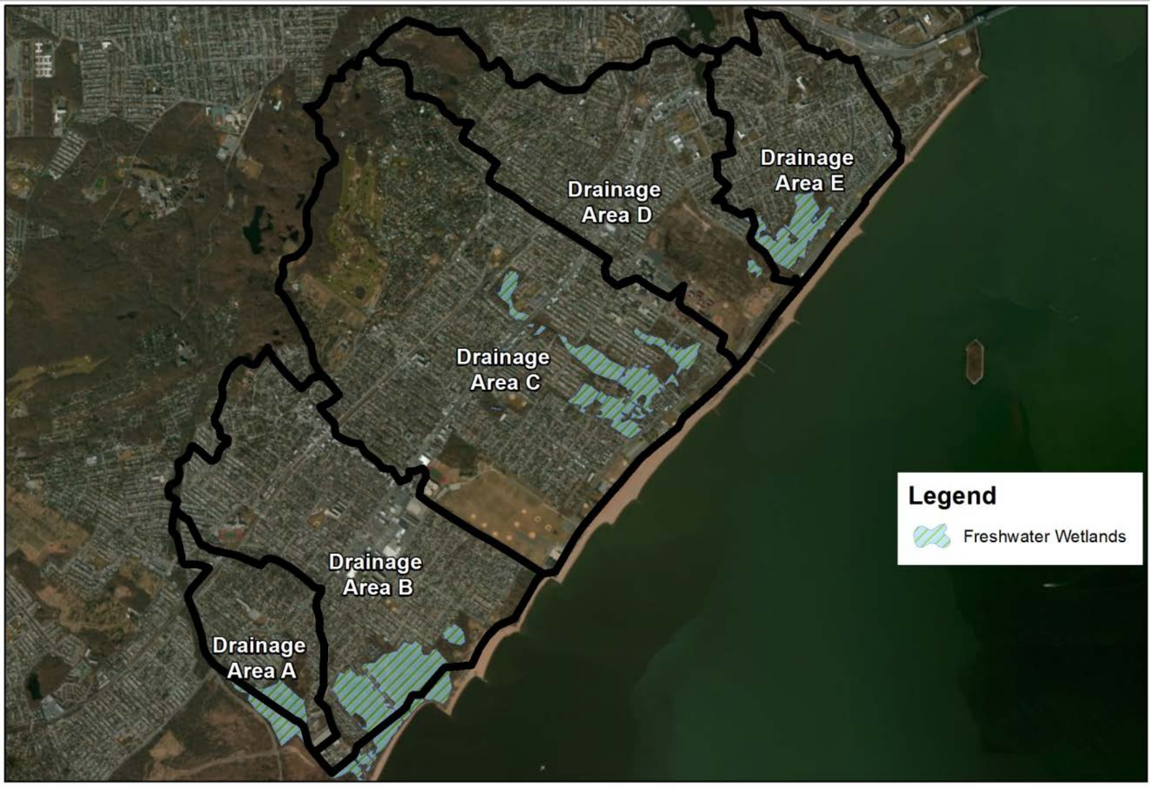

Figure 24 - Overview of Drainage Areas

6.5.2 Interior Drainage Alternative Analysis

6.5.2.1 Gravity & Pressure Outlets

230. The driving head of runoff outflow from the protected areas is the elevation difference between two water surfaces; the elevation of runoff that is accumulated landward of the plan alignment (headwater) and the elevation of the surge seaward of the plan alignment (tailwater).

231. If a significant portion of the drainage area is higher than the crest of the coastal storm risk management plan structure, it may be possible to divert the runoff from that higher area directly into the bay through pressure conduits. Typically, there must be sufficient head between the higher ground and the maximum tailwater to divert this runoff. Diversion effectively reduces the volume of runoff reaching the structure that would otherwise need to be handled by other means such as ponding or pumping. Pressurizing an existing gravity line by removing or sealing all of the lower catch basins is usually the least costly method but in some cases construction of a new pressure line is justified.

6.5.2.2 Ponding

232. Ponding can be an effective means for flood risk management. Runoff is stored

in low-lying, non-damaging areas until the tailwater (tidal surge) drops sufficiently to permit gravity discharge. Ponding is most effective when runoff is first discharged through gravity outlets during low tailwater conditions, and then diverted into the pond as the gravity outlets become blocked. Directing all runoff into a pond will increase the size of the pond required.

233. Excavating ponds to increase the runoff storage volume can be expensive, so natural flood storage areas should be used wherever possible, especially where development has already occurred or is expected to occur in floodplains.

6.5.2.3 Pumping

234. Pumping is usually the most costly option in initial construction as well as operation and maintenance, and therefore is typically considered the "last resort". Similar to pond excavation and pressure outlets, pumping is most effective during higher exterior stages when gravity outlets are blocked and there is insufficient natural flood storage area landward of the plan alignment. Pumping can be used to reduce the volume of a ponding area, or it can be used to handle the peak runoff.

235. While the Line of Protection defends against flood water originating from exterior sources, interior drainage facilities are intended to alleviate flooding that may subsequently occur from interior runoff. Table 18 presents a preliminary evaluation of how the viable Interior Drainage management measures would address the planning objectives of this Interim Report.

Table 18: Preliminary Evaluation of Interior Drainage Management Measures

	Measure	Objective 1: Reduce risk of damages	Objective 2: Reduce risk to life and safety
Interior Drainage Measures	Gravity & Pressure Outlets	Lowers flood elevations landward of Line of Protection	Reduces the flood depth landward of the Line of Protection, preventing potential harm to people.
	Natural Storage (Ponding)		
	Excavated Storage (Ponding)		
	Pumping		

6.5.3 Interior Drainage Alternatives

236. No single Interior Drainage management measure is effective in all situations and typically no single hydraulic measure is effective by itself. The most cost effective approach to reducing interior flooding stages is likely to be a combination of hydraulic measures. Alternatives examined include combinations of gravity outlets, pump stations/submersible pumps, and excavated ponding. No reasonable options for diversion

of upland runoff were identified. Table 19 provides a list of Alternatives that were considered based on drainage areas.

Table 19: List of Interior Drainage Plans		
Drainage Basins	**Plan Name**	**Plan Details**
A	Minimum Facility	Minimum Facility
	Alternative 1	DEC Conceptual Alternative*
B	Minimum Facility	Modified DEC Conceptual Plan*
	Alternative 1	Interior Levee/Non Structural Alternative
	Alternative 2	DEC Conceptual Plan with 2 Ponds Alternative*
C	Minimum Facility	Minimum Facility
	Alternative 1	1500 c.f.s. Pump Station Alternative
	Alternative 2	900 c.f.s. Pump Station with Four Excavated Ponds Alternative
	Alternative 3	Non-Structural Alternative
	Alternative 4	Seven Excavated Ponds Alternative
	Alternative 5	Nine Excavated Ponds Alternative
	Alternative 6	Four Excavated Ponds Alternative
	Alternative 7	Two Excavated Ponds Alternative
	Alternative 8	DEP Bluebelt Plan (Midland Beach)*
D	Minimum Facility	Minimum Facility
	Alternative 1	Non-Structural
E	Minimum Facility	Minimum Facility
	Alternative 1	1800 c.f.s. Pump Station
	Alternative 2	Two Excavated Ponds
	Alternative 3	600 c.f.s. Pump Station with Two Excavated Ponds
	Alternative 4	Non-Structural
	Alternative 5	DEP Bluebelt Plan (Midland Beach)*

* - Also known as “Sponsor Identified Plan”

237. The Minimum Facility Plan was the starting point from which all other Alternatives were measured. The benefits accrued are attributable to the reduction in the residual flood damages that would have remained under the Minimum Facility Plan. If another Alternative is to be justified, it must be implementable and reasonably maximize benefits versus the additional cost required for its construction, operation and maintenance.

6.5.4 Comparison of Alternatives by Drainage Area

6.5.4.1 Oakwood Creek – Drainage Area A

238. In Drainage Area A, the Tentatively Selected Line of Protection (levee) will impede the exiting of precipitation run-off floodwaters, causing a rise in pooling elevations behind the levee. To eliminate the adverse effects of the implementation of the Line of Protection, the Minimum Facility Plan includes 17.19 acres of currently available natural flood storage that is to be preserved by New York City (NYCDPR and NYCDEP property) in conjunction with a proposed tide gate structure with three 5’ x 5’ sluice gates that will allow Oakwood Creek to flow through the levee. Tide gates are designed to permit backflow at low (non-damaging) exterior elevations. In addition to the tide gate, two sluice gate structures will help drain the interior flooding for the Minimum Facility Plan. A total of two intermediate pipe outlets with flap gates will be incorporated to ensure that the proposed ditches will drain properly. The modeling and comparison of Alternatives in this area used the water surface elevation of the 2-year storm surge coupled with 100-year rainfall condition and the 100-year storm surge coupled with 2-year rainfall condition, whichever is more restrictive. The interior peak interior stillwater surface elevation with the implementation of the Line of Protection and Minimum Facility is expected to be 5.5 feet lower compared to the without-project 100-yr coastal storm surge level.

239. The Minimum Facility Plan described above resulted in interior water levels that were below the first level structures in this drainage area, hence additional measures were not found to be cost effective.

6.5.4.2 Oakwood to New Dorp Beach –Area B

240. In the case of Drainage Area B, the excess runoff is blocked by an existing dune. The proposed LOP would be located somewhat landward of the existing dune because the post-Sandy availability of acquired real-estate affords a more cost effective alignment for the buried seawall/armored levee. The realignment reduces reach length of the buried seawall by over 1,000 feet and reduces the wave heights at the LOP during a coastal storm. The new alignment, however, decreases the natural flood storage volume and therefore would cause an increase in interior flood stages compared to the existing conditions. In order to meet the minimum facility requirement of not inducing flooding, the plan includes 86.41 acres of natural storage of which 46 acres will be excavated to create the “East Pond” on Figure 38 providing 94,200 cubic yards of additional storage. The proposed excavation essentially offsets the storage lost by relocating the LOP landward. Culverts would convey flow from existing wetland areas to the East Pond.

241. The minimum facility for Drainage Area B (Figure 38) includes a tide gate on the East Pond to control the inflow to and outflow from the drainage area. It would be constructed to elevation 20.5 NGVD29 with the same features as the tide gate in Area A, but with slight variations in dimension. New chambers containing flap and sluice gate would also be added at the existing Ebitts Street, New Dorp Lane, and Tysens Lane

outfalls. The minimum facility would also include a road raising along Mill Road to an elevation of approximately 7.1 feet NGVD29 and Kissam Avenue to an elevation of approximately 7.1 feet NGVD29. The Mill Road raising will disallow the spillover of floodwater from Drainage Area A to Drainage Area B, while the Kissam Avenue road raising would provide vehicle access to the buried seawall/armored levee during storm events (USACE 2014a). Cross section details for the gate chambers are presented in Section 7.1.1.

242. The non-Federal Sponsors have identified a plan that proposes additional excavation to create permanent ponds and wetlands within the properties identified for acquisition. The additional excavation and drainage features allow additional flow from the existing outfall to be directed to these ponding and wetland areas. The additional excavation would take place below 3 ft. NGVD 1929 and thus will not provide significant effective flood storage because the excavation will be below the predicted water table. The additional excavation is a cost that does not provide relief from flood related damages and is not included as a project cost.

243. The alternatives considered beyond the Minimum Facility were not cost justified based on a reduction in storm damages.

6.5.4.3 New Dorp Beach to Midland Beach – Area C

244. In Drainage Area C, during rainfall events, the excess runoff is blocked from escaping into the bay by Father Capodanno Boulevard, which has a minimum crest elevation of approximately 10.1 feet NGVD 1929 in this area. The Minimum Facility Plan for drainage Area C includes four new gate chambers (Greeley, Midland, Naughton and Seaview Avenue outfalls) below the selected Line of Protection and the acquisition and preservation of the currently available freshwater wetland areas for a total natural storage area of 120.44 acres. A section of Seaview Avenue will be raised to an elevation of +10 feet NGVD 1929 in the area of Quincy Avenue and Father Capodanno Blvd to prevent potential overland flow from the adjacent interior drainage Area D into drainage Area C and vice versa up to the 100-yr event used in this interim feasibility study. The peak water surface elevation landward of the Line of Protection with the Minimum Facility Plan in place is estimated to be 6.36 feet NGVD 1929.

245. In addition to the Minimum Facility, eight Alternatives were formulated and evaluated utilizing varying combinations of pumps and ponds. Each Alternative assumes acquisition of the same properties as the Minimum Facility Plan. Some of the Alternatives were eliminated early in the evaluation process based on preliminary estimates on the cost effectiveness. For instance, the evaluation of pump stations initially considered pump sizes ranging from 600 c.f.s. to 1500 c.f.s. A preliminary economic analysis identified that the most cost effective pump size would be 1500 c.f.s., so only pump stations with 1500 c.f.s. were considered for the final comparison of Alternatives.

246. An economic analysis indicated that the cost of the four most viable Alternatives

ranged between $17 million and $40 million. The highest net benefits in excess of costs occur with Alternative 4, the 7 Pond Alternative, with 377,200 cy of excavation. Alternative 4 provides $3,071,200 in net annual benefits as compared with Alternative 6 (the 4 pond alternative), which has a higher BCR, but only $2,210,400 in net benefits. The other alternatives considered both had lower BCR's and net annual benefits.

6.5.4.4 Midland Beach to South Beach – Area D

247. In Drainage Area D, during rainfall events, excess runoff is blocked by Father Capodanno Boulevard, which has a minimum crest elevation of approximately 9.6 feet NGVD 1929 for this area. The Minimum Facility Plan for drainage Area D includes the replacement of one existing gate chamber (Quintard Street/Raritan Avenue outfall) under the Line of Protection Plan and 30.76 acres of available natural flood storage area that must be preserved by NYC Parks. The water surface elevation landward of the proposed Line of Protection with the Minimum Facility condition in place is estimated to be 9.78 feet NGVD 1929 for the 100-year event.

248. The Minimum Facility Plan provides interior water levels that are below the first level of significant damage in this drainage area with the exception of a small number of structures that are only impacted by rare storms (i.e. storms with a return period greater than 50 years). Therefore no further screening of additional alternative facilities was warranted.

6.5.4.5 South Beach – Area E

249. In Drainage Area E, during rainfall events, excess runoff is blocked by Father Capodanno Boulevard, which has an average crest elevation of approximately 10 feet NGVD 1929 for this area. The Minimum Facility Plan for Drainage Area E includes one new gate chamber at Sand Lane underneath the planned Line of Protection and the acquisition and preservation of 46.7 acres of available natural storage.

250. The screening of alternatives in this area used the water surface elevation of the 2-year storm surge with 100-year rainfall condition and the 100-year storm surge with 2-year rainfall condition, whichever was more restrictive. The with project Minimum Facilities condition results in high level damages for this Drainage Area so in addition to the Minimum Facility Plan five Alternatives were formulated and evaluated for Area E.

251. These Alternatives considered different combinations of pumps, ponds and non-structural measures. Each Alternative assumes the acquisition of the same properties as the Minimum Facility Plan. Some of the Alternatives were eliminated from consideration early on based on preliminary economic evaluations. For instance, the evaluation of the 1,800 c.f.s. pump stations was identified as having annual costs that exceed the annual damages with Minimum Facility and was eliminated from consideration.

252. Two ponding Alternatives, Alternative 2 (two ponds, 222,720 cy of excavation) and Alternative 5 (the Sponsor Bluebelt Alternative) provided cost effective options for reducing storm damage. An economic comparison indicated that Alternative 2 had the higher Net Benefits between the two Alternatives. The interior water surface elevation landward of the Line of Protection with the selected Alternative is estimated to be 6.84 feet NGVD 1929 for the 100-year event.

6.5.5 Summary of Tentatively Selected Interior Drainage Alternatives

253. The Interior Drainage comparison as summarized above and described in full within the Draft Interior Drainage Appendix suggests that drainage areas A, B and D will include only the minimum facilities. Drainage areas C and E will include optimized drainage facility Alternatives. The Tentatively Selected Interior Drainage Plans are included in Table 20.

Table 20: Tentatively Selected Interior Drainage Plans

Drainage Area	Optimum Plans	Annual Minimum Facility Costs*	Annual Cost of Measures in the Tentatively Selected Alternative	Total Annual Cost*	Annual Benefits*	Net Benefits*
Area A	Minimum Facility	$349,000	N/A	$349,000	$0	$0
Area B	Minimum Facility	$1,432,000	N/A	$1,432,000	$0	$0
Area C	Alternative 4: 7 Ponds (377,200 cy of excavation)	$1,093,000	$1,296,000	$2,390,800	$4,368,000	$3,071,200
Area D	Minimum Facility	$716,000	N/A	$716,000	$0	$0
Area E	Alternative 2: 2 Ponds (222,720 cy of excavation)	$387,000	$670,200	$1,056,000	$1,915,000	$1,243,700
Total	-	$3,977,000	$1,966,200	$5,943,800	$6,283,000	$4,314,000

**Rounded to the nearest thousand*

6.6 National Economic Development (NED) Plan

6.6.1 NED Plan Criteria

254. The NED plan is the coastal storm risk management plan that reasonably maximizes average annual Net Benefits and is the baseline against which other locally-preferred plans are compared. Normally, the Federal share of the NED plan is the limit of Federal expenditures on any more costly plan. Although the NED plan forms the basis for establishing the Federal share of a project cost, the planning process recognizes that the non-Federal partners may have additional desires for coastal storm risk management and erosion control that may differ from that provided by the NED plan. A locally-preferred plan may be recommended provided the non-Federal partner agrees to pay any difference in cost and the plan is economically feasible with a benefit-to-cost ratio greater than unity.

255. The NED Plan is selected based on the design level that produces the greatest Net Benefits, and is the plan the USACE must recommend unless there is an overriding reason for choosing another plan. Such reasons may include local support for another Alternative, which must also be demonstrated to be economically justified. In a case where an Alternative is recommended in place of the NED plan, the Federal Sponsor's share of the cost of construction of the Locally-Preferred Plan (LPP) will be based on their share of the cost in the NED plan, with the local non-Federal Sponsors contributing the balance.

6.6.2 No Action Alternative

256. A no-action plan means that no additional federal actions would be taken to provide for coastal storm risk management. Failure to provide the study area with additional storm damage and erosion control measures may lead to potential loss of life, physical and environmental damage, municipal infrastructure damage and harm to economic activity within the study area as previously discussed.

257. The no-action (without project) plan fails to meet any of the objectives or needs of a coastal storm risk management plan, but it provides the base against which project benefits are measured. Additionally, this plan would be implemented if project costs for any of the coastal storm risk management alternatives were to exceed project benefits, thus indicating that risk management measures are not in the Federal interest under current NED guidelines.

258. Estimated annual storm damages (inundation only) for the No Action Alternative for the Base Year (2019) and future year (2019) condition are presented in Table 21 along with the Equivalent Annual Damages, which were calculated using a 3.375% federal discount rate and a 50-year period of analysis and a historic rate of relative sea level rise.

Table 21: Without-Project Damage Summary			
Reach/ Interior Area	**Base Year**	**Future Year**	**Equivalent Annual Damage*** **
FWOB-1	$7,700	$10,930	$8,860
FWOB-2	$1,607,760	$2,206,500	$1,821,940
FWOB-3	$4,186,700	$5,573,780	$4,682,860
FWOB-4	$14,749,570	$19,604,910	$16,486,350
FWOB-5	$1,364,300	$1,859,950	$1,541,590
FWOB-6	$374,030	$498,560	$418,570
FWOB-7	$964,250	$1,281,030	$1,077,560
FWOB-TP	$113,940	$160,430	$130,570
Boardwalk	$397,830	$564,020	$457,280
Subtotal Coastal Storm Damage*	$23,766,080	$31,760,110	$26,625,580
Interior Area A	$77,800	$97,900	$84,970
Area B	$96,620	$136,020	$110,720
Area C	$5,178,700	$6,421,100	$5,623,090
Area D	$116,300	$175,500	$137,490
Area E	$2,107,200	$2,377,600	$2,203,940
Subtotal Interior Flood Damage**	$7,576,620	$9,208,120	$8,160,210
Total Without Project Damage	$31,346,810	$40,975,320	$34,790,960

*Coastal storm damage associated with storm surges greater than existing line of protection
**Interior flood damage associated with storm surge below existing line of protection
***3.375% Discount Rate

6.6.3 Nonstructural Plan Alternative

259. The Water Resources Development Act of 1986, Section 905 (Feasibility Reports), stipulates that a nonstructural alternative to the recommended plan with an equivalent level of protection be considered. As described earlier, several nonstructural plans with lower levels of protection were screened out in the preliminary evaluation of alternatives.

260. For comparison with the recommended plan, a rough costs and benefits analysis of acquiring and all vulnerable structures in the 100-year and 300-year floodplains was performed. The first costs based on the total depreciated replacement value of affected structures is would be approximately $2 billion and $2.5 billion respectively. When

additional costs (for land, demolition, real estate agreements, permits, S&A) are added, the annualized costs for the two plans total more than $120 million and $150 million, respectively. Since the total without project equivalent annual damage is only $34 million. The benefit-cost ratios for each of these alternatives are less than 0.2.

6.6.4 NED Plan Optimization

261. Applying the NED Plan Criteria the Tentatively Selected Plan (TSP) for the Line of Protection Alternative was Alternative 4, and the Tentatively Selected Interior Drainage Alternative were the Minimum facilities for Drainage Areas A, B, and D, Alternative 4 for Drainage Areas C, and Alternative 2 for Drainage Areas E.

262. The Alternative comparison and Tentative Plan Selection utilized a constant stillwater design level. In order to the plan, four different stillwater design levels were analyzed. Table 22 shows the With Project Damages for each of the stillwater design levels considered, 13.3 feet, 14.3 feet, 15.6 feet, and 16.6 feet NGVD 1929, respectively.

Table 22: With Project Damage Summary

Reach	Equivalent Annual Damage			
	Alt 1 (Levee 13.3 ft) NGVD 1929 Stillwater Design	**Alt 2 (Levee 14.3 ft) NGVD 1929 Stillwater Design**	**Alt 3 (Levee 15.6 ft) NGVD 1929 Stillwater Design**	**Alt 4 (Levee 16.6 ft) NGVD 1929 Stillwater Design**
FWOB-1	$9,000	$9,000	$9,000	$9,000
FWOB-2	$1,067,000	$829,000	$570,000	$413,000
FWOB-3	$1,781,000	$1,315,000	$883,000	$645,000
FWOB-4	$6,096,000	$4,386,000	$2,771,000	$1,910,000
FWOB-5	$876,000	$693,000	$483,000	$352,000
FWOB-6	$169,000	$130,000	$93,000	$71,000
FWOB-7	$393,000	$287,000	$188,000	$133,000
FWOB-TP	$101,000	$89,000	$68,000	$52,000
Boardwalk	$318,000	$198,000	$111,000	$71,000
Interior Area A	$85,000	$85,000	$85,000	$85,000
Area B	$116,000	$116,000	$116,000	$116,000
Area C	$1,256,000	$1,256,000	$1,256,000	$1,256,000
Area D	$137,000	$137,000	$137,000	$137,000
Area E	$289,000	$289,000	$289,000	$289,000
Total With Project Damage	**$12,693,000**	**$9,819,000**	**$7,059,000**	**$5,539,000**

3.375% Discount Rate

263. For the Buried Seawall/Armored Levee reach (Reach 4), the structure crest

elevations corresponding to the aforementioned stillwater design levels were 16.0 feet, 18.0
feet, 20.5 feet and 22 feet NGVD 1929 respectively. The structure crest elevations are greater than the stillwater design levels to meet the desired wave overtopping design limits. As the height of structure increased so did the width of the structures footprint. In addition, the median weights of the armor stone increases from one ton to three ton as the design crest elevations increased. The Floodwall portion (Reach 3) of the Line of Protection utilized the same four structure crest elevations as the Buried Seawall/Armored Levee (16.0 feet, 18.0 feet, 20.5, and 22 feet NGVD 1929). As the top of wall elevations increased so did the amount of reinforced concrete material, number of supporting piles, and supporting pile lengths. The levee portion of the Line of Protection included structure crest elevations of 16.0 feet, 17.0 feet, 18.0, 20.0 feet NGVD 1929 with respect to the four stillwater design levels. As the levee crest increased so did the levee footprint size, and required excavation dimensions.

6.6.4.1 Stillwater Design Heights for Optimization and NED Plan Identification

264. As noted above, the Alternative comparison and Tentative Plan Selection utilized a constant stillwater design level, four different stillwater design levels were compared as part of an economic optimization process identifying the National Economic Development (NED) Plan. The stillwater design levels were 13.3 feet, 14.3 feet, 15.6 feet, and 16.6 feet NGVD 1929.

265. For the Buried Seawall/Armored Levee reach, the structure crest elevations corresponding to the aforementioned stillwater design levels were 16.0 feet, 18.0 feet, 20.5 feet and 22 feet NGVD 1929 respectively. The structure crest elevations are greater than the stillwater design levels to meet the desired wave overtopping design limits. As the height of structure increased so did the width of the structures footprint. In addition, the median weights of the armor stone increases from one ton to three ton as the design crest elevations increased.

266. The Floodwall portion of the Line of Protection utilized the same four structure crest elevations as the Buried Seawall/Armored Levee (16.0 feet, 18.0 feet, 20.5, and 22 feet NGVD 1929). As the top of wall elevations increased so did the amount of reinforced concrete material, number of supporting piles, and supporting pile lengths.

267. The levee portion of the Line of Protection included structure crest elevations of 16.0 feet, 17.0 feet, 18.0, 20.0 feet NGVD 1929 with respect to the four stillwater design levels. As the levee crest increased so did the levee footprint size, and required excavation dimensions.

As expected, the estimated with-project damages are reduced with a higher stillwater design - all of which are much less than the No-Action Plan. In order to identify the NED Plan, the costs of each design level was compared to the associated benefits to determine the design with the highest Net Benefits. Table 23 and Table 24 provide the benefit and cost relationships for the four design levels. Included in the cost is major rehabilitation which is an estimate of damages to the LOP from events exceeding the design storm. As shown in Table 25, the 15.6 ft. Stillwater design provides the highest the net benefits and highest BCR of the 4 Stillwater design levels and was selected as the NED Plan. Detailed information and calculations for the benefits are available in the Draft Economics Appendix. Quantities, costs and plan details for the four stillwater designs are provided in the Draft Engineering and Design Appendix.

Table 23: Benefit Summary for Stillwater Design Optimization

Scenario	13.3 ft. NGVD 1929 Stillwater Design	14.3 ft. NGVD 1929 Stillwater Design	15.6 ft. NGVD 1929 Stillwater Design	16.6 ft. NGVD 1929 Stillwater Design
Annual Without Project Damage				
Coastal Storm Damage	$26,626,000	$26,626,000	$26,626,000	$26,626,000
Interior Flood Damage	$8,165,000	$8,165,000	$8,165,000	$8,165,000
Total Damage	$34,791,000	$34,791,000	$34,791,000	$34,791,000
Annual With Project Damage				
Coastal Storm Damage	$10,810,000	$7,936,000	$5,176,000	$3,656,000
Interior Flood Damage	$1,883,000	$1,883,000	$1,883,000	$1,883,000
Total Damage	$12,693,000	$9,819,000	$7,059,000	$5,539,000
Annual Reduction in Damage				
Coastal Flood Benefit	$15,816,000	$18,690,000	$21,450,000	$22,970,000
Interior Flood Benefit	$6,282,000	$6,282,000	$6,282,000	$6,282,000
Total Benefit	**$22,098,000**	**$24,972,000**	**$27,732,000**	**$29,252,000**

Rounded to the nearest thousand, 3.375% Discount Rate

Table 24: Cost Summary for Stillwater Design Optimization				
Scenario	**13.3 ft. NGVD 1929 Stillwater Design**	**14.3 ft. NGVD 1929 Stillwater Design**	**15.6 ft. NGVD 1929 Stillwater Design**	**16.6 ft. NGVD 1929 Stillwater Design**
First Costs*				
Line of Protection	$252,258,000	$285,262,000	$345,824,000	$393,715,000
Interior Drainage Improvements**	$86,855,000	$86,855,000	$86,855,000	$86,855,000
Real Estate	$40,022,000	$40,022,000	$40,022,000	$40,022,000
Total First Cost	**$379,135,000**	**$412,139,000**	**$472,701,000**	**$520,592,000**
Interest & Investment Cost				
Interest During Construction (IDC)	$22,702,000	$24,678,000	$28,305,000	$31,172,000
Total Investment	**$401,837,000**	**$436,817,000**	**$501,006,000**	**$551,764,000**
Annual Costs				
Annualized Investment	$16,747,000	$18,205,000	$20,881,000	$22,996,000
Annual O&M Cost	$555,000	$555,000	$555,000	$555,000
Major Rehab	$388,000	$245,000	$115,000	$52,000
Total Annual Cost	**$17,690,400**	**$19,005,400**	**$21,551,400**	**$23,603,400**

Rounded to the nearest thousand, 3.375% Discount Rate
*First Costs Include 20% for Engineering and Design and Construction Management
**$41,255,000 of Minimum Facility Costs are included in the Interior Drainage

Table 25: Economic Comparison of Stillwater Designs				
Scenario	**13.3 ft. NGVD 1929 Stillwater Design**	**14.3 ft. NGVD 1929 Stillwater Design**	**15.6 ft. NGVD 1929 Stillwater Design**	**16.6 ft. NGVD 1929 Stillwater Design**
Annual Benefits	$22,098,000	$24,972,000	$27,732,000	$29,252,000
Annual Costs	$17,690,400	$19,005,400	$21,551,400	$23,603,400
Net Benefits	$4,407,600	$5,966,600	$6,180,600	$5,648,600
BCR	**1.2**	**1.3**	**1.3**	**1.2**
Selected as NED Plan			✓	

Rounded to the nearest thousand, 3.375% Discount Rate

The Plan that maximizes the average annual net benefits is identified as the National Economic Development Plan and is recommended for Federal interest as the recommended plan for implementation. The NED plan is identified as the 15.6 ft. NGVD 1929 stillwater design. In the following sections of this report, the design of the 15.6 ft. NGVD 1929 stillwater design plan will be refined and the total project cost will be determined.

7. NATIONAL ECONOMIC DEVELOPMENT (NED) PLAN

7.1 Description of the NED Plan

268. The NED Plan for the Interim Feasibility Study on the South Shore of Staten Island from Fort Wadsworth to Oakwood Beach incorporates the optimum design stillwater height for the Tentatively Selected Line of Protection Plan and Tentatively Selected Interior Drainage Plans. The NED Plan meets the needs of the Disaster Relief Appropriations Act of 2013 (Public Law 113-2; herein P.L. 113-2) as detailed in Section 9.

269. Figure 25 below provides an overview of the NED Plan.

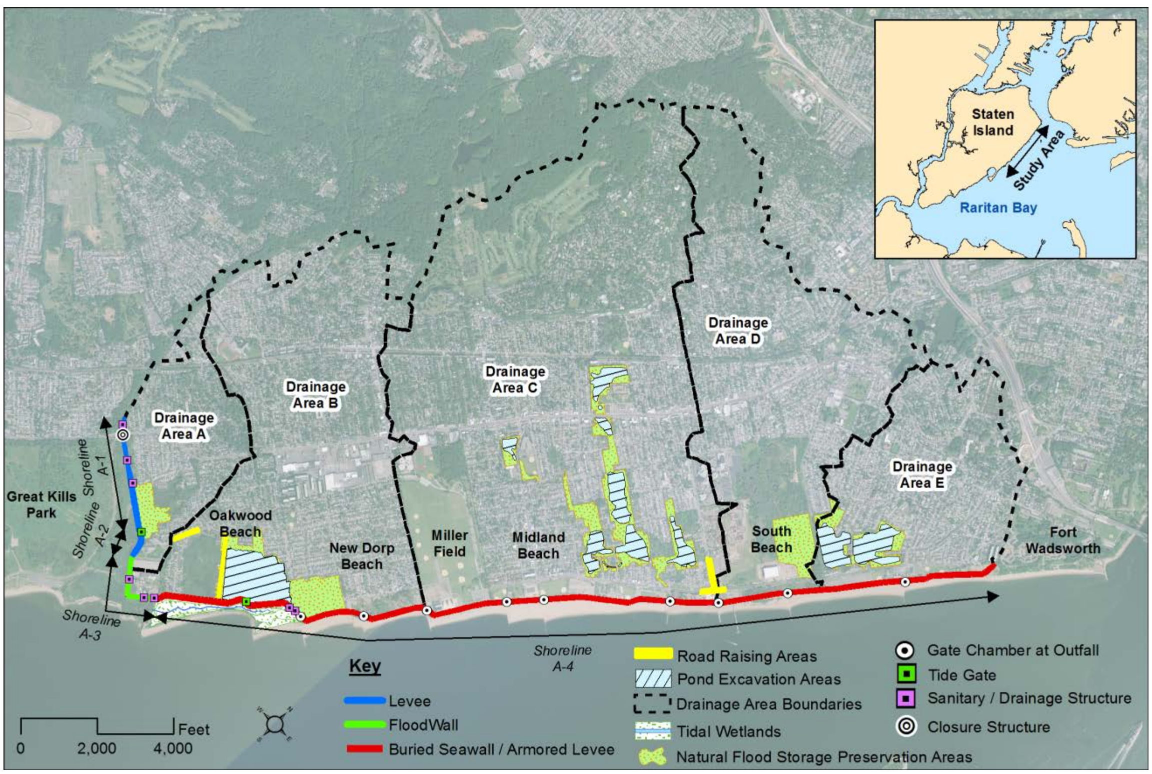

Figure 25 - NED Plan Overview

7.1.1 Line of Protection

270. The NED Plan includes the Line of Protection Alternative that consists of a buried seawall/armored levee along a majority of the reach (approximately 80%) serving as the first line of defense against severe coastal surge flooding and wave forces. The remainder of the Plan consists of a T-Type Vertical Floodwall, and Levee. The Plan also includes a closure structure at Hylan Boulevard, drainage control structures for existing storm water outfalls, tide gate structures, vehicle and pedestrian access structures. In general the Plan structure was split into four engineering reaches based on different design sections as listed below and depicted in Figure 26:

- Reach A-1: Levee
- Reach A-2: Levee
- Reach A-3: Floodwall
- Reach A-4: Buried Seawall

Figure 26 - Overview of Line of Protection

Detailed plan view drawings are available in Section 14 (Drawings C-100 through C110).

7.1.1.1 Alignment

271. Starting in Oakwood Beach in Shoreline Reach A-1, the earthen levee with a 10-foot wide crest ties into high ground on the northwest side of Hylan Boulevard. A closure structure is proposed at Hylan Boulevard to prevent floodwaters from flanking the levees during rare high water events. The earthen levee continues southeast through Oakwood Beach parallel to Oakwood Creek and Buffalo Street until the levee crosses over

Oakwood Creek. A tide gate structure is proposed at this location. The total length of this Shoreline Reach A-1 is 2,800 ft.

272. Shoreline Reach A-2 is a 600 foot long earthen levee section with a 15-foot wide crest to accommodate maintenance vehicles accessing the tide gate structure. This wider levee section begins on the south side of the tide gate and terminates at the northwest corner of the Oakwood Beach Waste Water Treatment Plant.

273. In Shoreline Reach A-3 the structures transitions from an earthen levee to a vertical concrete T-shaped floodwall due to the limited area between Oakwood Creek and the Oakwood Beach Waste Water Treatment Plant (WWTP). The 1,800 foot long vertical floodwall protects the west and south sides of the WWTP.

274. Shoreline Reach A-4 extends 22,700 feet from the southeast corner of the WWTP to Fort Wadsworth. Pre-Hurricane Sandy alternative analysis indicated that Reach A-4 line of protection consisted of various heights of exposed armor stone revetments, buried seawalls, and vertical steel sheet pile flood walls ranging from approximately 18 feet to 28 feet NGVD, located along the shoreline fronting existing infrastructure. Following Hurricane Sandy, the line of protection was revised to a continuous buried seawall structure at a consistent height of 20.5 feet NGVD. The alignment of the buried seawall through Oakwood Beach deviates from previously developed alternatives, extending more landward across a portion of the Fox Beach neighborhood that is being acquired in coordination with the State of New York. The alignment continues across the marshes of Oakwood Beach and past Kissam Avenue. The proposed alignment in this area is landward of New York City's sanitary sewer interceptor to the WWTP. This plan has fewer environmental impacts than the prior alignment. A tidal wetland fronts the alignment at the Oakwood Beach area of the project to attenuate wave energy and provide erosion prevention for this section. A bend in the alignment occurs at the eastern end of Oakwood Beach to accommodate a second proposed tide gate structure.

275. From Midland Beach to Fort Wadsworth the alignment generally follows the footprint of the existing promenade and FDR Boardwalk. There are a few exceptions where the alignment was shifted landward to maintain a protective buffer between the shoreline and buried seawall/armored levee. This is most noticeably at the eastern end of the project area where the beach narrows. The buried seawall/armored levee ties-in to high ground at Fort Wadsworth. The buried seawall/armored levee in this reach extends 22,700 feet from the Oakwood Beach to Fort Wadsworth.

A more detailed description of the line of protection is presented below:

Shoreline Reaches A-1 and A-2: Earthen Levee (Station 10+25 to Station 47+14.81)

276. An earthen levee is proposed in Shoreline Reaches A-1 and A-2 to terminate the structures in the optimized NED plan into high ground northwest of Hylan Boulevard, thereby creating a closed system that protects the project area from floodwaters. The

termination point of the earthen levee on the northwest side of Hylan Boulevard will be refined in the design phase once updated topographic information is collected and coordination with NYC Parks on the trail system integration is complete. The proposed levee in Shoreline Reaches A-1 and A-2 has acrest elevation of 18-ft NGVD (corresponding to 15.6 ft NGVD design still water level). The proposed levee is a trapezoidal core section consisting of compacted impervious fill placed at 2.5H:1V side slopes. An inspection/seepage trench, created by excavating native soil a minimum of 6 ft below the existing ground surface and replacing it with compacted impervious fill, is incorporated into the design to prevent seepage. A high performance turf reinforcement mat will be placed on the exterior side slopes and levee crest to minimize scour and erosion during storm events. The levee along Shoreline Reach A-1 has a crest width of 10 feet, which is widened to 15 feet in Shoreline Reach A-2 to accommodate maintenance vehicle access to the tide gate. With the ground elevation ranging between 6 and 10 feet NGVD 1929 the width of the levees in Shoreline Reaches A1 and A-2 vary between about 50 and 75 feet. Figure 27 presents a typical section of the Levee in Reach A-1. Figure 28 presents a typical section for the levee in reach A-2.

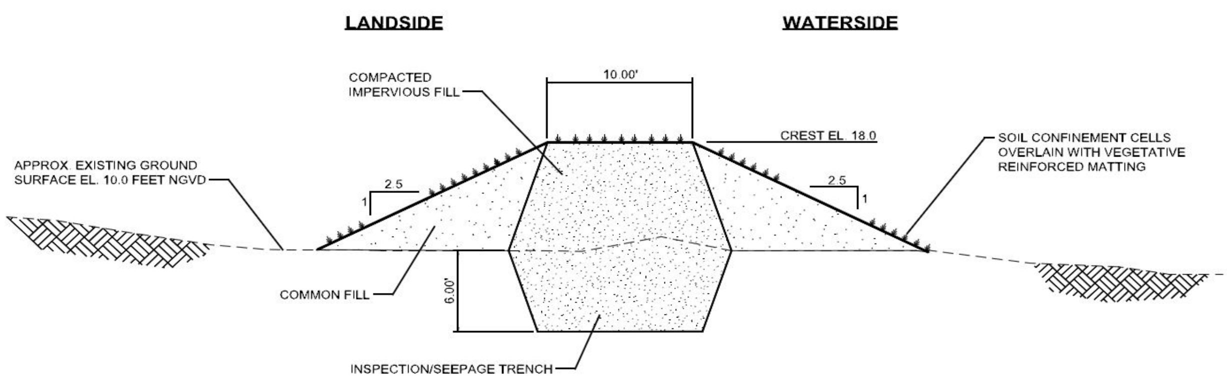

Figure 27 – Levee Typical Section (Reach A-1)

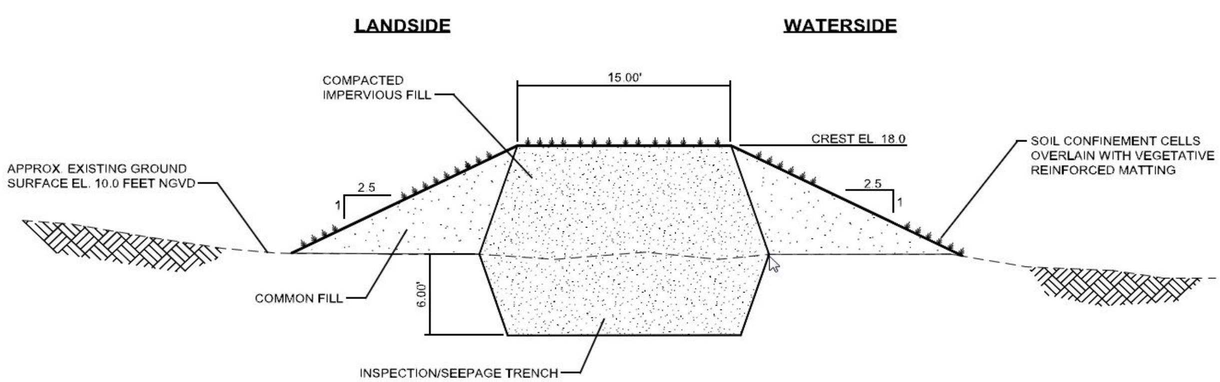

Figure 28 -Levee Typical Section (Reach A-2)

Shoreline Reach A-3: Vertical Floodwall (Station 47+14.87 to Station 65+00)

277. A reinforced concrete floodwall is proposed where a confined footprint is necessary to minimized impacts to the Oakwood Beach WWTP. The floodwall design consists of an H-pile supported T-shaped concrete floodwall with top of wall elevations of 20.5 ft. NGVD 1929. The structure footing was designed to accommodate localized wave induced and overtopping jet scour by defining a 4-foot thick base set 2-feet below grade. In addition, a rock blanket extends 15-foot seaward side of the wall to address wave scour and a rock splash apron extends 10 to 15 feet landward from the concrete footing to provide adequate overtopping jet scour protection. A vertical steel sheet pile wall has been added beneath the wall to prevent seepage below the footing. Figure 29 presents a typical section of the Floodwall (Reach A-3).

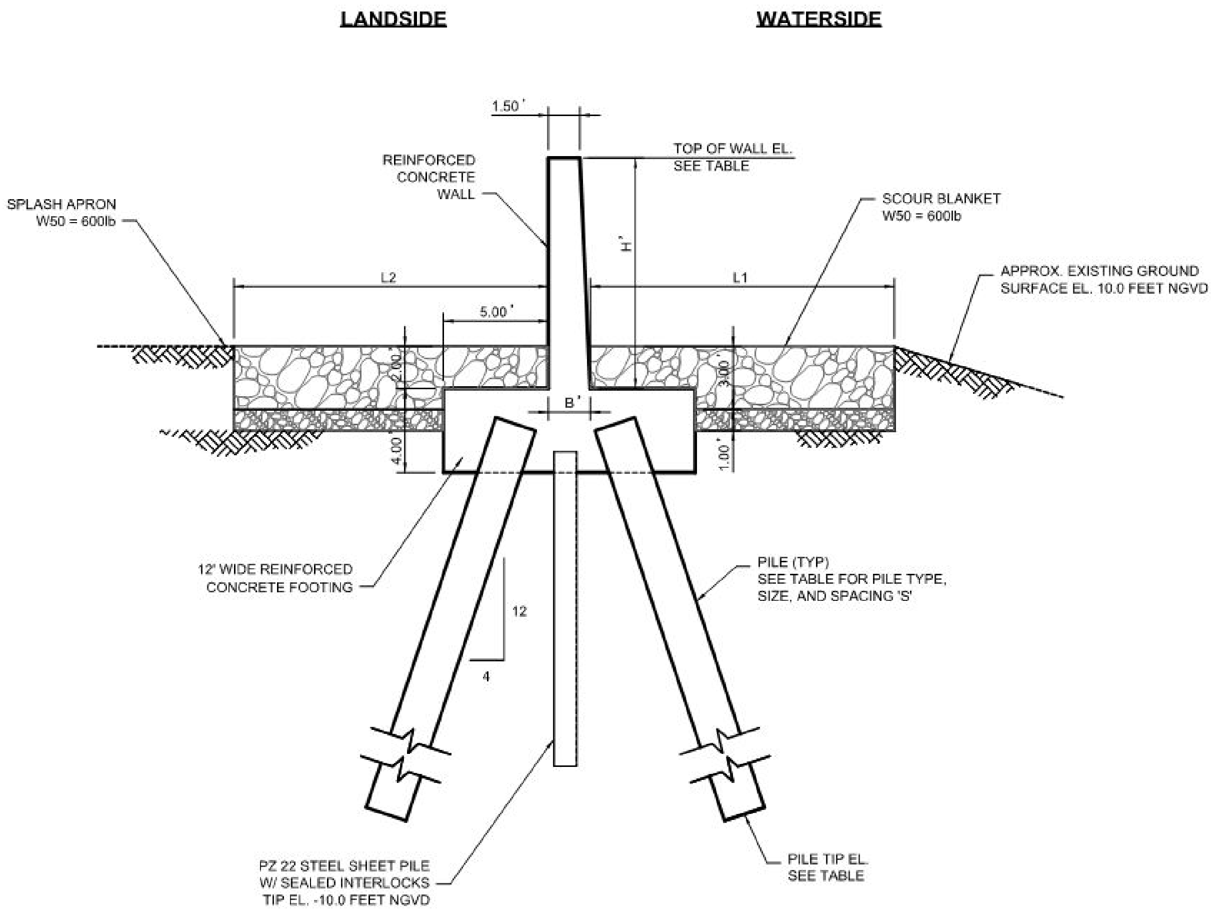

Figure 29 – Floodwall Typical Section (Reach A-3)

Integrated approach to Coastal Resilience

278. The shorelines along the southeastern shore of Staten Island have generally been mildly erosional, which indicate that the rate of erosion over most large areas of the shoreline is low, averaging less than 1 foot per year of shoreline loss. However, the segment near the Oakwood Beach area is at a much lower elevation (within 5 feet or less

of sea level), shoreline recession has been as high as 20 feet per year. Physical properties of the area seaward of the line of protection in Oakwood Beach include poorly drained, organic and erosive soils. Therefore, to inhibit erosion, attenuate wave energy that can cause scour to the Project area, and to reduce sedimentation through the creek and tide gate into the freshwater wetland, the NED Plan has been designed to preserve the functional effectiveness of tidal exchange. This would facilitate wetland drainage and enable the tidal wetlands seaward of the LOP to help filter sediments so they are not brought into the freshwater wetlands (see Figure 28). In addition, the NED plan will utilize sand excavated during construction of the foundation for the Line of Protection.

279. The proposed project features along the coastline include approximately 46 acres of tidal wetlands on the seaward side of the proposed revetment (Figure 30). This includes approximately 10.1 acres of maritime forest/scrub-shrub habitat would also be planted along the front of the revetment, while 12.9 acres of low marsh and 6 acres of high marsh acres of living shoreline are proposed in the shallow waters adjacent to the existing beachfront. Further, 17 acres of dune grass is proposed to be planted. In addition to attenuating wave energy and erosion prevention, these features include multiple habitats systems that would provide environmental enhancements, as well as public benefits to the Oakwood Beach area.

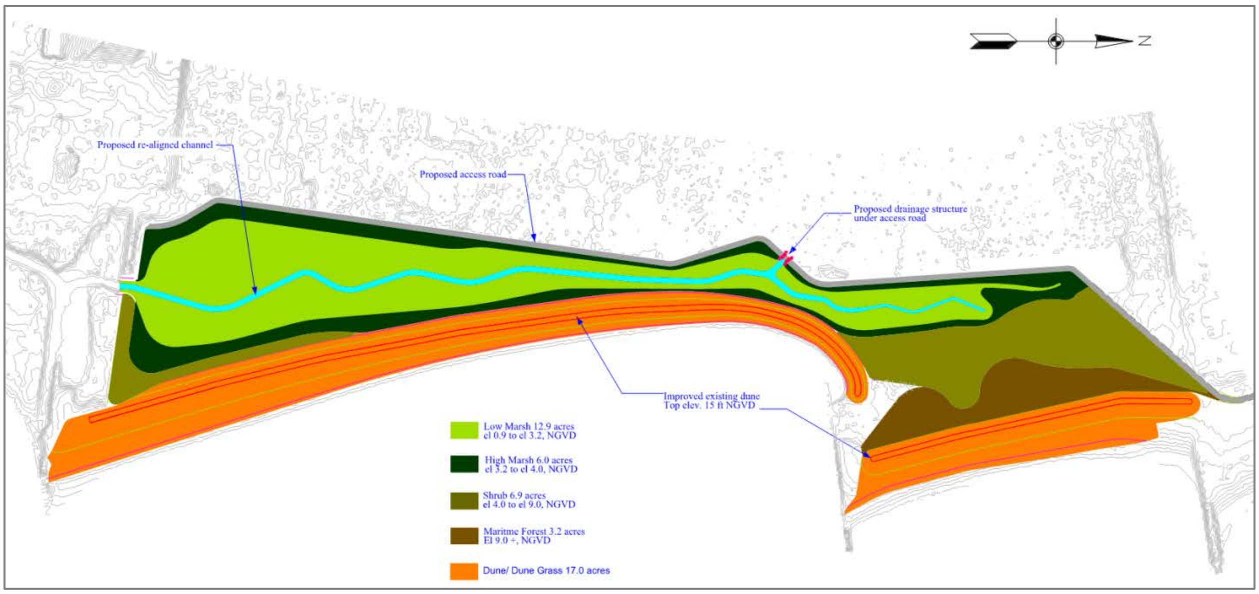

Figure 30 – Setback Alignment

Buried Seawall

Shoreline Reach A-4: Buried Seawall (Station 65+00 to Station 292+44.67)

280. A buried seawall, at crest elevation 20.5 feet NGVD 1929 is the structure type that is used for the majority of the optimized plan. The buried seawall comprises a trapezoidal shaped core structure with a 10 to 18-foot wide crest and 1.5:1 (horizontal: vertical) side slopes. The core is constructed with two-stone thickness armor stone and bedding stone layers. A 10 to 18-foot wide scour apron is incorporated into the seaside structure toe. The seaward face or the landward and seaward faces of the above-grade portions of the structure are covered with material excavated to accommodate the structure foundation. This material, primarily sand with some clay, silts, and topsoil, will be placed on 2:1 side slope to support native beach vegetation. The material cover is used to visually integrate the buried seawall with surrounding topography and to protect the public from climbing and/or falling on the uneven rock surface. A brief description of the design is provided below. Geotextile fabric is placed underneath the bedding layer to reduce settlement and around the core structure to minimize loss of fill through the voids. A vertical steel sheet pile wall will be installed in the interior of the structure to prevent seepage.

281. The two sanitary sewer interceptor lines (30-inch and 60-inch diameter) that convey wastewater from the eastern communities of Staten Island to the Oakwood Beach Wastewater Treatment Plant generally follows an alignment that is landward of the Line of Protection (LOP) except within the Oakwood Beach Corridor. The two interceptors lines cross underneath the LOP on the south side of Cedar Grove Beach and generally follow a parallel alignment to that of the LOP on the seaward side. As a means to provide the City of New York with access to the interceptor lines for maintenance purposes and to minimize the risk of flooding to the sanitary system during more frequent storm events, a service vehicle access road has been provided.

282. The service vehicle access road consists of raising the grade above the two interceptor lines to elevation +10 feet NGVD, installing concrete junctions boxes with sealed manhole covers, and adding a 20-foot paved surface to facilitate vehicle movements. The seaward face of the raised grade will be stabilized with armor stone to minimize erosion during storm events. The landward face of the access road will be integrated with the seaward face of the LOP except where it crosses drainage flow paths associated with the City's Bluebelt plan. In these locations, the landward face will not extend to the LOP but will be sloped to meet existing grade and stabilized with armor stone. Vehicular ramps to provide entry to the service access corridor will be incorporated into the LOP at Cedar Grove Beach, Oakwood Beach WTTP, and Kissam Avenue. The integration of the Bluebelt plan and the final location and alignment of the vehicular ramps will be coordinated with the City during the Preliminary Engineering and Design (PED) phase.

283. Approximately 80% of the interceptor is landward of the line of protection. For areas where the interceptor is seaward of the line of protection, the design includes an access road seaward of the buried seawall to provide access and facilitate operation and maintenance of the wall and interceptor pipe. The access road construction includes the elevation of the interceptor manholes to +10 feet NGVD, and sealing of the manhole covers. The area seaward of the buried seawall and the interceptor includes a low lying area that will be restored to a tidal wetland. The tidal wetland area limits exposure to high wave energy or erosion, although the area will remain exposed to inundation. There is a risk of flooding from storm surge due to a storm greater than a 4% annual exceedance probability, when the surge height exceeds the height of the access road.

284. The level of risk reduction for storm-water entry into the interceptor pipe is less than could be provided if the interceptor pipe was located landward of the line of protection. Relocation of the interceptor pipe is not included as a project feature. Relocation of the sewer pipe to an area landward of the line of protection, with raised manhole covers, if implemented by others would further reduce the risk of storm water intrusion into the system, complement the storm damage reduction provided by the recommended plan, and improve the functioning of the Oakwood Beach waste water treatment plant by further reducing the amount of storm water discharge that may occur under high surge events.

285. The WWTP is currently subject to flooding when storm elevations reach the micro-strainer building at +10.6 ft NAVD. During Hurricane Sandy, storm surge elevations were reported as +13.1 ft NAVD near the WWTP. The proposed line of protection is designed to reduce damages from flooding with storm surges up to 14.5 ft NAVD. The buried seawalls, levees and floodwalls will reduce the probability of flooding (under current sea level conditions) from approximately 5% per year to below 0.4% per year.

286. Areas behind the line of protection may sometimes be flooded from interior runoff, seepage or other sources of inflow. Because the plant is at a higher elevation than adjacent areas, runoff is directed away from the WWTP and will pond in the lower lying areas when high stages block the stormwater outfalls. At the WWTP an additional source of flooding is overflow from the wastewater process during high storm tides, when the wastewater is blocked from the high surge conditions. The effects and flood damage associated with overtopping from the treatment process are part of the residual interior flood conditions.

287. The solution to address the overflow of the wastewater under high surge conditions would be the construction of an effluent pumping system, likely consisting of pumps and a surge tank to overcome the hydrostatic pressure of tidal conditions and head loss through the outfall. In order for USACE to recommend the construction of an effluent pumping system, the costs of this system would need to be offset by the reduction in flooding damages that would accrue from the system. The District has

evaluated the vulnerability of the plant, and the storm damages that would remain with the line of protection in-place. The Corps has determined that the construction of an effluent pumping system to maintain discharge capacity against storm flood elevations for purposes of storm damage reduction would not be economically supported based upon the cost of the effluent system and the reduced damages to the sewage treatment plant, and surrounding areas. It is recognized that an effluent pumping system would allow the WWTP to maintain operations and discharge capacity under high surge conditions and provide additional benefits beyond what the Corps can consider as storm damage reduction benefits. The construction of an effluent pump, if undertaken by others would complement the existing storm risk management benefits of the project by further reducing the flooding damages and negative environmental effects that would continue to occur under high surge conditions.

288. *Oakwood Beach to Miller Field (Station 65+00 and Station 158+00):* This is a 9,300 foot stretch and includes 17 foot crest width buried seawall with raised promenade (22.5 feet NGVD) as shown in Figure 31. The raised promenade is constructed with reinforced cast-in-place concrete with an asphalt or paver surface finish to support maintenance vehicles. Seaward and landward faces of the buried seawall are covered with the excavated material and planted with native dune vegetation. Phragmites control will be conducted on the seaward faces between Station 65+40 and Station 102+00 within the Oakwood Beach corridor.

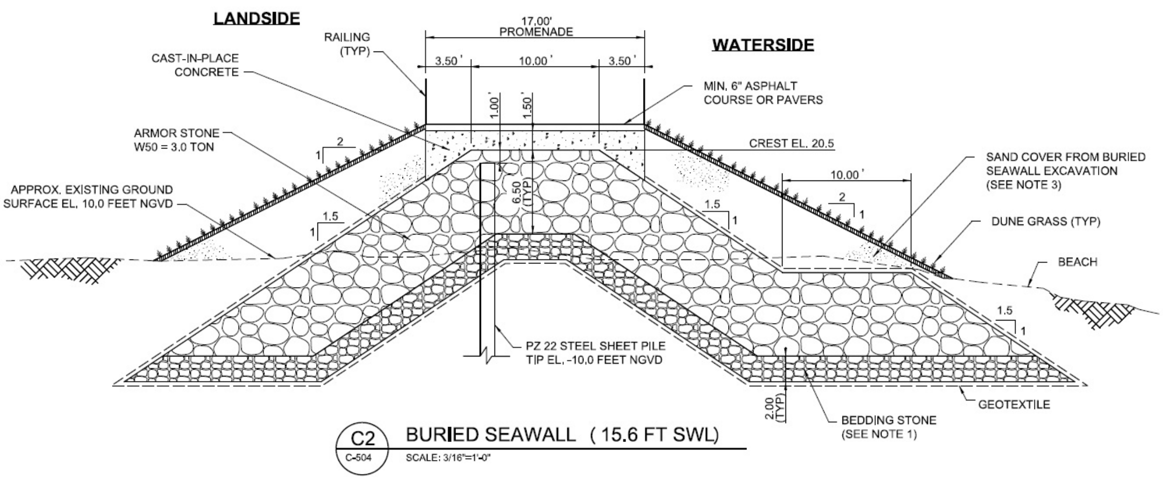

Figure 31 – Buried Seawall Typical Section (Reach A-4)

289. *Miller Field to South Beach (Station 158+00 to Station 268+00):* This 11,000 foot long stretch incorporates a 2.4 mile long, 38-ft wide pile supported promenade to replace the 1.0 mile long 38-ft wide at-grade paved and 1.4 mile long 40-ft wide pile supported promenade of the FDR Boardwalk and esplanade that currently extends between Fort Wadsworth and Miller Field (Figure 32). A new designed pile supported boardwalk integrated into the buried seawall will have a deck elevation of 22.5 ft NGVD. The specific deck surface finishes of the boardwalk will be developed in collaboration with NYC DPR, consistent with the principle of "providing a functional equivalent facility", as described in the Real Estate Plan Appendix. A minimum 3 foot sand cover and native beach vegetation will be placed on seaward facing slope only.

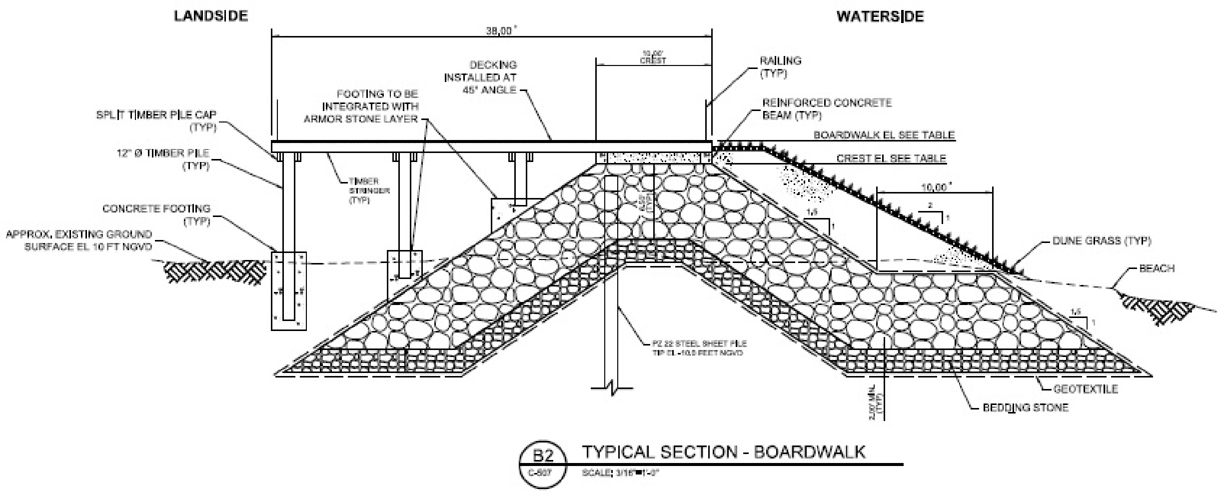

Figure 32 – Boardwalk Typical Section (Reach A-4)

290. Several recreational facilities operated by NYC Parks as well as concessions along the existing at-grade paved esplanade and pile support sections of the FDR Boardwalk have first floor elevations lower than the deck elevation of the designed boardwalk. To provide access to these facilities, the buried seawall design was modified. Landward of the structure crest, the rock slope was replaced by a combination wall comprised of steel H-piles and steel sheet pile. This vertical element accommodates the boardwalk, with a width of 25 feet at elevation 22.5 feet NGVD and a 13-foot wide section that may be ramped down to meet building first floor elevations. The 13-foot section is ADA compliant. The ramp maintains a minimum 12-ft clear distance between railings for two way pedestrian and bicycle traffic. The refined design of the functional replacement boardwalk including the accommodation of the adjacent concessions will be developed in collaboration with NYC DPR during PED.

291. *South Beach to Fort Wadsworth (Station 268+00 to Station 288+00):* The buried seawall in this 2,000 foot section also incorporates a 38-ft wide-foot pile supported promenade as between Station 158+00 to Station 268+00. In this 2,000 foot section, from Sand Lane to Ocean Ave, the width of the armored crest of the buried seawall is increased to 18 ft to accommodate the larger design waves and reduce wave overtopping (Figure 33). The weight of the armor stone and depth of scour protection are also increased to handle the larger design waves.

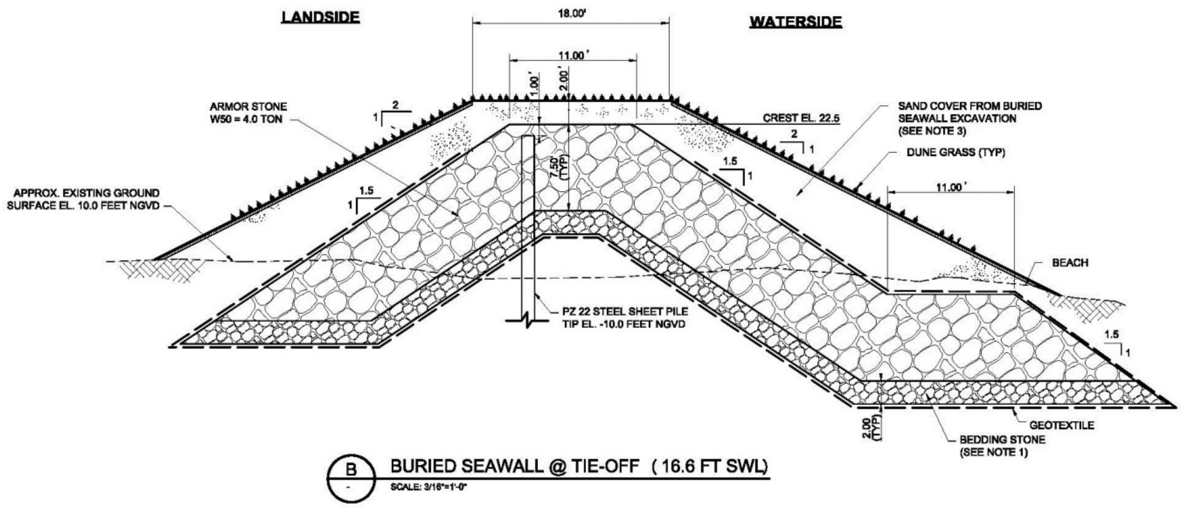

Figure 33 – Buried Seawall Section (Reach A-4)

292. *Fort Wadsworth tie-off:* The section of the buried seawall ties into high ground adjacent the Seaside Plaza Apartments and the south boundary of Fort Wadsworth, the former military installation that is now operated by NPS as part of the Gateway National Recreational Area. This 400 foot stretch includes 17 foot crest width buried seawall (20.5 feet NGVD) with a minimum 2- foot sand cover on top and a minimum 3-foot sand cover on the seaward facing slope. Native dune vegetation will be planted along the seaward face of the structure adjacent to the boardwalk, transitioning to upland grasses and planting along the remaining areas.

7.1.1.2 Closure Structure Details

293. At Hylan Boulevard a closure gate closure structure will be used to close off the roadway as needed to prevent flooding during rare storm events. The closure structure is needed for the Line of Protection (LOP) to function as a comprehensive system and to avoid the flanking of storm surge.

294. The LOP (i.e., the levee, floodwall, and armored levee/seawall) is not expected to impact accessibility to and from the community because it does not impede upon the local roadways. However, in the event that an extreme coastal storm event is projected to make landfall near Staten Island, Hylan Boulevard will need to be closed so that a removable closure structure can be installed in order to close off the study area from high storm surge levels. The closure structure will connect two adjacent levee segments to form a barrier of consistent elevation along the Line of Protection.

295. NYCOEM evacuation strategies call for facilitating evacuation prior to the onset of hazards which would likely be prior to the installation of the closure structure. Hylan

Boulevard is not a part of the Staten Island hurricane evacuation route as of January 2015. Any additional emergency provisions or communication systems would be implemented as part of the Local Flood Risk Management Plan or Emergency Evacuation Plan procedures, which is a part of the non-Federal sponsor responsibility. Figure 34 presents a typical section view. The plan view and structure details of the closure structure are also included in Section 14, Drawings C-515 and C-516.

296. In order to tie-off the optimized NED plan at Drainage Area A (Figure 34), the alignment extends to the north of Hylan Boulevard by approximately 300 linear feet. The grades on Hylan Boulevard are not high enough, at elevation 13 feet NGVD, to prevent floodwaters from affecting areas in Oakwood Beach. Raising of the road would affect existing residential and commercial buildings and existing intersection at Buffalo Road.

297. In order to prevent water from passing through the 110 foot wide opening, closure structure alternatives were considered Comparing closure structure alternatives indicates that a closure structure must have have limited impact on utilities and road closures. However the closure itself could take several hours to gather, deliver and install. Since the proposed crossing at Hylan Boulevard is higher than the 100-year Stillwater stage (12.6 ft. NGVD 1929) and therefore the anticipated number of gate closures is infrequent the stop log gate structure is currently the recommended plan for closing off Hylan Boulevard and economically justified for Feasibility Report purposes.

298. During the Plans & Specifications phase conducted once the Feasibility Report is approved, design refinements will conducted for all plan elements based on tasks such as new topographic surveys, utility survey and geotechnical data. These surveys/analyses will allow USACE to more definitely determine what the appropriate closure structure that will be recommended for construction. If an alternate closure structure is identified and incorporated into the final design, it would be required to be evaluated for construction and environmental impacts to ensure that the appropriate cumulative impacts are evaluated. Design will also be coordinated with New York City Department of Transportation (NYCDOT).

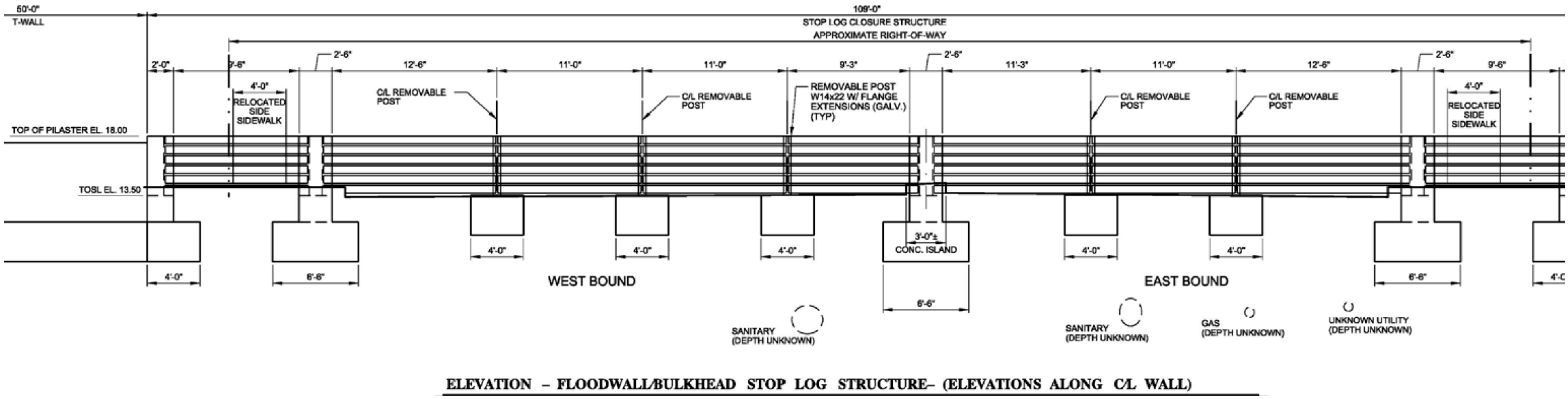

Figure 34 – Typical Section of Closure Structure

7.1.1.3 Stormwater Outfalls/Gate Chambers

299. Existing stormwater outfalls, consisting of single and double concrete box culverts, pass beneath the Buried Seawall at nine locations. In addition two new ocean outfalls are proposed in the Midland Beach area and in South Beach as discussed in section 4.3. At these locations, the sheet pile seepage wall terminates either side of the existing culverts and the buried seawall rock structure will be constructed around the culverts and proposed gate chambers. A typical section view of the designed gate chamber is presented in Figure 35.

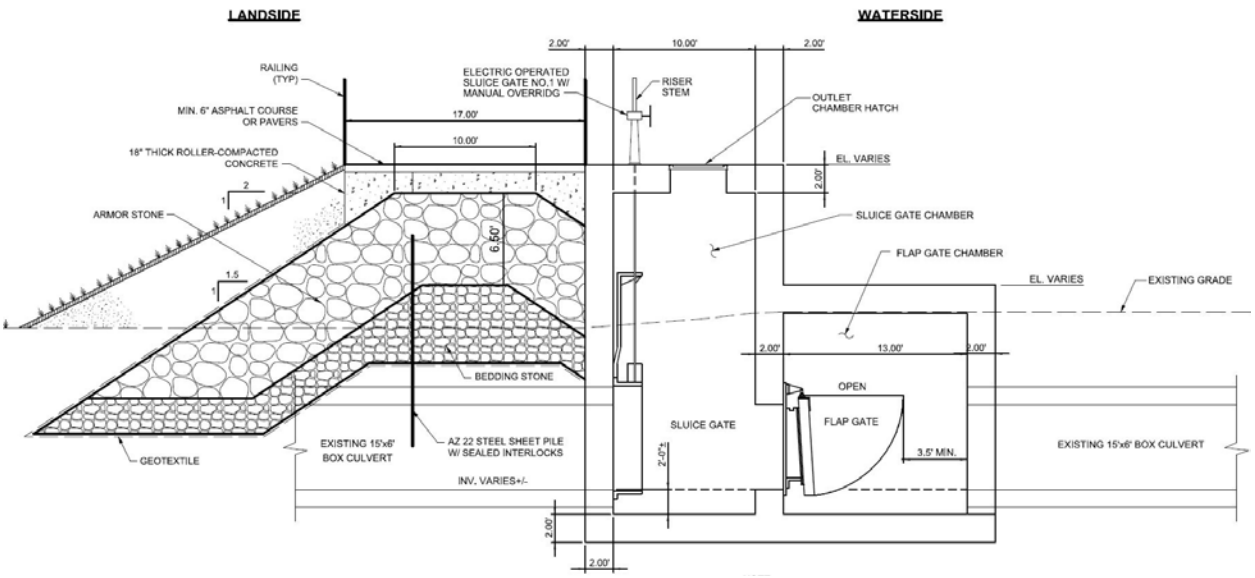

Figure 35 - Typical Section Gate Chamber

7.1.1.4 Tide Gates

300. Tide gate structures with reinforced concrete wing walls are proposed at two locations along the Line of Protection in the vicinity of Oakwood Beach. Aside from increases in wall height and thickness, the basic design of the proposed tide gate structures is consistent with the design of the existing tide gate structure located to the east of the Water Treatment Plant at Oakwood Beach. The tide gate structures are not designed for vehicular loading. Figure 36 presents a typical section of the tide gates.

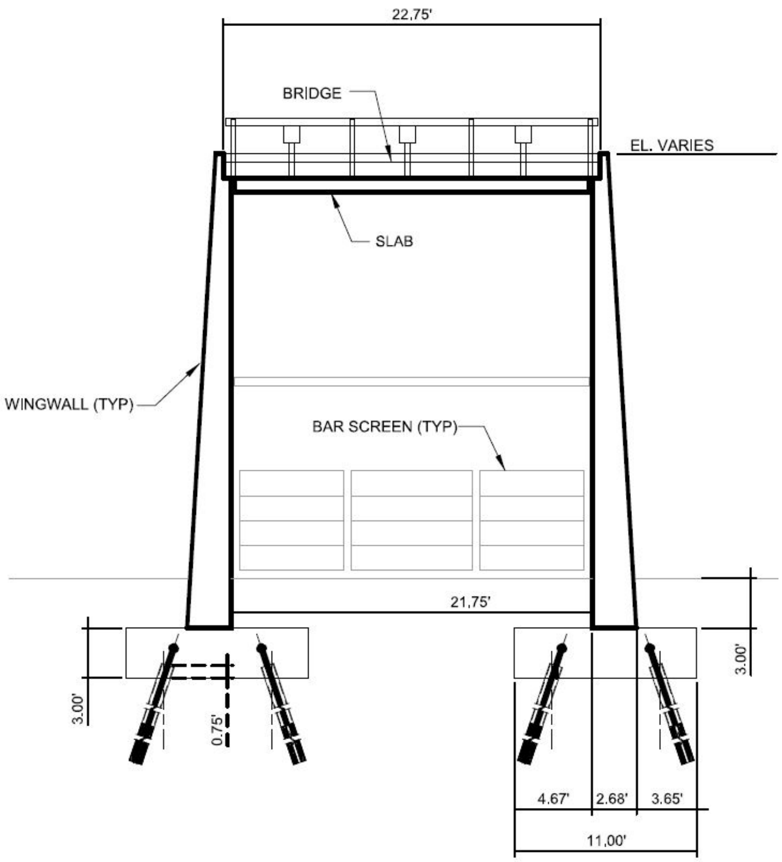

Figure 36 - Typical Section Tide Gate

7.1.1.5 Pedestrian and Vehicular Access

301. Three types of access points are provided along the Line of Protection: Maintenance vehicle access (MVA), combined truck and pedestrian access (DTP), and pedestrian access (PA). Details of the access points are provided in the plan sheets in the Interim Engineering and Design Appendix.

302. Maintenance vehicle access is provided at one location in Reach A-2 and at four locations along Reach A-4 between New Dorp Beach and Oakwood Beach to provide vehicular access to the tide gate and stormwater outfall gate chambers. Earthen ramps are proposed to provide vehicular access to the tide gate and stormwater outfall gate chambers. These ramp sections are designed to handle HS-20 loading to allow maintenance vehicles to access the sluice gates in the drainage structures from above.

303. An additional nine earthen ramps are proposed between Oakwood Beach and South Beach. These ramps are designed for both pedestrian and HS-20 vehicular access and meet the 1:12 maximum slope required by ADA guidelines. The ramps have been located to provide beach access from existing roads and access paths.

304. Pedestrian access points, spaced approximately every 500 feet, are located along the Buried Seawall between Midland Beach and South Beach. Each access point consists of 10-foot wide reinforced concrete stairs on both the landward and seaward sides of the buried seawall that provide access to the promenade and the beach. There are a total of 27 access points for pedestrians along the promenade including combined vehicle/pedestrian access ramps. All access points are ADA accessible. The number, location and design of access points will be coordinated with NYCDPR.

305. The buried seawall crest elevation exceeds the existing deck elevation for the Ocean Breeze fishing pier. The pier segments nearest to the promenade will need to be reconstructed to ramp up to the promenade at a 1:12 maximum slope required by ADA guidelines.

7.1.2 Interior Drainage Measures

306. The Interior Drainage measures as part of the NED Plan include tide gates, sluice gates, stormwater outfall structures, road raisings, and excavated ponds. The tide gates, sluice gates and outfall chambers are listed above as part of the Line of Protection design but are also included in this summary. The Interior Drainage Measures utilized in each of Drainage Areas are described followed by a descriptive figure.

7.1.2.1 Area A: Minimum Facility

Natural Storage: 17.19 acres (acquisition and preservation of open space)
Tide Gate
- Length: 22.75 ft. along levee alignment
- Height: 18 ft. NGVD 1929 crest elevation
- Width: 16 ft. wide
- Features: 3 @ 5 ft. by 5 ft. sluice gates, wingwalls, pre-engineered bridge on top of the tide gate

Outlets: 2 sluice gate structures (2 ft. by 2ft.) & 2 intermediate pipe outlets with flap gates

Figure 37 – Drainage Area A

7.1.2.2 Area B: Minimum Facility

Natural Storage:	86.41 acres (acquisition and preservation of open space)
Excavated Pond:	1 Pond
Volume:	94,200 c.y.
Area:	46 acres
Invert:	2.75 NGVD 1929
Tide Gate	
Length:	22.75 ft. along levee alignment
Height:	20.5 ft. NGVD 1929 crest elevation
Width:	16 ft. wide
Features:	3 @ 5 ft. by 5 ft. sluice gates, wingwalls, pre-engineered bridge on top of the tide gate
Road Raising	Kissam Ave. to 7.1 ft. NGVD 1929, Mill Rd. to 7.1 ft. NGVD 1929
Length:	1,730 lf. @ Kissam Avenue & 630 lf. @ Mill Road
Width:	30 ft. @ Kissam Avenue & 60 ft. @ Mill Road
Avg. Height:	3 ft. @ Kissam Avenue & 1 ft. @ Mill Road
Outlets:	Ebbits Street, New Dorp Lane, Tysens Lane outfall Gate Chambers
Pond Restoration	
Planting:	Wetland plugs 2.5 ft on center
	Phragmites control for 5 years

Figure 38 – Drainage Area B

7.1.2.3 Area C: Alternative 4

Natural Storage:	120.44 acres (acquisition and preservation of open space)
Excavated Ponds	7 ponds
Volume:	377,200 c.y.
Area:	100.51 acres
Invert:	2 ft. NGVD 1929
Road Raising	Seaview Ave. & Father Capodanno Blvd. to 10 ft. NGVD 1929
Length:	820 lf. @ Seaview Ave & 300 lf @ Father Capodanno Blvd.
Width:	90 ft. @ Seaview Ave & 60 ft. @ Father Capodanno Blvd.
Avg. Height:	1 ft. for both
Outlets:	Greely Avenue, Midland Avenue, Naughton Avenue, Seaview Avenue outfall Gate Chambers

Figure 39 – Drainage Area C

7.1.2.4 *Area D: Minimum Facility*

Natural Storage:	30.76 acres (preservation of open space)
Outlets:	Quintard Street Outfall Gate Chamber

Figure 40 – Drainage Area D

7.1.2.5 Area E: Alternative 2

Natural Storage:	46.7 acres (acquisition and preservation of open space)
Excavated Ponds:	2 Ponds
Volume:	222,720 c.y.
Area:	34.0 acres
Invert:	2 ft. NGVD 1929
Outlets:	Sand Lane outfall Gate Chamber, Quincy Ave. Gate Chamber

Figure 41 – Drainage Area E

307. Detailed plan view drawings of the Interior Drainage Measures are available by Drainage Area in Figures 37 through 41.

7.1.2.6 Ponds

308. Drainage Areas B, C, and E include ponds excavated to 2 ft. NGVD 1929. The pond locations are shown on the Interior Drainage area, Figures 37 through 41 and details on the pond design and specifications may be found in the Draft Interior Drainage Appendix. The Figures also include overlays of all of the other Interior Drainage

Measures included in the NED Plan such as flowage easements, road raisings, tide gates, etc. as well as the alignment of the Line of Protection.

7.1.2.7 Road Raisings

309. The recommended plan includes road raising for three (3) roads: Seaview Avenue (@ Father Capodanno), Kissam Avenue and Mill Road.

Seaview Avenue

310. Based on the original survey conducted for this analysis, the maximum road raising to obtain elevation +10.0 feet NGVD at Seaview Avenue is approximately 2.5 feet and 1.5 feet along Father Capodanno Boulevard (FCB). Final geometry/ roadway elevations will be established during the design phase, in collaboration with the State and City of New York.

311. Seaview is to be raised to control the spillover of interior water between Interior Drainage Areas C and D. Father Capodanno is to be raised to meet the new crest elevation at Seaview.

312. Along Father Capodanno there should be no issue with raising the intersection of FCB/Seaview Avenue up to 1.5 feet or tying back into higher ground east and west of the intersection. On Seaview Avenue there may be some issue with grading down from elevation 10+/- NGVD to the homes located on the west side of the road between Quincy Avenue and Oceanside Avenue which are generally between elevation +7 feet NGVD and +8 feet NGVD based on the two foot contours. This would make the driveway slope at least 10 to 15%. Additional survey would be needed for the design in the design phase. The eastside should have no issues with grading. The roadway transition onto Quincy and Oceanside Avenues may also impact a few additional residential structures on the north side of the road.

313. Items of note include the need to make sure that the raising does not cause any clearance issues with the traffic signals, sight distance issue, lights etc. Additionally, some raising/adjustment of hydrants, valves, inlets, manholes etc may be required.

Mill Road and Kissam Avenue

314. The Mill Road raising will disallow the spillover of floodwater from Interior Drainage Area A to Interior Drainage Area B up to the 100-yr event used in this interim feasibility study whereas the Kissam Avenue road raising provides vehicle access to the buried seawall/armored levee during storm events where the surrounding roadways will be inundated. Intermittent culverts and drainage structures will be utilized to convey the flow through Kissam Avenue towards the tide gate. New gate chambers are to be added at the existing Ebbits Street, New Dorp Lane, and Tysens Lane outfalls.

315. Kissam Avenue will be raised as part of the Minimum Facility Plan to allow additional drainage culverts to convey flow towards the Area B tide gate.

7.1 feet NGVD29 = (6.0 ft. NAVD88).

Road Raising Kissam Ave. to 7.1 ft. NGVD 1929, Mill Rd. to 7.1 ft. NGVD 1929
Length: 1,730 lf. @ Kissam Avenue & 630 lf. @ Mill Road
Width: 30 ft. @ Kissam Avenue & 60 ft. @ Mill Road
Avg. Height: 3 ft. @ Kissam Avenue & 1 ft. @ Mill Road
Outlets: Ebbits Street, New Dorp Lane, Tysens Lane Gate Chambers

316. With the proposed acquisition of most of the properties surrounding these two areas, the impact of these two road raisings is limited. No private properties are expected to be impacted by the raising of these roads.

Crown Roadway and Access Ramps

317. The levee crown should be maintained and all crown roadways, ramps, and access roads should be properly maintained and kept serviceable. This work involves periodically grading and gravelling road surfaces.

Non-Federal Responsibility

318. In accordance with USACE guidance (USACE Planning Guidance Letter No.16), road raisings are considered "relocation" and therefore, are subject to LERRDs cost sharing requirements, accordingly. Relocations are 100% non-Federal responsibility subject to credit towards construction cost share requirements. As such, legal grade determination is also a non-Federal responsibility.

Communications Plan

319. During the Plans & Specifications phase of the project, individual properties will be identified that may/will be affected by road-raising activities. Affected owners will be notified and a public meeting scheduled to discuss the design the design and construction of road raising details. This public meeting will give individuals an opportunity to express any concerns or provide additional information that may determine if design modifications/refinements are required. This public meeting will occur after the non-federal sponsor and local stakeholders have had the opportunity to review and approve the design details and will be conducted in coordination/cooperation with the NYCDOT.

Locations of road raisings are also identified on the Drainage Area Figures 37 through 41.

7.2 Project First Costs

320. For the detailed cost estimate, project quantities were developed using On Screen Take-Off (OST), Microsoft Excel calculations, and manual calculations, where applicable. The cost estimate was compiled using the Micro-Computer Aided Cost Estimating System, Second Generation (MCACES 2nd Generation or MII).

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

322. The engineering estimates utilized to compare and identify the NED Plan did not include detailed cost estimating factors such as prime, subcontractor and overtime mark-ups. The engineering estimate used for the comparison and identification of the NED Plan was approximately 2% lower than the Project First Costs from the MII Cost estimate, which is presented below.

323. The specific components in the cost basis are outlined in the Draft Cost Appendix. Cost contingencies were developed through a standard Cost and Schedule Risk Analysis (CSRA). The Project First Cost (Constant Dollar Basis) for the NED Plan is approximately $528.4 million. Project First Costs for the NED Plan by line item are presented in Table 26.

7.3 Real Estate Requirements

324. The Project impacts 666 parcels, affecting 270 private owners and 396 public owners (including two Federal agencies). In some instances, more than one estate is required to be obtained over the lands of the same owner.

Easements

325. Six types of Standard Estate easements are required for the Coastal Storm Risk Management project. They are as follows:

- *Flowage Easements*[7] – Portions of land to be subjected to permanent inundation and portions to be subjected to occasional flooding. Flowage easements will be required where excavation of ponding areas will increase frequency and duration of flooding.
- *Flood Protection Levee Easement* – Portions of land required for the construction, operation and maintenance of the Line of Protection.
- *Restrictive Easement* – Portions of land restricted from any future development. This is essential to the effectiveness of ponding areas.
- *Temporary Work Area Easement* – Portions of land required for staging/work area purposes. The required temporary work areas are typically adjacent to land to be acquired for construction of the Line of Protection
- *Pipeline Easement* - required for the construction, operation and maintenance of an underground storm water drainage structure.
- *Road Easement* - required for the construction of an access road to provide access to sewer manhole.

Flowage Easements	112.08 acres
Flood Protection Levee Easements	87.62 acres[8]
Restrictive Easements	143.84 acres
Temporary Work Area Easements	62.62 acres
Pipeline Easement	0.09 acres
Road Easements	1.14 acres

326. The Project provides the construction of 10 ponds across Interior Drainage Areas B, C, and E. Changes in flood depth for each of the proposed excavated ponds are identified in Table 10 of Interior Drainage Analysis (Appendix II). Based upon the available data, a Physical Taking Analysis prepared by the District's Office of Counsel concluded that the current Draft Study for the Project does not appear to require use of a standard flowage easement. However, the District's Real Estate Division asserts that the standard flowage easement would be appropriate for East Pond located in Interior Drainage Area B and that further analysis and consideration is needed for the ponds in Interior Drainage Areas C and E. Since there is not concurrence on this issue at the time of the release of the Draft Interim Feasibility Report, the Office of Counsel and Real Estate Division will continue to coordinate on this issue and resolve prior to release of the Final Report, which will contain a final Physical Takings Analysis.

[7] Flowage easements are required in the optimization of the National Economic Development Plan to store interior flooding during high intensity precipitation storm events

[8] Real Estate Easement acreages based on the Real Estate Plan dated May 2015. Real Estate acreages and values in this Interim Report are subject to change pending Federal review and coordination

Table 26: NED First Project Costs*				
Description	**Amount**	**Cont.%**	**Cont. $**	**Total**
01 - Lands and Damages				
LER	$29,828,000	39.3%	$11,710,000	$41,538,000
Relocations (Road Raisings)	$3,605,000	39.3%	$1,440,000	$5,045,000
Relocations (Boardwalk)	$28,621,000	39.3%	$11,237,000	$39,858,000
			Subtotal	**$86,441,000**
11 - Levees and Floodwalls				
Mob/Demob	$1,335,000	39.3%	$536,000	$1,871,000
Construction	$199,903,000	39.3%	$78,550,000	$278,453,000
			Subtotal	**$280,324,000**
15 - Interior Drainage				
Area A	$3,630,000	39.3%	$1,425,000	$5,055,000
Area B	$14,381,000	39.3%	$5,646,000	$20,027,000
Area C	$29,090,000	39.3%	$11,435,000	$40,525,000
Area D	$2,022,000	39.3%	$794,000	$2,816,000
Area E	$12,940,000	39.3%	$5,090,000	$18,030,000
			Subtotal	**$86,453,000**
30 - Engineering & Design	$35,548,000	39.3%	$13,970,000	$49,518,000
31 - Construction Management	$18,432,000	39.3%	$7,244,000	$25,676,000
TOTAL	**$379,334,000**		**$149,078,000**	**$528,412,000**

*Minimum Facility Costs are captured under "15 - Interior Drainage"

7.4 Operation and Maintenance Considerations

327. The O&M Plan includes annual inspections of the Line of Protection and its features such as the road closure structure, gate chambers, stop log structure, tide gates, access ramps, mowing of the flowage easements and maintenance of the ponds, as well as the sand/soil cover over the buried seawall. The O&M costs also include annual inspections and maintenance of the interior drainage features and include the annualized cost of replacement of interior drainage appurtenant structures (e.g., gates, backflow valves, sluice gates, etc.) at the end of their useful project life of approximately 25 years. The total annual O&M costs are estimated to be $555,000.

328. Specific tasks relating to the Line of Protection Measures include:

- Annual survey (including surveying of the buried seawall and earthen levee), visual observations, aerial photography and summary report of conditions at an annual cost of $71,000.

- Replacement of sand cover ($84,000 annually), dune grass replanting over the buried seawall due to wind movement, poor establishment of plants ($20,000 annually), and levee mowing ($3,000 annual cost).

- Closure gate testing and maintenance, with an estimated annual cost of $20,000. Operation and Maintenance will be required to be coordinated with NYPD/FDNY and the NYC Office of Emergency Management.

329. Interior drainage features and line of protection (LOP) annualized replacement costs and O&M, as shown in Table 27.

Table 27: Annual O&M Costs	
Project Element	**O&M; Replacement Costs**
AREA A	$39,000
AREA B	$93,000
AREA C	$159,000
AREA D	$17,000
AREA E	$49,000
Project Element	**O&M**
LOP	$198,000
Total	**$555,000**

330. The O&M cost basis is outlined in the Draft Cost Appendix.

7.5 Residual Flooding Under NED Plan

331. The National Economic Development (NED) Plan for the South Shore of Staten Island Interim Study is designed to manage the risk from exterior coastal surge and from interior precipitation-runoff flooding. Residual flooding, by definition, is the flooding that still occurs with the NED Plan in place. For the studied 500 year peak coastal surge level, the peak flooding stage exceeds the design level of the Line of Protection measure in the NED Plan, which is designed to a 15.6 ft. NGVD 1929 stillwater stage. The overtopping in this case will create flood levels throughout the study area equivalent to the without-project condition. While the peak interior and exterior flood stages in the study area will be coincident during a hypothetical 500-yr storm event, they will vary during the other studied frequency intervals.

332. The predicted exterior flood stages from FEMA's forthcoming coastal Flood Insurance report are presented in Table 28 and the residual (with-project) peak interior flood stages are presented in Table 29. The residual peak interior flood stages are the expected flood conditions from the Interior Drainage Analysis. From the analysis it was found that the risk condition can increase or decrease according to the relationship between the interior and exterior stages. This phenomenon is characterized by three separate likelihoods or combinations of interior/exterior events: the lower bound, expected, or upper bound condition. For this study, the expected condition is used as the condition for recording with project damage reduction, but there is still a chance that a worse flooding condition could occur.

333. To communicate the increased risk associated with the upper bound condition, the "with" project inundation extents presented in Figure 42 depict both the expected (blue hatch) and upper bound (green) conditions for the 100-yr event. The figure also depicts the without project condition (gray). In addition, residual flood maps, depicting the flood risk for the 10-yr, 50-yr, 100-yr, and 500-yr) expected condition for each Drainage Area, are presented in the Draft Interior Drainage Appendix.

Table 28: Peak Exterior Stillwater Elevations for Project Area (FEMA)

Frequency of Occurrence in years	Stillwater Stage (ft. NGVD 1929)
10	8.5
50	11.3
100	12.6
500	15.9

Table 29: Peak Residual Interior Flood Stages				
Drainage Area (TSP Plan)	Peak Residual Flood Stages (ft. NGVD 1929)			
	10-yr Event	50-yr Event	100-yr Event	500-yr Event*
Area A (Minimum Facility)	6.41	6.93	7.10	15.9
	7.51	8.04	8.22	
Area B (Minimum Facility)	5.48	6.00	6.21	15.9
	5.84	6.55	6.86	
Area C (Alternative 4)	3.28	4.17	4.53	15.9
	4.89	6.25	6.75	
Area D (Minimum Facility)	8.62	9.62	9.78	15.9
	9.52	10.35	10.35	
Area E (Alternative 2)	5.54	6.42	6.84	15.9
	6.05	7.39	8.04	

*Exterior Stillwater Elevation exceeds Project Design and overtops into all Drainage Areas

334. The risk analysis and economic performance of the selected plan, as required by ER 1105-2-101, "Risk Analysis for Flood Damage Reduction Studies (USACE, January 3, 2006) are provided in a sub-appendix to the Economics Appendix. Specifically it assesses the engineering performance of the project in terms of:

- The annual exceedance probability
- The long-term risk of exceedance
- The conditional non-exceedance probability

7.5.1 Residual Flood Damage

335. The NED Plan will provide risk management for the two most common sources of flood damage in the Study Area: Hurricanes and Nor'easters. The Line of Protection will be the first line of defense against surge and wave action during future coastal events. Extremely rare frequency coastal events where the stillwater level exceeds the 15.6 NGVD 1929 NED Plan design level (the 100-yr stillwater elevation + 3 ft.) such as a 500-yr Hurricane or an even more rare event, may cause damages to structures and life-safety risks that are comparable to those seen during Hurricane Sandy. Though the damages from overtopping surge may be similar to Sandy, the chance that the Line of Protection will be overtopped will drastically decrease with the implementation of the project, effectively reducing the risks to life and property within the study area.

336. It, however, will not eliminate all flood related damages behind the Line of Protection. There are a number of structures within the study area that are still at risk of being flooded above adjacent ground level due to interior run-off flooding during the with-project condition. Figure 42 shows the residual flooding along with restrictive and flowage easement for the study area.

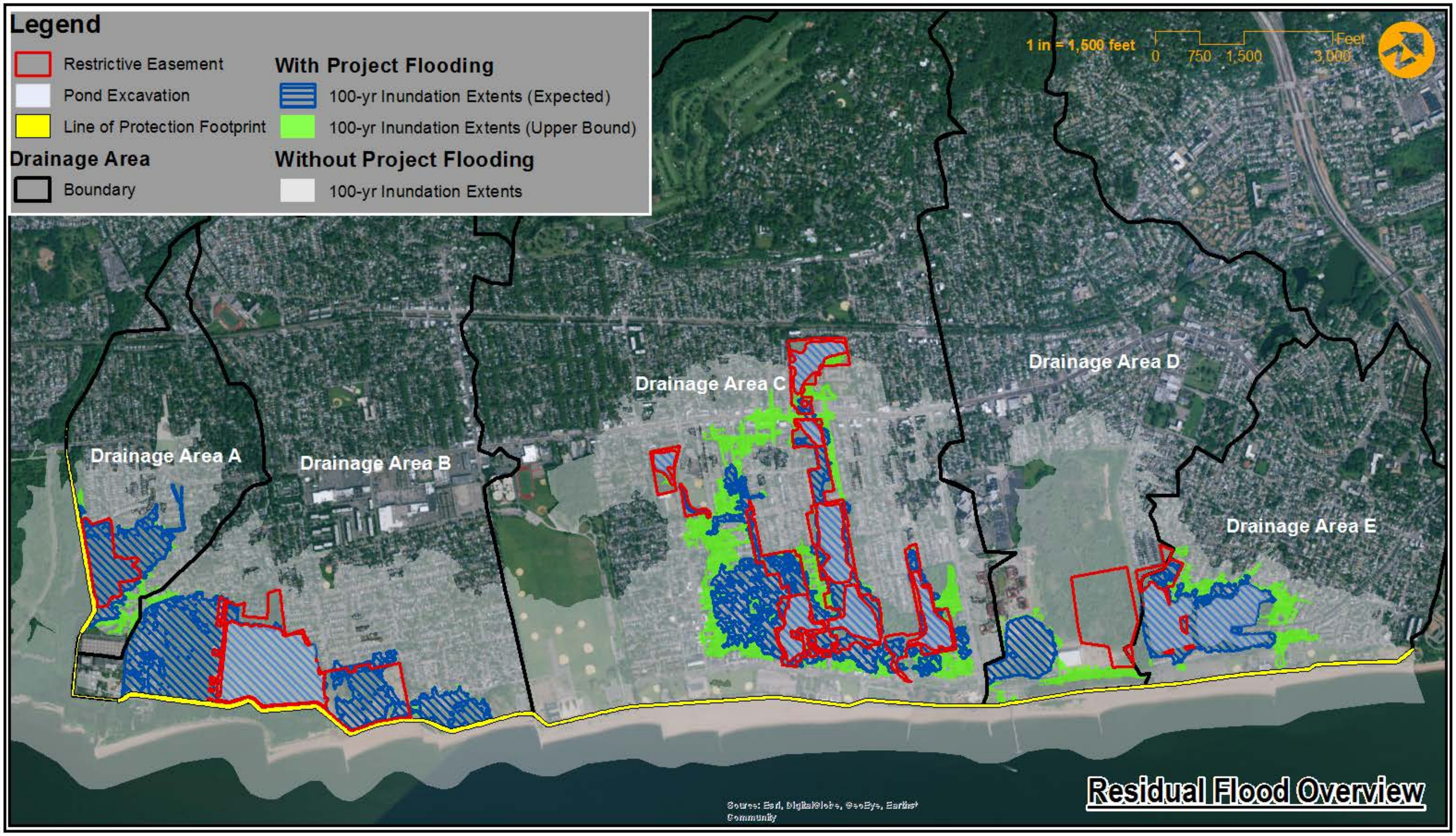

Figure 42 – Residual Flood Overview

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337. The counts of structures by frequency and Drainage Area that experience flooding at least above the adjacent grade in both the without and with-project conditions are presented in Table 30. Table 31 shows the residual damage values by Economic Reach and Drainage Area.

Table 30: Damage, Residual Flooding						
Drainage Area	**Number of Structures Flooded**					
	10-yr Event		**50-yr Event**		**100-yr Event**	
	Without Project	**With Project**	***Without Project***	**With Project**	***Without Project***	**With Project**
Area A	*20*	8	*198*	11	*287*	15
Area B	*335*	11	*962*	11	*1,144*	33
Area C	*1,325*	95	*2,402*	334	*2,579*	337
Area D	*11*	11	*149*	33	*212*	33
Area E	*171*	34	*408*	43	*460*	43
Totals	***1,862***	**159**	***4,119***	**432**	***4,682***	**461**

Table 31: With Project Residual Damage Summary*	
Economic Reach	**Equivalent Annual Damage**
FWOB-1	$9,000
FWOB-2	$570,000
FWOB-3	$883,000
FWOB-4	$2,771,000
FWOB-5	$483,000
FWOB-6	$93,000
FWOB-7	$188,000
FWOB-TP	$68,000
Boardwalk	$111,000
Total	$5,176,000
Drainage Area	**Equivalent Annual Damage**
Drainage Area A – Minimum Facility	$85,000
Drainage Area B – Minimum Facility	$116,000
Drainage Area C – Alternative 4: 377,200 cy, 6 Ponds	$1,256,000
Drainage Area D – Minimum Facility	$137,000
Drainage Area E – Alternative 2: 222,720 cy, 4 Ponds	$289,000
Total	$1,878,000
Total With Project Damage	**$7,059,000**

*Residual damage summary presents equivalent annual damages based on overtopping the Line of Protection and residual interior flooding for the drainage areas.

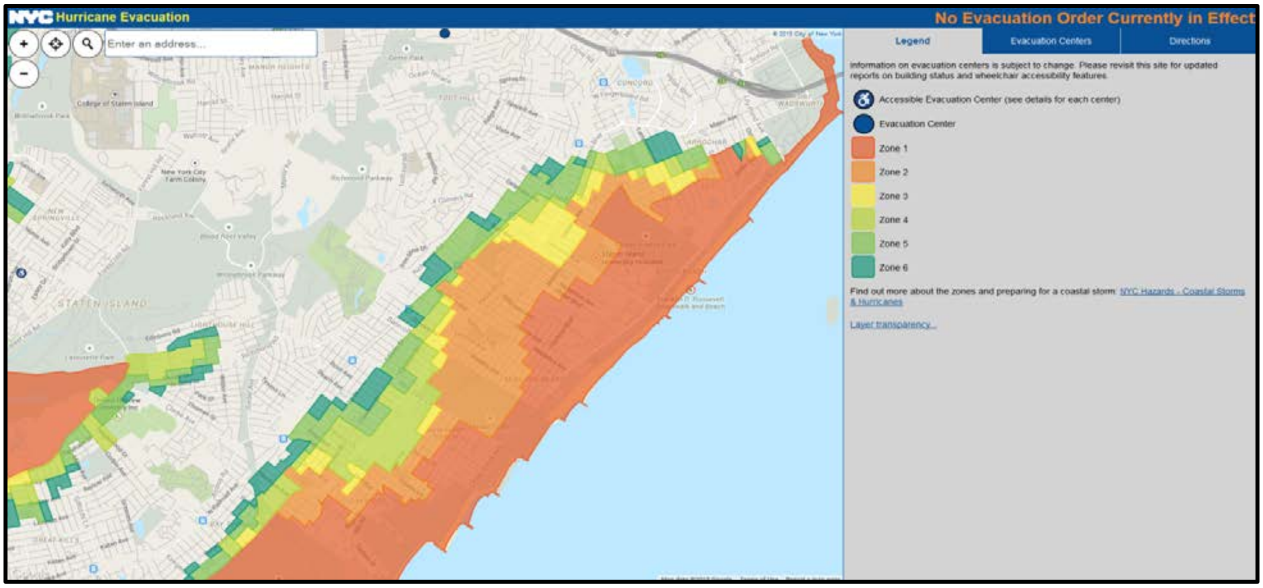
7.5.2 Potential Loss of Life

338. The implementation of the NED Plan will not eliminate the potential for loss of life. The NED Plan will reduce the risk of loss of life by reducing the frequency of flooding from Bay surge. Under design conditions, instead of high velocity overtopping flows from the coast, the Interior Drainage Areas will experience pools of water in low-lying areas from surface run-off. Interior Drainage flooding is predicted to have waters that rise over two feet per hour in some areas, which may generate life safety risks in addition to those created by the depth of flooding alone.

339. A coastal storm event that produces surges that exceed the capacity of the Line of Protection stillwater design, could create a situation similar to Hurricane Sandy (October 29-30, 2012 where there were fourteen deaths within the study area alone.

340. New York City has an education and outreach program called ReadyNY, which campaigns to increase hurricane evacuation awareness among NYC residents. To support this objective, New York City Emergency Management runs a Web site that provides a broad approach to communicating preparedness and evacuation information. Of note on the Web site is a "Zone Finder" online mapping tool (shown in the figure below) to inform the public which evacuation zone they reside and what evacuation procedures to adhere in the event of a significant coastal storm event. The online mapping tool also shows the locations of the evacuation centers, which are the central nodes for a system of shelters strategically placed throughout the City that would be put in use in the event that an evacuation order was in effect. In addition to the functionality included on the New York City Emergency Management website, the ReadyNY program supports presentations at schools and Senior Citizen communities and a coastal storm awareness month to convey the strategy and significance of the NYC coastal storm preparedness plan. In the event of a coastal storm, official evacuation orders are sent through a wide range of networks to communicate the level of risk to the public. Further, as part of the "Know Your Zone" campaign implemented by New York City Emergency Management, signs are displayed in the windows of city businesses indicating which zone they occupy for evacuation awareness. http://www.nyc.gov/html/oem/html/get_prepared/know_your_zone/knowyourzone.html

341. Media broadcasts, e-mail and twitter alerts, and Wireless Emergency Alerts are all sent to notify NYC residents at risk. Special attention is given to notify those who are homebound or need special assistance.



342. Evacuation orders are issued by evacuation zone by the City Mayor's office and are based on the maximum possible surge levels as modeled by the SLOSH model's maximum envelope of water (MEOWs) based upon the storm's predicted intensity and direction (bearing). Evacuation decisions typically must occur before real-time/storm specific probabilistic storm surge forecasts are made available by the National Hurricane Center, usually when a Tropical Storm or Hurricane Watch is issued. Any person living in a zone or area with an evacuation order in place is required to vacate the area and seek shelter away from the storm at a friend/family's home or at one of the evacuation centers. Evacuation of healthcare facilities should begin 72 hours before the onset of tropical storm force winds and the evacuation of the general public should begin 48 hours before the onset of Tropical Storm force winds.

343. As part of the South Shore of Staten Island Coastal Storm Risk Management Feasibility Study, New York City Emergency Management should conduct an analysis of the existing evacuation zones/routes within the study area upon plan implementation to ensure the appropriate level of evacuation safety.

7.5.3 Critical Infrastructure

The wastewater treatment plant and interceptor sewerage pipe for the plant are the most significant critical infrastructure within the study area. Approximately 80% of the Oakwood Beach Wastewater Treatment Plant's sewerage interceptor pipe is landward of the line of protection. For areas where the interceptor is seaward of the line of protection, the design includes an access road seaward of the buried seawall to provide access and facilitate operation and maintenance of the wall and interceptor pipe. The access road construction includes the elevation of the interceptor manholes to +10 feet NGVD, and sealing of the manhole covers. The area seaward will remain exposed to inundation. There is a risk of flooding from storm surge due to a storm greater than a 4% annual exceedance probability, when the surge height exceeds the height of the access road.

The level of risk reduction for storm-water entry into the interceptor pipe is less than could be provided if the interceptor pipe was located landward of the line of protection. Relocation of the interceptor pipe is not included as a project feature. Relocation of the sewer pipe to an area landward of the line of protection, with raised manhole covers, if implemented by others would further reduce the risk of storm water intrusion into the system, complement the storm damage reduction provided by the recommended plan, and improve the functioning of the Oakwood Beach waste water treatment plant by further reducing the amount of storm water discharge that may occur under high surge events.

The WWTP is currently subject to flooding when storm elevations reach the micro-strainer building at +10.6 ft NAVD. During Hurricane Sandy, storm surge elevations were reported as +13.1 ft NAVD near the WWTP. The proposed line of protection is designed to reduce damages from flooding with storm surges up to 14.5 ft NAVD. The buried seawalls, levees and floodwalls will reduce the probability of flooding (under current sea level conditions) from approximately 5% per year to below 0.4% per year.

Areas behind the line of protection may sometimes be flooded from interior runoff, seepage or other sources of inflow. Because the plant is at a higher elevation than adjacent areas, runoff is directed away from the WWTP and will pond in the lower lying areas when high stages block the stormwater outfalls. At the WWTP an additional source of flooding is overflow from the wastewater process during high storm tides, when the wastewater is blocked from the high surge conditions. The effects and flood damage associated with overtopping from the treatment process are part of the residual interior flood conditions.

The solution to address the overflow of the wastewater under high surge conditions would be the construction of an effluent pumping system, likely consisting of pumps and a surge tank to overcome the hydrostatic pressure of tidal conditions and head loss through the outfall. In order for USACE to recommend the construction of an effluent pumping system, the costs of this system would need to be offset by the reduction in flooding damages that would accrue from the system. The District has evaluated the vulnerability of the plant, and the storm damages that would remain with the line of protection in-place. The Corps has determined that the construction of an effluent pumping system to maintain discharge capacity against storm flood elevations for purposes of storm damage reduction would not be economically supported based upon the cost of the effluent system and the reduced damages to the sewage treatment plant, and surrounding areas. It is recognized that an effluent pumping system would allow the WWTP to maintain operations and discharge capacity under high surge conditions and provide additional benefits beyond what the Corps can consider as storm damage reduction benefits. The construction of an effluent pump, if undertaken by others would complement the existing storm damage reduction benefits of the project by further reducing the flooding damages and negative environmental effects that would continue to occur under high surge conditions.

8. ECONOMIC ANALYSIS OF THE NED PLAN

8.1 Overview

344. The NED Plan First Project Cost is approximately $528 million, which includes a contingency of approximately $149 million as determined in the Cost and Schedule Risk Analysis (CSRA).

8.2 Interest During Construction

345. Interest During Construction (IDC) is a time value adjustment of money invested before completion of the project. The IDC begins with the final design in PED to determine the total investment in the project and is calculated by computing interest at the applicable project discount rate on the monthly expenditures, from the start of PED to the completion of the project. The project is currently estimated to take approximately 3.5 years to construct with an approximately 17-month PED effort. This value is simply an economic time value adjustment and does not require monetary expenditures. It is used to estimate annual NED costs for economic evaluation. The interest rate utilized is 3.375% over the 3.5-year period.

8.3 Annual Cost

346. The cost basis for the detailed cost estimate is a combination of MII's 2012 English Cost Book, estimator-created site specific cost items, local subcontractor quotations, and local material suppliers' quotations. For the purposes of updating the Cost Book to present day pricing, a current, area-specific labor library was used to reflect market labor conditions. Major material costs were verified. For cost book material items that did not reflect current commodities pricing, vendor quotes were obtained and estimator judgment applied where warranted. The Draft Cost Appendix presents the basis for the project costs as summarized in Table 32.

Table 32: Annual Project Cost	
Project First Cost	**$528,412,000**
IDC	$31,641,000
Total Investment	$560,053,000
Annualized Investment	$23,341,000
O&M	$555,000
Major Rehab	$115,000
Project Annual Cost	$24,011,000

8.4 Annual Benefits

347. The Project Benefits are based on the damages that will be prevented by the project and annualized over the 50-year period of analysis. The Draft Benefit Appendix presents the basis for the project benefits as summarized inTable 33.

Table 33: Annual Project Benefit	
Total Benefit	**$27,732,000**

8.5 Feasibility Assessment

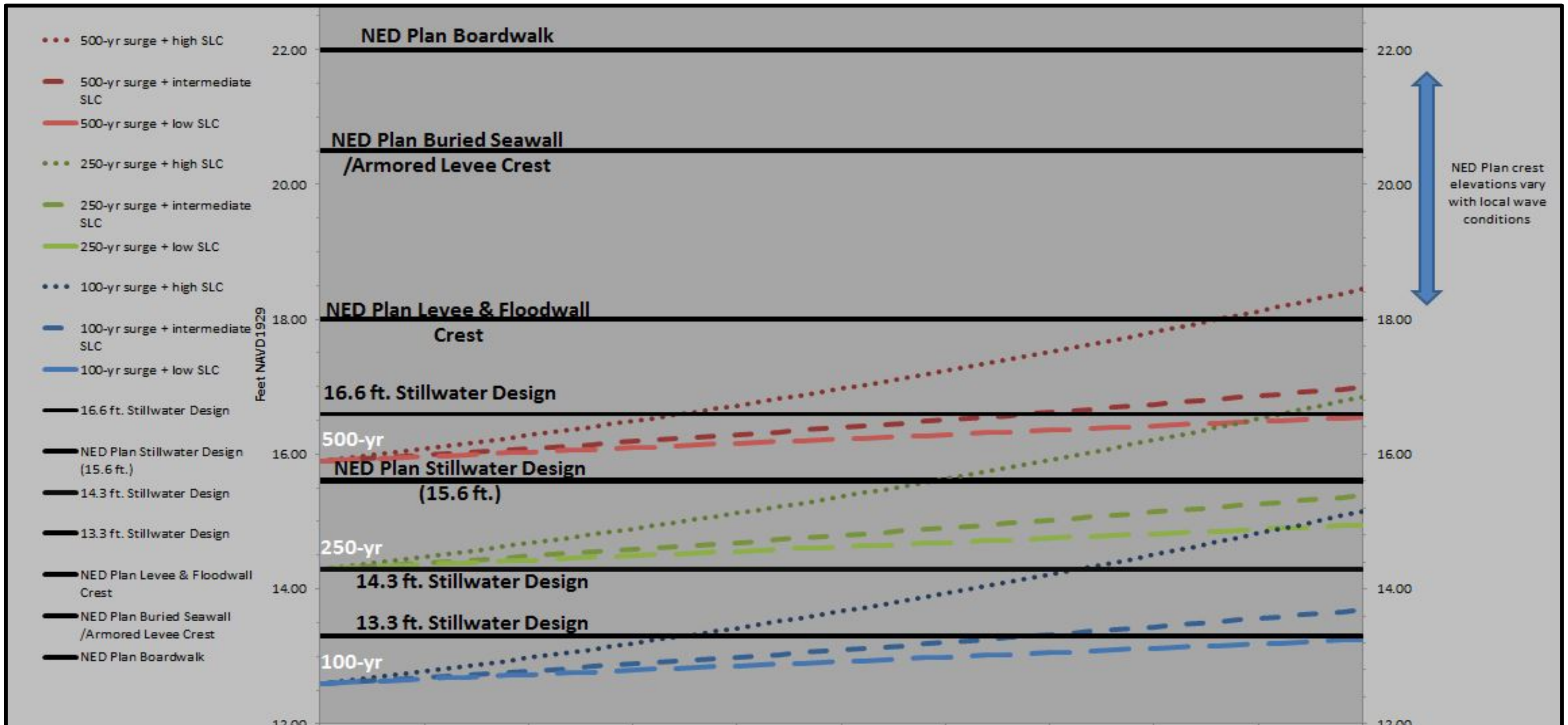
348. An economic comparison of the annual costs and benefits as presented in Table 34 provides the basis for a decision as to whether or not the NED Plan is a feasible Coastal Storm Risk Management Solution. With Net Benefits of $3.5 million per year and a Benefit to Cost ratio of 1.2, the NED Plan as recommended in this interim feasibility study presents a feasible solution that meets the planning objectives and NED criteria.

Table 34: Feasibility Assessment	
Annual Benefits	$27,732,000
Annual Costs	$24,011,000
Net Benefits	$3,721,000
BCR	1.2
Economically Feasible	**Yes**

8.6 Sensitivity Testing – Sea Level Change

349. Current USACE guidance requires that potential relative sea level change must be considered in every USACE coastal activity as far inland as the extent of estimated tidal influence. The base level of potential relative sea-level change is considered the historically recorded changes for the study site, which is estimated to be an increase of 0.013 feet/year. All economic analyses for which results are tabulated in previous sections of this report were based on this historic rate of sea level change. However, in accordance with Engineering Regulation ER 1100-28162 (incorporating Sea Level changes in Civil Works Program, 31 Dec 2013), proposed projects must be also evaluated for a range of possible sea level rise rates: In addition to the historical rate ("low") which is a 0.7 ft. increase over the period of analysis, the project must also be evaluated using "intermediate" and "high" rates derived from modified NRC Curves I and III, which for this Interim Study are estimated to be 1.1 ft. and 2.6 ft. increases, respectively over the fifty year period-of-analysis.

350. Figure 43 presents the four Line of Protection stillwater design elevations with an overlay of the three anticipated rates of sea level change for the 100-yr, 250-yr, and 500-yr storm events. The figure also contains the crest elevations for the different design elements of the NED Plan.



FEET NGVD 1929

Year		2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069
Promenade Crest		22	22	22	22	22	22	22	22	22	22	22
Buried Seawall/Armored Levee Crest		20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5
Levee Crest		18	18	18	18	18	18	18	18	18	18	18
Floowall Crest		18	18	18	18	18	18	18	18	18	18	18
100-yr surge	+SLC, Low	12.6	12.6	12.6	12.6	12.7	12.7	12.7	12.7	12.7	12.7	12.7
	+SLC, Intermediate	12.6	12.7	12.8	12.9	13.0	13.1	13.2	13.3	13.4	13.6	13.7
	+SLC, High	12.6	12.8	13.0	13.2	13.4	13.7	13.9	14.2	14.5	14.8	15.2
250-yr surge	+SLC, Low	14.3	14.3	14.3	14.3	14.4	14.4	14.4	14.4	14.4	14.4	14.4
	+SLC, Intermediate	14.3	14.4	14.5	14.6	14.7	14.8	14.9	15.0	15.1	15.3	15.4
	+SLC, High	14.3	14.5	14.7	14.9	15.1	15.4	15.6	15.9	16.2	16.5	16.9
500-yr surge	+SLC, Low	15.9	15.9	15.9	15.9	16.0	16.0	16.0	16.0	16.0	16.0	16.0
	+SLC, Intermediate	15.9	16.0	16.1	16.2	16.3	16.4	16.5	16.6	16.7	16.9	17.0
	+SLC, High	15.9	16.1	16.3	16.5	16.7	17.0	17.2	17.5	17.8	18.1	18.5

Figure 43 - Line of Protection Designs against Sea Level Change Curves

351. The Equivalent Annual Damages for the without project condition and for the four design stillwater levels considered for the Tentatively Selected Line of Protection Alternative were re-computed using the “intermediate” and “high” rates of sea level rise in HEC-FDA, for comparison with the baseline analysis using the “low” rate. The results of these analyses are presented in Table 35. Benefit-Cost ratios in Table 35 were derived using costs in Table 24 with the addition of the costs to adapt the project in response to the “intermediate and “high” sea level rise scenarios ($37.5 million and $57.6 million respectively).

Table 35: Impacts of Sea Level Rise on Damages, Benefits & BCRs

Damages/ Benefits	Condition/ Alternative	Historic "Low"	Curve I "Intermediate"	Curve III "High"
Equivalent Annual Damages	Without Project	$34,329,000	$36,879,000	$45,003,000
	Stillwater Design 13.3 NGVD 1929	$12,370,000	$12,915,000	$15,792,000
	Stillwater Design 14.3 NGVD 1929	$9,617,000	$9,983,000	$12,007,000
	Stillwater Design 15.6 NGVD 1929	$6,944,000	$7,151,000	$8,383,000
	Stillwater Design 16.6 NGVD 1929	$5,462,000	$5,554,000	$6,398,000
Annual Benefits	Stillwater Design 13.3 NGVD 1929	$21,959,000	$23,964,000	$29,211,000
	Stillwater Design 14.3 NGVD 1929	$24,712,000	$26,896,000	$32,996,000
	Stillwater Design 15.6 NGVD 1929	$27,385,000	$29,728,000	$36,620,000
	Stillwater Design 16.6 NGVD 1929	$28,867,000	$31,325,000	$38,605,000
Net Benefits	Stillwater Design 13.3 NGVD 1929	$3,701,000	$4,713,000	$9,319,000
	Stillwater Design 14.3 NGVD 1929	$5,070,000	$6,261,000	$11,720,000
	Stillwater Design 15.6 NGVD 1929	$5,070,000	$6,420,000	$12,671,000
	Stillwater Design 16.6 NGVD 1929	$4,400,000	$5,865,000	$12,504,000

Interest rate 3.375%, 50-year period of analysis

Note: Table 35 does not include damages and benefits associated with the boardwalk.

352. The “intermediate” and “high” rates of sea level change would increase the without project equivalent annual damages above those resulting from the “low” rate by 7% and 31% respectively. The basic line of protection benefits would rise by 9% and 34% above the baseline benefits using the “intermediate” and “high” rates.

353. In summary, the NED Plan stillwater design (15.6 ft. NGVD 1929) compares well against the historic and more rapid rates of sea level change analyzed in this report. The NED Plan design crest is only predicted to be overtopped by surge during the most restrictive combination of storm event and sea level change studied. Out of the events plotted, only the 500-yr + the “high” rate of sea level change will overtop the minimum crest elevation of 18 ft. NGVD 1929. In comparison, the minimum crest for the 13.3 ft. NGVD 1929 and 14.3 NGVD1929 stillwater designs would be overtopped by more than a foot if a 500-yr storm event occurred during the base year. The NED Plan design also meets the overtopping requirements in the event of a 100-yr storm in year 2069 for the low, intermediate, and high predictions of sea-level change. Beyond the 50-yr period-of-analysis, the robust design of the NED Plan may support the added loads of structural expansion or adaptation to meet the needs of future sea level change. More detail on potential adaptation is presented in section 9.3 of this report.

9. EXECUTIVE ORDER (EO) 11988 AND PUBLIC LAW (PL)113-2 CONSIDERATIONS

354. This study has considered the requirements of EO 11988, Flood Plain Management and PL 113-2, the Disaster Relief Appropriations Act of 2013. Specifically, this section of the report addresses:

- The Water Resources Council Floodplain Management implementing guidelines for EO 11988;
- The specific requirements necessary to demonstrate that the project is economically justified, technically feasible, and environmentally acceptable, per PL 113-2;
- The specific requirements necessary to demonstrate resiliency, sustainability, and consistency with the North Atlantic Coast Comprehensive Study (NACCS), per PL 113-2.

9.1 EO 11988

355. Executive Order 11988 requires federal agencies avoid, to the extent possible, the long and short term adverse impacts associated with the occupancy and modification of flood plains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. In accomplishing this objective, "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 flood plains in carrying out its responsibilities."

356. The Water Resources Council Floodplain Management Guidelines for implementation of EO 11988, as referenced in USACE ER 1165-2-26, requires an eight step process that agencies should carry out as part of their decision making on projects that have potential impacts to, or are within the floodplain. The eight steps and project-specific responses to them are summarized below.

357. Recognizing the Federal government's commitment to ensure no inducement of development in the floodplain, pursuant to Executive Order 11988, this project will identify in the Project Partnership Agreement, the need for the local partner to develop a Floodplain Management Plan. The NYC Bluebelt program supports floodplain management as the properties to be acquired under this program are located within the FEMA designated Special Flood Hazard Area and are restricted from future development and therefore in accordance with Executive Order 11988.

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

2. **If the action is in the base flood plain, identify and evaluate practicable alternatives to the action or to location of the action in the base flood plain.** Chapter 5 of this document presents an analysis of potential alternatives. Practicable measures and alternatives were formulated and evaluated against the Corps of Engineers guidance, including non-structural measures such as retreat, demolition and land acquisition.

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

4. **Identify beneficial and adverse impacts due to the action and any expected losses of natural and beneficial flood plain values. Where actions proposed to be located outside the base flood plain will affect the base flood plain, impacts resulting from these actions should also be identified.** The anticipated impacts associated with the Selected Plan are summarized in Chapters 5 and 6 of this report. The project would not alter or impact the natural or beneficial flood plain values.

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

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

7. **If the final determination is made that no practicable alternative exists to locating the action in the flood plain, advise the general public in the affected area of the findings.** The Draft Interim Feasibility Report and Environmental Impact Statement will be provided for public review and a public hearing will be scheduled during the public review period. Each comment received will be addressed and, if appropriate, incorporated into the Final Report. A record of all comments received will also be included in the Pertinent Correspondence Appendix.

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

consistent with the executive order.

9.2 Economics Justification, Technical Feasibility and Environmental Compliance

358. The prior sections of this report demonstrate how the NED Plan manages flood and coastal storm risks, and contributes to improved capacity to manage such risks. It also identifies the NED Plan to be economically justified for the authorized period of federal participation.

359. The Environmental Impact Statement has been prepared to meet the requirements of NEPA and demonstrate that the NED Plan is compliant with environmental laws, regulations, and policies and has effectively addressed any environmental concerns of resource and regulatory agencies.

9.3 Resiliency, Sustainability, and Consistency with the NACCS

360. This section has been prepared to address how the NED Plan contributes to the resiliency of the South Shore of Staten Island Study Area; how it affects the sustainability of environmental conditions in the affected area; and how it will be consistent with the findings and recommendations of the North Atlantic Coast Comprehensive Study (NACCS).

361. Resiliency is defined in the February 2013 USACE-NOAA Infrastructures Systems Rebuilding Principles white paper as the ability to adapt to changing conditions and withstand, and rapidly recover from disruption due to emergencies. Sustainability is defined as the ability to continue (in existence or a certain state, or in force or intensity), without interruption or diminution.

9.3.1 Resiliency

362. The NED Plan is a resilient, sustainable, and a robust solution. The system has been optimized to a high surge and wave level that would only be seen during rare coastal storm events and also integrates sea-level rise. The selected alignment of the NED Plan, landward of the existing beach and on higher ground, adds resiliency and sustainability to the system by allowing the beach to respond naturally during (beach erosion) and after storm events (beach recovery) and in future in response to sea level changes. The selected structure type (primarily buried seawall) adds resiliency to the system since it will still dissipate wave energy even after the system's design parameters are exceeded. Also, in contrast to beach berm and dune systems, the NED Plan has the ability to defend against back to back high intensity storms because of the low expected structural damage.

9.3.2 Sustainability/Adaptability

363. The low relative sea level was used in the evaluation of the structures based on current guidance (ETL 1100-2-1 dated 30 Jun 2014). However, immediate or high rates

of sea level change may affect the performance of the optimized NED Plan. The ability of the structures to adapt to higher rates of sea level change by raising their crest and/or top of wall height, without the need to rebuild the structures, was evaluated during the optimization phase. The intent in developing the adaptability measures was to minimize enlarging the structure footprint, therefore the measures were developed to raise structures height within the existing structure footprint where possible.

364. A reinforced concrete parapet wall and base constructed atop the crest of the buried seawall would raise the crest height of the structure by up to 5 feet as shown in Figure 44. The parapet wall and base may be aligned with the landward or seaward crest edge of the buried seawall (Figure 35 shows the latter alignment). A concrete base integrated with the armor layer of the buried seawall is designed to prevent overtopping and sliding of the parapet wall due to wave-induces horizontal and vertical forces.

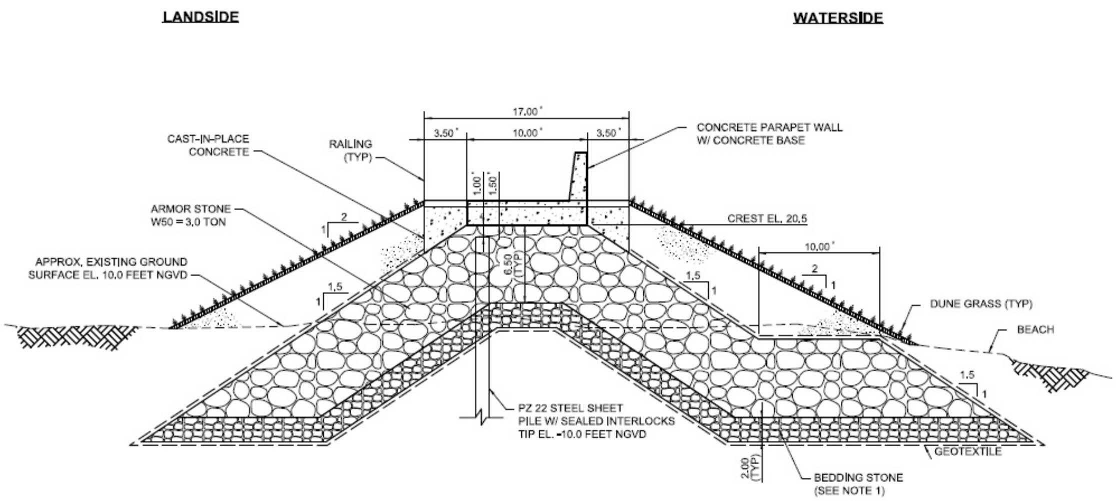


Figure 44 - Concrete Parapet Wall atop Buried Seawall

365. The concrete vertical floodwall may accommodate sea level change by raising the top of wall height. By designing the foundation of the concrete floodwall during the initial construction to counteract future hydrostatic and wave forces, the reinforcing steel matrix is arranged to accept doweling of the future cast-in-place concrete wall addition as shown in Figure 45.

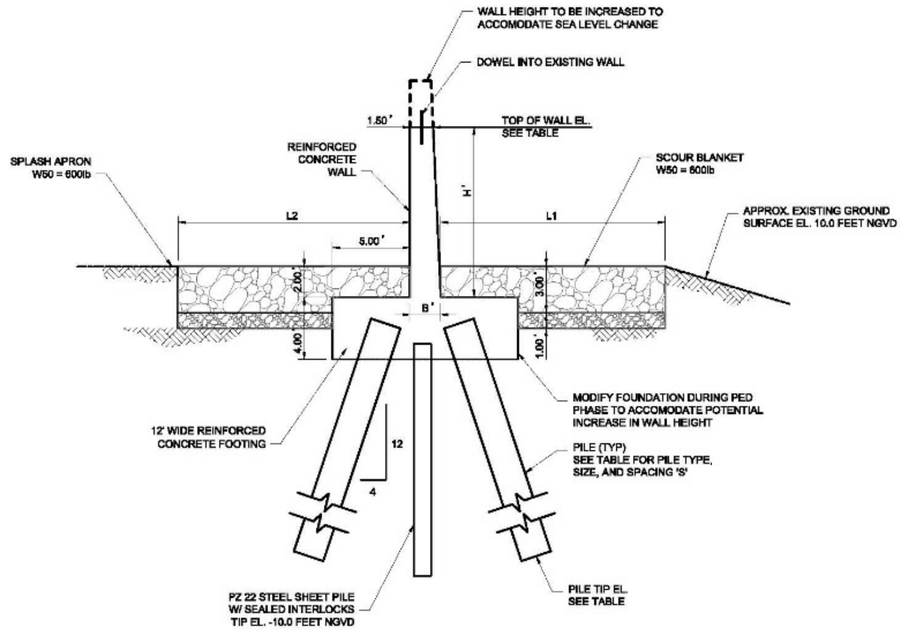


Figure 45 - Raising of Concrete Floodwall

366. Raising of the earthen levee by up to 3 feet may be accomplished by adding imperious and selected backfill to the same lines and grades of the initial construction as shown in Figure 46. This raising will increase the footprint of the structure but would fall within the 15-foot wide flood protection easement. If additional height is required, a concrete parapet wall, similar to that shown for the buried seawall, could be added to the levee crest.

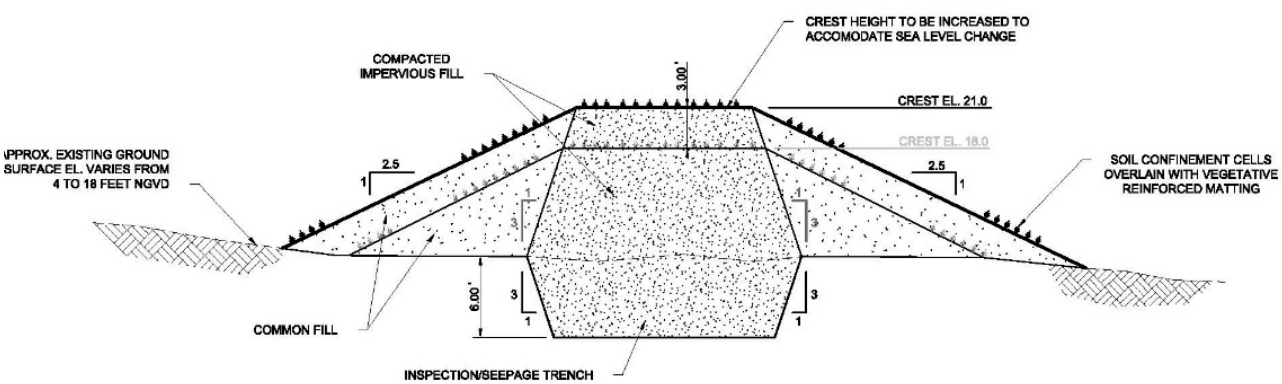


Figure 46 - Raising of Earthen Levee

367. The beach along the South Shoreline of Staten Island is a buffer between the Line of Protection (LOP) structures (earthen levee, concrete vertical floodwall, and buried seawall) and Raritan Bay, dissipating wave energy and insulating the LOP structures from short and long-term changes in shoreline position. The alignment of the LOP

structures was selected so the structures are set back and elevated, minimizing their exposure to storm induced water levels and waves except during infrequent extreme events (i.e. 25-year event and greater). The with-project coastal impacts are expected to be minor for the LOP structures.

368. Beach erosion is not anticipated to affect the performance of the structures or the sediment transport processes that may affect the stability of beaches in or adjacent to the project area until it reaches a minimum beach width. A minimum beach width threshold of 75 feet (measured from MHW) was determined based on analysis of the impact of LOP structures on storm induced beach change using a validated SBEACH model.

369. Since the long-term sediment budget for the project area indicates that the beach is relatively stable, it is not anticipated over the project period of analysis (50-years) for the beach to erode below the minimum 75-foot threshold. A project cost to maintain the beach was not included for this reason.

370. In general the impact of placement loss, passive erosion, active erosion and active erosion mechanisms for this project are expected to be minimized by the selected alignment of the structures comprising the Line of Protection and relatively stable shoreline positions in the project area. Placement losses are minimized by positioning the buried seawall at the landward edge of the beach. Since the majority of the South Beach, Midland Beach, New Dorp Beach, and Cedar Grove Beach shorelines lack dunes or bluffs to supply sediment to the littoral system, the storm induced modeling results provided in the Engineering and Design Appendix indicate that the buried seawall location is positioned landward of the active littoral zone to avoid placement losses (e.g. cutting off supply of sand from berm/dune). In some instances, the buried seawall may actually increase sediment in the system by blocking overwash and wind transport. The sand cover on the buried seawall will also provide a layer of erodible material that will help supply sediment to the beach. Similarly, passive erosion is expected to be minor since the shoreline positions are relatively stable in the project area.

371. The long-term beach erosion rate may be affected by climate variability, including increasing sea level rise and frequency/duration of coastal storm events. Beach maintenance/restoration activities may be evaluated as a future project adaptation, if beach erosion accelerated to the extent that a minimum beach width to 75 feet cannot be maintained. The implementation of future project adaption measures for the earthen levee, concrete vertical floodwall, buried seawall, and beach maintenance/restoration would be dependent on a future decision document that would evaluate and record the changed metrological and oceanographic conditions.

9.3.2.1 Consistency with the North Atlantic Coast Comprehensive Study (NACCS)

372. The North Atlantic Coast Comprehensive Study (NACCS, 2015) was released in January 2015 and provides a risk management framework designed to help local communities better understand changing flood risks associated with climate change and

to provide tools to help those communities better prepare for future flood risks. In particular it encourages planning for resilient coastal communities that incorporates wherever possible sustainable coastal landscape systems that takes into account, future sea level and climate change scenarios. The process used to identify the NED plan utilized the NACCS Risk Management framework that included evaluating alternative solutions and also considering future sea level change and climate change.

10. PLAN IMPLEMENTATION

373. The completion of the Interim Feasibility Study and Recommendation by the District Engineer are the first steps toward implementing the design and construction of the Coastal Storm Risk Management Project along the South Shore of Staten Island from Fort Wadsworth to Oakwood Beach. Upon approval by USACE's Assistant Secretary of the Army, Civil Works (ASA[CW]), the project will be considered for design and construction with funding made available through P.L. 113-2.

10.1 Project Partnership – Local Sponsor's Responsibilities

374. The Total Project Cost (Fully Funded) of the coastal storm risk management project will be cost-shared 65% by the Federal Government and 35% by the non-Federal Sponsor.

375. The non-Federal project sponsor, New York State Department of Environmental Conservation (NYSDEC) must comply with all applicable Federal laws and policies and other requirements, including but not limited to:

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

    a. Provide all lands, easements, rights of way and relocations (LERR) determined by the Federal Government to be necessary for the initial construction and operation, and maintenance of this project, which may be creditable to the non-federal share of the initial project cost.

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

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

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

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

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

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

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

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

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

7. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1790, Public Law 91-646, as amended by Title IV of the Surface Transportation and 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.

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

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

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

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

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

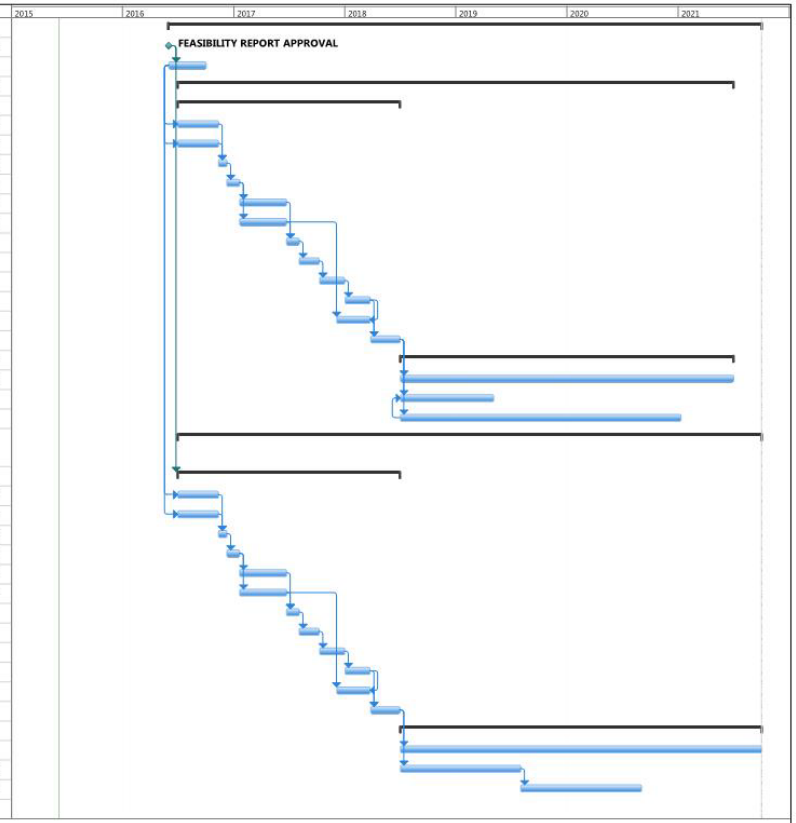
13. Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms.

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

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

10.2 Implementation Schedule

ID	Task Name	Duration	Start	Finish
1	**South Shore of Staten Island Phase 1**	**1395 days**	**Mon 5/30/16**	**Fri 10/1/21**
2	**FEASIBILITY REPORT APPROVAL**	**1 day**	**Mon 5/30/16**	**Mon 5/30/16**
3	Field Survey	89 days	Tue 5/31/16	Fri 9/30/16
4	**CONTRACT 1: Oakwood to Miller field**	**1305 days**	**Thu 6/30/16**	**Wed 6/30/21**
5	**Design Activities**	**522 days**	**Thu 6/30/16**	**Fri 6/29/18**
6	DDR - 30%	95 days	Thu 6/30/16	Wed 11/9/16
7	P&S - 30%	95 days	Thu 6/30/16	Wed 11/9/16
8	30% DQC review	20 days	Thu 11/10/16	Wed 12/7/16
9	VE Study	30 days	Thu 12/8/16	Wed 1/18/17
10	DDR - 90%	110 days	Thu 1/19/17	Wed 6/21/17
11	P&S - 90%	110 days	Thu 1/19/17	Wed 6/21/17
12	90% DQC, BCOES Reviews	30 days	Thu 6/22/17	Wed 8/2/17
13	Revised 90% for review	47 days	Thu 8/3/17	Fri 10/6/17
14	90% ATR & IEPR Reviews	60 days	Mon 10/9/17	Fri 12/29/17
15	100% DDR and P&S	60 days	Mon 1/1/18	Fri 3/23/18
16	Real Estate Acquisition	80 days	Mon 12/4/17	Fri 3/23/18
17	Contract Advertise and Award	70 days	Mon 3/26/18	Fri 6/29/18
18	**Construction Activities**	**783 days**	**Mon 7/2/18**	**Wed 6/30/21**
19	Reinforced Levee/ Seawall	783 days	Mon 7/2/18	Wed 6/30/21
20	Ponding Area B	220 days	Mon 7/2/18	Fri 5/3/19
21	Floodwall/ Levee	660 days	Mon 7/2/18	Fri 1/8/21
22	**CONTRACT 2: Miller Field To Fort Wadsworth**	**1372 days**	**Thu 6/30/16**	**Fri 10/1/21**
23	**Design Activities**	**522 days**	**Thu 6/30/16**	**Fri 6/29/18**
24	DDR - 30%	95 days	Thu 6/30/16	Wed 11/9/16
25	P&S - 30%	95 days	Thu 6/30/16	Wed 11/9/16
26	30% DQC review	20 days	Thu 11/10/16	Wed 12/7/16
27	VE Study	30 days	Thu 12/8/16	Wed 1/18/17
28	DDR - 90%	110 days	Thu 1/19/17	Wed 6/21/17
29	P&S - 90%	110 days	Thu 1/19/17	Wed 6/21/17
30	90% DQC, BCOES Reviews	30 days	Thu 6/22/17	Wed 8/2/17
31	Revised 90% for review	47 days	Thu 8/3/17	Fri 10/6/17
32	90% ATR & IEPR Reviews	60 days	Mon 10/9/17	Fri 12/29/17
33	100% DDR and P&S	60 days	Mon 1/1/18	Fri 3/23/18
34	Real Estate Acquisition	80 days	Mon 12/4/17	Fri 3/23/18
35	Contract Advertise and Award	70 days	Mon 3/26/18	Fri 6/29/18
36	**Construction Activities**	**850 days**	**Mon 7/2/18**	**Fri 10/1/21**
37	Reinforced Levee/ Seawall	850 days	Mon 7/2/18	Fri 10/1/21
38	Ponding Area C Construction	283 days	Mon 7/2/18	Wed 7/31/19
39	Ponding Area E Construction	283 days	Thu 8/1/19	Mon 8/31/20
40				



Project: SSSI construction_June
Date: Fri 6/5/15

Task	Project Summary	Manual Task	Start-only	Deadline
Split	Inactive Task	Duration-only	Finish-only	Progress
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress
Summary	Inactive Summary	Manual Summary	External Milestone	

Page 1

Figure 47- Tentative Implementation Schedule

10.3 Cost Sharing

376. Table 36 displays the apportionment of the Total Project Costs (Fully Funded) between the Federal government and the non-Federal partners for the structural storm risk management features, in accordance with the Water Resources Development Act of 1986, as amended. The cost sharing is 65% federal and 35 % non-federal, which includes cash and credits associated with obtaining the required, lands, easements, rights-of way, and relocations (LERR). P.L. 113-2 also permits the full non-Federal contribution to be made, without interest, during construction of the project, or, with interest over a period of not more than thirty years from the date of completion, The table includes costs associated with flood risk management features. The Total Project Costs does not include Interest During Construction (used for the annualization of project costs for economic purposes) and O&M costs. (O&M is a 100% non-Federal responsibility and is included in the calculation of annualized project costs for economic purposes). As indicated in Table 36, the Federal share of the total first cost is $376,302,000. 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.

377. The non-Federal partner is responsible for all Lands, Easements, Right-of-ways, and Relocations (LERR) costs and all Operations and Maintenance (O&M) costs. The non-Federal share is $202,624,000, which include $91,261,000 in estimated LERR costs and $111,363,000 in cash.

Table 36: Cost Apportionment	
Federal Project Cost (65%)	**$376,302,000**
Non-Federal Project Cost (35%)	**$202,624,000**
LERR	$91,261,000
LER	$43,854,000
Relocations	
Road Raising	$5,328,000
Boardwalk	$42,079,000
Cash Balance	$111,363,000
TOTAL	**$578,926,000***

*includes $50.5M for the escalation of costs through the mid-point of construction.

10.4 Views of Non-Federal Partners and Other Agencies

378. New York District is anticipating that the non-Federal sponsor will seek FEMA accreditation under the Code of Federal Regulations (CFR) 44-65.10 in order to incorporate the significant risk management measures (i.e. Armored Levee System) into the effective Flood Insurance Rate Maps (FIRMS).

379. Additionally, NYSDEC, the non-Federal sponsor, in compliance with New York City's Special Initiative for Rebuilding and Resiliency (SIRR), plans to support projects that afford a risk management level equivalent to the 100-year coastal storm event plus an additional three feet of freeboard.

380. The non-federal partners acknowledge their responsibilities with regard to providing and undertaking the required Lands, Easements, Rights-of-way and Relocations (LERR). During the PED phase, USACE will coordinate directly with NYSDEC and NYC, consistent with the principle of providing a "functionally equivalent facility", on the detailed design of project components that interface with park and recreational facilities such as the materials and finishes of the raised promenade, licensed concessions, and the number, location and design of access points over the LOP.

381. There will also be coordination with NYSDEC and NYC during the PED phase with regard to the design of the drainage ponds, access points to the planned outfalls, localized flood drainage at the base of the levee, roads, closure structures and other project components that interface with New York City managed facilities. USACE will also coordinate with NYSDEC and NYC during the PED phase in the development of the O&M manual for the project.

382. As requested by NYC Parks and Recreation, USACE will consider the use of their Staten Island Greenbelt Native Plant Center as a resource for plant material needed for the project.

10.5 Areas of Concern

383. The areas of concern are as following:

a. Schedule of real estate acquisition: The plan requires the acquisition of approximately 275 privately-owned parcels and over 400 acres of easements. The timing of construction is dependent upon the timely acquisition of the real estate requirements for this project.

b. CERCLA remediation of radium contamination schedule by NPS at Great Kills GNRA: The construction schedule assumes that either construction will only be performed in areas where no contamination exists or known contamination has been remediated by the responsible party and the appropriate “No Further Action” requirements have been met in accordance with Federal and State laws.

10.6 Major Conclusions and Findings

384. In such a populous area, finding and implementing a feasible Coastal Storm Risk Management Plan solution is critical to the continued functionality and livelihood of the local residents. The implementation of the National Economic Development (NED) Plan would be the difference between saving lives and businesses in the event of another coastal storm event like Sandy (October 29-30,2012). The Net Benefits of the NED Plan are approximately $3.3 million per year. The estimated Total Project Cost to achieve these benefits is $578,926,000.

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

386. The recommended NED plan provides a Line of Protection as the first line of defense against severe coastal surge flooding and wave forces, and reduces the risk of storm damage with a still water elevation (tide plus storm surge) of 15.6 NGVD 1929. This is about 2 feet higher than the peak water levels during Hurricane Sandy. The design storm is estimated to have an annual chance of exceedance of 0.3 % (300 year event) under current sea level conditions.15.6 NGVD 1929 stillwater design height provides l crest elevations ranging between 18 and 20.5 feet NGVD 1929. The project provides risk management against ocean surge from a Hurricane Sandy-like event over the 50-year period of analysis even when taking into account SLC of 1.1 ft. In contrast, the current coastal structure is approximately 10 ft. NGVD 1929, with lower spots sporadically throughout the project area that only provides coastal storm protection from surge and waves up to a 10% annual-chance-event (also known as the 10-year storm).

387. While the project impacts 117 acres of wetlands, most of which are *Phragmites* dominated freshwater wetlands, no mitigation is required. As discussed in Section 6.5.2, the optimum plan for Drainage Area B provides for the removal of about 46 acres of *Phragmites* (including 5 years of spraying*)* to provide the needed interior drainage storage capacity. More desirable wetland plant species that do not have the potential hydraulic issues that *Phragmites* presents with its aggressive rhizomes would be planted. Both the U.S. Fish and Wildlife Service and the NYSDEC acknowledge that the plan to remove the non-native *Phragmites* monoculture would result in greater plant diversity that will also increase wildlife diversity both at the line of protection and within the interior drainage pond.

388. In addition to the three major post-Hurricane Sandy (October 29-30,2012) changes to the design that largely increased the Project Total Cost, a contingency of $149 million was factored in to the Total Project Cost as determined by the Cost and Schedule Risk Analysis (CSRA).

389. The NED Plan is a resilient, sustainable, and a robust solution. The system has been optimized to a high surge and wave level that would only be seen during rare coastal storm events which also integrates sea-level rise. The selected alignment of the NED Plan, landward of the existing beach and on higher ground, adds resiliency and sustainability to the system by allowing the existing beach to respond naturally during (beach erosion) and after storm events (beach recovery) and in response to sea level changes. The selected structure type (primarily buried seawall) adds resiliency to the system since it will still dissipate wave energy even after the system's design parameters are exceeded. Also, in contrast to beach berm and dune systems, the NED Plan has the ability to defend against back to back high intensity storms because of the low expected structural damage to the buried seawall in contrast to beach berm and dune system that would likely suffer significant erosion. The benefits of implementing the NED plan outweigh the cost by approximately $3.3 million per year.

11. PUBLIC INVOLVEMENT

390. The Draft FS and EIS are scheduled to be released for public review in June 2015. Notice will be posted in the Federal Register, local newspapers and there will be a public meeting held during the 45 day review period. In addition there will be periodic meetings with Community Boards 2 and 3 to provide updates on the project and address any comments and concerns. Current project information can also be obtained at the New York District web site:

http://www.nan.usace.army.mil/Missions/CivilWorks/ProjectsinNewYork/SouthShoreofStatenIsland.aspx

12. RECOMMENDATIONS

Prefatory Statement

391. In making the following recommendations, I have given consideration to all significant aspects of this study as well as the overall public interest in coastal storm risk management within the Interim South Shore Staten Island (SSSI) Study Area and the Fort Wadsworth to Oakwood Beach Project Area in particular. The aspects considered include engineering feasibility, economic effects, environmental impacts, social concerns, and compatibility of the project with the policies, desires, and capabilities of the local government, State, Federal government, and other interested parties.

Recommendations

392. A number of alternatives have been examined as part of the ongoing SSSI study and a National Economic Development Plan has been identified and considered. In accordance with current Planning Guidance and the guidance outlined in P.L. 113-2, the NED plan described in this report is acceptable to the non-Federal partner, agencies, and stakeholders as a Coastal Storm Risk Management Project.

393. I make this recommendation based on findings that the Selected Line of Protection and Interior Drainage Plans constitute engineering feasibility, economic justification, and environmental acceptability. This recommended project, which is subject to modifications by the ASA(CW), has a total project first cost of $528.4 million (at current price levels) and a fully funded cost of $578.9 million (that includes $50.5 million in estimated inflation costs through the midpoint of construction). My recommendation is subject to the non-Federal interests agreeing to execute and comply with the terms of a Project Partnership Agreement following approval of this report.

Disclaimer

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

David A. Caldwell
Colonel, U.S. Army
Commander

13. REFERENCES

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14. PLATES

Plate 1: G-101 OVERALLSITE AERIAL(1 OF 3)

PRELIMINARY
NOT FOR CONSTRUCTION

SCALE: GRAPHIC ONLY

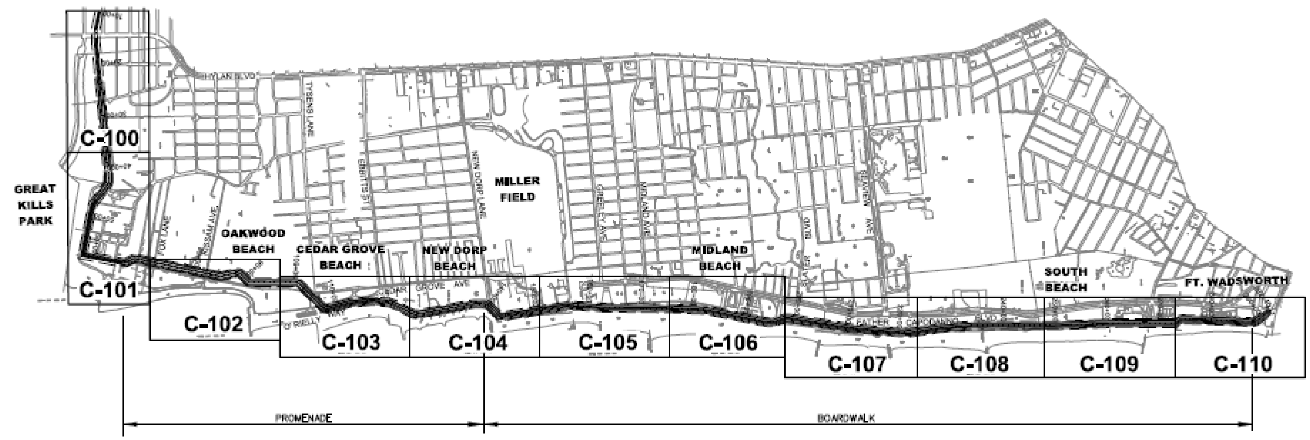
Plate 2: G-102 Plate 2: OVERALLSITE AERIAL(2OF3)

DRAFT

PRELIMINARY
NOT FOR CONSTRUCTION

SCALE: GRAPHIC ONLY

Plate 3: G-103 OVERALLSITE AERIAL(3OF3)



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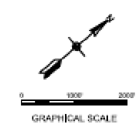

Plate 4: G-104 SHEETKEY PLAN

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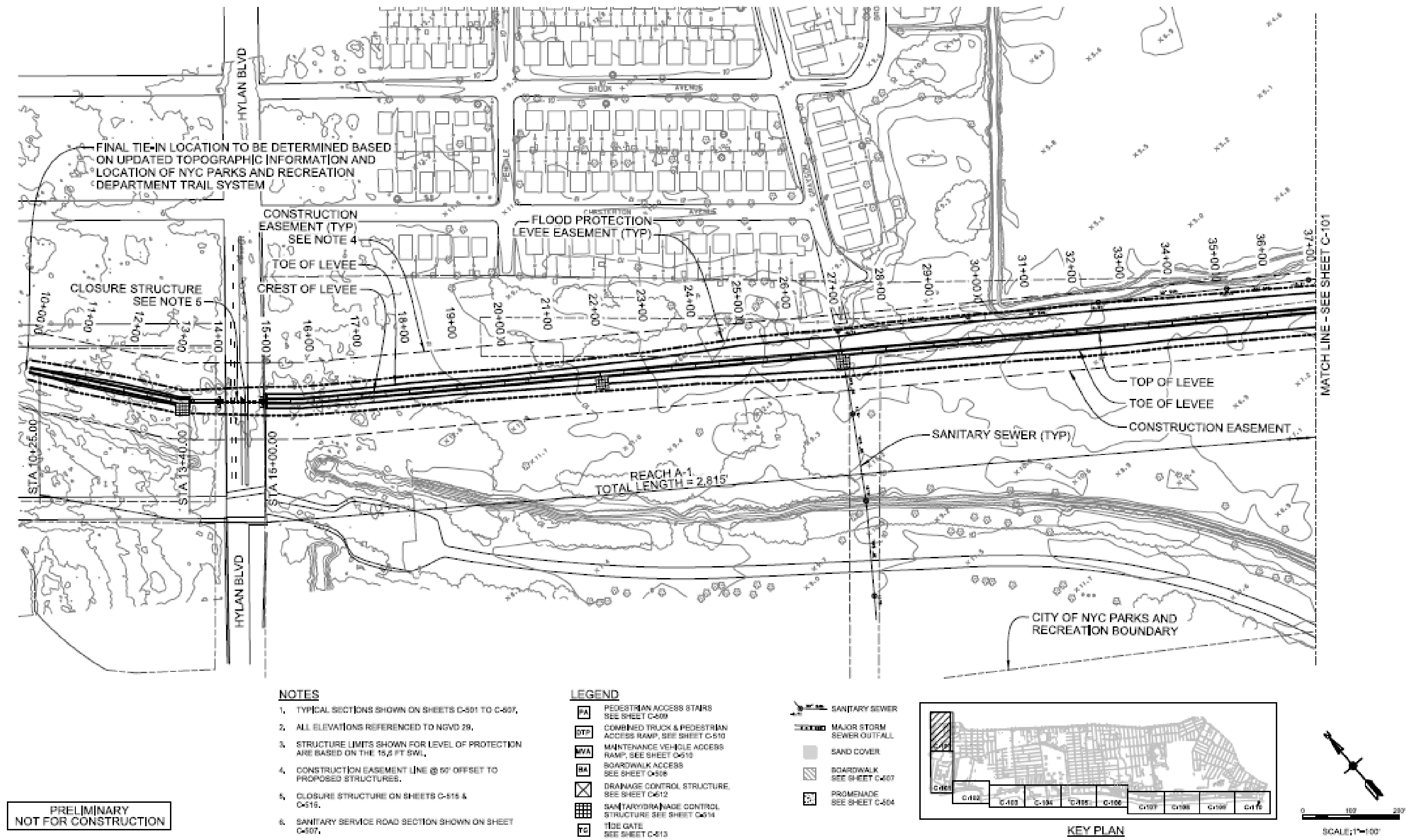

Plate 5: C-100 SITE PLAN (1OF11)

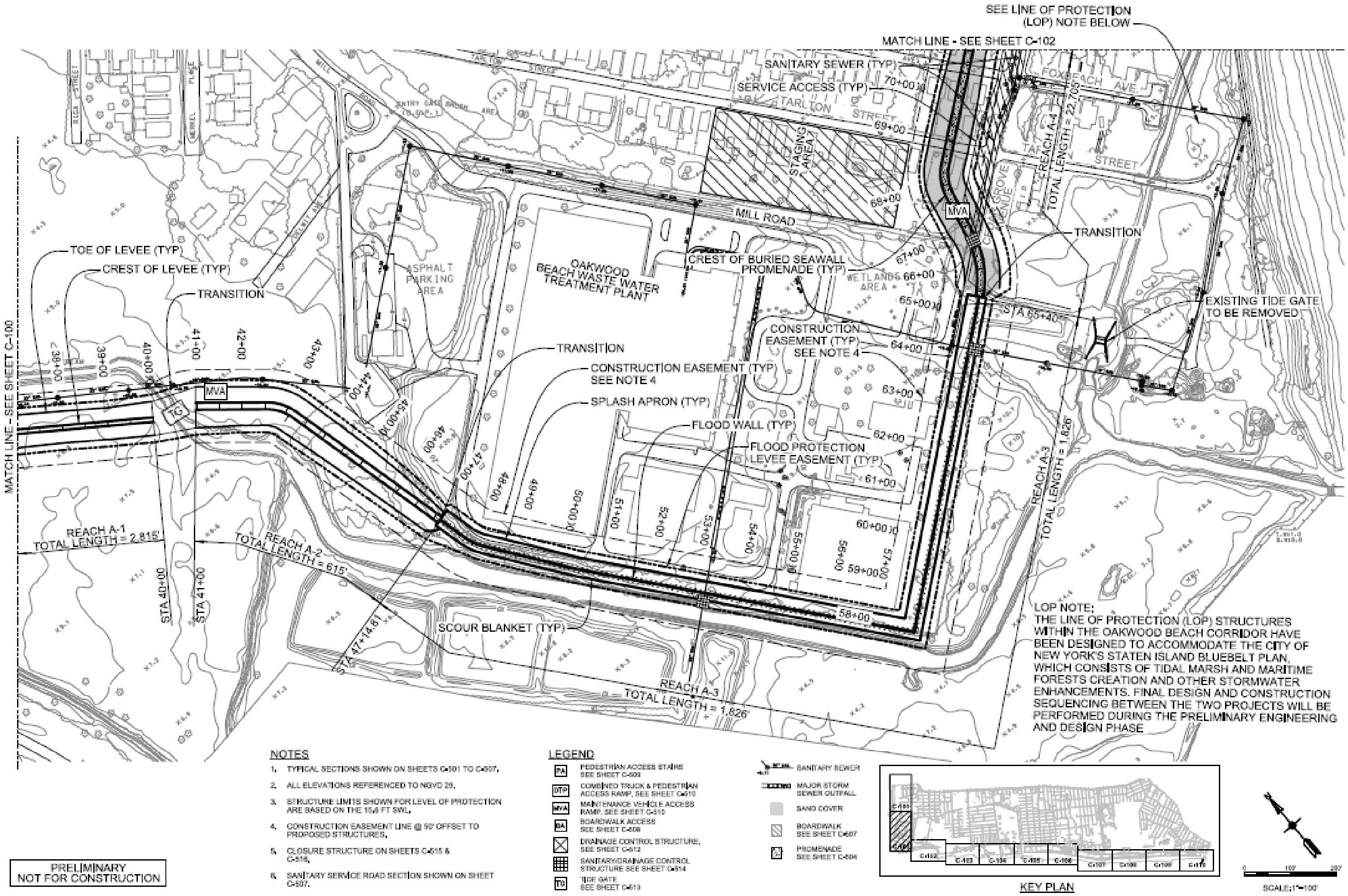

Plate 6: C-101 SITE PLAN (2 OF 11)

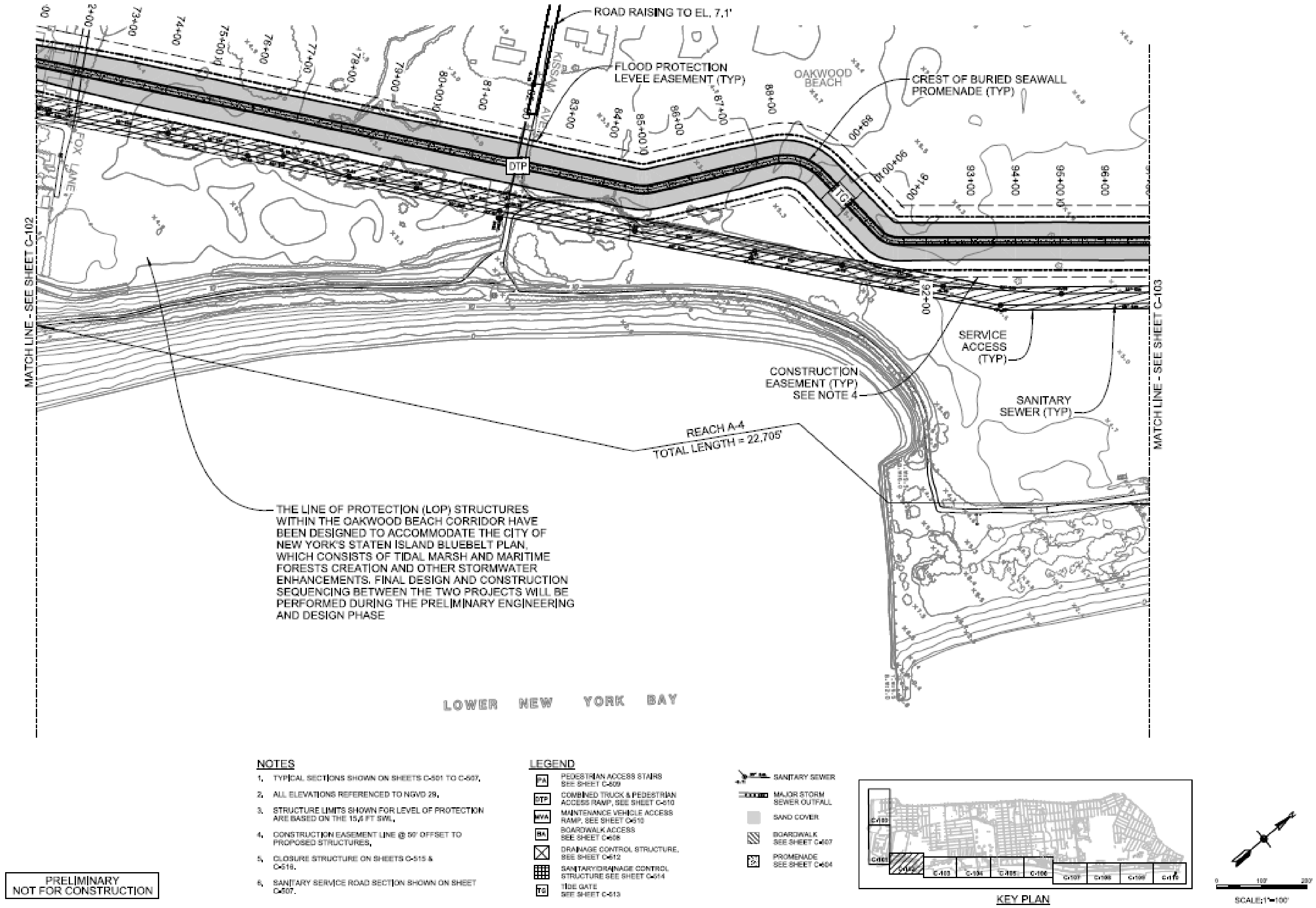

Plate 7: C-102 SITE PLAN (3OF11)

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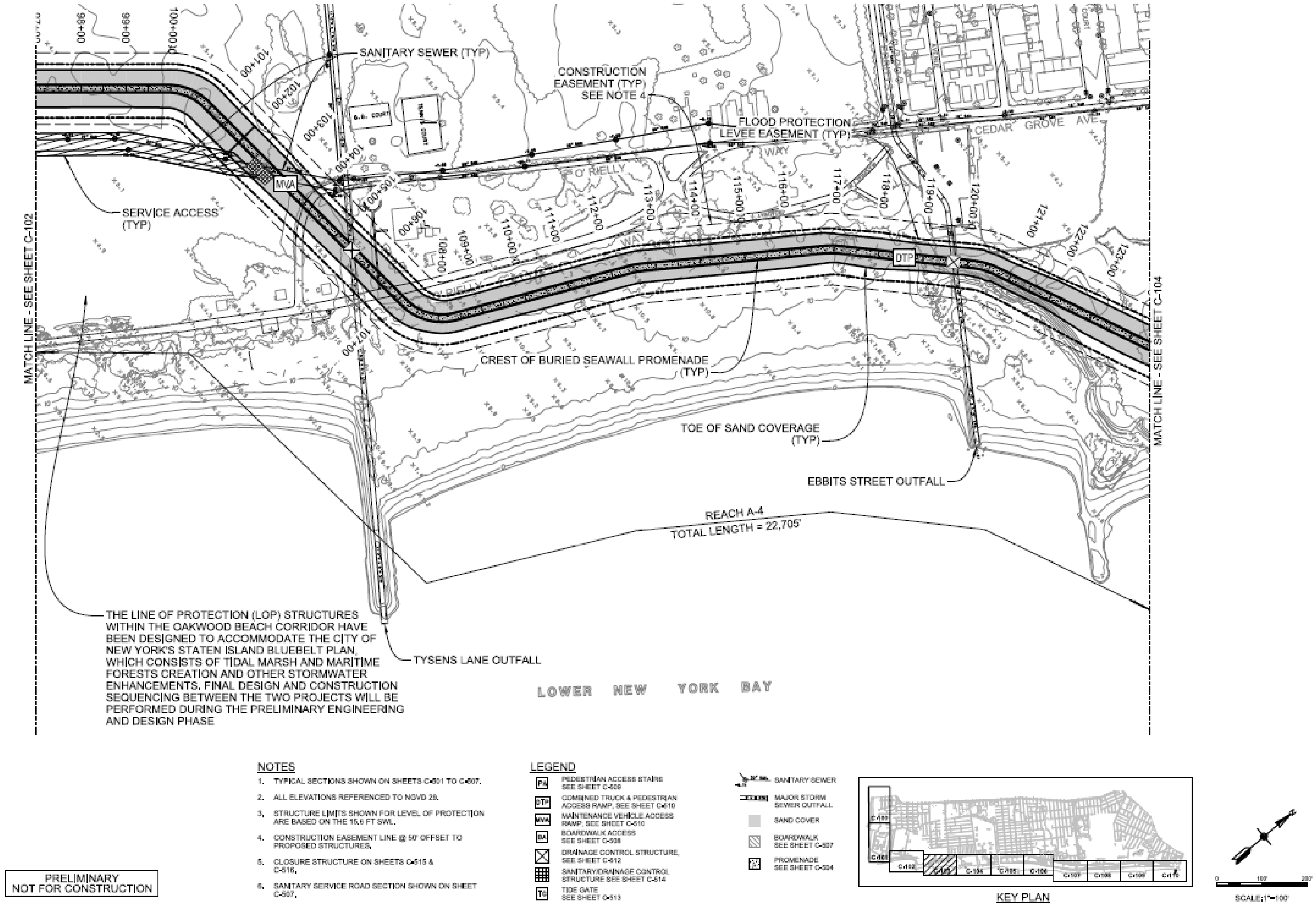

Plate 8: C-103 SITE PLAN (4OF11)

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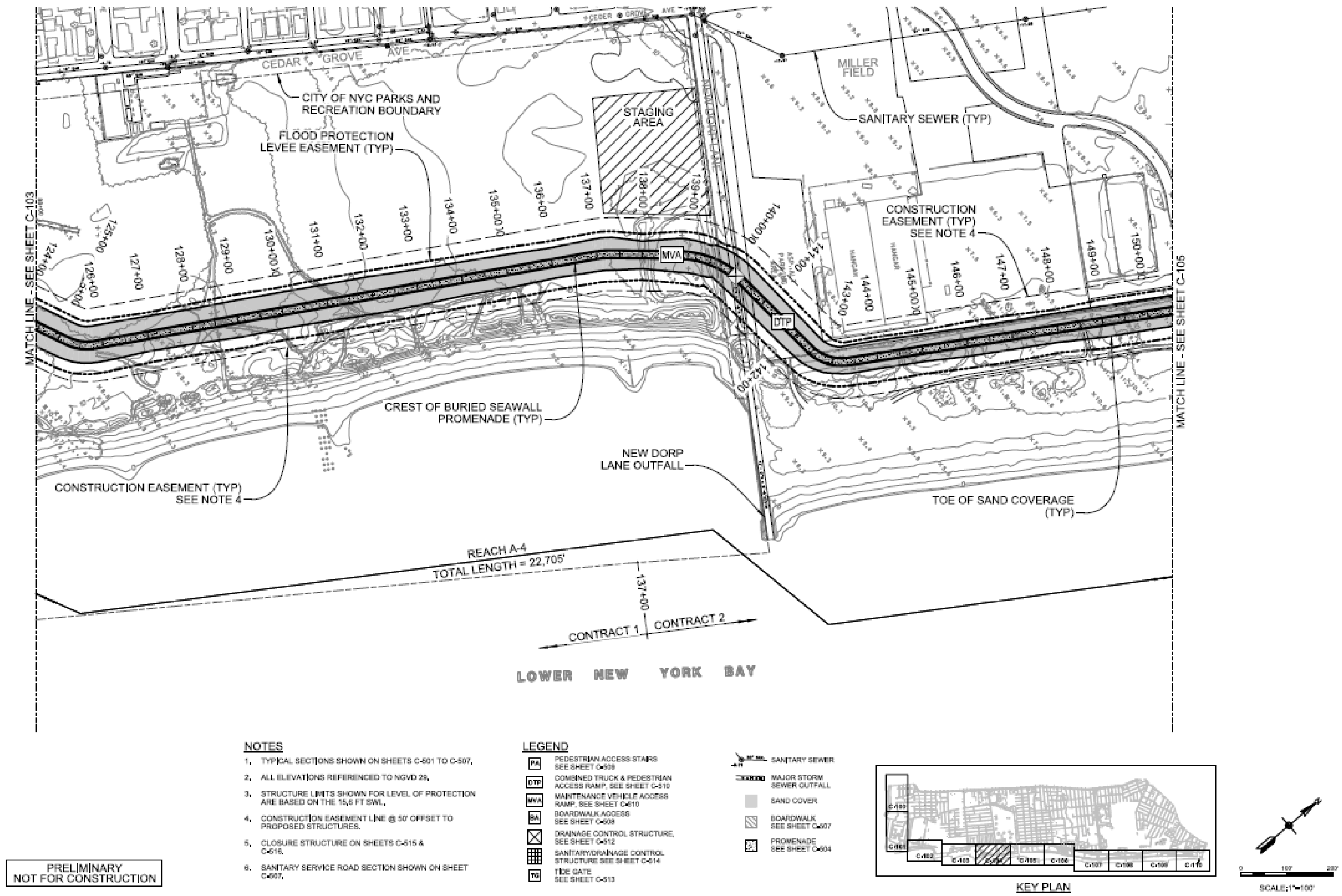

Plate 9: C-104 SITE PLAN (5OF11)

DRAFT

South Shore of Staten Island, New York

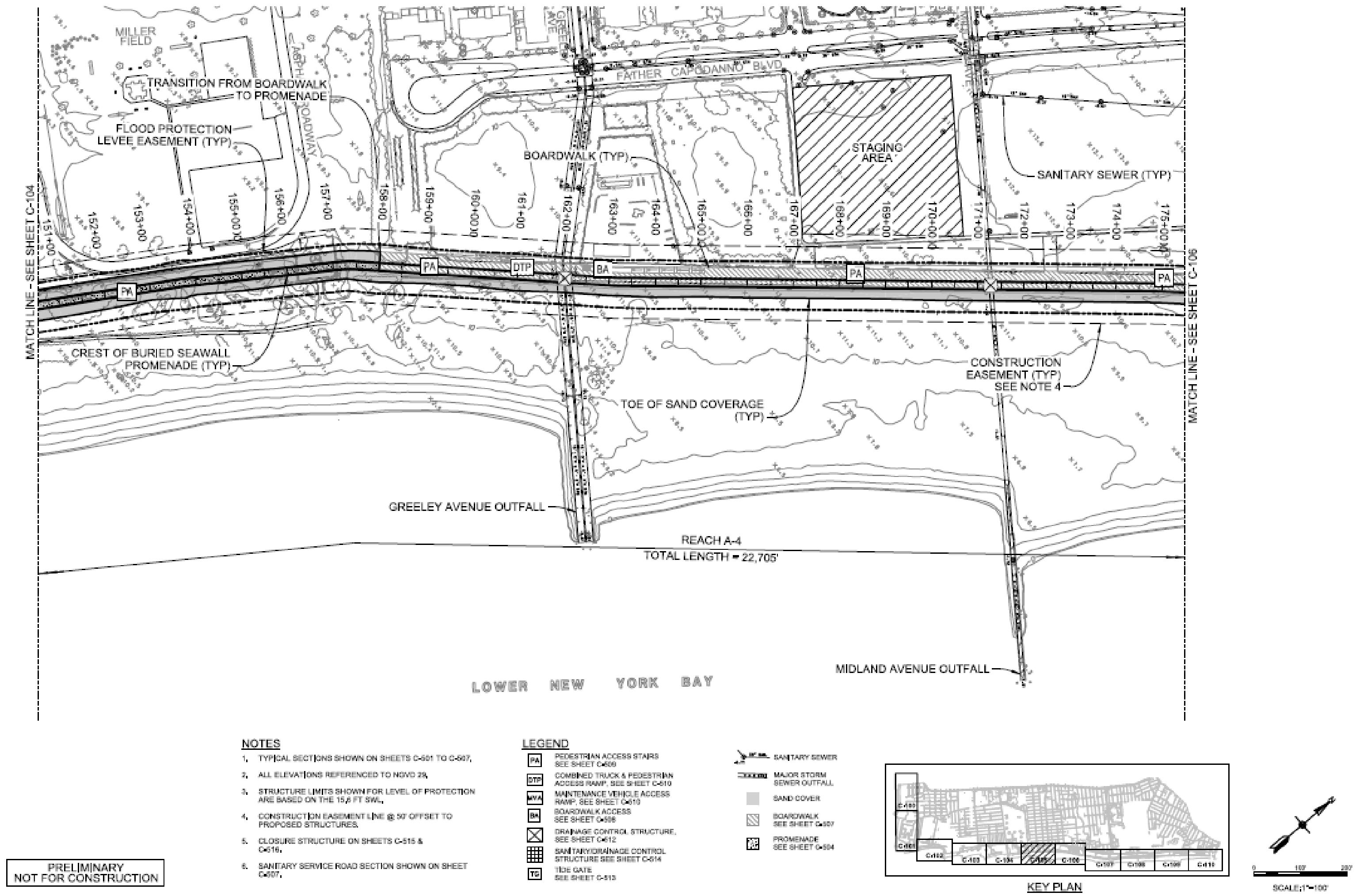

Plate 10: C-105 SITE PLAN (6OF11)

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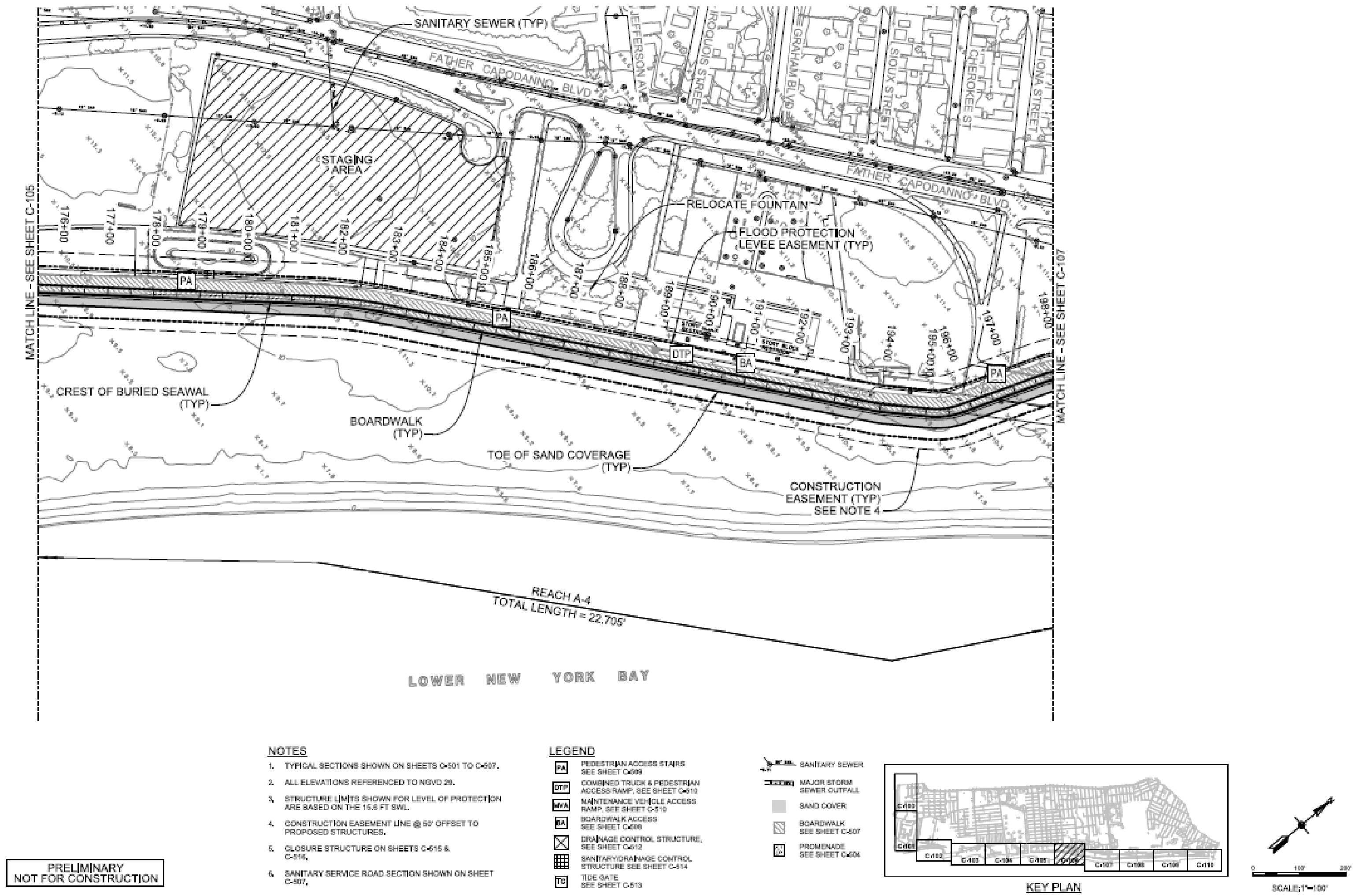

Plate 11: C-106 SITE PLAN (7OF11)

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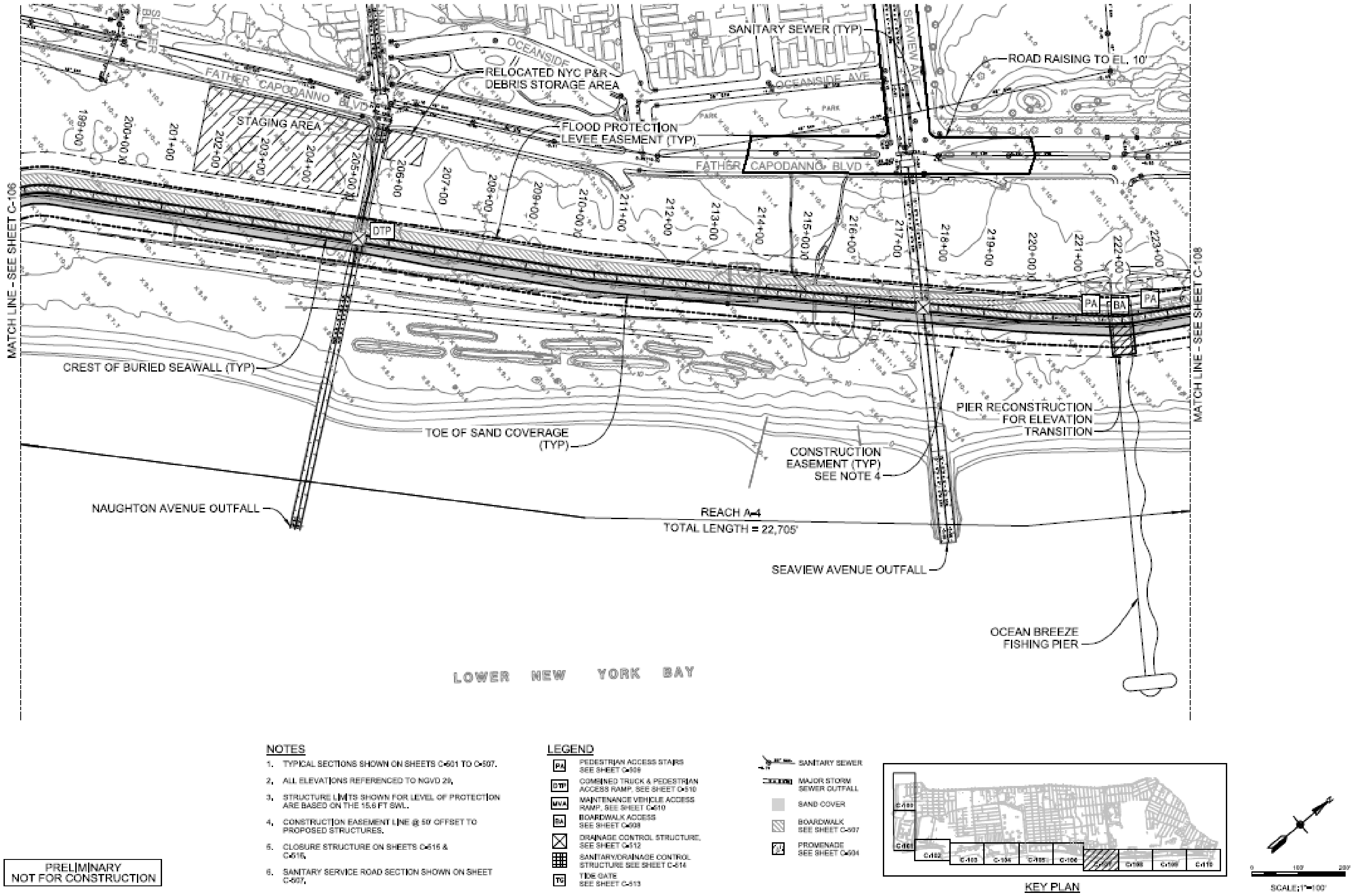

Plate 12: C-107 SITE PLAN (8OF11)

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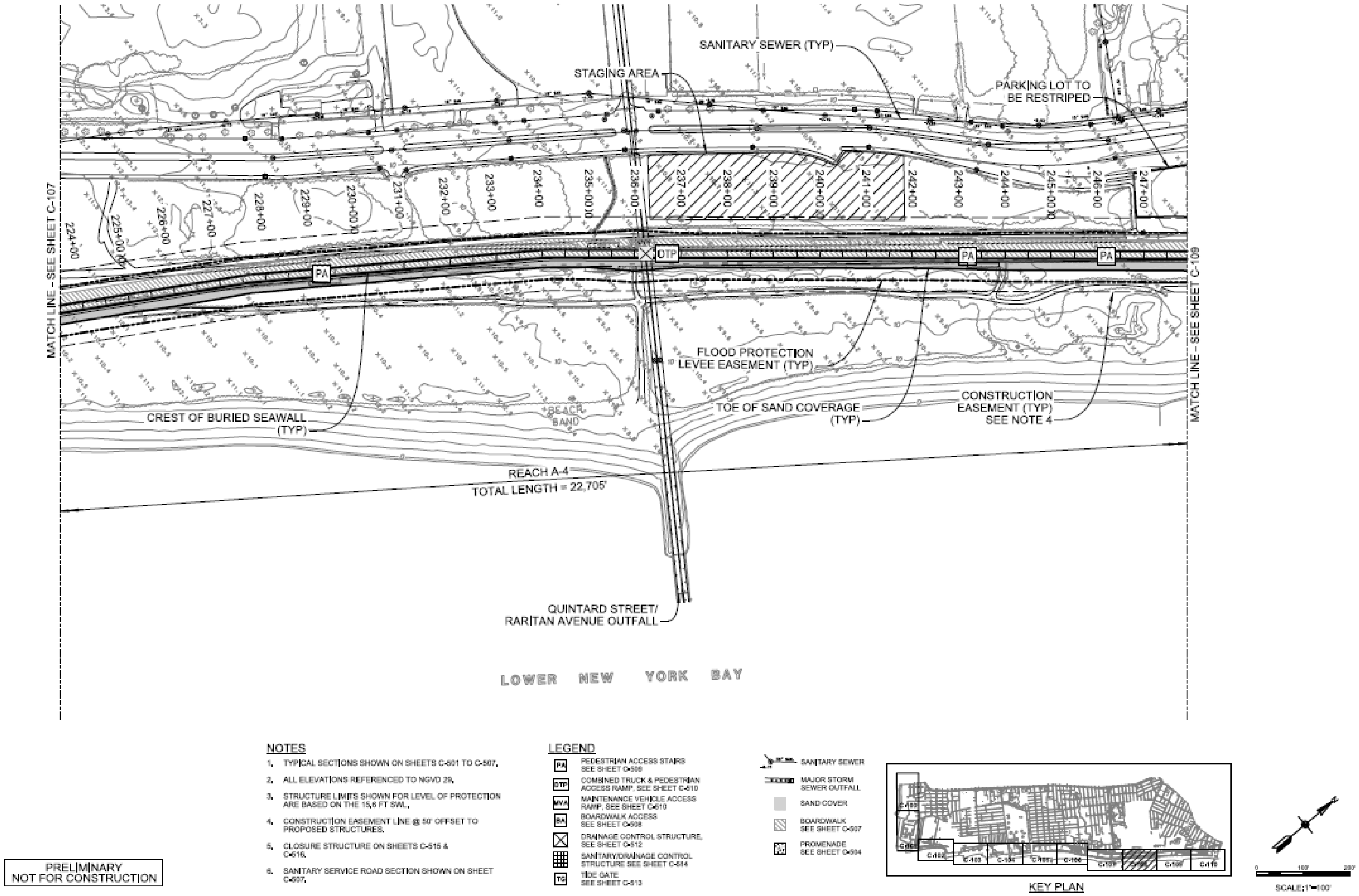

Plate 13: C-108 SITE PLAN (9OF11)

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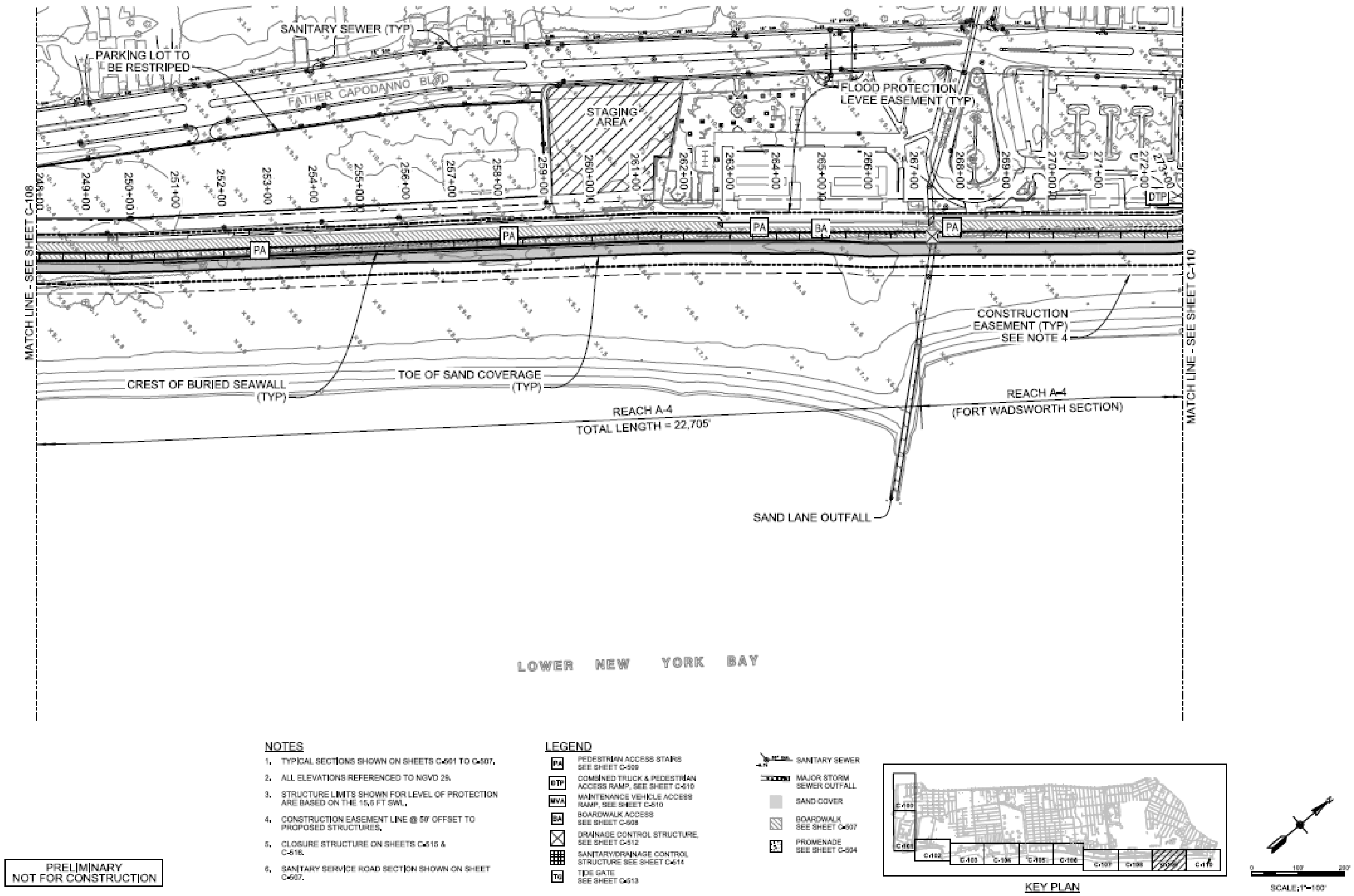

Plate 14:C-109 SITE PLAN (10OF11)

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South Shore of Staten Island, New York

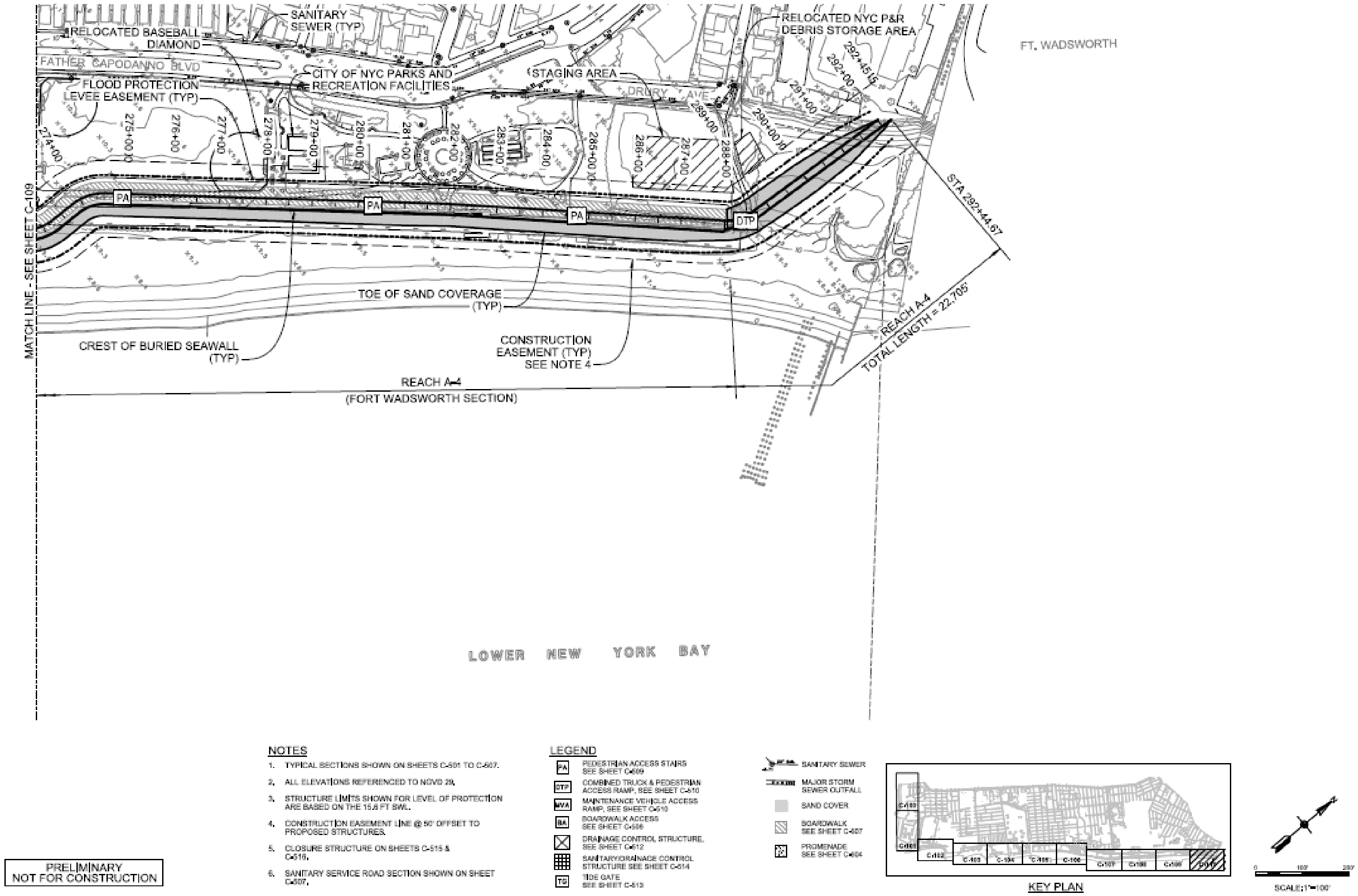

Plate 15: C-110 SITE PLAN (11OF11)

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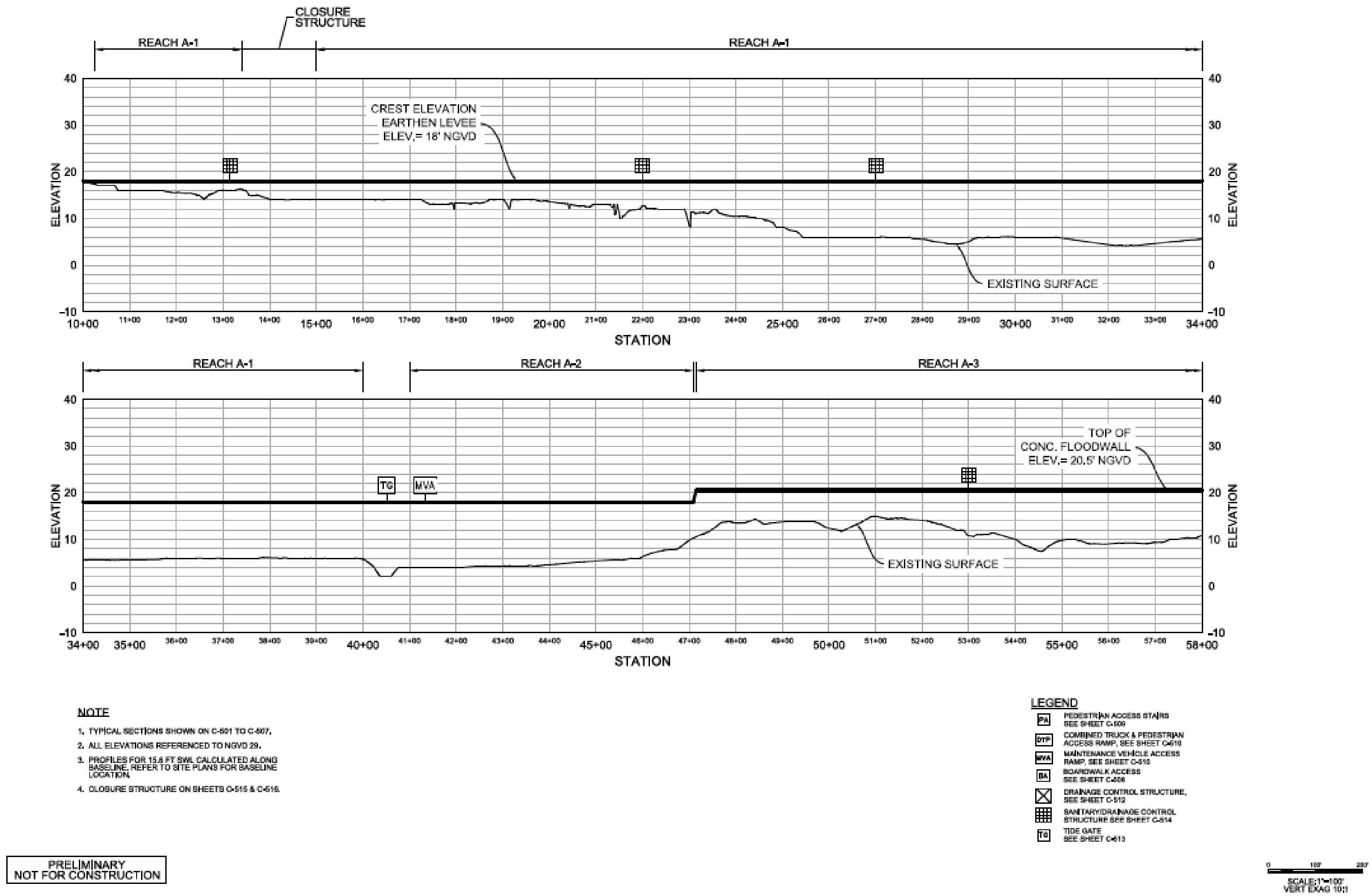


Plate 16: C-301 SITE PROFILE (1OF6)

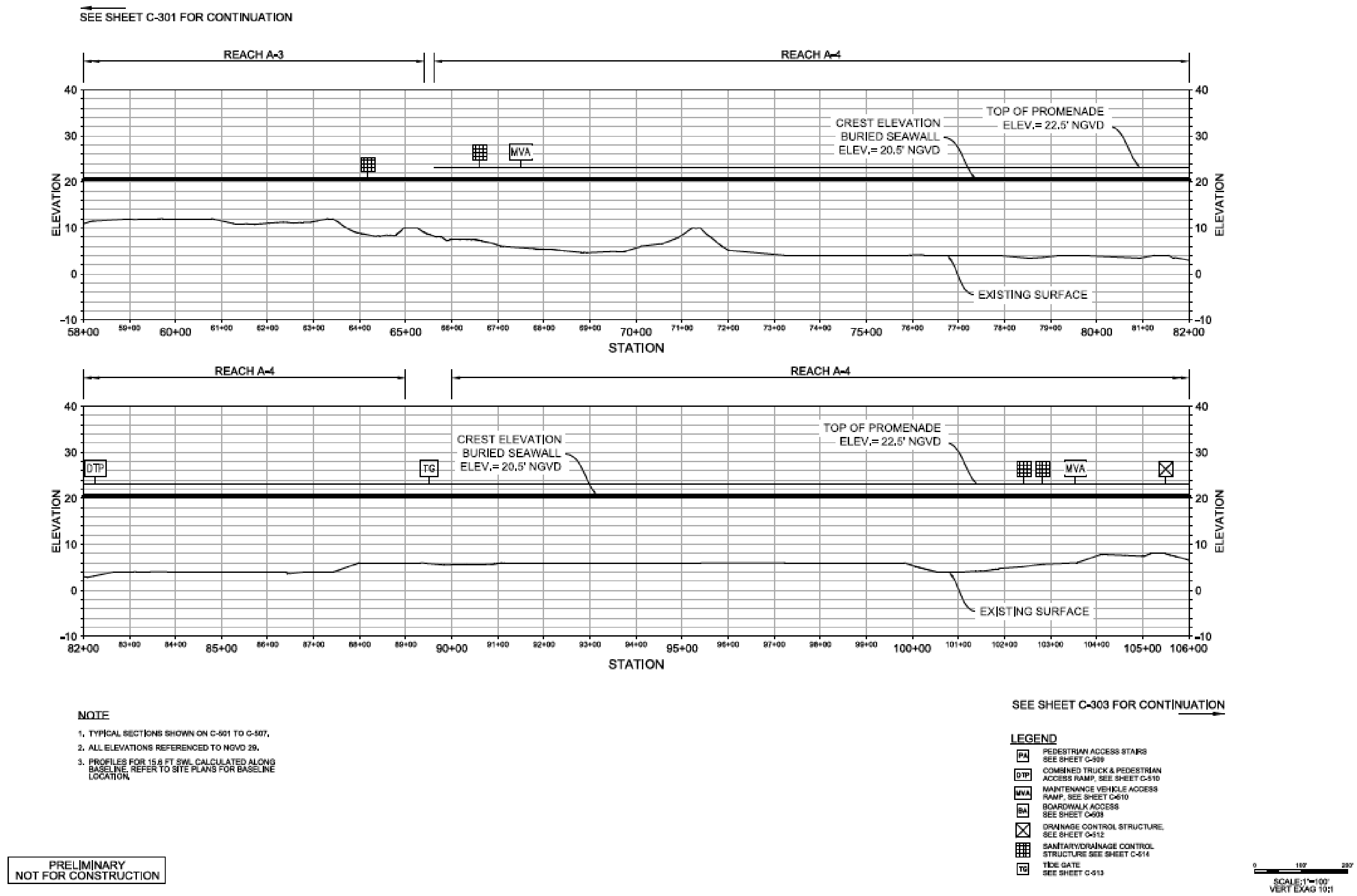


Plate 17: C-302 SITE PROFILE (2OF6)

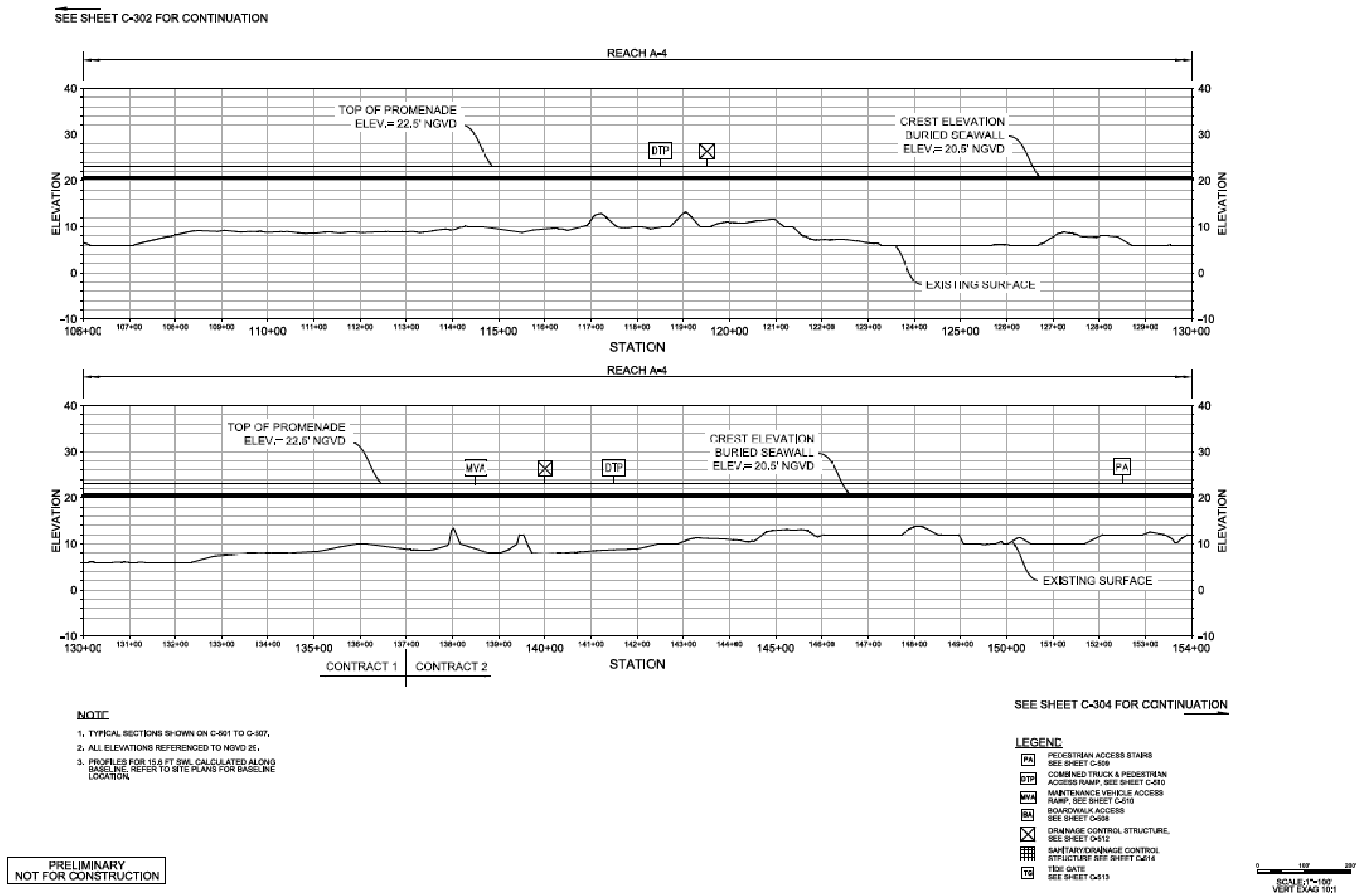


Plate 18: C-303 SITE PROFILE (3OF6)

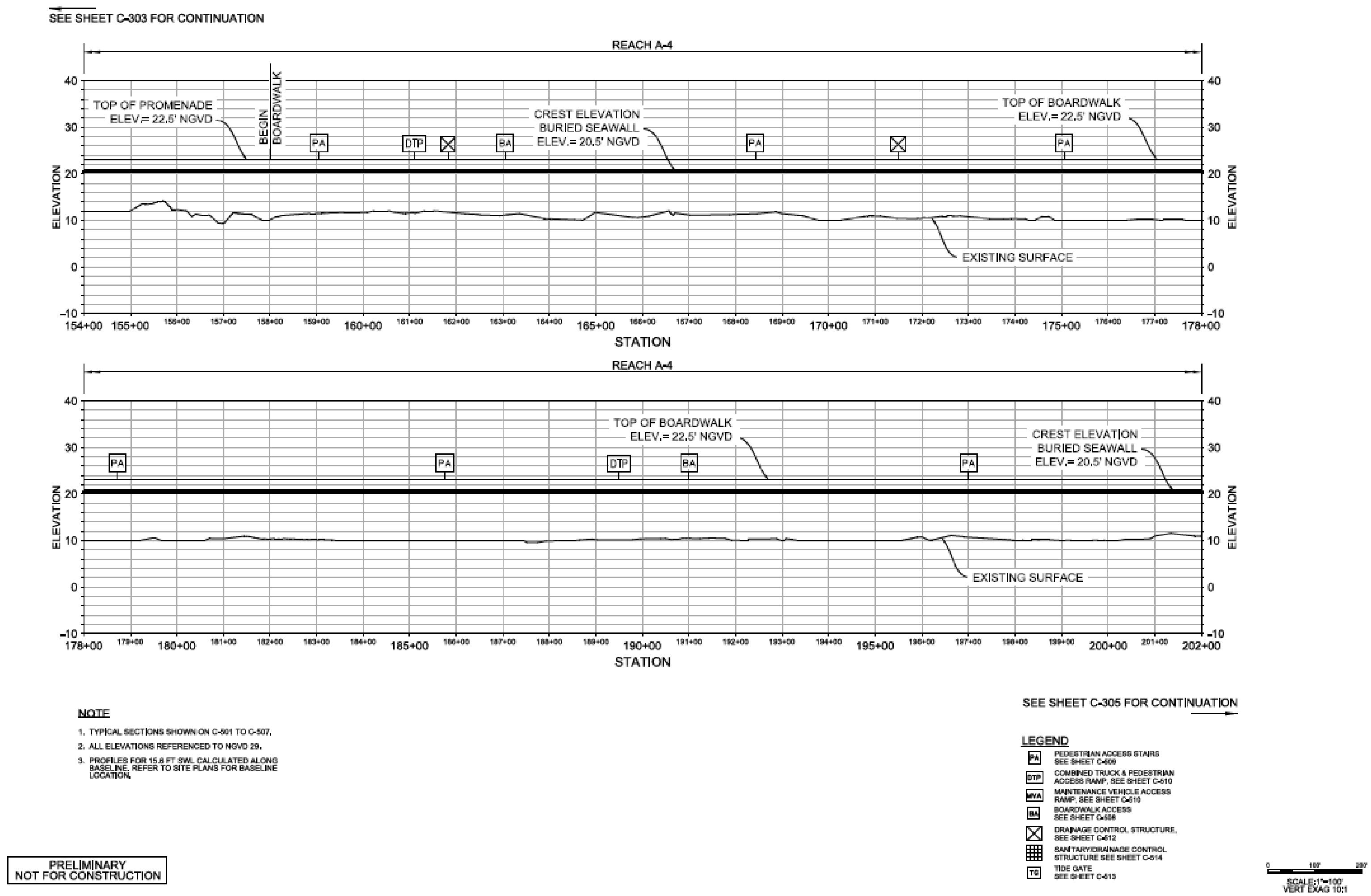


Plate 19: C-304 SITE PROFILE (4OF6)

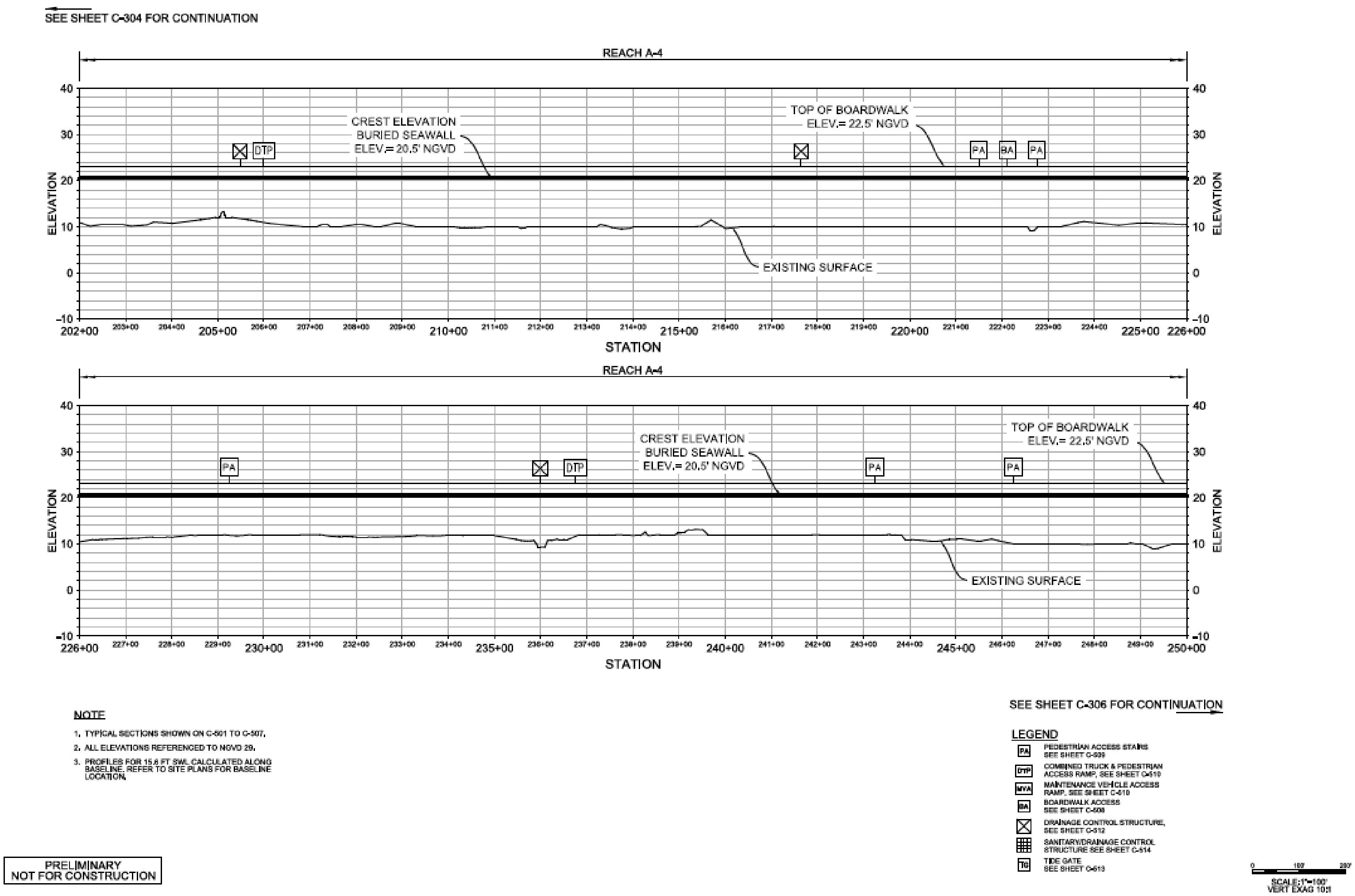


Plate 20: C-305 SITE PROFILE (5OF6)

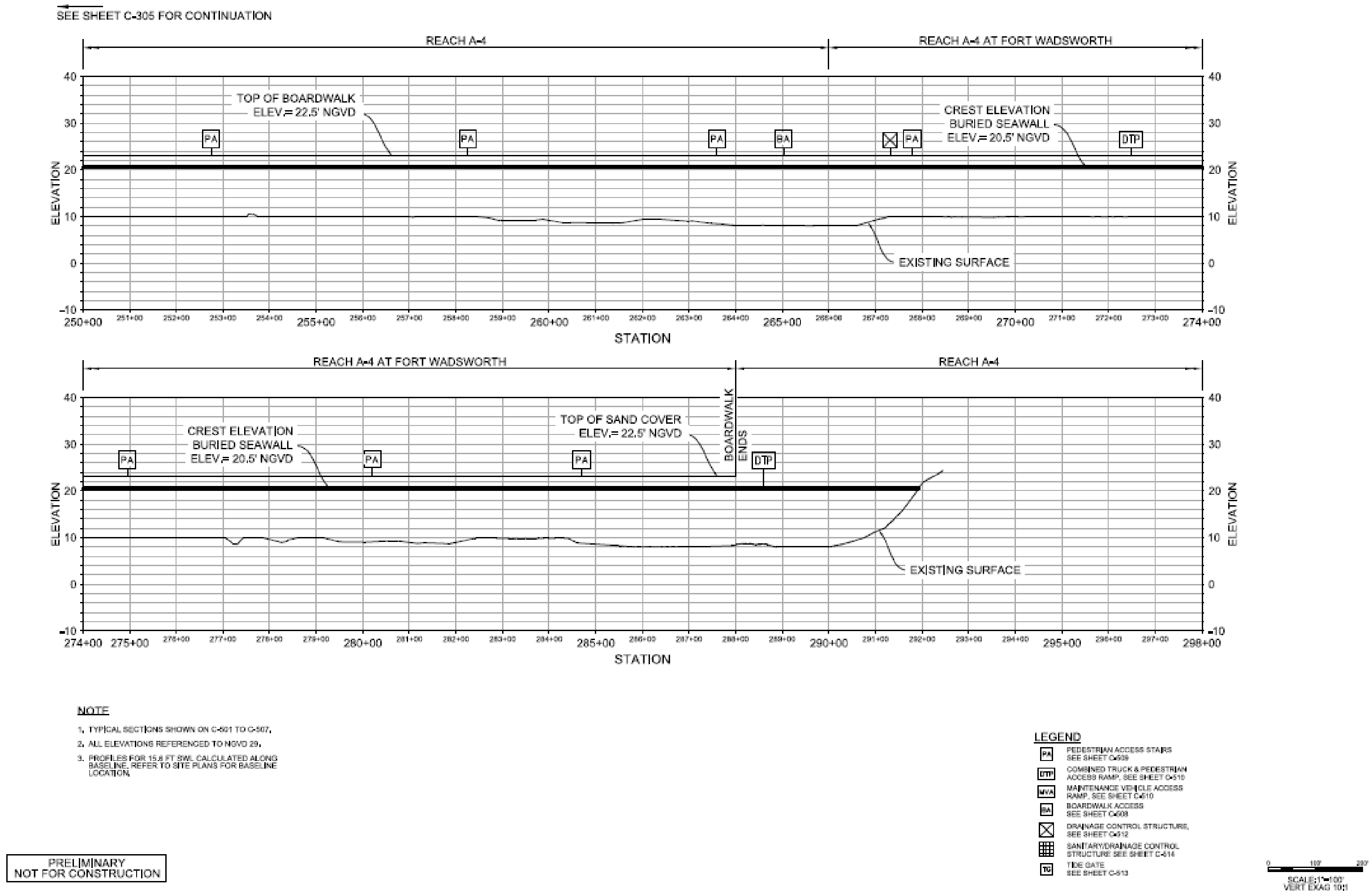


Plate 21: C-306 SITE PROFILE (6OF6)

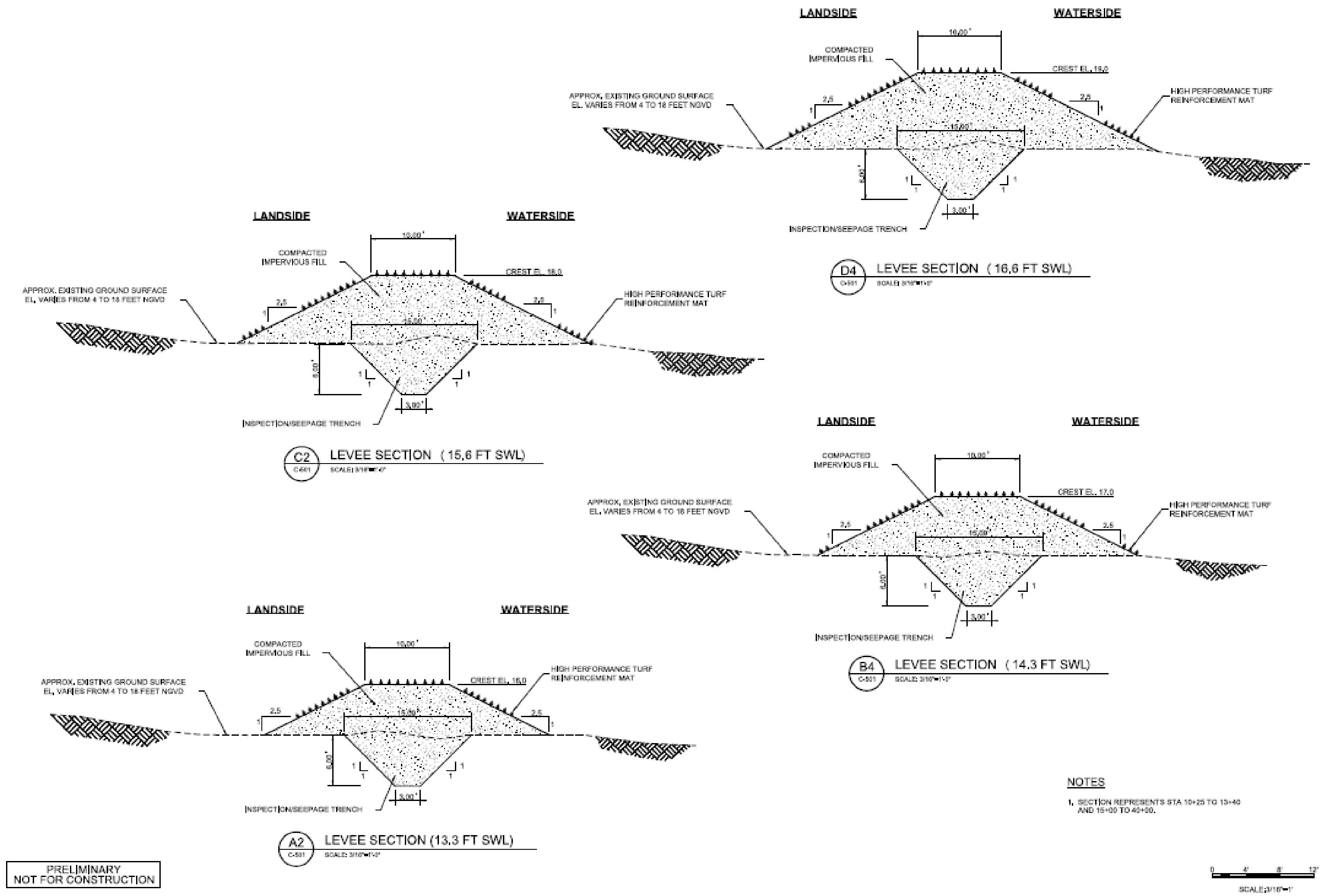


Plate 22: C-501 TYPICALSECTIONS REACH A-1

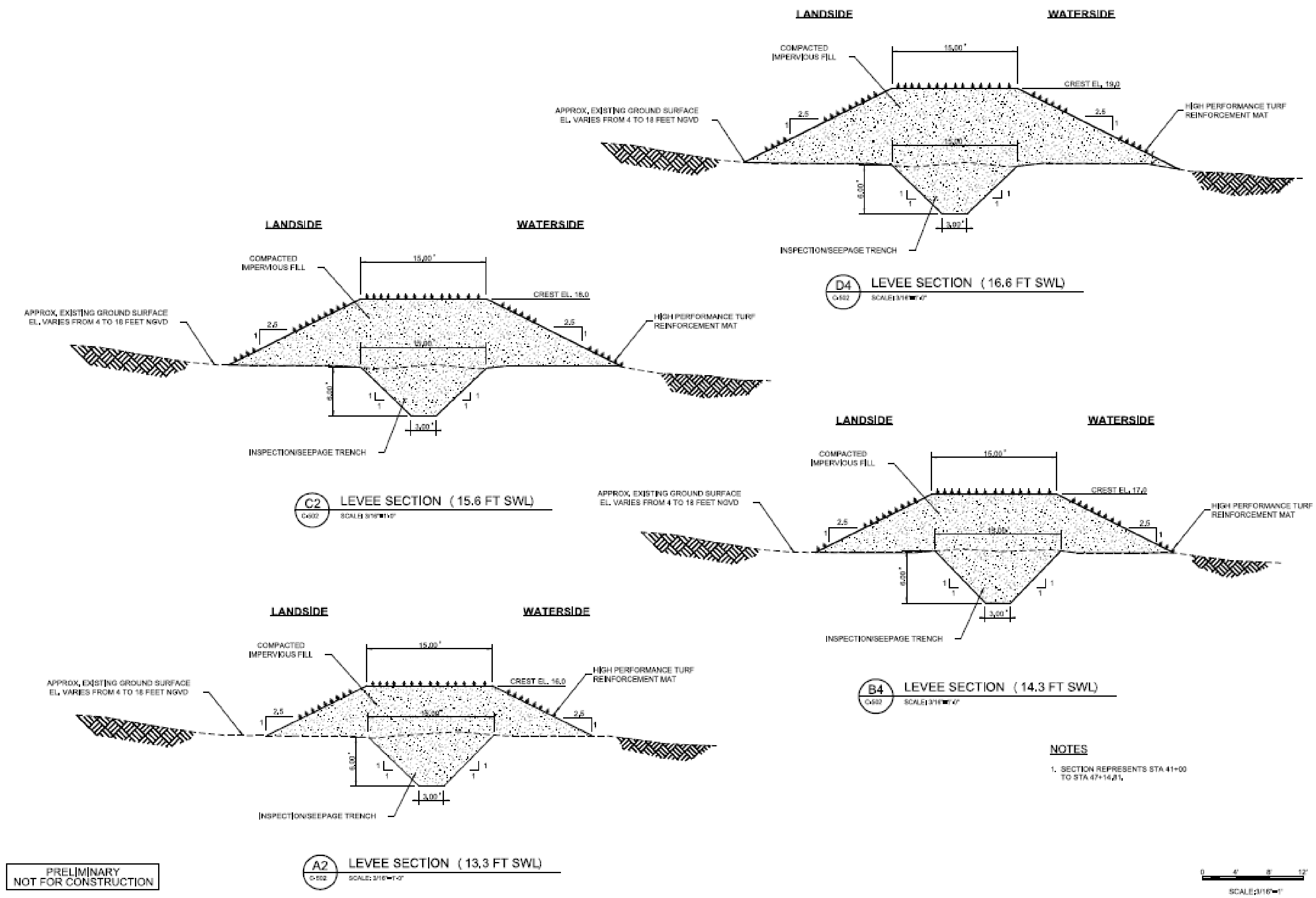
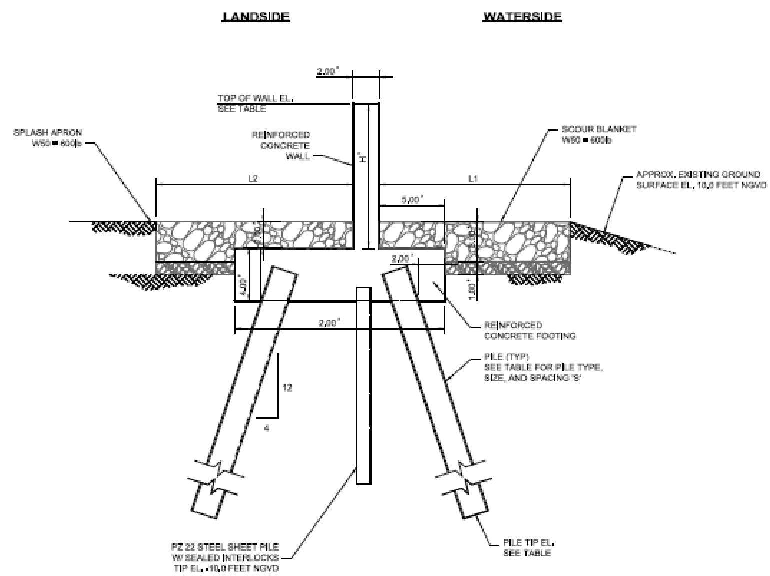


Plate 23: C-502 TYPICALSECTIONS REACH A-2

NOTES

1. SECTION REPRESENTS STA 47+14.81 TO STA 65+40.



B2 C-503 FLOOD WALL SECTION
SCALE: 1/4"=1'-0"

ELEVATIONS (FT, NGVD)			PILE DATA		DIMENSIONS					
SWL (FT)	TOP OF WALL	PILETIP	TYPE	SIZE	H (FT)	B (FT)	T (FT)	L1 (FT)	L2 (FT)	S (FT)
13.3	16.0	-75.0	H-PILE	HP14 X 89	8.0	12.0	1.5	15.0	10.0	12.0
14.3	18.0	-75.0	H-PILE	HP14 X 89	10.0	15.0	1.5	15.0	12.0	11.0
15.6	20.5	-90.0	H-PILE	HP14 X 89	12.5	16.0	2.0	15.0	15.0	12.0
16.6	22.5	-90.0	H-PILE	HP14 X 90	14.5	18.0	2.5	15.0	16.0	10.0

PRELIMINARY NOT FOR CONSTRUCTION

SCALE: 1/4"=1'

Plate 24: C-503 TYPICALSECTIONS REACH A-3

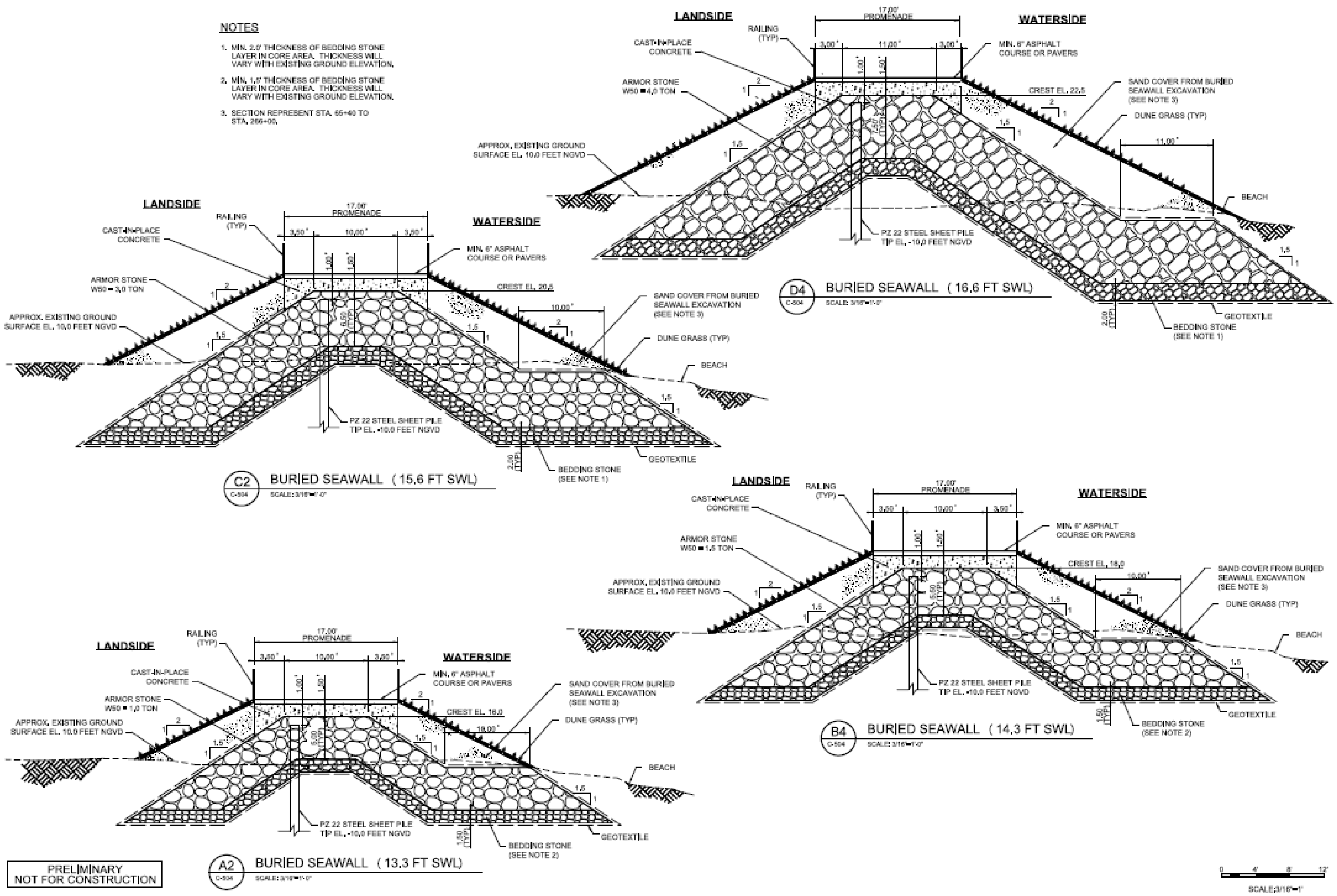


Plate 25: C-504 TYPICALSECTIONS REACH A-4

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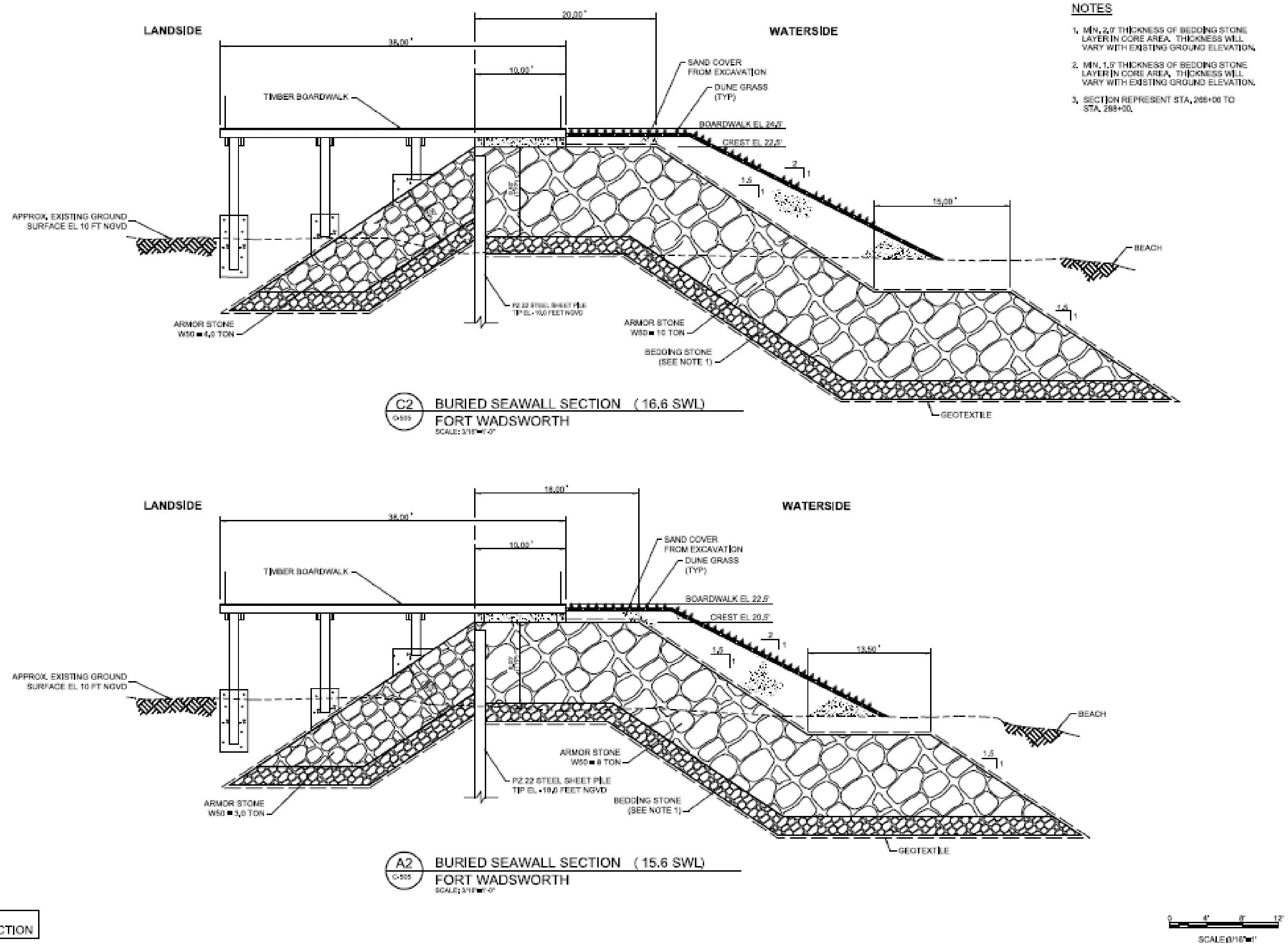

PRELIMINARY
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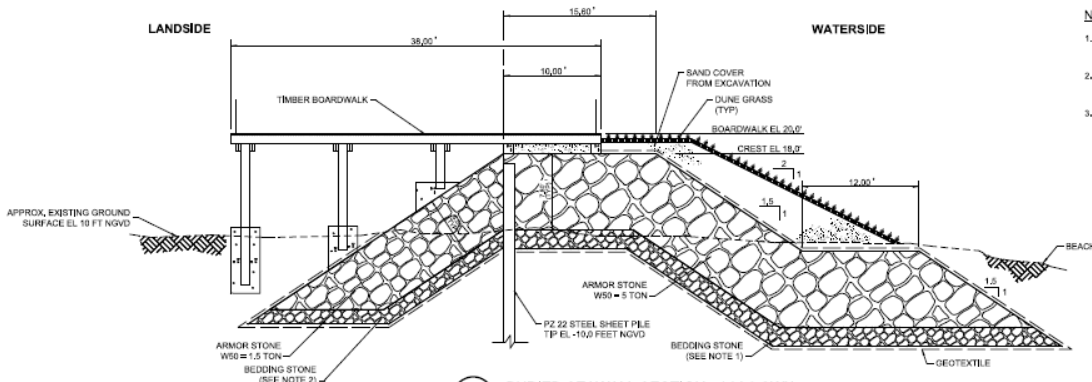
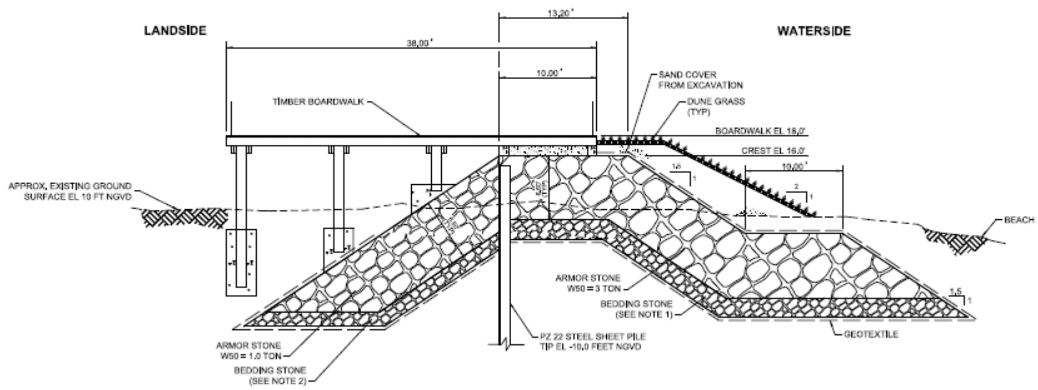
Plate 26: C-505 TYPICALSECTIONS REACH A-4A (1OF2)



C2 BURIED SEAWALL SECTION (14.3 SWL)
FORT WADSWORTH
SCALE: 3/16"=1'-0"

NOTES

1. MIN. 2.0' THICKNESS OF BEDDING STONE LAYER IN CORE AREA. THICKNESS WILL VARY WITH EXISTING GROUND ELEVATION.
2. MIN. 1.5' THICKNESS OF BEDDING STONE LAYER IN CORE AREA. THICKNESS WILL VARY WITH EXISTING GROUND ELEVATION.
3. SECTION REPRESENT STA. 266+00 TO STA. 288+00.

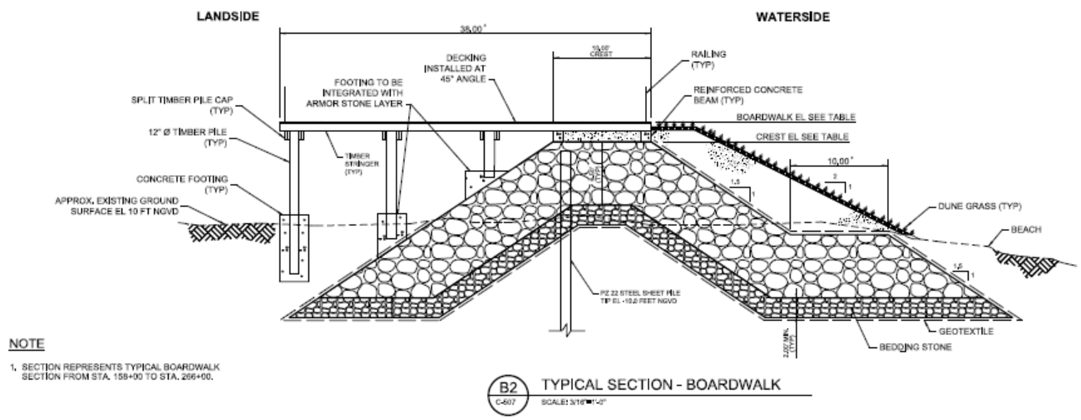


A2 BURIED SEAWALL SECTION (13.3 SWL)
FORT WADSWORTH
SCALE: 3/16"=1'-0"

PRELIMINARY
NOT FOR CONSTRUCTION

SCALE:3/16"=1'

Plate 27: C-506 C-505 TYPICALSECTIONS REACH A-4A (2OF2)



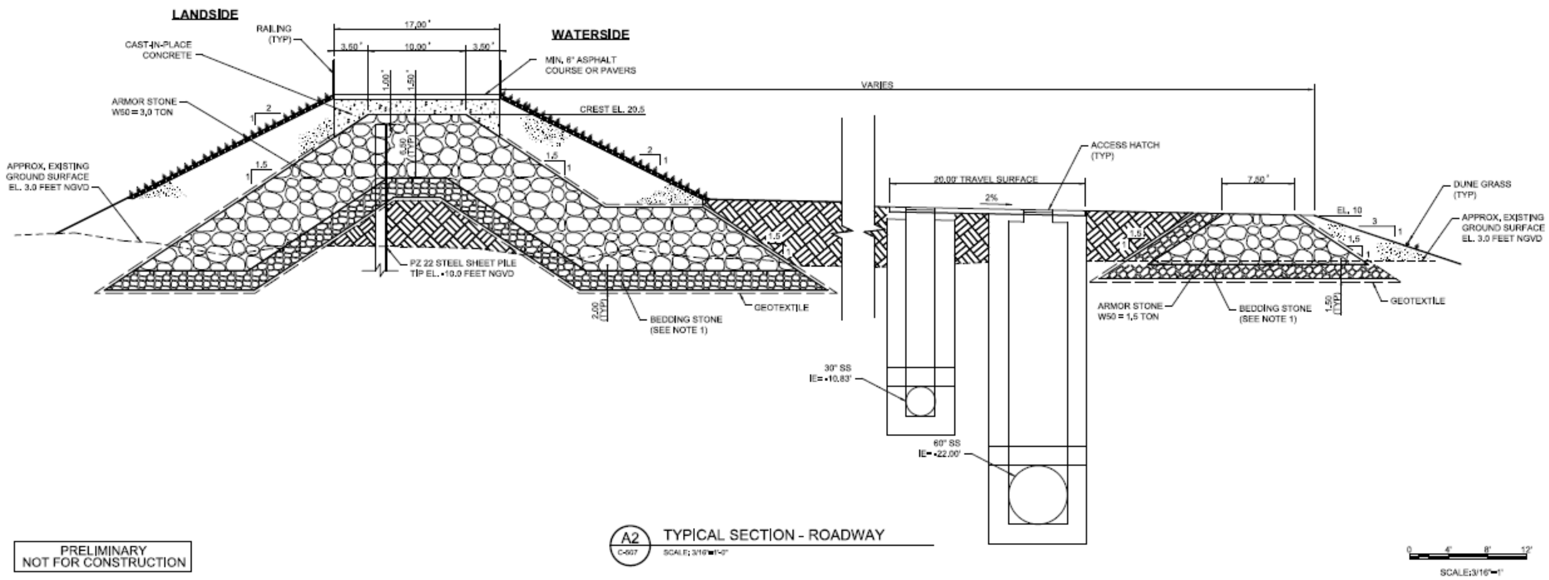
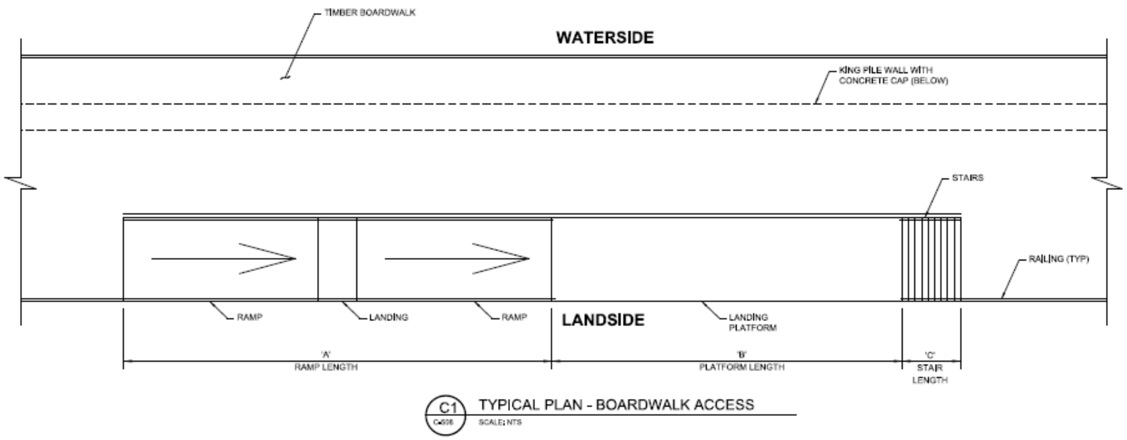


Plate 28: Plate 28: C-507 BOARDW ALK AND ROADWAY



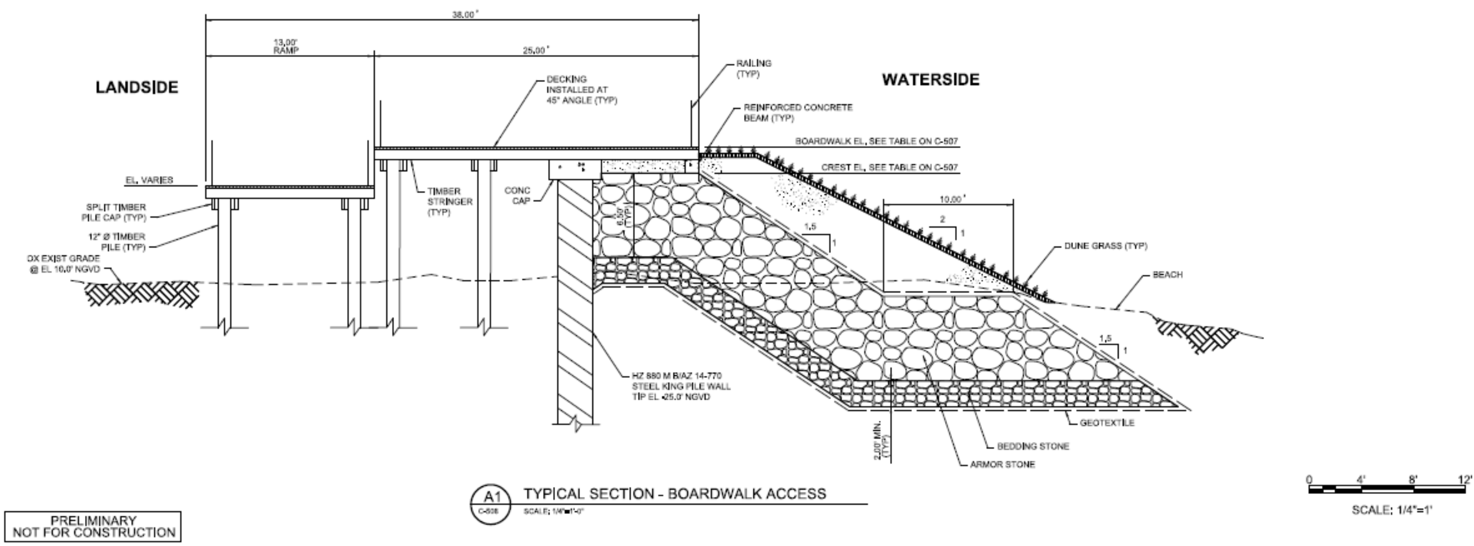
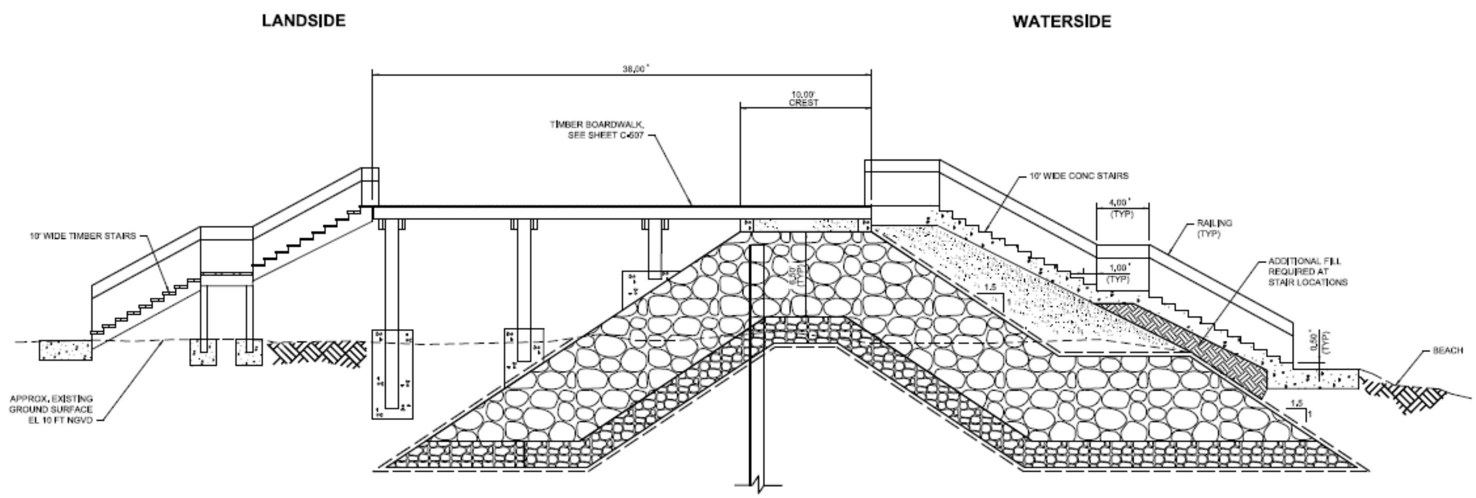


Plate 29: C-508 TYPICALSECTION BOARDW ALK ACCESS



B2 C-509 TYPICAL SECTION - PEDESTRIAN ACCESS STAIRS
SCALE: 1/4"=1'-0"

NOTES

1. STAIR LAYOUT SHOWN FOR THE 15.6 FT SWL. NUMBER OF STAIRS WILL VARY BASED ON SWL. SEE SHEETS C-504 THROUGH C-506 FOR BURIED SEAWALL DIMENSIONS.

0 4' 8' 12'
SCALE: 1/4"=1'

PRELIMINARY
NOT FOR CONSTRUCTION

Plate 30: C-509 PEDESTRIAN ACCESS STAIRS

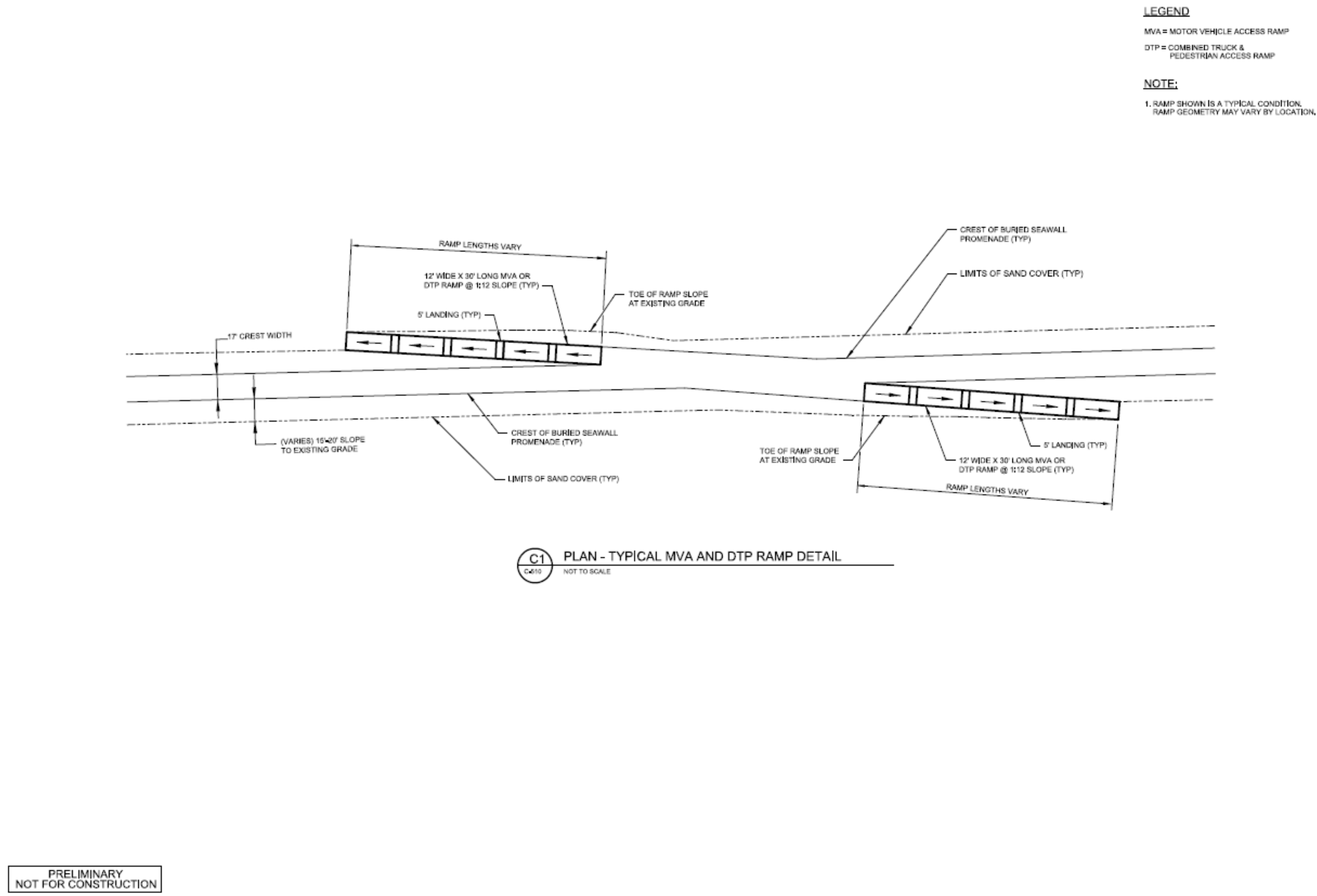
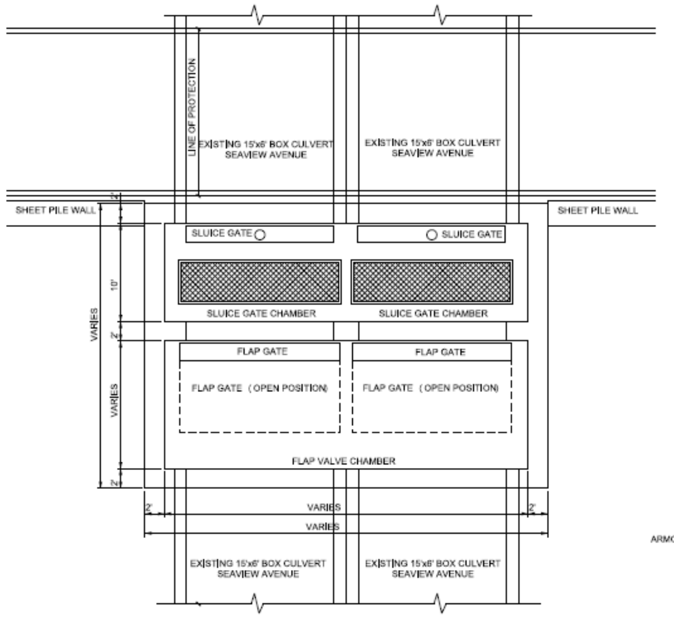


Plate 31: C-510 TYPICALMVA AND DTP RAMP DETAIL

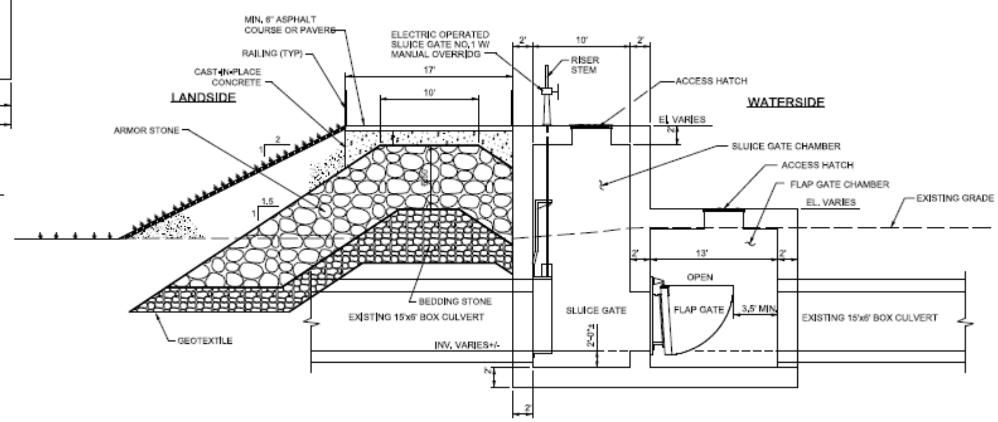
LOCATION	PIPE WIDTH (ft.)	PIPE HEIGHT (ft.)	INVERT AT CHAMBER (ft.)	# OF PIPES	WIDTH INSIDE SLUICE GATE CHAMBER (ft.)	ROOF ELEVATION FLAP GATE CHAMBER (ft.)	WIDTH INSIDE FLAP GATE CHAMBER (ft.)	LENGTH INSIDE FLAP GATE CHAMBER (ft.)	SLUICE GATE CHAMBER WIDTH (ft.)	FLAP GATE CHAMBER WIDTH (ft.)
EBBITS STREET	10,00	5,00	-1,44	1,00	15,00	11,00	15,00	12,00	19,00	19,00
NEW DROP LANE	13,00	5,50	-3, ±	1,00	21,00	12,00	21,00	13,00	25,00	25,00
TYSENS LANE	11,00	8,00	-4, ±	1,00	16,00	12,50	16,00	15,00	20,00	20,00
GREELY AVENUE	15,00	6,25	-2,66	2,00	38,00	13,00	38,00	14,00	42,00	42,00
MIDLAND AVENUE	8,00	4,00	-1,48	1,00	13,00	13,50	13,00	11,00	17,00	17,00
NAUGHTON AVENUE	10.00	6.50	-2.63	2.00	27.00	11.00	27.00	14.00	31.00	31.00
SEAVIEW AVENUE	15,00	8,00	-2,93	2,00	38,00	11,50	38,00	13,00	42,00	42,00
QUINTARD STREET	10,00	6,75	-2,87	2,00	27,00	11,50	27,00	14,00	30,00	30,00
SAND LANE	10.00	6.00	-2.60	1.00	15.00	12.00	15.00	13.00	19.00	19.00

* VERTICAL CONTROL IS IN NGVD 1929.



TYPICAL PLAN

SCALE: 3/16"=1'-0"



NOTE:
ALL REBARAS ARE #6@6" O.C. TOP AND BOTTOM, AND EACH FACE

A2 C-512 SECTION - TIDE ACTUATED DRAINAGE CONTROL STRUCTURE

SCALE: 3/16"=1'-0"

PRELIMINARY
NOT FOR CONSTRUCTION

SCALE: 3/16"=1'

Plate 32: C-512 CONTROL STRUCTURE

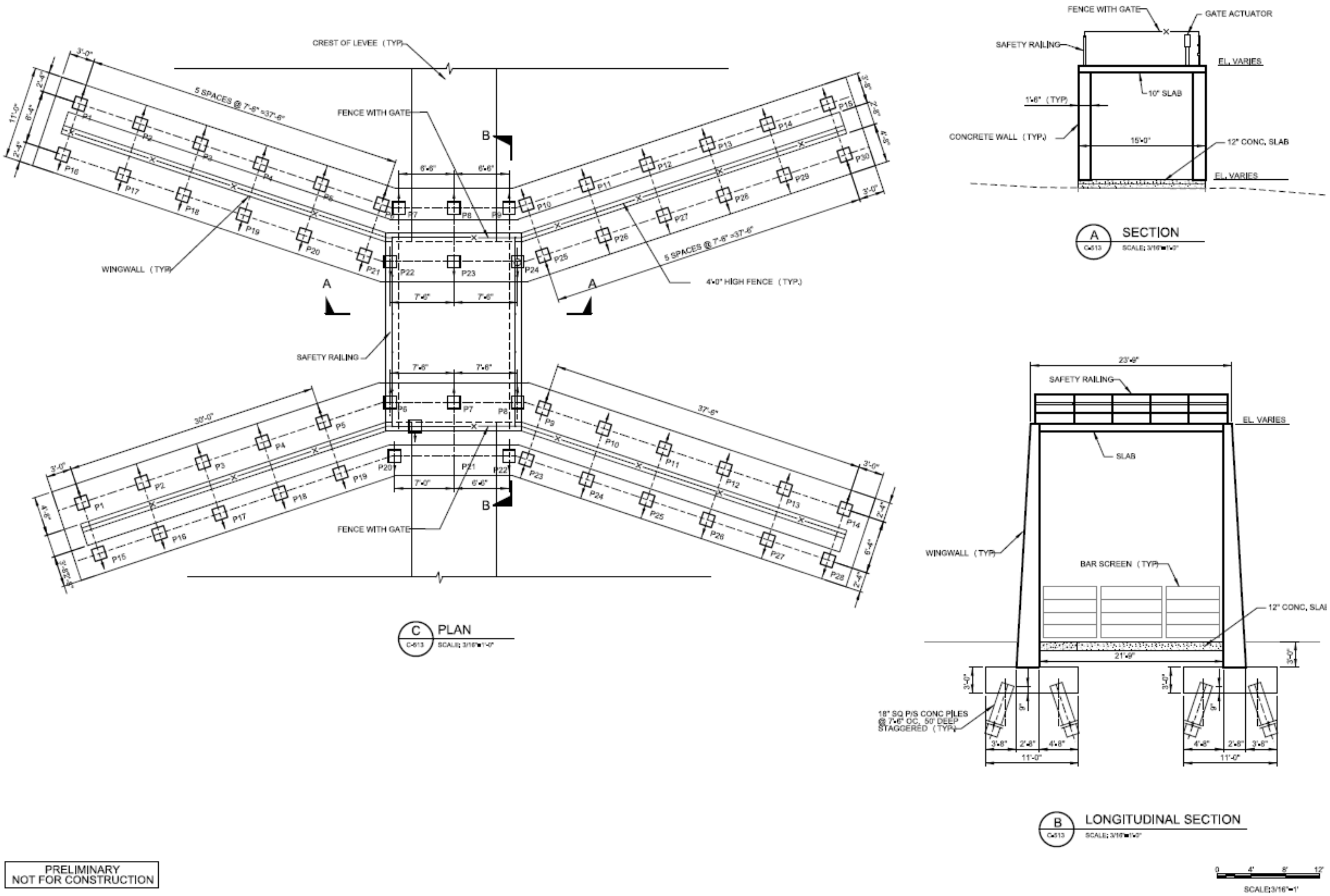


Plate 33: C-513 TIDE GATE STRUCTURE DETAILS

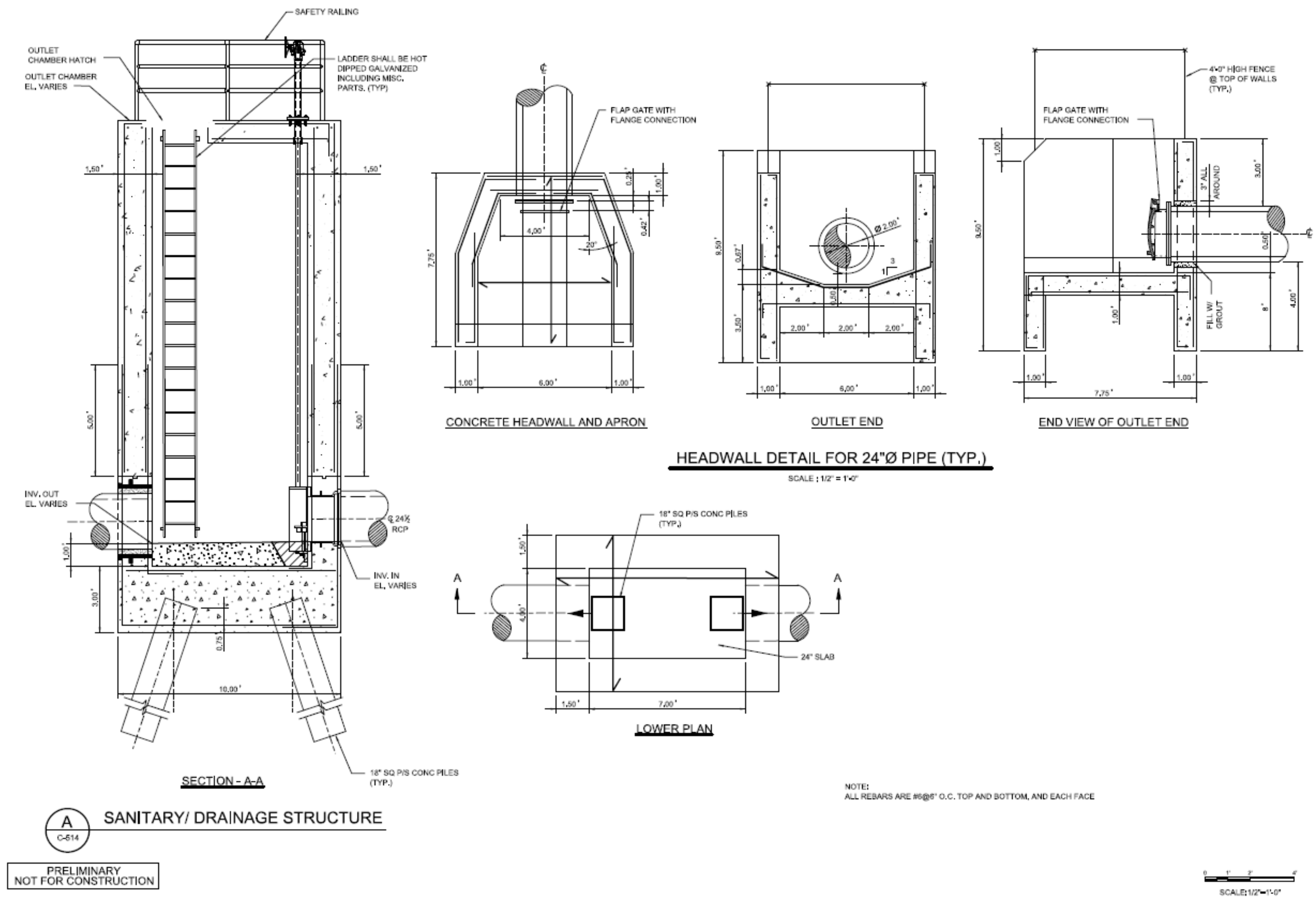


Plate 34: C-514 CONCRETE HEADW ALLDETAILS

DRAFT

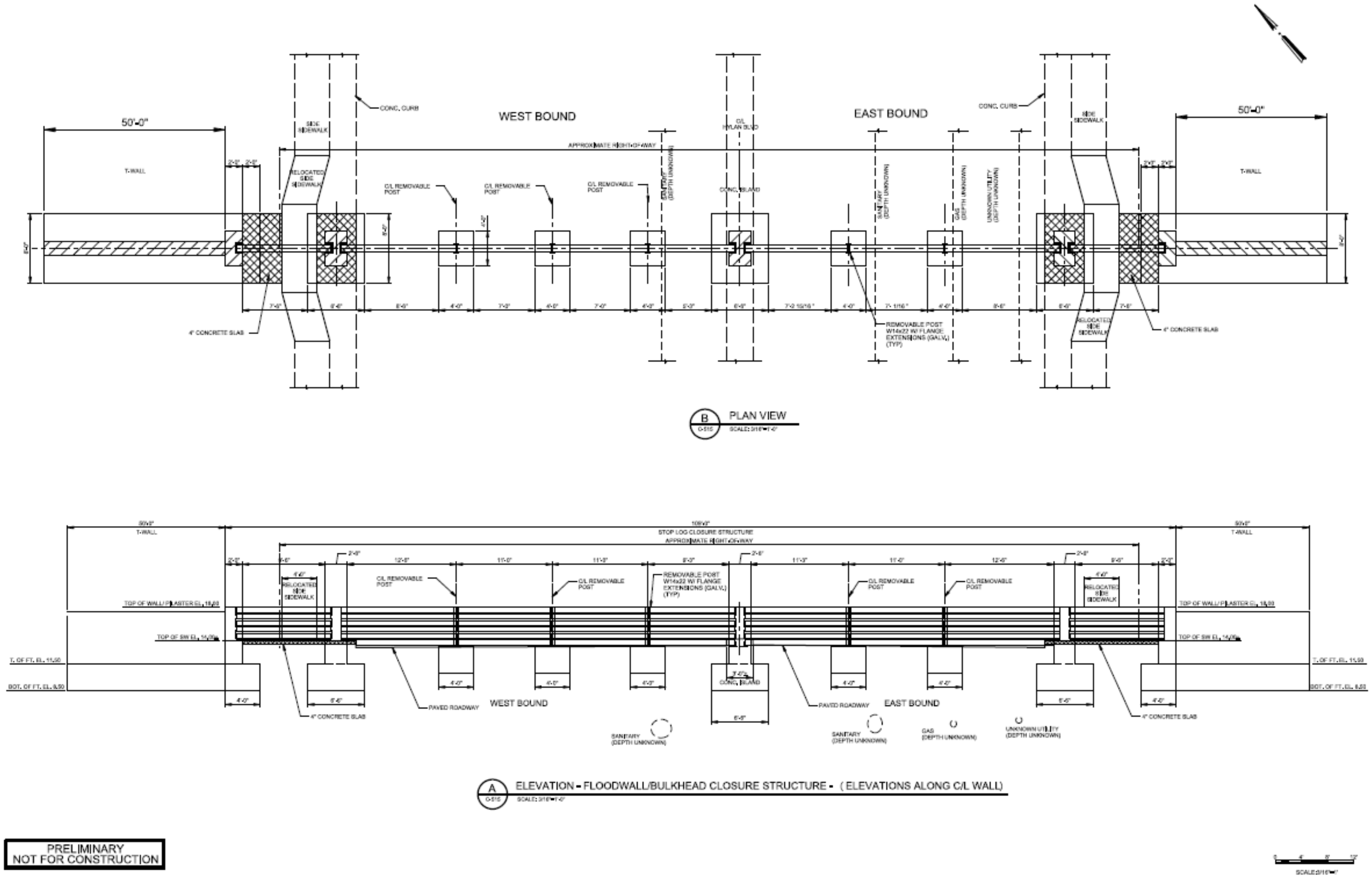


Plate 35: C-515 CLOSURE STRUCTURE PLAN AND ELEVATION

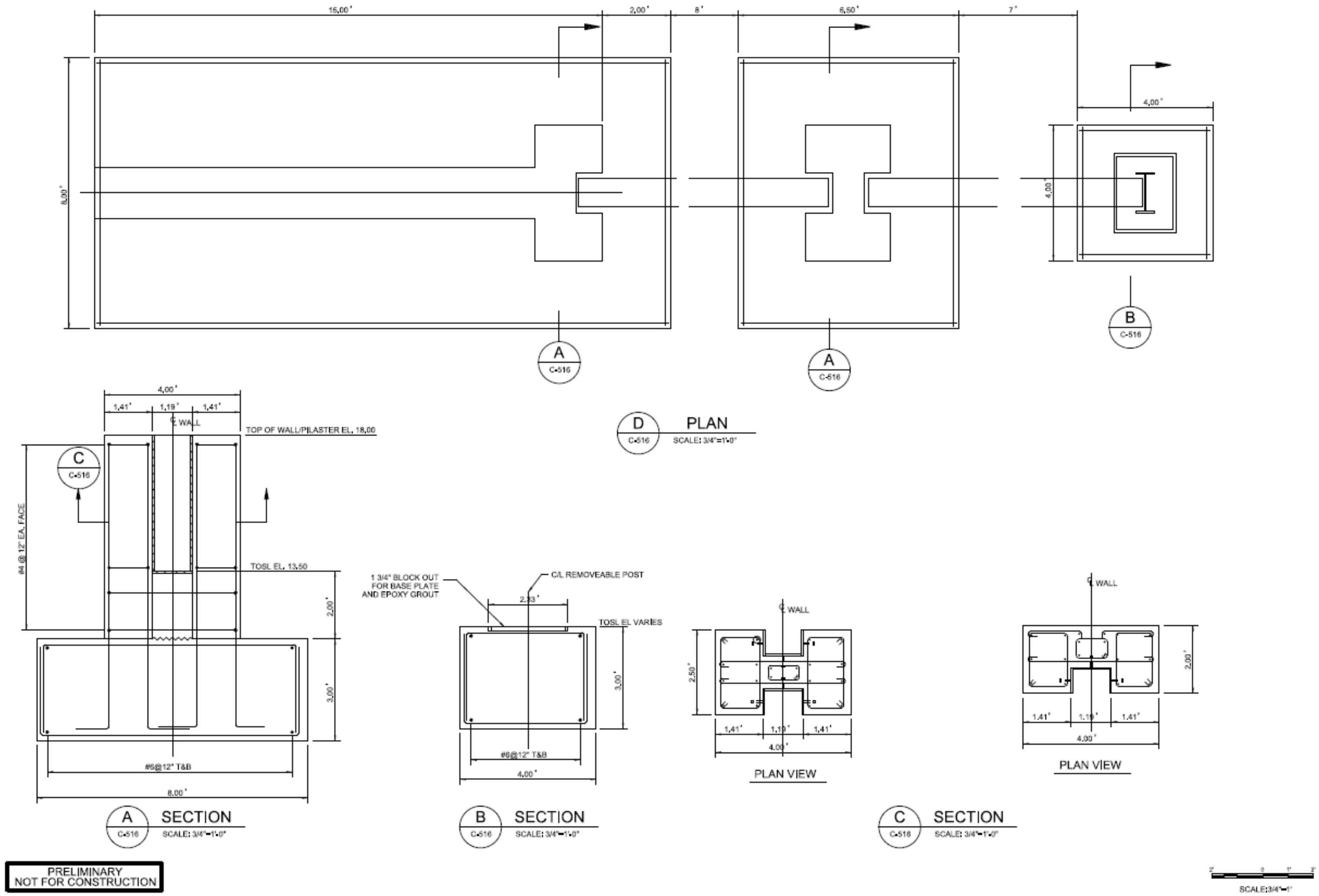


Plate 36: C-516 CLOSURE STRUCTURE DETAILS