US Army Corps of Engineers®
New York District

Cost Engineering Appendix

DRAFT

New York – New Jersey Harbor and Tributaries Coastal Storm Risk Management Feasibility Study

Appendix C

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LIST OF TABLES

LIST OF ACRONYMS

Term/Acronym	Expanded
AK	Arthur Kill
AMF	Access Material Factor
CSI	Construction Specifications Institution
CWWBS	Civil Works Work Breakdown Structure
E&D	Engineering & Design
EL.	Elevation
EM	Engineering Manual
ER	Engineer Regulation

Term/Acronym	Expanded
FC	Flushing Creek
GC	Gowanus Canal
GIS	Geographic Information System
NYNJHAT	New York–New Jersey Harbor and Tributaries Coastal Storm Risk Management Feasibility Study
HFFPF	High Frequency Flood Protection Feature
HOOH	Home Office Overhead
HR	Hackensack River
HRL	Hackensack Perimeter Lower Area – Polygon
IFF	Induced Flooding-Mitigation Features
JB	Jamaica Bay
JOOH	Job Office Overhead
KV	Kill Van Kull
LOP	Line of Protection
MCASES	Micro-Computer Aided Cost Estimating System
MCLEM	Marine Crew Labor and Equipment
MII	MCASES Second Generation
NAVD88	North American Vertical Datum of 1988
NAVD88	North American Vertical Datum of 1988
NC	Newton Creek
NJ	New Jersey
NY	New York
NYC	New York City
OMRRR	Operation Maintenance Repair Replacement Rehabilitation
PED	Planning, Engineering, & Design
PDT	Project Delivery Team
RRF	Risk Reduction Features
SBM	Shore-Based Measures
SH	Sandy Hook
SIOH	Supervision, Inspection, and Overhead
SoW	Scope of Work
SSB	Storm Surge Barriers
TN	Throg's Neck
TPCS	Total Project Cost Summary
TSP	Tentatively Selected Plan
USACE	United States Army Corps of Engineers
USACE ER	USACE Engineering Regulation
USACE-NAN	USACE New York District
VN	Verrazano Narrows
WBS	Work Breakdown Structure

1 Introduction

This appendix presents the cost estimates and construction durations developed for the NYNJHAT study, including both the in-water (e.g., storm-surge barriers) and land-based features (e.g., levees, floodwalls, etc.), to achieve a Class 4 (Class 5 for some cases) cost estimate per Engineer Regulation (ER) 1110-2-1302 for the purpose of assisting with distinguishing the current five project alternatives described in the main feasibility report for the selection of a tentatively selected plan (TSP).

1.1 Study Alternatives Overview

The six alternatives for the NYNJHAT Study (no action, and five project alternatives) are presented in the body of the main feasibility report. An overview of each study alternative is presented in Table 1.

Table 1: NYNJHAT Study Alternatives – Structural Measure Overview

Alt.	Areas that see flood risk reduction as a result of the Alternative	Feature	Location Description of Features and Measures
1	None.		No Action Alternative.
2	Most of the NYNJHAT Study area.	SSBs:	Outer Harbor (OH) and Throgs Neck (TN)
		SBMs:	Tie-ins to TN SSB and tie-ins to OH SSB
		IFFs:	Along shorelines at the western end of the Long Island Sound. IFFs include additional SSB structures.
		RRFs:	Within the newly created basin between the OH and TN SSB.
3A	A large portion of the NYNJHAT Study area.	SSBs:	Arthur Kill (AK), Verrazzano Narrows (VN), Throgs Neck (TN), Jamaica Bay (JB), Sheepshead Bay (SB), Gerritsen Creek (GRC).
		SBMs:	Tie-ins to the JB SSB, tie-ins to VN SSB, tie-ins to AK SSB and tie-ins to TN SSB.
		IFFs:	Along shorelines at the western end of the Long Island Sound, IFFs at Breezy Point and IFFs in the Lower Bay along the Staten Island and Jersey shoreline. IFFs include additional SSB structures.
		RRFs:	Within the newly created basin between the AK, VN and TN SSB and within Jamaica Bay, upstream of the JB SSB.
3B	Inland NJ areas (incl port, oil terminals and Newark airport) and west side of Staten Island as result of SSBs. In addition, areas with relative high flood risk in NYC.	SSBs:	AK, Kill van Kull (KVK), JB, Flushing Creek (FC), SB, GRC, Newtown Creek (NC), Gowanus Canal (GC).
		SBMs:	Tie-ins to the JB SSB, tie-ins to the AK SSB, tie-ins to KvK and tie-ins to the FC SSB. In addition, SBMs in the Red Hook neighborhood tied into the GC SSB and SBMs in Long Island City tied into the NC SSB. SBMs along the shorelines of Jersey City, the south side and west side of Manhattan and SBMs along the Harlem River.
		IFFs:	At Breezy Point and IFFs in the East River and Harlem River.
		RRFs:	Within the newly created basin between the AK and KVK SSB and within Jamaica Bay, upstream of the JB SSB.
4	Only the areas with higher flood risk or smaller tributary basins in NYNJHAT study area.	SSBs:	Hackensack River (HR), NC, GC, JB, FC, SB, GRC
		SBMs:	Tie-ins to the JB SSB, tie-ins to the HR SSB and tie-ins to the FC SSB. In addition, SBMs in the Red Hook neighborhood tied into the GC SSB and SBMs in Long Island City tied into the NC SSB. SBMs along the shorelines of Jersey City, the south side and west side of Manhattan and SBMs along the Harlem River
		IFFs:	At Breezy Point and IFFs in Newark Bay and the lower reaches of the Passaic and Hackensack River.
		RRFs:	Within Jamaica Bay, upstream of the JB SSB.
5	No SSBs and only SBMs for the areas with higher flood risk in NYNJHAT study area.	SSBs:	None
		SBMs:	SBMs along the shorelines of Jersey City, the south side and west side of Manhattan, SBMs along the Harlem River and SBMs in the Meadowlands
		IFFs:	None
		RRFs:	None

2 Work Breakdown Structure

The project work breakdown structure (WBS) within MII has 5 levels. The NYNJHAT MII WBS follows the following format:

1. Structure (Alphanumeric)
    - Differentiates SSB, SBM, RRF, IFF, Interior Drainage, Non-Structural, and Utility Relocation costs.
    - (e.g., JB = Jamacia Bay SSB, HR = Hackensack River SSB, HRL = Hackensack Perimeter Lower Area – Polygon, etc.)
2. Phase
3. Feature
4. Sub-feature
5. Activity

Table 2 shows the allocation of each structure type (WBS Level 1) within the CWWBS.

Table 2: WBS Classification by Cost Items

NYNJHAT Cost Item	CWWBS
Real Estate/Lands and Damages	01 – Lands and Damages
Utility Relocation	02 – Relocations
Environmental Mitigation	06 – Fish and Wildlife Facilities
SSB	10 – Breakwaters and Seawalls
IFF & RRF Navigable Gates	10 – Breakwaters and Seawalls
SBM	11 – Levees and Floodwalls
RRF	11 – Levees and Floodwalls
IFF	11 – Levees and Floodwalls
Interior Drainage	11 – Levees and Floodwalls
Cultural Resource Mitigation	18 – Cultural Resource Mitigation
Non-Structural	19 – Buildings, Grounds, and Utilities
Planning, Engineering and Design	30 – Planning, Engineering, and Design
Construction Management	31 – Construction Management

3 Cost Estimating Methodology

3.1 Scope of Work Summary

This section presents a narrative on the development of the construction cost estimate for the following elements:

- SSB
- SBM
- RRF
- IFF
- Interior Drainage Features
- Individual Structure Risk Management (Non-structural and Ring-walls)

- Relocation

3.2 SSB and Other Navigation Gates

The methodology adopted for the NYNJHAT study for estimating the construction cost of the SSBs included the following methodology:

- Develop a Class 4 cost estimate for VN, JB, and HR.
- Develop a hybrid/parametric Class 4 cost estimate for the remaining SSBs using scalable equivalent features from the VN, JB, and HR SSBs.
- Develop a hybrid/parametric Class 4 cost estimate for SSB alternative alignments (i.e. VN, AK, and KVKK) using scalable equivalent features from the original VN, JB, and HR SSB alignments.

3.2.1 VN, JB, & HR SSBs – Class 4 Cost Estimate

Project quantities were developed primarily using Microsoft Excel calculations for major elements following the design development described in Appendix B. The cost estimates for the VN, JB, and HR SSBs were developed in MCACES, Second Generation (MII) relying heavily on RSMeans data, engineering judgment, and historical data. Remaining SSBs – Hybrid Parametric Class 4 Cost Estimate.

The development of a Class 4 cost estimate for the remaining storm-surge barriers (SSBs) using scalable equivalent features from the VN, JB, and HR SSBs was completed in two steps.

Step 1: Assign the most applicable VN, JB, and HR sector gate, lift gate, or dam section (WBS Level 2 or 3) (i.e., Scalable Equivalent) to all remaining SSBs under consideration in the study using engineering judgment and the general criteria outlined in Table 3.

Table 3: Scalable Equivalent Selection General Criteria

Scalable Equivalent	Sector Gate Criteria	Lift Gate Criteria (NAVD88)	Dam Section Criteria
HR	gate height < ~59 ft navigable passage span < ~400 ft	lift gate height < ~54 ft, span < ~900 ft	dam height < ~28 ft
JB	gate height < ~59 ft navigable passage span > ~400 ft	lift gate height < ~54 ft, span > ~900 ft	~28 ft < dam height < ~34 ft
VN	gate height > ~59 ft navigable passage span > ~1,000 ft	lift gate height > ~54 ft (use phase 4, 5, or 6 depending on how the gate characteristics match)	dam height > ~34 ft

Step 1 includes making assumptions on the number of construction phases required to limit hydrodynamic and navigational impacts, as follows:

- For most SSBs, keep each phase under ~1,000 linear feet

- For Sandy Hook (SH) to Breezy Point SSB, keep each phase under ~1,500 linear feet

Table 4 and Table 5 present the Scalable Equivalent adopted for each of the remaining SSBs under consideration.

Table 4: Remaining SSB (except SH) Scalable Equivalent VN, JB, & HR Sector Gate, Lift Gate, or Dam Section

Remaining SSB under consideration	Scalable Equivalent WBS Phase 1 (generally, the Navigable Gate)	Scalable Equivalent WBS Phase 2	Scalable Equivalent WBS Phase 3	Scalable Equivalent WBS Phase 4
AK	VN01	HR03	HR03	n/a
KV	VN01	JB03	HR0303	n/a
GC	HR01	n/a	n/a	n/a
NC	HR01	n/a	n/a	n/a
FC	n/a	HR02	HR02	n/a
TN	VN01	JB03 (w/o dam section)	VN06	JB04

Table 5: SH Scalable Equivalent VN, JB, & HR Sector Gate, Lift Gate, or Dam Section

Phase Number	Phase Name	Scalable Equivalent WBS	Phase Number	Phase Name	Scalable Equivalent WBS
1	Primary Floating Sector Gate	VN01	3 – W	West Dam Section	VN0603
2	Sandy Hook Floating Sector Gate	VN01	4 – W	L Lifts Gates, West Intermediate Dam	VN06
3 – E	A Lift Gates, East Dam Section	VN06	5 – W	L Lifts Gates	VN05
4 – E	Rockaway Inlet Sector Gate, Vertical Axis	VN02	6 – W	L Lifts Gates	VN05
5 – E	C Lift Gates, E Intermediate Dam Section	VN06	7 – W	L Lifts Gates	VN05
6 – E	D Lifts Gates	VN05	8 – W	L Lifts Gates	VN05
7 – E	D Lifts Gates	VN05	9 – W	K Lifts Gates	VN05
8 – E	E Lifts Gates	VN05	10 – W	J Lifts Gates	VN05
9 – E	E Lifts Gates	VN05	11 – W	I Lifts Gates	VN05
10 – E	F Lifts Gates	VN05	12 – W	I Lifts Gates	VN05
11 – E	F Lifts Gates	VN05	13 – W	I Lifts Gates	VN05
12 – E	F Lifts Gates	VN05	14 – W	G Lifts Gates	VN05
13 – E	F Lifts Gates	VN05	15 – W	G Lifts Gates	VN05

Phase Number	Phase Name	Scalable Equivalent WBS	Phase Number	Phase Name	Scalable Equivalent WBS
14 – E	G Lifts Gates	VN05			
15 – E	G Lifts Gates	VN05			

Step 2: Develop a scaling factor to scale the quantities developed for each Scalable Equivalent.

Sector Gate Section: The Sector Gate sections are scaled by the navigable passage area (navigable passage span × gate height). Navigable passage span is defined as the gate width + pier/island widths. Gate height is defined as the distance between the sill elevation and the top of the gate/top of structure elevation (elevation B in the engineering appendix).

Lift Gate Section: The Lift Gate sections are scaled by the auxiliary area (span × gate height). Total span is defined as the distance between the outside of the outermost piers in the lift gate sections. Gate height is defined as the distance between the average sill elevation and the top of structure elevation (elevation B in the engineering appendix).

Dam Section: The dam sections are scaled by the dam area (length × dam height). Dam span is defined as the total length of the dam section between the outermost lift gate pier and the shore-based measures. Dam height is defined as the distance between the average dam mudline elevation and the top of the dam structure/top of structure elevation (elevation B in the engineering appendix).

Combined Lift Gate and Dam Section: The VN, JB, and HR Phases (WBS Level 2) generally include a combined lift gate and dam section. As such, a combined lift gate and dam section scaling factor was developed using a weighted equation based off the interim study SSB construction cost equation (USACE, 2019b).

3.2.2 SSB Alternative Alignments and RRF and IFF Navigation Gates – Hybrid Parametric Class 4 Cost Estimate

The project construction costs for the SSB Alternative Alignments and RRF and IFF Navigation Gates were developed with the same process as the remaining SSBs outlined in Section 3.2.2.

3.3 SBM, RRF, and IFF

Project quantities were developed for typical measure cross-sections primarily using Microsoft Excel calculations for major elements following the design development described in Appendix B. Linear foot costs for typical SBM, RRF, and IFF measures were developed in MII as assemblies, relying heavily on cost book data and supplemented with quotes for major equipment (i.e., flip-up barriers and operable floodgates). Within MII, the quantity measure assemblies are multiplied by the length of each measure attributed to the specific site.

The typical SBM and IFF features developed in MII include:

- XL Floodwall
- Large Floodwall
- Medium Floodwall
- Medium Levee
- Large Levee
- Elevated Promenade

- Reinforced Dune
- Seawall
- Floodwall w/ Park Integration
- Levee with Road Ramp
- Flip-up Barrier
- Deployable Floodgate
- Tide Gates

The typical RRF features developed in MII include:

- High Floodwall
- Standard Floodwall
- Low Floodwall
- High Berm
- Medium Berm
- Low Berm
- Hybrid Berm
- Revetment with Floodwall
- Deep Bulkhead
- Shallow Bulkhead
- Tide Gates
- Deployable Floodgate
- Road Ramp
- Road Raising

Site specific modifiers, such as population density, site access, and staging conditions, were applied as productivity, marine crew labor and equipment (MCLEM), and access material factor (AMF) markups within MII to account for construction cost variability at each site.

3.4 Interior Drainage Features

Cost estimates for interior drainage features associates with SSBs, SBMs, and RRFs were developed as follows:

- **SSB Interior Drainage Features** - Pump station costs have been estimated using a cost curve developed from prior projects.
- **SBM & RRF Interior Drainage Features** – Cost estimates for interior drainage facilities behind fixed lines of protection were developed from historical costs of such facilities for previously constructed or currently proposed projects of a similar nature in the New York/New Jersey area. The costs were applied as a linear foot cost and based off storage/access constrains.

3.5 Individual Structure Risk Management (Non-structural and Ring-walls)

Cost estimates for individual structure risk management were developed as follows:

- **Wet Floodproofing, Dry Floodproofing, & Elevation** - The analysis referenced non-structural costs developed for other projects and assigned costs based on structure type (i.e., slab on grade, basement – subgrade, basement – walkout, raised/crawlspace, bilevel / raised ranch, split level), flood depth / elevation height, and building footprint.
- **Structural Ring-walls and Ring-levees** - The reference cost for ring-walls was taken from the cost estimate for a stand-alone floodwall of height 6.5 feet above grade, derived as part of the structural plan development.

The individual structure risk management costs were incorporated into the MII cost estimate as a direct cost allowance within an individual CSI task. Reference Engineering Sub-Appendix B.5 for

additional information on the individual structure risk management costs. Individual structure risk management costs are input into MII at the effective price level.

3.6 SBM, RRF, and IFF Relocation

Relocation costs include removing, relocating, or reconstructing property of others, such as roads, railroads, cemeteries, utilities, buildings, and other structures, and includes real estate planning and acquisition expenses. For the NYNJHAT study, relocations costs for each project were developed at a Class 5 level without site-specific investigations or surveys. A parametric formula for relocation costs was developed from recent similar projects in the Northeast using a best-fit exponential equation relating site-specific characteristics of the project area to the cost per foot for relocations. Cost data were gathered from the following sources:

- East Harlem Resiliency Study – Costing Memo, October 23, 2018;
- South Shore of Staten Island, NY Coastal Storm Risk Management; Interim Feasibility Study for Fort Wadsworth to Oakwood Beach – USACE Cost Engineering Appendix, September 2016; and
- Rahway River Basin, New Jersey Coastal Storm Risk Management Feasibility Study – USACE Cost Engineering Appendix.

3.7 Lands and Damages

Studies were conducted by the USACE New York District Real Estate Division to determine the estimates value of land and easements needed for each alternative. The estimates for Alternatives 2 and 5 were completed at a higher level than Alternatives 3A, 3B, and 4.

3.8 Planning, Engineering, & Design

The cost was developed for all activities associated with the planning, engineering, and design effort. The cost for this account includes the preparation of Design Documentation Reports, plans, specifications, and engineering support during construction through project completion. It includes all the in-house labor based upon work-hour requirements, material and facility costs, travel, and overhead.

3.9 Construction Management

The cost was developed for all construction management activities from pre-award requirements through final contract closeout. This cost includes the in-house labor based upon work-hour requirements, materials, facility costs, support contracts, travel and overhead. The cost was developed based on the input from the construction division in accordance with the CWBS and include but not limited to anticipated items such as salaries of the resident engineer and staff, survey men, inspectors, draftsmen, clerical, and custodial personnel; operation, maintenance and fixed charges for transportation and for other field equipment; field supplies; construction management, general construction supervision; project office administration, distributive cost of area office and general overhead charged to the project. The work items and activities would

include, but not be limited to: the salaries of all supervisory, engineering, office and safety field personnel; all on site expenses.

4 Schedule Methodology

This section provides background on how the construction durations were developed for each project and each NYNJHAT study alternative.

4.1 Environmental Restriction Windows

Environmental restriction windows are a major impact on the duration of marine construction projects. The initial environmental restriction windows assumptions adopted for the study were developed based on previous projects and are presented in Table 6 and Table 7. The construction schedule durations for the NYNJHAT study are based on these environmental windows.

Table 6: SSB Environmental Restriction Windows

SSB	Environmental Restriction Window	% of Year
SH	Jan 1 – May 31	41%
HR	Mar 1 – Jun 30	33%
AK, KV	Mar 1 – May 31	25%
VN	Nov 15 – Apr 15	42%
JB	Apr 1 – Sep 15	46%
FC, NC, GC, TN	Jul 1 – Sep 30	25%

Table 7: SBM, RRF, and IFF Environmental Restriction Windows

SBM	Environmental Restriction Window	% of Year
ALL SBMs, RRFs, and IFFs	Mar 1 – Jun 30	33%

4.2 NYNJHAT Study Alternative - Construction Duration Methodology

The construction durations for each NYNJHAT study alternative were developed with a simplified contracting strategy consistent across each alternative for the purpose of determining the TSP. The adopted methodology used the following major assumptions:

- Four (4) of each category of perimeter measure/feature (primary SBMs, RRFs and IFFs) will be under construction at any given time.
- The number of SSBs under construction at any given time is not limited.
- If any single measure/feature (such as an SSB or a major SBM) has a construction duration larger than the previous assumption calculations, then that becomes the critical path.
- If the average amount of "schedule float" associated with the categories of construction which are not on the critical path is less than 25% of the duration of the estimated

construction duration associated with the critical path, an additional year is added to the total duration estimate.

The NYNJHAT study alternative construction durations are presented in Table 8.

Table 8: NYNJHAT Study Alternative Construction Duration

Alternative	Construction Duration (years)
2	32
3A	25
3B	14
4	14
5	6

5 Contingencies

As stated in ER 1110-2-1302, the goal in contingency development is to identify the uncertainty associated with an item of work or task, forecast the cost/risk relationship, and assign a value to this task that would limit the cost risk to an acceptable degree of confidence. Consideration must be given to the details available at each stage of planning, design, or construction for which a cost estimate is being prepared. Contingencies may vary throughout the cost estimate and could constitute a significant portion of the overall costs when a lack of investigative data or design details are available. Final contingency development and assignment that describes the potential for cost growth is included in the cost estimate. During the development of the cost estimates, sufficient contingencies developed via PDT discussions during Abbreviated Risk Analysis (ARA) were applied to develop the Total Project First Cost. Major contingency drivers determined by the PDT in the project include geotechnical conditions, limited field investigations, navigation access, and potential for scope growth. These drivers all have the potential to bring forth unforeseen costs. The contingency factors for each of the five (5) alternatives resulted from the ARA are summarized in Tables 9-13.

Table 9: Alternative 2 Contingency Factors

Element	Features of Work	Contingency Factor
02 Relocations	Relocations	54.23%
06 Fish & Wildlife Facilities	Environmental Mitigation	80.82%
10 Breakwater & Seawalls	SSB: Breezy Point to Sandy Hook	62.17%
10 Breakwater & Seawalls	SSB: Throgs Neck	47.49%
10 Breakwater & Seawalls	IFF SSB and RRF Navigable Barriers	85.11%
11 Levees and Floodwalls	Shoreline Based Measures	29.24%
11 Levees and Floodwalls	Induced Flooding-Mitigation Features	36.30%
11 Levees and Floodwalls	Risk Reduction Features	53.98%
11 Levees and Floodwalls	Interior Drainage Features	50.76%
11 Levees and Floodwalls	Individual Structure Protection/Non-Structural	45.25%
19 Building, Grounds, and Utilities	Individual Structure Protection/Non-Structural	45.25%
Total Construction Contingency		**59.24%**
01 Lands and Damages	Lands and Damages	50.00%
30 Planning, Engineering, and Design	Planning, Engineering, and Design	59.24%
31 Construction Management	Construction Management	59.24%

Table 10: Alternative 3A Contingency Factors

Element	Features of Work	Contingency Factor
02 Relocations	Relocations	54.23%
06 Fish & Wildlife Facilities	Environmental Mitigation	80.82%
10 Breakwater & Seawalls	SSB: Verrazano Narrows	79.40%
10 Breakwater & Seawalls	SSB: Arthur Kill	42.65%
10 Breakwater & Seawalls	SSB: Jamaica Bay	33.70%
10 Breakwater & Seawalls	SSB: Throgs Neck	47.49%
10 Breakwater & Seawalls	IFF SSB and RRF Navigable Barriers	85.11%
11 Levees and Floodwalls	Shoreline Based Measures	32.76%
11 Levees and Floodwalls	Induced Flooding-Mitigation Features	37.53%
11 Levees and Floodwalls	Risk Reduction Features	53.98%
11 Levees and Floodwalls	Interior Drainage Features	50.76%
11 Levees and Floodwalls	Individual Structure Protection/Non-Structural	45.25%
18 Cultural Resource Mitigation	Cultural Resource Mitigation	23.31%
19 Building, Grounds, and Utilities	Individual Structure Protection/Non-Structural	45.25%
Total Construction Contingency		**59.10%**
01 Lands and Damages	Lands and Damages	50.00%
30 Planning, Engineering, and Design	Planning, Engineering, and Design	59.10%
31 Construction Management	Construction Management	59.10%

Table 11: Alternative 3B Contingency Factors

Element	Features of Work	Contingency Factor
02 Relocations	Relocations	76.33%
06 Fish & Wildlife Facilities	Environmental Mitigation	56.68%
10 Breakwater & Seawalls	SSB: Arthur Kill	42.65%
10 Breakwater & Seawalls	SSB: Kill Van Kull	42.65%
10 Breakwater & Seawalls	SSB: Jamaica Bay	33.70%
10 Breakwater & Seawalls	SSB: Gowanus, Newtown, and Flushing	85.11%
10 Breakwater & Seawalls	IFF SSB and RRF Navigable Barriers	85.11%
11 Levees and Floodwalls	Shoreline Based Measures	52.47%
11 Levees and Floodwalls	Induced Flooding-Mitigation Features	37.53%
11 Levees and Floodwalls	Risk Reduction Features	53.98%
11 Levees and Floodwalls	Interior Drainage Features	65.52%
11 Levees and Floodwalls	Individual Structure Protection/Non-Structural	49.47%
18 Cultural Resource Mitigation	Cultural Resource Mitigation	61.94%
19 Building, Grounds, and Utilities	Individual Structure Protection/Non-Structural	49.47%
Total Construction Contingency		**50.71%**
01 Lands and Damages	Lands and Damages	30.00%
30 Planning, Engineering, and Design	Planning, Engineering, and Design	50.71%
31 Construction Management	Construction Management	50.71%

Table 12: Alternative 4 Contingency Factors

Element	Features of Work	Contingency Factor
02 Relocations	Relocations	76.33%
06 Fish & Wildlife Facilities	Environmental Mitigation	56.68%
10 Breakwater & Seawalls	SSB: Hackensack	34.74%
10 Breakwater & Seawalls	SSB: Jamaica Bay	33.70%
10 Breakwater & Seawalls	SSB: Gowanus, Newtown, and Flushing	85.11%
10 Breakwater & Seawalls	RRF Navigation Gates	85.11%
11 Levees and Floodwalls	Shoreline Based Measures	52.47%
11 Levees and Floodwalls	Induced Flooding-Mitigation Features	47.52%
11 Levees and Floodwalls	Risk Reduction Features	53.98%
11 Levees and Floodwalls	Interior Drainage Features	65.52%
11 Levees and Floodwalls	Individual Structure Protection/Non-Structural	61.94%
18 Cultural Resource Mitigation	Cultural Resource Mitigation	23.31%
19 Building, Grounds, and Utilities	Individual Structure Protection/Non-Structural	61.94%
Total Construction Contingency		**51.75%**
01 Lands and Damages	Lands and Damages	50.00%
30 Planning, Engineering, and Design	Planning, Engineering, and Design	51.75%
31 Construction Management	Construction Management	51.75%

Table 13: Alternative 5 Contingency Factors

Element	Features of Work	Contingency Factor
02 Relocations	Relocations	75.10%
06 Fish & Wildlife Facilities	Environmental Mitigation	56.68%
11 Levees and Floodwalls	Shoreline Based Measures	52.47%
11 Levees and Floodwalls	Interior Drainage Features	65.52%
18 Cultural Resource Mitigation	Cultural Resource Mitigation	23.31%
19 Building, Grounds, and Utilities	Individual Structure Protection/Non-Structural	61.94%
Total Construction Contingency		**58.93%**
01 Lands and Damages	Lands and Damages	50.00%
30 Planning, Engineering, and Design	Planning, Engineering, and Design	58.93%
31 Construction Management	Construction Management	58.93%

Table 14: NYNJHAT Features of Work

CWWBS Account Number	Description of the Division of the Features of Work
02 Relocations	One Feature of Work for all relocations.
06 Fish and Wildlife Facilities	One Feature of Work for all environmental mitigation.
10 Breakwaters and Seawalls	Each major SSB was evaluated as a separate Feature of Work with the exception of the smaller SSBs (GC, NC, FC) and the RRF/IFF navigation gates.
11 Levees and Floodwalls	SBMs, IFFs, RRFs, and IDFs were evaluated as separate Features of Work.
18 Cultural Resource Preservation	One Feature of Work for all cultural resource mitigation.
19 Buildings, Grounds, and Utilities	One Feature of Work for all ISRM.

6 OMRRR Costs

Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRRR) costs are calculated as a function of construction costs and applied at the appropriate years, after construction is complete. The OMRRR percentages were developed and described in the interim report (USACE, 2019a).

Operations: All features are treated as if functional/deployed at a rate of once every 2 years at the start of the 50-year period of analysis, growing to three-times every 2 years at the end of the period of analysis.

Maintenance: Annual maintenance costs are calculated at 0.3% of construction costs, to be applied annually once the feature is constructed. Five-year maintenance costs are calculated and applied every 5 years.

Repair: Repair costs are to be applied every 10 years once the feature is constructed.

Rehabilitation: Rehabilitation costs applied twice within the period of analysis, at the 25-year mark and at the 50-year mark.

7 NYNJHAT Study Alternatives First Cost Tables

The NYNJHAT study alternatives cost estimates by First Costs are presented in Table 15, Table 16, Table 17, Table 18, and Table 19.

Table 15: Alternative 2 First Cost Table

Feat. Acct	Description	Subtotal	Cont. %	Cont. $$	Total Cost
01	LANDS AND DAMAGES	$350,830,000	50%	$175,410,000	$526,240,000
02	RELOCATIONS	$985,240,000	54%	$534,300,000	$1,519,530,000
06	FISH AND WILDLIFE FACILITIES	$1,340,000,000	81%	$1,083,040,000	$2,423,040,000
10	BREAKWATERS AND SEAWALLS	$49,931,600,000	62%	$30,893,380,000	$80,824,970,000
11	LEVEES AND FLOODWALLS	$7,238,890,000	38%	$2,746,600,000	$9,985,500,000
19	BUILDINGS, GROUNDS, AND UTILITIES	$77,530,000	45%	$35,080,000	$112,610,000
30	PLANNING, ENGINEERING, AND DESIGN	$8,489,190,000	59%	$5,028,040,000	$13,517,230,000
31	CONSTRUCTION MANAGEMENT	$2,234,000,000	59%	$1,323,170,000	$3,557,170,000
	Total Alt 2	**$70,647,270,000**		**$41,819,030,000**	**$112,466,300,000**

Table 16: Alternative 3A First Cost Table

Feat. Acct	Description	Subtotal	Cont. %	Cont. $$	Total Cost
01	LANDS AND DAMAGES	$2,904,950,000	50%	$1,370,170,000	$4,275,120,000
02	RELOCATIONS	$1,076,310,000	54%	$583,680,000	$1,659,990,000
06	FISH AND WILDLIFE FACILITIES	$1,540,000,000	81%	$1,244,690,000	$2,784,690,000
10	BREAKWATERS AND SEAWALLS	$27,801,500,000	64%	$17,854,390,000	$45,655,890,000
11	LEVEES AND FLOODWALLS	$8,477,570,000	39%	$3,322,460,000	$11,800,030,000
18	CULTURAL RESOURCE PRESERVATION	$39,000,000	23%	$9,090,000	$48,090,000
19	BUILDINGS, GROUNDS, AND UTILITIES	$25,450,000	45%	$11,520,000	$36,970,000
30	PLANNING, ENGINEERING, AND DESIGN	$5,551,780,000	59%	$3,280,650,000	$8,832,430,000
31	CONSTRUCTION MANAGEMENT	$1,460,990,000	59%	$863,330,000	$2,324,320,000
	Total Alt 3A	**$48,877,550,000**		**$28,539,970,000**	**$77,417,520,000**

Table 17: Alternative 3B First Cost Table

Feat. Acct	Description	Subtotal	Cont. %	Cont. $$	Total Cost
01	LANDS AND DAMAGES	$4,488,850,000	30%	$1,316,880,000	$5,805,740,000
02	RELOCATIONS	$1,342,640,000	76%	$1,024,830,000	$2,367,470,000
06	FISH AND WILDLIFE FACILITIES	$3,220,000,000	57%	$1,825,100,000	$5,045,100,000
10	BREAKWATERS AND SEAWALLS	$12,448,260,000	44%	$5,486,220,000	$17,934,480,000
11	LEVEES AND FLOODWALLS	$9,200,320,000	54%	$4,945,580,000	$14,145,890,000
18	CULTURAL RESOURCE PRESERVATION	$94,000,000	62%	$58,220,000	$152,220,000
19	BUILDINGS, GROUNDS, AND UTILITIES	$23,040,000	49%	$11,400,000	$34,440,000
30	PLANNING, ENGINEERING, AND DESIGN	$3,751,780,000	51%	$1,902,300,000	$5,654,080,000
31	CONSTRUCTION MANAGEMENT	$987,310,000	51%	$500,610,000	$1,487,910,000
	Total Alt 3B	**$35,556,190,000**		**$17,071,130,000**	**$52,627,320,000**

Table 18: Alternative 4 First Cost Table

Feat. Acct	Description	Subtotal	Cont. %	Cont. $$	Total Cost
01	LANDS AND DAMAGES	$3,072,350,000	50%	$1,453,890,000	$4,526,240,000
02	RELOCATIONS	$1,371,150,000	76%	$1,046,600,000	$2,417,750,000
06	FISH AND WILDLIFE FACILITIES	$3,430,000,000	57%	$1,943,990,000	$5,373,990,000
10	BREAKWATERS AND SEAWALLS	$6,010,930,000	40%	$2,418,880,000	$8,429,810,000
11	LEVEES AND FLOODWALLS	$10,894,870,000	54%	$5,847,440,000	$16,742,310,000
18	CULTURAL RESOURCE PRESERVATION	$85,000,000	23%	$19,810,000	$104,810,000
19	BUILDINGS, GROUNDS, AND UTILITIES	$1,750,000	62%	$1,080,000	$2,830,000
30	PLANNING, ENGINEERING, AND DESIGN	$3,105,600,000	52%	$1,607,480,000	$4,713,090,000
31	CONSTRUCTION MANAGEMENT	$817,260,000	52%	$423,020,000	$1,240,290,000
	Total Alt 4	**$28,788,910,000**		**$14,762,210,000**	**$43,551,130,000**

Table 19: Alternative 5 First Cost Table

Feat. Acct	Description	Subtotal	Cont. %	Cont. $$	Total Cost
01	LANDS AND DAMAGES	$150,000,000	50%	$75,000,000	$225,000,000
02	RELOCATIONS	$789,270,000	75%	$592,740,000	$1,382,010,000
06	FISH AND WILDLIFE FACILITIES	$2,830,000,000	57%	$1,603,940,000	$4,433,940,000
11	LEVEES AND FLOODWALLS	$4,762,400,000	58%	$2,760,550,000	$7,522,950,000
18	CULTURAL RESOURCE PRESERVATION	$50,000,000	23%	$11,650,000	$61,650,000
30	PLANNING, ENGINEERING, AND DESIGN	$1,201,510,000	59%	$707,970,000	$1,909,480,000
31	CONSTRUCTION MANAGEMENT	$316,190,000	59%	$186,310,000	$502,500,000
	Total Alt 5	**$10,099,370,000**		**$5,938,170,000**	**$16,037,540,000**

8 Annual Cost Summary

In order to compare the alternatives to the project benefits the project first costs including contingencies were adjusted to reflect the total present value of the investment at the 2044 base year. This analysis assumed that the project design would begin in year 2025 and that construction, real estate acquisition and construction management expenditures would begin in year 2030. Expenditures were assumed to be a uniform amount over the construction period. The calculation of investment costs includes interest during construction for expenditures prior to the 2044 base year and present value discounting of all expenditures after the base year to reflect economic opportunity costs. The total present value of the investment cost plus the present value of OMRRR costs were multiplied by the capital recovery factor to determine the average annual costs over the 50-year period of analysis. Table 20 provides a summary comparison of the first and annual costs of alternatives.

Table 20: Alternative Costs Summary

Civil Works Feature & Sub-Feature Description	Alternative 2	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
02 - RELOCATIONS	$ 985,239,409	$ 1,076,309,448	$ 1,342,637,223	$ 1,371,153,126	$ 789,270,692
06 - FISH & WILDLIFE FACILITIES	$ 1,340,000,000	$ 1,540,000,000	$ 3,220,000,000	$ 3,430,000,000	$ 2,830,000,000
10 - BREAKWATER & SEAWALLS	$ 49,931,595,963	$ 27,801,495,009	$ 12,448,259,897	$ 9,335,488,309	$ -
11 - LEVEES & FLOODWALLS	$ 7,238,894,674	$ 8,477,569,861	$ 9,200,316,220	$ 7,570,305,765	$ 4,762,402,283
18 - CULTURAL RESOURCE PRESERVATI	$ -	$ 39,000,000	$ 94,000,000	$ 85,000,000	$ 50,000,000
19 - BUILDINGS, GROUNDS & UTILITIES	$ 77,528,856	$ 25,453,929	$ 23,039,081	$ 1,748,257	$ -
01 - LANDS AND DAMAGES	$ 350,828,924	$ 2,904,949,139	$ 4,488,854,765	$ 3,072,350,717	$ 150,000,000
30 - PLANNING, ENGINEERING & DESIGN	$ 8,489,189,393	$ 5,551,775,525	$ 3,751,775,970	$ 3,105,601,603	$ 1,201,513,399
31 - CONSTRUCTION MANAGEMENT	$ 2,233,997,209	$ 1,460,993,559	$ 987,309,466	$ 817,263,580	$ 316,187,737
PROJECT COST	**$ 70,647,274,427**	**$ 48,877,546,471**	**$ 35,556,192,622**	**$ 28,788,911,356**	**$ 10,099,374,110**
Construction Contingency (%)	59.24%	59.10%	50.71%	51.75%	58.93%
Account 01 Contingency (%)	50.00%	50.00%	30.00%	50.00%	50.00%
CONTINGENCY:	$ 41,819,028,778	$ 28,539,974,693	$ 17,071,131,456	$ 14,762,214,290	$ 5,938,166,163
TOTAL:	**$ 112,466,303,205**	**$ 77,417,521,164**	**$ 52,627,324,078**	**$ 43,551,125,646**	**$ 16,037,540,273**
OMRRR COSTS: (Present Value)	$ 31,325,614,852	$ 9,604,654,164	$ 10,345,508,365	$ 8,561,068,683	$ 3,704,745,959
INTEREST DURING CONSTRUCTION:	$ 6,503,054,914	$ 9,145,800,054	$ 13,154,506,010	$ 10,885,557,816	$ 6,075,902,202
TOTAL CURRENT INVESTMENT COSTS:	**$ 150,294,972,971**	**$ 96,167,975,381**	**$ 76,127,338,453**	**$ 62,997,752,145**	**$ 25,818,188,435**
ANNUALIZED COSTS (50 YRS, 2.25% discount Rate):	$ 5,037,640,836	$ 3,223,392,708	$ 2,551,663,448	$ 2,111,581,262	$ 865,383,305

9 Cost Summary

The Total Fully Funded Project Cost for the Tentatively Selected Plan (Alternative 3B) considers future inflation to midpoint of construction. The Total Fully Funded Project Cost for the TSP is estimated at $77,346,381,000 as presented in Table 21.

Table 21: Total Project Cost Summary for the Tentatively Selected Plan

PROJECT: New York – New Jersey Harbor and Tributaries Coastal Storm Risk Management Feasibility Study
DISTRICT: New York District — PREPARED: 9/18/2022
PROJECT NO: P2 404586 — POC: CHIEF, COST ENGINEERING, Jeffrey Gross
LOCATION: New York & New Jersey
This Estimate reflects the scope and schedule in report; 0

Civil Works Work Breakdown Structure		Estimated Cost				Project First Cost (Constant Dollar Basis Program Year (Budget EC): 2022 Effective Price Level Date: 1 Oct 2021						Total Project Cost (Fully Funded)			
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	**TOTAL ($K)**	Spent Thru: 1-Oct-21 ($K)	**TOTAL FIRST COST** ($K)	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*		*K*	*L*	*M*	*N*	*O*
02	RELOCATIONS	$1,342,637	$1,024,835	76.3%	$2,367,472	0.0%	$1,342,637	$1,024,835	$2,367,472	$0	$2,367,472	48.5%	$1,994,003	$1,522,023	$3,516,026
06	FISH & WILDLIFE FACILITIES	$3,220,000	$1,825,096	56.7%	$5,045,096	0.0%	$3,220,000	$1,825,096	$5,045,096	$0	$5,045,096	48.5%	$4,782,149	$2,710,522	$7,492,671
10	BREAKWATER & SEAWALLS	$12,448,261	$5,486,216	44.1%	$17,934,477	0.0%	$12,448,261	$5,486,216	$17,934,477	$0	$17,934,477	48.5%	$18,487,404	$8,147,796	$26,635,201
11	LEVEES & FLOODWALLS	$9,200,316	$4,945,575	53.8%	$14,145,891	0.0%	$9,200,316	$4,945,575	$14,145,891	$0	$14,145,891	48.5%	$13,663,753	$7,344,869	$21,008,622
18	CULTURAL RESOURCE PRESERVATION	$94,000	$58,224	61.9%	$152,224	0.0%	$94,000	$58,224	$152,224	$0	$152,224	48.5%	$139,603	$86,470	$226,073
19	BUILDINGS, GROUNDS & UTILITIES	$23,039	$11,397	49.5%	$34,436	0.0%	$23,039	$11,397	$34,436	$0	$34,436	48.5%	$34,216	$16,927	$51,143
	CONSTRUCTION ESTIMATE TOTALS:	$26,328,253	$13,351,343		$39,679,596	0.0%	$26,328,253	$13,351,343	$39,679,596	$0	$39,679,596	48.5%	$39,101,129	$19,828,607	$58,929,736
01	LANDS AND DAMAGES	$4,488,855	$1,316,884	29.3%	$5,805,739	0.0%	$4,488,855	$1,316,884	$5,805,739	$0	$5,805,739	48.5%	$6,666,576	$1,955,756	$8,622,332
30	PLANNING, ENGINEERING & DESIGN	$3,751,776	$1,902,299	50.7%	$5,654,075	0.0%	$3,751,776	$1,902,299	$5,654,075	$0	$5,654,075	34.5%	$5,047,688	$2,559,378	$7,607,066
31	CONSTRUCTION MANAGEMENT	$987,309	$500,605	50.7%	$1,487,915	0.0%	$987,309	$500,605	$1,487,915	$0	$1,487,915	47.0%	$1,451,352	$735,893	$2,187,245
	PROJECT COST TOTALS:	$35,556,194	$17,071,132	48.0%	$52,627,325		$35,556,194	$17,071,132	**$52,627,325**	$0	**$52,627,325**	47.0%	$52,266,745	$25,079,635	$77,346,381

_____ CHIEF, COST ENGINEERING, Jeffrey Gross

ESTIMATED TOTAL PROJECT COST: $77,346,381

_____ PROJECT MANAGER, Bryce Wisemiller
_____ CHIEF, REAL ESTATE, Allen Roos
_____ CHIEF, PLANNING, Cliff Jones
_____ CHIEF, ENGINEERING, Encer Shaffer
_____ CHIEF, OPERATIONS, Thomas Creamer
_____ CHIEF, CONSTRUCTION, Richard English
_____ CHIEF, ENGINEERING, Encer Shaffer
_____ CHIEF, PM-PB, xxxx
_____ CHIEF, DPM, Joseph Seebode

10 References

USACE. (2019a). *New York-New Jersey Harbor and Tributaries - Interim Report Cost Appendix.* New York: USACE New York District.

USACE. (2019b). *New York-New Jersey Harbor and Tributaries - Overview of Engineering Work for the NYNJHATS Interim Report.* New York: USACE New York District.