US Army Corps of Engineers®
New York District

FINAL

Integrated Hurricane Sandy General Reevaluation Report and Environmental Impact Statement

Atlantic Coast of New York

East Rockaway Inlet to Rockaway Inlet and Jamaica Bay

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December 2018

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1 INTRODUCTION

This Atlantic Coast of New York, East Rockaway Inlet to Rockaway Inlet Hurricane Sandy General Revaluation Report Cost Engineering Appendix summarizes the cost engineering methods used to calculate project costs for features for each planning reach within the study area. There were initially three reaches within the study area, but one reach, Motts Basin North was removed during the Recommended Plan as its benefit-to-cost ratio dropped below 1.0. The remaining two reaches within the study area: 1) the Atlantic Shorefront and 2) Jamaica Bay. Since each planning reach is exposed to different risk mechanisms, two engineering appendices are included within this GRR/EIS: Appendix A1 - Shorefront Engineering and Design Appendix, and Appendix A2 - Jamaica Bay High Frequency Flood Risk Reduction Features Engineering and Design Appendix.

This Cost Engineering Appendix provides an overview of the cost analyses supporting both the development of the High Frequency Flood Risk Reduction Features (HFFRRF) for Jamaica Bay and the shorefront reach. This appendix describes the development of MII Cost Estimate for the Recommended Plan for these two reaches. Lastly, this appendix details the cost and schedule risk analysis (CSRA), with the recommended contingency value for the MII estimate and Total Project Cost Summary (TPCS) determined from the CSRA analysis.

The initial study was initially limited to the Atlantic Ocean Shoreline Planning Reach and was conducted as a legacy study. The engineering analyses were conducted to satisfy a more rigorous design level and the Atlantic Ocean shorefront summary engineering documents were written to satisfy those study requirements. The Jamaica Bay Planning Reach analysis was added following Hurricane Sandy and was conducted to broaden the recommended plan to the entire authorized study area and was conducted under SMART planning guidelines.

As a result of the Agency Decision Milestone, the storm surge barrier component of the Tentatively Selected Plan was moved into the New York and New Jersey Harbor and Tributaries Study for further study and possible recommendation. Without the barrier, the communities surrounding Jamaica Bay still experience substantial risk for coastal flooding. Therefore, the study team sought to identify stand-alone features that could complement a potential future storm surge barrier, but also be economically justified on their own. Residents in many parts of the Back-Bay experience regular flooding due to rainfall events and high tides that occur frequently. Since the proposed barrier would not be closed at every high tide or rainfall event, there is an opportunity to recommend features to mitigate flood risk for high frequency flooding events where the proposed storm surge barrier would remain open yet inundation still occurs.

2 PROJECT DESCRIPTION

2.1 Location

Please refer to Figure 2-4 in the HFFRRF Engineering Appendix A2 and Figure 1-1 of the Shorefront Engineering Appendix A1 for details relating to the project location.

2.2 Feature Descriptions

The high frequency flood risk reduction features are detailed in Section 4 of the Engineering Appendix (A2), including typical sections for all features. The alternative development options for the shorefront are detailed in Section 7 of the Shorefront Appendix (A1).

3 RECOMMENDED PLAN FOR EAST ROCKAWAY INLET TO ROCKAWAY INLET AND JAMAICA BAY

3.1 Introduction

The Recommended Plan (RP) for the East Rockaway inlet to Rockaway inlet and Jamaica Bay includes the shorefront sections along Rockaway beach that feature beach fill, groin construction and composite seawall construction. Typical sections and plan views are included in Sub Appendix A1-C of the shorefront Engineering Appendix. The Jamaica Bay section of the project includes various features to reduce flooding in the area including berms, bulkheads, and floodwalls. The Jamaica Bay reach consists of two HFFRRF sites: Mid-Rockaway and Cedarhurst Lawrence. Costs for these areas were developed in MCACES II (MII) in accordance with USACE guidelines and contingency was calculated via the cost and schedule risk analysis using Crystal Ball software.

All labor is assumed to be from prevailing wage rates for New York City and equipment rates estimated from published Blue Book Rates for equipment and supplemented with USACE Region 1 equipment data.

3.2 HFFRRF for Jamaica Bay

The HFFRRF for Jamaica Bay recommended plan initially included three locations, Mid-Rockaway, Motts Basin North, and Cedarhurst Lawrence. However, during the recommended plan phase, increases to the costs of the Motts Basin North location without any corresponding increases in the benefits caused its benefit-to-cost ratio to drop below 1.0, removing it from the recommended plan. The recommended plan described below consists only of Mid-Rockaway and Cedarhurst Lawrence.

3.2.1 Description of Tasks

3.2.1.1 01 – Lands & Damages

Real Estate costs have been provided by the USACE for this project.

3.2.1.2 11 – Floodwalls

Floodwalls were designed using steel sheet pile walls with a concrete cap, with excavation of material and fill material compacted on site. It was assumed that pavement demolition was required, as well as utility relocations, although no location information for utilities was provided. Three different heights of floodwalls were considered, low, medium, and high, but they all contain the same construction features and materials, just varying quantities of each. All steel shapes were assumed to be shapes that are domestically supplied. A description of the individual elements are included in the MII estimate.

3.2.1.1 13 - Pump Stations

Pump stations were estimated using pump cost curves for the New York Metropolitan area. Costs are estimated based off of the size and number of pumps in a given HFFRRF site. Please refer to Sub-appendix G for further information on pump cost development.

3.2.1.2 18 – Cultural Resource Preservation

Costs for the cultural resource preservation were estimated using data provided by the USACE on November 20, 2018. These costs include Phase 1 and Phase II surveys, historic structure documentation and Phase II data recovery efforts. The Phase III data recovery costs do not exceed the 1% threshold.

3.2.2 30 - Planning, Engineering, and Design

Code of Account 30, Planning, Engineering, and Design (PED) was estimated at 12% of construction costs for the Jamaica Bay sections that require additional survey, utility location, and further site specific design.

3.2.3 31 - Construction Management

Code of Account 31, Construction management costs were estimated using the USACE Supervision and Administration cost formula [% = 17 – 2.1 * log (subtotal / 1000) / 100]. This calculated to a 6.11% construction management percentage for the Jamaica Bay project.

3.2.4 Cost Summary

The Summary of costs for the Jamaica Bay portion of the project including the 28.36% contingency calculated in the CSRA (see section 4) are included in Tables 3-1 and 3-2 below.

Table 3-1: Mid-Rockaway HFFRRF Costs

Mid-Rockaway **** CONTRACT COST SUMMARY ****

PROJECT: East Rockaway Inlet to Rockaway Inlet and Jamaica Bay DISTRICT: NY District PREPARED: 8/20/2018
LOCATION: Queens, NY POC: CHIEF, COST ENGINEERING, xxx
This Estimate reflects the scope and schedule in report; East Rockaway Inlet to Rockaway Inlet and Jamaica Bay

Civil Works Work Breakdown Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**				**TOTAL PROJECT COST (FULLY FUNDED)**				
		Estimate Prepared:			**20-Aug-18**	Program Year (Budget EC):			2019					
		Effective Price Level:			1-Oct-17	Effective Price Level Date:			1 OCT 18					
				RISK BASED										
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	Mid-Rockaway													
02	RELOCATIONS	$4,155	$1,178	28.4%	$5,333	2.1%	$4,240	$1,203	$5,443	2020Q4	3.5%	$4,390	$1,245	$5,636
11	LEVEES & FLOODWALLS	$91,240	$25,876	28.4%	$117,116	2.1%	$93,113	$26,407	$119,519	2022Q2	6.7%	$99,309	$28,164	$127,473
13	PUMPING PLANT	$33,824	$9,592	28.4%	$43,416	2.1%	$34,518	$9,789	$44,307	2022Q2	6.7%	$36,815	$10,441	$47,256
17	BEACH REPLENISHMENT	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
07	POWER PLANT	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATI	$1,250	$355	28.4%	$1,605	2.1%	$1,276	$362	$1,637	2022Q2	6.7%	$1,361	$386	$1,746
09	CHANNELS & CANALS	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
10	BREAKWATER & SEAWALLS	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:	$130,469	$37,001	28.4%	**$167,470**		$133,146	$37,760	$170,907			$141,875	$40,236	$182,111
01	LANDS AND DAMAGES	$15,384	$1,355	8.8%	$16,739	2.1%	$15,699	$1,382	$17,082	2020Q4	3.5%	$16,255	$1,431	$17,687
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$1,305	$370	28.4%	$1,675	3.9%	$1,355	$384	$1,739	2019Q3	2.1%	$1,383	$392	$1,775
0.5%	Planning & Environmental Complianc	$652	$185	28.4%	$837	3.9%	$677	$192	$870	2019Q3	2.1%	$691	$196	$888
6.0%	Engineering & Design	$7,828	$2,220	28.4%	$10,048	3.9%	$8,130	$2,306	$10,436	2019Q3	2.1%	$8,297	$2,353	$10,650
0.5%	Reviews, ATRs, IEPRs, VE	$652	$185	28.4%	$837	3.9%	$677	$192	$870	2019Q3	2.1%	$691	$196	$888
0.5%	risks)	$652	$185	28.4%	$837	3.9%	$677	$192	$870	2019Q3	2.1%	$691	$196	$888
0.5%	Contracting & Reprographics	$652	$185	28.4%	$837	3.9%	$677	$192	$870	2019Q3	2.1%	$691	$196	$888
1.0%	Engineering During Construction	$1,305	$370	28.4%	$1,675	3.9%	$1,355	$384	$1,739	2022Q2	14.0%	$1,545	$438	$1,984
1.0%	Planning During Construction	$1,305	$370	28.4%	$1,675	3.9%	$1,355	$384	$1,739	2022Q2	14.0%	$1,545	$438	$1,984
0.5%	Adaptive Management & Monitoring	$652	$185	28.4%	$837	3.9%	$677	$192	$870	2022Q2	14.0%	$773	$219	$992
0.5%	Project Operations	$652	$185	28.4%	$837	3.9%	$677	$192	$870	2019Q3	2.1%	$691	$196	$888
31	CONSTRUCTION MANAGEMENT													
4.0%	Construction Management	$5,219	$1,480	28.4%	$6,699	3.9%	$5,420	$1,537	$6,957	2022Q2	14.0%	$6,181	$1,753	$7,934
1.0%	Project Operation:	$1,305	$370	28.4%	$1,675	3.9%	$1,355	$384	$1,739	2022Q2	14.0%	$1,545	$438	$1,984
1.1%	Project Management	$1,448	$411	28.4%	$1,859	3.9%	$1,504	$427	$1,931	2022Q2	14.0%	$1,715	$486	$2,202
	CONTRACT COST TOTALS:	$169,481	$45,057		$214,537		$173,385	$46,102	**$219,487**			$184,572	$49,166	**$233,738**

Table 3-2: Cedarhurst Lawrence HFFRRF Costs

Cedarhurst LawrenceCedarhurst LawrenceCedarhurst Lawrence **** CONTRACT COST SUMMARY ****

PROJECT: East Rockaway Inlet to Rockaway Inlet and Jamaica Bay DISTRICT: NY District PREPARED: 8/20/2018
LOCATION: Queens, NY POC: CHIEF, COST ENGINEERING, xxx
This Estimate reflects the scope and schedule in report; East Rockaway Inlet to Rockaway Inlet and Jamaica Bay

Civil Works Work Breakdown Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**				**TOTAL PROJECT COST (FULLY FUNDED)**				
		Estimate Prepared:			**20-Aug-18**	Program Year (Budget EC):			2019					
		Effective Price Level:			1-Oct-17	Effective Price Level Date:			1 OCT 18					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	***B***	***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***	***P***	***L***	***M***	***N***	***O***
	Cedarhurst Lawrence													
02	RELOCATIONS	$175	$50	28.4%	$225	2.1%	$179	$51	$230	2020Q4	3.5%	$185	$53	$238
11	LEVEES & FLOODWALLS	$6,694	$1,898	28.4%	$8,592	2.1%	$6,831	$1,937	$8,768	2021Q3	5.1%	$7,178	$2,036	$9,214
13	PUMPING PLANT	$2,753	$781	28.4%	$3,534	2.1%	$2,809	$797	$3,606	2021Q4	5.6%	$2,967	$841	$3,809
06	FISH & WILDLIFE FACILITIES	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
07	POWER PLANT	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATI	$750	$213	28.4%	$963	2.1%	$765	$217	$982	2021Q3	5.1%	$804	$228	$1,032
09	CHANNELS & CANALS	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
10	BREAKWATER & SEAWALLS	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:	$10,372	$2,941	28.4%	**$13,314**		$10,585	$3,002	$13,587			$11,135	$3,158	$14,293
01	LANDS AND DAMAGES	$809	$61	7.5%	$870	2.1%	$826	$62	$888	2020Q3	3.0%	$851	$64	$915
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$104	$29	28.4%	$133	3.9%	$108	$31	$138	2019Q3	2.1%	$110	$31	$141
0.5%	Planning & Environmental Complianc	$52	$15	28.4%	$67	3.9%	$54	$15	$69	2019Q3	2.1%	$55	$16	$71
6.0%	Engineering & Design	$622	$176	28.4%	$799	3.9%	$646	$183	$830	2019Q3	2.1%	$660	$187	$847
0.5%	Reviews, ATRs, IEPRs, VE	$52	$15	28.4%	$67	3.9%	$54	$15	$69	2019Q3	2.1%	$55	$16	$71
0.5%	risks)	$52	$15	28.4%	$67	3.9%	$54	$15	$69	2019Q3	2.1%	$55	$16	$71
0.5%	Contracting & Reprographics	$52	$15	28.4%	$67	3.9%	$54	$15	$69	2019Q3	2.1%	$55	$16	$71
1.0%	Engineering During Construction	$104	$29	28.4%	$133	3.9%	$108	$31	$138	2021Q3	10.7%	$119	$34	$153
1.0%	Planning During Construction	$104	$29	28.4%	$133	3.9%	$108	$31	$138	2021Q3	10.7%	$119	$34	$153
0.5%	Adaptive Management & Monitoring	$52	$15	28.4%	$67	3.9%	$54	$15	$69	2021Q3	10.7%	$60	$17	$77
0.5%	Project Operations	$52	$15	28.4%	$67	3.9%	$54	$15	$69	2019Q3	2.1%	$55	$16	$71
31	CONSTRUCTION MANAGEMENT													
4.0%	Construction Management	$415	$118	28.4%	$533	3.9%	$431	$122	$553	2021Q3	10.7%	$477	$135	$612
1.0%	Project Operation:	$104	$29	28.4%	$133	3.9%	$108	$31	$138	2021Q3	10.7%	$119	$34	$153
1.1%	Project Management	$115	$33	28.4%	$148	3.9%	$120	$34	$153	2021Q3	10.7%	$132	$38	$170
	CONTRACT COST TOTALS:	$13,060	$3,535		**$16,595**		$13,362	$3,617	**$16,979**			$14,057	$3,809	**$17,866**

3.2.5 MII Estimate

The MII Estimate for Jamaica Bay is included in Sub-Appendix A.

3.2.6 Schedule

The Project Schedule is included in Sub-Appendix B.

3.3 Rockaway Shorefront

3.3.1 Description of Tasks

Beach fill is planned for construction starting in December 2019. Since it is impossible to predict the exact shoreline position for the point in time that construction is to start, beach fill quantities required for initial construction are estimated based on the expected shoreline position in December 2019. The unknown quantities are due to the fact that wave conditions vary from year to year and affect shoreline change rates. The assumptions utilized in the quantity estimate are detailed in the Shorefront Engineering and Design Appendix (Appendix A1).

3.3.1.1 17 - Beach Fill

Beach fill was estimated by a USACE provided CEDEP estimate for this project using a hydraulic cutterhead dredge. Mobilization and Demobilization for this dredge was also provided by the USACE using a CEDEP.

3.3.1.2 10 - Groin Extensions

Five groins in Reaches 5 & 6 have been proposed to be extended to reduce erosion and improve overall project performance. These groins will have a layer of bedding stone that is 30 – 130 lbs. The core layer of the groin will be the same size, with a larger layer of underlayer stone that will serve as a dividing layer between the armor and the core stone. The underlayer stone is proposed as 500 – 1500 lbs stone. The top layer of armor stone is estimated as 7-10 tons in weight. A diagram showing the cross section of the groin extensions is located on Sheet CS-407 of Sub-Appendix C of Appendix A1, the Shorefront Engineering Appendix (A1).

3.3.1.3 10 - New Groin Construction

16 total groins are to be constructed in addition to the five groin extensions discussion previously. These groins range from 298 feet - 498 feet long. These groins have the same design as the groin extensions with a layer of bedding stone, core stone, underlayer stone, and armor stone on top. A typical section of the new groin construction is located in Figure 7-6 of the Shorefront Engineering Appendix (A1). The new groin construction had the same components as the groin extensions, and are described below.

3.3.1.4 10 - Composite Seawall

Construction of a 32,450 foot composite wall has been proposed along the beach to protect the boardwalk and residential homes adjacent to the beach, including a taper to connect the seawall with other flood protection features. The composite wall consists of steel sheet piles with a concrete cap. The wall is then protected using large armor stone with an underlayer stone to separate the armor from the sand beneath. A significant amount of sand must also be excavated for the placement of the underlayer and armor stone.

3.3.2 Markups

Markups for the shorefront work included sales tax on materials and overtime. It was assumed that the composite wall was constructed 6 days a week, with a single shift per day. This resulted in an 8.875% markup in the MII file. Profit was estimated at 10.0% using the USACE profit weighted guidelines.

3.3.3 18 – Cultural Resource Preservation

Costs for the cultural resource preservation were estimated using data provided by the USACE on November 20, 2018. These costs include Phase 1 and Phase II surveys, historic structure documentation and Phase II data recovery efforts. The Phase III data recovery costs do not exceed the 1% threshold.

3.3.4 30 - Planning, Engineering, and Design

Code of Account 30, Planning, Engineering, and Design (PED) was estimated at 8% for the shorefront portions, with detailed survey and further refinement required for the design near the boardwalk.

3.3.5 31 - Construction Management

Code of Account 31, Construction management costs were estimated using the USACE Supervision and Administration cost formula [% = 17 – 2.1 * log (subtotal / 1000) / 100]. This calculated to a 5.8% construction management percentage for the shorefront project.

3.3.6 Cost Summary

The summary of costs for the shorefront including the 28.36% contingency calculated from the CSRA (See section 4) is included in Table 3-4 below.

Table 3-3: Shorefront Costs

Shorefront ****** CONTRACT COST SUMMARY ******

PROJECT: East Rockaway Inlet to Rockaway Inlet and Jamaica Bay — DISTRICT: NY District — PREPARED: 12/5/2018
LOCATION: Queens, NY — POC: CHIEF, COST ENGINEERING, xxx
This Estimate reflects the scope and schedule in report; East Rockaway Inlet to Rockaway Inlet and Jamaica Bay

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 20-Aug-18 Effective Price Level: 1-Oct-17				Program Year (Budget EC): 2019 Effective Price Level Date: 1 OCT 18				FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	Shorefront													
02	RELOCATIONS	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
13	PUMPING PLANT	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
10	BREAKWATER & SEAWALLS	$187,704	$53,233	28.4%	$240,936	2.1%	$191,556	$54,325	$245,881	2022Q1	6.1%	$203,281	$57,650	$260,931
17	BEACH REPLENISHMENT	$26,966	$7,648	28.4%	$34,614	2.1%	$27,519	$7,804	$35,324	2020Q3	3.0%	$28,353	$8,041	$36,393
18	CULTURAL RESOURCE PRESERVATI	$10,000	$2,836	28.4%	$12,836	2.1%	$10,205	$2,894	$13,099	2021Q3	5.1%	$10,724	$3,041	$13,766
09	CHANNELS & CANALS	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
10	BREAKWATER & SEAWALLS	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:	$224,670	$63,716	28.4%	**$288,386**		$229,280	$65,024	$294,304			$242,358	$68,733	$311,090
01	LANDS AND DAMAGES	$528	$106	20.0%	$634	2.1%	$539	$108	$647	2019Q3	1.0%	$544	$109	$653
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$2,247	$637	28.4%	$2,884	3.9%	$2,333	$662	$2,995	2019Q1	0.0%	$2,333	$662	$2,995
0.5%	Planning & Environmental Complianc	$1,123	$319	28.4%	$1,442	3.9%	$1,167	$331	$1,498	2019Q1	0.0%	$1,167	$331	$1,498
2.0%	Engineering & Design	$4,493	$1,274	28.4%	$5,768	3.9%	$4,667	$1,323	$5,990	2019Q1	0.0%	$4,667	$1,323	$5,990
0.5%	Reviews, ATRs, IEPRs, VE	$1,123	$319	28.4%	$1,442	3.9%	$1,167	$331	$1,498	2019Q1	0.0%	$1,167	$331	$1,498
0.5%	risks)	$1,123	$319	28.4%	$1,442	3.9%	$1,167	$331	$1,498	2019Q1	0.0%	$1,167	$331	$1,498
0.5%	Contracting & Reprographics	$1,123	$319	28.4%	$1,442	3.9%	$1,167	$331	$1,498	2019Q1	0.0%	$1,167	$331	$1,498
1.0%	Engineering During Construction	$2,247	$637	28.4%	$2,884	3.9%	$2,333	$662	$2,995	2022Q1	12.9%	$2,635	$747	$3,382
1.0%	Planning During Construction	$2,247	$637	28.4%	$2,884	3.9%	$2,333	$662	$2,995	2022Q1	12.9%	$2,635	$747	$3,382
0.5%	Adaptive Management & Monitoring	$1,123	$319	28.4%	$1,442	3.9%	$1,167	$331	$1,498	2019Q3	2.1%	$1,191	$338	$1,528
0.5%	Project Operations	$1,123	$319	28.4%	$1,442	3.9%	$1,167	$331	$1,498	2019Q1	0.0%	$1,167	$331	$1,498
31	CONSTRUCTION MANAGEMENT													
4.0%	Construction Management	$8,987	$2,549	28.4%	$11,535	3.9%	$9,333	$2,647	$11,980	2022Q1	12.9%	$10,539	$2,989	$13,528
1.0%	Project Operation:	$2,247	$637	28.4%	$2,884	3.9%	$2,333	$662	$2,995	2022Q1	12.9%	$2,635	$747	$3,382
0.8%	Project Management	$1,797	$510	28.4%	$2,307	3.9%	$1,867	$529	$2,396	2022Q1	12.9%	$2,108	$598	$2,706
	CONTRACT COST TOTALS:	$256,202	$72,615		**$328,817**		$262,019	$74,263	**$336,282**			$277,477	$78,647	**$356,124**

3.3.7 MII Estimate

The MII Estimate for the Rockaway Shorefront is included in Sub-Appendix C.

3.3.8 Schedule

The Project Schedule is included in Sub-Appendix B.

3.4 Recommended Plan Cost Summary

A summary table showing the total cost without contingency and with the calculated 28.36% contingency for both the Shorefront and Jamaica Bay project locations is included below in Table 3-4. In addition, Table 3-4 displays the Total Project Cost Summary (TPCS) sheet for the project based on the anticipated Project Schedule as shown in Appendix B.

Table 3-4: TPCS for East Rockaway Inlet to Rockaway Inlet and Jamaica Bay

PROJECT: **East Rockaway Inlet to Rockaway Inlet and Jamaica Bay** — **DISTRICT: NY District** — **PREPARED: 8/20/2018**
PROJECT NO: P2 403429 — **POC: CHIEF, COST ENGINEERING, xxx**
LOCATION: Queens, NY

This Estimate reflects the scope and schedule in report; East Rockaway Inlet to Rockaway Inlet and Jamaica Bay

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)						TOTAL PROJECT COST (FULLY FUNDED)			
						Program Year (Budget EC): 2019; Effective Price Level Date: 1 OCT 18									
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-17** ($K)	**TOTAL FIRST COST** ($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	$4,330	$1,228	28.4%	$5,559	2.1%	$4,419	$1,253	$5,673	$0	$5,673	3.5%	$4,576	$1,298	$5,874
11	LEVEES & FLOODWALLS	$97,934	$27,774	28.4%	$125,707	2.1%	$99,944	$28,344	$128,288	$0	$128,288	6.5%	$106,487	$30,200	$136,687
13	PUMPING PLANT	$36,577	$10,373	28.4%	$46,950	2.1%	$37,327	$10,586	$47,913	$0	$47,913	6.6%	$39,783	$11,282	$51,065
10	BREAKWATER & SEAWALLS	$187,704	$53,233	28.4%	$240,936	2.1%	$191,556	$54,325	$245,881	$0	$245,881	6.1%	$203,281	$57,650	$260,931
17	BEACH REPLENISHMENT	$26,966	$7,648	28.4%	$34,614	2.1%	$27,519	$7,804	$35,324	$0	$35,324	3.0%	$28,353	$8,041	$36,393
18	CULTURAL RESOURCE PRESERVATI	$12,000	$3,403	28.4%	$15,403	2.1%	$12,246	$3,473	$15,719	$0	$15,719	5.3%	$12,889	$3,655	$16,545
09	CHANNELS & CANALS	$0	$0	-	$0	-	$0	$0	$0	$0	$0	-	$0	$0	$0
10	BREAKWATER & SEAWALLS	$0	$0	-	$0	-	$0	$0	$0	$0	$0	-	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:	$365,511	$103,659		$469,169	2.1%	$373,011	$105,786	$478,797	$0	$478,797	6.0%	$395,368	$112,126	$507,495
01	LANDS AND DAMAGES	$16,721	$1,521	9.1%	$18,242	2.1%	$17,064	$1,552	$18,617	$0	$18,617	3.4%	$17,651	$1,604	$19,255
30	PLANNING, ENGINEERING & DESIGN	$34,874	$9,890	28.4%	$44,765	3.9%	$36,219	$10,272	$46,491	$0	$46,491	3.9%	$37,636	$10,674	$48,310
31	CONSTRUCTION MANAGEMENT	$21,636	$6,136	28.4%	$27,772	3.9%	$22,470	$6,373	$28,843	$0	$28,843	13.3%	$25,452	$7,218	$32,670
	PROJECT COST TOTALS:	$438,743	$121,206	27.6%	$559,949		$448,765	$123,982	**$572,748**	$0	**$572,748**	6.1%	$476,107	$131,622	$607,729

3.4.1 Operations and Maintenance (O&M) Costs

Operations and maintenance costs were estimated as $19 / linear foot of feature per year. The vehicular gates were estimated separately at 0.5% of the initial gate cost, and pump stations were assumed to have an O&M cost of 2% of the initial construction cost. These values were estimated from other flood protection and pump cost data for the NYC metropolitan area.

3.5 Interest During Construction

The interest during construction calculated for the project based on the project schedule and project first costs are included below in Table 3-5: Interest During Construction.

Table 3-5: Interest During Construction

Recommended Plan Component	Project First Costs	Duration (Months)	Interest During Construction
Shorefront Element	336,282,000	44	18,730,000
Mid-Rockaway HFFRRF	219,487,000	41	13,083,000
Cedarhurst-Lawrence HFFRRF	16,979,000	12	266,000
TOTAL			**32,079,000**

3.6 Annualized Costs

The annualized costs for the Shorefront, Cedarhurst-Lawrence, and Mid-Rockaway Components are shown in Table 3-6: Annualized Project Costs below.

Table 3-6: Annualized Project Costs

Recommended Plan Component	Annual Project Costs
Shorefront Element	22,457,000
Mid-Rockaway HFFRRF	9,972,000
Cedarhurst-Lawrence HFFRRF	743,000
TOTAL	**33,172,000**

4 COST AND SCHEDULE RISK ANALYSIS

4.1 Introduction

The United States Army Corps of Engineers (USACE) requires a risk analysis for projects over $40 million. Preliminary estimates for the East Rockaway to Rockaway Inlet and Jamaica Bay Project is over $400 million, exceeding the $40 million limit, requiring this risk analysis to be completed.

4.2 Background

The project's cost estimate is prepared using MCACES MII software in accordance with USACE policy and can be found in Sub-Appendix A and Sub-Appendix C. MII uses existing or custom unit cost databases and allows contingency, taxes, insurance, and profit to be added to each item as needed to create an accurate construction cost estimate. Dredging unit costs were created using USACE's CEDEP spreadsheets and provided by the USACE NY District. Low, middle, and high unit costs were evaluated and a median unit cost was typically selected for the cost estimate.

4.3 Report Scope

The scope of the risk analysis report is to calculate and present the cost and schedule contingencies at the 80 percent confidence level using the risk analysis processes as mandated by USACE Engineer Regulation (ER) 1110-2-1150, Engineering and Design for Civil Works, ER 1110-2-1302, Civil Works Cost Engineering, and Engineer Technical Letter 1110-2-573, Construction Cost Estimating Guide for Civil Works.

4.4 USACE Risk Analysis Process

The risk analysis process follows the USACE Headquarters requirements as well as the guidance provided by the Cost Engineering Directory of Expertise for Civil Works (Cost Engineering DX). The risk analysis process uses probabilistic cost and schedule risk analysis methods within the framework of the *Crystal Ball* software. The risk analysis results are intended to serve several functions, one being the establishment of reasonable contingencies reflective of an 80 percent confidence level to successfully accomplish the project work within that established contingency amount. Furthermore, the scope of the report includes the identification and communication of important steps, logic, key assumptions, limitations, and decisions to help ensure that risk analysis results can be appropriately interpreted.

Risk analysis results are also intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as provide tools to support decision making and risk management as the project progresses through planning and implementation. To fully recognize its benefits, cost and schedule risk analyses should be considered as an ongoing process conducted concurrent to, and along with, other important project processes such as scope and execution plan development, resource planning, procurement planning, cost estimating, budgeting, and scheduling.

In addition to broadly defined risk analysis standards and recommended practices, the risk analysis is performed to meet the recommendations of the following documents and sources:

- ER 1110-2-1150, Engineering and Design for Civil Works Projects.
- ER 1110-2-1302, Civil Works Cost Engineering.
- ETL 1110-2-573, Construction Cost Estimating Guide for Civil Works.
- Cost and Schedule Risk Analysis Process guidance prepared by the USACE Cost Engineering DX.

4.5 Methodology / Process

The purpose of the risk analysis process is to determine what can be expected for the project as a whole, allowing variation within the individual project components. Natural variation allows the simulation to mimic real-world scenarios more closely, accounting for unforeseen changes that could affect a project, but within reason for the given distributions.

As recommended in the above references, *Crystal Ball* Risk Analysis Software was selected to run the risk analysis for the project. *Crystal Ball* uses a mathematical modeling technique called a Monte Carlo Simulation that takes distributions of assumed unit costs, quantities and production rates and runs thousands of trials, taking one input from each distribution in each simulation, adding in natural variation when selecting the points. The input data was based on the Risk Register, MII Cost Estimate, Project schedule, and PDT involvement.

Crystal Ball allows multiple trials, 5,000 trials were used for the analysis, in order to model the distribution given to that assumption. All of the individual assumptions (i.e. cost, volumes, etc.) are then summed for each trial and plotted to show cost and schedule versus probability. The median is the most likely project cost/schedule and, based on USACE policy, the 80% confidence value is the probable upper bound cost/schedule. The software is also used to create sensitivity plots that show which risk items have the greatest impacts in the overall project cost distribution.

4.5.1 Identify and Assess Risk Factors

Risk factors are events and conditions that may influence or drive uncertainty in project performance. They may be inherent characteristics or conditions of the project or external influences, events, or conditions such as weather or economic conditions. Risk factors may have either favorable or unfavorable impacts on project cost and schedule.

Checklists or historical databases of common risk factors are sometimes used to facilitate risk factor identification. However, key risk factors are often unique to a project and not readily derivable from historical information. Therefore, input from the entire PDT is obtained using creative processes such as brainstorming or other facilitated risk assessment meetings. In practice, a combination of professional judgment from the PDT and empirical data from similar projects is desirable and is considered. Identifying the risk factors is considered a qualitative process that results in establishing a list of risks that serves as the document for the further study using the Crystal Ball risk software.

The risk analysis process, for this project, began by gathering input from the PDT. The PDT identified potential risks associated with each part of the project and designated each risk. In accordance with the current *Cost and Schedule Risk Analysis Guidance* (May 2009), all risks were then identified as low, moderate, or high risks based on their respective likelihoods and overall effects, as defined in the risk matrix shown below (Figure 4-1: Risk Level Matrix). These were used to identify what the PDT considered to be the key risks of the project and the degree that these risks might affect the final cost and schedule.

Risk Level

Likelihood of Occurrence	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	Low	Moderate	High	High	High
Likely	Low	Moderate	High	High	High
Unlikely	Low	Low	Moderate	Moderate	High
Very Unlikely	Low	Low	Low	Low	High

Impact or Consequence of Occurrence

Figure 4-1: Risk Level Matrix

The risk register records the PDT's risk concerns, discussions related to those concerns, and potential impacts to the current cost and schedule estimates. The concerns and discussions are meant to support the team's decisions related to event likelihood, impact, and the resulting risk levels for each risk event.

4.5.2 Quantify Risk Factor Impacts

The quantitative impacts of risk factors on project plans are analyzed using a combination of professional judgment, empirical data, and analytical techniques. Risk factor impacts are quantified using probability distributions (density functions), because risk factors are entered into the *Crystal Ball* software in the form of probability density functions.

Similar to the identification and assessment process, risk factor quantification involved multiple project team disciplines. For each of the risks identified, quantifying risk factor impacts were determined to include:

- Maximum possible value for the risk factor.
- Minimum possible value for the risk factor.
- Most likely value (the statistical mode), if applicable.
- Nature of the probability density function used to approximate risk factor uncertainty.

- Mathematical correlations between risk factors.
- Affected cost estimate and schedule elements.

The resulting risk register includes discussion of the above.

4.5.3 Analyze Cost Estimate and Schedule Contingency

Contingency is analyzed using the *Crystal Ball* software, an add-in to the *Microsoft Excel* format of the cost estimate and schedule. Monte Carlo simulations are performed by applying the risk factors (quantified as probability density functions) to the appropriate estimated cost and schedule elements identified by the PDT. Contingencies are calculated by applying risks identified.

For the cost estimate, the contingency is calculated as the difference between the P80 cost forecast and the base cost estimate. P80 is the value that with 80% confidence one can conclude the project cost will not exceed, or 80% of the Monte Carlo simulations were less than or equal to that number. Each option-specific contingency is then allocated on a civil works feature level based on the dollar-weighted relative risk of each feature as quantified by Monte Carlo simulation. Standard deviation is used as the feature-specific measure of risk for contingency allocation purposes. This approach results in a relatively larger portion of all the project feature cost contingency being allocated to features with relatively higher estimated cost uncertainty.

Schedule contingency is calculated as the difference between the P80 option duration forecast and the base schedule duration.

Schedule contingency is analyzed only on the basis of each option and not allocated to specific tasks. Based on Cost Engineering DX guidance, only critical path and near critical path tasks are considered to be uncertain for the purposes of schedule contingency analysis.

4.6 RISK ANALYSIS RESULTS

This section discusses the major components of the risk register, data used to develop the distributions for the risk analysis and results.

4.6.1 Risk Register – Cost Risk Analysis

During development of the risk register, risk items were discussed and evaluated by the PDT. A risk register is a tool commonly used in project planning and risk analysis and serves as the basis for the risk studies and *Crystal Ball* risk models. The risk register reflects the results of risk factor identification and assessment, risk factor quantification, and contingency analysis. From this process, 16 items were determined by the PDT to warrant inclusion in the final risk register for the cost risk analysis. Each of the risks was then evaluated in detail to determine the variability and distribution in quantities, cost and schedule so they could be evaluated in *Crystal Ball*. The detailed risk register is provided in Sub-Appendix D to this report and summarized in Table 4-1 below.

Table 4-1: Key Cost Risks Identified

Risk No.	PDT-Developed Risk/Opportunity Event
PM-3	Project Scope Definition
CA-1	Beach Fill Bidding Climate
CA-3	Rock Source for Groin Construction
CA-5	Composite Wall Rock Source
TL-4	Additional Groins Added to Project
TL-9	Design of Pumps for Saltwater
TL-15	Armor Stone Required for Floodwalls
TL-18	Drainage Improvements for Bulkheads
TL-19	Additional Fill for Bulkheads
TL-21	Baffle Wall Repairs / Replacement
LD-1	Additional Real Estate Relocations Required
CO-6	Additional Utility Relocations Required
ET-1	Beach Fill Bidding Climate
PR-1	Extreme Weather
PR-3	Quarry Monopoly
PR-4	Similar Projects Reducing Contractor Supply
PR-5	Stakeholders Requesting Mechanical Cleaning of Trash Racks

Based on the above, 21 different variables were used in the Crystal Ball Cost Risk analysis to model the above risks, with 14 variables for unit costs and 7 for quantities. These assumptions consider values from the MII cost estimate, historical data and PDT recommendations on individual risk items.

Following is a discussion of the more significant risks shown above, and assumptions used in developing the analysis. Crystal ball reports show details on ranges and distributions.

PM-3. Project Scope Definition

Some of the non-federal sponsors are not in favor of adding pump stations, as they increase maintenance costs for the local jurisdictions. This is expected to add $7 million to the project on the high end if a significant amount of resources must be utilized to review alternatives to appease the non-federal sponsors.

CA-1. Beach Fill Bidding Climate

An additional 25% cost was added for the high end to account for a bidding climate where only one contractor bids on a beach fill contract. 10% was reduced on the low end to account for a highly competitive bidding environment.

CA-3 Rock Source for Groin Construction

The low rock material cost was reduced 10% to account for new quarries opening up that could increase competition. A 50% increase was included for the high end to account for only one quarry having the capability to supply the project and having to spend a considerable amount of resources to produce the correct size armor stone.

CA-5 Composite Seawall Rock Source

The low rock material cost was reduced 10% to account for new quarries opening up that could increase competition. A 50% increase was included for the high end to account for only one quarry having the capability to supply the project and having to spend a considerable amount of resources to produce the correct size armor stone.

TL-4 Additional Groins Required

No change in the low cost of the groins was considered. The weight of the rock was increased by 19,700 tons to account for additional groins being required.

TL-9 Pumps Designed for Saltwater

A $5 million fee was associated with providing all pumps with parts designed for pumping saltwater. No change in low prices to the pump stations was considered.

TL-15 Armor Stone Required for Floodwalls

The high quantity for armor stone was calculated assuming a 7' wide, 1' deep section of stone on the protected side of the floodwalls was required. No change in low quantity was considered, as the current design does not have stone on the floodwalls.

TL-18 Drainage Improvements for Bulkheads

High costs for drainage improvements increased by $1.5 million to account for additional improvements needed in the tight areas near many of the bulkheads.

TL-19 Additional Fill Required for Bulkheads

The uneven nature of the existing bulkheads may require that the proposed bulkhead be a few feet away from some of the existing bulkheads, requiring fill. Additional volume assumes 18 square feet of additional fill per foot of bulkhead.

TL-21 Baffle Wall Repairs / Replacement

The existing baffle wall may require repairs and / or upgrades. Although no known issues existing for the wall, any repairs or replacement would add a critical amount of cost to the project. A unit cost of $4,500 / lf was estimated for full replacement of the wall on the high end. No cost was assumed for the low end.

LD-1 Real Estate

Real estate is a significant unknown for this project. Low prices were reduced 50%, while high prices were increased 300%.

CO-6 Utility Relocations

Utilities have not been located and are a significant unknown for the project. A 50% decrease was considered for the low end and a 500% increase for the high end.

ET-1 Beach Fill Bidding Climate

Mobilization price decreased by $1.3 million to $2 million on the low end and increased $1.8 million to $5.1 million on the high end. These limits were determined from historical beach fill bids in the area.

PR-1 Weather Issues

Weather impacts can cause quantities of sand and groin rock to increase as a storm erodes away the existing materials. A 20% increase was considered in quantities on the high end.

PR-3 Quarry Monopoly

Some of the quarries in the area have been purchased by the same company. If this trend continues, an increase of 25% higher was considered to account for this lack of competition.

PR-4 Other Similar Projects

Since there are other coastal storm risk management (CSRM) projects in the area, it may be possible that the quarries and contractors do not have enough supply to complete this project with the other work going on. To account for this, the profit was considered to be as high as 18% (instead of 10%), or as low as 6%.

PR-5 NFS Request Mechanical Cleaning Trash Racks

An additional cost of $1 million was included to account for the potential of the mechanical cleaning trash racks on the drainage structures.

Distributions

For this analysis, most quantities were assumed to be triangular distributions since minimum, maximum, and expected quantities have been determined. Unit costs were typically modeled as triangular functions. The triangular distribution was used as expected, low, and high values were known for all major variables. However, some items were modeled as uniform if the expected value was not a confidence value and the range of possible outcomes was broad. The Crystal Ball Software Output contains all of the assumptions and distributions used for each element in the analysis, as well as descriptive statistics for the distributions.

The full risk register and Crystal Ball reports are included in Sub-Appendix D, E, and F and contain additional details.

4.6.1 Risk Register – Schedule Risk Analysis

Although this schedule risk register was completed at the same time for both the cost and schedule risk analysis, the key risks are displayed separately, as different risks impact the cost and schedule differently. Below in Table 4-2 is the list of key schedule risks determined for the project.

Table 4-2: Key Schedule Risks Identified

Risk No.	PDT-Developed Risk/Opportunity Event
PM-2	Groin Scope Growth
PM-4	Coordination of Plan with NFS
PM-5	Timely Response from NFS
PM-6	Local Agency / Permit Issues
PM-7	NFS Priorities Change
CA-4	Composite Wall Construction Access
TL-1	Beach fill – Quantity Changes
TL-4	Additional Groins Added
TL-7	Energy Dissipation may impact wetlands
TL-15	Riprap Required for Floodwalls
LD-1	Delays in Real Estate
LD-2	Additional RW Access Needed
LD-4	Relocation Delays
CO-2	Beach fill – Equipment Availability
ET-2	Groin Construction Methods
ET-3	Groin and Seawall Construction Timing
ET-5	Groin Extensions Turn into Rebuilds

Based on the above risks, 14 different variables were used in the *Crystal Ball* Schedule Risk analysis to model the identified risks.

Following is a discussion of the more significant risks shown above, and assumptions used in developing the analysis. Crystal ball reports show details on ranges and distributions.

PM-2. Groin Scope Growth

An additional 40 days was added to the schedule to account for the possibility of additional groins added to the project.

PM-4. Coordination of Plan with NFS

An additional 120 days was added to coordinate with NFS.

PM-5 Timely Response from NFS

The 120 days included in PM-4 addressed this delay as well.

PM-6 Local Agency / Permit Issues

An additional 120 days was added to the Notice to Proceed of the project to account for permit delays.

PM-7 NFS Priorities Change

The 120 days included in PM-4 addressed this delay as well.

CA-4 Composite Wall Construction Access

An additional 40 days was added to the composite wall construction duration to account for potential delays due to limited construction access.

TL-1 Beach fill – Quantity Changes

A 20% increase in days was added on the high end and a decrease of 10% was added to the low end to account for volume changes since the survey utilized for this project quantity calculations.

TL-4 Additional Groins Added

60 days was added on the high end construction duration o account for construction of the additional groins.

TL-7 Energy Dissipation may impact wetlands

The notice to proceed duration high value was increased by 80 days to account for mitigation delays.

TL-15 Riprap Required for Floodwalls

An additional 30 days was added to the floodwall construction high value to account for the riprap.

LD-1 Delays in Real Estate

The notice to proceed duration high value duration was increased by 260 days to account for mitigation delays.

LD-2 Additional RW Access Needed

The notice to proceed duration high value duration was increased by 180 days to account for RW access delays.

LD-4 Relocation Delays

The notice to proceed duration high value duration was increased by 180 days to account for utility relocation delays.

CO-2 Beach fill – Equipment Availability

An additional 120 days was added on the high value for the beach fill construction duration to account for a delay in mobilization.

ET-2 Groin Construction Methods

An additional 50 days on the high end construction duration was added to account for slower construction methods.

ET-3 Groin and Seawall Construction Timing

An additional 80 days was added to the high value construction duration to account for summer windows when the local cities may not want limitations on the beach access.

ET-5 Groin Extensions Turn into Rebuilds

An additional 60 days on the high end construction duration was added to account for the additional quantities required to rebuild the groins instead of only extending them.

4.7 Cost Risk Analysis - Cost Contingency Results

Using an initial base cost of $355.8 million (not including real estate, engineering, or construction management) a distribution of costs was calculated in *Crystal Ball*. Based on the *Crystal Ball* Analysis of the 100% Design Estimate, the most probable project cost (50 percentile) is $435.5 million. The project cost at the 80% confidence interval is $456.8 million. The confidence interval and total project distribution are shown in Figure 4-2 below. Detailed figures and statistical analysis from the simulation are contained in Sub-Appendix E. The range from the minimum total cost to the maximum cost is approximately $157.6 million and the range from the 80% upper limit to the minimum value is approximately $102.4 million. Please note that these are not Project First Costs or Total Project Costs as this analysis is done on the expected costs without contingency.

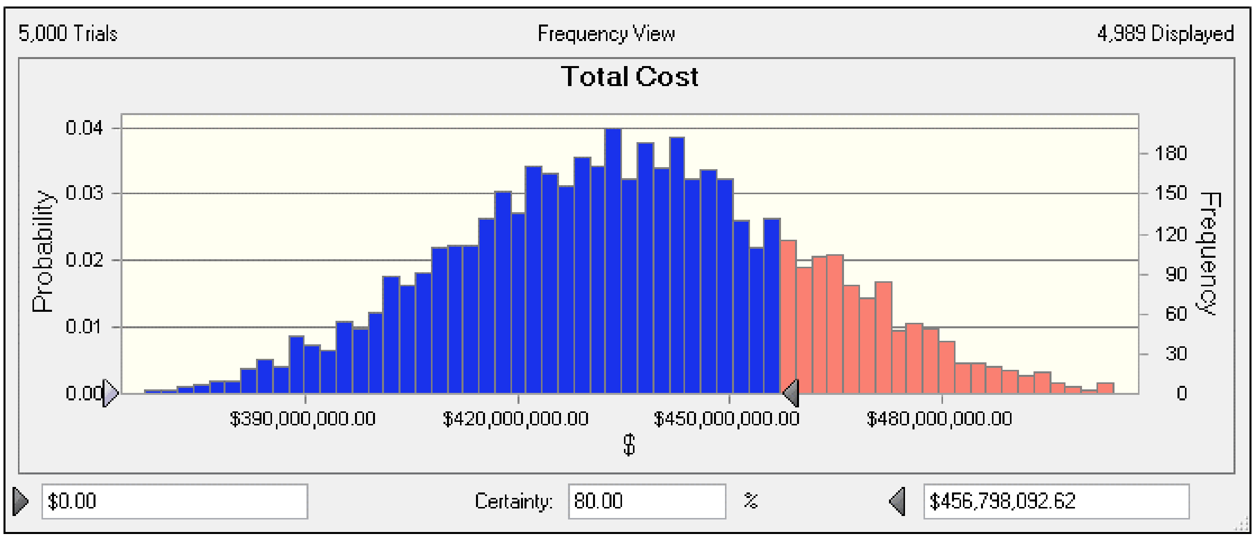


Figure 4-2: Cost Distribution with the 80% Confidence Interval Shown

A sensitivity analysis was conducted to determine which items cause the greatest change in overall project cost. The results are displayed in Figure 4-3 below. The two most significant items were the real estate costs and the limited competition of contractors, which both represented approximately 26% of the cost variance and is a significant unknown for the project. These are identified in risks LD1 and PR-4, respectively. The third major risk is the quarry competition relating to rock supply and availability at the time of the job (Risks CA-5 and PR-3). It represents approximately 21% of the variation in the project. Two other risks represented about 10% of the total project variation, the baffle wall repairs / replacement along the shorefront and the utilities, relating to risks TL-21 and CO, respectively. Those items have significant unknowns at this time and will be narrowed down in final design.

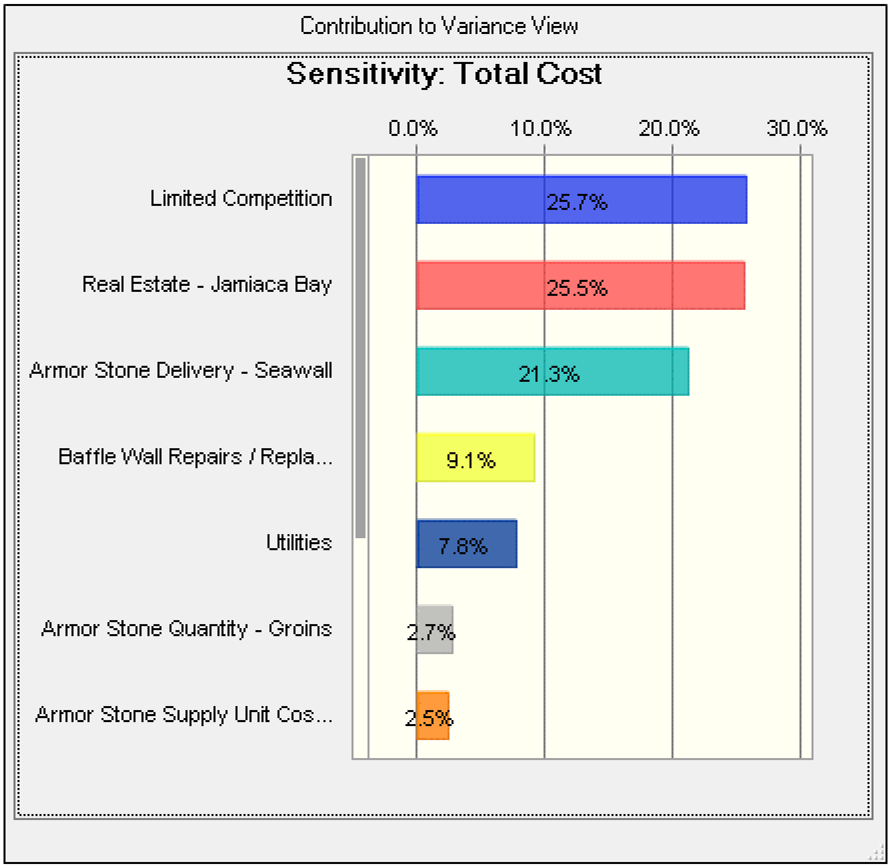


Figure 4-3: Sensitivity Analysis for Cost Risk

Note that these results reflect only those contingencies established from the cost risk analysis.

Table 4-3: Confidence Table of Total Cost

Percentiles:	Forecast values ($)
0%	$354,392,835.80
10%	$404,101,189.97
20%	$414,924,691.45
30%	$422,372,011.90
40%	$429,329,968.13
50%	$435,488,722.73
60%	$441,691,565.03
70%	$448,323,726.59
80%	$456,798,092.62
90%	$467,933,686.11
100%	$512,055,589.86

The cost risk analysis determined that a 28.36% contingency (calculated as the difference from the 80% to the base case divided by the base case of $355.8 million) should be expected for the project as a whole. This percentage represents the funds that should be allocated to complete this project based on the risks developed by the PDT. Table 4-4: Project Contingencies (Base Cost Plus Cost and Contingencies) shows the change in contingency with different confidence levels of the cost estimate.

Table 4-4: Project Contingencies (Base Cost Plus Cost and Contingencies)

Confidence Level	Project Cost ($)	Contingency ($)	Contingency (%)
P0	$354,392,835.80	($1,472,540.62)	-0.41%
P10	$404,101,189.97	$48,235,813.56	13.55%
P20	$414,924,691.45	$59,059,315.04	16.60%
P30	$422,372,011.90	$66,506,635.49	18.69%
P40	$429,329,968.13	$73,464,591.72	20.64%
P50	$435,488,722.73	$79,623,346.32	22.37%
P60	$441,691,565.03	$85,826,188.62	24.12%
P70	$448,323,726.59	$92,458,350.18	25.98%
P80	**$456,798,092.62**	**$100,932,716.21**	**28.36%**
P90	$467,933,686.11	$112,068,309.70	31.49%
P100	$512,055,589.86	$156,190,213.45	43.89%

5 SCHEDULE RISK ANALYSIS

The schedule risk analysis was very dependent on many issues relating to getting the construction started, including permitting, real estate acquisitions, and coordination with local sponsors. The results are included below.

5.1 Results

The Monte Carlo Simulation results indicate to an 80% certainty that it would be unlikely for the project delay to exceed 630 working days, a delay of approximately 2.4 years. The results are shown in Figure 5-1 below.

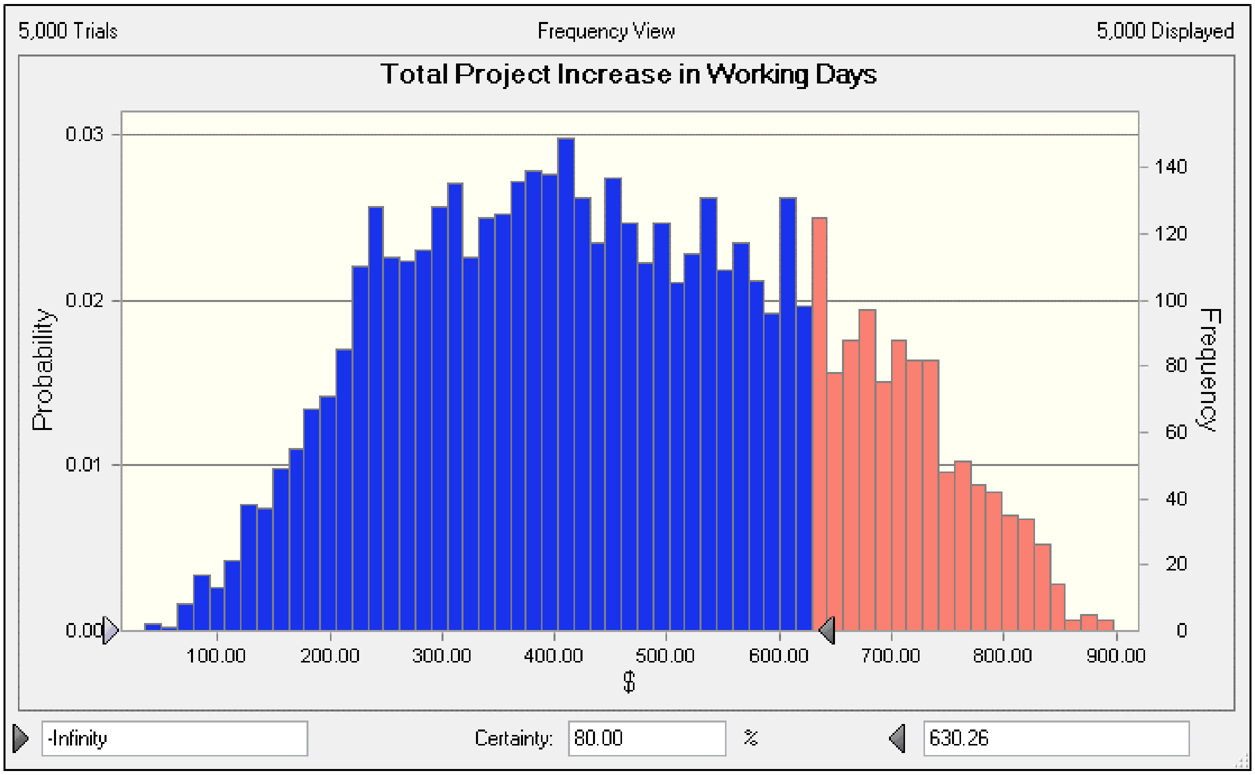


Figure 5-1: Schedule Risk Analysis Results

A sensitivity analysis was also completed for the schedule risk analysis and included in Figure 5-2. It indicated that issuing the notice to proceed for the construction contracts in Arverne, and Edgemere were the most important factors relating to the schedule by a significant margin. These are relating to delays with regards to permitting, utilities, real estimate, and non-federal sponsors identified in risks PM4, PM5, PM6, PM7, TL7, LD1, LD2 and LD4 of the risk register.

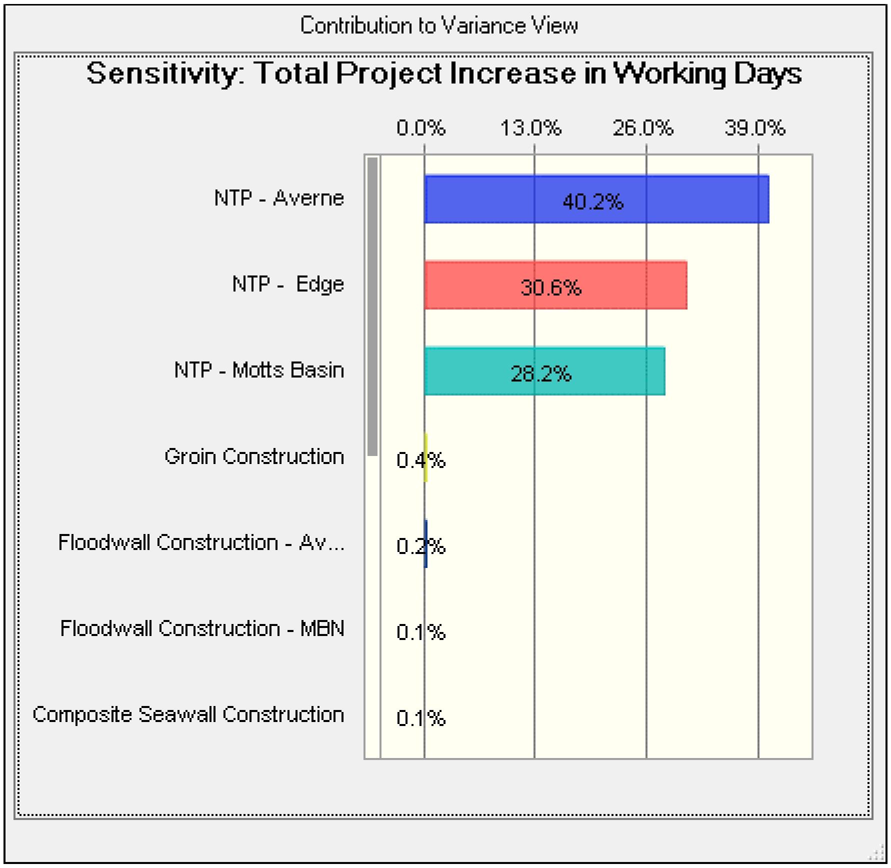


Figure 5-2: Schedule Risk Analysis Sensitivity

6 MAJOR FINDINGS/OBSERVATIONS

Based on analysis of the 100% design, the most probable project cost is currently estimated to be $435.5 million with an 80% confidence interval for the cost to not exceed $456.8 million. This means the contingency to be utilized for the project is 28.36%. The project schedule is anticipated to be completed in approximately 3.5 years based upon the expected schedule, but is likely to be delayed due to permitting and other relocation issues, with an 80% confidence that the project schedule will be completed within 2.4 years of the expected completion date. The total project schedule duration is expected to be approximately 5.9 years instead of 3.5 years due to these delays, although this may not impact the duration of actual construction, as many of the key risks are to the notice to proceed for construction and not relating to construction activities' durations themselves.

7 RECOMMENDATIONS

The identified risks for the project may be unavoidable, but identifying ways to mitigate their effect on the final project cost is essential to the success of the project and has been pursued through project development by the PDT. Efforts to reduce risk continue as described below.

Contractor Outreach – An extensive contractor outreach program is recommended to maintain interest in the projects, especially with potential armor stone suppliers so that they can prepare for the large volumes of stone required for the project.

Coordination with State and NFS – A significant amount of delays are anticipated due to not getting the NTP issued, which can be mitigated if the NFS and other state agencies are in support of the project.

A. SUB-APPENDIX A: MII ESTIMATE – JAMAICA BAY

The MII Estimate for the Jamaica Bay section of the project.

Jamaica Bay Reformulation Study

Cost Estimate for the HFFRRF located in Queens, New York based upon the Recommended Plan features determined from Moffatt & Nichol and AECOM analyis of maximum project benefits to provide flood protection. 2018 Prevailing Wages for NYC with 2017 Blue Book Equipment rates and 2018 quotes from Skyline Steel for sheet piles and a 2018 quote from Tilcon for stone.

Estimated by	Moffatt & Nichol
Designed by	Moffatt & Nichol
Prepared by	Sean Jessup, PE, Moffatt & Nichol
Preparation Date	8/20/2018
Effective Date of Pricing	4/1/2018
Estimated Construction Time	1,200 Days

Description	UOM	Quantity	ProjectCost
Project Owner Summary			140,845,398
			130,469,442.53
Mid-Rockaway	EA	1.0	130,469,443
			18,491,904.35
Hammels	EA	1.0	18,491,904
			455,175.00
02 - Utility Relocations	EA	1.0	455,175
			9,703,729.35
11 - Levees & Floodwalls	EA	1.0	9,703,729
			4,166,500.00
13 - Pump Stations	EA	2.0	8,333,000
			39,054,225.40
Edgemere	EA	1.0	39,054,225
			1,336,965.00
02 - Utility Relocations	EA	1.0	1,336,965
			28,007,260.40
11 - Levees & Floodwalls	EA	1.0	28,007,260
			9,710,000.00
13 - Pump Stations	EA	1.0	9,710,000
			71,673,312.79
Arverne	EA	1.0	71,673,313
			2,363,340.00
02 - Utility Relocations	EA	1.0	2,363,340
			53,528,972.79
11 - Levees & Floodwalls	EA	1.0	53,528,973
			15,781,000.00
13 - Pump Stations	EA	1.0	15,781,000
			1,250,000.00
18 Cultural Resources Preservation	EA	1.0	1,250,000
			10,375,955.76
Cedarhurst Lawrence	EA	1.0	10,375,956
			175,465.50
02 - Utility Relocations	EA	1.0	175,466
			6,697,490.26
11 - Levees & Floodwalls	EA	1.0	6,697,490

Description	UOM	Quantity	ProjectCost
			1,277,600.43
Drainage	EA	1.0	1,277,600
			3,455.55
Medium Floodwall	LF	20.0	69,111
			5,573.73
Deep Bulkhead	LF	960.0	5,350,779
			2,753,000.00
13 - Pump Stations	EA	1.0	2,753,000
			750,000.00
18 Cultural Resources Preservation	EA	1.0	750,000

B. SUB-APPENDIX B: PROJECT SCHEDULE

The anticipated schedule for the project.

East Rockaway to Rockaway Inlet

ID	Task Name	Duration	Start	Finish
1	**Shorefront Engineering**			
2	Beachfill Plans and Specs	450 days	Wed 2/28/18	Tue 11/19/19
3	Groin Plans and Specs	450 days	Wed 2/28/18	Tue 11/19/19
4	Composite Seawall Plans and Specs	450 days	Wed 2/28/18	Tue 11/19/19
5	Real Estate	150 days	Mon 6/3/19	Fri 12/27/19
6	**Shorefront Construction**	**942 days**	**Thu 12/5/19**	**Fri 7/14/23**
7	NTP Beachfill	18 days	Thu 12/5/19	Sat 12/28/19
8	Construction Beachfill	196 days	Sat 12/28/19	Fri 9/25/20
9	NTP Groin	23 days	Mon 4/6/20	Wed 5/6/20
10	Groin Construction	633 days	Wed 5/6/20	Fri 10/7/22
11	NTP Composite Seawall	22 days	Fri 8/14/20	Sun 9/13/20
12	Composite Seawall Construction	741 days	Sun 9/13/20	Fri 7/14/23
13				
14	**Cedarhurst Lawrence Pre-Construction**	**565 days**	**Tue 1/22/19**	**Mon 3/22/21**
15	PED	310 days	Tue 1/22/19	Mon 3/30/20
16	Real Estate	385 days	Tue 10/1/19	Mon 3/22/21
17	Utility Relocations	256 days	Mon 3/30/20	Mon 3/22/21
18	**Cedarhurst Lawrence**	**259 days**	**Mon 3/22/21**	**Thu 3/17/22**
19	NTP Cedarhurst Lawrence	20 days	Mon 3/22/21	Fri 4/16/21
20	Cedarhurst Lawrence Floodwall Construction	5 days	Fri 4/16/21	Thu 4/22/21
21	Cedarhurst Lawrence Bulkhead Construction	115 days	Thu 4/22/21	Wed 9/29/21
22	Cedarhurst Lawrence Pump Station Construction	240 days	Fri 4/16/21	Thu 3/17/22
23				
24	**Mid-Rockaway**	**1299 days?**	**Tue 1/22/19**	**Fri 1/12/24**
25	**Hammels Pre-Construction**	**565 days**	**Tue 1/22/19**	**Mon 3/22/21**
26	PED	310 days	Tue 1/22/19	Mon 3/30/20
27	Real Estate	385 days	Tue 10/1/19	Mon 3/22/21
28	Utility Relocations	256 days	Mon 3/30/20	Mon 3/22/21
29	**Hammels**	**587 days?**	**Mon 3/22/21**	**Tue 6/20/23**
30	NTP Hammels	20 days	Mon 3/22/21	Fri 4/16/21
31	Hammels Floodwall Construction	450 days	Wed 9/29/21	Tue 6/20/23
32	Hammels Pump Station Construction	240 days	Thu 3/17/22	Wed 2/15/23
33				
34	**Edgemere Pre-Construction**	**565 days**	**Tue 1/22/19**	**Mon 3/22/21**
35	PED	310 days	Tue 1/22/19	Mon 3/30/20
36	Real Estate	385 days	Tue 10/1/19	Mon 3/22/21
37	Utility Relocations	256 days	Mon 3/30/20	Mon 3/22/21
38	**Edgemere**	**502 days**	**Mon 3/22/21**	**Tue 2/21/23**
39	NTP Edgemere	20 days	Mon 3/22/21	Fri 4/16/21
40	Edgemere Floodwall Construction	365 days	Fri 4/16/21	Thu 9/8/22
41	Edgemere Berm Construction	434 days	Thu 6/24/21	Tue 2/21/23
42	Edgemere Bulkhead Construction	40 days	Thu 9/8/22	Wed 11/2/22
43	Edgemere Pump Station Construction	240 days	Fri 4/16/21	Thu 3/17/22
44				
45	**Arverne Pre-Construction**	**565 days**	**Tue 1/22/19**	**Mon 3/22/21**
46	PED	310 days	Tue 1/22/19	Mon 3/30/20
47	Real Estate	385 days	Tue 10/1/19	Mon 3/22/21
48	Utility Relocations	256 days	Mon 3/30/20	Mon 3/22/21
49	**Averne**	**735 days**	**Mon 3/22/21**	**Fri 1/12/24**
50	NTP Averne	20 days	Mon 3/22/21	Fri 4/16/21
51	Averne Floodwall Construction	716 days	Fri 4/16/21	Fri 1/12/24
52	Avern Berm Construction	286 days	Fri 4/16/21	Fri 5/20/22
53	Averne Bulkhead Construction	364 days	Fri 4/16/21	Wed 9/7/22
54	Averne Revetment Construction	218 days	Wed 9/7/22	Fri 7/7/23
55	Averne Vehicular Gate Construction	40 days	Fri 7/7/23	Thu 8/31/23
56	Averne Pump Station Construction	240 days	Thu 3/17/22	Wed 2/15/23

Project: Project Schedule 2018102
Date: Tue 10/30/18

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

C. SUB-APPENDIX C: MII ESTIMATE - SHOREFRONT

The MII Estimate for the Shorefront section of the project.

East Rockaway to Rockaway Inlet and Jamaica Bay, NY

This project includes the beach nourishment and groin extension / construction and construction of an approximately 33,000 foot long sheet pile wall with armor stone at Rockaway Beach, located in Queens, New York. This project in located in the New York District of the United States Army Corps of Engineers and is based upon the Recommended Plan completed by Moffatt & Nichol for the US Army Corps of Engineers. This estimate includes USACE provided CEDEP estimates used for the beach nourishment costs. Labor Rates were based upon 2018 prevailing wage rates for the State of New York, with April 2017 Blue Book Rates utilized for equipment, and August 2018 quotes from Skyline steel for the sheet piles and Tilcon for the stone.

Estimated by	Sean Jessup, PE, M&N
Designed by	Rob Hampson, PE, M&N Maarten Kluijver, PE, M&N
Prepared by	Sean Jessup, PE, M&N
Preparation Date	8/19/2018
Effective Date of Pricing	4/1/2018
Estimated Construction Time	720 Days

Description	UOM	Quantity	ProjectCost
Project Owner Summary			224,669,563
10 Breakwater & Seawalls	EA	1.0	*187,703,587.22* 187,703,587
Groin Construction Reach 2	EA	1.0	*5,648,481.54* 5,648,482
Groin Construction Reach 3	EA	1.0	*9,007,420.48* 9,007,420
Groin Construction Reach 4	EA	1.0	*10,553,627.24* 10,553,627
Groin Construction Reach 5/6	EA	1.0	*3,589,824.37* 3,589,824
Groin Extensions Reach 5/6	EA	1.0	*6,347,093.21* 6,347,093
Composite Wall	EA	1.0	*150,757,140.39* 150,757,140
17 Beach Replenishment	EA	1.0	*26,965,975.93* 26,965,976
18 Cultural Resource Preservation	EA	1.0	*10,000,000.00* 10,000,000

Description	Page

D. SUB-APPENDIX D: RISK REGISTER

The Risk Register was developed during the risk workshop on June 13, 2018.

East Rockaway to Rockaway Inlet and Jamaica Bay, NY

Risk Matrix

Likelihood of Occurrence	Negligible	Marginal	Significant	Critical	Crisis
	Impact or Consequence of Occurrence				
Certain	Moderate	Moderate	High	High	High
Very Likely	Low	Moderate	High	High	High
Likely	Low	Moderate	High	High	High
Unlikely	Low	Low	Moderate	Moderate	High
Very Unlikely	Low	Low	Low	Low	Moderate

SEE ASSUMPTIONS TAB FOR COST VALUE RANGES DEVELOPMNENT

Negligible--- *Less than*			**$989,255**		**3 Months**
Marginal ---*between*	**$989,256**	**and**	**$3,957,020**	**3 Months**	**and 4 Months**
Significant ---*between*	**$3,957,021**	**and**	**$5,935,530**	**4 Months**	**and 9 Months**
Critical--- *between*	**$5,935,531**	**and**	**$9,892,550**	**9 Months**	**and 18 Months**
Crisis ---*Over*	**$9,892,551**			**18 Months**	

Risk No.	Risk/Opportunity Event	Concerns	PDT Risk Conclusions, Justification	Project Cost: Likelihood*	Project Cost: Impact*	Project Cost: Risk Level*	Project Cost: Rough Order Impact ($)	Project Schedule: Likelihood*	Project Schedule: Impact*	Project Schedule: Risk Level*	Project Schedule: Rough Order Impact (mo)
Contract Risks (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.)											
	PROJECT & PROGRAM MGMT										
PM1	Beach Fill Initial Construction Scope Growth (Length of Shoreline)	Scope could get expanded before congressional authorization for the extent of the beach renourishment.	Unlikely to occur at this point with design well progressed.	Unlikely	Marginal	LOW	$2,000,000	Unlikely	Marginal	LOW	3 Months
PM2	Groin Scope Growth	Scope for the number and length of groins could be changed from the TSP before congressional authorization	Unlikely to occur at this point with design well progressed.	Unlikely	Marginal	LOW	$3,500,000	Very Likely	Marginal	MODERATE	3 Months
PM3	Project Scope Definition	Concern that local sponsors may not agree to take ownership (maintenance) of pump stations	During meeting with NFS, concern was raised about O&M costs for pump stations, there was an indication that NFS may not want to take on O&M costs on	Likely	Critical	HIGH	$7,000,000	Likely	Negligible	LOW	1 Month
PM4	Coordination of plan with local NFS	NFS may not want certain features and may request different features in lieu of recommended plan.	Would impact schedule to determine acceptable outcome to NFS	Likely	Negligible	LOW	$500,000	Likely	Significant	HIGH	6 Months
PM5	Timely response from NFS	NFS will likely respond on their own schedules and not to the desired project schedule.	This is mostly a schedule risk, which is likely to occur. The project delays could be significant.	Likely	Negligible	LOW	$500,000	Likely	Significant	HIGH	6 Months
PM6	Local agency / permit issues	Concern that impacts to wetlands may require mitigation in addition to those created by project.	State or local agencies may have particular concerns with impacts to existing wetlands, that could cause delays to the project schedule to get resolved.	Likely	Negligible	LOW	$500,000	Likely	Significant	HIGH	6 Months
PM7	NFS priorities change	NFS may change their minds on what is more important for project goals relating to minimizing impacts to existing property vs protection levels.	NFS will likely change their minds as public provides input and influential people weigh in. Likely to occur with a significant impact to the schedule, negligible to cost.	Likely	Negligible	LOW	$500,000	Likely	Significant	HIGH	6 Months
	CONTRACT ACQUISITION RISKS										
CA1	Beach Fill Bidding Climate	Limited number of qualified contractors with equipment to complete the dredging.	Lots of dredging work is completed in the area. Sharp increase in unit prices unexpected. May depend on where large dredges are.	Unlikely	Significant	MODERATE	$2,000,000	Very Unlikely	Marginal	LOW	3 Months
CA2	Groins Installation Contractor	Limited amount of marine contractors to complete work at sea (if done by sea)	Work can be completed from both land and sea. Similar projects have been completed recently on Long Island, so means and methods are known.	Unlikely	Marginal	LOW	$3,000,000	Very Unlikely	Marginal	LOW	3 Months
CA3	Rock Source for Groin Construction	Limited amount of quarries to supply rock.	Local quarries have been contacted and say they have the sizes of stone needed.	Likely	Significant	HIGH	$5,000,000	Very Unlikely	Critical	LOW	1 Year
CA4	Composite Wall Construction Access	Rock deliveries to project site may be difficult due to traffic in NYC area.	Barging could work with temporary sheet pile walls and sand to form access at beach.	Unlikely	Marginal	LOW	$2,000,000	Likely	Marginal	MODERATE	2 Months
CA5	Composite Wall Rock Source	Limited amount of quarries to supply rock.	Local quarries have been contacted and say they have the sizes of stone needed.	Likely	Critical	HIGH	$8,000,000	Very Unlikely	Critical	LOW	1 Year
	TECHNICAL RISKS										
TL1	Beach Fill - quantities changes since survey	Minor storms could cause quantities to increase before construction (major storms covered in External Risks section)	USACE has lots of experience with beach fill at Rockaway, and assumptions and design are reliable. Quantities could increase due to higher than expected erosion prior to initial construction. Two borrow areas have been identified for use at this time. Both borrow sites have similar distances to the project site and should not impact costs.	Likely	Marginal	MODERATE	$2,000,000	Likely	Marginal	MODERATE	2 Months
TL2	Groins - Appropriate method applied to calculate quantities	Seabed varies and the template for the groins is uniform. It was assumed sand would be leveled out beneath groins	There is a small risk of variation in quantities for new groins. However, there is a low risk in reusing existing stone in groin extensions. Performance of existing groins in the project area provides confidence in design and lifespan.	Likely	Negligible	LOW	$250,000	Likely	Negligible	LOW	1 Month
TL3	Composite Wall - Quantity changes due to design updates possible?	Quantity changes could occur if design is updated.	The design/typical section is unlikely to change as analysis has already been completed. Quantities are uniform along the shoreline.	Very Unlikely	Significant	LOW	$5,000,000	Very Unlikely	Significant	LOW	6 Months
TL4	Groin- Additional Groins added, increasing quantity	Quantity changes due to additional length / # of groins	Latest design increases quantities	Very Likely	Marginal	MODERATE	$2,000,000	Very Likely	Marginal	MODERATE	3 Months
TL5	Drainage Feature Outfalls may need to be lengthened	Outfalls may be lengthened to get past the wetlands	Increased quantities to get outfalls past the wetlands, adding cost	Unlikely	Marginal	LOW	$1,000,000	Unlikely	Marginal	LOW	3 Months
TL6	Existing drainage structures may be able to be used	Estimate assumes all new drainage features, if existing structures are able to be used, quantities will decrease	This would represent a savings to the project	Very Likely	Negligible	LOW	($1,500,000)	Very Likely	Negligible	LOW	1 Month
TL7	Energy Dissipation may impact wetlands	Dissipation measures may need a larger area than existing footprints	Wetland impacts would then need to be mitigated and permitting may be more difficult	Likely	Negligible	LOW	$750,000	Likely	Significant	HIGH	6 Months
TL8	Further modeling may reduce pump sizes	Conservative modeling used to date that may be able to be further refined	Although it is possible the pumps could get larger, it is more likely the pumps get smaller.	Likely	Negligible	LOW	$500,000	Likely	Negligible	LOW	1 Month
TL9	Pumps designed for saltwater?	PDT believes that with a 10 year return period design level, pumps will get exposed to salt water	Costs are estimated as fresh water pumps, salt water pumps are more expensive	Likely	Significant	HIGH	$5,000,000	Likely	Negligible	LOW	1 Month
TL10	Disposal cost of excavated material	Unknown quantities and contamination levels of soil being excavated.	disposal is currently estimated to not be contaminated or hazardous. It is unlikely that the material may be contaminated, but possible. However, the quantity of soil requiring disposal is small relative to the project, so the impact is marginal.	Unlikely	Marginal	LOW	$1,500,000	Likely	Negligible	LOW	1 Month
TL11	Seepage under berms impacting stability	Seepage analysis has not been completed for features. Berms may require additional design for stability	Exit velocities are high with current design with sandy soils. Stability checks may lead to further design measures to accommodate seepage.	Unlikely	Marginal	LOW	$1,500,000	Likely	Negligible	LOW	1 Month
TL12	Detailing of transitions between features	Quantities may increase as we detail the overlap of features where they tie in to each other.	Detailing the transitions will include areas were there is overlap, increasing quantities slightly. Likely to occur, but with a negligible impact.	Likely	Negligible	LOW	$500,000	Likely	Negligible	LOW	1 Month
TL13	Berm width changed due to NFS requests	Low berm only 5 ft wide, local sponsors may request a wider berm for alternative uses	Unlikely to occur, and would represent a marginal additional volume.	Unlikely	Marginal	LOW	$100,000	Unlikely	Negligible	LOW	1 Month
TL14	Geotextile required in drainage ditch for berms	Flow from pump stations may require lining of the ditches	Unlikely to occur. Geotextile cost would be negligible to the cost of the berm.	Unlikely	Negligible	LOW	$500,000	Unlikely	Negligible	LOW	1 Month
TL15	Riprap required for floodwalls	Fill around footing of floodwall may require riprap to protect it from waves	Likely to occur, cost would be marginal for project as stone would not be too large.	Likely	Marginal	MODERATE	$2,500,000	Likely	Marginal	MODERATE	3 Months
TL16	Geotechnical data lacking.	Relatively conservative interpretations of existing geotechnical data used, so worse than expected geotech over the whole project is unexpected.	Unlikely to occur due to assumptions used in the design and MII estimate.	Unlikely	Marginal	LOW	$1,000,000	Unlikely	Marginal	LOW	3 Months
TL17	Drainage ditch may be required for floodwalls	To direct water into pump stations, ditches may need to be added to the floodwalls to direct the flow of water.	This is likely to occur, but would represent a negligible cost to the floodwalls.	Likely	Negligible	LOW	$500,000	Likely	Negligible	LOW	1 Month
TL18	Drainage for bulkheads may require significant investment to appease landowners.	Water drains over existing bulkheads and would not be able to with higher bulkhead. To avoid flooding residents, significant drainage improvements in and above those estimated may be required.	This is likely to occur as localized flooding is possible with higher bulkheads. Costs with be marginal, as existing drainage costs are conservative.	Likely	Marginal	MODERATE	$1,500,000	Likely	Negligible	LOW	1 Month
TL19	Additional fill required for bulkheads	To make a straight bulkhead, fill will be required behind the bulkhead due to uneven existing bulkheads	Very likely to occur, but marginal in cost as fill is cheap compared to the overall cost of the bulkheads.	Very Likely	Marginal	MODERATE	$2,000,000	Very Likely	Negligible	LOW	1 Month
TL20	Feature Transitions have not been designed	Underestimation of quantities and associated costs due to frequent and complex transitions between floodwalls, berms, vehicular gates, bulkheads, and other HFFRR Features.	This is very likely to occur, as the complex urban environment will require site specific designs for the transitions. Some cost has been included for the transitions, but the case-by-case nature of these elements may lead to additonal costs and project delays. Delays and costs would be negligible	Very Likely	Negligible	LOW	$250,000	Very Likely	Negligible	LOW	1 Month

TL21	Baffle Wall Repairs Required	The existing baffle wall along approximately 6,000 lf of shorefront may require structural repairs or upgrades.	The wall does not have any known structural issues, but could add a significant cost if it requires upgrades.	Unlikely	Crisis	HIGH	$27,000,000	Unlikely	Marginal	LOW	4 months
	LANDS AND DAMAGES RISKS										
LD1	Status of Real estate / easements	Could cause project delays and may require additional costs is more easements are required	Increased costs are likely to occur, but should be marginal to the total project cost. The schedule impacts could be significant.	Likely	Marginal	MODERATE	$2,500,000	Likely	Critical	HIGH	1 Year
LD2	Additional RW access needed	RW needed for construction access?	RW costs are negligible, but significant impacts to the schedule could occur. Likelihoods are likely for both.	Likely	Negligible	LOW	$500,000	Likely	Critical	HIGH	1 Year
LD3	Railroad impacts	small sections of features on railroad properties, which do not have to cooperate and couldn't be forced to.	The sections on the railroad could be mitigated in design, so although it may be likely to occur, the impacts are negligible to the project.	Likely	Negligible	LOW	$500,000	Likely	Negligible	LOW	1 Month
LD4	Relocations may not happen in time	Delays in relocations could impact the schedule	Relocation delays are unlikely, but could cause a significant impact.	Unlikely	Negligible	LOW	$500,000	Unlikely	Significant	MODERATE	6 Months
										0	
	REGULATORY AND ENVIRONMENTAL RISKS										
REG1	Beach Fill - marine life impacts	Marine life can be impacted by dredging, with weather windows imposed on the contractor.	Dredging work is common in the area, with no issues expected.	Unlikely	Marginal	LOW	$2,000,000	Unlikely	Marginal	LOW	3 Months
REG2	Groins - Water Quality Impacts	Water quality issues can arise when dredging and placing stone in water	Groin work is common in the area and the contractors know how to complete within allowed turbidity limits.	Very Unlikely	Marginal	LOW	$2,000,000	Very Unlikely	Significant	LOW	6 Months
REG3	Environmental Mitigation Needs Identified?	Project is expected to be self-mitigating, but agencies may not concur	Additional mitigation needs may be required. This is unlikely to occur, but could represent a marginal cost and marginal delay to the schedule.	Unlikely	Marginal	LOW	$2,000,000	Unlikely	Marginal	LOW	3 Months
REG4	Agency acceptance of final design	Size and acceptability of NNBF features may require modifications in PED to achieve permits	Changes to design could cause schedule delays and slightly increase costs. This is likely to occur, as some NFS have requested changes in the design already. It would only have a negligible impact on the project cost and schedule as other features can be utilized.	Likely	Negligible	LOW	$500,000	Likely	Negligible	LOW	1 month
REG5	Environmental windows in Back Bay?	Red Knot and Plover and Diamondback Terrapins	If Red Knots or Diamondbacks Terrapins are found during PED, additional construction windows would be required. This is unlikely to occur given previous history, but would represent a marginal impact to cost and a significant increase to the schedule.	Unlikely	Marginal	LOW	$2,500,000	Unlikely	Marginal	LOW	6 Months
	CONSTRUCTION RISKS										
CO1	Beach Fill - Weather down time	Weather impacts could delay the beach renourishment.	Weather delays and downtime included in CEDEP estimate. Recent project history and familiarity with beach fill work allow for high certainty that contractor will not have significant issues. Unlikely that proximity of boardwalk will impact construction.	Unlikely	Marginal	LOW	$2,000,000	Unlikely	Marginal	LOW	4 months
CO2	Beach Fill - Equipment available	Other dredging contracts in the area could make a smaller dredge be used for this project.	Standard work that is performed commonly in the area, risks are minimal.	Unlikely	Marginal	LOW	$4,000,000	Unlikely	Significant	MODERATE	6 months
CO3	Groins - Construction in surf zone	Construction in the surf zone is challenging and could take longer than expected.	Construction crew will need a staging area, but there will be room. Work may be completed by a mixture of land or water. Groin construction is common in the area and there are no unique construction methods that should result in an increase risk.	Unlikely	Marginal	LOW	$2,000,000	Very Likely	Negligible	LOW	2 Months
CO4	Composite Wall - Site Access for material delivery	Delivery by barge will be difficult in sea conditions, while truck deliveries through New York City Traffic will be difficult.	Uncertainty in whether the stone would be barged or trucked in. No unique mobilization is required and construction methods are common. Project is estimated assuming trucks, if a contractor finds a more efficient way to deliver stone, that would lead to lower costs.	Unlikely	Marginal	LOW	$2,000,000	Likely	Negligible	LOW	3 Months
CO5	Construction close to existing boardwalk	Construction close to the existing boardwalk may present access issues.	This is anticipated in the production rates used in the estimate, so although this may be a likely issue, the impact to the schedule and cost is negligible.	Likely	Negligible	LOW	$500,000	Likely	Negligible	LOW	1 month
CO6	Utilities	Unknown amount of utilities requiring relocations at this time	This is very likely to occur, but also typical for construction in New York, so only a marginal delay and cost would occur.	Very Likely	Marginal	MODERATE	$1,500,000	Very Likely	Negligible	LOW	4 months
CO7	Adequate staging Areas	Staging areas are limited in the dense urban areas of this project.	This is anticipated in the production rates used in the estimate, so although this may be a likely issue, the impact to the schedule and cost is negligible.	Likely	Negligible	LOW	$500,000	Likely	Negligible	LOW	2 Months
	ESTIMATE AND SCHEDULE RISKS										
ET1	Beach Fill Bidding Climate	Mobilization and Demobilization costs vary significantly in bidding history	There is a large amount of historic data to review to determine mob / demob costs and unit prices. This project is unlikely to vary significantly from that.	Very Likely	Marginal	MODERATE	$2,500,000	Very Unlikely	Negligible	LOW	0 Months
ET2	Groin Construction methods	Job could be completed from land or sea	Land based equipment would need temporary access to construct groins. Sea based equipment would have difficulty in the surf zone, especially where waves are breaking. Estimate assumes mostly sea based equipment, which is slower and more expensive.	Unlikely	Marginal	LOW	$1,500,000	Likely	Marginal	MODERATE	3 Months
ET3	Groin and Seawall Construction Timing	Public utilizes the beach in the summer, construction in off season preferred.	Project should be able to be completed in off-season if the contract is issued at beginning of off season	Unlikely	Marginal	LOW	$500,000	Unlikely	Significant	MODERATE	4 Months
ET4	Disposal of groin stone	Some stone can't be used and would need to be disposed of at an outside site	This is likely to occur, but would represent a negligible cost to groins given the low amount of volumes relative to the project.	Likely	Negligible	LOW	$500,000	Likely	Negligible	LOW	1 Month
ET5	Groin extensions turn into groin rebuilds	Existing structures are too deteriorated to meet project goals and the existing stone is rebuilt.	This may increase the groin costs significantly, although it would only marginally impact the schedule. This is likely to occur as the groins are somewhat old.	Likely	Significant	HIGH	$5,000,000	Likely	Marginal	MODERATE	4 Months
	Programmatic Risks	(External Risk Items are those that are generated, caused, or controlled exclusively outside the PDT's sphere of influence.)									
PR1	Extreme Weather	A hurricane could hit the project area and cause extensive damage to the existing beach and groins, requiring further analysis before completing the work.	Unlikely to occur as major hurricanes are rare in New York, but certainly possible.	Very Unlikely	Crisis	HIGH	$10,000,000	Very Unlikely	Significant	LOW	6 months
PR2	Fuel Price increases	Fuel prices could increase faster than inflation and cause the estimate to be inaccurate by the time construction occurs.	Fuel has stabilized over the past couple years and is unlikely to drastically spike.	Unlikely	Marginal	LOW	$500,000	Unlikely	Negligible	LOW	0 Months
PR3	Quarry Monopoly	Quarries buying out each other could create a monopoly in the supply of stone from quarries	Possible, with few options available for stone supply.	Likely	Significant	HIGH	$8,000,000	Likely	Negligible	LOW	1 month
PR4	Other similar projects	A similar project New York could cause a reduction in the supply of qualified contractors to complete the work.	Most work of this nature is bid by the Corps and can be properly spread out.	Unlikely	Significant	MODERATE	$4,000,000	Unlikely	Marginal	LOW	3 Months
PR5	NFS stakeholders request mechanical cleaning of trash racks	Clogged drains would increase flood elevation, so an automatic system for keeping drainage open is likely to be requested.	Mechanical cleaning increases costs, but not significantly for the project. This is likely to occur with a marginal increase to project costs. Negligible impact to schedule.	Likely	Marginal	MODERATE	$1,000,000	Likely	Negligible	LOW	1 Month

*Likelihood, Impact, and Risk Level to be verified through market research and analysis (conducted by cost engineer).

1. Risk/Opportunity identified with reference to the Risk Identification Checklist and through deliberation and study of the PDT.
2. Discussions and Concerns elaborates on Risk/Opportunity Events and includes any assumptions or findings (should contain information pertinent to eventual study and analysis of event's impact to project).
3. Likelihood is a measure of the probability of the event occurring -- **Very Unlikely**, **Unlikely**, **Moderately Likely**, **Likely**, **Very Likely.** The likelihood of the event will be the same for both Cost and Schedule, regardless of impact.

4. Impact is a measure of the event's effect on project objectives with relation to scope, cost, and/or schedule -- **Negligible**, **Marginal**, **Significant**, **Critical**, or **Crisis.** Impacts on Project Cost may vary in severity from impacts on Project Schedule.
5. Risk Level is the resultant of Likelihood and Impact **Low**, **Moderate**, or **High**. Refer to the matrix located at top of page.
6. Variance Distribution refers to the behavior of the individual risk item with respect to its potential effects on Project Cost and Schedule. For example, an item with clearly defined parameters and a solid most likely scenario would probably follow a triangular or normal distribution. A risk item for which the PDT has little data or probability of modeling with respect to effects on cost or schedule (i.e. "anyone's guess") would probably follow a uniform or discrete uniform distribution.
7. The responsibility or POC is the entity responsible as the Subject Matter Expert (SME) for action, monitoring, or information on the PDT for the identified risk or opportunity.
8. Correlation recognizes those risk events that may be related to one another. Care should be given to ensure the risks are handled correctly without a "double counting."
9. Affected Project Component identifies the specific item of the project to which the risk directly or strongly correlates.
10. Project Implications identifies whether or not the risk item affects project cost, project schedule, or both. The PDT is responsible for conducting studies for both Project Cost and for Project Schedule.
11. Results of the risk identification process are studied and further developed by the Cost Engineer, then analyzed through the Monte Carlo Analysis Method for Cost (Contingency) and Schedule (Escalation) Growth.

E. SUB-APPENDIX E: COST RISK ANALYSIS

Crystal Ball Report - East Rockaway to Rockaway Inlet and Jamaica Bay	
Simulation started on 10/18/2018 at 3:59 PM	
Simulation stopped on 10/18/2018 at 3:59 PM	
Run preferences:	
Number of trials run	5,000
Monte Carlo	
Random seed	
Precision control on	
Confidence level	95.00%
Run statistics:	
Total running time (sec)	7.50
Trials/second (average)	666
Random numbers per sec	13,995
Crystal Ball data:	
Assumptions	21
Correlations	0
Correlation matrices	0
Decision variables	0
Forecasts	1

Forecasts

Worksheet: [Risk_Register_Rockaway_Rev2_v20181018.xlsm]Cost Risk Model

Forecast: Total Cost

Summary:

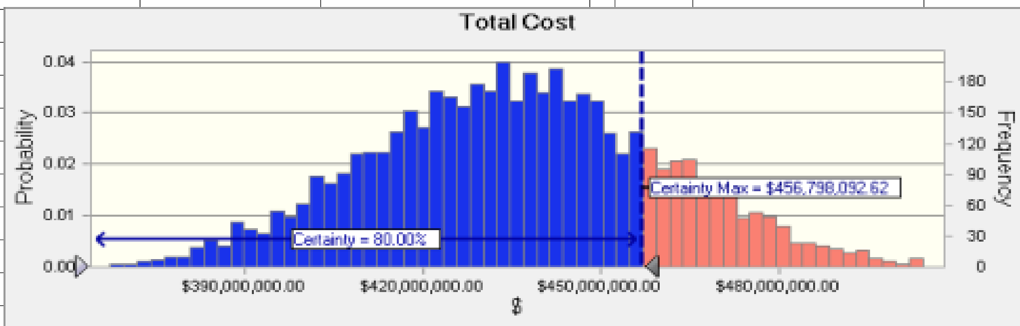
Certainty level is 80.00%

Certainty range is from $0.00 to $456,798,092.62

Entire range is from $354,392,835.80 to $512,055,589.86

Base case is $355,865,376.41

After 5,000 trials, the std. error of the mean is $344,901.62



Statistics:	Forecast values
Trials	5,000
Base Case	$355,865,376.41
Mean	$435,746,538.44
Median	$435,493,833.32
Standard Deviation	$24,388,227.35
Minimum	$354,392,835.80
Maximum	$512,055,589.86
Range Width	$157,662,754.07

Forecast: Total Cost (cont'd)	
Percentiles:	Forecast values
0%	$354,392,835.80
10%	$404,101,189.97
20%	$414,924,691.45
30%	$422,372,011.90
40%	$429,329,968.13
50%	$435,488,722.73
60%	$441,691,565.03
70%	$448,323,726.59
80%	$456,798,092.62
90%	$467,933,686.11
100%	$512,055,589.86
End of Forecasts	

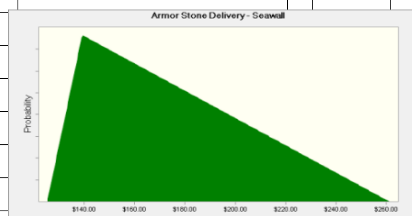
Assumptions

Worksheet: [Risk_Register_Rockaway_Rev2_v20181018.xlsm]Cost Risk Model

Assumption: Armor Stone Delivery - Seawall

Triangular distribution with parameters:

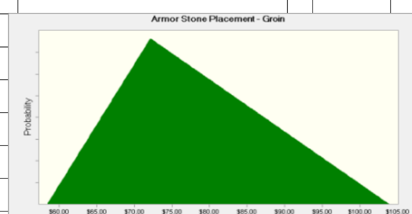
Minimum	$125.33
Likeliest	$139.26
Maximum	$261.11



Assumption: Armor Stone Placement - Groin

Triangular distribution with parameters:

Minimum	$58.43
Likeliest	$72.14
Maximum	$103.88

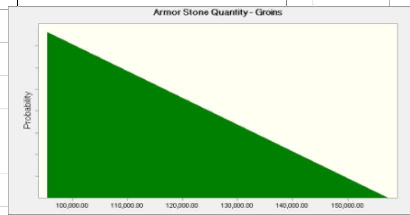


Assumption: Armor Stone Quantity - Groins

Triangular distribution with parameters:

Minimum	95,384.00
Likeliest	95,384.00
Maximum	157,383.60

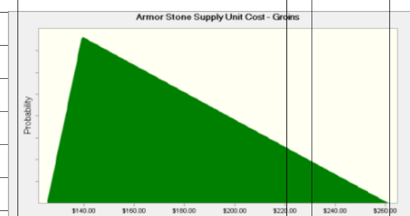
Assumption: Armor Stone Quantity - Groins (cont'd)



Assumption: Armor Stone Supply Unit Cost - Groins

Triangular distribution with parameters:

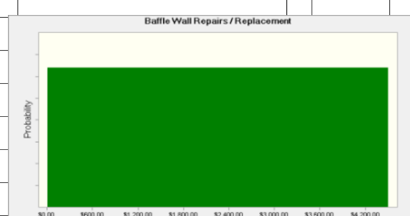
Minimum	$125.33
Likeliest	$139.26
Maximum	$261.11



Assumption: Baffle Wall Repairs / Replacement

Uniform distribution with parameters:

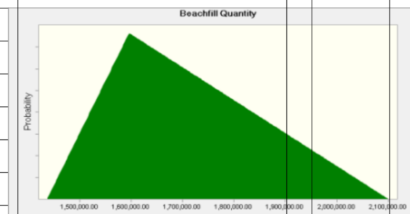
Minimum	$0.00
Maximum	$4,500.00



Assumption: Beachfill Quantity

Triangular distribution with parameters:

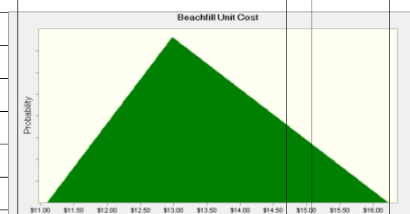
Minimum	1,436,400.00
Likeliest	1,596,000.00
Maximum	2,100,000.00



Assumption: Beachfill Unit Cost

Triangular distribution with parameters:

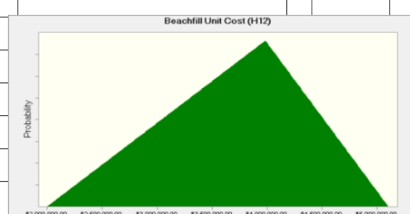
Minimum	$11.10
Likeliest	$12.98
Maximum	$16.23



Assumption: Beachfill Unit Cost (H12)

Triangular distribution with parameters:

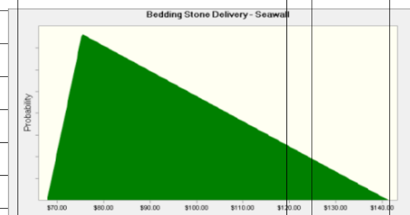
Minimum	$2,000,000.00
Likeliest	$3,983,290.00
Maximum	$5,100,000.00



Assumption: Bedding Stone Delivery - Seawall

Triangular distribution with parameters:

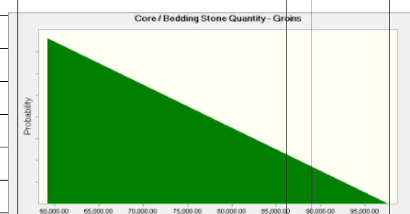
Minimum	$67.82
Likeliest	$75.36
Maximum	$141.30



Assumption: Core / Bedding Stone Quantity - Groins

Triangular distribution with parameters:

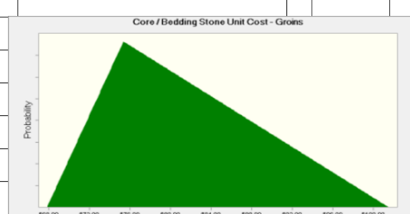
Minimum	59,161.00
Likeliest	59,161.00
Maximum	97,615.65



Assumption: Core / Bedding Stone Unit Cost - Groins

Triangular distribution with parameters:

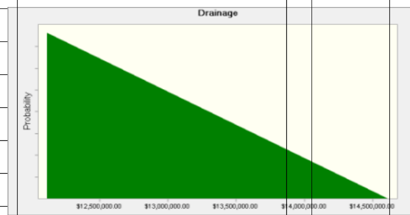
Minimum	$67.82
Likeliest	$75.36
Maximum	$101.48



Assumption: Drainage

Triangular distribution with parameters:

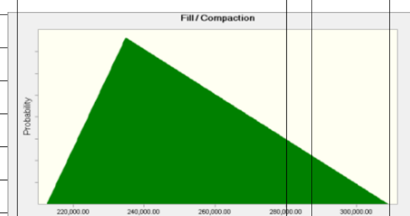
Minimum	$12,112,568.54
Likeliest	$12,112,568.54
Maximum	$14,612,568.54



Assumption: Fill / Compaction

Triangular distribution with parameters:

Minimum	212,545.70
Likeliest	234,845.70
Maximum	308,845.70



Assumption: Limited Competition

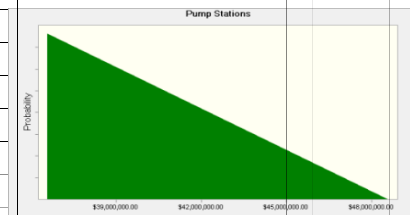
Uniform distribution with parameters:

Minimum	$(14,232,000.00)
Maximum	$28,464,000.00

Assumption: Pump Stations

Triangular distribution with parameters:

Minimum	$36,577,000.00
Likeliest	$36,577,000.00
Maximum	$48,577,000.00



Assumption: Real Estate - Jamiaca Bay

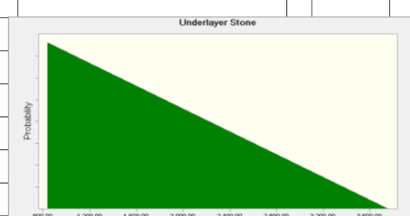
Uniform distribution with parameters:

Minimum	$(8,380,709.00)
Maximum	$33,522,836.00

Assumption: Underlayer Stone

Triangular distribution with parameters:

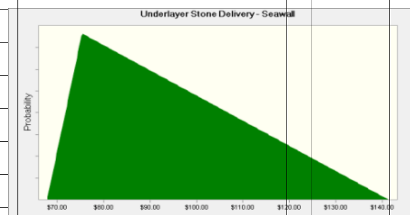
Minimum	835.36
Likeliest	835.36
Maximum	3,754.60



Assumption: Underlayer Stone Delivery - Seawall

Triangular distribution with parameters:

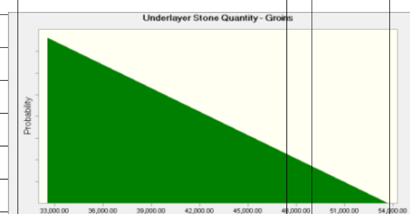
Minimum	$67.82
Likeliest	$75.36
Maximum	$141.30



Assumption: Underlayer Stone Quantity - Groins

Triangular distribution with parameters:

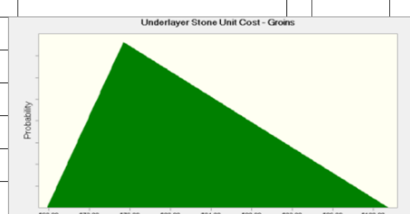
Minimum	32,538.00
Likeliest	32,538.00
Maximum	53,687.70



Assumption: Underlayer Stone Unit Cost - Groins

Triangular distribution with parameters:

Minimum	$67.82
Likeliest	$75.36
Maximum	$101.48



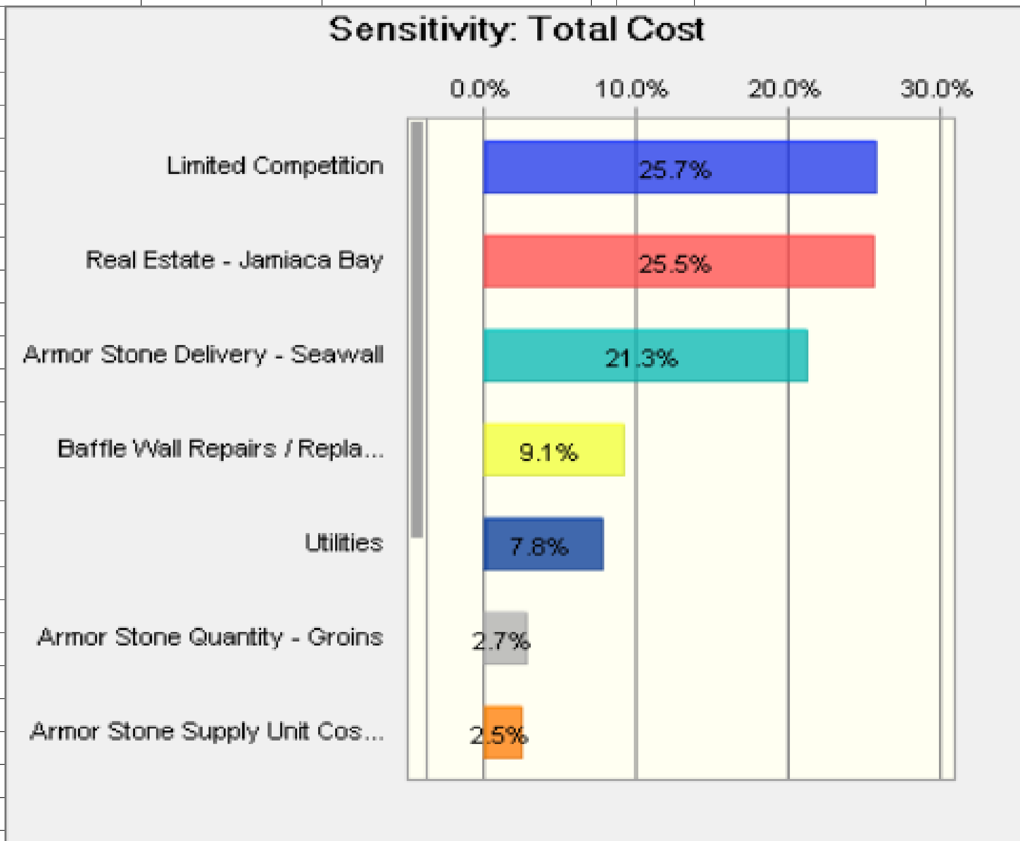
Assumption: Utilities

Uniform distribution with parameters:

Minimum	$89.25
Maximum	$1,071.00

End of Assumptions

Sensitivity Charts



End of Sensitivity Charts

F. SUB-APPENDIX F: SCHEDULE RISK ANALYSIS

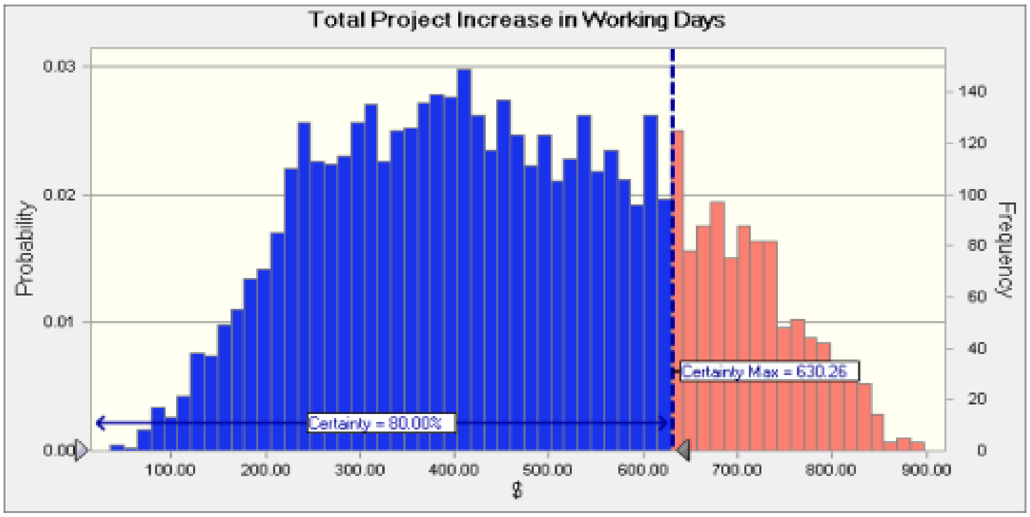
Crystal Ball Report - Schedule Risk Analysis - Rockaway
Simulation started on 7/25/2018 at 1:38 PM
Simulation stopped on 7/25/2018 at 1:38 PM

Run preferences:	
Number of trials run	5,000
Monte Carlo	
Random seed	
Precision control on	
Confidence level	95.00%
Run statistics:	
Total running time (sec)	6.63
Trials/second (average)	754
Random numbers per sec	10,560
Crystal Ball data:	
Assumptions	14
Correlations	0
Correlation matrices	0
Decision variables	0
Forecasts	5

Forecasts

Forecast: Total Project Increase in Working Days

Summary:
Certainty level is 80.00%
Certainty range is from -Infinity to 630.26
Entire range is from 36.05 to 896.65
Base case is 0.00
After 5,000 trials, the std. error of the mean is 2.55



Statistics:	Forecast values
Trials	5,000
Base Case	0.00
Mean	457.01
Median	448.06
Mode	---
Standard Deviation	180.13
Variance	32,447.74
Skewness	0.1193
Kurtosis	2.14
Coeff. of Variation	0.3942
Minimum	36.05
Maximum	896.65
Range Width	860.60
Mean Std. Error	2.55

Forecast: Total Project Increase in Working Days (cont'd)

Percentiles:	Forecast values
0%	36.05
10%	224.72
20%	284.67
30%	341.77
40%	394.84
50%	448.05
60%	505.61
70%	565.14
80%	630.26
90%	708.21
100%	896.65

End of Forecasts

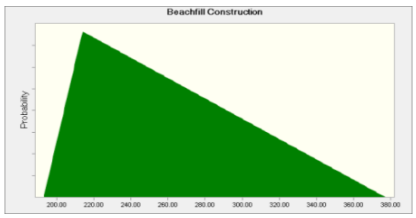
Assumptions

Worksheet: [Risk_Register_Rockaway_v20180723.xlsm]Schedule Risk Model

Assumption: Beachfill Construction

Triangular distribution with parameters:

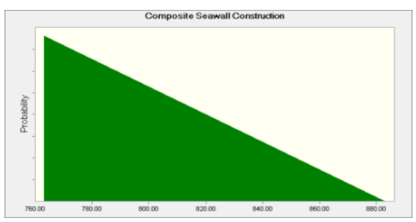
Minimum	193.00
Likeliest	214.00
Maximum	377.00



Assumption: Composite Seawall Construction

Triangular distribution with parameters:

Minimum	763.00
Likeliest	763.00
Maximum	883.00

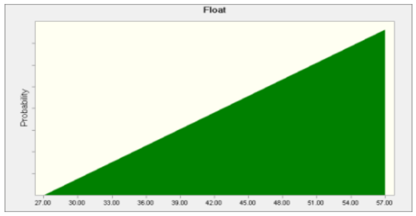


Assumption: Float

Triangular distribution with parameters:

Minimum	27.00
Likeliest	57.00
Maximum	57.00

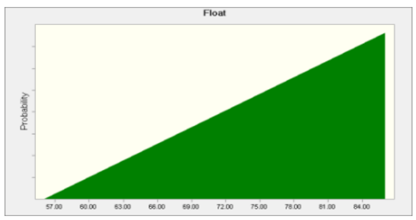
Assumption: Float (cont'd)



Assumption: Float

Triangular distribution with parameters:

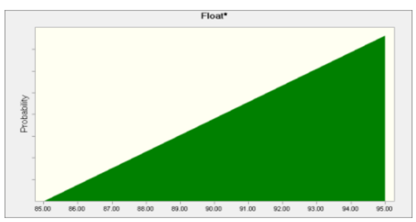
Minimum	56.00
Likeliest	86.00
Maximum	86.00



Assumption: Float*

Triangular distribution with parameters:

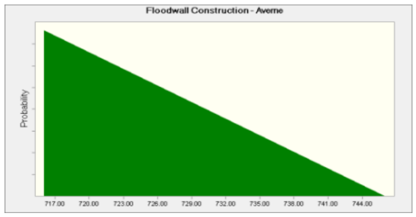
Minimum	85.00
Likeliest	95.00
Maximum	95.00



Assumption: Floodwall Construction - Averne

Triangular distribution with parameters:

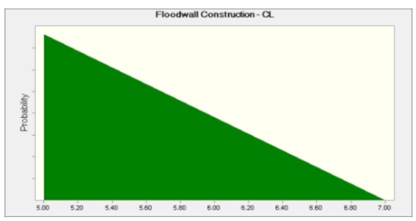
Minimum	716.00
Likeliest	716.00
Maximum	746.00



Assumption: Floodwall Construction - CL

Triangular distribution with parameters:

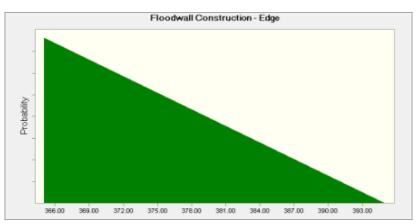
Minimum	5.00
Likeliest	5.00
Maximum	7.00



Assumption: Floodwall Construction - Edge

Triangular distribution with parameters:

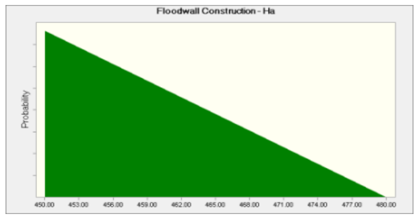
Minimum	365.00
Likeliest	365.00
Maximum	395.00



Assumption: Floodwall Construction - Ha

Triangular distribution with parameters:

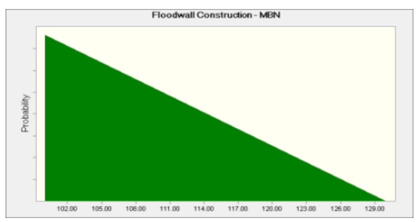
Minimum	450.00
Likeliest	450.00
Maximum	480.00



Assumption: Floodwall Construction - MBN

Triangular distribution with parameters:

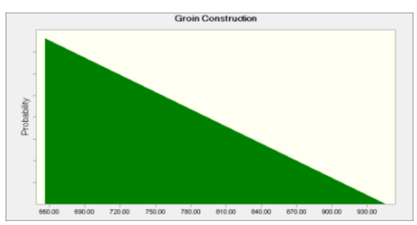
Minimum	100.00
Likeliest	100.00
Maximum	130.00



Assumption: Groin Construction

Triangular distribution with parameters:

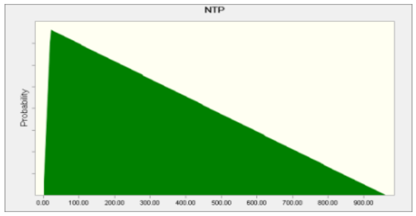
Minimum	656.00
Likeliest	656.00
Maximum	946.00



Assumption: NTP

Triangular distribution with parameters:

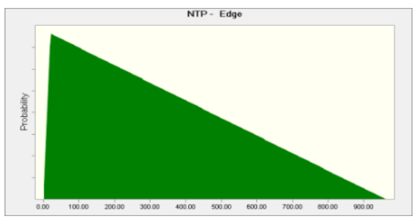
Minimum	1.00
Likeliest	20.00
Maximum	960.00



Assumption: NTP - Edge

Triangular distribution with parameters:

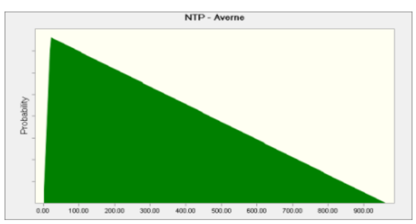
Minimum	1.00
Likeliest	20.00
Maximum	960.00



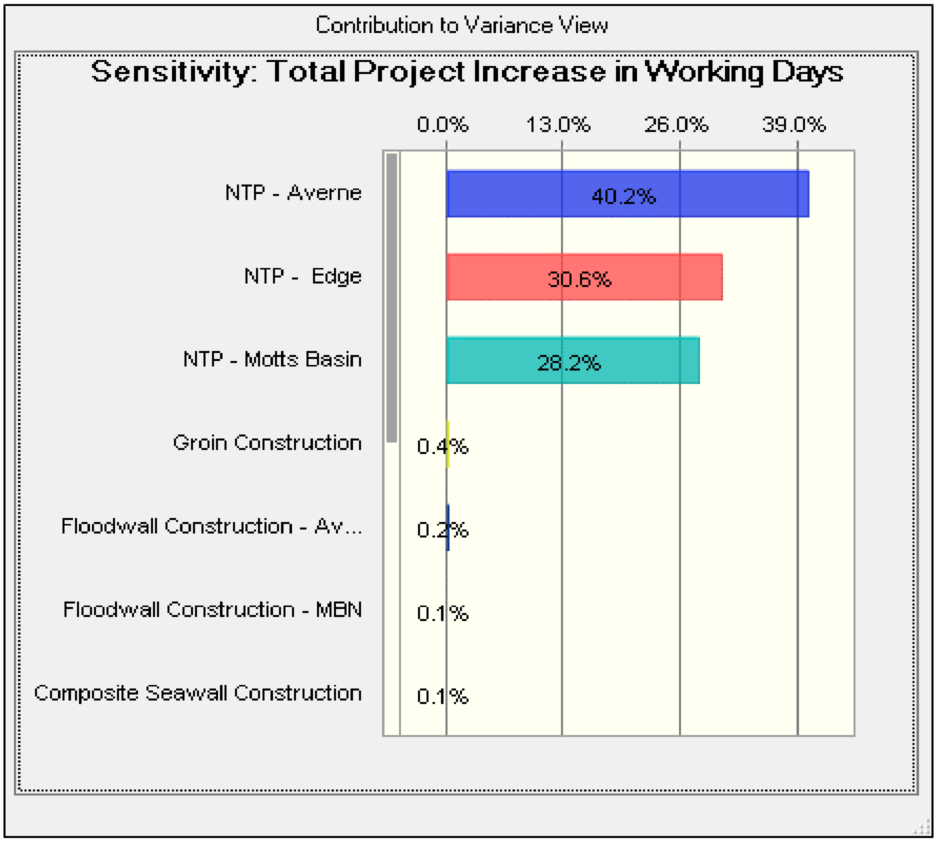
Assumption: NTP - Averne

Triangular distribution with parameters:

Minimum	1.00
Likeliest	20.00
Maximum	960.00



End of Assumptions


Contribution to Variance View
Sensitivity: Total Project Increase in Working Days
0.0%
13.0%
26.0%
39.0%
NTP - Averne
40.2%
NTP - Edge
30.6%
NTP - Motts Basin
28.2%
Groin Construction
0.4%
Floodwall Construction - Av...
0.2%
Floodwall Construction - MBN
0.1%
Composite Seawall Construction
0.1%

G. SUB-APPENDIX G: PUMP COST CURVE

AECOM
1255 Broad Street
Suite 201
Clifton, NJ 07013
www.aecom.com

973-883-8500 tel
973-883-8501 fax

Memorandum

To	File	Pages	17
CC			
Subject	Pump Station Cost Curve – Green Brook 902 Cap Analysis		
From	Nick De Graaff		
Date	September 2018		

This cost curve was created to calculate the pump station cost (including pumps, control building and miscellaneous components) in relation to pump capacity; engineering and design as well as construction management were not included in the costs for the curve. Due to the capacity of the pump station being evalauted, to develop the cost vs capacity curve, nine pump station costs were used. Three of the costs were developed from bid documents provided in an email dated December 5, 2013 by Mukesh Kumar of the New York District US Army Corps of Engineers. Six pump stations' construction costs were provided by Barry Fehl of the URS Metairie, LA office in an email dated December 15, 2011. In addition, a cost estimate sheet was included for a small pump station estimated by the URS Wayne, NJ office in June 2005. The pumps included in the cost curve are:

- 3.1 cfs (700 gpm) – Green Brook-500 East Street in Bound Brook – Estimated June 2005
- 60 cfs – Green Brook pump station GR1 – Segment T – Bid December 2001
- 100 cfs – Green Brook pump station GL4 – Segment B1 – Bid August 2010
- 180 cfs – Green Brook pump station RL1 – Segment R2 – Bid March 2008
- 500 cfs – Mt Kennedy, Estelle, La – Constructed 2004
- 1050 cfs – Dwyer Rd, New Orleans, La – Constructed 2011
- 1200 cfs – Westminister, Westwego, La – Constructed 2000
- 2100 cfs – Everglades, Fl – Constructed 2011
- 2400 cfs – Elmwood, Metairie, La – Constructed 2005
- 3600 cfs – Whitney, Plaquemines, La – Constructed 2000

The costs for all ten of the stations are shown in the table below. The largest pump station on the Green Brook project is less than 700 cfs, thus inclusion of the very large stations would result in the loss of accuracy in the pump range of interest (0-700 cfs). Therefore, of the six pump stations provided by Mr. Fehl, only the 500cfs pump in Estelle, Louisiana and the 1200 cfs pump in Westego, Louisiana were used in this calculation. The remaining four are displayed in the calculation spreadsheet for reference only. The Dwyer Road station was not used because it was an outlier in comparison to the other stations, with exceptional design and construction requirements.

All pump station costs were updated from their bid / construction costs to the 2018 price level using the yearly cost indexes provided in the Civil Works Construction Cost Index System (CWCCIS) for pumping plants. An additional state adjustment factor was used to adjust the costs from Louisiana and Florida to New Jersey.

The costs for the pump stations provided by Barry Fehl (URS) are final construction costs and have been escalated from their construction date to 2018. The costs from the bid sheets and estimate sheet are the winning/lowest bid and provided as an itemized cost for the pump stations. Additional information including final construction cost is not available. These costs were used as they are the best available data even though they include contingencies.

Since the bid sheets did not contain an individual bid item for the pump station, percentages of the bid items were used to obtain the pump station costs. These percentages are provided by Mukesh Kumar (USACE) and are based upon the internal government estimate. The percentages are as follows:

- 22% of bid item 0003 – Segment T
- 33% of clin 0002 option 1 – Segment R2
- 49% of bid item 0009 – Segment B

To develop a cost curve for the Green Brook Cost update, a best fit equation was developed focusing on closely matching the pump station sizes at the lower pump discharges. The best fit curve is a second order polynomial equation. The equation developed is:

$y=-11.536x^2 + 27406x$

The resulting graph and supporting data are provided below.

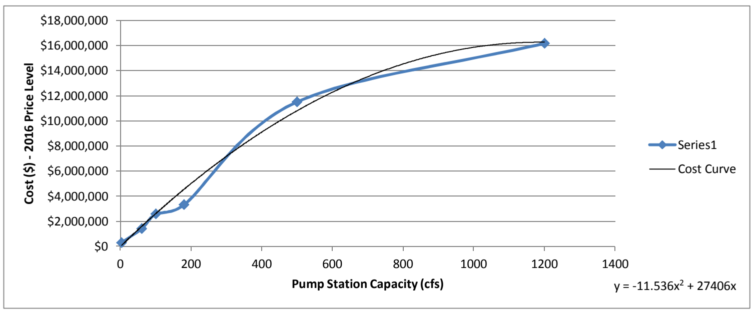
Capacity (MGD)	Pump Stations Capacity (cfs)	Pump Station Name	Original Price	Original Price Year	Original Price Index (AVG 4-QTRS)	Current Price Index (AVG 4-QRTS)	Price Update Factor	Location Adjustment	**2018 Price Level**
2.0026	3.1	G.B. East Union Ave	$234,500	2005	605.47	802.53	1.33	1.00	**$311,000**
38.76	60	G.B. GR1 - Seg T	$830,000	2001	472.18	802.53	1.70	1.00	**$1,411,000**
64.6	100	G.B. GL4 - Seg B1	$2,320,000	2010	720.80	802.53	1.11	1.00	**$2,583,000**
116.28	180	G.B. RL1 - Seg R2	$3,070,000	2008	741.36	802.53	1.08	1.00	**$3,323,000**
323	500	Mt Kennedy, Estelle, La	$6,000,000	2004	563.78	802.53	1.42	1.35	**$11,516,000**
775.2	1200	Westminister, Westwego, La	$7,000,000	2000	468.05	802.53	1.71	1.35	**$16,183,000**
678.3	1050	Dwyer Rd, New Orleans, La	$25,000,000	2011	758.79	802.53	1.06	1.35	**$35,651,000**
1356.6	2100	Everglades, Fl	$35,000,000	2011	758.79	802.53	1.06	1.30	**$48,283,000**
1550.4	2400	Elmwood, Metairie, La	$19,300,000	2005	605.47	802.53	1.33	1.35	**$34,492,000**
2325.6	3600	Whitney, Plaquemines, La	$25,000,000	2000	468.05	802.53	1.71	1.35	**$57,796,000**

Not included in pump station curve cost calculation

Pump Capacity (CFS)
100

y=-11.536x^2 + 27406x

Pump Station Cost
$2,625,240



Pump Stations (cfs)	Description	Cost Type
3.1	2 x 700gpm	Estimate Sheet
60	2 x 30 cfs	Bid Document
100	2 x 50 cfs	Bid Document
180	2 x 90 cfs	Bid Document
500	3 x 167 cfs vertical	Construction Cost
1200	3 x 400 cfs horizontal	Construction Cost
1050	2 x 350 vertical pumps	Construction Cost
2100		Construction Cost
2400	2 x 1200 cfs horizontal	Construction Cost
3600	3 x 1200 cfs horizontal	Construction Cost

Backup

DeGraaff, Nick

From: Ulshafer, Bob
Sent: Wednesday, October 08, 2014 10:56 AM
To: DeGraaff, Nick
Cc: Dromsky-Reed, John
Subject: FW: Staten Island Project

Nick:

Second E-mail.

Bob.

From: Fehl, Barry
Sent: Wednesday, December 14, 2011 11:21 AM
To: Ulshafer, Bob
Subject: RE: Staten Island Project

Bob,

Below are 5 pump stations completed in the New Orleans area in the last 11 years.

Elmwood PS – completed in 2005; 2400 cfs (2-1200 cfs, horizontal pumps); construction cost = $19,300,000

Whitney/Barataria PS – completed in 2000, 3600 cfs (3-1200 cfs, horizontal pumps); construction cost = $25,000,000

Westminister/Lincolnshire PS – completed in 2000; 1200 cfs (3-400 cfs, horizontal pumps); construction cost = $7,000,000

Mt. Kennedy PS – completed in 2004; 500 cfs (3-167 cfs, vertical pumps); construction cost = $6,000,000

Dwyer Road PS – completed in 2011; 1050 cfs (2-350cfs, vertical pumps); construction cost = $25,000,000

Sorry, but I don't have the E&D costs for these. Hope this helps.

Barry

*** Please note my new e-mail address: barry.fehl@urs.com ***

Barry D. Fehl, PE, DSc
Senior Project Manager
URS Corporation
1001 Highlands Plaza Drive West, Suite 300
St. Louis, MO 63110
Phone: 314-743-4147
Cell: 225-252-0420

From: Ulshafer, Bob
Sent: Tuesday, December 13, 2011 12:41 PM
To: Fehl, Barry
Subject: RE: Staten Island Project

Thanks Barry:

The 2.100cfs pump station is a little bigger than the 1,800cfs (max) we considered but it definitely provides me with an upper limit on cost. Do you know if this is the total cost with E&D, profit etc.

Bob.

From: Fehl, Barry
Sent: Tuesday, December 13, 2011 8:56 AM
To: Ulshafer, Bob
Subject: RE: Staten Island Project

Bob,

Got feedback on one pump station. We worked with the Boca Raton office on a pump station in the Everglades. It was a 2100 cfs pump station and its cost is $35M. Is this the information you were looking for? Let me know and I will pass along more as I get it.

There is the 20,000 cfs pump station in New Orleans that they built as part of the hurricane protection and is being completed now. Its cost was about $1B but it included a sector gate and some tie-in flood protection.

They are also planning to build 3 pump stations in the next 3 years in New Orleans as part of a single contract. The pumping capacities of the 3 stations will be 12,500 cfs, 2,700 cfs, and 9,000 cfs. They intend to build all 3 for $700M.

I'm not sure how helpful the ones in New Orleans are but I thought I would pass them along. Thanks.

Barry

*** Please note my new e-mail address: barry.fehl@urs.com ***

Barry D. Fehl, PE, DSc
Senior Project Manager
URS Corporation
1001 Highlands Plaza Drive West, Suite 300
St. Louis, MO 63110
Phone: 314-743-4147
Cell: 225-252-0420

From: Ulshafer, Bob
Sent: Friday, December 09, 2011 2:09 PM
To: Fehl, Barry
Subject: Staten Island Project

Barry:

Do you or someone that you know down in Saint Louis or Metairie have any information on the cost of large pump stations (say 600cfs to 1800cfs) We have some preliminary design curves developed for Green Brook back in 1996 but they seem rather small when updated to today's dollars (largest 640cfs). We should be able to pull together information for smaller pump stations (through 180cfs) from MCACES and bids if we need them.

Our ultimate goal is to try and develop a cost curve for use in determining the cost of multiple interior drainage alternatives. Any information would be useful including pump stations that are smaller than 600cfs.

If you do find something let me know.

Thanks Bob.

MacAllen, Tom

From:	Kumar, Mukesh NAN <Mukesh.Kumar@usace.army.mil>
Sent:	Thursday, December 05, 2013 3:10 PM
To:	MacAllen, Tom
Cc:	Zhang, Cynthia NAN02; Shaffer, Encer R NAN02
Subject:	RE: Historical Pump Data (UNCLASSIFIED)
Attachments:	Bid Abstract GreenBrook FCP Segment T (12-28-01).pdf; Bid Abstract R2 Greenbrook FCP.pdf; Bid Abstract Seabring Mills.pdf

Classification: UNCLASSIFIED
Caveats: NONE

The cost is for entire system:

Building, Pumps, electrical & mechanical including landscaping at the pump station.

I did list the wrong CFS. It should be double for what I listed since each project had two pumps of listed CFS. I wasn't sure if the 2nd pump was redundant.

IGE costs for pump station system were approximately 22% for Seg T; 33% for R2 & 49% for Sebring Mills.

Attached are the bid abstracts for each of the projects.

Bid item 0003 is Levee & Pump for Seg T; Clin 0002 Opt 1 is Levee & Pump Station for R2;

-Mukesh

-----Original Message-----
From: Shaffer, Encer R NAN02
Sent: Thursday, December 05, 2013 6:52 AM
To: Kumar, Mukesh NAN
Cc: Zhang, Cynthia NAN02
Subject: FW: Historical Pump Data (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Mukesh,

Please not Tom's question below. Can you clarify? Thank you.

v/r,

Encer

-----Original Message-----
From: MacAllen, Tom [mailto:tom.macallen@urs.com]
Sent: Wednesday, December 04, 2013 4:42 PM

To: Shaffer, Encer R NAN02; Dromsky-Reed, John
Cc: Dromsky-Reed, John
Subject: [EXTERNAL] RE: Historical Pump Data (UNCLASSIFIED)

Encer:

Not sure what he is reporting.

Sebrings I know is a 100 cfs pump station- 2 pumps 50 cfs each

R2 pump station is I think a 180 cfs pump station- 2 pumps 90 cfs each

Segment T station I think is a 60 cfs pump station- 2 pumps 30cfs each

Could this just be the pump cost per pump? Or is it the entire station costs and he is just got the flow rate of one pump?

From: Shaffer, Encer R NAN02 [mailto:Encer.R.Shaffer@usace.army.mil]
Sent: Wednesday, December 04, 2013 4:18 PM
To: MacAllen, Tom; Dromsky-Reed, John
Subject: FW: Historical Pump Data (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Tom/John,

Please note Mukesh's email below. This cost data was pulled from the lowest bidder's proposal.

v/r,

Encer

From: Kumar, Mukesh NAN
Sent: Wednesday, December 04, 2013 10:58 AM
To: Shaffer, Encer R NAN02
Cc: Zhang, Cynthia NAN02
Subject: Historical Pump Data (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Encer,

Below is what I could find in my files. View in HTML.

CFS Cost Notes

30 $830,000 Greenbrook Segment T - Dec 2001

50 $2,313,290 Seabrings Mills Rd - Aug 2010

90 $3,067,910 Greenbrook Segment R2 - Mar 2008

Double these pump station sizes as per statement on previous page

Thanks

VR

Mukesh Kumar, P.E., CCE

Chief, Cost Engineering Branch

US Army Corps of Engineers, New York District

26 Federal Plaza, Rm 2041

New York, NY 10278

Tel: 917-790-8421

Classification: UNCLASSIFIED
Caveats: NONE

Classification: UNCLASSIFIED
Caveats: NONE

PRELIMINARY BID REPORT

INVITATION FOR BID NUMBER	PROJECT & LOCATION	OPENED BY	DATE & TIME	SHEET
W912DS-08-B-0005	GREEN BROOK FLOOD DAMAGE CONTROL, SEGMENT R-2, BOUND BROOK, N.J.		3/4/08 2:00 PM	1 of 1

BID ITEM NUMBER or C.L.I.N.	I. G. E.	BID NR. 1 PILLAR BROTHERS CONSTRUCTION CORP. FARMINGDALE, NJ	BID NR. 2 CARBO CONSTRUCTION CORP HACKENSACK, NJ	BID NR. 3 SCAFAR CONTRACTING NEWARK, NJ	BID NR. 4 HUTTON CONSTRUCTION CEDAR GROVE, NJ	BID NR. 5 AGATE CONSTRUCTION OCEAN VIEW, NJ	BID NR. 6 ROCHELLE INC. SOMMERVILLE, NJ
0001 BB-1	5,285,100	4,292,700	4,888,000	3,600,000	4,566,684	7,050,000	5,417,000
0001AA BB-2	2,675,496	797,640	82,110	762,450	1,126,080	703,800	469,200
0001AB BB-3	7,439	81,420	5,900	69,000	88,500	59,000	118,000
0002 OP-1	15,069,300	13,161,000	10,862,000	9,237,000	10,814,000	9,000,000	10,400,000
0003 OP-2	47,000	47,000	47,000	47,000	47,000	47,000	47,000
0004 OP-3	12,900	11,600	30,000	14,000	11,000	4,000	35,000
0005 OP-4	550,500	110,500	75,000	160,000	161,000	250,000	75,000
0006 OP-5	6,000	6,000	6,000	6,000	6,000	6,000	6,000
0007 OP-6	70,000	11,000	200,000	81,000	100,000	50,000	140,000
0008 OP-7	5,656,632	1,686,400	173,600	1,605,000	2,232,000	1,488,000	992,000
0009 OP-8	15,710	171,120	10,200	165,000	186,000	124,000	248,000
0010 OP-9	46,302	13,804	1,421	13,195	17,265	12,180	8120
0011 OP-10	253	2760	200	2,000	3,800	2,000	4,000
0012	0	0	0	0	0	0	0
TOTAL BB + OP	29,442,632	20,392,944	16,373,631	15,738,645	19,361,319	18,795,980	17,969,320
		(6)	(2)	(1)	(5)	(4)	(3)

NANY FORM 66 — * FOR OFFICIAL USE ONLY * — Replaces edition dated 1 Jan '56 which is obsolete

Project: Greenbrook Flood Control Damage Reduction Project, Sebrings Mill Road Bridge Reconstruction
Location: Middlesex & Green Brook, NJ
W912DS-10-B-0011
Bid Opening Date: September 01, 2010 @ 2.00 PM

Bid Result

Item No.	Supply/Services	Unit	IGE	Rencor Inc Somerville, NJ	Cruz Enterprise Holmdel, NJ	Scafar Construct Newark, NJ	Cruz Contractor Holmdel, NJ	BZZ Construction Farmingdale, NY	Carbo Construct Hillsborough	Montana Construction, Inc. Lodi, NJ	Wafers & Bugbee Inc Hamilton, NJ	
	Base Bid Items											
0001	Sebrings Mills Road Bridge And Approach Roads	$	4,918,900	6,310,000	6,650,000	5,049,658	5,200,000	5,680,000	5,135,000	4,125,200	8,325,918	
0002	Remove & install NJ American water Line	$	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	
0003	Remove & Reistall PSE&G gas line	$	110,000	110,000	110,000	110,000	110,000	110,000	110,000	110,000	110,000	
0004	Design, Installation Verizon telephone line & serice connection	$	290,000	290,000	290,000	290,000	290,000	290,000	290,000	290,000	290,000	
0005	Modification, inspection and testing of a PARSA sewer Manhole	$	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	
0006	Design, installation and connection of permanent PSE&G line	$	410,000	410,000	410,000	410,000	410,000	410,000	410,000	410,000	410,000	
0007	Design, installation and connection of Cablevision line & services	$	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	
0008	US GEOLOGICAL SURVEY	$	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	
	Options Items											
0009	Levee (ST. 20+65 to 29+30) and Pumpstation	$	5,851,300	4,200,000	3,900,000	4,134,478	4,050,000	4,790,000	4,842,000	4,721,000	5,853,329	2313290
0010	Interim Levee Tie-off St. 0+00 to 0+80	$	26,800	100,000	33,000	37,942	65,000	60,000	115,000	60,000	291,277	
0011	NJ Department of Environmental Protection (NJDEP)	$	29,500	1,000	5,500	1,000	25,000	25,000	1,700	25,000	100	
0012	Floodwall-T-wall (St. 9+63.72 t0 19+00)	$	10,306,900	6,000,000	4,900,000	5,287,522	6,150,000	7,480,000	5,372,000	5,060,000	7,498,343	
0013	Floodwall-Composite -wall (St. 5.48.81 t0 9+63.72)	$	3,178,300	1,800,000	1,750,000	1,880,551	1,450,000	2,150,000	1,677,000	1,722,000	2,764,566	
0014	Floodwall-Composite -wall (St. 1.04.4 t0 5+48.81)	$	2,753,600	1,800,000	1,850,000	1,932,687	1,665,000	2,250,000	1,933,000	1,727,000	2,977,760	
0015	Cost to include payment for utility cost related to pumping station	$	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	
0016	Work to include Grass cutting for 1 year	$	22,000	17,500	15,000	15,550	12,500	22,400	16,000	130,000	43,073	
	Total Base Bid (CLINS 0001-CLINS 0008)	$	6,023,900	7,415,000	7,755,000	6,154,658	6,305,000	6,785,000	6,240,000	5,230,200	9,430,918	
	Total Options Bid (CLINS 0009-CLINS 0016)	$	22,174,400	13,924,500	12,459,500	13,295,730	13,423,500	16,783,400	13,962,700	13,451,000	19,434,448	
	Total Base Bid +Options Bid (CLINS 0001-CLINS 0016)	$	28,198,300	21,339,500	20,214,500	19,450,388	19,728,500	23,568,400	20,202,700	18,681,200	28,865,366	

PRELIMINARY BID REPORT

INVITATION FOR BID NR.	PROJECT & LOCATION	OPENED BY	DATE	TIME
DACW51-01-B-0027	CONSTRUCTION OF SEGMENT T LEVEE	Captain TAYLOR	DEC. 28, 2001	2 PM

BID ITEM NR.	GOVT. ESTIMATE	BID NR. 1	BID NR. 2	BID NR. 3	BID NR. 4	BID NR. 5	BID NR. 6
		ASERVIDONE 3170 BORDETOWN OLD BRIDGE NJ	CRUZ CO. HOLMDEL NJ 07733	CARBRO HILLSBOROUGH N.J. 0884[illegible]	SCAFAR CONTRACT NEWARK NJ 07114	MARSELLIS WARNER MONTCLAIR NJ	NORTHEAST CONSTRUCTION LAKEWOOD NJ
0001	1,260,600	2,300,000	2,120,000	2,130,000	1,500,000	2,440,250	2,500,000
0002	31,000	50,000	48,000	15,000	50,000	39,000	40,000
total basebid	1,291,600	2,350,000	2,168,000	2,145,000	1,550,000	2,479,250	2,540,000
0003 opt	5,542,600	4,000,000	4,047,150	3,574,000	4,853,637	4,370,000	5,062,000
0004 opt	3,531,900	1,904,000	2,075,000	2,270,000	2,700,000	2,650,000	1,500,000
0005 opt	173,200	30,000	35,000	10,000	10,000	114,000	5000
0006 opt	204/51,000	45,000	36,250	18,750	37,500	9,750	17,500
0007 opt	220/880,000	220,000	580,000	300,000	160,000	156,000	260,000
total options	10,178,700	6,199,000	6,774,000	6,172,750	7,761,137	7,299,750	6,844,500
total base+opts	11,470,300	8,549,000	8,942,000	8,317,750	9,311,137	9,779,900	9,384,500

NANY FORM 66
25 AUG. '60

Replaces edition dated 1 Jan. '56 which is obsolete.

6/15/2005

Pay Estimate Sheet
700 GPM Pump Station
At 500 East Street Bound Brook

Pay Item	**Cost**
Generator w/ Sound proof cover	$35,000.00
PS Piping and Fittings	$39,200.00
Valve Chamber	$12,000.00
8 Ft. Dia MH	$32,000.00
Sump Pump	$1,800.00
3.1 cfs (2) 700 GPM Submerseable Pumps	$16,000.00
Electrical (Estiamted as 90% of total job)	$72,000.00
Bollards	$500.00
(2) Aluminum Hatch and Frame	$10,000.00
(2) MH Cover Grates	$1,000.00
(2) 18"X18" Sluice Gate	$6,000.00
18" Check Valve	$5,000.00
12" Check Valve	$4,000.00
Total Pump Station Cost	**$234,500.00**

CWCCIS Amendment 7
9/30/15

TABLE A-2, YEARLY COST INDEXES BY CWBS FEATURE CODE
Base Year 1967 = 100

CWBS - FEATURE CODES	Wt %	FY98 Oct 97 - Sep 98	FY99 Oct 98 - Sep 99	FY00 Oct 99 - Sep 00	FY01 Oct 00 - Sep 01	FY02 Oct 01 - Sep 02	FY03 Oct 02 - Sep 03	FY04 Oct 03 - Sep 04	FY05 Oct 04 - Sep 05	FY06 Oct 05 - Sep 06	FY07 Oct 06 - Sep 07
02 RELOCATIONS	5%	490.26	501.14	507.97	513.30	529.95	541.73	586.53	618.63	646.72	676.51
03 RESERVOIRS	5%	521.42	540.51	552.38	568.09	590.21	605.47	627.11	651.67	672.52	709.45
04 DAMS	15%	479.06	488.39	496.78	503.96	518.66	529.45	566.66	602.14	635.50	667.25
05 LOCKS	2%	472.47	480.10	488.88	495.43	510.94	522.49	564.93	601.85	635.39	669.57
06 FISH & WILDLIFE FACILITIES	5%	472.75	481.62	488.90	494.06	508.96	519.27	562.94	600.07	634.08	665.87
07 POWER PLANT	10%	458.96	465.38	472.73	479.63	490.08	498.28	528.07	557.14	588.85	621.06
08 ROADS, RAILROADS & BRIDGES	10%	490.26	501.14	507.97	513.30	529.95	541.73	586.53	618.63	646.72	676.51
09 CHANNELS & CANALS	3%	503.55	516.11	526.72	536.03	552.56	565.40	584.38	612.13	641.81	667.91
10 BREAKWATER & SEAWALLS	5%	510.50	520.83	527.86	534.68	550.06	563.81	583.43	613.04	641.15	662.61
11 LEVEES & FLOODWALLS	5%	495.99	503.35	512.62	518.66	535.78	549.87	587.00	621.88	655.37	685.57
12 NAVIGATION PORTS & HARBORS	10%	457.55	465.45	500.23	504.84	506.25	526.58	569.50	632.53	674.39	702.23
13 PUMPING PLANT	5%	459.40	460.16	468.05	472.18	486.16	497.40	563.78	605.47	645.52	681.88
14 RECREATION FACILITIES	5%	459.40	460.16	468.05	472.18	486.16	497.40	563.78	605.47	645.52	681.88
15 FLOODWAY CONTROL & DIVERSION STRUCTURE	2%	472.75	481.62	488.90	494.06	508.96	519.27	562.94	600.07	634.08	665.87
16 BANK STABILIZATION	2%	476.48	489.61	501.50	513.00	529.80	543.40	564.43	594.88	630.42	668.28
17 BEACH REPLENISHMENT	2%	507.09	521.89	532.71	543.21	567.10	584.67	601.88	630.27	659.93	689.40
18 CULTURAL RESOURCE PRESERVATION	2%	459.40	460.16	468.05	472.18	486.16	497.40	563.78	605.47	645.52	681.88
19 BUILDINGS, GROUNDS & UTILITIES	5%	459.40	460.16	468.05	472.18	486.16	497.40	563.78	605.47	645.52	681.88
20 PERMANENT OPERATING EQUIPMENT	2%	462.01	460.16	468.05	472.18	486.16	497.40	563.78	605.47	645.52	681.88
COMPOSITE INDEX (WEIGHTED AVERAGE)	100%	478.10	486.21	497.07	503.52	517.46	529.95	571.29	608.36	641.91	673.52
YEARLY PERCENTAGE CHANGE		*1.3%*	*1.7%*	*2.2%*	*1.3%*	*2.8%*	*2.4%*	*7.8%*	*6.5%*	*5.5%*	*4.9%*

Note: FY indicates data developed based on OMB projections.*

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TABLE A-2, YEARLY COST INDEXES BY CWBS FEATURE CODE
Base Year 1967 = 100

CWBS - FEATURE CODES	Wt %	FY08 Oct 07 - Sep 08	FY09 Oct 08 - Sep 09	FY10 Oct 09 - Sep 10	FY11 Oct 10 - Sep 11	FY12 Oct 11 - Sep 12	FY13 Oct 12 - Sep 13	FY14 Oct 13 - Sep 14	FY15* Oct 14 - Sep 15	FY16* Oct 15 - Sep 16	FY17* Oct 16 - Sep 17
02 RELOCATIONS	5%	710.58	705.61	727.45	755.67	773.95	793.85	812.56	820.63	831.31	846.27
03 RESERVOIRS	5%	732.25	761.49	789.17	814.81	837.99	860.65	883.79	902.64	916.96	933.47
04 DAMS	15%	703.25	701.84	717.46	744.15	762.98	778.54	796.18	806.71	817.47	832.18
05 LOCKS	2%	710.71	701.51	719.50	748.95	763.91	776.25	794.63	802.60	812.87	827.50
06 FISH & WILDLIFE FACILITIES	5%	702.82	691.50	706.97	733.11	748.37	763.59	781.56	790.54	800.62	815.03
07 POWER PLANT	10%	658.09	660.94	679.02	703.04	716.75	726.90	740.45	745.17	754.82	768.41
08 ROADS, RAILROADS & BRIDGES	10%	710.58	705.61	727.45	755.67	773.95	793.85	812.56	820.63	831.31	846.27
09 CHANNELS & CANALS	3%	691.11	715.89	733.09	757.44	788.81	811.33	830.35	847.32	860.49	875.98
10 BREAKWATER & SEAWALLS	5%	684.51	708.72	718.92	742.55	765.73	788.06	804.41	820.42	832.68	847.66
11 LEVEES & FLOODWALLS	5%	722.13	718.30	737.97	769.26	788.89	803.44	820.60	827.87	838.46	853.55
12 NAVIGATION PORTS & HARBORS	10%	785.50	703.47	744.86	808.47	827.76	832.56	841.20	781.57	798.16	812.53
13 PUMPING PLANT	5%	741.36	699.70	720.80	758.79	769.30	776.44	791.59	788.00	794.97	809.28
14 RECREATION FACILITIES	5%	741.36	699.70	720.80	758.79	769.30	776.44	791.59	788.00	794.97	809.28
15 FLOODWAY CONTROL & DIVERSION STRUCTURE	2%	702.82	691.50	706.97	733.11	748.37	763.59	781.56	790.54	800.62	815.03
16 BANK STABILIZATION	2%	698.80	723.28	739.03	760.03	779.97	797.82	820.25	839.62	854.06	869.43
17 BEACH REPLENISHMENT	2%	709.35	734.89	757.20	781.96	801.74	821.70	840.86	857.06	870.84	886.52
18 CULTURAL RESOURCE PRESERVATION	2%	741.36	699.70	720.80	758.79	769.30	776.44	791.59	788.00	794.97	809.28
19 BUILDINGS, GROUNDS & UTILITIES	5%	741.36	699.70	720.80	758.79	769.30	776.44	791.59	788.00	794.97	809.28
20 PERMANENT OPERATING EQUIPMENT	2%	741.36	699.70	720.80	758.79	769.30	776.44	791.59	788.00	794.97	809.28
COMPOSITE INDEX (WEIGHTED AVERAGE)	100%	716.54	703.00	724.17	756.48	773.75	787.64	804.05	804.78	815.68	830.36
YEARLY PERCENTAGE CHANGE		*6.4%*	*-1.9%*	*3.0%*	*4.5%*	*2.3%*	*1.8%*	*2.1%*	*0.1%*	*1.4%*	*1.8%*

Note: FY indicates data developed based on OMB projections.*

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TABLE A-3, STATE ADJUSTMENT FACTORS

STATE	
ALABAMA	0.91
ALASKA	1.19
ARIZONA	0.96
ARKANSAS	0.87
CALIFORNIA	1.17
COLORADO	0.97
CONNECTICUT	1.18
DELAWARE	1.10
FLORIDA	0.92
GEORGIA	0.89
HAWAII	1.19
IDAHO	0.97
ILLINOIS	1.15
INDIANA	1.00
IOWA	0.98
KANSAS	0.94
KENTUCKY	0.99
LOUISIANA	0.89
MAINE	1.03
MARYLAND	0.99
MASSACHUSETTS	1.20
MICHIGAN	1.04
MINNESOTA	1.12
MISSISSIPPI	0.89
MISSOURI	1.04

STATE	
MONTANA	0.97
NEBRASKA	0.97
NEVADA	1.08
NEW HAMPSHIRE	1.06
NEW JERSEY	1.20
NEW MEXICO	0.92
NEW YORK	1.17
NORTH CAROLINA	0.87
NORTH DAKOTA	0.92
OHIO	1.02
OKLAHOMA	0.88
OREGON	1.06
PENNSYLVANIA	1.09
RHODE ISLAND	1.16
SOUTH CAROLINA	0.87
SOUTH DAKOTA	0.87
TENNESSEE	0.91
TEXAS	0.89
UTAH	0.95
VERMONT	1.01
VIRGINIA	0.94
WASHINGTON STATE	1.05
WEST VIRGINIA	1.04
WISCONSIN	1.06
WYOMING	0.92
WASHINGTON D.C.	1.03