

SAN JUAN HARBOR, PUERTO RICO NAVIGATION IMPROVEMENTS STUDY

Final Integrated Feasibility Report & Environmental Assessment

APPENDIX D Cost Engineering & Risk Analysis

June 2018



**US Army Corps
of Engineers**
Jacksonville District

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D. COST ESTIMATES

D.1. GENERAL INFORMATION

Corps of Engineers cost estimates for planning purposes are prepared in accordance with the following guidance:

- Engineer Technical Letter (ETL) 1110-2-573, Construction Cost Estimating Guide for Civil Works, 30 September 2008
- Engineer Regulation (ER) 1110-1-1300, Cost Engineering Policy and General Requirements, 26 March 1993
- ER 1110-2-1302, Civil Works Cost Engineering, 30 June 2016
- ER 1110-2-1150, Engineering and Design for Civil Works Projects, 31 August 1999
- ER 1105-2-100, Planning Guidance Notebook, 11 April 2000, as amended
- Engineer Manual (EM) 1110-2-1304 (Tables Revised 31 March 2009), Civil Works Construction Cost Index System, 31 March 2000
- CECW-CP Memorandum for Distribution, Subject: Initiatives to Improve the Accuracy of Total Project Costs in Civil Works Feasibility Studies Requiring Congress Authorization, 19 September 2007
- CECW-CE Memorandum for Distribution, Subject: Application of Cost Risk Analysis Methods to Develop Contingencies for Civil Works Total Project Costs, 3 July 2007
- Methods to Develop Contingencies for Civil Works Total Project Costs, 3 July 2007
- Cost and Schedule Risk Analysis Process, March 2008

The goal of the cost estimate for the San Juan Harbor Navigation Improvement Study is to present a Total Project Cost (construction and non-construction costs) for the Recommended Plan at the current price level to be used for project justification/authorization and to escalate costs for budgeting purposes. In addition, the costing efforts are intended to produce and final product (cost estimate) that is reliable and accurate, and that supports the definition of the Government's and the non-Federal sponsor's obligations.

The cost estimating effort for the study produced a series of alternative plan formulation cost estimates for decision making. The final set of plan formulation cost estimates used for plan selection rely on construction feature unit pricing and are prepared in Civil Works Work Breakdown Structure (CWWBS) format to the sub-feature level. The cost estimate supporting the National Economic Development (NED) plan (Recommended Plan) is prepared in Micro-computer Aided Cost Estimating System (MCACES) Second Generation (MII) to the CWWBS sub-feature level. This estimate is supported by the preferred labor, equipment, materials, and crew/production breakdown. A fully funded (escalated for inflation through project completion) cost estimate in the form of a Total Project Cost Summary has also been developed.

Contingency for this estimate is calculated to be 31% based upon development of a Cost and Schedule Risk Analysis (CSRA). This is in accordance with ER 1110-2-1302.

D.1.1 Plan Formulation Cost Estimates

For the plan formulation cost estimates, unit prices for dredging related work were developed in the Cost Engineering Dredge Estimating Program (CEDEP) and then entered into MII. Unit prices for the remaining major or variable construction elements were developed in MCACES/MIJ based on input from the PDT. Design details, information and assumptions were provided in the Engineering Appendix. Plan formulation alternatives were run through HarborSym for calculation of the Benefit-to-Cost Ratio (BCR). Cost Engineering provided estimates for the initial construction of all alternatives. Contingency for these estimates was assumed to be 35% prior to completion of the CSRA. This assumption was based on ER 1110-2-1302 from 30 June 2016, page 18, for a Class 4 project (early concept technical information). All major risk components were the same for each reach and alternative and there were little to know definable difference in the level of risk between one alternative and another. This assumption was coordinated with the Cost MCX to ensure reasonableness.

D.1.2 Recommended Plan (NED)

The Recommended Plan (NED) was chosen by the Project Delivery Team (PDT) according to the plan formulation described above. The Economics Appendix fully describes the plan selection. The scope of work for the Recommended Plan is found in Appendix A, Engineering. The MII cost estimate for the Recommended Plan was based on that scope and was formatted in the CWWBS. For project justification purposes, the estimate costs are categorized under the appropriate CWWBS code and include both construction and non-construction costs.

The construction costs fall under the following feature code:

- 12 Navigation Ports and Harbors

The non-construction costs fall under the following feature codes:

- 01 Lands and Damages
- 30 Planning, Engineering and Design
- 31 Construction Management

D.1.3 Construction Cost

For the construction costs, unit prices for dredging related work were developed in CEDEP and then entered into MCACES/MIJ. These costs include all major project components categorized under the appropriate CWWBS to the sub-feature level. The Total Project Cost Summary (TPCS) on the Recommended Plan contains contingencies as noted in the estimate (below) and were determined based on ER 1110-2-1302 from 30 June 2016. A full cost and schedule risk analysis (CSRA) was performed to establish the project contingency for the Recommended Plan's cost items. Oracle Crystal Ball Software was utilized to perform the CSRA. Risk assumptions were based upon a PDT brainstorming meeting held on 05 July 2016 and subsequent information provided during the planning process.

D.1.4 Non-Construction Cost

Non-construction costs typically include Lands and Damages (Real Estate), Planning, Engineering and Design (PED), and Construction Management (S&A). These costs were provided by the PDT either as a lump sum cost or as a percentage of the total construction contract cost. Lands and Damages are provided by Real Estate and are best described in the Real Estate Appendix. PED costs are for the preparation of contract plans and specifications (P&S) and include itemized costs that were provided by the PDT, as well as costs for Post-Construction Monitoring costs and percentages for Engineering During Construction (EDC) that were provided by the project manager. Construction Management costs are for the supervision and administration of a contract and include Project Management and Contract Admin costs. These costs were provided by the project manager and are included as a percentage of the total construction contract cost.

The main report details both allocations and cost apportionment for the Federal Government and the non-Federal sponsor. Also included in the main report are the non-Federal sponsor's obligations (items of local cooperation).

D.1.5 Construction Schedule

A construction schedule was prepared utilizing input from the PDT and reflects all project construction components. The schedule considers not only durations of individual components of construction, but also the timing of construction contracts based on funding and construction windows. The construction schedule was combined with the project schedule to create an overall schedule that was used for the generation of the TPCS. The construction schedule will change as the project moves through the various project lifecycle phases. The overall project schedule is provided below.

D.1.6 Total Project Cost Summary

The cost estimate for the Recommended Plan is prepared with an identified price level date and inflation factors are used to adjust the pricing to the project schedule. This estimate is known as the Fully Funded Cost Estimate or Total Project Cost Summary. It includes all Federal and non-Federal costs: Lands, Easements, Rights of Way and Relocations; construction features; Planning Engineering and Design; Construction Management; Contingency; and Inflation.

D.2 RISK AND UNCERTAINTY ANALYSIS (to be completed on the following weeks)

The CSRA was developed according to the procedures outlined in the following documents and sources:

- Cost and Schedule Risk Analysis Process guidance prepared by the USACE Cost Engineering MCX.
- Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated June 30, 2016.
- Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

D.2.1 Risk Analysis Methods

The risk analysis process for this study is intended to determine the probability of various cost outcomes and quantify the required contingency needed in the cost estimate to achieve the desired level of cost confidence.

The entire PDT was engaged to participate in a risk analysis brainstorming session to identify risks associated with the Recommended Plan. The risks are documented on the risk register, which is a tool commonly used in project planning and risk analysis, and evaluated by the PDT. Assumptions are made as to the likelihood and impact of each risk item, as well as the probability of occurrence and magnitude of the impact if it were to occur. A risk model is then developed to establish contingencies to be applied to the project cost. Risks to be evaluated for the following features of work:

- 01 Lands and Damages
- 12 Navigation Ports and Harbors
 - Mobilization, Demobilization & Preparatory Work
 - Mechanical/Clamshell Dredging
 - Hopper Dredging
- 30 Planning, Engineering & Design
- 31 Construction Management

The results will be then reviewed and all parameters re-evaluated by the PDT as a sanity check of assumptions and inputs. Adjustments will be made to the analysis accordingly and the final contingency will be established. The contingency is to be applied to the Recommended Plan estimate in the Total Project Cost Summary (TPCS) in order to obtain the Fully Funded Cost. This process has been completed for San Juan Harbor Improvement Study. The contingency calculated in the CSRA is 31% which has been applied to the Recommended Plan Estimate in the TPCS.

D.2.2 Risk Analysis Results

Risk analysis results are intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as projects progress through planning and implementation.

D.3 TOTAL PROJECT COST SUMMARY

The TPCS addresses inflation through project completion (accomplished by escalation to mid-point of construction per ER 1110-2-1302, Appendix C, Page C-2). It is based on the scope of the Recommended Plan and the official project schedule. The TPCS includes Federal and non-Federal costs for Lands and Damages, all construction features, PED, S&A, along with the appropriate contingencies and escalation associated with each of these activities. The TPCS is formatted according to the CWWBS and uses Civil Works Construction Cost Indexing System (CWCCIS) factors for escalation (EM 1110-2-1304) of construction costs and Office of Management and Budget (EC 11-2-18X, 20 Feb 2008) factors for escalation of PED and S&A costs.

The Total Project Cost Summary was prepared using the MCACES/MII cost estimate on the Recommended Plan, as well as the contingencies set by the risk analysis and the official project schedule.

D.3.1 Total Project Cost Summary Spreadsheet

Refer to the Total Project Cost Summary Spreadsheet on the next page.

D.4 COST MCX TPCS CERTIFICATION

The Recommended Plan estimate, formal cost and schedule risk analysis and total project cost summary spreadsheet have been reviewed by the Walla Walla Mandatory Center of Expertise. All Cost ATR Review comments are documented in Dr. Checks and have been resolved. The final Total Project Cost Summary and corresponding cost certification dated April 27, 2018 is provided below.

**WALLA WALLA COST ENGINEERING
MANDATORY CENTER OF EXPERTISE**

COST AGENCY TECHNICAL REVIEW

CERTIFICATION STATEMENT

For Project No. 443841

**SAJ – San Juan Harbor Improvement Study
San Juan, Puerto Rico**

The San Juan Harbor Improvement Study, as presented by Jacksonville District, has undergone a successful Cost Agency Technical Review (Cost ATR), performed by the Walla Walla District Cost Engineering Mandatory Center of Expertise (Cost MCX) team. The Cost ATR included study of the project scope, report, cost estimates, schedules, escalation, and risk-based contingencies. This certification signifies the products meet the quality standards as prescribed in ER 1110-2-1150 Engineering and Design for Civil Works Projects and ER 1110-2-1302 Civil Works Cost Engineering.

As of April 27, 2018, the Cost MCX certifies the estimated total project cost:

Total First Costs:	\$54,042,000 (Cost ATR Certified)
Fully Funded Costs:	\$62,209,000

It remains the responsibility of the District to correctly reflect these cost values within the Final Report and to implement effective project management controls and implementation procedures including risk management through the period of Federal Participation.



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DN: c=US, o=U.S. Government, ou=DoD, ou=PKI,
ou=USA, cn=JACOBS.MICHAEL.PIERRE.1160569537
Date: 2018.04.27 09:28:01 -0700

**Michael P. Jacobs, PE, CCE
Chief, Cost Engineering MCX
Walla Walla District**

**** TOTAL PROJECT COST SUMMARY ****

Printed:4/27/2018
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LOCATION: San Juan Harbor Improvement Study (44-FT Project) NED Recommended Plan
PROJECT NO: P2 443841
LOCATION: San Juan, PR

DISTRICT: SAJ Jacksonville
POC: CHIEF, COST ENGINEERING, Matthew W. Cunningham
PREPARED: 2/27/2018

This Estimate reflects the scope and schedule in report;

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)					TOTAL PROJECT COST (FULLY FUNDED)				
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST (\$K) C	CNTG (\$K) D	CNTG (%) E	TOTAL (\$K) F	Program Year (Budget EC): Effective Price Level Date: 2018 1 OCT 17				Spent Thru: 1-Oct-17 (\$K) K	TOTAL FIRST COST (\$K) K	INFLATED (%) L	COST (\$K) M	CNTG (\$K) N	FULL (\$K) O
						ESC (%) G	COST (\$K) H	CNTG (\$K) I	TOTAL (\$K) J						
12	NAVIGATION PORTS & HARBORS - Cost Shared Work	\$34,408	\$10,666	31.0%	\$45,074	0.0%	\$34,408	\$10,666	\$45,074	\$0	\$45,074	13.8%	\$39,160	\$12,139	\$51,299
	CONSTRUCTION ESTIMATE TOTALS:	\$34,408	\$10,666		\$45,074	0.0%	\$34,408	\$10,666	\$45,074	\$0	\$45,074	13.8%	\$39,160	\$12,139	\$51,299
01	LANDS AND DAMAGES	\$60	\$6	10.0%	\$66	0.0%	\$60	\$6	\$66	\$0	\$66	4.6%	\$63	\$6	\$69
30	PLANNING, ENGINEERING & DESIGN	\$3,526	\$1,093	31.0%	\$4,619	0.0%	\$3,526	\$1,093	\$4,619	\$0	\$4,619	14.3%	\$4,031	\$1,249	\$5,280
31	CONSTRUCTION MANAGEMENT	\$3,269	\$1,013	31.0%	\$4,282	0.0%	\$3,269	\$1,013	\$4,282	\$0	\$4,282	29.9%	\$4,245	\$1,316	\$5,561
	PROJECT COST TOTALS:	\$41,263	\$12,779	31.0%	\$54,042		\$41,263	\$12,779	\$54,042	\$0	\$54,042	15.1%	\$47,498	\$14,711	\$62,209

CHIEF, COST ENGINEERING, Matthew W. Cunningham

PROJECT MANAGER, Bryan Merrill

CHIEF, REAL ESTATE, Derrick Moton

CHIEF, PLANNING, Eric Summa

CHIEF, ENGINEERING, Lauren Borocharner

CHIEF, OPERATIONS, Carol Bernstein

CHIEF, CONSTRUCTION, Steven Duba

ACTING CHIEF, CONTRACTING, Ricardo Torres

CHIEF, PM-PB, Karen Smith

CHIEF, DPM, Tim Murphy

*TOTAL PROJECT COST: **\$62,209**

ESTIMATED ASSOCIATED COSTS - PREPA LNG LSF Modifications: **\$378,804**

ESTIMATED ASSOCIATED COSTS - Non-Federal Berths: **\$2,054**

ESTIMATED ASSOCIATED COSTS - Aids to Navigation: **\$119**

ESTIMATED TOTAL ASSOCIATED COST: **\$380,978**

*NOTES:

Cost Shared TPC does not include O&M, Local Service Facilities (LSF) and Associated Other Costs.

Cost share to be determined and presented in other documents such as the PPA.

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: San Juan Harbor Improvement Study NED/Recommended Plan (44-FT Project)
LOCATION: San Juan, PR
This Estimate reflects the scope and schedule in report;

DISTRICT: SAJ Jacksonville
POC: CHIEF, COST ENGINEERING, Matthew W. Cunningham
PREPARED: 2/27/2018

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	Estimate Prepared: Effective Price Level:			5-Jan-18 1-Oct-17	Program Year (Budget EC): Effective Price Level Date:				Mid-Point Date P	INFLATED (%) L	COST (\$K) M	CNTG (\$K) N	FULL (\$K) O
		COST (\$K) C	CNTG (\$K) D	CNTG (%) E	TOTAL (\$K) F	ESC (%) G	COST (\$K) H	CNTG (\$K) I	TOTAL (\$K) J					
12	DEEPENING CONTRACT NAVIGATION PORTS & HARBORS - Cost Shared Work	\$34,408	\$10,666	31.0%	\$45,074	0.0%	\$34,408	\$10,666	\$45,074	2024Q3	13.8%	\$39,160	\$12,139	\$51,299
	CONSTRUCTION ESTIMATE TOTALS:	\$34,408	\$10,666	31.0%	\$45,074		\$34,408	\$10,666	\$45,074			\$39,160	\$12,139	\$51,299
01	LANDS AND DAMAGES	\$60	\$6	10.0%	\$66	0.0%	\$60	\$6	\$66	2020Q2	4.6%	\$63	\$6	\$69
30	PLANNING, ENGINEERING & DESIGN													
1.5%	Project Management	\$516	\$160	31.0%	\$676	0.0%	\$516	\$160	\$676	2020Q2	9.3%	\$564	\$175	\$739
0.5%	Planning & Environmental Compliance	\$172	\$53	31.0%	\$225	0.0%	\$172	\$53	\$225	2020Q2	9.3%	\$188	\$58	\$246
4.0%	Engineering & Design	\$1,376	\$427	31.0%	\$1,803	0.0%	\$1,376	\$427	\$1,803	2020Q2	9.3%	\$1,504	\$466	\$1,970
0.5%	Reviews, ATRs, IEPs, VE	\$172	\$53	31.0%	\$225	0.0%	\$172	\$53	\$225	2020Q2	9.3%	\$188	\$58	\$246
0.5%	Life Cycle Updates (cost, schedule, risks)	\$172	\$53	31.0%	\$225	0.0%	\$172	\$53	\$225	2020Q2	9.3%	\$188	\$58	\$246
0.5%	Contracting & Reprographics	\$172	\$53	31.0%	\$225	0.0%	\$172	\$53	\$225	2020Q2	9.3%	\$188	\$58	\$246
2.0%	Engineering During Construction	\$688	\$213	31.0%	\$901	0.0%	\$688	\$213	\$901	2024Q3	29.9%	\$893	\$277	\$1,170
0.5%	Planning During Construction	\$172	\$53	31.0%	\$225	0.0%	\$172	\$53	\$225	2024Q3	29.9%	\$223	\$69	\$293
0.25%	Project Operations	\$86	\$27	31.0%	\$113	0.0%	\$86	\$27	\$113	2020Q2	9.3%	\$94	\$29	\$123
31	CONSTRUCTION MANAGEMENT													
8.8%	Construction Management	\$3,027	\$938	31.0%	\$3,965	0.0%	\$3,027	\$938	\$3,965	2024Q3	29.9%	\$3,931	\$1,219	\$5,149
0.5%	Project Operation:	\$174	\$54	31.0%	\$228	0.0%	\$174	\$54	\$228	2024Q3	29.9%	\$226	\$70	\$296
0.2%	Project Management	\$68	\$21	31.0%	\$89	0.0%	\$68	\$21	\$89	2024Q3	29.9%	\$88	\$27	\$116
	CONTRACT COST TOTALS:	\$41,263	\$12,779		\$54,042		\$41,263	\$12,779	\$54,042			\$47,498	\$14,711	\$62,209

**** TOTAL PROJECT COST SUMMARY ****

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 26-Jul-17		Effective Price Level: 1-Oct-16		Program Year (Budget EC): 2018		Effective Price Level Date: 1 OCT 17						
		RISK BASED												
<u>WBS NUMBER</u>	<u>Civil Works Feature & Sub-Feature Description</u>	<u>COST (\$K)</u>	<u>CNTG (\$K)</u>	<u>CNTG (%)</u>	<u>TOTAL (\$K)</u>	<u>ESC (%)</u>	<u>COST (\$K)</u>	<u>CNTG (\$K)</u>	<u>TOTAL (\$K)</u>	<u>Mid-Point Date</u>	<u>INFLATED (%)</u>	<u>COST (\$K)</u>	<u>CNTG (\$K)</u>	<u>FULL (\$K)</u>
<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>	<u>F</u>	<u>G</u>	<u>H</u>	<u>I</u>	<u>J</u>	<u>P</u>	<u>L</u>	<u>M</u>	<u>N</u>	<u>O</u>
	OTHER ASSOCIATED COSTS													
12	PREPA LNG FACILITIES MODIFICATIONS	\$346,303	\$0	0.0%	\$346,303	0.5%	\$348,023	\$0	\$348,023	2022Q2	8.8%	\$378,804	\$0	\$378,804
12	NON-FEDERAL BERTHS - FY18 Baseline Price Level	\$1,378	\$427	31.0%	\$1,805	0.0%	\$1,378	\$427	\$1,805	2024Q3	13.8%	\$1,568	\$486	\$2,054
12	USCG NAVIGATION AIDS	\$80	\$25	31.0%	\$104	0.5%	\$80	\$25	\$105	2024Q3	13.8%	\$91	\$28	\$119
	CONSTRUCTION ESTIMATE TOTALS:	\$347,760	\$452	0%	\$348,212		\$349,481	\$452	\$349,933			\$380,463	\$514	\$380,978