APPENDIX B: Cost Engineering and Risk Analysis

LAKE WORTH INLET
Palm Beach Harbor

NAVIGATION STUDY FOR
LAKE WORTH INLET, FLORIDA

INTEGRATED FEASIBILITY REPORT
AND ENVIRONMENTAL IMPACT STATEMENT

APPENDIX B
COST ENGINEERING AND RISK ANALYSIS APPENDIX

AUGUST 8, 2013

B5. RISK AND UNCERTAINTY ANALYSIS

A Cost and Schedule Risk Analysis was conducted according to the procedures outlined in the manual entitled, "Cost and Schedule Risk Analysis Process" dated March 2008.

B.5.1 Risk Analysis Methods

The entire PDT participated in a cost and schedule risk analysis brainstorming session to identify risks associated with the Recommended Plan. The risks were listed in the risk register and evaluated by the PDT. Assumptions were 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 was then developed in Crystal Ball in order to develop a contingency to apply to the project cost and schedule. After the model was run, the results were reviewed and all parameters were re-evaluated by the PDT as a sanity check of assumptions and inputs. Adjustments were made to the analysis accordingly and the final contingency was established. The contingency was applied to the recommended plan estimate in the Total Project Cost Summary in order to obtain the Fully Funded Cost.

B.5.2 Risk Analysis Results

Refer to the Project Cost and Schedule Risk Analysis Report provided by Walla Walla Mandatory Cost Center of Expertise as an attachment to this appendix.

B6. TOTAL PROJECT COST SUMMARY

The Total Project Cost Summary (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 contingency set by the risk analysis and the official project schedule.

B.6.1 Total Project Cost Summary Spreadsheet

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

Printed:8/9/2013

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

PROJECT: Lake Worth Inlet Feasibility Study
PROJECT NO: 131356
LOCATION: Palm Beach, FL

DISTRICT: SAJ- Jacksonville District PREPARED: 8/8/2013
POC: CHIEF, COST ENGINEERING, Tracy Leeser

This Estimate reflects the scope and schedule in report: DRAFT INTEGRATED FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT STATEMENT LAKE WORTH INLET, PALM BEACH HARBOR PALM BEACH COUNTY,

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
						Program Year (Budget EC): 2014 Effective Price Level Date: 1 OCT 13								
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Spent Thru: 1-Oct-12 ($K) K	L	COST ($K) M	CNTG ($K) N	FULL ($K) O
06	FISH & WILDLIFE FACILITIES	$10,493	$2,413	23%	$12,906	2.1%	$10,708	$2,463	$13,171	$0		$11,272	$2,592	$13,864
10	BREAKWATER & SEAWALLS	$2,092	$481	23%	$2,574	2.1%	$2,135	$491	$2,627	$0		$2,216	$510	$2,726
12	NAVIGATION PORTS & HARBORS	$49,838	$11,463	23%	$61,300	2.1%	$50,863	$11,698	$62,561	$0		$54,178	$12,461	$66,639
12	NAVIGATION PORTS & HARBORS	$20	$5	23%	$25	2.1%	$20	$5	$25	$0		$22	$5	$27
	CONSTRUCTION ESTIMATE TOTALS:	$62,443	$14,362		$76,805	2.1%	$63,727	$14,657	$78,385	$0		$67,687	$15,568	$83,255
01	LANDS AND DAMAGES (FEDERAL)	$15	$3	23%	$18	2.1%	$15	$4	$19	$0		$16	$4	$19
01	LANDS AND DAMAGES (NON-FEDERAL)	$10	$2	23%	$12	2.1%	$10	$2	$13	$0		$10	$2	$13
06	FISH & WILDLIFE FACILITIES	$1,031	$237	23%	$1,268	1.8%	$1,049	$241	$1,290	$0		$1,398	$322	$1,720
30	PLANNING, ENGINEERING & DESIGN	$2,075	$477	23%	$2,552	1.8%	$2,111	$486	$2,597	$0		$2,229	$513	$2,742
31	CONSTRUCTION MANAGEMENT	$4,999	$1,147	23%	$6,146	1.8%	$5,087	$1,167	$6,253	$0		$5,812	$1,333	$7,145
	PROJECT COST TOTALS:	$70,573	$16,228	23%	$86,801		$72,000	$16,557	**$88,556**	$0		$77,152	$17,741	**$94,894**

________________ CHIEF, COST ENGINEERING, Tracy Leeser

________________ PROJECT MANAGER, Tim Murphy

________________ CHIEF, REAL ESTATE, Audrey Ormerod

________________ CHIEF, PLANNING, Eric Bush

________________ CHIEF, ENGINEERING, Laureen Borochaner

________________ CHIEF, OPERATIONS, Jim Jeffords

________________ CHIEF, CONSTRUCTION, Steven Duba

________________ CHIEF, CONTRACTING, Carlos Clark

________________ CHIEF, PM-PB, Dan Haubner

________________ CHIEF, DPM, David Hobbie

ESTIMATED FEDERAL COST SHARE:	**75%**	**$71,141**
ESTIMATED NON-FEDERAL COST SHARE:	**25%**	**$23,714**
ESTIMATED 100% FEDERAL COST:	**100%**	**$27**
ESTIMATED 100% NON-FEDERAL COST:	**100%**	**$13**
ESTIMATED TOTAL PROJECT FULLY FUNDED COST:		**$94,894**

ESTIMATED FEDERAL COST SHARE:	**75%**	**$66,389**
ESTIMATED NON-FEDERAL COST SHARE:	**25%**	**$22,130**
ESTIMATED 100% FEDERAL COST:	**100%**	**$25**
ESTIMATED 100% NON-FEDERAL COST:	**100%**	**$13**
ESTIMATED TOTAL PROJECT FIRST COST:		**$88,556**

Filename: LakeWorthInlet_TPCS_Mar2013_r5-Rev6 by JGN.xlsx
TPCS

Printed:8/9/2013

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

**** CONTRACT COST SUMMARY ****

PROJECT: Lake Worth Inlet Feasibility Study
LOCATION: Palm Beach, FL
This Estimate reflects the scope and schedule in report: DRAFT INTEGRATED FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT STATEMENT LAKE WORTH INLET, PALM BEACH HARBOR PALM BEACH COUNTY,

DISTRICT: SAJ- Jacksonville District
POC: CHIEF, COST ENGINEERING, Tracy Leeser
PREPARED: 8/8/2013

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 7/2/2013 Effective Price Level: 1-Oct-2012				Program Year (Budget EC): 2014 Effective Price Level Date: 1 OCT 13								
				RISK BASED										
WBS	Civil Works	COST	CNTG	CNTG	TOTAL	ESC	COST	CNTG	TOTAL	Mid-Point	INFLATED	COST	CNTG	FULL
NUMBER	Feature & Sub-Feature Description	($K)	($K)	(%)	($K)	(%)	($K)	($K)	($K)	Date	(%)	($K)	($K)	($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 1 or CONTRACT 1													
06	FISH & WILDLIFE FACILITIES	$0	$0	23%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
10	BREAKWATER & SEAWALLS	$2,092	$481	23%	$2,574	2.1%	$2,135	$491	$2,627	2016Q1	3.8%	$2,216	$510	$2,726
12	NAVIGATION PORTS & HARBORS	$4,732	$1,088	23%	$5,820	2.1%	$4,829	$1,111	$5,940	2016Q2	4.3%	$5,035	$1,158	$6,193
12	NAVIGATION PORTS & HARBORS	$0	$0	23%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:	$6,824	$1,570	23%	**$8,394**		$6,964	$1,602	$8,566			$7,251	$1,668	$8,919
01	LANDS AND DAMAGES (FEDERAL)	$15	$3	23%	$18	2.1%	$15	$4	$19	2015Q1	1.8%	$16	$4	$19
01	LANDS AND DAMAGES (NON-FEDERAL)	$10	$2	23%	$12	2.1%	$10	$2	$13	2015Q1	1.8%	$10	$2	$13
30	PLANNING, ENGINEERING & DESIGN													
1.5%		$100	$23	23%	$123	1.8%	$102	$23	$125	2015Q1	3.7%	$105	$24	$130
1.8%	Project Management	$120	$28	23%	$148	1.8%	$122	$28	$150	2015Q1	3.7%	$127	$29	$156
15.0%	Planning & Environmental Compliance	$1,027	$236	23%	$1,263	1.8%	$1,045	$240	$1,285	2015Q1	3.7%	$1,083	$249	$1,332
1.3%	Engineering & Design	$86	$20	23%	$106	1.8%	$88	$20	$108	2015Q1	3.7%	$91	$21	$112
0.7%	Reviews, ATRs, IEPRs, VE	$50	$12	23%	$62	1.8%	$51	$12	$63	2015Q1	3.7%	$53	$12	$65
0.6%	Life Cycle Updates (cost, schedule, risks)	$40	$9	23%	$49	1.8%	$41	$9	$50	2015Q1	3.7%	$42	$10	$52
0.2%	Contracting & Reprographics	$14	$3	23%	$17	1.8%	$14	$3	$18	2016Q1	8.0%	$15	$4	$19
0.2%	Engineering During Construction	$14	$3	23%	$17	1.8%	$14	$3	$18	2016Q1	8.0%	$15	$4	$19
0.0%	Planning During Construction	$0	$0	23%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
	Project Operations													
31	CONSTRUCTION MANAGEMENT													
7.6%		$519	$119	23%	$638	1.8%	$528	$121	$650	2016Q1	8.0%	$570	$131	$702
0.2%	Construction Management	$14	$0	0%	$14	1.8%	$14	$0	$14	2016Q1	8.0%	$15	$0	$15
0.0%	Contract Admin	$0	$0	23%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.2%	Project Operation:	$14	$3	23%	$17	1.8%	$14	$3	$18	2016Q1	8.0%	$15	$4	$19
	Project Management													
	CONTRACT COST TOTALS:	$8,847	$2,032		**$10,879**		$9,023	$2,072	$11,095			$9,410	$2,161	**$11,571**

Filename: LakeWorthInlet_TPCS_Mar2013_r5-Rev6 by JGN.xlsx
TPCS

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

**** CONTRACT COST SUMMARY ****

PROJECT: Lake Worth Inlet Feasibility Study
LOCATION: Palm Beach, FL
This Estimate reflects the scope and schedule in report: DRAFT INTEGRATED FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT STATEMENT LAKE WORTH INLET, PALM BEACH HARBOR PALM BEACH COUNTY,

DISTRICT: SAJ- Jacksonville District
PREPARED: 8/8/2013
POC: CHIEF, COST ENGINEERING, Tracy Leeser

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: Effective Price Level:			7/2/2013 1-Oct-2012	Program Year (Budget EC): Effective Price Level Date:			2014 1 OCT 13					
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*
	PHASE 2 or CONTRACT 2													
06	FISH & WILDLIFE FACILITIES	$10,493	$2,413	23%	$12,906	2.1%	$10,708	$2,463	$13,171	2016Q4	5.3%	$11,272	$2,592	$13,864
10	BREAKWATER & SEAWALLS	$0	$0	23%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
12	NAVIGATION PORTS & HARBORS	$45,106	$10,374	23%	$55,480	2.1%	$46,034	$10,588	$56,622	2017Q3	6.8%	$49,143	$11,303	$60,446
12	NAVIGATION PORTS & HARBORS	$20	$5	23%	$25	2.1%	$20	$5	$25	2017Q3	6.8%	$22	$5	$27
	CONSTRUCTION ESTIMATE TOTALS:	$55,619	$12,792	23%	**$68,411**		$56,763	$13,055	$69,818			$60,436	$13,900	$74,337
01	LANDS AND DAMAGES (FEDERAL)	$0	$0	23%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES (NON-FEDERAL)	$0	$0	23%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
30	PLANNING, ENGINEERING & DESIGN													
0.2%		$100	$23	23%	$123	1.8%	$102	$23	$125	2015Q4	6.9%	$109	$25	$134
0.1%	Project Management	$41	$9	23%	$50	1.8%	$41	$9	$51	2015Q4	6.9%	$44	$10	$54
0.3%	Planning & Environmental Compliance	$169	$39	23%	$208	1.8%	$172	$40	$212	2015Q4	6.9%	$184	$42	$227
0.0%	Engineering & Design	$0	$0	23%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.1%	Reviews, ATRs, IEPRs, VE	$50	$12	23%	$62	1.8%	$51	$12	$63	2015Q4	6.9%	$54	$13	$67
0.1%	Life Cycle Updates (cost, schedule, risks)	$40	$9	23%	$49	1.8%	$41	$9	$50	2015Q4	6.9%	$44	$10	$54
0.2%	Contracting & Reprographics	$112	$26	23%	$138	1.8%	$114	$26	$140	2017Q3	15.0%	$131	$30	$161
0.2%	Engineering During Construction	$112	$26	23%	$138	1.8%	$114	$26	$140	2017Q3	15.0%	$131	$30	$161
0.0%	Planning During Construction	$0	$0	23%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
	Project Operations													
31	CONSTRUCTION MANAGEMENT													
7.6%		$4,228	$972	23%	$5,200	1.8%	$4,302	$989	$5,292	2017Q3	15.0%	$4,949	$1,138	$6,087
0.2%	Construction Management	$112	$26	23%	$138	1.8%	$114	$26	$140	2017Q3	15.0%	$131	$30	$161
0.0%	Contract Admin:	$0	$0	23%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.2%	Project Operation:	$112	$26	23%	$138	1.8%	$114	$26	$140	2017Q3	15.0%	$131	$30	$161
	Project Management													
	CONTRACT COST TOTALS:	$60,695	$13,960		**$74,654**		$61,928	$14,243	$76,171			$66,344	$15,259	**$81,603**

Filename: LakeWorthInlet_TPCS_Mar2013_r5-Rev6 by JGN.xlsx
TPCS

Printed:8/9/2013

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

**** CONTRACT COST SUMMARY ****

PROJECT: Lake Worth Inlet Feasibility Study
LOCATION: Palm Beach, FL
This Estimate reflects the scope and schedule in report: DRAFT INTEGRATED FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT STATEMENT LAKE WORTH INLET, PALM BEACH HARBOR PALM BEACH COUNTY,

DISTRICT: SAJ- Jacksonville District PREPARED: 8/8/2013
POC: CHIEF, COST ENGINEERING, Tracy Leeser

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: / Effective Price Level:			7/2/2013 / 1-Oct-2012	Program Year (Budget EC): / Effective Price Level Date:			2014 / 1 OCT 13					
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*
	PHASE 3 or CONTRACT 3													
06	FISH & WILDLIFE FACILITIES	$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
12	NAVIGATION PORTS & HARBORS	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
12	NAVIGATION PORTS & HARBORS	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:	$0	$0	0%	**$0**		$0	$0	$0			$0	$0	$0
01	LANDS AND DAMAGES (FEDERAL)	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES (NON-FEDERAL)	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
06	LANDS AND DAMAGES	$1,031	$237	23%	$1,268	1.8%	$1,049	$241	$1,290	2021Q1	33.3%	$1,398	$322	$1,720
30	PLANNING, ENGINEERING & DESIGN													
1.5%		$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
1.8%	Project Management	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
15.0%	Planning & Environmental Compliance	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
1.3%	Engineering & Design	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.7%	Reviews, ATRs, IEPRs, VE	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.6%	Life Cycle Updates (cost, schedule, risks)	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.2%	Contracting & Reprographics	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.2%	Engineering During Construction	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Planning During Construction	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
	Project Operations													
31	CONSTRUCTION MANAGEMENT													
7.6%		$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Construction Management	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.2%	Project Operation:	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
	Project Management													
	CONTRACT COST TOTALS:	$1,031	$237		**$1,268**		$1,049	$241	$1,290			$1,398	$322	**$1,720**

Filename: LakeWorthInlet_TPCS_Mar2013_r5-Rev6 by JGN.xlsx
TPCS

B7. COST DX TPCS CERTIFICATION

The Recommended Plan estimate as well as the Cost and Schedule Risk Analysis and Total Project Cost Summary underwent Cost Review and Certification by the Walla Walla Mandatory Center of Expertise. The attached Cost Agency Technical Review Certification Statement provides documentation of the review and certification of all cost products associated with the Recommended Plan for this project.

WALLA WALLA COST ENGINEERING MANDATORY CENTER OF EXPERTISE

COST AGENCY TECHNICAL REVIEW

CERTIFICATION STATEMENT

For Project No. P2 131356

SAJ LAKE WORTH INLET FEASIBILITY STUDY

The Lake Worth Inlet project, 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 August 9, 2013, the Cost MCX certifies the estimated total project cost of:

FY 2014 Price Level:	$88,556,000 (Project First Cost)
Fully Funded Amount:	$94,894,000

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 throughout the life of the project.

CALLAN.KIM.C.1231558221

Digitally signed by CALLAN.KIM.C.1231558221
DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=CALLAN.KIM.C.1231558221
Date: 2013.08.09 11:03:50 -07'00'

Kim C. Callan, PE, CCE, PM
Chief, Cost Engineering MCX
Walla Walla District

US Army Corps of Engineers®

ATTACHMENT A
PROJECT COST AND SCHEDULE RISK ANALYSIS REPORT

US Army Corps
of Engineers®

Lake Worth Inlet Navigation
Pilot Feasibility Study
Recommended Plan
Project Cost and Schedule Risk Analysis Report

Prepared for:

U.S. Army Corps of Engineers,
Jacksonville District

Prepared by:

U.S. Army Corps of Engineers
Civil Works Cost Engineering and ATR Mandatory Center of Expertise with Technical Expertise, Walla Walla

August 8, 2013

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Risk Register .... APPENDIX A

EXECUTIVE SUMMARY

Under the auspices of the U.S. Army Corps of Engineers (USACE), Jacksonville District, this report presents a recommendation for the total project cost and schedule contingencies for the Lake Worth Inlet Navigation Pilot Feasibility Study. In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a formal risk analysis study was conducted for the development of contingency on the total project cost. The purpose of this risk analysis study was to establish project contingencies by identifying and measuring the cost and schedule impact of project uncertainties with respect to the estimated total project cost.

Specific to the Lake Worth project, the base case project cost for the Recommended Plan is estimated at approximately $71 Million. Based on the results of the analysis, the Cost Engineering Mandatory Center of Expertise for Civil Works (Walla Walla District) recommends a contingency value of $16 Million, or 23%. This contingency includes $13 Million (19%) for risks related to cost and $3 Million (4%) for the effect of schedule delay on overall project costs.

Walla Walla Cost MCX performed the risk analysis using the *Monte Carlo* technique, producing the aforementioned contingencies and identifying key risk drivers.

The following tables ES-1, ES-2, and ES-3 portray the development of contingencies (23% overall). The contingency is based on an 80% confidence level, as per USACE Civil Works guidance.

Table ES-1. Contingency Analysis Table

Base Cost Estimate	**$70,572,047**	
Confidence Level	**Value ($$)**	**Contingency (%)**
5%	$68,587,459	-2.81%
50%	$80,004,197	13.37%
80%	**$86,777,741**	**22.96%**
95%	$93,825,426	32.95%

The following table ES-2 portrays the full costs of the recommended alternative based on the anticipated contracts. The costs are intended to address the congressional request of estimates to implement the project. The contingency is based on an 80% confidence level, as per accepted USACE Civil Works guidance.

Table ES-2. Cost Summary

LAKE WORTH FEATURE ACCOUNTS		COST ($1,000)	CNTG ($1,000)	TOTAL ($1,000)
01	LANDS AND DAMAGES	25	5	30
06	FISH AND WILDLIFE FACILITIES	11,524	2,650	14,174
10	BREAKWATERS AND SEAWALLS	2,092	481	2,574
12	NAVIGATION PORTS AND HARBORS	49,858	11,468	61,325
30	PLANNING, ENGINEERING, AND DESIGN	2,075	477	2,552
31	CONSTRUCTION MANAGEMENT	4,999	1,147	6,146
	TOTAL PROJECT COSTS	**70,573**	**16,228**	**86,801**

Notes: 1) Costs include the recommended contingency of 23%.
2) Costs exclude O&M and Life Cycle Cost estimates.

KEY FINDINGS/OBSERVATIONS RECOMMENDATIONS

The key cost risk drivers identified through sensitivity analysis are PR-1 (Market Conditions/Bidding Climate), CON-1 (Variation in Estimated Quantities), EST-1 (Production Estimates) and TL-2 (Blasting May Be Required) which together contribute over 83 percent of the statistical cost variance.

- Market Conditions/Bidding Climate captures the risk that market forces contribute to either a decrease or increase in the ultimate contract costs, either due to commodity price volatility or supply and demand forces on the bidding environment.
- Variation in Estimated Quantities captures the risk of an underrun or overrun.
- Production Estimates captures the risk that the contractor’s actual production could vary from what was assumed in the estimate.
- Blasting May Be Required captures the risk that due to the lack of geotechnical information currently available, blasting may be required in order to dredge part of the project footprint.

Additional moderate cost risks that should be closely monitored include TL-3 (Change in Subsurface Conditions), CON-7 (Contractor Mobilization), CON-6 (Construction Claims and Modifications), PR-4 (Fuel Prices), TL-8 (Jetty Slope Stability), EST-2 (Contract Markups), PR-2 (Limited Competition) and RE-5 (Availability of Sites for Mitigation).

- Change in Subsurface Conditions captures the risk that due to the lack of geotechnical investigations within the project footprint, there may be rock present in more areas that what has been assumed.
- Contractor Mobilization captures the risk of fluctuation in the mobilizations costs for various dredging equipment.

- Construction Claims and Modifications captures the inherent risk of construction modifications and claims that arise after contract award due to issues such as weather, schedules dictated by O&M cycles, differing site conditions, user directed changes or omissions, inaccurate surveys, and variations in estimated quantities (minor).
- Fuel Prices captures the risk of fluctuation in fuel costs, especially marine diesel.
- Jetty Slope Stability captures the possible risk to the stability of the jetty if blasting is required within the proximity of the jetty. This relies heavily on the results of the geotechnical investigations and whether or not blasting will be required.
- Contract Markups captures the risk that a contractor's actual markups could vary from what was assumed in the estimate.
- Limited Competition captures the risk that there may be too few bidders, limiting competition and driving prices up.
- Availability of Sites for Mitigation captures the risk that the mitigation sites are still not determined and that although there is a large list of possibilities, the ultimate cost of mitigation could vary from what was assumed in the estimate based on the final location of the mitigation site.

The key schedule risk drivers identified through sensitivity analysis are RE-3 (ODMDS Capacity), PPM-5 (Projects Competing Nationally for Funding), TL-2 (Blasting May Be Required) and CON-4 (Construction Schedule Accuracy), which together contribute over 71 percent of the statistical schedule variance.

- ODMDS Capacity captures the risk that the modeling for the capacity in the offshore disposal area shows a need for expansion and the project schedule slips while the issue is addressed.
- Projects Competing Nationally for Funding captures the risk that there may be a delay in obtaining project funds due to the competition amongst numerous projects, especially with recent budget constraints.
- Blasting May Be Required captures the risk that due to the lack of geotechnical information currently available, blasting may be required in order to dredge part of the project footprint.
- Construction Schedule Accuracy captures the risk that there may be components missing from the current estimated schedule which could impact the overall project and construction schedules.

Additional moderate cost risks that should be closely monitored include CON-1 (Variation in Estimated Quantities), RE-8 (Material Testing), PR-6 (Equipment Availability), PPM-4 (Projects Competing for Resources), TL-8 (Jetty Slope Stability), RE-2 (Delay in Obtaining Permits), EST-1 (Production Estimates) and CA-2 (Multiple Contracts Possible).

- Variation in Estimated Quantities captures the risk to the schedule due to an overrun or underrun.
- Material Testing captures the risk that testing may not be suitable for disposal offshore, delaying the project while alternatives are secured.
- Equipment Availability captures the impacts to the schedule due to non-availability of the most efficient dredge type to perform the work.
- Projects Competing for Resources captures the risk associated with there being a great deal of competition for the same resources.
- Jetty Slope Stability captures the risk that blasting may be required due to the presence of large rock in the dredging areas and may impact the jetty, thus impacting the schedule due to increased stabilization requirements.
- Delay in Obtaining Permits captures the risk that there may be delay in obtaining FDEP permits due to geotechnical uncertainty with the presence of rock.
- Production Estimates captures the impact to the schedule if the production varies from what was assumed.
- Multiple Contracts Possible captures the risk of more contracts than what is assumed in the estimtate.

Recommendations, as detailed within the main report, include the implementation of cost and schedule contingencies, further iterative study of risks throughout the project life-cycle, potential mitigation throughout the PED phase, and proactive monitoring and control of risk identified in this study.

MAIN REPORT

1.0 PURPOSE

Under the auspices of the US Army Corps of Engineers (USACE), Jacksonville District, this report presents a recommendation for the total project cost and schedule contingencies for the Lake Worth Inlet Navigation Pilot Study Project.

2.0 BACKGROUND

The Lake Worth Inlet Navigation Pilot Study consists of widening and deepening (to a project depth of 39-feet) within the navigation channel and inner harbor that serves the Port of Palm Beach. The estimated cost for the project is approximately $87 Million. The project sponsor is the Port of Palm Beach. The work includes mitigation features for potential impacts to sea grass and the creation of hard bottoms. The majority of the material will be placed in the approved ODMDS, while some material will be used to create the mitigation features and renourish beaches. The project will also include jetty stabilization (using sheet piles) due to the advanced maintenance deepening to greater than 40-feet. The work will likely be complete in 2-3 phases due to funding increment limitations. It is likely that the contracts will be acquired using a best value-tradeoff RFP procurement to secure performance. The current construction schedule is approximately 15 months in duration. The PDT estimates that a few months of feasibility remains, followed by 12-18 months of PED.

As a part of this effort, Jacksonville District requested that the USACE Cost Engineering Mandatory Center of Expertise for Civil Works (Cost Engineering MCX) provide an agency technical review (ATR) of the cost estimate and schedule for Recommended Project Plan. That tasking also included providing a risk analysis study to establish the resulting contingencies.

3.0 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 U.S. Army Corps of Engineers (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. The report presents the contingency results for cost risks for all project features. The study and presentation does not include consideration for life cycle costs.

3.1 Project Scope

The formal process included extensive involvement of the PDT for risk identification and the development of the risk register. The analysis process evaluated the baseline Micro Computer Aided Cost Estimating System (MCACES) cost estimate, schedule, and funding profiles using Crystal Ball software to conduct a *Monte Carlo* simulation and statistical sensitivity analysis, per the guidance in Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

The project technical scope, estimates and schedules were developed and presented by the Jacksonville District. Consequently, these documents serve as the basis for the risk analysis.

The scope of this study addresses the identification of problems, needs, opportunities and potential solutions that are viable from an economic, environmental, and engineering viewpoint.

3.2 USACE Risk Analysis Process

The risk analysis process for this study follows the USACE Headquarters requirements as well as the guidance provided by the Cost Engineering MCX. The risk analysis process reflected within this report uses probabilistic cost and schedule risk analysis methods within the framework of the Crystal Ball software. 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 to 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 analysis should be considered as an ongoing process conducted concurrent to, and iteratively 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, this risk analysis was performed to meet the requirements and recommendations of 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 September 15, 2008.

- Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

4.0 METHODOLOGY / PROCESS

The Walla Walla Cost Engineering MCX performed the Cost and Schedule Risk Analysis, relying on local Jacksonville District staff to provide information gathering. The Walla Walla Cost Engineering MCX facilitated an on-site risk identification meeting on September 11, 2012 with the Jacksonville District PDT to produce a risk register that served as the framework for the risk analysis. Participants in the risk identification meeting included the following:

Name	Organization	Title
Dan Abecassis	USACE - SAJ	PD-D, Economist
Steve Bratos	USACE - SAJ	EN-WC, Hydrodynamics Modeler
Stephen Conger	USACE - SAJ	EN-DW, Levee Design
Angela Dunn	USACE - SAJ	PD-ES, NEPA
Al Fletcher	USACE - SAJ	PM-WN, Operations manager
Pat Griffin	USACE - SAJ	PD-ES, NEPA
Mike Hensch	USACE - SAJ	PM-WN, Operations manager
Russ Jones	USACE - SAJ	PD-EQ, Water Quality
Max Millstein	USACE - SAJ	PD-D, Economist
Mike Neves	USACE - SAJ	EN-GS, Soils
Barbara Nist	USACE - SAJ	EN-GG, Geotechnical
Cynthia Perez	USACE - SAJ	PM-WN, Project Manager
Philip Sylvestor	USACE - SAJ	PM-WF, Ship Simulation
Jennifer Tyler	USACE - SAJ	EN-TC, Cost Estimating
Lynn Zediak	USACE - SAJ	RE-A, Real Estate Acquisition
Joelle Verhagen	USACE - SAJ	PD-EC, ODMDS Manager
Ian Mcclary	USACE - SAJ	CT, Contracting
Glenn Matlock	USACE - NWW	Chief, Cost MCX, Risk Facilitator
Stacey Roth	USACE - SAJ	PD-PN, Planning
Sheldon Shuff	USACE - SAJ	OC, Office of Council
David McCullough	USACE - SAJ	PD-EP, Archaeologist
Tim Murphy	USACE - SAJ	CD, Construction Division

The first cost risk model was completed November 26, 2012. However, scope and estimate updates since then, as well as a PDT sanity check review, necessitated a rerun of the original model. The final results were initially completed and reported to Jacksonville on November 30, 2012.

Subsequent project development and review necessitated updates to the risk register and the cost estimate and project schedule. As a result, the Jacksonville District requested an update to the risk analysis based on the risk register, cost estimate, and project schedule transmitted on July 3, 2013. The revised risk analysis and report were transmitted on July 22, 2013.

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. Per regulation and guidance, the P80 confidence level (80% confidence level) is the normal and accepted cost confidence level. District Management has the prerogative to select different confidence levels, pending approval from Headquarters, USACE.

In simple terms, contingency is an amount added to an estimate to allow for items, conditions or events for which the occurrence or impact is uncertain and that experience suggests will likely result in additional costs being incurred or additional time being required. The amount of contingency included in project control plans depends, at least in part, on the project leadership's willingness to accept risk of project overruns. The less risk that project leadership is willing to accept the more contingency should be applied in the project control plans. The risk of overrun is expressed, in a probabilistic context, using confidence levels.

The Cost MCX guidance for cost and schedule risk analysis generally focuses on the 80-percent level of confidence (P80) for cost contingency calculation. It should be noted that use of P80 as a decision criteria is a risk averse approach (whereas the use of P50 would be a risk neutral approach, and use of levels less than 50 percent would be risk seeking). Thus, a P80 confidence level results in greater contingency as compared to a P50 confidence level. The selection of contingency at a particular confidence level is ultimately the decision and responsibility of the project's District and/or Division management.

The risk analysis process uses *Monte Carlo* techniques to determine probabilities and contingency. The *Monte Carlo* techniques are facilitated computationally by a commercially available risk analysis software package (Crystal Ball) that is an add-in to Microsoft Excel. Cost estimates are packaged into an Excel format and used directly for cost risk analysis purposes. The level of detail recreated in the Excel-format schedule is sufficient for risk analysis purposes that reflect the established risk register, but generally less than that of the native format.

The primary steps, in functional terms, of the risk analysis process are described in the following subsections. Risk analysis results are provided in Section 6.

4.1 Identify and Assess Risk Factors

Identifying the risk factors via the PDT is considered a qualitative process that results in establishing a risk register that serves as the document for the quantitative study using the Crystal Ball risk software. 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.

A formal PDT meeting was held with the Jacksonville District office for the purposes of identifying and assessing risk factors. The meeting included capable and qualified representatives from multiple project team disciplines and functions, including project management, cost engineering, design, environmental compliance, and real estate.

The initial formal meetings focused primarily on risk factor identification using brainstorming techniques, but also included some facilitated discussions based on risk factors common to projects of similar scope and geographic location. Subsequent meetings focused primarily on risk factor assessment and quantification.

Additionally, numerous conference calls and informal meetings were conducted throughout the risk analysis process on an as-needed basis to further facilitate risk factor identification, market analysis, and risk assessment.

4.2 Quantify Risk Factor Impacts

The quantitative impacts of risk factors on project plans were analyzed using a combination of professional judgment, empirical data and analytical techniques. Risk factor impacts were 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 and functions. However, the quantification process relied more extensively on collaboration between cost engineering and risk analysis team members with lesser inputs from other functions and disciplines. This process used an iterative approach to estimate the following elements of each risk factor:

- 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 product from the PDT discussions is captured within a risk register as presented in section 6 for both cost and schedule risk concerns. Note that 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 support the team's decisions related to event likelihood, impact, and the resulting risk levels for each risk event.

4.3 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 only the moderate and high level risks identified for each option (i.e., low-level risks are typically not considered, but remain within the risk register to serve historical purposes as well as support follow-on risk studies as the project and risks evolve).

For the cost estimate, the contingency is calculated as the difference between the P80 cost forecast and the baseline cost estimate. 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.

5.0 PROJECT ASSUMPTIONS

The following data sources and assumptions were used in quantifying the costs associated with the Lake Worth Inlet project.

a. The Jacksonville District provided MII MCACES (Micro-Computer Aided Cost Estimating Software) files electronically. The MII and CWE files transmitted and downloaded on July 3, 2013 was the basis for the updated cost and schedule risk analyses.

b. The cost comparisons and risk analyses performed and reflected within this report are based on design scope and estimates that are at the feasibility level.

c. Schedules are analyzed for impact to the project cost in terms of both uncaptured escalation (variance from OMB factors and the local market) and unavoidable fixed contract costs and/or languishing federal administration costs incurred throughout delay.

Specific to the Lake Worth project, the schedule was analyzed only for impacts due to residual fixed costs.

d. Per the CWCCIS Historical State Adjustment Factors in EM 1110-2-1304, State Adjustment Factor for the State of Florida is 0.93, meaning that the average inflation for the project area is assumed to be 7% lower than the national average for inflation. Therefore, it is assumed that the project inflations experienced are similar to OMB inflation factors for future construction. Based on this information, the risk analysis accounted for a slight escalation adjustment over and above the national average.

e. Per the data in the estimate, the Overhead percentage for the Prime Contractor is 10%, and 7% for the Subcontractors. Thus, the assumed residual fixed cost rate for this project is 8.5%. For the P80 schedule, this comprises approximately 18.69% of the total contingency and 4.29% of the base cost estimate. This is due to the accrual of residual fixed costs associated with delay associated with the implementation schedule.

f. The Cost MCX guidance generally focuses on the eighty-percent level of confidence (P80) for cost contingency calculation. For this risk analysis, the eighty-percent level of confidence (P80) was used. It should be noted that the use of P80 as a decision criteria is a moderately risk averse approach, generally resulting in higher cost contingencies. However, the P80 level of confidence also assumes a small degree of risk that the recommended contingencies may be inadequate to capture actual project costs.

g. Only high and moderate risk level impacts, as identified in the risk register, were considered for the purposes of calculating cost contingency. Low level risk impacts should be maintained in project management documentation, and reviewed at each project milestone to determine if they should be placed on the risk “watch list”.

6.0 RESULTS

The cost and schedule risk analysis results are provided in the following sections. In addition to contingency calculation results, sensitivity analyses are presented to provide decision makers with an understanding of variability and the key contributors to the cause of this variability.

6.1 Risk Register

A risk register is a tool commonly used in project planning and risk analysis. The actual risk register is provided in Appendix A. The complete risk register includes low level risks, as well as additional information regarding the nature and impacts of each risk.

It is important to note that a risk register can be an effective tool for managing identified risks throughout the project life cycle. As such, it is generally recommended that risk registers be updated as the designs, cost estimates, and schedule are further refined, especially on large projects with extended schedules. Recommended uses of the risk register going forward include:

- Documenting risk mitigation strategies being pursued in response to the identified risks and their assessment in terms of probability and impact.
- Providing project sponsors, stakeholders, and leadership/management with a documented framework from which risk status can be reported in the context of project controls.
- Communicating risk management issues.
- Providing a mechanism for eliciting feedback and project control input.
- Identifying risk transfer, elimination, or mitigation actions required for implementation of risk management plans.

6.2 Cost Contingency and Sensitivity Analysis

The result of risk or uncertainty analysis is quantification of the cumulative impact of all analyzed risks or uncertainties as compared to probability of occurrence. These results, as applied to the analysis herein, depict the overall project cost at intervals of confidence (probability).

Table 1 provides the construction cost contingencies calculated for the P80 confidence level and rounded to the nearest thousand. The construction cost contingencies for the P50 and P100 confidence levels are also provided for illustrative purposes only.

Contingency was quantified as approximately $16 Million at the P80 confidence level (23% of the baseline cost estimate). For comparison, the cost contingency at the P50 and P100 confidence levels was quantified as 13% and 54% of the baseline cost estimate, respectively.

Table 1. Project Cost Contingency Summary

Risk Analysis Forecast	Baseline Estimate	Total Contingency[1,2] ($)	Total Contingency (%)
50% Confidence Level			
Project Cost	$80,004,197	$9,432,150	13.37%
80% Confidence Level			
Project Cost	$86,777,741	$16,205,694	22.96%
100% Confidence Level			
Project Cost	$108,656,525	$38,084,478	53.97%

Notes:
1) These figures combine uncertainty in the baseline cost estimates and schedule.
2) A P100 confidence level is an abstract concept for illustration only, as the nature of risk and uncertainty (specifically the presence of “unknown unknowns”) makes 100% confidence a theoretical impossibility.

6.2.1 Sensitivity Analysis

Sensitivity analysis generally ranks the relative impact of each risk/opportunity as a percentage of total cost uncertainty. The Crystal Ball software uses a statistical measure (contribution to variance) that approximates the impact of each risk/opportunity contributing to variability of cost outcomes during *Monte Carlo* simulation.

Key cost drivers identified in the sensitivity analysis can be used to support development of a risk management plan that will facilitate control of risk factors and their potential impacts throughout the project lifecycle. Together with the risk register, sensitivity analysis results can also be used to support development of strategies to eliminate, mitigate, accept or transfer key risks.

6.2.2 Sensitivity Analysis Results

The risks/opportunities considered as key or primary cost drivers are ranked in order of importance in contribution to variance bar charts. Opportunities that have a potential to reduce project cost are shown with a negative sign; risks are shown with a positive sign to reflect the potential to increase project cost. A longer bar in the sensitivity analysis chart represents a greater potential impact to project cost.

Figure 1 presents a sensitivity analysis for cost growth risk from the high level cost risks identified in the risk register. Likewise, Figure 2 presents a sensitivity analysis for schedule growth risk from the high level schedule risks identified in the risk register.

6.3 Schedule and Contingency Risk Analysis

Table 2 provides the schedule duration contingencies calculated for the P80 confidence level. The schedule duration contingencies for the P50 and P100 confidence levels are also provided for illustrative purposes.

Schedule duration contingency was quantified as 24 months based on the P80 level of confidence. These contingencies were used to calculate the projected residual fixed cost impact of project delays that are included in the Table 1 presentation of total cost contingency. The schedule contingencies were calculated by applying the high level schedule risks identified in the risk register for each option to the durations of critical path and near critical path tasks.

The schedule was not resource loaded and contained open-ended tasks and non-zero lags (gaps in the logic between tasks) that limit the overall utility of the schedule risk analysis. These issues should be considered as limitations in the utility of the schedule contingency data presented. Schedule contingency impacts presented in this analysis are based solely on projected residual fixed costs.

Table 2. Schedule Duration Contingency Summary

Risk Analysis Forecast	Baseline Schedule Duration (months)	Contingency[1] (months)
50% Confidence Level		
Project Duration	57	15
80% Confidence Level		
Project Duration	57	24
100% Confidence Level		
Project Duration	57	58

Notes:
1) The schedule was not resource loaded and contained open-ended tasks and non-zero lags (gaps in the logic between tasks) that limit the overall utility of the schedule risk analysis. These issues should be considered as limitations in the utility of the schedule contingency data presented in Table 2.
2) A P100 confidence level is an abstract concept for illustration only, as the nature of risk and uncertainty (specifically the presence of "unknown unknowns") makes 100% confidence a theoretical impossibility.

Figure 1. Cost Sensitivity Analysis

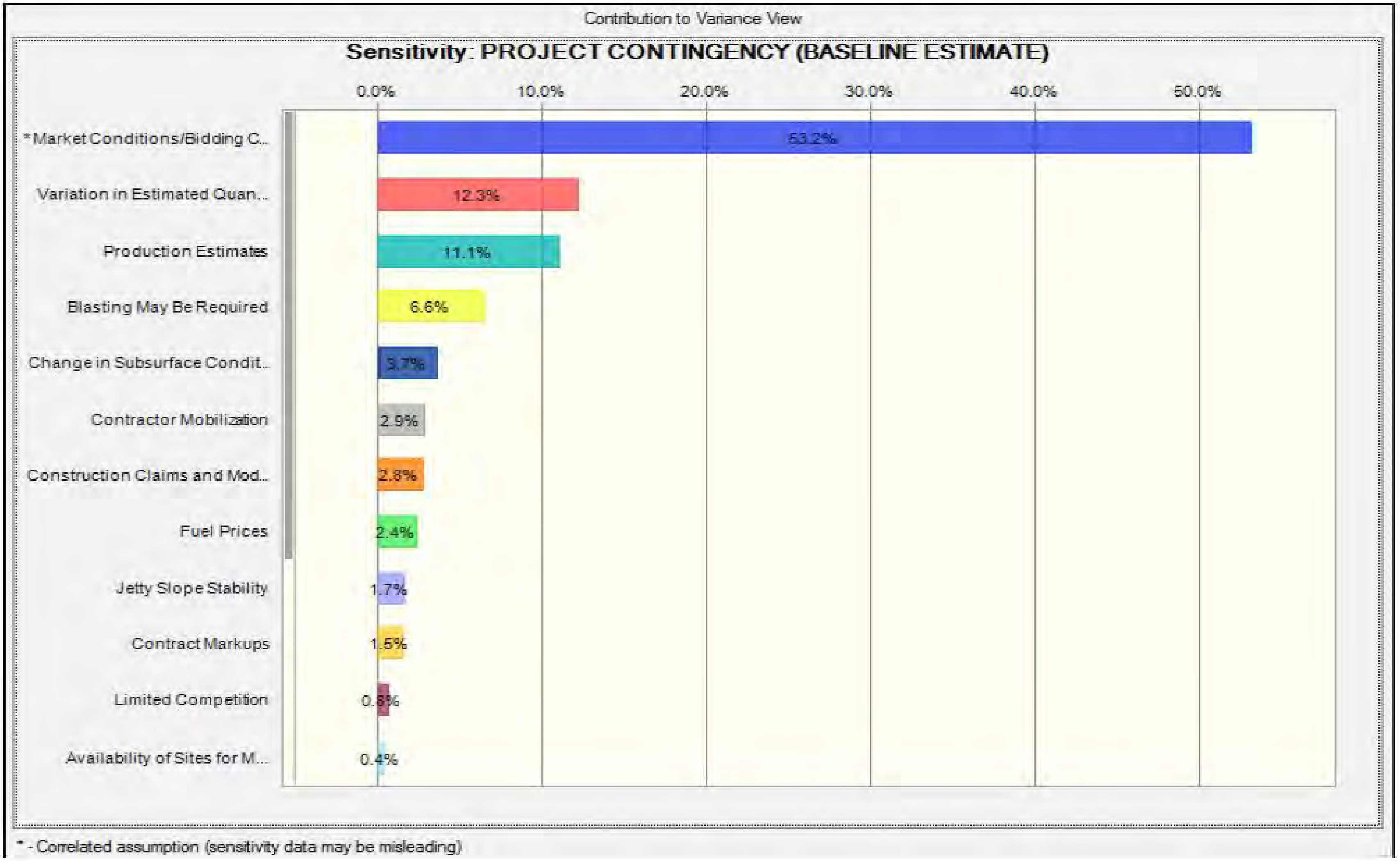
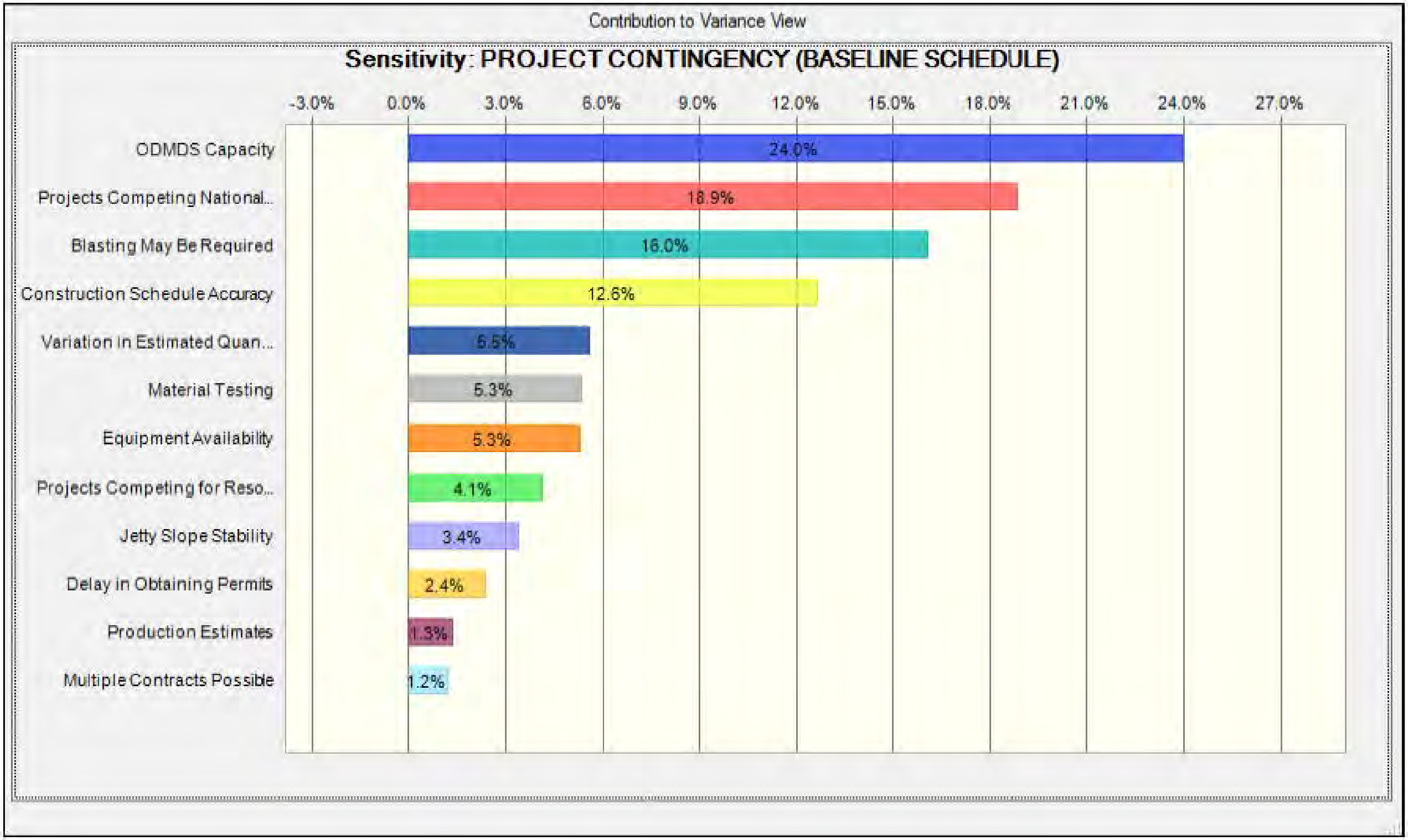


Figure 2. Schedule Sensitivity Analysis



7.0 MAJOR FINDINGS/OBSERVATIONS/RECOMMENDATIONS

This section provides a summary of significant risk analysis results that are identified in the preceding sections of the report. 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. Because of the potential for use of risk analysis results for such diverse purposes, this section also reiterates and highlights important steps, logic, key assumptions, limitations, and decisions to help ensure that the risk analysis results are appropriately interpreted.

7.1 Major Findings/Observations

Project cost comparison summaries are provided in Table 3 and Figure 3. Additional major findings and observations of the risk analysis are listed below.

1. The key cost risk drivers identified through sensitivity analysis are are PR-1 (Market Conditions/Bidding Climate), CON-1 (Variation in Estimated Quantities), EST-1 (Production Estimates) and TL-2 (Blasting May Be Required) which together contribute over 83 percent of the statistical cost variance.

2. Additional moderate cost risks that should be closely monitored include TL-3 (Change in Subsurface Conditions), CON-7 (Contractor Mobilization), CON-6 (Construction Claims and Modifications), PR-4 (Fuel Prices), TL-8 (Jetty Slope Stability), EST-2 (Contract Markups), PR-2 (Limited Competition) and RE-5 (Availability of Sites for Mitigation).

3. The key schedule risk drivers identified through sensitivity analysis are RE-3 (ODMDS Capacity), PPM-5 (Projects Competing Nationally for Funding), TL-2 (Blasting May Be Required) and CON-4 (Construction Schedule Accuracy), which together contribute over 71 percent of the statistical schedule variance.

4. Additional moderate cost risks that should be closely monitored include CON-1 (Variation in Estimated Quantities), RE-8 (Material Testing), PR-6 (Equipment Availability), PPM-4 (Projects Competing for Resources), TL-8 (Jetty Slope Stability), RE-2 (Delay in Obtaining Permits), EST-1 (Production Estimates) and CA-2 (Multiple Contracts Possible).

Table 3. Project Cost Comparison Summary (Uncertainty Analysis)

Confidence Level	Project Cost ($)	Contingency ($)	Contingency (%)
0%	**$59,301,344**	**($11,270,703)**	**-15.97%**
5%	**$68,587,459**	**($1,984,588)**	**-2.81%**
10%	**$70,382,649**	**($189,398)**	**-0.27%**
15%	**$71,901,283**	**$1,329,236**	**1.88%**
20%	**$73,344,634**	**$2,772,587**	**3.93%**
25%	**$74,652,212**	**$4,080,165**	**5.78%**
30%	**$75,791,312**	**$5,219,265**	**7.40%**
35%	**$76,760,961**	**$6,188,914**	**8.77%**
40%	**$77,912,457**	**$7,340,410**	**10.40%**
45%	**$78,789,912**	**$8,217,865**	**11.64%**
50%	**$80,004,197**	**$9,432,150**	**13.37%**
55%	**$80,933,996**	**$10,361,949**	**14.68%**
60%	**$82,069,227**	**$11,497,180**	**16.29%**
65%	**$82,962,561**	**$12,390,514**	**17.56%**
70%	**$84,127,868**	**$13,555,821**	**19.21%**
75%	**$85,286,613**	**$14,714,566**	**20.85%**
80%	**$86,777,741**	**$16,205,694**	**22.96%**
85%	**$88,131,959**	**$17,559,912**	**24.88%**
90%	**$90,587,844**	**$20,015,797**	**28.36%**
95%	**$93,825,426**	**$23,253,379**	**32.95%**
100%	**$108,656,525**	**$38,084,478**	**53.97%**

Figure 3. Project Cost Summary (Uncertainty Analysis)

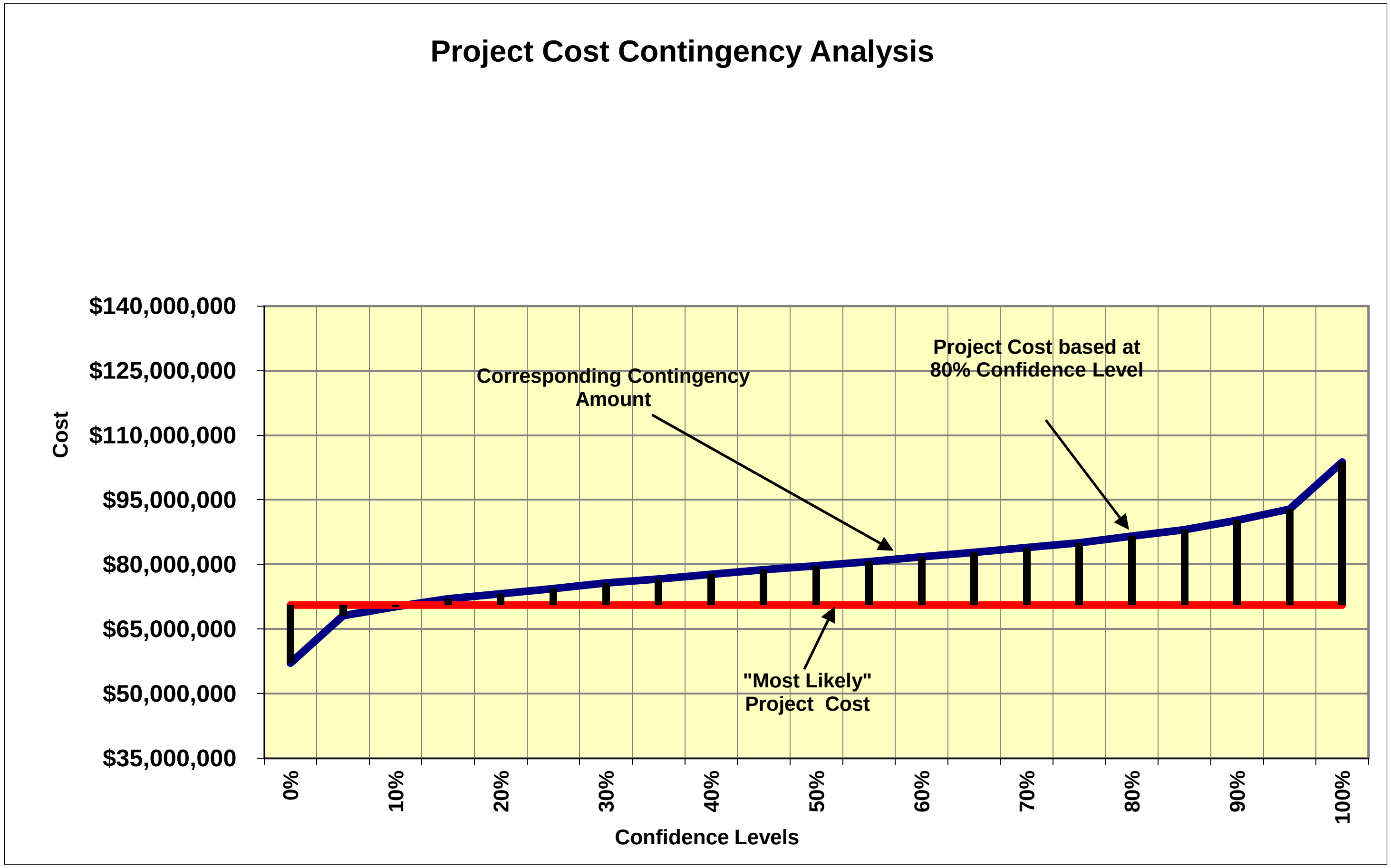
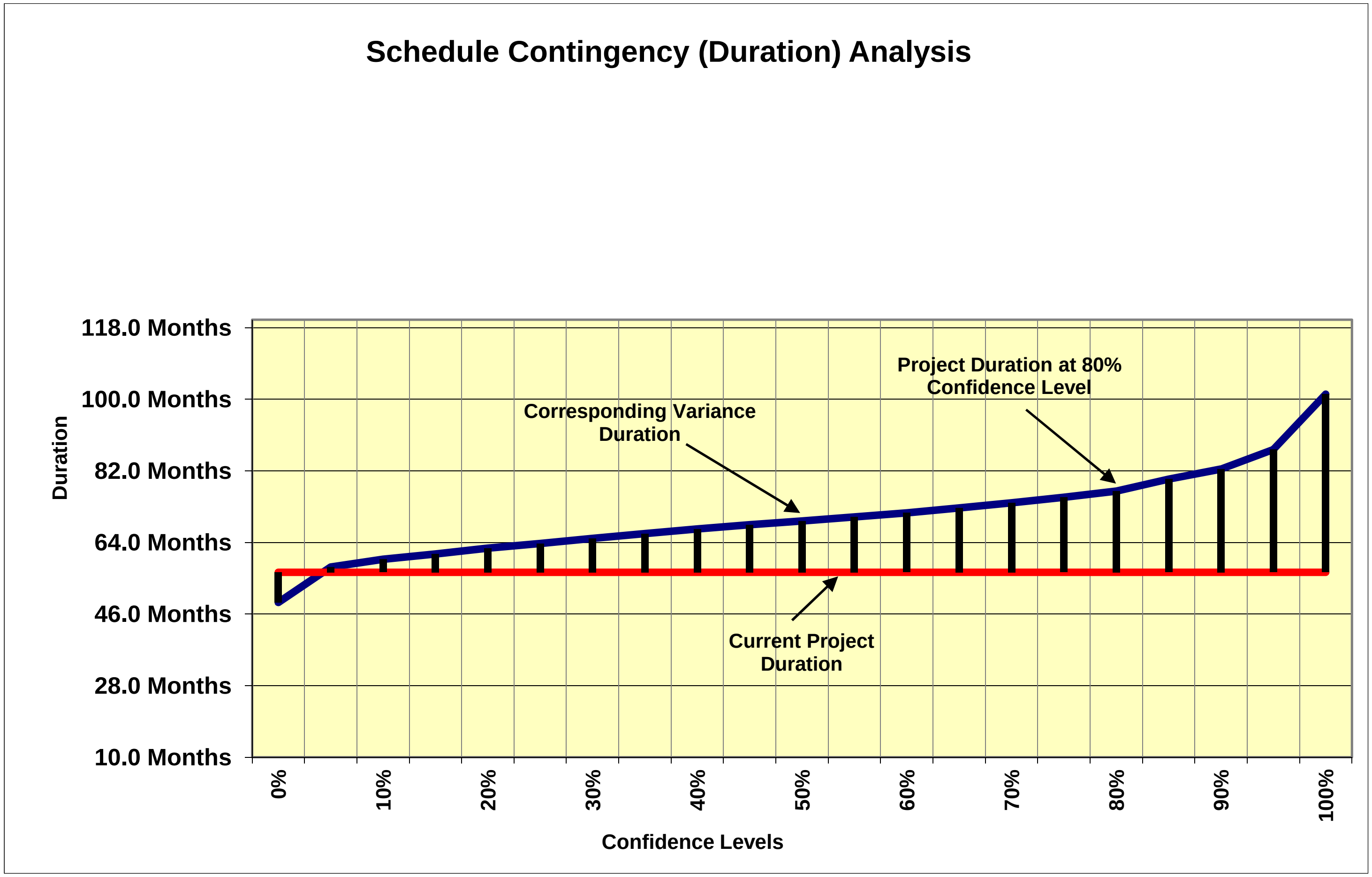


Figure 4. Project Duration Summary (Uncertainty Analysis)



7.2 Recommendations

Risk Management is an all-encompassing, iterative, and life-cycle process of project management. The Project Management Institute's (PMI) *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)*, *4th edition*, states that "project risk management includes the processes concerned with conducting risk management planning, identification, analysis, responses, and monitoring and control on a project." Risk identification and analysis are processes within the knowledge area of risk management. Its outputs pertinent to this effort include the risk register, risk quantification (risk analysis model), contingency report, and the sensitivity analysis.

The intended use of these outputs is implementation by the project leadership with respect to risk responses (such as mitigation) and risk monitoring and control. In short, the effectiveness of the project risk management effort requires that the proactive management of risks not conclude with the study completed in this report.

The Cost and Schedule Risk Analysis (CSRA) produced by the PDT identifies issues that require the development of subsequent risk response and mitigation plans. This section provides a list of recommendations for continued management of the risks identified and analyzed in this study. Note that this list is not all inclusive and should not substitute a formal risk management and response plan.

1. Key Cost Risk Drivers: The key cost risk drivers identified through sensitivity analysis are PR-1 (Market Conditions/Bidding Climate), CON-1 (Variation in Estimated Quantities), EST-1 (Production Estimates) and TL-2 (Blasting May Be Required) which together contribute over 83 percent of the statistical cost variance.

a) Market Conditions/Bidding Climate: There is inherent risk that the ultimate bidding climate at the time of award of future contracts will be unfavorable to the price, as compared to the current working estimates of contract price. The PDT should continue to perform market research and analysis of trends within the construction industry. Ultimately, this uncertainty cannot be mitigated until more information is available. This should be communicated to management, and an adequate amount of contingency should be reserved to capture this risk.

b) Variation in Estimated Quantities: There is a possible risk that estimated quantities at the time of the study may vary from what a contractor actually encounters in the field when the project is actually underway. The PDT should update surveys and calculate quantities periodically so that this item can be monitored. This item can be mitigated when final plans and specs surveys are done prior to solicitation of a contract.

c) Production Estimates: There is a risk that production will vary from what was estimated to what the contractor will actually produce in the field. Production was based on a similar project but it will be unknown until proposals are received on a contract exactly what type of equipment a contractor intends to use and what the equipment's production capabilities are. The PDT should analyze available production data each time an estimate is prepared and make sure that the production data used is the best representation of what equipment and production rates might be seen on the project. This item typically remains a risk through project solicitation but can be mitigated as much as possible by applying the most encompassing average production rates from similar work.

d) Blasting May Be Required: There is a possible risk that blasting may be required in order to dredge part of the project footprint. Since geotechnical investigations are still underway, the PDT was unable to completely rule this out as a risk item and due to the unknown subsurface conditions, there is the possibility of the existence of rock that is too large to dredge without blasting. The PDT should analyze the geotechnical data as soon as it is available and determine if there are any project areas that may require blasting.

2. Key Schedule Risk Drivers: The key schedule risk drivers identified through sensitivity analysis are RE-3 (ODMDS Capacity), PPM-5 (Projects Competing Nationally for Funding), TL-2 (Blasting May Be Required) and CON-4 (Construction Schedule Accuracy), which together contribute over 71 percent of the statistical schedule variance.

a) ODMDS Capacity: There is a current restriction on the volume per annum to be placed in the ODMDS. The current ODMDS has the technical capacity for the project material, but there is a restriction which impacts the volume required to be placed in the ODMDS for this project. If this placement volume restriction is not removed, then modeling may be required to show whether or not the material would migrate outside the boundaries of the site. If the modeling shows that expansion of the current ODMDS is required, then there would be an additional delay while permits are acquired and new limits are permitted. Mitigation efforts are currently underway as the PDT is coordinating with various environmental agencies to resolve this issue. Project Management should continue to monitor this risk until it has been mitigated and adjust the schedule accordingly to accurately account for any delays.

b) Projects Competing Nationally for Funding: With the risk that there may be a delay in obtaining project funds due to the competition amongst numerous projects, especially with recent budget constraints, Project Management needs to stay aware of the current project cost and schedule and ensure that estimates are updated yearly and economics verified on a routine basis until the project receives appropriations.

c) Blasting May Be Required: There is a possible risk that blasting may be required in order to dredge part of the project footprint. Since geotechnical investigations are still underway, the PDT was unable to completely rule this out as a risk item and due to the unknown subsurface conditions, there is the possibility of the existence of rock that is too large to dredge without blasting. The PDT should analyze the geotechnical data as soon as it is available and determine if there are any project areas that may require blasting. If so, the project schedule could be delayed while proper permits are obtained. A schedule contingency should be carried for this item until it can be confirmed whether or not blasting is a possibility. If blasting is required, then Management needs to factor in a more accurate timeline for permitting.

d) Construction Schedule Accuracy: Project Management needs to maintain an accurate construction schedule and make sure that they are updating as often as possible. As soon as new information is available regarding the project schedule, or if there's any changes to the construction plan (i.e. blasting is added), then the schedule needs to immediately be updated to capture the information. This will allow Project Management and Programs to regularly monitor and check 902 limits if the project is delayed.

3. Risk Management: Project leadership should use the outputs created during the risk analysis effort as tools in future risk management processes. The risk register should be updated at each major project milestone. The results of the sensitivity analysis may also be used for response planning strategy and development. These tools should be used in conjunction with regular risk review meetings.

4. Risk Analysis Updates: Project leadership should review risk items identified in the original risk register and add others, as required, throughout the project life-cycle. Risks should be reviewed for status and reevaluation (using qualitative measure, at a minimum) and placed on risk management watch lists if any risk's likelihood or impact significantly increases. Project leadership should also be mindful of the potential for secondary (new risks created specifically by the response to an original risk) and residual risks (risks that remain and have unintended impact following response).

APPENDIX A

US Army Corps
of Engineers®

Lake Worth Inlet Navigation
Pilot Feasibility Study
Recommended Plan
Project Cost and Schedule Risk Analysis Report

Prepared for:

U.S. Army Corps of Engineers,
Jacksonville District

Prepared by:

U.S. Army Corps of Engineers
Civil Works Cost Engineering and ATR Mandatory Center of
Expertise with Technical Expertise, Walla Walla

August 8, 2013

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EXECUTIVE SUMMARY

Under the auspices of the U.S. Army Corps of Engineers (USACE), Jacksonville District, this report presents a recommendation for the total project cost and schedule contingencies for the Lake Worth Inlet Navigation Pilot Feasibility Study. In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a formal risk analysis study was conducted for the development of contingency on the total project cost. The purpose of this risk analysis study was to establish project contingencies by identifying and measuring the cost and schedule impact of project uncertainties with respect to the estimated total project cost.

Specific to the Lake Worth project, the base case project cost for the Recommended Plan is estimated at approximately $71 Million. Based on the results of the analysis, the Cost Engineering Mandatory Center of Expertise for Civil Works (Walla Walla District) recommends a contingency value of $16 Million, or 23%. This contingency includes $13 Million (19%) for risks related to cost and $3 Million (4%) for the effect of schedule delay on overall project costs.

Walla Walla Cost MCX performed the risk analysis using the *Monte Carlo* technique, producing the aforementioned contingencies and identifying key risk drivers.

The following tables ES-1, ES-2, and ES-3 portray the development of contingencies (23% overall). The contingency is based on an 80% confidence level, as per USACE Civil Works guidance.

Table ES-1. Contingency Analysis Table

Base Cost Estimate	**$70,572,047**	
Confidence Level	**Value ($$)**	**Contingency (%)**
5%	$68,587,459	-2.81%
50%	$80,004,197	13.37%
80%	**$86,777,741**	**22.96%**
95%	$93,825,426	32.95%

The following table ES-2 portrays the full costs of the recommended alternative based on the anticipated contracts. The costs are intended to address the congressional request of estimates to implement the project. The contingency is based on an 80% confidence level, as per accepted USACE Civil Works guidance.

Table ES-2. Cost Summary

LAKE WORTH FEATURE ACCOUNTS		COST ($1,000)	CNTG ($1,000)	TOTAL ($1,000)
01	LANDS AND DAMAGES	25	5	30
06	FISH AND WILDLIFE FACILITIES	11,524	2,650	14,174
10	BREAKWATERS AND SEAWALLS	2,092	481	2,574
12	NAVIGATION PORTS AND HARBORS	49,858	11,468	61,325
30	PLANNING, ENGINEERING, AND DESIGN	2,075	477	2,552
31	CONSTRUCTION MANAGEMENT	4,999	1,147	6,146
	TOTAL PROJECT COSTS	**70,573**	**16,228**	**86,801**

Notes: 1) Costs include the recommended contingency of 23%.
2) Costs exclude O&M and Life Cycle Cost estimates.

KEY FINDINGS/OBSERVATIONS RECOMMENDATIONS

The key cost risk drivers identified through sensitivity analysis are PR-1 (Market Conditions/Bidding Climate), CON-1 (Variation in Estimated Quantities), EST-1 (Production Estimates) and TL-2 (Blasting May Be Required) which together contribute over 83 percent of the statistical cost variance.

- Market Conditions/Bidding Climate captures the risk that market forces contribute to either a decrease or increase in the ultimate contract costs, either due to commodity price volatility or supply and demand forces on the bidding environment.
- Variation in Estimated Quantities captures the risk of an underrun or overrun.
- Production Estimates captures the risk that the contractor's actual production could vary from what was assumed in the estimate.
- Blasting May Be Required captures the risk that due to the lack of geotechnical information currently available, blasting may be required in order to dredge part of the project footprint.

Additional moderate cost risks that should be closely monitored include TL-3 (Change in Subsurface Conditions), CON-7 (Contractor Mobilization), CON-6 (Construction Claims and Modifications), PR-4 (Fuel Prices), TL-8 (Jetty Slope Stability), EST-2 (Contract Markups), PR-2 (Limited Competition) and RE-5 (Availability of Sites for Mitigation).

- Change in Subsurface Conditions captures the risk that due to the lack of geotechnical investigations within the project footprint, there may be rock present in more areas that what has been assumed.
- Contractor Mobilization captures the risk of fluctuation in the mobilizations costs for various dredging equipment.

- Construction Claims and Modifications captures the inherent risk of construction modifications and claims that arise after contract award due to issues such as weather, schedules dictated by O&M cycles, differing site conditions, user directed changes or omissions, inaccurate surveys, and variations in estimated quantities (minor).
- Fuel Prices captures the risk of fluctuation in fuel costs, especially marine diesel.
- Jetty Slope Stability captures the possible risk to the stability of the jetty if blasting is required within the proximity of the jetty. This relies heavily on the results of the geotechnical investigations and whether or not blasting will be required.
- Contract Markups captures the risk that a contractor's actual markups could vary from what was assumed in the estimate.
- Limited Competition captures the risk that there may be too few bidders, limiting competition and driving prices up.
- Availability of Sites for Mitigation captures the risk that the mitigation sites are still not determined and that although there is a large list of possibilities, the ultimate cost of mitigation could vary from what was assumed in the estimate based on the final location of the mitigation site.

The key schedule risk drivers identified through sensitivity analysis are RE-3 (ODMDS Capacity), PPM-5 (Projects Competing Nationally for Funding), TL-2 (Blasting May Be Required) and CON-4 (Construction Schedule Accuracy), which together contribute over 71 percent of the statistical schedule variance.

- ODMDS Capacity captures the risk that the modeling for the capacity in the offshore disposal area shows a need for expansion and the project schedule slips while the issue is addressed.
- Projects Competing Nationally for Funding captures the risk that there may be a delay in obtaining project funds due to the competition amongst numerous projects, especially with recent budget constraints.
- Blasting May Be Required captures the risk that due to the lack of geotechnical information currently available, blasting may be required in order to dredge part of the project footprint.
- Construction Schedule Accuracy captures the risk that there may be components missing from the current estimated schedule which could impact the overall project and construction schedules.

Additional moderate cost risks that should be closely monitored include CON-1 (Variation in Estimated Quantities), RE-8 (Material Testing), PR-6 (Equipment Availability), PPM-4 (Projects Competing for Resources), TL-8 (Jetty Slope Stability), RE-2 (Delay in Obtaining Permits), EST-1 (Production Estimates) and CA-2 (Multiple Contracts Possible).

- Variation in Estimated Quantities captures the risk to the schedule due to an overrun or underrun.
- Material Testing captures the risk that testing may not be suitable for disposal offshore, delaying the project while alternatives are secured.
- Equipment Availability captures the impacts to the schedule due to non-availability of the most efficient dredge type to perform the work.
- Projects Competing for Resources captures the risk associated with there being a great deal of competition for the same resources.
- Jetty Slope Stability captures the risk that blasting may be required due to the presence of large rock in the dredging areas and may impact the jetty, thus impacting the schedule due to increased stabilization requirements.
- Delay in Obtaining Permits captures the risk that there may be delay in obtaining FDEP permits due to geotechnical uncertainty with the presence of rock.
- Production Estimates captures the impact to the schedule if the production varies from what was assumed.
- Multiple Contracts Possible captures the risk of more contracts than what is assumed in the estimtate.

Recommendations, as detailed within the main report, include the implementation of cost and schedule contingencies, further iterative study of risks throughout the project life-cycle, potential mitigation throughout the PED phase, and proactive monitoring and control of risk identified in this study.

MAIN REPORT

1.0 PURPOSE

Under the auspices of the US Army Corps of Engineers (USACE), Jacksonville District, this report presents a recommendation for the total project cost and schedule contingencies for the Lake Worth Inlet Navigation Pilot Study Project.

2.0 BACKGROUND

The Lake Worth Inlet Navigation Pilot Study consists of widening and deepening (to a project depth of 39-feet) within the navigation channel and inner harbor that serves the Port of Palm Beach. The estimated cost for the project is approximately $87 Million. The project sponsor is the Port of Palm Beach. The work includes mitigation features for potential impacts to sea grass and the creation of hard bottoms. The majority of the material will be placed in the approved ODMDS, while some material will be used to create the mitigation features and renourish beaches. The project will also include jetty stabilization (using sheet piles) due to the advanced maintenance deepening to greater than 40-feet. The work will likely be complete in 2-3 phases due to funding increment limitations. It is likely that the contracts will be acquired using a best value-tradeoff RFP procurement to secure performance. The current construction schedule is approximately 15 months in duration. The PDT estimates that a few months of feasibility remains, followed by 12-18 months of PED.

As a part of this effort, Jacksonville District requested that the USACE Cost Engineering Mandatory Center of Expertise for Civil Works (Cost Engineering MCX) provide an agency technical review (ATR) of the cost estimate and schedule for Recommended Project Plan. That tasking also included providing a risk analysis study to establish the resulting contingencies.

3.0 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 U.S. Army Corps of Engineers (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. The report presents the contingency results for cost risks for all project features. The study and presentation does not include consideration for life cycle costs.

3.1 Project Scope

The formal process included extensive involvement of the PDT for risk identification and the development of the risk register. The analysis process evaluated the baseline Micro Computer Aided Cost Estimating System (MCACES) cost estimate, schedule, and funding profiles using Crystal Ball software to conduct a *Monte Carlo* simulation and statistical sensitivity analysis, per the guidance in Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

The project technical scope, estimates and schedules were developed and presented by the Jacksonville District. Consequently, these documents serve as the basis for the risk analysis.

The scope of this study addresses the identification of problems, needs, opportunities and potential solutions that are viable from an economic, environmental, and engineering viewpoint.

3.2 USACE Risk Analysis Process

The risk analysis process for this study follows the USACE Headquarters requirements as well as the guidance provided by the Cost Engineering MCX. The risk analysis process reflected within this report uses probabilistic cost and schedule risk analysis methods within the framework of the Crystal Ball software. 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 to 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 analysis should be considered as an ongoing process conducted concurrent to, and iteratively 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, this risk analysis was performed to meet the requirements and recommendations of 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 September 15, 2008.

- Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

4.0 METHODOLOGY / PROCESS

The Walla Walla Cost Engineering MCX performed the Cost and Schedule Risk Analysis, relying on local Jacksonville District staff to provide information gathering. The Walla Walla Cost Engineering MCX facilitated an on-site risk identification meeting on September 11, 2012 with the Jacksonville District PDT to produce a risk register that served as the framework for the risk analysis. Participants in the risk identification meeting included the following:

Organization	Title
USACE - SAJ	PD-D, Economist
USACE - SAJ	EN-WC, Hydrodynamics Modeler
USACE - SAJ	EN-DW, Levee Design
USACE - SAJ	PD-ES, NEPA
USACE - SAJ	PM-WN, Operations manager
USACE - SAJ	PD-ES, NEPA
USACE - SAJ	PM-WN, Operations manager
USACE - SAJ	PD-EQ, Water Quality
USACE - SAJ	PD-D, Economist
USACE - SAJ	EN-GS, Soils
USACE - SAJ	EN-GG, Geotechnical
USACE - SAJ	PM-WN, Project Manager
USACE - SAJ	PM-WF, Ship Simulation
USACE - SAJ	EN-TC, Cost Estimating
USACE - SAJ	RE-A, Real Estate Acquisition
USACE - SAJ	PD-EC, ODMDS Manager
USACE - SAJ	CT, Contracting
USACE - NWW	Chief, Cost MCX, Risk Facilitator
USACE - SAJ	PD-PN, Planning
USACE - SAJ	OC, Office of Council
USACE - SAJ	PD-EP, Archaeologist
USACE - SAJ	CD, Construction Division

The first cost risk model was completed November 26, 2012. However, scope and estimate updates since then, as well as a PDT sanity check review, necessitated a rerun of the original model. The final results were initially completed and reported to Jacksonville on November 30, 2012.

Subsequent project development and review necessitated updates to the risk register and the cost estimate and project schedule. As a result, the Jacksonville District requested an update to the risk analysis based on the risk register, cost estimate, and project schedule transmitted on July 3, 2013. The revised risk analysis and report were transmitted on July 22, 2013.

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. Per regulation and guidance, the P80 confidence level (80% confidence level) is the normal and accepted cost confidence level. District Management has the prerogative to select different confidence levels, pending approval from Headquarters, USACE.

In simple terms, contingency is an amount added to an estimate to allow for items, conditions or events for which the occurrence or impact is uncertain and that experience suggests will likely result in additional costs being incurred or additional time being required. The amount of contingency included in project control plans depends, at least in part, on the project leadership's willingness to accept risk of project overruns. The less risk that project leadership is willing to accept the more contingency should be applied in the project control plans. The risk of overrun is expressed, in a probabilistic context, using confidence levels.

The Cost MCX guidance for cost and schedule risk analysis generally focuses on the 80-percent level of confidence (P80) for cost contingency calculation. It should be noted that use of P80 as a decision criteria is a risk averse approach (whereas the use of P50 would be a risk neutral approach, and use of levels less than 50 percent would be risk seeking). Thus, a P80 confidence level results in greater contingency as compared to a P50 confidence level. The selection of contingency at a particular confidence level is ultimately the decision and responsibility of the project's District and/or Division management.

The risk analysis process uses *Monte Carlo* techniques to determine probabilities and contingency. The *Monte Carlo* techniques are facilitated computationally by a commercially available risk analysis software package (Crystal Ball) that is an add-in to Microsoft Excel. Cost estimates are packaged into an Excel format and used directly for cost risk analysis purposes. The level of detail recreated in the Excel-format schedule is sufficient for risk analysis purposes that reflect the established risk register, but generally less than that of the native format.

The primary steps, in functional terms, of the risk analysis process are described in the following subsections. Risk analysis results are provided in Section 6.

4.1 Identify and Assess Risk Factors

Identifying the risk factors via the PDT is considered a qualitative process that results in establishing a risk register that serves as the document for the quantitative study using the Crystal Ball risk software. 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.

A formal PDT meeting was held with the Jacksonville District office for the purposes of identifying and assessing risk factors. The meeting included capable and qualified representatives from multiple project team disciplines and functions, including project management, cost engineering, design, environmental compliance, and real estate.

The initial formal meetings focused primarily on risk factor identification using brainstorming techniques, but also included some facilitated discussions based on risk factors common to projects of similar scope and geographic location. Subsequent meetings focused primarily on risk factor assessment and quantification.

Additionally, numerous conference calls and informal meetings were conducted throughout the risk analysis process on an as-needed basis to further facilitate risk factor identification, market analysis, and risk assessment.

4.2 Quantify Risk Factor Impacts

The quantitative impacts of risk factors on project plans were analyzed using a combination of professional judgment, empirical data and analytical techniques. Risk factor impacts were 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 and functions. However, the quantification process relied more extensively on collaboration between cost engineering and risk analysis team members with lesser inputs from other functions and disciplines. This process used an iterative approach to estimate the following elements of each risk factor:

- 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 product from the PDT discussions is captured within a risk register as presented in section 6 for both cost and schedule risk concerns. Note that 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 support the team's decisions related to event likelihood, impact, and the resulting risk levels for each risk event.

4.3 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 only the moderate and high level risks identified for each option (i.e., low-level risks are typically not considered, but remain within the risk register to serve historical purposes as well as support follow-on risk studies as the project and risks evolve).

For the cost estimate, the contingency is calculated as the difference between the P80 cost forecast and the baseline cost estimate. 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.

5.0 PROJECT ASSUMPTIONS

The following data sources and assumptions were used in quantifying the costs associated with the Lake Worth Inlet project.

a. The Jacksonville District provided MII MCACES (Micro-Computer Aided Cost Estimating Software) files electronically. The MII and CWE files transmitted and downloaded on July 3, 2013 was the basis for the updated cost and schedule risk analyses.

b. The cost comparisons and risk analyses performed and reflected within this report are based on design scope and estimates that are at the feasibility level.

c. Schedules are analyzed for impact to the project cost in terms of both uncaptured escalation (variance from OMB factors and the local market) and unavoidable fixed contract costs and/or languishing federal administration costs incurred throughout delay.

Specific to the Lake Worth project, the schedule was analyzed only for impacts due to residual fixed costs.

d. Per the CWCCIS Historical State Adjustment Factors in EM 1110-2-1304, State Adjustment Factor for the State of Florida is 0.93, meaning that the average inflation for the project area is assumed to be 7% lower than the national average for inflation. Therefore, it is assumed that the project inflations experienced are similar to OMB inflation factors for future construction. Based on this information, the risk analysis accounted for a slight escalation adjustment over and above the national average.

e. Per the data in the estimate, the Overhead percentage for the Prime Contractor is 10%, and 7% for the Subcontractors. Thus, the assumed residual fixed cost rate for this project is 8.5%. For the P80 schedule, this comprises approximately 18.69% of the total contingency and 4.29% of the base cost estimate. This is due to the accrual of residual fixed costs associated with delay associated with the implementation schedule.

f. The Cost MCX guidance generally focuses on the eighty-percent level of confidence (P80) for cost contingency calculation. For this risk analysis, the eighty-percent level of confidence (P80) was used. It should be noted that the use of P80 as a decision criteria is a moderately risk averse approach, generally resulting in higher cost contingencies. However, the P80 level of confidence also assumes a small degree of risk that the recommended contingencies may be inadequate to capture actual project costs.

g. Only high and moderate risk level impacts, as identified in the risk register, were considered for the purposes of calculating cost contingency. Low level risk impacts should be maintained in project management documentation, and reviewed at each project milestone to determine if they should be placed on the risk “watch list”.

6.0 RESULTS

The cost and schedule risk analysis results are provided in the following sections. In addition to contingency calculation results, sensitivity analyses are presented to provide decision makers with an understanding of variability and the key contributors to the cause of this variability.

6.1 Risk Register

A risk register is a tool commonly used in project planning and risk analysis. The actual risk register is provided in Appendix A. The complete risk register includes low level risks, as well as additional information regarding the nature and impacts of each risk.

It is important to note that a risk register can be an effective tool for managing identified risks throughout the project life cycle. As such, it is generally recommended that risk registers be updated as the designs, cost estimates, and schedule are further refined, especially on large projects with extended schedules. Recommended uses of the risk register going forward include:

- Documenting risk mitigation strategies being pursued in response to the identified risks and their assessment in terms of probability and impact.
- Providing project sponsors, stakeholders, and leadership/management with a documented framework from which risk status can be reported in the context of project controls.
- Communicating risk management issues.
- Providing a mechanism for eliciting feedback and project control input.
- Identifying risk transfer, elimination, or mitigation actions required for implementation of risk management plans.

6.2 Cost Contingency and Sensitivity Analysis

The result of risk or uncertainty analysis is quantification of the cumulative impact of all analyzed risks or uncertainties as compared to probability of occurrence. These results, as applied to the analysis herein, depict the overall project cost at intervals of confidence (probability).

Table 1 provides the construction cost contingencies calculated for the P80 confidence level and rounded to the nearest thousand. The construction cost contingencies for the P50 and P100 confidence levels are also provided for illustrative purposes only.

Contingency was quantified as approximately $16 Million at the P80 confidence level (23% of the baseline cost estimate). For comparison, the cost contingency at the P50 and P100 confidence levels was quantified as 13% and 54% of the baseline cost estimate, respectively.

Table 1. Project Cost Contingency Summary

Risk Analysis Forecast	Baseline Estimate	Total Contingency[1,2] ($)	Total Contingency (%)
50% Confidence Level			
Project Cost	$80,004,197	$9,432,150	13.37%
80% Confidence Level			
Project Cost	$86,777,741	$16,205,694	22.96%
100% Confidence Level			
Project Cost	$108,656,525	$38,084,478	53.97%

Notes:
1) These figures combine uncertainty in the baseline cost estimates and schedule.
2) A P100 confidence level is an abstract concept for illustration only, as the nature of risk and uncertainty (specifically the presence of “unknown unknowns”) makes 100% confidence a theoretical impossibility.

6.2.1 Sensitivity Analysis

Sensitivity analysis generally ranks the relative impact of each risk/opportunity as a percentage of total cost uncertainty. The Crystal Ball software uses a statistical measure (contribution to variance) that approximates the impact of each risk/opportunity contributing to variability of cost outcomes during *Monte Carlo* simulation.

Key cost drivers identified in the sensitivity analysis can be used to support development of a risk management plan that will facilitate control of risk factors and their potential impacts throughout the project lifecycle. Together with the risk register, sensitivity analysis results can also be used to support development of strategies to eliminate, mitigate, accept or transfer key risks.

6.2.2 Sensitivity Analysis Results

The risks/opportunities considered as key or primary cost drivers are ranked in order of importance in contribution to variance bar charts. Opportunities that have a potential to reduce project cost are shown with a negative sign; risks are shown with a positive sign to reflect the potential to increase project cost. A longer bar in the sensitivity analysis chart represents a greater potential impact to project cost.

Figure 1 presents a sensitivity analysis for cost growth risk from the high level cost risks identified in the risk register. Likewise, Figure 2 presents a sensitivity analysis for schedule growth risk from the high level schedule risks identified in the risk register.

6.3 Schedule and Contingency Risk Analysis

Table 2 provides the schedule duration contingencies calculated for the P80 confidence level. The schedule duration contingencies for the P50 and P100 confidence levels are also provided for illustrative purposes.

Schedule duration contingency was quantified as 24 months based on the P80 level of confidence. These contingencies were used to calculate the projected residual fixed cost impact of project delays that are included in the Table 1 presentation of total cost contingency. The schedule contingencies were calculated by applying the high level schedule risks identified in the risk register for each option to the durations of critical path and near critical path tasks.

The schedule was not resource loaded and contained open-ended tasks and non-zero lags (gaps in the logic between tasks) that limit the overall utility of the schedule risk analysis. These issues should be considered as limitations in the utility of the schedule contingency data presented. Schedule contingency impacts presented in this analysis are based solely on projected residual fixed costs.

Table 2. Schedule Duration Contingency Summary

Risk Analysis Forecast	Baseline Schedule Duration (months)	Contingency[1] (months)
50% Confidence Level		
Project Duration	57	15
80% Confidence Level		
Project Duration	57	24
100% Confidence Level		
Project Duration	57	58

Notes:
1) The schedule was not resource loaded and contained open-ended tasks and non-zero lags (gaps in the logic between tasks) that limit the overall utility of the schedule risk analysis. These issues should be considered as limitations in the utility of the schedule contingency data presented in Table 2.
2) A P100 confidence level is an abstract concept for illustration only, as the nature of risk and uncertainty (specifically the presence of "unknown unknowns") makes 100% confidence a theoretical impossibility.

Figure 1. Cost Sensitivity Analysis

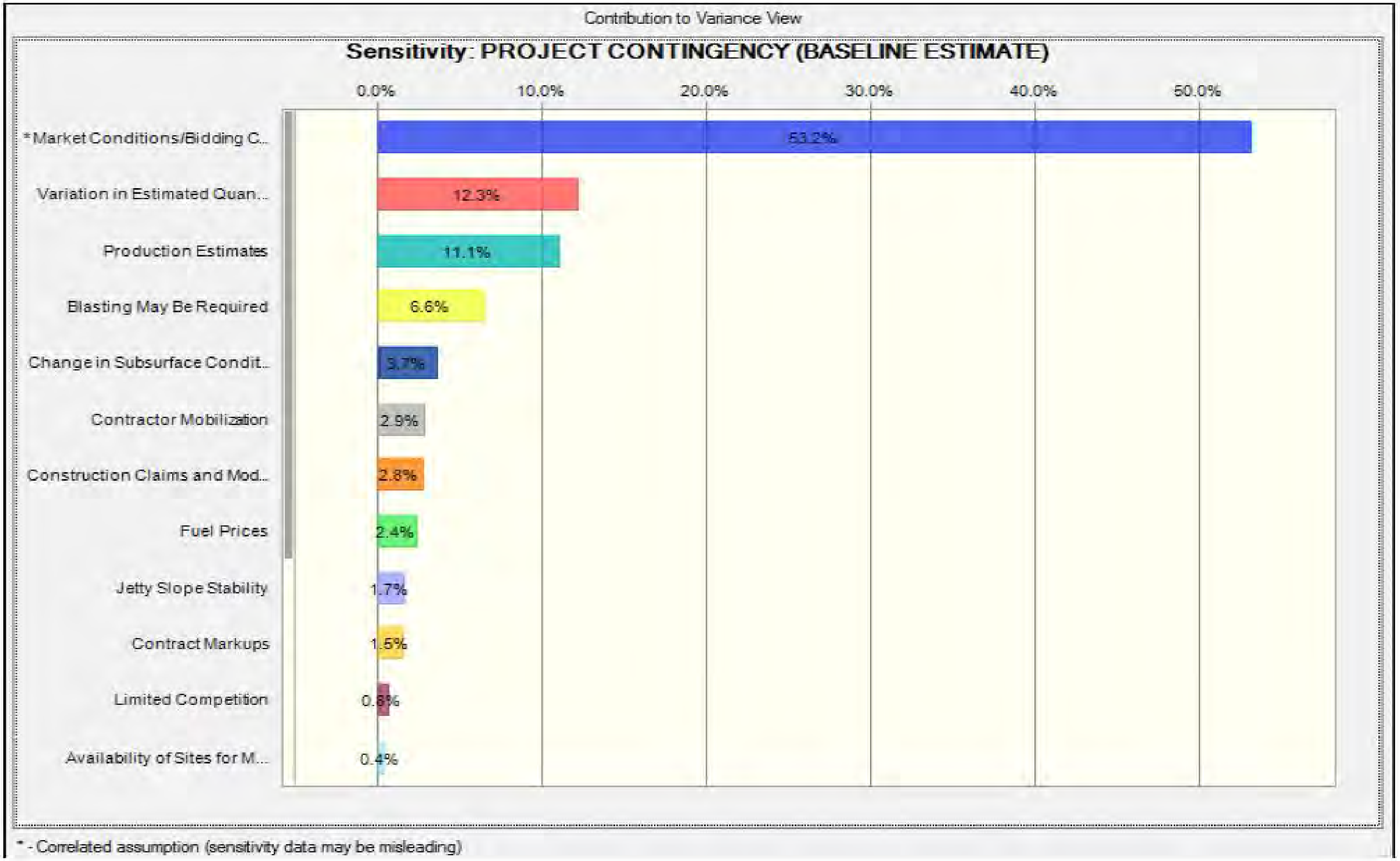
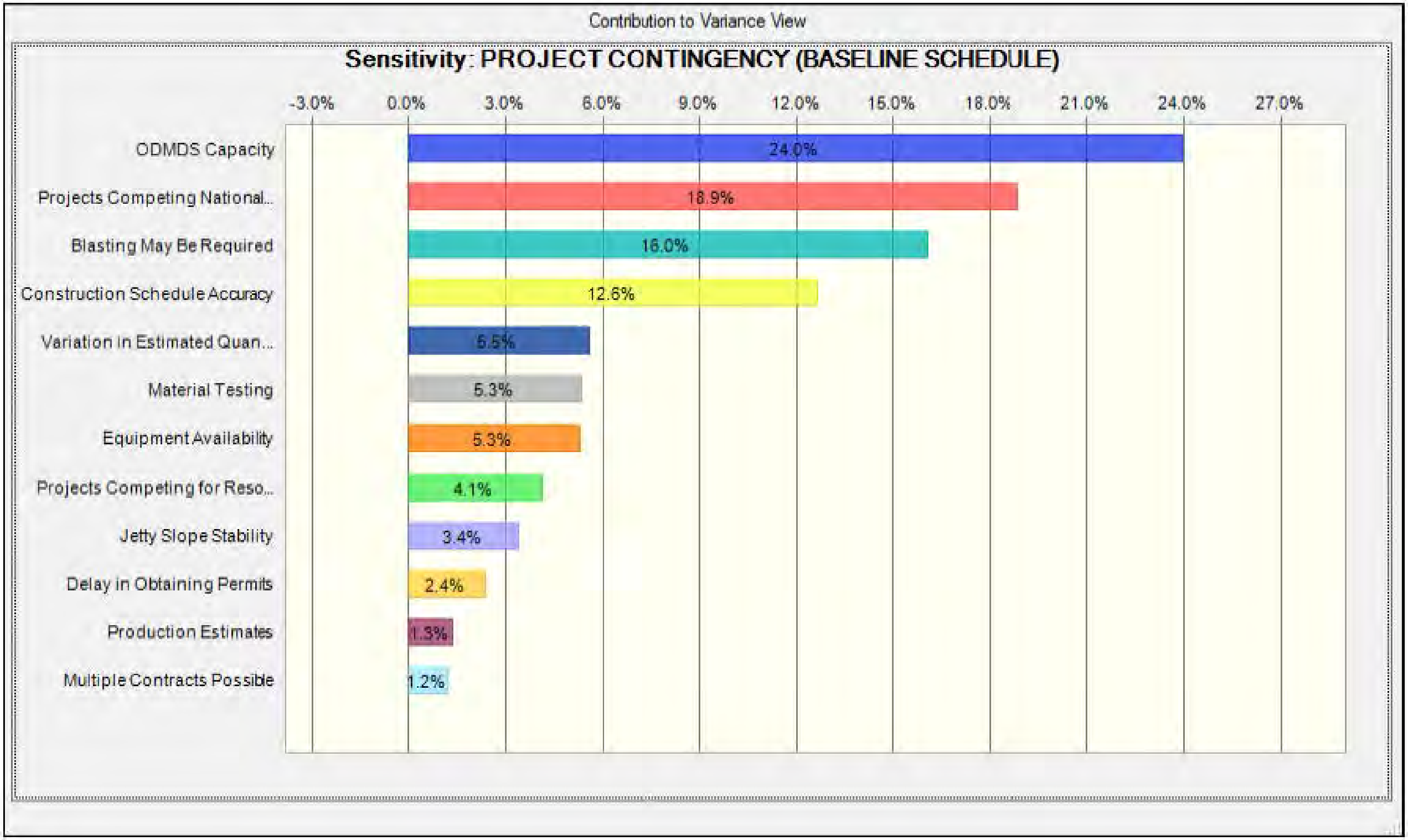


Figure 2. Schedule Sensitivity Analysis



7.0 MAJOR FINDINGS/OBSERVATIONS/RECOMMENDATIONS

This section provides a summary of significant risk analysis results that are identified in the preceding sections of the report. 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. Because of the potential for use of risk analysis results for such diverse purposes, this section also reiterates and highlights important steps, logic, key assumptions, limitations, and decisions to help ensure that the risk analysis results are appropriately interpreted.

7.1 Major Findings/Observations

Project cost comparison summaries are provided in Table 3 and Figure 3. Additional major findings and observations of the risk analysis are listed below.

1. The key cost risk drivers identified through sensitivity analysis are are PR-1 (Market Conditions/Bidding Climate), CON-1 (Variation in Estimated Quantities), EST-1 (Production Estimates) and TL-2 (Blasting May Be Required) which together contribute over 83 percent of the statistical cost variance.

2. Additional moderate cost risks that should be closely monitored include TL-3 (Change in Subsurface Conditions), CON-7 (Contractor Mobilization), CON-6 (Construction Claims and Modifications), PR-4 (Fuel Prices), TL-8 (Jetty Slope Stability), EST-2 (Contract Markups), PR-2 (Limited Competition) and RE-5 (Availability of Sites for Mitigation).

3. The key schedule risk drivers identified through sensitivity analysis are RE-3 (ODMDS Capacity), PPM-5 (Projects Competing Nationally for Funding), TL-2 (Blasting May Be Required) and CON-4 (Construction Schedule Accuracy), which together contribute over 71 percent of the statistical schedule variance.

4. Additional moderate cost risks that should be closely monitored include CON-1 (Variation in Estimated Quantities), RE-8 (Material Testing), PR-6 (Equipment Availability), PPM-4 (Projects Competing for Resources), TL-8 (Jetty Slope Stability), RE-2 (Delay in Obtaining Permits), EST-1 (Production Estimates) and CA-2 (Multiple Contracts Possible).

Table 3. Project Cost Comparison Summary (Uncertainty Analysis)

Confidence Level	Project Cost ($)	Contingency ($)	Contingency (%)
0%	**$59,301,344**	**($11,270,703)**	**-15.97%**
5%	**$68,587,459**	**($1,984,588)**	**-2.81%**
10%	**$70,382,649**	**($189,398)**	**-0.27%**
15%	**$71,901,283**	**$1,329,236**	**1.88%**
20%	**$73,344,634**	**$2,772,587**	**3.93%**
25%	**$74,652,212**	**$4,080,165**	**5.78%**
30%	**$75,791,312**	**$5,219,265**	**7.40%**
35%	**$76,760,961**	**$6,188,914**	**8.77%**
40%	**$77,912,457**	**$7,340,410**	**10.40%**
45%	**$78,789,912**	**$8,217,865**	**11.64%**
50%	**$80,004,197**	**$9,432,150**	**13.37%**
55%	**$80,933,996**	**$10,361,949**	**14.68%**
60%	**$82,069,227**	**$11,497,180**	**16.29%**
65%	**$82,962,561**	**$12,390,514**	**17.56%**
70%	**$84,127,868**	**$13,555,821**	**19.21%**
75%	**$85,286,613**	**$14,714,566**	**20.85%**
80%	**$86,777,741**	**$16,205,694**	**22.96%**
85%	**$88,131,959**	**$17,559,912**	**24.88%**
90%	**$90,587,844**	**$20,015,797**	**28.36%**
95%	**$93,825,426**	**$23,253,379**	**32.95%**
100%	**$108,656,525**	**$38,084,478**	**53.97%**

Figure 3. Project Cost Summary (Uncertainty Analysis)

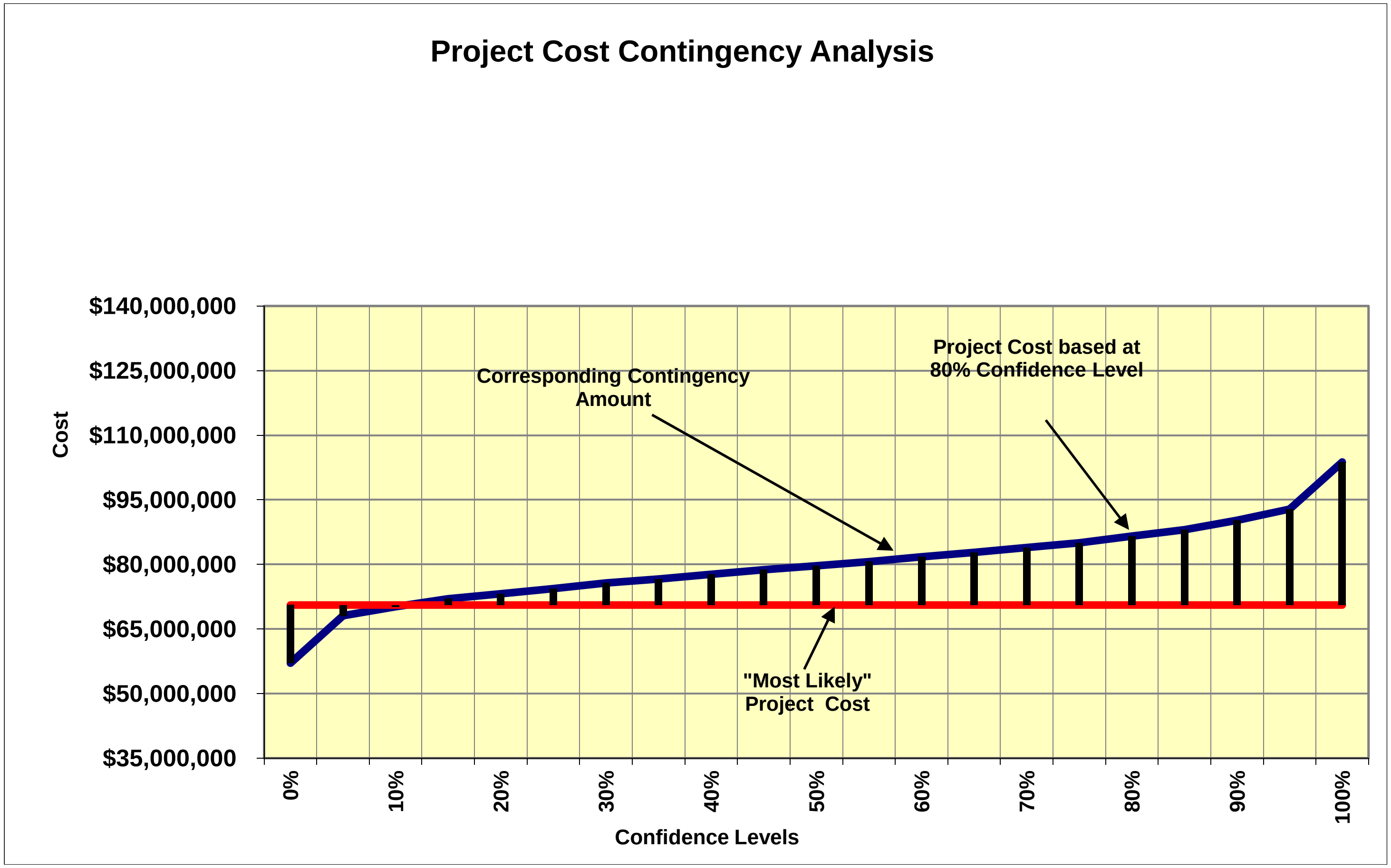
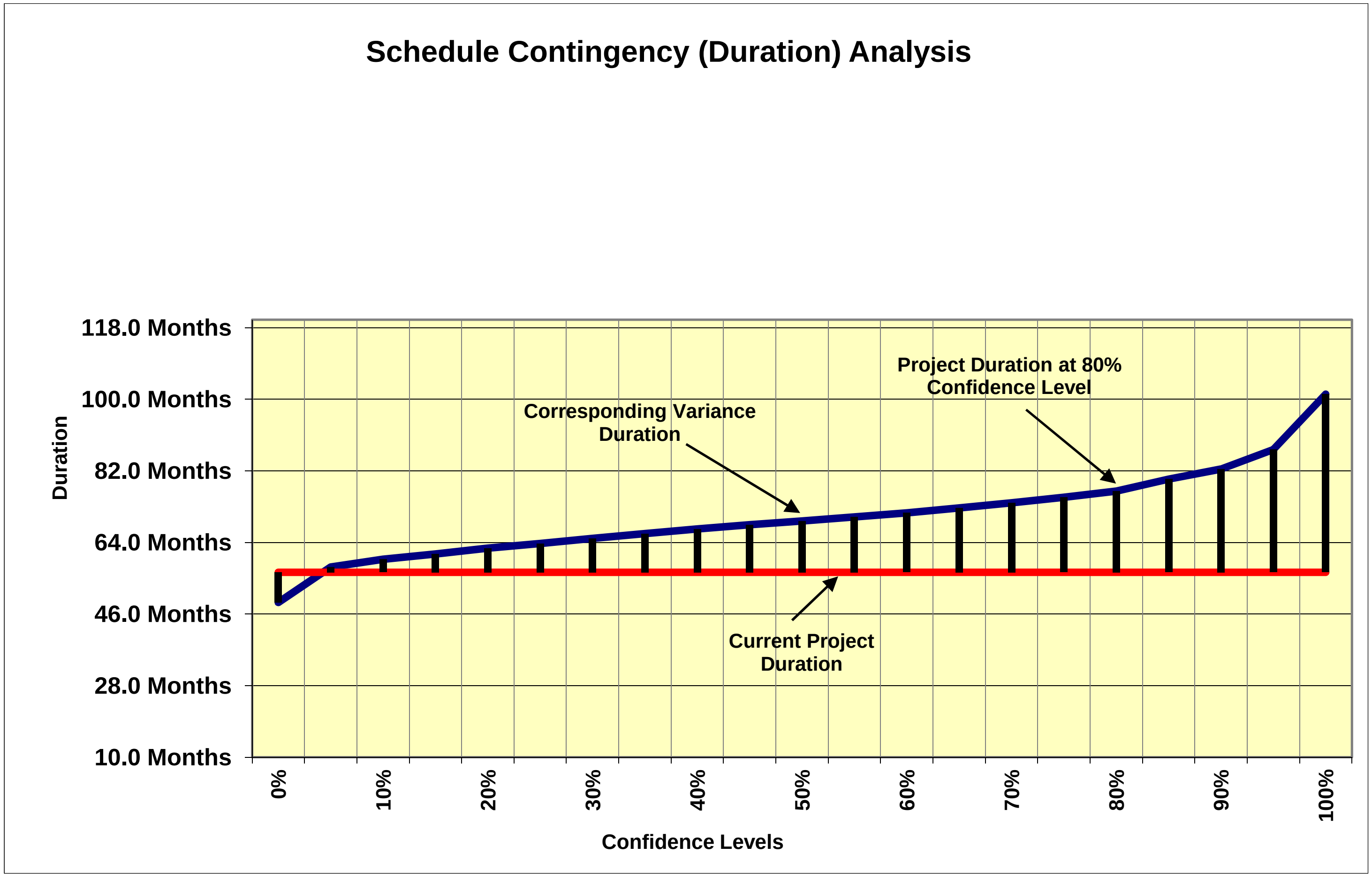


Figure 4. Project Duration Summary (Uncertainty Analysis)



7.2 Recommendations

Risk Management is an all-encompassing, iterative, and life-cycle process of project management. The Project Management Institute's (PMI) *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)*, *4th edition*, states that "project risk management includes the processes concerned with conducting risk management planning, identification, analysis, responses, and monitoring and control on a project." Risk identification and analysis are processes within the knowledge area of risk management. Its outputs pertinent to this effort include the risk register, risk quantification (risk analysis model), contingency report, and the sensitivity analysis.

The intended use of these outputs is implementation by the project leadership with respect to risk responses (such as mitigation) and risk monitoring and control. In short, the effectiveness of the project risk management effort requires that the proactive management of risks not conclude with the study completed in this report.

The Cost and Schedule Risk Analysis (CSRA) produced by the PDT identifies issues that require the development of subsequent risk response and mitigation plans. This section provides a list of recommendations for continued management of the risks identified and analyzed in this study. Note that this list is not all inclusive and should not substitute a formal risk management and response plan.

1. Key Cost Risk Drivers: The key cost risk drivers identified through sensitivity analysis are PR-1 (Market Conditions/Bidding Climate), CON-1 (Variation in Estimated Quantities), EST-1 (Production Estimates) and TL-2 (Blasting May Be Required) which together contribute over 83 percent of the statistical cost variance.

a) Market Conditions/Bidding Climate: There is inherent risk that the ultimate bidding climate at the time of award of future contracts will be unfavorable to the price, as compared to the current working estimates of contract price. The PDT should continue to perform market research and analysis of trends within the construction industry. Ultimately, this uncertainty cannot be mitigated until more information is available. This should be communicated to management, and an adequate amount of contingency should be reserved to capture this risk.

b) Variation in Estimated Quantities: There is a possible risk that estimated quantities at the time of the study may vary from what a contractor actually encounters in the field when the project is actually underway. The PDT should update surveys and calculate quantities periodically so that this item can be monitored. This item can be mitigated when final plans and specs surveys are done prior to solicitation of a contract.

c) Production Estimates: There is a risk that production will vary from what was estimated to what the contractor will actually produce in the field. Production was based on a similar project but it will be unknown until proposals are received on a contract exactly what type of equipment a contractor intends to use and what the equipment's production capabilities are. The PDT should analyze available production data each time an estimate is prepared and make sure that the production data used is the best representation of what equipment and production rates might be seen on the project. This item typically remains a risk through project solicitation but can be mitigated as much as possible by applying the most encompassing average production rates from similar work.

d) Blasting May Be Required: There is a possible risk that blasting may be required in order to dredge part of the project footprint. Since geotechnical investigations are still underway, the PDT was unable to completely rule this out as a risk item and due to the unknown subsurface conditions, there is the possibility of the existence of rock that is too large to dredge without blasting. The PDT should analyze the geotechnical data as soon as it is available and determine if there are any project areas that may require blasting.

2. Key Schedule Risk Drivers: The key schedule risk drivers identified through sensitivity analysis are RE-3 (ODMDS Capacity), PPM-5 (Projects Competing Nationally for Funding), TL-2 (Blasting May Be Required) and CON-4 (Construction Schedule Accuracy), which together contribute over 71 percent of the statistical schedule variance.

a) ODMDS Capacity: There is a current restriction on the volume per annum to be placed in the ODMDS. The current ODMDS has the technical capacity for the project material, but there is a restriction which impacts the volume required to be placed in the ODMDS for this project. If this placement volume restriction is not removed, then modeling may be required to show whether or not the material would migrate outside the boundaries of the site. If the modeling shows that expansion of the current ODMDS is required, then there would be an additional delay while permits are acquired and new limits are permitted. Mitigation efforts are currently underway as the PDT is coordinating with various environmental agencies to resolve this issue. Project Management should continue to monitor this risk until it has been mitigated and adjust the schedule accordingly to accurately account for any delays.

b) Projects Competing Nationally for Funding: With the risk that there may be a delay in obtaining project funds due to the competition amongst numerous projects, especially with recent budget constraints, Project Management needs to stay aware of the current project cost and schedule and ensure that estimates are updated yearly and economics verified on a routine basis until the project receives appropriations.

c) Blasting May Be Required: There is a possible risk that blasting may be required in order to dredge part of the project footprint. Since geotechnical investigations are still underway, the PDT was unable to completely rule this out as a risk item and due to the unknown subsurface conditions, there is the possibility of the existence of rock that is too large to dredge without blasting. The PDT should analyze the geotechnical data as soon as it is available and determine if there are any project areas that may require blasting. If so, the project schedule could be delayed while proper permits are obtained. A schedule contingency should be carried for this item until it can be confirmed whether or not blasting is a possibility. If blasting is required, then Management needs to factor in a more accurate timeline for permitting.

d) Construction Schedule Accuracy: Project Management needs to maintain an accurate construction schedule and make sure that they are updating as often as possible. As soon as new information is available regarding the project schedule, or if there's any changes to the construction plan (i.e. blasting is added), then the schedule needs to immediately be updated to capture the information. This will allow Project Management and Programs to regularly monitor and check 902 limits if the project is delayed.

3. Risk Management: Project leadership should use the outputs created during the risk analysis effort as tools in future risk management processes. The risk register should be updated at each major project milestone. The results of the sensitivity analysis may also be used for response planning strategy and development. These tools should be used in conjunction with regular risk review meetings.

4. Risk Analysis Updates: Project leadership should review risk items identified in the original risk register and add others, as required, throughout the project life-cycle. Risks should be reviewed for status and reevaluation (using qualitative measure, at a minimum) and placed on risk management watch lists if any risk's likelihood or impact significantly increases. Project leadership should also be mindful of the potential for secondary (new risks created specifically by the response to an original risk) and residual risks (risks that remain and have unintended impact following response).

APPENDIX A

SAJ Lake Worth Inlet Navigation Pilot Study

July 2013

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

Project Scope Narrative: The Lake Worth Inlet Navigation Pilot Study consists of widening and deepening (to a depth of 39-feet) in the navigation channel that serves the Port of Palm Beach. The ROM cost for the project is approximately $85 Million. The project sponsor is the Port of Palm Beach. The work includes mitigation features for potential impacts to sea grass and the creation of hard bottoms. The majority of the disposal will using the ODMDS, while some will be disposed to create the mitigation features and renourish beaches. The project will also include Jetty stabilization (using sheet piles) if the channel is deepened to 39-feet or greater. The work will likely be complete in 2-3 phases due to funding increment limitations. It is likely that the contracts will be acquired using a best value-tradeoff RFP procurement to secure performance. The current construction schedule is approximately 15 months in duration. The PDT estimate that one year of feasibility remains, followed by 12-18 months of PED.

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions & Conclusions	Project Cost Likelihood*	Project Cost Impact*	Project Cost Risk Level*	Project Schedule Likelihood*	Project Schedule Impact*	Project Schedule Risk Level*	Responsibility/POC	Affected Project Component
Contract Risks (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influenc											
PROJECT & PROGRAM MGMT											
PPM-1	IEPR Timing	If the IEPR takes longer than 4 months, then the authorization may be delayed up to one fiscal year.	This has impact to the preconstruction schedule. This is a program milestone. **6/12/13: IEPR is underway and is on schedule; comments to be received 6/24/13 with response scheduled for 7/9/13; schedule risk educed from Likely/Crisis (High) to Very Unlikely/Critical (Low)	Unlikely	Negligible	LOW	Very Unlikely	Critical	LOW	Project Manager	Project Schedule
PPM-2	Division/HQUSACE Approvals	If SAD/HQ does not approve report for public release as DP 2, then it could have a significant impact on the schedule.	This has impact to the preconstruction schedule. This is a program milestone. **6/12/13: DP2 has already occurred so no longer a risk to project schedule; CWRB is scheduled for 10/25/13; Schedule risk reduced from Unlikely/Significant (Moderate) to Unlikely/Negligible (Low)	Unlikely	Negligible	LOW	Unlikely	Negligible	LOW	Project Manager	Project Schedule
PPM-3	Economic Modeling Accuracy	Although highly unlikely, if the economic benefit/modeling was determined to be inaccurate through the ATR or IEPR process, it could significantly impact the project.	It is not likely that the whole project will not be economically justified. However, there is the possibility that the NED scope could change (i.e. the navigation depth), presenting a significant change to the cost and schedule. *This could be a show-stopping risk. Model only for impact to configuration different from current proposed plan.**Per PDT meeting 11/28/30- REMOVE from analysis. Model has been reviewed and ATR'd so risk of any issues has greatly decreased; Cost risk reduced from Unlikely/Critical (Moderate) to Very Unlikely/Critical (Low)	Very Unlikely	Critical	LOW	Unlikely	Marginal	LOW	Project Manager	Project Cost
PPM-4	Projects Competing for Resources	There is typically a great deal of competition for the same resources.	This has a delay impact to the preconstruction schedule (feasibility and PED); **8/9/13: Reconciled Impact ratings based on sensitivity results of risk analysis	Very Unlikely	Negligible	LOW	Likely	Marginal	MODERATE	Project Manager	Project Schedule
PPM-5	Projects Competing Nationally for Funding	Typically, several projects nationally are competing for funding. However, since this is a Pilot project, it has better chances of obtaining funds. May not receiving funding needed to complete report and obtain Authorization	This could have an impact to cost and schedule. Cost impacts would most likely be captured by the schedule. There is also risk of obtaining reduced increments (less than optimal funding). **6/12/13: We are funded through end of FY which covers most of the feasibility study remaining activities to get the project to CWRB; schedule risk reduced from Likely/Significant (High) to Unlikely/Significant (Moderate) NOTE: Cost risk modeled/captured w/in schedule model; **8/9/13: Reconciled Impact ratings based on sensitivity results of risk analysis	Unlikely	Significant	MODERATE	Unlikely	Crisis	HIGH	Project Manager	Project Schedule
PPM-6	ATR Impacts	There may be some expected delay due to the ATR review process.	Since this is a pilot project, it should receive some priority. The PDT does not feel that this will likely substantially impact the overall schedule.	Very Unlikely	Negligible	LOW	Unlikely	Marginal	LOW	Project Manager	Project Schedule
PPM-7	Need to Develop PPA with the Port	A new PPA must still be executed with the Port of Palm Beach. This may take some time.	This could impact the schedule.	Very Unlikely	Negligible	LOW	Unlikely	Marginal	LOW	Project Manager	Project Schedule
CONTRACT ACQUISITION RISKS											
CA-1	RFP - Tradeoff Procurement	The PDT is contemplating using a tradeoff (best value) type of contract procurement. This could impact the costs, either positively or negatively.	Could vary the ultimate contract costs and impact the schedule.	Unlikely	Marginal	LOW	Unlikely	Negligible	LOW	Contracting	Contract Cost & Project Schedule

CA-2	Multiple Contracts Possible	There could be more than one contract due to the funding limitations. Also, there could be one main contract with options.	If funding limitations drive the strategy to multiple contracts, it could impact the costs and schedule. There could be up to 3 separate contracts. The risk would impact the contractor mobilizations, markups, and potential efficiencies. **8/9/13: Reconciled Impact ratings based on sensitivity results of risk analysis	Likely	Marginal	MODERATE	Very Likely	Marginal	MODERATE	Contracting	Contract Cost & Project Schedule
CA-3	Contractor Protests	There is inherent risk of protests from the industry. The PDT feels that the acquisition plan minimizes the protest risk.	This could have impact on the schedule.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Contracting	Project Schedule
	TECHNICAL RISKS										
TL-1	Require Additional Borings	Although the design is quite well developed, the borings are not complete. The borings cannot begin until the initiation of PED. It will take at least 8 months from the development of the boring scope to receipt of the results/report.	This will be a delay to the current schedule. This was not in the PM's schedule. It will be added to the schedule and reflected in the estimates. **6/12/13: Additional Geotech investigations are underway and report summarizing findings should be complete in September; this would give better insight into whether or not blasting will be required and if there is additional beach compatible material; schedule risk reduced from Likely/Marginal (Moderate) to Likely/Negligible (Low) since borings are almost complete	Unlikely	Negligible	LOW	Likely	Negligible	LOW	Geotechnical/Civil Design	Project Schedule
TL-2	Blasting May Be Required	The PDT is fairly confident that blasting will not be required. There is no blasting in the current estimate. They could be blasting required in up to 20% of the present project footprint.	This could have a major impact to the costs. It may impact the work that can take place in the work windows (no blasting in winter due to manatees); could impact the schedule because we would need permits;**8/9/13: Reconciled Impact ratings based on sensitivity results of risk analysis	Unlikely	Significant	MODERATE	Unlikely	Crisis	HIGH	Geotechnical/Civil Design	Contract Cost
TL-3	Change in Subsurface Conditions	Less or more stiff material (rock) could have an impact on the ultimate quantities. It could also impact the overall footprint (prism). It could also impact the required mitigation.	This could have a significant impact on the costs. This is not at all likely for the deepening, but more likely for the widening. Overall, still unlikely; **8/9/13: Reconciled Impact ratings based on sensitivity results of risk analysis	Unlikely	Significant	MODERATE	Unlikely	Marginal	LOW	Geotechnical/Civil Design	Contract Cost
TL-4	Modeling for Advanced Maintenance Conservative	The PDT has identified that the assumptions made for the advanced maintenance dredging activities are extremely conservative. This could present opportunity for savings with respect to the advance maintenance dredging.	This could be an *opportunity* for cost savings.**6/12/13: Remove from analysis. Savings would be to future O&M by reducing the frequency of O&M required- risk is not to initial construction	Likely	Significant	HIGH	Very Unlikely	Negligible	LOW	Technical Lead	Contract Cost
TL-5	Sea Level Rise	If the PDT underestimates the effects of a sea level rise, it could have an impact on the project configuration.	This is seen as a low risk.	Very Unlikely	Significant	LOW	Very Unlikely	Significant	LOW	Technical Lead	Project Cost & Schedule
TL-6	Uncertainty with a Design Feature (Peanut Island)	There may be a competitor for the activity planned for Peanut Island that may impact the currently planned design for this feature.	Likely would require some reconfiguration, but could probably be handled with no net effect to construction costs. However, it may produce a marginal delay. **11/28/30: removed as a risk to this project because it was determined by the PDT that it is no longer applicable	Likely	Negligible	LOW	Likely	Marginal	MODERATE	Technical Lead	Project Schedule
TL-7	Port May Construct Additional Berths (Slip 3)	There may be a sponsor driven scope change that would cause a reformulation of feasibility and design activities.	Momentum for the Port's contemplated activity at Slip 3 is growing. This would have a ripple effect on the entire project scope. **11/28/30: removed as a risk to this project because it was determined by the PDT that if the Port were to propose to construct additional berths then most likely a new separate study would be initiated.	Unlikely	Significant	MODERATE	Unlikely	Significant	MODERATE	Technical Lead	Project Cost & Schedule
TL-8	Jetty Slope Stability	If blasting is required, then there is some concern regarding the jetty slope stability.	Current information suggests that it is not very likely to blast in proximity to the jetty (failure). However, there is a chance of blasting which could affect the jetty. This is highly correlated to the blasting risk, itself;**8/9/13: Reconciled Impact ratings based on sensitivity results of risk analysis	Unlikely	Marginal	LOW	Unlikely	Significant	MODERATE	Technical Lead	Project Cost & Schedule
TL-9	Jetty Stabilization Design	A cursory level design based on loosely defined assumptions was the basis for determining the need for jetty stabilization and to what extent.	Could have a significant impact to project cost if the location and amount of sheetpile has been underestimated; it could also be a cost savings if it is determined by a detailed design investigation during PED that jetty stabilization is not needed. **6/12/13: Reduced from Likely/Significant (High) to Unlikely//Significant (Moderate)	Unlikely	Marginal	LOW	Very Unlikely	Negligible	LOW		Project Cost
TL-10	Complications with the ATR of the Ship Simulation	The ATR of the Ship Simulation process has been protracted. It is likely that it will be resolved. However, it could delay the project.	It is unlikely that this will produce significant delays.	Very Unlikely	Negligible	LOW	Unlikely	Marginal	LOW	Technical Lead	Project Schedule
TL-11	Screening of Material	Based on current sand rule, screening of matrerial that will be placed in the nearshore is expected	6/29/30: Although current Geotech information does not indicate any substantial rock or rock fragments, screening is still assumed for the pipeline work within the EC since we are digging new material and may encounter unaccetpable material that will require separation and removal; however, for the area considered it is highly unlikely that the % of rock will increase above what is estimated	Unlikely	Marginal	LOW	Unlikely	Marginal	LOW	Technical Lead	Project Schedule
	LANDS AND DAMAGES RISKS										
LD-1	Extension of the Beach Disposal Template	The PDT is seriously contemplating extension of the beach disposal template from the current template configuration.	The issue is the potential addition of an additional 2,000 feet of extension. This would mean additional land acquisition. There is also the potential risk of condemnations, which could significantly delay the project. **11/28/30: The PDT decided that this risk item should be removed since we are no longer including beach placement as part of the selected plan; everything will be placed below MHW	Likely	Significant	HIGH	Likely	Significant	HIGH	Real Estate	Project Cost & Schedule
	REGULATORY AND ENVIRONMENTAL										

RE-1	Salinity Intrusion	Saline water could introduce brackish water into the bay.	This is seen as a low risk.	Unlikely	Marginal	LOW	Unlikely	Marginal	LOW	Environmental	Contract Cost & Project Schedule
RE-2	Delay in Obtaining Permits	There may be some delay in obtaining a permit from FDEP due to geotechnical uncertainties for any of the beach placements (since the geotechnical data is not complete).	Currently, the data suggests rock in the settling basin. However, presence of sand would require disposal to beaches; **8/9/13: Reconciled Impact ratings based on sensitivity results of risk analysis	Very Unlikely	Negligible	LOW	Likely	Marginal	MODERATE	Environmental	Project Schedule
RE-3	ODMDS Capacity	There is a current restriction on the volume per annum to be placed in the ODMDS. If there is no expansion to the current ODMDS, then there would not be capacity to accept the materia from this project.	The current ODMDS has the technical capacity for the material, but there is a restriction which impacts the volume required for this project. Issue is whether or not the material would migrate outside the boundaries of the site. **6/12/13: Reduced cost impact rating from Significant to Negligible because cost of expanding the ODMDS is less than 0.5% of TPC; **8/9/13: Reconciled Impact ratings based on sensitivity results of risk analysis	Unlikely	Negligible	LOW	Unlikely	Crisis	HIGH	Technical Lead	Project Cost & Schedule
RE-4	Uncertainty with the Level/Amount of Mitigatior	The mitigation modeling that has already been accomplished is not fully complete. There are 2 models that need to be completed. At this time, the ultimate level and amount of mitigation is not certain. NMFS may require different amounts and levels than are currently contemplated, as reflected in the cost estimate.	This could have an impact on the costs.**6/12/13: DEP is currently running their versions of the model and negotiations have not taken place yet	Unlikely	Marginal	LOW	Very Unlikely	Negligible	LOW	Environmental	Project Cost
RE-5	Availability of Sites for Mitigation Features	There are a number of sites. However, if they are taken or occupied by other entities, it could withhold the most cost effective sites from the project; 6/11/13: PDT determined that of the 5 Alternatives, Turtle Cove may not be best choice since Public is so opposed; estimate revised to be based on Bloomfield/Forest Hill with Risk Analysis capturing possibility of cost savings if going to Bingham or Turtle Cove and cost increase if filling Ibis Isle or Little Lake Worth	This could impact the costs; 6/11/13: Risk Level elevated from Unlikely/Marginal (Low) to Likely/Marginal (Moderate); **8/9/13: Reconciled Impact ratings based on sensitivity results of risk analysis	Likely	Marginal	MODERATE	Likely	Negligible	LOW	Technical Lead	Contract Cost & Project Schedule
RE-6	Success of the Mitigation Features	There is a track record of success with these measures. There will be a 5-year monitoring requirement to determine effectiveness. If issues arise, rework may be necessary.	This could impact the costs.	Unlikely	Marginal	LOW	Very Unlikely	Negligible	LOW	Technical Lead	Project Cost
RE-7	Environmental Work Windows	There are restrictions on dredging and excavation due to manatees. There is a large critical habitat for manatees (Lake Worth Inner Channel). There is currently a restriction on the O&M permit that does not allow mechanical dredging.	There is not a set work window for the manatees. The PDT is attempting to use mechanical dredging in the new work taking place under this project. There is a possibility that a concession to be made to restrict to no night time dredging. **11/28/30: Cost risk reduced from Likely/Significant (High) to Very Unlikely/Significant (Low) because current estimate assumes 24 hour dredging during window, no dredging outside of window, and full remobilization costs when window opens again. Current BO allows mechanical dredging and 12 hour dredging outside of window so it is assumed that cost difference as a result of reduce EWT is comparable to cost of full mobilizations;	Very Unlikely	Significant	LOW	Likely	Negligible	LOW	Technical Lead	Project Cost & Schedule
RE-8	Material Testing	Many projects these days are completely dependent on ocean disposal but need to pass testing to ensure it is suitable materia before we can take the material offshore. Material testing normally happens during PED a year or so before construction as the suitability is only good for a 3 year period	Material testing is mandatory. If it does not pass, it would need another placement area;**8/9/13: Reconciled Impact ratings based on sensitivity results of risk analysis	Very Unlikely	Significant	LOW	Unlikely	Significant	MODERATE	Technical Lead	Project Cost & Schedule
	CONSTRUCTION RISKS										
CON-1	Variation in Estimated Quantities	There may be some uncertainty in the quantities due to potentia scope changes.	This could impact the contract costs. If quantities are off by 15%, could be almost 9.5% increase in project cost.; if quantities are off, could increase or decrease construction duration. **6/12/13: Reduced from Likely/Significant (High) to Unlikely/Significant (Moderate); Construction quantities-only variation could be in the O&M overburden and the O&M material would be paid for separately; quantities calculated have already deducted the O&M material; **8/9/13: Reconciled Impact ratings based on sensitivity results of risk analysis	Unlikely	Critical	MODERATE	Unlikely	Significant	MODERATE	Technical Lead	Contract Cost
CON-2	Noise Pollution/Control	The local communities may restrict the noise levels permitted, particularly during nights and weekends.	While this may be a nuisance issue, it will not likely impact the cost or schedule.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Construction	Contract Cost
CON-3	Haul Route Construction/Loading Restriction	There is a limitation on the construction on the inlet channels that may cause the contractor to use smaller and more lightly loaded barges in order to reach mitigations site(s)	This could impact contractor productivity, and therefore contract costs.	Likely	Negligible	LOW	Very Unlikely	Negligible	LOW	Technical Lead	Contract Cost
CON-4	Construction Schedule Accuracy	There are many factors not considered in the current construction schedule, including the work windows, severe weather, permit delays, restrictions, etc.	This could impact both cost and schedule.**11/28/30: removed as a cost risk; **6/12/13: Current construction includes work windows; still some risk with order of work, weather, permit delays and any permit restrictions that may be imposed since permit has not been obtained; **8/9/13: Reconciled Impact ratings based on sensitivity results of risk analysis	Unlikely	Marginal	LOW	Likely	Critical	HIGH	Cost Engineering	Contract Cost & Project Schedule
CON-5	Air Quality	The contractor will have to comply with clean air restrictions.	This could impact contractor productivity, and therefore contract costs. **11/28/30: PDT decided that this was unlikely and removed as a risk	Unlikely	Marginal	LOW	Very Unlikely	Negligible	LOW	Construction	Contract Cost

CON-6	Construction Claims and Modifications	There is inherent risk of construction modifications and claims that arise after contract award due to issues such as weather, schedules dictated by O&M cycles, differing site conditions, user directed changes or omissions, inaccurate surveys, and variations in estimated quantities (minor).	Post-award construction contract modifications and claims could impact the ultimate contract costs and delay the overall schedule. **8/9/13: Reconciled Impact ratings based on sensitivity results of risk analysis	Likely	Marginal	MODERATE	Unlikely	Negligible	LOW	Construction	Project Cost & Schedule
CON-7	Contractor Mobilization	**The PDT added a risk for Mobilization to capture the possibility of a cost savings if the construction dredging is paired with the large maintenance event (which is typical).	There is also the possibility that the mobilization could be higher. The PDT assumed 1,000 miles for mobilization. The equipment may have to mobilize from a much greater distance, so there is a slight chance that the mobilization costs could be doubled; **8/9/13: Reconciled Impact ratings based on sensitivity results of risk analysis	Likely	Marginal	MODERATE	Very Unlikely	Negligible	LOW	Cost Engineering	Contract Cost
	ESTIMATE AND SCHEDULE RISKS										
EST-1	Production Estimates	Possibility of production estimates not accurately depicting production we will actually see on job	If production estimates are off, unit costs could be innaccurate and construction duration could be shorter or longer; **8/9/13: Reconciled Impact ratings based on sensitivity results of risk analysis	Unlikely	Critical	MODERATE	Unlikely	Marginal	LOW	Cost Engineering	Project Cost & Schedule
EST-2	Contract Markups	We have used average large dredging contractor markups for many years but the actual markups bid for the contracts could vary from this.	**8/9/13: Reconciled Impact ratings based on sensitivity results of risk analysis	Likely	Marginal	MODERATE	Very Unlikely	Negligible	LOW	Cost Engineering	Project Cost & Schedule
	ECONOMICS RISKS										
INT-1	Consideration for Low and Unknown Interna Risk	There is inherent risk in all projects that could contribute to cost and schedule variance due to uknowns.	This could impact cost and schedule;	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE	N/A	Project Cost & Schedule
	Programmatic Risks	(External Risk Items are those that are generated, caused, or controlled exclusively outside the PDT's sphere of influenc									
PR-1	Market Conditions/Bidding Climate	There is inherent variability and volatility in the dredging industry that could impact the ultimate contract costs.	This could have significant impact on the costs; **8/9/13: Reconciled Impact ratings based on sensitivity results of risk analysis	Likely	Crisis	HIGH	Very Unlikely	Negligible	LOW	Cost Engineering	Contract Cost
PR-2	Limited Competition	There may be too few bidders, limiting competition and driving prices up.	The Government is configuring the project with a barge mounted excavator in order to not limited competition.	Unlikely	Marginal	LOW	Very Unlikely	Negligible	LOW	Cost Engineering	Contract Cost
PR-3	Severe Tropical Storms	Severe weather could impact the project. Hurricanes could have a significant impact on the project.	Severe weather events, depending on severity, could impact the costs and the schedule.	Unlikely	Marginal	LOW	Unlikely	Marginal	LOW	N/A	Project Schedule
PR-4	Fuel Prices	Rising fuel prices for marine and off-road diesel could impact the contract costs.	This would likely have significant impact to equipment costs (dredging); **8/9/13: Reconciled Impact ratings based on sensitivity results of risk analysis	Very Likely	Marginal	MODERATE	Very Unlikely	Negligible	LOW	Cost Engineering	Contract Cost
PR-5	Communities May Not View the Project Favorably	While the local communities have not opposed the project or officially withdrawn support, many do not favor the project.	Enough opposition could impact implementation of the project.	Very Unlikely	Marginal	LOW	Unlikely	Marginal	LOW	Project Manager	Project Schedule
PR-6	Equipment Availability	Impacts due to non-availability of the most efficient dredge type to perform the work	Could have a significant impact to cost if have to convert to a sole source negotiation; critical impact to schedule if need to re-advertise or wait for available equipment- especially since we are working with strict environmental windows; **8/9/13: Reconciled Impact ratings based on sensitivity results of risk analysis	Unlikely	Marginal	LOW	Unlikely	Significant	MODERATE	Cost Engineering	Project Cost & Schedule
PR-7	Material Availability	Impacts due to non-availability of materials, especially for mitigation work	Although very unlikely for this project because we have plenty of material that should meet requirements for seagrasses and estimate already assumes purchase of rock for hardbottoms, could have a significant impact to cost if we have to purchase fill material vs obtaining from within project; could also impact cost if we have to purchase material from further away if local quarries do not have available quantities of material	Very Unlikely	Significant	LOW	Very Unlikely	Marginal	LOW	Cost Engineering	Project Cost & Schedule
PR-8	Labor	Dredge labor on larger size dredges are union wages and are regulated on the Davis-Bacon Act.	No unusual increases are anticipated during the life of this project.	Unlikely	Marginal	LOW	Very Unlikely	Negligible	LOW	Cost Engineering	Project Cost & Schedule
EXT-1	Consideration for Low and Unknown Externa Risk	There is inherent risk in all projects that could contribute to cost and schedule variance due to uknowns.	This could impact cost and schedule.	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE	N/A	Project Cost & Schedule

*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 Impac**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.

USACE Jacksonville District District
SAJ - Lake Worth Inlet Navigation Pilot Study
July 2013

Initial Risk Register Development Meeting

Date Tuesday, September 11, 2012 Jacksonville District

No.	Section	Title
1	USACE - SAJ	PD-D, Economist
2	USACE - SAJ	EN-WC, Hydrodynamics Modeler
3	USACE - SAJ	EN-DW, Levee Design
4	USACE - SAJ	PD-ES, NEPA
5	USACE - SAJ	PM-WN, Operations manager
6	USACE - SAJ	PD-ES, NEPA
7	USACE - SAJ	PM-WN, Operations manager
8	USACE - SAJ	PD-EQ, Water Quality
9	USACE - SAJ	PD-D, Economist
10	USACE - SAJ	EN-GS, Soils
11	USACE - SAJ	EN-GG, Geotechnical
12	USACE - SAJ	PM-WN, Project Manager
13	USACE - SAJ	PM-WF, Ship Simulation
14	USACE - SAJ	EN-TC, Cost Estimating
15	USACE - SAJ	RE-A, Real Estate Acquisition
16	USACE - SAJ	PD-EC, ODMDS Manager
17	USACE - SAJ	CT, Contracting
18	USACE - NWW	Chief, Cost MCX, Risk Facilitator
19	USACE - SAJ	PD-PN, Planning
20	USACE - SAJ	OC, Office of Council
21	USACE - SAJ	PD-EP, Archaeologist
22	USACE - SAJ	CD, Construction Division

SAJ Lake Worth Inlet Navigation Pilot Study

July 2013

Contingency on Base Estimate	80% Confidence Project Cost
Baseline Estimate Cost (Most Likely) ->	**$70,572,047**
Baseline Estimate Cost Contingency Amount ->	$13,176,139
Baseline Estimate Construction Cost (80% Confidence) ->	**$83,748,186**

Contingency on Schedule	80% Confidence Project Schedule
Project Schedule Duration (Most Likely) ->	**56.5 Months**
Schedule Contingency Duration ->	23.8 Months
Project Schedule Duration (80% Confidence) ->	**80.3 Months**
Project Schedule Contingency Amount (80% Confidence) ->	**$3,029,554**

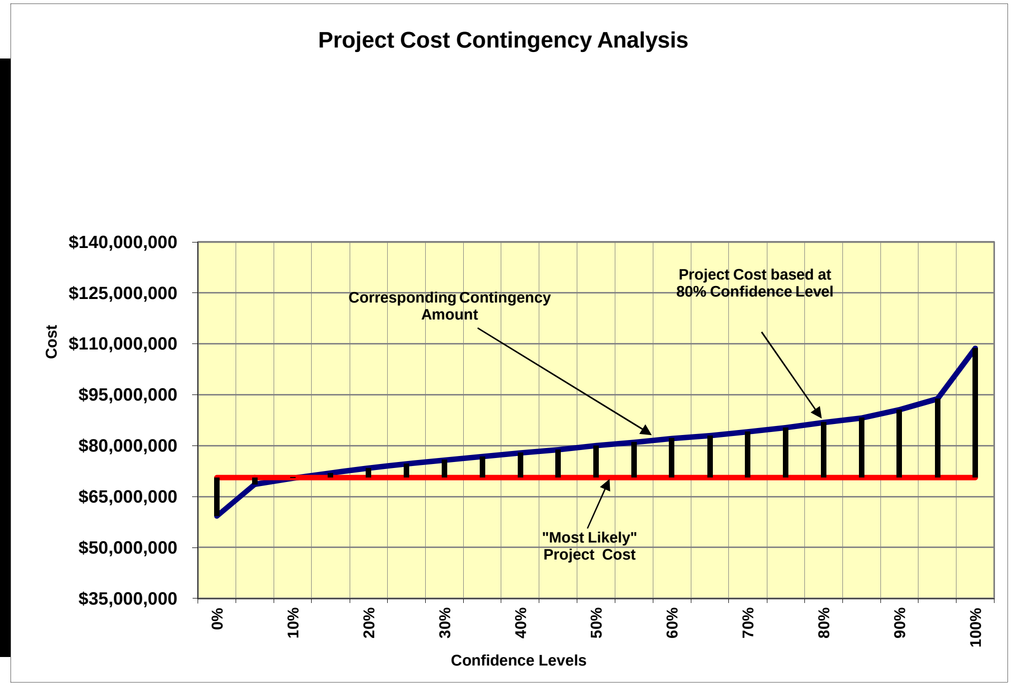
Project Contingency	80% Confidence Project Cost
Project Contingency Amount (80% Confidence) ->	**$16,205,694**
Project Contingency Percentage (80% Confidence) ->	**23%**

Project Cost (80% Confidence) ->	**$86,777,741**

- PROJECT CONTINGENCY DEVELOPMENT -

Contingency Analysis

Most Likely Cost Estimate	$70,572,047		
Confidence Level	Project Cost	Contingency	Contingency %
0%	$59,301,344	($11,270,703)	-15.97%
5%	$68,587,459	($1,984,588)	-2.81%
10%	$70,382,649	($189,398)	-0.27%
15%	$71,901,283	$1,329,236	1.88%
20%	$73,344,634	$2,772,587	3.93%
25%	$74,652,212	$4,080,165	5.78%
30%	$75,791,312	$5,219,265	7.40%
35%	$76,760,961	$6,188,914	8.77%
40%	$77,912,457	$7,340,410	10.40%
45%	$78,789,912	$8,217,865	11.64%
50%	$80,004,197	$9,432,150	13.37%
55%	$80,933,996	$10,361,949	14.68%
60%	$82,069,227	$11,497,180	16.29%
65%	$82,962,561	$12,390,514	17.56%
70%	$84,127,868	$13,555,821	19.21%
75%	$85,286,613	$14,714,566	20.85%
80%	**$86,777,741**	**$16,205,694**	**22.96%**
85%	$88,131,959	$17,559,912	24.88%
90%	$90,587,844	$20,015,797	28.36%
95%	$93,825,426	$23,253,379	32.95%
100%	$108,656,525	$38,084,478	53.97%

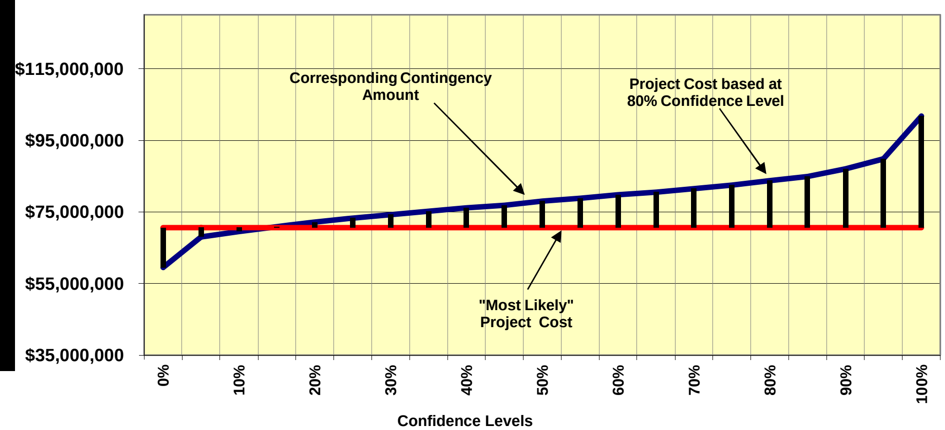


- BASE CONTINGENCY DEVELOPMENT -

Contingency Analysis

Most Likely Cost Estimate	$70,572,047		
Confidence Level	**Project Cost**	**Contingency**	**Contingency %**
0%	**$59,471,375**	**($11,100,671.59)**	**-15.73%**
5%	**$68,042,823**	**($2,529,223.43)**	**-3.58%**
10%	**$69,520,149**	**($1,051,898.17)**	**-1.49%**
15%	**$70,849,863**	**$277,816.30**	**0.39%**
20%	**$72,127,458**	**$1,555,411.10**	**2.20%**
25%	**$73,272,830**	**$2,700,782.65**	**3.83%**
30%	**$74,262,551**	**$3,690,504.10**	**5.23%**
35%	**$75,122,159**	**$4,550,111.69**	**6.45%**
40%	**$76,140,168**	**$5,568,121.37**	**7.89%**
45%	**$76,893,993**	**$6,321,946.16**	**8.96%**
50%	**$77,985,718**	**$7,413,671.47**	**10.51%**
55%	**$78,815,304**	**$8,243,257.14**	**11.68%**
60%	**$79,797,411**	**$9,225,364.49**	**13.07%**
65%	**$80,552,839**	**$9,980,791.94**	**14.14%**
70%	**$81,474,283**	**$10,902,235.84**	**15.45%**
75%	**$82,461,356**	**$11,889,309.07**	**16.85%**
80%	**$83,748,186**	**$13,176,139.38**	**18.67%**
85%	**$84,859,754**	**$14,287,707.17**	**20.25%**
90%	**$87,019,757**	**$16,447,710.13**	**23.31%**
95%	**$89,791,947**	**$19,219,899.85**	**27.23%**
100%	**$101,767,911**	**$31,195,863.86**	**44.20%**

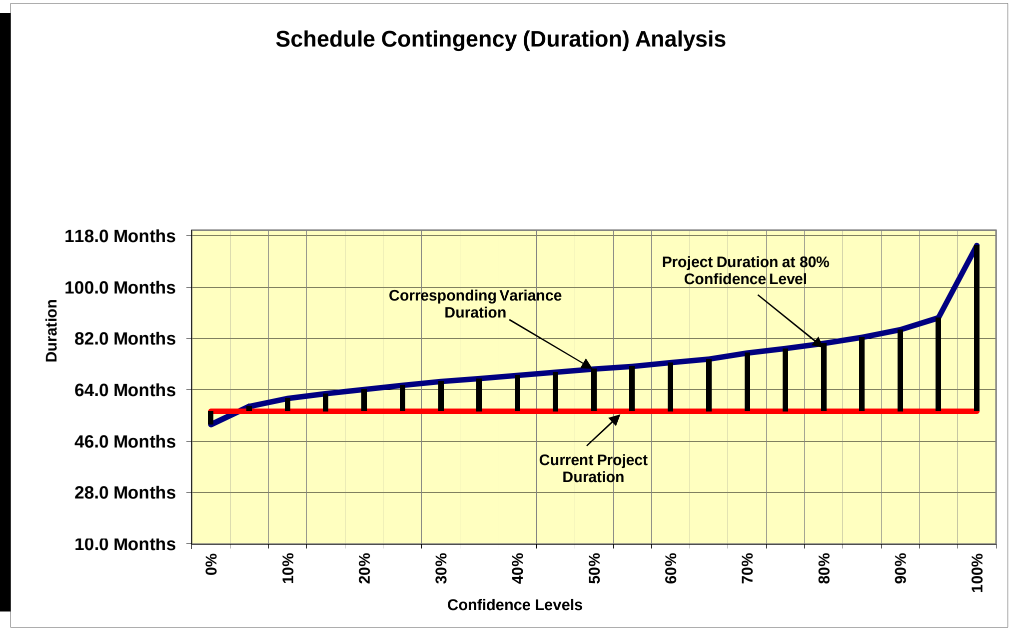
Base Estimate Cost Contingency Analysis (Does not Include Escalation)



- SCHEDULE CONTINGENCY (DURATION) DEVELOPMENT -

Contingency Analysis

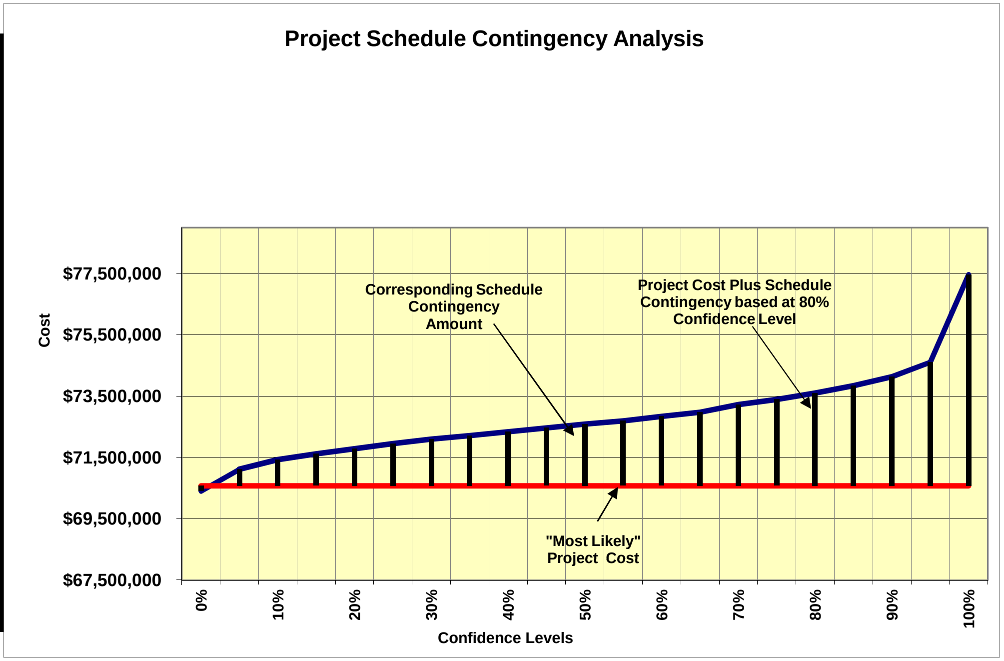
Most Likely Schedule Duration	56.5 Months		
Confidence Level	**Project Duration**	**Contingency**	**Contingency %**
0%	51.9 Months	-4.7 Months	-8.24%
5%	58.2 Months	1.7 Months	3.02%
10%	61.0 Months	4.5 Months	8.02%
15%	62.7 Months	6.2 Months	10.99%
20%	64.2 Months	7.7 Months	13.60%
25%	65.6 Months	9.1 Months	16.16%
30%	67.0 Months	10.5 Months	18.51%
35%	67.9 Months	11.4 Months	20.24%
40%	69.1 Months	12.6 Months	22.34%
45%	70.2 Months	13.7 Months	24.29%
50%	71.3 Months	14.8 Months	26.22%
55%	72.2 Months	15.7 Months	27.80%
60%	73.6 Months	17.1 Months	30.21%
65%	74.8 Months	18.3 Months	32.38%
70%	77.0 Months	20.5 Months	36.22%
75%	78.5 Months	22.0 Months	38.92%
80%	80.3 Months	23.8 Months	42.14%
85%	82.5 Months	26.0 Months	45.96%
90%	85.1 Months	28.6 Months	50.62%
95%	89.3 Months	32.7 Months	57.94%
100%	114.7 Months	58.1 Months	102.89%

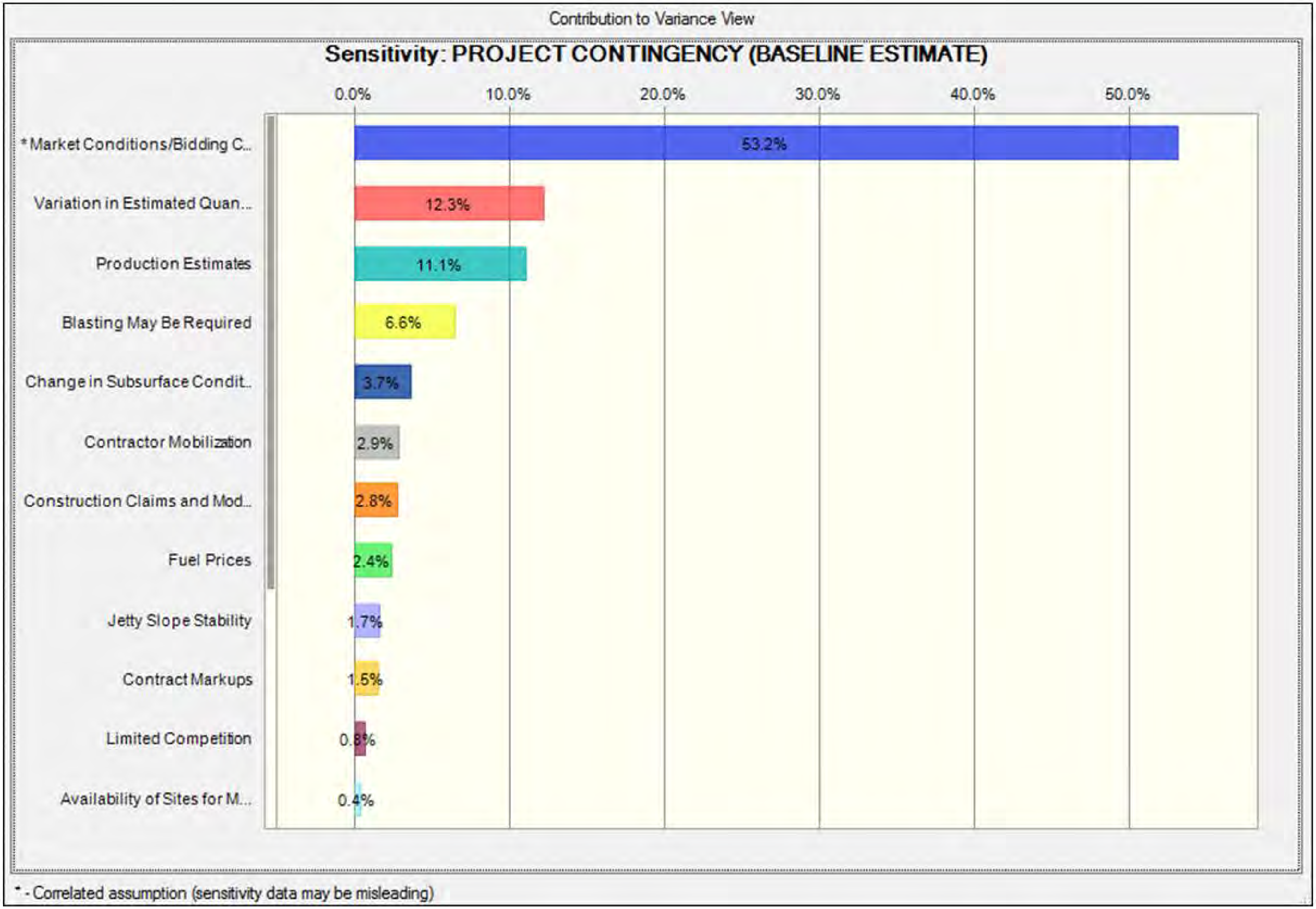


- SCHEDULE CONTINGENCY (AMOUNT) DEVELOPMENT -

Contingency Analysis

Most Likely Cost Estimate	$70,572,047		
Confidence Level	Project Cost	Contingency	Contingency %
0%	$70,402,016	($170,031)	-0.24%
5%	$71,116,682	$544,636	0.77%
10%	$71,434,547	$862,500	1.22%
15%	$71,623,466	$1,051,419	1.49%
20%	$71,789,223	$1,217,176	1.72%
25%	$71,951,429	$1,379,382	1.95%
30%	$72,100,808	$1,528,761	2.17%
35%	$72,210,849	$1,638,802	2.32%
40%	$72,344,336	$1,772,289	2.51%
45%	$72,467,965	$1,895,919	2.69%
50%	$72,590,525	$2,018,479	2.86%
55%	$72,690,739	$2,118,692	3.00%
60%	$72,843,862	$2,271,815	3.22%
65%	$72,981,769	$2,409,722	3.41%
70%	$73,225,633	$2,653,586	3.76%
75%	$73,397,303	$2,825,257	4.00%
80%	**$73,601,601**	**$3,029,554**	**4.29%**
85%	$73,844,252	$3,272,205	4.64%
90%	$74,140,134	$3,568,087	5.06%
95%	$74,605,526	$4,033,479	5.72%
100%	$77,460,661	$6,888,614	9.76%




Contribution to Variance View
Sensitivity: PROJECT CONTINGENCY (BASELINE ESTIMATE)
0.0%
10.0%
20.0%
30.0%
40.0%
50.0%
* Market Conditions/Bidding C...
53.2%
Variation in Estimated Quan...
12.3%
Production Estimates
11.1%
Blasting May Be Required
6.6%
Change in Subsurface Condit...
3.7%
Contractor Mobilization
2.9%
Construction Claims and Mod...
2.8%
Fuel Prices
2.4%
Jetty Slope Stability
1.7%
Contract Markups
1.5%
Limited Competition
0.8%
Availability of Sites for M...
0.4%
* - Correlated assumption (sensitivity data may be misleading)

SAJ Lake Worth Inlet Navigation Pilot Study

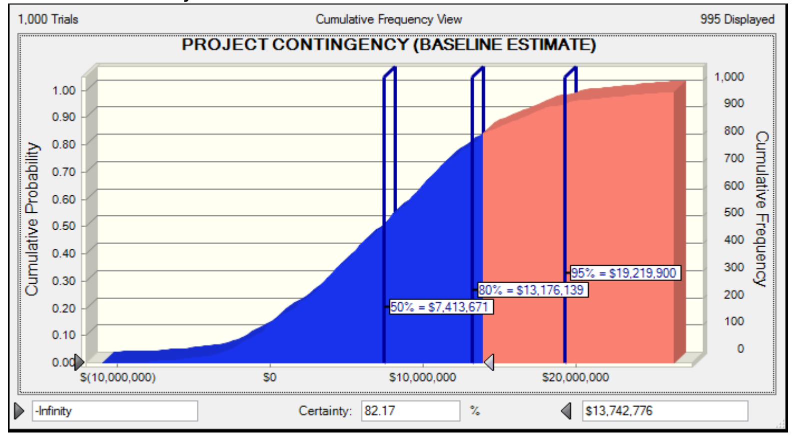
July 2013

Risk No.	Risk/Opportunity Event	Project Cost: Likelihood*	Impact*	Risk Level*	Variance Distribution	Correlation to Other(s)	Probability of Occurrence	Crystal Ball Simulation – Expected Values ($$$): Low	Most Likely	High	Contingency Model	Notes	Expected Values (%s): Low	Most Likely	High
Internal Risks (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.)															
	PROJECT & PROGRAM MGMT														
	CONTRACT ACQUISITION RISKS														
CA-2	Multiple Contracts Possible	Likely	Marginal	MODERATE	Triangular		100%	$	$	$	$		0.00%	0.00%	1.93%
	TECHNICAL RISKS									1,303,281					
TL-2	Blasting May Be Required	Unlikely	Critical	MODERATE	Yes-No/Uniform	TL-3, TL-8	20%	$ -	$ -	$ 7,742,500	$ -	*Correlated to Risks TL-3 and TL-8 by a factor of 0.75*	0.00%	0.00%	10.97%
TL-3	Change in Subsurface Conditions	Unlikely	Significant	MODERATE	Yes-No/Uniform	TL-2	35%	$ (986,069)	$ -	$ 4,967,840	$ -	*Correlated to Risk TL-2 by a factor of 0.75*	-1.40%	0.00%	7.04%
TL-8	Jetty Slope Stability	Unlikely	Marginal	LOW	Yes-No/Uniform	TL-2	5%	$ -	$ -	$ 3,584,555	$ -	*Correlated to Risk TL-2 by a factor of 0.75*	0.00%	0.00%	5.08%
TL-9	Jetty Stabilization Design	Unlikely	Marginal	LOW	Yes-No/Uniform		50%	$ (89,614)	$	$	$		-0.13%	0.00%	0.63%
	LANDS AND DAMAGES RISKS														
	REGULATORY AND ENVIRONMENTAL RISKS									448,069	-				
RE-4	Uncertainty with the Level/Amount of Mitigation	Unlikely	Marginal	LOW	Yes-No/Triangular		35%	$ (1,288,245)	$ -	$ 1,288,245	$ -		-1.83%	0.00%	1.83%
RE-5	Availability of Sites for Mitigation Features	Likely	Marginal	MODERATE	Triangular		100%	$ (1,416,241)	$ -	$	$ -				
RE-6	Success of the Mitigation Features	Unlikely	Marginal	LOW	Yes-No/Uniform		15%	$ -	$ -	$ 1,639,314 1,932,367	$ -		0.00%	0.00%	2.74%
	CONSTRUCTION RISKS														
CON-1	Variation in Estimated Quantities	Unlikely	Critical	MODERATE	Triangular		100%	$ (6,704,344)	$	$	$		-9.50%	0.00%	5.00%
CON-3	Haul Route Construction/Loading Restriction	Likely	Negligible	LOW	Triangular		100%	$	$ -	$	$ -		0.00%	0.00%	0.72%
CON-4	Construction Schedule Accuracy	Unlikely	Marginal	LOW	N/A	N/A	N/A	N/A	N/A	3,528,602 N/A	N/A	N/A	N/A	N/A	N/A
CON-5	Air Quality	Unlikely	Marginal	LOW	N/A	N/A	N/A	N/A	N/A	505,592 N/A	N/A	N/A	N/A	N/A	N/A
CON-6	Construction Claims and Modifications	Likely	Marginal	MODERATE	Triangular		100%	$	$	$	$		0.00%	0.00%	5.00%
CON-7	Contractor Mobilization	Likely	Marginal	MODERATE	Custom		100%	$ (645,995)	$	$	$		-0.92%	0.00%	6.49%
	ESTIMATE AND SCHEDULE RISKS									3,528,602					
EST-1	Production Estimates	Unlikely	Critical	MODERATE	Triangular		100%	$ (3,528,602)	$	$ 4,579,484	$		-5.00%	0.00%	10.00%
EST-2	Contract Markups	Likely	Marginal	MODERATE	Triangular		100%	$ (1,186,111)	$	$	$		-1.68%	0.00%	3.78%
	LOW AND UNKNOWN INTERNAL RISKS								-	7,057,205	-				
INT-1	Consideration for Low and Unknown Internal Risk	Likely	Marginal	MODERATE	Triangular		100%	$ (3,528,602)	$ -	$ 2,668,409	$		-5.00%	0.00%	5.00%
	Programmatic Risks									3,528,602					
PR-1	Market Conditions/Bidding Climate	Likely	Crisis	HIGH	Triangular	PR-2	100%	$ (7,057,205)	$ -	$ 14,114,409	$ -	*Correlated to PR-2 by a factor of 0.67*	-10.00%	0.00%	20.00%
PR-2	Limited Competition	Unlikely	Marginal	LOW	Yes-No/Triangular	PR-1	35%	$ -	$ -	$ 4,985,774	$ -	*Correlated to PR-1 by a factor of 0.67*	0.00%	0.00%	7.06%
PR-4	Fuel Prices	Very Likely	Marginal	MODERATE	Triangular		100%	$ (1,032,552)	$	$	$		-1.46%	0.00%	5.12%
PR-6	Equipment Availability	Unlikely	Marginal	LOW	Yes-No/Triangular		35%	$ -	$ -	$ 3,613,312 1,893,506	$ -		0.00%	0.00%	2.68%
EXT-1	Consideration for Low and Unknown External Risk	Likely	Marginal	MODERATE	Triangular		100%	$ (3,528,602)	$	$	$		-5.00%	0.00%	5.00%
									-	3,528,602	**$ -**				

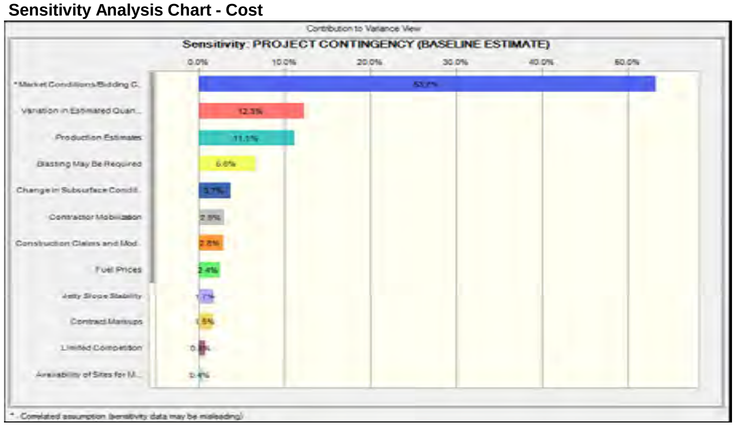
Percentages are calculated as the variance from the assumption value to facilitate iteration of the model should the cost values change throughout the project phases. Uniform distribution percentages reflect variation from the total project cost.

PROJECT CONTINGENCY (BASELINE ESTIMATE)	Percentile	Baseline TPC	Contingency Amount	Baseline w/ Contingency	Contingency %
	0%	$70,572,047	-$11,100,672	**$59,471,375**	**-15.73%**
	5%	$70,572,047	-$2,529,223	**$68,042,823**	**-3.58%**
	10%	$70,572,047	-$1,051,898	**$69,520,149**	**-1.49%**
	15%	$70,572,047	$277,816	**$70,849,863**	**0.39%**
	20%	$70,572,047	$1,555,411	**$72,127,458**	**2.20%**
	25%	$70,572,047	$2,700,783	**$73,272,830**	**3.83%**
	30%	$70,572,047	$3,690,504	**$74,262,551**	**5.23%**
	35%	$70,572,047	$4,550,112	**$75,122,159**	**6.45%**
	40%	$70,572,047	$5,568,121	**$76,140,168**	**7.89%**
	45%	$70,572,047	$6,321,946	**$76,893,993**	**8.96%**
	50%	$70,572,047	$7,413,671	**$77,985,718**	**10.51%**
	55%	$70,572,047	$8,243,257	**$78,815,304**	**11.68%**
	60%	$70,572,047	$9,225,364	**$79,797,411**	**13.07%**
	65%	$70,572,047	$9,980,792	**$80,552,839**	**14.14%**
	70%	$70,572,047	$10,902,236	**$81,474,283**	**15.45%**
	75%	$70,572,047	$11,889,309	**$82,461,356**	**16.85%**
	80%	$70,572,047	$13,176,139	**$83,748,186**	**18.67%**
	85%	$70,572,047	$14,287,707	**$84,859,754**	**20.25%**
	90%	$70,572,047	$16,447,710	**$87,019,757**	**23.31%**
	95%	$70,572,047	$19,219,900	**$89,791,947**	**27.23%**
	100%	$70,572,047	$31,195,864	**$101,767,911**	**44.20%**

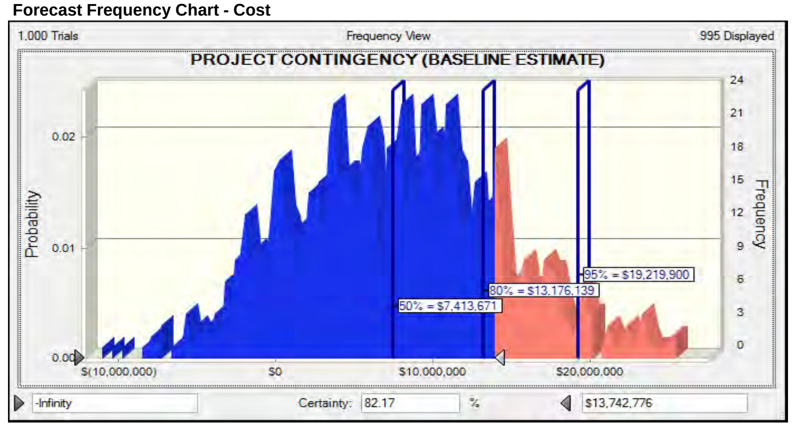
Cumulative Probability Forecast Chart - Cost



Sensitivity Analysis Chart - Cost



Forecast Frequency Chart - Cost



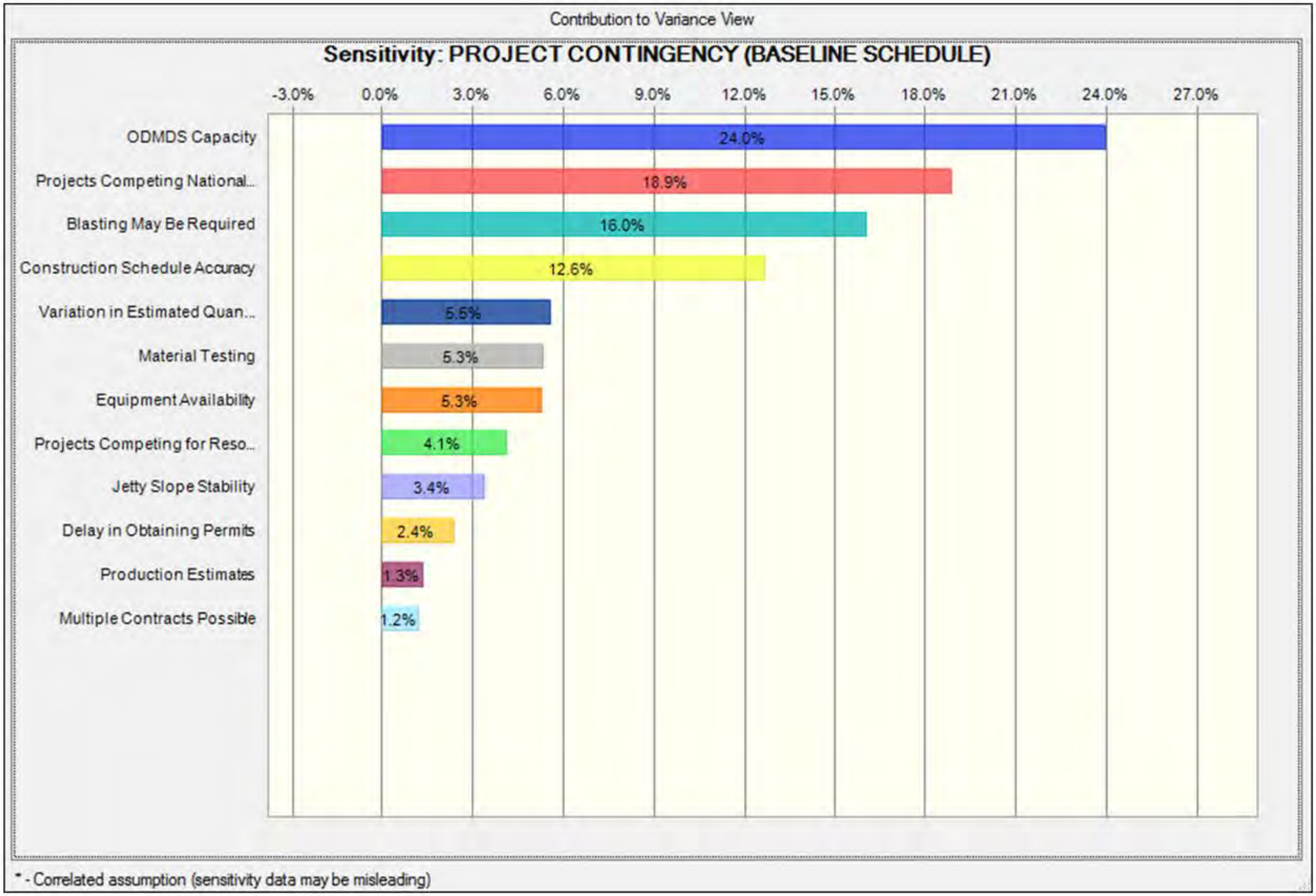
USACE Jacksonville District District | **Date of Cost Estimate:** July 2013
SAJ - Lake Worth Inlet Navigation Pilot Study

CWWBS No.	Project Cost
01 Lands and Damages	$25,000.00
06 Fish and Wildlife Facilities	$11,523,477.84
10 Breakwaters and Seawalls	$2,092,426.91
12 Navigation Ports and Harbors	$49,857,742.17
30 Planning, Engineering, and Design	$2,074,400.00
31 Construction Management	$4,999,000.00
Total	$70,572,046.92

Category	Project Cost
Labor Cost	$2,463,474.20
Equipment Cost	$3,787,011.75
Material Cost	$3,147,343.43
Sub Bid Cost	$717,627.40
User Cost	$44,481,670.35
Direct Cost	$54,597,127.12
Contract Cost	$70,572,046.92
Project Cost	$70,572,046.92

Construction Costs	Project Cost
06 Fish and Wildlife Facilities	$10,492,574.01
10 Breakwaters and Seawalls	$2,092,426.91
12 Navigation Ports and Harbors	$49,857,742.17
Total	$62,442,743.09

Non-Construction Costs	Project Cost
01 Lands and Damages	$25,000.00
06 Fish and Wildlife Facilities	$1,030,903.83
30 Planning, Engineering, and Design	$2,074,400.00
31 Construction Management	$4,999,000.00
Total	$8,129,303.83


Contribution to Variance View
Sensitivity: PROJECT CONTINGENCY (BASELINE SCHEDULE)
-3.0%
0.0%
3.0%
6.0%
9.0%
12.0%
15.0%
18.0%
21.0%
24.0%
27.0%
ODMDS Capacity
24.0%
Projects Competing National...
18.9%
Blasting May Be Required
16.0%
Construction Schedule Accuracy
12.6%
Variation in Estimated Quan...
5.5%
Material Testing
5.3%
Equipment Availability
5.3%
Projects Competing for Reso...
4.1%
Jetty Slope Stability
3.4%
Delay in Obtaining Permits
2.4%
Production Estimates
1.3%
Multiple Contracts Possible
1.2%
* - Correlated assumption (sensitivity data may be misleading)

SAJ Lake Worth Inlet Navigation Pilot Study

July 2013

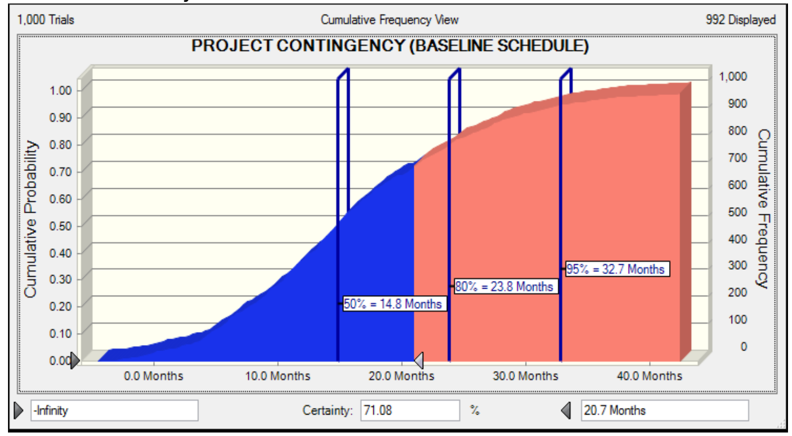
Risk No.	Risk/Opportunity Event	Project Schedule: Likelihood*	Impact*	Risk Level*	Variance Distribution	Correlation to Other(s)	Probability of Occurrence	Crystal Ball Simulation — Expected Values (Months): Low	Most Likely	High	Contingency Model	Notes	Expected Values (%s): Low	Most Likely	High
Internal Risks (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.)															
	PROJECT & PROGRAM MGMT														
PPM-4	Projects Competing for Resources	Likely	Marginal	MODERATE	Yes-No/Uniform		65%	0.0 Months	0.0 Months	4.0 Months	0.0 Months		0.00%	0.00%	7.08%
PPM-5	Projects Competing Nationally for Funding	Unlikely	Crisis	HIGH	Yes-No/Uniform		65%	0.0 Months	0.0 Months	12.0 Months	0.0 Months		0.00%	0.00%	21.24%
	CONTRACT ACQUISITION RISKS														
CA-2	Multiple Contracts Possible	Very Likely	Marginal	MODERATE	Triangular		100%	0.0 Months	0.0 Months	3.0 Months	0.0 Months		0.00%	0.00%	5.31%
	TECHNICAL RISKS														
TL-2	Blasting May Be Required	Unlikely	Crisis	HIGH	Yes-No/Uniform	TL-1, TL-8	20%	0.0 Months	0.0 Months	12.0 Months	0.0 Months	*Correlated to Risk TL-8 by a factor of 0.75*	0.00%	0.00%	21.24%
TL-8	Jetty Slope Stability	Unlikely	Significant	MODERATE	Yes-No/Uniform	TL-2	20%	0.0 Months	0.0 Months	6.6 Months	0.0 Months	*Correlated to Risk TL-2 by a factor of 0.75*	0.00%	0.00%	11.68%
	LANDS AND DAMAGES RISKS														
	REGULATORY AND ENVIRONMENTAL RISKS														
RE-2	Delay in Obtaining Permits	Likely	Marginal	MODERATE	Yes-No/Uniform	RE-3	65%	0.0 Months	0.0 Months	4.0 Months	0.0 Months	*Correlated to Risk RE-3 by a factor of 0.75*	0.00%	0.00%	7.08%
RE-3	ODMDS Capacity	Unlikely	Crisis	HIGH	Yes-No/Triangular	RE-2	35%	0.0 Months	0.0 Months	24.0 Months	0.0 Months	*Correlated to Risk RE-2 by a factor of 0.75*	0.00%	0.00%	42.47%
RE-7	Environmental Work Windows	Likely	Negligible	LOW	Uniform		100%	-6.0 Months	0.0 Months	0.0 Months	0.0 Months		-10.62%	0.00%	0.00%
RE-8	Material Testing	Unlikely	Significant	MODERATE	Yes-No/Uniform		10%	0.0 Months	0.0 Months	12.0 Months	0.0 Months		0.00%	0.00%	21.24%
	CONSTRUCTION RISKS														
CON-1	Variation in Estimated Quantities	Unlikely	Significant	MODERATE	Triangular		100%	-3.0 Months	0.0 Months	6.0 Months	0.0 Months		-5.31%	0.00%	10.62%
CON-4	Construction Schedule Accuracy	Likely	Critical	HIGH	Triangular		100%	-4.0 Months	0.0 Months	8.0 Months	0.0 Months		-7.08%	0.00%	14.16%
	ESTIMATE AND SCHEDULE RISKS														
EST-1	Production Estimates	Unlikely	Marginal	LOW	Triangular		100%	-2.0 Months	0.0 Months	4.0 Months	0.0 Months		-3.54%	0.00%	7.08%
	LOW AND UNKNOWN INTERNAL RISKS														
INT-1	Consideration for Low and Unknown Internal Risk	Likely	Marginal	MODERATE	Triangular		100%	-3.0 Months	0.0 Months	3.0 Months	0.0 Months		-5.31%	0.00%	5.31%
	Programmatic Risks														
PR-3	Severe Tropical Storms	Unlikely	Negligible	LOW	Yes-No/Triangular		35%	0.0 Months	0.0 Months	3.0 Months	0.0 Months		0.00%	0.00%	5.31%
PR-5	Communities May Not View the Project Favorably	Unlikely	Negligible	LOW	Yes-No/Uniform		35%	0.0 Months	0.0 Months	6.0 Months	0.0 Months		0.00%	0.00%	10.62%
PR-6	Equipment Availability	Unlikely	Significant	MODERATE	Yes-No/Triangular		35%	0.0 Months	0.0 Months	12.0 Months	0.0 Months		0.00%	0.00%	21.24%
EXT-1	Consideration for Low and Unknown External Risk	Likely	Marginal	MODERATE	Triangular		100%	-3.0 Months	0.0 Months	3.0 Months	0.0 Months		-5.31%	0.00%	5.31%
											0.0 Months				

variance from the assumption value to facilitate iteration of the model should the cost values change throughout the project phases. Uniform distribution percentages reflect variation from the total project cost.

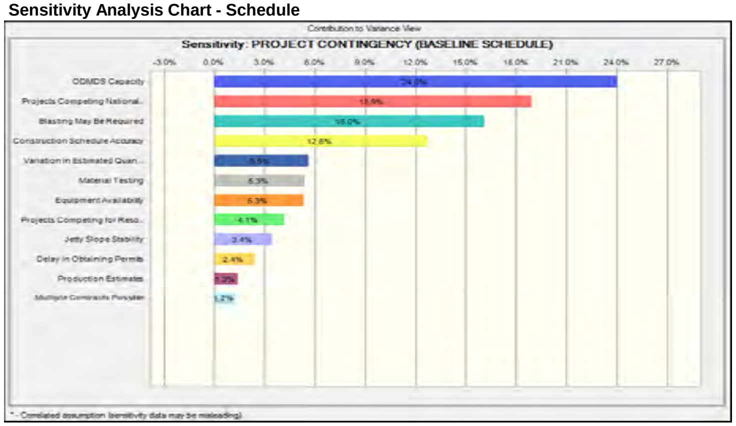
Contingency Summary Table - Schedule

PROJECT CONTINGENCY (BASELINE SCHEDULE)	Percentile	Baseline TPC	Contingency Amount	Baseline w/ Contingency	Contingency %
	0%	56.5 Months	-4.7 Months	**51.9 Months**	**-8.24%**
	5%	56.5 Months	1.7 Months	**58.2 Months**	**3.02%**
	10%	56.5 Months	4.5 Months	**61.0 Months**	**8.02%**
	15%	56.5 Months	6.2 Months	**62.7 Months**	**10.99%**
	20%	56.5 Months	7.7 Months	**64.2 Months**	**13.60%**
	25%	56.5 Months	9.1 Months	**65.6 Months**	**16.16%**
	30%	56.5 Months	10.5 Months	**67.0 Months**	**18.51%**
	35%	56.5 Months	11.4 Months	**67.9 Months**	**20.24%**
	40%	56.5 Months	12.6 Months	**69.1 Months**	**22.34%**
	45%	56.5 Months	13.7 Months	**70.2 Months**	**24.29%**
	50%	56.5 Months	14.8 Months	**71.3 Months**	**26.22%**
	55%	56.5 Months	15.7 Months	**72.2 Months**	**27.80%**
	60%	56.5 Months	17.1 Months	**73.6 Months**	**30.21%**
	65%	56.5 Months	18.3 Months	**74.8 Months**	**32.38%**
	70%	56.5 Months	20.5 Months	**77.0 Months**	**36.22%**
	75%	56.5 Months	22.0 Months	**78.5 Months**	**38.92%**
	80%	56.5 Months	23.8 Months	**80.3 Months**	**42.14%**
	85%	56.5 Months	26.0 Months	**82.5 Months**	**45.96%**
	90%	56.5 Months	28.6 Months	**85.1 Months**	**50.62%**
	95%	56.5 Months	32.7 Months	**89.3 Months**	**57.94%**
	100%	56.5 Months	58.1 Months	**114.7 Months**	**102.89%**

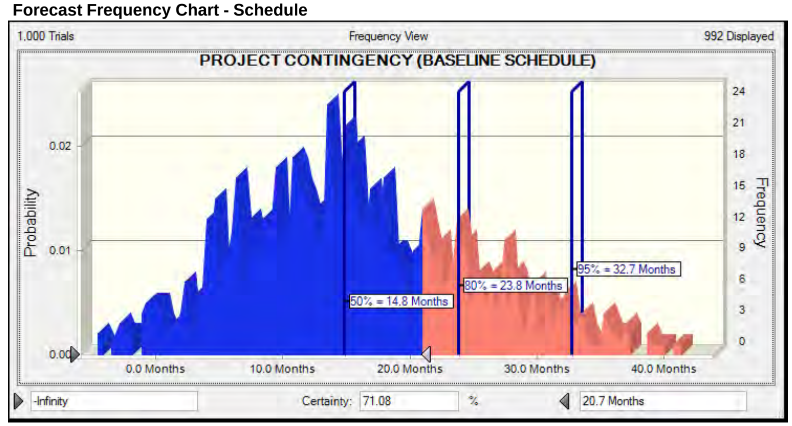
Cumulative Probability Forecast Chart - Schedule



Sensitivity Analysis Chart - Schedule



Forecast Frequency Chart - Schedule



APPENDIX C: Socio-Economic

LAKE WORTH INLET
Palm Beach Harbor

Lake Worth Inlet Feasibility Study

Socio-Economic Appendix

January 2014

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Attachments

Additional Response to Independent External Peer Review Final Panel Comment 1 .... A1-1

1 Introduction

Palm Beach Harbor is a deep-draft harbor located in Palm Beach County, on the lower Atlantic coast of Florida. The closest major ports to Palm Beach Harbor are Port Everglades, in Ft. Lauderdale, and Miami Harbor, approximately 40 miles and 65 miles to the south, respectively (Figure 1). Canaveral Harbor is approximately 90 miles to the north.

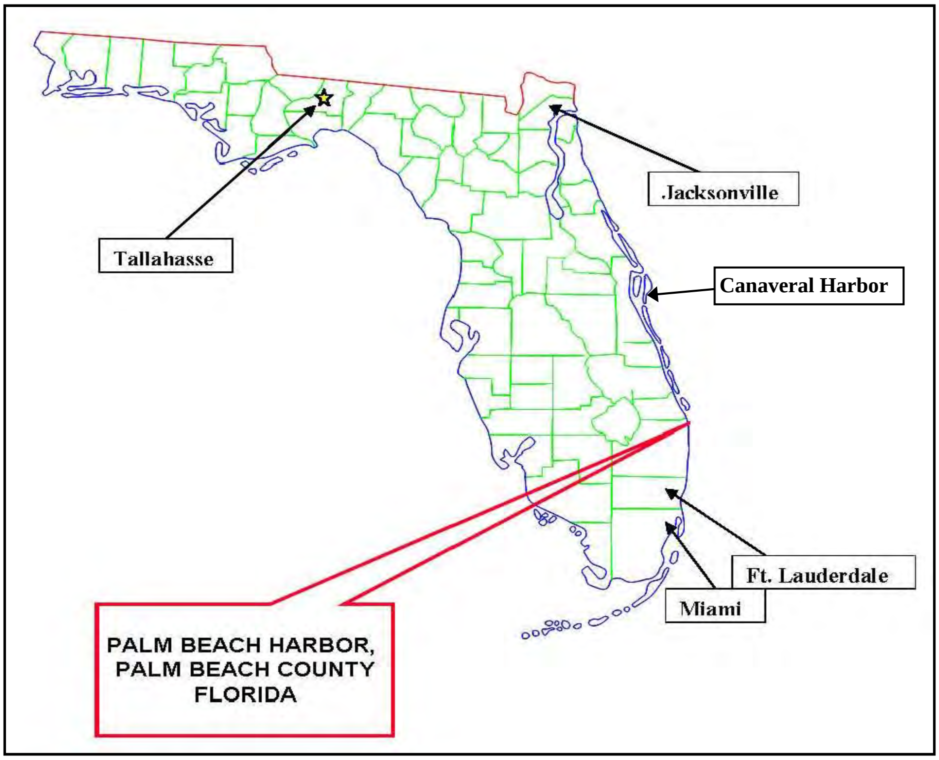


Figure 1. Project Location Map
Note: Locations are approximate.

The harbor entrance (known officially as Lake Worth Inlet) is an artificial cut through the barrier beach connecting Lake Worth, a coastal lagoon, with the Atlantic Ocean. The Atlantic Intracoastal Waterway passes through Lake Worth as well. Lake Worth Inlet contains a Federally-authorized channel, turning basin, and associated features which support a deepwater port, the Port of Palm Beach.

Communities bordering Palm Beach Harbor are Palm Beach Shores on the barrier island, Singer Island, to the north, Riviera Beach on the west shore of Lake Worth, and the town of Palm Beach on the barrier island to the south (Figure 2). West Palm Beach is located immediately south of Riviera Beach and is the largest community in the area.

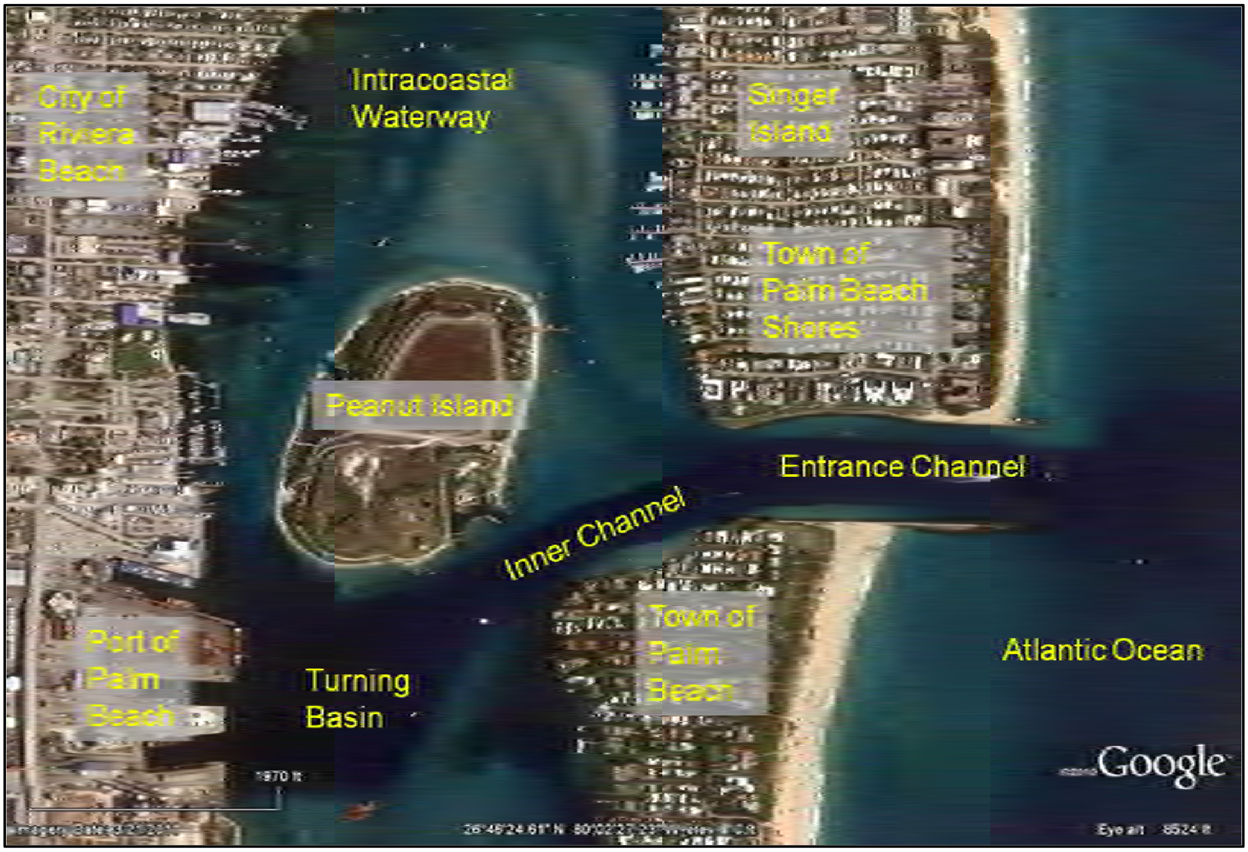


Figure 2. Detailed Project Area and Immediate Surrounding Towns Map

The existing Federal project at Palm Beach Harbor authorizes the maintenance of the inner channel and turning basin to a depth of 33 FT mean lower low water (MLLW). This feasibility study is evaluating the economic benefits of widening and deepening the existing channel and turning basin. To quantify these benefits, a computer simulation model called HarborSym[1] was used to model and simulate vessel traffic in the harbor over varying project conditions.

2 Background

The Port of Palm Beach is a niche port, meaning, a relatively small number of commodities make up a large portion of the total tonnage that transits through the port. For example, cement and concrete, molasses, sugar, and petroleum products represented only 10.1% of vessel calls in 2007. However, these same four commodity groups accounted for 59.7% of total tonnage that year. Niche ports also specialize in a particular cargo or market segment. In the case of Palm Beach, the Port is also home to an overnight cruise service to the Bahamas, a day-cruise that sails twice daily, and a containership operator that services the Caribbean islands on small container vessels. Palm Beach is also a niche port because of the specialized equipment for handling sugar and molasses, which no other port in South Florida can accommodate. Finally, the Port of Palm Beach has embraced its “niche port” status by further investing in assets suited to its target customers of smaller cargo and cruise operators.

[1] HarborSym Deepening Model, version 1.4.8, U.S. Army Corps of Engineers

The existing federal project (Figure 3) has a configuration that limits the maximum vessel draft, due to the authorized project depth of 33 FT, and vessel length, due to a sharp turn from the channel entrance into Lake Worth. Both of these limitations cause corresponding sailing restrictions, imposed by the Palm Beach Harbor Pilots Association, who pilot all foreign-flagged vessels and all deep-draft U.S.-flagged vessels transiting the harbor.

Figure 3. Lake Worth Inlet Authorized Project Map and Surrounding Area Features

The harbor pilots' existing restrictions are summarized in Table 1. These rules show that as cargo vessels increase in size, they face greater restrictions in terms of tide and current conditions, draft restrictions, and use of tugs, which means that the vessel will have less available time to transit through the harbor, and/or the entire voyage will be more costly. Additionally, large vessels may be forced to call light-loaded to either avoid restrictions or to even transit the harbor at all. All of these constraints increase total transportation costs. Therefore, this appendix is examining the economic benefits from transportation cost savings due to a wider and deeper navigation channel.

Table 1. Summary of Pilots' Rules for Without-Project Conditions

Rule #	Rule Description	Ship Types/Classes Affected	Applicable Condition	Tide Dependent?	Current Dependent?
1	One Way Traffic Only: No Passing, No Overtaking	All Vessels	Always	N	N
2	>= 600' LOA: Daylight Inbound Transit Only	All Single-screw Vessels >= 600' LOA	Daylight	N	N
3	>30' Sailing Draft: Restricted to High Slack Water (+/-0.5hrs); Daylight Inbound Transit Only	All Single-screw Vessels >30' Sailing Draft	Always/ Daylight	Y	Y
4	3rd Tug MAY be Req'd for ships >=600' LOA and >=28' Draft	All Single-Screw Vessels meeting dimension criteria	Always	N	N
5	3rd tug MAY be req'd for ships >=550' LOA and >30' draft OR >=85' beam and >30' draft	All Inbound Single-Screw Vessels meeting dimension criteria	Always	N	N
6	Petroleum-carrying vessels restricted to slack water only (+/-0.5hrs); daylight transit only	All Petroleum-carrying Tankers and Barges	Daylight	N	Y
7	Inbound Petroleum-carrying vessels restricted to 32'0" max sailing draft in high slack water, and 29'0" in low slack water	All Inbound Petroleum-carrying Tankers and Barges	Always	N	N
8	Large Cruise vessel restricted to slack-water (<2kts) transit when winds >=30 knots, and local tug may be required	Cruise - Bahamas Celebration	Always	N	Y
9	Safety Distance: 1/4 Mile fore and aft of all vessels	All Vessels	Always	N	N
10	33' 0" Max Sailing Draft at High Slack Water; 30' 0" Max Sailing Draft at low slack water	All (non-petroleum-carrying) Vessels	Always	Y	Y

Source: Palm Beach Harbor Pilots Association

2.1 General Study Area

While the footprint of the project is contained within Palm Beach Harbor, the surrounding area that will be most directly affected economically by the project includes a majority of Palm Beach County. Figure 4, below, shows the nearby cities within Palm Beach County. All labeled Florida counties are shown in Figure 5.

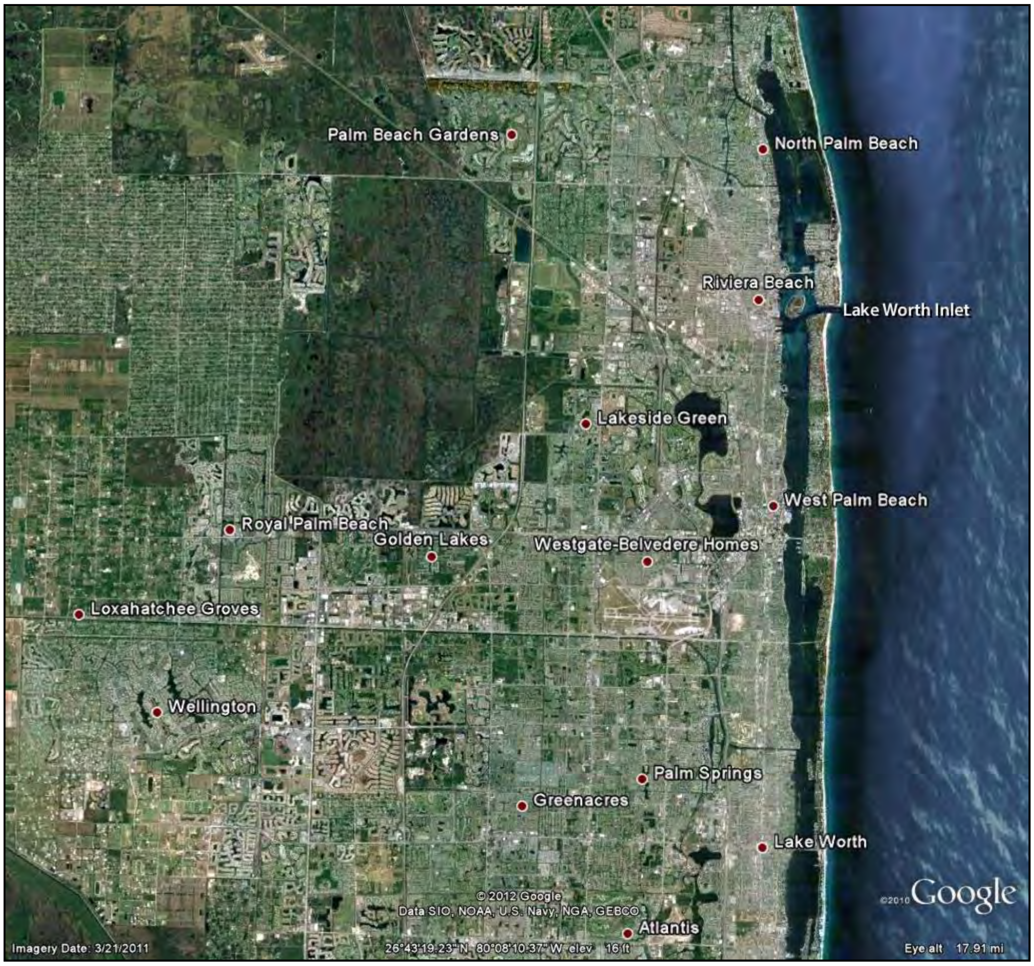


Figure 4. Map of Lake Worth Inlet Surrounding Cities and Towns in Palm Beach County, Florida

The level of hinterland population is an important factor in determining demand for consumption of goods that transit through the port. West Palm Beach has the greatest population in the immediate area, (Table 2), followed by the town of Lake Worth, further to the south. The rest of the most populous coastal South Florida counties, Broward and Miami-Dade, which are home to the cities of Ft. Lauderdale and Miami respectively, are even more heavily-populated metropolitan areas than Palm Beach County.

Table 2. Population of Selected Florida Counties and Census County Divisions within Coastal South Florida

Area	Population (2010)
Florida	18,801,310
Palm Beach County	1,320,134
West Palm Beach CCD	142,518
Riviera Beach CCD	101,148
Lake Worth CCD	207,482
Royal Palm Beach-West Jupiter CCD	103,335
Broward County	1,748,066
Ft. Lauderdale CCD	282,219
Miami-Dade County	2,496,435
Miami	908,839

Source: U.S. Census Bureau, 2010 Note: CCD = Census County Division

Figure 5. Florida Counties Map
Source: U.S. Census Bureau

2.1.1 Demographics

Population growth in the area has been rapid since 1950 (Table 3). This growth can be attributed to Florida's ideal climate and historically low property costs. Over the last 60 years Palm Beach County population increased from 114,688 to 1,320,134, an increase of over 1000%. Due to a more established community, Miami-Dade County achieved less growth than Palm Beach County, or the State as a whole. As seen in Table 3, Florida grew over 500% in the 60-year span. For the nine-county region shown, population statistics for the past sixty years are presented in Table 3.

Table 3. Historical Population Growth Statistics for Select South Florida Counties

Area	2010		2000		1990		1980		1970		1960		1950	
Florida	18,801,310		15,982,378		12,937,926		9,746,324		6,789,443		4,951,560		2,771,305	
	Population	%	Population	%	Population	%	Population	%	Population	%	Population	%	Population	%
Glades	12,884	0.2%	10,576	0.2%	7,591	0.2%	5,992	0.2%	3,669	0.1%	2,950	0.2%	2,199	0.3%
Hendry	39,140	0.7%	36,210	0.6%	25,773	0.6%	18,599	0.5%	11,859	0.5%	8,119	0.5%	6,051	0.8%
Lee	618,754	10.8%	440,888	7.7%	335,113	7.2%	205,266	5.7%	105,216	4.3%	54,539	3.3%	23,404	3.1%
Martin	146,318	2.6%	126,731	2.2%	100,900	2.2%	64,014	1.8%	28,035	1.1%	16,932	1.0%	7,807	1.0%
Miami-Dade	2,496,435	43.5%	2,253,362	39.3%	1,937,094	41.8%	1,625,781	45.2%	1,267,792	51.8%	935,047	57.2%	495,084	64.6%
Monroe	73,090	1.3%	79,589	1.4%	78,024	1.7%	63,188	1.8%	52,586	2.1%	47,921	2.9%	29,957	3.9%
Broward	1,748,066	30.5%	1,623,018	28.3%	1,255,488	27.1%	1,018,200	28.3%	620,100	25.3%	333,946	20.4%	83,933	10.9%
Okeechobee	39,996	0.7%	35,910	0.6%	29,627	0.6%	20,264	0.6%	11,233	0.5%	6,424	0.4%	3,454	0.5%
Palm Beach	1,320,134	23.0%	1,131,184	19.7%	863,518	18.6%	576,863	16.0%	348,753	14.2%	228,106	14.0%	114,688	15.0%
County SubTotal	6,494,817	40.6%	5,737,468	35.9%	4,633,128	35.8%	3,598,167	36.9%	2,449,243	36.1%	1,633,984	33.0%	766,577	27.7%

Source: U.S. Census Bureau

As a subset of Florida population, the summed total of these nine counties comprises a slowly increasing percentage of the Florida population over most of the period. Even though the populations of the counties have been increasing in absolute numbers, their share of Florida's population did not change substantially over the period from 1970-2000. From 2000 to 2010, the regional share of Florida population resumed increased at its fastest pace to its highest percentage ever, 40.6%.

Additionally, the proportional share of the population inside the nine country area has changed over the fifty year time period. Miami-Dade County's share of the nine-county population total population has declined from nearly 65% in 1950 to 43.5% in 2010. In contrast, Broward County's and Lee County's share of the regional total has increased nearly three-fold over the sixty-year period. Palm Beach County's share of the nine-county population has increased 8% over the last fifty years (over a 50% increase in share). While each county has seen an increase in its total population, the most rapid growth in population has been concentrated in Palm Beach, Broward, Martin, and Lee counties.

Of the total population of Florida, approximately 17% classify themselves as African Americans while 22.5% classify their heritage as Hispanic or Latino (Table 4). In the nine-county region, the populations of Miami-Dade and Broward counties contained some 49% of the Florida Latino population and some 31% of the Florida African American population. As a percentage, Hendry County' Latino population was almost double that of the Florida state average but the county has a significantly smaller total population when compared to Miami-Dade and Broward counties. Palm Beach County race and ethnicity percentages are the most similar to the state levels of the counties shown.

Table 4. Population Breakdown by Race and Ethnicity for Select South Florida Counties

County	White	African-American	Other	Total	Hispanic or Latino (of any race)
Florida	77.1%	17.0%	5.9%	100%	22.5%
Glades	72.4%	12.7%	14.9%	100%	21.1%
Hendry	62.1%	14.0%	23.9%	100%	49.2%
Lee	84.8%	9.1%	6.1%	100%	18.3%
Martin	88.6%	5.9%	5.5%	100%	12.2%
Miami-Dade	75.6%	19.9%	4.5%	100%	65.0%
Monroe	91.1%	6.3%	2.6%	100%	20.6%
Okeechobee	79.2%	8.6%	12.2%	100%	23.9%
Palm Beach	75.2%	18.3%	6.5%	100%	19.0%
Broward	65.1%	28.2%	6.7%	100%	25.1%

Source: U.S. Census Bureau, 2010

In the immediate project area, large differences in age from one census tract to another are clearly shown in Figure 6. The barrier islands and western suburbs have a relatively older population, while the more urban areas of Riviera Beach, West Palm Beach, and Lake Worth have a relatively younger population. Few areas shown are close to the national average, and most are highly polarized towards a younger or older population. This polarization is especially evident in the areas closest to the project.

Comparing median household incomes in the same area (Figure 7) shows a similar pattern to the polarization in median ages between census tracts. A notable exception is that the western suburban areas exhibit higher household incomes, while also having a relatively lower median age. Otherwise, with a few exceptions, there is a clear pattern of relatively younger areas having lower household incomes, especially in the areas closest to the project.

A similar pattern of median household income increasing with median age is exhibited across the three most populous counties in coastal South Florida. When median age is viewed at the county level (Figure 8), median age increases from Miami-Dade County to Broward County to Palm Beach County, and even further north to Martin County. Median household income also increases from Miami-Dade County northward (Figure 9). Palm Beach County has the highest median age and household income of the three most populous counties in coastal South Florida

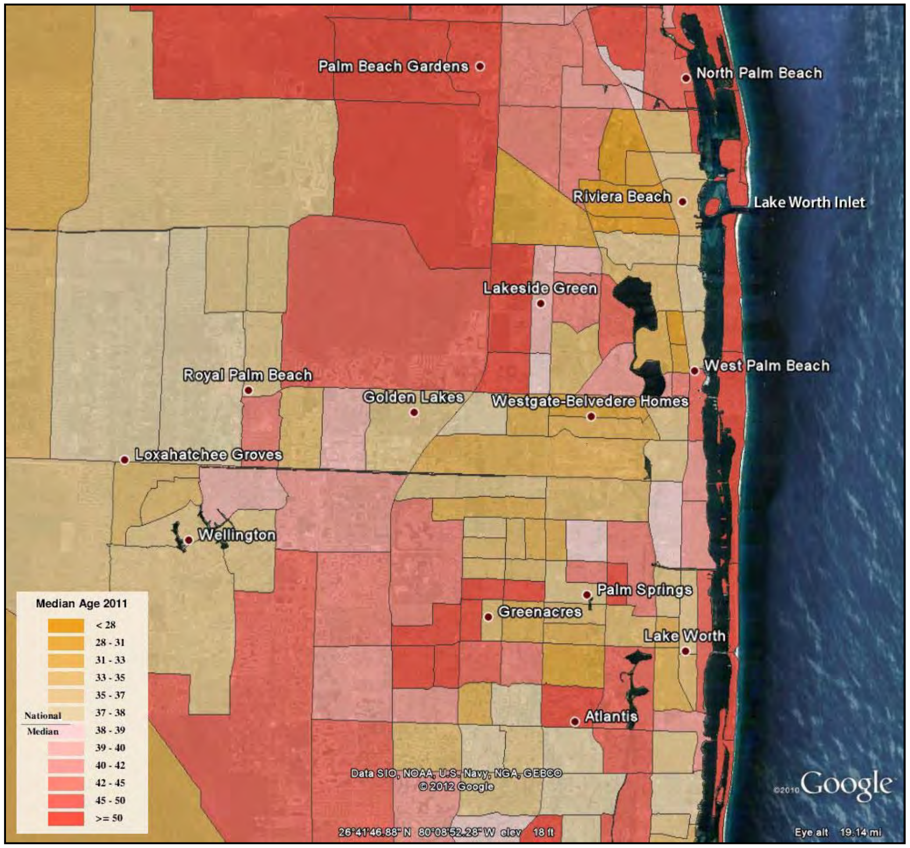


Figure 6. Palm Beach County Area Median Age by Census Tract
Source: The Nielsen Company, 2011

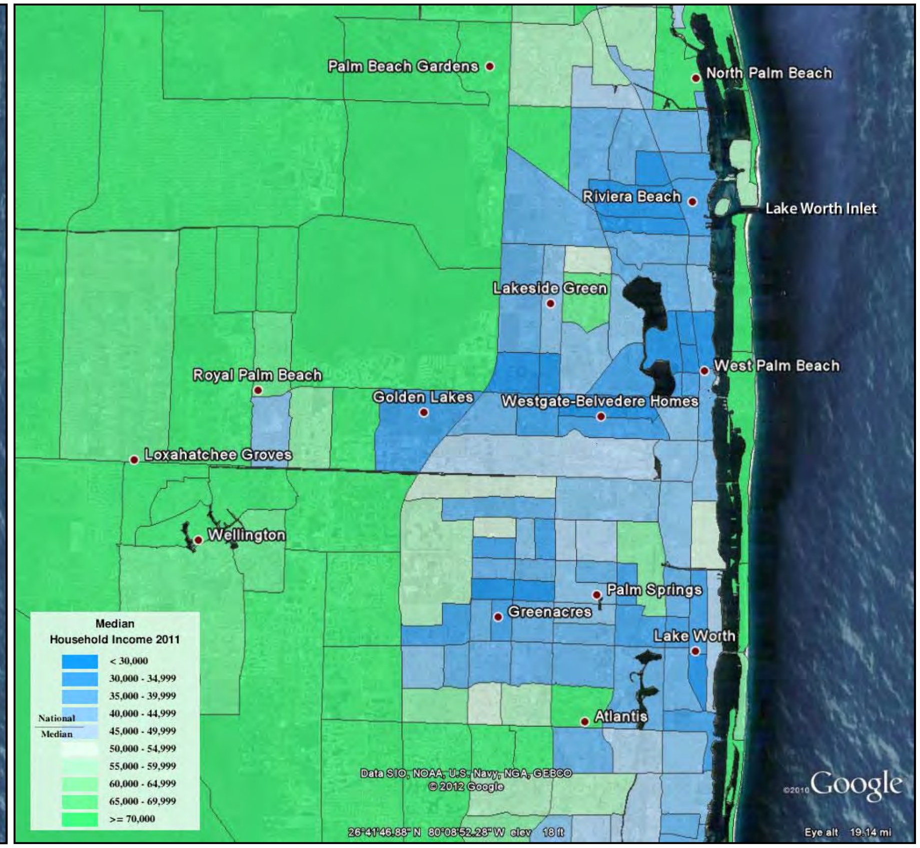


Figure 7. Palm Beach County Area Median Household Income by Census Tract
Source: The Nielsen Company, 2011

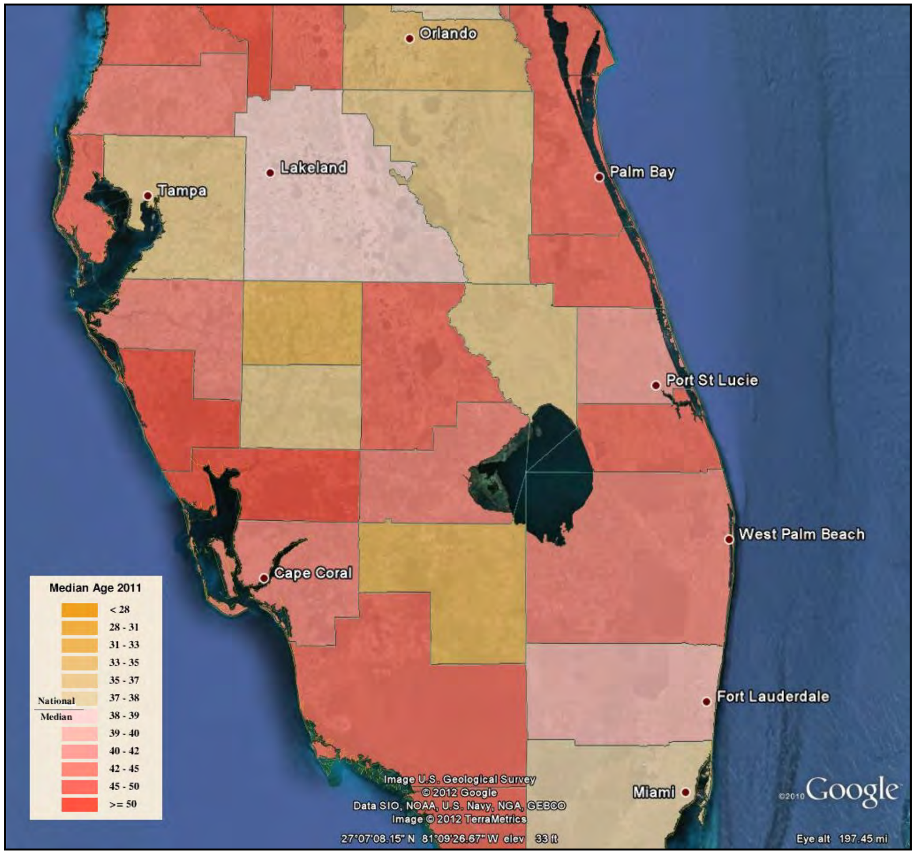


Figure 8. South Florida Median Age by County
Source: The Nielsen Company, 2011

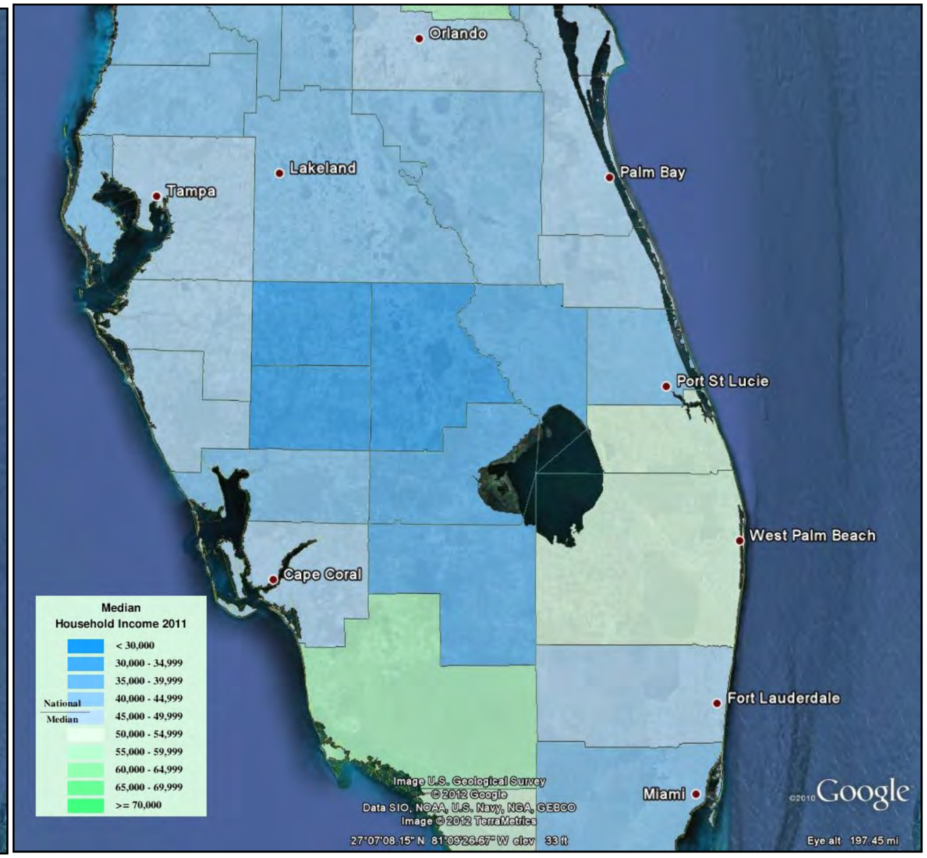


Figure 9. South Florida Median Household Income by County
Source: The Nielsen Company, 2011

2.1.2 Local Economy

Generally, tourism, strong wholesale and retail trade, government and service sectors characterize Florida's economy. Florida's warm weather and extensive coastline attracts vacationers and other visitors and helps make the state a significant retirement destination for people all over the country. Agricultural production is also an important sector of the state's economy, and is especially significant to portions of the study area. Compared to the national economy, the manufacturing sector has played less of a role in Florida, but high technology manufacturing has begun to emerge as a significant sector in the State over the last decade.

Of the nine counties shown in Table 5, the three largest, Broward, Miami-Dade and Palm Beach employ approximately 35% of Florida's work force and account for approximately 33% of state income. Table 6 indicates the importance of relatively low paying employment in the three counties of greatest economic impact. The results coincide with state averages across employment sectors and reflect the relative importance of industries related to tourism (retail, food service), the aged populations of South Florida (health care) and the growth experienced in Florida (construction).

Table 5. Employment as a Percentage of State Employment for Select South Florida Counties

County	Number of Wage & Salary Employees	Annual Wage & Salary Disbursements ($1,000)	Employee Percentage	Annual Salary Percentage
Florida	7,632,084	323,659,342	100%	100%
Glades	1,938	66,153	0.03%	0.02%
Hendry	14,224	418,654	0.19%	0.13%
Lee	208,538	8,238,828	2.73%	2.55%
Martin	59,631	2,378,068	0.78%	0.73%
Miami-Dade	1,038,010	48,445,712	13.60%	14.97%
Monroe	37,959	1,513,204	0.50%	0.47%
Okeechobee	11,016	364,625	0.14%	0.11%
Palm Beach	542,388	25,182,540	7.11%	7.78%
Broward	745,587	33,403,592	9.77%	10.32%
Select Counties Subtotal	2,659,291	120,011,376	35%	37%

Source: U.S. Bureau of Economic Analysis, 2010

Table 6. Employment by Industry for Three Major South Florida Counties

Industry	Broward County	Miami-Dade County	Palm Beach County	Three-County Total	Percentage of Employment by Industry
Health Care & Education	171,463	217,787	123,750	513,000	21%
Retail Trade	112,360	130,845	81,326	324,531	13%
Professional & Administration	108,344	134,619	81,209	324,172	13%
Food Service & Hospitality	86,607	112,057	63,721	262,385	11%
Construction	49,957	74,255	39,760	163,972	7%
Manufacturing	40,905	54,937	22,709	118,551	5%
Major Industry Sub-Total	398,173	506,713	288,725	1,193,611	48%
Total	826,452	1,075,625	577,572	2,479,649	100%

Source: 2010 U.S. Census Bureau American Community Survey.

2.1.3 Hinterland Demand for Specific Goods

The hinterland of the Port of Palm Beach for construction materials (cement and asphalt) includes undeveloped land north and west of the Port in Palm Beach and Martin counties. Generally, dry bulk construction materials are low-value per ton, which cause a tendency for shippers to import the goods as close to construction sites as possible. The proximity of the Port is also close to other high growth areas in Florida such as Indian River, Osceola, and Orange Counties, which are home to the cities of Vero Beach, Kissimmee, and Orlando, respectively. The expanded market of the Port of Palm Beach for construction materials is due to several factors. First, the shipper that receives asphalt at the port is vertically integrated with a construction company, which allows the construction company to receive asphalt at a lower cost, and for the shipper of asphalt to reach a larger market, from "Miami to Orlando," according to the shipper[2]. Second, dry bulk construction materials can be loaded directly to rail cars, which offer significant cost advantages over movement by truck. On-dock rail access for dry bulk shipments provides the Port of Palm Beach with a cost advantage in shipping low-value, high-tonnage goods compared to other south Florida ports and Port Canaveral. In 2010, the U.S. Census Bureau estimated the Orlando-Kissimmee Metropolitan Statistical Area to have over 2.1 million people. Future population projections for surrounding counties are shown in Table 14 in Section 4. One Port tenant that imports asphalt owns a subsidiary construction company that does business all over south Florida, and up to the Orlando metropolitan area. The Port is also in close proximity to highly-populated Broward and Miami-Dade counties. Figure 10, below, shows the spatial relationship of Palm Beach County to its neighboring hinterland counties.

[2] Source: Interviews with Port of Palm Beach tenants, August 30th, 2011.

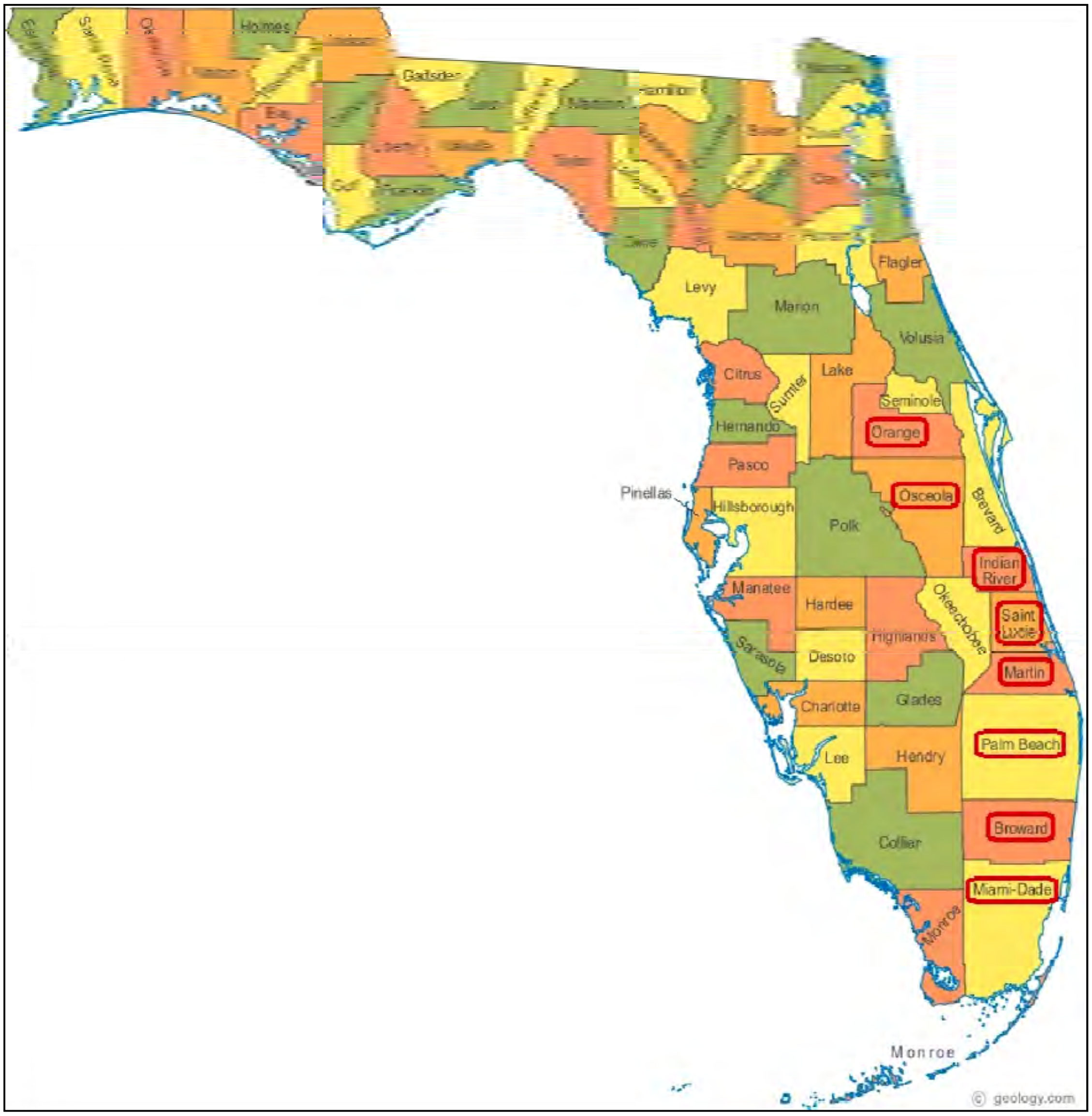


Figure 10. Florida Counties and Hinterland of Port of Palm Beach
Background Image Source: Geology.com; Note: Port of Palm Beach Hinterland County names are circled in red.

2.1.4 Hinterland Transit Connections

Compared to Port Everglades and Port of Miami the Port of Palm Beach has similar access to road connections. Major highway corridors of Interstate-95 and Florida's Turnpike run north and south through the county (Figure 11). Florida East Coast (FEC) and CSX rail lines both service the Port and immediate surrounding area, as well as other parts of Florida and link with the national rail network. The Port of Palm Beach is the only South Florida port to have on-dock rail access as of the writing of this report. However, both Port Everglades and Port of Miami have on-dock Intermodal Container Transfer Facility (ICTF) projects in development. Neither Port Everglades nor Port of Miami is developing on-dock rail access for dry bulk construction materials.

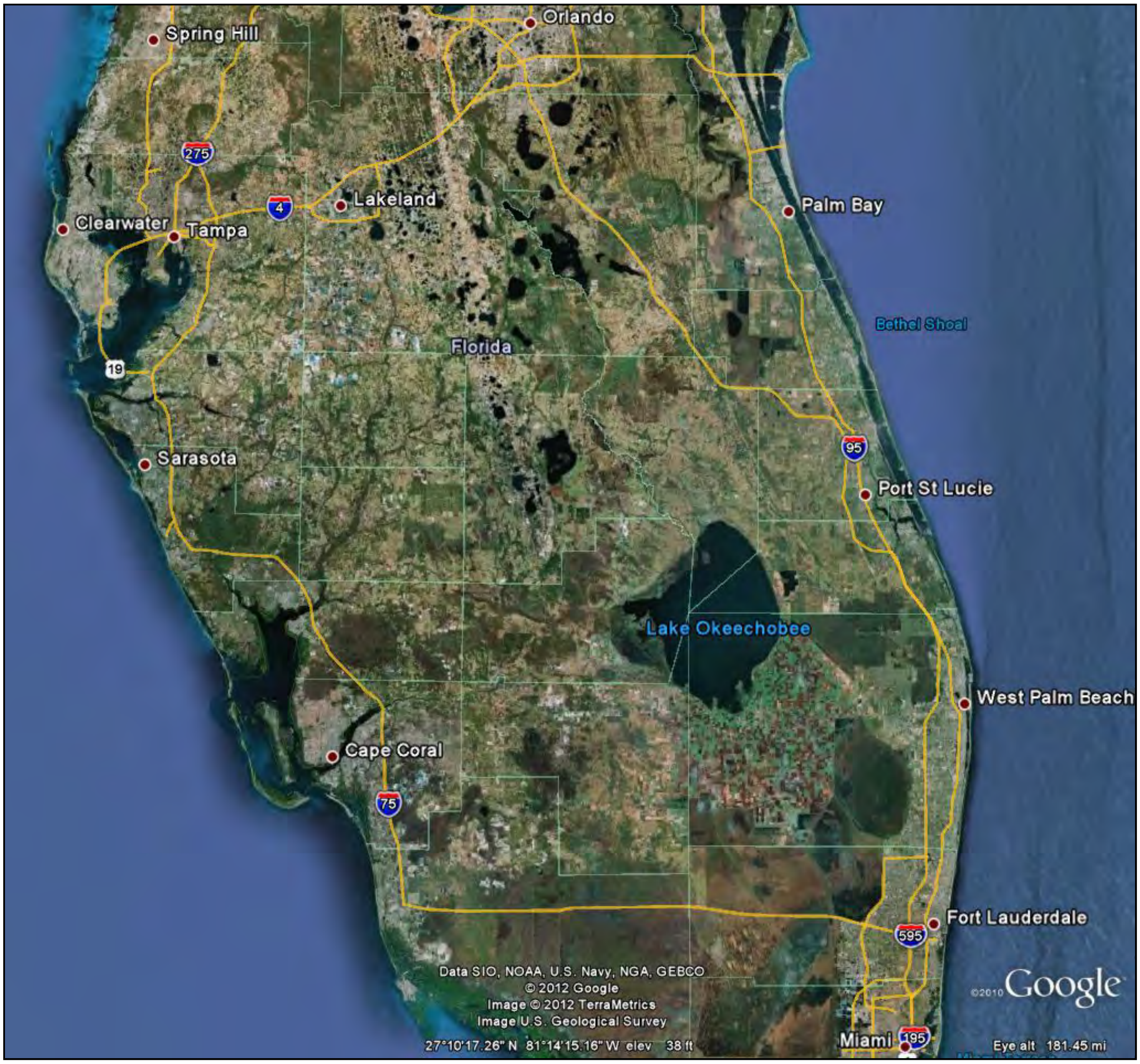


Figure 11. South Florida Major Roadways

Figure 12 shows an approximation of the inland movements of maritime cargo by truck through the Port of Palm Beach, Port Everglades, and Port of Miami. Tonnages shown are inbound and outbound, and were approximated by the Department of Transportation using a highway transportation network model. Most goods stay within, or originate from, the South Florida hinterland, followed by the rest of the State of Florida. Other states that send or receive the most goods to and from South Florida ports by truck are Georgia, Texas and New York, followed by North Carolina and Michigan to a lesser extent. Notice the arterial-looking nature of the highway system. Interstates 95, 75, 10, 77, and 24 are clearly visible as direct trucking routes with heavy annual cargo flows to and from South Florida ports. Even though this map is dated 1998, it still serves as a good representation of the movement of cargo by truck into and out of South Florida ports.

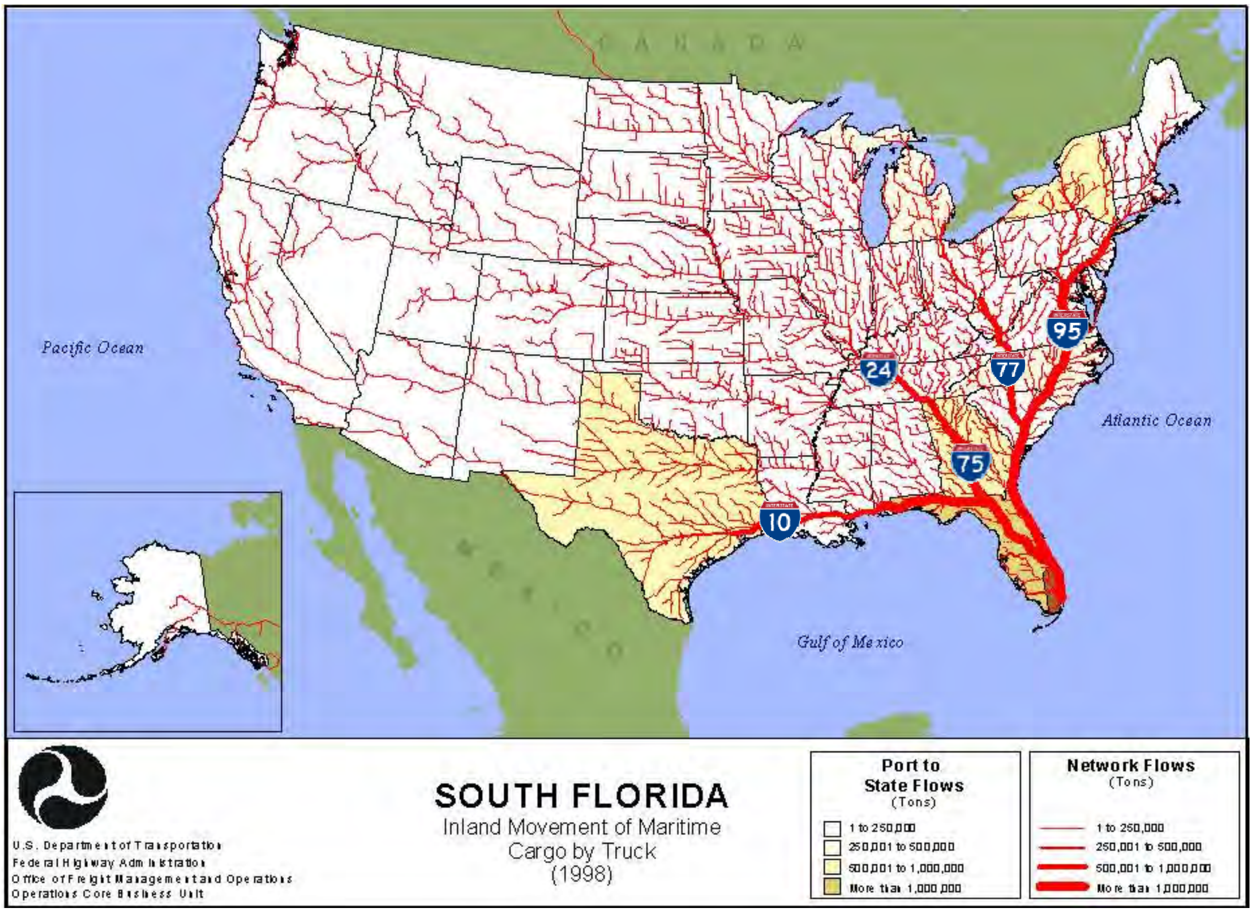


Figure 12. South Florida Inland Movement of Maritime Cargo by Truck

Source: U.S. Department of Transportation, Federal Highway Administration, Office of Freight Management Operations

2.2 Existing Port Facilities

The Port of Palm Beach handles passengers, general cargo, containerized cargo and liquid and dry bulk cargo. The top commodities handled at the port include receipts of petroleum products (residual fuel oil, diesel, and asphalt) and cement, and out-bound shipments of food and farm products, including sugar and molasses. The existing berths and land-side port facilities are shown in Figure 13. The port facilities in Palm Beach Harbor consist of four wharves (North Marginal Wharf, Main Marginal Wharf, Mid Marginal Wharf and South Marginal Wharf), three slips (Slip 1, 2 and 3) and 17 berthing areas. The current site consists of approximately 156 total acres of land.

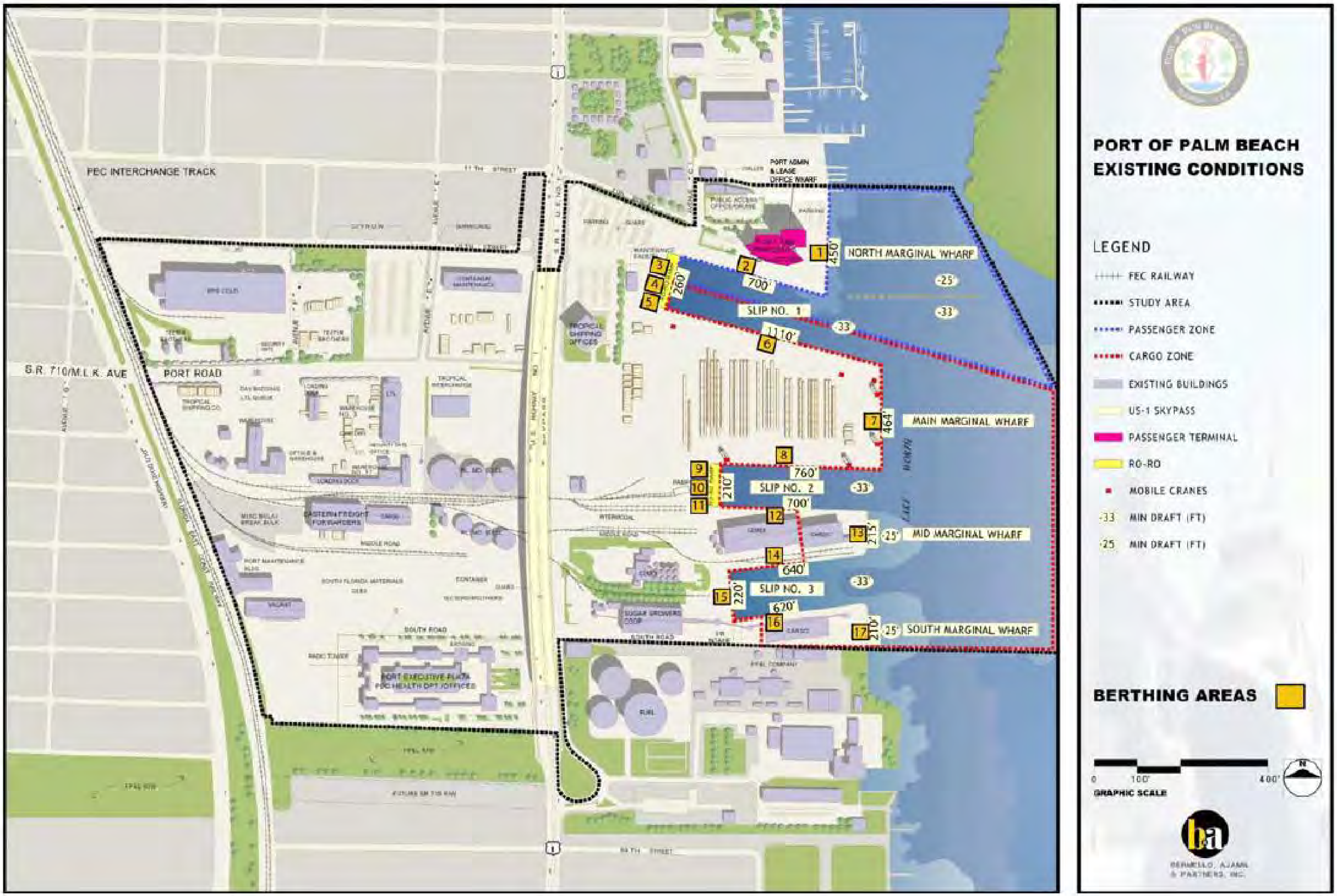


Figure 13. Port of Palm Beach Existing Facilities and Berth Configuration
Source: Port of Palm Beach Master Plan 2005-2015, February 2006.

Existing terminal facilities and berthing areas at Palm Beach Harbor and the types of cargo moved at each berth are described in the following list.

- North Marginal Wharf (Berth 1) – used exclusively for smaller day cruise vessels; it was previously occupied by the *Palm Beach Princess*, which had two scheduled off-shore sailings per day. The service catered primarily to the local gaming market. Another day cruise vessel has already begun operating and is assumed to be in place throughout the 50-year planning horizon.
- Slip 1 (Berths 2-6) – used by Tropical Shipping for container and Ro/Ro cargoes. The north side of the slip (Berth 2) is also used for the Bahamas Celebration, a cruise ship that transits to Freeport, Bahamas every other day from the Port of Palm Beach. Slip 1 is also used by small general cargo ships.
- Main Marginal Wharf (Berth 7) – used primarily by Tropical Shipping and small general cargo ships.
- Slip 2 (Berths 8-12) – generally an overflow slip for vessels that cannot be accommodated by slips 1 and 3. Slip 2 is primarily used by smaller Ro/Ro vessels as well as general cargo vessels. It is also used by Tropical Shipping, as needed.
- Mid Marginal Wharf (Berth 13) – used in conjunction with slips 2 and 3 by small general cargo ships.
- Slip 3 (Berths 14-16) – the major berth of the Port for all bulk cargoes, especially those on vessels with sailing drafts over 25 ft; primarily used for cement and fuel receipts and for shipments of sugar and molasses. Diesel and asphalt is also received at Slip 3. Large general cargo vessels carrying project cargo or other large break bulk will also use Slip 3.
- South Marginal Wharf (Berth 17) – primarily used by small general cargo ships.

The Port of Palm Beach has specialty equipment and storage areas for loading and storing the largest volume commodities that transit through the port. Residual fuel oil can be stored on-site in tanks at FPL's power generation facility, or transported via pipeline to a larger off-site holding facility where it can then be transferred via pipeline to FPL's Martin County power generation facility. Diesel fuel tanks at the port hold approximately 160,000 barrels (about 22,000 metric tons). Asphalt tanks at the port hold approximately 200,000 barrels (about 33,000 metric tons). Since the diesel and asphalt tanks are usually not completely empty when a petroleum tanker arrives at the port, the maximum amount of diesel or asphalt that a vessel is reasonably expected to unload in a single vessel call is between 130,000 barrels and 145,000 barrels (about 17,333 metric tons and 19,500 metric tons) for diesel, and from 150,000 barrels to 175,000 barrels (about 24,400 metric tons to 28,666 metric tons) for asphalt. Additionally, there is capacity for approximately 31,900 metric tons of cement in silos, 18,100 metric tons of cement in a warehouse facility, and storage for a large quantity of aggregate on the dock area between Slip 2 and Slip 3.

Other land-side facilities at the Port include specialty equipment for storing sugar and molasses and loading sugar and molasses onto vessels. Sugar and molasses are produced in the agricultural areas of Palm Beach County and central and southern Florida. The Port of Palm Beach is the only nearby port with equipment to load sugar and molasses onto ocean-going vessels. There are 6 steel molasses tanks with 11.5 million gallons (approximately 61,400 metric tons) total capacity, with pipelines connecting them to the south side of Slip 3. There is about 20,865 metric tons of storage capacity for sugar with a conveyor to the south side of Slip 3.

2.3 Multi-port Analysis

The closest major ports to Palm Beach Harbor are Port Everglades and Miami Harbor to the south and Port Canaveral to the north. Figure 14, below, shows that the Port of Palm Beach is in close proximity to larger and deeper draft ports with much greater cargo throughput at Port Everglades and Miami to the south. To the north, the next major port after Port Canaveral is Jacksonville. Port of Palm Beach is a niche port with regard to vessels calls, cargo-types, and passengers, as explained in Section 2. This means that its cargo does not normally compete directly with other nearby ports, and therefore growth at the Port of Palm Beach will not affect growth in Port Everglades or Miami, which share the same hinterland.

The Port of Palm Beach has a niche containership cargo carrier with Caribbean trade routes. However, these vessel types are limited to feeder-size vessels, with the largest size of 1700 TEUs that have design drafts of 33 ft. Port Everglades and Port of Miami collectively serve longer international trade routes with Northern Europe, the Mediterranean, Asia, and Central and South America. Furthermore, the Port of Palm Beach is the only port in South Florida with facilities to move sugar and molasses.

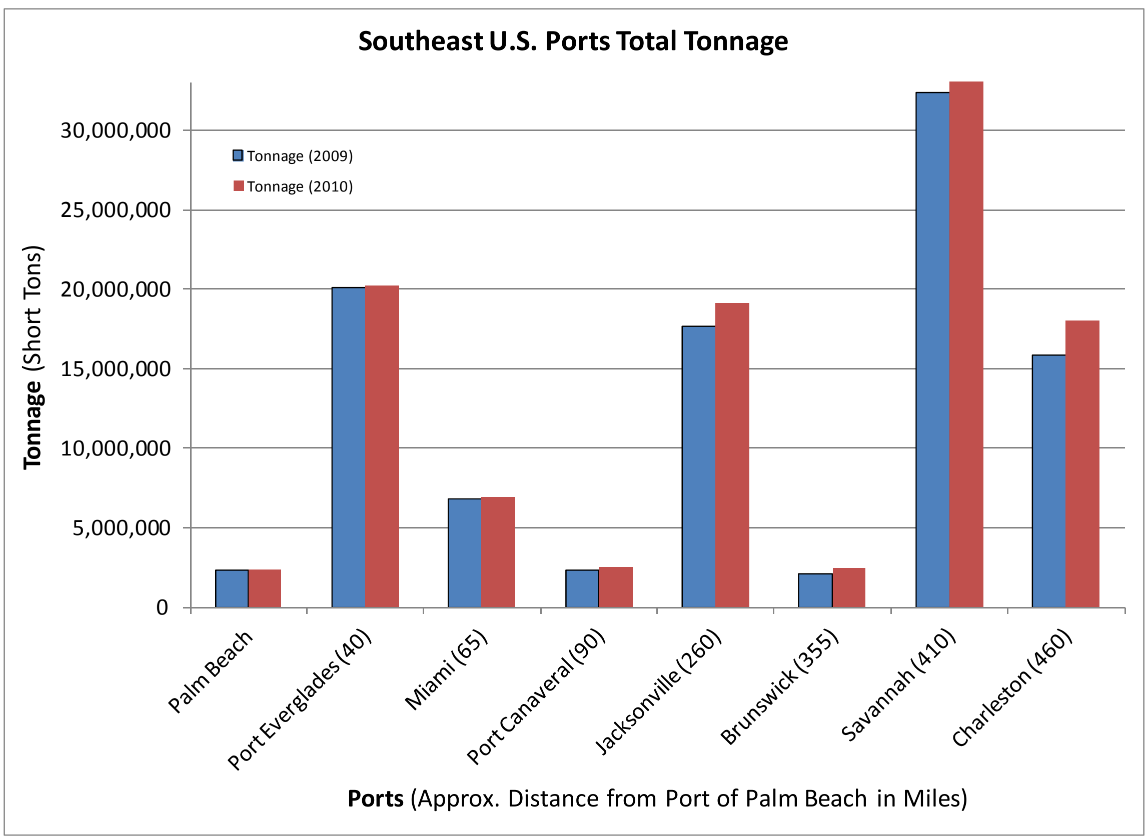


Figure 14. South Atlantic U.S. Ports Total Tonnage
Source: Waterborne Commerce Statistics Center

3 Existing Conditions

3.1 Historical and Existing Commodity Movements

Table 7 shows the total annual commodity tonnages at the Port for the period 1996 through 2010, and the associated annual growth rate for each year. The compound annual growth rate (CAGR) from 1996 to 2010 is also shown at 0.25 percent. Between 1996 and 2003 the Port's total annual tonnage rose from 2.29 million short tons to 4.36 million short tons, with a CAGR of 9.62 percent. Total commodity tonnage declined by 2008 to 2.38 million short tons, with a CAGR from 2004 to 2008 of -12.99 percent.

Table 7. Historical Total Tonnages for Port of Palm Beach and Annual Growth Rates

Port of Palm Beach Total Annual Cargo Tons (short tons)		
Year	Total Tons (in 1000s)	Annual Growth Rate (year-to-year)
1996	2294	
1997	2922	27.4%
1998	3149	7.8%
1999	3352	6.4%
2000	2950	-12.0%
2001	3518	19.3%
2002	4022	14.3%
2003	4362	8.5%
2004	4147	-4.9%
2005	3965	-4.4%
2006	2765	-30.3%
2007	3117	12.7%
2008	2377	-23.7%
2009	2341	-1.5%
2010	2374	1.4%
Compound Annual Growth Rate (1996-2010)		0.25%
Compound Annual Growth Rate (1996-2003)		9.62%

Source: Waterborne Commerce Statistics Center

Table 8 and Figure 15 depict the major bulk commodity tonnages for the period 1995 through 2010 that would be associated with the deepest draft vessels calling the Port. Total major bulk cargo grew from 1.71 million metric tons in 1996 to 2.42 million metric tons in 2004 for a CAGR of 4.42 percent. Bulk cargoes declined in 2005-2006 largely related to hurricane and storm disruptions, for example exports of molasses and receipts of fuel oil. Fuel oil has been declining recently due to the closure of the Riviera Beach power generation facility for renovations and modernization. Cement has declined due to the recent housing market decline in demand. Not shown on this table is the recent substantial increase in diesel fuel and asphalt tonnage due to a new port tenant who is importing diesel and asphalt. More discussion on each of the major bulk commodities can be found in Section 4.

Table 8. Major Bulk Commodity Tonnages 1995-2010

	(000 metric tons)															
	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Cement	200	187	241	173	210	60	49	64	83	152	213	115	137	44	24	6
Fuel Oil	846	541	813	986	1,107	1,043	1,351	1,200	1,062	1,215	905	665	697	389	208	213
Molasses	154	180	146	157	278	259	239	331	215	265	91	77	161	105	150	155
Sugar	987	806	908	947	816	541	725	1,094	1,003	789	692	357	626	364	635	531
Subtotal	**2,188**	**1,714**	**2,108**	**2,263**	**2,409**	**1,902**	**2,364**	**2,690**	**2,363**	**2,421**	**1,901**	**1,215**	**1,621**	**902**	**1,017**	**905**
Other	508	367	542	593	631	774	827	959	1,595	1,341	1,696	1,294	1,207	1,255	1,108	1,248
Total	**2,696**	**2,081**	**2,651**	**2,857**	**3,041**	**2,676**	**3,191**	**3,649**	**3,958**	**3,762**	**3,597**	**2,508**	**2,828**	**2,156**	**2,125**	**2,154**

Source: Waterborne Commerce Statistics Center

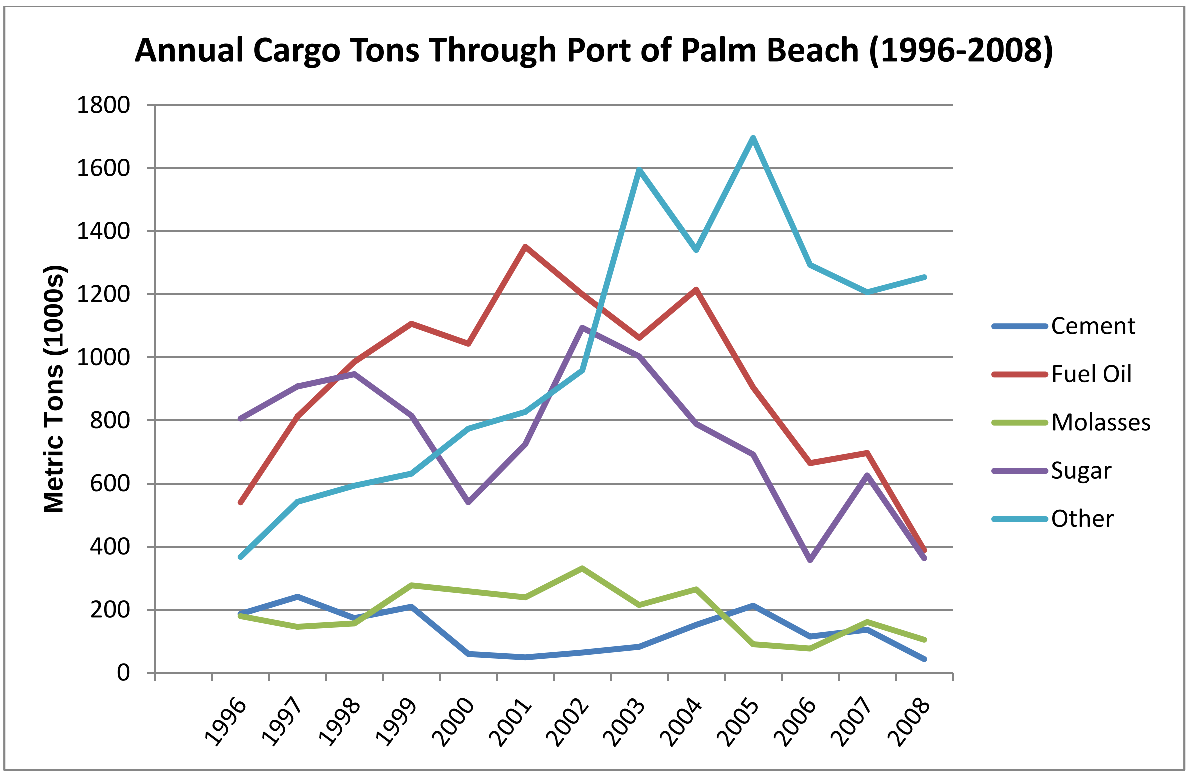


Figure 15. Annual Major Bulk Cargo Tons (1996-2008)

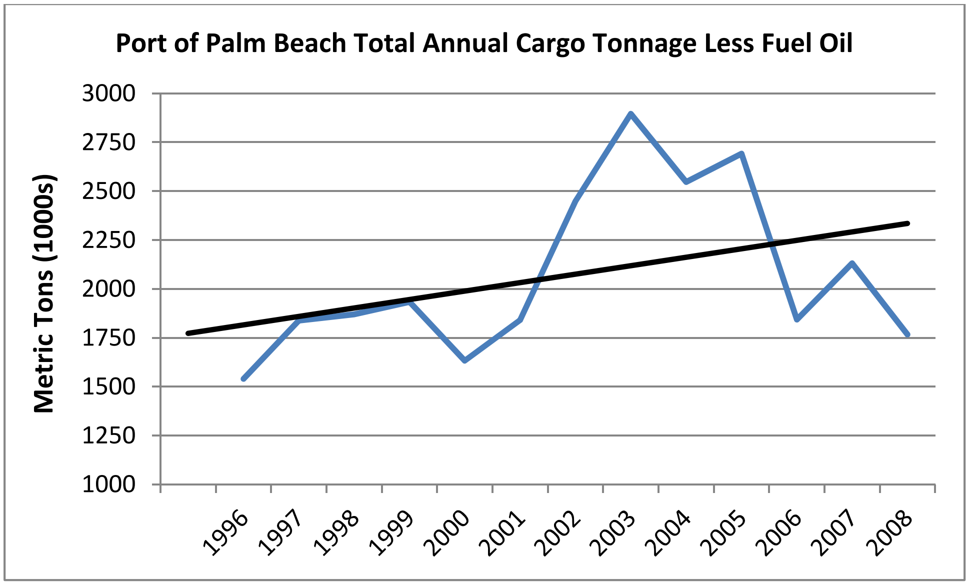
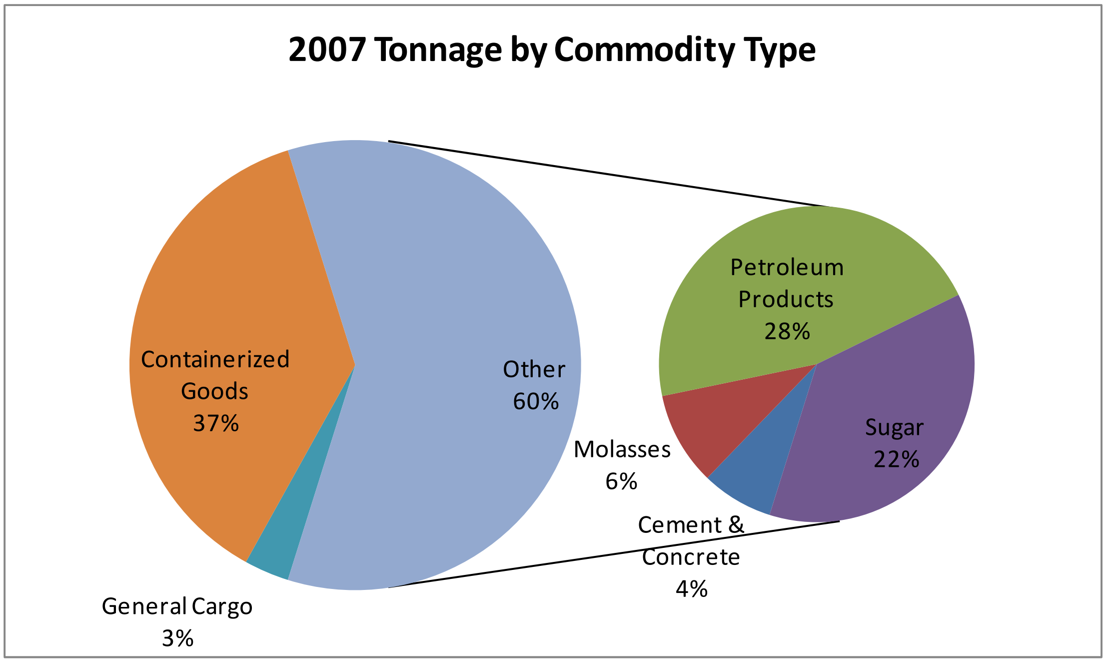


Figure 16. Annual Cargo Tonnage less Fuel Oil

Table 9. Long-term Growth Trends for Total Cargo and Total Cargo less Fuel Oil over 10 year and 14 year periods

Period	Description	Compound Annual Growth Rate
1996 – 2005	Total Cargo	6.27%
1996 – 2005	Total Cargo less Fuel Oil	6.40%
1996 – 2009	Total Cargo	0.16%
1996 – 2009	Total Cargo less Fuel Oil	1.70%

Table 9 above shows that annual cargo tonnage growth rates were very high over the 10-year period from 1996 to 2005. Fuel oil receipts began a trend of steady decline in 2005 when operations at the Riviera Beach power generation facility started to wane. Therefore, if fuel oil cargo tonnage is removed from the total cargo tonnage, the 14-year compound annual growth rate from 1996 to 2009 is 1.70% (Figure 16).



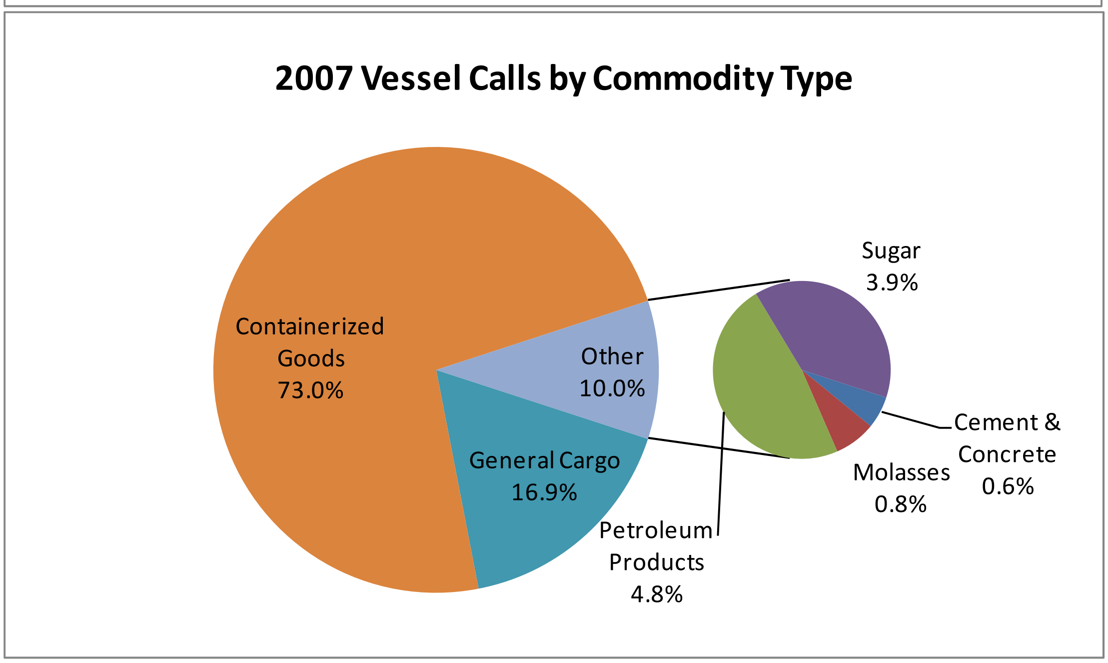


Figure 17. Comparison of Tonnage and Vessel Calls by Commodity Type
Source: Waterborne Commerce Statistics Center, and Port of Palm Beach Pilots' Log.
Notes: Petroleum Products includes: Residual Fuel Oil, Distillate Fuel Oil, Gasoline, Kerosene, and Asphalt.

Figure 17, above, shows the proportion of tonnage by commodity type compared to the number of vessel calls by commodity type, for the year 2007. The year 2007 was chosen for this example because it represented a typical level of historical commodity tonnage and vessel calls. It is clear that relative to the number of vessel calls, a small number of commodities make up a large portion of the total tonnage transiting through the Port of Palm Beach. Cement and concrete, molasses, sugar, and petroleum products represent only 10% of vessel calls in 2007. However, these same four commodity groups account for 60% of total tonnage in 2007.

3.2 Existing Vessel Fleet

Table 10 shows the total annual inbound and outbound vessel trips at the Port between 1996 and 2010. The sharp decline in total vessel trips, which occurred between 1996 and 1999, is primarily due to a reduction in small domestic vessel calls. This is also shown by the increase in annual cargo tons during the same period. From 2000 to 2005, annual vessel trips were steady, while cargo tonnage continued to increase from 2000 to 2003, suggesting more cargo was being loaded on the same or larger vessels. Since 2005, both annual cargo tonnage and annual vessel trips have steadily declined.

Table 10. Annual Vessel Movements

Port of Palm Beach Total Annual Vessel Trips		
Year	Inbound Trips (Receipts)	Outbound Trips (Shipments)
1996	4053	3425
1997	3415	2700
1998	2720	2514
1999	1793	1405
2000	1495	1467
2001	1536	1547
2002	1482	1476
2003	1482	1521
2004	1442	1503
2005	1536	1570
2006	1439	1473
2007	1334	1411
2008	1178	1246
2009	1101	1262
2010	1194	1413

Source: Waterborne Commerce Statistics Center

Note: Inbound and outbound trips will not match because domestic barge movements are only counted one way.

Table 11 shows the number of vessel movements by draft from 2004 to 2010. The existing authorized channel depth is 33 ft at MLLW. Generally, 2.5 ft of tide or greater is available about 32% of the time, and 3 ft of tide or greater is available about 15% of the time. Therefore, any calls with sailing drafts at 33 ft or greater are draft-constrained and high tide-constrained. Note that the number of calls at 33 ft draft or deeper peaked in 2005, which corresponds to the highest throughput of cement since 1997 (Table 8). Since that time, total tonnage has declined due to reduced demand for some goods. As the total number of movements has declined, movements that are 27 feet of draft and deeper have remained steady from 2006 to 2009, and increased substantially in 2010. A number of vessels in this range of sailing drafts are likely draft-constrained, and could be subject to deeper loading with greater available channel depth.

Table 11. Vessel Movements by Draft

Number of Total Vessel Movements by Draft							
Draft	2004	2005	2006	2007	2008	2009	2010
0-9 ft.	524	407	814	895	737	583	427
10-14 ft.	1181	1117	908	698	651	781	793
15-20 ft.	728	950	791	715	648	525	558
21-26 ft.	331	374	246	316	249	343	658
27-32 ft.	158	200	130	116	136	127	166
33-38 ft.	23	58	23	5	3	4	5

Source: Waterborne Commerce Statistics Center

Table 12. Existing Fleet Vessel Characteristics by Vessel Type (2007-2009)

	Number of Calls			Average Vessel LOA (ft)			Average Vessel Beam (ft)			Average Design Draft (ft)		
Vessel Type	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009
Molasses	9	6	8	555.4	551.0	556.0	83.4	87.3	87.2	35.4	34.3	33.5
Sugar	46	29	42	360.7	345.6	377.9	72.8	70.4	75.7	N/A	N/A	N/A
Liquid Petroleum	50	40	25	467.4	506.4	487.1	78.0	80.5	82.0	27.5	29.3	30.1
Asphalt	7	3	5	463.0	438.8	449.5	67.3	79.3	74.8	24.3	26.5	24.5
Cement & Concrete	7	7	1	514.6	308.4	574.0	78.8	59.0	85.3	31.2	20.3	32.2
Container Ships	867	802	678	318.4	315.3	323.0	61.1	60.7	62.3	16.2	16.0	16.5
General Cargo	203	175	156	223.4	250.2	302.5	44.8	48.2	53.7	13.2	15.2	17.9

	Number of Calls			Max LOA (ft)			Max Beam (ft)			Max Design Draft (ft)		
Vessel Type	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009
Molasses	9	6	8	587.0	576.0	619.0	90.5	98.3	97.0	41.0	39.6	38.5
Sugar	46	29	42	366.0	430.0	430.0	75.0	82.0	80.0	N/A	N/A	N/A
Liquid Petroleum	50	40	25	638.0	640.0	640.0	85.5	93.0	93.0	29.5	36.0	36.0
Asphalt	7	3	5	490.0	446.0	485.0	80.0	80.0	80.0	30.6	26.5	26.5
Cement & Concrete	7	7	1	612.3	308.4	574.0	95.1	59.0	85.3	37.7	20.3	32.2
Container Ships	867	802	678	588.0	524.5	524.5	83.0	76.3	76.3	32.5	28.5	28.5
General Cargo	203	175	156	655.0	635.0	608.3	100.0	92.0	101.5	36.0	36.8	36.0

	Number of Calls			Average Arrival Draft (ft)			Average Departure Draft			Max Sailing Draft (ft)		
Vessel Type	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009
Molasses	9	6	8	24.5	22.7	24.2	30.6	29.8	29.2	32.2	32.5	30.0
Sugar	46	29	42	14.9	14.5	15.0	22.8	23.0	23.4	24.0	24.0	24.0
Liquid Petroleum	50	40	25	27.0	26.1	25.8	18.7	18.4	18.4	30.8	29.5	29.0
Asphalt	7	3	5	21.6	26.4	25.4	16.9	19.7	20.0	24.7	27.3	27.0
Cement & Concrete	7	7	1	25.7	20.3	27.0	21.9	12.0	21.7	27.3	20.7	27.0
Container Ships	867	802	678	13.1	13.1	13.5	14.3	14.3	14.6	28.6	28.3	29.2
General Cargo	203	175	156	13.3	14.6	15.3	12.1	13.4	15.2	28.0	30.5	32.5

	Number of Calls			Average Tugs Used Inbound			Average Tugs Used Outbound			Majority Propulsion Type	Primary Berth(s) Used
Vessel Type	2007	2008	2009	2007	2008	2009	2007	2008	2009		
Molasses	9	6	8	2.0	2.0	2.4	1.9	2.0	1.9	Motor	16C
Sugar	46	29	42	1.0	1.0	1.0	1.0	1.0	1.2	Tug & Barge	16C
Liquid Petroleum	50	40	25	1.5	1.4	1.7	1.2	1.2	1.5	Tug & Barge	14C
Asphalt	7	3	5	1.4	2.0	2.0	1.1	1.7	1.2	Tug & Barge	12C
Cement & Concrete	7	7	1	2.1	0.3	2.0	1.9	0.1	2.0	Motor	14C
Container Ships	867	802	678	0.2	0.1	0.1	0.1	0.1	0.1	Motor	5C/6C/6E/7C
General Cargo	203	175	156	0.8	0.7	0.8	0.2	0.2	0.3	Motor	11C

Notes: All measurements in feet. Erroneous data was excluded from averages. Liquid Petroleum includes residual fuel oil and distillate fuel oil (diesel). Source: Palm Beach Harbor Pilots' Logs

Table 13. Average Loaded Sailing Draft as a Percent of Design Draft by Vessel Type

Average Percent of Design Draft Used when Loaded				
Vessel Type	2007	2008	2009	Overall
Molasses	87%	87%	88%	87%
Sugar	90%	91%	92%	91%
Liquid Petroleum	96%	89%	86%	91%
Asphalt	88%	98%	97%	93%
Cement & Concrete	84%	99%	84%	91%
Container Ships	89%	90%	88%	89%
General Cargo	96%	95%	90%	94%

Notes: All measurements in feet. Erroneous data was excluded from averages. Liquid Petroleum includes residual fuel oil and distillate fuel oil (diesel). Source: Palm Beach Harbor Pilots' Logs

Table 12 shows the characteristics of vessels in the existing fleet, broken down by commodity type over three years (2007-2009). Table 13, above, shows the average loaded sailing draft as a percent of design draft by vessel type over three years (2007-2009). When compared with the average design drafts and maximum design drafts in Table 12, it is clear molasses product tankers, liquid petroleum tankers, and cement bulk carriers are currently the most draft-constrained vessels in the existing fleet calling the Port of Palm Beach.

4 Expected Future Conditions

The planning horizon for this project is 50-years, with a base-year of 2017[3]. An assessment into the future involves a review of past trends leading up to current situations and the likelihood of those conditions continuing into the future with or without change.

Within the study area there are economic, environmental, and technical changes underway that will likely impact future conditions. Changing demands of the population will greatly influence those conditions. Table 14 shows the historical and projected population for Palm Beach County, surrounding hinterland counties and the State of Florida. Palm Beach County population is projected to grow at an average annual rate of less than one percent between 2010 and 2030. This slow rate of growth will affect the demand for certain commodities such as construction materials and fuel oil, as explained in further detail in Section 4.2. Table 14 also shows population projections for nearby southern and central Florida counties of Broward, Miami-Dade, Martin, St. Lucie, Indian River, Osceola, and Orange.

[3] The base-year of 2017 was used throughout the economic evaluation process for planning purposes, even though the final construction schedule is expected to complete in June 2018.

Table 14. Palm Beach County and Surrounding County Population Projections

County	1990	1995	2000	2005	2010	2015	2020	2025	2030	CAGR 1990-2010	CAGR 2010-2030	CAGR 1990-2030
Broward	1,255,531	1,428,708	1,623,018	1,740,987	1,745,570	1,787,228	1,834,967	1,880,047	1,921,172	1.66%	0.48%	1.07%
Indian River	90,208	100,375	112,947	130,043	142,303	154,988	169,319	183,403	196,916	2.31%	1.64%	1.97%
Martin	100,900	113,550	126,731	141,059	143,640	149,787	157,115	164,081	170,425	1.78%	0.86%	1.32%
Miami-Dade	1,937,194	2,076,171	2,253,779	2,422,075	2,480,757	2,561,276	2,653,957	2,742,987	2,825,874	1.24%	0.65%	0.95%
Orange	677,491	765,906	896,344	1,043,437	1,119,225	1,212,817	1,324,547	1,433,249	1,535,033	2.54%	1.59%	2.07%
Osceola	107,728	140,775	172,493	235,156	280,279	327,022	380,082	431,637	480,401	4.90%	2.73%	3.81%
Palm Beach	863,503	988,743	1,131,191	1,265,900	1,285,692	1,346,002	1,420,356	1,491,669	1,556,810	2.01%	0.96%	1.48%
St. Lucie	150,171	172,212	192,695	240,039	276,658	313,077	354,289	395,164	434,113	3.10%	2.28%	2.69%
Hinterland Sub-Total	5,182,726	5,786,440	6,509,198	7,218,696	7,474,124	7,852,197	8,294,632	8,722,237	9,120,744	1.85%	1.00%	1.42%
Florida	12,938,071	14,335,992	15,982,824	17,918,227	18,881,443	20,055,865	21,417,450	22,738,233	23,979,032	1.91%	1.20%	1.55%
Hinterland Percent of State Population	40.1%	40.4%	40.7%	40.3%	39.6%	39.2%	38.7%	38.4%	38.0%			

Note: CAGR = Compound Annual Growth Rate; Projections begin in 2010.
Source: Florida Demographic Estimating Conference, February 2009; Florida Demographic Database, August 2009

4.1 Caveats of Growth Estimates and Projections

No growth rate projection will ever be completely accurate, and the true ups and downs of business cycles cannot be accurately forecasted through a linear or exponential growth rate. Linear or steady compound growth rates (exponential growth) are meant only to be representative of projected tonnage that is expected to transit through the port over a longer period. Using smoother curves as estimates for actual tonnage acts to normalize peaks and valleys in future business cycles. In reality, future tonnage will likely exceed the forecast in some years, and fall short of the forecast in others. A "most-likely" steady growth rate will account for both of these occurrences over the long run because the positive and negative differences from the estimated to actual tonnage will eventually cancel each other out (Figure 18).

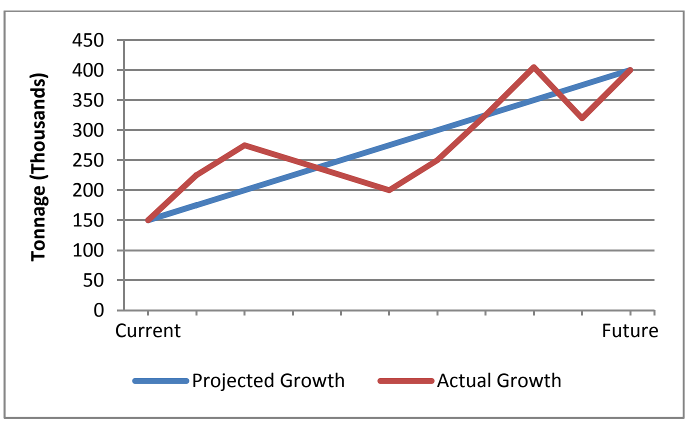


Figure 18. Example Graph of Differences between Estimated and Actual Growth
Note: Not actual growth forecast; for illustration purposes only.

4.2 Future Commodity Movements

Historical tonnages were presented in Table 8, in Section 3.1. The future commodity growth for the 50-year planning horizon from the base year of 2017 to 2067 is summarized in Table 15 and shown graphically in Figure 19. The "Benefitting Commodity?" column displays whether or not the commodity movements will benefit from channel deepening. In the following subsections, the assumptions and caveats behind each of the predictions for each commodity are detailed.

Table 15. Future Commodity Movement Forecasts for Port of Palm Beach (2017-2067)

	2017	2027	2037	2047	2057	2067	CAGR (2017-2067)	Benefitting Commodity?
Sugar (Shipments)	790	790	790	790	790	790	0.00%	No
Molasses (Shipments)	265	265	265	265	265	265	0.00%	Yes
Liquid Petroleum Products (Receipts)	232	251	272	295	320	347	0.80%	Yes (only diesel)
Asphalt (Receipts)	76	95	119	149	186	186	1.81%	Yes
Cement & Concrete (Receipts)	97	122	154	194	244	308	2.35%	Yes
Containerized Cargo (Both Directions)	999	1,343	1,805	1,805	1,805	1,805	1.19%	No
Non-Containerized General Cargo (Both Directions)	122	135	148	163	179	197	0.96%	Yes (only for largest vessels)
Total	2,581	3,000	3,552	3,660	3,789	3,897	0.83%	

Notes: Values shown in thousands of metric tons. Liquid Petroleum includes residual fuel oil and distillate fuel oil (diesel). "Cement and concrete" represents all dry bulk construction materials. The seed values of current tonnages before applying a projected growth rate for containerized goods and non-containerized general cargo were estimated values. Other commodities used historic values for the base year projection that represented either current traffic or pre-recession traffic levels. Non-containerized general cargo includes break-bulk, project cargo, and Ro-Ro.

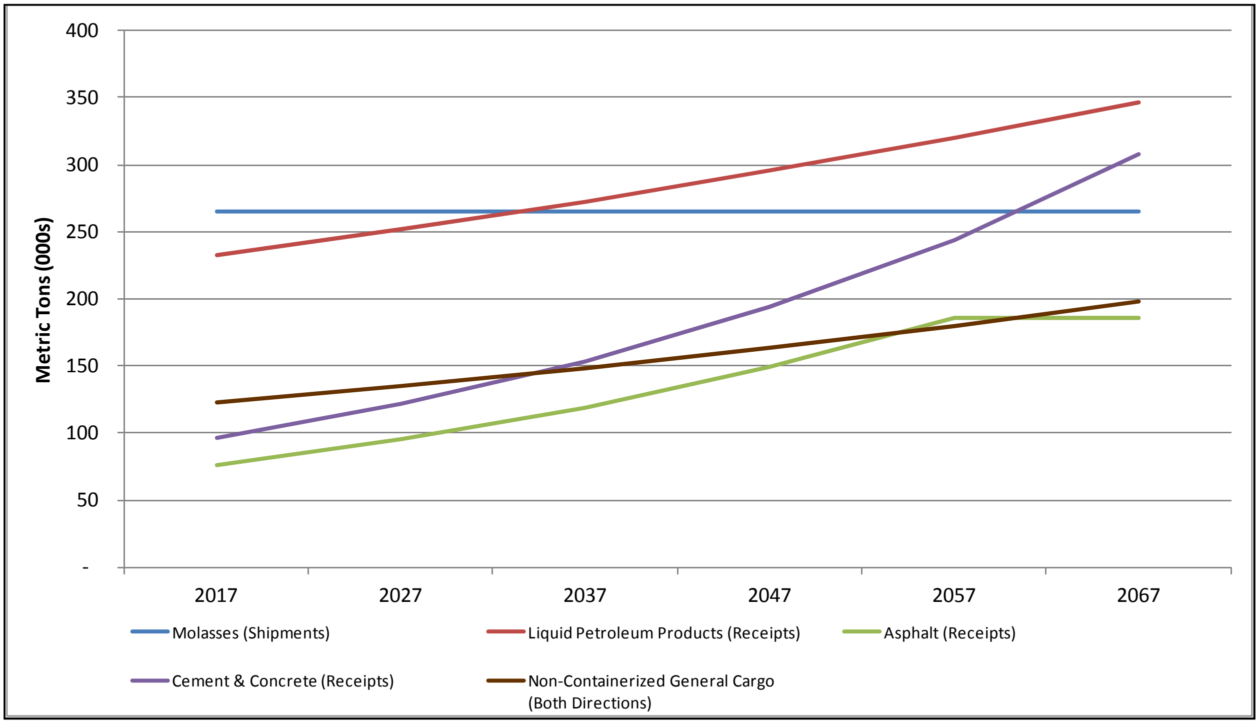


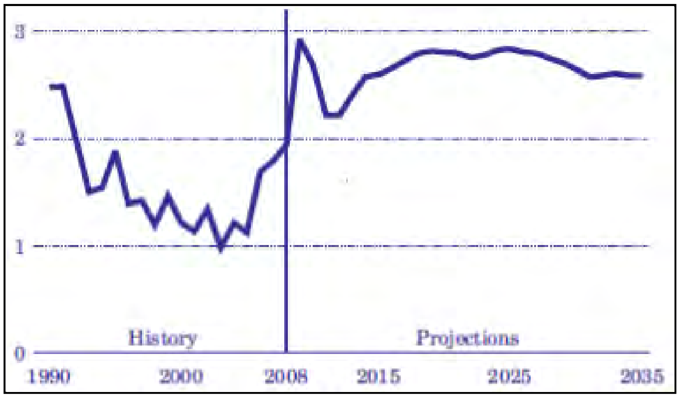
Figure 19. Port of Palm Beach Future Commodity Growth Projections

4.2.1 Fuel Oil and Diesel

For the purposes of this analysis, tonnage estimates for fuel oil and diesel fuel were combined into a single "liquid petroleum" category. These commodities were combined because fuel oil and diesel are each received by only a single firm, and the estimates for each commodity were considered too sensitive to publish individually. Also, note that even though asphalt is a liquid petroleum product, it is estimated separately and discussed in the following section because the drivers of demand for asphalt relate more closely to the demand for cement and dry bulk construction materials.

Historically, residual fuel oil (also known as "No. 6" fuel oil) receipts were a large percentage of port cargo traffic because it was used by the Riviera Beach electricity generating facility, owned and operated by Florida Power & Light Company (FPL), which was adjacent to the Port of Palm Beach. Fuel oil is moved via domestic tug and barge, primarily from Gulf Coast ports. In order to meet future energy demands and potential emissions requirements, FPL has recently shut down the Riviera Beach plant with plans to replace it with a more efficient Combined Cycle plant, which will run primarily on natural gas. The natural gas will be transported to the facility exclusively via pipeline. The new Riviera Beach facility will be operational by 2014. During 2012-2014, there will likely be a small increase in bulk movements of heavy equipment form the imports and exports of the new and old parts of the Riviera Beach facility.

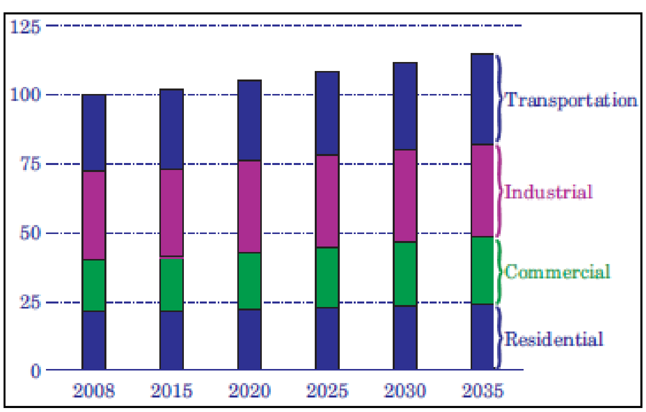
The rebuilt plant will have the capability to operate on diesel fuel, but this feature would only be used in an emergency that also caused a disruption in the supply of natural gas. The only other scenario that would cause the new power plant to run on diesel would be if the price of diesel were to drop below the price of natural gas. According to the U.S. Energy Information Administration (USEIA) Annual Energy Outlook 2010, "The ratio of low-sulfur light crude oil prices to Henry Hub natural gas prices on an energy equivalent basis remains high relative to the historical average throughout the projection [2009-2035]". The USEIA projection of natural gas prices is shown in Figure 20, below.



Source: USEIA, Annual Energy Outlook 2010

Figure 20. Ratio of low-sulfur light crude oil price to Henry Hub natural gas price on an energy equivalent basis, 1990-2035

The new Riviera Beach combined-cycle facility will have between 120,000 and 150,000 barrels of low-sulfur diesel fuel on-hand in case of emergencies. FPL will likely turn over this volume almost every year to test the backup capabilities of the new plant. However the volume is so low that it will likely be brought into the facility through truck rather than by barge. FPL's St. Lucie County power generation facility is expected to still require some residual fuel oil receipts through the Port for the period of analysis. Further FPL data, which supports the estimate of liquid petroleum in the base year of 2017, is considered sensitive and will be provided to reviewers upon request, if possible. Demand for energy is expected to increase (Figure 21). Specifically, demand for electricity is projected to grow at 1 percent per year from 2008 to 2035 (USEIA, 2010).



Source: USEIA, Annual Energy Outlook 2010

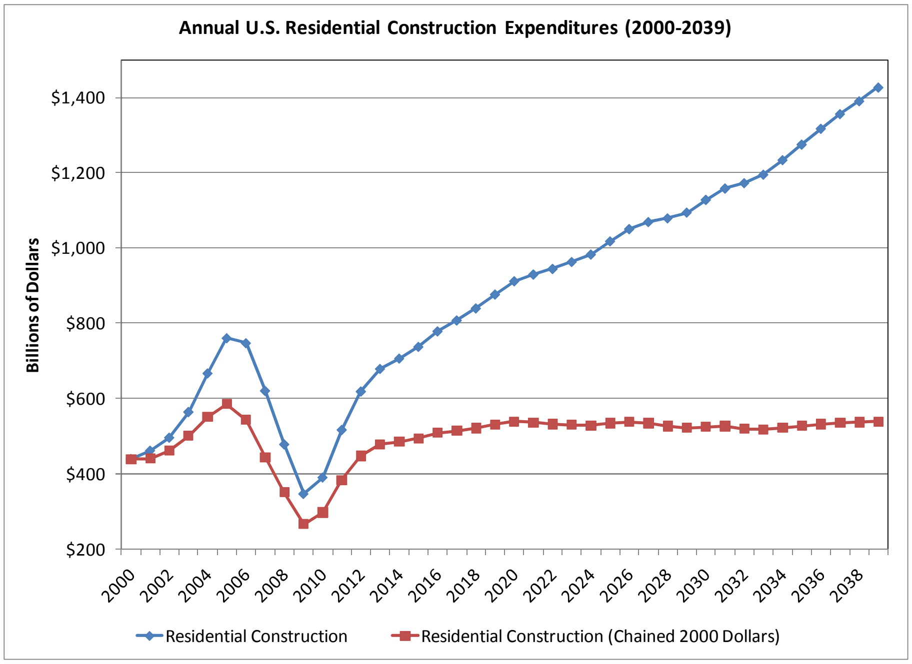
Figure 21. Primary energy use by end-use sector, 2008-2035 (quadrillion Btu)

Diesel fuel, or distillate fuel oil, is another commodity that is received in substantial quantities through domestic barge movements from Gulf Coast ports. One tenant at the Port of Palm Beach currently imports diesel products for resale. This tenant has seen rapid growth in their diesel shipments since they began operations at the Port. This rapid growth is attributed to a ramping-up of a new business, and high growth rates for diesel are not expected over the entire period of analysis. Diesel receipts are expected to grow at moderate rates over the period of analysis.

Diesel fuel consumption is expected to grow at rates similar to the general national demand for energy in the transportation sector. The USEIA projects an average annual growth rate of 0.6 percent from 2008 to 2035 (USEIA, 2010) (Figure 21). Furthermore, with the addition of a new bio-fuel firm at the port, there may be a slight increase above the national rate in traffic of refined fuels.

4.2.2 Asphalt and Cement

Asphalt has historically moved through the Port of Palm Beach by domestic tug and barge from U.S. Gulf Coast ports. Demand for asphalt is primarily related to the demand for infrastructure construction and repairs (roadways), as well as for residential and commercial construction and repairs (roofs, driveways, and parking lots). Both of these factors are ultimately dependent upon population growth and subsequently, demand for residential and commercial construction. Nationwide, unadjusted growth in expenditures for residential construction remains slow but constant over the next 30 years after a rebound from recession levels (Figure 22). The projected post-recession compound annual growth rate in construction expenditures from 2012 to 2039 is 3.14 percent. However, the compound annual growth rate of expenditures on residential construction from 2012 to 2039 in Chained 2000 dollars is 0.68 percent. The value of considering “Chained 2000 dollars” is that they are adjusted for inflation, which would represent a more accurate projection of the demand for quantities of construction materials.



Source: IHS Global Insight, "The 30-Year Focus", May 2009.

Figure 22. Residential Construction Expenditures: Historical and Projected

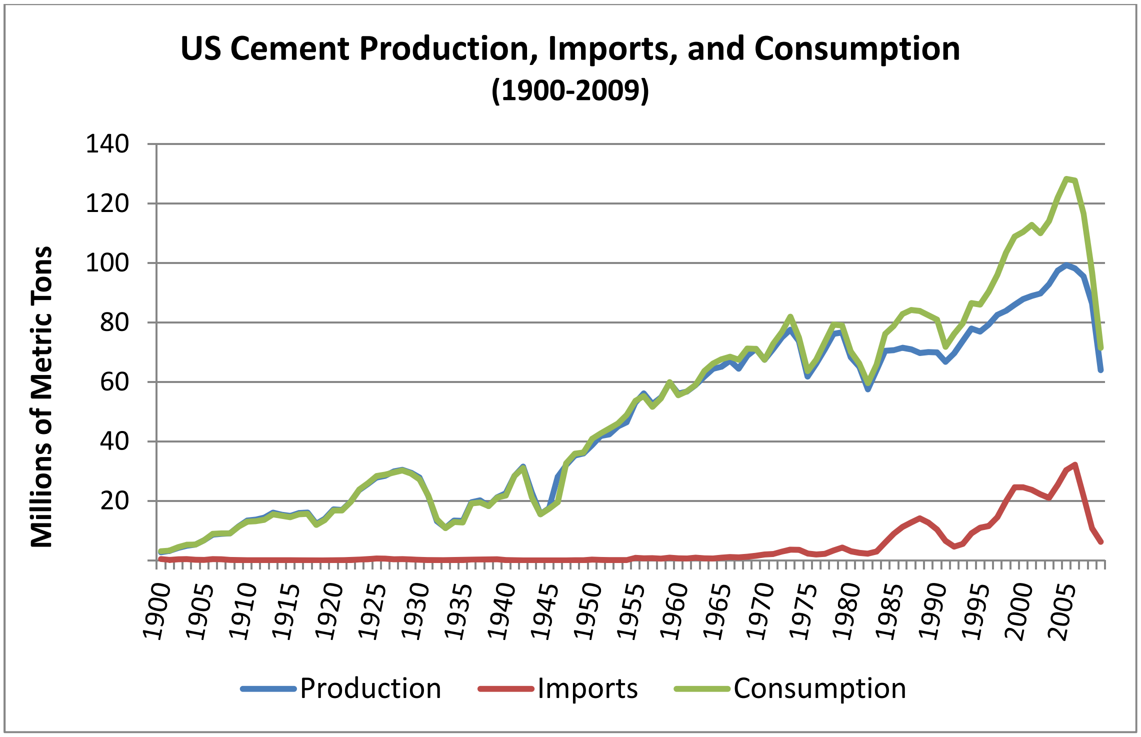
For the purposes of this economic analysis, projections and references to "cement and concrete" is intended to represent all dry bulk construction materials, such as cement, cement input materials, and aggregate. The Port of Palm Beach traditionally has moved a large amount of cement and other dry bulk construction materials through its facilities, in the hundreds of thousands of tons since the 1990s and earlier. This volume has dropped off significantly in recent years because of the decline in new construction, but it is expected to return to pre-recession levels by the base project year of 2017, as new construction rates return to normal (Figure 22). According to the IHS Global Insight forecast of U.S. Residential Construction expenditures, 2017 expenditures are projected to be $808 billion, while they were only $760 billion in 2005. Adjusting for inflation, the 2017 projected expenditures in chained 2000 dollars is $515 billion, while it was $586 billion in 2005. This indicates that in terms of real expenditures, which would correlate to demand for materials, the U.S. residential housing market is expected to make a recovery to nearly 88% of the peak 2005 values by 2017.

Cemex, a large cement company, has cement storage and processing facilities on-site at the Port, and Cemex is currently under a lease agreement with the Port until 2023[4]. The facility is now nearly idle, only recently bringing in relatively small quantities of cement input materials such as sand, fly ash, and aragonite, but the facility is still maintained on a regular basis and ready to return to service. This indicates that as soon as demand for cement rises, imports of cement will resume at normal rates, and should increase into the future along with the demand for new construction. Cement has traditionally been imported on foreign-flagged dry bulk carriers from various countries such as Mexico, Denmark, and Egypt.

[4] CEMEX representatives stated in an interview that they would not give up any facilities that they currently held at seaports, which leads to the conclusion that they will renew their lease in 2023.

4.2.2.1 Description of Cement Imports & Historical Rates

In the early 1970s, imports of cement began to steadily rise, up until the recent recession (Figure 23). Cement, aggregate, and cement input materials have historically been imported through the Port of Palm Beach to supplement local, domestic production. It is generally easier for cement producers to import cement to meet excess demand, and make adjustments to their import quantities, rather than constantly adjust their factory output.



Source: USGS Historical Statistics for Mineral and Material Commodities in the United States, Version 2010.
Figure 23. US Cement Production, Imports, and Consumption

Cement production also requires the input of other minerals that are not produced domestically, such as bauxite, alumina, and silica sands. These cement input materials must be imported in order to produce cement domestically. Furthermore, aggregate, or crushed stone is required as an addition to cement to produce "Ready-Mix" concrete, a primary building material. When demand for construction materials rises beyond the capacity of local production, aggregate is imported as well.

Since 1996, there have been two distinct peaks in cement imports through the Port of Palm Beach, in 1997 and in 2005. Table 16, below, shows the tonnage of cement imported through the Port of Palm Beach.

Table 17 shows the growth rate in imports and total tonnage moved over a 10-year period from 1996 to 2005, and over the 8-year period from 2000 to 2007. These two periods illustrate that the annual growth rates and annual throughput tonnages can be very sensitive to the period selected. Figure 24 emphasizes these trends graphically, and shows the cyclical nature of construction material demand.

Table 16. Annual Bulk Cement Cargo Tons through Port of Palm Beach

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Cement	187	241	173	210	60	49	64	83	152	213	115	137	44	24

Note: Values in 1000s of metric tons. Source: Waterborne Commerce Statistics Center.

Table 17. Cement Throughput and Growth Rates through Port of Palm Beach, FL

Period	Compound Annual Growth Rate	Total Tonnage Throughput (metric tons)	Average Annual Throughput over Period (metric tons)
1996 – 2005	1.47%	1,432,000 tons	143,200 tons
2000 – 2007	12.55%	874,000 tons	109,250 tons

Source: Waterborne Commerce Statistics Center.

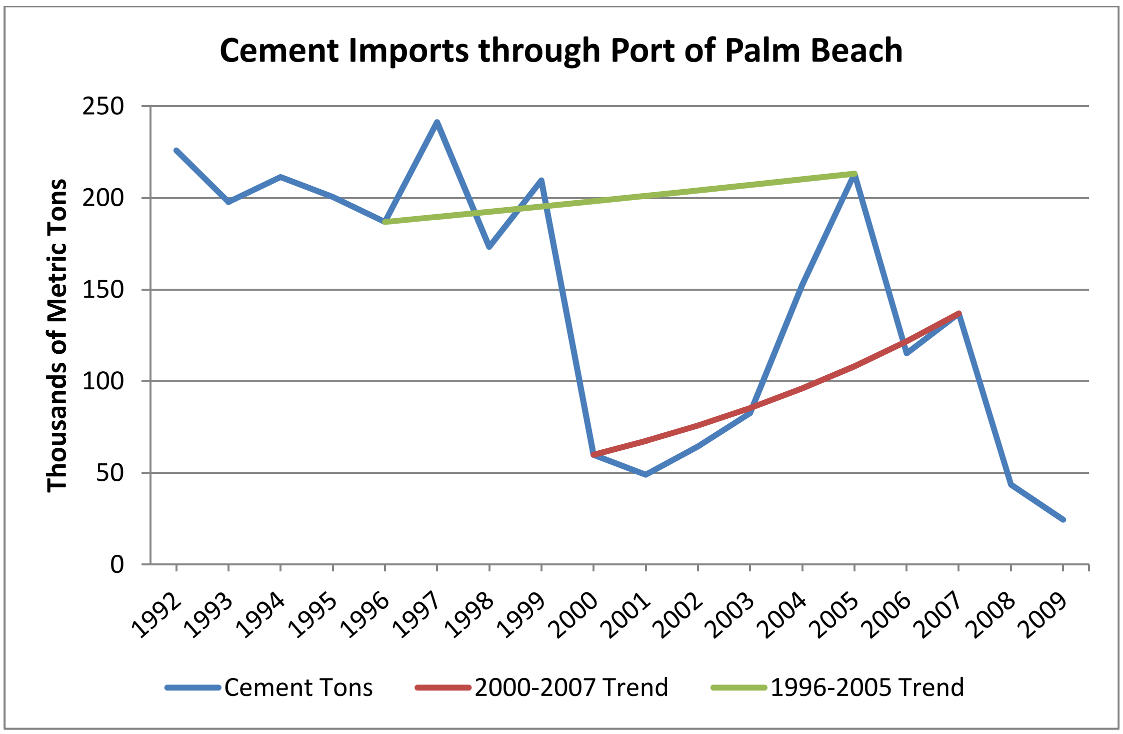


Figure 24. Cement Imports through Port of Palm Beach, with Trend Lines
Source: Waterborne Commerce Statistics Center.

4.2.2.2 Description of Market & Drivers of Demand

Demand for cement and asphalt is primarily related to the demand for infrastructure construction and repairs (roadways), as well as for residential and commercial construction and repairs. Long-run demand for these types of construction is ultimately dependent upon population growth (Table 14). During the 10-year period from 1996-2005, Palm Beach County's population growth rates slightly exceeded the growth rates of the South Florida Hinterland Counties and the entire State of Florida (Table 18). Another key indicator of demand for cement is residential building permits (Table 19 and Table 20).

Table 18. Historical Population Growth Rates

Area	Period	Compound Annual Growth Rate
Palm Beach County	1996-2005	2.50%
South Florida Hinterland	1996-2005	2.23%
State of Florida	1996-2005	2.28%
Palm Beach County	2000-2007	1.95%
South Florida Hinterland	2000-2007	1.95%
State of Florida	2000-2007	2.25%

Source: Florida Demographic Estimating Conference, February 2009; and Florida Demographic Database, August 2009.

Table 19. Historical Residential Building Permits in South Florida Hinterland

County	1990	1995	2000	2005	2009	CAGR (1990-2005)	CAGR (1996-2005)
Broward	5808	8489	9362	3826	607	-2.7%	-10.0%
Indian River	1068	836	1278	3702	285	8.6%	16.6%
Martin	904	947	1072	1235	109	2.1%	1.7%
Miami-Dade	5416	7794	6465	10500	683	4.5%	11.2%
Orange	6352	5500	6474	11303	1837	3.9%	7.3%
Osceola	2633	1570	3215	6002	650	5.6%	13.5%
Palm Beach	6199	7672	7016	8960	1128	2.5%	0.6%
St. Lucie	2335	1286	1752	8095	256	8.6%	20.3%
South Florida Hinterland Total	**30715**	**34094**	**36634**	**53623**	**5555**	**3.8%**	**5.2%**

Note: CAGR = Compound Annual Growth Rate. Source: US Census Bureau

Table 20. Historical Privately-owned Residential Building Permits for Select South Florida Counties by Year (1990-2009)

County	1990	1991	1992	1993	1994	CAGR
Broward	5808	4984	6840	9999	10961	17.2%
Indian River	1068	855	763	886	1089	0.5%
Martin	904	648	786	978	912	0.2%
Miami-Dade	5416	4496	5825	5982	6506	4.7%
Orange	6352	5546	5927	6034	6355	0.0%
Osceola	2633	1728	2037	1986	1690	-10.5%
Palm Beach	6199	5502	6669	7341	8860	9.3%
St. Lucie	2335	1518	1472	1515	1562	-9.6%

County	1995	1996	1997	1998	1999	CAGR
Broward	8489	9904	7860	9137	8810	0.9%
Indian River	836	927	938	1092	1129	7.8%
Martin	947	1057	1018	1062	1074	3.2%
Orange	5500	6020	6187	7234	7560	8.3%
Osceola	1570	1915	3068	2720	3163	19.1%
Palm Beach	7672	8506	6477	6583	6696	-3.3%
St. Lucie	1286	1532	1402	1469	1688	7.0%

County	2000	2001	2002	2003	2004	CAGR
Broward	9362	8476	6003	4133	5021	-14.4%
Indian River	1278	1271	1512	1841	3740	30.8%
Martin	1072	972	1458	1443	1287	4.7%
Miami-Dade	6465	7387	6741	9252	10079	11.7%
Orange	6474	7585	8442	10210	11925	16.5%
Osceola	3215	3614	3669	4742	6443	19.0%
Palm Beach	7016	7722	9707	11150	10581	10.8%
St. Lucie	1752	2201	3391	6902	7739	45.0%

County	2005	2006	2007	2008	2009	CAGR
Broward	3826	3740	1910	991	607	-36.9%
Indian River	3702	2882	1149	626	285	-47.3%
Martin	1235	941	326	185	109	-45.5%
Miami-Dade	10500	7193	3540	1213	683	-49.5%
Orange	11303	9817	4292	2539	1837	-36.5%
Osceola	6002	5916	2434	1068	650	-42.6%
Palm Beach	8960	4874	2182	1358	1128	-40.4%
St. Lucie	8095	4713	1727	710	256	-57.8%

Note: CAGR = Compound Annual Growth Rate over 5 year period shown in each sub-table.
Source: U.S. Census Bureau

4.2.2.3 Cement Tonnage Projections

Cement tonnage in these projections is used as proxy for all cement and cement input materials, for simplification purposes. Total "cement" tonnage represents cement, aggregate, and other bulk minerals used in the production of cement, such as bauxite, alumina, and silica sands. Some of these other input minerals must be imported as they are not produced domestically. Therefore, there will always be a demand to import some input minerals, even if demand for cement is relatively low.

In order to project the tonnages of cement and cement input products that will transit through the Port of Palm Beach in the future with- and without-project conditions, historical data and future projections of related factors such as population growth and residential construction expenditures were all examined. Since the Port of Palm Beach is not the only South Florida port to import cement, it is necessary to include the import tonnages through Port Everglades to show a clear historical relationship between residential building permits and cement import tonnages (Figure 25).

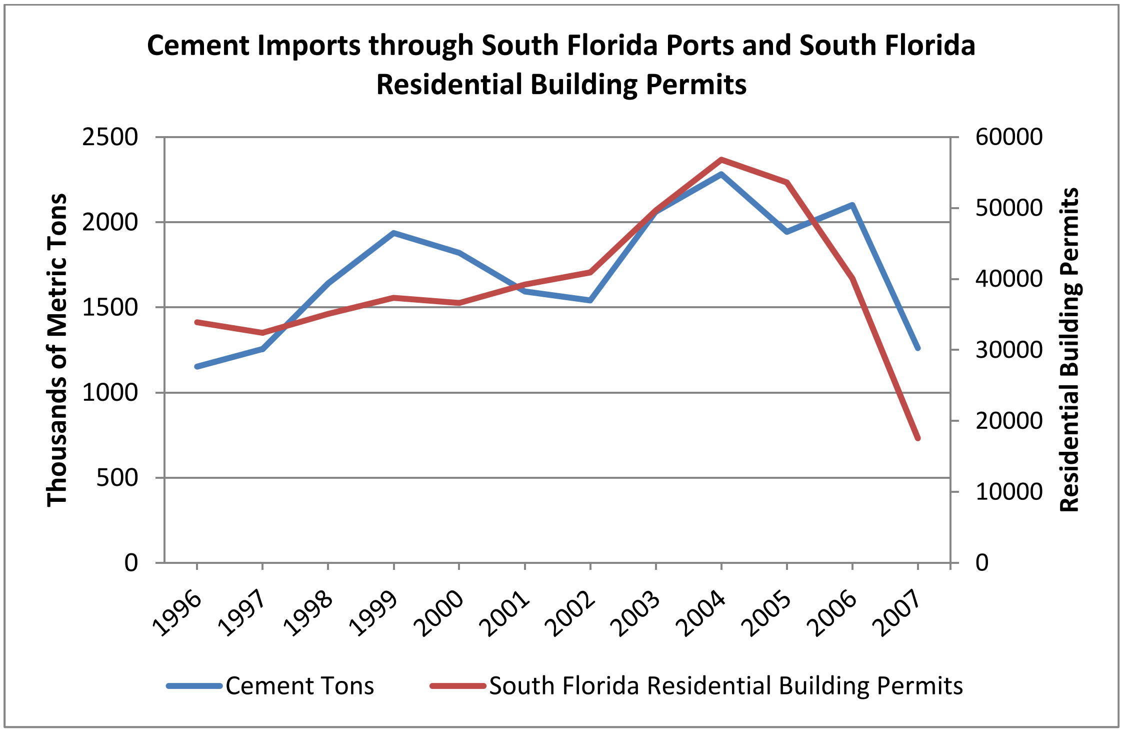


Figure 25. Cement Imports through South Florida Ports and South Florida Residential Building Permits (1996-2007)
Note: Includes tonnages through Port of Palm Beach and Port Everglades.
Sources: U.S. Census Bureau and Waterborne Commerce Statistics Center.

A growth scenario that was used to calculate primary project benefits, Scenario 2, and several alternative growth scenarios were developed based on this information. A summary of the projections is shown below in Figure 26, Table 22, and Table 21. Detailed description of how the projection was developed for Scenario 2 is contained in the following section. More detailed discussion on these other growth scenarios for cement can be found in the sensitivity analysis section, Section 6.

Table 21. Summary Description of Projection Methods for Cement

Projection	Summary of Method	Base-year Tonnage	Growth Rate / Equation
Scenario 2	Ratio of 96-05 residential construction permits to population growth	40% of 1997 peak cement import tonnage at Port	2.35%
Scenario 3	Linear regression of scaled long-term U.S. cement imports	Projected using linear regression equation	Linear Regression equation: *y=3.6461(x-1969)*
Scenario 1	Ratio of 96-05 cement imports at Port of Palm Beach to population growth	40% of 1997 peak cement import tonnage at Port	0.66%
Scenario 4	Based on input from interview with industry representative who currently imports cement products at Port of Palm Beach	120k short tons (from industry input)	double in 10 years; then 0% growth for remaining period of analysis

Table 22. Detailed Projected Import Tonnage of Cement Products through Port of Palm Beach

Projection	2017	2022	2027	2032	2037	2042	2047	2052	2057	2062	2067
Scenario 2	96.5	108.4	121.7	136.7	153.5	172.4	193.6	217.4	244.1	274.2	307.9
Scenario 3	175.0	193.2	211.5	229.7	247.9	266.2	284.4	302.6	320.9	339.1	357.3
Scenario 1	96.5	99.8	103.1	106.6	110.1	113.8	117.6	121.6	125.7	129.9	134.2
Scenario 4	108.9	163.3	217.8	217.8	217.8	217.8	217.8	217.8	217.8	217.8	217.8

Note: Values shown in 000 metric tons

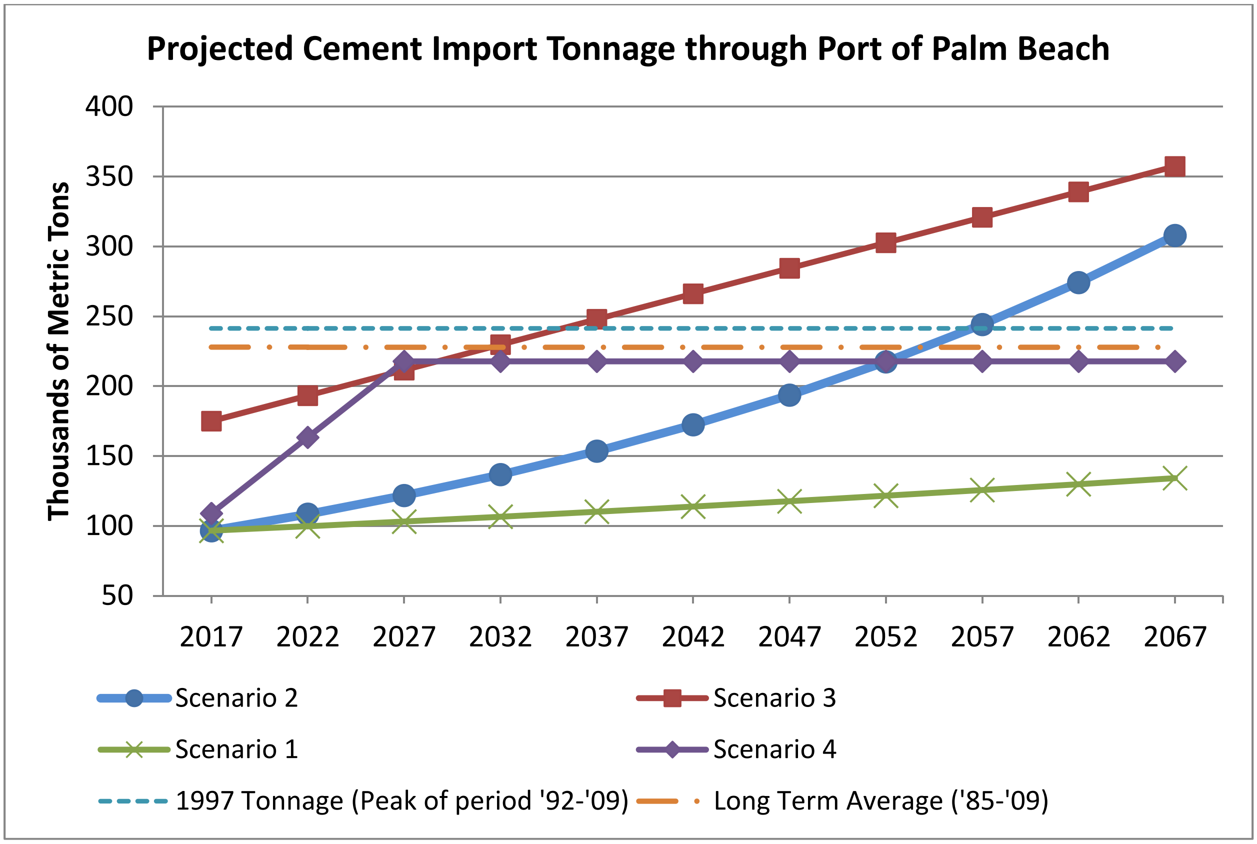


Figure 26. Graph of Projected Import Tonnage of Cement Products through Port of Palm Beach

4.2.2.4 Scenario 2 Projected Cement Import Tonnage Growth Rate and Assumptions

The Scenario 2 growth scenario was used for primary benefits calculations for the project. Its growth rate was derived from the ratio of compound annual growth in South Florida residential construction permits to compound annual growth rate in South Florida population over a 10-year period, 1996 to 2005 (Figure 27). This ratio was then applied to future population compound annual growth projections in South Florida from 2010-2030 (1%) to get a projected growth rate for import tonnage of cement and cement input products through the Port of Palm Beach over the entire period of analysis. The base project-year (2017) tonnage is based on 40% of the 14-year peak (1997) import tonnage through the Port (241,300 tons * 40% = 96,500 tons).

$$\frac{5.23\%}{2.23\%} = 2.35\ ratio\ of\ historical\ residential\ construction\ to\ population\ growth$$

$$2.35 * 1.00\% = 2.35\%\ projected\ growth\ rate\ for\ cement\ import\ tonnage$$

Figure 27. Calculations for Projected Cement Growth based on Historical Ratio of Residential Construction to Population Growth

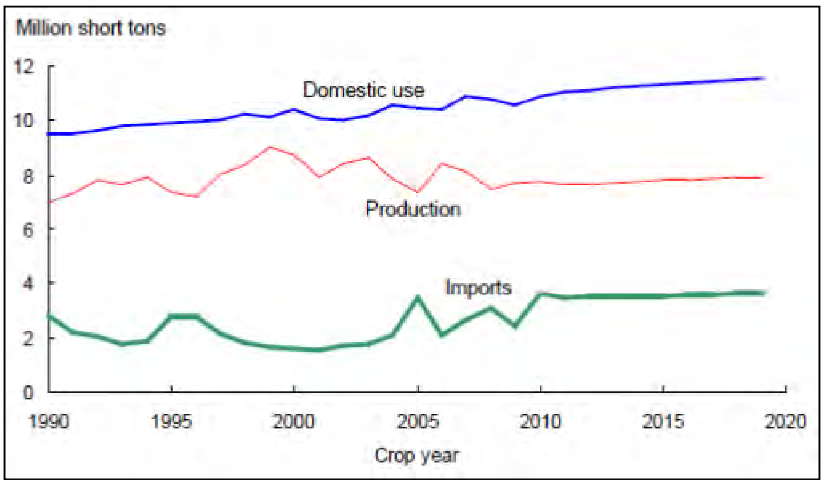
Assumptions behind using the ratio of residential construction permits to population growth over a 10-year period were that the demand for cement would be highly correlated to residential construction, which is a direct function of residential building permits. Along with residential construction comes an increased demand for infrastructure and related commercial and industrial buildings. All of these factors will play a role in riving the demand for cement. The assumption behind using 40% of the peak tonnage as the base-year tonnage was that this would represent a rebound in the construction industry, but still not a full return to historical mean import tonnage (126,000 metric tons on average from 1996-2009). It is not until 2029, over 10 years into the project, are annual tonnages expected to surpass the long-term historical average tonnage. By 2057, 40 years into the project, annual tonnages are expected to surpass the historical peak import tonnage. This growth scenario is a conservative estimate compared to the Scenario 4 estimate from industry input, and the Scenario 3 growth scenario which is based on national long-term growth trends. More detailed discussion on these other growth scenarios for cement can be found in Section 6.

4.2.3 Sugar and Molasses

Sugar and molasses are both major commodities that are shipped from the Port of Palm Beach through the Florida Sugar & Molasses Exchange, Inc. In 2007-2008, Florida cane sugar made up an estimated 48 percent of the cane sugar and 24.3 percent of the total sugar produced in the U.S. (from sugarcane and beets, combined) (UF/IFAS, Florida Sugarcane Handbook, SS-AGR-232, August 2009). About half of that amount was shipped out via domestic barge through the Port of Palm Beach. Domestic sugar refineries that typically receive Florida sugar via ocean-going barge are located in Yonkers, NY, Baltimore, MD, Savannah, GA, Chalmette, LA, and Gramercy, LA.

Molasses production is a direct by-product of sugar production and therefore its growth is inherently related to growth in production of sugar. These commodities will likely experience very slow but steady growth in the future up until the limit of production capacity in Florida is reached, at which point growth in production will remain constant. On a national level, the USDA expects sugar for human consumption to grow at approximately 0.6 percent per year (Figure 28). This level of growth is less than the projected growth rate of the population of the U.S. Therefore, this projection leads to a scenario in which per capita sugar consumption will decline slightly by 2019. Molasses is generally used as an additive in feed for livestock. Molasses is shipped through the port of Palm Beach via foreign-flagged products tankers to ports in Northern Europe.

This analysis assumes that sugar and molasses tonnage movements will likely return to 2004 levels by 2017 and then experience no growth over the period of analysis. Since the land in sugar production is finite, there was no growth forecasted over the period of analysis. The base-year tonnage was selected due to its similarity to the average exports over the period from 1999 to 2004. Sugar is an agricultural product which is subject to variation in yields due to external factors such as drought and weather (especially hurricanes). Steep declines in molasses exports in 2005 and 2006 were partially due to unusually active hurricane seasons in 2004 and 2005. Additionally, the Port experienced some issues with excessive shoaling, and lack of regular maintenance that reduced the available channel depths, which would have impacted the ability of molasses tankers to fully load, making the shipments more expensive, and not as price competitive. The return to historical average tonnages assumes that the channel will be properly maintained, and the historic demand for molasses in the European market continues to grow.



Source: USDA Agricultural Projections to 2019 (OCE-2010-1), February 2010.

Figure 28. U.S. Sugar Production, Use and Imports (1990-2019)

4.2.4 Containerized Cargo

The container traffic through the Port of Palm Beach is primarily moved by Tropical Shipping, who services the Caribbean islands with consumer goods, food, and retail products from the United States and Canada. For goods being exported in containers, their hinterland encompasses the entire U.S., parts of Canada, and some international goods for re-export.

Tropical Shipping has experienced steady historical growth up to the recession of 2008-2009. The post-recession number of container shipments is expected to continue to grow into the future at a rate of about 3 percent per year, according to Tropical's own estimate (personal communication on July 21, 2010). The rate of growth attributed to containerized cargo exports from the Port of Palm Beach is directly related to demand for goods in the Caribbean islands, which is primarily influenced by growth of travel and tourism in the area. Real growth of demand for the travel and tourism industry in the Caribbean is projected to increase by 3.9% per year to $107 billion by 2020 (World Travel and Tourism Council, 2010). Therefore, a growth estimate of 3 percent per year is reasonable, and it was applied to the 2011 PIERS' forecast, through 2037, at which point the Port will likely approach its throughput capacity.

4.2.5 Non-Containerized General Cargo, Break Bulk and Specialty Shipments

General cargo on benefitting vessels is made up of miscellaneous large project cargo (utility poles, and large machinery for industrial purposes like power generation and water pumps) and yachts. Only about 12% of general cargo vessel calls are assumed to be large deepening-benefitting vessels. This assumption was applied throughout the period of analysis, and for each project alternative. Since the actual individual project cargoes and yacht movements would be difficult to predict, these large general cargo types were combined as an assumption for simplification of the analysis.

Although general cargo movements have historically made up a smaller portion of commodity traffic at the Port of Palm Beach, a relatively new tenant has been handling various types of break bulk, project cargo and specialty goods since the fourth quarter of 2008. They move many different goods, such as heavy equipment, wire rod, linerboard paper, telephone poles, and equipment for FPL, from many different markets, such as Europe, the Mediterranean, Central America, and the Caribbean. Additionally, they specialize in large yacht relocation services. The yachts shipped are typically up to 200 feet long and placed on the deck of a loaded general cargo ship.

The new tenant has grown their commodity movement tonnages exponentially in the first two years of operations at the Port, and expects to continue to move a greater quantity of miscellaneous break bulk goods, specialty cargo, and yachts each year. The rate of growth estimated for all non-containerized general cargo is the same as the compound annual growth rate projection for South Florida population growth, 0.96 percent.

The methods of loading large general cargo vessels with project cargo or yachts are typically to place it on the deck of the vessel (which precludes further loading in the holds of the ship). This loading method limits the amount of cargo that the vessel can carry in the holds because the vessel is limited by the channel depth at Palm Beach Harbor. Deepening the channel would allow the vessel to load more cargo both in the holds and on the deck, thereby reducing total transportation costs for the large general cargo and yacht shipments.

4.2.6 Cruise Passengers

From 1997 to 2010, the *Palm Beach Princess* operated as a day-cruise out of the Port of Palm Beach. Day-cruises offer dining and gambling, once the ship has reached international waters. The *Princess* sailed twice daily throughout its time at the Port. In late 2009, the *Princess* suffered mechanical and financial troubles, which were compounded by decreased attendance because of unfavorable economic conditions nationwide. The operators of the Princess filed for bankruptcy and have relocated the ship as of April 7, 2010.

As of March, 2010, a new overnight cruise ship has been operating out of the Port of Palm Beach, the *Bahamas Celebration*. The *Bahamas Celebration* can accommodate up to 1311 passengers at maximum capacity (not including crew), on approximately 178 vessel calls per year. They run a two-day route to Freeport, Bahamas and back, every other day. The Celebration Cruise Line has been operating at an average of 67% of maximum capacity from their first voyage throughout the remainder of calendar year 2010, as shown in Table 23, below. The only way for Celebration Cruise Lines to expand their current service would be to add a second vessel to their route, which would effectively double their current passenger capacity. This scenario is a best-case future growth scenario. Since the cruise line has only been operating from March, 2010, and the industry exhibits high seasonality, a future growth estimate was not determined. The economic analysis was kept more conservative by assuming existing cruise traffic throughout the period of analysis.

Table 23. Bahamas Celebration Cruise Passenger Statistics by Month in 2010

Month	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Total Passengers	8,245	15,222	13,841	15,968	17,831	15,651	8,892	10,057	10,239	10,867	126,813
Number of Voyages	8	15	15	15	16	15	15	16	15	15	145
Avg. Passengers Per Voyage	1,031	1,015	923	1,065	1,114	1,043	593	629	683	724	882
Avg. Percent of Full Capacity	79%	77%	70%	81%	85%	80%	45%	48%	52%	55%	67%

Note: First record is March 17, 2010.
Source: U.S. Customs and Border Protection

Before the *Bahamas Celebration* began to sail out of the Port of Palm Beach, the Port renovated its current cruise passenger terminal to accommodate the larger vessel and greater number of passengers. The Port also left the smaller day-cruise passenger terminal intact and ready to service another day-cruise. Because of the general success of the *Palm Beach Princess* during its 13-year life at the Port of Palm Beach, another day-cruise vessel has already begun operating. In 2012, the Port accepted a contract from an operator of the vessel *Black Diamond*, a 160 ft long cruise vessel with a capacity of 600 passengers and 150 crew members. The *Black Diamond* began service in November 2012 and operates on a twice-daily schedule. The *Black Diamond* also provides regional economic development benefits because it is a U.S. flagged vessel and it employs 150 local workers. The Port of Palm Beach will realize increased revenues from parking and passenger fees as well. In 2013, the *Black Diamond* came under new ownership, and has been renamed *Island Breeze II*. It has stopped sailing briefly due renovations, but it is expected to begin a normal schedule in early 2014. The vessel operators have a 10-year contract with the port, which guarantees 125,000 passengers annually.

4.3 Future With- and Without-Project Vessel Movements

The future without-project vessel fleet will be similar to the composition of the existing fleet, particularly in the fact that it will be draft-constrained by the existing project depth minus under-keel clearance; and length-constrained by the sharp turn in the entrance channel. Under without-project conditions the future fleet will call at 30 foot drafts maximum for (non-petroleum) liquid bulk and dry bulk (33 foot project depth minus 3 foot under-keel clearance requirements). Compared to the existing condition, one main difference will be the number of vessel calls. The future without-project vessel calls were projected by applying the forecasted commodity tonnage for each commodity type to a vessel fleet distribution that is similar to the existing condition fleet mix. The future with and without-project vessel movements are summarized in Table 24, Table 25, and Table 26. In these tables you can clearly see the shift from smaller to larger vessels for the primary benefitting bulk commodities.

The future-with project vessel calls were projected by applying the forecasted commodity tonnage for each commodity type to a fleet distribution that minimizes total transportation costs by utilizing the most efficient mix of vessel sizes that take full advantage of increased channel width and depth in the future with-project conditions. In the following subsections, the assumptions and caveats behind each of the vessel fleet predictions are detailed.

Table 24. Vessel Movements by Vessel Type and Class for With- and Without-Project, 2017 forecast

Vessel Type	Vessel Class	Without Project	38 ft + Widening	39 ft + Widening	40 ft + Widening	41 ft + Widening
Container	Container - 300 TEU	714	714	714	714	714
Container	Container - 600 TEU	8	8	8	8	8
Container	Container - 1000 TEU	52	52	52	52	52
Container	Container - 1200 TEU	50	50	50	50	50
Container	Container - 1400 TEU	2	2	2	2	2
Barge	Dry Barge - Sugar	46	46	46	46	46
Barge	Tanker Barge - Petroleum	30	11	11	11	11
Tanker	Tanker Molasses - 20k DWT	3	0	0	0	0
Tanker	Tanker Molasses - 25k DWT	9	0	0	0	0
Tanker	**Tanker Molasses - 35k DWT**	**1**	**3**	**0**	**0**	**0**
Tanker	**Tanker Molasses - 50k DWT**	**0**	**3**	**3**	**3**	**3**
Tanker	**Tanker Molasses - 60k DWT**	**0**	**1**	**3**	**3**	**3**
Tanker	Tanker Petroleum - 10k DWT	3	0	0	0	0
Tanker	**Tanker Petroleum - 35k DWT**	**0**	**9**	**9**	**9**	**9**
Tanker	**Tanker Petroleum - 50k DWT**	**0**	**1**	**1**	**1**	**1**
Bulker	Bulker Cement - 15k DWT	3	0	0	0	0
Bulker	**Bulker Cement - 35k DWT**	**1**	**1**	**1**	**1**	**0**
Bulker	**Bulker Cement - 40k DWT**	**2**	**1**	**1**	**1**	**0**
Bulker	**Bulker Cement - 50k DWT**	**0**	**1**	**1**	**1**	**1**
Bulker	**Bulker Cement - 60k DWT**	**0**	**0**	**0**	**0**	**1**
Gen Cargo	Gen Cargo - Small	94	94	94	94	94
Gen Cargo	Gen Cargo - 20k DWT	6	1	0	0	0
Gen Cargo	**Gen Cargo - 24k DWT**	**1**	**2**	**2**	**2**	**0**
Gen Cargo	**Gen Cargo - 30k DWT**	**1**	**2**	**2**	**2**	**2**
Gen Cargo	**Gen Cargo - 37.5k DWT**	**0**	**1**	**1**	**1**	**2**
Cruise	Cruise - Bahamas Celebration	182	182	182	182	182
Cruise	Cruise - Day Cruise	703	703	703	703	703
Total		1911	1888	1886	1886	1884

Note: Primary benefitting vessel classes are shown in bold.

Table 25. Vessel Movements by Vessel Type and Class for With- and Without-Project, 2037 forecast

Vessel Type	Vessel Class	Without Project	38 ft + Widening	39 ft + Widening	40 ft + Widening	41 ft + Widening
Container	Container - 300 TEU	1093	1093	1093	1093	1093
Container	Container - 600 TEU	28	28	28	28	28
Container	Container - 1000 TEU	93	93	93	93	93
Container	Container - 1200 TEU	90	90	90	90	90
Container	Container - 1400 TEU	16	16	16	16	16
Barge	Dry Barge - Sugar	46	46	46	46	46
Barge	Tanker Barge - Petroleum	37	14	14	14	14
Tanker	Tanker Molasses - 20k DWT	3	0	0	0	0
Tanker	Tanker Molasses - 25k DWT	9	0	0	0	0
Tanker	**Tanker Molasses - 35k DWT**	**1**	**3**	**0**	**0**	**0**
Tanker	**Tanker Molasses - 50k DWT**	**0**	**3**	**3**	**3**	**3**
Tanker	**Tanker Molasses - 60k DWT**	**0**	**1**	**3**	**3**	**3**
Tanker	Tanker Petroleum - 10k DWT	4	0	0	0	0
Tanker	**Tanker Petroleum - 35k DWT**	**0**	**10**	**10**	**10**	**10**
Tanker	**Tanker Petroleum - 50k DWT**	**0**	**2**	**2**	**2**	**2**
Bulker	Bulker Cement - 15k DWT	4	0	0	0	0
Bulker	**Bulker Cement - 35k DWT**	**2**	**2**	**0**	**0**	**0**
Bulker	**Bulker Cement - 40k DWT**	**3**	**2**	**2**	**2**	**0**
Bulker	**Bulker Cement - 50k DWT**	**0**	**1**	**1**	**1**	**0**
Bulker	**Bulker Cement - 60k DWT**	**0**	**0**	**1**	**1**	**3**
Gen Cargo	Gen Cargo - Small	114	114	114	114	114
Gen Cargo	Gen Cargo - 20k DWT	8	3	1	1	0
Gen Cargo	**Gen Cargo - 24k DWT**	**1**	**2**	**1**	**1**	**1**
Gen Cargo	**Gen Cargo - 30k DWT**	**1**	**2**	**2**	**2**	**2**
Gen Cargo	**Gen Cargo - 37.5k DWT**	**0**	**1**	**2**	**2**	**2**
Cruise	Cruise - Bahamas Celebration	182	182	182	182	182
Cruise	Cruise - Day Cruise	703	703	703	703	703
Total		2438	2411	2407	2407	2405

Note: Primary benefitting vessel classes are shown in bold.

Table 26. Vessel Movements by Vessel Type and Class for With- and Without-Project, 2067 forecast

Vessel Type	Vessel Class	Without Project	38 ft + Widening	39 ft + Widening	40 ft + Widening	41 ft + Widening
Container	Container - 300 TEU	1093	1093	1093	1093	1093
Container	Container - 600 TEU	28	28	28	28	28
Container	Container - 1000 TEU	93	93	93	93	93
Container	Container - 1200 TEU	90	90	90	90	90
Container	Container - 1400 TEU	16	16	16	16	16
Barge	Dry Barge - Sugar	46	46	46	46	46
Barge	Tanker Barge - Petroleum	52	22	22	22	22
Tanker	Tanker Molasses - 20k DWT	3	0	0	0	0
Tanker	Tanker Molasses - 25k DWT	9	0	0	0	0
Tanker	**Tanker Molasses - 35k DWT**	**1**	**3**	**0**	**0**	**0**
Tanker	**Tanker Molasses - 50k DWT**	**0**	**3**	**3**	**3**	**3**
Tanker	**Tanker Molasses - 60k DWT**	**0**	**1**	**3**	**3**	**3**
Tanker	Tanker Petroleum - 10k DWT	6	0	0	0	0
Tanker	**Tanker Petroleum - 35k DWT**	**0**	**13**	**13**	**13**	**13**
Tanker	**Tanker Petroleum - 50k DWT**	**0**	**3**	**3**	**3**	**3**
Bulker	Bulker Cement - 15k DWT	9	0	0	0	0
Bulker	**Bulker Cement - 35k DWT**	**3**	**3**	**0**	**0**	**0**
Bulker	**Bulker Cement - 40k DWT**	**6**	**3**	**3**	**0**	**0**
Bulker	**Bulker Cement - 50k DWT**	**0**	**3**	**3**	**0**	**0**
Bulker	**Bulker Cement - 60k DWT**	**0**	**0**	**2**	**6**	**6**
Gen Cargo	Gen Cargo - Small	127	127	127	127	127
Gen Cargo	Gen Cargo - 20k DWT	12	2	2	0	0
Gen Cargo	**Gen Cargo - 24k DWT**	**3**	**5**	**4**	**4**	**4**
Gen Cargo	**Gen Cargo - 30k DWT**	**3**	**5**	**4**	**4**	**4**
Gen Cargo	**Gen Cargo - 37.5k DWT**	**0**	**3**	**2**	**3**	**3**
Cruise	Cruise - Bahamas Celebration	182	182	182	182	182
Cruise	Cruise - Day Cruise	703	703	703	703	703
Total		2485	2447	2442	2439	2439

Note: Primary benefitting vessel classes are shown in bold.

4.3.1 Design Vessel

The Institute for Water Resources (IWR) National Economic Development Deep Draft Navigation Manual defines a design vessel as the largest existing or future vessel call that is expected to use the harbor in on a recurring basis, but may be in insignificant numbers. The economic analysis should be able to show that the fleet and commodity forecast support the size of the design vessel. If not, then a smaller design vessel should be used.

Three design vessels were identified for the ship simulation. The dimensions of the design vessels are shown in Table 27, below. The *Palm Beach Brewer* and *Black Rose* are both single-screw Panamax bulkers, which represent the largest vessels with least-capable handling that are expected to call in the with-project condition. These vessel sizes coincide with the largest vessel sizes used in the HarborSym modeling analysis (see

Table 25 and Section 4.3.8). The *Norwegian Sea* is a larger cruise ship that could possibly call in the with-project condition when the existing cruise vessel reaches the end of its useful life, but it is not assumed to call in the future for the purposes of this study's economic analysis.

Table 27. Design Vessels Used for Ship Simulation

Ship Name	Palm Beach Brewer	Black Rose	Norwegian Sea
Condition	Loaded	Loaded	Design
Tonnage	62,820	65,085	19,810
LOA (ft)	656	707	710
Beam (ft)	106	105	93.2
Draft Fwd (ft)	40.02	40.02	22.3
Draft Aft (ft)	40.02	40.02	22.3
Propulsion	Diesel	Diesel	Diesel
Bow Thruster hp	none	none	2,682
Stern Thruster hp	none	none	2,682
Shaft HP	13,357	13,512	14,161
Propeller	1 Fixed	1 Fixed	2 Variable
Propeller Direction	CW	CW	Inward
Max Rudder	35	35	35

4.3.2 Residual Fuel Oil and Diesel

The 2017 base year for liquid petroleum projections assumes that growth will continue from 2010 on, as the local demand returns to normal from recession levels. The 2017 level of liquid petroleum products was determined by first calculating the 2011 tonnage of imports for diesel fuel and residual fuel oil, as self-reported by port tenants. Then growth rates were applied to these commodities using the projected national rates of growth of demand for electricity and transportation energy, respectively (USEIA, Annual Energy Outlook 2010).

In the without project condition, receipts of fuel oil continue to move primarily by domestic tug and barge. With the large reduction in fuel oil receipts because of the Riviera Beach power plant conversion to natural gas, it is less likely that the fleet of tanker vessels carrying fuel oil will transition to self-propelled vessels in the without-project condition. Diesel fuel will continue to be brought in by domestic tug and barge (which are not draft constrained) in the without-project condition as well. Panamax tankers, even light-loaded, cannot utilize the harbor in the without-project condition because they are too long to maneuver safely through the turn in the inner channel. In the with-project condition, a transition to self-propelled tankers would be likely because of the economies of scale offered by bringing in larger vessels, as well as the benefits of reduced sailing restrictions and less tugs used. This transition to self-propelled vessels will take place with widening-only, since channel width is the primary constraint for longer tankers.

4.3.3 Asphalt and Cement

Asphalt would continue to by domestic tug barge (which are not draft constrained) in the future without-project condition. Panamax tankers, even light-loaded, cannot utilize the harbor in the without-project condition because they are too long to maneuver safely through the turn in the inner channel. As asphalt receipts are expected to rise steadily, in the future with-project condition a transition of fleet to larger self-propelled tanker vessels would be likely because of economies of scale and benefits from fewer vessel movements, and less tugs used. This transition to self-propelled vessels will take place with widening-only, since channel width is the primary constraint for longer tankers. However, the amount of asphalt that can be moved through the Port is constrained by the available storage facilities at the Port. The on-dock storage capacity limitation for asphalt receipts only limits the volume that can be received in a single shipment. It does not limit the total throughput capacity at the port. This single shipment tonnage limitation was taken into account in the vessel movements and commodity transfers that were simulated in HarborSym. As demand increases into the future, the turnover rate of the storage tanks will increase to accommodate the additional throughput.

Cement receipts are already moved via self-propelled bulk ships, which are currently draft-constrained given the evidence that the largest cement vessels calling in recent years have had up to 37.7 foot design drafts. Cement ships also use tug assistance the most frequently. In the future with-project scenario, cement carriers would likely be larger vessels approaching 50,000 DWT, which would draw deeper drafts, and, if the channel were wider, they might use tug assistance less frequently. The main advantage of using larger vessels would be a transportation cost savings in the form of fewer shipments to move a similar amount of goods. In addition, the larger channel dimensions would relieve some of the sailing restrictions to which large bulk vessels must currently adhere.

4.3.4 Sugar and Molasses

Sugar and molasses have traditionally been two of the Port of Palm Beach's major domestic shipment and foreign export commodities. In the future without-project scenario, sugar and molasses tonnage movements will likely return to 2004 levels by 2017 and then experience no growth over the period of analysis because of how close the production level will be to the limit of sugar production in Florida, which is constrained by land available for production. Without capacity restrictions the growth rate of sugar production in Florida would follow the U.S. growth rate, which is forecasted to be 0.6 percent (USDA, 2010). Sugar would continue to move by domestic tug and barge in both the without-project and with-project conditions because of national price supports for US sugar production.

Molasses is generally exported to Europe for use in animal feed and other food products. The molasses products tankers are currently draft constrained, as the largest vessels that have called in recent years have design drafts up to 41 feet. Molasses products tankers (like cement vessels) also use the greatest number of tug assistance. In a future with-project condition, molasses tanker size would generally increase with a deeper channel, and their use of tugs would likely decrease with a wider channel.

4.3.5 Containerized Cargo

Tropical currently offers at least 6 different liner services, which visit nearly 30 Caribbean ports. Their total average capacity is 3000 TEUs per week through the Port of Palm Beach for all of their liner services combined, using mainly feeder-type vessels with capacities of less than 1000 TEUs. Extrapolated over the entire year, the total annual capacity for all Tropical Shipping services through the Port of Palm Beach is approximately 156,000 TEUs per year. According to Tropical, an estimated 135,000 loaded TEUs moved in 2010, which means they were operating at about 86.5% of their total capacity. Through chartering vessels to meet excess demand, Tropical can expand their liner services accordingly in a relatively short time period compared to building or purchasing a new vessel. However, once demand reaches a certain threshold it is more economical for Tropical to build or purchase a new vessel for their fleet.

The rate of growth attributed to containerized cargo exports from the Port of Palm Beach is directly related to demand for goods in the Caribbean islands that are serviced by Tropical Shipping. The demand for goods in the Caribbean islands is primarily influenced by growth of travel and tourism in the area. Travel and tourism direct industry's real GDP in the Caribbean has been estimated to grow at rates up to 4.2 percent from 2010 to 2020 (World Travel and Tourism Council, 2010). Therefore, the tenant's own growth estimate of 3 percent per year was applied to the 2009 number of loaded and empty TEUs as recorded by the Port, and extrapolated through 2037, at which point the Port will likely approach its throughput capacity.

4.3.6 Non-Containerized General Cargo and Specialty Shipments

Even with relatively low commodity tonnages and growth rates, the vessels calling the Port of Palm Beach in the future for general cargo shipments will likely be some of the largest vessels. This is primarily because the largest of these vessels are calling already fully loaded in order to pick up or deliver specialty shipments, such as yachts or project cargo. The vessels arrive heavily loaded and then add project cargo or specialty cargo to the deck before departing at the limits of the channel depth. Alternatively, the vessel may arrive at the maximum sailing draft in the channel, and then drop off only the cargo on its deck and depart heavily loaded. So, the large general cargo ships are using the maximum available draft or near the maximum draft both inbound and outbound. The existing fleet of the largest general cargo ships is already draft-constrained by the current channel depth, and it is length constrained by channel width. In the future without-project scenario, these limits will continue to be hardships for the port tenants that move these types of goods. Project cargo and yachts generally are placed on the top deck of a loaded general cargo ship. If the channel depth is limited, then the ships must light load in order to be able to call the Port of Palm Beach as the first stop or last stop in their route with the specialty goods on the top deck.

The largest general cargo vessels that have called in recent years have had lengths up to 655 feet, and design drafts up to 36.75 feet (Table 12). In the future without project, these vessels will continue to be draft and length constrained. With a deeper and wider channel in the with-project condition, vessels of this type will be larger and more able to more fully load to their design drafts with other types of cargo before calling Palm Beach to load or unload specialty cargo.

4.3.7 Cruise Passengers

Currently, the Bahamas Celebration, at 673.4 feet long, is the largest cruise vessel that will fit through the turn in the entrance channel of Lake Worth Inlet. Additionally, the *Bahamas Celebration* must make a sharp turn when backing out to avoid the shoal at the south side of Peanut Island. This turn prevents cargo vessels from berthing at Berth 6 (opposite Berths 2-3 in Slip 1) when the cruise ship present.

In the future without-project condition, the overnight cruise vessels will remain length constrained because of the sharp turn in the entrance channel, and the berth usage restriction will remain in place. If Celebration Cruise Line were to add a second vessel to their fleet in the without-project condition, it would be of a similar length. The overnight cruise vessel is only subject to current constraints under high wind conditions (> 30 knots) in the without-project condition (Table 1). Under with-project conditions, the current restriction would be lifted, and the berthing restriction would be lifted. Under with-project conditions, a longer cruise vessel may be likely to call as well. However, this was not assumed in the analysis to make the assumptions as conservative as possible. The day-cruise vessel would be the same in the with- and without-project conditions.

4.3.8 Future Without- and With-Project Vessel Size Comparison Summary

Currently, the largest self-propelled vessels will be limited to the 30,000 to 35,000 DWT range. With a deeper channel, larger vessels upwards of 50,000 DWT could operate into the Port with the result of carrying additional cargo on fewer dry bulk and general cargo vessels. A deeper channel would also result in more self-propelled tanker vessels for imports of diesel and asphalt (shifting from domestic barge).

Under with-project conditions there will likely be a decrease in the number of vessel calls because of a replacement of smaller vessels and some barges with larger vessels. Depending on future with-project channel depth, Panamax-beam dry bulk vessels are expected to call between approximately 50,000 and 60,000 DWT. Under with-project conditions there will be a shift from domestic tug and barge to self-propelled tankers for liquid petroleum bulk movements.

5 National Economic Development Benefits

The Planning Guidance Notebook, Engineer Regulation 1105-2-100, gives specific details of what can be considered a NED benefit for deep-draft navigation improvement projects. The NED benefits for the Lake Worth Inlet project were determined using the transportation cost reduction method. Transportation cost reductions, in the most basic terms, are calculated by subtracting the total cost of moving all of the goods through the port over the period of analysis in the with-project condition from the total cost in the without-project condition. Total transportation costs were calculated using the Corps-certified HarborSym simulation model.

5.1 Economic Model Setup and Inputs

5.1.1 Methods and Key Assumptions

Transportation cost savings benefits in the study were derived from increased efficiencies in the movement of cargo. For the purposes of this study, all benefits from reductions in transportation costs were assumed to have the same destination, and harbor with and without the project. For the sake of simplification of the analysis, it was assumed that increased efficiencies would reduce transportation costs without affecting the demand for import and export of goods through the harbor. This means that the commodity tonnages forecast to be transited through Palm Beach Harbor are expected to move with or without the proposed improvements. There will be no expected shift in destination, mode of transportation, or any induced movement of cargo due to the proposed navigation improvements. However, for some petroleum products there will be a shift in origin from the U.S. Gulf Coast to East Coast of South America and the Caribbean. Transportation cost savings will result primarily from the use of larger, more efficient vessels, more efficient use of large vessels that are currently transiting the harbor, and reduced congestion in the harbor.

Other primary assumptions include: that the rest of origin to destination and land-side costs remain the same in with-and without project; changes in additional fees (such as dockage, wharfage, tug-assist, etc.) were minimal and therefore were not included in the analysis.

The Corps-developed HarborSym model (version 1.4.8) was used to calculate transportation costs for entire routes and time in port for all vessel calls projected throughout the period of analysis. HarborSym was created by CDM-Smith (under contract) to serve as the primary Corps'-certified economic model for Deep Draft Navigation projects. For this study HarborSym version 1.4.8 was used for all final production modeling, and benefit calculations. The HarborSym Model has been certified for use on all deep draft navigation studies in accordance with Engineering Circular 1105-2-412, Assuring Quality of Planning Models.

HarborSym performs data-driven Monte Carlo simulations of vessel transits through harbors, based on user input. The model incorporates uncertainty through randomizing parameters over multiple model iterations, based on a user-inputted range for parameters such as vessel speed through a specified area (reach), loading and unloading times at docks, docking and undocking times, at-sea distances, etc.

The simulations are based upon vessels moving through reaches from the harbor entrance to their destination dock. At each time increment (step) the model determines if each vessel can move from one node to the next, without violating transit rules. If a transit rule would be violated by a vessel entering a reach, such as passing another vessel when the channel width is too narrow, then the vessel waits until the next time step. This waiting continues until the rule is no longer violated and the vessel resumes its journey.

HarborSym records and accumulates the total time and cost of vessel transits through the harbor and at sea. Since many variations of events can occur over a total voyage, many iterations of the simulation were run to obtain the average values for time in the harbor, time waiting, and total operating costs of vessels in the harbor and at sea.

Assumptions that were included in the development of the HarborSym model or are limitations of using the model are described in the following lists. The limitations of the model were not considered significant for the purposes of this study.

HarborSym Model limitations:

- Tug use and tug costs are not included.
- Wind is not simulated.
- Loading/unloading costs at the port of origin/destination (for imports/exports respectively) are not included.
- Additional handling fees at the study port or foreign port are not included.
- Pilotage costs and other terminal fees for the study port are not included.
- Hinterland transportation costs are not included.
- Ability to account for other fixed costs is not included.

Assumptions in model:

- HarborSym predefined assumptions:
    - All vessels can be classified into classes of similar vessels which exhibit similar operating costs and other characteristics.
    - All vessels of a similar type will have a similar commodity transfer rate for a specific commodity.
    - Arrival times for non-priority vessels will vary randomly within a 24 hour window of the originally designated arrival time.
    - Costs external to the port are the same for all conditions.
- Study-specific assumptions:
    - All vessels are foreign flagged except barges, which are all U.S. flagged.
    - Underkeel clearance for all non-petroleum carrying vessels is a minimum of 3 FT.
    - Underkeel clearance for all petroleum-carrying vessels is a minimum of 4 FT.
    - Vessel sailing draft distribution only differs within a vessel type.

- Vessels in a vessel class for a specific commodity have the same commodity loads transferred and sailing drafts for a specific project alternative and year.
- For simplification purposes, container vessels export goods only.
- For simplification purposes, large cruise vessels export passengers only.
- For simplification purposes and to utilize separate loading rates, smallest general cargo ships (<20,000 DWT) export goods only, while largest general cargo ships import goods only (>=20,000 DWT).
- For simplification purposes, all containers were assumed to be 5 metric tons per TEU in the model.
- Vessels will wait up to 4 days to berth before turning away (deleted from system).
- For draft-constrained vessels, as project depths increase, vessel fleet will transition to the most optimal combination, while observing other constraints such as land-side capacity.

Additional information on the use of HarborSym for this study can be found in the Economic Model Documentation appendix (Appendix H).

5.1.2 Vessel Operating Costs

The primary component of total transportation costs is vessel operating costs (VOCs). Vessel operating costs from VOC EGM 11-05 tables (dated 15 July 2011) were used for this study. Some ships were outside of the range of vessel sizes in the VOC tables; the costs for these vessels were interpolated or extrapolated using DWT or TEU capacity to proportion costs.

In HarborSym, at-sea costs were used while vessels were maneuvering within the harbor. There was not a separate entry available in the model to differentiate between sailing at-sea costs and maneuvering in-harbor costs. These costs were slightly overstated compared to actual maneuvering costs. However, since Palm Beach Harbor has such a short entrance channel, it was determined that this lesser overstatement of costs in-harbor was better than a larger understatement of at-sea costs.

5.1.3 Routes

HarborSym refers to the routes that vessels travel as “route groups.” Route groups represent the distances that vessels travel outside the study port to other ports along their respective routes. For this study, most of the route groups that were included apply to cargoes and vessel types that will benefit from channel deepening. Other vessel types and commodities that will not benefit from channel deepening were assigned to the “Default Route Group,” which only has a placeholder distance of 1 nautical mile for each leg of the journey. Route group distances are summarized in Table 28.

Table 28. Route Groups with Distances from HarborSym Inputs

		Prior Port			
Name	Description	Min Distance	Most Likely	Max Distance	Limiting Depth
Default RtGrp	Default route group	1	1	1	85
Sugar	Sugar Route to Baltimore and NewYork	821	860	898	85
USTankBrg-Gulf	Gulf Coast US Tanker Barge Route with Split Shipment	23	70	131	85
Molasses	Molasses Tanker Route to Northern Europe	4004	4039	4073	85
Petrol-Split	Petroleum Imports with Split Shipment	23	70	131	85
Petrol-Direct	Petroleum Imports with Direct Shipment	74	832	1233	85
Cement-Split	Cement imports with split shipment	56	265.5	499.5	85
Cement-Direct	Cement imports with direct shipment	1188	1483	4253	85
GenCargo	General Cargo world-wide routes	262	1795	4004	85

	Next Port				Additional Sea Distance		
Name	Min Distance	Most Likely	Max Distance	Limiting Depth	Min	Most Likely	Max
Default RtGrp	1	1	1	85	1	1	1
Sugar	821	860	898	85	1	1	1
USTankBrg-Gulf	409.5	459	508.5	85	389.5	511	634.5
Molasses	4004	4039	4073	85	1	1	1
Petrol-Split	37	416	616.5	85	39	460.5	721
Petrol-Direct	74	832	1233	85	1	1	1
Cement-Split	594	741.5	2126.5	85	638.5	989	2366.5
Cement-Direct	1188	1483	4253	85	1	1	1
GenCargo	262	1100	6664	85	1	1	1

Notes: Distances are in nautical miles and depths are in feet. 85 ft limiting depth indicates no limitations at other ports on route.

Route groups were determined based on Waterborne Commerce Statistics Center data, interviews with port tenants, and port-to-port distance estimates from http://sea-distances.com/. The basis for each route group is detailed in the paragraphs below.

The "Sugar" route group is based on a combination of the destinations of most sugar barges departing from the Port of Palm Beach. These primary destinations are Baltimore and New York. Since barges will go to either destination with equal probability, the two distances were averaged to create the most likely distance, while Baltimore was used for the minimum distance, and New York was used for the maximum distance. These min-most likely-max distances were used for both the prior port and next port distances because the barges will operate in a simple back and forth service.

The "USTankBrg-Gulf" route group is based on a combination of the origins and destinations of most US-flagged petroleum tanker barges that call the Port of Palm Beach. Tanker barges will originate from the Gulf Coast, usually from either New Orleans or Houston area petroleum refineries. The barges split their shipment between Florida ports, usually with a first port of call at Port Everglades, Port Canaveral or Jacksonville. Then Palm Beach is the second port of call before returning to the Gulf Coast. In the case of a split shipment, costs are also split between the shippers at each receiving port. To simulate this in the model, distances were halved for each of the distances on the route. Therefore, the "Prior Port" distances reflect half of the distances from other Florida ports to the Port of Palm Beach, the "Next Port" distances reflect half of the distances from the Port of Palm Beach to the Gulf Coast, and the "Additional Sea Distances" reflect half of the distances from the Gulf Coast to other Florida ports.

The “Molasses” route group is based on a combination of the destinations of foreign-flagged molasses tankers, departing from the Port of Palm Beach. These primary destinations are Dagenham on the Thames River near London, U.K. and Amsterdam, Netherlands. Since tankers will go to either destination with equal probability, the two distances were averaged to create the most likely distance, while London was used for the minimum distance, and Amsterdam was used for the maximum distance. These min-most likely-max distances were used for both the prior port and next port distances because the tankers will operate in a simple back and forth service.

The “Petrol-Split” route group is based on a combination of origins and destinations of petroleum tankers that operate in a split-shipment service with other Florida ports. The concept of this route is similar to the “USTankBrg-Gulf” route, except the origin is a foreign port instead of a domestic port. Tankers originate from either the Caribbean (Freeport, Bahamas and Willemstad, Curacao) or the East Coast of South America (Maracaibo, Venezuela). The tankers split their shipments between other Florida Ports and Port of Palm Beach, and then return to their origin after calling the Port of Palm Beach. In the case of a split shipment, costs are also split between the shippers at each receiving port. To simulate this in the model, distances were halved for each of the distances on the route. The “Petrol-Direct” route is similar to the Petrol-Split route, except that it excludes the distances to other Florida ports, and distances are not halved.

The “Cement-Split” route is based on a combination of origins and destinations of cement bulkers that operate in a split-shipment service with other U.S. ports. Cement bulkers will originate from the Caribbean (Netherlands Antilles), East Coast South America (Maracaibo, Venezuela), or Northern Europe (Aalborg, Denmark). They will stop at another U.S. East Coast or U.S. Gulf Coast port (Tampa, Jacksonville, New York, Port Canaveral, Providence, or Mobile), and then stop at the Port of Palm Beach before returning to the port of origin. In the case of a split shipment, costs are also split between the shippers at each receiving port. To simulate this in the model, distances were halved for each of the distances on the route. The most likely distances for each leg of the route are based on weighted averages of distances for that leg derived from Waterborne Commerce Statistics Center data. The “Cement-Direct” route is similar to the Cement-Split route, except that it excludes the distances to other U.S. ports, and distances are not halved.

The share of tonnages allocated to “direct” and “split” routes were dependent on the most cost effective allocation of the vessel fleet calling the Port of Palm Beach.

Generally:

- In the without-project condition and the with-project condition, all petroleum tankers 35,000 DWT (deadweight tons) and above were assigned to split routes.
- In the without-project condition, all dry bulkers were assigned to split routes.
- In the with-project condition, all dry bulkers were assigned to direct routes.
- All petroleum product movements on domestic barges were assigned to split routes.

The “GenCargo” route is based on a combination of origins and destinations for large general cargo vessels (sailing draft greater than or equal to 30 FT) that called the Port of Palm Beach. The most likely distances for each leg of the route are based on weighted averages of distances for that leg derived from Waterborne Commerce Statistics Center data. For modeling purposes, it was assumed that large general cargo vessels operate similar to bulkers in a back-and-forth pattern, and therefore no additional at-sea distance was included. In reality, large general cargo ships will often visit more than one port on a route, however, the large number of possible combinations of ports, limited available data, and relatively low project benefits made this reality not as valuable to include in the model in greater detail. Therefore, it was assumed that the large distribution between minimum and maximum distances for both prior and next ports will also cover the possibility of additional at-sea distances. This route group is only applied to the largest classes of general cargo ships; those that are greater than or equal to 20,000 DWT.

5.1.4 HarborSym Transportation Cost Accounting

This section is intended to provide an example and explanation of how, once the model is set-up, HarborSym accounts for total transportation costs of moving cargo and vessels through the port.

In-port cost allocation:
For each vessel that enters the harbor, the total transportation cost for time spent in the harbor is calculated. Known as "time in system," the total time spent within the harbor is calculated by using the speeds by reach, commodity loading rates, docking times, undocking times, turning times, and waiting times. Then the hourly operating costs of each vessel (specified at the class level) are multiplied by the times that vessels take to transit the harbor. See figure/table below

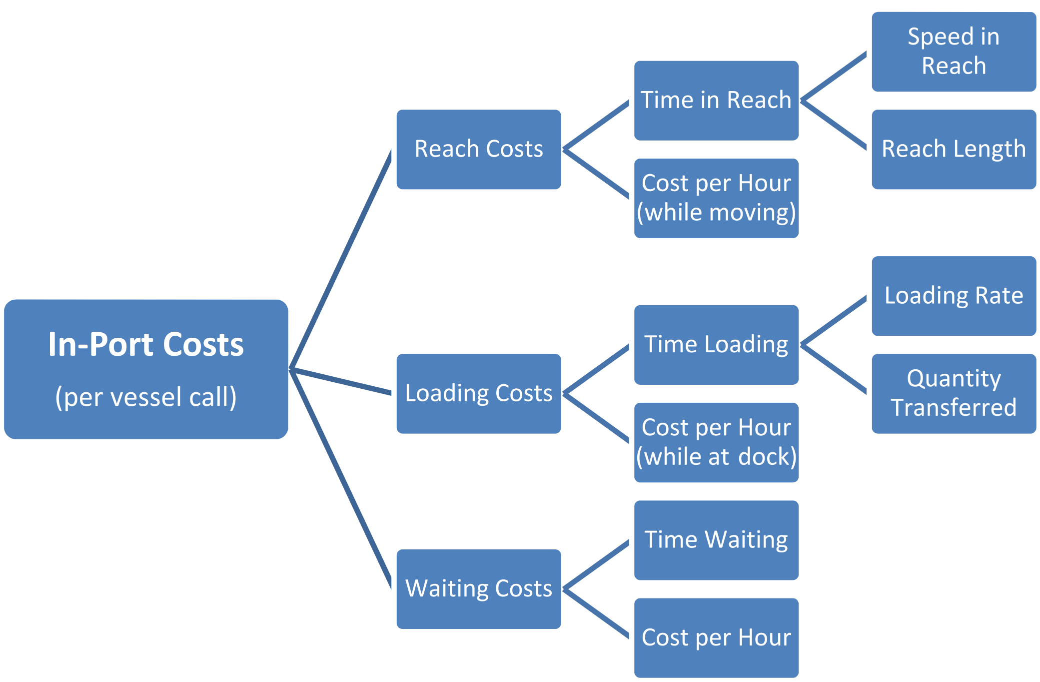


Figure 29. In-Port Cost Computation Chart

At-sea cost allocation:

To calculate transportation costs that occur while the vessel is transiting the ocean leg of the voyage, the speeds and route distances are used to determine the total time at-sea. Then the time at sea is multiplied by the hourly cost at sea to determine the transportation cost at sea. See figure/table below.

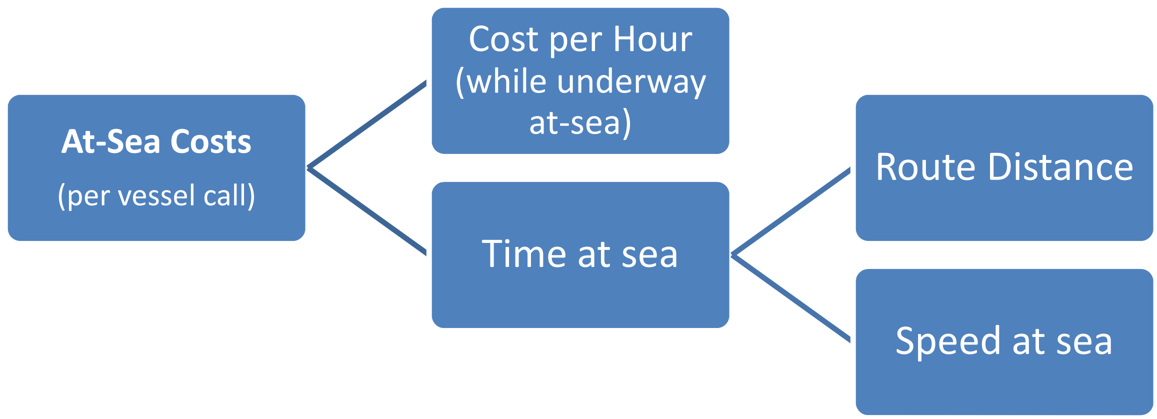


Figure 30. At-Sea Cost Computation Chart

Total transportation costs were then calculated by summing the in-port and at-sea transportation costs, for each vessel call in the simulation.

Figure 31. Total Transportation Cost Computation Chart

Differences in transportation costs between with- and without-project conditions:
The total transportation costs in the with-project condition were subtracted from the total transportation costs in the without-project condition to determine the total transportation cost savings in each project condition.

Table 29. Example of Transportation Cost Savings Calculation

2017 Molasses Tonnage	
264,628	Tons of Molasses

Vessel DWT	Capacity	Tonnage Loaded per Call	Loading Rate	Time in Port per Call (hrs)	Cost in Port per Call	Speed at Sea (knots)	Round-trip Voyage Distance (nm)	Time at Sea per Voyage (hrs)	Cost at Sea per Voyage	Total Cost per Call	Number of Calls	Total Cost for all Calls
20,000	18,000	16,246	300	54	$ 25,000	12.6	8000	635	$ 540,000	$ 565,000	3	$ 1,695,000
25,000	23,000	20,759	300	69	$ 35,000	12.8	8000	625	$ 563,000	$ 598,000	9	$ 5,382,000
35,000	32,200	29,062	300	97	$ 56,000	13.0	8000	615	$ 628,000	$ 684,000	1	$ 684,000
											Total	$ 7,761,000

Vessel DWT	Capacity	Tonnage Loaded per Call	Loading Rate	Time in Port per Call (hrs)	Cost in Port per Call	Speed at Sea (knots)	Round-trip Voyage Distance (nm)	Time at Sea per Voyage (hrs)	Cost at Sea per Voyage	Total Cost per Call	Number of Calls	Total Cost for all Calls
50,000	46,000	40,095	300	134	$ 88,000	13.2	8000	606	$ 703,000	$ 791,000	3	$ 2,373,000
60,000	55,200	48,114	300	160	$ 125,000	13.3	8000	602	$ 794,000	$ 919,000	3	$ 2,757,000
											Total	$ 5,130,000
											Savings	$ 2,631,000

Notes: Some values were approximated or rounded for this example. Hourly transportation costs were rounded for this example and are not shown in the table above to protect proprietary data sources.

Table 29 shows an example of transportation cost savings calculations for molasses cargo in 2017 in order to illustrate the flow charts shown in the figures above. These calculations are all performed by the HarborSym model for each commodity type and vessel movement. The model will vary certain inputs randomly within a triangular distribution based on a specified range over multiple iterations.

5.2 Economic Modeling Results and Plan Selection

Plan formulation started before any economic modeling took place. The first phase of screening used the ship simulation results to narrow down the widening alternatives to a single widening plan footprint that was used throughout all of the alternatives (Figure 32). In general, the entrance channel will be widened from 400' to 440' and 460' (width varies), the inner channel (Cut-1 and Cut-2) will be widened from 300' to 450' minimum, and the south end of the main turning basin will be extended by 150'.

The widening footprint was refined and reduced over several iterations as environmental concerns were raised and addressed, costs were identified and refined, and as the widening plan was evaluated further by the harbor pilots with respect to the ship simulation results. Only a single widening footprint was modeled because the widening features had already been reduced to their smallest practicable dimensions, while still guaranteeing the necessary level of safety for larger vessels and rule changes according to the harbor pilots. Any greater widening measures would have increased the project costs without increasing the benefits, and therefore were not modeled.

The design vessels that were identified as the largest vessels that will call on a recurring basis were used in the ship simulation. The vessel tracks assisted in determination of the widening footprint. These vessels also determined the maximum inner channel depth to evaluate for deepening, 43 ft. A 43 ft inner channel project depth would allow the design vessels to transit the harbor fully-laden, without tide restrictions. All project depths in this appendix refer to the inner channel and main turning basin at mean lower-low water (MLLW).

The outer entrance channel will be several feet deeper than the inner channel and include widening features to account for wave action in the with-project condition. According to Engineer Manual (EM) 1110-2-1613, safe navigation will usually require a wider and deeper entrance channel than the port interior channel because navigation in entrance channels is often affected adversely by strong and variable (in space and time) tidal currents, rough seas and swell, breaking waves, and wind. See the Engineering Appendix (Appendix A) for more info on specific depths in areas of the project.

The existing project depth is 33 ft MLLW in the inner channel and turning basin. It was determined through interviews with port users and harbor pilots that some shipping and vessel-transit practices would be changed to realize transportation cost savings if the channel were widened only, without deepening. Accordingly, a widening-only project alternative was evaluated for the 33 ft existing depth. Furthermore, the harbor pilots and port users maintained that widening would be required for any benefits to be recognized from deepening. Therefore, the intermediate array of project alternatives was identified for economic modeling as widening only, and for each 1 ft incremental depth, deepening from 34 ft to 43 ft with widening.

Figure 32. Recommended Plan Widening Features

Note: Figure is shown for reference purposes only.

5.2.1 Annual Cost Savings for Intermediate Array of Alternatives

Once the widening alternatives were screened down to one single set of widening features, the HarborSym model was used to analyze the “intermediate array” of alternatives. This first round of modeling was at a lower level of detail than subsequent modeling of the final array. One major difference is that the split-shipment route groups and distanced were not yet defined at this stage of the modeling effort. Also, to save time and study costs, only every other depth increment was modeled, and then benefits were interpolated between depths to compare the full array of alternatives. Finally, for the initial and intermediate screening, the costs shown were calculated at a lower level of detail, and interest during construction (IDC) was estimated based on uniform monthly payments instead of the actual construction schedule. The first level of modeling results and intermediate screening-level costs are shown in Table 30, Table 31, and Table 32, below.

Table 32 shows a summary of the net NED benefits and benefit-cost ratios for the intermediate array of alternatives. The alternative with the highest net NED benefits is the 40 ft project depth with widening. Both the 39 ft and 41 ft depth alternatives showed net NED benefits very close to the 40 ft depth.

Table 30. Intermediate Array of Alternatives Total Present-Value and Average Annual Benefits

Project (Depth)	Sum of Present-Value Total Transportation Cost Savings	Average Annual Transportation Cost Savings
Widening-Only	$ 92,360,668	$ 4,116,905
34'+Widening	$ 140,105,583	$ 6,245,097
35'+Widening	$ 154,813,739	$ 6,900,701
36'+Widening	$ 169,521,895	$ 7,556,306
37'+Widening	$ 184,230,051	$ 8,211,911
38'+Widening	$ 196,953,886	$ 8,779,066
39'+Widening	$ 209,677,721	$ 9,346,221
40'+Widening	$ 219,161,213	$ 9,768,940
41'+Widening	$ 228,644,705	$ 10,191,659
42'+Widening	$ 236,256,816	$ 10,530,963
43'+Widening	$ 243,868,926	$ 10,870,267

Notes: Annualized at 3.75% over 50 years. Linear interpolation was used for benefits of even-numbered depths. Benefits are based on 10-iteration model runs. Results based on preliminary version of model that did not account for practice of split-shipments of petroleum products and cement.

Alternatives beyond 39 ft benefit cement, general cargo, molasses, and petroleum. All of these commodities experience reduced tidal, current, and daylight restriction delays with increased project depths. Cement and general cargo vessels are also able to increase loading and reduce vessel calls from the 39 ft plan to the 40 ft plan in 2067, and from the 40 ft plan to the 41 ft plan in 2017 and 2037.

Table 31. Intermediate Array of Alternatives Total and Average Annual Project Cost

Project Depth +Widening (Feet)	Project Cost	Construction Duration (days)	Construction Duration (months)	Interest During Construction	Total Cost Including IDC	Average Annual Cost
33	$ 48,000,000	321	10.7	$ 723,144	$ 48,723,144	$ 2,171,796
34	$ 48,000,000	322	10.7	$ 725,546	$ 48,725,546	$ 2,171,903
35	$ 49,000,000	327	10.9	$ 752,700	$ 49,752,700	$ 2,217,688
36	$ 50,000,000	337	11.2	$ 794,760	$ 50,794,760	$ 2,264,137
37	$ 53,000,000	355	11.8	$ 891,974	$ 53,891,974	$ 2,402,193
38	$ 58,000,000	404	13.5	$ 1,125,621	$ 59,125,621	$ 2,635,478
39	$ 65,000,000	462	15.4	$ 1,459,427	$ 66,459,427	$ 2,962,377
40	$ 71,000,000	514	17.1	$ 1,788,055	$ 72,788,055	$ 3,244,471
41	$ 85,000,000	676	22.5	$ 2,873,359	$ 87,873,359	$ 3,916,886
42	$ 94,000,000	750	25.0	$ 3,548,866	$ 97,548,866	$ 4,348,164
43	$ 101,000,000	811	27.0	$ 4,145,108	$ 105,145,108	$ 4,686,761

Notes: Annualized at 3.75% over 50 years. Interest during construction estimated based on mid-month uniform payments. Jetty stabilization costs were only included from 41-43 ft project depths. Advance maintenance costs not included. Construction duration months were calculated as construction duration days / 30.

Table 32. Summary of Intermediate Array of Alternatives Net Benefits and Benefit-Cost Ratios

Project (Depth)	Widening-Only	34'+ Widening	35'+ Widening	36'+ Widening	37'+ Widening	38'+ Widening	39'+ Widening	**40'+ Widening**	41'+ Widening	42'+ Widening	43'+ Widening
Average Annual Benefits	$ 4,116,905	$ 6,245,097	$ 6,900,701	$ 7,556,306	$ 8,211,911	$ 8,779,066	$ 9,346,221	**$ 9,768,940**	$10,191,659	$10,530,963	$10,870,267
Average Annual Costs	$ 2,171,796	$ 2,171,903	$ 2,217,688	$ 2,264,137	$ 2,402,193	$ 2,635,478	$ 2,962,377	**$ 3,244,471**	$ 3,916,886	$ 4,348,164	$ 4,686,761
Net Benefits	$ 1,945,109	$ 4,073,194	$ 4,683,014	$ 5,292,169	$ 5,809,718	$ 6,143,587	$ 6,383,844	**$ 6,524,469**	$ 6,274,773	$ 6,182,798	$ 6,183,506
BCR (x:1)	1.90	2.88	3.11	3.34	3.42	3.33	3.15	**3.01**	2.60	2.42	2.32

Notes: Annualized at 3.75% over 50 years. Yellow shaded and bolded column represents highest net benefits (40'). Orange shaded columns are within 5% of highest net benefits (39' and 41').

5.2.2 Annual Cost Savings for Final Array of Alternatives

Based on the net benefit results of the intermediate array of alternatives, the final array of alternatives was identified as project depths from 38 ft to 41 ft, with widening for each. For the final array of alternatives, both the model and costs were refined to a higher level of detail. The model results now included the accounting for split-shipment practices for petroleum and cement. Also, each of these four depths was modeled, and none of the alternative's results were interpolated. The costs and benefits for the final array of alternatives are shown in Table 33, Table 34, and Table 35.

Table 35 shows a summary of the net NED benefits and benefit-cost ratios for the final array of alternatives. In the final array, the 40 ft depth alternative still shows the highest net NED benefits, but 39 ft is even closer compared to the intermediate array results, and 41 ft net benefits have fallen due to an increase in jetty stabilization feature costs, which are required at the 41 ft depth (when not considering advance maintenance).

Table 33. Final Array of Alternatives Total Present-Value and Average Annual Benefits

Project (Depth)	38'+Widening	39'+Widening	40'+Widening	41'+Widening
Sum of Present-Value Benefits	$ 143,950,872	$ 164,350,855	$ 173,791,403	$ 174,849,043
Annualized Cost Savings	$ 6,416,498	$ 7,325,811	$ 7,746,616	$ 7,793,759

Notes: Annualized at 3.75% over 50 years. Benefits are based on 10-iteration model runs.

Table 34. Final Array of Alternatives Total and Average Annual Project Cost

Project Depth +Widening (Feet)	Project Cost	Construction Duration (days)	Construction Duration (months)	IDC Est. based on mid-month uniform payments	Total Cost Including IDC	Average Annual Cost
38	$ 66,000,000	299	10.0	$ 916,951	$ 66,916,951	$ 2,982,771
39	$ 73,000,000	369	12.3	$ 1,282,646	$ 74,282,646	$ 3,311,091
40	$ 79,000,000	459	15.3	$ 1,761,054	$ 80,761,054	$ 3,599,861
41	$ 94,000,000	521	17.4	$ 2,403,041	$ 96,403,041	$ 4,297,090

Notes: Annualized at 3.75% over 50 years. Interest during construction estimated based on mid-month uniform payments. 600 linear foot jetty stabilization costs were included for 41 ft project depth. Advance maintenance costs were not included.

Table 35. Summary of Final Array of Alternatives Net Benefits and Benefit-Cost Ratios

Project (Depth)	38'+Widening	39'+Widening	**40'+Widening**	41'+Widening
Average Annual Benefits	$ 6,416,498	$ 7,325,811	**$ 7,746,616**	$ 7,793,759
Average Annual Costs	$ 2,982,771	$ 3,311,091	**$ 3,599,861**	$ 4,297,090
AA Net Benefits	$ 3,433,727	$ 4,014,720	**$ 4,146,755**	$ 3,496,669
BCR (x:1)	2.15	2.21	**2.15**	1.81

Notes: Annualized at 3.75% over 50 years.

5.2.3 Annual Cost Savings for the Recommended Plan

ER 1105-2-100 states the following: “Identification of the NED plan is to be based on consideration of the most effective plans for providing different levels of output or service. Where two cost effective plans produce no significantly different levels of net benefits, the less costly plan is to be the NED plan, even though the level of outputs may be less.” Therefore, the 39 ft plan was selected as the recommended plan. So, the 39 ft plan HarborSym model was re-run for 100 iterations to achieve a higher level of certainty surrounding the benefits. Results of the 100-iteration benefits model are shown in Table 36, and Table 37 after the advance maintenance costs and benefits were included.

Table 36. Summary of Recommended Plan Net Benefits and Benefit-cost Ratio without Advance Maintenance

Project (Depth)	39'+Widening
Sum of Present-Value Benefits	$ 166,220,000
Total Costs with IDC	$ 81,800,000
Increased Ann. O&M	$ 110,000
Annualized Cost Savings (Benefits)	$ 7,090,000
Annualized Costs incl. O&M	$ 3,600,000
AA Net NED Benefits	$ 3,490,000
BCR (x:1)	2.0

Notes: Annualized at 3.5% over 50 years. Numbers rounded to nearest $10,000. Benefits are based on 100-iteration model runs. Interest during construction estimated based on mid-month uniform payments. Improved advance maintenance and settling basin costs were not included.

Table 37. Summary of Recommended Plan Net Benefits and Benefit-cost Ratio including Advance Maintenance

Project (Depth)	39'+Widening
Sum of Present-Value Benefits	$ 166,220,000
Total Costs with IDC	$ 92,930,000
Annualized Transportation Cost Savings (Benefits)	$ 7,090,000
Annualized Advance Maintenance Cost Savings (Benefits)	$ 850,000
Total Average Annual Benefits	$ 7,940,000
Total Average Annual Costs	$ 3,960,000
AA Net NED Benefits	$ 3,980,000
BCR (x:1)	2.0

Notes: Net benefits were annualized at 3.5% discount rate, over 50 years. Costs are in FY14 Price Levels. Dollar amounts rounded to nearest $10,000. BCR rounded to nearest 0.1. Benefits are based on 100-iteration model runs. Interest during construction estimated based on mid-month uniform payments, broken down by contract. Jetty stabilization costs and advance maintenance cost savings were included.

5.2.4 Cost Savings by Commodity

A breakdown of cost savings by commodity is shown in Table 38. This table shows that the largest portion of the NED benefits can be attributed to petroleum products (diesel and asphalt) at 43% of total benefits. These benefits are derived partly from the shift in vessels from barges to self-propelled tankers. Molasses benefits account for 27% of total benefits, and are derived from the more efficient use of existing vessels and utilization of larger vessels. Cement and general cargo together account for the remaining 30% of total NED benefits.

Table 38. Summary of Benefits by Commodity

Commodity	Tonnage	Total Cost WOP	Total Cost for 39' project	Total Cost Savings	Cost Savings per Ton	Percent of Total
Cement	307,869	$ 4,702,533	$ 3,387,215	$ 1,315,318	$ 4.27	13%
Molasses	264,628	$ 7,935,092	$ 5,301,442	$ 2,633,650	$ 9.95	27%
Petroleum	532,702	$ 9,585,851	$ 5,335,448	$ 4,250,404	$ 7.98	43%
General Cargo	197,425	$ 6,991,197	$ 5,346,582	$ 1,644,616	$ 8.33	17%
Total	1,302,624	$ 29,214,674	$ 19,370,687	$ 9,843,987		100%

Notes: Benefits are based on 100-iteration model runs. Commodity forecasts are based on “Scenario 2” cement growth for project year 2067. “Petroleum” includes asphalt, diesel, and fuel oil.

6 Advance Maintenance and Life-cycle Cost Analysis

Analysis on advance maintenance and total life-cycle costs:

The project area has a high rate of shoaling, which has historically often led to multiple maintenance events in a single year. The advance maintenance plan for the existing project has recently been changed to reduce the frequency and magnitude of annual maintenance. This advance maintenance plan was further improved upon during the course of this feasibility study to completely eliminate the need for annual maintenance in favor of a biennial cycle. The estimate of these maintenance cycles over the period of analysis are detailed in Table 39.

Table 39. Cost Comparison for Additional Advance Maintenance Features

Period	Present Value Factor	Maintenance Costs without Project, with existing advance maintenance		Maintenance Costs with-Project, without improved Advance Maintenance		Maintenance Costs with-Project, with improved Advance Maintenance	
		Avg Costs/yr	Present Value	Avg Costs/yr	Present Value	Avg Costs/yr	Present Value
1	0.96618	$5,602,000	$5,412,560	$0	$0	$0	$0
2	0.93351	$1,922,000	$1,794,208	$2,118,000	$1,977,176	$0	$0
3	0.90194	$5,602,000	$5,052,683	$6,123,000	$5,522,595	$6,299,000	$5,681,337
4	0.87144	$1,922,000	$1,674,912	$2,118,000	$1,845,715	$0	$0
5	0.84197	$5,602,000	$4,716,734	$6,123,000	$5,155,402	$6,299,000	$5,303,589
6	0.81350	$1,922,000	$1,563,548	$2,118,000	$1,722,994	$0	$0
7	0.78599	$5,602,000	$4,403,121	$6,123,000	$4,812,623	$6,299,000	$4,950,957
8	0.75941	$1,922,000	$1,459,589	$2,118,000	$1,608,434	$0	$0
9	0.73373	$5,602,000	$4,110,361	$6,123,000	$4,492,635	$6,299,000	$4,621,771
10	0.70892	$1,922,000	$1,362,542	$2,118,000	$1,501,490	$0	$0
11	0.68495	$5,602,000	$3,837,066	$6,123,000	$4,193,923	$6,299,000	$4,314,473
12	0.66178	$1,922,000	$1,271,947	$2,118,000	$1,401,657	$0	$0
13	0.63940	$5,602,000	$3,581,942	$6,123,000	$3,915,072	$6,299,000	$4,027,607
14	0.61778	$1,922,000	$1,187,377	$2,118,000	$1,308,462	$0	$0
15	0.59689	$5,602,000	$3,343,781	$6,123,000	$3,654,761	$6,299,000	$3,759,814
16	0.57671	$1,922,000	$1,108,429	$2,118,000	$1,221,463	$0	$0
17	0.55720	$5,602,000	$3,121,456	$6,123,000	$3,411,759	$6,299,000	$3,509,827
18	0.53836	$1,922,000	$1,034,730	$2,118,000	$1,140,249	$0	$0
19	0.52016	$5,602,000	$2,913,912	$6,123,000	$3,184,913	$6,299,000	$3,276,461
20	0.50257	$1,922,000	$965,932	$2,118,000	$1,064,435	$0	$0
21	0.48557	$5,602,000	$2,720,168	$6,123,000	$2,973,151	$6,299,000	$3,058,611
22	0.46915	$1,922,000	$901,708	$2,118,000	$993,661	$0	$0
23	0.45329	$5,602,000	$2,539,306	$6,123,000	$2,775,468	$6,299,000	$2,855,246
24	0.43796	$1,922,000	$841,754	$2,118,000	$927,593	$0	$0
25	0.42315	$5,602,000	$2,370,469	$6,123,000	$2,590,929	$6,299,000	$2,665,403
26	0.40884	$1,922,000	$785,786	$2,118,000	$865,918	$0	$0
27	0.39501	$5,602,000	$2,212,859	$6,123,000	$2,418,660	$6,299,000	$2,488,182
28	0.38165	$1,922,000	$733,540	$2,118,000	$808,344	$0	$0
29	0.36875	$5,602,000	$2,065,727	$6,123,000	$2,257,845	$6,299,000	$2,322,745
30	0.35628	$1,922,000	$684,767	$2,118,000	$754,598	$0	$0
31	0.34423	$5,602,000	$1,928,378	$6,123,000	$2,107,722	$6,299,000	$2,168,307
32	0.33259	$1,922,000	$639,237	$2,118,000	$704,425	$0	$0
33	0.32134	$5,602,000	$1,800,162	$6,123,000	$1,967,581	$6,299,000	$2,024,138
34	0.31048	$1,922,000	$596,735	$2,118,000	$657,588	$0	$0
35	0.29998	$5,602,000	$1,680,470	$6,123,000	$1,836,758	$6,299,000	$1,889,554
36	0.28983	$1,922,000	$557,058	$2,118,000	$613,866	$0	$0
37	0.28003	$5,602,000	$1,568,737	$6,123,000	$1,714,634	$6,299,000	$1,763,919
38	0.27056	$1,922,000	$520,020	$2,118,000	$573,050	$0	$0
39	0.26141	$5,602,000	$1,464,433	$6,123,000	$1,600,629	$6,299,000	$1,646,637
40	0.25257	$1,922,000	$485,444	$2,118,000	$534,948	$0	$0
41	0.24403	$5,602,000	$1,367,064	$6,123,000	$1,494,204	$6,299,000	$1,537,154
42	0.23578	$1,922,000	$453,167	$2,118,000	$499,380	$0	$0
43	0.22781	$5,602,000	$1,276,169	$6,123,000	$1,394,855	$6,299,000	$1,434,949
44	0.22010	$1,922,000	$423,037	$2,118,000	$466,177	$0	$0
45	0.21266	$5,602,000	$1,191,317	$6,123,000	$1,302,113	$6,299,000	$1,339,541
46	0.20547	$1,922,000	$394,909	$2,118,000	$435,181	$0	$0
47	0.19852	$5,602,000	$1,112,107	$6,123,000	$1,215,536	$6,299,000	$1,250,475
48	0.19181	$1,922,000	$368,652	$2,118,000	$406,246	$0	$0
49	0.18532	$5,602,000	$1,038,164	$6,123,000	$1,134,716	$6,299,000	$1,167,332
50	0.17905	$1,922,000	$344,141	$2,118,000	$379,235	$0	$0

Notes: Cost estimates are in FY 14 price level; present value factor calculated using 3.5% discount rate.

Table 40. Summary of Additional Advanced Maintenance Cost Savings

	Total Present Value	Average Annual O&M Cost
Maintenance Costs without Project, with existing advance maintenance	$88,980,000	$3,790,000
Maintenance Costs with-Project, without improved Advance Maintenance	$91,540,000	$3,900,000
Maintenance Costs with-Project, with improved Advance Maintenance	$69,060,000	$2,940,000
Additional Annual O&M Costs	$110,000	
Annual O&M Savings from Improved Advance Maintenance and Settling Basin	$960,000	
Net Annual O&M Savings from Improved Advance Maintenance and Settling Basin	$850,000	

Notes: Cost estimates are in FY 14 price level; amortized at 3.5%; rounded to nearest $10,000. Additional Annual O&M costs are from widening, without improved advance maintenance or expanded settling basin.

7 Sensitivity Analysis

Sensitivity analyses were performed to determine how robust the recommended plan would be with different commodity growth scenarios. Additional sensitivity analyses and discussion can also be found in Attachment 1 of this appendix.

7.1 Alternative Cement Growth Scenarios

Several alternative growth scenarios were then developed for comparison to the most-likely scenario.

First, the "Scenario 1" growth scenario uses the same base project-year tonnage as the Most-Likely scenario, but then a different growth rate is applied throughout the period of analysis. The 10-year compound annual growth rate of cement imports through the Port of Palm Beach was divided by the compound annual growth rate in South Florida population over a 10-year period, 1996 to 2005, (1.46% / 2.23% = 0.66). This ratio was then applied to future population compound annual growth projections in South Florida from 2010-2030 (1%) to get a projected growth rate for import tonnage of cement and cement input products through the Port of Palm Beach over the entire period of analysis (1.00% * 0.66 = 0.66%). Assumptions behind using the ratio of historical import tonnage at the Port related to population growth over a 10-year period are that the actual tonnage imported should be related directly to population growth. However, there are many other factors that contribute to demand for cement that may not be captured by using population growth and import tonnage alone. This is especially true when the period selected can greatly skew the growth rates, depending on if construction was on an up-turn or a down-turn. The period from 1996 to 2005 starts before a peak in tonnage in 1997, and it ends at the next peak tonnage in 2005. If the period from 2000 to 2007 were selected instead, then the growth rate using this method would have been high at 6.4%. The import tonnages vary too much in a short period to be tied directly to something as steady as population growth. Therefore, while the "Scenario 1" growth estimate in this application is an extremely conservative estimate, it is not recommended as the primary growth scenario because it has a much greater probability of underestimating import tonnage in the future.

"Scenario 2" growth was selected as the primary growth rate used for the analysis. This growth scenario was described in Section 4.2.2.4.

Next, the "Scenario 3" growth scenario was developed from the linear regression of long-term US imports, scaled to average proportion of Palm Beach imports level from 1996-2009, including economic downturn.

The largest historical dataset available was the U.S. Geological Survey's Cement Statistics from the Statistics for Mineral and Material Commodities in the United States, Version 2010. This dataset includes the total metric tonnage of cement for domestic production, imports, exports, stocks, and apparent consumption in the United States for years from 1900 through 2009. The data showed a clear upward trend in U.S. imports of cement from the early 1970s onward (Figure 23).

The total import tonnage of cement through the Port of Palm Beach was then compared to the U.S. import tonnage over the available period of record for the Port (1996-2009). An average percent of total annual U.S. import tonnage that was transited through the Port of Palm Beach was then identified as 0.66%. Then this percentage was derived by dividing the cement import tonnage through the Port of Palm Beach by the total U.S. import tonnage for each year from 1996-2009, and then averaging these percentages. The average percent of U.S. import tonnage that transited through the Port of Palm Beach was applied to the record of U.S. imports from 1970 through 2009 to determine a "theoretical historical trend" of U.S. imports, scaled to the level of imports for the Port of Palm Beach. A linear regression equation then found the growth trend in U.S. cement imports, scaled to the level of the Port of Palm Beach, from 1970 through 2009 to be:

$Y = 3.6461(x-1969)$, where Y = thousands of metric tons, and X = projection year.

The assumption in applying this percentage and regression line is that growth trends in Palm Beach will follow the trends at the national level. The base-year (2017) projected tonnage for the High estimate was predicted using the regression equation. However, the "Scenario 3" estimate is not recommended as the primary growth scenario, because it bases the growth rate on national-level data, and does not reflect regional or local trends, and therefore this estimate has a greater probability of not representing future import tonnage to the Port's hinterland. It could also under-estimate growth if the local area had historical growth above the national average.

Finally, an alternative mid-range projection was created based on industry input. The "Scenario 4" projection estimates that 120,000 short tons of cement and cement input products will transit through the Port in the base-year (2017). That amount was predicted to have a quicker rebound time than other projections, and it doubles within ten years to 240,000 short tons, but then falls to zero growth for the remainder of the period of analysis. Assumptions behind the "Scenario 4" are that the actual importers of cement at the Port have the most knowledge of the local industry, market conditions, and other factors related to drivers of demand for their products. The industry representatives also have the most historical knowledge of the cement industry, and past trends on which to base their future projections. However, the industry estimate is not recommended as the primary growth projection because it may have a greater probability of containing bias toward higher growth rates in the near-term.

Scenario 1 sensitivity analysis results are shown in Table 41 and Table 42, below. Compared to the final array net benefits shown in Table 35 and **Error! Reference source not found.**, the Scenario 1 benefits re within 0.5% at the 39 ft project depth and 1.0% at the 40 ft project depth.

Table 41. Summary of Scenario 1 Cement Growth Sensitivity Analysis Net Benefits without Advance Maintenance

Project (Depth)	38'+Widening	39'+Widening	**40'+Widening**
Average Annual Benefits	$ 6,447,358	$ 7,308,151	**$ 7,668,318**
Average Annual Costs	$ 2,982,771	$ 3,311,091	**$ 3,599,861**
AA Net Benefits	$ 3,464,587	$ 3,997,060	**$ 4,068,457**
BCR (x:1)	2.16	2.21	**2.13**

Notes: Annualized at 3.75% over 50 years. 600 linear foot jetty stabilization costs were included for 41 ft project depth. Advance maintenance costs were not included.

Table 42. Summary of Scenario 1 Cement Growth Sensitivity Analysis Net Benefits including Advance Maintenance

Project (Depth)	38'+Widening	**39'+Widening**	40'+Widening
Average Annual Transportation Cost Savings Benefits	$ 6,447,358	**$ 7,308,151**	$ 7,668,318
Average Annual Advance Maintenance Benefits	$ 250,588	**$ 250,588**	$ 250,588
Total Average Annual Benefits	$ 6,697,946	**$ 7,558,739**	$ 7,918,906
Average Annual Costs	$ 3,448,595	**$ 3,870,829**	$ 4,392,087
AA Net Benefits	$ 3,249,351	**$ 3,687,910**	$ 3,526,819
BCR (x:1)	1.94	**1.95**	1.80

Notes: Annualized at 3.75% over 50 years. 600 linear foot jetty stabilization costs were included for 40 ft and 41 ft project depths. 200 linear foot jetty stabilization costs were included for 39 ft project depth. Advance maintenance costs were included.

7.2 Reduced Overall Growth Sensitivity Scenarios

In addition to the reduced forecasts for cement growth, sensitivity analyses were conducted with reduced overall commodity growth in various scenarios. Additional sensitivity analyses and discussion can also be found in Attachment 1 of this appendix.

7.2.1 No Growth after 20 Years

In the "No Growth after 20 years" scenario, all commodity tonnages were held constant after 20 years into the period of analysis. Results from this scenario are shown in Table 43 and Table 44.

Table 43. Summary of No Growth after 20 Years Sensitivity Analysis Net Benefits without Advance Maintenance

Project (Depth)	38'+Widening	39'+Widening	**40'+Widening**	41'+Widening
Average Annual Benefits	$ 6,081,747	$ 6,918,637	**$ 7,344,016**	$ 7,368,413
Average Annual Costs	$ 2,982,771	$ 3,311,091	**$ 3,599,861**	$ 4,297,090
AA Net Benefits	$ 3,098,976	$ 3,607,546	**$ 3,744,155**	$ 3,071,323
BCR (x:1)	2.04	2.09	**2.04**	1.71

Notes: Annualized at 3.75% over 50 years. 600 linear foot jetty stabilization costs were included for 41 ft project depth. Advance maintenance costs were not included.

Table 44. Summary of No Growth after 20 Years Sensitivity Analysis Net Benefits including Advance Maintenance

Project (Depth)	38'+Widening	**39'+Widening**	40'+Widening	41'+Widening
Average Annual Transportation Cost Savings Benefits	$ 6,081,747	**$ 6,918,637**	$ 7,344,016	$ 7,368,413
Average Annual Advance Maintenance Benefits	$ 250,588	**$ 250,588**	$ 250,588	$ 250,588
Total Average Annual Benefits	$ 6,332,335	**$ 7,169,225**	$ 7,594,604	$ 7,619,001
Average Annual Costs	$ 3,448,595	**$ 3,870,829**	$ 4,392,087	$ 4,773,324
AA Net Benefits	$ 2,883,740	**$ 3,298,396**	$ 3,202,517	$ 2,845,677
BCR (x:1)	1.84	**1.85**	1.73	1.60

Notes: Annualized at 3.75% over 50 years. 600 linear foot jetty stabilization costs were included for 40 ft and 41 ft project depths. 200 linear foot jetty stabilization costs were included for 39 ft project depth. Advance maintenance costs were included.

7.2.2 No Growth after Base Year

In the "No Growth after Base Year" scenario, commodity tonnages were increased from the existing levels to the base year and then held constant from the base project year throughout the period of analysis. Results are shown in Table 45 and Table 46.

Table 45. Summary of No Growth after Base Year Sensitivity Analysis Net Benefits without Advance Maintenance

Project (Depth)	38'+Widening	39'+Widening	**40'+Widening**	41'+Widening
Average Annual Benefits	$ 5,703,293	$ 6,171,926	**$ 6,739,391**	$ 6,790,789
Average Annual Costs	$ 2,982,771	$ 3,311,091	**$ 3,599,861**	$ 4,297,090
AA Net Benefits	$ 2,720,522	$ 2,860,835	**$ 3,139,531**	$ 2,493,699
BCR (x:1)	1.91	1.86	**1.87**	1.58

Notes: Annualized at 3.75% over 50 years. 600 linear foot jetty stabilization costs were included for 41 ft project depth. Advance maintenance costs were not included.

Table 46. Summary of No Growth after Base Year Sensitivity Analysis Net Benefits including Advance Maintenance

Project (Depth)	38'+Widening	39'+Widening	**40'+Widening**	41'+Widening
Average Annual Transportation Cost Savings Benefits	$ 5,703,293	$ 6,171,926	**$ 6,739,391**	$ 6,790,789
Average Annual Advance Maintenance Benefits	$ 250,588	$ 250,588	**$ 250,588**	$ 250,588
Total Average Annual Benefits	$ 5,953,881	$ 6,422,514	**$ 6,989,979**	$ 7,041,377
Average Annual Costs	$ 3,448,595	$ 3,870,829	**$ 4,392,087**	$ 4,773,324
AA Net Benefits	$ 2,505,286	$ 2,551,685	**$ 2,597,892**	$ 2,268,053
BCR (x:1)	1.73	1.66	**1.59**	1.48

Notes: Annualized at 3.75% over 50 years. 600 linear foot jetty stabilization costs were included for 40 ft and 41 ft project depths. 200 linear foot jetty stabilization costs were included for 39 ft project depth. Advance maintenance costs were included.

7.2.3 Existing Traffic with No Growth

In the “Existing Traffic with No Growth” scenario, all commodity tonnages were set to the existing level of traffic[5] and then held constant throughout the period of analysis. Results from this scenario are shown in Table 47, below. This sensitivity scenario was not modeled for other alternatives because it was considered to be the absolute lowest and most conservative growth scenario. It is shown for information only to demonstrate that even with conservative growth assumptions (i.e. no growth from today’s level of traffic), the 39 ft alternative is still economically feasible.

Table 47. Summary of Existing Traffic with No Growth Sensitivity Analysis Net Benefits

Project (Depth)	39'+Widening
Average Annual Benefits	$ 3,318,965
Average Annual Costs	$ 3,311,091
AA Net Benefits	$ 7,874
BCR (x:1)	1.00

Notes: Annualized at 3.75% over 50 years. Advance maintenance and jetty stabilization costs were not included.

7.2.4 7% Discount Rate

In the “7% Discount Rate” scenario, all benefits and costs were annualized at the 7% discount rate, which is required by the Office of Management and Budget (OMB) to be displayed for comparison. Results from this scenario are shown in Table 48. This sensitivity scenario is shown for information only to demonstrate the responsiveness in annualized project costs and benefits to changes in the Federal discount rate.

[5] Based on 2007 commodity tonnage

Table 48. Benefit Cost Ratio and Net Benefits at 7% Discount Rate

Project (Depth)	39'+Widening
Sum of Present-Value Benefits	$ 93,410,000
Total Costs with IDC	$ 97,590,000
Annualized Transportation Cost Savings (Benefits)	$ 6,770,000
Annualized Advance Maintenance Cost Savings (Benefits)	$ 990,000
Total Average Annual Benefits	$ 7,760,000
Total Average Annual Costs	$ 7,070,000
AA Net NED Benefits	$ 690,000
BCR (x:1)	1.1

Notes: Annualized at 7% over 50 years. Dollar amounts rounded to nearest $10,000. BCR Rounded to nearest 0.1. Benefits are based on 100-iteration model runs. Interest during construction estimated based on mid-month uniform payments. Jetty stabilization costs and advance maintenance costs were included. FY14 Price Level.

8 Regional Economic Development Benefits

Regional economic development (RED) benefits were calculated for the project using an input-output model. RED benefits were calculated only for the impact of construction expenditures on the local community while the project construction is taking place.

IMPLAN is an input-output model, developed by the company MIG, which is widely used for economic impact analysis. The job-creation estimates for this project were developed using most recent version of the model, Version 3.0. These estimates use the 2010 dataset for the entire State of Florida, which is the most recent data available. The dataset includes employment and impact multipliers for specific areas and industries. All multipliers were developed by MIG using empirical data, including wage, salary, and income data as well as information about the number of firms in various sectors of the economy and sector size classes (as defined by number of employees).

Once the IMPLAN model was set up, it was used to calculate employment creation effects in different industries or sectors of the economy based on the input of additional expenditures in a specific industry or sector. For this analysis, the “non-residential construction” sector was used to account for all input expenditures. This sector is the most applicable to Corps of Engineers’ civil works projects.

A “job created” is defined as the employment of one person for one year that would not have otherwise been employed. The estimates produced by IMPLAN include three categories of employment impacts: direct, indirect, and induced.

- **Direct Impacts:** The jobs directly generated by a project. This category typically consists of workers hired by the contractors who are building USACE projects.
- **Indirect Impacts:** Employment changes occurring in other businesses/industries in the community that supply inputs to the project industry. For example, if the project requires a contractor to purchase new equipment or materials from another company, any new employment created as a result of that purchase would be considered an indirect impact.
- **Induced Impacts:** The jobs created when employees who are working for the project spend their new income in the community. For example, construction workers may spend their wages at local restaurants, grocery stores, and apartments. Any job created as result of these expenditures is considered induced.

The RED jobs-created estimates include both full-time and part-time jobs. These jobs will be spread out over the period of construction, and will last only for the period of construction. The RED analysis did not estimate any job impacts based on the primary economic benefits of the project.

Table 49. Regional Economic Development Job Impact Multipliers

Direct Jobs Created per $1 million expenditure	7.1
Indirect and induced jobs created per $1 million expenditure	8.2
Total Jobs Created per $1 million expenditure	15.3

Table 50. Regional Economic Development Job Impacts from Project Construction Expenditures

Total Construction Costs	$ 88,556,000
Direct Job Impacts	628.7
Indirect and Induced Job Impacts	726.2
Total Job Impacts	1354.9

Lake Worth Inlet Feasibility Study
Socio-Economic Appendix

Attachment 1

Additional Response to Independent External Peer Review Final Panel Comment 1

Background

This document is intended to address any outstanding concerns related to Independent External Peer Review (IEPR) Final Panel Comment (FPC) 1.

From the final paragraph of the back-check, it appears that the Panel's primary remaining concerns are related to the forecasts from current levels to the base year (2017) for molasses and cement-related dry bulk. Additional supporting information for each of the commodity forecasts over this period are discussed in the sections below.

In the Feasibility Report Economic Appendix, Table 38 was a summary of benefits by commodity. Those proportions were mentioned in the FPC. However, that table was based on a single model year (2067) and not the total average annual benefits. The following table shows the breakdown of average annual benefits by commodity:

Commodity	Total Avg. Annual Transportation Cost Savings for 39 ft. project	Percent of Total
Dry Bulk	$ 689,000	10%
Molasses	$ 2,662,000	38%
Petroleum	$ 3,070,000	43%
General Cargo	$ 538,000	8%
Other Congestion	$ 128,000	2%
Total	$ 7,087,000	100%

Notes: Benefits are based on 100-iteration model runs. Benefits were annualized over 50 years at 3.5% interest rate. Totals may not sum correctly due to rounding.

Cement-related Dry Bulk Additional Discussion and Rationale

For the purposes of this economic analysis, projections and references to "cement and concrete" is intended to represent all dry bulk construction materials, such as cement, cement input materials (gypsum, silica sands, alumina, aragonite, etc.), and aggregate. Information on the cement-related dry bulk forecast from the existing condition to the base year can be found in the feasibility report's economic appendix in Section 4.2.2. Particularly, Figure 22 shows the projected residential construction expenditures from the IHS Global Insight forecast "The 30-year Focus" (May 2009). Notice the red line in the figure represents "Chained 2000 dollars." The value of considering "Chained 2000 dollars" is that they are adjusted for inflation, which would represent a more accurate projection of the demand for quantities of construction materials. Notice that by 2017, chained expenditures are projected to be greater than their levels in 2000-2003.

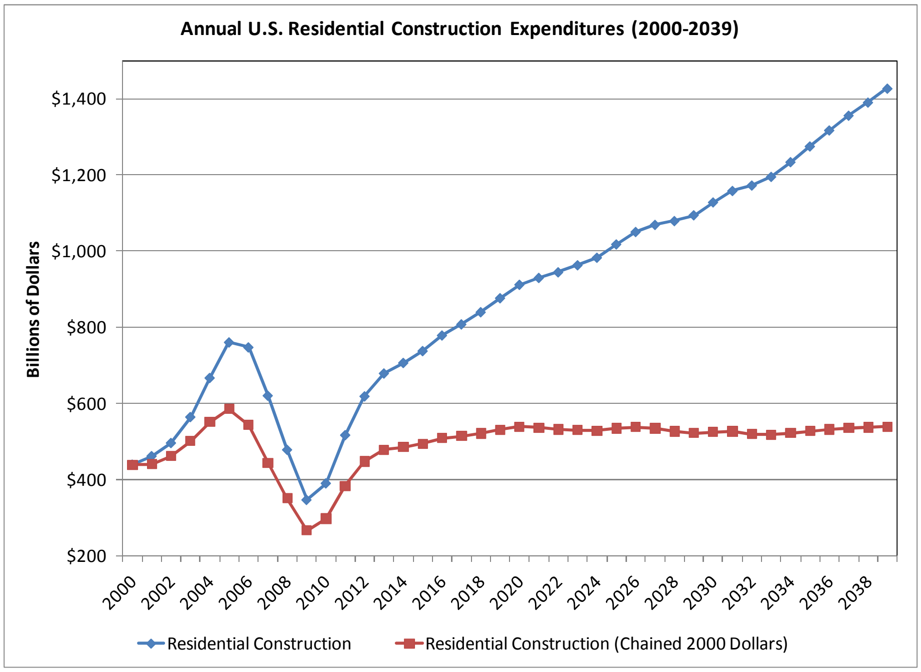


Figure 22. Residential Construction Expenditures: Historical and Projected
Source: IHS Global Insight, "The 30-Year Focus", May 2009.

Residential construction expenditures are a good proxy for imports of construction materials, as the residential building permits are highly correlated to cement imports through South Florida ports. Figure 25 in the draft appendix clearly shows this correlation. Note that 2009 is the lowest value for residential building permits and cement imports, and that both show a slight increase in 2010 and 2011.

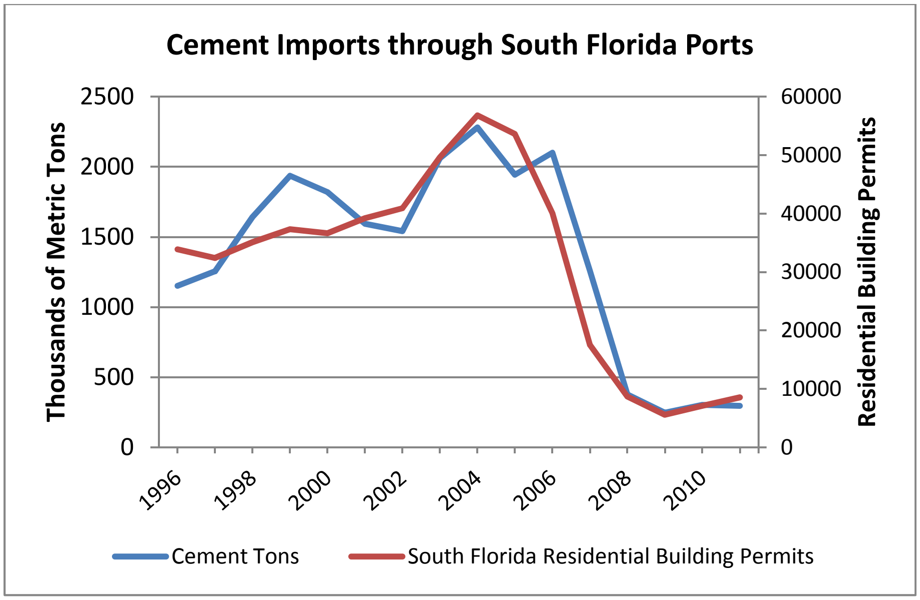
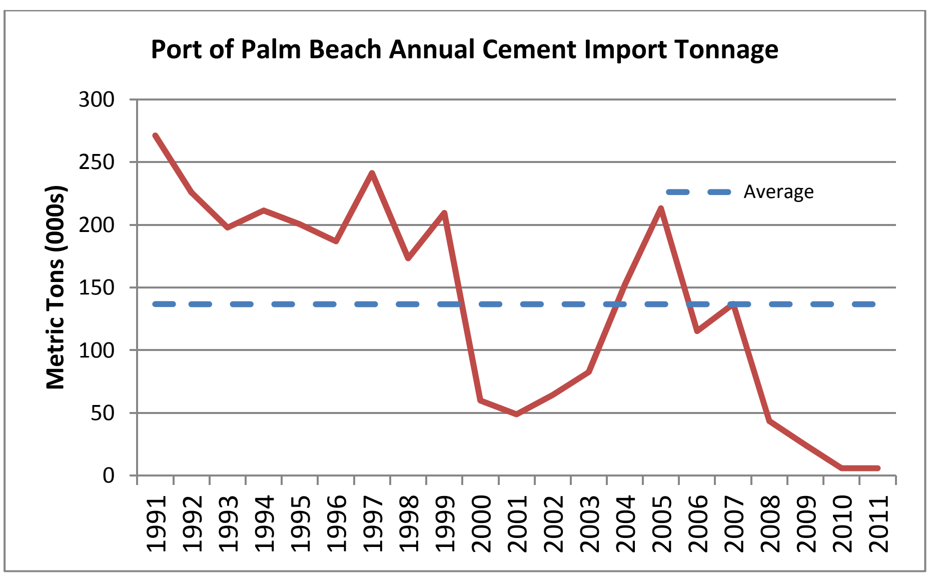


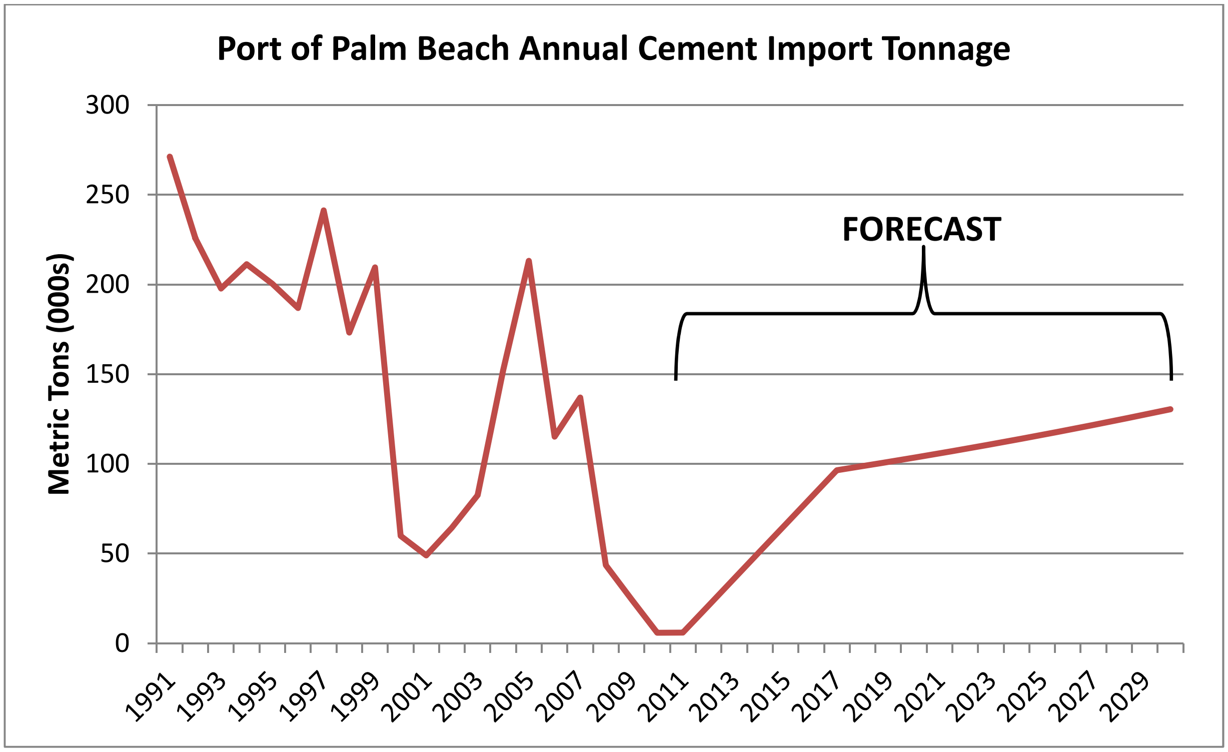
Figure 25. Cement Imports through South Florida Ports and South Florida Residential Building Permits (1996-2011)
Note: Includes tonnages through Port of Palm Beach and Port Everglades.
Sources: U.S. Census Bureau and Waterborne Commerce Statistics Center.

The Port of Palm Beach traditionally has moved a large amount of cement and other dry bulk construction materials through its facilities, typically in the hundreds of thousands of tons since the 1990s and earlier. The average annual tonnage over the period from 1991-2011 was 137,000 metric tons. This volume has dropped off significantly in recent years because of the decline in new construction, but it is expected to return to pre-recession levels by the base project year of 2017, as new construction rates return to normal. The figure below shows the historical tonnage throughput and average annual throughput over the period from 1991 through 2011.



Source: Waterborne Commerce Statistics Center

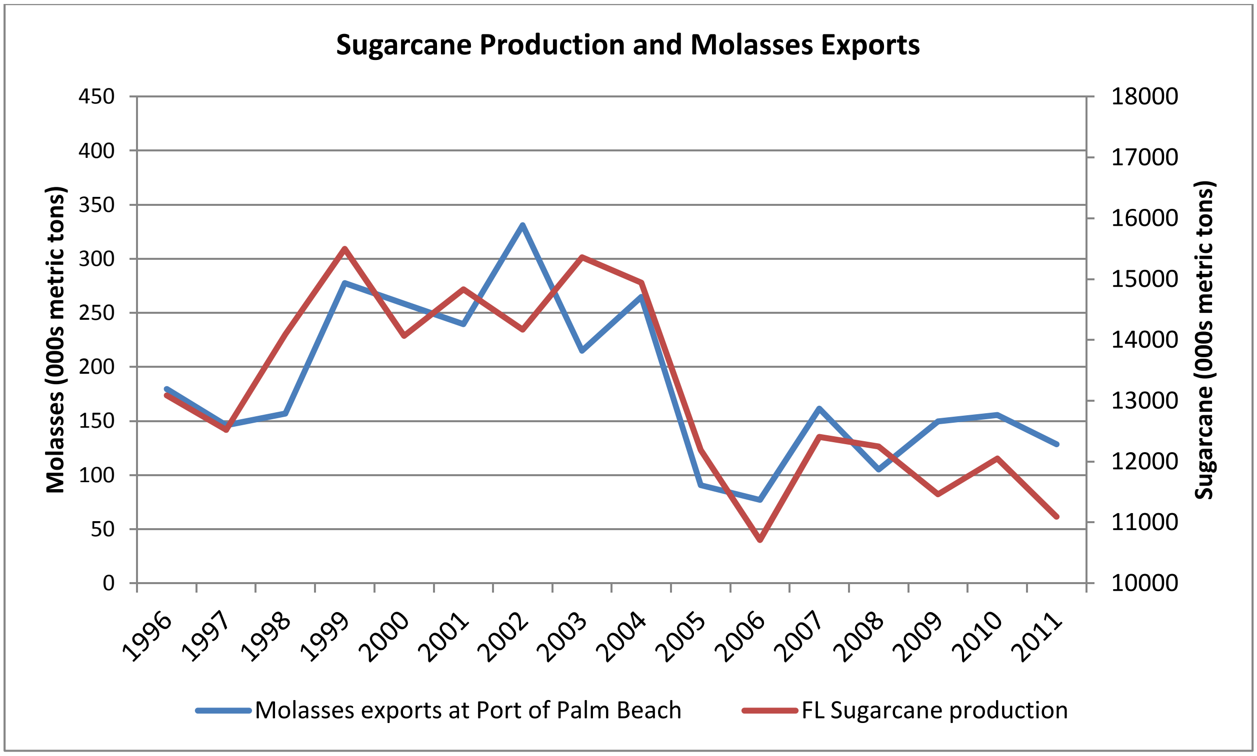
The forecast from existing throughput to the base year, assumed that throughput tonnage would return to 40% of the 1997 peak throughput (from the past 20 years) by 2017. This assumption was intended to be a conservative assumption of return to throughput that is similar to historical levels, but lower than the long term average tonnage, since the increase in hinterland construction has been slower than the IHS Global Insight forecast from 2009 had originally predicted. The figure below shows the historical throughput and the forecasted tonnage through 2030.



Molasses Additional Discussion and Rationale

Benefits from reduced transportation costs for molasses exports represent the second highest category of benefits at 38% of total average annual benefits (after petroleum at 43%). Palm Beach County is home to nearly 300,000 acres of sugarcane-producing farmland, which is over 77% of the total acreage of sugarcane-producing farmland in Florida[1]. Molasses is a by-product of sugar production, and therefore its growth is inherently related to growth in production of sugar. It is used primarily as an ingredient in animal feed. The Port of Palm Beach is the only port in Florida with facilities to load molasses onto ocean-going tanker vessels. Therefore, any molasses exported to foreign countries will be transported through the Port of Palm Beach. The figure on the following page clearly shows the correlation between molasses exports and sugarcane production in Florida.

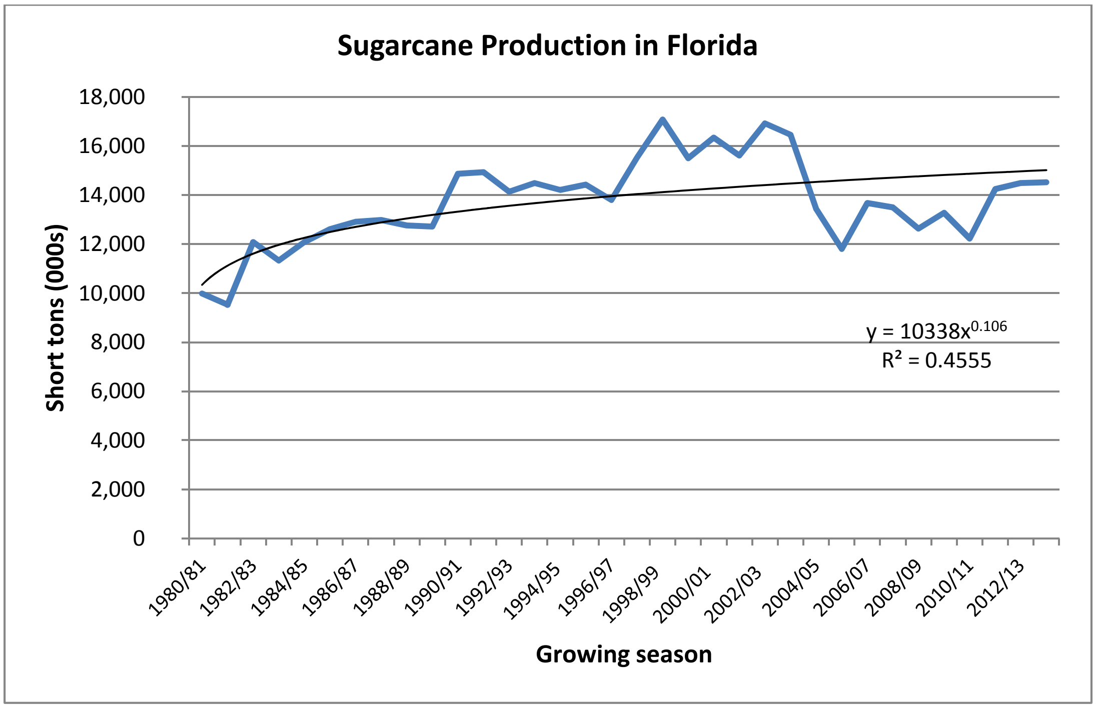
[1] 2007 USDA Census of Agriculture



The molasses tonnage forecast is discussed in the feasibility report economic appendix in Section 4.2.3. This analysis assumed that sugar and molasses tonnage movements will likely return to 2004 levels by 2017 and then experience no growth over the period of analysis. Since the land in sugar production is finite, there was no growth forecasted over the period of analysis. The base-year tonnage was selected due to its similarity to the average exports over the period from 1999 to 2004. Sugar is an agricultural product which is subject to variation in yields due to external factors such as drought and weather (especially hurricanes). Steep declines in molasses exports in 2005 and 2006 were partially due to unusually active hurricane seasons in 2004 and 2005. Additionally, the Port experienced some issues with excessive shoaling, and lack of regular maintenance that reduced the available channel depths, which would have impacted the ability of molasses tankers to fully load, making the shipments more expensive, and not as price competitive.

The return to historical average tonnages assumes that the channel will be properly maintained, and the historic demand for molasses in the European market continues to grow. There is already an existing advance maintenance feature in the entrance channel and associated settling basin that was recently constructed as of 2013. These features will ensure that the full channel depth remains available, even after a storm event. The proposed project will further expand on these advance maintenance features and settling basin to reduce dredging costs and provide greater assurance that the full channel depth will be available 100% of the time. The European demand for molasses is directly tied to the demand for animal feed, which is used for cattle, horses, and pigs. Demand for animal products is highly associated with income, and Europe has some of the wealthiest countries in the world. Additionally, Florida is one of the few origins of molasses that is as accredited by the European market as having “good manufacturing practices."[2] Finally, as more countries become more developed across the globe, their demand for animal products will increase, along with their demand for animal feed and molasses.

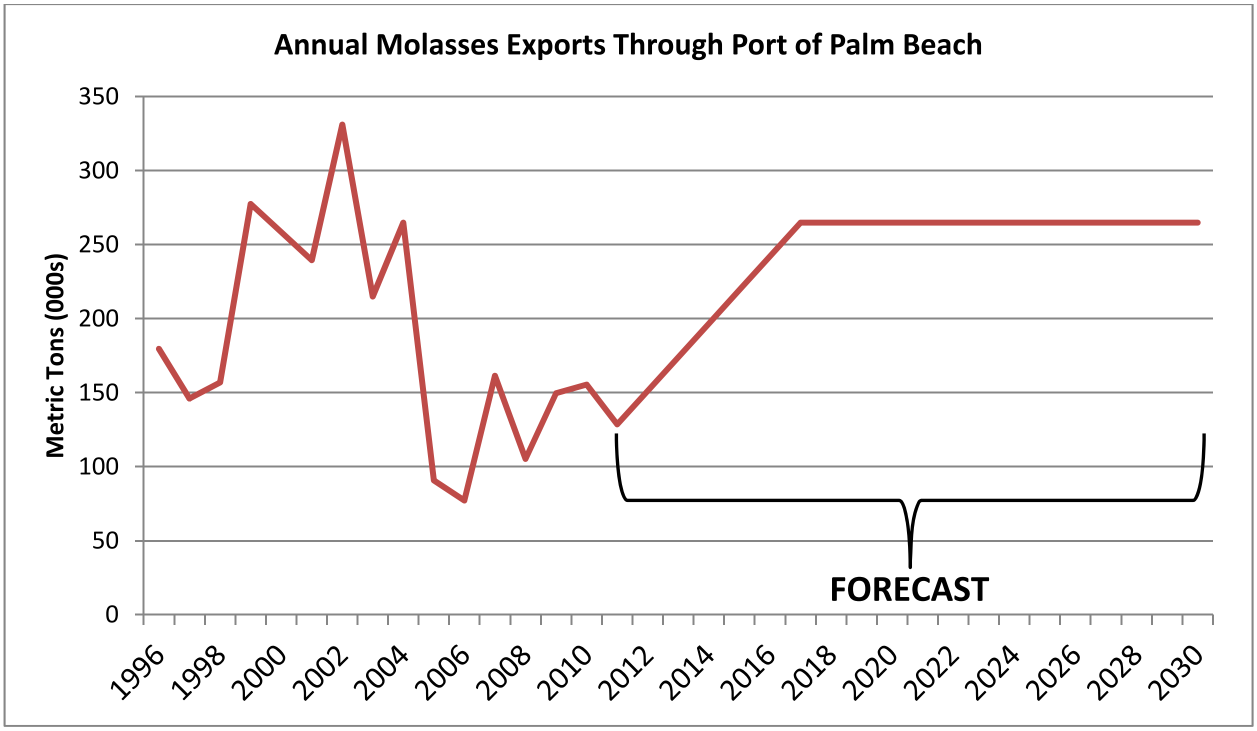
The long term production of sugar in Florida clearly shows an increasing trend with a production ceiling. The figure below shows the annual sugarcane production in Florida. A trend-line with a power function has been overlaid on the graph. The R^2 value, which represents the correlation between the trendline and the dataset, is somewhat low at 0.455. However, the production values are not expected to be consistent every year due to the variable nature of farming. Many different factors such as weather conditions, irrigation, disease, storms, etc., affect the final output of a crop each year.



Source: USDA

The power function regression is a good estimate of the average annual tonnage output, without taking into account the variability of each individual year. When the regression equation shown is carried out to 2067, the total tonnage reaches 16,616,000 short tons, which is less than the peak historical tonnage at 17,083,000 short tons in the 1998/99 growing season. Using the regression equation as a forecast, the average annual production over the period from 2017 to 2067 is 15,995,000 tons. This value is very similar to the average production from the historical period from 1998/99 to 2004/05, at 15,913,000 tons. Therefore, assuming sugarcane production continues on its current trajectory, the average annual future molasses exports should be similar to the average exports from the period 1999-2004, at 264,400 metric tons. The export tonnage from 2004 was selected as the base year (2017) tonnage since it was very close to the average over this period, at 264,900 metric tons. The figure below shows the historical throughput and the forecasted tonnage through 2030.

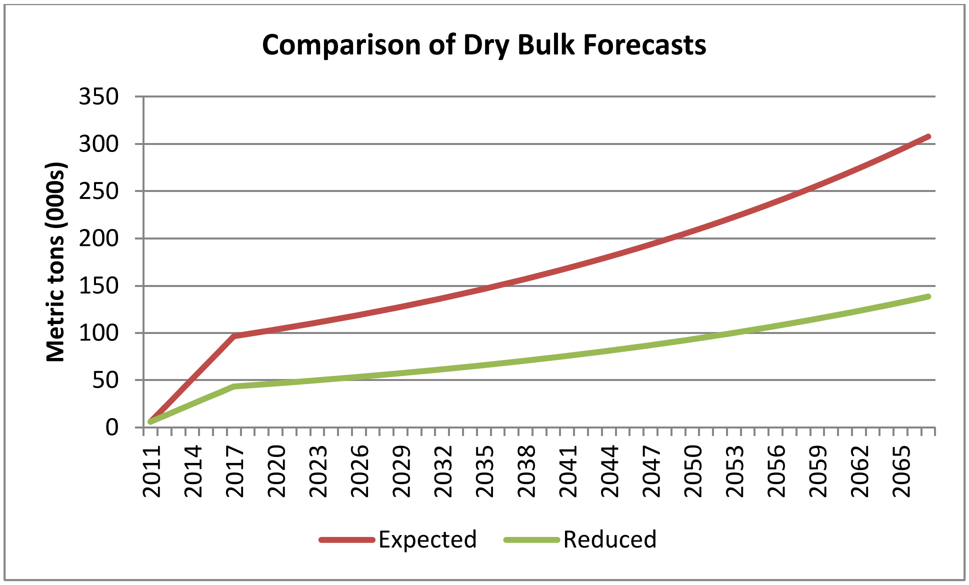
[2] Tate & Lyle Molasses Monthly Market Report, February 2006.



Additional Sensitivity Analyses

To further ensure that the viability of the project does not depend upon base-year forecasts for cement and molasses that may have been overestimated, additional sensitivity analyses were performed based on the final model outputs for the without-project condition and the 39 ft project depth.

The first sensitivity analysis was for reduced cement tonnage throughput throughout the life of the project. The 2017 base-year tonnage for the sensitivity analysis was determined based on the average historical throughput for the previous 5 years of record, 2007-2011. This was intended to represent a failure of tonnage throughput to return to pre-recession levels. The average cement tonnage was 43,400 metric tons. Compared to the previously-forecasted base-year tonnage of 96,500 tons, this represents a reduction in throughput of 55%. The cement cargo throughput reduction was carried through the entire period of analysis by reducing the cement cargo movement costs in the with- and without-project conditions by this factor. A comparison of the expected forecast and the sensitivity are shown in the figure below. The results of the sensitivity analysis are shown in the table below.

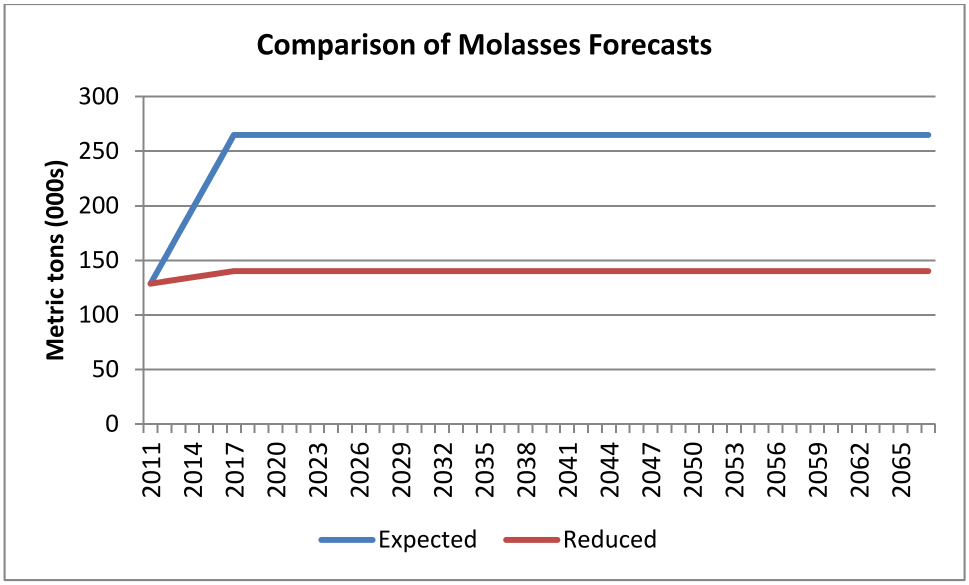


Reduced Cement-related Dry Bulk Forecast Sensitivity Analysis Results

Average Annual Transportation Cost Savings Benefits	$ 6,710,000
Average Annual Advance Maintenance Benefits	$ 850,000
Total Average Annual Benefits	$ 7,560,000
Total Average Annual Costs	$ 3,960,000
Average Annual Net Benefits	$ 3,600,000
Benefit-Cost-Ratio (x:1)	1.9

Benefits and costs were annualized over 50 years at 3.5% interest rate.

The second sensitivity was for reduced molasses tonnage throughput throughout the life of the project. The 2017 base-year tonnage for the sensitivity analysis was determined based on the average historical throughput for the previous 5 years of record, 2007-2011. This was intended to represent a failure of tonnage throughput to return to pre-recession levels. The average molasses tonnage was 140,100 metric tons. Compared to the previously-forecasted base-year tonnage of 264,900 tons, this represents a reduction in throughput of 47%. The molasses cargo throughput reduction was carried through the entire period of analysis by reducing the molasses cargo movement costs in the with- and without-project conditions by this factor. A comparison of the expected forecast and the sensitivity are shown in the figure below. The results of the sensitivity analysis are shown in the table below.



Reduced Molasses Forecast Sensitivity Analysis Results

Average Annual Transportation Cost Savings Benefits	$	5,830,000
Average Annual Advance Maintenance Benefits	$	850,000
Total Average Annual Benefits	$	6,680,000
Total Average Annual Costs	$	3,960,000
Average Annual Net Benefits	$	2,720,000
Benefit-Cost-Ratio (x:1)		1.7

Benefits and costs were annualized over 50 years at 3.5% interest rate.

The third sensitivity was performed for **both** reduced molasses tonnage and cement tonnage throughput throughout the life of the project. Both tonnage forecasts were reduced as described above. The results of the sensitivity analysis are shown in the table below.

Reduced Molasses and Cement Forecast Sensitivity Analysis Results

Average Annual Transportation Cost Savings Benefits	$	5,450,000
Average Annual Advance Maintenance Benefits	$	850,000
Total Average Annual Benefits	$	6,300,000
Total Average Annual Costs	$	3,960,000
Average Annual Net Benefits	$	2,340,000
Benefit-Cost-Ratio (x:1)		1.6

Benefits and costs were annualized over 50 years at 3.5% interest rate.

A fourth sensitivity analysis was performed using the reduced molasses forecast described above and an assumption of **no** cement-related dry bulk cargo throughput over the entire period of analysis. This essentially represents existing conditions (as of FY 2014) for these commodities with no post-recession increase in cargo tonnages. The table shows that the 39 ft. project is still justified at a BCR of 1.5:1.

No Cement Cargo Tonnage and Reduced Molasses Sensitivity Analysis Results

Average Annual Transportation Cost Savings Benefits	$	5,150,000
Average Annual Advance Maintenance Benefits	$	850,000
Total Average Annual Benefits	$	6,000,000
Total Average Annual Costs	$	3,960,000
Average Annual Net Benefits	$	2,040,000
Benefit-Cost-Ratio (x:1)		1.5

Benefits and costs were annualized over 50 years at 3.5% interest rate.

The final set of sensitivity analyses addressed the forecast of petroleum products. Benefits from the transportation cost savings of petroleum products (diesel, asphalt, and residual fuel oil[3]) make up the largest portion of total project benefits. The forecast of diesel fuel imports was identified by the IEPR panel as having some uncertainty due to a recent decrease in existing tonnages. Since the readily-available HarborSym outputs only grouped transportation costs at the vessel-type level[4], a sensitivity analysis could not be performed on diesel fuel imports alone. Therefore, all petroleum product imports were adjusted to have no growth after the base year. The reduced molasses and reduced cement with no growth sensitivities were also applied to this sensitivity. The results are shown in the table below.

No-Growth Petroleum, Reduced Molasses and Cement with No-Growth Forecast Sensitivity Analysis Results

Average Annual Transportation Cost Savings Benefits	$	4,760,000
Average Annual Advance Maintenance Benefits	$	850,000
Total Average Annual Benefits	$	5,610,000
Total Average Annual Costs	$	3,960,000
Average Annual Net Benefits	$	1,650,000
Benefit-Cost-Ratio (x:1)		1.4

Benefits and costs were annualized over 50 years at 3.5% interest rate.

A final sensitivity was performed on a no-growth petroleum scenario that also included the reduced molasses forecast and zero cement tonnage. The results are shown in the following table.

[3] Note that there was no shift in fleet assumed for residual fuel oil and therefore there were no direct benefits attributed to it.
[4] Note that HarborSym outputs can be turned on which would have information at the commodity and vessel call level of detail, but the model would have had to be re-run to obtain those outputs.

No-Growth Petroleum, Reduced Molasses Forecast and No Cement Cargo Tonnage Sensitivity Analysis Results

Average Annual Transportation Cost Savings Benefits	$ 4,590,000
Average Annual Advance Maintenance Benefits	$ 850,000
Total Average Annual Benefits	$ 5,440,000
Total Average Annual Costs	$ 3,960,000
Average Annual Net Benefits	$ 1,480,000
Benefit-Cost-Ratio (x:1)	1.4

Benefits and costs were annualized over 50 years at 3.5% interest rate.

Conclusions

This document provides additional information to support the base-year forecasts for cement and molasses. However, even if the cargo throughput did not reach the predicted levels, then the sensitivity analyses show that the project would still be justified. Since all of these commodities (especially cement-related dry bulks) have uncertainties regarding their forecasts it is important to demonstrate that the project will still be justified for the 39 ft. NED plan with cargo throughput similar to existing conditions.

As shown in the sensitivity analyses above, the NED project is still justified even with significantly more conservative cargo throughput assumptions than present in the report. I would describe the final sensitivity mentioned above as an absolute minimum cargo projection, and “floor” for the benefit-cost ratio.

Additionally, in the Socio-economic appendix, Section 7.2.3, Table 47 shows an even more conservative sensitivity analysis of existing traffic with no growth. This sensitivity still produced a BCR of 1.0:1 (at 3.75%).