

**U.S. Army Corps of Engineers, Kansas City District**



**Final Feasibility Report**

**APPENDIX E**

**COST ESTIMATING**

*Kansas Citys, Missouri and Kansas  
Flood Risk Management Project  
Final Feasibility Report*



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KANSAS CITYS, MO & KS  
FLOOD RISK MANAGEMENT STUDY

APPENDIX E  
COST ESTIMATING

CONTENTS

Cost Certification  
Total Project Cost Summary

Armourdale Unit  
Cost Risk Analysis Report - Executive Summary  
Cost Contingency Table

CID Unit  
Cost Risk Analysis Report - Executive Summary  
Cost Contingency Table

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

**COST AGENCY TECHNICAL REVIEW**

**CERTIFICATION STATEMENT**

**For Project No. P2 106927**

**NWK – Kansas City Levees Phase II  
Armourdale Reach 500yr+3ft  
Central Industrial Districts 500yr+3ft**

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

As of April 9, 2014, the Cost MCX certifies the estimated total project cost:

FY 2015 Price Level: \$318,517,000  
Fully Funded Amount: \$399,395,000

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.



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of Engineers®**

**JACOBS.MICHAEL.P  
IERRE.1160569537**

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JACOBS.MICHAEL.PIERRE.1160569537  
DN: c=US, o=U.S. Government, ou=DoD,  
ou=PKI, ou=USA,  
cn=JACOBS.MICHAEL.PIERRE.1160569537  
Date: 2014.04.09 13:24:11 -07'00'

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



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

PROJECT: Kansas City Levees Phase II  
 PROJECT NO: 106927  
 LOCATION: Kansas City, KS/MO

DISTRICT: Kansas City District  
 PREPARED: 4/8/2014  
 POC: CHIEF, COST ENGINEERING, John I

This Estimate reflects the scope and schedule in report; Feasibility Report Dated April 2014

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)					TOTAL PROJECT COST (FULLY FUNDED)				
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST (\$K) C	CNTG (\$K) D	CNTG (%) E	TOTAL (\$K) F	ESC (%) G	COST (\$K) H	CNTG (\$K) I	TOTAL (\$K) J	Program Year (Budget EC): 2015 Effective Price Level Date: 1 OCT 14		ESC (%) M	COST (\$K) N	CNTG (\$K) O	FULL (\$K) O
										Spent Thru: 10/1/2013 (\$K)	FIRST COST (\$K)				
02	RELOCATIONS	\$1,635	\$504	31%	\$2,139	1.6%	\$1,661	\$512	\$2,173	\$0	\$2,173	24.1%	\$2,061	\$636	\$2,697
11	LEVEES & FLOODWALLS	\$195,698	\$60,395	31%	\$256,093	1.6%	\$198,742	\$61,334	\$260,076	\$0	\$260,076	24.1%	\$246,707	\$76,137	\$322,844
13	PUMPING PLANT	\$7,914	\$2,442	31%	\$10,356	1.6%	\$8,037	\$2,480	\$10,517	\$0	\$10,517	24.1%	\$9,977	\$3,079	\$13,056
<b>CONSTRUCTION ESTIMATE TOTALS:</b>		<b>\$205,247</b>	<b>\$63,341</b>		<b>\$268,589</b>	<b>1.6%</b>	<b>\$208,439</b>	<b>\$64,326</b>	<b>\$272,766</b>	<b>\$0</b>	<b>\$272,766</b>	<b>24.1%</b>	<b>\$258,745</b>	<b>\$79,851</b>	<b>\$338,596</b>
01	LANDS AND DAMAGES	\$3,754	\$1,161	31%	\$4,915	1.6%	\$3,812	\$1,179	\$4,991	\$0	\$4,991	10.2%	\$4,202	\$1,299	\$5,502
30	PLANNING, ENGINEERING & DESIGN	\$16,122	\$4,976	31%	\$21,098	2.2%	\$16,470	\$5,083	\$21,553	\$0	\$21,553	19.8%	\$19,737	\$6,091	\$25,828
31	CONSTRUCTION MANAGEMENT	\$14,367	\$4,434	31%	\$18,801	2.2%	\$14,677	\$4,530	\$19,207	\$0	\$19,207	53.4%	\$22,519	\$6,950	\$29,469
<b>PROJECT COST TOTALS:</b>		<b>\$239,490</b>	<b>\$73,912</b>	<b>31%</b>	<b>\$313,402</b>		<b>\$243,399</b>	<b>\$75,118</b>	<b>\$318,517</b>	<b>\$0</b>	<b>\$318,517</b>	<b>25.4%</b>	<b>\$305,203</b>	<b>\$94,192</b>	<b>\$399,395</b>

- Mandatory by Regulation CHIEF, COST ENGINEERING, John Dillon
- Mandatory by Regulation PROJECT MANAGER, Eric Lynn
- Mandatory by Regulation CHIEF, REAL ESTATE, Greg Wilson
- CHIEF, PLANNING, Jennifer Switzer
- CHIEF, ENGINEERING, David Mathews
- CHIEF, OPERATIONS, Stuart Cook
- CHIEF, CONSTRUCTION, Chris Prinslow
- CHIEF, CONTRACTING, Theresa McCarthy
- CHIEF, PM-C, John Holm
- CHIEF, DPM, Steven Iverson

ESTIMATED FEDERAL COST: 65% \$259,607  
 ESTIMATED NON-FEDERAL COST: 35% \$139,788  
**ESTIMATED TOTAL PROJECT COST: \$399,395**

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

\*\*\*\* CONTRACT COST SUMMARY \*\*\*\*

PROJECT: Kansas City Levees Phase II  
LOCATION: Kansas City, KS/MO  
This Estimate reflects the scope and schedule in report;

Feasibility Report Dated April 2014

DISTRICT: Kansas City District  
POC: CHIEF, COST ENGINEERING, John Dillon

PREPARED: 4/8/2014

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: <b>3/15/2014</b>		Effective Price Level: <b>10/1/2013</b>		Program Year (Budget EC): <b>2015</b>		Effective Price Level Date: <b>1 OCT 14</b>						
		RISK BASED												
WBS	Civil Works	COST	CNTG	CNTG	TOTAL	ESC	COST	CNTG	TOTAL	Mid-Point	ESC	COST	CNTG	FULL
<u>NUMBER</u>	<u>Feature &amp; Sub-Feature Description</u>	<u>(\$K)</u>	<u>(\$K)</u>	<u>(%)</u>	<u>(\$K)</u>	<u>(%)</u>	<u>(\$K)</u>	<u>(\$K)</u>	<u>(\$K)</u>	<u>Date</u>	<u>(%)</u>	<u>(\$K)</u>	<u>(\$K)</u>	<u>(\$K)</u>
<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>	<b>F</b>	<b>G</b>	<b>H</b>	<b>I</b>	<b>J</b>	<b>P</b>	<b>L</b>	<b>M</b>	<b>N</b>	<b>O</b>
	<b>Armourdale - 500 Yr + 3ft</b>													
<b>02</b>	RELOCATIONS	\$1,389	\$428	31%	\$1,816	1.6%	\$1,410	\$434	\$1,845	2026Q1	24.1%	\$1,751	\$539	\$2,290
<b>11</b>	LEVEES & FLOODWALLS	\$145,867	\$44,912	31%	\$190,779	1.6%	\$148,135	\$45,611	\$193,746	2026Q1	24.1%	\$183,887	\$56,619	\$240,506
<b>13</b>	PUMPING PLANT	\$5,943	\$1,830	31%	\$7,772	1.6%	\$6,035	\$1,858	\$7,893	2026Q1	24.1%	\$7,491	\$2,307	\$9,798
	<b>CONSTRUCTION ESTIMATE TOTALS:</b>	<b>\$153,198</b>	<b>\$47,170</b>	<b>31%</b>	<b>\$200,368</b>		<b>\$155,581</b>	<b>\$47,903</b>	<b>\$203,484</b>			<b>\$193,129</b>	<b>\$59,464</b>	<b>\$252,594</b>
<b>01</b>	LANDS AND DAMAGES	\$2,024	\$623	31%	\$2,647	1.6%	\$2,055	\$633	\$2,688	2020Q1	10.2%	\$2,266	\$698	\$2,963
<b>30</b>	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	\$1,532	\$472	31%	\$2,004	2.2%	\$1,565	\$482	\$2,047	2018Q1	11.6%	\$1,747	\$538	\$2,285
1.0%	Planning & Environmental Compliance	\$1,532	\$472	31%	\$2,004	2.2%	\$1,565	\$482	\$2,047	2018Q1	11.6%	\$1,747	\$538	\$2,285
1.0%	Engineering & Design	\$1,532	\$472	31%	\$2,004	2.2%	\$1,565	\$482	\$2,047	2018Q1	11.6%	\$1,747	\$538	\$2,285
1.0%	Reviews, ATRs, IEPRs, VE	\$1,532	\$472	31%	\$2,004	2.2%	\$1,565	\$482	\$2,047	2018Q1	11.6%	\$1,747	\$538	\$2,285
0.3%	Life Cycle Updates (cost, schedule, risks)	\$383	\$118	31%	\$501	2.2%	\$391	\$120	\$512	2018Q1	11.6%	\$437	\$134	\$571
1.0%	Contracting & Reprographics	\$1,532	\$472	31%	\$2,004	2.2%	\$1,565	\$482	\$2,047	2018Q1	11.6%	\$1,747	\$538	\$2,285
1.0%	Engineering During Construction	\$1,532	\$472	31%	\$2,004	2.2%	\$1,565	\$482	\$2,047	2026Q1	53.4%	\$2,401	\$739	\$3,141
0.5%	Planning During Construction	\$827	\$255	31%	\$1,082	2.2%	\$845	\$260	\$1,105	2026Q1	53.4%	\$1,296	\$399	\$1,695
1.0%	Project Operations	\$1,532	\$472	31%	\$2,004	2.2%	\$1,565	\$482	\$2,047	2018Q1	11.6%	\$1,747	\$538	\$2,285
<b>31</b>	CONSTRUCTION MANAGEMENT													
5.0%	Construction Management	\$7,660	\$2,359	31%	\$10,019	2.2%	\$7,825	\$2,409	\$10,235	2026Q1	53.4%	\$12,006	\$3,697	\$15,703
0.0%	Project Operation:	\$0	\$0	31%	\$0	0.0%	\$0	\$0	\$0	0	0.0%	\$0	\$0	\$0
2.0%	Project Management	\$3,064	\$943	31%	\$4,007	2.2%	\$3,130	\$964	\$4,094	2026Q1	53.4%	\$4,803	\$1,479	\$6,281
	<b>CONTRACT COST TOTALS:</b>	<b>\$177,880</b>	<b>\$54,769</b>		<b>\$232,650</b>		<b>\$180,783</b>	<b>\$55,663</b>	<b>\$236,447</b>			<b>\$226,822</b>	<b>\$69,838</b>	<b>\$296,660</b>

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

\*\*\*\* CONTRACT COST SUMMARY \*\*\*\*

PROJECT: Kansas City Levees Phase II  
LOCATION: Kansas City, KS/MO  
This Estimate reflects the scope and schedule in report;

Feasibility Report Dated April 2014

DISTRICT: Kansas City District  
POC: CHIEF, COST ENGINEERING, John Dillon

PREPARED: 4/8/2014

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: <b>3/15/2014</b>		Program Year (Budget EC): 2015		Effective Price Level: 10/1/2013		Effective Price Level Date: 1 OCT 14						
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	ESC (%)	COST (\$K)	CNTG (\$K)	FULL (\$K)
A	B	C	D	E	F	G	H	I	J	P	L	M	N	O
<b>Central Industrial District KS - 500 Yr + 3ft</b>														
02	RELOCATIONS	\$246	\$77	31%	\$323	1.6%	\$250	\$78	\$328	2026Q1	24.1%	\$311	\$97	\$407
11	LEVEES & FLOODWALLS	\$49,451	\$15,364	31%	\$64,816	1.6%	\$50,220	\$15,603	\$65,824	2026Q1	24.1%	\$62,341	\$19,369	\$81,710
13	PUMPING PLANT	\$1,971	\$613	31%	\$2,584	1.6%	\$2,002	\$622	\$2,624	2026Q1	24.1%	\$2,485	\$772	\$3,257
		\$0												
<b>CONSTRUCTION ESTIMATE TOTALS:</b>		\$51,669	\$16,054	31%	\$67,723		\$52,473	\$16,303	\$68,776			\$65,137	\$20,238	\$85,374
01	LANDS AND DAMAGES	\$1,730	\$538	31%	\$2,268	1.6%	\$1,757	\$546	\$2,303	2020Q1	10.2%	\$1,937	\$602	\$2,538
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	\$517	\$161	31%	\$678	2.2%	\$528	\$164	\$692	2018Q1	11.6%	\$590	\$183	\$773
1.0%	Planning & Environmental Compliance	\$517	\$161	31%	\$678	2.2%	\$528	\$164	\$692	2018Q1	11.6%	\$590	\$183	\$773
1.0%	Engineering & Design	\$517	\$161	31%	\$678	2.2%	\$528	\$164	\$692	2018Q1	11.6%	\$590	\$183	\$773
1.0%	Reviews, ATRs, IEPRs, VE	\$517	\$161	31%	\$678	2.2%	\$528	\$164	\$692	2018Q1	11.6%	\$590	\$183	\$773
0.5%	Life Cycle Updates (cost, schedule, risks)	\$258	\$80	31%	\$338	2.2%	\$264	\$82	\$345	2018Q1	11.6%	\$294	\$91	\$386
1.0%	Contracting & Reprographics	\$517	\$161	31%	\$678	2.2%	\$528	\$164	\$692	2018Q1	11.6%	\$590	\$183	\$773
1.0%	Engineering During Construction	\$517	\$161	31%	\$678	2.2%	\$528	\$164	\$692	2026Q1	53.4%	\$810	\$252	\$1,062
0.5%	Planning During Construction	\$279	\$87	31%	\$366	2.2%	\$285	\$89	\$374	2026Q1	53.4%	\$437	\$136	\$573
1.0%	Project Operations	\$517	\$161	31%	\$678	2.2%	\$528	\$164	\$692	2018Q1	11.6%	\$590	\$183	\$773
31	CONSTRUCTION MANAGEMENT													
5.0%	Construction Management	\$2,583	\$803	31%	\$3,386	2.2%	\$2,639	\$820	\$3,459	2026Q1	53.4%	\$4,049	\$1,258	\$5,307
0.0%	Project Operation:	\$0	\$0	31%	\$0	0.0%	\$0	\$0	\$0	0	0.0%	\$0	\$0	\$0
2.0%	Project Management	\$1,033	\$321	31%	\$1,354	2.2%	\$1,055	\$328	\$1,383	2026Q1	53.4%	\$1,619	\$503	\$2,122
<b>CONTRACT COST TOTALS:</b>		\$61,171	\$19,006		\$80,177		\$62,169	\$19,316	\$81,485			\$77,821	\$24,179	\$102,000

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

\*\*\*\* CONTRACT COST SUMMARY \*\*\*\*

PROJECT: Kansas City Levees Phase II  
 LOCATION: Kansas City, KS/MO  
 This Estimate reflects the scope and schedule in report;

Feasibility Report Dated April 2014

DISTRICT: Kansas City District  
 POC: CHIEF, COST ENGINEERING, John Dillon

PREPARED: 4/8/2014

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		Estimate Prepared: <b>3/15/2014</b>		Program Year (Budget EC): 2015										
		Effective Price Level: 10/1/2013		Effective Price Level Date: 1 OCT 14										
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	ESC (%)	COST (\$K)	CNTG (\$K)	FULL (\$K)
A	B	C	D	E	F	G	H	I	J	P	L	M	N	O
<b>02</b>	<b>Central Industrial District MO - 500 Yr + 3ft RELOCATIONS</b>	\$0	\$0	31%	\$0	0.0%	\$0	\$0	\$0	0	0.0%	\$0	\$0	\$0
<b>11</b>	<b>LEVEES &amp; FLOODWALLS</b>	\$380	\$118	31%	\$498	1.6%	\$386	\$120	\$506	2026Q1	24.1%	\$479	\$149	\$628
<b>13</b>	<b>PUMPING PLANT</b>	\$0	\$0	31%	\$0	0.0%	\$0	\$0	\$0	0	0.0%	\$0	\$0	\$0
							\$0							
	<b>CONSTRUCTION ESTIMATE TOTALS:</b>	\$380	\$118	31%	\$498		\$386	\$120	\$506			\$479	\$149	\$628
<b>01</b>	<b>LANDS AND DAMAGES</b>	\$0	\$0	31%	\$0	0.0%	\$0	\$0	\$0	0	0.0%	\$0	\$0	\$0
<b>30</b>	<b>PLANNING, ENGINEERING &amp; DESIGN</b>													
1.0%	Project Management	\$4	\$1	31%	\$5	2.2%	\$4	\$1	\$5	2018Q1	11.6%	\$5	\$1	\$6
1.0%	Planning & Environmental Compliance	\$4	\$1	31%	\$5	2.2%	\$4	\$1	\$5	2018Q1	11.6%	\$5	\$1	\$6
1.0%	Engineering & Design	\$4	\$1	31%	\$5	2.2%	\$4	\$1	\$5	2018Q1	11.6%	\$5	\$1	\$6
1.0%	Reviews, ATRs, IEPRs, VE	\$4	\$1	31%	\$5	2.2%	\$4	\$1	\$5	2018Q1	11.6%	\$5	\$1	\$6
0.5%	Life Cycle Updates (cost, schedule, risks)	\$2	\$1	31%	\$3	2.2%	\$2	\$1	\$3	2018Q1	11.6%	\$2	\$1	\$3
1.0%	Contracting & Reprographics	\$4	\$1	31%	\$5	2.2%	\$4	\$1	\$5	2018Q1	11.6%	\$5	\$1	\$6
1.0%	Engineering During Construction	\$4	\$1	31%	\$5	2.2%	\$4	\$1	\$5	2026Q1	53.4%	\$6	\$2	\$8
0.5%	Planning During Construction	\$2	\$1	31%	\$3	2.2%	\$2	\$1	\$3	2026Q1	53.4%	\$3	\$1	\$4
1.0%	Project Operations	\$4	\$1	31%	\$5	2.2%	\$4	\$1	\$5	2018Q1	11.6%	\$5	\$1	\$6
<b>31</b>	<b>CONSTRUCTION MANAGEMENT</b>													
5.0%	Construction Management	\$19	\$6	31%	\$25	2.2%	\$19	\$6	\$25	2026Q1	53.4%	\$30	\$9	\$39
0.0%	Project Operation:	\$0	\$0	31%	\$0	0.0%	\$0	\$0	\$0	0	0.0%	\$0	\$0	\$0
2.0%	Project Management	\$8	\$2	31%	\$10	2.2%	\$8	\$3	\$11	2026Q1	53.4%	\$13	\$4	\$16
	<b>CONTRACT COST TOTALS:</b>	\$439	\$136		\$575		\$446	\$139	\$585			\$560	\$174	\$735



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of Engineers®**

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**KANSAS CITYS FLOOD RISK MANAGEMENT  
PROJECT – ARMOURDALE UNIT  
FEASIBILITY STUDY**

**Project Cost and Schedule Risk Analysis Report**

*Prepared for:*

U.S. Army Corps of Engineers,  
Kansas City District

*Prepared by:*

U.S. Army Corps of Engineers  
Kansas City District

October 11, 2013

## TABLE OF CONTENTS

EXECUTIVE SUMMARY .....	ES 1
MAIN REPORT .....	5
1.0 PURPOSE .....	5
2.0 BACKGROUND .....	5
3.0 REPORT SCOPE .....	6
3.1 Project Scope .....	6
3.2 USACE Risk Analysis Process.....	6
4.0 METHODOLOGY / PROCESS .....	7
4.1 Identify and Assess Risk Factors .....	9
4.2 Quantify Risk Factor Impacts .....	9
4.3 Analyze Cost Estimate and Schedule Contingency.....	10
5.0 PROJECT ASSUMPTIONS .....	11
6.0 RESULTS .....	12
6.1 Risk Register .....	12
6.2 Cost Contingency and Sensitivity Analysis.....	12
6.2.1 Sensitivity Analysis .....	13
6.2.2 Sensitivity Analysis Results .....	13
6.3 Schedule and Contingency Risk Analysis .....	14
7.0 MAJOR FINDINGS/OBSERVATIONS/RECOMMENDATIONS .....	16
7.1 Major Findings/Observations.....	16
7.2 Recommendations .....	20

## **LIST OF TABLES**

Table ES-1. Construction Contingency Results .....	ES-1
Table ES-2. Cost Summary of Remaining Costs (FY 2013) .....	ES-2
Table 1. Construction Cost Contingency Summary .....	9
Table 2. Schedule Duration Contingency Summary .....	11
Table 3. Project Cost Comparison Summary (Uncertainty Analysis) .....	15
Table 4. Construction Schedule Comparison Summary .....	16

## **LIST OF FIGURES**

Figure 1. Cost Sensitivity Analysis .....	10
Figure 2. Schedule Sensitivity Analysis .....	12

## **LIST OF APPENDICES**

Risk Register .....	APPENDIX A
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## EXECUTIVE SUMMARY

The US Army Corps of Engineers (USACE), Kansas City District, presents this cost and schedule risk analysis (CSRA) report regarding the risk findings and recommended contingencies for the Kansas City's Flood Risk Management Project – Armourdale Unit Feasibility Study. In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a formal risk analysis, *Monte-Carlo* based-study was conducted by the Project Development Team (PDT) on remaining costs. The purpose of this risk analysis study is to present the cost and schedule risks considered, those determined and respective project contingencies at a recommend 80% confidence level of successful execution to project completion.

The Armourdale Unit is located in Wyandotte County Kansas, along the left bank of the Kansas River from mile 7 (Mattoon Creek) to mile 0.3, near the confluence of the Kansas and Missouri Rivers. Prior to the Federal project, levees and floodwalls were constructed by the Kaw Valley Drainage District. These original works were modified and expanded in the initial Federal projects. Construction of the Federal project began in 1949 and was completed in 1951. More recent improvements, separately authorized under the 1962 Modification, were completed in 1976. The levees and floodwalls of the Armourdale Unit are currently authorized to pass a maximum Kansas River flow of 390,000 cfs coincident with a Missouri River flow of up to 220,000 cfs.

The primary components of the unit consist of earthen levees, floodwalls, riprap and toe protection on riverward slopes of levees, toe drains along the concrete floodwalls, sandbag gaps, stoplog gaps, drainage structures, relief wells and pumping plants. The floodwalls, in two reaches, vary from 11 to 17 feet high and total approximately 6,200 feet. The levees, in three reaches, vary from 4 to 17 feet high and total about 5.3 miles.

The unit begins with a stoplog gap across the Union Pacific (UP) Railroad which creates a tieback from high ground west of Mattoon Creek. The first levee section heads downstream approximately 1.28 miles along the left bank of the Kansas River, incorporating a portion of the UP embankment near the mouth of Mattoon Creek, and ends just north of the West Kansas Avenue Bridge. The first section of floodwall then extends downstream approximately 1,740 feet, ending just south of the Osage Pump Station. The second section of levee continues downstream approximately 3.3 miles to a point downstream (north) of the Chicago, Rock Island and Pacific (CRI&P) railroad bridge. This section contains one stoplog gap at the Kansas City Terminal (KCT) railroad bridge, five pumping stations, and a short reach of floodwall at the East Kansas Avenue Bridge. The second major reach of floodwall continues downstream another 4,493 feet to connect with the final levee section downstream of the Central Avenue

Bridge. This section contains two sandbag gaps at the UP and Missouri Pacific (MO Pac) railroad bridges, and two pumping stations. The final levee section extends another 4,156 feet and ties back into high ground at the embankment of the Lewis and Clark Viaduct.

Specific to the Armourdale Flood Risk Management Project, the current fully funded estimate approximates \$298M. This CSRA study is expressed in FY 2014 dollars. Real Estate office provided a separate 25% contingency for its real estate requirements, which in turn was used in the Cost Risk Model. The Cost Engineering Section performed study on the total estimated project costs. Based on the results of the analysis, the Cost Engineering Section (located in Kansas City District) recommends a contingency value of approximately \$55M or approximately 31% of base project cost. This contingency includes a separate \$800K for Real Estate, another \$47.2M for the construction costs, and \$7M for design and construction management.

The Kansas City District Cost Engineering Section performed risk analysis using the Monte Carlo technique for the estimated construction costs, supported by the district PDT input. The following table ES-1 portrays the development of the construction contingencies (approx. 31%). The contingency is based on an 80% confidence level, as per USACE Civil Works guidance. It should be noted cost estimates fluctuate over time. During this period of study, minor cost fluctuations can and have occurred. For this reason, contingency reporting is based in cost and percent values. Should cost vary to a slight degree with similar scope and risks, contingency percent values will be reported, cost values rounded.

**Table ES-1. Construction Contingency Results**

<b>Base Case Construction Cost Estimate</b>	<b>\$178,439,000</b>	
<b>Confidence Level</b>	<b>Construction Value (\$\$)</b>	<b>Contingency (%)</b>
5%	\$197,759,174	10.83%
50%	\$221,077,594	23.90%
<b>80%</b>	<b>\$233,385,329</b>	<b>30.79%</b>
90%	\$239,776,832	34.37%

The following table ES-2 portrays the full costs of the cost recommendations, combining all remaining costs. 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. The contingency has been rounded to 31%.

**Table ES-2. Cost Summary of Remaining Costs (FY2014 dollars)**

ARMOURDALE FRM FEATURE ACCOUNTS		COST	CNTG	CNTG	TOTAL
		(\$1,000)	(\$1,000)	%	(\$1,000)
01	LANDS AND DAMAGES	2,579	794	30.79	3,373
02	RELOCATIONS	5,731	1,765	30.79	7,496
06	FISH & WILDLIFE FACILITIES	0	0	0	0
11	LEVEES & FLOODWALLS	141,797	43,659	30.79	185,456
13	PUMPING PLANT	5,943	1,830	30.79	7,773
30	PLANNING, ENGINEERING, AND DESIGN	11,610	3,575	30.79	15,185
31	CONSTRUCTION MANAGEMENT	10,779	3,319	30.79	14,097
<b>FY 2013 PROJECT COSTS</b>		<b>178,439</b>	<b>54,941</b>	<b>30.79</b>	<b>233,380</b>
<b>Schedule Completion with Contingency</b>		<b>120 mo</b>	<b>104 mo</b>	<b>86.57</b>	<b>224</b>

Notes:

- 1) Cost and Time contingencies presented w/ an 80% confidence level.
- 2) Costs exclude O&M and Life Cycle Cost estimates.
- 3) Differences between ES-1 and ES-2 are due to rounding

### KEY FINDINGS/OBSERVATIONS RECOMMENDATIONS

The PDT worked through the risk register on 15 and 16 March 2012. Additional PDT members met again on 10 July 2013 to provide additional experiences outside the original PDT team. During this timeframe the PDT discussed project scope definition, investigations, design and cost information, and determined risks in certain project areas. The key risk drivers identified through sensitivity analysis suggest a cost contingency of approximately \$55M and schedule risks adding another potential of 104 months, both at an 80% confidence level.

**Cost Risks:** From the CSRA, the key or greater Cost Risk items of include:

- PR-1: Adequacy of Project Funding – Incremental congressional appropriations, and the sponsors ability to cost share. Congressional appropriations will most likely be incrementally funded with minimal appropriations per year assigned to this project. The risk of the schedule slipping is assumed and therefore a 1.5% annual escalation rate compounded has been included in the cost model.

- PR-3: Market Conditions/Bidding Conditions – The economy is currently in a downturn with signs of improvement. A range was given to account for the variance of possibilities. The estimate assumes a normal bidding climate.
- TL-1 : Confidence in Scope – Not enough information to adequately formulate a design. Designers did not always use a conservative approach but rather used design intuition for assumptions. In cases where no information was available, extrapolation techniques were used. Additional subsurface investigations may be required.

#### Moderate Risks

- CA-1 – Undefined Acquisition Strategy – Large business competitive pricing could be eliminated if other acquisition strategies are used.
- CON-4 – Contract Modifications – There are possible areas with HTRW concerns, unknown utilities not currently captured in the costs.
- EST-4 – Prime/Subcontractor structure matches likely acquisition strategy – Additional layers of markup may be required.

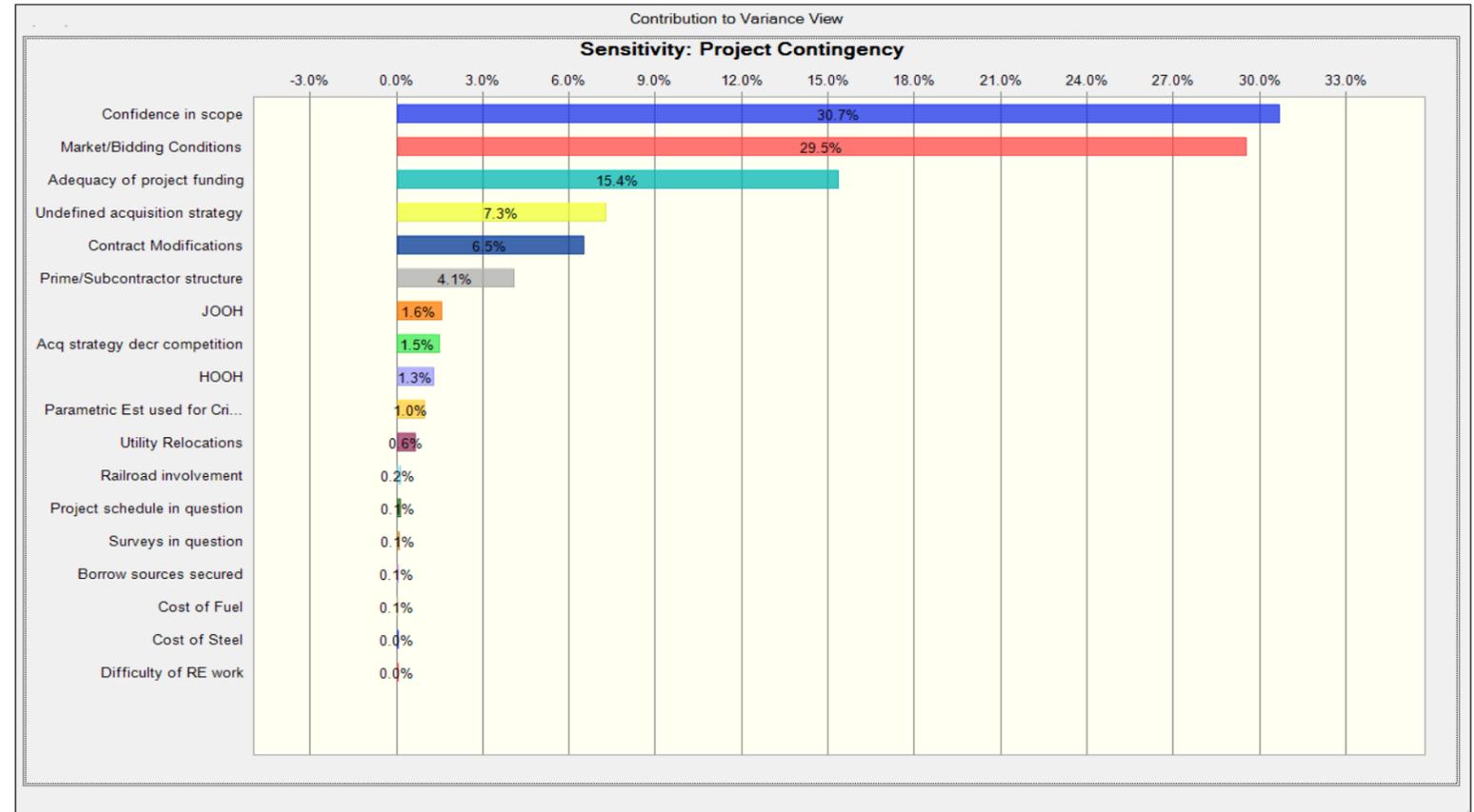
**Schedule Risks:** The high value of schedule risk indicates a significant uncertainty of key risk items, time duration growth that can translate into added costs. Over time, risks increase on those out-year contracts where there is greater potential for change in new scope requirements, uncertain market conditions, and unexpected high inflation. The greatest risk is:

- PR-1: Adequacy of Project Funding – Congressional appropriation will most likely be incrementally funded with minimal appropriation per year assigned to this project. The sponsor will most likely be unable to afford their cost share portion on a timely manner.

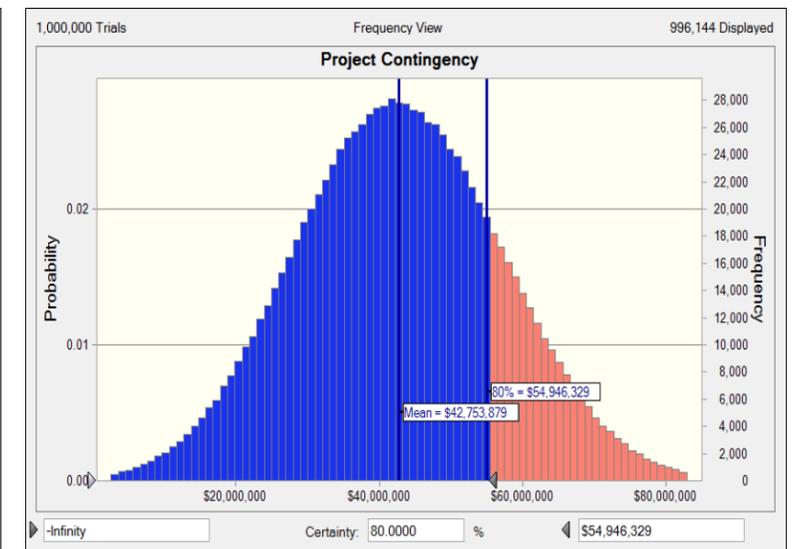
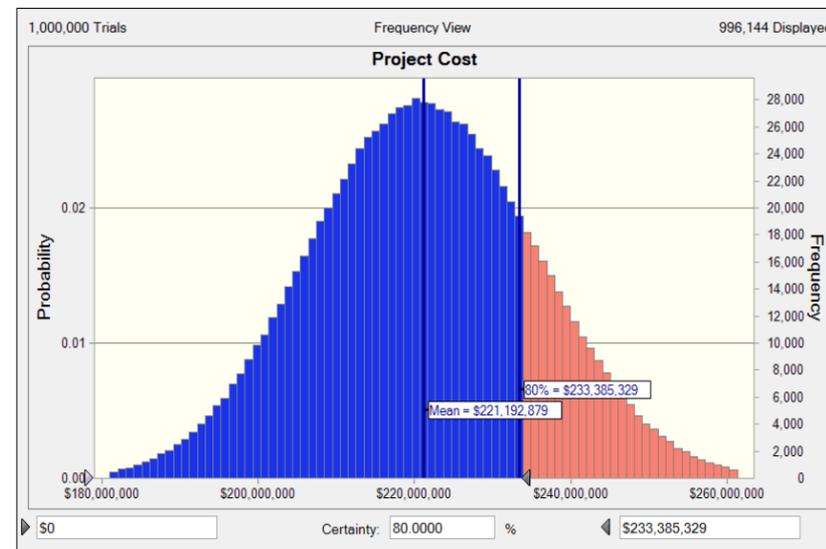
**Recommendations:** Timely coordination and risk resolution between the Sponsor, and USACE is needed in areas of funding needs and updates as applicable. The PDT must include the recommended cost and schedule contingencies and incorporate risk monitoring and mitigation on those identified risks. Further iterative study and update of the risk analysis throughout the project life-cycle is important in support of the remaining project work within an approved budget and appropriation.

Armourdale n500+3 ft. Recommended Alternative - Cost Risk Analysis Model

Risk No.	Risk/Opportunity Event	Likelihood*	Project Cost			Variance Distribution	Correlation to Other(s)	Crystal Ball Simulation Expected Values (\$\$\$)		
			Impact*	Risk Level*	Risk Level*			Low	Most Likely	High
<b>Internal Risks (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.)</b>										
<b>PROJECT &amp; PROGRAM MGMT</b>										
PPM-3	Project schedule in question	Very Likely	Critical	HIGH	Triangular	Schedule Risk covered by PR2	\$0	\$2,250,000	\$2,250,000	
<b>CONTRACT ACQUISITION RISKS</b>										
CA-1	Undefined acquisition strategy	Very Likely	Marginal	MODERATE	Triangular		(\$1,250,000)	\$0	\$7,500,000	
CA-3	Acq strategy decr competition	Very Likely	Negligible	LOW	Triangular		\$0	\$0	\$7,500,000	
<b>TECHNICAL RISKS</b>										
TL-1	Confidence in scope	Likely	Significant	HIGH	Triangular	Duplicate with PPM-2. PPM-2 not modeled.	(\$5,750,000)	\$0	\$30,270,000	
TL-2	Surveys in question	Likely	Negligible	LOW	Triangular		(\$1,100,000)	\$0	\$1,100,000	
TL-3	Borrow sources secured	Likely	Negligible	LOW	Uniform		\$0	\$0	\$1,671,000	
<b>LANDS AND DAMAGES RISKS</b>										
LD-5	Difficulty of RE work	Likely	Negligible	LOW	Triangular		\$0	\$0	\$1,288,000	
<b>REGULATORY AND ENVIRONMENTAL RISKS</b>										
<b>CONSTRUCTION RISKS</b>										
CON-4	Contract Modifications	Likely	Marginal	MODERATE	Triangular		(\$1,500,000)	\$0	\$15,000,000	
CON-5	Railroad involvement	Likely	Negligible	LOW	Triangular		\$0	\$0	\$2,400,000	
<b>ESTIMATE AND SCHEDULE RISKS</b>										
EST-1	Cost of Fuel	Likely	Negligible	LOW	Triangular		\$0	\$0	\$1,400,000	
EST-2	Cost of Steel	Likely	Negligible	LOW	Triangular		\$0	\$0	\$1,270,000	
EST-3	Parametric Est used for Critical Items	Likely	Negligible	LOW	Triangular		(\$2,800,000)	\$0	\$4,200,000	
EST-4	Prime/Subcontractor structure	Likely	Marginal	MODERATE	Triangular		\$0	\$0	\$12,470,000	
EST-5	Utility Relocations	Likely	Negligible	LOW	Triangular		\$0	\$0	\$5,000,000	
EST-6	JOOH	Likely	Negligible	LOW	Triangular		\$0	\$0	\$7,700,000	
EST-7	HOOH	Likely	Negligible	LOW	Triangular		\$0	\$0	\$7,000,000	
<b>Programmatic Risks (External Risk Items are those that are generated, caused, or controlled exclusively outside the PDT's sphere of influence.)</b>										
PR-1	Adequacy of project funding	Very Likely	Significant	HIGH	Triangular	Duplicate with PPM-3. Portions of PPM-3 not modeled.	\$0	\$24,000,000	\$24,000,000	
PR-3	Market/Bidding Conditions	Likely	Significant	HIGH	Triangular		(\$22,500,000)	\$0	\$15,000,000	



PROJECT CONTINGENCY (BASELINE)	Percentile	Baseline TPC	Contingency Amt	Baseline w/ Contingency	Contingency %
	0%	\$178,439,000	(\$19,319,022)	\$160,119,978	-10.27%
	5%	\$178,439,000	\$19,320,174	\$197,759,174	10.83%
	10%	\$178,439,000	\$24,321,459	\$202,760,459	13.63%
	15%	\$178,439,000	\$27,764,385	\$206,203,385	15.56%
	20%	\$178,439,000	\$30,508,657	\$208,947,657	17.10%
	25%	\$178,439,000	\$32,901,066	\$211,340,066	18.44%
	30%	\$178,439,000	\$35,052,909	\$213,491,909	19.64%
	35%	\$178,439,000	\$37,054,403	\$215,493,403	20.77%
	40%	\$178,439,000	\$38,969,601	\$217,408,601	21.84%
	45%	\$178,439,000	\$40,828,410	\$219,267,410	22.88%
	50%	\$178,439,000	\$42,638,594	\$221,077,594	23.90%
	55%	\$178,439,000	\$44,475,234	\$222,914,234	24.92%
	60%	\$178,439,000	\$46,345,931	\$224,784,931	25.97%
	65%	\$178,439,000	\$48,280,766	\$226,719,766	27.06%
	70%	\$178,439,000	\$50,310,661	\$228,749,661	28.19%
	75%	\$178,439,000	\$52,491,510	\$230,930,510	29.42%
	80%	\$178,439,000	\$54,946,329	\$233,385,329	30.79%
	85%	\$178,439,000	\$57,793,215	\$236,232,215	32.39%
	90%	\$178,439,000	\$61,337,832	\$239,776,832	34.37%
	95%	\$178,439,000	\$66,527,751	\$244,966,751	37.28%
	100%	\$178,439,000	\$103,159,513	\$281,598,513	57.81%



COST RISK ANALYSIS



**US Army Corps  
of Engineers®**

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**KANSAS CITYS FLOOD RISK MANAGEMENT  
PROJECT – CENTRAL INDUSTRIAL  
DISTRICT UNIT FEASIBILITY STUDY**

**Project Cost and Schedule Risk Analysis Report**

*Prepared for:*

U.S. Army Corps of Engineers,  
Kansas City District

*Prepared by:*

U.S. Army Corps of Engineers  
Kansas City District

October 11, 2013

## TABLE OF CONTENTS

EXECUTIVE SUMMARY .....	ES 1
MAIN REPORT .....	5
1.0 PURPOSE .....	5
2.0 BACKGROUND .....	5
3.0 REPORT SCOPE .....	6
3.1 Project Scope .....	6
3.2 USACE Risk Analysis Process .....	6
4.0 METHODOLOGY / PROCESS .....	7
4.1 Identify and Assess Risk Factors .....	9
4.2 Quantify Risk Factor Impacts .....	9
4.3 Analyze Cost Estimate and Schedule Contingency .....	10
5.0 PROJECT ASSUMPTIONS .....	10
6.0 RESULTS .....	11
6.1 Risk Register .....	11
6.2 Cost Contingency and Sensitivity Analysis .....	12
6.2.1 Sensitivity Analysis .....	12
6.2.2 Sensitivity Analysis Results .....	13
6.3 Schedule and Contingency Risk Analysis .....	13
7.0 MAJOR FINDINGS/OBSERVATIONS/RECOMMENDATIONS .....	15
7.1 Major Findings/Observations .....	16
7.2 Recommendations .....	19

## **LIST OF TABLES**

Table ES-1. Construction Contingency Results .....	ES-2
Table ES-2. Cost Summary of Remaining Costs (FY 2013) .....	ES-2
Table 1. Construction Cost Contingency Summary .....	13
Table 2. Schedule Duration Contingency Summary .....	15
Table 3. Project Cost Comparison Summary (Uncertainty Analysis) .....	17
Table 4. Construction Schedule Comparison Summary .....	18

## **LIST OF FIGURES**

Figure 1. Cost Sensitivity Analysis .....	14
Figure 2. Schedule Sensitivity Analysis .....	15

## **LIST OF APPENDICES**

Risk Register .....	APPENDIX A
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## EXECUTIVE SUMMARY

The US Army Corps of Engineers (USACE), Kansas City District, presents this cost and schedule risk analysis (CSRA) report regarding the risk findings and recommended contingencies for the Kansas City's Flood Risk Management Project – Central Industrial District Unit Feasibility Study. In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a formal risk analysis, *Monte-Carlo* based-study was conducted by the Project Development Team (PDT) on remaining costs. The purpose of this risk analysis study is to present the cost and schedule risks considered, those determined and respective project contingencies at a recommend 80% confidence level of successful execution to project completion.

The Central Industrial District – Kansas flood protection unit is located in Wyandotte County, Kansas, and extends from the Kansas/Missouri state line along the right bank of the Missouri River to the mouth of the Kansas River. It then continues upstream along the right bank of the Kansas River to mile 3.4. The Kaw Valley Drainage District is the local agency responsible for operation and maintenance. The original unit was constructed by the Kaw Valley Drainage District prior to May, 1948, when initial improvements began. The bulk of the improvements were completed by November, 1955. The most recent improvements were completed in December, 1979. The unit consists of a system of levees and floodwalls, underseepage control including 17 relief wells, a stoplog gap, a sandbag gap, 10 pump plants, and 23 drainage structures. The levee is approximately 1.8 miles long and the floodwalls total about 7,900 feet.

The Central Industrial District – Missouri flood protection unit is located in Kansas City, Missouri within Jackson County. The unit extends along the right bank of the Missouri River, upstream from the Grand Avenue Viaduct (river mile 365.7); to the Kansas/Missouri state line (river mile 367.2). The City Council passed four resolutions between 1941 and 1947 to provide the required assurances of local cooperation. The initial construction began in March, 1946 and was completed in September, 1947. Significant improvements and repair of 1951 flood damage followed the initial construction and were completed in November, 1955.

The unit consists of a system of levees, floodwalls, underseepage control, 1 sandbag and 7 stoplog gaps, 7 pump plants, and 5 conduits. The levees total about 430 feet in length and the floodwalls are about 1.45 miles long.

Specific to the Central Industrial District Flood Risk Management Project, the current fully funded estimate approximates \$104M. This CSRA study is expressed in FY 2014 dollars. Real Estate office provided a separate 25% contingency for its real estate requirements, which in turn was used in the Cost Risk Model. The Cost Engineering Section performed study on the total estimated project costs. Based on the results of the analysis, the Cost Engineering Section (located in Kansas City District) recommends a contingency value of approximately \$19M or approximately 31% of base project cost. This contingency includes a separate \$700K for Real Estate, another \$16M for the construction costs, and \$2.3M for design and construction management.

The Kansas City District Cost Engineering Section performed risk analysis using the *Monte Carlo* technique for the estimated construction costs, supported by the district PDT input. The following table ES-1 portrays the development of the construction contingencies (31.07%). The contingency is based on an 80% confidence level, as per USACE Civil Works guidance. Cost estimates fluctuate over time. During this period of study, minor cost fluctuations can and have occurred. For this reason, contingency reporting is based in cost and percent values. Should cost vary to a slight degree with similar scope and risks, contingency percent values will be reported, cost values rounded.

**Table ES-1. Construction Contingency Results**

<b>Base Case Construction Cost Estimate</b>	<b>\$62,079,416</b>	
<b>Confidence Level</b>	<b>Construction Value (\$\$)</b>	<b>Contingency (%)</b>
5%	\$70,323,663	13.28%
50%	\$77,658,057	25.09%
<b>80%</b>	<b>\$81,367,278</b>	<b>31.07%</b>
90%	\$83,272,942	34.14%

The following table ES-2 portrays the full costs of the cost recommendations, combining all remaining costs. 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 of Remaining Costs (FY2014 dollars)**

<b>CENTRAL INDUSTRIAL DISTRICT FORM FEATURE ACCOUNTS</b>		<b>COST (\$1,000)</b>	<b>CNTG (\$1,000)</b>	<b>CNTG %</b>	<b>TOTAL (\$1,000)</b>
<b>01</b>	LANDS AND DAMAGES	2,297	714	31.07	3,011
<b>02</b>	RELOCATIONS	4,814	1,496	31.07	6,310
<b>06</b>	FISH & WILDLIFE FACILITIES	0	0	0	0
<b>11</b>	LEVEES & FLOODWALLS	45,343	14,088	31.07	59,431
<b>13</b>	PUMPING PLANT	1,971	612	31.07	2,583
<b>30</b>	PLANNING, ENGINEERING, AND DESIGN	3,969	1,233	31.07	5,202
<b>31</b>	CONSTRUCTION MANAGEMENT	3,685	1,145	31.07	4,830
<b>FY 2014 PROJECT COSTS</b>		<b>62,079</b>	<b>19,288</b>	<b>31.07</b>	<b>81,366</b>
<b>Schedule Completion with Contingency</b>		<b>120 mo</b>	<b>108 mo</b>	<b>90.00</b>	<b>228 mo</b>

Notes:

- 1) Cost and Time contingencies presented w/ an 80% confidence level.
- 2) Costs exclude O&M and Life Cycle Cost estimates.

3) Differences between ES-1 and ES-2 are due to rounding.

## KEY FINDINGS/OBSERVATIONS RECOMMENDATIONS

The PDT worked through the risk register on September 17, 2012 and July 10, 2013. During this timeframe the PDT discussed project scope definition, investigations, design and cost information, and determined risks in certain project areas. The key risk drivers identified through sensitivity analysis suggest a cost contingency of \$19M and schedule risks adding another potential of 108 months, both at an 80% confidence level.

**Cost Risks:** From the CSRA, the key or greater Cost Risk items of include:

### High Risks

- PR-3: Market Conditions/Bidding Conditions – The economy is currently in a downturn with signs of improvement. A range was given to account for the variance of possibilities. The estimate assumes a normal bidding climate.
- PR-1: Adequacy of Project Funding – Incremental congressional appropriations, and the sponsors ability to cost share. Congressional appropriations will most likely be incrementally funded with minimal appropriations per year assigned to this project. The risk of the schedule slipping is assumed and therefore a 1.5% annual escalation rate compounded has been included in the cost model.
- TL-3: Confidence in Floodwalls Design – Not enough information to adequately formulate a design. Designers did not always use a conservative approach but rather used design intuition for assumptions. In cases where no information was available, extrapolation techniques were used. Additional subsurface investigations may be required resulting in the floodwalls needing to be replaced instead of raised.

### Moderate Risks

- CA-1: Undefined Acquisition Strategy – Large business competitive pricing could be eliminated if other acquisition strategies are used.
- CON-4: Contract Modifications – Large project could have several large modifications.
- TL-4: Pump Plants Design – Not enough information to adequately formulate a design. Designers did not always use a conservative approach but rather used design intuition for assumptions. In cases where no information was available, extrapolation techniques were used. Additional pump plant investigations may be required resulting in more extensive modifications than originally anticipated.
- TL-1: Relief Wells Design – Not enough information to adequately formulate a design. Designers did not always use a conservative approach but rather used design intuition for assumptions. In cases where no information was available, extrapolation techniques

were used. Additional subsurface investigations may be required resulting in more relief wells being added than originally anticipated.

Low risks were not modeled.

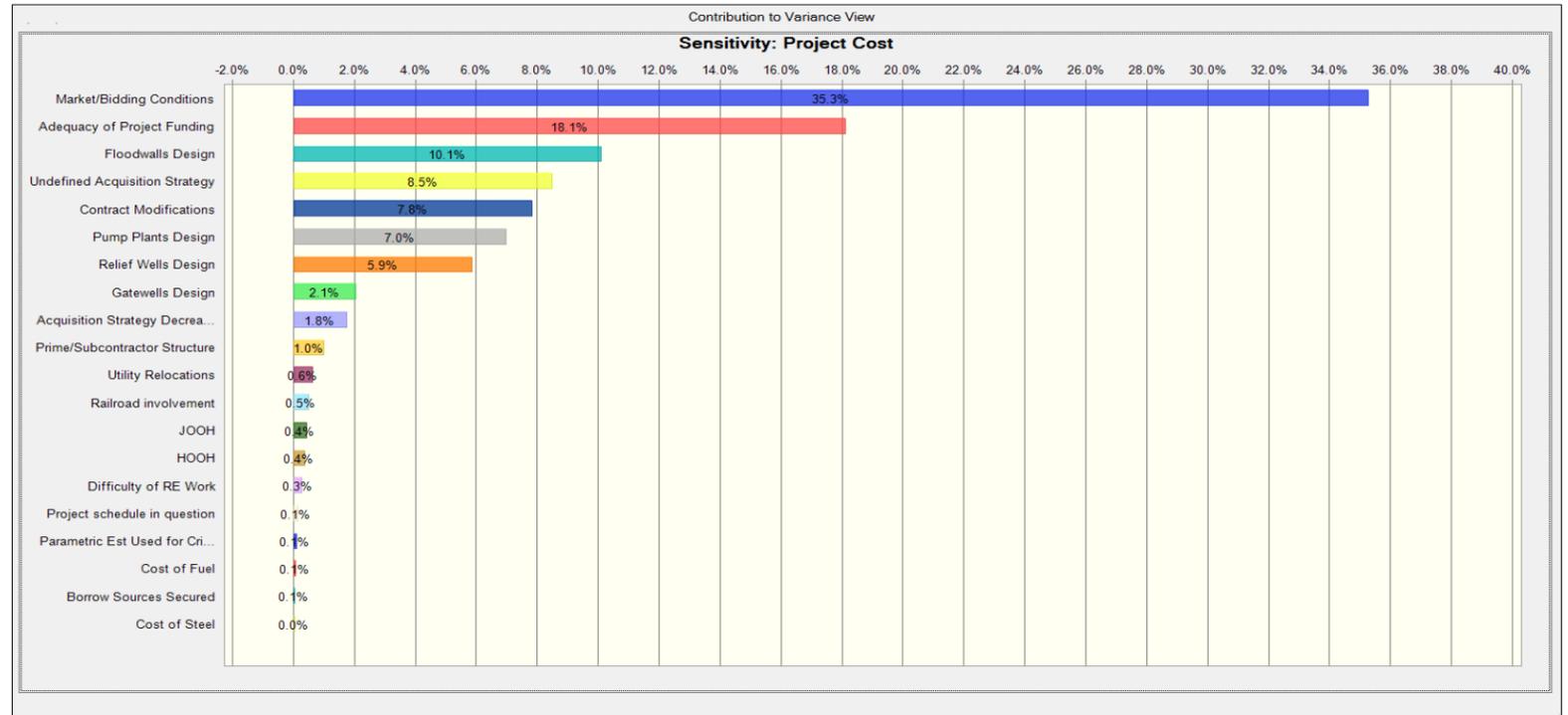
**Schedule Risks:** The high value of schedule risk indicates a significant uncertainty of key risk items, time duration growth that can translate into added costs. Over time, risks increase on those out-year contracts where there is greater potential for change in new scope requirements, uncertain market conditions, and unexpected high inflation. The greatest risk is:

- PR-1: Adequacy of Project Funding – Congressional appropriation will most likely be incrementally funded with minimal appropriation per year assigned to this project. The sponsor will most likely be unable to afford their cost share portion on a timely manner.

**Recommendations:** Timely coordination and risk resolution between the Sponsor and USACE is needed in areas of funding needs and updates as applicable. The PDT must include the recommended cost and schedule contingencies and incorporate risk monitoring and mitigation on those identified risks. Further iterative study and update of the risk analysis throughout the project life-cycle is important in support of the remaining project work within an approved budget and appropriation.

Central Industrial District n500+3 ft. Recommended Alternative - Cost Risk Analysis Model

Risk No.	Risk/Opportunity Event	Likelihood*	Project Cost			Variance Distribution	Correlation to Other(s)	Crystal Ball Simulation Expected Values (\$\$\$)		
			Impact*	Risk Level*				Low	Most Likely	High
<b>Internal Risks (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.)</b>										
<b>PROJECT &amp; PROGRAM MGMT</b>										
PPM-3	Project schedule in question	Very Likely	Negligible	LOW	Triangular	Schedule Risk covered by PR2	\$0	\$750,000	\$750,000	
<b>CONTRACT ACQUISITION RISKS</b>										
CA-1	Undefined Acquisition Strategy	Very Likely	Marginal	MODERATE	Triangular		(\$3,750,000)	\$0	\$2,500,000	
CA-3	Acquisition Strategy Decreasing Competition	Likely	Negligible	LOW	Triangular		\$0	\$0	\$2,500,000	
<b>TECHNICAL RISKS</b>										
TL-1	Relief Wells Design	Unlikely	Significant	MODERATE	Triangular	Duplicate with PPM-2. PPM-2 not modeled.	\$0	\$0	\$4,600,000	
TL-2	Gatewells Design	Unlikely	Marginal	LOW	Triangular	Duplicate with PPM-2. PPM-2 not modeled.	(\$750,000)	\$0	\$2,250,000	
TL-3	Floodwalls Design	Likely	Marginal	MODERATE	Triangular	Duplicate with PPM-2. PPM-2 not modeled.	(\$520,000)	\$0	\$5,720,000	
TL-4	Pump Plants Design	Unlikely	Significant	MODERATE	Triangular	Duplicate with PPM-2. PPM-2 not modeled.	\$0	\$0	\$5,000,000	
TL-6	Borrow Sources Secured	Likely	Negligible	LOW	Uniform		\$0	\$0	\$345,000	
<b>LANDS AND DAMAGES RISKS</b>										
LD-5	Difficulty of RE Work	Likely	Negligible	LOW	Triangular		\$0	\$0	\$1,000,000	
<b>REGULATORY AND ENVIRONMENTAL RISKS</b>										
<b>CONSTRUCTION RISKS</b>										
CON-4	Contract Modifications	Likely	Marginal	MODERATE	Triangular		(\$500,000)	\$0	\$5,000,000	
CON-5	Railroad involvement	Likely	Negligible	LOW	Triangular		\$0	\$0	\$1,350,000	
<b>ESTIMATE AND SCHEDULE RISKS</b>										
EST-1	Cost of Fuel	Likely	Negligible	LOW	Triangular		\$0	\$0	\$460,000	
EST-2	Cost of Steel	Likely	Negligible	LOW	Triangular		\$0	\$0	\$420,000	
EST-3	Parametric Est Used for Critical Items	Likely	Negligible	LOW	Triangular		(\$260,000)	\$0	\$390,000	
EST-4	Prime/Subcontractor Structure	Likely	Negligible	LOW	Triangular		\$0	\$0	\$1,900,000	
EST-5	Utility Relocations	Likely	Negligible	LOW	Triangular		\$0	\$0	\$1,500,000	
EST-6	JOOH	Likely	Negligible	LOW	Triangular		\$0	\$0	\$1,200,000	
EST-7	HOOH	Likely	Negligible	LOW	Triangular		\$0	\$0	\$1,100,000	
<b>Programmatic Risks (External Risk Items are those that are generated, caused, or controlled exclusively outside the PDT's sphere of influence.)</b>										
PR-1	Adequacy of Project Funding	Likely	Significant	HIGH	Triangular	Duplicate with PPM-3. Portions of PPM-3 not modeled.	\$0	\$8,000,000	\$8,000,000	
PR-3	Market/Bidding Conditions	Likely	Significant	HIGH	Triangular		(\$7,500,000)	\$0	\$5,000,000	



Percentile	Baseline TPC	Contingency Amt	Baseline w/ Contingency	Contingency %
0%	\$62,079,416	(\$4,267,564)	\$57,811,852	-6.87%
5%	\$62,079,416	\$8,244,247	\$70,323,663	13.28%
10%	\$62,079,416	\$9,849,424	\$71,928,840	15.87%
15%	\$62,079,416	\$10,940,749	\$73,020,165	17.62%
20%	\$62,079,416	\$11,812,432	\$73,891,848	19.03%
25%	\$62,079,416	\$12,555,394	\$74,634,810	20.22%
30%	\$62,079,416	\$13,231,657	\$75,311,073	21.31%
35%	\$62,079,416	\$13,853,575	\$75,932,991	22.32%
40%	\$62,079,416	\$14,445,650	\$76,525,066	23.27%
45%	\$62,079,416	\$15,020,673	\$77,100,089	24.20%
50%	\$62,079,416	\$15,578,641	\$77,658,057	25.09%
55%	\$62,079,416	\$16,139,963	\$78,219,379	26.00%
60%	\$62,079,416	\$16,706,394	\$78,787,810	26.91%
65%	\$62,079,416	\$17,297,758	\$79,372,174	27.86%
70%	\$62,079,416	\$17,901,994	\$79,981,410	28.84%
75%	\$62,079,416	\$18,561,975	\$80,641,391	29.90%
80%	\$62,079,416	\$19,287,862	\$81,367,278	31.07%
85%	\$62,079,416	\$20,131,920	\$82,211,336	32.43%
90%	\$62,079,416	\$21,193,526	\$83,272,942	34.14%
95%	\$62,079,416	\$22,737,994	\$84,817,400	36.63%
100%	\$62,079,416	\$35,230,355	\$97,309,771	56.75%

