

**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

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ARMOURDALE UNIT

Total Project Cost Summary  
Cost Risk Analysis Report - Executive Summary  
Cost Contingency Table

CENTRAL INDUSTRIAL DISTRICT UNIT

Total Project Cost Summary  
Cost Risk Analysis Report - Executive Summary  
Cost Contingency Table

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PROJECT: 7 Levees - Armourdale Reach - 500 Yr + 3ft - P2 Number 106927  
LOCATION: Kansas City, Kansas

DISTRICT: NWK Kansas City District  
POC: CHIEF, COST ENGINEERING  
PREPARED: %\$#%\$%

This Estimate reflects the scope and schedule in report;

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST (\$K)	CNTG (\$K)	CNTG (%)	TOTAL (\$K)	Program Year (Budget EC): 2015 Effective Price Level Date: 1 OCT 14				HCH5 @DFC>97H7CGH'GI @M: I B898L				
						ESC (%)	COST (\$K)	CNTG (\$K)	HCH5 @ (%)	Spent Thru: 1-Oct-13				
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
	RELOCATIONS	\$5,731	\$1,765	31%	\$7,496	1.8%	\$5,836	\$1,797	+Z''			\$7,179	\$2,210	\$9,389
	LEVEES & FLOODWALLS	\$141,797	\$43,659	31%	\$185,456	1.8%	\$144,398	\$44,460	% , Z )-			\$177,615	\$54,688	\$232,303
	PUMPING PLANT	\$5,943	\$1,830	31%	\$7,773	1.8%	\$6,052	\$1,863	+Z %			\$7,444	\$2,292	\$9,736
									SSSSSSSSSS					
	<b>7 CBGHI 7 HCB'9GHA 5 H9 'HCH5 @G.</b>	\$153,471	\$47,254		\$200,725	1.8%	\$156,287	\$48,121	Z (\$ Z +)			\$192,238	\$59,190	\$251,428
01	LANDS AND DAMAGES	\$2,579	\$794	31%	\$3,373	1.8%	\$2,626	\$809	' Z ')			\$2,885	\$888	\$3,774
30	PLANNING, ENGINEERING & DESIGN	\$11,610	\$3,575	31%	\$15,185	3.7%	\$12,035	\$3,706	% ) Z (\$			\$14,796	\$4,556	\$19,352
31	CONSTRUCTION MANAGEMENT	\$10,779	\$3,319	31%	\$14,097	3.7%	\$11,173	\$3,440	% Z %			\$17,921	\$5,518	\$23,439
									SSSSSSSSSS					
	<b>DFC&gt;97 H7 CGH'HCH5 @G.</b>	\$178,439	\$54,941	31%	\$233,380	2.1%	\$182,121	\$56,075	Z , Z% *			\$227,841	\$70,152	\$297,993

_____	CHIEF, COST ENGINEERING	
_____	PROJECT MANAGER	
_____	CHIEF, REAL ESTATE	
_____	CHIEF, PLANNING	
_____	CHIEF, ENGINEERING	
_____	CHIEF, OPERATIONS	
_____	CHIEF, CONSTRUCTION	
_____	CHIEF, CONTRACTING	
_____	CHIEF, PM-C	
_____	CHIEF, DPM	

	ESTIMATED FEDERAL COST:	*)1 ...	% ' Z' -)
	ESTIMATED NON-FEDERAL COST:	35%	% ( Z%- +

9 GHA 5 H98 'HCH5 @DFC>97 H7 CGH'GI @M: I B898L

C/ A 'CI HG-89' C: 'HCH5 @DFC>97 H7 CGH'GI @M: I B898L

PROJECT: 7 Levees - Armourdale Reach - 500 Yr + 3ft - P2 Number 106927  
 LOCATION: Kansas City, Kansas  
 This Estimate reflects the scope and schedule in report;

DISTRICT: NWK Kansas City District PREPARED: %\$#/%\$%  
 PO: CHIEF, COST ENGINEERING

Estimate Prepared: 19-Jan-13 Effective Price Level: 1-Oct-13						Program Year (Budget EC): 2015 Effective Price Level Date: 1 OCT 14				FULLY FUNDED PROJECT ESTIMATE				
RISK BASED														
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST (\$K)	CNTG (\$K)	CNTG (%)	TOTAL (\$K)	ESC (%)	COST (\$K)	CNTG (\$K)	TOTAL (\$K)	Mid-Point Date	ESC (%)	COST (\$K)	7BH (\$K)	: I @@ (\$K)
A	B	C	D	E	F	G	H	I	J	P	L	M	N	O
	PHASE 1													
\$&	RELOCATIONS	\$5,731	\$1,765	30.79%	\$7,496	1.8%	\$5,836	\$1,797	\$7,633	2026Q1	23.0%	\$7,179	&Z&S	- Z , -
%&	LEVEES & FLOODWALLS	\$141,797	\$43,659	30.79%	\$185,456	1.8%	\$144,398	\$44,460	\$188,859	2026Q1	23.0%	\$177,615	) (Z , ,	' & Z \$'
%	PUMPING PLANT	\$5,943	\$1,830	30.79%	\$7,773	1.8%	\$6,052	\$1,863	\$7,916	2026Q1	23.0%	\$7,444	' &Z& - &	' - Z+ '*
	<b>7 CBGHI 7 HCB'9GHA 5 H9'HCH5 @G</b>	\$153,471	\$47,254	30.79%	\$200,725		\$156,287	\$48,121	\$204,407			\$192,238	) - Z% \$	' &) %Z &
01	LANDS AND DAMAGES	\$2,579	\$794	30.79%	\$3,373	1.8%	\$2,626	\$809	\$3,435	2020Q1	9.9%	\$2,885	, , ,	' Z+(
' \$	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	\$1,540	\$474	30.79%	\$2,014	3.7%	\$1,596	\$491	\$2,088	2018Q1	13.3%	\$1,809	) ) +	' &Z **
1.0%	Planning & Environmental Compliance	\$1,540	\$474	30.79%	\$2,014	3.7%	\$1,596	\$491	\$2,088	2018Q1	13.3%	\$1,809	) ) +	' &Z **
1.0%	Engineering & Design	\$1,540	\$474	30.79%	\$2,014	3.7%	\$1,596	\$491	\$2,088	2018Q1	13.3%	\$1,809	) ) +	' &Z **
1.0%	Engineering Tech Review ITR & VE	\$1,540	\$474	30.79%	\$2,014	3.7%	\$1,596	\$491	\$2,088	2018Q1	13.3%	\$1,809	) ) +	' &Z **
1.0%	Contracting & Reprographics	\$1,540	\$474	30.79%	\$2,014	3.7%	\$1,596	\$491	\$2,088	2018Q1	13.3%	\$1,809	) ) +	' &Z **
1.0%	Engineering During Construction	\$1,540	\$474	30.79%	\$2,014	3.7%	\$1,596	\$491	\$2,088	2026Q1	60.4%	\$2,560	' + , ,	' Z ( ,
0.54%	Planning During Construction	\$831	\$256	30.79%	\$1,088	3.7%	\$862	\$265	\$1,127	2026Q1	60.4%	\$1,382	' (&*	' %Z \$,
1.0%	Project Operations	\$1,540	\$474	30.79%	\$2,014	3.7%	\$1,596	\$491	\$2,088	2018Q1	13.3%	\$1,809	) ) +	' &Z **
' %	CONSTRUCTION MANAGEMENT													
5.0%	Construction Management	\$7,699	\$2,371	30.79%	\$10,070	3.7%	\$7,981	\$2,457	\$10,438	2026Q1	60.4%	\$12,801	' Z ( %	' %Z+ (&
	Project Operation:			30.79%										
2.0%	Project Management	\$3,080	\$948	30.79%	\$4,028	3.7%	\$3,192	\$983	\$4,175	2026Q1	60.4%	\$5,120	' %Z) ++	' *Z+ -
	<b>7 CBHF57H7CGH'HCH5 @G</b>	\$178,439	\$54,941		\$233,380		\$182,121	\$56,075	\$238,196			\$227,841	' + Z% &	' &- +Z -'



**US Army Corps  
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

June 17, 2013

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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 \$302M. This CSRA study is expressed in FY 2013 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 \$50M or approximately 27% of base project cost. This contingency includes a separate \$2.87M for Real Estate, another \$40.72M for the construction costs, and \$5.94M 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 (26.51%). The contingency is based on an 80% confidence level, as per USACE Civil Works guidance.

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

<b>Base Case Construction Cost Estimate</b>	<b>\$183,452,117</b>	
<b>Confidence Level</b>	<b>Construction Value (\$\$)</b>	<b>Contingency (%)</b>
5%	\$196,494,741	7.11%
50%	\$219,550,129	19.68%
<b>80%</b>	<b>\$232,078,791</b>	<b>26.51%</b>
90%	\$238,676,450	30.10%

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 27%.

**Table ES-2. Cost Summary of Remaining Costs (FY2013 dollars)**

ARMOURDALE FRM FEATURE ACCOUNTS		COST	CNTG	CNTG	TOTAL
		(\$1,000)	(\$1,000)	%	(\$1,000)
<b>01</b>	LANDS AND DAMAGES	10,640	2,873	27.00	13,513
<b>02</b>	RELOCATIONS	5,637	1,522	27.00	7,159
<b>06</b>	FISH & WILDLIFE FACILITIES	0	0	0	0
<b>11</b>	LEVEES & FLOODWALLS	139,350	37,624	27.00	176,974
<b>13</b>	PUMPING PLANT	5,823	1,572	27.00	7,395
<b>30</b>	PLANNING, ENGINEERING, AND DESIGN	11,410	3,081	27.00	14,490
<b>31</b>	CONSTRUCTION MANAGEMENT	10,592	2,860	27.00	13,452
<b>FY 2013 PROJECT COSTS</b>		<b>183,452</b>	<b>49,936</b>	<b>27.00</b>	<b>232,984</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.

### 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 \$50M 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.

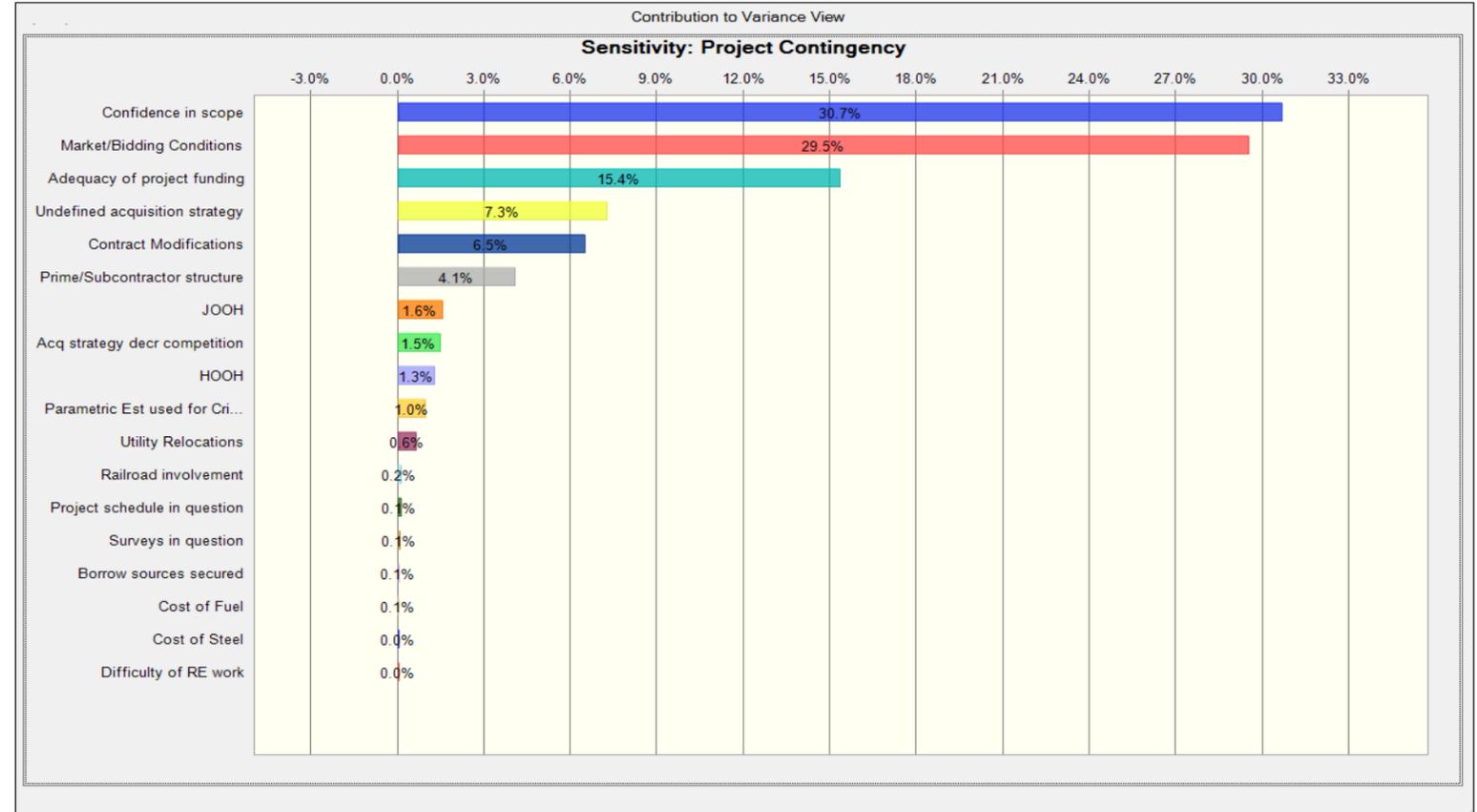
**Schedule Risks:** The high value of schedule risk indicates a significant uncertainty of key risk items, time duration growth that can translate into added costs. Over time, risks increase on those out-year contracts where there is greater potential for change in new scope requirements, uncertain market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

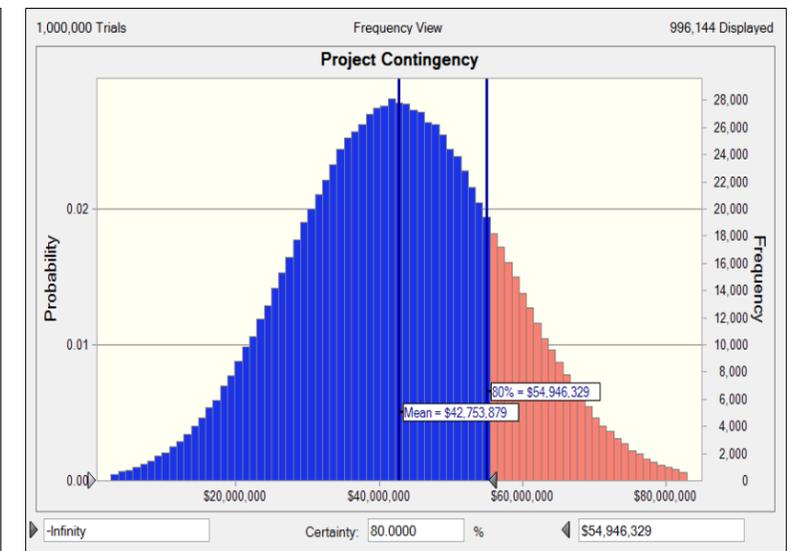
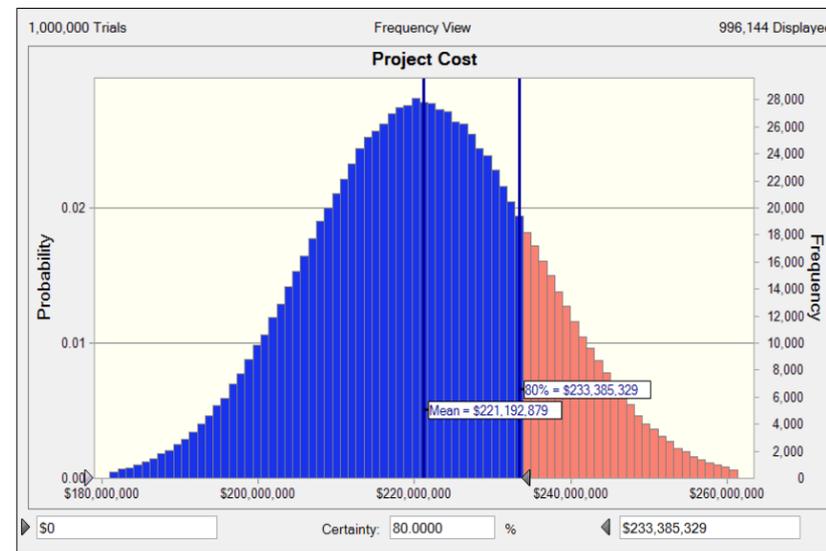
**Recommendations:** Timely coordination and risk resolution between the Sponsor, and USACE is needed in areas of funding needs and updates as applicable. The PDT must include the recommended cost and schedule contingencies and incorporate risk monitoring and mitigation on those identified risks. Further 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*				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	(\$18,319,022)	\$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

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

PROJECT: 7 Levees - Central Industrial District Reach - 500 Yr + 3ft - P2 Number 106927  
 LOCATION: Kansas City, Kansas

DISTRICT: NWK Kansas City District  
 POC: CHIEF, COST ENGINEERING  
 PREPARED: 10/1/2013

This Estimate reflects the scope and schedule in report;

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST (\$K)	CNTG (\$K)	CNTG (%)	TOTAL (\$K)	Program Year (Budget EC): 2015 Effective Price Level Date: 1 OCT 14				TOTAL PROJECT COST (FULLY FUNDED)				
						PROJECT FIRST COST				Spent Thru:				
						ESC (%)	COST (\$K)	CNTG (\$K)	TOTAL (\$K)	1-Oct-13 (\$K)	L	COST (\$K)	CNTG (\$K)	FULL (\$K)
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
02	RELOCATIONS	\$4,814	\$1,496	31%	\$6,310	1.8%	\$4,902	\$1,523	\$6,425			\$6,030	\$1,874	\$7,904
06	FISH & WILDLIFE FACILITIES													
11	LEVEES & FLOODWALLS	\$45,343	\$14,088	31%	\$59,431	1.8%	\$46,175	\$14,347	\$60,521			\$56,797	\$17,647	\$74,443
13	PUMPING PLANT	\$1,971	\$612	31%	\$2,583	1.8%	\$2,007	\$624	\$2,631			\$2,469	\$767	\$3,236
	<b>CONSTRUCTION ESTIMATE TOTALS:</b>	\$52,128	\$16,196		\$68,324	1.8%	\$53,084	\$16,493	\$69,578			\$65,296	\$20,287	\$85,583
01	LANDS AND DAMAGES	\$2,297	\$714	31%	\$3,011	1.8%	\$2,339	\$727	\$3,066			\$2,570	\$798	\$3,368
30	PLANNING, ENGINEERING & DESIGN	\$3,969	\$1,233	31%	\$5,202	3.7%	\$4,114	\$1,278	\$5,392			\$5,058	\$1,572	\$6,629
31	CONSTRUCTION MANAGEMENT	\$3,685	\$1,145	31%	\$4,830	3.7%	\$3,819	\$1,187	\$5,006			\$6,126	\$1,903	\$8,030
	<b>PROJECT COST TOTALS:</b>	\$62,079	\$19,288	31%	\$81,366	2.1%	\$63,357	\$19,685	\$83,042			\$79,050	\$24,561	\$103,611

- \_\_\_\_\_ CHIEF, COST ENGINEERING
- \_\_\_\_\_ PROJECT MANAGER
- \_\_\_\_\_ CHIEF, REAL ESTATE
- \_\_\_\_\_ CHIEF, PLANNING
- \_\_\_\_\_ CHIEF, ENGINEERING
- \_\_\_\_\_ CHIEF, OPERATIONS
- \_\_\_\_\_ CHIEF, CONSTRUCTION
- \_\_\_\_\_ CHIEF, CONTRACTING
- \_\_\_\_\_ CHIEF, PM-C
- \_\_\_\_\_ CHIEF, DPM

ESTIMATED FEDERAL COST: 65% **\$67,347**  
 ESTIMATED NON-FEDERAL COST: 35% **\$16,264**  
**ESTIMATED TOTAL PROJECT COST: \$103,611**

**O&M OUTSIDE OF TOTAL PROJECT COST:**

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

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

PROJECT: 7 Levees - Central Industrial District Reach - 500 Yr + 3ft - P2 Number 106927  
 LOCATION: Kansas City, Kansas  
 This Estimate reflects the scope and schedule in report;

DISTRICT: NWK Kansas City District  
 POC: CHIEF, COST ENGINEERING  
 PREPARED: 10/1/2013

Estimate Prepared: 1-Jul-13 Effective Price Level: 1-Oct-13						Program Year (Budget EC): 2015 Effective Price Level Date: 1 OCT 14				FULLY FUNDED PROJECT ESTIMATE					
RISK BASED															
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST (\$K)	CNTG (\$K)	CNTG (%)	TOTAL (\$K)	ESC (%)	COST (\$K)	CNTG (\$K)	TOTAL (\$K)	Mid-Point Date	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>	PHASE 1 RELOCATIONS	\$4,814	\$1,496	31.07%	\$6,310	1.8%	\$4,902	\$1,523	\$6,425	2026Q1	23.0%	\$6,030	\$1,874	\$7,904	
<b>06</b>	FISH & WILDLIFE FACILITIES			31.07%											
<b>11</b>	LEVEES & FLOODWALLS	\$45,343	\$14,088	31.07%	\$59,431	1.8%	\$46,175	\$14,347	\$60,521	2026Q1	23.0%	\$56,797	\$17,647	\$74,443	
<b>13</b>	PUMPING PLANT	\$1,971	\$612	31.07%	\$2,583	1.8%	\$2,007	\$624	\$2,631	2026Q1	23.0%	\$2,469	\$767	\$3,236	
<b>CONSTRUCTION ESTIMATE TOTALS:</b>		\$52,128	\$16,196	31.07%	\$68,324		\$53,084	\$16,493	\$69,578			\$65,296	\$20,287	\$85,583	
01	LANDS AND DAMAGES	\$2,297	\$714	31.07%	\$3,011	1.8%	\$2,339	\$727	\$3,066	2020Q1	9.9%	\$2,570	\$798	\$3,368	
<b>30</b>	PLANNING, ENGINEERING & DESIGN														
1.0%	Project Management	\$526	\$164	31.07%	\$690	3.7%	\$546	\$170	\$715	2018Q1	13.3%	\$618	\$192	\$810	
1.0%	Planning & Environmental Compliance	\$526	\$164	31.07%	\$690	3.7%	\$546	\$170	\$715	2018Q1	13.3%	\$618	\$192	\$810	
1.0%	Engineering & Design	\$526	\$164	31.07%	\$690	3.7%	\$546	\$170	\$715	2018Q1	13.3%	\$618	\$192	\$810	
1.0%	Engineering Tech Review ITR & VE	\$526	\$164	31.07%	\$690	3.7%	\$546	\$170	\$715	2018Q1	13.3%	\$618	\$192	\$810	
1.0%	Contracting & Reprographics	\$526	\$164	31.07%	\$690	3.7%	\$546	\$170	\$715	2018Q1	13.3%	\$618	\$192	\$810	
1.0%	Engineering During Construction	\$526	\$164	31.07%	\$690	3.7%	\$546	\$170	\$715	2026Q1	60.4%	\$875	\$272	\$1,147	
0.54%	Planning During Construction	\$284	\$88	31.07%	\$373	3.7%	\$295	\$92	\$386	2026Q1	60.4%	\$473	\$147	\$619	
1.0%	Project Operations	\$526	\$164	31.07%	\$690	3.7%	\$546	\$170	\$715	2018Q1	13.3%	\$618	\$192	\$810	
<b>31</b>	CONSTRUCTION MANAGEMENT														
5.0%	Construction Management	\$2,632	\$818	31.07%	\$3,450	3.7%	\$2,728	\$848	\$3,576	2026Q1	60.4%	\$4,376	\$1,360	\$5,736	
	Project Operation:			31.07%											
2.0%	Project Management	\$1,053	\$327	31.07%	\$1,380	3.7%	\$1,091	\$339	\$1,430	2026Q1	60.4%	\$1,750	\$544	\$2,294	
<b>CONTRACT COST TOTALS:</b>		\$62,079	\$19,288		\$81,366		\$63,357	\$19,685	\$83,042			\$79,050	\$24,561	\$103,611	



**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

August 21, 2013

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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 \$108M. This CSRA study is expressed in FY 2013 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 \$20M or approximately 31% of base project cost. This contingency includes a separate \$1.6M

for Real Estate, another \$16M for the construction costs, and \$2.4M 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 (31.00%). The contingency is based on an 80% confidence level, as per USACE Civil Works guidance.

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

<b>Base Case Construction Cost Estimate</b>	<b>\$63,879,000</b>	
<b>Confidence Level</b>	<b>Construction Value (\$\$)</b>	<b>Contingency (%)</b>
5%	\$72,594,570	13.64%
50%	\$79,953,295	25.16%
<b>80%</b>	<b>\$83,683,091</b>	<b>31.00%</b>
90%	\$85,582,396	33.98%

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 (FY2013 dollars)**

<b>ARMOURDALE FRM 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	5,218	1,618	31.00	6,836
<b>02</b>	RELOCATIONS	4,734	1,468	31.00	6,202
<b>06</b>	FISH & WILDLIFE FACILITIES	0	0	0	0
<b>11</b>	LEVEES & FLOODWALLS	44,483	13,790	31.00	58,273
<b>13</b>	PUMPING PLANT	1,933	599	31.00	2,532
<b>30</b>	PLANNING, ENGINEERING, AND DESIGN	3,895	1,208	31.00	5,103
<b>31</b>	CONSTRUCTION MANAGEMENT	3,616	1,121	31.00	4,737
<b>FY 2012 PROJECT COSTS</b>		<b>63,879</b>	<b>19,803</b>	<b>31.00</b>	<b>83,682</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.

## 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 \$20M 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.

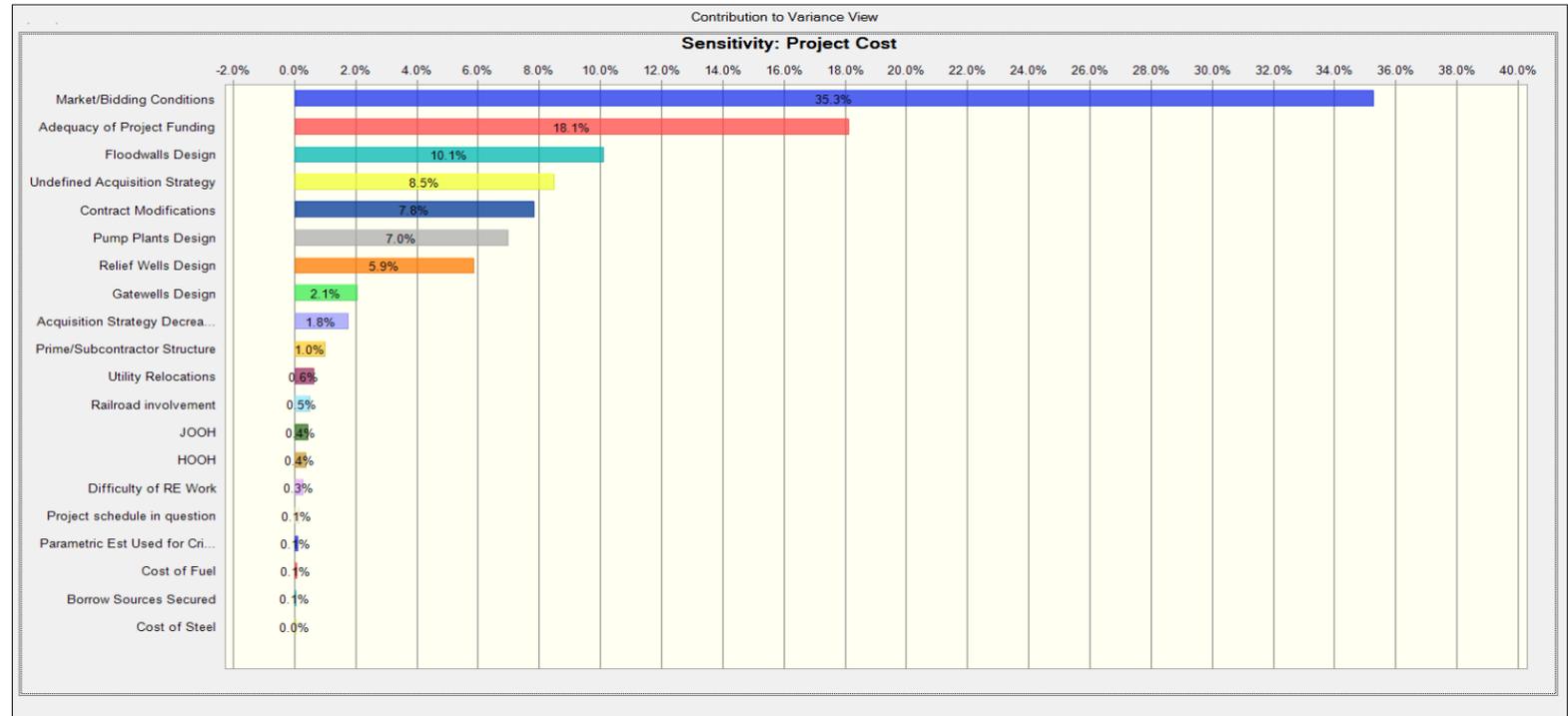
**Schedule Risks:** The high value of schedule risk indicates a significant uncertainty of key risk items, time duration growth that can translate into added costs. Over time, risks increase on those out-year contracts where there is greater potential for change in new scope requirements, uncertain market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

