Three Rivers Southeast Arkansas Study

Appendix E: Cost Analysis

THREE RIVERS SOUTHEAST ARKANSAS

Introduction

The Three Rivers Southeast Arkansas Feasibility Study (Three Rivers Study) is being conducted by the U. S. Army Corps of Engineers (USACE) to recommend modifications to the McClellan-Kerr Arkansas River Navigation System (MKARNS) that would provide long-term sustainable navigation and promote the continued safe and reliable economic use of the MKARNS.

Study Authority

Section 216, Flood Control Act of 1970 (Public Law 91-611) authorizes a feasibility study due to examine significantly changed physical and economic conditions in the Three Rivers study area. The study will evaluate and recommend modifications for long-term sustainable navigation on the MKARNS.

Study Purpose

There is a risk of a breach of the existing Soil Cement Structure near the entrance channel to the MKARNS on the White River. During high water events, Mississippi backwater can create significant head differentials between the Arkansas and White rivers. The existing Soil Cement Structure in the isthmus between the Arkansas and White rivers is subject to damaging overtopping, flanking and seepage flows that could result in a catastrophic breach and failure of the system. The uninhibited development of a breach, or cutoff, has the potential to create navigation hazards, increase the need for dredging, and adversely impact an estimated 200 acres of bottomland hardwood forest in the isthmus.

Based on the Section 216 authority, the study is investigating alternatives that would minimize the risk of cut off development, including reducing the cost of maintence associated with preventing cutoff development, while minimizing impacts to the surrounding ecosystem.

Non-Federal Sponsor

The Arkansas Waterways Commission is the non-federal sponsor for the Three Rivers Southeast Arkansas Study. An amended feasibility cost-sharing agreement was executed in June 2015.

Recommended Plan

The recommended plan consists of a newly constructed 2.5-mile long containment structure at an elevation of 157 feet above mean sea level (ft msl) that would begin on natural high ground just south and west of the existing Melinda Structure located on the south side of Owens Lake. It would continue east and cross the Melinda head cut south of the existing Melinda Structure. From there, it would head northeast and connect to the existing Soil Cement Structure north of Jim Smith Lake. It continues to follow the existing Soil Cement Structure alignment terminating at the existing Historic Closure Structure. The recommended plan also includes a relief opening at the Historic Cutoff to an elevation 145 ft msl regardless of the width. In addition, the existing Melinda Structure would be demolished in place and the debris would be pushed into the deep scour hole at the top of the head cut. Finally, adding an opening in the existing Owens Lake Structure between Owens Lake and the White River would prevent water from backing up into Owens Lake, which would impact the bottomland hardwood forest. The opening would be designed to allow fish passage into Owens Lake.

P2-145513 – THREE RIVERS SOUTHEAST ARKANSAS STUDY,
ARKANSAS AND WHITE RIVER,
ARKANSAS AND DESHA COUNTIES, ARKANSAS
COST ANALYSIS SUMMARY

LOCATION AND DESCRIPTION:
The Three Rivers Southeast Arkansas Study (Three Rivers Study) is being conducted by the United States Army Corps of Engineers (USACE), Little Rock District, to study potential modifications to the McClellan-Kerr Arkansas River Navigation System (MKARNS) in an effort to seek a long-term sustainable navigation system that promotes the continued safe and reliable economic use of the MKARNS.

COST METHODOLOGY:

A. General

The MII is developed using October 2017 Price Levels (FY18) and the latest labor and equipment rates. The contract is organized in accordance with a work breakdown structure. Midpoint dates for the construction contract are developed in conjunction with the project manager for developing fully-funded costs, which assumes one contract (large business). The estimate is prepared in accordance with ER 1110-2-1302 Civil Works Cost Engineering. The costs are escalated in accordance with the above Engineering Regulation and EM 1110-2-1304 Civil Works Construction Cost Index System (CWCCIS).

Hazardous, Toxic, and Radioactive Wastes are not anticipated.

Impacts to Cultural Resources are not anticipated.

Operation and Maintenance (OM) estimates were not performed on the alternatives or the selected plan. More information is found in the Economics Appendix.

An Abbreviated Risk Analysis was performed for each alternative. A Cost and Schedule Risk Analysis (CSRA) was performed on the selected plan. The CSRA was performed with the cooperation of the Project Delivery Team and Cost Engineering Directory of Expertise (DX) of the Walla Walla District. The risks were quantified and a cost and schedule risk model developed to determine a contingency at 80% Confidence Level.

Cost data was input into the Total Project Cost Summary (TPCS) spreadsheet and certified by Cost Engineering DX of the Walla Walla District.

B. Direct and Indirect Costs

Labor Rates are based on 03/16/2018 Davis-Bacon Wage Rates General Decision Pemiscot County, Missouri, as Missouri labor rates are more conservative than Arkansas labor rates, and out-of-state contractors are expected due to the magnitude of the project.

All equipment costs are from MII Equipment Region 3.

Overtime was considered and deemed necessary due to the remoteness of the project, so it was applied in the estimate. Local taxes were applied. Production rates were included and have been noted in the Estimate. Job Office Overhead (JOOH) and Home Office Overhead (HOOH) were applied as a running percentage. Profit was included as a percentage, using Profited Weighted Guidelines.

C. Project Feature Accounts

The following Work Breakdown Structures are based on the National Economic Development Plan: Alternative 1: Containment Structure at Elevation 157 and Relief Openings.

ACCOUNT CODE 01 - LANDS AND DAMAGES:
The cost for this account is based on land purchase for the containment structure and potential land purchase in historic cutoff flow path. More information is found in the Real Estate Appendix.

ACCOUNT CODE 06 - FISH AND WILDLIFE FACILITIES:
The cost for this account is based on mitigation for WBS 11. It includes purchasing 169 credits from the Fourche Bayou Mitigation Bank. More information is found in the Mitigation Appendix.

ACCOUNT CODE 11 - LEVEES AND FLOODWALLS:
The cost for this account is based on a new stone containment structure approximately 2.5 miles long; a new opening and armoring of it in the Historic Closure Structure; and a new opening, e.g. ConSpan or box culverts, in the Owen's Lake Structure. Work includes clearing and grubbing and removal of the Melinda Structure.

ACCOUNT CODE 30 - ENGINEERING AND DESIGN:
The cost for this account is developed using the guidelines provided in the TPCS, with the agreement of the cost engineer and the project manager.

ACCOUNT CODE 31 - CONSTRUCTION MANAGEMENT:
The cost for this account is developed using the guidelines provided in the TPCS, with the agreement of the cost engineer and the project manager.

US Army Corps
of Engineers®

Three Rivers Southeast Arkansas Integrated Feasiblity Report and Environmental Assessment

Project Cost and Schedule Risk Analysis Report

Prepared for:

U.S. Army Corps of Engineers,
Little Rock District

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April 2018

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EXECUTIVE SUMMARY

The US Army Corps of Engineers (USACE), District, presents this cost and schedule risk analysis (CSRA) report regarding the risk findings and recommended contingencies for the Three Rivers Southeast Arkansas Integrated Feasibility Report and EA. In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a *Monte-Carlo* based risk analysis 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 recommended 80% confidence level of successful execution to project completion.

The study is to recommend modifications to the McClellan-Kerr Arkansas River Navigation System (MKARNS) that will ensure the long-term sustainability of reliable navigation on the MKARNS.

The recommended plan consists of a new containment structure at an elevation of 157 feet above mean sea level with a relief channel through the Historic Closure Structure, and would dramatically reduce the risk of a cutoff forming. The structure would be approximately 2.5 miles long, and would begin on natural high ground south and west of the Melinda Structure located on the south side of Owens Lake. As designed, it continues east and cross the Melinda head cut south of the Melinda Structure, and then heads northeast and connects to the existing containment structure north of Jim Smith Lake. It then continues to follow the Soil Cement Structure alignment and terminates at the Historic Closure Structure. This alignment takes advantage of natural high ground, in most locations the structure would only rise five to seven feet above the ground, and would be no more than 12 feet above the ground at its highest point. The relief opening at the Historic Cutoff would be at an elevation of 145 feet, and engineers and hydrologists would optimize the width of the opening during the Preconstruction, Engineering and Design (PED) phase of the project to ensure that flows through the Historic Cutoff, the natural path by which waters of the White River have historically flowed across to the Arkansas and vice versa, would not impact navigation.

Opening the Historic Cutoff would reduce maximum head differentials across the isthmus allowing USACE to better control the location of future overtopping events and would decrease the duration of head differentials and flow velocities and hence erosion across the isthmus. Lastly, the opening would restore ecosystem functions of Webfoot Lake and reduce erosion on the east side of the lake where there are knickpoints that will likely lead to head cutting and a resultant decline in ecosystem function of Webfoot Lake. Similarly, removing the Melinda Structure would reconnect Owens Lake to its former southern limb, thereby returning open water ecosystem functions to the oxbow portion of the flooded bottomland hardwood forest. Demolition debris would be pushed into the deep scour hole at the top of the Melinda head cut to reduce water turbulence and erosion in the immediate Melinda Structure vicinity. Finally, opening the Owens Lake Structure between Owens Lake and the White River would prevent water from

backing up into Owens Lake, which may benefit adjacent bottomland hardwood forests. The opening's design would also provide a fish passage into Owens Lake that will be eliminated after the construction of the Containment Structure at elevation 157 feet. Other than changes described above, implementation of the recommended plan would not alter hydrology in surrounding bottomland hardwood forests, and most importantly, navigation would continue with no operational changes to the MKARNS.

Specific to the Three Rivers Southeast Arkansas Integrated Feasibility Report and EA, the current project base cost estimate, pre-contingency, approximates $117M. This CSRA study excluded the spent costs of $0M, excludes contingencies and is expressed in FY 2018 dollars. Since the Real Estate office provided a separate 11% contingency for its real estate requirements, the Cost MCX performed study on the estimated remaining construction costs of $116M. Based on the results of the analysis, the Cost Engineering Mandatory Center of Expertise for Civil Works (MCX located in Walla Walla District) recommends a contingency value of $41M or approximately 35% of base project cost at an 80% confidence level of successful execution. Total contingency includes a separate $89K for Real Estate, $41M for the construction costs, and $6M for design and construction management.

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 per cent values. Should cost vary to a slight degree with similar scope and risks, contingency per cent values will be reported, cost values rounded.

Table ES-1. Construction Contingency Results

Base Case Construction Cost Estimate	**$116,000,000**	
Confidence Level	**Construction Value ($$) w/ Contingencies**	**Contingency (%)**
50%	$146,000,000	25%
80%	**$157,000,000**	**35%**
90%	$163,000,000	40%

KEY FINDINGS/OBSERVATIONS RECOMMENDATIONS

The PDT worked through the risk register on February 27, 2018. The key risk drivers identified through sensitivity analysis suggest a cost contingency of $41M and schedule risks adding 18 months, both at an 80% confidence level.

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

- CA3 – Market Conditions/Bidding Climate: This risk is present across all contracts. It is possible conflicting project schedules force contractors to pick and choose what projects they want to propose on, resulting in higher costs. While competitive at this time, out-year contracts face greater uncertainty relative to market and inflation conditions. No impact to schedule is anticipated due to "no bidders."
- PM10 - Breach During Construction: If a breach occurs during construction, then a significant impact could be realized to the construction costs. It could involve a new design and change to construction costs. Since no cutoff (defined, in this case, as full breach) has formed in the last +40 years (never has a full breach been recorded), the likelihood is unlikely to possible.
- ES5 - Stone Pricing for the Historic Closure Structure: A driving cost is stone. For TSP, one quote (Dec-2016) received. USACE historical prices for R7400 could be as high as $90/TON for material, transport, and place in locations where local quarries are not available which significantly increases transportation costs. Current estimate is $50/TON. Due to reasonably close proximity of quarries, the apparent availability of stone and stone to be transported by barges not trucks, assume a $20/TON increase (to $70/TON) for possible price increase of stone at 810,000 TON for a $16.2M increase. An increase would be a critical impact.
- TR3 – Sheet pile Structure: Surveys and soil borings are required during PED. Limited bathymetry and survey exists in corridor of Historic Cutoff Structure, except near the road/structure. New data could (possibly) indicate a matrix of subsurface soils and higher chance of sheet pile wall instability, which could create need for additional subsurface earthwork and/or quantities. It could increase (or possibly reduce) sheet pile needs, e.g. length and depth.
- TR7 Modifications and Claims: Unanticipated items of work, quantity variations and differing site conditions which could result in modifications and changes that occur during construction are unknown.

Schedule Risks: The moderate schedule risk indicates a significant uncertainty of key risk items and time duration growth. 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 schedule risks are:

- EX3 – Containment Structure, Historic Closure Structure, Owens Structure PED: Current estimate assumes all money in one (1) FY, one (1) contract. Hydrologically the project should not be separated. It is uncertain whether all needed Congressional funding for construction will be made available in a timely manner. In addition, it is uncertain whether all Congressional funding will be provided for one (1) contract. This could delay project schedule one (1) year.
- EX-1 - Severe Weather: Elevated river flow based on normal weather conditions could impact work. Area floods regularly. For example, New Containment

Structure would be completely submerged in 100YR event (or a lesser event). Equipment may need to be moved during a flood. This could delay the project and have a moderate impact on costs, e.g. wet and soggy conditions for an extended period of time.

- EX2 – Compatibility Use Permit: USFW may not approve the Compatibility use permit. Currently, that is not anticipated. However, Congress could override it.
- TR3 – Sheet Pile Structure: Surveys and soil borings are required during PED. Limited bathymetry and survey exists in corridor of Historic Cutoff Structure, except near the road/structure. New data could (possibly) indicate a matrix of subsurface soils and higher chance of sheet pile wall instability, which could create need for additional subsurface earthwork and/or quantities. It could increase (or possibly reduce) sheet pile needs, e.g. length and depth.
- PM10 – Breach During Construction: If a new cutoff occurs during or prior to construction, O&M will be used to repair the breach. If a new cutoff occurs during construction, DDC could be impacted. Since no cutoff (defined, in this case, as full breach) has formed in the last +40 years (never has a full breach been recorded), the likelihood is unlikely to possible.

Recommendations: 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.

MAIN REPORT

1.0 PURPOSE

Within the authority of the US Army Corps of Engineers (USACE), Little Rock District, this report presents the efforts and results of the cost and schedule risk analysis for the Three Rivers Southeast Arkansas Integrated Feasibility Report and EA. The report includes risk methodology, discussions, findings and recommendations regarding the identified risks and the necessary contingencies to confidently administer the project, presenting a cost and schedule contingency value with an 80% confidence level of successful execution.

2.0 BACKGROUND

The study is to recommend modifications to the McClellan-Kerr Arkansas River Navigation System (MKARNS) that will ensure the long-term sustainability of reliable navigation on the MKARNS.

The recommended plan consists of a new containment structure at an elevation of 157 feet above mean sea level with a relief channel through the Historic Closure Structure, and would dramatically reduce the risk of a cutoff forming. The structure would be approximately 2.5 miles long, and would begin on natural high ground south and west of the Melinda Structure located on the south side of Owens Lake. As designed, it continues east and cross the Melinda head cut south of the Melinda Structure, and then heads northeast and connects to the existing containment structure north of Jim Smith Lake. It then continues to follow the Soil Cement Structure alignment and terminates at the Historic Closure Structure. This alignment takes advantage of natural high ground, in most locations the structure would only rise five to seven feet above the ground, and would be no more than 12 feet above the ground at its highest point. The relief opening at the Historic Cutoff would be at an elevation of 145 feet, and engineers and hydrologists would optimize the width of the opening during the Preconstruction, Engineering and Design (PED) phase of the project to ensure that flows through the Historic Cutoff, the natural path by which waters of the White River have historically flowed across to the Arkansas and vice versa, would not impact navigation.

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Lake. Similarly, removing the Melinda Structure would reconnect Owens Lake to its former southern limb, thereby returning open water ecosystem functions to the oxbow portion of the flooded bottomland hardwood forest. Demolition debris would be pushed into the deep scour hole at the top of the Melinda head cut to reduce water turbulence and erosion in the immediate Melinda Structure vicinity. Finally, opening the Owens Lake Structure between Owens Lake and the White River would prevent water from backing up into Owens Lake, which may benefit adjacent bottomland hardwood forests. The opening's design would also provide a fish passage into Owens Lake that will be eliminated after the construction of the Containment Structure at elevation 157 feet. Other than changes described above, implementation of the recommended plan would not alter hydrology in surrounding bottomland hardwood forests, and most importantly, navigation would continue with no operational changes to the MKARNS.

3.0 REPORT SCOPE

The scope of the risk analysis report is to identify cost and schedule risks with a resulting recommendation for 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 construction features. The CSRA excludes Real Estate costs and 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 Micro Computer Aided Cost Estimating System (MCACES) cost estimate, project 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, risk register, and schedules were developed and presented by the Little Rock District. Consequently, these documents serve as the basis for the risk analysis.

The scope of this study addresses the identification of concerns, 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 Cost Engineering MCX performed the Cost and Schedule Risk Analysis, relying on local Little Rock District staff to provide expertise and information gathering. The Little Rock PDT conducted a risk analysis meeting on February 27, 2017. The initial risk identification meeting also included qualitative analysis to produce a risk register that served as the draft framework for the risk analysis.

Participants in the risk identification meeting included:

Cost and Schedule Risk Analysis

Three Rivers Southeast Arkansas Study

Risk Facilitator | Martin Regner

Risk Register Meeting

Date: 2/27/2018

Attendance	Name	Office	Representing
Full	Nancy Parrish	USACE-SWF	Planning
Full	Norm Gartner	USACE-MVP	Design, Civil Engineer
Full	Cathy Funkhouser	USACE-SWL	Hydrology, Hydraulic Engineer
Full	Craig Hilburn	USACE-SWF	Environmental, Biologist
Full	Melinda Fisher	USACE-SWF	Environmental, Biologist
Full	Stuart Norvell	USACE-SWL	Economist
Full	Brian Raley	USACE-SWL	Real Estate, Specialist
Full	Kelly Turner	USACE-SWL	Cost, Engineer

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 Little Rock 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, economics, 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.

4.2 Quantify Risk Factor Impacts

The quantitative impacts (putting it to numbers of cost and time) 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 project.

a. The Little Rock District provided MII MCACES (Micro-Computer Aided Cost Estimating Software) files electronically. The MII and CWE files transmitted and downloaded on February 28, 2018 was the basis for the initial cost and schedule risk analyses. The MII and CWE files were updated April 5, 2018 (post ATR) served as the basis for the final CSRA.
b. The cost comparisons and risk analyses performed and reflected within this report are based on design scope and estimates that are at the preconstruction engineering and design (PED) level.
c. Schedules are analyzed for impact to the project cost in terms of delays to the critical path schedule.
d. The Cost Engineering 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.
e. 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 P5, P50 and P90 confidence levels are also provided for illustrative purposes only.

Cost contingency for the Construction risks was quantified as approximately $41 Million at the P80 confidence level (35% of the baseline construction cost estimate).

Table 1. Construction Cost Contingency Summary

Base Case Construction Cost Estimate	**$116,000,000**	
Confidence Level	**Construction Value ($$)**	**Contingency (%)**
50%	$146,000,000	25%
80%	**$157,000,000**	**35%**
90%	$163,000,000	40%

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.

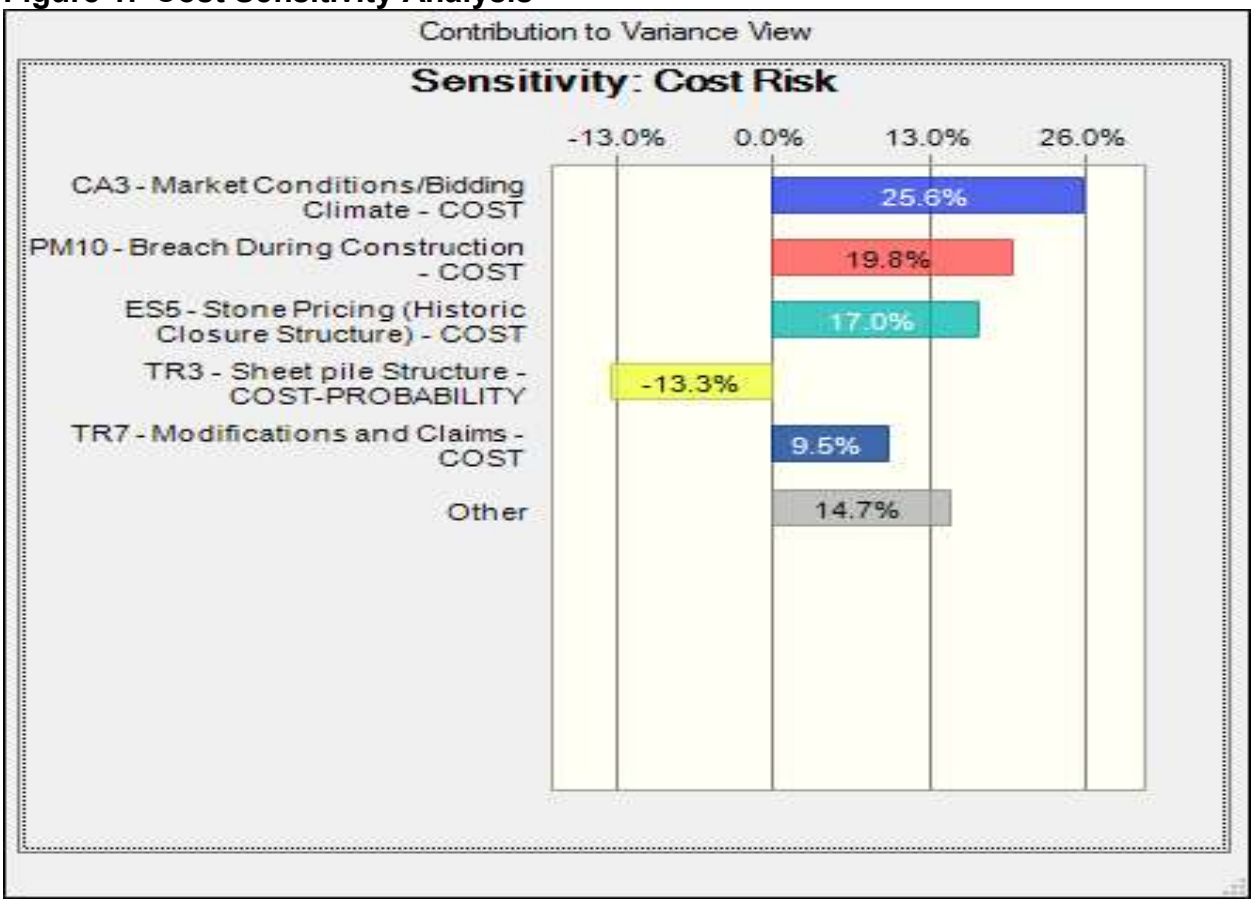
Key cost drivers identified in the sensitivity analysis can be used to support development of a risk management plan that will facilitate control of risk factors and their potential impacts throughout the project lifecycle. Together with the risk register, sensitivity analysis results can also be used 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 and the respective value variance are ranked in order of importance in contribution to variance bar charts. Opportunities that have a potential to reduce project cost and 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.

Figure 1. Cost Sensitivity Analysis



6.3 Schedule and Contingency Risk 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 duration at intervals of confidence (probability).

Table 2 provides the schedule duration contingencies calculated for the P80 confidence level. The schedule duration contingencies for the P50 and P90 confidence levels are also provided for illustrative purposes.

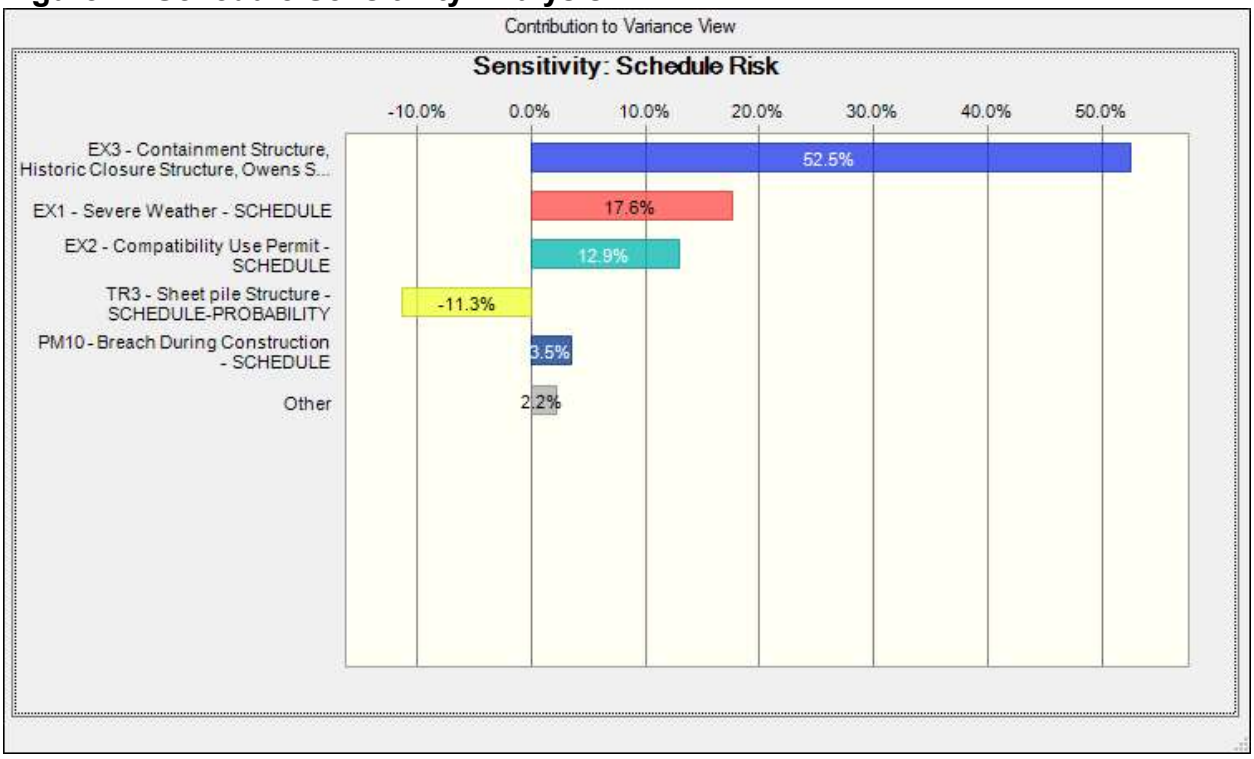
Schedule duration contingency was quantified as 18 months based on the P80 level of confidence. These contingencies were used to calculate the projected residual fixed cost impact of project delays that are included in the Table 1 presentation of total cost contingency. The schedule contingencies were 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 (base schedule of 57 months)	Duration w/ Contingencies (months)	Contingency[1] (months)
50% Confidence	62	14
80% Confidence	66	18
90% Confidence	68	20

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 and schedule comparison summaries are provided in Table 3 and Table 4 respectively. Additional major findings and observations of the risk analysis are listed below.

The PDT worked through the risk register on February 27, 2018. The key risk drivers identified through sensitivity analysis suggest a cost contingency of $41M and schedule risks adding another 18 months, both at an 80% confidence level.

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

- CA3 – Market Conditions/Bidding Climate: This risk is present across all contracts. It is possible conflicting project schedules force contractors to pick and choose what projects they want to propose on, resulting in higher costs. While competitive at this time, out-year contracts face greater uncertainty relative to market and inflation conditions. No impact to schedule is anticipated due to "no bidders."
- PM10 - Breach During Construction: If a breach occurs during construction, then a significant impact could be realized to the construction costs. It could involve a new design and change to construction costs. Since no cutoff (defined, in this case, as full breach) has formed in the last +40 years (never has a full breach been recorded), the likelihood is unlikely to possible.
- ES5 - Stone Pricing for the Historic Closure Structure: A driving cost is stone. For TSP, one quote (Dec-2016) received. USACE historical prices for R7400 could be as high as $90/TON for material, transport, and place in locations where local quarries are not available which significantly increases transportation costs. Current estimate is $50/TON. Due to reasonably close proximity of quarries, the apparent availability of stone and stone to be transported by barges not trucks, assume a $20/TON increase (to $70/TON) for possible price increase of stone at 810,000 TON for a $16.2M increase. An increase would be a critical impact.

- TR3 – Sheet pile Structure: Surveys and soil borings are required during PED. Limited bathymetry and survey exists in corridor of Historic Cutoff Structure, except near the road/structure. New data could (possibly) indicate a matrix of subsurface soils and higher chance of sheet pile wall instability, which could create need for additional subsurface earthwork and/or quantities. It could increase (or possibly reduce) sheet pile needs, e.g. length and depth.
- TR7 Modifications and Claims: Unanticipated items of work, quantity variations and differing site conditions which could result in modifications and changes that occur during construction are unknown.

Schedule Risks: The moderate schedule risk indicates a significant uncertainty of key risk items and time duration growth. 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 schedule risks are:

- EX3 – Containment Structure, Historic Closure Structure, Owens Structure PED: Current estimate assumes all money in one (1) FY, one (1) contract. Hydrologically the project should not be separated. It is uncertain whether all needed Congressional funding for construction will be made available in a timely manner. In addition, it is uncertain whether all Congressional funding will be provided for one (1) contract. This could delay project schedule one (1) year.
- EX-1 - Severe Weather: Elevated river flow based on normal weather conditions could impact work. Area floods regularly. For example, New Containment Structure would be completely submerged in 100YR event (or a lesser event). Equipment may need to be moved during a flood. This could delay the project and have a moderate impact on costs, e.g. wet and soggy conditions for an extended period of time.
- EX2 – Compatibility Use Permit: USFW may not approve the Compatibility use permit. Currently, that is not anticipated. However, Congress could override it.
- TR3 – Sheet Pile Structure: Surveys and soil borings are required during PED. Limited bathymetry and survey exists in corridor of Historic Cutoff Structure, except near the road/structure. New data could (possibly) indicate a matrix of subsurface soils and higher chance of sheet pile wall instability, which could create need for additional subsurface earthwork and/or quantities. It could increase (or possibly reduce) sheet pile needs, e.g. length and depth.
- PM10 – Breach During Construction: If a new cutoff occurs during or prior to construction, O&M will be used to repair the breach. If a new cutoff occurs during construction, DDC could be impacted. Since no cutoff (defined, in this case, as full breach) has formed in the last +40 years (never has a full breach been recorded), the likelihood is unlikely to possible.

Table 3. Construction Cost Comparison Summary (Uncertainty Analysis)

- PROJECT CONTINGENCY DEVELOPMENT -

INITIAL CONSTRUCTION
Contingency Analysis

Base Case Estimate (Excluding 01)	$116,555,000	
Confidence Level	**ntingency Va**	**Contingency**
0%	-6,993,300	-6%
10%	12,821,050	11%
20%	18,648,800	16%
30%	22,145,450	19%
40%	26,807,650	23%
50%	29,138,750	25%
60%	32,635,400	28%
70%	37,297,600	32%
80%	40,794,250	35%
90%	46,622,000	40%
100%	69,933,000	60%

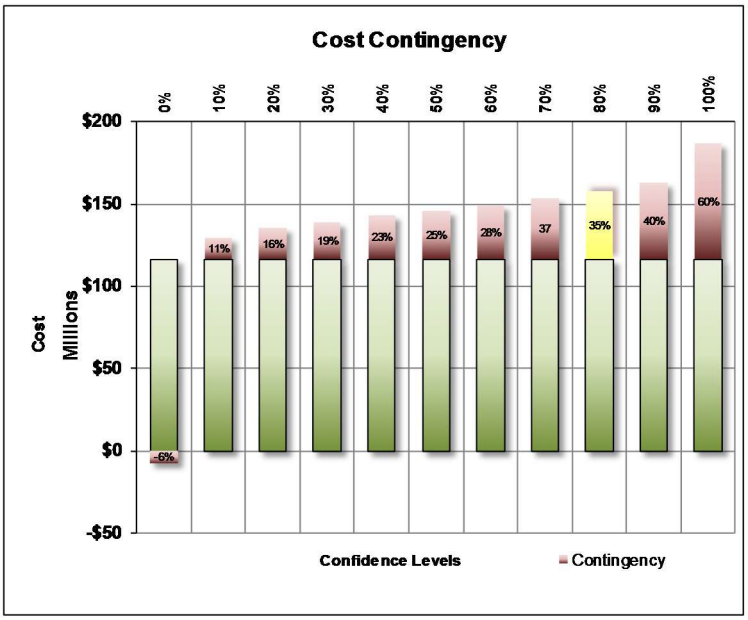
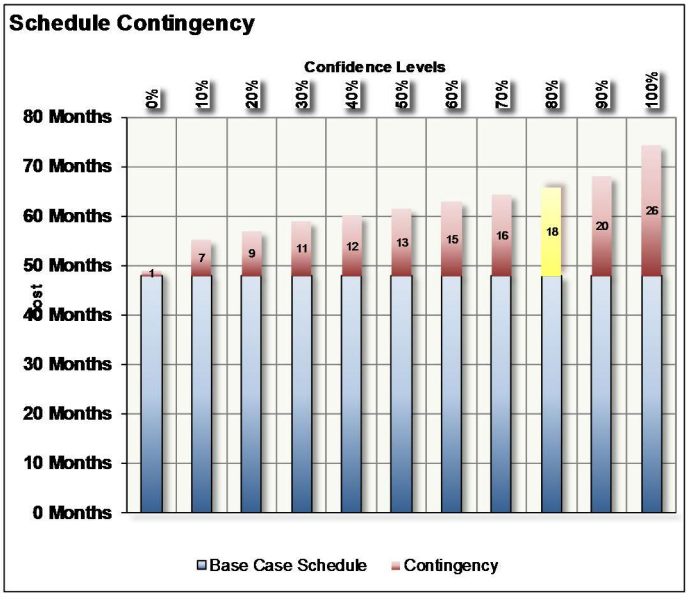


Table 4. Construction Schedule Comparison Summary (Uncertainty Analysis)

- SCHEDULE CONTINGENCY (DURATION) DEVELOPMENT -

Contingency Analysis

Base Case Schedule	48.0 Months	
Confidence Level	ntingency Va	Contingency
0%	1 Months	2%
10%	7 Months	15%
20%	9 Months	19%
30%	11 Months	23%
40%	12 Months	25%
50%	13 Months	28%
60%	15 Months	31%
70%	16 Months	34%
80%	18 Months	37%
90%	20 Months	42%
100%	26 Months	55%



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.

The CSRA study serves as a "road map" towards project improvements and reduced risks over time. Timely coordination and risk resolution between the Sponsor (Arkansas Waterways Commission), and USACE is needed in areas of ROW, site access and staging, and 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 remaining within an approved budget and appropriation.

Risk Management: Project leadership should use of 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.

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

				Project Cost			Project Schedule		
CREF	Risk/Opportunity Event	Risk Event Description	PDT Discussions on Impact and Likelihood	Likelihood ©	Impact ©	Risk Level ©	Likelihood (S)	Impact (S)	Risk Level (S)
Organizational and Project Management Risks (PM)									
PM1	Mitigation	Easements are narrow for New Containment Structure.	New Containment Structure easements are limited to 20FT, each side. This width may be insufficient for stockpile of toe material and equipment maneuverability and structure constructability. In addition, if a timber road requires a ramp and/or relocation, it could impact mitigation requirements.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
PM2	Mitigation	No access easements shown for New Containment Structure on west side of New Melinda Structure.	Assumption is Contractor will build New Melinda Structure from east bank to west bank. Then Contractor will build New Containment Structure on west side. The rock structure will have to be stable enough for construction equipment to travel across it. Should a new easement be required to reach this structure, i.e. no travel across the new structure, then mitigation requirements could increase.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
PM3	Mitigation	Easements for berthing area are not clear.	Easement for berthing area does not show on plans. It could be problematic to move barged stone from water to location of placement without easements. Increased easement areas could increase mitigation requirements.	Unlikely	Marginal	**Low**	Unlikely	Negligible	**Low**

PM4	Mitigation	Easements are missing for possible work along corridor (at Historic Cutoff Structure).	Corridor for flow to pass from White River to Arkansas River (and vice versa) across New Historic Cutoff structure could require riprap and/or training dikes/jetties (erosion control). There are private land owners in this area. Real Estate has included a contingency in their estimate to purchase lands. Mitigation unlikely since this is a temporary construction easement.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
PM5	Mitigation	Real Estate scope, costs, and contingencies are covered separately.	Changes in easements could impact Real Estate. Real Estate to cover scope, cost, and contingencies separately. Mitigation unlikely since this is a temporary construction easement.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
PM6	Containment Structure, Historic Closure Structure, Owens Structure	HTRW and archaeological finds are not anticipated.	No HTRW and archaeological finds anticipated. But selection of natural, higher ground for new structure could unearth unknown historic sites. However, minimum impact is anticipated.	Unlikely	Moderate	**Low**	Unlikely	Moderate	**Low**
PM7	Containment Structure	Existing Melinda structure may be unstable.	If Melinda structure is unstable, then construction crews will be forced to create a longer path (debris, haul, and temporary road) or cross an expanse of water by barge and tug. This is a unlikely scenario with a moderate cost growth.	Unlikely	Moderate	**Low**	Unlikely	Moderate	**Low**
PM8	Containment Structure	New Melinda structure does not include a keyway.	Melinda structure does not include a keyway but it's possible a keyway will be needed depending on the geotechnical discoveries during PED. The likelihood is possible. The cost would be marginal.	Possible	Marginal	**Low**	Unlikely	Negligible	**Low**
PM9	Increase Rip Rap size (Melinda Structure)	New Melinda structure does not specify larger riprap, as appears on existing Melinda structure.	Increasing riprap size could moderately increase cost. Increasing riprap size would align with conditions at existing Melinda structure. However, need for larger stone is not anticipated.	Possible	Moderate	**Medium**	Unlikely	Moderate	**Low**
PM10	Breach During Construction	Breach occurs during construction.	If a breach occurs during construction, then a significant impact could be realized to the construction costs. It could involve a new design and change to construction costs. Since no cutoff (defined, in this case, as full breach) has formed in the last +40 years (never has a full breach been recorded), the likelihood is unlikely to possible.	Possible	Critical	**High**	Possible	Significant	**Medium**

PM11	Containment Structure	Timber roads across New Containment Structure.	Coordination with timber companies and their roads could necessitate construction of ramps over new structure. Should a ramp be needed, the likely choice would be at natural, high ground, unless such location required relocation of road, impacting more Bottomland Hardwoods. This is a likely scenario with a marginal cost growth.	Unlikely	Marginal	**Low**	Unlikely	Marginal	**Low**
PM12	Historic Closure Structure	Cut material is in mound (+30FT greater than height of New Containment Structure; +20FT greater than road). No defined flow line for White River and Arkansas River across New Historic Cutoff Structure.	New 1000-FT weir structure requires excavation. Material is shown as stockpiled in a mound adjacent to the structure. If material is unable to be indefinitely stored, then haul away may be required. Due to the site's remote location, haul away of cut material is a critical cost increase. HH model does not include this mound. It could possibly be spread, which is assumed (low impact). [Mound mirrors challenges SWL has had with DMMP (similar location) where partners were upset with SWL due to Placement Area size, management, and maintenance. But in our case, land is Corps owned.] In addition, weir structure includes no earthwork and erosion protection from weir to White River and weir to Arkansas River, which means water will find its own path and possibly across private land. It could become a NEPA challenge. If additional excavation and erosion protection is required, then the cost increase would be significant to critical. However, Real Estate added a contingency to their estimate to purchase lands. Erosion protection is likely anticipated immediately north of weir structure where eddies could form; this would be a marginal cost increase.	Possible	Marginal	**Low**	Possible	Marginal	**Low**
PM13	Remaining Construction Items	La Grues Culvert appears to be damaged.	Replacement of culverts may be necessary.	Very Likely	Negligible	**Low**	Very Likely	Negligible	**Low**
PM14	Breach During Construction	Breach occurs during construction.	If a new cutoff occurs during or prior to construction, O&M will be used to repair the breach. If a new cutoff occurs during construction, DDC could be impacted. Since no cutoff (defined, in this case, as full breach) has formed in the last +40 years (never has a full breach been recorded), the likelihood is unlikely to possible. This is modeled in PM10	Possible	Marginal	**Low**	Possible	Moderate	**Medium**

PM15	Planning, Engineering, & Design	Feasibility-level design for corridor from White River to Arkansas River, crossing New Historic Cutoff, does not exist.	Corridor for flow to pass from White River to Arkansas River (and vice versa) across New Historic Cutoff structure could require riprap and/or training dikes/jetties (erosion control). Adding construction elements to this area could increase PED costs, as this addition was not considered. Real Estate has included a contingency to include a channel improvement easement, if necessary.	Possible	Marginal	**Low**	Possible	Marginal	**Low**
PM16	Construction Management	Cutoff occurs during construction.	If a new cutoff occurs during construction, then a significant impact could be realized to the construction costs. It could involve a new design (PM14) and increased CM oversight and costs. Since no cutoff (defined, in this case, as full breach) has formed in the last +40 years (never has a full breach been recorded), the likelihood is unlikely to possible. This risk is captured in PM10.	Possible	Marginal	**Low**	Possible	Moderate	**Medium**
Contract Acquisition Risks (CA)									
CA1	Containment Structure, Historic Closure Structure, Owens Structure	Current assumption is all construction money will be received in year one.	It is likely funds will be dispersed across multiple years, requiring multiple contracting actions. This could cause a marginal impact to construction costs due to multiple mobilizations and demobilizations, escalation, etc. (See "External Risks")	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
CA2	Containment Structure, Historic Closure Structure, Owens Structure	Contracting plan not firmly established.	Estimate assumes large business (unrestricted, best value) performs majority of work (horizontal construction) due to the complexity and size of project. However, SWL goals are for 40% small business so it is possible that contracting will include a portion for small business.	Possible	Moderate	**Medium**	Possible	Moderate	**Medium**
CA3	Market Conditions/Bidding Climate	Market conditions and competing projects may impact bid competition.	This risk is present across all contracts. It is possible conflicting project schedules force contractors to pick and choose what projects they want to propose on, resulting in higher costs. While competitive at this time, out-year contracts face greater uncertainty relative to market and inflation conditions. No impact to schedule is anticipated due to "no bidders."	Possible	Moderate	**Medium**	Possible	Marginal	**Low**

CA4	Acquisition Strategy E&D	Contracting plan not firmly established.	Utilizing a small business contract instead of a large business contract (assumed) could increase Government Design During Construction (DDC). That is, the Government is likely to become more involved throughout construction, e.g. reviewing RFIs. Increased oversight is likely but the impact is marginal. This is E&D and therefore not modeled.	Unlikely	Moderate	**Low**	Unlikely	Significant	**Medium**
General Technical Risks (TR)									
TR1	Containment Structure, Owens Structure	Limited survey. Limited soils data.	Surveys and soil borings are required during PED. Impacts to construction from the results are unlikely.	Unlikely	Moderate	**Low**	Unlikely	Moderate	**Low**
TR2	Containment Structure, Historic Closure Structure, Owens Structure	Quantities are neat line but conservative. Densities are assumed.	Quantities are conservative for assumptions made. Any scope growth should be accounted for under "Project Management and Scope Growth."	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
TR3	Sheet pile Structure	Limited survey. Limited bathymetry. Limited soils data.	Surveys and soil borings are required during PED. Limited bathymetry and survey exists in corridor of Historic Cutoff Structure, except near the road/structure. New data could (possibly) indicate a matrix of subsurface soils, which could decrease the need for subsurface earthwork and/or quantities. It could possibly reduce sheet pile needs, e.g. length and depth.	Possible	Significant	**Medium**	Possible	Moderate	**Medium**
TR4	Historic Closure Structure	Study does not include a Ship Tow simulator for cross-currents. Study references ERDC reports over ten (10) years old, one which does not contain the mesh for Montgomery Lock and Dam. The other simulates a 2000FT weir and reducing to a 1000FT weir could increase velocities.	Further study could require moderate to critical scope changes. Without more data, the likelihood of impact is unknown. However, an opening of 500FT-1000FT is anticipated, and the estimate assumes 1000FT. Cross-currents and velocities could require additional riprap protection in channels north and south of New Historic Cutoff Structure; this example of scope growth is noted under "Project Management and Scope Growth."	Unlikely	Significant	**Medium**	Unlikely	Moderate	**Low**
TR5	Planning, Engineering, & Design	Limited survey. No bathymetry. Limited soils data. No cross-currents study.	Significant changes in subsurface design and quantities may lead to increased PED expenditures of time and money. Time to acquire adequate data could be a challenge during PED window, e.g. flood heights south of Owens Lake Structure. Updated data could change game plan.	Possible	Marginal	**Low**	Possible	Marginal	**Low**

TR6	Construction Management	Limited survey. No bathymetry. Limited soils data. No cross-currents study.	Differing site conditions due to lack of soil borings and/or soil data, or inadequate coverage during PED, could cause a marginal impact to cost.	Possible	Marginal	**Low**	Possible	Marginal	**Low**
TR7	Modifications and Claims	Differing site conditions, unanticipated work items.	Unanticipated items of work, quantity variations and differing site conditions which could result in modifications and changes that occur during construction are unknown.	Possible	Significant	**Medium**	Possible	Marginal	**Low**
Lands and Damages (LD)									
LD1	See Real Estate Plan			Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
Regulatory Environmental Risks (RG)									
RG1	See Mitigation Plan			Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
Construction Risks (CO)									

CO1	Containment Structure	Limited construction easement due to Bottomland Hardwoods.	Possibility exists for easement to be narrow, as BLH are protected, but confined area is unlikely to be problematic.	Unlikely	Marginal	**Low**	Unlikely	Marginal	**Low**
CO2	Stone Delivery	Delivery method for stone is unknown.	Delivery of stone (+1M tons) could be by truck or barge. Temporary berthing area (or run-aground) may be required for stone delivery by barge; streambank mitigation (by land) could be required for run-aground. Road repair may be required for stone delivery by truck. The risk is likely. The impact would be marginal for road repair or run-aground and for a berthing area/mitigation. A berthing area with offload area is anticipated. Clearing and grubbing for berthing area would be required. [Owens Structure location could be used to unload barged material. This would then add a longer haul distance, e.g. additional 2 miles round-trip. A location closer to the Historic Closure Structure is possible.	Likely	Marginal	**Medium**	Likely	Marginal	**Medium**
CO3	Productivity	Reasonableness of crews, productivities, multiple subcontractors.	Very conservative approach was taken which includes overtime for crews, reduced productivity and subcontractors for many tasks. There are uncertainties pertaining to crew and productivity development. The likelihood is possible. The cost of impact would be moderate.	Possible	Moderate	**Medium**	Possible	Marginal	**Low**
CO4	Planning, Engineering, & Design	Delivery method for stone is unknown.	Construction means and methods are generally driven by Contractor. If a berthing area design is required, then it could increase PED costs. Since the berthing area would be temporary, the amount of design required may be negligible next to the overall PED costs included in the estimate.	Likely	Negligible	**Low**	Likely	Negligible	**Low**
Estimate and Schedule Risks (ES)									
ES1	Riprap Pricing (Containment Structure)	Limited number of quotes.	A driving cost is riprap For NED. One quote (Dec-2016) received. Historical data referenced. DQC Feb 2018 (Chicago) noted similar sized riprap in area has a material price of $19-23/TON, which is greater than $14/TON assumed in estimate.	Likely	Significant	**High**	Unlikely	Negligible	**Low**

ES2	Containment Structure, Historic Closure Structure, Owens Structure	Species protection.	Possibility exists for unaccounted wildlife to be discovered in the area and/or nesting, which may delay project schedule. Unanticipated discoveries (e.g. least terns, pallid sturgeons, etc.) could lead to cost increases in order to account for environmental oversight.	Unlikely	Marginal	**Low**	Unlikely	Moderate	**Low**
ES3	Stone Transport Pricing	Transport of stone from Pine Bluff or Russellville, AR or Kentucky.	Need to visit barge transport of stone from Pine Bluff/Russellville versus Kentucky and return barge transport. Impact is marginal next to the cost of stone, but it is likely the cost will increase.	Possible	Marginal	**Low**	Possible	Marginal	**Low**
ES4	Containment Structure	Handling cleared and grubbed material.	Clearing and grubbing of Bottomland Hardwoods (BLH) is by sidecast. Sidecast of 50AC of BLH does not seem reasonable. Estimate does not include timber sales or haul away. Haul away would be costly. [No agreement exists with timber company. But it is possible they would clear and haul away, which could reduce cost. But it does not guarantee they could accommodate the project schedule, unless notified far in advance.]	Unlikely	Moderate	**Low**	Unlikely	Moderate	**Low**
ES5	Stone Pricing (Historic Closure Structure)	Limited number of quotes.	A driving cost is stone. For TSP, one quote (Dec-2016) received. USACE historical prices for R7400 could be as high as $90/TON for material, transport, and place in locations where local quarries are not available which significantly increases transportation costs. Current estimate is $50/TON. Due to reasonably close proximity of quarries, the apparent availability of stone and stone to be transported by barges not trucks, assume a $20/TON increase (to $70/TON) for possible price increase of stone at 810,000 TON for a $16.2M increase. An increase would be a critical impact.	Possible	Critical	**High**	Possible	Negligible	**Low**
External Risks (EX)									
EX1	Severe Weather	Potential for severe adverse weather?	Elevated river flow based on normal weather conditions could impact work. Area floods regularly. For example, New Containment Structure would be completely submerged in 100YR event (or a lesser event). Equipment may need to be moved during a flood. This could delay the project and have a moderate impact on costs, e.g. wet and soggy conditions for an extended period of time.	Very Likely	Marginal	**Medium**	Very Likely	Marginal	**Medium**

EX2	Compatibility Use Permit	Political influences, lack of support, obstacles?	USFW may not approve the Compatibility use permit. Currently, that is not anticipated. However, Congress could override it.	Unlikely	Negligible	**Low**	Unlikely	Significant	**Medium**
EX3	Containment Structure, Historic Closure Structure, Owens Structure, Planning, Engineering, & Design	Concern with Federal cost share? 1) Receive all money in one (1) FY, one (1) contract, which is the current assumption. 2) Receive pots of money across multiple FYs, multiple contracts.	Current estimate assumes all money in one (1) FY, one (1) contract. Hydrologically the project should not be separated. It is uncertain whether all needed Congressional funding for construction will be made available in a timely manner. In addition, it is uncertain whether all Congressional funding will be provided for one (1) contract. This could delay project schedule one (1) year.	Possible	Negligible	**Low**	Likely	Significant	**High**
EX4	Containment Structure, Historic Closure Structure, Owens Structure	NEPA litigation?	Do not anticipate NEPA concerns as EIS has been replaced by EA with resource public agency involvement. Arkansas currently is aligned with FEMA, but prior to design and construction Arkansas could join a handful of States that are requiring no more than 0.0FT.	Unlikely	Moderate	**Low**	Unlikely	Marginal	**Low**
EX5	Planning, Engineering, & Design	Sponsor has adequate funds for their share.	Sponsor feels confident their share is not a critical constraint and that the Federal share and funding are a greater concern. But a delay in Congressional funding could impact Sponsor funding, i.e. Sponsor spends money on another project.	Unlikely	Negligible	**Low**	Unlikely	Moderate	**Low**
EX6	Construction Management	Potential for severe adverse weather?	Elevated river flow based on abnormal weather conditions could impact work. Equipment may need to be moved during a flood. This could delay the project and have a moderate impact on costs, e.g. wet and soggy conditions for an extended period of time. Construction is assumed as part of base contract construction cost and therefore not modeled.	Very Likely	Marginal	**Medium**	Very Likely	Negligible	**Low**
EX7	Construction Management	Political influences, lack of support, obstacles?	Interested parties (environmental, hunting clubs, etc) could delay construction.	Unlikely	Moderate	**Low**	Unlikely	Moderate	**Low**

Alternative 1 - Containment Structure at Elevation 157 and Relief Openings

P2-145513 – THREE RIVERS SOUTHEAST ARKANSAS STUDY
ARKANSAS AND WHITE RIVER,
ARKANSAS AND DESHA COUNTIES, ARKANSAS

LOCATION AND DESCRIPTION:
The Three Rivers Study Area is located in portions of Arkansas and Desha counties in southeast Arkansas, encompassing the confluence of the Arkansas and White rivers with the Mississippi River. At the request of the Arkansas Waterways Commission, and under authority of Section 216 of the Flood Control Act of 1970 (Public Law 91-611), the Little Rock District Corps of Engineers conducted a feasibility study to recommend solutions to problems impacting the long-term sustainable use of the McClellan-Kerr Arkansas River Navigation System (MKARNS).

The MII is developed using October 2018 Price Levels and the latest labor rates for Little Rock District areas. The contract is organized in accordance with a work breakdown structure. Midpoint dates for the construction contract are developed in conjunction with the project manager for developing the fully-funded costs. The estimate is prepared in accordance with ER 1110-2-1302 Civil Works Cost Engineering. The costs are escalated in accordance with the above Engineering Regulation and EM 1110-2-1304 Civil Works Construction Cost Index System (CWCCIS). All data is input into the Total Project Cost Summary (TPCS) spreadsheet.

There are no Hazardous, Toxic, and Radioactive Wastes anticipated.

ACCOUNT CODE 11 - LEVEES AND FLOODWALLS:
This cost for this account is based on a new stone containment structure approximately 2.5 miles long. Work includes clearing and grubbing and removal of both the Historic Cutoff Containment Structure and the Melinda Structure.

ACCOUNT CODE 30 - ENGINEERING AND DESIGN:
The cost for this account are developed using the guidelines provided in the TPCS, with the agreement of the cost engineer and the project manager.

ACCOUNT CODE 31 - CONSTRUCTION MANAGEMENT:
The cost for this account are developed using the guidelines provided in the TPCS, with the agreement of the cost engineer and the project manager.

Estimated by	CESWL-EC-DG
Designed by	CESWL-EC-DG
Prepared by	CESWL-EC-DG
Preparation Date	4/5/2018
Effective Date of Pricing	4/5/2018
Estimated Construction Time	1,095 Days

Labor ID: LA 2 18 | EQ ID: EP16R03 | Currency in US dollars | TRACES MII Version 4.0

Date	Author	Note
1/10/2018	Turner	PRIME CONTRACTOR MARK-UPS:JOOH - 20%HOOH - 10%Profit - 8.84% (Profit Weighted Guidelines)SUBCONTRACTOR MARK-UPS:JOOH - 12%HOOH - 8%Profit - 10%DIRECT COST:Overtime - 10%Productivity - 85% Sales Tax - 6% ACCOUNT CODE 11 - LEVEES AND FLOODWALLS:This cost for this account is based on a new stone containment structure approximately 2.5 miles long. Work includes clearing and grubbing and removal of both the Historic Cutoff Containment Structure and the Melinda Structure.ACCOUNT CODE 30 - ENGINEERING AND DESIGN:The cost for this account are developed using the guidelines provided in the TPCS, with the agreement of the cost engineer and the project manager.ACCOUNT CODE 31 - CONSTRUCTION MANAGEMENT:The cost for this account are developed using the guidelines provided in the TPCS, with the agreement of the cost engineer and the project manager.
1/10/2018	PRIME Profit	Degree of Risk: 0.1 Comment: Area subject to flooding and therefore subject to scour damageRelative Difficulty of Work: 0.075 Size of Job: 0.03 Comment: Expected cost is in excess of $10,000,000Period of Performance: 0.12 Contractor's Investment: 0.07 Comment: Work includes excavation and hauling and placing large amount of riprap.Assistance by Government: 0.1 Subcontracting: 0.105 Comment: Scope is narrow (excavation and hauling).

Labor ID: LA 2 18 EQ ID: EP16R03 Currency in US dollars TRACES MII Version 4.0

Description	Quantity	UOM	ProjectCost
Project Cost Summary			**117,382,231**
Lands and Damages	**1**	**JOB**	**827,200**
Fish and Wildlife Facilities	**1**	**JOB**	**507,000**
Levees and Floodwalls	**1**	**JOB**	**116,048,031**

Description **Page**

WALLA WALLA COST ENGINEERING MANDATORY CENTER OF EXPERTISE

COST AGENCY TECHNICAL REVIEW

CERTIFICATION STATEMENT

For Project No. 145513

SWL – Three Rivers Southeast Arkansas Feasibility Study

The Three Rivers Southeast Arkansas Feasibility Study, as presented by Little Rock 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 17, 2018, the Cost MCX certifies the estimated total project cost:

FY18	Project First Cost:	$180,295,000
	Fully Funded Amount:	$201,652,000

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

JACOBS.MICHAEL.PIERRE.1160569537

Digitally signed by JACOBS.MICHAEL.PIERRE.1160569537
DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=JACOBS.MICHAEL.PIERRE.1160569537
Date: 2018.04.17 11:24:29 -07'00'

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

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

PROJECT: **Three Rivers Southeast Arkansas Study**
PROJECT NO: P2 145513
LOCATION: Rural section of Arkansas and Desha Counties, Arkansas

DISTRICT: SWL Little Rock District **PREPARED: 4/17/2018**
POC: CHIEF, COST ENGINEERING, Nicholas Barner

This Estimate reflects the scope and schedule in report; Three Rivers Southeast Arkansas Study 2018

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)						TOTAL PROJECT COST (FULLY FUNDED)			
						Program Year (Budget EC): 2018 Effective Price Level Date: 1 OCT 17									
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-17 ($K)	TOTAL FIRST COST ($K) K	INFLATED (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
06	FISH & WILDLIFE FACILITIES	$507	$177	35.0%	$684	0.0%	$507	$177	$684	$0	$684	11.0%	$563	$197	$760
11	LEVEES & FLOODWALLS	$116,048	$40,617	35.0%	$156,665	0.0%	$116,048	$40,617	$156,665	$0	$156,665	11.0%	$128,837	$45,093	$173,930
	CONSTRUCTION ESTIMATE TOTALS:	$116,555	$40,794		$157,349	0.0%	$116,555	$40,794	$157,349	$0	$157,349	11.0%	$129,400	$45,290	$174,690
01	LANDS AND DAMAGES	$827	$89	10.8%	$917	0.0%	$827	$89	$917	$0	$917	6.2%	$878	$95	$973
30	PLANNING, ENGINEERING & DESIGN	$9,324	$3,264	35.0%	$12,588	0.0%	$9,324	$3,264	$12,588	$0	$12,588	14.0%	$10,628	$3,720	$14,348
31	CONSTRUCTION MANAGEMENT	$6,993	$2,448	35.0%	$9,441	0.0%	$6,993	$2,448	$9,441	$0	$9,441	23.3%	$8,622	$3,018	$11,640
	PROJECT COST TOTALS:	$133,700	$46,595	34.9%	$180,295		$133,700	$46,595	**$180,295**	$0	**$180,295**	11.8%	$149,529	$52,123	$201,652

Nicholas H Barner
CHIEF, COST ENGINEERING, Nicholas Barner

Dana D. Coburn
PROJECT MANAGER, Dana Coburn

CHIEF, REAL ESTATE, Jason Mann

CHIEF, PLANNING, Brian Harper

CHIEF, ENGINEERING, Craig Pierce

CHIEF, OPERATIONS, Kevin McDaniels

CHIEF, CONSTRUCTION, Craig Pierce

CHIEF, CONTRACTING, Sandra Easter

CHIEF, PM, Brinda Jackson

CHIEF, DPM, Kevin McDaniels

ESTIMATED TOTAL PROJECT COST: **$201,652**

Filename: Three Rivers 145513 - TPCS-NONCAP - 2018-04-17.xlsx
TPCS

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

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

PROJECT: Three Rivers Southeast Arkansas Study
LOCATION: Rural section of Arkansas and Desha Counties, Arkansas
This Estimate reflects the scope and schedule in report; Three Rivers Southeast Arkansas Study 2018

DISTRICT: SWL Little Rock District
POC: CHIEF, COST ENGINEERING, Nicholas Barner
PREPARED: 4/17/2018

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 5-Apr-18 Effective Price Level: 1-Oct-17				Program Year (Budget EC): 2018 Effective Price Level Date: 1 OCT 17								
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	RISK BASED 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 1 or CONTRACT 1													
06	FISH & WILDLIFE FACILITIES	$507	$177	35.0%	$684	0.0%	$507	$177	$684	2023Q2	11.0%	$563	$197	$760
11	LEVEES & FLOODWALLS	$116,048	$40,617	35.0%	$156,665	0.0%	$116,048	$40,617	$156,665	2023Q2	11.0%	$128,837	$45,093	$173,930
	CONSTRUCTION ESTIMATE TOTALS:	$116,555	$40,794	35.0%	**$157,349**		$116,555	$40,794	$157,349			$129,400	$45,290	$174,690
01	LANDS AND DAMAGES	$827	$89	10.8%	$917	0.0%	$827	$89	$917	2021Q1	6.2%	$878	$95	$973
30	PLANNING, ENGINEERING & DESIGN													
0.5%	Project Management	$583	$204	35.0%	$787	0.0%	$583	$204	$787	2021Q1	12.7%	$657	$230	$886
0.5%	Planning & Environmental Compliance	$583	$204	35.0%	$787	0.0%	$583	$204	$787	2021Q1	12.7%	$657	$230	$886
3.5%	Engineering & Design	$4,079	$1,428	35.0%	$5,507	0.0%	$4,079	$1,428	$5,507	2021Q1	12.7%	$4,596	$1,608	$6,204
0.5%	Reviews, ATRs, IEPRs, VE	$583	$204	35.0%	$787	0.0%	$583	$204	$787	2021Q1	12.7%	$657	$230	$886
0.5%	Life Cycle Updates (cost, schedule, risks)	$583	$204	35.0%	$787	0.0%	$583	$204	$787	2021Q1	12.7%	$657	$230	$886
0.5%	Contracting & Reprographics	$583	$204	35.0%	$787	0.0%	$583	$204	$787	2021Q1	12.7%	$657	$230	$886
0.5%	Engineering During Construction	$583	$204	35.0%	$787	0.0%	$583	$204	$787	2023Q2	23.3%	$719	$251	$970
0.5%	Planning During Construction	$583	$204	35.0%	$787	0.0%	$583	$204	$787	2023Q2	23.3%	$719	$251	$970
0.5%	Adaptive Management & Monitoring	$583	$204	35.0%	$787	0.0%	$583	$204	$787	2021Q1	12.7%	$657	$230	$886
0.5%	Project Operations	$583	$204	35.0%	$787	0.0%	$583	$204	$787	2021Q1	12.7%	$657	$230	$886
31	CONSTRUCTION MANAGEMENT													
5.0%	Construction Management	$5,828	$2,040	35.0%	$7,867	0.0%	$5,828	$2,040	$7,867	2023Q2	23.3%	$7,185	$2,515	$9,700
0.5%	Project Operation:	$583	$204	35.0%	$787	0.0%	$583	$204	$787	2023Q2	23.3%	$719	$251	$970
0.5%	Project Management	$583	$204	35.0%	$787	0.0%	$583	$204	$787	2023Q2	23.3%	$719	$251	$970
	CONTRACT COST TOTALS:	$133,700	$46,595		$180,295		$133,700	$46,595	**$180,295**			$149,529	$52,123	**$201,652**