US Army Corps
of Engineers®

Middle Rio Grande Flood Protection
Bernalillo to Belen, New Mexico:
Mountain View, Isleta and Belen Units

Project Cost and Schedule Risk Analysis Report

Prepared for:

U.S. Army Corps of Engineers,
Albuquerque District

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Cost Section

December 2019

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EXECUTIVE SUMMARY

Under the auspices of the US Army Corps of Engineers (USACE), Albuquerque District, this report presents a recommendation for the project cost and schedule contingencies for this integrated General Reevaluation Report (GRR) and Supplemental Environmental Impact Statement (SEIS) addresses alternative plans to provide higher levels of flood risk management to floodplain communities within the Bernalillo to Belen portion of the Middle Rio Grande floodway. This GRR/SEIS presents recommendations on future actions to best meet flood risk reduction needs within the study area. In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a formal risk analysis study was conducted for the development of contingency on the project cost. The purpose of this risk analysis study was to establish project contingencies by identifying and measuring the cost and schedule impact of project uncertainties with respect to the estimated project cost.

Specific to the Bernalillo to Belen Levee Project, the project cost (base case at price level) is estimated at approximately $184 Million. Based on the results of the analysis, the Cost Engineering Technical Center of Expertise for Civil Works (Walla Walla District) recommends a contingency value of $47.77 Million, or 26%. This contingency includes 74.9 Month growth potential due to risk analyzed in the baseline schedule.

Cost estimates can fluctuate over time. During this period of study, minor cost fluctuations can and have occurred. For this reason, contingency reporting is based in cost and percent values. Should cost vary to a slight degree with similar scope and risks, contingency percent values will be reported, cost values rounded.

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

The following table ES-1 portrays the development of contingencies (17%). The contingency is based on an 80% confidence level, as per USACE Civil Works guidance

Table ES-1. Construction Contingency Results

Base Case Construction Cost Estimate	**$183,734,812**	
Confidence Level	**Construction Value ($$) w/ Contingencies**	**Contingency (%)**
50%	$224,156,470	22%
80%	**$231,505,863**	**26%**
90%	$235,180,559	28%

KEY FINDINGS/OBSERVATIONS RECOMMENDATIONS

The PDT worked through the risk register on three separate occasions: August 4, 2011, March 16, 2017. That period of time allowed improved project scope definition, investigations, design and cost information, and resulted in reduced risks in certain project areas. The key risk drivers identified through sensitivity analysis suggest a cost contingency of $47.771M and schedule risks adding 74.9 months to the contract at an 80% confidence level.

Cost Risks: From the CSRA, the key or greater Cost Risk item in terms of cost variability potential include:

- TR-2: Usable Fill– The fill material will be processed from existing excavated materials on site. It is possible that only 50% of the excavated material is suitable for fill then the rest would have to be purchased/imported from an offsite commercial source, and there would be a cost for hauling off the unusable material. The PDT agrees that it is possible to occur and the impact would be Critical for a cost impact and it is unlikely to occur a schedule delay but if it did the impact would be negligible. This resulted in a significant risk for cost and a low risk for schedule.
- CO-1: Equipment Fuel: Heavy equipment will be utilized for every aspect of this project. The excavation activities require the use of a large tracked hydraulic excavator with limited mobility. It is essential that a safe and efficient refueling operation is established so that productivity rates are not affected. Additional time and cost for fueling equipment is necessary.
- CO-2: Levee Construction Productivity: It is estimated that a crew consisting of a hydraulic excavator, compaction roller and water truck with required operators can accomplish the placement and compaction of the fill material at the rate of 165 cubic yards per hour. This production rate may not be conservative enough since the amount of passes required by the compaction roller to reach the desired compaction is still unknown. The actual production rate is likely to vary from estimated and changes could have a significant impact on cost with the large amount of earthwork on the project. Schedule impact is negligible due to the ample time for work to be complete each phase.
- CO-11: Changes during Construction- Scope of work may change throughout the life of the project. Construction modifications or claims are possible throughout the life of the project. These will bring additional contracting efforts and may increase the total project cost. The work in general is not complex and is repetitive. A change or condition that would create a marginal impact to the cost is likely and the impact is marginal and schedule is unlikely and the impact is negligible.
- ES-4: Concrete Revetment Mat- It is likely that the articulated mat cost in the estimate will not reflect the actual material cost required in the final design.

- EX-1: Market Conditions/Bid Competition- If market conditions at the time of contract acquisition differ from estimate assumptions, then higher or lower than estimated contract costs may be experienced. Some years may bring more aggressive bidding climates which will lower the overall project costs by 3%. Others will offer a less aggressive climate which may drive up the costs by 4%.

Moderate risks, when combined, can also become a cost impact.

- TR-1: Mountain View North Extension Construction– The discussed the per linear foot cost of levee construction can be used to estimate this +/- 700 feet long section. PDT agrees that it is very likely that this will need to be added to this project to avoid having a hole in the protection provided and the impact is marginal. This will increase project cost and add about 2 months to the schedule.
- TR-7: Earthwork quantities– The quantities used for the cost estimate are based on assumptions regarding the width of the maintenance roads at curves (14' versus 20' width as required for seepage control). The earthwork quantities for excavation and fill could increase by approximately 3% to 5%. The PDT agrees that the cost risk is likely to happen and the impact is marginal. The PDT also agree that it is unlikely to have any effect on the schedule and the impact is negligible.
- RG-5: Pending NEPA compliance – Additional mitigation or design requirements may be necessary in order to meet NEPA compliance. Mitigation costs may increase total cost estimate by 4%.
- CON-9: Riprap Material Source- It is estimated that all in situ material needs to be excavated to obtain the required material for the current riprap and filter blanket designs. It was assumed that the borrow source would be at an average distance of 25 miles from the project site. If an adequate supplier cannot be identified within a 25 mile radius the bid cost is expected to be higher due to delivery cost. The likelihood the source will be at a different distance than estimated is likely and this would have a significant impact on the cost of the riprap. It is unlikely that this would translate into an overall schedule delay of marginal size. The updated estimate is based on a supplier delivering the rock to the construction site. The risk the fluctuating material cost. The PDT agrees that the likelihood of the material cost will increase is likely and the impact to the cost risk is Marginal. The likelihood of this affecting the schedule is unlikely and the impact is negligible.
- ES-6: Alternate Disposal Site– The identification of appropriate disposal sites is needed. The cost estimate includes 20 mile round-trip haulage. Clearing and grubbing material are assumed to be landfilled. The 20 mile haul distance is assumed to be adequate. Conclusion is that site could be +/- 5 miles. A different waste area located around the midpoint of the new levee alignment will result in a potential cost savings.

- EX3: Inadequate Funding or Funding Delay– The project requires completed construction phases that are stand alone in case funding dries up and future work is cancelled. Due to funding constraints the estimate is broken up into phases that break up the entire levee alignment into 16 phases (separate contracts). The assumption is that each phase would have a funding limitation of 20 million. If the funding decreases then the risk of adding additional phases increases. The PDT agrees that it is likely and moderate to impact the cost for example Mob and De-Mob. The PDT agrees that a schedule risk is likely to occur and the impact is moderate, if the funding reduces the project could add approximately 6 phases pushing the schedule out 6 years. . The escalation cost for extending the project schedule will be addressed in the TPCS.

Schedule Risks: The significantly 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:

- PPM-2: Sponsor Obligations– The project will require a continuous funding stream of approximately $20 million every FY during construction. Throughout the life of the project, the sponsor will need to provide their share of the cost. This includes both sunk costs (Feasibility) and construction costs. If the local sponsor cannot meet cost sharing obligations the project schedule will be impacted. The Sponsor may need to acquire funding from outside sources (State, City, and local community, tribal). The PDT agreed that this could cause a schedule extension of up to 4 years if Sponsor funds are not available on an annual basis. This risk is to capture a schedule slippage, but no additional phase's added.

Moderate risks, when combined, can also become a time and resulting cost impact.

- TR-1: Mountain View North Extension Construction– The discussed the linear foot cost of levee construction can be used to estimate this +/- 700 feet long section. PDT agrees that it is very likely that this will need to be added to this project to avoid having a hole in the protection provided and the impact is marginal. This will increase project cost and add about 2 months to the schedule.
- TR-9: Railroad and Highway Embankment– The new levee must tie into a certified structure. This may be an issue at the railroad and the highway crossings. Scheduling work with the railroad company could extend the project schedule. Due to the level of design there is limited information on how the new levee will tie into existing or future features.

- CON-11: Changes during Construction- Scope of work may change throughout the life of the project. Construction modifications or claims are possible throughout the life of the project. These will bring additional contracting efforts and may increase the total project cost. The work in general is not complex and is repetitive. A change or condition that would create a marginal impact to the cost is likely and the impact is marginal and schedule is unlikely and the impact is negligible.
- EX3: Inadequate Funding or Funding Delay– The project requires completed construction phases that are stand alone in case funding dries up and future work is cancelled. Due to funding constraints the estimate is broken up into phases that break up the entire levee alignment into 16 phases (separate contracts). The assumption is that each phase would have a funding limitation of 20 million. If the funding decreases then the risk of adding additional phases increases. The PDT agrees that it is likely and moderate to impact the cost for example Mob and De-Mob. The PDT agrees that a schedule risk is likely to occur and the impact is moderate, if the funding reduces the project could add approximately 6 phases pushing the schedule out 6 years. . The escalation cost for extending the project schedule will be addressed in the TPCS.

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

The US Army Corps of Engineers (USACE), Albuquerque District presents the results of the cost and schedule risk analysis for Bernalillo to Belen, Rio Grande Levee Project. 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 for successful execution.

2.0 BACKGROUND

The U.S. Army Corps of Engineers (USACE) proposed an engineered levee system is to reduce flood risk along approximately 32 river miles of the Rio Grande in the communities between Albuquerque and Belen, NM.

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 and schedules were developed and presented by the Albuquerque 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 Section at the Albuquerque District performed an abbreviated Cost Risk Analysis, relying on local Albuquerque District staff to provide expertise and information gathering. The Albuquerque District PDT conducted initial risk identification on April 13, 2016. 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 of April 13, 2016 included:

Attendance	Name	Office	Representing
Full	Corinne V. O'Hara	CESPA - Project Management	Corp of Engineers
Full	Debbie Smith	CESPA - Civil Engineering	Corp of Engineers
Full	Rich Zaragoza	CESPA - Structural Design Section	Corp of Engineers
Full	Doug Walther	OD-W	Corp of Engineers
Full	Steve Boberg	CESPA - Hydraulics	Corp of Engineers
Full	Gregory D. Everhart	CESPL - PM	Corp of Engineers
Full	Chris Velasquez	CESPL -Chief Civil Engineering Design	Corp of Engineers
Full	Ben Miranda	CESPL - Real Estate	Corp of Engineers
Full	Stacy Samuelson	CESPA - Plan Formulation	Corp of Engineers

Full	Michael Porter	CESPA - Environmental Studies	Corp of Engineers
Full	Robert L. Browning II	CESPA - Economics	Corp of Engineers
Full	Philip T. Roybal	CESPA- Construction Branch	Corp of Engineers
Full	Timothy Tetrick	CESPA - Cost Section	Corp of Engineers

The formal Cost Schedule Risk Analysis (CSRA) model was completed April 13, 2016. However, subsequent sanity checks and technical review of the base cost estimate required revisions, necessitating a rerun of the original model. Results were furthered on May 30, 2018 ready for ATR. Since sufficient time had elapsed, key PDT members readdressed the risk register.

Participants in the risk identification meeting of May 30, 2018 included:

Attendance	Name	Office	Representi
Full	Corinne O'Hara	CESPA - PM	Corp of Engineers
Full	Steven Boberg	CESPA - H & H	Corp of Engineers
Full	Robert Browning	CESPA - Economist	Corp of Engineers
Full	Bruce Jordan	CESPA - Dam Safety	Corp of Engineers
Full	Debbie Smith	CESPA - Civil Engineering	Corp of Engineers
Full	Asley Tellier	CESPA - Office of Council	Corp of Engineers
Full	Doug Walther	CESPA-OD-W	Corp of Engineers
Full	Jonathon AuBuchon	PM-LH	Corp of Engineers
Full	Ariane Pinson	PM-LP	Corp of Engineers
Full	Ben Miranda	Real Estate Section	Corp of Engineers
Full	Stacy Samuelson	CESPA-Planner	Corp of Engineers
Full	Michael Porter	PM-LE	Corp of Engineers
Full	Tim Tetrick	Cost Engineering Section	Corp of Engineers

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 Albuquerque District office for the purposes of identifying and assessing risk factors. The meeting (conducted March 9, 2015) included capable and qualified representatives from multiple project team disciplines and functions, including project management, cost engineering, design, environmental compliance, and real estate

The initial formal meetings focused primarily on risk factor identification using brainstorming techniques, but also included some facilitated discussions based on risk factors common to projects of similar scope and geographic location. Additionally, numerous conference calls and informal meetings were conducted throughout the risk analysis process on an as-needed basis to further facilitate risk factor identification, market analysis, and risk assessment. A final meeting was held March 16, 2017 for finalization of the risk register, resulting CSRA model, findings and results.

4.2 Quantify Risk Factor Impacts

The quantitative impacts (putting it to numbers for 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 Albuquerque District provided MII MCACES (Micro-Computer Aided Cost Estimating Software) files electronically. The files transmitted and downloaded on March 19, 2017 were the basis for the initial cost and schedule risk analyses. The files transmitted and downloaded on March 2017 were the basis for the final cost and schedule risk analyses.

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

c. Schedules are analyzed for impact to the project cost in terms of both uncaptured escalation (variance from OMB factors and the local market) and unavoidable fixed contract costs and/or languishing federal administration costs incurred throughout delay. Specific to the San Acacia project, the schedule was analyzed only for impacts due to residual fixed costs.

d. Per the CWCCIS Historical State Adjustment Factors in EM 1110-2-1304, State Adjustment Factor for the State of New Mexico is 0.95, meaning that the average inflation for the project area is assumed to be 5% lower than the national average for inflation. Therefore, it is assumed that the project inflations experienced are similar to OMB inflation factors for future construction. Thus, the risk analyses accounted for no escalation over and above the national average.

e. Per the data in the estimate, the Job Office Overhead (JOOH) percentage for the Prime Contractor is 15%. However, since engineering and construction is occurring seasonally over 16 separate phases, a weighted average based on overall duration

versus construction duration was calculated. The assumed residual fixed cost rate for construction PED is 12%. For the P80 schedule, this comprises approximately 0.17% of the total contingency (or 0.17% of the base case project cost) due to the accrual of residual fixed costs associated with delay.

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

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

6.0 RESULTS

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

6.1 Risk Register

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

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

- Documenting risk mitigation strategies being pursued in response to the identified risks and their assessment in terms of probability and impact.
- Providing project sponsors, stakeholders, and leadership/management with a documented framework from which risk status can be reported in the context of project controls.
- Communicating risk management issues.

- Providing a mechanism for eliciting feedback and project control input.
- Identifying risk transfer, elimination, or mitigation actions required for implementation of risk management plans.

6.2 Cost Contingency and Sensitivity Analysis

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

Table 1 provides the construction cost contingencies calculated for the P80 confidence level and rounded to the nearest thousand. The construction cost contingencies for the P50, P80 and P90 confidence levels are also provided for illustrative purposes only.

Cost contingency for the Construction risks (including schedule impacts converted to dollars) was quantified as approximately $47.771 Million at the P80 confidence level (26% of the baseline construction cost estimate).

Table 1. Construction Cost Contingency Summary

Base Case Construction Cost Estimate	**$183,734,812**	
Confidence Level	**Construction Value ($$) w/ Contingencies**	**Contingency (%)**
50%	$224,156,470	22%
80%	**$231,505,863**	**26%**
90%	$235,180,559	28%

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.

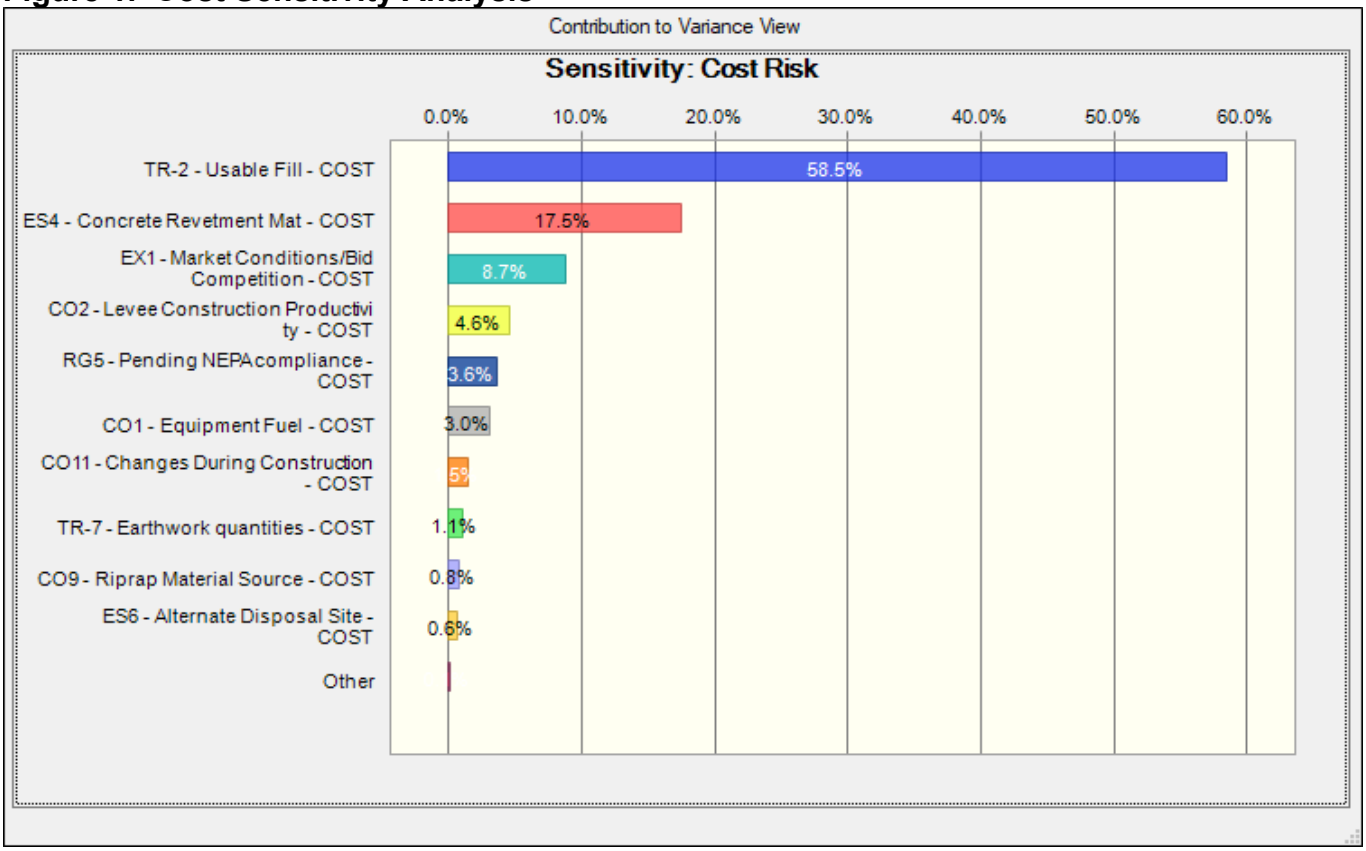
Key cost drivers identified in the sensitivity analysis can be used to support development of a risk management plan that will facilitate control of risk factors and their potential impacts throughout the project lifecycle. Together with the risk register, sensitivity analysis results can also be used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

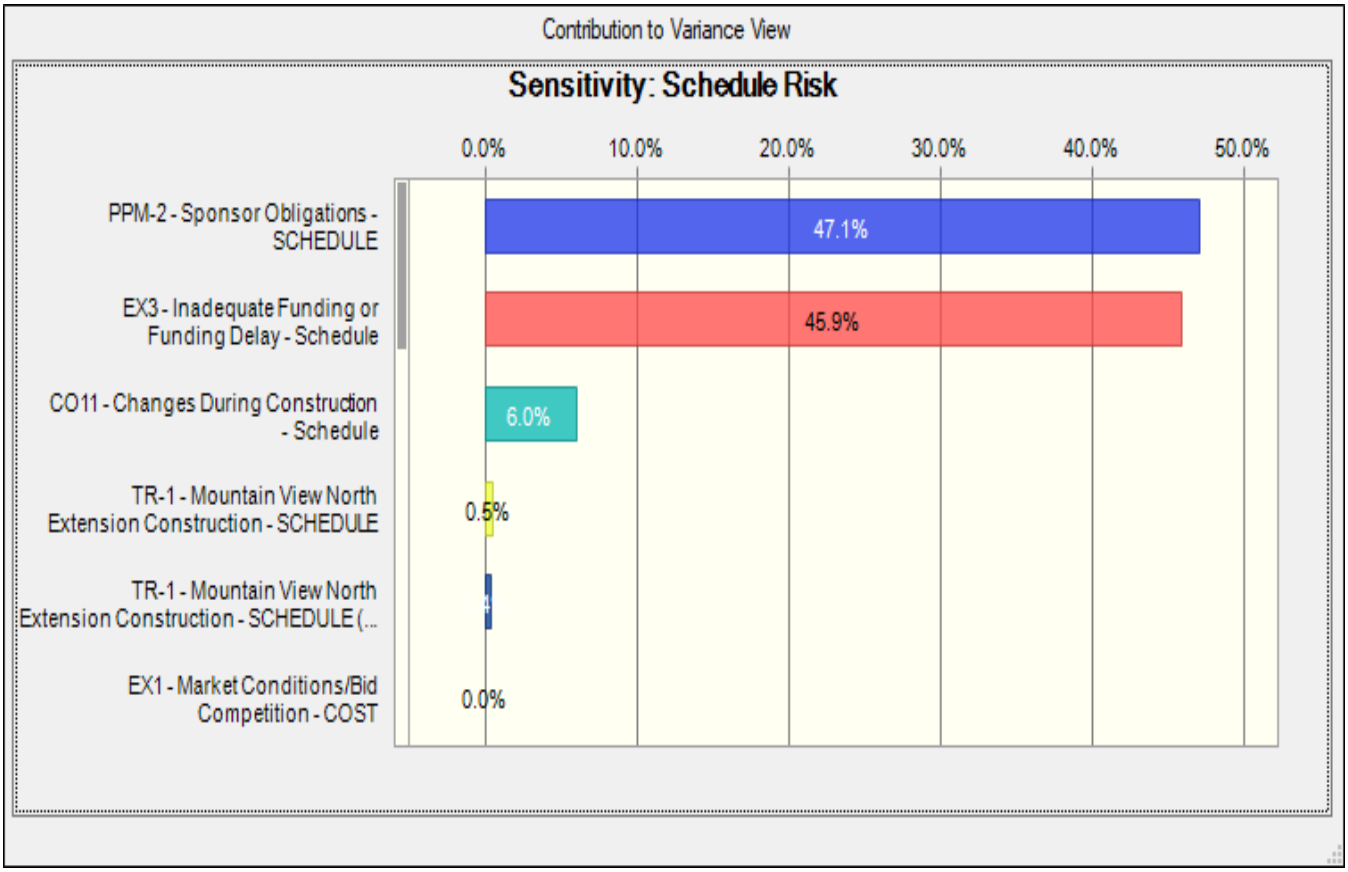
Table 2 provides the schedule duration contingencies calculated for the P80 confidence level. The schedule duration contingencies for the P50 and P90 confidence levels are also provided for illustrative purposes.

Schedule duration contingency was quantified as 235.2 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. 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 288 months)	Duration w/ Contingencies (months)	Contingency[1] (months)
50% Confidence	357.1	69.1
80% Confidence	362.9	74.9
90% Confidence	365.8	77.8

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 two separate occasions: April 13, 2016 and again May 30, 2018. That period of time allowed improved project scope definition, investigations, design and cost information, and resulted in reduced risks in certain project areas. The key risk drivers identified through sensitivity analysis suggest a cost contingency of $24M and schedule risks adding another potential of $248K, both at an 80% confidence level.

Cost Risks: From the CSRA, the key or greater Cost Risk item in terms of cost variability potential include:

- TR-2: Usable Fill– The fill material will be processed from existing excavated materials on site. It is possible that only 50% of the excavated material is suitable for fill then the rest would have to be purchased/imported from an offsite commercial source, and there would be a cost for hauling off the unusable material. The PDT agrees that it is possible to occur and the impact would be Critical for a cost impact and it is unlikely to occur a schedule delay but if it did the impact would be negligible. This resulted in a significant risk for cost and a low risk for schedule.
- CO-1: Equipment Fuel: Heavy equipment will be utilized for every aspect of this project. The excavation activities require the use of a large tracked hydraulic excavator with limited mobility. It is essential that a safe and efficient refueling operation is established so that productivity rates are not affected. Additional time and cost for fueling equipment is necessary.
- CO-2: Levee Construction Productivity: It is estimated that a crew consisting of a hydraulic excavator, compaction roller and water truck with required operators can accomplish the placement and compaction of the fill material at the rate of 165 cubic yards per hour. This production rate may not be conservative enough since the amount of passes required by the compaction roller to reach the

desired compaction is still unknown. The actual production rate is likely to vary from estimated and changes could have a significant impact on cost with the large amount of earthwork on the project. Schedule impact is negligible due to the ample time for work to be complete each phase.

- CO-11: Changes during Construction- Scope of work may change throughout the life of the project. Construction modifications or claims are possible throughout the life of the project. These will bring additional contracting efforts and may increase the total project cost. The work in general is not complex and is repetitive. A change or condition that would create a marginal impact to the cost is likely and the impact is marginal and schedule is unlikely and the impact is negligible.
- ES-4: Concrete Revetment Mat- It is likely that the articulated mat cost in the estimate will not reflect the actual material cost required in the final design.
- EX-1: Market Conditions/Bid Competition- If market conditions at the time of contract acquisition differ from estimate assumptions, then higher or lower than estimated contract costs may be experienced. Some years may bring more aggressive bidding climates which will lower the overall project costs by 3%. Others will offer a less aggressive climate which may drive up the costs by 4%.

Moderate risks, when combined, can also become a cost impact.

- TR-1: Mountain View North Extension Construction– As discussed the linear foot cost of levee construction can be used to estimate this +/- 700 feet long section. PDT agrees that it is very likely that this will need to be added to this project to avoid having a hole in the protection provided and the impact is marginal. This will increase project cost and add about 2 months to the schedule.
- TR-7: Earthwork quantities– The quantities used for the cost estimate are based on assumptions regarding the width of the maintenance roads at curves (14' versus 20' width as required for seepage control). The earthwork quantities for excavation and fill could increase by approximately 3% to 5%. The PDT agrees that the cost risk is likely to happen and the impact is marginal. The PDT also agree that it is unlikely to have any effect on the schedule and the impact is negligible.
- RG-5: Pending NEPA compliance – Additional mitigation or design requirements may be necessary in order to meet NEPA compliance. Mitigation costs may increase total cost estimate by 4%.
- CON-9: Riprap Material Source- It is estimated that all in situ material needs to be excavated to obtain the required material for the current riprap and filter blanket designs. It was assumed that the borrow source would be at an average distance of 25 miles from the project site. If an adequate supplier cannot be identified within a 25 mile radius the bid cost is expected to be higher due to delivery cost. The likelihood the source will be at a different distance than estimated is likely and this would have a significant impact on the cost of the riprap. It is unlikely that this would translate into an overall schedule delay of

marginal size. The updated estimate is based on a supplier delivering the rock to the construction site. The risk the fluctuating material cost. The PDT agrees that the likelihood of the material cost will increase is likely and the impact to the cost risk is Marginal. The likelihood of this affecting the schedule is unlikely and the impact is negligible.

- ES-6: Alternate Disposal Site– The identification of appropriate disposal sites is needed. The cost estimate includes 20 mile round-trip haulage. Clearing and grubbing material are assumed to be landfilled. The 20 mile haul distance is assumed to be adequate. Conclusion is that site could be +/- 5 miles. A different waste area located around the midpoint of the new levee alignment will result in a potential cost savings.

- EX3: Inadequate Funding or Funding Delay– The project requires completed construction phases that are stand alone in case funding dries up and future work is cancelled. Due to funding constraints the estimate is broken up into phases that break up the entire levee alignment into 16 phases (separate contracts). The assumption is that each phase would have a funding limitation of 20 million. If the funding decreases then the risk of adding additional phases increases. The PDT agrees that it is likely and moderate to impact the cost for example Mob and De-Mob. The PDT agrees that a schedule risk is likely to occur and the impact is moderate, if the funding reduces the project could add approximately 6 phases pushing the schedule out 6 years. . The escalation cost for extending the project schedule will be addressed in the TPCS.

Schedule Risks: The significantly 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:

- PPM-2: Sponsor Obligations– The project will require a continuous funding stream of approximately $20 million every FY during construction. Throughout the life of the project, the sponsor will need to provide their share of the cost. This includes both sunk costs (Feasibility) and construction costs. If the local sponsor cannot meet cost sharing obligations the project schedule will be impacted. The Sponsor may need to acquire funding from outside sources (State, City, and local community, tribal). The PDT agreed that this could cause a schedule extension of up to 4 years if Sponsor funds are not available on an annual basis. This risk is to capture a schedule slippage, but no additional phase's added.

Moderate risks, when combined, can also become a time and resulting cost impact.

- TR-1: Mountain View North Extension Construction– As discussed the linear foot cost of levee construction can be used to estimate this +/- 700 feet long section.

PDT agrees that it is very likely that this will need to be added to this project to avoid having a hole in the protection provided and the impact is marginal. This will increase project cost and add about 2 months to the schedule.

- TR-9: Railroad and Highway Embankment– The new levee must tie into a certified structure. This may be an issue at the railroad and the highway crossings. Scheduling work with the railroad company could extend the project schedule. Due to the level of design there is limited information on how the new levee will tie into existing or future features.
- CON-11: Changes during Construction- Scope of work may change throughout the life of the project. Construction modifications or claims are possible throughout the life of the project. These will bring additional contracting efforts and may increase the total project cost. The work in general is not complex and is repetitive. A change or condition that would create a marginal impact to the cost is likely and the impact is marginal and schedule is unlikely and the impact is negligible.
- EX3: Inadequate Funding or Funding Delay– The project requires completed construction phases that are stand alone in case funding dries up and future work is cancelled. Due to funding constraints the estimate is broken up into phases that break up the entire levee alignment into 16 phases (separate contracts). The assumption is that each phase would have a funding limitation of 20 million. If the funding decreases then the risk of adding additional phases increases. The PDT agrees that it is likely and moderate to impact the cost for example Mob and De-Mob. The PDT agrees that a schedule risk is likely to occur and the impact is moderate, if the funding reduces the project could add approximately 6 phases pushing the schedule out 6 years. . The escalation cost for extending the project schedule will be addressed in the TPCS.

Table 3. Construction Cost Comparison Summary (Uncertainty Analysis)

Base Case Estimate (Excluding 01)	$183,734,812	
Confidence Level	**Contingency Value**	**Contingency**
0%	**16,536,133**	**9%**
10%	**31,234,918**	**17%**
20%	**33,072,266**	**18%**
30%	**36,746,962**	**20%**
40%	**38,584,310**	**21%**
50%	**40,421,659**	**22%**
60%	**42,259,007**	**23%**
70%	**44,096,355**	**24%**
80%	**47,771,051**	**26%**
90%	**51,445,747**	**28%**
100%	**71,656,577**	**39%**

Table 4. Construction Schedule Comparison Summary (Uncertainty Analysis)

Base Case Schedule	288.0 Months	
Confidence Level	**Contingency Value**	**Contingency**
0%	**43 Months**	**15%**
10%	**60 Months**	**21%**
20%	**63 Months**	**22%**
30%	**66 Months**	**23%**
40%	**66 Months**	**23%**
50%	**69 Months**	**24%**
60%	**72 Months**	**25%**
70%	**72 Months**	**25%**
80%	**75 Months**	**26%**
90%	**78 Months**	**27%**
100%	**92 Months**	**32%**

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.

The CSRA study serves as a "road map" towards project improvements and reduced risks over time. 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).

Organizational and Project Management Risks (PM)																													
PP M-1	Project Sequencing (Internal Impacts)	It is assumed that 16 contracts will be required to complete the project. Project sequencing might impact cost and schedules.	The 16 phases making up the project will all require different scopes of work. Individual phase schedules and costs will depend on which features are required for a particular phase. This may potentially impact the 30 and 31 accounts. If the sequence is changed then there is a risk of losing the Isleta West Reach which would change the design and increase the cost. The PDT agrees that it is unlikely to happen but if it did the impact would be Moderate. It is unlikely and the impact to the schedule would be marginal.	Unlikely	Moderate	**Low**	Unlikely	Marginal	**Low**	N/A - Not Modeled	N/A - Not Modeled	Project Management	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	
PP M-2	Sponsor Obligations	The proposed cost sharing is 75% federal dollars to 25% non-federal dollars.	The project will require a continuous funding stream of approximately $20 million every FY during construction. Throughout the life of the project, the sponsor will need to provide their share of the cost. This includes both sunk costs (Feasibility) and construction costs. If the local sponsor cannot meet cost sharing obligations the project schedule will be impacted. The Sponsor may need to acquire funding from outside sources (State, City, and local community, tribal). The PDT agreed that this	Likely	Marginal	**Medium**	Likely	Significant	**High**	Triangular	Triangular	Construction	Project Schedule	$0	$0	$0	12.0 Months	24.0 Months	36.0 Months	$0	$0	$0	100 %	1	$0	100 %	24 Mo	The LOW variance is based on the sponsor not having the funds for 1 phase and that would extend the project 12 months. The Likely variance has the sponsor not having funds for 2 phases for the life of the project and that would extend the project 2 years. The HIGH variance has the sponsor not having funds for 4 phases for the life of the project and that would extend the project 4 years. The

			could cause a schedule extension of up to 4 years if Sponsor funds are not available on an annual basis. This risk is to capture a schedule slippage, but no additional phases added.																											"Cost from Schedule delay" is not modeled in the CSRA, as we prefer to capture the 80% confident schedule in the TPCS project duration that will account for the increase in escalation.
PP M-3	Project Reviews (External)	The project will require additional reviews before it is approved (ATR of Design, Type II IEPR, and Federal Agency Reviews).	Reviews will impact the PED costs (account 30) and may potentially delay the project. Also, additional reviews may stop/delay the project if it is determined that the project needs to be reevaluated. Per the PDT's meeting on May 25, 2018 the PDT agrees that the Likelihood of Cost and Schedule risk is Unlikely to occur and the impact is marginal giving this concern a low risk.	Unlikely	Marginal	**Low**	Unlikely	Marginal	**Low**	Triangular	Triangular	Project Management	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	
PP M-4	Compressed Schedule (Feasibility and PED)	The current compressed schedule may impact the quality of the delivered project.	There is a risk that some decisions will be pushed to PED that may have an impact on the design that will not be captured in feasibility. The PDT is confident with the design for the current product. However, different approaches for the design of some of the features in the project could have been analyzed and compared to what is proposed. This would have confirmed that the team selected best alternatives. Per the PDT's meeting on May 25, 2018 the PDT agrees that the Likelihood of Cost and Schedule risk is Unlikely to occur and the impact is marginal giving this concern a low risk.	Unlikely	Marginal	**Low**	Unlikely	Marginal	**Low**	Triangular	Triangular	Technical Lead	Contract Cost & Schedule	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	

PP M-5	O&M Costs	Operation and maintenance requirements for the project have not been established.	An average cost for de-vegetation, rodent prevention, erosion repair, and rip rap/haul road/toe drain maintenance have been included. The extent or frequency of the required O&M is still unknown. A baseline from Albuquerque levees would be helpful. We need to establish a reasonable cost for O&M..	Likely	Negligible	**Low**	Unlikely	Negligible	**Low**	Triangular	Triangular	Technical Lead	Contract Cost & Schedule	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100%	1	$0	100%	0 Mo	
PP M-6	Additional Real Estate Requirement	MRGCD may have only an operational easement on Pueblo lands (Isleta Reach). There may be additional requirements for construction and access.	MRGCD needs to acquire the required easement. Acquiring the necessary easement may impact the total schedule since the PPA cannot be signed without an agreement to acquire the easement. The PDT does not feel that this would delay the schedule.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**	Triangular	Triangular	Project Management	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	0.5	0.5	$0	100%	0 Mo	
PP M-7	Scope Evolution	Over time the scope of the project may evolve and potentially result in a cost increase. For example, issues with tying in to the railroad may impact the design/cost.	Future surveys and investigations will show additional design refinements which tend to increase cost. Possible refinements may include additional areas requiring rip rap protection and additional material requiring excavation and disposal. The railroad only impacts one or two phases so impact is likely to be low over the full project. The schedule could extend out 1 - 2 FY. The PDT agrees that the Likelihood of Cost risk is Unlikely to occur and the impact is Negligible giving this concern a low risk and for the Schedule risk it is unlikely to occur and the impact is Marginal for a low risk.	Unlikely	Negligible	**Low**	Unlikely	Marginal	**Low**	N/A - Not Modeled	Triangular	Project Management	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100%	1	$0	100%	0 Mo	

PP M-8	Staffing Turnover	Throughout the duration of the project there will be inexperienced or new staff.	It is assumed that the project will require no less than 18 years to complete. Throughout the life of the project PDT members will likely change. Adding new members to the project may reduce efficiency in the design process that will impact the schedule.	Unlikely	Marginal	**Low**	Likely	Negligible	**Low**	N/A - Not Modeled	Triangular	Project Management	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.00 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	
PP M-9	Coordination/ Communication Concerns	The project requires many parties to communicate effectively.	Effective communication among the local sponsors, the public and other federal agencies in critical to follow the proposed schedule. A break in communication may delay a task that follows the critical path for the completion of the project and therefore effect the schedule.	Unlikely	Negligible	**Low**	Unlikely	Marginal	**Low**	N/A - Not Modeled	Triangular	Project Management	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	
PP M-10	Evolving Guidance	New guidance being applied retroactively to old projects.	Technical guidance is expected to change throughout the life on the project that may deem our design obsolete. The cost and schedule for the project will be significantly affected if new methods will be required to be applied to the current design.	Unlikely	Moderate	**Low**	Unlikely	Marginal	**Low**	N/A - Not Modeled	Triangular	Project Management	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	
Contract Acquisition Risks (CA)																												
CA-1	Defined Acquisition Strategy	The acquisition assumption is that this will be a design/bid/build IFB (lowest price).	Initial intent is that it will be an IFB with a possibility for change in acquisition strategy over the years. Per Contracting Section this district is moving towards Best Value with its acquisition strategy. The PDT agrees that the likelihood would increase from unlikely to likely and the impact is significant giving this concern a high risk. The likelihood for a schedule deviation	Likely	Negligible	**Low**	Likely	Negligible	**Low**	N/A - Not Modeled	N/A - Not Modeled		Project Cost	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	

			occurrence is unlikely and the impact is marginal. Project phasing is not going to change with the acquisition strategy (schedule deviation and impact remains a low risk), however the cost can be affected by the change in acquisition strategy from IFB to Best Value. The estimate was built for small business contractors. Therefor the risk is likely not to be IFB and the impact is negligible for cost and schedule risks.																									
CA-2	Small Business Acquisition	Small business acquisition might drive up bid cost and possibly decrease competition. 35% of all construction awards/year must be to small business per USACE. Small business may not be able to complete construction in time to accommodate next phase.	Small business acquisition might drive up bid cost and possibly decrease competition. PDT assumption is that this will be an IFB open competition, and will not be limited to small business. The estimates are constructed for small business acquisition. The PDT agrees that it is likely to be small business and the impact is negligible due to the cost estimate being constructed for small business. It is possible and the impact to any schedule risk is marginal. These equal to a low cost and schedule risk.	Likely	Negligible	**Low**	Possible	Marginal	**Low**	N/A - Not Modeled	N/A - Not Modeled	Contracting	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100%	1	$0	100%	0 Mo	
CA-3	Additional Phases	Adding additional phases to the project will increase the required efforts for design and by the contracting team.	Creating more phases for the project will result in the need for more design packages and additional submittal reviews. This additional effort will increase to total project cost. This risk was captured in the limited funding risk.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**	N/A - Not Modeled	N/A - Not Modeled		N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100%	1	$0	100%	0 Mo	

CA-4	Trucking Subcontractors	A significant portion of the work required for the construction of the new levee is the transportation of waste and fill material.	The general contractor for the project will probably not have the capabilities of performing all of the required hauling for the job. Instead, several trucking subcontractors will be used. This will drive up the bid cost for this portion of the work. The estimate has already accounted for the hauling being performed by a subcontractor so the risk of cost increase is reduced.	Likely	Negligible	**Low**	Unlikely	Marginal	**Low**	N/A - Not Modeled	N/A - Not Modeled		N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	
CA-5	Specialized Equipment Contractor	The screening of spoil material required for the new levee will be performed by specialized equipment.	An equipment contractor will be required to provide the specialized screening plant. The accessibility of the needed equipment is still unclear. The need for specialized equipment has the ability to affect project duration and cost.	Likely	Negligible	**Low**	Unlikely	Marginal	**Low**	Triangular	N/A - Not Modeled	Contracting	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	
General Technical Risks (TR)																											
TR-1	Mountain View North Extension Construction	There is a section of spoil bank levees between Albuquerque Levee project and the Mountain View reach that is not currently included in the project and will likely need to be added.	As discussed the linear ft. cost of levee construction can be used to estimate this +/- 700 ft. long section. PDT agrees that it is very likely that this will need to be added to this project to avoid having a hole in the protection provided and the impact is marginal. This will increase project cost and add about 2 months to the schedule.	Very Likely	Marginal	**Medium**	Likely	Marginal	**Medium**	Uniform	Uniform	Local Sponsor	Contract Cost & Schedule	$0	$0	$482,223	0.5 Months	1.0 Months	2.0 Months	$0	$0	$0	60 %	1	$0	60 %	1 Mo	The linear foot cost is $688.89 * 700' = $482,223.00. The defined assumption is yes/no at 40%.

TR-2	Usable Fill	The existing excavated dirt does not meet the requirements for Fill.	The Fill material will be processed from existing excavated materials on site. It is possible that only 50% of the excavated material is suitable for fill then the rest would have to be purchased/imported from an offsite commercial source, and there would be a cost for hauling off the unusable material. The PDT agrees that it is possible to occur and the impact would be Critical for a cost impact and it is unlikely to occur a schedule delay but if it did the impact would be negligible. This resulted in a Significant risk for cost and a low risk for schedule.	Possible	Critical	**High**	Likely	Negligible	**Low**	Triangular	Triangular	Technical Lead	N/A -Not Modeled	$0	$0	$26,187,949	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100%	1	$0	100%		The Low is the baseline estimate with no cost increase or decrease to the project. The likely is the baseline estimate with no cost increase or decrease to the project. The High variance is 50% increase of imported fill material due to unsuitable excavated material increases the baseline estimate to $192,044,956.21 - (the base line estimate of $174,586,323.8) for a total increase of $17,458,632.38. The cost for just hauling of unusable material increases the baseline estimate to 183,315,640.02 - (the base line estimate of $174,586,323.83) for a total increase of $8,729,316.19 + 17,458,632.38 = $26,187,948.57.
TR-3	Levee Tiebacks	The new levee must tie into a certified structure. This may be an issue at the railroad and the highway crossings.	Due to the level of design there is limited information on how the new levee will tie into existing or future features. It is assumed that the levee tie-ins will have similar requirements as the new engineered levee and will follow the same construction methodology. The PDT agrees that it is unlikely to occur and the impact is moderate for cost and schedule risk.	Unlikely	Moderate	**Low**	Unlikely	Moderate	**Low**	N/A - Not Modeled	N/A - Not Modeled	Technical Lead	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100%	1	$0	100%	0 Mo	

TR-4	Riprap Design	Throughout the life of the project, the plan form of the river might undergo several changes which could create a need for the riprap design to be reevaluated.	It is anticipated that this project will be constructed in no less than 18 phases with an approximate duration of 1 year each. Through the course of the project the plan form of the river could change, which would require the riprap design to be reevaluated. The updated riprap design might call for adjustment in the location of the riprap. This conclusion is based on implementation of the adaptive management plan and lessons learned from previous construction phases.	Unlikely	Marginal	**Low**	Unlikely	Negligible	**Low**	N/A - Not Modeled	N/A - Not Modeled	Technical Lead	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	
TR-5	Levee Access	The owner might want to have access onto the levee crest for maintenance purposes at various locations of the levee alignment.	The current design does not account for any type of access onto the levee crest. Additional features to include access ramps and turn-around can be added throughout the levee. These will generate additional cost for construction but will also create savings in spoil hauling cost. Turn around and access ramps are included in the cost estimate, but may need to be refined in design.	Very Likely	Negligible	**Low**	Likely	Negligible	**Low**	N/A - Not Modeled	N/A - Not Modeled	Technical Lead	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	
TR-6	Riprap Quantities	The current rip rap design is preliminary and subject to changes.	The current quantities used for the design are conservative throughout the project. Rip rap thickness and size is subject to change in the final design. Rip rap placement areas are also subject to change.	Unlikely	Marginal	**Low**	Unlikely	Marginal	**Low**	Triangular	Triangular	Technical Lead	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0		100 %	1	$0	100 %	0 Mo	

TR-7	Earthwork quantities	The Excavation and Fill earthwork quantities used are based on preliminary design and could increase.	The quantities used for the cost estimate are based on assumptions regarding the width of the maintenance roads at curves (14' versus 20' width as required for seepage control). The earthwork quantities for excavation and fill could increase by approximately 3% to 5%. The PDT agrees that the cost risk is likely to happen and the impact is marginal. The PDT also agree that it is unlikely to have any effect on the schedule and the impact is negligible.	Likely	Marginal	**Medium**	Unlikely	Negligible	**Low**	N/A - Not Modeled	N/A - Not Modeled	Technical Lead	Project Cost	$0	$3,322,063	$4,240,118	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$3,322,063	100 %	0 Mo	The Low is the baseline estimate with no cost increase or decrease to the project. The likely is the 3% increase of excavation and fill quantities increases the baseline estimate to $177,908,386.81 - (the base line estimate of $174,586,323.8) for a total increase of $3,322,062.98. The High variance is the 5% increase of excavation and fill quantities increases the baseline estimate to $178,826,441.40 - (the base line estimate of $174,586,323.83) for a total increase of $4,240,117.57.
TR-8	Slope Stability and Seepage	The side slopes of the levee at the southern end of the project may be conservative	The current levee side slopes may be conservative. Changes can be made that could increase the slopes from 3:1 to 2.5:1 at the southern end. This will decrease the cost for screening material and constructing that portion of the new levee but it will also slightly increase the cost for hauling off excess material. The change of slope is not expected to significantly impact the cost of the project. The PDT agrees that the likelihood for cost and schedule risk is unlikely to occur. The impact to the cost and schedule risk is negligible.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**	N/A - Not Modeled	N/A - Not Modeled	Technical Lead	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	

LANDS AND DAMAGES (LD)

LD-1	Assumed Waste Disposal Areas	Waste soil material disposal/staging sites have not been identified. Clearing, grubbing and unsuitable material disposal sites have not been identified.	The identification of appropriate disposal sites is needed. The cost estimate includes 20 mile round-trip haulage. Clearing and grubbing material are assumed to be landfilled. The 15 mile haul distance is assumed to be adequate.	Unlikely	Marginal	**Low**	Unlikely	Marginal	**Low**	N/A - Not Modeled	N/A - Not Modeled	Construction	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	
LD-2	Other Federal Agencies	Various permits will be required from different government agencies	The required permits will demand coordination with different agencies. A delay with any of the required permits might have impacts on schedule.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**	N/A - Not Modeled	N/A - Not Modeled	Construction	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$106,000	$424,000	100 %	0.5	$53,000	100 %	0 Mo	
LD-3	Alternate Disposal Site	There is an opportunity for a shorter haul distance if an alternate disposal site can be identified.	The identification of appropriate disposal sites is needed. The cost estimate includes 20 mile round-trip haulage. Clearing and grubbing material are assumed to be landfilled. The 20 mile haul distance is assumed to be adequate. Conclusion is that site could be +/- 5 miles. A different waste area located around the midpoint of the new levee alignment will result in a potential cost savings.	Likely	Moderate	**Medium**	Unlikely	Marginal	**Low**	N/A - Not Modeled	N/A - Not Modeled	Mechanical Design	Project Cost	-$1,272,204	$0	$2,544,409	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	The likely variance is the baseline estimate with no cost increase or decrease to the project. The Low is based on a reduced to a 15 mile round trip for waste disposal and is established at $173,314,119.22 - (the base line estimate of $174,586,323.8) for a total decrease of -$1,272,204.61. The High variance is 30 mile trip each way for disposal and is established at $177,130,733.05 - (the base line estimate of $174,586,323.8) for a total increase of $2,544,409.22.

LD-4	Utility (Known and Unknown) Relocation	The quantity of utility encroachments are unknown.	The owner will be responsible for relocation costs of any existing utilities that may interfere with the project. Timing of relocations may affect schedule. Due to unknown number of relocations, cost could be impacted. A conservative approach based on previous experience is included in the cost estimate. The PDT agrees that the likelihood of this occurring is unlikely and the impact is marginal for any cost risk. It is unlikely to affect the schedule and the impact is negligible.	Unlikely	Marginal	**Low**	Unlikely	Negligible	**Low**	Triangular	Triangular	Construction	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$106,000	$212,000	100%	1	$106,000	100%	0 Mo				
LD-5	Railroad and Highway Embankment	The new levee must tie into a certified structure. This may be an issue at the railroad and the highway crossings. Scheduling work with the railroad company could extend the project schedule.	Due to the level of design there is limited information on how the new levee will tie into existing or future features. It is assumed that the levee tie-ins will have similar requirements as the new engineered levee and will follow the same construction methodology. The PDT agrees that the likelihood of this occurring is unlikely and the impact is marginal for any cost risk. The likelihood of this occurring is unlikely but the impact is significant if we have to schedule around the railroad.	Unlikely	Marginal	**Low**	Unlikely	Significant	**Medium**	N/A - Not Modeled	Triangular	Construction	N/A -Not Modeled	$0	$0	$0	4.0 Months	6.0 Months	12.0 Months	$0	$0	$0			$0					The Low variance is a 4 month schedule extension. The Likely variance is a 6 month schedule extension. The High variance is a 12 month schedule extension.
LD-6	Real Estate Contingency	Real estate acquisitions may contain unforeseen risks not covered by contingency.	The real estate section has included a 30% contingency in their estimate. However, the 30% contingency might not be enough to capture all risks since some issues are still unclear.	Likely	Negligible	**Low**	Unlikely	Negligible	**Low**	Triangular	Triangular	Construction	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100%	1	$0	100%				

LD-7	O&M LERRD	LERRD O&M needs have not been identified.	Easements for O&M work may be needed once LERRD O&M requirements are identified. At this point there isn't much information about possible requirements but this concern is likely to affect the cost of the project. Previous project experience has shown that this is a negligible cost driver.	Likely	Negligible	**Low**	Unlikely	Negligible	**Low**	Triangular	Triangular	Construction	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0			
Regulatory Environmental Risks (RG)																													
RG 1	HTRW Concerns	The railroad ROW may contain contaminated soils.	Assessments will be required on soil to verify that it does not contain any type of hazardous materials. Previous investigation did not determine any type of concerns but the 2006 report needs to be updated to increase its validity. The PDT agrees that the likelihood that this risk occurs is Possible and the impact if it did occur is Marginal for both cost and schedule risks.	Possible	Marginal	**Low**	Possible	Marginal	**Low**	N/A - Not Modeled	N/A - Not Modeled	Environmental Compliance	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	
RG 2	Archeological Resources Update	There is always possibility of discovery of unknown archeological sites.	The project is assuming the usage of existing access routes, staging and disposal areas. If any of these assumptions change, additional surveys may be required to locate any possible archeological sites. Based on Tribal consultation and surveys it is unlikely that additional sites will be identified during construction.	Unlikely	Marginal	**Low**	Unlikely	Marginal	**Low**	N/A - Not Modeled	N/A - Not Modeled	Environmental Compliance	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	
RG 3	Unknown Cultural Resource Impacts	The proposed project might affect cultural resources downstream due to	Based on Tribal consultation and surveys it is unlikely that potential sites downstream of the project will be affected.	Unlikely	Negligible	**Low**	Unlikely	Marginal	**Low**	N/A - Not Modeled	N/A - Not Modeled	Environmental Compliance	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	

		changes in stage.																										
RG 4	Yellow-billed Cuckoo	Yellow-billed cuckoo may be found throughout the project area.	The Yellow-billed Cuckoo can be found in the project area. Since this is a protected species construction activities are not permitted between April 15 through August 15 when the species is present. The project area will be surveyed yearly before the start of any construction activity.	Unlikely	Negligible	**Low**	Unlikely	Marginal	**Low**	N/A - Not Modeled	N/A - Not Modeled	Environmental Compliance	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	
RG 5	Pending NEPA compliance	Unknown stakeholder issues or mitigation.	Additional mitigation or design requirements may be necessary in order to meet NEPA compliance. Mitigation costs may increase total cost estimate by 4%.	Likely	Marginal	**Medium**	Likely	Negligible	**Low**	N/A - Not Modeled	N/A - Not Modeled	Environmental Compliance	Project Cost	$0	$4,364,658	$6,983,453	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$4,364,658	100 %	0 Mo	The Low is the baseline estimate with no cost increase or decrease to the project. The Likely is the baseline estimate 0f $174,586,323.83 times 2.5% and total cost of $178,950,981.93 - (the base line estimate of $174,586,323.8) for a total increase of $4,364,658.10. The High variance is the baseline estimate 0f $174,586,323.83 times 4% and total cost of $ 181,569,776.78 - (the base line estimate of $174,586,323.8) for a total increase of $6,983,452.95.
RG 6	Regulatory Litigation	Unknown potential for legal challenge related to Endangered Species Act.	Based on San Acacia levee project being challenged for ESA compliance, potential for comparable challenge exists to this project. The total Mitigation cost could be increased by 0.10% if challenge was successful at any level. One year schedule extension would be unlikely.	Possible	Marginal	**Low**	Unlikely	Marginal	**Low**	N/A - Not Modeled	N/A - Not Modeled	Environmental Compliance	Project Cost & Schedule	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	

			The PDT agrees that the likelihood that this occurs is possible and the impact would be marginal.																									
RG 7	Endangered Species	Endangered species act consultation has not been started. It might provide the project with additional requirements.	Mitigation requirements have not been negotiated. There is a potential increase in the 1 to 1 planting ratio. This may include real estate, plant installation and plant establishment period.	Likely	Negligible	**Low**	Likely	Negligible	**Low**	N/A - Not Modeled	N/A - Not Modeled	Environmental Compliance	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	
RG 8	Rio Grande Silvery Minnow	Minnows use the floodplain habitat during flood stages of the river.	Rio Grande Silvery Minnow are commonly found throughout the project area. Additional measures may be required to protect the species. The species may be affected by activities for the installation of riprap.	Likely	Negligible	**Low**	Unlikely	Negligible	**Low**	N/A - Not Modeled	N/A - Not Modeled	Environmental Compliance	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	
RG 9	Southwestern Willow Flycatcher	Flycatchers are commonly found adjacent to the levee at the southern end of the project area.	The Southwestern Willow Flycatcher can be found in the project area. There is a possibility that the population can move to other project locations. Since this is a protected species construction activities are not permitted between April 15 through August 15 when the species is present. The project area will be surveyed yearly before the start of any construction activity.	Likely	Negligible	**Low**	Unlikely	Negligible	**Low**	N/A - Not Modeled	N/A - Not Modeled	Environmental Compliance	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	
Construction Risks (CO)																												

CO 1	Equipment Fuel	Fueling staging locations are not identified.	Heavy equipment will be utilized for every aspect of this project. The excavation activities require the use of a large tracked hydraulic excavator with limited mobility. It is essential that a safe and efficient refueling operation is established so that productivity rates are not affected. Additional time and cost for fueling equipment is necessary.	Likely	Significant	**High**	Likely	Negligible	**Low**	Triangular	N/A - Not Modeled	Construction	Project Cost	$0	$3,789,544	$7,579,088	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$3,789,544	100 %		The Low is the baseline estimate with no cost increase or decrease to the project. The Likely is 2.5% productivity decrease on certain activities and will require additional costs of approximately $75,000.00/phase for appropriate refueling locations complete with safety measures. The productivity equals approx. $161,846.50 + $75,000.00 = $236,846.5 * 16 phases (separate contracts) = $3,789,544.00. The High Variance covers more stringent refueling requirements will cause a productivity decrease of approximately 5% on certain activities and will require additional costs of approximately $150,000.00/phase for appropriate refueling locations complete with safety measures. The productivity equals approx. $323,693.00 + $150,000.00 = $473,693.00 * 16 phases (separate contracts) = $7,579,088.00

CO 2	Levee Construction Productivity	The productivity rate for building the new engineered levee is not conservative enough.	It is estimated that a crew consisting of a hydraulic excavator, compaction roller and water truck with required operators can accomplish the placement and compaction of the fill material at the rate of 165 cubic yards per hour. This production rate may not be conservative enough since the amount of passes required by the compaction roller to reach the desired compaction is still unknown. The actual production rate is likely to vary from estimated and changes could have a Significant impact on cost with the large amount of earthwork on the project. Schedule impact is negligible due to the ample time for work to be complete each phase.	Likely	Significant	**High**	Likely	Negligible	**Low**	Triangular	N/A - Not Modeled	Construction	Project Schedule	$0	$4,293,950	$9,065,007	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$4,293,950	100 %	0 Mo	The Low is the baseline estimate with no cost increase or decrease to the project. The Likely is 95% productivity and is established at $178,880,274.29 - (the base line estimate of $174,586,323.8) for a total increase of $4,293,950.46. The High variance is 90% productivity and is established at $183,651,330.37 - (the base line estimate of $174,586,323.83) for a total increase of $9,065,006.54.
CO 3	Construction Constraints	The plan of operation requires that no more than one mile of levee is open at any given time during the construction of the new engineered levee.	Due to flood risks no more than 1 mile of levee will be open at any given time. A system will be developed so that the construction activities (excavation, hauling, processing, and the construction of the new levee) are cycled in order to satisfy the condition of only having 1 mile of levee open at any given time. Coordination of all these ongoing construction activities could lead to reduced productivity. Our current estimate is conservative for these operations, so the risk will be minimal.	Unlikely	Marginal	**Low**	Unlikely	Negligible	**Low**	N/A - Not Modeled	N/A - Not Modeled	Construction	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	

CO 4	Crest Elevation Refinement	There is no gentle change in levee heights at structures. Instead the change in elevation is done very abruptly.	Crest elevation refinement may be implemented to create subtle transitions in elevation changes required on the levee. This crest elevation refinement may be needed for constructability purposes. Fill quantities are expected to increase and haul quantities will decrease. The refinement is likely to occur, but the offsetting cost and savings result in a negligible impact to project cost. Schedule impact is unlikely and negligible.	Unlikely	Negligible	**Low**	Unlikely	Marginal	**Low**	Triangular	Triangular	Construction	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %		
CO 5	Replacing vegetation	Variable re-vegetation methods may require replacement to attain desired establishment criteria.	A percentage of replanting will be required for each phase. The PDT assumes a 10% replanting requirement. The contractor would be required to enforce 80% survival rate. The PDT agrees that it is unlikely and marginal cost impact to the cost risk. It is unlikely and negligible for any schedule impact.	Unlikely	Marginal	**Low**	Unlikely	Negligible	**Low**	Triangular	Triangular	Construction	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %		
CO 6	Drainage System Maintenance	Maintenance and repairs will be required on the implemented drainage system until the project is turned over to the owner.	Maintenance which includes cleaning the toe drain system and removing any debris that may block flow will be required to keep the system functioning properly, Also any risers, outlets, or clean-outs that are damaged during any construction or levee maintenance activities will need to be replaced. Expected to be very low cost due to turning over each completed phase to sponsor shortly after construction completion.	Likely	Negligible	**Low**	Unlikely	Negligible	**Low**	Triangular	Triangular	Construction	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %		

CO 7	Discovery of Cultural Resources	Cultural resources could be discovered during constructio n.	Site discovery would temporarily halt construction and require Section 106 consultation, affecting schedule and cost. Mitigation could cost as much as 1% of construction cost. Curation of artifact could add additional cost.	Unlik ely	Margi nal	**Low**	Unlikel y	Margin al	**Low**	Tria ngu lar	Triang ular	Construc tion	N/A -Not Modeled	$0	$0	$0	0.0 Mont hs	0.0 Mont hs	0.0 Mont hs	$0	$0	$0	100 %	1	$0	100 %	0 Mo	
CO 9	Riprap Material Source	The borrow source for the required rip rap material has not been confirmed.	It is estimated that all in situ material needs to be excavated to obtain the required material for the current riprap and filter blanket designs. It was assumed that the borrow source would be at an average distance of 25 miles from the project site. If an adequate supplier cannot be identified within a 25 mile radius the bid cost is expected to be higher due to delivery cost. The likelihood the source will be at a different distance than estimated is likely and this would have a significant impact on the cost of the riprap. It is unlikely that this would translate into an overall schedule delay of marginal size. The updated estimate is based on a supplier delivering the rock to the construction site. The risk the fluctuating material cost. The PDT agrees that the likelihood of the material cost will increase is likely and the impact to the cost risk is Marginal. The likelihood of this affecting the schedule is unlikely and the impact is negligible.	Likely	Margi nal	**Med ium**	Unlikel y	Negligi ble	**Low**	Tria ngu lar	N/A - Not Modele d	Construc tion	Project Schedule	$0	$27 3,9 08	$557,167	0.0 Mont hs	0.0 Mont hs	0.0 Mont hs	$0	$0	$0	100 %	1	$273,90 8	100 %	0 Mo	The cost of rip rap has been fluctuating between $50.00 and $70.00 per cubic yard delivered. The Low Variance is the baseline estimate that is based on a quote for $50.33 per cubic yard delivered and is the baseline estimate that has a productivity of 100% and is the baseline estimate with no cost increase or decrease to the project. The likely is based on $60.00 per cubic yard and total cost of $174,860,232.21 - (the base line estimate of $174,586,323.83) for a total increase of $273,908.38. The High is based on $70.00 per cubic yard and total cost of $ 175,143,490.36 - (the base line estimate of $174,586,323.8) for a total increase of $557,166.53.

CO 10	Trucking Operations	The hauling of spoil material to the assumed dump site will require a massive trucking operation with crews of multiple dump trucks.	A major aspect of the project is hauling off excess material not needed for the construction of the new levee to an assumed dump site. Dump trucks will constantly be traveling on the establish haul routes transporting waste material. The magnitude of the excess material that requires hauling might impact the productivity of the activity due to congestion.	Likely	Negligible	**Low**	Likely	Negligible	**Low**	N/A - Not Modeled	N/A - Not Modeled	Construction	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	
CO 11	Changes During Construction	Scope of work may change throughout the life of the project.	Construction modifications or claims are possible throughout the life of the project. These will bring additional contracting efforts and may increase the total project cost. The work in general is not complex and is repetitive. The PDT agrees that it is likely to occur and the impact would be significant for a cost impact and it is likely to occur. Over the life of this project a schedule delay is likely but if it did the impact would be moderate. This resulted in a High risk for cost and a medium risk for schedule. Per Construction Branch the cost could increase as high as 4% the most likely is 2.5% and the low would be 1%. The schedule could extend as much as 12 months but most likely 6 months with a low of 3 months	Likely	Significant	**High**	Likely	Moderate	**Medium**	Triangular	Triangular	Construction	Project Cost	$1,745,863	$4,364,658	$6,983,453	3.0 Months	6.0 Months	12.0 Months	$0	$0	$0	100 %	1	$4,364,658	100 %	6 Mo	The low is the baseline estimate 0f $174,586,323.83 times 101% and total cost of $176,332,187.07 - (the base line estimate of $174,586,323.83) for a total increase of $1,745,863.24. The Likely is the baseline estimate of $174,586,323.83 times 102.5% and total cost of $178,950,981.93 - (the base line estimate of $174,586,323.83) for a total increase of $4,364,658.10. The High variance is the baseline estimate 0f $174,586,323.83 times 104% and total cost of $ 181,569,776.78 - (the base line estimate of $174,586,323.83) for a total increase of $6,983,452.95. The "Cost from Schedule delay" is not modeled in the CSRA, as we prefer to capture the 80% confident schedule in the TPCS project duration that will account for the increase in escalation.

CO 12	Gas lines Relocation	This line will need to be relocated .	Per the PDT this will be addressed by the Gas Company.	Likely	Negligible	**Low**	Unlikely	Negligible	**Low**	Triangular	Triangular	Construction	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	
Estimate and Schedule Risks (ES)																												
ES1	Number of Subcontractor Tiers	The number of subcontractor tiers and associated markups may differ from cost estimate assumptions. Contractual requirements for Small business utilization and/or other requirements may result in additional subcontract tiers.	If the number of subcontractor tiers differs from cost estimate assumptions, then bid costs may exceed the Independent Government Estimate (IGE). The PDT agrees that it is unlikely and is marginal for this to cost risk to occur. The schedule risk is unlikely and the impact is negligible for low risk to cost and schedule.	Unlikely	Marginal	**Low**	Unlikely	Negligible	**Low**	N/A - Not Modeled	N/A - Not Modeled	Cost Engineering	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	
ES2	Construction Schedule	A construction schedule only exists at a high level. A fully integrated, logic driven, critical path method construction schedule has not been developed for this project.	If the construction durations identified in the cost estimates are unreasonable, then costs associated with general conditions (Field Office Overhead) may increase and construction may take longer than anticipated.	Unlikely	Moderate	**Low**	Unlikely	Moderate	**Low**	N/A - Not Modeled	N/A - Not Modeled	Cost Engineering	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	
ES3	Fill Material Properties	Material properties might not be suitable for the construction of an engineered levee.	It was estimated that the majority of required fill for the engineered levee will be obtained from the existing Levee removal. If a percentage of this material is not suitable for the construction for the new levee, then a borrow source would need to be identified. Having a different borrow source will	Unlikely	Moderate	**Low**	Unlikely	Moderate	**Low**	N/A - Not Modeled	N/A - Not Modeled	Cost Engineering	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100 %	1	$0	100 %	0 Mo	

			have a significant impact on the total project cost. The PDT agrees that the quality of the existing material is suitable for construction of new levee and agrees this is very unlikely to occur but the impact would be moderate. Similar is true for schedule impact because of slow production from borrow haul.																									
ES4	Concrete Revetment Mat	The size used in the estimate is smaller than the size and thickness used in the final design.	It is likely that the Articulated mat cost in the estimate will not reflect the actual material cost required in the final design. If the design requires a change it could decrease the material cost by $1.00 but could increase the cost by $2.00 per square foot. The PDT agrees that is likely and is critical to impact the cost. It is unlikely and marginal to impact the schedule.	Likely	Critical	**High**	Unlikely	Marginal	**Low**	Triangular	N/A - Not Modeled	Cost Engineering	Project Cost	$0	$8,350,766	$16,350,794	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100%	1	$8,350,766	100%	0 Mo	The Low is the baseline estimate with no cost increase or decrease to the project. The likely is the increase of material cost by $1.00 this increases the baseline estimate to $182,937,089.63 - (the base line estimate of $174,586,323.83) for a total increase of $8,350,765,80. The High variance is the increase of material cost by $2.00 this increases the baseline estimate to $190,937,117.35 - (the base line estimate of $174,586,323.83) for a total increase of $16,350,793.52.
External Risks (EX)																												

EX1	Market Conditions/Bid Competition	Uncertain future market conditions may result in higher than anticipated cost for the construction contract.	If market conditions at the time of contract acquisition differ from estimate assumptions, then higher or lower than estimated contract costs may be experienced. Some years may bring more aggressive bidding climates which will lower the overall project costs by 3%. Others will offer a less aggressive climate which may drive up the costs by 4%. It is likely given the long duration (16 phases of construction) of the project that overall economic climate will vary and cost impact could be moderate. A marginal impact to the schedule is possible, but unlikely as most of the risk is associated with cost to do the work as opposed to speed of construction. This resulted in a Significant risk for cost and a low risk for schedule.	Likely	Significant	**High**	Possible	Marginal	**Low**	Triangular	N/A - Not Modeled	Cost Engineering	Contract Cost & Schedule	-$4,413,724	$0	$7,061,958	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100%	1	$0	50%	0 Mo	Problems that arise from changes in market conditions either contractor fear of the unknown during performance of this contract or things that happen in the world post contract award and the contractor is able to be compensated. For the LOW variance it is assumed that the current schedule does not change, but that there is a decrease in the cost by $4,413,724.00 (2.5% of construction cost). The likely is the baseline estimate that has a productivity of 100% and total cost of $176,548,959.82 or $0.00. The HIGH variance is that the project construction cost could increase by 4% = $7,061,958.39.
EX2	Stakeholder Influences	Third-party influences, including multiple stakeholders and political interests, may result in schedule delays due to deviations from scope or planned means and methods.	If stakeholder influences result in changes to the project scope or execution plan, then schedule delays may be experienced and/or additional costs may be incurred.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**	N/A - Not Modeled	N/A - Not Modeled	Project Management	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0	$0	100%	1	$0	100%	0 Mo	

EX3	Inadequate Funding or Funding Delay	The project requires a minimum of 16 years of an uninterrupted funding stream. Concern is that the project will have more than 16 phases due to awarding smaller construction contracts due to less funding available.	The project requires completed construction phases that are stand alone in case funding dries up and future work is cancelled. Due to funding constraints the estimate is broken up into phases that break up the entire levee alignment into 16 phases (separate contracts). The assumption is that each phase would have a funding limitation of 20 million. If the funding decreases then the risk of adding additional phases increases. The PDT agrees that it is likely and moderate to impact the cost for example Mob and De-Mob. The PDT agrees that a schedule risk is likely to occur and the impact is moderate, If the funding reduces the project could add approximately 6 phases pushing the schedule out 6 years. . The escalation cost for extending the project schedule will be addressed in the TPCS.	Likely	Moderate	**Medium**	Likely	Moderate	**Medium**	Triangular	Triangular	Cost Engineering	Project Cost & Schedule	$320,000	$480,000	$960,000	24.0 Months	36.0 Months	48.0 Months	$216,974	$325,461	$433,948	100%	1	$805,461	100%	36 Mo	the average cost for Mob & De-Mob per phase is approx. $160k. The Low is 2 years * $160,000.00 = $320,000.00. The Likely is 3 years * $160,000.00 = $480,000.00. The High is 6 years * $160,000.00 = $960,000.00. The "Cost due to Schedule Risk in the model will only capture estimated PED and CM cost increase due to the additional phases. The average cost for PED per phase is $61,992.52. The Low is 2 years * $61,992.52 = $123,985.04. The Likely is 3 years * $61,992.52 = $185,977.56. The High is 4 years * $61,992.52 = $247,970.08. The average cost for CM per phase is $46,494.39. The Low is 2 years * $46,494.39 = $92,988.78. The Likely is 3 years * $46,494.39 = $139,483.17. The High is 4 years * $46,494.39 = $185,977.56. The total Low for schedule PED and CM = $123,985.04 + $92,988.78 = $216,973.82. The total Likely for schedule PED and CM = $185,977.56 + $139483.17 = $325,460.74. The total High for schedule PED and CM = $247,970.08

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EX4	Public Complaints	Local neighbors and/or medical center staff/patients may complain about traffic, noise, dust and/or loss of parking during demolition and construction. Dust is a primary concern.	If public complaints are extensive, then modifications to the contractor's means and methods may be required and result in higher costs or a longer schedule duration.	Likely	Negligible	**Low**	Likely	Negligible	**Low**	N/A - Not Modeled	N/A - Not Modeled	Construction	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0		100 %	1	$0	100 %	0 Mo	
EX 5	Natural Disasters	Extreme weather events may affect the construction of the project.	The project location is prone to extreme weather events that may impact the schedule for the project. Flash floods and wild fires are some of these events that may cause construction delays and increase the cost for the project. Potential exists for significant cost and schedule impact, but the likelihood of such a catastrophic event is	Unlikely	Moderate	**Low**	Unlikely	Moderate	**Low**	N/A - Not Modeled	N/A - Not Modeled	Construction	N/A -Not Modeled	$0	$0	$0	0.0 Months	0.0 Months	0.0 Months	$0	$0		100 %	1	$0	100 %	0 Mo	

			unlikely but it did occur then the impact would be moderate for cost and schedule. Estimate and design assume that the levee is never permitted to be breached during the entire project. Temporary measures must be in place where levee construction is taking place.																									