# LEE COUNTY, FLORIDA

## SHORE PROTECTION PROJECT

## GASPARILLA ISLAND SEGMENT

## Final Integrated Section 934 Report and Environmental Assessment

# APPENDIX B

## Cost Engineering and Risk Analysis

May 2018

US Army Corps of Engineers
Jacksonville District

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## B. COST ESTIMATES

### B1. GENERAL INFORMATION

Corps of Engineers cost estimates for planning purposes are prepared in accordance with the following guidance:

- Engineer Technical Letter (ETL) 1110-2-573, Construction Cost Estimating Guide for Civil Works, 30 September 2008
- Engineer Regulation (ER) 1110-1-1300, Cost Engineering Policy and General Requirements, 26 March 1993
- ER 1110-2-1302, Civil Works Cost Engineering, 30 June 2016
- ER 1110-2-1150, Engineering and Design For Civil Works Projects, 31 August 1999
- ER 1105-2-100, Planning Guidance Notebook, 22 April 2000, as amended
- Engineer Manual (EM) 1110-2-1304 (Amendment 3: Tables revised 30 September 2013), Civil Works Construction Cost Index System, 31 March 2012
- CECW-CP Memorandum For Distribution, Subject: Initiatives To Improve The Accuracy Of Total Project Costs In Civil Works Feasibility Studies Requiring Congressional Authorization, 19 Sep 2007
- CECW-CE Memorandum For Distribution, Subject: Application of Cost Risk Analysis Methods To Develop Contingencies For Civil Works Total Project Costs, 3 Jul 2007
- Cost and Schedule Risk Analysis Process, October 2010

The goals of Cost Engineering for the Lee County, Gasparilla Island Section 934 Report is to present the Total Project Cost (construction and non-construction costs) for the recommended plan at the current price level. This information will be used to determine if a 40-year extension of Federal participation in the Gasparilla Island Segment of the Lee County authorized project is economically justified. In addition, the costing efforts are intended to produce a final product (cost estimate) that is reliable and accurate and that supports the definition of the Government's and the non-Federal sponsor's obligations. The cost estimating effort for the study was coordinated with the economic effort to determine the appropriate nourishment interval based upon annualized costs and benefits. The final cost estimate included in the report was based on construction feature unit pricing and are prepared in Civil Works, Work Breakdown Structure (CWWBS) format to the sub-feature level. This cost estimate supports the National Economic Development (NED) plan - Recommended Plan. This estimate is supported by the preferred labor, equipment, materials and crew/production breakdown. A fully funded (escalated for inflation through project completion) cost estimate, the Baseline Cost Estimate or Total Project Cost Summary, has also been developed. A risk analysis was prepared that addresses uncertainties in and sets contingencies for the Recommended Plan cost items. The Cost Schedule Risk Analysis (CSRA) Report, reviewed by the Cost Engineering Mandatory Center of Expertise (MCX) for Civil Works, is appended to this attachment as Addendum C. The MCX is located at the Walla Walla District Cost Engineering Branch.

### B.1.1 Project Information

The Lee County, Gasparilla Island Project is located at the southern end of Gasparilla Island at the northern end of Lee County, Florida between DNR Reference monuments R10.5 and R-24.5.

The sand source encompasses approximately 425 acres with approximately 3.5 million cubic yards of beach-quality sand available. This volume of material is sufficient to cover the estimated project need of 624,500 cubic yards and 617,200 cubic yards for the next and future nourishment, which will cover the remainder of the project life. Initial construction of the approved project was completed in 2007. The first renourishment was performed in 2013 as part of the Flood Control and Coastal Emergency (FCCE) rehabilitation work following Tropical Storm Debby and Hurricane Isaac in 2012.

Currently, the nourishment interval is set at a 22 year period based upon project cost and benefits. Project limits remain the same and have not changed.

### B.1.2. Recommended Plan

The final Recommended Plan was chosen previously by the Project Delivery Team (PDT) according to Cost Effectiveness/Incremental Cost Analysis procedures resulting directly from plan formulation. The project has since been constructed in 2007 and renourished in 2013. The Economics Appendix fully describes the basis for the development of the project benefits. The scope of work for the project cost estimates can be found in the original project decision document. Additional details can be found within the 2007 contract documents. The Micro-Computer Aided Cost Estimating System (MCACES/MII) cost estimate for the Recommended Alternative Plan (Attachment 3) is based on the scope provided in the main report and is formatted in the CWWBS. The notes provided in the body of the estimate detail the estimate parameters and assumptions. These include pricing at the Fiscal Year 2017. For project identification purposes the estimated costs are categorized under the appropriate CWWBS code and include both construction and non-construction costs.

The construction costs fall under the following feature code:

- 17 Beach Replenishment

The non-construction costs fall under the following feature codes:

- 01 Lands and Damages
- 30 Planning, Engineering and Design
- 31 Construction Management

Cost estimates were completed and updated for this study to account for adjustments resulting from District Quality Control and Agency Technical Review. Unit prices for each major or variable construction element were developed in MCACES/MII. The latest MCACES/MII Cost Book Libraries covering Region III Equipment and Labor adjusted for the project location, have been used for the construction cost estimate. This included use of the latest FCCM rate and past five year average fuel prices (in accordance with current Cost MCX guidance). Dredging unit prices and mobilization/demobilization costs were primarily developed in the Cost Engineering Dredge Estimating Program (CEDEP) and input into MCACES/MII where additional work items were added and markups were applied. Refer to the Economics Attachment of the report for the final Plan Formulation cost tables.

### B.1.3. Construction Cost

The MCACES/MII estimate, located in Addendum 1 below, on the final Recommended Plan contains no contingency as noted in the estimate. Construction cost have been captured under the 17 Beach Replenishment account and include mobilization, demobilization, and preparatory work for hydraulic dredging, beach fill, and associated general items. Associated general items include construction vibration controls and monitoring, beach tilling, turbidity monitoring, remediation of non-compliant material and screening, and removal of unacceptable material. Environmental monitoring has also been accounted for within the estimate.

The project limits extend from R-10.5 to R-24.5. The 17 Beach Replenishment account is to be cost shared between the Federal Government and the Non-Federal Sponsor. Additional information regarding separation in the project cost share structure can be found in the main report and the Economic Appendix.

The contingency was determined as a result of the risk analysis. Contingency has been applied within the Total Project Cost Summary Report located in Addendum D. Additional information is available in Addendum C: Risk Report regarding the risk analysis and major risk factors.

### B.1.4. Non-Construction Cost

Non-construction costs include Real Estate, Planning, Engineering and Design (PED), and Construction Management (Supervision and Administration or S&A). Real Estate costs were provided by the Jacksonville District Real Estate Division. They include administrative costs and are to account for coordination of beach access prior to contract advertisement. Risk associated with lands and damages were considered during the Cost and Schedule Risk Analysis (CSRA).
PED costs are itemized accounting for Project Management, Planning and Environmental Compliance, Engineering and Design, Life Cycle Updates, and Project Operations. Project Operations accounts for the physical monitoring requirements associated with this project. PED costs were provided by the Project Manager based upon submitted fiscal year budgets.
Construction Management costs were acquired from Construction-Operations Division and coordinated with the Project Manager as suggested by the guidance.

A percentage of the construction contract cost is used as the rate for Construction Management costs for the Recommended Plan cost estimate. This percentage is based on actual funds spent for construction management on past contracts.

The main report details both cost allocation and cost apportionment for the Federal government and the Non-Federal sponsor. Also included in the main report are the non-Federal sponsor's obligations (items of local cooperation).

### B.1.5. Construction Schedule

A construction schedule was prepared with input from the PDT. The primary construction period for dredging work was developed within CEDEP and based upon historical contract production. The schedule considered not only durations of individual components but also timing of construction contracts. This schedule was coupled with the project schedule in preparation for the generation of the Total Project Cost Summary as well as for the completion of the risk analysis. The construction schedule will change as design of the project proceeds into the plans and specifications phase. It will change again when the contract is awarded and the contractor provides their official schedule, which may be based on multiple crews with shift work and overtime. The estimate project schedule is provided below as Addendum B.

## B2. RISK ANALYSIS

### B.2.1 Risk Analysis Methods

A risk analysis was conducted according to the procedure outlined in the manual entitled; 'Cost and Schedule Risk Analysis Process' dated January 2016 and downloaded from the Corps' Cost Center of Expertise website. First, members of the PDT met to identify risk items, in both the construction cost estimate and the construction schedule. Then, the Risk Register was completed. Following this, the Risk Model was customized using commercially available "Crystal Ball" software. 'Most likely,' 'high,' and 'low' values were assigned to estimate items using the software's 'Assumption' function. 'Forecasts' were defined and the model was then run to generate the project contingencies.

For the features costed by the Corps, it is assumed that the work will be performed by a prudent contractor at a fair and reasonable cost. While the cost estimate analyzed in the risk analysis may contain adjustments due to quotations on direct and indirect costs, it contains no separate adjustment due to competitiveness or bid strategies (ETL 1110-2-573, 30 Sep 2008). Market conditions such as the current price of fuel are included in the estimate.

After the model was run, the results were documented by extracting the sensitivity chart, the forecast chart, and the percentiles table for major items. The percentiles were used to determine the contingency at the 80% confidence level. At this time, risk reduction efforts were discussed within the Engineering PDT for further discussion.

The appropriate contingencies were then applied to the MCACES/MII estimate for the NED Plan, producing the 'After Risk Analysis' cost estimate contained in Addendum C. Upon completion, the Total Project Cost Summary (TPCS) was prepared incorporating escalation

### B.2.2 Risk Analysis Results

The Final CSRA Report was produced by Jacksonville District with assistance by the Cost Engineering MCX for Civil Works. This report is appended to this attachment as Addendum C. The CSRA resulted in project contingencies of 26 percent. This 26 percent contingency has been applied to the estimated cost of the upcoming renourishment event anticipated for 2028 and the event following in 2042. Additional details of this risk analysis results are provided in Addendum C.

## B3. TOTAL PROJECT COST

### B.3.1. Total Project Cost Summary

The Total Project Cost Summary addresses inflation through project completion (accomplished by escalation to mid-point of construction per ER 1110-2-1302, Appendix C, Page C-2). It is based on the scope of the Recommended Plan and the anticipated project schedule. The TPCS includes Federal and non-Federal costs for lands and damages, all construction features, PED, and S&A, along with the appropriate contingencies and escalation associated with each of these activities. The TPCS also includes cost spent on the project through 30 September 2016, all construction features, PED and S&A. These amounts were provided by the project budget analyst in the form of the project PB3 report. The TPCS is formatted according to the CWWBS and uses Civil Works Construction Cost Indexing System factors for escalation (EM 1110-2-1304) of construction costs and Office of Management and Budget (EC 11-2-18X, 20 Feb 2008) factors for escalation of PED and S&A costs.

The TPCS includes contingency developed as a result of the CSRA. The cost estimate for the Recommended Plan is prepared with an identified price level date. Inflation factors are used to adjust the pricing based upon the project schedule. This estimate is known as the Fully Funded Cost Estimate or TPCS. The TPCS is located below in Addendum D. The CSRA based contingences mentioned above in the paragraph titled "Risk Analysis Results" have been applied within the Total Project Cost Summary.

**B4. COST MCX ATR CERTIFICATION**

# WALLA WALLA COST ENGINEERING MANDATORY CENTER OF EXPERTISE

## COST AGENCY TECHNICAL REVIEW

## CERTIFICATION STATEMENT

For Project No. 113085

SAJ – Lee County, Florida Shore Protection
Gasparilla Segment Section 934

The Lee County Shore Protection – Gasparilla Section 934, as presented by Jacksonville District, has undergone a successful Cost Agency Technical Review (Cost ATR), performed by the Walla Walla District Cost Engineering Mandatory Center of Expertise (Cost MCX) team. The Cost ATR included study of the project scope, report, cost estimates, schedules, escalation, and risk-based contingencies. This certification signifies the products meet the quality standards as prescribed in ER 1110-2-1150 Engineering and Design for Civil Works Projects and ER 1110-2-1302 Civil Works Cost Engineering.

As of January 12, 2017, the Cost MCX certifies the estimated total project cost:

| | | |
|---|---|---|
| FY18 Remaining Costs: | $35,771,000 | (Cost MCX ATR) |
| FY16 Spent Costs: | $18,981,000 | (Provided by SAJ) |
| FY18 Project First Cost: | $54,752,000 | |
| Fully Funded Amount: | $78,288,000 | |

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

CALLAN.KIM.C.1231558221

Digitally signed by CALLAN.KIM.C.1231558221
DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=CALLAN.KIM.C.1231558221
Date: 2017.01.12 08:20:19 -08'00'

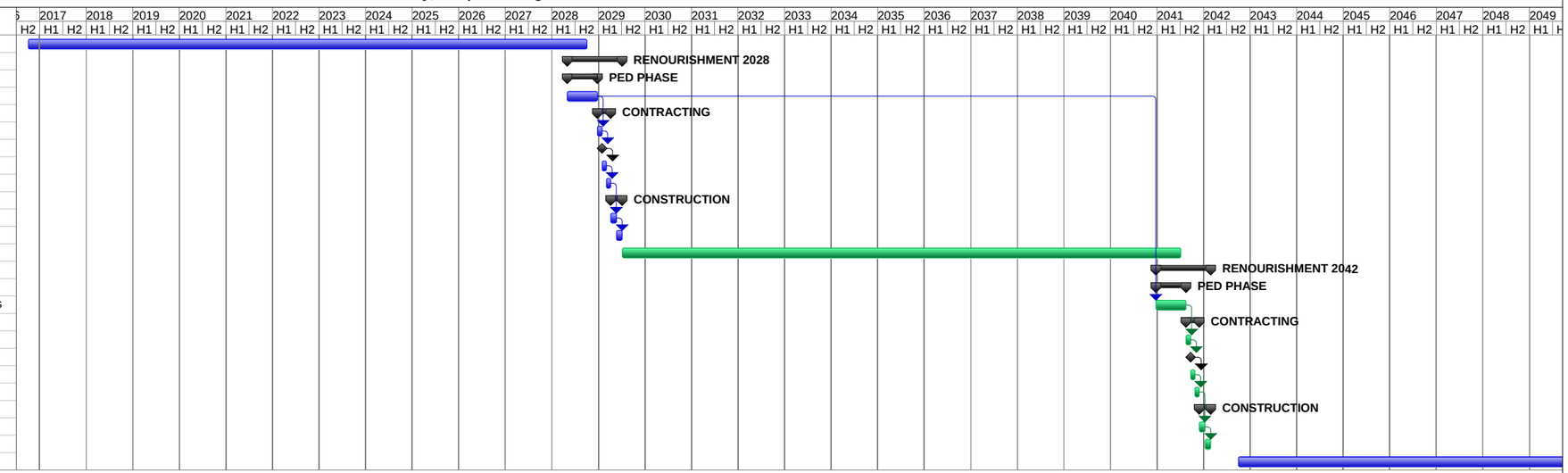
**Kim C. Callan, PE, CCE, PM**
**Chief, Cost Engineering MCX**
**Walla Walla District**

**ADDENDUMS TO APPENDIX B**

## ADDENDUM A: Schedule

# Lee County, Gasparilla Segment SPP

| ID | Task Name | Duration | Start | Finish | Predecessors |
|---|---|---|---|---|---|
| 1 | MONITORING 2016 - 2027 | 4382 days | Sat 10/1/16 | Sat 9/30/28 | |
| 2 | **RENOURISHMENT 2028** | **430 days** | **Mon 5/1/28** | **Thu 7/5/29** | |
| 3 | **PED PHASE** | **236 days** | **Mon 5/1/28** | **Sat 12/23/28** | |
| 4 | P&S Development | 236 days | Mon 5/1/28 | Sat 12/23/28 | |
| 5 | **CONTRACTING** | **104 days** | **Sat 12/23/28** | **Fri 4/6/29** | |
| 6 | Advertise | 37 days | Sat 12/23/28 | Mon 1/29/29 | 4 |
| 7 | Bid Opening | 0 days | Mon 1/29/29 | Mon 1/29/29 | 6 |
| 8 | Award | 34 days | Mon 1/29/29 | Sun 3/4/29 | 7 |
| 9 | Issue NTP | 33 days | Sun 3/4/29 | Fri 4/6/29 | 8 |
| 10 | CONSTRUCTION | 90 days | Fri 4/6/29 | Thu 7/5/29 | |
| 11 | Mobiilzation | 45 days | Fri 4/6/29 | Mon 5/21/29 | 9 |
| 12 | Dredging | 45 days | Mon 5/21/29 | Thu 7/5/29 | 11 |
| 13 | MONITORING 2028-2041 | 4382 days | Fri 7/6/29 | Fri 7/5/41 | |
| 14 | **RENOURISHMENT 2042** | **430 days** | **Sat 12/22/40** | **Tue 2/25/42** | |
| 15 | **PED PHASE** | **236 days** | **Sat 12/22/40** | **Thu 8/15/41** | |
| 16 | P&S Development | 236 days | Sat 12/22/40 | Thu 8/15/41 | 4FS+4382 days |
| 17 | **CONTRACTING** | **104 days** | **Thu 8/15/41** | **Wed 11/27/41** | |
| 18 | Advertise | 37 days | Thu 8/15/41 | Sat 9/21/41 | 16 |
| 19 | Bid Opening | 0 days | Sat 9/21/41 | Sat 9/21/41 | 18 |
| 20 | Award | 34 days | Sat 9/21/41 | Fri 10/25/41 | 19 |
| 21 | Issue NTP | 33 days | Fri 10/25/41 | Wed 11/27/41 | 20 |
| 22 | CONSTRUCTION | 90 days | Wed 11/27/41 | Tue 2/25/42 | |
| 23 | Mobiilzation | 45 days | Wed 11/27/41 | Sat 1/11/42 | 21 |
| 24 | Dredging | 45 days | Sat 1/11/42 | Tue 2/25/42 | 23 |
| 25 | MONITORING 2042-2056 | 2647.38 days | Wed 10/1/42 | Fri 12/31/49 | |




Project: Miami Harbor Ph 3 - CONST S
Date: Fri 12/30/16

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Task | | Rolled Up Task | | Split | | Inactive Task | | Duration-only | | Finish-only | |
| Critical Task | | Rolled Up Critical Task | | External Tasks | | Inactive Milestone | | Manual Summary Rollup | | Progress | |
| Milestone | | Rolled Up Milestone | | Project Summary | | Inactive Summary | | Manual Summary | | Deadline | |
| Summary | | Rolled Up Progress | | Group By Summary | | Manual Task | | Start-only | | | |

**ADDENDUM B: Risk Report**

US Army Corps of Engineers®

# Lee County, Gasparilla Island, Florida

# Section 934 Report

# Project Cost and Schedule Risk Analysis Report

*Prepared by:*

U.S. Army Corps of Engineers,
Jacksonville District

*Supported by:*

U.S. Army Corps of Engineers,
Cost Engineering Mandatory Center of Expertise (MCX) for Civil Works

JANUARY 2017

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**EXECUTIVE SUMMARY**

This Cost and Schedule Risk Analysis (CSRA) Report has been completed by the US Army Corps of Engineers (USACE), Jacksonville District. The CSRA was developed with support by the Cost Engineering Mandatory Center of Expertise (MCX) for Civil Works. The CSRA was reviewed by the MCX during Agency Technical Review (ATR) as part of the Life Cycle Update and FY16 Budget Submission. The CSRA has been modified in response to ATR comments and subsequent revisions. This report presents a recommendation for the total project cost and schedule contingencies for the Lee County Shore Protection Project, Gasparilla Island, Florida. In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated June 30, 2016, a formal risk analysis study was conducted. The purpose of this risk analysis study was to establish project contingencies by identifying and measuring the cost and schedule impact of project uncertainties with respect to the estimated total project cost and project schedule.

Specific to the Lee County, Gasparilla project, the most likely total project cost (at current price level) is approximately $26.9 million. Based on the results of the analysis, the Jacksonville District recommends a contingency value of approximately $6.4 million, or 24.0%. This contingency includes $4.8 million (18%) for risks related to cost and $1.6 million (5.9%) for the effect of schedule delay on overall project costs.

The Jacksonville District Cost Engineering Section performed the risk analysis for this project and the risk analysis has been reviewed, as required, by the MCX, Walla Walla District. A *Monte Carlo* technique was used, producing the aforementioned contingencies and identifying key risk drivers.

The following tables portray the development of the contingencies. The contingency is based on an 80% confidence level, as per USACE Civil Works guidance. The costs presented are rounded and the 80% confidence value may not match the final TPCS. The models developed were based upon the total cost associated with each renourishment including construction costs, PED costs, construction management costs, and annual monitoring and life cycle costs. Cost estimates fluctuate over time. During this period of study, minor cost fluctuations can and have occurred. For this reason, contingency reporting is based in cost and percentage values. Should cost vary to a slight degree with similar scope and risks, contingency percentage values will be reported, cost values rounded. Cost may vary slightly throughout the report based upon rounding and minor changes during the study.

**Table 1. Contingency Analysis Table (Remaining Renourishments)**

| Most Likely Cost Estimate | $27,772,000 | |
|---|---|---|
| **Confidence Level** | **Value ($$)** | **Contingency (%)** |
| 5% | $31,327,153 | 12.80% |
| 50% | $33,449,204 | 20.44% |
| **80%** | **$34,957,501** | **25.90%** |
| 95% | $36,455,955 | 31.27% |

## KEY FINDINGS/OBSERVATIONS RECOMMENDATIONS

For future periodic renourishments, the key cost risk drivers identified through sensitivity analysis were Acquisition Type/Bidding Climate, Quantity Estimates, Equipment availability and Production Estimates, which combined contribute 78.4% of the statistical cost variance. These items are discussed in Section 7.1 Major Findings/Observations.

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

## MAIN REPORT

### 1.0 PURPOSE

This report presents a recommendation for the total project cost and schedule contingencies for the Lee County, Gasparilla Island project.

### 2.0 BACKGROUND

Specific to the Lee County, Gasparilla Island Shore Protection project; located southern end of Gasparilla Island at the northern end of Lee County Florida between DNR Reference monuments R-10 and R-26, the planning level estimate is for excavation of beach quality material and placement of that material on the beach from R-10.5 to R-24.5. This estimate has assumed the use of a large cutter suction dredge with direct pump out of material for the renourishment. The sand source encompasses approximately 425 acres with approximately 3.5 million cubic yards of beach-quality sand available. This volume of material is sufficient to cover the estimated project need of 624,500 cubic yards and 617,200 cubic yards for the next and future nourishment, which will cover the remainder of the project life. Initial construction of the approved project was completed in 2007.

The dredging and beach fill cost was updated for this effort; the assumed plant type of a 30" hydraulic dredge had been previously used on the last contract. Production for the dredge, beach fill, and associated equipment was based on the last beach renourishment contract administered. This contract was completed in 2013. In accordance with the ETL 1110-2-573, Appendix D-4d, the most current version of CEDEP was used as a basis for dredging costs within the total project cost estimate.

As a part of this effort, Jacksonville District has provided an MII estimate and schedule to the MCX for review. An ATR of the cost estimate and schedule for the authorized project has been completed. As part of the ATR, a review of the risk analysis was completed to establish the resulting contingencies.

### 3.1 REPORT SCOPE

The scope of the risk analysis report is to calculate and present the cost and schedule contingencies at the 80% 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, dated June 30, 2016
- Engineer Technical Letter (ETL) 1110-2-573, Construction Cost Estimating Guide for Civil Works, dated September 30, 2008.

The report presents the contingency results for cost risks for all project features. The study and presentation does not include consideration for life cycle costs.

### 3.2 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 most likely Micro Computer Aided Cost Estimating System (MCACES) cost estimate, schedule, and funding profiles using Crystal Ball software to conduct a *Monte Carlo* simulation and statistical sensitivity analysis, per the guidance in (ETL)1110-2-573,.

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

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

### 3.3 USACE Risk Analysis Process

The risk analysis process for this study follows the USACE Headquarters requirements as well as the guidance provided by the 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.
- (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated June 30, 2016.
- Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

### 4.1 METHODOLOGY / PROCESS

The Jacksonville Cost Engineer facilitated a risk identification and qualitative analysis meeting the Jacksonville PDT on July 12, 2016. The initial risk identification meeting also included qualitative analysis

to produce a risk register that served as the framework for the risk analysis. The Jacksonville District Cost Engineer assisted in the creation of the cost and schedule risk analysis models. Cost MCX during ATR provided input and guidance towards the final risk analysis and resulting contingency.

The risk analysis process for this study is intended to determine the probability of various cost outcomes and to quantify the required contingency needed in the cost estimate to achieve any desired level of cost confidence. 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 the 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%- 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% 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, which 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.

Checklists or historical databases of common risk factors are sometimes used to facilitate risk factor identification. However, key risk factors are often unique to a project and not readily derivable from historical information. Therefore, input from the entire PDT was obtained using creative processes such as brainstorming or other facilitated risk assessment meetings.

A formal PDT was held for the purposes of identifying and assessing risk factors. The formal meeting conducted on August 08, 2016 included the following PDT members:

**Table 2. PDT Members**

| No. | Name | Section | Title |
|---|---|---|---|
| 1 | Ricardo Stallings | EN-TC | Cost Estimator |
| 2 | Paul Karch | PD-EC | Environmental Water Quality |
| 3 | Carolina Burnette | PD-PN | Planning |
| 4 | James Lagrone | EN-WC | Coastal Engineer |
| 5 | Laurel Reichold | PM-WN | Project Manager |
| 6 | Jennifer Coor | EN-GG | Geologist |
| 7 | Lori Hadley | EN-WC | Water Quality |
| 8 | Katherine Rivers | RE-A | Real Estate |
| 9 | Frank Fisher | PD-PN | Planning |
| 10 | Meredith Moreno | PD-ES | Economist |
| 11 | Steven Boutelle | N/A | Sponsor (Lee County) |

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. A subsequent meeting was held with the project management and planning on August 11, 2016 to further evaluate risk. In addition, discussions with the project field office were conducted on the risk associated with this project.

### 4.2 Quantify Risk Factor Impacts

The quantitative impacts of risk factors on project plans were analyzed using a combination of professional judgment, empirical data and analytical techniques. Risk factor impacts were quantified using probability distributions (density functions) because risk factors are entered into the Crystal Ball software in the form of probability density functions.

Similar to the identification and assessment process, risk factor quantification involved multiple project team disciplines and functions. However, the quantification process relied more extensively on collaboration between cost engineering and risk analysis team members with lesser inputs from other functions and disciplines. This process used an iterative approach to estimate the following elements of each risk factor:

- Maximum possible value for the risk factor
- Minimum possible value for the risk factor
- Most likely value (the statistical mode), if applicable
- Nature of the probability density function used to approximate risk factor uncertainty
- Mathematical correlations between risk factors
- Affected cost estimate and schedule elements

The resulting product from the PDT discussions is captured within a risk register as presented in Section 6 for both cost and schedule risk concerns. Note that the risk register records the PDT's risk concerns,

discussions related to those concerns, and potential impacts to the current cost and schedule estimates. The concerns and discussions support the team's decisions related to event likelihood, impact, and the resulting risk levels for each risk event.

### 4.3 Analyze Cost Estimate and Schedule Contingency

Contingency is analyzed using the Crystal Ball software, an add-in to the Microsoft Excel format of the cost estimate and schedule. *Monte Carlo* simulations are performed by applying the risk factors (quantified as probability density functions) to the appropriate estimated cost and schedule elements identified by the PDT. Contingencies are calculated by applying only the moderate and high level risks identified for each option (i.e., low-level risks are typically not considered, but remain within the risk register to serve historical purposes as well as support follow-on risk studies as the project and risks evolve).

For the cost estimate, the contingency is calculated as the difference between the P80 cost forecast and the baseline cost estimate. Each option-specific contingency is then allocated on a civil works feature level based on the dollar-weighted relative risk of each feature as quantified by the *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 with- and without-project conditions.

a. The MII MCACES (Micro-Computer Aided Cost Estimating Software) file: "LeeCtyGasparilla_FY16_06JAN17" was the basis for the 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. The schedule was analyzed for impact to the project cost in terms of both uncaptured escalation (variance from OMB factors and the local market) and monthly recurring costs (unavoidable fixed contract costs and/or languishing federal administration costs incurred throughout delay).

d. Per the CWCCIS Historical State Adjustment Factors in EM 1110-2-1304, Amd8 dated 31 March 2016, State Adjustment Factor for Florida is 0.92, meaning that this project is not susceptible to differential between the local market and OMB inflation factors for future construction.

e. The Cost MCX guidance generally focuses on the 80% level of confidence (P80) for cost contingency calculation. For this risk analysis, the 80% 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.

f. 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" for further monitoring and evaluation.

## 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

Table 3 provides the raw construction cost contingencies calculated for the P80 confidence level and rounded to the nearest thousand. The construction cost contingencies for the P50 and P100 confidence levels are also provided for illustrative purposes only.

Contingency was quantified as approximately $6.7 million at the P80 confidence level (24.0% of the baseline cost estimate). For comparison, the cost contingency at the P50 and P100 confidence levels was quantified as 19.0% and 37.0% of the baseline cost estimate, respectively for the remaining periodic renourishments.

**Table 3. Base Cost Contingency Summary**

| Most Likely Cost Estimate | $27,772,000 | | |
|---|---|---|---|
| | | | |
| **Confidence Level** | **Project Cost** | **Contingency** | **Contingency %** |
| 5% | **$31,104,640** | **$3,332,640** | **12.00%** |
| 50% | **$33,048,680** | **$5,276,680** | **19.00%** |
| **80%** | **$34,437,280** | **$6,665,280** | **24.00%** |
| 100% | **$38,047,640** | **$10,275,640** | **37.00%** |

### 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 the *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 life cycle. Together with the risk register, sensitivity analysis results can also be used to support development of strategies to eliminate, mitigate, accept or transfer key risks.

### 6.2.2 Sensitivity Analysis Results

The risks/opportunities considered as key or primary cost drivers are ranked in order of importance in contribution to variance bar charts. Opportunities that have a potential to reduce project cost 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 total project cost.

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

### 6.3 Schedule and Contingency Risk Analysis (Remaining Renourishments)

Table 4 provides the schedule duration contingencies calculated for the P80 confidence level. The schedule duration contingencies for the P50 and P100 confidence levels are also provided for illustrative purposes.

Schedule duration contingency was quantified as approximately 36.9 months for each renourishment activity based on the P80 level of confidence. This contingency was used to calculate the projected monthly recurring cost impact of project delays that are included in the Table 1 presentation of total

cost contingency. The schedule contingencies were calculated by applying the high level schedule risks identified in the risk register for each option to the durations of critical path and near critical path tasks.

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

**Table 4. Base Schedule Contingency Summary**

| **Most Likely Schedule Duration** | **486.0 Months** | | | |
|---|---|---|---|---|
| | | | | |
| **Confidence Level** | **Baseline w/ Contingency** | **Contingency Amount (Months)** | **Schedule Contingency Dollar Amount** | **Contingency %** |
| 5% | **501.8 Months** | **15.8 Months** | **$222,513** | **0.80%** |
| 50% | **514.4 Months** | **28.4 Months** | **$400,524** | **1.44%** |
| **80%** | **522.9 Months** | **36.9 Months** | **$520,221** | **1.87%** |
| 100% | **545.0 Months** | **59.0 Months** | **$832,287** | **3.00%** |

Notes:

1) The schedule was not resource loaded and contained open-ended tasks and non-zero lags (gaps in the logic between tasks) that limit the overall utility of the schedule risk analysis. These issues should be considered as limitations in the utility of the schedule contingency data presented in Table 4.
2) A P100 confidence level is an abstract concept for illustration only, as the nature of risk and uncertainty (specifically the presence of "unknown unknowns") makes 100% confidence a theoretical impossibility.

**Figure 1. Sensitivity Analysis (Baseline Estimate)**

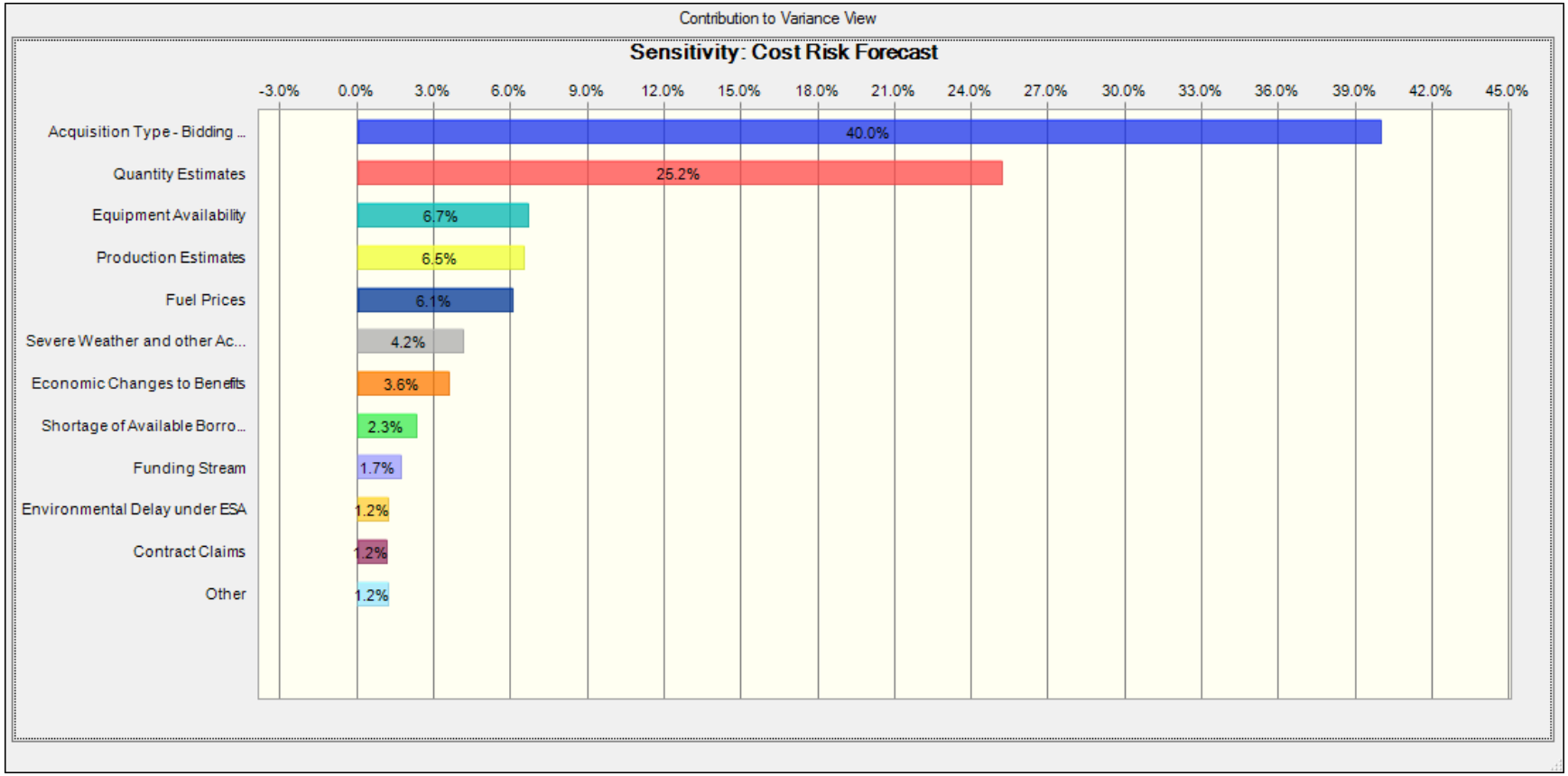
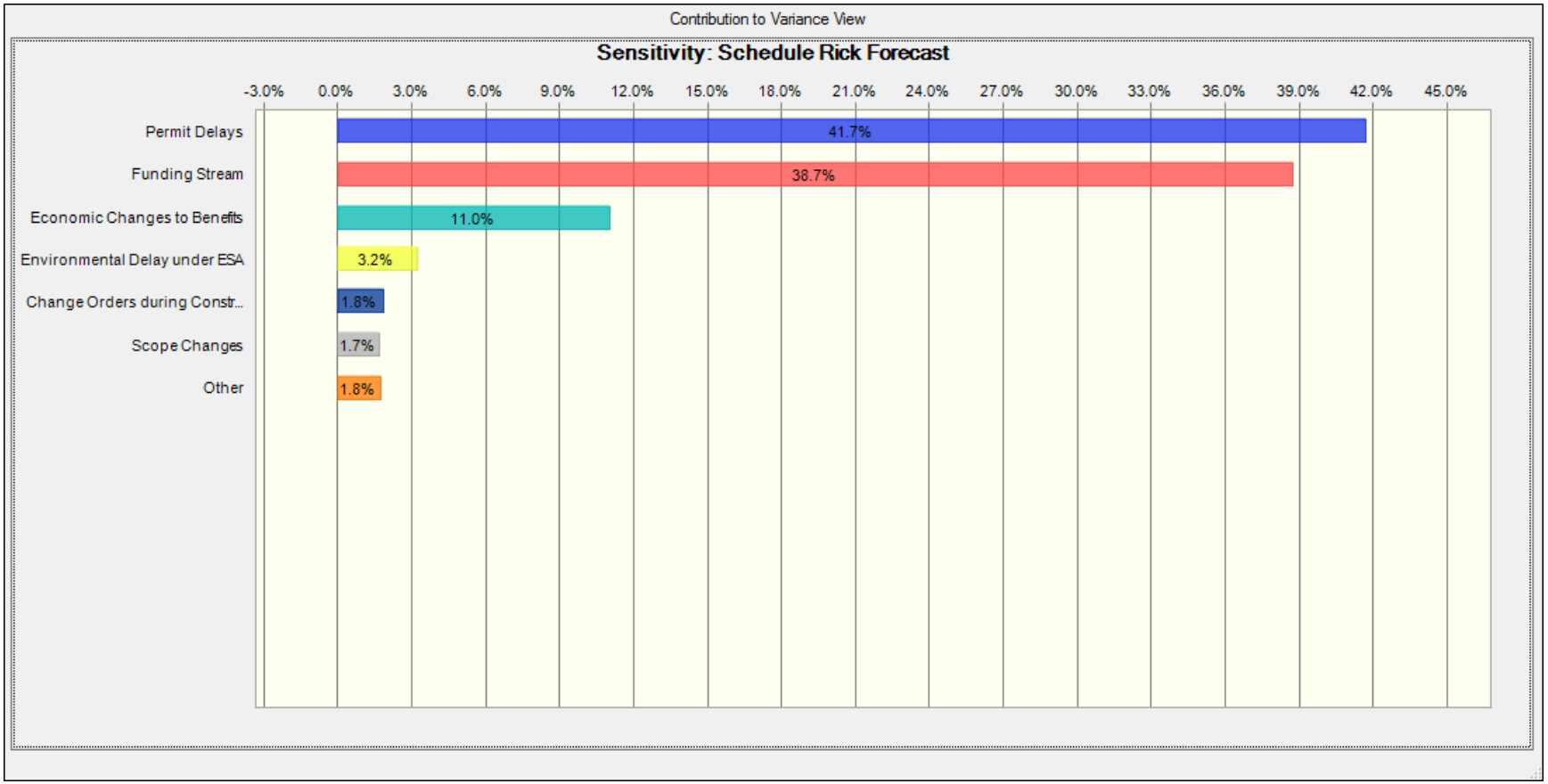


**Figure 2. Sensitivity Analysis (Baseline Schedule)**



## 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

Total project cost comparison summaries are provided in Table 3 and Figures 3 and 4. Additional major findings and observations of the risk analysis are listed below. Refer to the sensitivity chart for a complete list of risk items evaluated and their impact. In addition, the risk registers for each analysis are at the end of this report.

For future periodic renourishments, the key cost risk drivers identified through sensitivity analysis were Acquisition Type/Bidding Climate, Quantity Estimates, Equipment availability and Production Estimates, which combined contribute 78.4% of the statistical cost variance. These items are discussed in further detail within Section 7.2 Recommendations below.

In addition to these key cost risk drivers the following risk item was evaluated as an additional moderate risk:

- Weather: This risk item represents the concern that severe weather could cause damage to the project during construction, resulting in schedule delays.

The key schedule risk drivers identified through sensitivity analysis are Permit Delays and Funding Stream which combined contribute 80.4% percent of the statistical schedule variance. Details identifying the concerns associated with each of these risk drivers and information on how each risk item was modeled is explained in Section 7.2 Recommendations below.

In addition to key schedule risk drivers the following risk items were evaluated as additional moderate risks:

- Economic Changes to Benefits: This risk identifies the concern that BC Ratio could affect priority for receiving needed funds. This is unlikely because of long interval between events funding can be coordinated well in advance. However, if total funding is not provided, additional sponsor coordination may be needed.

**Table 5. Project Cost Comparison Summary**

| Most Likely Cost Estimate | $27,772,000 | | |
|---|---|---|---|
| | | | |
| **Confidence Level** | **Project Cost** | **Contingency** | **Contingency %** |
| 0% | **$29,539,016** | **$1,767,016** | **6.36%** |
| 5% | **$31,327,153** | **$3,555,153** | **12.80%** |
| 10% | **$31,636,147** | **$3,864,147** | **13.91%** |
| 15% | **$31,939,093** | **$4,167,093** | **15.00%** |
| 20% | **$32,237,598** | **$4,465,598** | **16.08%** |
| 25% | **$32,535,843** | **$4,763,843** | **17.15%** |
| 30% | **$32,829,260** | **$5,057,260** | **18.21%** |
| 35% | **$32,846,489** | **$5,074,489** | **18.27%** |
| 40% | **$33,137,215** | **$5,365,215** | **19.32%** |
| 45% | **$33,431,698** | **$5,659,698** | **20.38%** |
| 50% | **$33,449,204** | **$5,677,204** | **20.44%** |
| 55% | **$33,745,716** | **$5,973,716** | **21.51%** |
| 60% | **$34,039,777** | **$6,267,777** | **22.57%** |
| 65% | **$34,058,884** | **$6,286,884** | **22.64%** |
| 70% | **$34,352,804** | **$6,580,804** | **23.70%** |
| 75% | **$34,652,677** | **$6,880,677** | **24.78%** |
| **80%** | **$34,957,501** | **$7,185,501** | **25.90%** |
| 85% | **$35,256,758** | **$7,484,758** | **26.95%** |
| 90% | **$35,574,179** | **$7,802,179** | **28.09%** |
| 95% | **$36,455,955** | **$8,683,955** | **31.27%** |
| 100% | **$38,879,927** | **$11,107,927** | **40.00%** |

Notes:

1) Table taken from Crystal Ball software. Values have been rounded and may not match when calculated.

**Figure 3. Project Cost Summary**

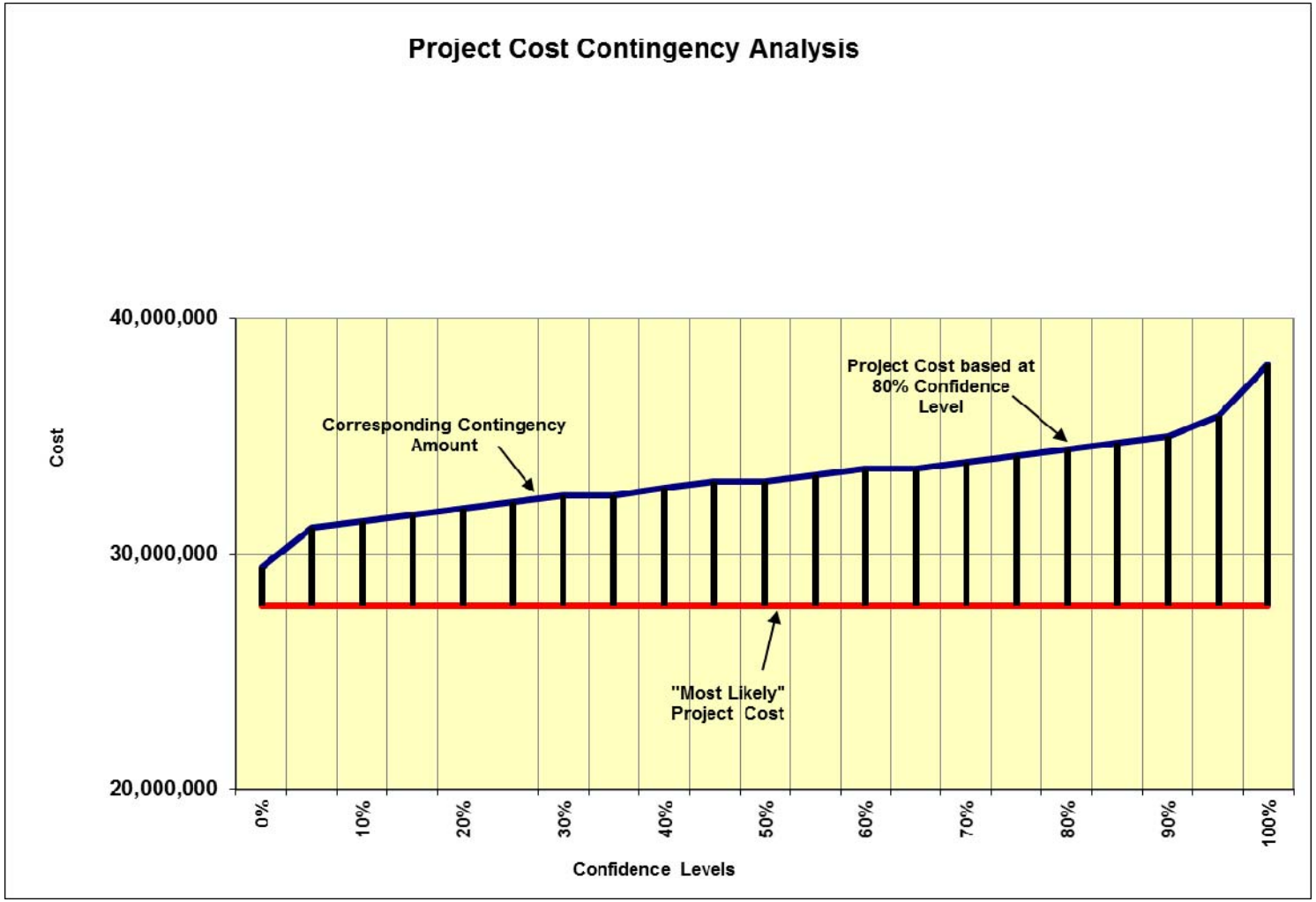
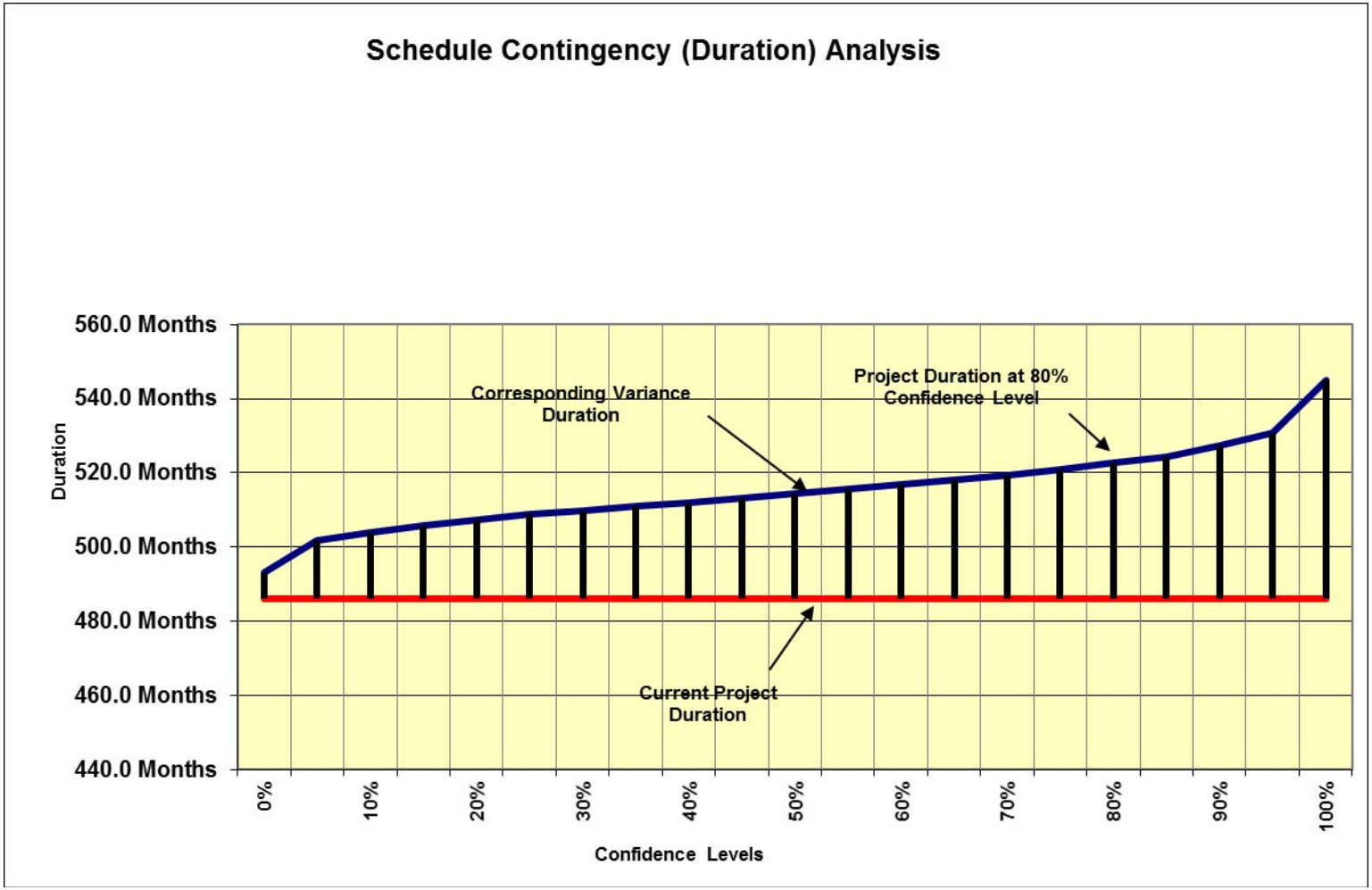


**Figure 4. Project Schedule Summary**



### 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 proactive management of risks does not conclude with the study completed in this report.

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

1. Key Cost Risk Drivers: The key cost risk drivers identified through sensitivity analysis were, Acquisition Type/Bidding Climate, Quantity Estimates, Equipment Availability, Production Estimates and Fuel Prices.

    a. Acquisition Type: Bidding Climate: This risk item represents the concern that multiple contracting methods available could represent uncertainty in contract cost. Also, any risk to cost due to severe economic swings, which could increase/decrease the number of potential bidders. The state of the economy could also impact how that pool of potential bidders prices the project.

    b. Quantity Estimates: This risk item represents the concern that quantities could vary based upon losses during or prior to construction. Quantities changes could result between renourishments due to severe weather, sea level changes, change in erosion rate, etc. The greater quantity variance risks would likely be in the out-years.

    c. Equipment Availability: This risk item represents the availability of the equipment at time of award to perform the contract without incurring contractor impact cost to be pulled from other projects. This can result in limited equipment available can lead to possibly less efficient equipment bidding resulting in higher prices.

    d. Production Estimates: This risk item represents the concern that quantities could vary based upon losses during or prior to construction. The total dredge quantities from the borrow area and placed on the beach include estimated losses that could vary somewhat during construction. Quantities changes could result between renourishments due to severe weather, sea level changes, change in erosion rate, etc. The greater quantity variance risks would likely be in the out-years.

e. Fuel Prices: This risk item represents the concern that fuel prices could increase substantially in the next thirty years. The annual fuel price trend has been somewhat stable the last 3-4 years. The market has experienced some declines recently but some increases are expected in the future. To take a more conservative approach, rather than using the current fuel price a five year average has been utilized based upon coordination with the Cost MCX.

2. Key Schedule Risk Drivers: The key schedule risk driver identified through sensitivity analysis were Permit Delays and Funding Stream.

   a. Permit Delays: This risk item represents the concern for the schedule that could be affected by any permitting delays. Permits are for periods of 10 years with a possible two year extension. An extension would be required and an additional permit for the remainder of the project life. The schedule allows for ample time to acquire permit extensions. This is also unlikely for the schedule, but could be significant if delays are experienced.

   b. Funding Stream: Increasing the difficulty in obtaining funds in a timely manner could have an impact to cost.

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

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

## ADDENDUM C: Total Project Cost Summary

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

**PROJECT:** **Lee County, Florida Gasparilla Segment Section 934**
PROJECT NO: P2 113085
LOCATION: Lee County, FL.

**DISTRICT: SAJ**
**POC: CHIEF, COST ENGINEERING, Matthew Cunningham**

**PREPARED: 12/6/2016**

This Estimate reflects the scope and schedule in report; Gasparilla 934 Study - ATR Engineering Appendix

| Civil Works Work Breakdown Structure | | ESTIMATED COST | | | | PROJECT FIRST COST (Constant Dollar Basis) | | | | | | TOTAL PROJECT COST (FULLY FUNDED) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Program Year (Budget EC): 2018<br>Effective Price Level Date: 1 OCT 17 | | | | | | | | | |
| WBS NUMBER | Civil Works Feature & Sub-Feature Description | COST ($K) | CNTG ($K) | CNTG (%) | TOTAL ($K) | ESC (%) | COST ($K) | CNTG ($K) | **TOTAL ($K)** | Spent Thru: **1-Oct-16** ($K) | **TOTAL FIRST COST** ($K) | INFLATED (%) | COST ($K) | CNTG ($K) | FULL ($K) |
| *A* | *B* | *C* | *D* | *E* | *F* | *G* | *H* | *I* | *J* | | *K* | *L* | *M* | *N* | *O* |
| **17** | BEACH REPLENISHMENT | $21,407 | $5,566 | 26.0% | $26,972 | 1.8% | $21,802 | $5,669 | $27,471 | $16,857 | $44,328 | 42.0% | $30,954 | $8,048 | $55,859 |
| | **CONSTRUCTION ESTIMATE TOTALS:** | $21,407 | $5,566 | | $26,972 | 1.8% | $21,802 | $5,669 | $27,471 | $16,857 | $44,328 | 42.0% | $30,954 | $8,048 | $55,859 |
| **01** | LANDS AND DAMAGES | $420 | $109 | 26.0% | $529 | 1.8% | $428 | $111 | $539 | $0 | $539 | 17.7% | $503 | $131 | $634 |
| **30** | PLANNING, ENGINEERING & DESIGN | $5,645 | $1,468 | 26.0% | $7,113 | 3.6% | $5,849 | $1,521 | $7,369 | $1,987 | $9,356 | 155.0% | $14,916 | $3,878 | $20,781 |
| **31** | CONSTRUCTION MANAGEMENT | $300 | $78 | 26.0% | $378 | 3.6% | $311 | $81 | $392 | $137 | $529 | 123.8% | $696 | $181 | $1,013 |
| | **PROJECT COST TOTALS:** | $27,772 | $7,221 | 26.0% | $34,992 | | $28,389 | $7,381 | **$35,771** | $18,981 | **$54,752** | 65.8% | $47,069 | $12,238 | $78,288 |

**ESTIMATED TOTAL PROJECT COST:** **$78,288**

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**CHIEF, REAL ESTATE,** ~~Audrey Ormerod~~ Tori White

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**CHIEF, OPERATIONS, Carol Bernstein**

**CHIEF, CONSTRUCTION, Steve Duba**

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**CHIEF, CONTRACTING, Timothy Black**

**CHIEF, PM-PB, Karen Smith**

**CHIEF, DPM, Tim Murphy**

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