# APPENDIX C:
# COST ENGINEERING

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## INTRODUCTION

The construction cost estimate for the 2005 RGRR Tamiami Trail modifications selected plan (called Alternative 14) has changed significantly over the last two years. The following table provides a list of cost estimates for the 2005 RGRR Alternative 14 plan, which is the LRR Alternative 4.2.3, a 2-mile western bridge, 1-mile eastern bridge and requisite road raising to accommodate a 9.7 feet stage in the L-29 canal.

**Table 1: List of 2005 RGRR Alternative 14/LRR 4.2.3 Plan Estimates**

| Estimate | Date | Price Level | Construction Cost |
|---|---|---|---|
| **2005 RGRR Alt 14** | August 2005 | FY-05 | $125.1 Million[1] |
| **Alt 14 @ 30 Percent Design** | March 2007 | FY-07 | $277.1 Million[2] |
| **Alt 14/LRR Alt 4.2.3** | April 2008 | FY-08 | $304.6 Million[3] |

Notes:
1. Includes a contingency of 25 percent.
2. Includes a contingency of 25 percent.
3. 90 percent confidence level estimate with escalation to mid-point of construction.

## COST INCREASES FROM THE REVISED GENERAL REEVALUATION REPORT TO THE 30 PERCENT DESIGN

### Increase in Construction Material Prices

Between the RGRR and 30 percent current working estimate (CWE), construction materials price increases added approximately $60 million to the construction cost. Other cost increases include maintenance of traffic and mobilization, both as a result of new survey information, as well as escalation through construction. The RGRR cost estimate did not include escalation through construction, however as the project approaches bid this cost must be incorporated. These other cost increases added approximately $25 million to the overall construction estimate. It is important to note there was no significant scope growth or quantity "busts" as the design progressed to this point, except for some increases in asphalt and embankment quantities as more accurate survey and geotechnical data was obtained.

Pricing in the RGRR was based on FDOT unit pricing, given the nature of this project and its similarity to other FDOT work. The unit prices were adjusted as necessary to account for market conditions. The adjusted unit prices were independently verified by the USACE to ensure accuracy and were validated against bid prices maintained by FDOT. FDOT staff both reviewed the preliminary design a presented in the RGRR and found it technically adequate and consistent with their experiences. In addition, the RGRR estimate was compared with FDOT historic bid prices available in the summer of 2005 and was again found to be consistent.

The 30 percent CWE used actual construction material price quotes received from manufacturers, conversations with FDOT and construction contractors regarding construction methods and equipment. It is important to note that the 30 percent CWE unit prices were based on current estimates of the labor, equipment and materials (forward pricing). FDOT unit prices are based on historic data of actual contract unit prices. When recent FDOT experience is considered, these prices are more closely aligned. While there are different assumptions between the RGRR and 30 percent CWE (i.e., better survey data, current pricing data), no errors or omissions were found in the RGRR estimate. The increased cost estimate is primarily the result of extraordinary market forces that would have affected any construction project similarly.

**Table 2: Florida Statewide Weighted Average Prices** (Fiscal Year)

| Material | Unit | FY 03/04 | FY 04/05 | Change | FY 05/06 | Change | FY 06/07 (Jul-Feb) | Change |
|---|---|---|---|---|---|---|---|---|
| **Earthwork** | CY | $4.73 | $5.66 | +19.7% | $7.93 | +40.1% | $7.43 | -6.31% |
| **Asphalt** | TN | $57.62 | $68.49 | +18.9% | $90.81 | +32.6% | $103.58 | +14.1% |
| **Structural Concrete** | CY | $546.32 | $653.43 | +19.6% | $892.89 | +36.7% | $778.40 | -12.8% |
| **Structural Steel** | LB | $1.51 | $1.34 | -11.3% | $1.68 | +25.4% | $2.08 | +23.8% |
| **Reinforcing Steel** | LB | $0.67 | $0.86 | +28.4% | $0.96 | +11.6% | $0.95 | -1.04% |

**Independent Technical Review and Department of the Interior Cost Estimate**

An Independent Technical Review (ITR) of the 30 percent design CWE was conducted in December 2006 by the Cost Engineering Center of Expertise at Walla Walla District. Overall, the ITR team concluded that the 30 percent design cost estimate accurately captured the anticipated construction costs given the design and market conditions. In addition, an independent construction cost estimate of approximately $254 million was developed for the Tamiami Trail Modifications selected plan by a Department of the Interior (DOI) contractor (revised estimate dated 7 March 2007). This estimate was also based on the 30 percent design completed by the USACE. A technical analysis of the DOI cost estimate identified several differences in scope and engineering assumptions; however the overall conclusions were consistent with the USACE 30 percent CWE these differences were discussed and resolved between the DOI and the USACE in January 2007. It is interesting to note that DOI indicated that the range of accuracy of their estimate is between $216 million and $330 million.

### Risk and Uncertainty Considerations

The cost estimates for the RGRR and the 30 percent design did not include risk and uncertainty analyses. Jacksonville District recognized the need to perform a risk based analysis on the 30 percent CWE, however at the time it was decided to go forward with only the point estimate in order to begin resolving the problem of significant cost growth revealed by the 30 percent CWE. The ITR team also identified several areas of risk and uncertainty that needed to be included in the risk analysis. Combined, these risk elements had the potential to drive the actual construction costs significantly higher and these were evaluated and mitigated as much as possible.

## THE LIMITED REEVALUATION REPORT COST ESTIMATE

### Cost Model

As indicated, the 30 percent design CWE for the Tamiami Trail RGRR selected plan was based on the 30 percent design quantities and estimates on the labor, material (including price quotes from vendors and contractors), and equipment necessary to construct the project. The LRR cost estimate also used the 30 percent design quantities as well as additional information from the 60 percent design geotechnical report plus updated vendor price quotes. In addition, prices and unit costs were validated against FDOT historic bid data for accuracy.

The 2005 RGRR and 30 percent design cost estimates for the RGRR selected plan served as the starting point for the LRR cost estimate for the RGRR selected plan. There were very few changes in the scope of the project since the 30 percent design was complete. The final geotechnical report did provide updated foundation requirements for the eastern and western bridges. The western bridge will require more and longer piles than originally designed, which increased the cost (and schedule) for the project. Using the 30 percent design CWE as a basis, a parametric cost model was constructed to allow various alternatives to be evaluated against each other. This model was based on selecting and structuring cost elements that were common across all the alternatives, establishing unit prices and pro-rating quantities. The parametric model was calibrated to the 30 percent CWE to less than a 2 percent difference.

### Point Estimate and Construction Contingency

The results of the parametric model yielded the “best”, or point, estimate of expected construction cost that is able to be made given the limited information available on the variations of the base alternative, as well as new alternatives where the design information was significantly less than the 30 percent design level. Traditionally, a construction contingency would be added to this cost to cover the elements of the project that are yet to be designed as well as

anticipated variations in quantities and pricing. Construction contingency is not used to anticipate new elements of work or significant variations in scope. Similarly, construction contingency is not used to anticipate market conditions or the impact of extreme events. If these conditions warrant consideration in the construction cost estimate, then they must be accounted for separately. Historically, contingency was assigned to a project based on the level of design in accordance with EM 1110-2-1302. For this LRR, contingency was not applied in the traditional sense.

**Risk and Uncertainty Analysis**

In September 2007, the USACE mandated the use of risk and uncertainty analysis for major civil works projects in Engineering and Construction Bulletin (ECB) Number 2007-17, Application of Cost Risk Analysis Methods to Develop Contingencies for Civil Works Total Project Costs. The bulletin states that "A formal cost risk analysis shall be prepared for all decision documents requiring Congressional authorization for projects exceeding forty million dollars." Further, it states, "During the PED phase, a new cost risk analysis shall be conducted upon major changes in design and for each update in the Total Project Cost Estimate." The bulletin defines the cost risk analysis as "the process of identifying and measuring the cost and schedule impact of project uncertainties on the estimated total project cost. When considerable uncertainties are identified, cost risk analysis can establish the areas of high cost uncertainty and the probability that the estimated project cost will or will not be exceeded. This gives the management team an effective additional tool to assist in the decision-making process associated with project planning and design."

The bulletin does not provide specific guidance on how to conduct the cost risk analysis other than to direct the use of Crystal Ball software. Crystal Ball is a commercial, off-the-shelf software tool that performs risk analyses using Microsoft Excel as a base platform. This, however, is only the tool that facilitated the repetitive computations involved in a Monte Carlo type evaluation. The actual process of "risk analysis" for this project was based on the model in "Guide to Risk Assessment and Allocation for Highway Construction Management", Report No. FHWA-PL-06-032 produced by the Federal Highway Administration. In summary the three main steps were risk identification, quantitative risk analysis (computations) and risk mitigation. This can and should be an iterative process where risks are identified, quantified, mitigated (when possible), and re-evaluated for their effect on project costs or schedules. The process of quantitative risk analysis is not intended to be the goal, it is these results that should be used to focus the PDT's efforts to efficiently and effectively reduce either the cost / schedule, or reduce the probability of undesirable events occurring that would increase either dollars or duration. Keep in mind that reductions in dollars or duration are not the only

goals. A successful risk analysis may actually show an increase in projected cost. The important thing here is to identify these items before they become bad surprises during construction.

**Risk Elements for the LRR**

The cost estimates developed for the LRR was guided by the risk analysis methodology directed in ECB 2007-17. Items that had the most impact on risk were identified as follows: Embankment Fill; Bridge Foundation; Transition Retaining Walls; Temporary Right of Way for Construction; Aggregate and Asphalt Materials; and Asphalt Disposal / Recycling.

The Lake Belt quarry issue has greatly increased the uncertainty associated with the availability and price for aggregate and fill material, as evidenced by the large variation in prices and the hesitancy of many vendors to provide quotes. Oil prices also add uncertainty impacting both fuel and asphalt. Finally, the constraints on right-of-way severely limit potential contractors and forcing them to use costly and inefficient construction methodologies. Since these methods are not fully developed, additional uncertainty is added. Based on these and other concerns, a cost-risk assessment was performed for all of the alternatives included in the LRR matrix using the cost model (based on the 60 percent design CWE for Alternative 14) as a basis for the estimate.

**Major Estimate Assumptions**

The following are the major assumptions for the cost model used to develop the costs in the LRR:

1. Embankment or aggregate materials would be available within a 15 mile radius, including disposal areas.
2. All fill and aggregates would be purchased from a commercial source.
3. Milled asphalt would have to be disposed in a landfill.
4. Retaining walls would be needed for the transition embankments.
5. Asphalt would have to be brought up uniformly across the road cross section in 3 - 4" lifts to allow for uninterrupted traffic flow.
6. Safety and access limitations would make top-down construction of the bridges the prudent method for construction.
7. No utility re-location costs were included.
8. All construction activities (roadway and bridge construction) occur during the same construction period, which is assumed to be 3 years.

**90 Percent Confidence Interval**

The results of the risk and uncertainty analysis is presented as a frequency of occurrences, percentile results, and contribution to variance. Using this

information and considering that the cost identified in this report represents the total authorization limit for this project, the 90 percent confidence level was selected as the appropriate level for the Total Construction Cost (TCC). This means that there is a 90 percent chance that the final cost for this project (at FY-08 pricing levels) will be equal to **or less** than this cost. This is an extremely important point and is different than how USACE project costs have traditionally reported. In the past, USACE civil works projects generally include a cost estimate for authorization and subsequent appropriation from Congress. Congressional authorization allows for inflationary cost increases on the project not to exceed 20 percent (also called the 902 limit). For the Tamiami Trail Modifications project, though, this is not the case since the Modified Water Deliveries project is not subject to 902 limits. As a result, the cost estimate must provide the total budget necessary to complete the project without having to request additional funding short of extreme events (hurricanes, acts of terrorism, etc). The use of a 90 percent confidence level cost estimate, along with future escalation, is meant to ensure that this is the case.

**Market Conditions and Escalation**

Generally, civil works projects are escalated using annual indices in accordance with the Civil Works Construction Cost Index System (EM 1110-2-1304). The indices consider changes in labor, equipment and material costs and are essentially lagging indicators of inflation. The indices are used only for near-term escalation for two years or less. Beyond that timeframe it is necessary to evaluate market conditions. The 90% TCC estimates were escalated to the mid-point of construction, and then adjusted based on recent inflation trends in the construction industry and the anticipated construction schedule for each alternative. Since 2003, there has been unprecedented inflation in the construction industry due to rising oil prices, huge demand from overseas economies, natural disasters, and the continuing globalization of the construction industry. Since 2005, the Producer Price Index for construction inputs has increased at more than three times the rate of the Consumer Price Index (typically used to measure overall inflation). Leading construction economists predict this may be a new trend, not just an anomaly. Therefore, the adjustment rates used for the LRR alternatives (see ***Figure 1***) were greater than typical inflationary rates and provide a relatively conservative estimate for potential cost increases into the future. For the Tamiami Trail Modification project, adjustment was based on historic increases from 2003 to 2007 (see **Figure 2**, ***Figure 3*** and ***Figure 4***) and industry forecasts from groups such as AGC (Association of General Contractors). It is very difficult to predict inflation even one year out let alone 5-10 years.

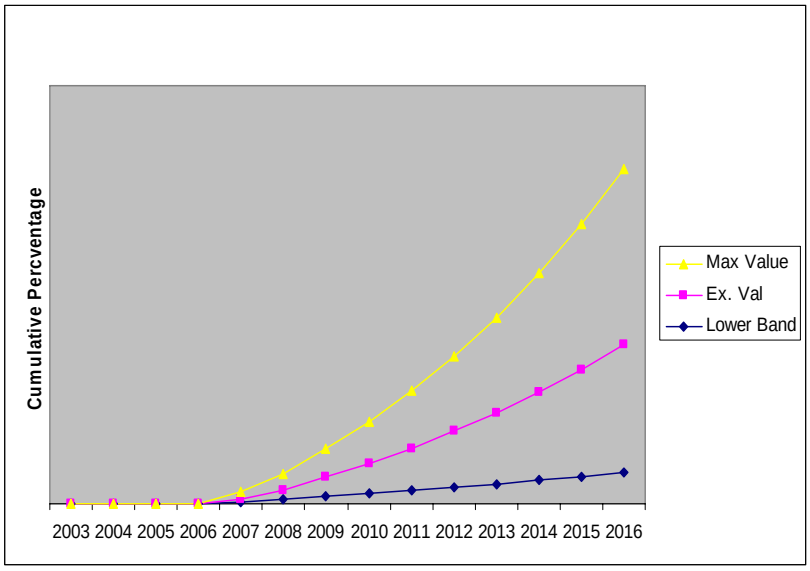


**Figure 1: Market Conditions and Escalation**

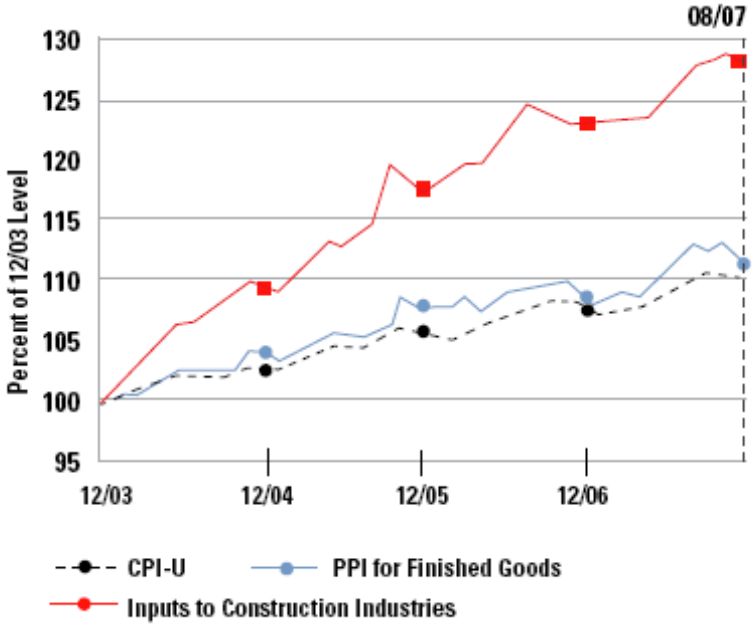


**Figure 2: Cumulative Change in Consumer, Producer, and Construction Price Indices**
**(Source: Association of General Contractors Construction Inflation Alert – Oct 2007)**

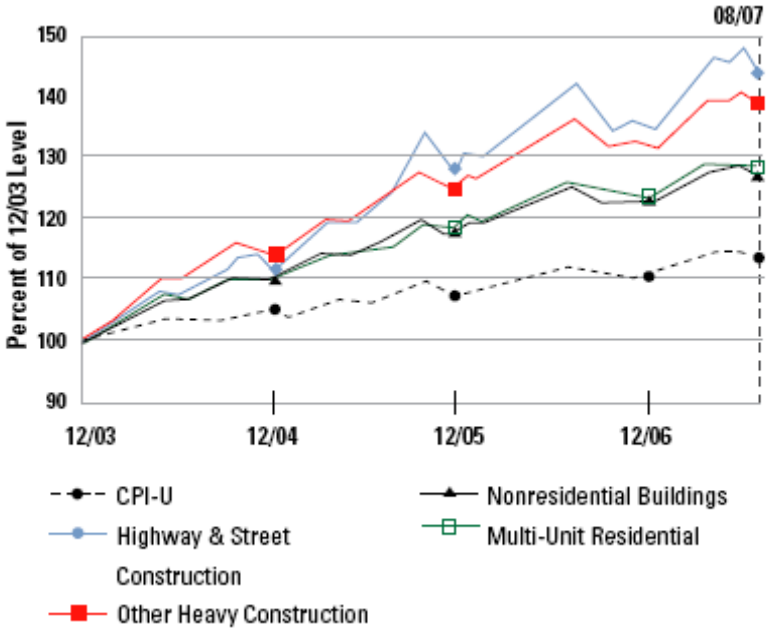


**Figure 3: Cumulative Change in Producer Price Indices for Selected Construction Types**

(Source: Association of General Contractors Construction Inflation Alert – Oct 2007)

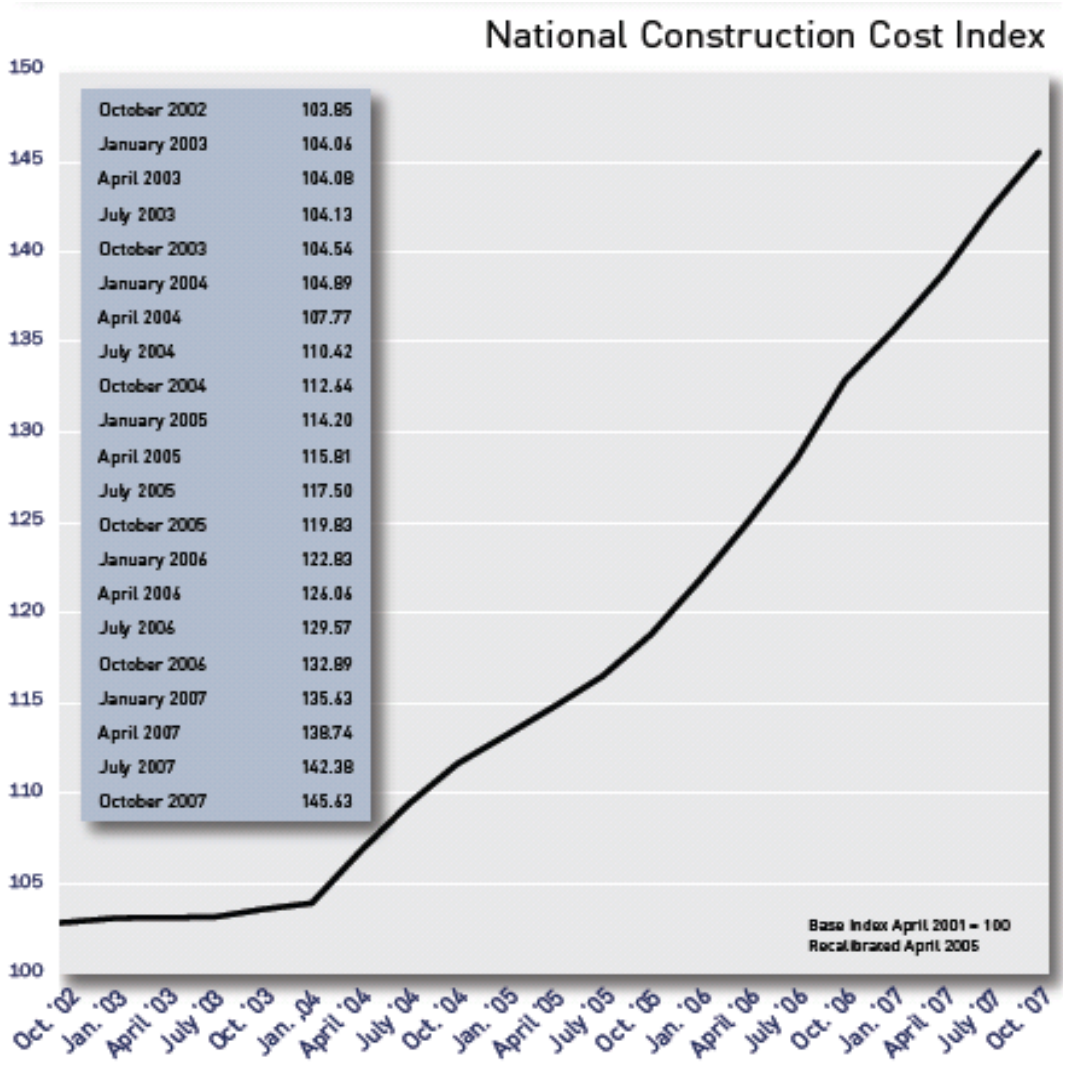


**Figure 4: Change in the National Construction Cost Index from 2002–2007**
(Source: Quarterly Construction Cost Report, 2007 Fourth Quarter Issue -Rider Levett Bucknall)

## Cost Saving Options

In an effort to reduce construction costs and mitigate risk, the following cost saving options were evaluated for the final suite of alternatives. Not all cost saving alternatives are applicable to all alternatives. It is important to note that these alternatives were evaluated using the parametric model built to screen the array of alternatives and that only some of these options have been finalized by the approving agencies. The approximate cost savings shown are for Alternative 3.2.2a and are calculated at the 90% confidence limit:

- Reduce asphalt placement based on revised FDOT criteria received Jan 2008
  -- Savings: ~$20 million (FDOT)

- Additional Temporary RoW for Construction
  -- Savings: ~$10 million (USDOI/ENP)
- Reduction in Low Chord Height for Bridge Inspection
  -- Savings: ~$7 million (FDOT)
- Obtain Fill Material from L-31(N) Spoil Mounds
  -- Savings: ~$6 million (SFWMD/USACE)
- Eliminate Spreader Swales from all Alternatives
  -- Savings: ~$9 million (USACE)

In addition to these options, there is the possibility that the scheduled contract award date can be moved up to Oct 2008. If this is done, an additional $30 million could be saved in future escalation. In addition, it was determined that the assumed level of S&A could be reduced from 10% to 8.5% and still have sufficient funds available for adequate administration of the contract.

**Final Cost Estimate for TSP**

Based on the results of the parametric model, the cost estimate for the TSP, Alternative 3.2.2a, is $325 million (based on a Total Construction Cost @ 90% confidence of $198.8 million plus costs for real estate, future PED, EDS, S&A, and escalation). **This cost can be reduced if the cost saving options discussed above are approved and incorporated into the final plan.** Assuming that these changes are made, the cost of the TSP could be reduced to $226.6 million as follows:

| | |
|---|---|
| Original Construction Cost @ 90% Confidence | $ 198,800,000 |
| - Reduce Asphalt Placement w/ New FDOT Criteria | $ 12,200,000 |
| - Obtain Additional Temporary Right-of-Way | $ 12,000,000 |
| - Reduce Low Chord Elevation | $ 5,200,000 |
| - Obtain Fill from L-31(N) Spoil Mounds | $ 5,900,000 |
| - Remove Spreader Swales | $ 8,700,000 |
| **Revised Construction Cost @ 90% Confidence** | **$ 154,800,000** |
| + Real Estate | $ 5,900,000 |
| + Future PED | $ 1,500,000 |
| + S&A (reduced from 10% to 8.5%) | $ 13,200,000 |
| + EDC (2%) | $ 3,100,000 |
| + Escalation (based on October 2008 Award) | $ 48,100,000 |
| **Total Cost of TSP if all Potential Cost Savings are Implemented** | **$ 226,600,000** |

**Risk Analysis Results for the TSP**

As discussed earlier, a risk analysis was done for all alternatives evaluated in the initial array. This analysis provides a distribution of potential costs based on the uncertainties associated with various components of the project. For the TSP shown in the initial array, the risk analysis produced the cost distribution shown in Table 3.

The major risk factors that influence this alternative include the price of asphalt, suitable fill, pre-stressed concrete piling, AASHTO Beams, concrete for bridge decking, and pre-drilling of piles. Based on discussions with material suppliers and economic forecasts for the construction industry, it is apparent that the volatility in pricing for all of these items comes from either the cost of oil, the availability of fill and aggregate (depending upon the extent of a court order to halt mining in the Lake Belt area of South Florida), or a combination of both oil and fill.

When the cost-saving options are applied to the TSP, some of these risks can be mitigated by either reducing or eliminating the need for some of the more volatile materials. For the TSP estimate assuming incorporation of all cost saving options, the risk analysis produced the cost distribution shown in Table 4.

The major risk factors that influence this alternative include the price of asphalt, pre-stressed concrete piling, AASHTO Beams, concrete for bridge decking, pre-drilling of piles, and asphalt disposal. Although many of the risk factors are the same for both alternatives, the required amount of purchased items such as asphalt and suitable fill has been reduced or eliminated. This reduces both the point estimate as well as the associated risk.

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**Table 3: Alternative 3.2.2a -- Cost-Risk Distribution**

| | Risk Analysis Results | | | |
|---|---|---|---|---|
| | 0.1% Confidence | 50% Confidence | 90% Confidence | 99.9% Confidence |
| Roadway Improvements ** | $ 61,300,000 | $ 66,900,000 | $ 69,900,000 | $ 79,200,000 |
| Bridge - Transitions ** | $ 14,000,000 | $ 15,300,000 | $ 16,000,000 | $ 18,100,000 |
| Bridge - Remove Old Rdwy ** | $ 2,800,000 | $ 3,100,000 | $ 3,200,000 | $ 3,600,000 |
| Bridge - Structure w/ Abutments ** | $ 64,700,000 | $ 70,700,000 | $ 73,800,000 | $ 83,600,000 |
| Other - MOT, Mob, Swales ** | $ 31,500,000 | $ 34,400,000 | $ 35,900,000 | $ 40,700,000 |
| **Total Construction Costs** | **$ 174,300,000** | **$ 190,400,000** | **$ 198,800,000** | **$ 225,200,000** |
| Real Estate | $ 2,000,000 | $ 2,000,000 | $ 2,000,000 | $ 2,000,000 |
| Planning, Engineering & Design | $ 6,500,000 | $ 6,500,000 | $ 6,500,000 | $ 6,500,000 |
| Engineering During Construction (2%) | $ 3,500,000 | $ 3,800,000 | $ 4,000,000 | $ 4,500,000 |
| Supervision & Administration (10%) | $ 17,400,000 | $ 19,000,000 | $ 19,900,000 | $ 22,500,000 |
| Escalation (43.5% based on Oct 2009 Award) | $ 84,900,000 | $ 92,700,000 | $ 96,900,000 | $ 109,700,000 |
| **Total Project Cost** | **$ 288,600,000** | **$ 314,400,000** | **$ 328,100,000** | **$ 370,400,000** |

** The Risk & Uncertainty analysis was calculated for the Total Construction Cost. The distribution of risk across project elements is approximate.

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**Table 4: Alternative 3.2.2a w/ Potential Cost Saving Options -- Cost-Risk Distribution**

| | Risk Analysis Results | | | |
|---|---|---|---|---|
| | 0.1% Confidence | 50% Confidence | 90% Confidence | 99.9% Confidence |
| Roadway Improvements ** | $ 30,400,000 | $ 32,200,000 | $ 33,100,000 | $ 35,800,000 |
| Bridge - Transitions ** | $ 12,500,000 | $ 13,200,000 | $ 13,600,000 | $ 14,700,000 |
| Bridge - Remove Old Rdwy ** | $ 3,500,000 | $ 3,700,000 | $ 3,800,000 | $ 4,100,000 |
| Bridge - Structure w/ Abutments ** | $ 68,400,000 | $ 72,600,000 | $ 74,500,000 | $ 80,600,000 |
| Other - MOT, Mob ** | $ 27,400,000 | $ 29,000,000 | $ 29,800,000 | $ 32,300,000 |
| **Total Construction Costs** | **$ 142,200,000** | **$ 150,700,000** | **$ 154,800,000** | **$ 167,500,000** |
| Real Estate | $ 5,900,000 | $ 5,900,000 | $ 5,900,000 | $ 5,900,000 |
| Planning, Engineering & Design | $ 1,500,000 | $ 1,500,000 | $ 1,500,000 | $ 1,500,000 |
| Engineering During Construction (2%) | $ 2,800,000 | $ 3,000,000 | $ 3,100,000 | $ 3,400,000 |
| Supervision & Administration (8.5%) | $ 12,100,000 | $ 12,800,000 | $ 13,200,000 | $ 14,200,000 |
| Escalation (28.1% based on Oct 2008 Award) | $ 44,100,000 | $ 46,800,000 | $ 48,100,000 | $ 52,000,000 |
| **Total Project Cost** | **$ 208,600,000** | **$ 220,700,000** | **$ 226,600,000** | **$ 244,500,000** |

** The Risk & Uncertainty analysis was calculated for the Total Construction Cost. The distribution of risk across project elements is approximate.

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