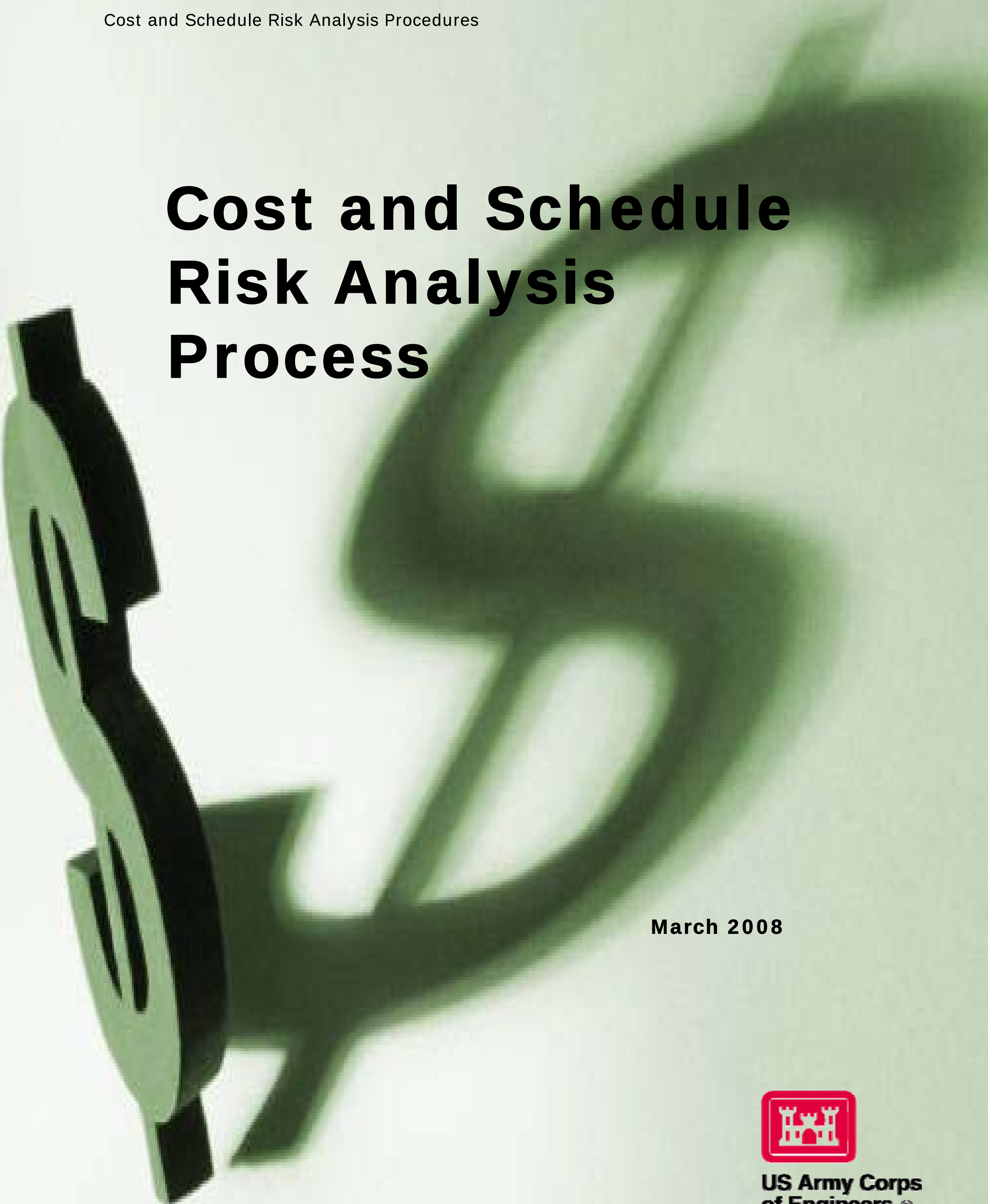
Cost and Schedule Risk Analysis Process



March 2008

US Army Corps of Engineers ®

POC: Kim Callan: (509) 527-7511

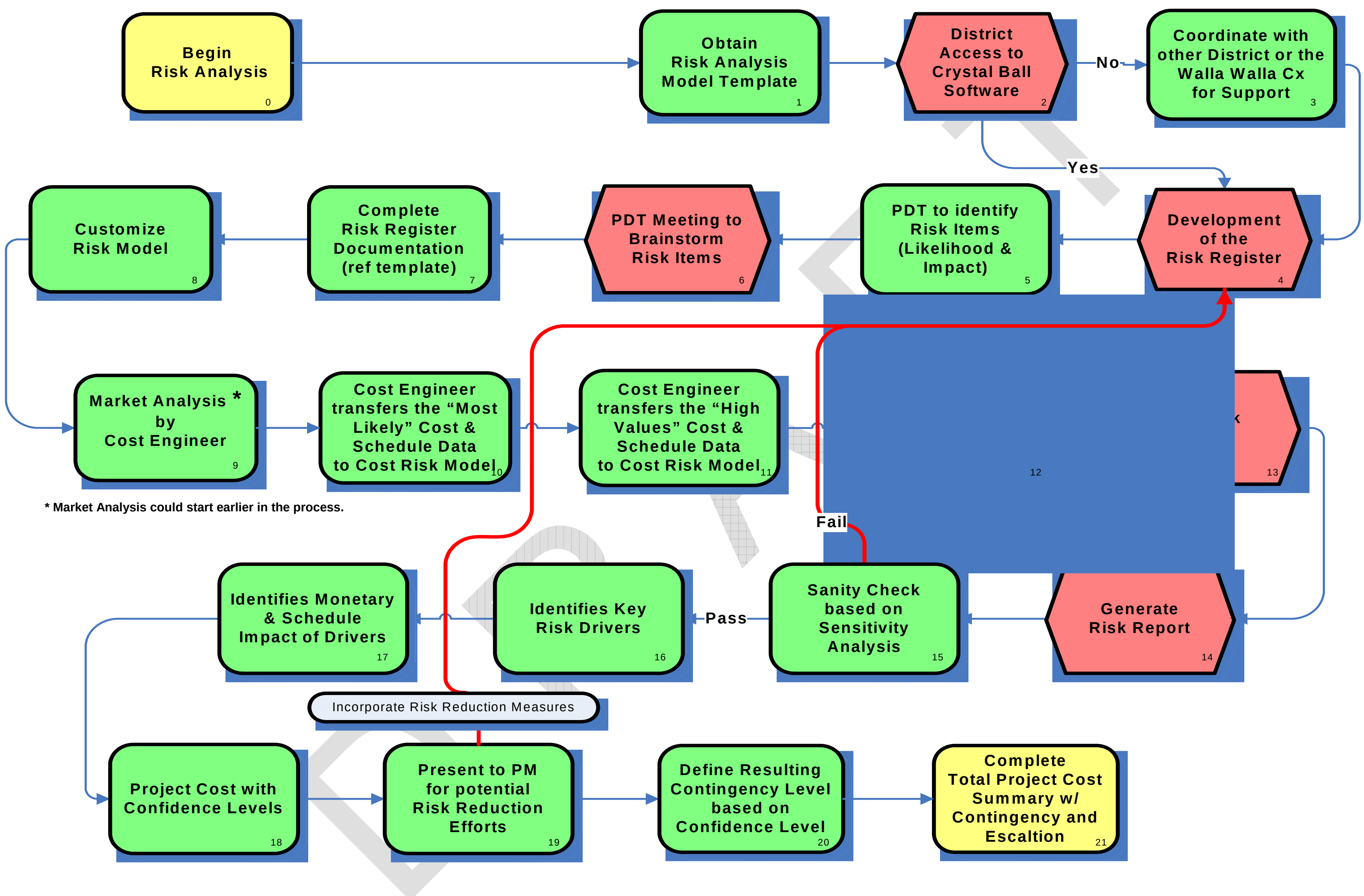


Figure 1 - Cost & Schedule Risk Process

Table of Contents

Cost and Schedule Risk Analysis Process

Risk Analysis Overview

Cost risk analysis is the process of determining the probability of cost and schedule overruns and assigning a studied growth potential as a percentage or a value applied as a contingency. It is a formal process that includes involvement of the PDT, utilizing nationally recognized software based on the Monte-Carlo principles.

A risk analysis should be provided on the Total Project Cost, including all features of the project, but excluding escalation and contingency. Too often, risk focuses on just the construction activities, which can result in critical risk elements remaining unidentified. Through early determination of potential project risks, management can then focus efforts in those areas for potential risk mitigation, resulting in cost and schedule savings. A formal risk analysis should be accomplished as a joint analysis between the Cost Engineer and the other PDT members that have specific knowledge and expertise on all possible project risks for all features, internal risks and external project risks.

Beginning a Cost and Schedule Risk Analysis (CSRA) (Process Box 0)

As part of the project delivery team (PDT), the project manager shall establish a risk analysis member/facilitator, their funding, and delivery schedule. The task of the PDT risk analysis facilitator is to lead the PDT in risk assessment and then produce a Cost and Schedule Risk Analysis (CSRA). CSRA's vary in complexity, with costs ranging from $10,000 - $15,000 on smaller defined projects, to well over $100,000 for large complex projects that require intensive market surveys and cost and schedule analysis. In short, the CSRA begins with assembling members of the PDT to brainstorm the project's risk elements. PDT members who have the responsibility of either defining scope or the development of data would participate in the brainstorming session. Members are likely to include the project manager, risk facilitator, real estate, relocations, environmental, designers, contracting, construction, scheduling and estimating.

Communication is the key, since the cost engineer has based the construction estimate on certain assumptions. Risk elements are any aspects of the project which could cause the cost and/or schedule to vary from the estimators' cost estimate and schedule. The brainstorming sessions typically last 1 day or less, during which the team identifies risk elements, their likelihood, and their potential impacts. The PDT considers internal risks within the project, but also external influences. The outcome of the initial brainstorming session is a preliminary risk register(s) that displays the PDT's perceived risks and impacts to cost and schedule.

After the brainstorming session, the cost engineer will require several days to develop low (best case) and high (worst case) cost and schedule estimates based upon the risk elements identified by the PDT. Additional time may be required to perform local market surveys on key commodities such as fuel, material cost and labor. The studies will identify the actual significance of the risk items and whether they warrant further risk study. At that time, the cost engineer can complete the risk register(s) with the identified risk items and their significance to the subsequent risk analysis. The PDT risk analysis member will need several days to customize the risk model based on the data available for the CSRA. During that period, the cost engineer will assign distribution curves depicting the best, most likely and worst case for each high risk item within the register(s). Once the CSRA model has been developed, run, and the results analyzed, a quality check is made to assure the results are logic-based on model assumptions.

A typical CSRA requires 10 – 15 days to perform. Internal labor costs to perform the risk study would vary but in general $10,000 - $15,000 for the risk analysis PDT member, plus additional costs for the cost engineer and remaining PDT members who have provided support to the risk development effort.

The remainder of this document is an outline of the steps involved in conducting a CSRA (as shown in the flow chart of Figure 1).

Obtain CSRA Template (Process Box 1)

The Corps of Engineers has a standard draft template for CSRA. This template is in Microsoft Excel format, and can be downloaded from the Walla Walla Cost Engineering Center of Expertise (Cx) web page.

District Access to Crystal Ball Software (Process Box 2 & 3)

The CSRA template requires Crystal Ball software in order to conduct a risk analysis. If your district does not have access to this software, you will need to coordinate with another district, A/E cost firm, or the Walla Walla Cost Engineering Cx to support you on the CSRA.

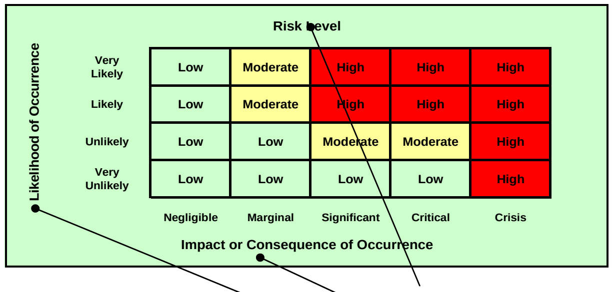
Development of the Risk Register (Process Box 4)

The first of four worksheets which make up the CSRA template is the Risk Register. The Risk Register is a structured approach to communicate potential risk of the program or project and to assign risk potentials.

PDT to Identify Risk Items (Process Box 5 & 6)

The first step in building the Risk Register is for the cost engineer to identify to the PDT the basis of the cost estimate and schedule. The PDT would brainstorm what potential risks items could potentially cause a variance to the cost estimate or schedule would be identified. are associated with the project or program. Drivers which should be discussed, as a minimum, are: bidding climate, saturated local

Risk Register



Risk No.	Risk Event	Likelihood	Impact	Risk Level	Notes
1	Bidding Climate – Saturated Local Market	LIKELY	MARGINAL	MODERATE	$3 Billion construction will be going on in downtown Pittsburgh over the next 5 years.
2	Volatile Real Estate Values	UNLIKELY	NEGLIGIBLE	LOW	Little to no Real Estate to be purchased
3	Scope Definition	UNLIKELY	NEGLIGIBLE	LOW	Scope is well defined, There is minimal likelihood of scope increase or changes from the current documents used for estimate development
4	Scope Growth / Reduction	LIKELY	NEGLIGIBLE	LOW	Scope is well defined, There is minimal likelihood of scope increase or changes from the current documents used for estimate development
5	Weather	LIKELY	MARGINAL	MODERATE	Work will be done on the river, unpredictable, scour protection is more vulnerable
6	Schedule Constraints	LIKELY	SIGNIFICANT	HIGH	There are tight delivery windows that will require mitigation efforts if not met.
7	Labor Availability/Pricing	LIKELY	MARGINAL	MODERATE	$3 Billion construction will be going on in downtown Pittsburgh over the next 5 years.
8	Equipment Availability/Pricing	UNLIKELY	NEGLIGIBLE	LOW	Fuel prices will impact equipment operating costs
9	Material Availability/Pricing	LIKELY	SIGNIFICANT	MODERATE	Fuel prices will impact delivery of materials and the cost of petroleum based materials, steel market still potentially volatile
10	Fuel Prices	VERY LIKELY	SIGNIFICANT	HIGH	$2.65 per gallon was used in the Oct 06 MCACES, increases will effect equipment and delivery or materials
11	Potential savings due to innovation, streamlining, and gains in efficiency	UNLIKELY	NEGLIGIBLE	LOW	Value Engineering has already been incorporated into the project
12	Acquisition Plan	LIKELY	SIGNIFICANT	HIGH	The estimate was based on full and open competition, with minimal tiering of contractor subs. The Acq Plan has not been finalized, therefore there is a potential for additional tiering of the contracts

Figure 2 -Example of a Risk Register

Market, volatile real estate values, scope definition, evolving design changes, weather, schedule constraints, labor availability/pricing, equipment availability/pricing, material availability/pricing, fuel prices, productivity, potential savings due to innovation, streamlining, acquisition strategy and gains in efficiency.

Complete Risk Register Documentation (Process Box 7)

Once the risk events have been identified, the team will then assign a likelihood and potential impact to each event within a preliminary risk register. The Risk Register will identify the high cost and schedule drivers on which the risk model should focus. This will allow the risk model to place emphasis on the events which drive the risk. The team will provide the PDT cost engineer the information required to calculate impacts of the identified driver or event. Once the risk item impacts have been determined for cost and schedule, a final Risk Register can be completed, demonstrating the significant or high risk items that warrant inclusion within the risk model. The final Risk Register is commonly completed by the cost engineer that has performed the estimate and studied the cost impacts through research.

To adequately address risk associated with potential design or original assumption changes, the PDT shall provide enough information for the cost engineer to develop a reasonable cost estimate and schedule to reflect these potential changes. This risk driver, more than any other, demonstrates that the CSRA process is a team tasking. The risk model is only as good as the data provided.

Customize Risk Model (Process Box 8)

Having now completed the first worksheet (the Risk Register) of the CSRA template, the second worksheet (the Risk Model) will need to be customized for the CSRA currently being developed. The Risk Model will include one row for every item to be included in the cost and schedule estimates, and must encompass the full scope of the project. The risk model must address the low (best case) estimate, the most likely estimate and the high (worst case) estimate for those individual items that are deemed significant risks. When developing the best and worst cases, the extremes should not be included because they can skew the results unreasonably. For this reason the best and worst cases are commonly presented as bounded by 20% (best case 20%: worst case 80%) It is highly recommended that the best and worst cases are developed from the most likely estimate. In that way, all estimates reflect the same work breakdown structure and format for comparison purposes. More discussion on this topic follows.

The level of detail of these items, and hence the number of items, should be determined by the PDT risk analysis member working together with the cost engineer. Typically risk that potentially effects the overall estimate by 1% or more would be addressed in the risk model. A standard number of critical risk items under study would approximate 8-12 variables.

The next step would be to assign what are called in Crystal Ball "assumptions" to each risk item. Assumptions are simply probability distributions, e.g., triangular, uniform, binomial, or Bernoulli. The distributions most commonly used in CSRAs are triangle and uniform. The distribution reflects the best, most likely and worst case parameters; thus a triangular distribution is established. It is strongly suggested that someone who has been trained in performing a CSRA customize the Risk Model.

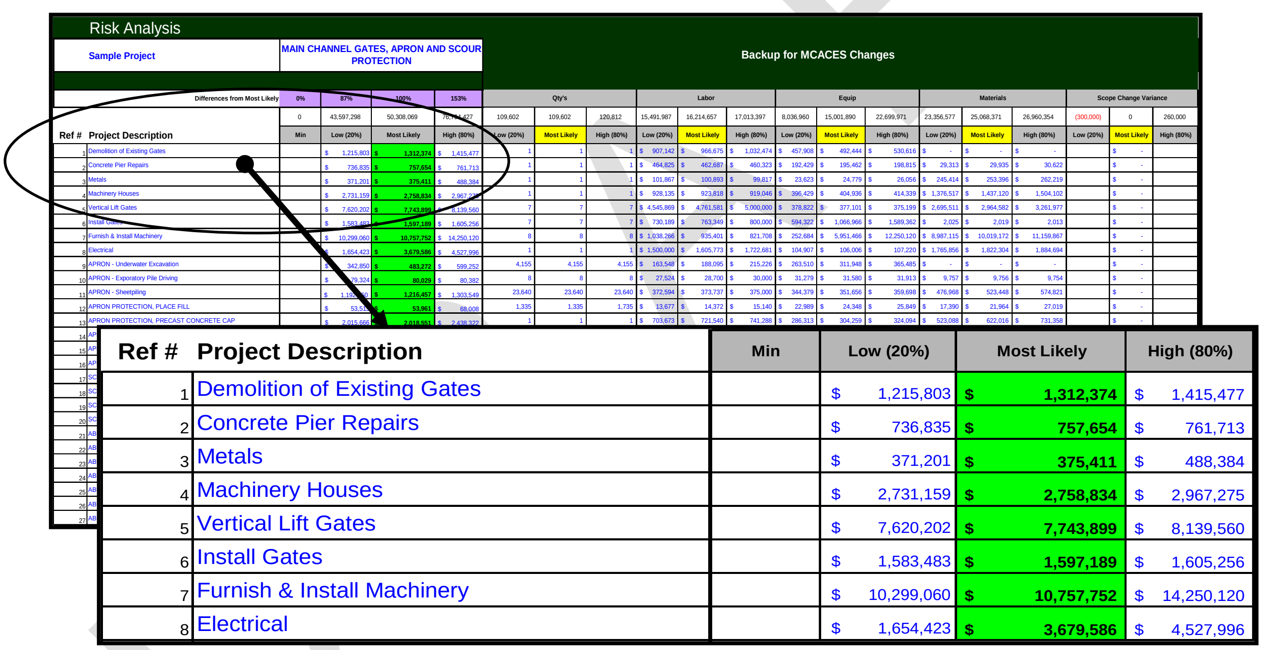
Note that the study includes both a cost and a schedule risk run. Both are treated in a best, most likely and worst case scenario. The results can be displayed as a percentage or as a cost in dollars or schedule by months. The schedule growth can then be converted into a risk escalation and placed as part of the contingency.

Market Analysis by Cost Engineer

To establish the best and worst case estimates, the cost engineer will need to perform a market analysis for the local area on the critical risk items. This would include information such as labor market, construction market, fuel cost, material cost, bidding climate and competition. Some of this effort can begin prior to customizing the risk model, as the market conditions may uncover other risks. Various tools are used for this study, sources such as:

- Historical bid data
- Internet research
- Engineering News Record
- Construction records
- Engineering and Planning
- Real Estate

This process could start at anytime prior to running the risk model. Typically the cost engineer may have already sought current data for the estimate development. For the risk analysis, additional data would be required such as the range of values including high's and lows.



Ref #	Project Description	Min	Low (20%)	Most Likely	High (80%)
1	Demolition of Existing Gates		$ 1,215,803	$ 1,312,374	$ 1,415,477
2	Concrete Pier Repairs		$ 736,835	$ 757,654	$ 761,713
3	Metals		$ 371,201	$ 375,411	$ 488,384
4	Machinery Houses		$ 2,731,159	$ 2,758,834	$ 2,967,275
5	Vertical Lift Gates		$ 7,620,202	$ 7,743,899	$ 8,139,560
6	Install Gates		$ 1,583,483	$ 1,597,189	$ 1,605,256
7	Furnish & Install Machinery		$ 10,299,060	$ 10,757,752	$ 14,250,120
8	Electrical		$ 1,654,423	$ 3,679,586	$ 4,527,996

Figure 3 - Example of Cost Model Input

Transfer the "Most Likely[1]" Cost & Schedule Data to the Risk Model **(Process Box 10)**

[1] "Most Likely" is the cost developed by the cost engineer based on current project data and assumptions.

The cost engineer will transfer data from the escalation and contingency-free cost estimate to the Risk Model's "Most Likely" column (Figure 3). The most likely estimate is the estimate represented within the Total Project Cost Summary as presented within appendix I. The level of detail to be run in the model will vary on a project by project basis, and the cost engineer will be required to communicate with the PDT risk analysis member to establish the level of detail.

Transfer the "High Values" Cost & Schedule Data to Cost Risk Model

(Process Box 11)

The cost engineer will be required to develop the "High Cost" estimate based on the information from the Risk Register. It is important to have clear communications with the PDT risk analysis member to define what the high estimate should reflect. The software program allows the user to customize the model for what the "High" estimate constitutes, In figure 3 the high estimate was based on cost that reflects a 80% chance of covering the item. This is an input that the cost model requires to define the distribution (Figure 3).

Transfer the "Low Values" Cost & Schedule Data to Cost Risk Model

(Process Box 12)

The cost engineer will be required to develop the "Low Cost" estimate based on the information from the Risk Register. It is also important to have clear communications with the PDT risk analysis member to define what the low estimate should reflect. The software program allows the user to customize the model for what the "Low" estimate constitutes. In figure 3 the low estimate was based on cost that reflects a 20% chance of covering the item. This is an input that the cost model requires to help define the distribution (Figure 3).

Schedule Risk Analysis **(Process Box 10,11 & 12)**

A schedule risk analysis uses statistical techniques to predict the level of confidence in meeting a program's completion date. This analysis focuses not only on critical path activities but also on activities near the critical path, since they can potentially affect program status. Like a cost estimate risk and uncertainty analysis, a schedule risk analysis relies on Monte Carlo simulation to randomly vary activity durations according to their probability distributions to develop a level of confidence in the overall integrated schedule. This analysis can provide valuable insight into "what-if" drills and quantify the impact of program changes.

To develop a schedule risk analysis, probability distributions for each activity's duration along and near the critical path have to be established. (The critical path based on the schedule network identifies the specific tasks that will lead to the entire program slipping if not completed on time.) Typically, three-point estimates are used to develop the probability distributions for the duration of workflow activities, including best, most likely, and worst case estimates.

After the distributions are developed, the Monte Carlo simulation is run and the resulting cumulative confidence diagrams display the probability associated with the range of program completion dates. If the analysis is to be credible, the program must have a good schedule network that clearly identifies the critical path and that is based on a minimum number of date constraints.

The risk analysis should also identify which tasks during the simulation most often ended up on the critical path, so that near–critical path activities can also be closely monitored and managed.

One of the most important reasons for performing a schedule risk analysis is that the overall program schedule will always be greater than the sum of the durations for lower-level activities. This is because of schedule uncertainty, which can cause activities to lengthen. When they do, other activities can be affected by network schedule linkages. Lengthening of schedule would cause escalation increases to the estimate.

Such uncertainty is typically brought on by

- a large number of activities and tasks,
- independent parallel tasks that have to finish at the same time,
- the interdependence of two or more tasks,
- work packages lasting longer than 3 months,
- planning packages longer than 6 months, and
- the reflection of a great deal of lag time in the schedule.

Since each activity has an uncertain duration, it stands to reason that the duration of the overall program schedule will also be uncertain. Therefore, unless a statistical simulation is run, the sum of most likely duration distributions will tend to underestimate the overall program critical path duration. Accordingly, because critical path activity durations are uncertain, the probability distribution of the program's total duration must be determined statistically, by adding the individual probability distributions of critical path activities.

To capture the uncertainty for each critical path activity distribution, various estimates must be collected. They should be formulated by a consensus of knowledgeable technical experts and coordinated with the same people who manage the program's risk mitigation watch list. Once the distributions have been established, the Monte

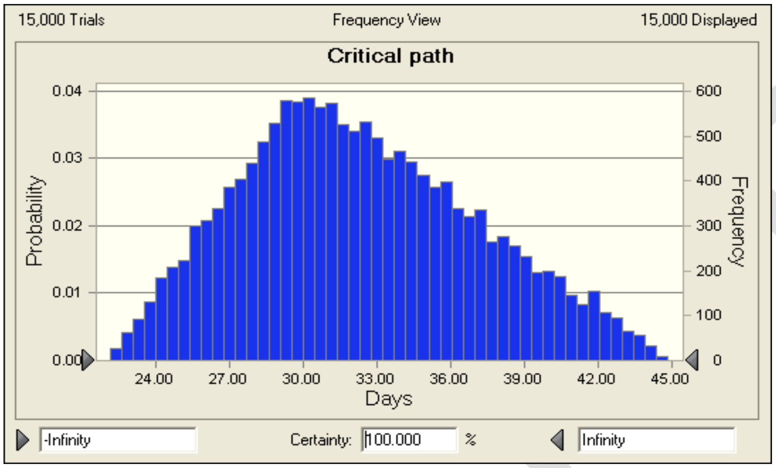


Figure 4 -Example of Critical Path Distribution

Carlo simulation uses random numbers to select specific durations from each critical path activity probability distribution and calculates a new critical path. The Monte Carlo simulation continues this random selection thousands of times, creating a new program duration estimate and critical path each time. The resulting frequency distribution displays the range of program completion dates along with the probabilities that these dates will occur, as seen in figure 7.

The program schedule should satisfy the 11-point schedule assessment listed below. Questions that should be answered during a
schedule risk assessment include

1. Does the schedule reflect all work to be completed?
2. Are the program critical dates used to plan the schedule?
3. Are the activities sequenced logically?
4. Are activity interdependencies identified and logical?
5. If there are constraints, lags, and lead times, what documentation is available to justify the amounts?
6. How realistic are the schedule activity duration estimates?
7. How were resource estimates developed for each activity and will the resources be available when needed?
8. How accurate is the critical path and was it developed with scheduling software?
9. How reasonable are float estimates?

10. Can the schedule determine current status and provide reasonable completion date forecasts?
11. What level of confidence is associated with the program schedule completion date?

Other rules of thumb that can mitigate schedule risk include:

- longer activities should be broken down to show critical handoffs—for example, if a task is 4 months long but a critical hand-off is expected halfway through, the task should be broken down into separate 2-month tasks that logically link the handoff between tasks;
- work packages should be no longer than 2 months so that work can be planned within two reporting periods;
- lag should represent only the passing of time and should never be used to replace a task;
- resources should be scheduled to reflect constraints, such as availability of staff or equipment;
- constraints should be minimized—not to exceed 5 percent—because they impose a movement restriction on tasks and can cause false dates in a schedule; and
- total "float" that is more than 5 percent of the total program schedule may indicate that the network schedule is not yet mature.

Run Model, Interpret Data, and Apply Results

Run Risk Model (Process Box 13)

Once the model has been setup and populated with data, the PDT risk analysis member will run the Risk Model using the Crystal Ball software.

Generate Risk Report (Process Box 14)

After running the risk model, there are several information reports that can be generated to help communicate the areas of cost and schedule risk on the project, and their potential impacts to the project cost development. These reports will enable management to better understand the critical risks that should be closely monitored and managed since they will reflect potential cost and schedule growth.

Sanity Check based on Sensitivity Analysis (Process Box 15)

An important step in the CSRA process is to check to assure the outcome fits a logical result from the data. During the data generation stage, the cost engineer has most likely had to make assumptions while generating model data. After running the Risk Model, the results are available to analyze, and a sanity check of the results is required. The risk result should be commensurate with the PDT confidence, a reflection of the scope development, the estimate quality and the perceived risk impacts. A sanity check may require the team to review previous assumptions for accuracy or engage in risk reduction efforts; keep in mind that the CSRA process typically requires several passes. There is potential that the same or similar risks overly influence the outcome, thereby unreasonably magnifying a risk. An example might be contract acquisition strategy that drives bidding competition. If both are measured separately, an undue exaggeration of risk can result. Other risks can have a similar correlation whereby, if one risk increases, the other must follow. An example might be aggregate, cement, asphalt and concrete. Care must be given to consider and minimize these potentials.

Note: This is not a step to artificially reduce the results. The PM and team must show great resolve to accurately define the risk and potential impacts of the project or to enact risk reduction measures through various means, such as more accurate information or assurance of sound acquisition strategies.

Identify Key Risk Drivers and their Impact (Process Box 16 & 17)

The PDT risk analysis member will be able to generate reports that identify key risk drivers and respective impacts to the project. This will allow management the ability to focus efforts on risk reduction measures for the project. These reports are called tornado charts. A tornado chart is a visual attempt to sort risks in the project (Figure 5).

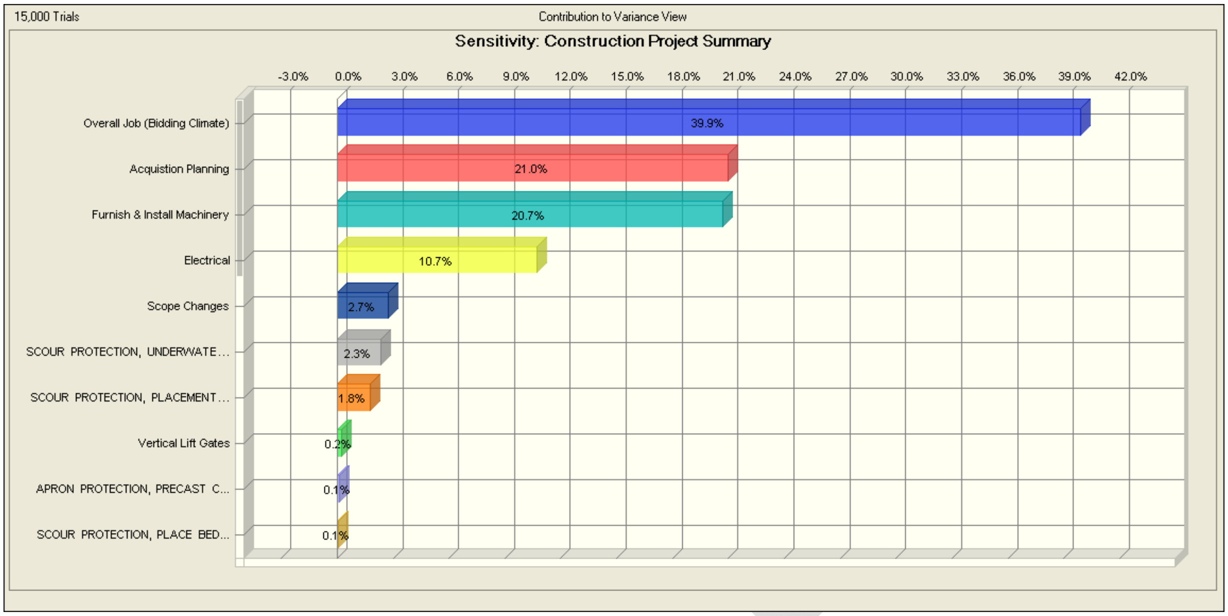


Figure 5 - Example of Sensitivity (Tornado) Chart

Project Cost with Confidence levels (Process Box 18)

The next step is to generate a table which depicts the project cost with corresponding confidence levels. This data is generated from the Risk Model (Figure 6).

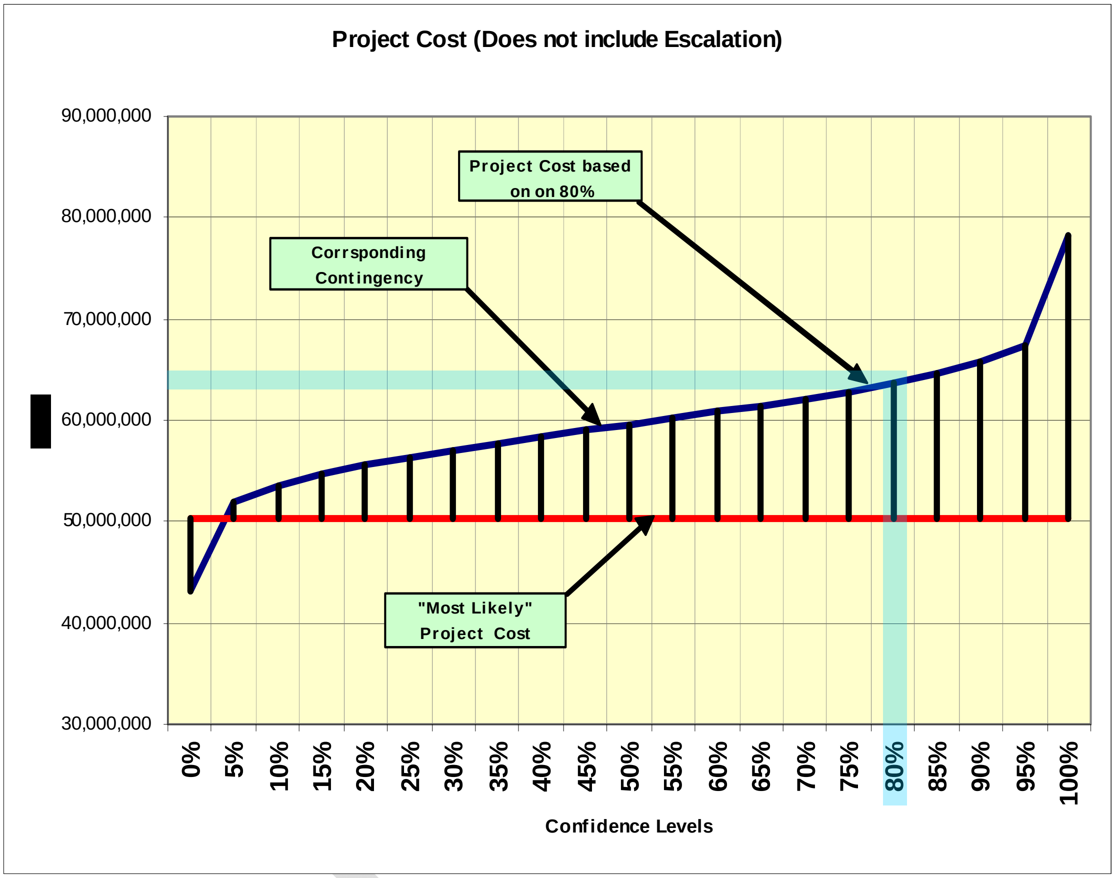


Figure 6 - Project Cost vs. Confidence Levels

Present to PM for Potential Management Risk Reduction Efforts (Process Box 19)

An important outcome of the CSRA is the communication of high risk areas which have a high potential to affect the project cost and/or schedule. When considerable uncertainties are identified, a CSRA 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 another and effective tool in assisting the decision making process associated with project planning and design.

Define Resulting Contingency Levels (Process Box 20)

The next step is to determine what confidence level and associated contingency to report. This is a management decision. The Project Manager will be responsible to direct what confidence level will be used for final contingency develop. Typically, an 80% confidence level is used. However, factors such as how much risk reduction the PDT will be able to generate will factor into this decision. A sample of a Contingency Analysis Table is provided in Figure 7. It is not necessary to carry the values to the nearest dollar.

Contingency Analysis		
Most Likely Cost Estimate		$ 50,308,069
Confidence Level	Value	Contingency
0%	43,155,265	-14%
5%	51,821,453	3%
10%	53,502,697	6%
15%	54,686,375	9%
20%	55,611,609	11%
25%	56,380,494	12%
30%	57,058,654	13%
35%	57,715,962	15%
40%	58,371,325	16%
45%	58,979,742	17%
50%	59,584,456	18%
55%	60,179,500	20%
60%	60,823,452	21%
65%	61,468,369	22%
70%	62,132,732	24%
75%	62,851,176	25%
80%	**63,650,172**	**27%**
85%	64,564,879	28%
90%	65,751,019	31%
95%	67,449,189	34%
100%	78,119,072	55%

Figure 7 - Example of Contingency Analysis Table

Complete Total Project Cost Summary w/ Contingency (Process Box 21)

The last step is to generate the Total Project Cost Summary which identifies base cost by feature, project and construction management costs, contingency cost and escalation cost. The confidence level is decided upon and provide to the cost member through the project manager. The contingency rate is used from the Contingency Analysis Table. Total project cost, including contingency, may differ slightly from the contingency analysis table, since the contingency rate applied is usually rounded. In addition, small changes to the estimate would not require that a complete new risk analysis be run, since the contingency rate is used and should be relative to cost. If significant changes are made to the construction cost estimate or schedule, then a new risk analysis may be required.

Effective Price Level: 15-Jan-01

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)
06	**Fish and Wildlife Facilities**	50,308,069	13,342,103	27%	63,650,172
	CONSTRUCTION ESTIMATE TOTALS:	50,308,069	13,342,103		**63,650,172**

PROJECT: Example Project, XXXXX
LOCATION: West Coast
DISTRICT: Walla Walla
POC: Coug Smith, Chief, Cost Engineering
PREPARED: 16-Aug-07

This Estimate reflects the scope and schedule in feasibility report; Enter the report or document this estimate is based upon.

Estimate Prepared: 14-Aug-07
Effective Price Level: 15-Jan-01
Program Year (Budget EC): 2007
Effective Price Level Date: 1 OCT 07

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
06	**Fish and Wildlife Facilities**	50,308,069	13,342,103	27%	63,650,172	3.2%	51,917,847	13,769,029	65,686,876
	CONSTRUCTION ESTIMATE TOTALS:	50,308,069	13,342,103		**63,650,172**		51,917,847	13,769,029	65,686,876
01	LANDS AND DAMAGES	-	-	-	-		-	-	-
21	RECONNAISSANCE STUDIES								
22	FEASIBILITY STUDIES	50	13	26%	63		52	13	65
30	PLANNING, ENGINEERING & DESIGN	13,331,639	3,332,910	25%	16,664,549		13,758,231	3,439,556	17,197,787
31	CONSTRUCTION MANAGEMENT	7,294,670	1,823,668	25%	9,118,338		7,528,088	1,882,022	9,410,110
	PROJECT COST TOTALS:	70,934,428	18,498,694	26%	**89,433,122**		73,204,218	19,090,620	92,294,838

TOTAL PROJECT COST ESTIMATE

WBS NUMBER	Spent Thru: ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
06	-	10.8%	55,741,819	14,783,177	70,524,996
	0		55,741,819	14,783,177	70,524,996
01	-		-	-	-
21	**100,000**				100,000
22	-		52	14	66
30	-		14,306,681	3,576,672	17,883,353
31	-		8,082,564	2,020,642	10,103,206
	100,000		78,131,116	20,380,505	**98,611,621**

CHIEF, COST ENGINEERING
Project Management, {Enter PM Name}
CHIEF, REAL ESTATE
CHIEF, PLANNING
CHIEF, ENGINEERING
CHIEF, OPERATIONS
CHIEF, CONSTRUCTION
CHIEF, CONTRACTING
CHIEF, PM-PB
CHIEF, DPM

ESTIMATED FEDERAL COST: **98,611,621**
ESTIMATED NON-FEDERAL COST: -
ESTIMATED TOTAL PROJECT COST: 98,611,621

Figure 8 - Example of Total Project Cost Sheet

Risk Register Checklist

Provided here is a checklist of risk items for consideration when performing a risk analysis. Of critical importance is consideration of all feature accounts as presented within the civil works breakdown structure.

FEATURE CODE	DESCRIPTION
01	Lands And Damages
02	Relocations
03	Reservoirs
04	Dams
05	Locks
06	Fish And Wildlife Facilities
07	Power Plant
08	Roads, Railroads, And Bridges
09	Channels And Canals
10	Breakwaters And Seawalls
11	Levees And Floodwalls
12	Navigation Ports & Harbors
13	Pumping Plants
14	Recreation Facilities
15	Floodway Control-Diversion Structure
16	Bank Stabilization
17	Beach Replenishment
18	Cultural Resource Preservation
19	Buildings, Grounds, & Utilities
20	Permanent Operation Equipment
30	Planning, Engineering And Design
31	Construction Management

1. Engineering and Construction Management Risk Document Checklist.

Risk management reports vary depending on the size, nature, and phase of the project. The following are examples of risk management documents and reports that may be useful:

- Risk management plan
- Risk information form
- Risk assessment report
- Risk handling priority list
- Risk handling plan of action
- Aggregated risk list

- Risk monitoring documentation:
  - Project metrics
  - Technical reports
  - Earned value reports
  - Watch list
  - Schedule performance report
  - Critical risk processes reports

2. The following items are a composite of several checklists from various agencies. They have been tailored to better address the more common USACE civil works project risks. The list, though not all encompassing provides a valuable tool, meant to serve as an aid in PDT discussions of potential risk items for a specific project.

Organizational Risks
- ❑ Inexperienced staff assigned
- ❑ Losing critical staff at crucial point of the project
- ❑ Insufficient time to plan
- ❑ Unanticipated project manager workload
- ❑ Internal red tape causes delay getting approvals, decisions
- ❑ Functional units not available or overloaded
- ❑ Priorities change on existing program

Project Management Risks
- ❑ Project purpose and need are poorly defined
- ❑ Project scope definition is poor or incomplete
- ❑ Project scope, schedule, objectives, cost, and deliverables are not clearly defined or understood
- ❑ No control over staff priorities
- ❑ Timely response to critical decisions
- ❑ Consultant or contractor delays
- ❑ Estimating and/or scheduling errors
- ❑ Unplanned work that must be accommodated
- ❑ Communication breakdown with project team
- ❑ Pressure to deliver project on an accelerated schedule
- ❑ Lack of coordination/communication
- ❑ Inexperienced workforce/inadequate staff/resource availability
- ❑ Local agency issues

Contract Acquisition Risks
- ❑ Undefined acquisition strategy
- ❑ Preference to SBD and 8(a) contracts
- ❑ Strategy decreasing competition
- ❑ Acquisition strategy results in higher scope risk (Design Build)

Technical Risks
- ❑ Design development stage, incomplete or preliminary

- ❑ Confidence in critical quantities
- ❑ Innovative designs, highly complex or prototypes
- ❑ Right-of-way analysis in error
- ❑ Environmental analysis incomplete or in error
- ❑ Unknown geotechnical issues
- ❑ Inaccurate assumptions on technical issues in planning stage
- ❑ Surveys late and/or surveys in error
- ❑ Subsurface information for in-water work
- ❑ Structural designs incomplete or in error
- ❑ Hazardous waste site analysis incomplete or in error
- ❑ Need for design exceptions
- ❑ Consultant design not up to department standards
- ❑ Context-sensitive solutions
- ❑ Dredge Estimate equipment and quantities

Lands and Damages

- ❑ Real Estate defined
- ❑ Real Estate acquisition
- ❑ Objections to right-of-way appraisal take more time and/or money
- ❑ Freeway agreements
- ❑ Railroad involvement
- ❑ Relocations identified
- ❑ Utility impacts identified
- ❑ Relocations may not happen in time
- ❑ Environmental mitigation identified
- ❑ Quality of L&D estimates as "most likely" case
- ❑ Hidden estimate/schedule contingencies

Regulatory Risks

- ❑ Water quality regulations change
- ❑ New permits or new information required
- ❑ Reviewing agency requires higher-level review than assumed

Environmental Risks

- ❑ Define initial project environmental impacts
- ❑ Environmental investigations
- ❑ Environmental permits
- ❑ Permits or agency actions delayed or take longer than expected
- ❑ Environmental regulations change
- ❑ Reviewing agency requires higher-level review than assumed
- ❑ Lack of specialized staff (biology, anthropology, archeology, etc.)
- ❑ Historic site, endangered species, or wetlands present
- ❑ Project in an area of high sensitivity for paleontology
- ❑ Project in the Coastal Zone
- ❑ Project on a Scenic Highway, state or national park

- ❑ Project does not conform to the State implementation plan for air quality at the program and plan level
- ❑ Environmental and Water quality issues
- ❑ Negative community impacts expected
- ❑ Hazardous waste preliminary site investigation required
- ❑ Pressure to compress the environmental schedule

Construction Risks

- ❑ Accelerated contract schedule
- ❑ Inefficient contractor
- ❑ Subcontractor capabilities
- ❑ Conflicts with other contracts
- ❑ Innovative project construction
- ❑ Timely delivery of critical GFE
- ❑ Permits, licenses, submittal approvals
- ❑ Permit and environmental work windows
- ❑ Environmental restrictions (equipment use, exhaust, paint)
- ❑ Site access / restrictions (highways, bridges, dams, water, utilities)
- ❑ Adequate staging areas
- ❑ Rural locale
- ❑ Inadequate skilled trades labor force
- ❑ Inadequate housing/utilities to support labor force
- ❑ Special equipment
- ❑ Material availability
- ❑ Productivity of critical items
- ❑ Unexpected escalation on key materials
- ❑ Critical fabrication and delivery
- ❑ Unknown utilities
- ❑ Survey information
- ❑ In-water work
- ❑ Control and diversion of water
- ❑ Differing site conditions
- ❑ Unidentified hazardous waste

External Risks

- ❑ Adequacy of project funding (incremental or full funding)
- ❑ Priorities change on existing program
- ❑ Local communities pose objections
- ❑ Political factors change
- ❑ Stakeholders request late changes
- ❑ New stakeholders emerge and demand new work
- ❑ Influential stakeholders request additional needs to serve their own commercial purposes
- ❑ Political opposition / threat of lawsuits
- ❑ Stakeholders choose time and/or cost over quality

- ❑ Market conditions and bidding competition
- ❑ Labor disruptions
- ❑ Acts of God (flooding or hurricane)