Washington State
Department of Transportation

Project Risk Management Guide

Part I: Guidance for WSDOT Projects

Part II: Guidelines for CRA-CEVP® Workshops

February 2018

Engineering and Regional Operations
Development Division, Design Office, SAEO

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Foreword

The future is uncertain. It is certain that these three questions will be asked about our projects: (1) How much will it cost? (2) How long will it take? And, of course - Why? (Why that much and why that long?)

These questions, posed in the future tense, seek to predict an uncertain future. Because the future is uncertain, the fundamental answer to these questions is that ***an estimate is best expressed not as a single number, but a range***. To determine an estimate range for both cost and schedule, risk and uncertainty must be measured.

> *What gets us in trouble is not what we don't know. It's what we know for sure that just ain't so.*
>
> ~ Mark Twain

Inaccurate cost estimating has vexed transportation projects for years. A noted study by B. Flyvbjerg on the results of transportation project estimating found that, for the past 70 years, the cost of transportation projects has been consistently underestimated in many parts of the world, including the U.S.

Estimates have two components: the ***base cost*** component and the *risk* (or uncertainty) component. Base cost is defined as the likely cost of the planned project if no significant problems occur. Once the base cost is established, a list of uncertainties is created of both opportunities and threats, called a "risk register." The risk assessment replaces general and vaguely defined contingency with explicitly defined risk events and with the probability of occurrence and the consequences of each potential risk event. Scope control is necessary for project management and estimating. Cost estimates are reviewed and validated, and a base cost for the project is determined.

Project risk management is a scalable activity and should be commensurate with the size and complexity of the project under consideration. Less complicated projects may utilize qualitative analyses. Larger, more complex projects may wish to use more robust analytical techniques such as Monte Carlo simulation models.

The guidance in this manual has been developed by the Strategic Analysis and Estimating Office (SAEO) in alignment with the goals of the Statewide Program Management Group. This document would not have been possible without the contributions of dozens of key WSDOT people who participated in the development and review of these guidelines. Credit is also due to many of the consultant partners, academics, and others who continually advance the cause of project risk management in the transportation industry.

Comment Form

Your feedback and input are appreciated.

From: _____ Date: _____

_____ Phone: _____

_____

To: WSDOT Headquarters
Development Division, Design Office
Attn: Strategic Analysis and Estimating Office
Mailstop 47330 – PO Box 47330
Olympia, WA 98501-7330

Subject: Comments about the *Project Risk Management Guide*

Comment (marked copies attached):

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Contents

Part II: Guidelines for CRA-CEVP® Workshops

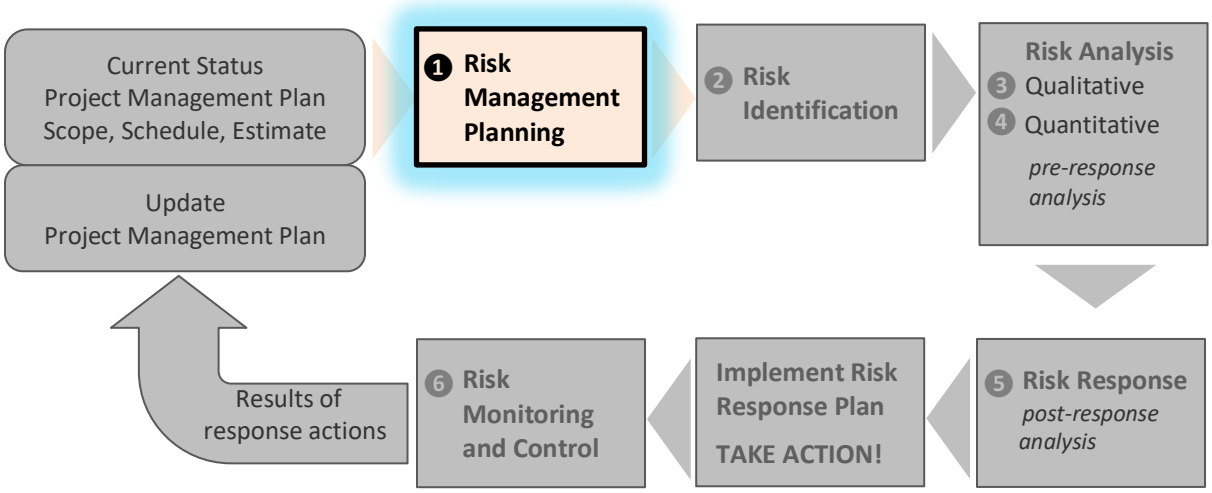
List of Exhibits

Part I: Guidance for WSDOT Projects

Part II: Guidelines for CRA-CEVP® Workshops

Part I:
Guidance for WSDOT Projects

Chapter 1 Project Risk Management Planning



1-1 Project Risk Management Overview

This document provides information to Project Managers, project teams, and staff involved directly or indirectly with project risk management. It provides:

- Uniformity in project risk management activities.
- Techniques and tools for project risk management.
- Data requirements for risk analysis input and output.
- The project risk management role in overall project management.
- Guidance on how to proactively respond to risks.

Project teams can more effectively establish and fulfill expectations by understanding the risk. Assessing project risk informs decision-making during project development and delivery. These decisions contribute to public safety and clarify project expectations.

Estimating the cost of transportation projects is fundamental to project design and development. In recognition of the importance of cost estimating, these guidelines provide consistent practices across the agency to enhance methods for meeting this responsibility. These guidelines were developed by the Strategic Analysis and Estimating Office (SAEO), with contributions from a number of specialists in cost estimating and project development.

Estimators must be shielded from pressures to produce estimates that match preconceived notions of what a project should cost. Estimates are an objective opinion of cost based on project scope, project schedule, and bidding environment. Risk based estimating is a vital component of project risk management that benefits the projects we deliver. The backbone of risk based estimating is a sound base cost estimate.

> *No construction project is risk free. Risk can be managed, minimized, shared, transferred, or accepted. It cannot be ignored.*
>
> ~ Sir Michael Latham, 1994

1-2 Benefits of Risk Management

Project risk management delivers a number of values to the project, including:

- Recognizes uncertainty and provides forecasts of possible outcomes.
- Produces better business outcomes through more informed decision making.
- Has a positive influence on creative thinking and innovation.
- Creates opportunities for improved project monitoring and control.
- Can aide in addressing concerns with respect to overhead and time.
- Contributes to project success.

Project risk management is an integral component of project management and is found at the heart of WSDOT's project management processes.

Risk management is also a key component of project cost estimating and scheduling, as noted in National Cooperative Highway Research Program (NCHRP) Report 574.

Exhibit 1-1 portrays balanced project risk management through project development and balanced risk management.

With effective risk management as an integral and required part of project management, we can not only predict possible future outcomes, we can take action to shift the odds in favor of project success.

Exhibit 1-1 Balanced Risk Management (Risk Tolerance)

Risk-seeking behavior in an organization	**Risk-aversion behavior in an organization**
is characterized by: • Paying too little attention to risk management • Not allocating resources for risk management • Surprise at bad news • Missing opportunities	is characterized by: • Over-allocation of resources on risk management • Low return on investment for risk management • Money spent on low-priority risks • Tedious processes
Balanced project risk management is characterized by: • Efficient processes that match the organization's tolerance for risk • A proactive approach to management of projects and risks • Effective allocation of resources for risk management • Well-managed projects with few surprises • Taking advantage of opportunities • Dealing with threats effectively	

1-3 Project Risk Management Process

Risk management, as an integral part of project management, occurs on a daily basis. With proactive risk management, we look at projects in a comprehensive manner and assess and document risks and uncertainty. The steps for risk management are provided below.

1-3.1 Risk Management Steps

WSDOT recognizes the following steps of project risk management:

1.	**Risk Management Planning**	Risk management planning is the systematic process of deciding how to approach, plan, and execute risk management activities throughout the life of a project. It is intended to maximize the beneficial outcome of the opportunities and minimize or eliminate the consequences of adverse risk events.
2.	**Identify Risk Events**	Risk identification involves determining and documenting which risks can affect the project. It may be a simple risk assessment organized by the project team, or an outcome of a formal risk assessment process such as the Cost Estimate Validation Process, CEVP®.
3.	**Qualitative Risk Analysis**	Qualitative risk analysis involves Project teams assessing identified risks for probability of occurrence and impact on project objectives. Teams may elicit assistance from subject matter experts or functional units to assess the risks in their respective fields. Risks are measured by their "quality" in words rather than quantified in numbers.
4.	**Quantitative Risk Analysis**	Quantitative risk analysis is a way of numerically estimating the probability that a project will meet its cost and time objectives. Quantitative analysis is based on a simultaneous evaluation of the impacts of all identified and quantified risks.
5.	**Risk Response**	Risk response involves developing options and determining actions to reduce threats or enhance opportunities to project objectives. Actions are identified and assigned to parties that take responsibility for the risk response. This process ensures each risk requiring a response has an "owner." The Project Manager and the project team identify a strategy that is best for each risk, and then select specific actions to implement that strategy.
6.	**Risk Monitoring & Control**	Risk monitoring and control tracks identified risks, monitors residual risks, and identifies new risks—ensuring the execution of risk plans and evaluating their effectiveness in reducing risk. Risk monitoring and control is an ongoing process for the life of the project.

More details on the steps above are found throughout this document. Understand that project risk management is an art and a science involving careful consideration and thought about the project and the associated uncertainties and risks.

Much of project risk management relies on sound engineering judgment and knowing where to focus energy and resources. Knowing when to engage appropriate expertise is vital to good project risk management.

Exhibit 1-2 provides a helpful comparison between risk and objectives for various types of risk management. For this document we are interested in project risk management.

Exhibit 1-2 Relationship between Risk and Objectives

Type of Risk Management	Description	Sample Objectives
Generic	*Risk:* Any uncertainty that, if it occurs, would affect one or more objectives.	----------
Project Risk Management	*Project Risk:* Any uncertainty that, if it occurs, would affect one or more project objectives.	Time, cost, performance, quality, scope, client satisfaction.
Business Risk Management	*Business Risk:* Any uncertainty that, if it occurs, would affect one or more business objectives.	Profitability, market share, competitiveness, Internal Rate of Return (IRR), reputation, repeat work, share price.
Safety Risk Management	*Safety Risk:* Any uncertainty that, if it occurs, would affect one or more safety objectives.	Low accident rate, minimal lost days, reduced insurance premiums, regulatory compliance.
Technical Risk Management	*Technical Risk:* Any uncertainty that, if it occurs, would affect one or more technical objectives.	Performance, functionality, reliability, maintainability.
Security Risk Management	*Security Risk:* Any uncertainty that, if it occurs, would affect one or more security objectives.	Information security, physical security, asset security, personnel security.

Credit: David Hillson, Effective Opportunity Management for Projects

1-4 Smart Effort = Less Risk

1-4.1 Taking Action

The power of risk management is fully realized when a Project Manager takes action to respond to identified risks based on the risk analysis. Directed effort toward risks that can have significant impact to project objectives improves the odds of project success.

1-4.1.1 Inputs

The project scope, schedule, and estimate package should include the most current versions of the following items:

- Project Summary
- Detailed Scope of Work (commensurate with the level of development)
- Project Cost Estimate (with Basis of Estimate completed)
  - PE cost estimate
  - ROW cost estimate
  - Construction cost estimate
- Previous Risk Analyses (if applicable)
- Project Management Plan
- Project Schedule

  - Overall project schedule
  - Detailed construction schedule (commensurate to level of development)
- QA/QC Status
- Additional Information (as necessary)

1-4.1.2 Techniques and Tools

WSDOT provides a number of techniques and tools to assist in project risk management. These tools and techniques provide scalability and flexibility so that project teams can match the tool with the specific needs of their projects. Often, the appropriate tool is determined by the size and complexity of the project. These tools include:

- Project Management Guide
  - Project Management Plan (fundamental for all projects)
  - A qualitative risk matrix for smaller, simpler projects
  - Risk planning, risk assessment, and risk management are integral elements of project management
- Risk Management Plan spreadsheet template (found on SAEO website)
- Self-modeling tool for quantitative risk analysis
- CRA workshops for all projects between $25M and $100M
- CEVP® workshops for all projects over $100M

1-4.1.3 Output

Capital Program Management System (CPMS) data requirements per Policy Statement 2047. Project teams must provide specific data to the region program management office for inclusion in CPMS and the Transportation Executive Information System (TEIS). The required data is:

1. Project scheduling data for the following milestone dates:
   - Project definition completion date
   - Date for the beginning of preliminary engineering
   - Completion date for the environmental document
   - Start date for the acquisition of right of way
   - Date of right of way certification
   - Project advertisement date
   - Date project is operationally complete (substantially complete)
2. Estimated project cost data (in Current Year Dollars, CY$):
   - Date of estimate basis (e.g., “2018 $”)
   - Design cost estimate
   - Right of way cost estimate
   - Construction cost estimate
3. Midpoint for construction phases using the project award date and the operationally complete date.

1-5 Statement of Policy

1-5.1 Project Risk Management and Risk-Based Estimating

It is WSDOT's policy to conduct risk-based estimating workshops for all projects over $10 million (PE, R/W, and Const). These workshops provide information to Project Managers that can help them control scope, cost, and schedule, and manage risks for all projects (Exhibit 1-3). This policy reaffirms the requirement that a Risk Management Plan is a component of every Project Management Plan.

Exhibit 1-3 Levels of Risk-Based Estimating, in Support of Risk Management (E 1053)

Project Size ($M)	Required Process*
Less than $10M	Qualitative spreadsheet in the *Project Management Online Guide*[1]
$10M to $25M	Informal workshop using the self-modeling spreadsheet[1][3]
$25M to $100M	Cost Risk Assessment (CRA) workshop[1][2]
Greater than $100M	Cost Estimate Validation Process® (CEVP®) workshop[2]

[1] In some cases, it is acceptable to combine a Value Engineering Study with a Risk-Based Estimating Workshop.

[2] Projects $25 million and over should use the self-modeling spreadsheet in the scoping phase of the risk-based estimating process, followed up by the more formal CRA or CEVP® process during the design phase.

[3] An informal workshop is composed of the project team (or key project team members); other participants may be included as the Project Manager/project team deem necessary.

*Project Managers can use a higher-level process if desired.

1-6 Project Risk Management Planning

Great project risk management requires good planning. Begin with proven project management practices: review organizational policies and guidance; initiate and align the project team; and follow the steps provided in the *Project Management Guide*. Risk management must commence early in project development and proceed as the project evolves and project information increases in quantity and quality. Plan to:

- Identify, assess/analyze, and respond to major risks.
- Continually monitor project risks and response actions.
- Conduct an appropriate number and level of risk assessments to update the Risk Management Plan and evolving risk profile for the project.

Consider the resources needed for project risk management and build them into the project development budget and schedule. Risk management activities, including events such as Cost Risk Assessment (CRA), Cost Estimate Validation Process (CEVP®), Value Engineering – Risk Assessment (VERA), or other meetings, need to be part of the project work plan and built into the project schedule and budget (Exhibit 1-4).

Exhibit 1-4 General Comparison of a Few Typical Characteristics of CRA and CEVP®

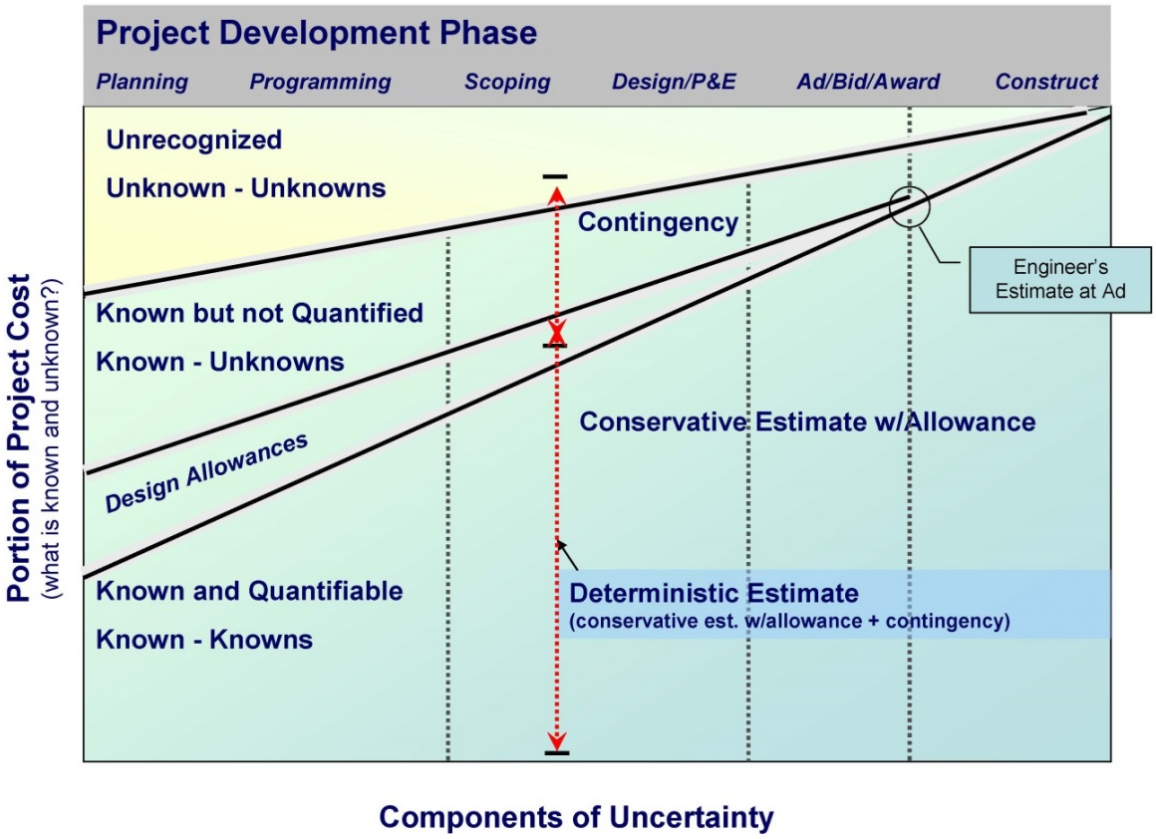
Details	CRA	CEVP®
Typical Length	1 – 3 days	3 – 5 days
Subject Matter Experts	Internal and local.	Internal and external.
Timing	Early is preferred but can be conducted any time. Typically updated when changes warrant.	It is best to start early in the process; major projects are typically updated as needed.
General	An assessment of risks with an evaluation and update of costs and schedule estimates.	An intense workshop that provides an external validation of cost and schedule estimates and assesses risks.
Note: Policies and practices for project risk assessments are established by the Cost Risk Estimating Management unit of the Strategic Analysis and Estimating Office at Headquarters. Risk assessment workshops are orchestrated by Region Coordinators or the CREM Unit at Headquarters. The Project Manager submits a workshop request and works collaboratively to determine workshop type and candidate participants. (See Part II: Guidelines for CRA-CEVP® Workshops for more details.)		

Exhibit 1-5 illustrates how project information develops and evolves over time. With rising project knowledge comes an understanding that contending with some elements of the project will require significant additional resources. These elements could involve: scope; environmental mitigation and permitting; rising cost of right of way as corridors develop in advance of the project; utilities; seismic issues; and other elements.

In the past, traditional estimating practices tended to produce "the number" for a project; but the single number masks the critical uncertainty inherent in a particular project. It implies a sense of precision beyond what can be achieved during planning, scoping, or early design phases.

We recognize that an estimate is more accurately expressed as a range, not as a single number. To determine an accurate estimate range for both cost and schedule, risk must be measured. Formerly, WSDOT measured risk based on the estimator's experience and best judgment, without explicitly identifying the project's uncertainties and risks. That has changed. Estimates are now composed of two components: the base cost component and the risk (or uncertainty) component. The base cost represents the cost that can reasonably be expected if the project materializes as planned. The base cost does not include contingencies. Once the base cost is established, a list of risks is created of opportunities and threats, called a "risk register." The risk assessment replaces general and vaguely defined contingency with explicitly defined risk events. Risk events are characterized in terms of probability of occurrence and the consequences of each potential risk event.

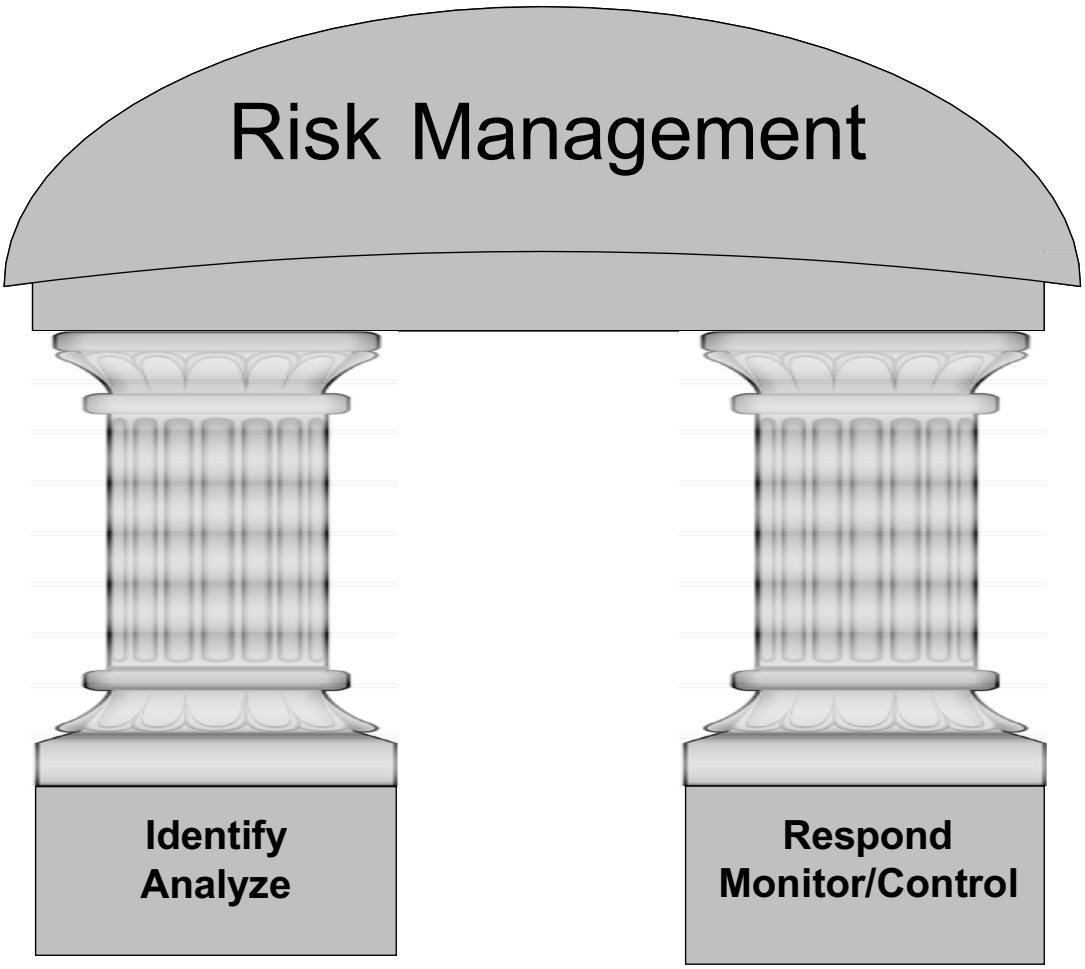
Exhibit 1-5 Evolution of Project Knowledge Through Project Development



Executive Order (EO) E 1053 instructs employees to actively manage their projects risks.

Risk reviews are an integral part of budget development, with the intent that the department makes informed decisions about risk tolerance. It can be inferred that determined Enterprise Risk Management includes comprehensive project risk management Project risk management is a major element in the Project Management Plan, which is required for all WSDOT projects (EO E 1032). We, as stewards of the public trust, must endeavor to inform decision makers of the uncertainty and risk associated with the projects we develop. We must understand risk tolerance and we must weigh the value of project decisions against project risks.

Chapter 5 of the book *Risk, Uncertainty and Government* notes, "…lawyers and economists are accustomed to think of contracts for future performance as devices for allocating risks of future events." In order for us to understand this allocation of risk, projects must be examined and the uncertainty and risks must be documented and characterized.



We can think of risk management as two pillars (depicted above). They are: "IDENTIFY and ANALYZE" the risks, then, "RESPOND, MONITOR, and CONTROL" project risk.

Unless we incorporate the second pillar, we are not realizing the full value of risk management. When preparing the Project Management Plan and work activities for our project, we must include both pillars of risk management.

1-7 How to Plan for Project Risk Management

Do you plan to manage risk for your project? YES! Then include risk management in your Project Management Plan.

1. Determine the level of risk assessment for your project (Exhibit 1-6).
2. Incorporate risk management activities into the project schedule (Exhibit 1-7).
3. Make risk management an agenda item for regularly scheduled project meetings.
4. Communicate the importance of risk management to the entire project team.
5. Establish the expectation that risk will be managed, documented, and reported.

1-7.1 Tips for Risk Management Planning

- Risk assessment planning should begin early. There is a minimum level of project knowledge needed to understand what is being assessed. This varies depending on the point in project development at which the risk assessment is conducted (planning, scoping, design/PS&E); hence, schedule risk assessments at appropriate times.
- At a minimum there must be an understood project scope of work, associated project cost estimate – with a basis of estimate complete, and an estimated project schedule.
- Allow time in the schedule for preparation activities; this includes review and QA/QC of project schedules and cost estimates at appropriate times (Exhibits 1-8 and 1-9).
- Allow a budget and time in the schedule for risk assessment, risk management, and risk response activities.
- Report on the status of project risk at regularly scheduled project meetings.
- Know the organization's tolerance for risk. Are Project Managers (and upper management) risk averse or risk seeking? How much risk is the organization willing to accept? Knowing the answers to these questions will help with risk management and contribute to the decision-making process when determining risk response actions.
- Contact the Strategic Analysis and Estimating Office (SAEO) and discuss the possibility of coordinating or integrating project risk assessment with value engineering.

Exhibit 1-6 Determine the Level of Risk Assessment

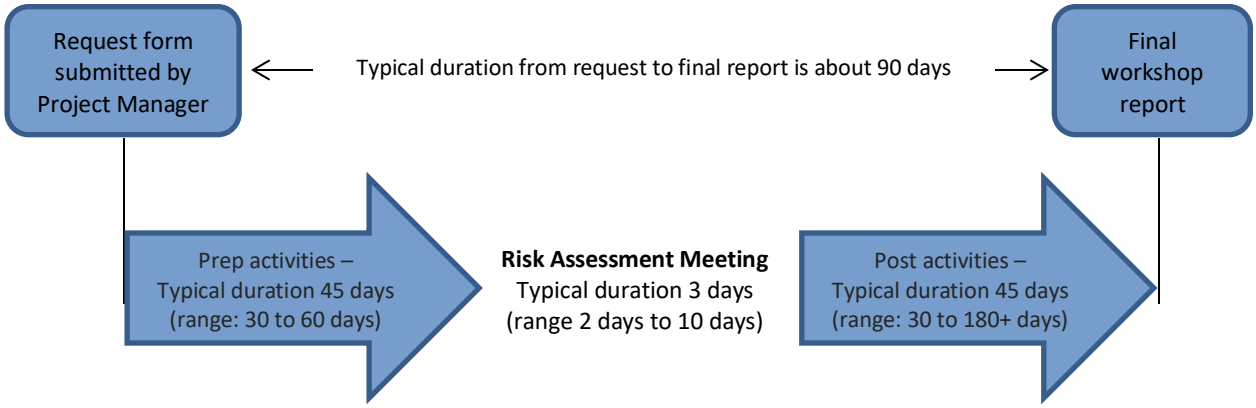
	Project Size ($M)	Risk Assessment Level	Notes
Less Formal Risk Assessment	0 to 10	Project Team Risk Assessment *Project Management Guide* Risk Management Plan ***Qualitative Tool***	The project team assesses each identified risk for its probability of occurrence and its impact on project objectives. Project teams may request assistance from subject matter experts or functional units to assess the risks in their respective fields. The self-modeling spreadsheet can be used for any project.
	10 to 25	Project Team Risk Assessment Self-Modeling Spreadsheet ***Quantitative Tool***	
More Formal Risk Assessment (Workshops)	25 to 100	Cost Risk Assessment (CRA) Workshop ***Quantitative Tool***	The team, working collaboratively with independent subject matter experts, reviews and/or validates cost and schedule estimating and identifies, characterizes, and analyzes risks. Workshops are accomplished in a structured setting. Modeling can be accomplished with off-the-shelf software or using the self-modeling spreadsheet.
	Over 100	Cost Estimate Validation Process® (CEVP®) Workshop ***Quantitative Tool***	

Exhibit 1-7 Include Risk Management Milestones in the Project Schedule

Less Formal Risk Assessment*	Formal Workshop (CRA/CEVP®)
Milestones include: • Project Scope, Schedule, and Estimate are Complete (apt for the level of development) • Prep Meeting (initial review of areas of concern; determine tool: qualitative or self-modeling) • Risk Meeting (risks are identified and characterized) • Risk Response Actions Developed • Risk Response Actions Implemented	**Milestones include:** • Workshop Request Form Submitted • Project Scope, Schedule, and Estimate are Complete (apt for the level of development) • Prep Session (flowchart project; determine subject matter experts; additional prep items) • Workshop • Preliminary Results Presented • Draft Report • Final Report

*Does not require a formal workshop.

Exhibit 1-8 Simplified Workshop Timeline



Typical prep activities include:

Prep meeting
Prepare agenda
Review materials
Advance elicitation
Process task orders
Negotiate contracts
Identify cost-risk team
Confirm & invite participants
Schedule activities (pre- and post-)
Determine type of risk assessment
Establish duration of risk assessment

Typical post activities include:

Perform action items
Prepare Monte Carlo models
Prepare draft and final reports
Conduct risk treatment follow-up meeting
Prepare preliminary presentation
Review and process consultant invoices

Causes of delay to the start or analysis

Poorly defined scope of work
Poorly prepared cost estimate
Poorly prepared schedule estimate
No current project management plan

Note: If the project team cannot clearly describe the project to be evaluated, with a well-defined problem statement, and provide a cost and schedule estimate, the risk assessment meeting should be postponed.

Causes of delaying the finsih

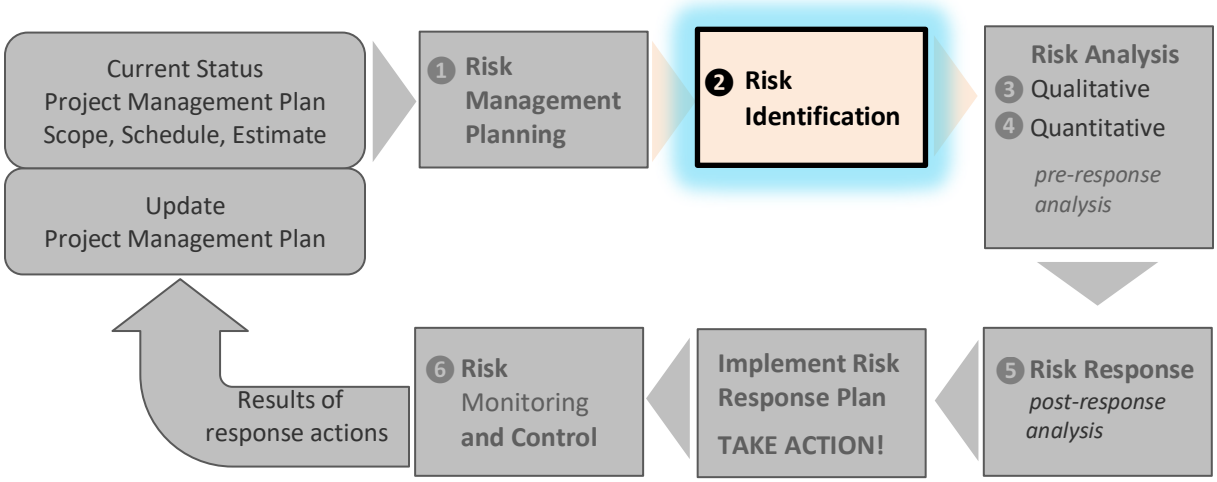
Delays in decision-making
Unresolved isses at end of meeting
Requested information not provided

Note: Once the risk assessment meeting is over, ***it is over.*** Allow the process to come to a conclusion so the model can be developed and the report delivered. Endless permutations and combinations of hypothetical scenarios that will not contribute to decision-making do not add value to the process. Evaluate results, develop a response; update the Project Management Plan.

Exhibit 1-9 Risk Management Schedule: With Workshop and Postworkshop Activities

	DURATION RANGE (days)		
TASK NAME	Shorter	**Common**	Longer
Risk Assessment Process (90 days +/-) – Typical timeline for CRA/CEVP	~30	**~90**	~120 +
Request Form submitted by the Project Manager to the Cost Risk Estimating Management (CREM) Unit of the Strategic Analysis and Estimating Office (SAEO)		**Start**	
PREWORKSHOP ACTIVITIES	24	**30**	44
• CREM works with PM to identify appropriate cost-risk team • CREM determines appropriate workshop type and length • CREM works with PM to schedule risk assessment activities (including pre- and post-) • Project team prepares materials for prep session and begins preparing for workshop • REALITY CHECK (is project team ready?) > Scope, Schedule, Estimate for workshop • CREM prepares and distributes PREP Session agenda and sends invites • PREP SESSION (run by CREM – results in: Draft Flowchart, Estimate, Participants List) • MILESTONE > PREP SESSION COMPLETE • PM sends email reminder to region participants/SMEs for workshop • CREM schedules and conducts advance elicitation with appropriate parties • CREM sends invites to all workshop participants for workshop • Project team prepares for workshop (review Flowchart, Estimate, and Participants List) • CREM, working with PM, finalizes workshop agenda and sends to participants • Project team makes project information available via email, ftp, and/or other			
WORKSHOP ACTIVITIES	1	**3**	5 or more
• WORKSHOP (run by CREM) • MILESTONE > WORKSHOP COMPLETE			
POSTWORKSHOP ACTIVITIES	10	**45**	90 +
• Cost Lead prepares their portion of the DRAFT REPORT • Risk Lead prepares models and writes DRAFT REPORT • Risk Lead prepares preliminary presentation • Risk Lead delivers preliminary presentation • Preliminary presentation complete • RISK LEAD ASSEMBLES DRAFT REPORT • MILESTONE > DRAFT REPORT COMPLETE • PROJECT TEAM REVIEWS & COMMENTS ON DRAFT REPORT • Cost Lead prepares their portion of the FINAL REPORT • Risk Lead finalizes models and writes FINAL REPORT • MILESTONE > FINAL REPORT COMPLETE • PM makes sure payment groups are set up in TRAINS			
POSTREPORT ACTION (RISK RESPONSE)	Project risk management is an ongoing activity that is performed as part of the daily and regular project development and delivery activities.		
• PM updates Project Risk Management Plan (collaborates w/CREM) • PM implements risk response actions (collaborate w/CREM) • PM initiates monitoring for effectiveness of risk response actions • Update Risk Management Plan: response costs and estimated value of risk avoided • Perform post-mitigation analysis and report			

Chapter 2 Risk Identification



2-1 Risk Identification during Project Development

Risk identification is ongoing through project development:

1. Planning
2. Scoping
3. Design/Plans, Specifications, and Estimate (Engineer's Estimate)
4. Construction

As projects evolve through project development, the risk profile changes and project understanding grows. Previously identified risks may change and new risks may emerge.

2-2 Risk Identification: Inputs, Tools and Techniques, Outputs

2-2.1 Risk Identification Inputs

The most important first input is a defined project. In order to fully understand and assess project risks we must ensure a mutual understanding of the project under evaluation. Fundamental information about a project includes a clear statement of need. To focus on risks and uncertainties our project will face, we must know the project in context, scope, schedule, and estimate. Information is commensurate with the level of project development at the time of risk analysis. Progressive elaboration should not be confused with scope creep. (Source: *Project Management Book of Knowledge*)

Projects tend to develop in small steps. This incremental process of project development is sometimes termed "progressive elaboration." Progressive elaboration means developing in steps, and continuing by increments. For example, the project scope will be broadly described early in the project and made more explicit and detailed as the project team develops a better and more complete understanding of the objectives and deliverables.

2-2.2 Risk Identification Tools and Techniques

The project team, sometimes in collaboration with cost risk experts and subject matter experts, identify as many risks as possible that may affect project objectives (Exhibit 2-1). State the assumptions for risk identification and analysis, and delineate thresholds for risks. For example, a project team may want to describe risks with impacts below $100,000 or less than two weeks as minor. By doing so, we do not spend excessive amounts of time on risks that do not significantly impact our ability to meet project objectives. Focus must be directed toward risks that can significantly impact the project. Assumptions and thresholds for risk assessment are project-specific and are influenced by the size and complexity of the project and project environment, and the owners' tolerance for risk. There are a wide variety of techniques used for risk identification. Some common techniques used at WSDOT are provided below.

2-2.2.1 Documentation Reviews

Peer-level reviews of project documentation, studies, reports, preliminary plans, estimates, and schedules are a common and early method to help identify risks that may affect project objectives.

2-2.2.2 Information Gathering

- **Brainstorming** – Formal and informal brainstorming sessions with project team members, specialty groups, stakeholders, and regulatory agency representatives is a technique for risk identification. This technique can be scaled for use on the simplest to the most complex projects. This technique can also be tailored to specific areas of interest for the project risk; for example, if a Project Manager is most concerned about geotech conditions, a brainstorming session on geotech can be convened.
- **Lessons Learned Database** – Searching for lessons learned using key words in the WSDOT Lessons Learned Database that are relevant to your project can provide an abundance of information on projects that may have faced similar risks.
- **Other Methods** – Other techniques include: questionnaires and surveys; interviews, checklists, and examination of the work breakdown structure for the project with appropriate specialty groups; and asking "what if" questions (for example, "what if we miss the fish window?" or "what if our environmental documentation is challenged and we have to prepare an EIS?").

2-2.3 Risk Identification Outputs

An expected deliverable from risk identification includes the "risk register,"[1] which documents the following information:

[1] A list of risks comprised of potential project opportunities and threats.

Identification # for each risk identified – Assign a unique number to each risk for tracking purposes. If available, do this by utilizing an established Risk Breakdown Structure (RBS); the WSDOT RBS is provided in Exhibit 2-4.

Date risk was identified – Document the date the risk was identified and in which project development phase (planning, scoping, design/PS&E, construction).

Name of risk - (is the risk a threat or an opportunity?) – Ensure each identified risk has an appropriate name; for example, "NEPA Delay" or "Reduction in Condemnation." Also, document the nature of the risk with respect to project objectives (threat or opportunity); you can do this by using the RBS for naming conventions.

Detailed description of risk event – The detailed description of the identified risk must provide information that is Specific, Measurable, Attributable (a cause is indicated), Relevant, and Time-bound (SMART). Ensure the description is clear enough and thorough enough so that others reading about the description of the risk will understand what it means.

Risk trigger – Each identified risk must include the risk trigger(s). Risks rarely just suddenly occur; usually there is some warning of imminent threat or opportunity. Clearly describe and document these warning signs and information about the risk. For example, "NEPA Approval Date" may be considered a risk trigger on a project that has a risk of a legal challenge.

Risk type – Does the identified risk affect project schedule, cost, or both?

Potential responses to identified risk – Document, if known, possible response actions to the identified risk—can the identified threat be avoided, transferred, or mitigated, or is it to be accepted? Can the identified opportunity be exploited, shared, or enhanced?

Comments about risk identification – Risk management is an iterative process, project risks must be reviewed regularly. Document and assess new risks. The resulting risk register is preliminary and is refined over time and is a prominent input of Cost Risk Assessment or Cost Estimate Validation Process® (CRA/CEVP®) workshops. More detail about the WSDOT workshops for CRA/CEVP® is provided later in this document, and at: www.wsdot.wa.gov/projects/projectmgmt/riskassessment

2-3 Identifying Risk Events

2-3.1 How to Identify Risk

1. Determine, for your project, what constitutes "significant" risk.
2. Determine risk thresholds for the project—establish a minimum dollar amount and time duration considered significant for the project under evaluation.
3. Focus on identifying large significant risks that affect project objectives.
4. Carefully document and describe risks in a risk register (see Exhibit 2-4).

5. Characterize risks in terms of impact and probability. Note: High-impact risks with low probabilities should be of particular interest to the Project Risk Manager.[2]

2-3.2 Tips for Risk Identification

- Thoroughly describe the risk; there are forms on the following pages to help with this, or you may create your own.
- Include specialty groups and/or other persons who may have meaningful input regarding the challenges the project may face.
- Determine who "owns" the risk and who will develop a response.

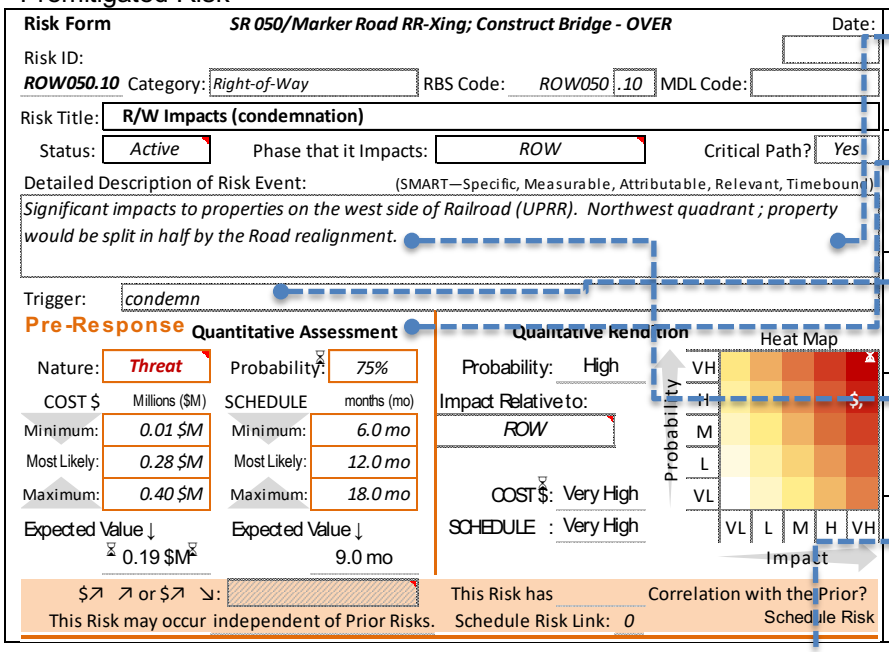
Exhibit 2-1 Risk Identification

Brainstorming: An effective method, brainstorming can range from a small informal project team effort for simpler projects to a full-blown CEVP® workshop. Effective brainstorming requires a skilled facilitator, working together with the project team and specialists who can bring additional expertise.
Checklists and/or questionnaires to "specialty groups": Checklists/questionnaires are quick and easy to use, but limited in nature; they only deal with the items on the list. Each project is unique, so a standard list will often not capture the project-specific risks of most concern. Though it can be limited, a checklist/questionnaire can spark thinking prior to a more formal brainstorming process.
Examination of past similar projects: Lessons learned from past projects help us to avoid repeating mistakes. Using past examples requires prudent and objective judgment, since a previous project may be similar but is nonetheless different because each new project has unique requirements and features, including uncertainties and risks. WSDOT Lessons Learned website: http://wwwi.wsdot.wa.gov/projects/delivery/lessonslearned/
A combination of the above methods and/or others: It is quite likely that for most projects, a combination of the above methods will be used to identify risks. The important thing is that, once identified, the risks are properly documented (see the following exhibits): Exhibit 2-2 – Risk identification example (tailor to the needs of the project team). Exhibit 2-3 – Risk Breakdown Structure for categorizing and organizing risks. Exhibit 2-5 – Example of qualitative risk identification.

[2] High-Impact, low-probability risks, referred to as "black swan" events by some, can devastate a project and, unfortunately, are not always given the attention they deserve. This is due to the fact that the "expected value" of this type of risk does not always rank it highly on risk register.

Exhibit 2-2 Risk Identification Example (SMART)

Premitigated Risk



Specific - A detailed description of the Risk Event. What is the specific issue of concern?

Measurable - Probability ***and*** consequence of Risk Event Occuring? (cost or schedule impact)

Attributable - What will trigger (cause) this risk? How do we know? Who owns this risk?

Relevant - Why is this risk important to our project? Will it impact project objectives? Is it critical?

Timebound - Risks have a "shelf life" – the project is not indefinitely exposed - when are we at risk?

Supplemental notes about this risk event

Risk trigger details (include estimated life of risk)		Risk exposure during R/W phase (March 15, 2929 to March 15, 2930)		Trigger – negotiations to acquire property are unsuccessful and it is necessary to go through condemnation.	
Risk owner		Mr. R. Ofway			
Critical path (yes or no?)		Yes			
Possible response actions		Evaluate all possible alternatives to either avoid property or reduce the amount needed.			
Action by date	May 15, 2929	Status review dates	June 15, 2929	July 15, 2929	August 15, 2929

Potential response actions?
If potential mitigation strategies are identified be sure to capture them so they can be more fully explored later.

Exhibit 2-3 Risk Breakdown Structure (RBS)

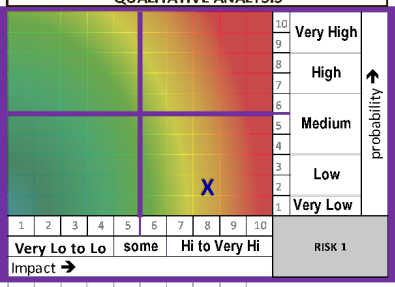
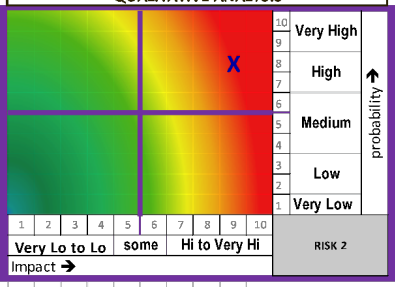
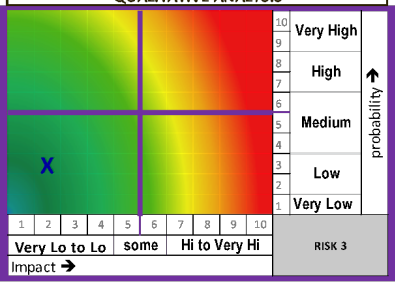
Level 1	Project Risk									
Level 2	**Environmental & Hydraulics ENV**	**Structures & Geotech STG**	**Design / PS&E DES**	**Right-of-Way ROW**	**Utilities UTL**	**Railroad RR**	**Partnerships Stakeholders PSP**	**Management / Funding MGT**	**Contracting Procurement CTR**	**Construction CNS**
Level 3	ENV 10 NEPA/SEPA	STG 10 Design Changes	DES 10 Design Changes	ROW 10 ROW Plan	UTL 10 Coordination	RR 10 Design Coordination	PSP 10 Tribal Issues	MGT 10 Management Change	CTR 10 Change in Delivery Method	CNS 10 Traffic Control and Staging
	ENV 20 ESA Issues	STG 20 Design Changes	DES 20 Deviations' Approval	ROW 20 inflation	UTL 20 Conflicts	RR 20 Construction coordination	PSP 20 Public Involvement	MGT 20 Delayed Decision Making	CTR 20 Contract Language	CNS 20 Construction Permitting
	ENV 30 Environmental Permitting	STG 30 Changes to design Criteria	DES 30 architecture or landscape changes	ROW 30 Limited Access IJR		RR 30 Right of Entry	PSP 30 Additional Scope for third parties	MGT 30 Cash Flow Restrictions	CTR 30 Delays in Ad/Bid/Award	CNS 30 Work Windows
	ENV 40 Archaeological Cultural		DES 40 Projects by other agencies affected	ROW 40 Managed Access Appeal				MGT 40 Political/Policy Changes	CTR 40 Market Conditions	CNS 40 Schedule Uncertainty
	ENV 50 Hazardous Materials		DES 50 Changes to Design of Traffic Items	ROW 50 Acquisition Issues				MGT 50 State Workforce Limitations	CTR 50 Delays in Procurement	CNS 50 Marine Construction
	ENV 60 Wetlands / Habitat		DES 60 Design / PS&E Reviews	ROW 60 Additional ROW is required					CTR 60 Contractor Non-Performance	CNS 70 Earthwork Issues (re-use,
	ENV 70 Stormwater, Potential								CTR 70 Availability of Specialty	CNS 80 Coordination with Adjacent
	ENV 80 Impacts during Construction									CNS 90 Contractor Access / Staging
	ENV 90 Permanent Noise Mitigation									CNS 100 Construction Accidents
	ENV 900 Other ENV Issues	STR 900 Other STR Issues	DES 900 Other Design Issues	ROW 900 Other ROW Issues	UTL 900 Other UTL Issues	RR 900 Other RR Issues	PSP 900 Other PSP Issues	MGT 900 Other MGT Issues	CTR 900 Other CTR Issues	CNS 900 Other CN Issues

The RBS provides several functions and benefits to the project team and to management, including:
1) Consistency with taxonomy (wording); 2) Organizes risk events into common categories; 3) Helps identify trends with respect to common usage of risk eventcategories & event types, categories & event types along with their probability and impact values; 4) Helps to identify common risk events among projects that the Region and HQ offices should be aware of due to their potential cumulative effects; e.g. negotiating agreements with agencies or other municipalities; 5) Provides a basis to work from for risk elicitors during CEVP workshops; 6) Provides a basis for development of independent risk surveys for those that are unable to attend a CEVP workshop.

This RBS serves as a starting point in assessing project risks in CEVP and CRA workshops; and also for smaller projects that may not conduct a formal workshop.

RBS CODE	RISK TRIGGER (CAUSE or PRECIPITATING EVENT)		RISK EVENT	CONSEQUENCE (effect on project objectives)	PROBABILITY	IMPACT ($ or time)
ENV 10.01	As a result of…	the public involvement process	NEPA/SEPA document challenge	delays delivery of EA document	70%	↑$5M, 8 weeks
ENV 10.02	Because of…	public pressure and internal reviews	env documentation increases,	need to prepare an EIS	10%	↑$0.1M, 6 months
ENV 10.03	Due to…	reviews by WSDOT Environmental	design info deemed inadequate	additional design, cost, and time	10%	↑$0.1M, 4 months

Exhibit 2-4 Example Risk ID Sheet, Qualitative

Project Name		Project Identification Number (PIN)		Date:	
Project Manager		Name of Risk Owner:			
		QUALITATIVE ANALYSIS		RISK RESPONSE	MONITOR and CONTROL
Status	Active Risk	RISK EVENT NAME: unknown utilities RISK TRIGGER: discovery THREAT		STRATEGY avoid ACTION TO BE TAKEN	Date, Status and review comments
RBS Category	UTL	Areas outside of R/W have not been investigated for conflicts. Additional work is required for sewer/storm, water, gas, power, communications. Triggers include: utilities found late in design or during construction.		subsurface utility investigations immediately; assign team member to this full time.	update at the next Quarterly Project Report (QPR) meeting
Risk Number	20				
Project Phase	Design				
Date	May 32, 2929				
Risk Owner	M. Example				
		Name of Risk Owner:			
		QUALITATIVE ANALYSIS		RISK RESPONSE	MONITOR and CONTROL
Status	Active Risk	RISK EVENT NAME: noise wall RISK TRIGGER: analysis results THREAT		STRATEGY avoid ACTION TO BE TAKEN	Date, Status and review comments
RBS Category	ENV	possibility that a noise wall will have to be added to the project - pending results of the type 1 analysis; this is a high impact high probability threat		press for noise analysis ASAP	analysis due August 39th.
Risk Number	90				
Project Phase	Design				
Date	May 32, 2929				
Risk Owner	Green Jeans				
		Name of Risk Owner:			
		QUALITATIVE ANALYSIS		RISK RESPONSE	MONITOR and CONTROL
Status	Item of Interest	RISK EVENT NAME: cultural resources RISK TRIGGER: discovery THREAT		STRATEGY accept ACTION TO BE TAKEN	Date, Status and review comments
RBS Category	ENV	discovery of artifact; triggered during design if field investigation results in discovery; also trigger if discovered during construction | deemed low probability - this area has been investigated previously and very little new ground is being disturbed.		monitor	supplemental field investigation report due November 31.
Risk Number	40				
Project Phase	Design				
Date	May 33, 2929				
Risk Owner	Green Jeans				

2-3.3 After Risk Identification

Risk identification prepares us for risk analysis. The next two chapters present the two types of risk analysis: qualitative and quantitative.

Chapter 3 Qualitative Risk Analysis

3-1 General

Qualitative Risk Analysis assesses the impact and likelihood of the identified risks and develops prioritized lists of these risks for further analysis or direct mitigation.

The project team assesses each identified risk for its probability of occurrence and its impact on project objectives. Project teams may elicit assistance from subject matter experts or functional units to assess the risks in their respective fields.

Qualitative risk analysis is often used:

- As an initial screening or review of project risks.
- When a quick assessment is desired.
- As the preferred approach for some simpler and smaller projects where robust and/or lengthy quantitative analysis is not necessary.

> **Qualitative:** Observations that do not involve measurements and numbers; for example, the risk of a heavy rainstorm affecting our erosion control is "Very High."
>
> **Qualitative assessment:** An assessment of risk relating to the qualities and subjective elements of the risk—those that cannot be quantified accurately. Qualitative techniques include the definition of risk, the recording of risk details and relationships, and the categorization and prioritization of risks relative to each other.
>
> SOURCE: *Project Risk Analysis and Management Guide*, 2004, APM Publishing

Qualitative analysis provides a convenient and user-friendly way to identify, describe, and characterize project risks.

Risk identification, as mentioned in Chapter 3, results in the generation of a risk register. The risk register can be sizeable and it is necessary to evaluate and prioritize the risk events

identified in the risk register. Evaluation and prioritization is typically an iterative process and can take place at various points in project development.

A thoroughly developed register of risks is helpful. In some situations moving forward is difficult because of indecision. Identifying, describing, and assessing project risks allows for prioritization that offers actionable information by providing specific, documented risk events. Prioritizing risks offers Project Managers an opportunity to focus project resources. Prioritization helps make decisions in an uncertain environment and address project risk in a direct and deliberate manner.

Qualitative analysis utilizes *relative* degrees of probability and consequence of each identified project risk event in descriptive non-numeric terms; see Exhibit 3-2 and Exhibit 3-3 for examples of qualitative risk matrices.

3-2 How to Perform Qualitative Risk Analysis

Once a risk is identified, write a thorough description of the risk *and* risk triggers. This aids in characterizing the risk in terms of probability of occurrence and the consequence.

1. Gather the project team and appropriate persons to discuss project risk. Establish which of the qualitative risk matrices you intend to use, and define the terms you plan to use (Very High, High, Medium, Low, etc.).
2. Review the risk information from the risk identification step.
3. Discuss the risk with the group.
4. Evaluate the likelihood of the risk occurring by asking the group "How likely is it that this risk will occur?" Record the result that the group agrees on.
5. Evaluate the consequences if the risk does occur by asking the group "What will be the impacts if this risk does occur?" Record the result that the group agrees on.
6. Prioritize the risks based on the results of the qualitative analysis. If it is desirable, the risks can also be grouped by category (e.g., Environmental, Structures/Geotech) and ranked within each category.

3-2.1 Helpful Hints for Qualitative Risk Analysis

- Invite *appropriate* participants (not too many, not too few).
- Define terms.
- Stay focused—put a time limit on discussion if necessary.
- Record the results.
- Prioritize the risks based on the results.

Sometimes, people who are relatively new to risk analysis claim that it is nothing more than guessing. However, the actuality is that assigning values for probability and impact relies on the expertise and professional judgment of experienced participants.

Determining an estimated probability of a risk occurring and it's consequence is for many a new activity. In any field, with experience, professionals develop intuition and an ability to understand projects to a greater degree than those not involved with project development and delivery. This experience and intuition is extremely valuable—in a risk workshop forum, we surround ourselves with "wise counsel" to seriously and thoroughly discuss the project. It might be helpful to examine the word "guess" and compare it to other words, such as "discernment" and "judgment," that more appropriately describe risk assessment. The definitions in the following table come from the Merriam-Webster Online Dictionary/Thesaurus (with edits).

Exhibit 3-1 Risk Assessment-Related Definitions

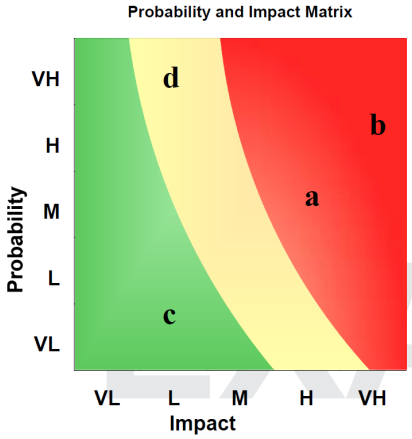
Risk-Assessment Terms	Definitions / Synonyms / Related Words
Decision	**Definitions:** (1) a: The act or process of deciding, b: a determination arrived at after consideration: <make a decision>; report of a conclusion; (2) A position arrived at after consideration <after much deliberation, we made a decision about what to use for an estimated unit price> **Synonyms:** Conclusion, determination, diagnosis, judgment, resolution **Related Words:** choice, option, selection.
Discernment	**Definition:** The quality of being able to grasp and comprehend what is obscure; skill in discerning (insight and understanding); the process of forming an opinion or evaluation by discerning and comparing; an opinion or estimate so formed; the capacity for judging; the exercise of this capacity. **Synonyms:** Perception, penetration, insight, and acumen mean a power to see what is not evident to the average mind. DISCERNMENT stresses accuracy; PERCEPTION implies quick discernment; PENETRATION implies a searching mind that goes beyond what is obvious or superficial; INSIGHT suggests depth of discernment coupled with understanding; and ACUMEN implies characteristic penetration combined with keen practical judgment.
Guess	**Definition:** To form an opinion from little or no evidence. **Synonyms:** Assume, conjecture, presume, speculate, suppose, surmise **Related Words:** Gather, infer, hypothesize, theorize, believe, conceive, imagine, reckon.
Judgment	**Definitions:** (1) The process of forming an opinion or evaluation by discerning and comparing; (2) An opinion or estimate so formed; a formal utterance of an authoritative opinion; a position arrived at after consideration; an idea that is believed to be true or valid without positive knowledge; an opinion on the nature, character, or quality of something.

Exhibit 3-2 Probability Impact Matrix (5 x 5)

EXAMPLE (depicts a simple list of risks evaluated and ranked qualitatively)

Qualitative Risk List

count	T/O	RBS #	Risk Title	Probability	Impact
a	T	ENV 30.1	Permits and Permit Appeals	Medium	High
b	T	UTL 20.1	Unidentified Utility Conflicts	High	Very High
c	T	STG 20.4	Change to Substructure Assumptions	Very Low	Low
d	T	ROW 40.1	Managed Access challenge	Very High	Low



Probability (Likelihood)	Synonyms		[1]Approximate %
Very high	Almost certain	Very Sure	≥ 90%
High	Likely	Pretty Sure	80%
Medium	Possible	Maybe	50%
Low	Unlikely	Seldom	20%
Very Low	Rare	Improbable	≤ 10%
Consequence (Impact)	**Synonyms**		**[1]Approximate % of Phase (PE, RN, CN)**
Very high	Very Critical	Very Strong	≥ 10%
High	Critical	Strong	8%
Medium	Moderate	Average	4%
Low	Slight	Mild	2%
Very Low	Very Little	Very Mild	≤ 1%

[1]Suggested percentages; project teams may adjust if they desire.

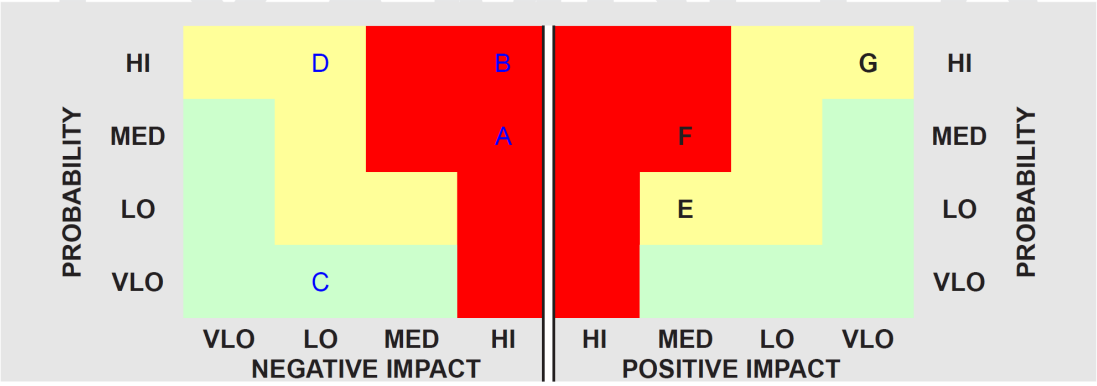
Exhibit 3-3 Probability Impact Matrix (Double 4 x 4)

Qualitative Risk List (ranked based on qualitative risk analysis)

rank	count	T/O	RBS #	Risk Title	Probability	Impact
2	a	T	ENV 30.1	Permits and Permit Appeals	Medium	High
1	b	T	UTL 20.1	Unidentified Utility Conflicts	High	Very High
4	c	T	STG 20.4	Change to Substructure Assumptions	Very Low	Low
3	d	T	ROW 40.1	Managed Access challenge	Very High	Low

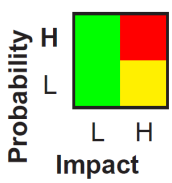
Qualitative Risk List (threats and opportunities)

count	T/O	RBS #	Risk Title	Probability	Impact
A	T	ENV 30.1	Permits and Permit Appeals	Medium	High
B	T	UTL 20.1	Unidentified Utility Conflicts	High	High
C	T	STG 20.4	Change to Substructure Assumptions	Low	Low
D	T	ROW 40.1	Managed Access challenge	High	Low
E	O	CNS 30.1	Negotiate Better Work Windows	Low	Medium
F	O	CNS 50.1	Able to salvage some material for $	Medium	Medium
G	O	DES 10.1	Opportunity to switch to ACP (HMA)	High	High



EXAMPLES ONLY

A simple matrix, provided below, is suitable for smaller, less complex or routing projects; it also appears in the WSDOT's Project Management Guide.

	High (probability): more likely than not to happen. High (impact): Substantial impact on cost, schedule, or technical. Substantial action required to alleviate issue.
	Low (probability): less likely than not to happen. Low (impact): Minimal impact on cost, schedule, or technical. Normal management oversight is sufficient.

The Project Management Online Guide is found at:
www.wsdot.wa.gov/projects/projectmgmt/pmog.htm

Exhibit 3-4 Simplified Risk Management Plan Spreadsheet with 2 x 2 Probability Impact Matrix

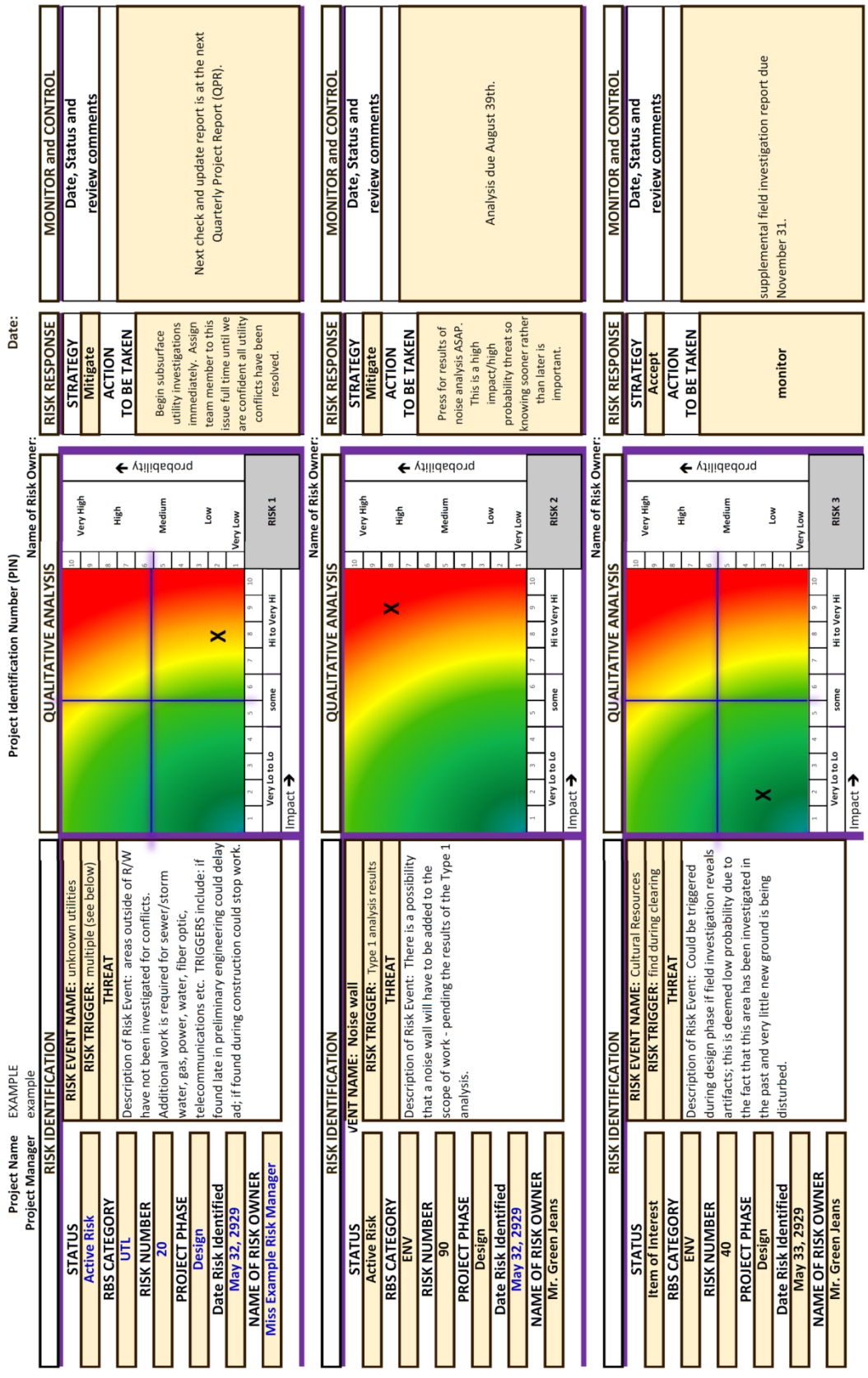
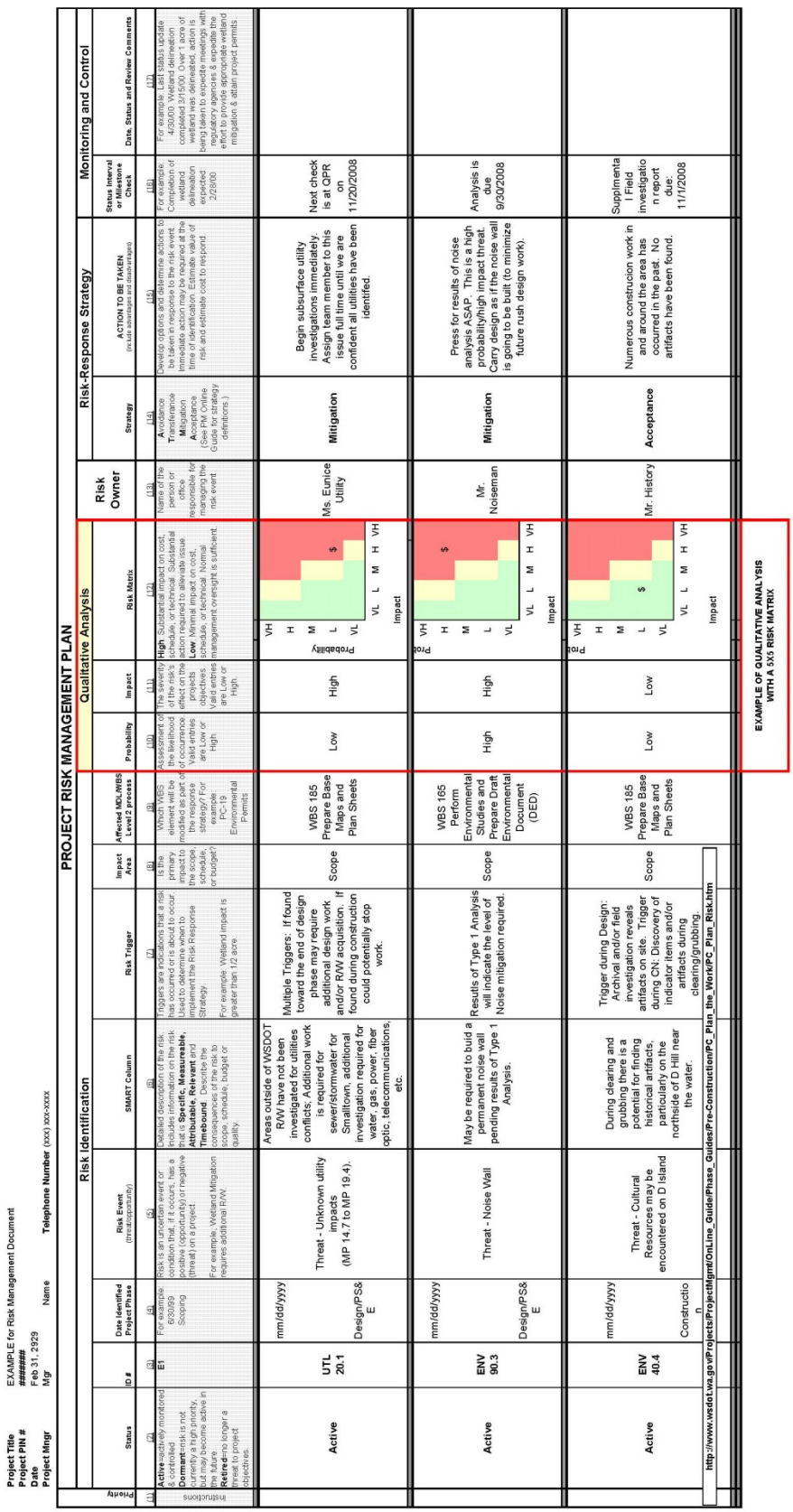


Exhibit 3-5 Simplified Risk Management Plan Spreadsheet, 5 x 5 Probability Impact Matrix



4-1 General

Quantitative Risk Analysis is a way of numerically estimating the probability that a project will meet its cost and time objectives. Quantitative analysis is based on a simultaneous evaluation of the impacts of all identified and quantified risks.

The Strategic Analysis and Estimating Office (SAEO) at WSDOT offers several tools for quantitative analysis of risk. These tools are described in Executive Order E 1053 and summarized in Exhibit 4-1.

Exhibit 4-1 Levels of Risk-Based Estimating, in Support of Risk Management

Project Size ($M)		Required Process*
Quantitative	**$10M to $25M**	Informal workshop using the self-modeling spreadsheet[1][3]
	$25M to $100M	Cost Risk Assessment (CRA) Workshop[1][2]
	Greater than 100M	Cost Estimate Validation Process® (CEVP®) Workshop[2]
[1] In some cases, it is acceptable to combine the Value Engineering Study and Risk-Based Estimating Workshop.		
[2] Projects $25M and over should use the self-modeling spreadsheet in the scoping phase risk-based estimating process, followed up by the more formal CRA or CEVP® process during the design phase.		
[3] An informal workshop is comprised of the project team (or key project team members); other participants may be included as the Project Manager/project team deem necessary.		
Note: For projects less than $10M, qualitative analysis is sufficient, although a higher level may be used if desired.		

*Project Managers can use a higher-level process if desired.

Quantitative techniques, such as Monte Carlo simulation, can be a powerful tool for analysis of project risk and uncertainty. This technique provides project forecasts with

an overall outcome variance for estimated project cost and schedule. Probability theory allows us to look into the future and predict possible outcomes.

Use of quantitative analysis, while very powerful, also can be misleading if not used properly. WSDOT provides a comprehensive guide for risk workshops that, if followed, helps ensure a consistent process and safeguards against biased and/or misleading results. The comprehensive set of workshop guidelines are provided in Part II of this document.

The following caution comes from the paper "Top Down Techniques for Project Risk Management" by Martin Hopkinson, presented at the 2006 PMI Conference in Madrid.

> *Poor modeling can produce an output that looks convincing to managers but is so flawed that the results are dangerously misleading. On a project with unrealistically tight targets, poor risk analysis may thus become a tool that fosters management delusions about the prospects for success.*

Project risk management is an integral component of ongoing project management.

Project Managers sometimes ask "when is the best time to conduct a CRA or CEVP® workshop?" This is answered by reviewing the status of project development.

Project risk management is an integral part of the Project Management Plan, PMP. As the PMP is developed include requirements for keeping the plan current and the approximate timing for conducting formal risk analyses. At a minimum quantitative risk analysis requires a project scope associated schedule and cost estimate. When the scope, schedule and estimate are ready the project team can begin in earnest to prepare for their risk management workshop.

Contact the Design Analysis Office at WSDOT HQ to discuss your project risk analysis requirements. They can guide you through the process, including scheduling consultants and WSDOT resources to effect the completion of a quantitative analysis, either through the workshop process or use of the self-modeling spreadsheet.

When a project team prepares for a workshop, much of the work that is performed on a daily or regular basis becomes the input for the analysis. This includes scope or work, schedule estimate (with backup and assumptions), cost estimate (including the Basis of Estimate), assumptions, and backup information. Estimates are used to make financial decisions; hence, in order to facilitate this, materials should be developed that result in an informed decision-making process. Capital Program Management System (CPMS) data requirements are listed in Exhibit 4-2.

Exhibit 4-2 CPMS Data Requirements

Required CPMS Data
Project teams must provide specific data to the region program management office for inclusion into CPMS and the Transportation Executive Information System (TEIS). The required data is: **1. Project Scheduling Data for the Following Milestone Dates** • Project definition completion date • Date for the beginning of preliminary engineering • Completion date for the environmental document • Start date for the acquisition of right of way • Date of right of way certification • Project advertisement date • Date project is operationally complete (substantially complete) **2. Estimated Project Cost Data (in Current Year Dollars, CY$)** • Date of estimate basis (e.g., "March 2015 $") • Design cost estimate • Right of way cost estimate • Construction cost estimate 3. **CPMS Modifications** • CPMS will be modified to calculate the midpoint for construction phases using the project award date and the operationally complete date.

4-2 How to Perform Quantitative Risk Analysis

4-2.1 General Process

Once risks are identified and have been screened via qualitative analysis, they can be analyzed quantitatively. Recall that identification includes a thorough description of the risk and risk triggers (see Chapter 2). With quantitative analysis, the probability of occurrence and consequence if the risk event occurs must also be documented. Exhibit 4-3 depicts the workshop process.

4-2.1.1 Tools and Techniques

1. Gather and Represent Data

- Interviews: Can be formal or informal settings, such as smaller group meetings and/or larger formal workshops.
- Subject matter expert input: Participate collaboratively with the project team and cost-risk team; can also participate in interviews or contribute opinions in other ways such as surveys (questionnaires).
- Data: Represent data in terms of probability and impact; impacts can be represented using discrete distributions or continuous distributions.

2. Quantitative Risk Analysis and Modeling

- Project simulation: Use the Monte Carlo technique to generate a probability distribution of project cost and schedule based on uncertainty and risk effects.

4-2.1.2 Quantitative Risk Analysis Outputs

1. Risk Register

The risk register begins during risk identification and is further developed during analysis (qualitative and/or quantitative); the risk register is a key component of the Project Management Plan.

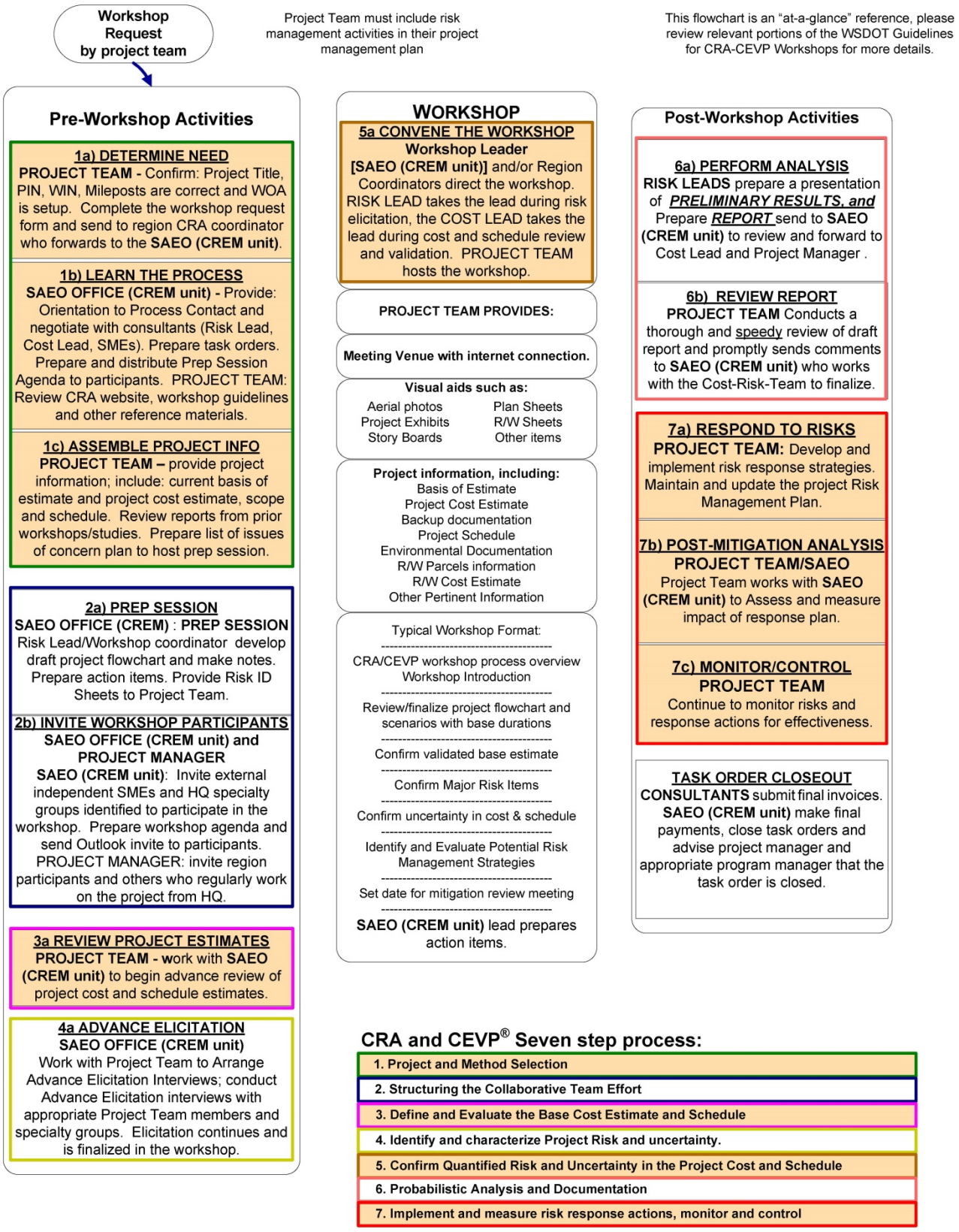
- Prioritized list of quantified risks: Those risks that have the most significant impact (threats or opportunities) to project objectives (tornado diagrams, expected values, decision trees).
- Probabilistic analysis of the project: Estimated cost and completion dates and associated confidence levels.
- Quantitative analyses: Can be conducted several times throughout project development; trends can be identified, and mitigation strategies can be implemented and monitored. The risk profile of a project evolves and changes as the project is developed, knowledge is gained, and design changes occur.

2. Informal Workshop (Meeting)

For smaller projects, an informal workshop comprised of the project team and/or key project team members and other participants (such as specialty groups involved with critical items) may suffice.

Risk management is ongoing and iterative; periodically, workshop members can regroup to evaluate the project and associated uncertainty and risks. **Workshops typically occur for a project every 12 to 24 months or at key project milestones**. Project risks and mitigation efforts should be discussed at regular project meetings; make changes as appropriate and, following those changes, re-run the risk model. Value is gained when action is taken to respond to risks, resulting in cost and schedule savings to the project.

Exhibit 4-3 Workshop Process for CRA or CEVP®



In order to fully understand our projects, we must determine what we know and what we do not know about a project. In our industry, Civil Engineering – Transportation, we have devoted a good deal of resources to clearly explain **what is known** of a project. We have many specialty offices that gather and provide data in support of project delivery, including: aerial photography, surveying, site investigations, bid histories, real estate services, right of way, utilities, access management, environmental, hydraulics, structures, geotechnical, railroad, tribal, planning and programming, ad/bid/award, construction, tolling, economic, programming, external resource agencies and stakeholders, public interest groups, and others.

Just as important is to **devote some energy and resources to assess what is not known** and/or is uncertain about a project. One tool for accomplishing this is intentional, thoughtful, and deliberate project risk management, as part of an overall Project Management Plan. Risk assessment is not a measure of estimate accuracy:

> *The project team must examine each critical item and predict its possible extreme values considering all risks, including compounding effects. It is important to understand that the range, as considered in this method, is not the expected accuracy of each item.* ***This is a key issue.*** *Risk analysis is not an analysis of estimate accuracy. Accuracy is dependent upon estimate deliverables and estimate maturity.*
>
> AACE International Recommended Practice No. 41R-08
> **RISK ANALYSIS AND CONTINGENCY DETERMINATION USING RANGE ESTIMATING**
> TCM Framework: 7.6 – Risk Management
> June 25, 2008

Risk management must be partnered with a well-organized and properly documented project base cost estimate. Risk management introduces reality into our project management process by recognizing that every project has a risk of cost overrun—this does not mean cost overrun is inevitable, it means it is possible.

In the book *Project Risk Management* by Chris Chapman and Stephen Ward, there is an acronym presented (on page 58) to describe a risk management process framework for projects: SHAMPU, which refers to: Shape, Harness, And Manage Project Uncertainty. There are some helpful ideas expressed via this acronym and they are presented in Exhibit 4-4.

Exhibit 4-4 SHAMPU Process in 3 Levels of Detail

Detailed Steps of Process	Mid-Level Portrayal	Simplest Portrayal
define the project **focus** the process	clarify the **basis of analysis**	shape the project strategy
identify the issues **structure** the issues clarify **ownership**	execute the **qualitative analysis**	
estimate variability **evaluate** implications	execute the **quantitative analysis**	
harness the plans	**harness** the plans	**harness** the plans
manage implementation	**manage** implementation	**manage** implementation

Exhibit 4-5 is a schematic of how an estimate range emerges from a risk-based estimating process. The first estimate, or "plan value," provided by the project team often will contain contingencies (explicit and/or implicit) within the estimate; the first step is to review the estimate and remove the contingencies and make any needed corrections that are identified. Exhibit 4-6 depicts the regions of an estimate.

Exhibit 4-5 Creating a Probabilistic Estimate

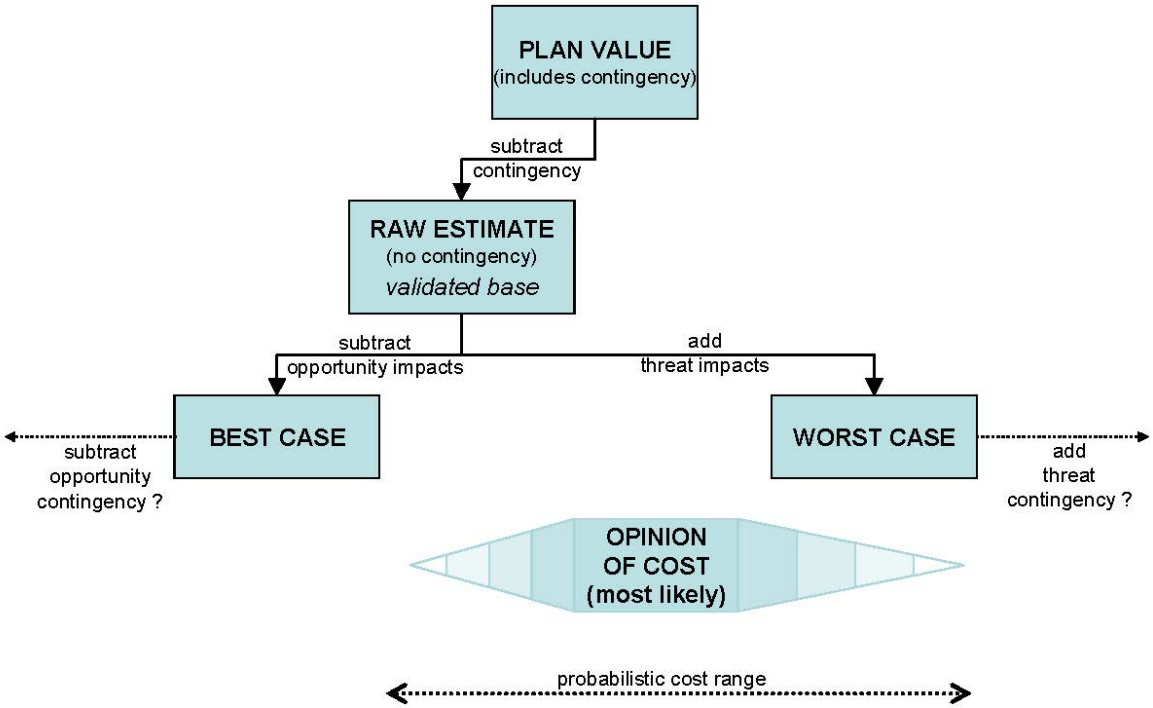
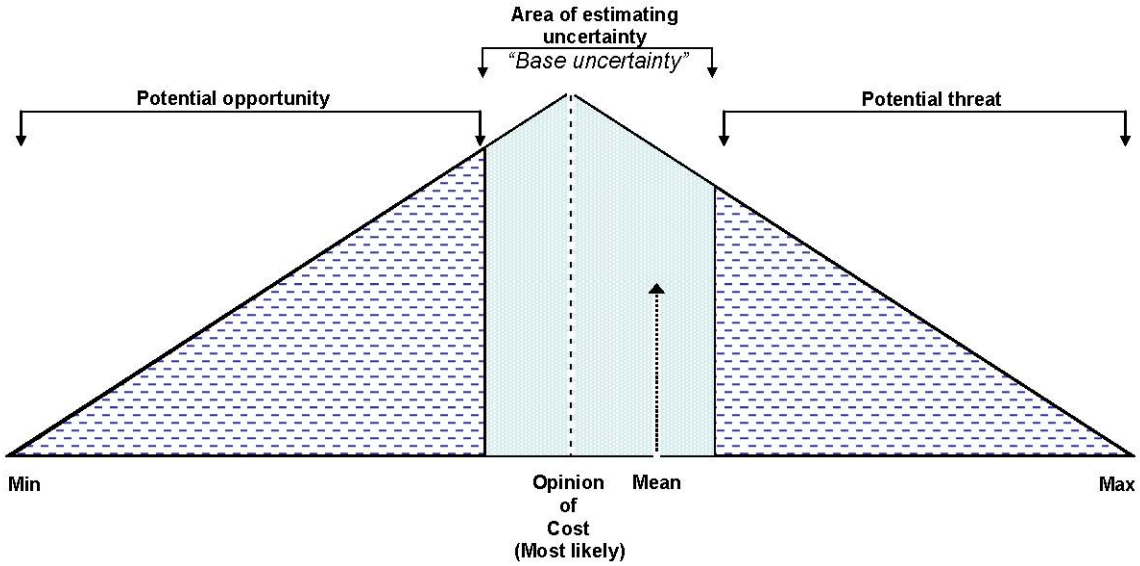
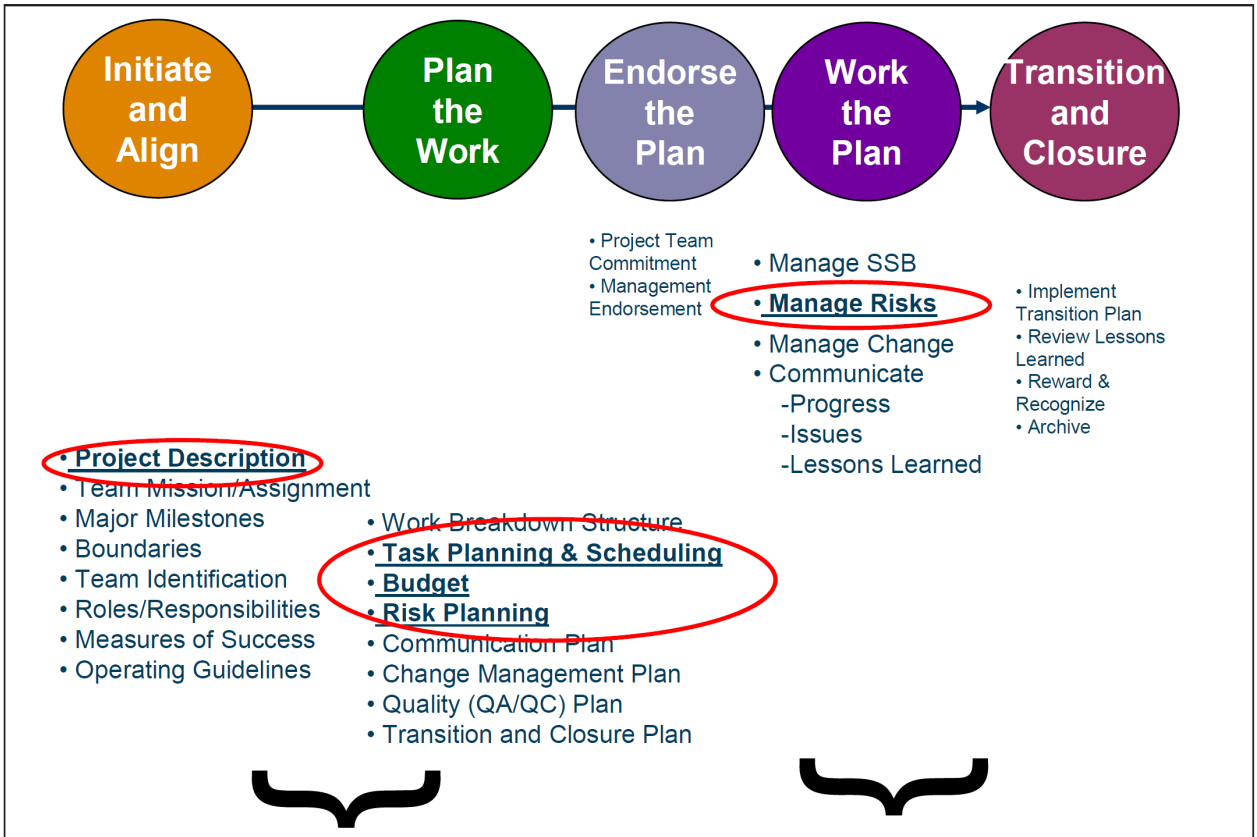


Exhibit 4-6 Regions of an Estimate



Quantitative analysis is a natural activity that fits into our standard project management process, and unfolds something like this:

Exhibit 4-7 Risk Management: A Part of Project Management



IDENTIFY and ANALYZE Risk

Project Description: subject of the risk assessment

Task Planning & Scheduling Budget	This produces a project estimate and schedule.

Risk Planning:
The project team, as part of their normal project development and project management activities needs to include activities for risk management in its work plan.

The team prepares a project estimate based on what is known about the project at that time; the estimate reflects the project if things go per the project plan. Uncertainty and risk events are identified and characterized.

RESPOND, MONITOR and CONTROL Risk

Risk Management is an integral component of day-to-day project management. Project teams implement and continuously upgrade the Risk Management Plan throughout the project. Primary Risk Management functions include:

- Monitor risks (threats and opportunities)
- Identify new risks
- Evaluate/update probability of occurrence and potential impacts
- Devise and implement response strategies
- Evaluate and document effectiveness of response
- Report to Management and Stakeholders

4-3 Reporting results of the Quantitative Risk Analysis

4-3.1 General

Most commonly asked questions about any project, repeated from the foreword of this document:

- How much will it cost?
- How long will it cost?
- Why?

Declarations of cost estimates should be complete and transparent. Report results as a range.

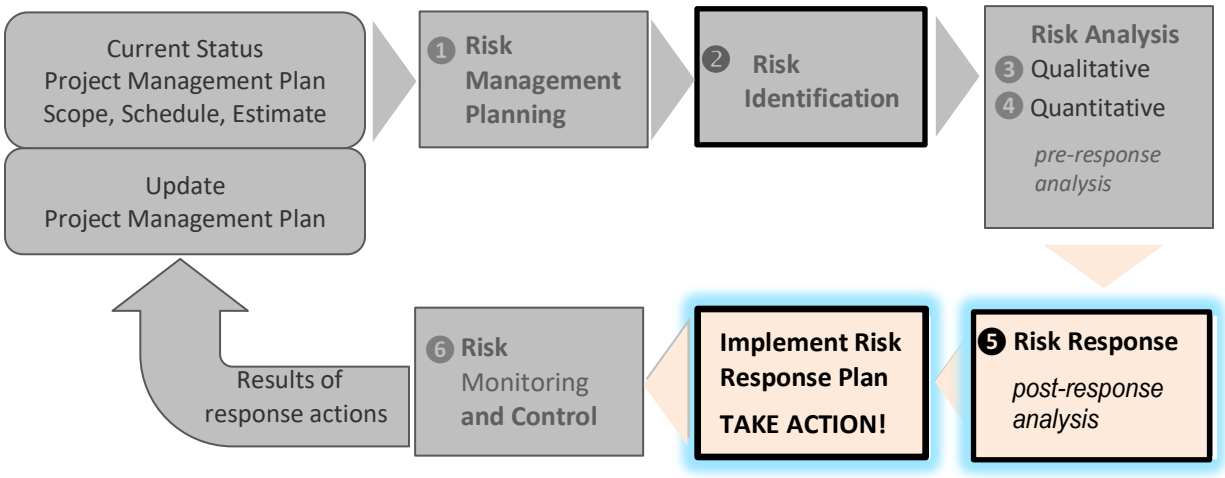
When asked "how much it will cost?" we must report the total cost – this includes previously incurred expenses (Pre-NEPA study, NEPA, ROW, or any preliminary engineering costs, etc.) in the total project cost results. If the risk analysis is conducted for the cost to complete, be sure to also report all monies spent to date – that is the ***total*** cost.

Results should be reported as a range and typically in Year Of Expenditure dollars. In any case be complete and identify the dollars being reported (Current Year or Year of Expenditure).

4-3.1 FHWA requirements.

WSDOT endeavors to ensure all requirements are met or exceeded for projects with federal funding. FHWA requirements are summarized below:

- a probabilistic risk-based review that verifies accuracy and reasonableness of current cost and schedule and identifies project uncertainty as described in FHWA CER guidance.
- Include previously incurred expenses (Pre-NEPA study, NEPA, ROW, or any preliminary engineering costs, etc.) in the total project cost results.
- For projects being procured as P3s, the workshop must include an analysis of the allocation of risks with respect to delivering the project through a P3.
- For projects with phasing plans, at a minimum YOE results must be prepared for the funded phase as well as the total project. *(note: scope as defined by NEPA document).*
- Be consistent with the Major Project Financial Plan guidance.
- Be consistent with the FHWA CER guidance.
    - At this time WSDOT and FHWA have adopted different percentiles for budgeting and risk reserve calculations. This is an area for continuing research.



5-1 Risk Responses

Project Managers and teams must take action in response to identified risks. Focusing on risks of most significance can shift the odds in favor of project success.

Early in project development, activities and information may seem chaotic, coming to us from multiple directions and multiple sources. Risk management provides a structured and disciplined way to document, evaluate, and analyze the information, so we emerge with a well-organized and prioritized list of project risks. This prioritization can be used to direct project risk management resources most effectively.

To maximize project risk management benefits incorporate risk management activities into the Project Management Plan and work activities. This means building risk management activities into the Work Breakdown Structure (WBS).

WSDOT's WBS is the Master Deliverables List (MDL). The MDL helps ensure project work plans are comprehensive, consistent, and complete. Risk Response requires effort to develop and implement response actions. Plan for this effort in the project management plan and work activities. WSDOT tools and guidance to aid this effort (www.wsdot.wa.gov/projects/projectmgmt/riskassessment/).

5-1.1 Actions in Response to Risks

Threats	Opportunities
1. Avoid	1. Exploit
2. Transfer	2. Share
3. Mitigate	3. Enhance
4. Accept	

5-1.1.1 Risk Response: Actions (With Edits)

AVOID (threats)

Action taken to ensure the probability or impact of a threat is eliminated.

Avoidance actions include: changing the Project Management Plan to eliminate a threat; isolating project objectives from the risk's impact; or relaxing the project objective that is in jeopardy, such as extending schedule or reducing scope. Some risks that arise early in the project can be avoided by clarifying requirements, obtaining information, improving communication, or acquiring expertise. *(Project Management Body of Knowledge [PMBOK])*

There are two types of action: (1) remove the cause of the risk (risk trigger), or (2) execute the project in a different way while still aiming to achieve project objectives. Not all risks can be avoided or eliminated, and for others this approach may be too expensive or time-consuming, but this should be the first strategy considered for each risk. *(Effective Opportunity Management for Projects by David Hillson)*

EXPLOIT (opportunities)

Action taken to ensure the benefit of an opportunity is realized.

The opposite of avoid, this strategy is to ensure a positive impact, or realize an opportunity. Taking action to make the opportunity definitely happen; such response actions include: assigning more talented resources to a project to reduce time to completion and/or providing better quality than originally planned. *(PMBOK)*

Eliminate the uncertainty associated with a particular upside risk. An opportunity is defined as a risk event that, if it occurs, will have a positive effect on achievement of project objectives. Avoid and Exploit are the most aggressive of the response strategies and should be reserved for those "golden opportunities" with high probability and impacts. *(Effective Opportunity Management for Projects by David Hillson)*

TRANSFER (threats)

Action to allocate ownership for more effective management of a threat.

Transferring a threat does not eliminate it—the threat still exists; however, it is owned and managed by another party. Transferring risk can be an effective way to deal with financial risk exposure. Transferring project risk almost always involves payment of a risk premium to the party taking the risk; for example, insurance, performance bonds, or warranties. Contracts may be used to transfer specified risks to another party. *(PMBOK)*

Transferring risk involves finding another party who is willing to take responsibility for its management, and who will bear the liability of the risk should it occur. The aim is to ensure that the risk is owned and managed by the party best able to deal with it effectively. Risk transfer usually involves payment of a premium, and the cost-effectiveness of this must be considered when deciding whether to adopt a transfer strategy. *(Effective Opportunity Management for Projects by David Hillson)*

SHARE (opportunities)

Action to share with a third party; enhance/exploit opportunity.

Sharing a positive risk involves allocating ownership to a third party who is best able to capture the opportunity for the benefit of the project. Examples of sharing actions

include forming risk-sharing partnerships, teams, or joint ventures, which can be established with the express purpose of managing opportunities. *(PMBOK)*

Allocating risk ownership for an opportunity to another party who is best able to handle it, in terms of maximizing probability of occurrence and increasing potential benefits if it does occur. Transferring threats and sharing opportunities are similar in that a third party is used; those to whom threats are transferred take on the liability and those to whom opportunities are allocated should also be allowed to share in the potential benefits. *(Effective Opportunity Management for Projects by David Hillson)*

MITIGATE – or reduce (threats)

Action taken to reduce the probability and/or impact of a threat.

Risk mitigation implies a reduction in the probability and/or impact of an adverse risk event to an acceptable threshold. Taking early action is often more effective to repair than trying to repair the damage after the risk has occurred. Examples of mitigation strategies include: adopting less complex processes, conducting more tests and/or field investigations, developing a prototype. Measures to address impacts include: targeting linkages that determine the severity, such as designing redundancy into a subsystem, may reduce the impact from a failure of the original component. *(PMBOK)*

Mitigation or acceptance are the strategies most often used since the number of threats that can be addressed by avoidance or transfer are usually limited. Preventive responses are better than curative responses because they are more proactive and if successful can lead to risk avoidance. Preventive responses tackle the causes of the risk; where it is not possible to reduce probability, a mitigation response should address the adverse impact, targeting the drivers that determine the extent of the severity. *(Effective Opportunity Management for Projects by David Hillson)*

ENHANCE (opportunities)

Action to enhance opportunity.

This response modifies the "size" of an opportunity by increasing probability and/or impact. Seeking to facilitate or strengthen the cause of the opportunity, and proactively targeting and reinforcing its trigger conditions. Impact drivers can also be targeted, seeking to increase the project's susceptibility to the opportunity. *(PMBOK)*

This response aims to modify the "size" of the positive risk. We enhance the opportunity by increasing the probability and/or impact of an opportunity thereby maximizing benefits realized for the project. If the probability can be increased to 100%, this is effectively an exploit response. *(Effective Opportunity Management for Projects by David Hillson)*

ACCEPT

Action taken to document acceptance of the risk.

The term "accept" refers to risks that remain after response actions and/or for which response is not cost-effective are accepted; risks that are uncontrollable

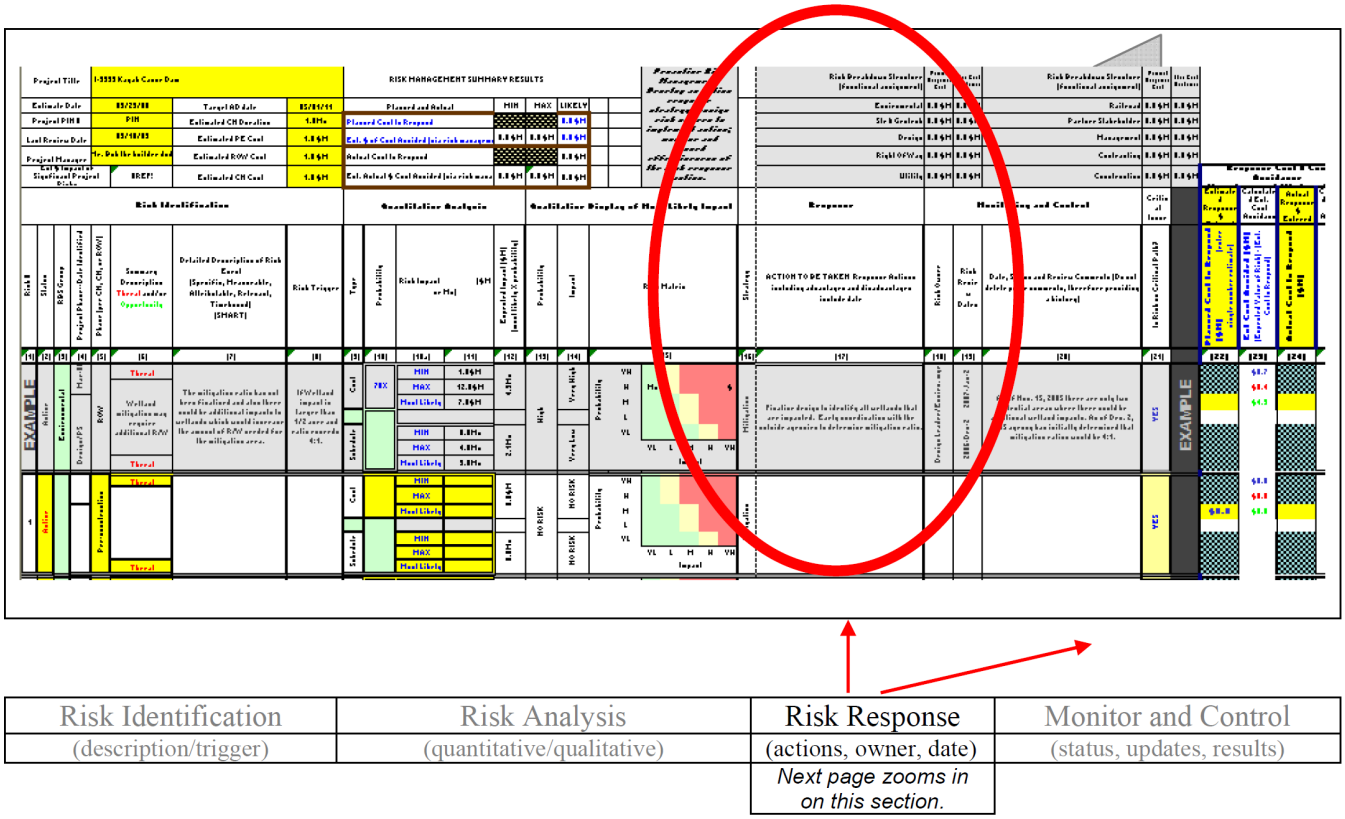
(no response actions are practical) are also accepted. *(Effective Opportunity Management for Projects by David Hillson)*

Ultimately, it is not possible to eliminate all threats or take advantage of all opportunities; we can document them and at least provide awareness that these exist and have been identified; some term this "passive acceptance." In some cases, in some industries, a contingency reserve is established to deal with the aggregate residual risk that has been accepted; some term this "active acceptance."

As project development continues the risk profile will change. As we successfully respond to risks and our project knowledge increases, our risk exposure will diminish. In effect, we can retire risk reserve as risk events are successfully avoided or mitigated or we have passed the time during which the risk is active and it becomes retired.

The following is from the Risk Management Planning Spreadsheet:
www.wsdot.wa.gov/projects/projectmgmt/riskassessment

Exhibit 5-1 Risk Management & Planning Spreadsheet



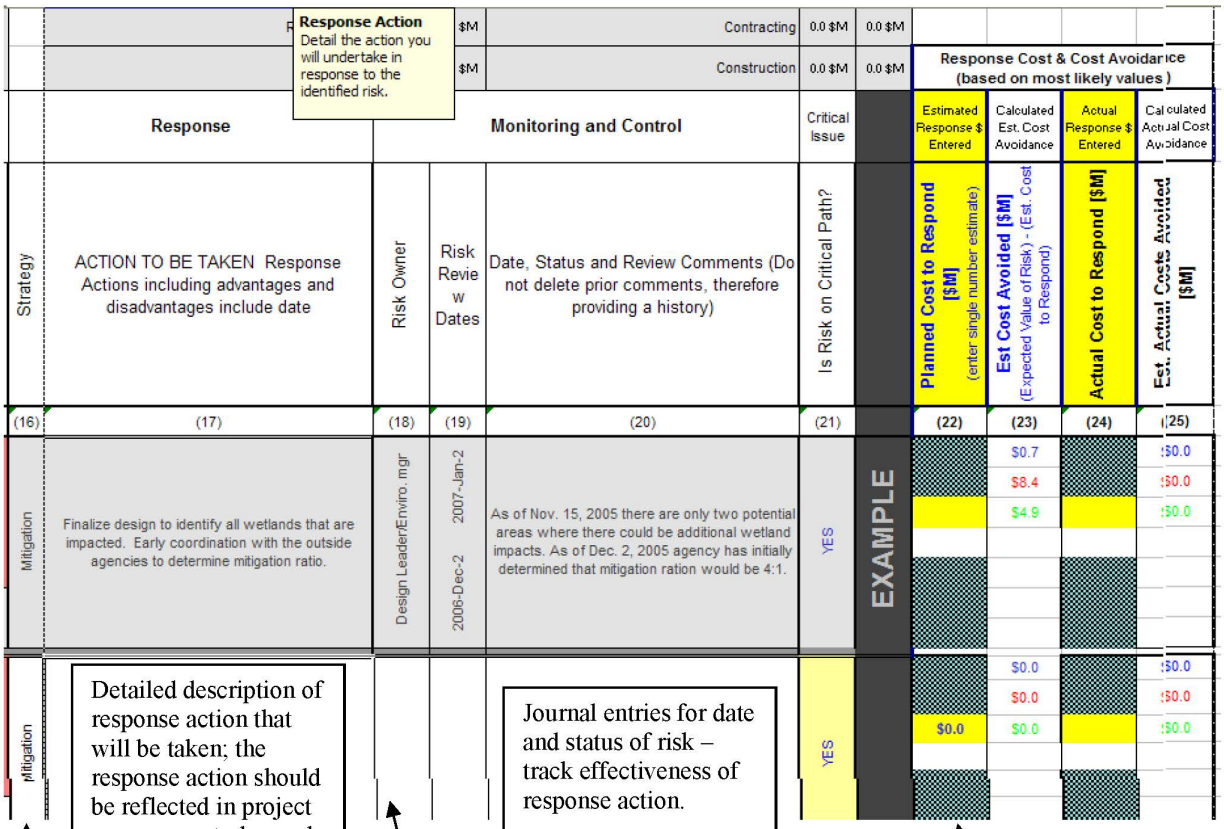
Risk Identification	Risk Analysis	Risk Response	Monitor and Control
(description/trigger)	(quantitative/qualitative)	(actions, owner, date)	(status, updates, results)

Next page zooms in on this section.

IN THIS CHAPTER WE FOCUS ON RESPONSE

Exhibit 5-2 RMP Spreadsheet: Response

Type of Response Action:



Type of Response action

Threats	Opportunities
Avoid	Exploit
Transfer	Share
Mitigate	Enhance
Accept	

5-2 Risk Response Tools and Techniques

After we have identified and analyzed the risks, we know where to focus our efforts. The output from the analysis provides a ranked risk register with the risks of greatest significance to project objectives determined. Apt response actions to significant risks must be cost-effective and realistic.

Critical risks must be met with vigorous response actions; lower-ranking risks should receive response actions commensurate with their significance.

5-2.1 Documentation of Response Actions

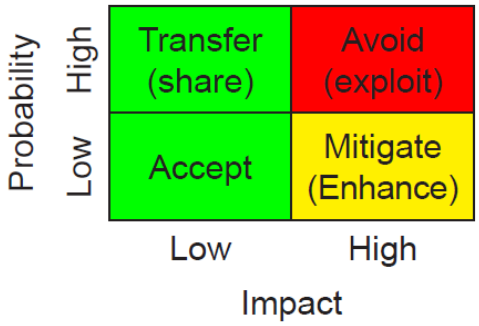
Document the response action by describing the action, which work activities it will affect, and the cost of the response action. Identify the person(s) responsible for successful implementation of the response action. Also, consider the time impacts of the response action and how the risk response may affect the overall project and/or other risks.

5-2.2 Planning Risk Response Actions

Select a response action – The action selected is influence by the level of the risk; consider Exhibit 5-3:

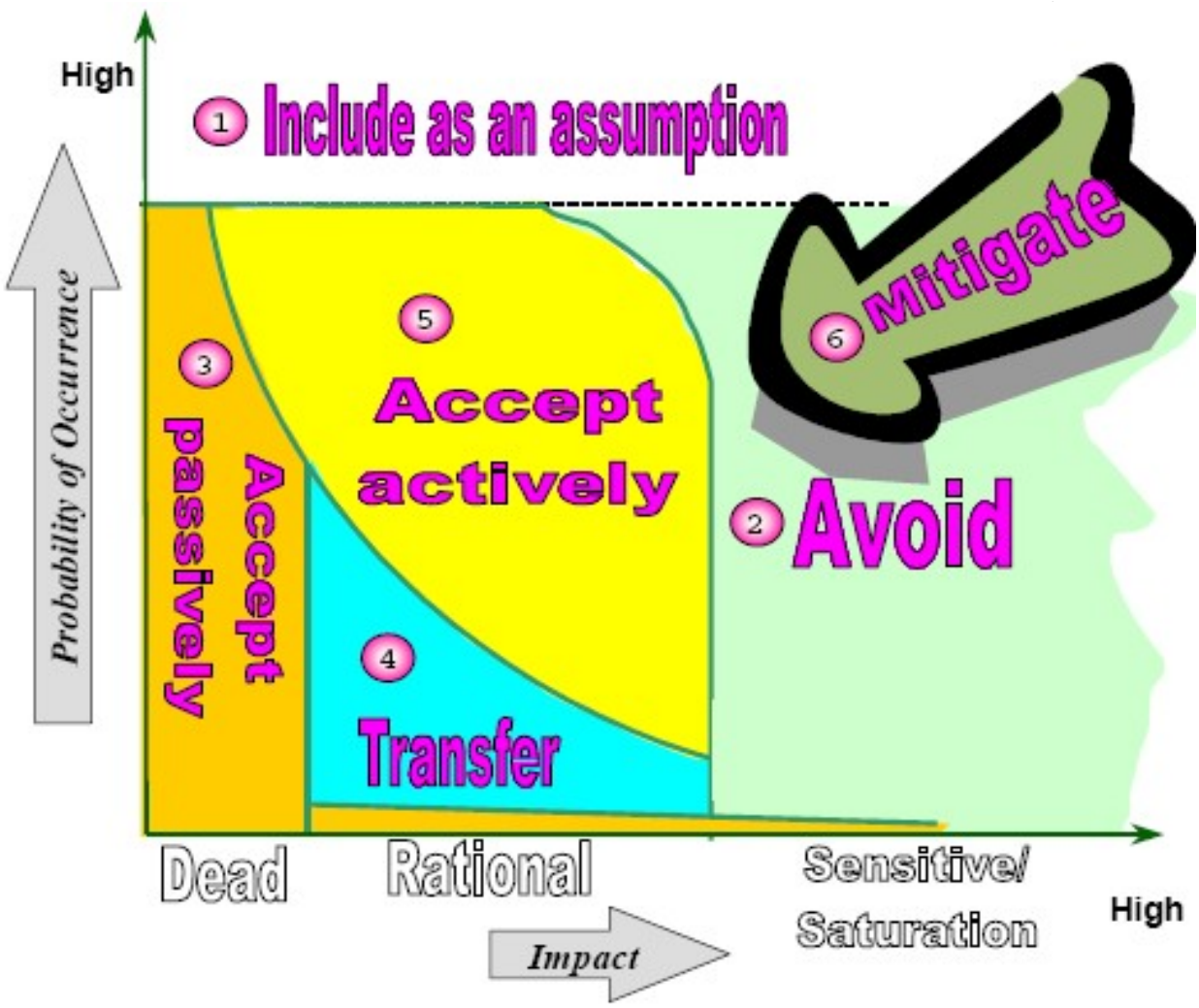
Exhibit 5-3 Simple Response Matrix

High impact and high probability risks require aggressive responses (threats should be avoided and opportunities exploited if possible).



Exhibits 5-4 and 5-5 depict typical response actions for threats and for opportunities depending on the region of probability and impact in which the risk resides.

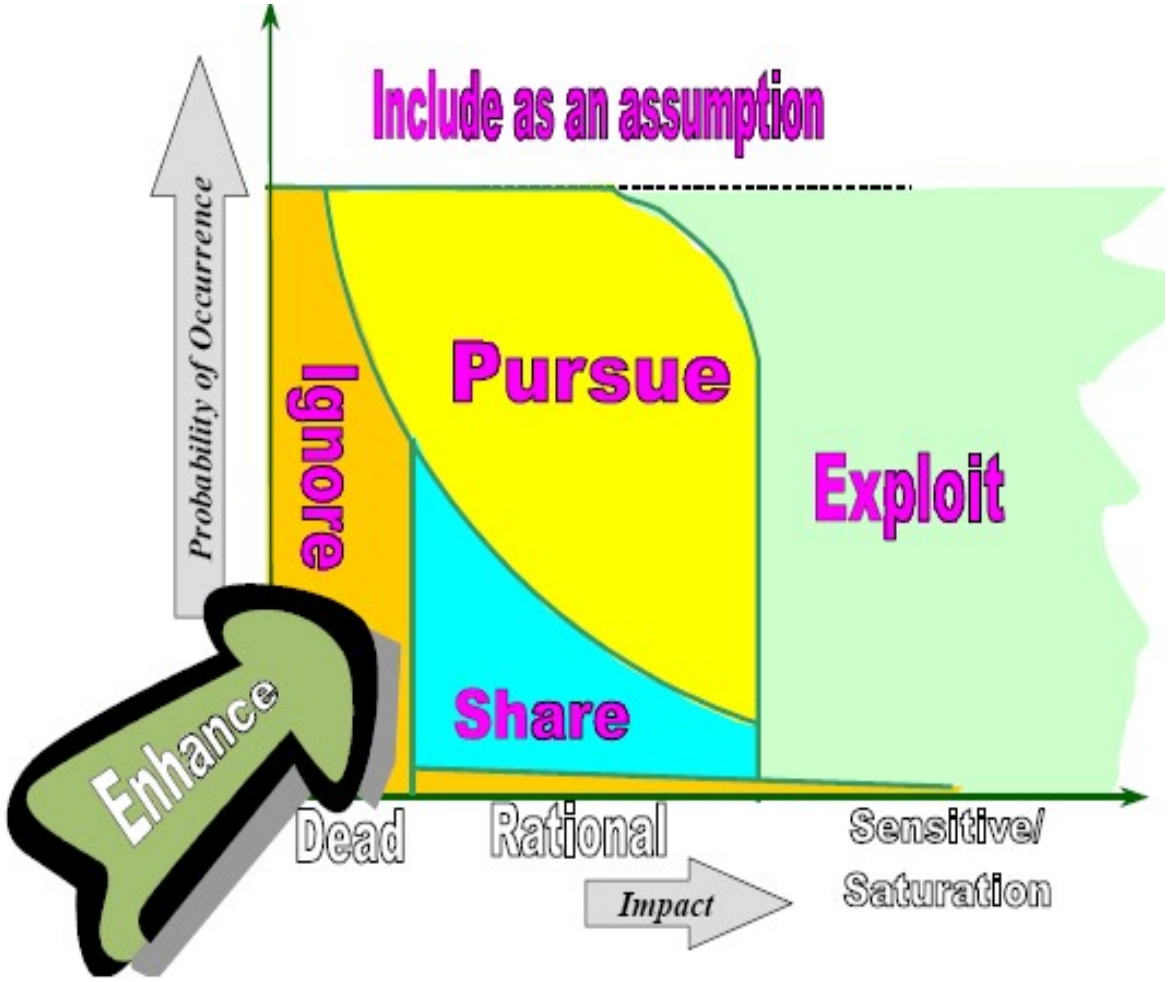
Exhibit 5-4 Typical Risk Response Planning Chart for Threats – Risk Response Planning: Selecting the Right Strategy (Piney, 2002)



Notes:

1. If a risk has an extremely high probability of occurrence, it may be best to assume the condition as part of the base.
2. Risks (threats) with high impacts can, over a given limit, wreck a project; these risks must be avoided.
3. Insignificant risks can be accepted—passive response.
4. Between avoidance and acceptance, we can take other actions such as mitigation; for risks with low probabilities, we may want to transfer them.
5. For risks (threats) above a certain probability, we may choose to accept actively by mitigating and/or preparing contingency plans in the event of its occurrence.
6. All risks (threats) should be mitigated where practical and cost-effective.

Exhibit 5-5 Typical Risk Response Planning Chart for Opportunities – Risk Response Planning: Selecting the Right Strategy (Piney, 2002)

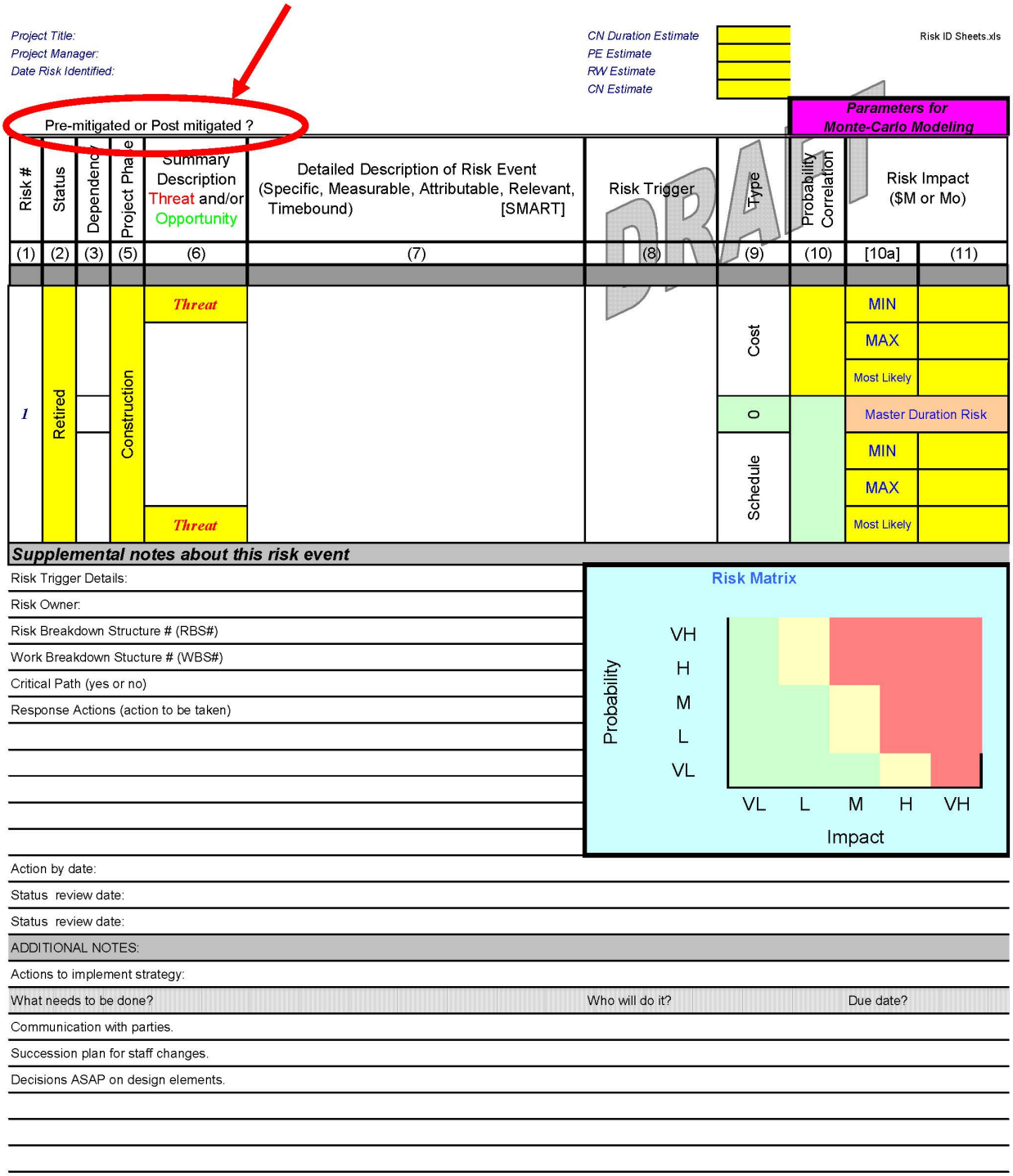


Notes:

1. If a risk has an extremely high probability of occurrence, it may be best to assume the condition as part of the base.
2. Risks (opportunities) with high impacts; these risks should be exploited.
3. Insignificant risks can be accepted—passive response.
4. Between exploit and accept, we can take other actions such as enhance and/or share opportunity risks.
5. For risks (opportunities) above a certain probability, we may choose to accept actively by preparing plans in the event of its occurrence—how will we take advantage of a fortunate occurrence?
6. All risks (opportunities) should be enhanced where practical and cost-effective.

Exhibit 5-6 Risk ID Sheet

Recall the Identified Risk (compare pre-mitigated to mitigated).



Project Title:
Project Manager:
Date Risk Identified:

CN Duration Estimate
PE Estimate
RW Estimate
CN Estimate

Risk ID Sheets.xls

Pre-mitigated or Post mitigated ?

Parameters for Monte-Carlo Modeling

Risk #	Status	Dependency	Project Phase	Summary Description Threat and/or Opportunity	Detailed Description of Risk Event (Specific, Measurable, Attributable, Relevant, Timebound) [SMART]	Risk Trigger	Type	Probability Correlation	Risk Impact ($M or Mo)	
(1)	(2)	(3)	(5)	(6)	(7)	(8)	(9)	(10)	[10a]	(11)
1	Retired		Construction	*Threat*			Cost		MIN	
									MAX	
									Most Likely	
							0		Master Duration Risk	
							Schedule		MIN	
									MAX	
				Threat					Most Likely	

DRAFT

Supplemental notes about this risk event

Risk Trigger Details:
Risk Owner:
Risk Breakdown Structure # (RBS#)
Work Breakdown Stucture # (WBS#)
Critical Path (yes or no)
Response Actions (action to be taken)

Risk Matrix

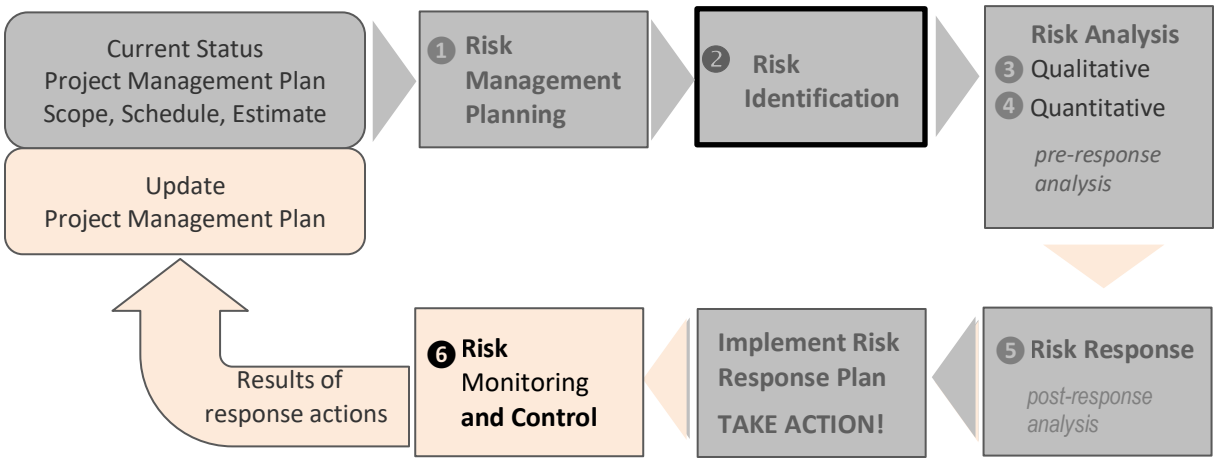
Probability: VH, H, M, L, VL
Impact: VL, L, M, H, VH

Action by date:
Status review date:
Status review date:

ADDITIONAL NOTES:

Actions to implement strategy:

What needs to be done?	Who will do it?	Due date?
Communication with parties.		
Succession plan for staff changes.		
Decisions ASAP on design elements.		



6-1 General

Perhaps you have heard the phrase, "control is an illusion." We may have experiences when we felt this to be true; however, this phrase does not tell the whole story. There may be little control over the external environment, but we do have control over how we interact with it. We have control over our state of readiness; we can look ahead and innovate. We control the robustness of our response to identified risk events and the quality of our documentation. We control how earnestly we integrate risk management into our Project Management Plans.

6-1.2 Risk Monitoring and Control Tools and Techniques

After we have implemented response actions, we must track and record their effectiveness and any changes to the project risk profile. Did the response actions have a positive or negative effect on achieving project objectives? If so, explain how and why in the Risk Management Plan.

6-1.2.1 Documentation of Response Actions

This section is devoted to measuring project risk management performance, and determining whether a project is tracking to plan or deviating. This requires a blend of qualitative judgments and quantitative measures to determine the "health" of the project.

Describe and document the response action it's cost and the work activities affected. Identify the person(s) responsible for implementation of the response. Consider time impacts and how the risk response may affect the overall project and/or other risks.

Determine the appropriate metrics for the project, ensuring they are not burdensome and do not affect behavior. Too often, metrics change behavior to provide better metrics, not better performance. Set the amounts and conditions for use of the project

risk reserves. Establish the final objectives of the project with stakeholders to improve the chances of project success. Confirm endorsement of team members and stakeholders as the project plan evolves.

6-1.2.2 Monitoring and Controlling Project Risk

The Project Manager and team apply the Project Management Plan toward completion of deliverables. Monitor project status, look for trends that indicate variations (good and bad) in project execution. Results should be communicated and if needed adjustments made through a change management or issue resolution process. Be able to describe the project history and it's evolution – this is essential to develop lessons learned.

Helpful Hints

- Be thorough and tenacious in gathering status update information for risks.
- Monitor status and trends continually (scope, schedule, cost estimates, quality of product, etc.).
- Address problems and issues immediately; in fact, anticipate and discuss in advance if possible.
- Communicate.

6-1.2.3 Risk Management Planning (RMP) Spreadsheet

The RMP spreadsheet (🖱 www.wsdot.wa.gov/projects/projectmgmt/riskassessment) is shown in Exhibit 6-1 and can be used to to summarize project risk management activities. The spreadsheet is typically used for the most significant risks as determined via the quantitative risk analysis; some term these risks "candidates for mitigation."

Notice that the spreadsheet is arranged into four sections: (1) risk identification, (2) risk analysis, (3) risk response, and (4) monitor and control. In this chapter, we focus on monitor and control.

Exhibit 6-1 Risk Management Plan Spreadsheet

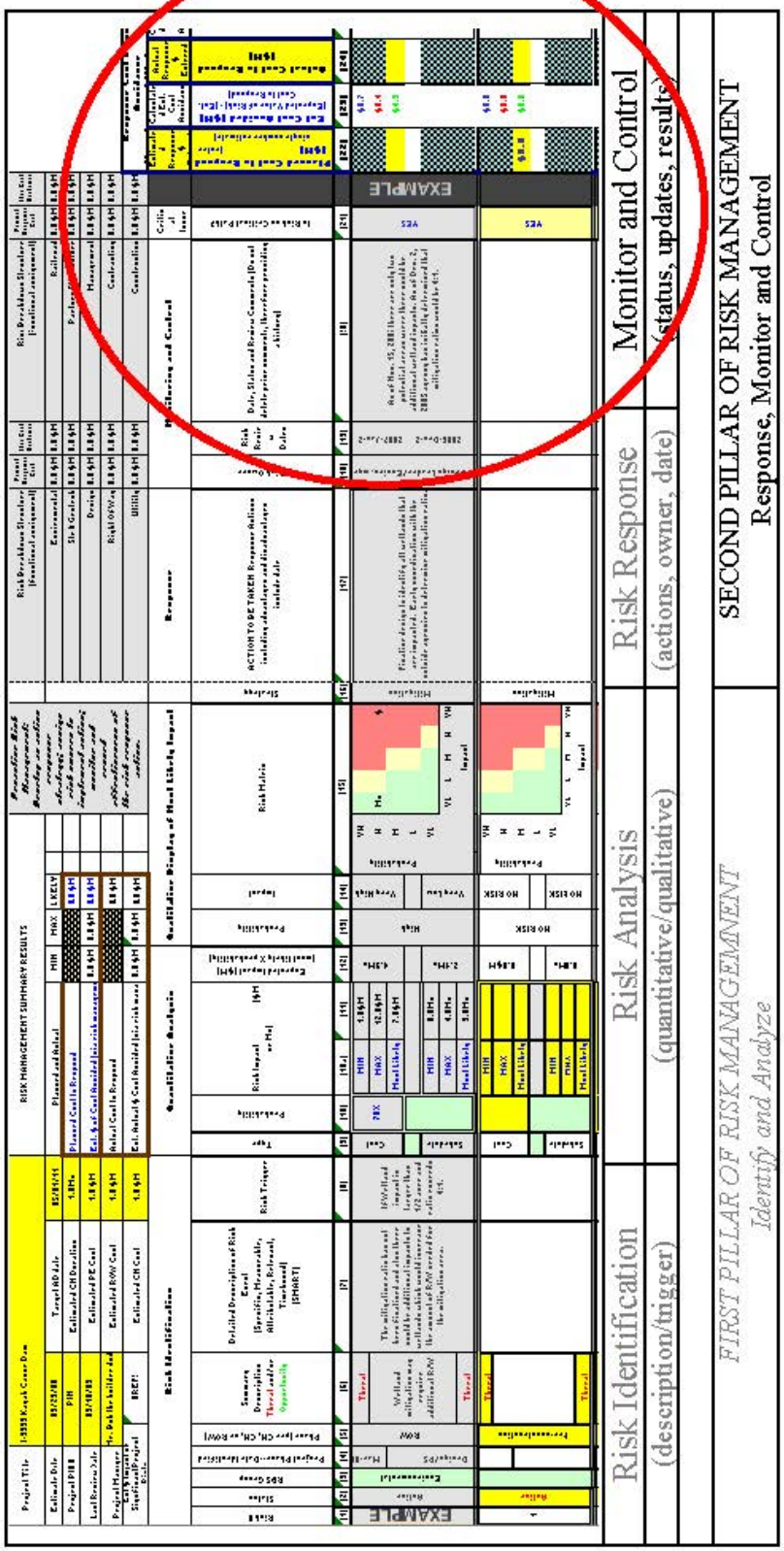


Exhibit 6-2 focuses on the second pillar of risk management – RESPOND – MONITOR and CONTROL.

Exhibit 6-2 Second Pillar of Risk Management

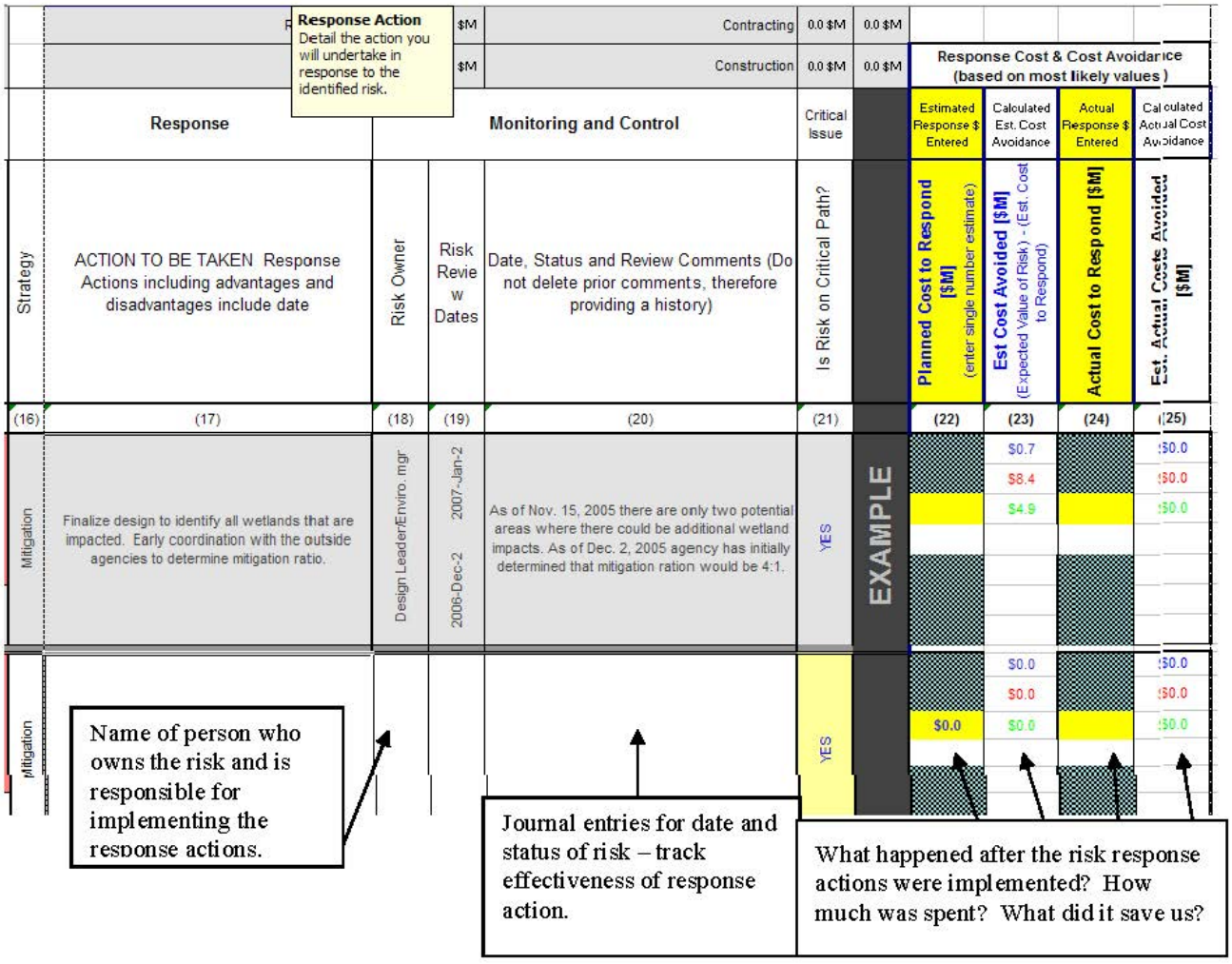
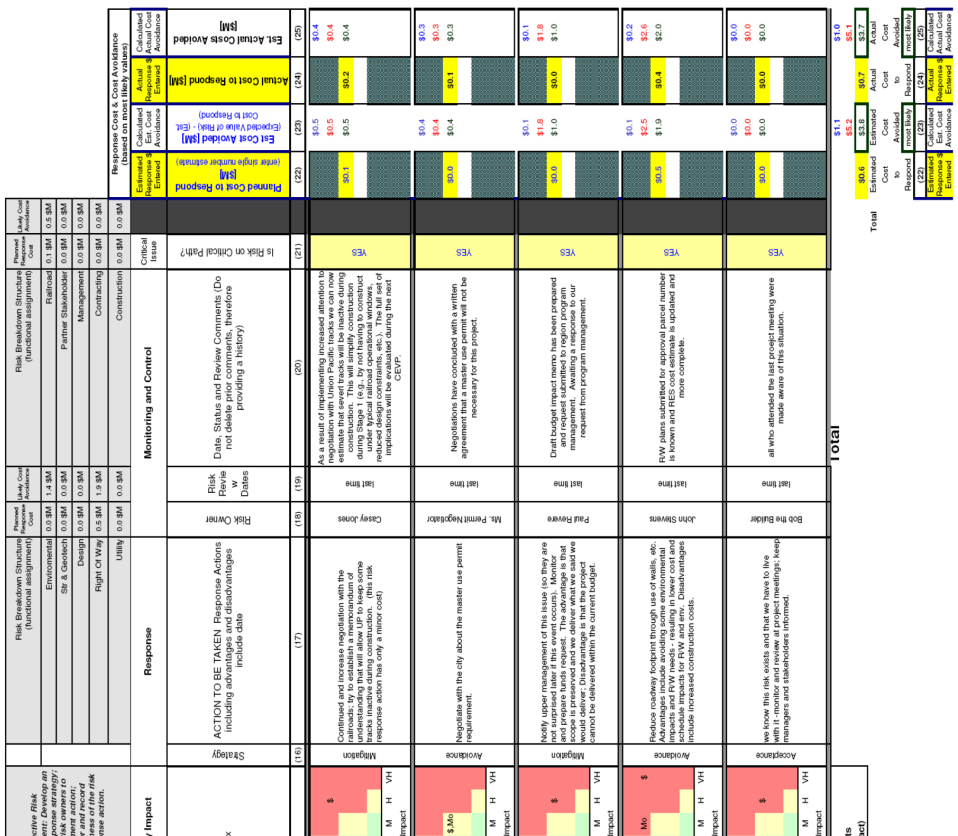


Exhibit 6-3 provides an example of a completed RMP spreadsheet, and the following pages describe how to use the Risk Management Plan spreadsheet to monitor and control project risk.

Exhibit 6-3 Risk Management Plan Spreadsheet (Completed)



www.wsdot.wa.gov/projects/projectmgmt/riskassessment

Notice that the first 15 columns in the Risk Management Plan spreadsheet are devoted to IDENTIFY and ANALYZE: the first pillar of risk management (see Chapter 1). The remaining columns (16 thru 25) are devoted to the second pillar of risk management: RESPONSE, MONITOR, and CONTROL.

In Chapter 5, we reviewed in some detail risk response actions; in this chapter, we follow up and follow through with monitoring and control. The way we "monitor and control" risk is to regularly review the effectiveness of the response. Are the response actions working? Are things getting better? Are we more confident about our ability to meet project objectives after the response actions have been implemented?

In effect, response, monitor, and control are natural components of our day-to-day project management activities (e.g., communicate with the project team and ascertain how things are going; make note in the Risk Management Plan and document the results).

Notice that Exhibit 6-1 lists only 5 risks. Most will agree this is not too many to manage, but is it enough to make a difference in our project? The answer is a resounding YES, and it is demonstrated in the example provided. Exhibit 6-4 depicts the bottom of the RMP spreadsheet under column 11; notice that for these 5 risks, there is an expected value of $7.1M.

It should also be recognized that this project identified over 50 risks, 23 of which were deemed significant enough to warrant inclusion in the quantitative risk analysis model. These 5 emerged as the top-ranked risks after the analysis and provided the Project Manager a prioritized list of risks to manage. The other 40+ risks were not simply ignored; they provided "issues awareness" for various specialty groups and were dealt with as each specialty group deemed appropriate for relevant risks. These additional risks also acted as a "watch list" for the project.

Exhibit 6-4 Total Estimated Cost Impacts of Top 5 Risks for the Example Project

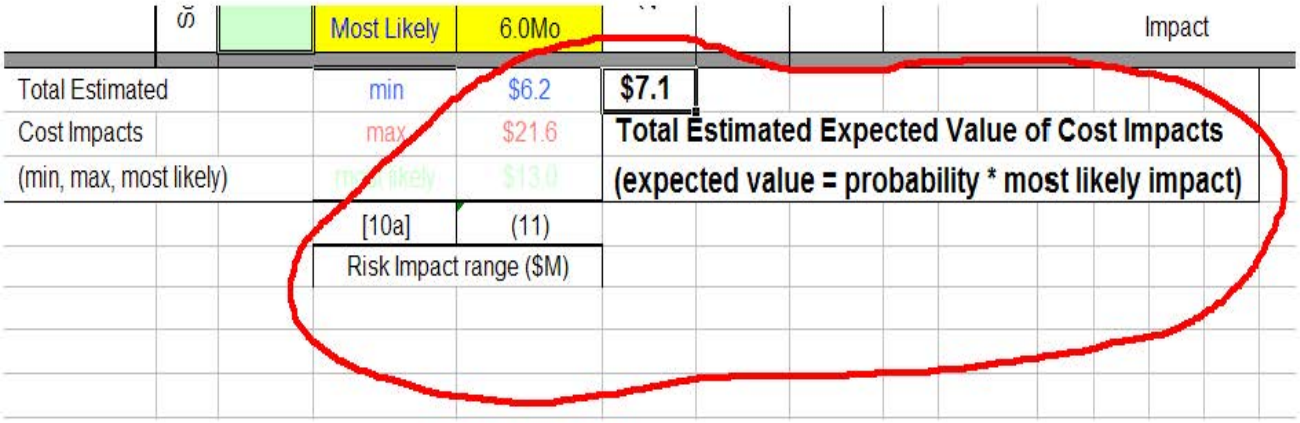
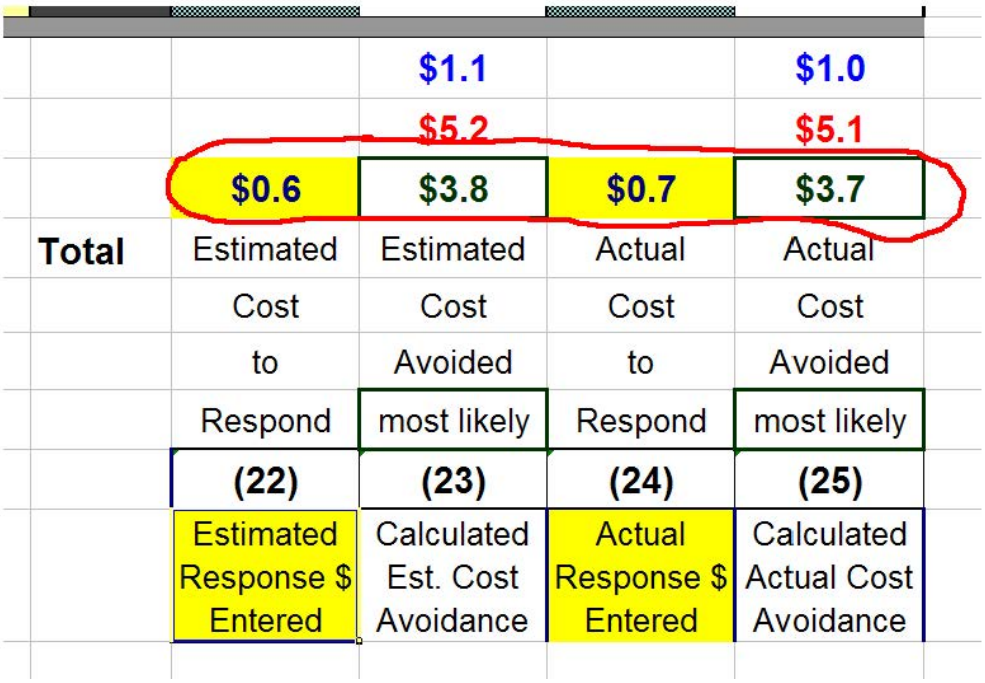


Exhibit 6-5 depicts a performance measure for the effectiveness of risk management on this project.

Exhibit 6-5 Performance Measure of Risk Management for This Project



When reporting on the risk management efforts for this project, we can summarize as follows:

> *The total dollar amount planned for response actions was $0.6M, to achieve reduced project risk exposure by an estimated $3.8M (expected value of risk reduction). After implementing the response actions, we found the total cost of the response actions were $0.7M, which avoided an estimated $3.7M in project costs.*

This example illustrates an excellent return on the dollar for risk management efforts. Other benefits, less quantifiable, included:

- Improved communication among team members and externally to stakeholders and the public.
- Identified areas of concern for each specialty group as it helped develop the risk register during risk elicitation.
- Greater confidence by the Project Manager and project team during project development.
- Fewer surprises as upper management was informed of the issues.
- More informed decision making, due to information gleaned from the overall risk workshop and risk management effort.

We can monitor and control a number of things in our risk management efforts, including:

1. Our state of readiness.
2. Our commitment to looking ahead, and being prepared to improvise and adapt.
3. The robustness of our risk response actions.
4. The quality of our documentation.
5. How earnestly we integrate risk management into our Project Management Plan.
6. Keeping our RMP up to date, including the RMP spreadsheet.
7. Our preparedness to provide the following performance data regarding our risk management efforts:
    - Number of risks identified
    - Number of significant risks, as determined through quantitative analysis
    - Dollar value of significant risks
    - Estimated cost of planned response actions
    - Estimated value of costs avoided through risk management
    - Actual cost of response actions
    - Estimated actual value of costs avoided through risk management
    - Estimated amount of delay (months) avoided through risk management

Chapter 7 Project Risk Management Plan-Example

7-1 General

A project Risk Management Plan describes how a project team will incorporate the risk management process into its Project Management Plan. **Particular emphasis should be given to how a team will respond to risks and monitor and control risk throughout the life of the project.**

The example in Exhibit 7-1 offers an approach to developing a detailed Project Risk Management Plan document. The example presents an approach and is a starting point. Project teams must tailor their document to meet the needs of their project.

7-2 Project Risk Management Plan[1]

The process to: develop and document an organized, comprehensive, and interactive risk management strategy; determine the methods to be used to execute a risk management strategy; and plan for adequate resources. The project RMP may be specific in some areas and general in others. The key to this tool is its scalability. Every project should have a formal RMP, but the level of detail varies with project complexity.

7-2.1 What is a Project Risk Management Plan?

A document that gives a summary of the project and outlines the risk management approach.

The RMP employed will vary based on the complexity of the project, but most project RMPs should include an outline similar to the following:

1. Introduction
2. Summary
3. Definitions
4. Organization and roles
5. Risk management strategy/approach
6. Risk identification
7. Risk assessment and analysis
8. Risk Response actions/allocations
9. Risk monitoring and control

[1] From NCHRP 7-60 review draft – with edits.

Exhibit 7-1 Project Risk Management Plan Template

Project Risk Management Plan

Official Project Title: _____

SR ###, MP limits:

_____Project Manager:_____

_____Risk Manager:_____

_____WIN:_____

PIN:_____

L#:_____

Introduction

This document is the Risk Management Plan for this project. It is a plan of action that describes how this project team will deal with uncertainty and risk. Project risk management is an ongoing and integral part of project management and is performed throughout the life of the project.

The Project Manager is responsible for reviewing and maintaining the Risk Management Plan to ensure that risk is appropriately dealt with by the project team.

Project Manager Review

Initial and date after each review and update of this Risk Management Plan:

Year	Quarter 1	Quarter 2	Quarter 3	Quarter 4
2014				
2015				
2016				

7-2.2 Why Use a Project Risk Management Plan?

It explains how a Project Manager and project team manages risk for their project. It provides guidance and requirements, and serves as a communication tool for those who wish to be informed of a project's risk management approach. The plan formalizes the ideas presented during the risk management process and may clarify some of the assumptions the project team has regarding the risk management process.

7-2.3 What Does a Project Risk Management Plan Do?

It provides specific guidance for the project team members in all steps of the risk management process for their project. The RMP documents the processes to use throughout the project for identifying, assessing, and managing risk.

7-2.4 When Should You Develop and Use a Project Risk Management Plan?

The formal plan should be developed during the planning and scoping process and updated during subsequent project development phases (see Exhibit 7-2).

7-2.5 How Do You Use a Project Risk Management Plan?

The RMP is developed early in the project by collaboration with as many members of the team as possible. It should be consulted and revised throughout the project development process to guide the project through to completion.

7-3 Project Risk Management Process

This project complies with all WSDOT directional documents and guidance for project risk management, including the following:

WSDOT Project Risk Management References	
Project Management Online Guide (preconstruction)	www.wsdot.wa.gov/projects/projectmgmt/
Project Risk Management, Part I: Guidance for WSDOT Projects	www.wsdot.wa.gov/projects/projectmgmt/
Risk Management Plan Spreadsheet	
Reference materials on the topic of risk management and risk workshops at WSDOT	

WSDOT Project Risk Management References
IL 4071, Inflation and Market Conditions Applied to Base Estimates E 1032, Project Management E 1038, Enterprise Risk Management E 1053, Project Risk Management and Risk Based Estimating Project Delivery Memo 07-01, Cost Estimating Guidance

Exhibit 7-2 Project Risk Management Plan Duties

Project Manager	• Approve the project RMP. • Approve and ensure implementation of response actions to identified risks, particularly significant risks that emerge as prospects for risk response. • Confirm who will carry out response actions and when action will be taken; incorporate into work plan. • Monitor effectiveness of response actions. • Regularly review and update the project RMP. • Promote aggressive risk management for this project. • Actively participate in risk workshops. • Communicate to senior management the risk and uncertainty the project is exposed to and the action that will be taken to address it.
Project Team Member	• Proactively identify risks and their characteristics in terms of probability of occurrence and impact. • Proactively respond to risks within specialty area. • Document actions and report to Project Manager for inclusion in risk management updates. • Monitor effectiveness of response actions. • Communicate with Project Manager regarding risk management actions and changing project risk profile (addition of new risks or retirement of old risks –as appropriate).
Project Risk Manager	• Prepare and update the project RMP. • Develop a schedule for key check-in milestones for review and update of the RMP. • Determine when risk workshops will be needed and ensure appropriate preparation is accomplished prior to the workshop. • Collaborate with the Strategic Analysis and Estimating Office, CREM Unit, to coordinate pre-workshop, workshop, and post-workshop activities, including the need for consultants and/or other participants—both internal and external. • Oversee and manage day-to-day risk management process for the project. • Ensure quality of risk data. • Track and monitor effectiveness of response actions. • Promote risk management activities within the project team and with stakeholders. • Communicate with Project Manager on all matters related to risk
Risk Owner (Action Owner)	• Implement agreed response actions. • Report on effectiveness of the risk actions to the Project Manager/Risk Manager and affected project team members. • Identify new risks that may emerge after response actions. • Communicate with Project Manager regularly, including the need for other risk response actions if needed.

7-3.1 Risk Management Planning

Risk management will be a directed, focused, and intentional effort for this project. To that end, the following items are included in this RMP:

1. **Level of risk assessment is determined.**

   As indicated in E 1053, this project will conduct a Cost Risk Assessment workshop as required for all projects between $25M and $100M.

2. **Risk management activities are included in the project schedule.**

   Risk management activities are included in the appropriate sections of the project schedule, using the appropriate WSDOT Master Deliverables List (MDL) codes.

MDL Code	MDL Name	Description
PM.04	Cost Risk Estimate & Management	Cost Risk Assessment is an integral element of project risk management at WSDOT, and quantifies, within a reasonable range, the cost and schedule to complete a project. We will identify, assess, and evaluate risk that could impact cost and/or schedule during project delivery.
PM.04.20	CRA Workshop	Cost Risk Assessment (CRA) is a workshop process similar to, but less intense than, CEVP®. The CRA workshop for this project is planned for January 2015 and is included in the project schedule; pre- and post-workshop activities are also included in the project schedule.
Note: Project teams add tasks, as appropriate, for their risk management activities.		

3. **Risk management is an agenda item at regularly scheduled project meetings.**

   Risk management is included as an agenda item on our monthly project meetings and is the number one agenda item each quarter.

4. **Risk management expectations are communicated to the project team.**

   During Initiate and Align, Plan the Work, and Endorse the Plan, risk management has been communicated as an item of work for this project. Specifically, it is included in the Team Mission/Assignment and in our Roles and Responsibilities.

5. **Risk are managed, documented, and reported.**

   Incorporated into the project schedule and monthly meetings is an item for reporting on status of risk response actions. In addition, this team will use the Risk Management Plan spreadsheet for summarizing and tracking risk response action efforts for significant risks.

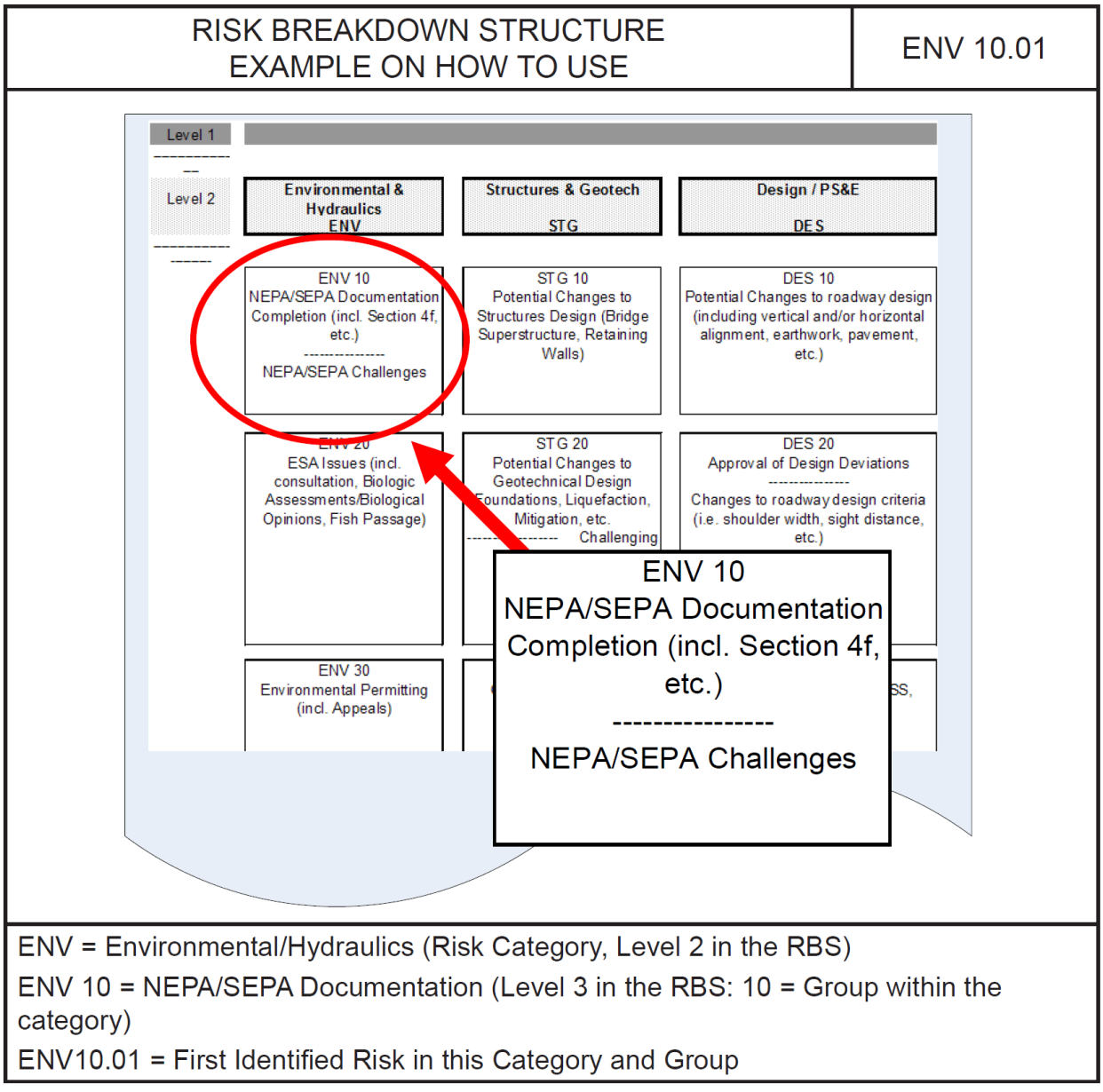
This project team is committed to aggressively and proactively manage risk. Project risk management is at the heart of project management and is an ongoing activity throughout the life of the project. The two pillars of risk management are embraced and responses to identified risks will be implemented and tracked.

7-3.2 Identify Risk Events

The project team will identify risks and build a risk register early in project development. The Risk Manager will maintain the risk register in anticipation of the risk assessment workshops. The WSDOT Risk Breakdown Structure (RBS), provided in Chapter 2, is used for organizing risks, and for monitor, tracking and reporting on risk status.

An example of how to use the RBS is provided in Exhibit 7-3.

Exhibit 7-3 How to Use a Risk Breakdown Structure (Example)



7-3.3 Qualitative Risk Analysis

Initial analysis of risks will begin with a qualitative assessment; see Chapter 3.

7-3.4 Quantitative Risk Analysis

Quantitative analysis of risks will begin with our CRA workshop in January_____; see Chapter 4 for more detail on quantitative analysis.

7-4 Second Pillar of Risk Management (Respond, Monitor, and Control)

7-4.1 Risk Response Planning[2]

The project team[3] is committed makes use of actionable information from risk identification and analysis.

Response actions will be developed and implemented **promptly** following identification and analysis. Risks have a shelf life, and Risk Management Plans can become stale if not monitored and updated regularly. We are committed to making use of information when it is fresh and keeping our Project Management Plans and Risk Management Plans up to date so they do not lapse into irrelevance because they have become outdated and obsolete.

Chapter 5 describes response actions for threats and opportunities. The project work plan, including the schedule and resource assignment, establishes points at which response actions to identified risks will be implemented, including immediately following the CRA workshop for this project. In addition, the members of this project team are reminded to be vigilant regarding risk for this project and to identify potential risk events as they think of them, so they can respond appropriately to risks encountered.

7-4.1.1 Residual Risks and Responses (primary and secondary risks)

As a project develops, its risk profile will change. Risks are identified, and response actions are implemented, which changes the nature of the project risk profile and new risks are identified. During risk identification, we identify risk events. The first time this is accomplished, it constitutes a list of primary risks; as actions are taken, secondary risks can emerge as a result of implementing the treatment response to the primary risk.

If it is possible, secondary risks should be dealt with as part of the primary risk response action. When developing our response actions, we will be vigilant in considering the ramifications of the response actions. We will take measures to include strategies that deal with the primary risk as well as secondary risks and endeavor to minimize or eliminate residual risk as part of risk response efforts.

7-4.2 Risk Monitoring and Control

Monitoring and control is not complete unless communication has occurred. COMMUNICATION is the lynch-pin of effective project management and risk management.

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[2] Also referred to as risk treatment, risk mitigation, risk management, or risk prevention in some publications.

[3] *Practical Risk Management* by David Hillson and Peter Simon (with edits).

Communication within and among the project team will be crisp, concise, complete, correct, and timely, as will the communication to upper management and executives. Effectiveness of the risk response actions will be monitored and reported regularly, as indicated previously, at our project meetings; adjustments will be made as needed.

7-4.2.1 Risk Monitoring and Control (communication)

- Project Team
  - Record assumptions that underlie judgments and decisions.
  - Monitor and document results of implemented risk response actions.
- Upper Management and Executives
  - Avoid unpleasant surprises.
  - Fully inform parties of risks, response actions, and trade-offs.
- Accountability
  - Document the risk assessment process in such a way that it can be reviewed and examined to learn the reasons particular judgments and decisions were made.
- Control of Risk and Management Activities
  - Specify criteria for risk management success, including targets and measures used to assess performance.
  - Follow up with risk owners regarding the status of completing the risk response actions and the resulting effect; track resource allocation(s) associated with risk response actions.

Exhibit 7-4 Project Risk Management Performance Template

Project Risk Management Performance

Date of This Report:_____

Cost-Risk Estimating Management

Project Risk Management Performance Summary Report
(Workshops held between MMMM DD, YYYY and MMMM DD, YYYY)

Performance Measures

	CRA Workshop #1	**CRA** Workshop #2	**CRA** Workshop #3	**CRA** Workshop #4
Workshop Date(s)				

	CRA Workshop #1	**CRA** Workshop #2	**CRA** Workshop #3	**CRA** Workshop #4
Pre-Workshop Base Cost Estimate for Project				
Validated Base Cost Estimate for Project				

	CRA Workshop #1	**CRA** Workshop #2	**CRA** Workshop #3	**CRA** Workshop #4
Total # of Risks Identified				
Total $ Value of Threats				
Total $ Value of Opportunities				
$ Value of Prospects for Risk Response Actions				
$ Cost of Risk Response				
$ Cost Avoided through Proactive Risk Response				

RBS Code	**Risk Break Down Structure Group (Level 2)**	**Number of Risks**	**Value of Threats $**	**Value of Opportunities $**
ENV	Environmental and Hydraulics			
STG	Structures and Geotechnical			
DES	Design/PS&E			
ROW	Right of Way and Access			
UTL	Utilities			
RR	Railroad			
PSP	Partnerships and Stakeholders			
MGT	Management and Funding			
CTR	Contracting and Procurement			
CNS	Construction			

Part II:
WSDOT Guidelines for CRA-CEVP® Workshops

(Includes Common Assumptions)

We may not be able to get certainty, but we can get probability…

~ CS Lewis

Section A CRA-CEVP® Workshops

A-1 Purpose

This document establishes consistency in the practice of risk-based estimating at the Washington State Department of Transportation (WSDOT) and includes guidance for: project teams, Risk Leads, Cost Leads, region CRA Coordinators, and subject matter experts (SMEs). The Cost Risk Estimating Management (CREM) Unit, part of WSDOT's Strategic Analysis and Estimating Office (SAEO), delivers risk-based estimating workshops for the state. Projects vary in terms of size, location, and complexity; the process can be tailored to the needs of the project. The workshops are accomplished with the committed and diligent work and contributions of our partners in the consulting community and WSDOT staff who contributed to the development of these guidelines.

Three questions are fundamental to the search for a more accurate estimate on projects:

(1) How much will it cost? ***(2) How long will it take?*** ***(3) Why?***

One answer we found to these fundamental questions is that an estimate is more accurately expressed as a *range*, not as a single number. To determine an accurate estimate range for both cost and schedule, key risks must be identified and considered. To present a comprehensive portrayal of a project in terms of cost and schedule, we must begin with a solid, well-prepared, and well-documented base estimate. Base cost is defined as the planned cost of the project; the base cost does not include contingency. A list of risks is created for both opportunities and threats, called a risk register. The risk assessment replaces general and vaguely defined contingency with explicitly defined risk events, which include their associated probability of occurrence and impact on project cost and/or schedule. The risk component, for projects over $10 million, is developed as part of a formal or informal cost risk workshop.

This process is consistent with the professional codes of ethics to which many of the workshop participants are bound. The agreements below represent fundamental aspects of estimating for public works projects, and are consistent with the nationally recognized codes of ethics for the American Society of Civil Engineers (ASCE) (https://www.asce.org/inside/codeofethics.cfm) and the Association for the Advancement of Cost Engineering International (AACEI) (http://www.aacei.org/membership/about/canonethics.shtml).

A note about risk, uncertainty, and estimating: "It is better to be approximately right rather than precisely wrong."

Ten "Agreements" for Workshop Participants:

I agree to:

1. Observe the highest standards of my profession.
2. Communicate honestly and effectively.
3. Be accountable and open in my estimating practice.
4. Listen as others speak without regard to position or title.
5. Foster broad participation in the process.
6. Exercise authority appropriately and not pressure others to develop estimates to a predetermined dollar figure.
7. Be a good steward of public funds on projects for the public good.
8. Strengthen my understanding/practice of the principles and values of estimating uncertainty and risk.
9. Work to deepen my understanding of estimating project costs and schedules.
10. Continue my education and encourage the education of others.

*A-1.1 Helpful Hints for Project Teams**

1	**Be prepared:** Know what is to be evaluated at the workshop; clearly describe the scope of the project; have a well-organized, up-to-date, and easy-to-present project schedule and cost estimate appropriate to the level of project development.
2	**Submit workshop request form *after*** it is clear what project alternatives and/or scenarios are to be evaluated. Allow at least 8 weeks advance notice from the time the workshop request form is submitted to when the first prep session will be held.
3	**Use the project management process** as outlined in the WSDOT Project Management Online Guide.
4	**Follow the guidance** provided throughout this document.
5	**Keep workshop attendance to a manageable size:** An effective workshop has all of the necessary people present, but not more than is necessary. Too many people in a meeting can make it less effective, slow, and cumbersome. Read the sections on Pre-Workshops and Workshop Meetings in this document, particularly Cautionary Notes Regarding Workshop Dynamics.
6	**Project Manager or Assistant Project Manager attends the workshop:** It is crucial that someone able to speak from the owner's perspective be present throughout the workshop.
7	**Become familiar with the workshop process in advance of the workshop:** The Strategic Analysis and Estimating Office can provide a representative from the CREM Unit to conduct training and orientation in advance of the workshop.
8	**When the workshop is over, it's over!** The workshop is a "snapshot" examination of the project, and issues of concern should be brought up during the workshop. Elicitation of risks and their characteristics are completed by the end of the workshop. The modelers then need to complete the modeling and analysis of the information generated at the workshop, without interference and disruption due to post-workshop wrangling and debate. Following the completion of the analysis risk response, actions are to be developed and incorporated, by the project team, into the Risk Management Plan. Benefits of the process resonate for weeks and months following the workshop as the project team uses information gained from the workshop in their day-to-day decision-making and project development activities.

**Use as a quick reference; more detailed information is found throughout this document.*

A-1.2 CRA and CEVP® Workshops: Statement of Purpose

Provide a useful, sound, and objective analysis and report that the project team will own and act upon to improve and/or validate project cost schedule estimates. Workshops, conducted collaboratively with cost-risk experts and the project team, will:

1. **Define and review or validate cost and schedule base estimates** using a Lead Cost and schedule reviewer, subject matter experts, and WSDOT specialists.
2. **Document assumptions and constraints** used in developing the estimated project cost and schedule range.
3. **Replace (or greatly reduce) the traditional project "contingency"** with key identifiable risks that can be more clearly understood and managed.
4. Under the direction of a Risk Lead, **identify and quantify key events** in a project that can cause a significant deviation from the base cost or schedule. This identification and quantification should begin prior to the workshop through advance elicitation meetings.
5. **Perform a Monte Carlo simulation analysis to model the collective impact** of base and risk issues for the complete project as a system **to produce an estimate of a reasonable range and distribution.**
6. **Discuss and develop concepts** for responses to risks to the schedule that could impact the cost of the project. Promote proactive risk management by project teams. Provide the project team with actionable information on risk events that allows them to manage the risks (threats/opportunities) on an ongoing basis, via mitigation strategies to better control project costs and schedules.
7. **Perform a "post-mitigation"** analysis to ascertain the effectiveness of planned and/or implemented risk response actions.

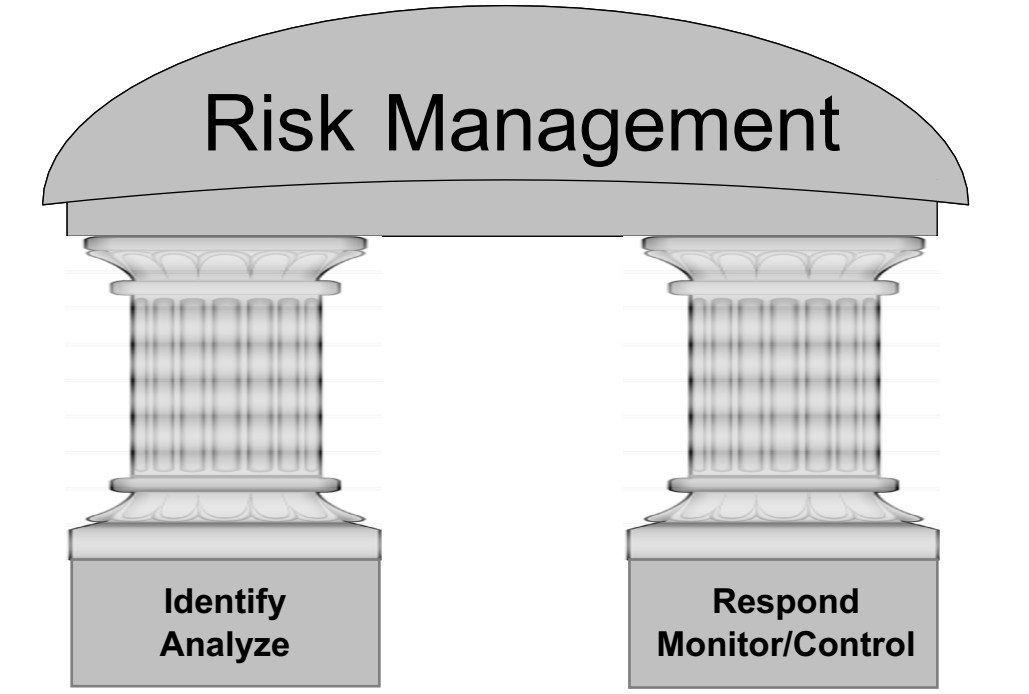
A-1.3 CRA and CEVP® Seven-Step Process:

1. Select the project and method.
2. Structure the project team effort.
3. Define and evaluate the base cost estimate and schedule.
4. Assess uncertainty and risk.
5. Quantify uncertainty in the project cost and schedule.
6. Apply probabilistic analysis and document.
7. Implement and measure risk response actions, monitor, and control.

A-1.4 Base and Risk Defined

The **base cost** represents the cost that can reasonably be expected if the project materializes as planned. The base cost estimate is unbiased and neutral.

A **project risk** is characterized quantitatively with the combination of the probability of an uncertain event and its consequences. A *positive consequence* presents an opportunity; a *negative consequence* poses a threat. In a project context, it is the chance of something happening that will have an impact upon project objectives.



*P = Probability, I = Impact

*RMP = Risk Management Plan

Two Pillars of Risk Management

We can think of risk management as two pillars (depicted above): "IDENTIFY and ANALYZE," and "RESPOND, MONITOR, and CONTROL."

Unless we incorporate the second pillar, we are not realizing the full value of risk management. When preparing the Project Management Plan and work activities for our project, **we must include both pillars of risk management**.

- The preparation activities before the workshop, the workshop itself, and the analysis of the input comprise the first pillar.
- The second pillar requires that the Project Manager and project team develop response actions for the key risks, document the response actions, and incorporate this information into their Risk Management Plan (as part of the Project Management Plan update).

The Project Manager and team then track the risks and the effectiveness of the response actions. A follow-up analysis can be performed to demonstrate the effectiveness of the response actions.

Exhibit A-1 Pre-Workshop, Workshop, and Reporting Activities

Workshop Request by project team

Project Team must include risk management activities in their project management plan

This flowchart is an "at-a-glance" reference, please review relevant portions of the WSDOT Guidelines for CRA-CEVP Workshops for more details.

Pre-Workshop Activities

1a) DETERMINE NEED
PROJECT TEAM - Confirm: Project Title, PIN, WIN, Mileposts are correct and WOA is setup. Complete the workshop request form and send to region CRA coordinator who forwards to the **SAEO (CREM unit)**.

1b) LEARN THE PROCESS
SAEO OFFICE (CREM unit) - Provide: Orientation to Process Contact and negotiate with consultants (Risk Lead, Cost Lead, SMEs). Prepare task orders. Prepare and distribute Prep Session Agenda to participants. PROJECT TEAM: Review CRA website, workshop guidelines and other reference materials.

1c) ASSEMBLE PROJECT INFO
PROJECT TEAM – provide project information; include: current basis of estimate and project cost estimate, scope and schedule. Review reports from prior workshops/studies. Prepare list of issues of concern plan to host prep session.

2a) PREP SESSION
SAEO OFFICE (CREM) : **PREP SESSION** Risk Lead/Workshop coordinator develop draft project flowchart and make notes. Prepare action items. Provide Risk ID Sheets to Project Team.

2b) INVITE WORKSHOP PARTICIPANTS
SAEO OFFICE (CREM unit) and PROJECT MANAGER
SAEO (CREM unit): Invite external independent SMEs and HQ specialty groups identified to participate in the workshop. Prepare workshop agenda and send Outlook invite to participants. PROJECT MANAGER: invite region participants and others who regularly work on the project from HQ.

3a REVIEW PROJECT ESTIMATES
PROJECT TEAM - work with **SAEO (CREM unit)** to begin advance review of project cost and schedule estimates.

4a ADVANCE ELICITATION
SAEO OFFICE (CREM unit)
Work with Project Team to Arrange Advance Elicitation Interviews; conduct Advance Elicitation interviews with appropriate Project Team members and specialty groups. Elicitation continues and is finalized in the workshop.

WORKSHOP

5a CONVENE THE WORKSHOP
Workshop Leader [SAEO (CREM unit)] and/or Region Coordinators direct the workshop. RISK LEAD takes the lead during risk elicitation, the COST LEAD takes the lead during cost and schedule review and validation. PROJECT TEAM hosts the workshop.

PROJECT TEAM PROVIDES:

Meeting Venue with internet connection.

Visual aids such as:

Aerial photos	Plan Sheets
Project Exhibits	R/W Sheets
Story Boards	Other items

Project information, including:
Basis of Estimate
Project Cost Estimate
Backup documentation
Project Schedule
Environmental Documentation
R/W Parcels information
R/W Cost Estimate
Other Pertinent Information

Typical Workshop Format:

CRA/CEVP workshop process overview
Workshop Introduction

Review/finalize project flowchart and scenarios with base durations
---
Confirm validated base estimate

Confirm Major Risk Items

Confirm uncertainty in cost & schedule

Identify and Evaluate Potential Risk Management Strategies

Set date for mitigation review meeting

SAEO (CREM unit) lead prepares action items.

Post-Workshop Activities

6a) PERFORM ANALYSIS
RISK LEADS prepare a presentation of ***PRELIMINARY RESULTS, and*** Prepare ***REPORT*** send to **SAEO (CREM unit)** to review and forward to Cost Lead and Project Manager .

6b) REVIEW REPORT
PROJECT TEAM Conducts a thorough and speedy review of draft report and promptly sends comments to **SAEO (CREM unit)** who works with the Cost-Risk-Team to finalize.

7a) RESPOND TO RISKS
PROJECT TEAM: Develop and implement risk response strategies. Maintain and update the project Risk Management Plan.

7b) POST-MITIGATION ANALYSIS
PROJECT TEAM/SAEO
Project Team works with **SAEO (CREM unit)** to Assess and measure impact of response plan.

7c) MONITOR/CONTROL
PROJECT TEAM
Continue to monitor risks and response actions for effectiveness.

TASK ORDER CLOSEOUT
CONSULTANTS submit final invoices. **SAEO (CREM unit)** make final payments, close task orders and advise project manager and appropriate program manager that the task order is closed.

CRA and CEVP® Seven step process:

1. **Project and Method Selection**
2. **Structuring the Collaborative Team Effort**
3. **Define and Evaluate the Base Cost Estimate and Schedule**
4. **Identify and characterize Project Risk and uncertainty.**
5. **Confirm Quantified Risk and Uncertainty in the Project Cost and Schedule**
6. **Probabilistic Analysis and Documentation**
7. **Implement and measure risk response actions, monitor and control**

A-1.5 Workshop Teams and Participation

A-1.5.1 The Right Size and Participants

The main criterion for project workshop participation has to be "Who is absolutely critical to identify the problems we are dealing with?" The criterion of "criticalness" should include not only technical expertise and responsibility but also problem-solving and team skills. Workshop participants should:

1. Be involved
2. Be heard (in relation to their responsibility and/or expertise)

Recommended Participants

Preparation for the workshop may take one or several meetings depending on the project size and complexity, and the knowledge of the participants. The Project Manager/project team should work with the workshop coordinator and cost-risk team to identify the best combination of participants at each meeting (see Exhibit A-2). All participants do not need to attend all meetings. The goal is to effectively use time for all parties in a manner that ensures a sound and objective analysis (see Exhibit A-3).

Exhibit A-2 Workshop Team (Typical Participants)

Project Team Members	Roles & Responsibilities
Project Manager*	Project resource and decision maker.
Estimator*	Prepare and document project estimate.
Scheduler*	Prepare and document project schedule.
Lead Designer*	Primary resource for design questions.
Key Technical Experts	Specialty groups as needed.
Subject Matter Experts	**Roles & Responsibilities**
Project Team Experts	Internal subject matter experts (SMEs) work with external SMEs to review and validate project cost and schedule estimates. They provide objective review and comment regarding project issues, risks, and uncertainty. At the end of the workshop, the SMEs should provide a brief (i.e., one-page) summary of their thoughts about the workshop.
Agency Experts (HQ, et al.)	
Other Stakeholders	
External Consultants	
Cost-Risk Team Members	**Roles & Responsibilities**
Risk Lead*	Conducts risk elicitation and manages meeting during risk elicitation; performs or directs the performance of the statistical analysis.
Risk Lead Assistant	Assists with risk elicitation and meeting management during risk elicitation.
Cost Lead*	Conducts base cost and schedule review and validation; manages the meeting during the review.
Cost Lead Assistant	Assists the Cost Lead position, as appropriate.
CREM Workshop Coordinator	Coordinates the agenda and participants' discussions, works with the Project Manager to ensure the success of the workshop.

*These participants should also attend the prep session.

A-1.5.2 Pre-Workshops

Exhibit A-3 Pre-Workshop: Determine Need, Process & Assemble Project Information

Strategy Session	Orientation Session	Assemble Project Info
Determine: Does the project need a risk-based estimating workshop? If yes, what type: informal, CRA, CEVP®, combined VE-CRA? (See WSDOT directional document IL 4071.) Determine timing and scheduling of workshop events. This can typically be accomplished via telecon between the CREM Unit and the Project Manager.	**Process:** Participants must understand the process and their role in it. Formal training provides a comprehensive presentation of the process. However, there are varying levels of experience and proficiency with the CRA/CEVP® workshop process. Orientation sessions can be tailored to the project team and participants as appropriate.	**Evaluate:** The Project Manager and project team need to know what it is they are going to evaluate, and clearly communicate that to the workshop participants. The process provides an opportunity to examine more than one scenario, but it is not practical to evaluate "the universe of every conceivable concept."
Conduct Prep Session		
Prep sessions should be attended by the Risk Lead, the Cost Lead, and the core project team because they will be tasked to help develop the project flowchart, assemble initial project costs/durations, and develop a list of risks eligible for significant impact on the project schedule or cost. At this meeting, additional participants will be identified who should participate at the upcoming workshop. The identification of needed support from subject matter experts (SME) is an especially important outcome of the prep session.		
Invite Participants		
Determine who will be needed to attend the workshop and when they will be needed. Determine who will send the invitations; typically, the project team will schedule the rooms and invite region participants and specialists from Headquarters (HQ) with whom they have been working. The CREM Unit will invite the external cost-risk team members (consultants and other independent experts from HQ).		
Review Estimate and Schedule		
After the prep session and before the workshop, the Cost Lead and Cost SME review the project team's base cost and schedule estimate and provide recommendations for their consideration. (See Section D for a sample of Cost Lead review questions that should be asked at this stage.) The estimate review and base cost validation should begin in advance of the workshop. The draft estimate and flowchart/schedule should be reviewed by affected project team disciplines prior to the workshop. The pre-workshop base cost estimate and flowchart/schedule must be submitted to the WSDOT region Risk Manager and all significant non-WSDOT stakeholders prior to the workshop.		
Advance Elicitation Interviews		
Prior to the workshop, the Risk Leads should meet with those specialty groups that elicit the most critical risks and are most crucial to project success; these are the risks that have significant effects on project objectives.		

Note: The best workshops, in terms of being effective and efficient, are those that have had ample advance work conducted—particularly in the areas listed above.

A-1.6 Preparing Workshop Participants[1]

Prior to the actual workshop, participants need to know what to expect and what is expected of them. Participants are reminded to: (1) avoid bias and be impartial during the workshop discussions, (2) listen open-mindedly to all opinions, and (3) not advocate for a predetermined point of view.

The following sections describe procedures for preparing the project team and SMEs to ready themselves for the workshop. The Risk Leads and Cost Leads are expected to be aware of potential biasing as they conduct their respective portions of the workshop.

A-1.7 Preparing the Project Team – Overview for "Bias Reduction"

The CRA/CEVP® environment provides an opportunity for the project team to share their cost and schedule estimates with others. The assurance of an accurate project cost estimate and schedule begins when a project team initiates and aligns their team for the project.

Project teams work hard to maintain the quality of their estimates and schedules. They are often optimistic about their project, particularly early in project development. An optimistic estimate is generally a low estimate. A pessimistic or *conservative* estimate is generally an estimate that, in the judgment of the estimator, is intentionally high in order to make sure there is enough money for the project.

Project teams should guard against all forms of bias at all stages of project development. Optimistic bias has been observed, in some cases, to reverse itself as a project approaches completion of design. As the contract package begins to come together in advance of the advertisement date, Project Managers/engineers may become increasingly guarded about the financial needs of the project and give estimates for costs and schedule that are too high, thereby driving the project cost estimate higher.

Following the Process

The process, when properly followed, provides a sound base estimate and identifies risk events that can cause the project to turn out differently than planned. Attempting to revise estimates for the analysis outside this framework can make it difficult to disentangle effects and make the management of risks less effective.

Identification and quantification of risk events will provide the project team with knowledge regarding identified risk events. The Project Manager must decide what action to take in response to the identified risks: avoid, transfer, mitigate, or accept the risk. Decisions regarding risk management may affect project budget and schedule.

[1] "The human element introduces an additional layer of complexity into the risk process, with a multitude of influences both explicit and covert. These act as sources of bias…which affect every aspect of risk management." *Understanding and Managing Risk Attitude* by Hillson and Murray-Webster. In our processes, we attempt to "condition" (prepare) participants to be aware of bias and make efforts to avoid and reduce bias in workshop inputs.

A-1.8 Preparing the Project Team – Procedures

It is important that the project team be prepared both before and during the upcoming meetings. They should review the following steps, which are needed to complete the cost risk analysis:

1. Emphasize the "Statement of Purpose" to workshop participants.
2. Set up a prep meeting (ideally held a few weeks prior to the workshop).
    a. Contact the project lead and arrange a visit to the project site for workshop participants who may not know the project. This can occur any time before the workshop. Discuss the significant risks faced by the team.
    b. Send the Project Manager an example of a project flowchart from a recent project. Contact the Project Manager to let them know that a project flowchart will need to be completed by the end of the prep meeting.
    c. The flowchart is less detailed than a project schedule and needs to show the sequence and duration of major project activities; the flowchart depicts the assumed project delivery strategy.
3. The Cost Lead reviews the basis for the estimate of project cost and schedule durations, and discusses it with the project team member(s) who prepared and/or compiled the estimate.
4. At the prep meeting, remind the project team to work up initial lists of "risks to the project"—both threats and opportunities—that have the potential to cause the project cost/schedule to be significantly and measurably different than planned.
5. Inform participants that it is okay to have outcomes significantly different from what was planned—as long as they are plausible. At a very early stage of design, the divergence from planned values is expected to be greater.

A-1.9 Preparing Subject Matter Experts – Procedures

Proper preparation of subject matter experts and the risk elicitor is required to reduce the bias in expert response. Three biases (described below) tend to dominate in expert response: "anchoring and adjustment bias," "availability bias," and "representativeness bias." These were all researched and documented in the 1970s by Kahneman and Tversky[2] and further refined by others. The biases tend to work in the direction of understating the range of uncertainty.

[2] "Judgment Under Uncertainty: Heuristics and Biases" Tversky & Kahneman, 1974

A-1.9.1 Anchoring and Adjustment Bias

The *anchoring and adjustment bias* is the phenomenon of experts thinking they know more than they actually do. If you ask an expert for their best guess first, then they will tend to provide inadequate ranges. Following are better ways to reduce biased answers:

1. Ask experts for the limits of the potential ranges first.
2. When providing extremes, experts should be able to describe the type of outcome that will generate the extreme case.
3. Ask the expert for a "plausible low" and "plausible high." These can be treated in a variety of ways by the analyst who quantifies the risk. A standard needs to be established.
    a. One method is to ask the expert for a plausible minimum and plausible maximum.
    b. Another method is to ask the expert for a low and high percentile (i.e., 10% and 90%), and then use this information to generate the distribution.
    c. A third method is to request another low and high percentile that the expert wishes to provide.
4. After obtaining the highs and lows, ask for the expert's most likely value.

A Note on Risk Identification and Assessment

Consider: Sometimes, those new to risk analysis claim it is nothing more than guessing. However, this view does not represent the actuality that assigning values for probability and impact relies on the *expertise* and *professional judgment* of experienced participants. The determination of a value for the probability of occurrence and its consequence to project objectives, if it occurs, is a new activity for many people, and can seem strange at first.

In any field, with experience, professionals develop intuition and an ability to understand projects to a greater degree than those not involved with project development and delivery in their industry. This experience and intuition is extremely valuable—in a risk workshop forum we surround ourselves with "wise counsel" to seriously and thoroughly discuss the project. It might be helpful to examine the word "guess" and compare it to other words, such as "discernment" and "judgment," that more appropriately describe risk assessment (see Exhibit 3-1 in Part 1 for the definitions and synonyms).

A-1.9.2 Availability Bias

Experts are always receiving new information to add to their knowledge base. Frequently, when approached for their judgment, experts will have recent information that they have not had time to "blend-in" to their knowledge base.

One practical way to address this information *availability bias* is to ask the expert a simple follow-up question regarding the issue being elicited: "Is there recent information you are using to provide your judgment?" If the answer is yes, then ask, "How does that new information weigh in relative to all the other information you have accumulated over the years?" If the availability bias exists here, the expert will often say something like, "That's a good question; let me think about it and get back to you" or "I've thought about it and I have given the new information the proper weighting."

A-1.9.3 Representativeness or Stereotyping Bias

This is the case where experts have base information, but don't use it. Instead, they match an event with a stereotypical case. Biases, in expert response, can potentially lead to understating the range, so it is important that the risk elicitor properly prepare participants, and monitor and question participants if a bias is detected.

A-1.10 Conflict Resolution

Although uncommon, there may be situations where a significant difference of opinion has arisen between workshop participants, either during or following the workshop. There are many resources and references on the topic of conflict management and conflict resolution. This workshop guide is not a substitute for those resources, many of which can be found at libraries and bookstores. However, a progressive process for resolving such disagreements at workshops is offered below:

1. **Capture the difference as a range**

   One benefit of the CRA/CEVP® workshop process is that it allows input in the form of ranges and percent probabilities. Usually, the ability to capture input in ranges meets the needs of participants offering input. For example, if one participant states, "This risk event could cause $1 million in additional cost…," and another says, "This risk event could cause up to $3 million in additional cost…," we can simply offer to capture the risk with a $1 million to $3 million impact range. Typically, this will satisfy the parties with differing opinions about the impact. (Note: Persons offering opinions should be able to state why they have the opinion and document the information used to develop the opinion.)

2. **Evaluate different scenarios**

   If we are not able to resolve the difference by capturing it as a range, in some cases it may be appropriate to evaluate additional scenarios that address the different opinions being offered. This is practical in some cases—to a point. Having too many scenarios can add cost and complexity to the workshop and may not be necessary or helpful to the overall evaluation of the project.

3. Meet with relevant parties and review the data

If a strong difference of opinion persists, and the first two options above will not resolve the matter, agree to gather data and meet to review and discuss the matter with the relevant parties and subject matter experts. Strive to use objective data, with guidance from the Risk Lead and Cost Lead, to reach an agreed-upon input. If, after a concerted effort to reach a consensus decision, disagreement still exists, it may be necessary to adopt a solution and document the dissenting opinion in the report.

When evaluating information, consider the following:

Less Reliable (less certain)	More reliable (more certain)
One or very few observations	Many observations
Anecdote or case study	Scientific study
Unpublished	Published and peer-reviewed
Unrepeated	Results have been reproduced
Dissimilar projects	Similar projects
No constraints or assumptions identified	Constraints and assumptions listed
No comparative explanation of information	Comparative analysis provided

Thompson, Kimberly M., *Risk In Perspective,* with edits.

A-2 Workshop

The workshop will be attended by project team members, the cost risk team, and necessary SMEs and/or project specialists.

The overall workshop objectives are:

1. Review and validate base cost estimates.
2. Identify uncertainties and risks.
3. Characterize uncertainties and risk (in terms of likelihood and impacts).

A-3 Workshop Activities

A-3.1 Elicitation (Characterizing Risk and Uncertainty)

Eliciting information from SMEs and project team participants is a vital part of the process. Risks are treated as events defined by both cause and outcome. A positive outcome *presents an opportunity*, while a negative outcome *poses a threat* to project objectives. Elicited information is recorded into a risk register for the project and becomes input for the Monte Carlo modeling. The risk register lists all identified risk events (both threats and opportunities), with appropriate detail describing the risk event. The risk register should be comprehensive and must be reviewed to ensure that all risks and uncertainties have been quantified and that there is no double-counting of risk events.

Risk Event Properties

- Likelihood (probability of occurrence)
- Consequences (impact to cost/schedule relative to the base estimate if the event occurs)
- Relationship with other events (independent versus correlated with other events)

Nature of Event Occurrence

- Frequency of occurrence
- Number of occurrences during the project
- Number of potential outcomes (consequences)
- Event is independent or correlated with other events or among project activities

Consequences of Event Occurrence to Project Objectives

- Defined in terms of cost impacts, schedule impacts, or both
- Uncertainty in event outcome

Elicitation[3] can be accomplished in a number of ways and may utilize any one or a combination of the following approaches:

- In the workshop
- Through a questionnaire
- Through interviews of individuals or small groups in advance of the workshop
- By teleconferencing
- Other methods

Preparation for elicitation provides:

- Base estimate and schedule (including the Basis of Estimate)
- Document of assumptions as a basis for risk assessment
- List of base uncertainties

Elicitor guidance provides:

- Balance in participants' perspectives (watch for bias in responses)
- Formal elicitation
- Facilitated brainstorming
    - List and discuss all credible ideas
    - Assess consequences for likelihood and impact (frequency/magnitude)
    - Combine similar risks into one well-defined risk with a comprehensive description

[3] Elicit – To draw forth…; to bring out… *from* the data in which they are implied. To extract, draw out (information) *from* a person…

- "Weed-out" smaller, less significant risks that do not warrant inclusion in a formal quantitative analysis; these can be summarized into a "watch-list" for the project team

- Guidance on:
  - Anchoring (see Preparing Workshop Participants)
  - Worst- and best-case scenarios for consequences

A-3.1.1 Elicitation of Subgroups

Rather than having everyone attend every elicitation session, subgroups can in some cases provide a more efficient and effective approach to help ensure a properly focused elicitation with the correct SMEs present. This approach can help keep the number of individuals in the meeting to a manageable size. Group dynamics may begin to deteriorate after a group reaches a certain large size (i.e., many contributions but not necessarily from knowledgeable participants), and subdividing the elicitation provides a practical offset to the size problem. The subdivision of elicitation can happen on the same day, which could allow each of the Risk Leads to take a group into a separate room for elicitation.

The following elicitation subgroups have been used:

1. Right of Way, Utilities, and Railroad
2. Environmental, Cultural Resources, Stormwater
3. Structures, Geotech
4. All Other: Design, Traffic, Work Zone Traffic Control, Constructability (staging/ sequencing), scope issues/uncertainties, public pressures/opposition, local jurisdiction concerns, local market conditions/uncertainties, uncertainty in the base, management and other costs.

A-3.2 Cautionary Notes Regarding Workshop Dynamics

1. **The size of the group needs to be kept manageable**. Group dynamics deteriorates beyond a certain-sized group. While a good mix of expert input is desired, care needs to be taken that the number of participants does not overwhelm the process or diminish the effectiveness of the workshops. For example, too many people in the room attempting to speak can "drown out" or dominate time that should be used to listen to the SMEs.
2. Participants who are not familiar with the workshop process and/or risk-based estimating need to be educated/acclimated to the process. Participants should know their roles and what will be expected from them during the workshop.
3. The workshop effort should be commensurate to project size and complexity. Choose the right size and approach for the project. The process is scalable.

4. The workshop environment itself should be large and comfortable. Workshop participants will be working together for several days; it is best not to have venues that are too small or confining.
5. Biases in expert response, and failures to characterize distributions and dependencies, can result in understatement of the tails of the distribution. Elicitors need to be well informed on the biases and have experience in reducing them.
6. Be careful of "discrete" thinking. The risks being quantified are schedule and cost. These are conceptually continuous random variables and can be modeled as such. However, *likelihoods* are properly modeled using a discrete distribution as discussed under "Distributions to Consider for Quantifying Risk," in Section G, Technical Notes for Risk Modelers.
7. For some specific events, discrete probabilities are appropriate.

A-3.3 Report Preparation

The workshop report documents the results and process followed; the report is built in service of and to support the project team's risk management and project delivery efforts. Report preparation is a collaborative effort primarily between the project team and the cost risk team, with final control of editing and publishing the report resting in the hands of the Project Manager. Exhibit A-4 provides a guide/checklist for report writing and Exhibit A-5 provides a flow chart.

A-3.3.1 Draft Report

The draft report is due two weeks after the workshop (or after the final inputs document has been provided to the risk modeler). Every attempt should be made to provide inputs by the final day of the workshop. Allow one week for comments.

A-3.3.2 Workshop Report (Final)

The final report (see Exhibit A-6) is due two weeks after the draft report is delivered (one week after comments are due). This report should be ready and complete with the one-pager and Risk Management Plan spreadsheet. If no comments are received for the draft report, the draft report becomes the workshop report of record.

Exhibit A-4 Workshop Report Guide/Checklist

Project Manager/Project Team

The Project Manager and project team actively participate in the review and editing of the report. They own the results and use them in their management system, including communication of results.

- ☐ An accurate and complete workshop request form
- ☐ Project photo for cover
- ☐ Cost and schedule estimates and a brief written summary describing their preparation
- ☐ Reconciliation of differences from previous estimates

Subject Matter Experts

Make notes during the workshop to provide for the report-writing efforts.

- ☐ Key risks
- ☐ Possible response strategies

Risk Lead

Make notes of key discussion topics during the workshop that may be helpful during report preparation, review, and editing. Works closely with the project team and Cost Lead to ensure the report is useful and understandable to the project team. Document the model logic and steps taken to ensure a sound and objective analysis. Clearly identify "candidates for mitigation" and potential response strategies.

Prepare/assemble a written draft of the report:

- ☐ Foreword
- ☐ One-Pager
- ☐ Executive Summary
- ☐ Chapter 1: Overview (project summary/project objectives/workshop objectives/methodology)
- ☐ Chapter 2: Project Description (scenario(s)/flowchart(s)/assumptions/exclusions/notes)
- ☐ Chapter 3: Base Review (base cost and schedule estimate review and validation)
- ☐ Appendix A – Attendees
- ☐ Appendix B – Base Cost Estimate
- ☐ Appendix C – Inputs
- ☐ Appendix D – Outputs
- ☐ Glossary
- ☐ Double-check report for clear and easy-to-understand language
- ☐ Check against QA/QC checklist
- ☐ Bring report to final ready condition with edits in a timely manner.

Cost Lead

Makes notes to aid in writing the estimate validation.

- ☐ Written overview of cost and schedule estimates
- ☐ Written overview of the actions taken to review and validate cost and schedule for the report

Workshop Coordinator from CREM Unit

The workshop report is reviewed against the cost and risk quality control checklist.

- ☐ Review QA/QC checklist
- ☐ Work with project team and cost-risk team through completion of report
- ☐ Obtain final copy from Project Manager for the file

Note: It is recommended that a designated "report editor/coordinator" be identified prior to the workshop. The Project Manager can work with the CREM Unit to help determine who might serve in this role. The report editor/coordinator might be someone from the project team's communication office, the cost-risk team, or other appropriate position.

Exhibit A-5 Report Writing Responsibility

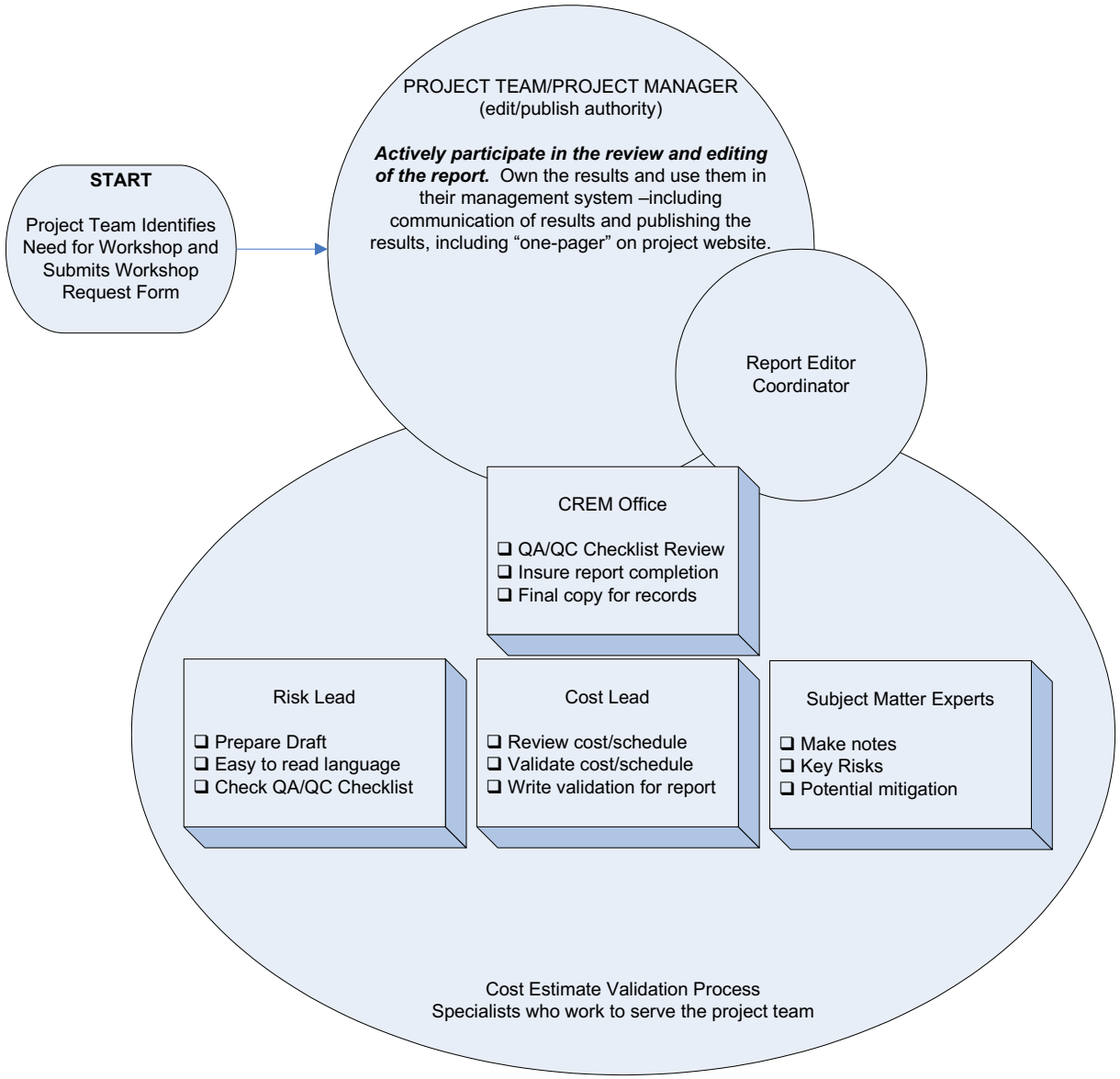


Exhibit A-6 Workshop Report

Responsible Party	Responsibilities
Project Team Members	The project team, just as they did before the workshop, owns the Project Management Plan, and all project development and delivery responsibilities. This includes all project cost and schedule estimates and the Risk Management Plan. The project team owns the report for their use in aiding and assisting their risk management and project management activities.
Subject Matter Experts	During the workshop process, the SMEs are responsible for their opinions and objective advice offered during the workshop and report preparation.
Risk Lead	The Risk Lead is responsible for preparing workshop participants and for conducting the risk elicitation. The Risk Lead is responsible for the modeling, analysis, and conclusions to be drawn from the analysis. The Risk Lead is also responsible for writing their portion of the report. Uses a quality control (QC) checklist as a guide to ensure an effective workshop experience that results in a sound and objective analysis of project costs, schedules, and risks. Clearly identifies "candidates for mitigation" and possible strategies for mitigating these key risks.
Cost Lead	The Cost Lead is responsible for reviewing and validating the project cost estimate and schedule. The Cost Lead is also responsible for preparing their portion of the report.
CREM Unit Workshop Coordinator	The workshop coordinator is responsible for ensuring the appropriate participants are in attendance at the appropriate times. In addition, the review of the report against the QC checklist will be performed by the workshop coordinator or others in the CREM office.

A-3.5 CEVP® Results and Capital Budget Development Data Needs

In order to load agency management systems and provide budget information, specific data needs to be provided to the region program management offices. This data is then loaded in to the Capital Program Management System (CPMS) and transferred to the Transportation Executive Information System (TEIS) for use in gaining budget approval.

	Project Schedule Data Milestone Dates	Project Estimated Cost Data
Required Data	Begin Preliminary Engineering Begin Right of Way Acquisition Phase Advertisement Date Operationally Complete Date	Design Cost Estimate Right of Way Cost Estimate Construction Cost Estimate

A-3.6 Management Endorsement

Along with the data provided by the project team, agency management endorses which costs are to be used and the schedule to be assumed. Guidance on use and reporting of CEVP®/CRA results and CPMS data requirements is provided in Instructional Letter 4071 posted at: http://wwwi.wsdot.wa.gov/publications/policies/fulltext/4071.pdf

A-4 QA/QC: All Have a Role

A-4.1 Prior to the Workshop

The project team, Project Manager, appropriate specialty groups, and appropriate stakeholders must perform a reasonability check on materials developed prior to the workshop. The Cost and Risk QC checklist provided in Exhibit A-7 should be used by the Project Manager to ensure the project team is ready for the workshop. When the workshop is convened, most attendees should already be familiar with, and have had an opportunity to comment on, the scope, schedule, and cost estimate that the project team has developed. The scope, schedule, and cost estimate will be the subject of review and analysis at the CRA or CEVP® workshop. At the discretion of the CREM Unit, region Risk Manager, or the Project Manager, the workshop may be postponed if the cost and risk quality control checklist items are not all satisfactorily completed.

Exhibit A-7 Cost and Risk QC Checklist

Cost and Risk Quality Control Checklist	
Cost Lead Review	
1	☐ The "Basis of Estimate" has been completed.
2	☐ All project team backup available has been reviewed and incorporated.
3	☐ The estimate scope has been validated with the CEVP® workshop scope.
4	☐ All unit costs have been validated by professional judgment and/or historical cost information.
5	☐ All spreadsheet formulas have been reviewed and totals have been cross-checked.
6	☐ All costs and durations have been allocated to flowchart activities.
7	☐ Contingencies have been sufficiently removed from the base cost estimate and the inclusion in the risk estimate has been verified.
8	☐ All design allowances have been validated; allowances with large variation have been transferred to the risk estimate.
9	☐ All markup amounts have been verified and confirmed appropriate.
10	☐ All estimate assumptions and clarifications have been documented.
11	☐ Base uncertainty has been assessed and documented.
Risk Lead Review	
1	☐ The workshop process has been presented to the workshop team.
2	☐ Project team issues and concerns have all been explored.
3	☐ Consensus on initial risk identification list has been achieved.
4	☐ The focus is on key risks. Minor issues have been filtered out by consistent screening criteria.
5	☐ Remaining risks (threats and opportunities) are quantified in terms of likelihood and consequences.
6	☐ Potential risk mitigation measures have been captured.
7	☐ Contingencies and allowances have been coordinated with the cost team.
8	☐ Cost Lead has verified that risks are not included in the base cost estimate (no double counting).
9	☐ All issues, impacts, likelihoods, and mitigation measures are documented consistently.
10	☐ All assumptions and clarifications have been documented.
11	☐ Team consensus has been reached on all risk items.
12	☐ All risk estimate backup has been documented (date, page number, and estimator's name).

A-4.2 During and After the Workshop

1. The Project Manager, appropriate project team members, and specialty groups perform a reasonability check on the preliminary draft results, including charts.
2. The project team, Risk Lead, and Cost Lead work together to deliver useful products that can improve project control through managing project cost and schedule risks. All members are equally important and must work cooperatively to achieve this objective.
3. Risk and cost elicitors coordinate and assist each other to make sure information is properly defined and coordinated during the workshop.
4. The modelers must carefully review the model to ensure the information from the workshop is properly represented. The model logic must be described in the report, and the results presented to the project team and the CREM Unit.
5. Throughout the analysis, the risk elicitor works with the project team, WSDOT subject matter experts (SMEs), and external SMEs to make certain the risk information is correctly captured for use in the analysis.
6. Throughout the analysis, the Cost Lead works with the project team, WSDOT SMEs, and external SMEs to make certain the cost information is correctly captured for use in the analysis.
7. The CREM Unit reviews the analysis/report for correctness and clarity; the project team reviews the analysis/report to ensure they understand the results and can confidently discuss them with others.

A-5 Risk Response

Take action in response to identified risks. Following identification and analysis of project risks, Project Managers and project teams must take action in response to the identified project risks, focusing on risks of most significance.

In order to maximize the benefits of project risk management, we must incorporate the project risk management activities into our Project Management Plan and work activities. This means building risk management activities into our Work Breakdown Structure (WBS). WSDOT has a ready-made WBS in the form of its Master Deliverables List (MDL) to help ensure our project work plans are comprehensive, consistent, and complete.

Risk response requires effort to develop and implement response actions; we must plan for expending this effort following the results of our risk analysis. See Chapter 5 “Risk Response” of this document for detailed descriptions of risk response actions.

Remember…

- CEVP® is iterative in nature and represents a "snapshot in time" of that project for the known conditions at that point.
- CEVP® normally deals with identifiable and quantifiable project-type risks (i.e., those events that can occur in planning, design, bidding, construction, and changed conditions).
- CEVP® could also consider the larger, more difficult risks—"acts of God" that can have very high impact in cost and schedule on large programs—but at this point, these risks are generally not included. This is an area for review and development—in particular, how to characterize such events in a useful manner for better management of the projects. All exclusions and assumptions need to be clearly documented in the workshop report.

It is good to remember that risk-based estimating, as in CRA/CEVP® workshops, does not provide an "answer book" with all uncertainty removed from the project. Risk-based estimating and consideration of project uncertainty and project risk does not add costs to a project, it reveals them.

We have to do the best we know how at the moment...; If it doesn't turn out right, we can modify it as we go along.

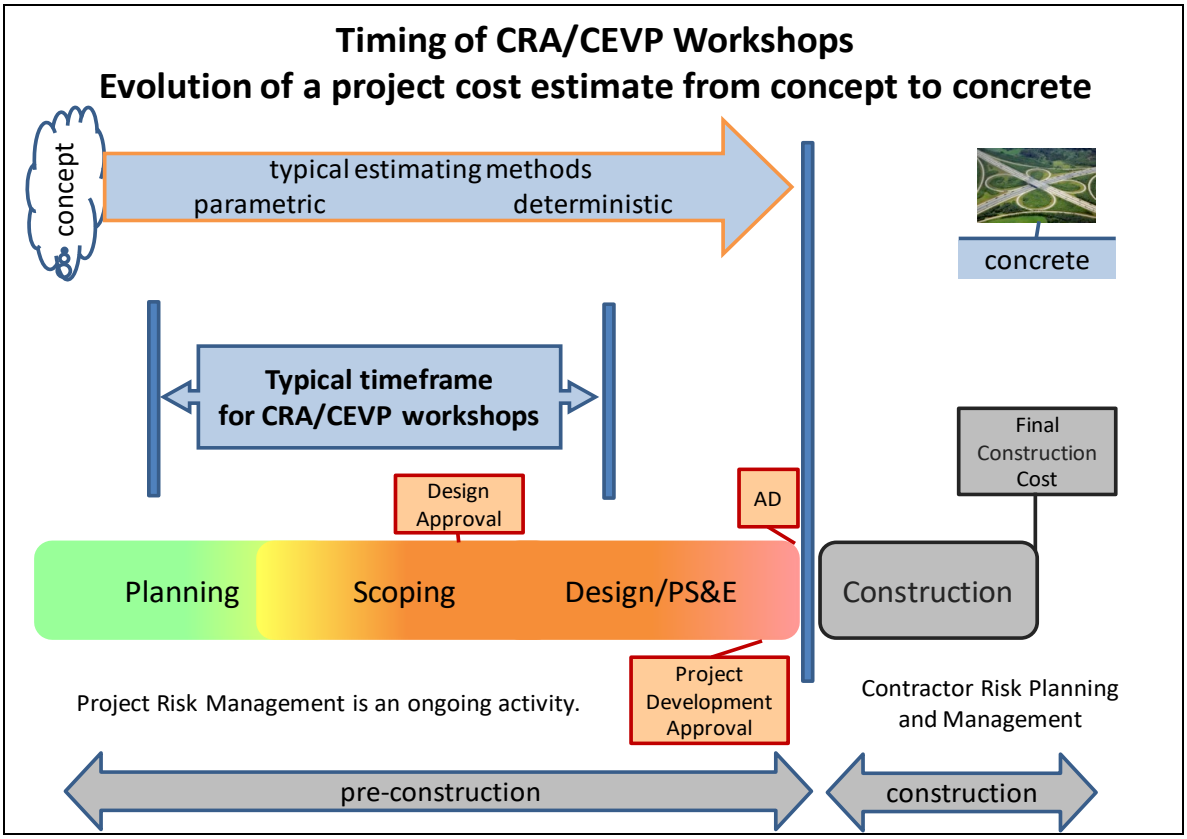
~ FDR

B-1 Description of Work

Project teams typically look to the CRA/CEVP® workshop process as a tool to help improve the accuracy, consistency, and confidence in their project cost and schedule estimates. This process also helps Project Managers and teams with their project risk management efforts, a required component of all Project Management Plans. During this collaborative process, uncertainty within a project is identified and quantified. Project schedules and cost estimates are owned by the project teams. Development of risk-based estimates through the CRA/CEVP® workshop process is a collaborative effort between the project team, experts in cost and risk analysis, and external subject matter experts.

Workshops are usually held early in project development, from late planning to the early stages of developing the contracts plans, specifications, and estimate (PS&E). Risk management is an ongoing project management activity; the Project Manager and project team should continue to proactively manage risk up until advertising the contract. Continuing risk management and risk assessment should look at the knowledge gained through the workshop process, and pay particular attention to evaluating the sequence of construction activities and scheduling through completion of the PS&E.

Exhibit B-1 Timing of Workshops



Project schedules and cost estimates are owned by the project teams, and they must be updated regularly. This may involve conducting workshops periodically (typically, every one to two years). The workshop effort begins with a request from the project team. The process focuses on the project team for input of primary information; the project team utilizes the workshop results as they deem appropriate, to more effectively manage their projects. The two main elements of an estimate are: base cost, which represents the cost if the project materializes as planned, and risk events, a combination of the probability of an uncertain event and its consequences. A positive consequence presents an opportunity; a negative consequence poses a threat. Note that risk events are separate from variability that is inherent in the base.

B-2 CEVP®

Generally, CEVP® follows the seven-step process outlined below:

1. Select the Project and Method
2. Structure the Project Team Effort
3. Define and Evaluate the Base Cost Estimate and Schedule
4. Assess Uncertainty and Risk
5. Quantify Uncertainty in the Project Cost and Schedule
6. Conduct Probabilistic Analysis and Documentation
7. Implement and Measure Risk Response Actions, Monitor and Control

After the probabilistic analysis is complete, the results are then interpreted, documented, and reported to the project team. Standard results include total project cost and schedule distributions, both in terms of current dollars and year of expenditure dollars. The resulting distributions, or ranges, have specific probability characteristics and are reported as percentage values.

B-2.1 Statement of Purpose for CRA/CEVP® Workshops

The purpose of the workshops is to: (1) provide the Project Manager and project team with actionable information that can be used to shift the odds in favor of project success, and (2) provide a useful, sound, and objective analysis and report that the project team will own and act upon to improve, as well as to validate and confirm, their project cost and schedule.

The project risk management performance can be measured by comparing “pre-mitigated” to “post-mitigated” results, then identifying risk responses to ascertain the amount of risk relief to be accomplished through risk management efforts.

The process provides a tool for the project team to evaluate the quality and completeness of the current project estimate. It is intended to increase confidence in the project cost and schedule forecasts and to identify areas of uncertainty.

The workshop process is not intended to “recreate the wheel,” or second-guess the project team. It is not a substitute for other necessary project management functions such as project control and value engineering.

Typical applications of results are as follows:

- Presentation of cost estimate range
- Project assessment and management
- Risk management
- Value engineering
- Integrated project/program management
- Design-build and other applications
- Communications
- Financial management

Note: Risk-based estimating, such as CRA/CEVP®, does not provide an "answer book" with all uncertainty removed from the project. Probability, not certainty, is the outcome from the workshop process.

The CRA/CEVP® workshop effort is an analysis of data provided by the team in collaboration with subject matter experts and cost and risk experts. It provides useful information for risk management and is an integral part of the overall Project Management Plan. The project team owns the workshop report and results to help them develop a plan of action to respond to the identified risks. The report written from the CEVP® analysis is not a decision document— it is an information document for decision makers.

B-3 Project Team Status Prior to CRA/CEVP® Workshop

The project team must:

1. Provide plans and documents that describe the scope, schedule, and cost estimate of the project. The Project Manager needs to approve of the Project Management Plan, including scope, schedule, and cost estimate, prior to the workshop. In addition, all key contributors need to confirm and accept the estimate that is being presented for analysis in the workshop. The information presented by the project team should not be a surprise to the specialty groups and stakeholders involved in the project.
2. Describe the level of project maturity (i.e., percentage of design completion).
3. Describe the character and time frame of the project and issues of concern.

The Project Manager and project team should remain mindful of the overall workshop objectives, which are to:

1. Review and/or validate base cost estimates.
2. Identify project uncertainties and elicitation of project risks
3. Characterize uncertainties and risk, which are documented in a risk register

To ensure the quality of our workshops and effectively use the participating subject matter experts, the Project Manager and project team do the following:

- Submit CRA/CEVP® workshop request forms at least 8 weeks prior to the workshop; for some projects, such as SR 520 and AWV, Project Managers have asked that the forms be submitted at least 12 weeks in advance.
- Submit the following documents 2 weeks prior to the workshop:
  - Updated Project Management Plan (including Risk Management Plan)
  - Current project schedule (to be used at the workshop)
  - Current estimate file (with assumptions and Basis of Estimate)
  - Current project summary (and detailed project scope)

The items above need to be completed and turned in early so that workshop participants can learn the basic elements of the project, and begin review of cost estimate key items. **Project estimate review** and **risk assessment** are the main workshop topics.

B-4 Project Team Responsibilities and Requirements

The project team needs to make available, for the majority of the workshop, key people who can represent the project in areas essential to the project objectives. These includes:

- ☐ Project management (to provide project context and relationship with stakeholders)
- ☐ Engineering (design and construction)
- ☐ Cost estimating
- ☐ Scheduling
- ☐ Environmental (permits, processes, and mitigation)

The Project Manager is to ensure the availability of project team members who can speak to the issues raised in the workshop and are familiar with the documentation.

The project team must be prepared to identify applicable risk elements (global and project specific), the interrelationships of the risks, and the characterization of the risks in terms of likelihood and impacts. If the project team is interested in pricing the project for different delivery methods (e.g., design-bid-build vs design-build), they need to be prepared to discuss this.

The project team, working collaboratively with the workshop team, should be prepared to discuss and determine:

- ☐ Exclusions
  - ☐ Funding
  - ☐ Programmatic Issues
  - ☐ Others
- ☐ Adequate subject matter expert participation
- ☐ Authority to “de-bias” the input
- ☐ The optimal process balance between effort and accuracy; level of analytical detail and how to handle dependence, correlations, and distributions

- ☐ The probabilistic risk-based integrated cost and schedule modeling needs
- ☐ Global versus project-specific risks and other uncertainties
- ☐ Treatment of base uncertainties

B-4.1 Items Required from the Project Team Prior to the Workshop

The project team must produce the following items ahead of time and have them available at the workshop:

- ☐ Project team organizational chart.
- ☐ Project team contact information.
- ☐ Project vicinity map, informational documents, aerial photos, et al.
- ☐ Project definition documents and design criteria used.
- ☐ Summary or overview of project plan(s) that indicate the project elements at the type, size, and location level. This may include concept plans, cross sections, illustrations, public information documents, memorandums of understanding, geotech info, etc.
- ☐ If there are multiple alternatives, there needs to be a description of status and relationships sufficient to understand the options and to plan the workshop priorities.
- ☐ The Basis of Estimate.
- ☐ Current estimates (unit prices, parametric estimates, combination, etc.), including an overall "project/program rollup estimate." Note the base year of the estimate.
- ☐ A preliminary listing of risks and the project team's issues of concern.
- ☐ A preliminary project flowchart showing key tasks and relationships from current status through completion of construction and open to traffic.
- ☐ Current design and construction schedule, including description of how durations were determined and an explanation of the construction sequencing strategy.
- ☐ **Estimated durations and costs associated with completion of preliminary engineering:**
  - ☐ Mapping and surveys
  - ☐ Engineering and design
  - ☐ Geotechnical investigation
  - ☐ Environmental process and permitting
  - ☐ Environmental mitigation design (including administrative costs)
  - ☐ Hazmat remediation design
  - ☐ Structures
  - ☐ Hydraulics
  - ☐ All other relevant areas for the subject project

- ☐ **Estimated durations and costs associated with completion of right of way:**
  - ☐ Real Estate Services
  - ☐ Right of way acquisition services (includes administrative costs)
  - ☐ Access management
  - ☐ Right of way property costs
  - ☐ All other relevant areas for the subject project
- ☐ **Estimated durations and costs associated with completion of construction:**
  - ☐ Construction engineering
  - ☐ Construction cost of project
  - ☐ Lump sum items (weigh station, maintenance facility/equipment, park & ride lot, etc.)
  - ☐ Utility relocations
  - ☐ Hazmat remediation
  - ☐ Environmental mitigation (cost to construct)
  - ☐ Allowances for miscellaneous add-ons (lighting, signing, striping, SC&DI, etc.) with explanation as to what items are covered and percentage to be used, and why.
  - ☐ All other relevant areas for the subject project.

Section C Risk Lead – Duties

C-1 Description of Work

Risk Leads participate in a peer-level review or due diligence analysis on the scope, schedule, and cost estimate for various projects to evaluate quality and completeness, including anticipated risk and uncertainty in the projected cost and schedule.

The Risk Lead:

- Leads the risk portion of the process, including risk elicitation and **project flowchart development**[1] for modeling.
- Keeps the flowchart practical; it should be a simple but complete representation of the project schedule. It is the ”backbone” of the analysis and can be thought of as an abstract of the project schedule.
- Participates in cost validation or review and risk uncertainty workshops for selected projects.
- Conducts prep sessions, follow-up meetings, or rerun sessions as necessary.
- Provides reports and presentations documenting workshops.
- Provides reports using report guide or table of contents.
- Develops or implements workshops on topics such as project definition and risk identification and management.

These functions are critical to WSDOT's success in delivering projects on time and on budget. It is anticipated that Cost Risk Assessment (CRA) and Cost Estimate Validation Process® (CEVP®) reviews for each project can be accomplished in a reasonable time frame, including a 1–5 day concentrated workshop. WSDOT personnel, with the aid of multiple specialty groups, will coordinate CRA/CEVP®. Work may include the documentation of the viability of assumptions made regarding a project's configuration, scope, schedule, character, and, through risk analysis, the potential impact of risk events that may occur. The project may include creating reports that document information determined or discovered.

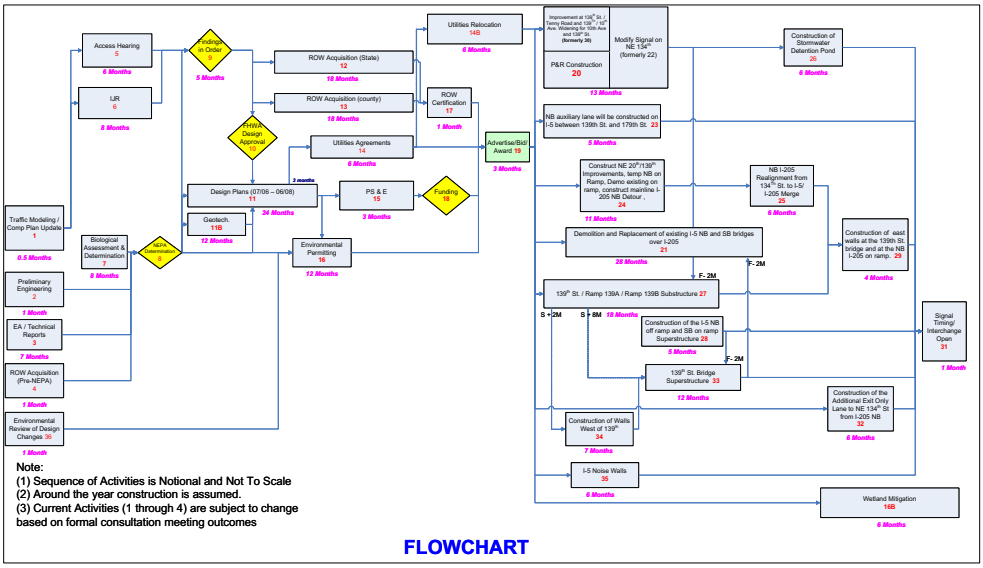
Risk workshops vary based on project needs, but include risk identification, probabilistic risk assessment, development of management strategies, a probabilistic look at the effectiveness of management strategies, and other variants. The Risk Lead must use consistent methodology for probabilistic risk assessments.

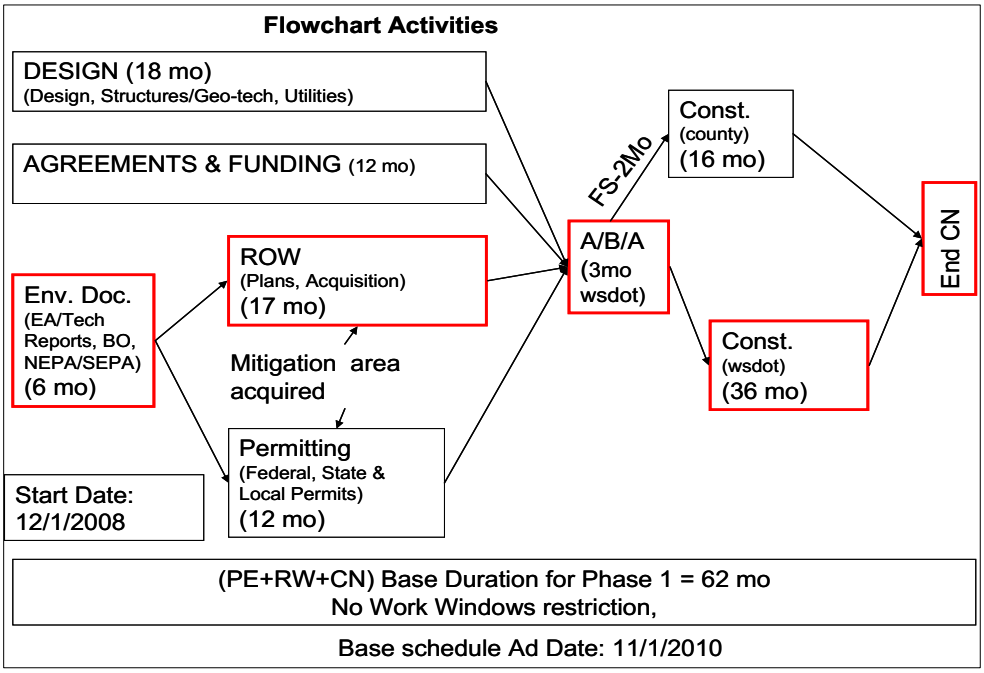
[1] Flowcharts should as simple as possible but still represent the project activities in a realistic manner with proper sequence and durations (see Exhibit C-1).

The Risk Lead plays a vital role in ensuring the analysis is sound and objective. It is also imperative that the analysis process and results are clear and usable by the project team. The process, as documented, must include the underlying assumptions and constraints of the analysis in a manner that is easily comprehended by the project team, who will have to communicate the results of the workshop to others. The report should "tell the story" of the project scope, schedule, and cost estimate.

Notice the two flowcharts in Exhibit C-1. They are for the same project; however, one is simple and easy to follow, while the other one is more complex. They both meet the needs for risk modeling, but one is much easier to work with. Remember, more activities do not always mean more clarity.

Exhibit C-1 Flowchart Examples





Section D Cost Lead – Duties

D-1 Description of Work

The Cost Lead will participate and lead portions of a Cost Estimate Validation Process® (CEVP®) or Cost Risk Assessment (CRA) workshop for the project. Work includes: workshop participation; leadership and facilitation; preparation; pre-workshop meetings; documentation; follow up; reconciliation of workshop results; management consulting; technical report writing; process evaluation and communication; and scheduling meeting requests to rerun models or assess new scenarios for the project. Also included is traveling to and from the workshop and project locations. Provides support for the workshop for the project.

D-1.1 Cost Lead Duties

The Cost Lead assists with the workshop process by taking primary responsibility for the following:

- Leads the review and validates the project team's estimate.
- Supports the project team in the development of the base cost estimate.
- Supports the project team in making any adjustments to the base estimate as a result of the review.
- Supports the development of the risk register by proposing cost and schedule risk items to deal with risks and opportunities that are identified as part of the cost and schedule review.
- Reviews the project team's work to distribute the base costs against the activities identified in the flow chart (see Section C).
- Works collaboratively with the project team to review and validate the final cost estimate to be used in the model. Confirms concurrence of the validated estimate with the project team and subject matter experts.
- Leads the review and critiques the project team's schedule.

D-1.1.1 Deliverables

The Cost Lead will:

1. Provide comments and validation of the project base estimate.
2. Work with the project team's estimator to develop base cost breakdowns for the flowchart activities of the project for use in the risk modeling as soon as possible during or immediately following the workshop.
3. Provide a written report on the base cost review and validation, and schedule the review for inclusion in the risk analysis workshop report to the project office and CREM Unit. The report is due within one week following the end of workshop or earlier if required and agreed to at the workshop.

D-1.1.2 Typical Cost Questions

Typical cost questions to be asked by the Cost Lead and subject matter experts:

- Have you completed the Project Estimate Basis form? What is the basis of the estimate?
  - How current is it? When was it updated?
  - Do unit prices correlate to similar scope projects in the area? Are they truly comparable?
  - Does the current scope of the work match the scope that the estimate is based on?
  - Does the estimate include engineering, engineering services during construction, construction management services?
- What is the stage of the design?
- What is the accuracy of the survey data?
- What field investigations have been done? - describe the existing conditions.
- What geotechnical work has been done to date? Is there data from past projects in the area?
- Cuts and fills: What has been assumed for reuse, import, export and disposal, temporary stockpiling, haul distances, location of imported materials?
- Are there assumptions on compaction? Seasonal variability?
- Are there assumptions on stability of cuts, sheeting, retaining walls, slope protection during construction?
- If dewatering is required, are there perched water tables and other maintenance of excavations during construction, treatment of dewatering to meet permits?
- ROW: How current are surveys and estimates of costs? Partial or full parcels?
- Are there temporary utilities, staging areas, parking storage, lay down?
- Is there knowledge of utilities in project area, relocation requirements, ability to isolate and shutdown? Are replacements needed prior to isolation? Can replacements be installed at proper elevation?
- Is there erosion protection?
- Are there special conditions: extraordinary staffing requirements, night work, stop times due to fish or wildlife issues, noise limits, dust control?
- What has been assumed for overhead, insurance, bonding, project management, safety, QC community liaison, trailers, utilities, parking home office overhead, profit?
- Are there assumptions for material availability: backfill, sheeting, piles, concrete, rebar access for delivery, double handling requirements?
- Production rates assumed? Is this work similar to other work done in the area?
- Are there assumptions for maintenance of traffic, staging of construction, needed temporary barriers, ramps bridges, supports, technology?

- Is there estimated mitigation, noise walls, stormwater detention ponds, wetlands?
- What contingencies are built into the estimate?
- Has a change order allowance been built into the estimate?

D-1.1.3 Typical Schedule Questions

Typical schedule questions include:

- How long have similar projects taken?
- How many $/month at average and at peak would have to be spent to meet the schedule?
- In what season is it expected that the Notice To Proceed (NTP) will be issued? Will certain months be lost due to the start date?
  - If the NTP is issued as planned, can the landscaping be completed in the required season for the specified plantings?
- Has mobilization and demobilization time been included in the schedule? How many workers are assumed to be working on the project at the peak of construction?
- Does the construction phasing and traffic management plan match the schedule assumptions?
- How many concurrent work areas are assumed? Are there crews available to staff all of those areas?
- What are the assumed production rates for each of the major elements: earthwork, foundations, piers, beams deck, sub-base, base, paving, etc.?

D-1.1.4 Tips for Cost Leads

1. The project team owns the estimate—let them establish what they want out of the process.
2. Don't get bogged down in details; keep the discussion relevant to the overall size of the project. For example, don't waste a lot of time discussing a $100,000 item on a $50,000,000 project.

D-2 Base Cost Assessment

Estimating is a maturation process that follows project development. Therefore, there is always a story behind the estimate; it is rarely a straightforward, linear process. It is imperative that you understand how the estimate was generated. Take the time to have the project team explain the history of the estimating process. Also, while the project team talks through how the estimate was generated, they are mentally checking that the process is correct. Following is a step-by-step guide through the assessment process.

D-2.1 Confirm the Cost Matches Scope

Gain a comprehensive understanding of the project scope, limits, major items of work such as structures, construction staging, phases, etc., during the project team's presentation. Validate that the scope description, drawings, and estimate match in terms of work items. Use the expertise of the team to validate the design elements. For example, if there is a curved bridge, has the team assumed steel girders and factored that into the unit price?

D-2.2 Confirm Unit Prices Are Valid

Experience, bid-tab data, and recent projects in the area can be used to validate unit prices. Estimating the "per square foot" unit price of bridge deck is sometimes contentious; topics of discussion frequently center on foundation type, superstructure type, and geometry. Unit price estimates also include confirming the tax rate, which varies by county; the per-acre cost for right of way; mobilization markup; and engineering markup. Bid histories are useful but not the final answer, especially if bid histories are more than 3 months old. In such cases, care and judgment must be used to ascertain the appropriate and valid current unit prices.

D-2.3 Identify Contingency (internal & external)

Strip out the contingency in the base cost estimate. It will be obvious that this needs to be done when contingency appears as an explicit line item in the estimate. There can also be contingency hidden within the line items, such as inflated unit prices, rounding up of quantities, etc. What needs to be taken out is a judgment call based on discussions with the estimator.

D-2.4 Organize Estimate to Flowchart

The estimate needs to be organized to match the flowchart boxes. This is typically environmental cost, preliminary engineering, PSE, ROW, and construction. This work needs to be closely coordinated with the risk group and confirmed by the workshop participants (project team, cost-risk team, and subject matter experts).

D-2.5 Determine Risk Costs in Collaboration with the Risk Team

Generate risk items and determine costs (this occurs in the workshop).This should be a high-level estimating effort. If this step becomes voluminous, consider ways to divide and conquer. It is imperative that the cost and risk scope items match and that there is no overlap of costs and risks, nor are there any omissions.

Section E Subject Matter Experts – Duties

E-1 Description of Work

Cost Risk Estimating Management (CREM) is a program created and developed to better estimate transportation projects. The program provides the framework for two comparable processes: Cost Estimating Validation Process® (CEVP®) and Cost Risk Assessment (CRA). These processes involve intensive collaborative workshops where transportation projects are examined by teams of top engineers, Risk Managers, internal and external subject matter experts (SMEs) from local and national private firms and public agencies, and from WSDOT specialty groups within the project team.

E-1.1 Special Notes for Subject Matter Experts

External and/or internal SMEs participate in **peer-level** systematic project review (or due-diligence analysis) and risk assessment to identify and describe cost and schedule risks based on the information at hand. The review process examines how risks can be lowered and how the project cost and schedule vulnerability can be reduced.

Subject matter experts should have extensive expertise in their specialty areas. In addition to technical expertise, SMEs are expected to provide guidance and assistance on defining the cost and schedule of project activities related to their expertise. While SMEs should focus on their area of expertise, it is expected that SMEs will provide input on one or more of the following risk categories: Management; Environmental; Third Party; Design; Construction Cost Estimating and Cost Control; Construction Planning and Phasing; Construction Implementation; Construction Claims and Disputes; Real Estate and Right of Way; Operation & Maintenance; and Safety.

SMEs should understand that risk management could require a negative frame of mind, but once identified, risks should be managed positively, so that the risks are addressed in the best possible way to minimize their influence on a project.

SMEs should also understand that risk assessment does not need to be exact to be useful, particularly during the early stages of a project. Risks and opportunities go hand in hand and their analysis should have equal consideration. Much of the power of CEVP® and CRA workshops lies in the rigorous, disciplined approach and the ability of team members to focus collectively, both inwardly and outwardly, on a broad range of topics. SMEs should:

- Provide objective input in their field and cooperate with all team members by crossing conventional boundaries.
- Have an open attitude to change by encouraging creative thinking by teams and individuals.
- Stay aligned to the workshop process and focus on fulfilling the ultimate workshop mission: projects delivered on time and on budget.

- Be familiar with the WSDOT process for CRA and CEVP® workshops, including the policy statement, common assumptions, and other guidance.
- Have a clear understanding of the specific terminology used during workshops, such as: allowances, contingency, base cost, cost uncertainty, schedule uncertainty, risk, and opportunity.

In addition to active participation in the workshops, SMEs may be asked to provide documentation of the viability of assumptions made regarding a project's configuration, scope, schedule, cost estimate, and the potential impact of risk events that may occur.

SMEs may be asked to participate in follow-up or rerun sessions as requested, and provide reports or presentations documenting their work.

SMEs and project team members should strive to produce clear and concise products (CEVP® or CRA report) that would help decision makers with sound and objective analyses in order to make informed decisions.

Note: It is preferred to have at least one SME with estimating experience from a "contractor's" perspective; that SME would participate with the Cost Lead in the review and critique of the project team's estimates and schedule. This discussion should take place, if possible, in advance of the workshop.

Section F CRA Coordinator – Duties (HQ/Region)

F-1 Description of Work

Cost Risk Assessment (CRA) Coordinators help accomplish the CRA/CEVP® program in accordance with department policy and guidelines. It is expected that the Headquarters (HQ) CRA Coordinator will provide direct support and coordination to project teams around the state. For those regions that have a CRA Coordinator, the HQ CRA Coordinator will work with the region CRA Coordinator to ensure the effective use of CRA/CEVP® workshops in the regions.

Project Managers and project teams use the workshop results to actively manage risk. Project teams know the details of their projects; cost-risk teams know the workshop process, modeling, and the goals of the risk analysis effort, and the limitations of risk analysis. The region CRA Coordinator should be familiar with WSDOT resources available in the field of cost-risk management.

F-1.1 CRA Coordinator Duties

Specific duties include the following:

1. Identify the need for CRA-CEVP® workshops for region projects (work with project offices) to estimate workshops for the upcoming 12 months.
2. Establish approximate time frames for CRA-CEVP® workshops, with as much advance notice as is practical (discuss with project offices).
3. Review workshop request forms for completeness:
   - Make sure all information is provided.
   - Make sure the project office is setting up a Work Order Authorizations (WOA) with appropriate Group Numbers, prior to the workshop.
4. **Work with the project office to make sure appropriate location(s) are reserved for the workshop (adequate size and space), and that other helpful meeting items are available (including Internet access).**
5. Be familiar with the CRA/CEVP® workshop process.
6. Be familiar with the CREM website. It is frequently updated and additional material is occasionally posted:
   http://www.wsdot.wa.gov/projects/projectmgmt/riskassessment/default.htm
7. Help identify training needs and take advantage of training opportunities as they arise (cost estimating class, risk-based estimating class).
8. Advocate, within the regions, participation in CRA/CEVP® workshops as opportunities arise. For example, in order to have independent specialty group representation, it may be possible, on occasion, to request that a person from a neighboring region provide subject matter expertise.

9. Advocate proactive risk response actions that are documented in the project Risk Management Plan.
10. Make sure that feedback from workshops is provided using the post-workshop evaluation form.
11. Maintain records of CRA/CEVP® accomplishments within the region. Include the involvement of workshop participants, key risks identified, and mitigation strategies implemented. Monitor the effectiveness of the risk assessment and mitigation efforts.
12. Report on the risk management and estimating support needs of the region.
13. Attend training to improve skill levels and maintain and improve proficiency in the areas of project risk management and estimating.

F-2 CRA Coordinator "How-To"

F-2.1 Example Walk-Through of a Typical Project

- Meet with the project team.
  - Determine upcoming projects that will require a risk-based estimating workshop. Work with the team early to help them identify, well in advance (8 weeks lead time or more), appropriate timing for a workshop. These target dates can be entered into the project work schedule.
  - Advise the project team to include risk management (activities) in their project schedule. This includes: risk planning, risk identification, qualitative risk analysis, quantitative risk analysis, risk response planning, and monitoring and control.
- Once a time frame for a workshop is established, take the following steps:
  1. Go to the Cost Risk Estimating Management (CREM) website and download a workshop request form:
     http://www.wsdot.wa.gov/projects/projectmgmt/riskassessment/
  2. Work with the project team to make sure the form is completed in its entirety. During this time, check Outlook Calendar "WSDOT re VERA" to determine dates that may be available for workshops, and include this information in the workshop request form.
  3. Meet with the Area Engineer or Project Development Engineer and Design Team to give an overview of the workshop process.
  4. Work with the CREM team to determine appropriate Cost Leads, Risk Leads and subject matter experts, and help complete the participation matrix.

5. Determine who will send invitations to workshop participants. Often the region will invite the region participants and project team, and the CREM workshop coordinator will invite others (Cost Lead, Risk Leads, SMEs, HQ representatives, etc.)
6. Continue to communicate/coordinate to make sure workshop materials are being made ready and available by the project team to the cost-risk team and Subject Matter Experts. Follow up with certain workshop participants to ensure their participation in the process is well timed and appropriate.
7. Attend prep sessions and workshops.
8. Post-workshop: Follow up with the CREM workshop coordinator and others as appropriate to make sure action items are being communicated, and follow up on them to make sure they are progressing. Help tie up any remaining loose ends from the workshop. Make sure the risk register properly documents the risks discussed at the workshop (particularly the larger risks).

F-2.2 Specific Things the Region CRA Coordinator Can Do to Enhance the Process

1. Advise the project team that the project scope, schedule, and estimate need to be current for the workshop. Estimates should be well organized and easy to follow, and they should align with the flowchart that is drafted at the prep session. The estimator should have a backup notebook, calculations, and assumptions available for rapid retrieval of information, if needed.
2. Assist with coordinating advance elicitation between the project team and Risk Leads.
3. Work with the CREM workshop coordinator to help develop an effective agenda (participants in the workshop will know what to expect and when to attend).
4. Advocate for early geotechnical explorations and other specialty work as appropriate, for the subject project.

Section G Technical Notes for Risk Modelers

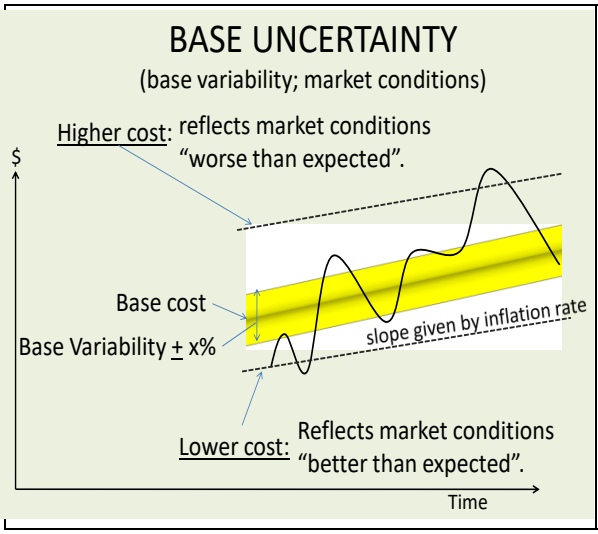
G-1 Guidance

Following is guidance for Cost Leads, Risk Leads, and risk modelers, and for all interested in the technical aspects of risk-based estimating and modeling.

G-1.1 Base Cost Uncertainty

Did you want to put some text here describing the following exhibit?

Exhibit G-1 Combination of Base Variability and Market Conditions



Base variability is inherent in the base estimate. Base variability is always present and is not caused by risk events. Variability exists even if no risk events are present. Base variability is captured as a symmetric range about the estimated value; that is, of the form: base value ±x%.

Market conditions are the consequence of supply and demand factors, which determine prices and quantities in a market economy and which are separate from inflation. Market conditions include things like: competitive environment during bidding and contracting, the labor market, and resource availability.

For many projects, the greatest uncertainty is market conditions; given that fact, we market uncertainty must be represented in the model. There are times when the bidding environment is favorable (highly competitive), other times the bidding climate is not as competitive. Given the volatility in the market and the many varied factors influencing bids, both possibilities must be captured (bids could come in "worse than planned," i.e., over the Engineer's Estimate, or "better than planned," i.e., under the Engineer's Estimate). To that end, Exhibit G-2 provides a simple example of how to capture this uncertainty.

Exhibit G-2 Capturing Base Market Condition Uncertainty

Base Market Conditions		
Bid Result	**Probability**	**Impact**
BETTER than planned[1]	**40%**	**15%**
WORSE than planned[2]	**10%**	**10%**

[1] "BETTER than planned" indicates that as a result of favorable market conditions, in the form of a highly competitive bidding environment, it is estimated there is a 40% chance that bids will come in **up to 15% below** the Engineer's Estimate.

[2] "WORSE than planned" indicates that, as a result of market condition influences in the form of a noncompetitive bidding environment ,it is estimated there is a 10% chance that bids will come in **up to 10% above** the Engineer's Estimate.

G-1.2 Base Schedule Uncertainty

Just as base uncertainty for the cost estimate was captured, we also need to capture a base uncertainty for schedule (i.e., +5% or +10%) (see Exhibit G-3). We should discuss base schedule uncertainty with the schedulers: what is appropriate for this uncertainty? This base schedule uncertainty captures the fact that we do not know for certain what is the exact duration of an activity—even if no risk events occur, we do not have exact precision—particularly on large complex projects, early in project development or design.

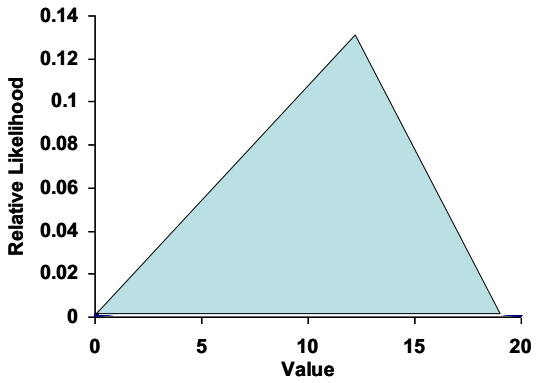
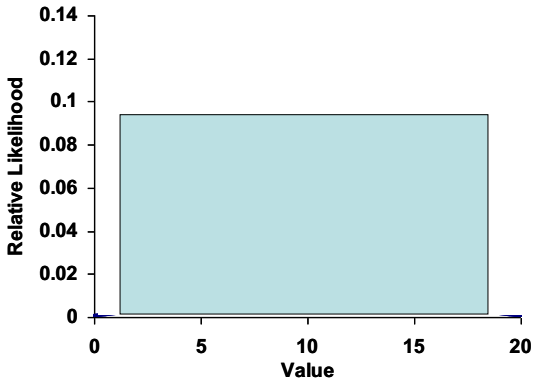
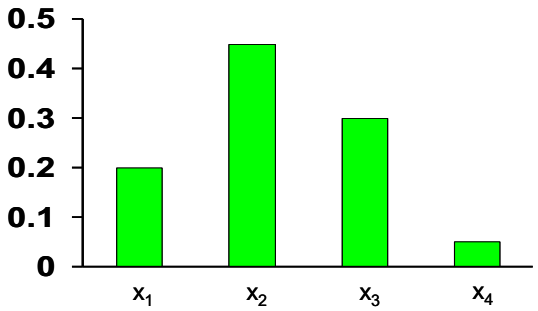
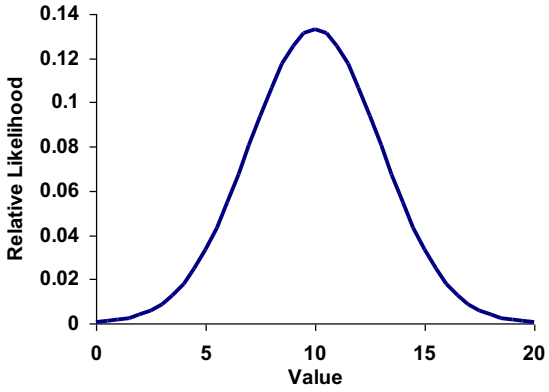
G-1.3 Distributions to Consider for Quantifying Risk

When characterizing risks during workshops, many elicitors and workshop participants may be more comfortable using simple distributions or multi-point discrete distributions to characterize uncertainties. The Risk Lead (elicitor) should determine the risk characterization that meets the need of the risk elicited and fits the group dynamics of a particular workshop membership. The distributions are representations of the "range and shape" of uncertainty. Elicitors may elicit ranges of information (min/max; low/high) and shape of information (symmetric, skewed). Consider this: Simulations are useful to the extent that they reflect reality. Cost and duration (schedule) are conceptually continuous, random variables and should be modeled in a way that simulates this nature. This can be accomplished through continuous distributions or approximated with a discrete representation, as depicted above.

There are two parts to the risk, which define the risk register:

1. **Probability of Occurrence:** What is the estimated likelihood of this event occurring?
2. **Impact:** If the event occurs, what is the impact in terms of cost and/or schedule? This part typically requires only 3 inputs from the expert: minimum, maximum, and most likely or best guess. As depicted in Exhibit G-3, the uniform distribution is used when only the minimum and maximum values can be estimated.

Exhibit G-3 Capturing Base Schedule Uncertainty

Triangular Distribution	Uniform Distribution
	
A triangular distribution is a continuous distribution representing a three-point estimate. This is one of the most common and widely used distributions in risk modeling. It is common to assume that there is a chance that the min and max values will be exceeded (5/95, 10/90, etc.). These percentiles may change to represent different levels of uncertainty in the estimate.	A uniform distribution is a continuous distribution where only the maximum and minimum values can be estimated. This distribution is used when there is considerable uncertainty over the duration of an activity or cost impact of a risk event and hence a "most likely" value cannot be estimated.
Multi-Point Discrete Distribution	**Continuous Curve Distribution**
	
X_1 = 20% X_2 = 45% X_3 = 30% X_4 = 5% **Multi-point discrete distribution**: In some cases, a risk element can only take particular values (i.e., is not continuous) or be used to approximate a continuous distribution.	Three points are defined: high (max), low (min), and best guess; then a continuous distribution (such as Pert or other) is used to characterize the potential risk impact. Although these methods can provide a realistic representation of uncertainty, these curves are hard to define and so should only be used when there is sound, documented information on the variability of a particular risk element. It is common to assume that there is a chance that the min and max values will be exceeded (5/95, 10/90, etc.). These percentiles may change to represent different levels of uncertainty in the estimate.

G-1.4 Interdependencies or Correlations Between Random Variables

Interdependencies between two or more uncertainties, cost and durations, risk events, or their impacts, in an analysis, can occur due to a variety of conditions. The uncertainties may be:

1. Mutually exclusive.
2. Conditionally dependent in terms of likelihood, but independent in terms of impact.
3. Correlated (commonly, cost and duration for a given risk event).

Items 1 and 2 can easily be modeled with analysis logic. Correlation can be modeled statistically or the relationship among correlated events can be described in terms of conditional probability networks. The conditional probability "event tree" has been used successfully in WSDOT and other transportation-oriented risk evaluations.

G-1.5 Typical Model Settings

Consider the following settings:

1. 5,000 iterations (typical).
2. Latin-hypercube sampling.

G-1.6 Directives for Implementing the Response Actions to Major Risks

Following are items for the project team to review and take action on:

- A critical and useful output of the risk analysis for the project team is the ranked risks indicating the risks, in a prioritized order, that most significantly affect project objectives. This information provides a roadmap to the risks that have the most promise for benefiting the project through proactive efforts to respond to the risks.
- The more significant risks, sometimes termed "candidates for mitigation," are oftentimes known by the Project Manager and project team in advance of the formal analysis. The Monte Carlo simulation more formally quantifies and ranks these significant risks. It identifies those risks that are most responsible for variation in the bottom-line (cost or schedule) as determined from the modeling.
- An effective way to present risks that have the largest potential impact to the cost or the schedule is by use of a "regression sensitivity" chart (i.e., "Tornado diagram"), depicting the "candidates for mitigation" in order of importance.

G-1.7 Integrating Cost and Schedule Risks: A History and Practice at WSDOT

Since 2002, when WSDOT first introduced the Cost Estimate Validation Process® (CEVP®), the cost and schedule risks have been integrated into the risk model as part of the Monte Carlo simulation. It is our expectation that the risk-based estimating models used for evaluation of WSDOT projects integrate both cost and schedule risks.

Section H Common Assumptions

H-1 CRA, CEVP®, and Informal Workshops

Common assumptions provide a consistent approach to common and recurring issues encountered at CRA/CEVP® and informal risk workshops. Common assumptions are *not* intended to replace the sound judgment and wise counsel provided by the workshop participants who have gathered to review the cost and schedule estimates, and identify risks and assess uncertainty in the project schedule and cost estimates. If additional project-specific assumptions are identified, they shall be documented in the workshop report for the project.

The common assumptions in this section allow completion of CRA and CEVP® workshops within the time allowed and resources available. They have been chosen to produce the best results possible under these constraints. Consequently, workshop results are, in general, limited by these assumptions. It is also noted that project-specific assumptions are often also required to allow a defined project to be put forward for evaluation.

Evaluated risks reflect a "snapshot" of the project at the specific time of the risk assessment. The snapshot is based on the project scope presented by the project team from current plans and available information. This means that the risk model is based on current best estimates for costs, schedules, risks, and construction phasing and activity sequencing. Risk identification depends on the expertise of the project and cost-risk team. After evaluating the project cost and schedule estimate along with an assessment of risks results, a report is written to identify a range for the cost and schedule, and a register of the risks. Significant risks are ranked in order of importance based on impact to project objectives, in an effort to control project costs and schedule and to manage project risks.

A risk event may hold the possibility of a positive or negative effect on a project. A positive potential *presents an opportunity* to the project and a negative potential *poses a threat* to the project.

Project Managers, and the project teams, are expected to use the results of the risk assessment by developing and implementing responses to significant risks. The response actions should be documented and incorporated into the Project Management Plan updates and monitored and controlled.

H-2 Scope Change versus Scope Variations

- **Scope –** The sum of the products, services, and results to be provided as a project (i.e., the Work Breakdown Structure).
- **Scope Change –** Any change to the project scope. A scope change almost always requires an adjustment to the project cost or schedule.

- **Scope Creep –** Adding features and functionality (project scope) without addressing the effects on time, costs, and resources, or without customer approval.
- **Scope Definition** (process) **–** The process of developing a detailed project scope statement as the basis for future project decisions.

(Source: Project Management Institute, PMI PMBOK® GUIDE, 2004, 3rd Edition)

WSDOT may elect, on its own initiative, to revise the scope of the project by adding, removing, or revising particular elements of the project. Such items are not risk events. Instead, these can be treated as alternative project scenarios or "deltas" to the base assumed project.

Scope variations (commonly referred to as scope creep) are uncertain items or events, not entirely within WSDOT's control, that may cause variations to the scope and hence changes to the schedule or budget. They are considered risks and will be captured as risk events and included in the risk-based estimate analysis.

H-3 Design Criteria (general)

It is left to the project teams to ensure they are using current and appropriate design criteria for their projects, and that any design deviations or variances are properly documented and shared. It is also expected that project schedules and estimates provided by the project team will reflect this.

H-4 Bridge Seismic Design Criteria

Check with WSDOT HQ Bridge and Geotechnical Branch to confirm.

H-5 Inflation Rate Information & Market Conditions

Note: Project teams need to ensure their base estimates are current and reflect current prices at the time the estimate is prepared for the workshop (for more information, see: http://wwwi.wsdot.wa.gov/ppsc/pgmmgt/cpms/tables.asp).

H-6 Construction Market Condition Risks

H-6.1 Number of Bidders

Data provided from the WSDOT Construction Office indicates that, as the number of bidders is reduced, bid amounts tend to increase. Typically, with four or more bidders, the effect on the bid amount is negligible. To capture this effect, workshops need to consider to what extent the reduction below the normal number of bidders will influence the bid amount. A reasonable range of impact is: a 0% to 8% increase over Engineer's Estimate for construction. The probability of the occurrence of this risk will be determined during the workshop. The project team must explain why they feel their project will be subject to a "noncompetitive" bidding environment. In addition, as part of the workshop process, strategies for enhancing the bidding environment in order to

attract more bidders must be discussed and identified as a mitigation strategy for this risk. Common mitigation strategies include: timing of the advertisement and work packaging.

Phase	PE	R/W	Construction Cost Estimate Risk	
Reduced Number of Bidders	n/a	n/a	Impact +0% to +8%	Probability Determined at Workshop

H-6.2 Other Market Condition Risks for Construction

Other market conditions[1] are typically reflected in risks captured through the risk elicitation process. Project teams wishing to capture additional market condition risks beyond that described above must justify why they think their project is subject to additional market condition risks. They must provide a well-documented explanation describing what makes their project susceptible to additional market condition risks, and clearly state the sources for characterization of the risk (probability and consequences).

H-7 Right of Way Market Condition Risks

Guidance: Real estate markets are best characterized by those professionals familiar with the geographic area. In consideration of this fact, subject matter experts such as: region Real Estate Services and region Right of Way staff, or others considered knowledgeable about real estate markets in and around the project area, should be elicited. These subject matter experts can provide input regarding the cost of right of way and uncertainty associated with the real estate market in the geographic area of the project. Issues to consider are: zoning and speculation.

H-8 Preliminary Engineering Market Condition Risks

Guidance: In general, risks related to preliminary engineering (PE) adequately reflect market conditions. Occasionally, there may be concern regarding availability of skilled labor, a topic that can be discussed in the workshop, if necessary. If it can be shown that project-specific market condition risks for PE need to be captured, they must be clearly identified and documented. Sources for characterization of the risk (probability and consequences) must be clearly stated, along with why this project has this risk when other projects do not.

H-9 Design-Build (DB) versus Design-Bid-Build (DBB)

To date, the DB versus the DBB decision is being made project by project. Project directors are expected to discuss the overall contracting approach with their Regional Administrator, and final approval must come from Headquarters.

[1] Caution needs to be exercised regarding market condition risks. While the Risk Lead must be thorough in making sure to capture and recognize risk uncertainty, he/she must also guard against the potential of double counting. The analysis must clearly document what is being used and why.

Workshop general guidance: With regard to added or reduced cost expectations resulting from going to a design-build, look at categorizing the risks that you are asking the design-builder to assume, then estimate the cost. Also consider risk allocation – owner, design-builder, or shared.

H-10 Fuel Price Inflation

It is assumed the Construction Cost Index (CCI) table accounts for fuel price inflation. It is typically assumed that no additional risk factors are needed to address fuel prices. However in times of high volatility the cost risk team may discuss and determine how best to address fuel cost uncertainty.

H-11 Project-Specific Assumptions

Project-specific assumptions, that are in addition to or different from these common assumptions, should be documented in the project workshop report.