



# **Risk Management Guidelines**

**Managing project costs through identification and  
management of risks**

**October 2016**

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# Purpose

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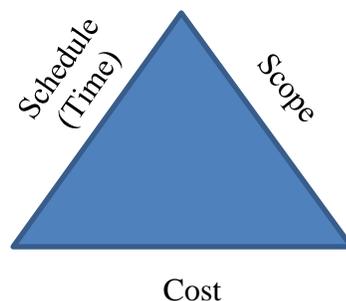
This document provides information to project managers and project teams that will help with their risk management efforts in the following ways:

- Provide a consistent methodology for performing project risk management activities.
- Provide techniques and tools for project risk management.
- Provide information on how project risk management fits into the overall project management process at MDT.
- Provide guidance on how to respond to risks proactively.

Understanding project risks will better enable project teams in making decisions regarding project development and delivery. These decisions contribute to public safety add value to Montana on many levels.

Estimating the cost of transportation projects is a fundamental responsibility of the Montana Department of Transportation (MDT). In recognition of the fundamental and strategic 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 Highways Bureau with contributions from a number of specialists in cost estimating and project development.

Fundamental to good program and project management is the understanding that project scope, cost, and schedule are tied together to form the project constraints like the three legs of a triangle. A change to one leg of the triangle will force an adjustment to the other legs. For example, an increase in the scope will cause an increase in schedule and/or the cost.



MDT construction estimates are made up of the base cost component and the risk component. Inflation and indirect costs are added to this estimate. For the purpose of these guidelines, we will be focusing on the base cost and risk component. Base cost consists of unit bid prices that are adjusted for specific projects based on quantity, difficulty of work, location, etc. (refer to MDT Cost Estimating Guidelines for additional information), and it is defined as the likely cost

of the planned project if no significant problems occur. The base cost can also include allowances for quantity uncertainties in bid items, which we call design allowances. For most projects, the risk component is estimated using a risk contingency in the planning, nomination, and early design stages. Once the project scope is well defined, the risk component can be determined through a risk analysis. Risk analysis replaces general and vaguely defined contingency with explicitly defined risk events and includes the probability of occurrence and the consequences of each potential risk event.

For project concepts under development using the Other (OT) phase, risk analysis will help refine project objectives, scope, and cost estimates prior to moving into project programming. Alternatively, risk analysis may assist with the determination to scale back or not proceed with a project as originally proposed.

A list of uncertainties is developed of both opportunities and threats. This list can be developed at any time beginning in the planning stage and should be added to as more risks are identified throughout project development. Risks are recorded in the Risk Identification section of the Risk Management Plan (RMP) worksheet.

Project risk management is the active management of the significant project risks identified through the risk analysis to minimize the impacts of threats and maximize the chances for opportunities. Risk management is a scalable activity and should be commensurate with the size and complexity of the project under consideration. Simpler projects will have less chances of risk and can be managed by the Project Design Manager. Larger, more complex projects will require involvement from functional managers, Construction personnel, and possibly outside experts.

### **Project Risk Management Policy**

Program Managers are expected to include potential risk in nomination estimates, document the risks, and provide the information to the Project Design Manager. Project Design Managers will continue risk management by identifying additional risks and officially documenting those risks with a potential to significantly affect project objectives. For high risk complex projects, risk teams will participate in workshops to identify, analyze, and determine response strategies for potential risks. Active management of the potential risk to project objectives will include monitoring and controlling, reviewing previously identified risks, and adding or retiring risks.

Active risk management is expected for all medium and high risk projects. Active risk management is also required for all projects on the National Highway system and for projects that have restricted funding (i.e. STPU, NHPB, STPS, etc.). The risk management process can be scaled up or down to match the level of risk unique to each project.

Use the level of project risk to determine the minimum risk management process as shown table P-1.

<b>Project Level of Risk</b> See table in RMP	<b>Minimum Process</b> Project managers may use a higher level process if desired
Low Risk Pavement Preservation or minor projects	Risk identification using the Project Risk Documentation worksheet and document in milestone reports
Medium Risk Rehab or Reconstruct	Qualitative risk analysis using the RMP worksheet
High Risk Complex projects	Risk analysis workshop using the RMP worksheet
<p><b>NOTES:</b></p> <p><sup>1</sup>The Risk Management Plan (RMP) is explained later in these guidelines</p> <p><sup>2</sup>If done prior to a Value Analysis Study, the results can be used for the VA. The VA may identify additional risks (hopefully opportunities) that can be addressed in a follow-up risk analysis meeting.</p> <p><sup>3</sup>A risk meeting is comprised of the project team (or key project team members); other participants may be included as the project manager/project team deem necessary.</p> <p><sup>4</sup>Very complex or major projects (typically evaluated through an Environmental Impact Statement process) should use the RMP spreadsheet early in the project development, followed up by the more formal risk analysis workshop during the design phase. Risk workshops last a full day and involve project team members, Construction staff, and subject matter experts (internal or external).</p>	

**Required Risk Management Process**  
**Table P-1**



# Definitions of Selected Terms

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**Base Cost Estimate** – The base cost represents the cost that can reasonably be expected if the project materializes as planned. This estimate typically is the Construction Cost from the Parametric Estimating Tool (PET) or the Construction Total taken from the cost estimate spreadsheet. This estimate is not adjusted for risk.

**Construction Engineering (CE)** - The activities associated with the administration of a contract for specified services and physical infrastructure. Primarily, construction engineering includes overseeing the contractor, managing the execution of and changes to the contract plans package, assuring that safety and associated impacts to the traveling public are mitigated, payment for work completed, and the documentation of physically constructed elements, certification and documentation of quality.

**Construction Estimate (CN)** – The costs associated with the execution of the contract plans package in payment for construction work completed by the contractor and subcontractors. CN includes payment for all elements in the contract (awarded price). This estimate is adjusted for risk.

**Contingency** – A markup applied to account for substantial uncertainties in quantities and unit costs and the possibility of currently unforeseen risk events related to quantities, work elements, other project requirement. Contingency is a risk cost. (Source: NCHRP 574)  
MDT will use contingency to estimate all risk at the planning and early design stages. As design progresses, design allowances will be included in the base cost as a contingency for uncertain quantities.

**Design Allowances** – A contingency factor added to the construction subtotal amount in the cost estimate spreadsheet to account for bid item quantity uncertainties.

**Elicitation** – The process of bringing something to light or causing something to be disclosed, especially by a process of questioning or research. Drawing out something hidden. (Source: Encarta Dictionary)

**Estimated Impact** – The value assigned to the impact of a risk, if it were to occur. Often the estimated value of a risk impact is a product of the probability of the risk occurring times the most likely value of time or monetary cost to the project. MDT uses the PERT formula (defined later) to determine the mean value of the risk impact and multiplies this times the probability.

**Incidental Construction (IC)** – The costs associated with necessary project requirements that are incidental to construction, such as moving utilities that are in conflict with construction activities. For MDT, the IC typically includes payments to the utility companies to compensate them for relocating their utilities prior to or in conjunction with the construction project.

**PERT Formula** – The Program Evaluation Review Technique to determine the mean value for the estimated impact that weighs the best case, worst case, and most likely values of time or monetary cost to the project.

**Preliminary Engineering (PE)** – The cost of developing a plans package for a construction project. This effort generally includes the scoping, environmental review, survey, design, and securing permits and right-of-way for all permanent project components.

**PS&E** – Plans, Specifications, and Estimate package that goes to FHWA for project obligation of CN funds. The estimate included in the PS&E is the Engineer’s Estimate that is produced by the Contract Plans Bureau.

**Qualitative Risk Analysis** - An assessment of risk relating to the qualities and subjective elements of the risk that cannot be quantified accurately. Qualitative techniques include defining the risk, recording risk details and relationships, and categorizing and prioritizing risk relative to each other.

**Quantitative Analysis** – A way of numerically assessing the probability that a project will meet its cost and time objectives. Quantitative analysis is based on an evaluation of the cost and schedule impacts of all identified and quantified risks.

**Right-Of-Way Estimate (RW)** – The estimated cost of acquiring the right-of-way necessary to construct the project. Access fees, temporary construction permits, condemnation, and permanent acquisition fees are included.

**Risk** – The combination of the probability of an uncertain event and its consequences. A positive consequence presents an opportunity; a negative consequence poses a threat. (Source: WSDOT Project Risk Management Guidance)

**Risk Analysis** – The process of determining the effect of risk uncertainties on the project cost estimates.

**Risk Breakdown Structure (RBS)** – The breakdown of potential risk events into functional categories to provide a basis for tracking and managing risks for a construction project. Each functional subgroup contains groupings of potential risk categories which have been organized into a labeled matrix. See Appendix B.

**Risk Contingency** – A factor applied to the base cost to estimate risk uncertainties. For planning purposes, the risk contingency can be taken from the contingency table in the MDT Risk Management Plan workbook and adjusted for obvious potential risks that are identified early. As design progresses, design allowances will account for quantity uncertainty; the risk contingency will account for unknown risks that have been identified.

**Risk Identification** – The process of identifying and defining potential risk factors for a specific project. Identified risks can be negative (threats) or positive (opportunities). As potential risks are identified, they are recorded in the Risk Management Plan spreadsheet.

**Risk Management** –Refers to the culture, processes, and structures that are directed toward effective management of risks, including potential opportunities and threats to project objectives.

**Risk Management Plan (RMP)** – MDT’s tool that aids the project design team accomplish the four main elements of risk management: risk identification, risk analysis (qualitative and quantitative), risk response strategy, and risk monitoring and control. The RMP workbook contains several individual worksheets, including the RMP sheet for analyzing and managing risk for medium to high risk projects and the Project Risk Management worksheet for tracking risk on low-risk projects.

**Risk Monitoring and Control** – The process of tracking the identified risks and adjusting strategies as necessary to achieve project success.

**Risk Response** – The process of managing identified risks by developing appropriate strategies and assigning tasks to project team members, focusing on risks of with the most significance. Strategies are designed to maximize project success by minimizing the impacts of threats and capitalizing on the opportunities.

**Total Project Cost Estimate** – Total project cost estimate includes PE, IC, RW, CN & CE.

**Uncertainty** – The combination of the probability of an uncertain event and its consequences. A positive consequence presents an opportunity; a negative consequence poses a threat. Uncertainties can be broken down into quantity uncertainties, which we refer to as design uncertainties, and risk uncertainties.

**Value Analysis (VA)** – A formal process that evaluates project designs to enhance value and/or reduce costs.



# Introduction

Project risk management is the culture, processes, and structures that are directed toward effectively managing project costs by identifying and managing risks. Once risks are identified, the project design team can manage them by focusing on maximizing the opportunities and minimizing the threats to project objectives.

Risk management is not a new concept for MDT. This guidance will help formalize the process and integrate it into MDT's cost estimating practice.

## The Value of Risk Management

Project risk management adds the following values to MDT project design:

- Contributes to project success;
- Recognizes uncertainty and provides forecasts of possible outcomes;
- Produces better business outcomes through more informed decision-making;
- Is a positive influence on creative thinking and innovation;
- Offers better control – less overhead and less time wasted, greater focus on benefits;
- Helps senior management to understand what is happening with the project and the challenges the project has to overcome.

This guidance introduces a new policy for MDT cost estimators to include risk management in their estimating and design project management. The level of analysis will be commensurate with the complexity of the project. In general, the following level of risk management is required for MDT projects. These requirements are a minimum; project managers can use a higher level of analysis as appropriate for individual projects.

Project Level of Risk	Required process	Level of analysis
Low	Risk identification and tracking	Informal
Medium	Qualitative risk analysis	Risk meeting with small team
High	Quantitative risk analysis	Formal, in-person workshop with large team

*Note that the risk assessment results can be used in Value Analysis (VA) studies, and that VA studies may identify additional risks.  
Informal analysis can be completed by an individual project manager or with design team members.  
Formal analysis should include design team members as well as other experts with construction and cost estimating experience appropriate for the project.*

Based on recent data, most MDT projects will qualify for the informal qualitative risk analysis or risk identification alone. The projects under design with high potential for risk will benefit from

formal quantitative risk analysis with a team. Factors to consider when determining the level of risk analysis and management effort include:

- Political sensitivity
- Type and complexity of project
- Location of project and the community it serves
- Project duration
- Stakeholder involvement
- Project delivery method selected

Any of these factors may warrant the use of a higher level of analysis.

#### **Discussing Risk as a Team has Value**

Conducting risk management meetings as a team has value. Team members listen to one another as they discuss risks and then have the opportunity to provide input from different perspectives. In discussing risks as a team, the words of individuals can impact and trigger additional thoughts of other team members. Listening to team members and providing input on the challenges discussed provides a greater likelihood that the impact of a risk will be properly assessed.

Estimates will have two components: the base cost component and the risk (or uncertainty) component. The Base Cost represents the cost which can reasonably be expected if the project materializes as planned. The base cost does not include risk contingencies. Design allowances are included in the base cost for early project estimates. Once the base cost is established, a list of risks is created of both opportunities and threats. This is the Risk Identification element of the Risk Management Plan. Once risks are identified, qualitative and quantitative Risk Analysis is undertaken. This risk assessment replaces general and vaguely defined risk contingency with explicitly defined risk events. Risk events are characterized in terms of probability of occurrence and the consequences of each potential risk event. Risk is then managed, first by developing the Risk Response element and then following through with Risk Monitoring and Control as project design progresses. Risk management consists of the following steps:

- Identify risks
- Analyze risks
- Manage risks

It is MDT's goal to proactively assess and respond to significant risks through a process that will identify, share, and manage risk across all functions. Risk management is one of four key steps of project cost estimating and scheduling, as noted in the National Cooperative Highway Research Program in NCHRP Report 574, *Guidance for Cost Estimation and Management for Highway Projects During Planning, Programming, and Preconstruction (2007)*. This document contains information on good cost estimating practices and can be borrowed from the MDT library. These steps are included in the MDT cost estimating procedures and will be documented more thoroughly in the MDT Cost Estimating Manual. For this document, we only address the step that is highlighted in the Table I-1.

<b>Cost Estimation Step</b>	<b>Description</b>
<b>Determine estimate basis</b>	Document project type and scope, including: <ul style="list-style-type: none"> <li>▪ Scoping documents</li> <li>▪ Available drawings or plan sheets</li> <li>▪ Project design parameters</li> <li>▪ Project complexity</li> <li>▪ Unique project location characteristics</li> <li>▪ Disciplines required to prepare the cost estimate</li> </ul>
<b>Prepare base estimate</b>	Prepare estimate, including: <ul style="list-style-type: none"> <li>▪ Documentation of estimate assumptions, types of cost data, and adjustments to cost data</li> <li>▪ Application of appropriate estimation techniques, parameters, and cost data</li> <li>▪ Consideration of all known project elements, including allowances for uncertain quantities for known items</li> <li>▪ Consideration of all known project conditions</li> </ul>
<b>Determine risk and set contingency or risk cost component</b>	Identify and quantify areas of uncertainty related to: <ul style="list-style-type: none"> <li>▪ Project knowns and unknowns</li> <li>▪ Potential risk associated with these uncertainties</li> <li>▪ Appropriate level of contingency (planning/scoping stage) or risk cost component (design stage)</li> </ul>
<b>Review total estimate</b>	Review estimate basis and assumptions, including: <ul style="list-style-type: none"> <li>▪ Methods used to develop estimate parameters (e.g. quantities) and associated costs</li> <li>▪ Completeness of estimate relative to the project scope</li> <li>▪ Application of cost data, including project-specific adjustments</li> <li>▪ Reconciliation of current estimates with the baseline estimate (explain differences)</li> <li>▪ Updating of cost estimate documentation to include assumptions and adjustments made to estimate during project design</li> </ul>

**Cost Estimation Steps  
Table I-1**

## Project Management and Risk Management

Project Design Managers and the design team can reduce the chances for project cost escalation by maximizing their efforts to identify and manage risk during project design. This is especially important for larger, more complex projects. This process is the most effective when combined with day to day project management efforts. Communication is a key component of this management process.

### Description

The power of risk management is fully realized when a project manager takes action to respond to identified risks based on the risk analysis, with effort being directed toward those risks that rank the highest in terms of significant impact (positive and negative) to project objectives.

### Inputs

Inputs for risk management include the best information available, which varies depending on the project design stage. At a minimum, include the defined project scope, schedule, plans package (plans, cross sections, special provisions) and cost estimate information. Information should include the most current versions of the following items:

- Project summary
- Detailed anticipated scope of work (commensurate to the level of development), including documentation of what's in and what's out of the project.
- Project cost estimate with year of obligation (target letting date)
  - PE cost estimate
  - R/W cost estimate
  - Construction cost estimate (cost estimate spreadsheet with price adjustments and Estimator file if available)
- Previous risk analyses, if applicable
- Project Risk Management Plan
- Project Schedule
  - Overall project design schedule
  - Contract time calculation, if complete
- Additional information as necessary

### Techniques and Tools

This guidance outlines the available 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. Tools include:

- Cost Estimating Guidance
- Risk Element chart (Figure 2-1)
- Contingency table for planning and early scoping estimates<sup>1</sup>
- Risk Management Plan (RMP) spreadsheet<sup>2</sup>
- Risk workshops<sup>2</sup> for high risk projects
- Communication with project design team and Management

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<sup>1</sup> See [MDT Cost Estimating Guidelines](#)

<sup>2</sup> Taken from WSDOT and modified for MDT use

Additional information is available on the MDT cost estimating webpage:  
<http://www.mdt.mt.gov/business/contracting/cost.shtml>

Monitor the following throughout project development, keeping in mind that significant changes will alter the project costs developed through the risk analysis process.

1. Project scheduling data for project design milestones:
  - Preliminary Field Review
  - Alignment and Grade Review
  - Completion date for the environmental document
  - Scope of Work report
  - Plan-in-Hand review
  - Start date for the acquisition of right-of-way
  - Project advertisement date
  - Estimated construction duration
2. Estimated Project Cost Data
  - Date of estimate basis and inflationary factor used
  - PE cost estimate
  - Right-of-way cost estimate
  - Construction cost estimate

## **Output**

Benefits from the risk management process include outputs that can be used to assist with project cost and schedule management.

- Potential impacts of individual and combined risk events can be evaluated to prioritize project management focus.
- Summary information from the Risk Management Plan can be used to communicate the impact of risk events on project cost and schedule, broken down by functional group.
- Action items and dates are developed for individual risk events.
- Schedule adjustments can be made using judgment based on the expected schedule impacts of individual risk events for specific functional groups.
- The risk contingency can be developed based on the risk analysis. The total estimated impact of the risk analysis shown in the header information is a summation of the expected cost impacts (threats are a positive cost; opportunities are a negative cost) to the project at the time of the risk analysis. This number, along with judgment based on the individual risk events, will assist with developing an appropriate risk contingency to add to the project base cost.
- All significant risk events are documented, along with analysis and response actions, for all project design staff and managers to view and update.



# Project Risk Analysis Process

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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:

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## 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.

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## 2) Identify Risk Events

**Risk Identification** involves determining which risks might affect the project and documenting their characteristics. It may be a simple risk assessment organized by the project team, part of a risk analysis workshop, or results from a VA study.

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## 3) Risk Analysis

**Qualitative Risk Analysis** assesses the impact and likelihood of the identified risks (high, medium, low) and develops prioritized lists of these risks for further analysis or direct mitigation. The 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.

**Quantitative Risk Analysis** is a way of numerically estimating the probability that a project will meet its cost and time objectives and the associated impacts. Quantitative analysis is based on the risk impact to the overall project cost and schedule.

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## 4) Risk Response Planning

**Risk Response Strategy** is the process of developing options and determining actions to enhance opportunities and reduce threats to the project's objectives. It identifies and assigns parties to take responsibility for each risk response. This process ensures that each risk requiring a response has an "owner." The Project Design Manager and the project team identify which strategy is best for each risk, and then select specific actions to implement that strategy.

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## 5) 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.

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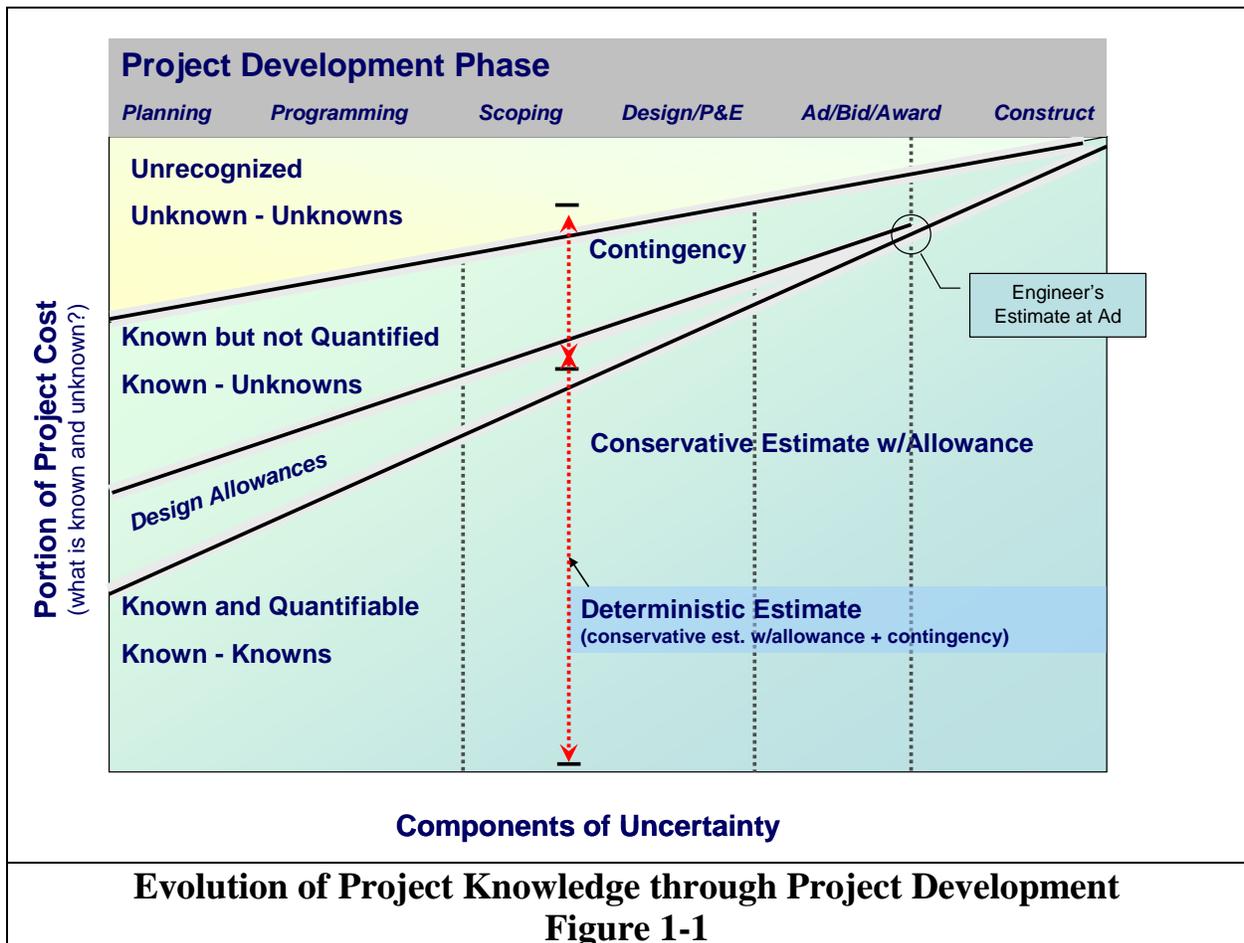
The remainder of this guidance includes more detail on the steps listed above.



# Chapter 1: Risk Management Planning

**Risk management** begins early in the project development process and proceeds as project knowledge evolves and project information increases in quantity and quality. Monitoring project development and risk exposure continues and formal or informal risk assessments may occur several times through the life of the project. Planning and project design staff must consider the resources needed for project risk management and build it into their project development budget and schedule. Risk management activities, including risk workshops should be built into the project design schedule and budget as well.

As the project develops and moves through scoping and early design phases, more knowledge about the project becomes available as depicted in Figure 1-1.



With the rising knowledge about a project's scope comes an understanding that contending with some elements of the project will require significant additional resources. Such elements could be related to scope, environmental mitigation and permitting, rising cost of right-of-way as corridors develop in advance of the project, utilities, geotechnical and other considerations.

## Risk Management Planning “How to”

<b>Risk Management Planning</b>	Risk Identification	Risk Analysis	Risk Response	Risk Monitoring and Control
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### 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 and budget.

1. Determine the level of Risk Analysis required for your project, based on the construction estimate (see Table 1-1).
2. Incorporate risk management activities into the project schedule (see Table 1-2).
3. Include additional budget for PE to adequately perform all Risk Management activities.
4. Make Risk Management an agenda item for regularly scheduled project meetings. Communicate the importance of risk management to the entire project team and to others outside the team, such as members of Management (such as the Preconstruction Engineer or District Administrator) or stakeholders.
5. Establish the expectation that risk will be managed, documented, and reported.

	<b>Project Risk Level</b>	<b>Risk Analysis Level</b>	<b>Notes</b>
<b>Risk Identification</b>	Low	Individual Project Manager or small group Risk Identification and documentation	The project team identifies potential risk events that could occur during the design or construction of the project. These are recorded in the Risk Management Plan (RMP) Project Risk Documentation sheet.
<b>Formal Risk Analysis</b>	Medium	Individual Project Manager or project team Risk Analysis Risk Management Plan <b>Qualitative Tool</b>	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 RMP can be used for any project.
	High	Project Team Risk Analysis Risk Management Plan <b>Quantitative Tool</b>	

**Level of Risk Analysis**  
**Table 1-1**

**Risk Management Milestones include:**

- Project Scope, Schedule, and Estimate are complete (appropriate for the level of development)
- Prep time (initial review of areas of concern, determine level - qualitative or quantitative)
- Risk meeting (risks are identified and characterized)
- Risk Response Actions Developed
- Risk Response Actions Implemented

**Risk Management Milestones  
Table 1-2****Hints for Risk Management Planning**

- ◆ Budget for risk identification, risk analysis, risk response, and risk monitoring and control activities in the PE.
- ◆ Schedule risk assessments at appropriate times. Risk assessment should begin early, but there must be enough known about the project to understand what is being assessed. This will be to varying levels of detail depending on the point in project development at which the risk assessment is conducted (planning, scoping, or design).
- ◆ Allow time in the schedule for preparation activities. This includes review and QA/QC of project schedules and cost estimates at appropriate times.
- ◆ Report on status of project risk in regularly scheduled project meetings and document in milestone reports, such as Alignment & Grade and Scope of Work.
- ◆ Know the organization's tolerance for risk. Specifically, how much risk is the organization willing to accept for the project? Knowing the answer to this question will help with risk management and contribute to the decision making process when determining risk response actions.

# Chapter 2: Risk Identification

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**Risk identification** occurs through all of the phases of project development:

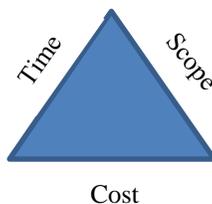
1. Planning
2. Survey
3. Design
4. Right of Way
5. Construction

As projects develop, knowledge and understanding grows, and the risk profile evolves. Previously identified risks may change and new risks are identified throughout the life of the project. Effective risk identification and management will help manage project costs and schedules.

## Risk Identification: Inputs, Techniques, and Tools

### Risk Identification Inputs

The first and most important input is a defined project. In order to fully understand and assess the risks to which our projects are exposed, we must first ensure that there is a mutual understanding of the project under evaluation. This means that when we prepare to deliberately focus on the risks and uncertainties our project could face, we must first be able to define the project in terms of scope, schedule and estimate - commensurate with the level of project development at the time of risk analysis. Remember the triangle:



For projects in planning or early development stages, document the assumptions made regarding the project scope, i.e. what key features were assumed to be in the project scope and which features were not included.

### Risk Identification Techniques

Try to identify as many risks as possible that may affect project objectives. State the assumptions for risk identification and analysis and delineate thresholds for risks. For example, major risks may be described as all cost risks housed in bid items that make up 80 percent or more of the cost estimate<sup>3</sup> and all schedule risks greater than 3 months. Minor risks don't require further analysis. This allows the project team to focus on the

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<sup>3</sup> Remember the 80/20 rule: 80% of the project costs are generally represented in 20% of the bid items.

most significant risks. Assumptions and thresholds for risk analysis will be influenced by the size and complexity of the project, project environment, and the project-specific tolerance for risk. There are a wide variety of techniques used for risk identification. Some common techniques are provided below.

### *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.

### *Field Reviews*

Preliminary field reviews with the project design team often provide an opportunity to observe and record physical constraints that may lead to project risk. Environmental issues, geotechnical or hydraulic constraints, utility concerns, and right-of way considerations should be noted and discussed.

### *Information Gathering*

- **Crawford Slip Method.** Give each team member 5 to 10 sticky notes and have them write one fully defined risk per slip during a timed, silent session. Be sure to ask for at least one opportunity. At the end of the session, collect, combine, and group the risks. Grouping can be done in groups or by the facilitator during a short break.
- **Brainstorming.** Formal and informal brainstorming sessions with project team members and other experts, stakeholders and regulatory agency representatives is an effective technique for risk identification. Brainstorming 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 team is most concerned about geotechnical conditions, a brainstorming session focusing on just geotechnical issues can be convened. The same can be done for project schedule and any other critical project area of concern. The brainstorming session can build on ideas gathered from the Crawford Slip session.
- **Project Level of Risk table.** The RMP workbook includes a sheet with the Project Level of Risk table which can be used early in the project to identify project aspects with the potential for medium or high risk. This table will also help screen out those areas of lower risk that won't need further consideration.
- **The Risk Element chart.** Figure 2-1 can be used to fill in gaps of potential risk events missed in the brainstorming exercise.
- **Lessons Learned data.** Searching for lessons learned that are relevant to your project can provide an abundance of information on projects that may have faced similar risks. Construction Reviewers, post-construction review reports, and Lessons Learned from contractor claims are other good sources for lessons learned.
- **Examination of previous, similar projects.** Discussions with District personnel often reveal risks encountered on similar past projects, especially for projects located nearby. Using past examples requires objective judgment. Although a previous project may be similar, each new project has unique requirements and features, including uncertainties and risks.
- **Other methods.** Other common techniques include: questionnaires and surveys, interviewing, checklists, examination of the OPX2 schedule, and discussions with

appropriate specialty groups, 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?” etc.

### Risk Identification Tools

Any form of documentation can serve as a tool for identifying risks. A simple spreadsheet or Word table is acceptable if the project is in early planning or scoping. However, use of the Project Risk Documentation (for low risk projects) or Risk Management Plan (RMP) worksheets is recommended for all projects stages. Store the RMP workbook on DMS for accessibility by all functional managers.

#### *Risk Management Plan (RMP) Worksheet*

The RMP worksheet is a tool that is used for all stages of Risk Management<sup>4</sup>. Filling out the risk identification section early in the life of a project, whether during a corridor planning study or at nomination time, will ensure that assumptions affecting cost estimates are not lost. Planning and scoping risk identification would only require completion of the description columns. Risk identification and analysis conducted in later project stages also require filling out the information described below. Figure 2-2 shows an example of the Risk Identification section of the RMP. Column reference numbers are shown in the third row down from the top.

Information required for Risk Identification in the RMP includes:

Column Name (#)	Contents
<b>Risk Number (1)</b>	A unique number is assigned to each risk for tracking purposes.
<b>Risk Status (2)</b>	There are three choices in the drop-down menu for risk status: <ul style="list-style-type: none"> <li>• <i>Active</i>, when the risk is being actively monitored and controlled</li> <li>• <i>Dormant</i>, when the risk is low priority but may become high priority in the future</li> <li>• <i>Retired</i>, when the risk is managed or conditions change to eliminate the risk</li> </ul>
<b>RBS Group (3)</b>	The Risk Breakdown Structure is a grouping used to assign risks to functional areas, based on the Risk Elements shown in Figure 2-1. Appendix B contains additional information on the RBS. Figure B-1 shows the abbreviated category titles for the RBS that correspond to the drop down menu choices in the RMP. Eventually, the Risk Breakdown Structure will be used for tracking and quantifying risks as recommended in <u>Highway Project Cost Estimating and Management, 2009 (Alavi)</u> .
<b>RBS Code (3a)</b>	The Risk Breakdown Structure elements are sorted into numbered sub-groups. When a risk element is selected from

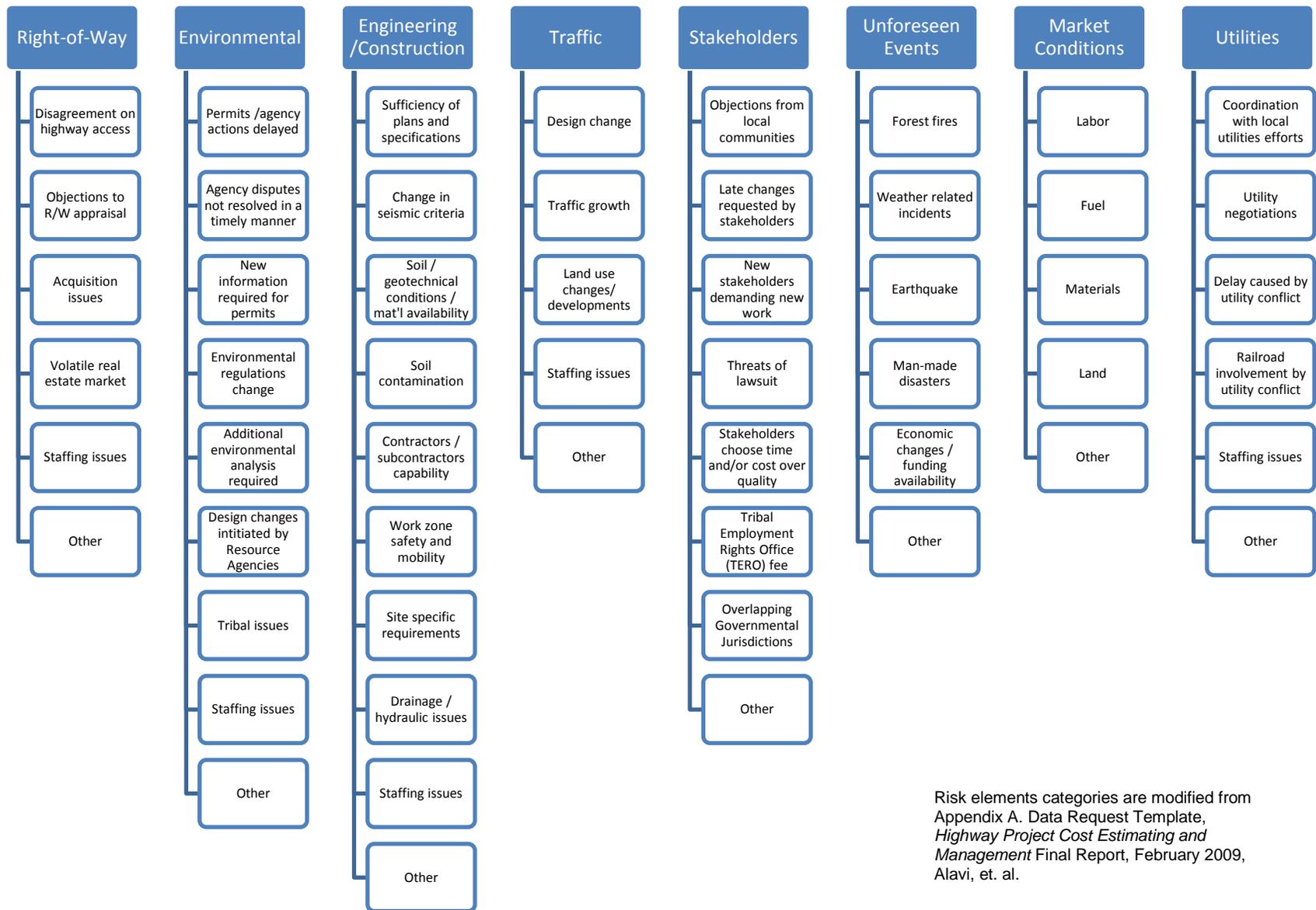
<sup>4</sup> See Appendix A for more information on the Risk Management Plan.

	the RBS in Figure B-1, the corresponding number in the left-hand column is entered into the RMP for the RBS code.
<b>Project Phase/Date Identified (4)</b>	Document the date the risk was identified and the project development phase: Planning (includes OT phase concept reviews), Survey, Design, Right-of-Way, or Construction.
<b>Functional Assignment (5)</b>	The functional area that will be responsible for risk response actions. Choices come from OPX2: Bridge, Consulting, TA, District, Environmental, Helena, MSU, Safety, Traffic, R/W, Utilities, Survey, Construction (includes Materials), and Legal.
<b>Summary Description Threat and/or Opportunity (6)</b>	Each identified risk should have an appropriate name, for example “NEPA Delay” or “Condemnation potential.” The nature of the risk with respect to project objectives (threat or opportunity) should also be documented. Figure 2-1 can be used as a basis for naming the risks.
<b>Description of Risk Event (7)</b>	Provide a description of the identified risk that is specific and detailed. The description must be clear enough and thorough enough so that others reading about the risk will understand what it means and appreciate the implications to project outcomes. Clearly state the cause, the risk, and the impact.
<b>Risk Trigger (8)</b>	Each identified risk must include the risk trigger(s). Risks rarely just suddenly occur; usually there is some warning of imminent threat or opportunity. These warning signs should be clearly described and information about the risk trigger should be documented. For example “NEPA Approval Date” may be considered a risk trigger on a project that has a risk of a legal challenge.
<b>Type (9)</b>	Does the identified risk affect project schedule, cost, or both?
<b>Response Actions<sup>5</sup> (17)</b>	Document, if known, possible response actions to the identified risk. Can the identified threat be avoided, transferred, 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; risks should be reviewed regularly and as new risks are identified they should be documented and assessed. The risk identification in the RMP is dynamic and can be added to at any time during project development. Additional risks may be identified as the different functional areas work on design features, and as a result of VA studies, changed site conditions, environmental analyses, and right-of-way negotiations.

<sup>5</sup> Filling out the Response Action field is not a requirement at the risk identification stage. However, if the team has an idea for a potential risk response, document the idea at this time. It can be revised during the Risk Analysis process later.



Risk elements categories are modified from Appendix A. Data Request Template, *Highway Project Cost Estimating and Management* Final Report, February 2009, Alavi, et. al.

**Risk Element Categories**  
**Figure 2-1**

## “How to” Identify Risk Events

Risk Management Planning	<b>Risk Identification</b>	Risk Analysis	Risk Response	Risk Monitoring and Control
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### How to Identify Risk

1. Determine risk thresholds for the project (establish a minimum dollar amount and time duration considered significant for the project under evaluation). Identify the scale of the dollar amounts to be considered (thousands or millions).
2. If there are alternate alignments under consideration, perform a separate risk assessment and use individual RMP worksheets for each alignment. This helps separate the identification of threats and opportunities.
3. Focus on identifying significant risks which affect project objectives. Use the 80/20 rule for cost items and focus on the major items. Use the OPX2 critical path as a starting point for identifying schedule risks.
  - a. Use techniques described earlier in this chapter to identify major potential risks to the project, starting with a brainstorming session (for workshops) or a review of the Project Level of Risk table (for Planning or early design).
4. Carefully document and describe risks in the RMP or Project Risk Documentation (for low risk projects) worksheet:
  - a. Determine the status of the risk:
    - Active - the risk is being actively monitored and controlled
    - Dormant - the risk is low priority but may become high priority in the future
    - Retired - the risk is demised for any reason (usually selected in a later stage risk review).
  - b. Determine the Risk Breakdown Structure (RBS) category from Appendix B.
  - c. Record the date and project phase when the risk was first identified.
  - d. Identify the responsible functional area.
  - e. Determine whether the risk is a threat or an opportunity.
    - Threat = if event occurs it negatively impacts objectives (increase cost or schedule)
    - Opportunity = if event occurs it positively impacts objectives (decrease cost or schedule)
  - f. Provide a short description and a detailed description of the risk event. The detailed description should be written as the cause, the risk, and the impact.
  - g. Determine the Risk Trigger and present the symptoms and warning signs that a risk event is about to occur. This information is used to determine when to implement the Risk Response Strategies.
5. If a practical risk response action has been identified, scroll over to the Risk Response section and fill in a tentative risk response.
6. Save the RMP. Perform a data sort by RBS group to look for duplication or overlapping risk events. Modify overlapping events to ensure that all listed events are unique.

Risk Identification									
Risk #	Status	RBS Group	RBS Code Number	Project Phase   Date Identified	Functional Assignment	Summary Description Threat and/or Opportunity	Description of Risk Event (Cause-Risk-Impact)  Clearly state the cause, the risk, and the impact.	Risk Trigger	Type
(1)	(2)	(3)	(3a)	(4)	(5)	(6)	(7)	(8)	(9)
<b>EXAMPLE</b>	Active	ROW	03	Feb-10	Design	Threat	Because the mitigation ratio has not been finalized and there could be additional impacts to wetlands, the amount of R/W needed for the mitigation area may significantly increase, resulting in additional R/W costs and potential acquisition delays.	If Wetland impact is larger than 1/2 acre and ratio exceeds 4:1.	Cost
				Design		Threat			Schedule
1	Active	ENG	07	Design	District	Threat	Because bridge decks in the area are continuing to deteriorate at an unpredictable rate, deck replacement may be necessary instead of the planned rehabilitation, resulting in an additional 2 months of design time, additional costs for each bridge, and considerations for special traffic control measures.	Inspection reveals catastrophic corrosion and deterioration.	Cost
						Threat			Schedule
						Threat			Cost

**Risk Identification in RMP  
Figure 2-2**



### Hints for Risk Identification

- ◆ Determine, for your project, what constitutes “significant” risk.
- ◆ Begin identifying risk during the Preliminary Field Review or Planning stage and continue the process throughout project development.
- ◆ Analyze alternative alignments separately.
- ◆ Thoroughly describe the risk in a manner that can be understood; be specific and detailed. Clearly state the cause, the risk, and the impact.
- ◆ Include specialty groups and/or other persons who may have meaningful input regarding the challenges or opportunities the project may face.
- ◆ Think about who “owns” the risk and who will develop a response.
- ◆ Be sure that all risk events are unique and not overlapping with others so that they can be analyzed individually.
- ◆ Identify any unacceptable risk events that would result in stopping the project immediately (either during design or construction).



## Chapter 3: Risk Analysis

**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 team assesses each identified risk for its relative chance 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 analysis is often used...

- As an initial screening or review of project risks;
- When a quick assessment is desired;
- As the preferred approach for most projects where robust and/or lengthy quantitative analysis is unnecessary.

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

Detailed quantitative analysis of risks is performed...

- As a more accurate review of the effects of project risks;
- When project risk has the potential to significantly impact project outcomes;
- As the required approach for high risk projects where risk events have the potential to change project cost estimates or schedule significantly.

**Qualitative** - observations that do not involve measurements and numbers; relating to or based on the quality or character of something, often as opposed to its size or quantity (Encarta on-line dictionary, 2010) EXAMPLE: the risk of a heavy rainstorm affecting our erosion control is "Very High."

**Quantitative** – observations that involve measurements or numbers; relating to, concerning, or based on the amount or number of something (Encarta on-line dictionary, 2010) EXAMPLE: the risk of a heavy rainstorm affecting our erosion control is 90%.

Qualitative analysis provides a convenient and user-friendly way to identify, describe and characterize project risks. Qualitative judgments can be converted to a quantitative measure for use in the RMP worksheet by using guidance in Table 3-1.

Risk Identification, as described in Chapter 2, starts the development of the Risk Management Plan. Depending on the project complexity, the number of identified risks can be sizeable. A process is needed to evaluate and prioritize the risk events. Evaluation and prioritization is typically an iterative process and can take place at various points in project development.

Identifying, describing, and assessing project risks allow us to prioritize risks. Prioritization provides specific, documented risk events that we can act on to shift the odds in favor of project

success. Assessing the risks that present the highest potential for significantly affecting project objectives gives project managers the information necessary to focus project resources. Prioritization helps us make decisions in an uncertain environment and address project risk in a direct and deliberate manner.

Qualitative analysis uses relative degrees of probability and consequence of each identified project risk event in descriptive non-numeric terms. Quantitative analysis involves the use of probabilities assigned to the various risk events and the associated costs.

Risk analysis must be partnered with a well-organized and properly documented project base cost estimate. Risk analysis 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.

Probability (Likelihood)	Synonyms		Approximate %
Very high	Almost certain	Very Sure	> 90%
High	Likely	Pretty Sure	70% - 90%
Medium	Possible	Maybe	30% - 70%
Low	Unlikely	Seldom	10% - 30%
Very Low	Rare	Improbable	< 10%
Consequence (Impact)	Synonyms		Approximate % of CN or Remaining Time
Very high	Very Critical	Very Strong	> 10%
High	Critical	Strong	5% - 10%
Medium	Moderate	Average	2% - 5%
Low	Slight	Mild	1% - 2%
Very Low	Very Little	Very Mild	< 1%

**Relating Qualitative Analysis to Quantitative Analysis  
Table 3-1**

**Risk Analysis: Inputs, Techniques, and Tools**

**Risk Analysis Inputs**

As with Risk Identification, the first and most important input is a defined project. In order to fully understand and assess the risks to which our projects are exposed, we must first ensure that there is a mutual understanding of the project under evaluation. Secondly, risks must be identified and described in detail sufficient for the analysis team to understand and deliberate.

## **Risk Analysis Techniques**

Review the identified risks and descriptions. Deliberate the probabilities of occurrence and the impacts to the project using qualitative or quantitative terms as appropriate to the complexity of the project and to the specific risk element. For example, a complex project may have some less significant risk events that can be evaluated quickly in qualitative terms. The major items would require more discussion and more effort to assign numeric probabilities of the risk occurring and for the cost and schedule impact to the project. Conversely, a small project may have an identified risk that could significantly affect the project. The Project Design Manager may decide to discuss that particular risk quantitatively with the appropriate team members to determine probabilities of occurrence and impact. The remaining risk events could be reviewed qualitatively.

Risk analysis must be performed periodically throughout the life of a project. Risk management is an integral component of ongoing project management. It is ongoing and iterative. At a minimum, the Project Design Manager must review the Risk Management Plan at key project milestones. Periodically workshop members can regroup to evaluate the project and associated uncertainty and risks. Project risks and mitigation efforts must be discussed at regular project meetings; make changes as appropriate to the RMP and reanalyze as needed. Critical risks and proposed responses should be documented in every milestone report. When action is taken to respond to risks, cost and schedule savings can result.

### ***Appropriate Level of Review***

Carefully review the project scope and identified risks. Determine the level of review that would be appropriate to adequately analyze the risks.

- For low to medium risk projects: Are there any risks that could cause design changes, lead to scope changes, or effect contract letting? These may require quantitative analysis with a small team of functional experts. Otherwise, a qualitative review with the designer may be adequate.
- For more high risk projects: The Risk Analysis should be performed with the appropriate design team members and District Construction staff. Some risk events will require more analysis than others.

### ***Cost Estimate and Schedule Review***

- Project team members review OPX2 schedule for realistic completion times, critical activity completion (activities that are on the critical path as well as those that could move to the critical path), and activities at risk. Remember that risk can be an opportunity (deliver early) or a threat (add time to schedule/miss fiscal year delivery).
- Project team members review the base cost estimate and validate major bid item estimates prior to meeting for the Risk Analysis. During the analysis meeting or workshop, focus on the items that make up the identified risk areas. The base cost estimate should include design allowances at the earlier stages of project development; however, contingencies for uncertainty must be removed.

### *Gather and Represent Data*

- Interviews – Elicit information through formal or informal settings, such as smaller group meetings and/or part of the formal workshop.
- Subject Matter Expert input – participating collaboratively with the project team and cost-risk team or contributing opinions in other ways such as questionnaires.
- Represent data in terms of probability and impact. Fill in the Qualitative Analysis columns in the RMP worksheet (columns 10, 10a, 11 in Figure 3-1). Think about:
  - Likelihood (probability of occurrence)
  - Consequences (impact to cost/schedule relative to base if the event occurs)
  - Relationship with other risk events (independent vs. correlated with other events)

### **Risk Analysis Tools**

Efficient review and documentation are critical for successful Risk Analysis. The RMP worksheet is set up to step the risk team through the Risk Analysis process.

### *Risk Management Plan (RMP) Worksheet*

As stated earlier, the RMP worksheet is the key tool for all stages of Risk Management. The Risk Analysis section includes a probabilistic modeling component that runs in the background. The following elements must be included in project Risk Analysis. Refer to Figure 3-1.

<b>Column Name (#)</b>	<b>Contents</b>
<b>Type (9)</b>	Risk events can impact project schedule, project cost, or both. The Risk Analysis must be performed for at least one of the risk types.
<b>Probability (10)</b>  Quantitative Analysis component	Determine the probability of the risk occurring. For major risks on complex projects, careful deliberation with subject matter experts is critical. For minor risks and small projects, Table 3-1 can be used as a guide for assigning probability to a qualitative analysis.
<b>Risk Impact (11, 11a)</b>  Quantitative Analysis component: only necessary high risk projects	Enter the dollar value of the estimated impact of the risk event, in thousands or millions (depending on the magnitude of the project), or time impact in months. For threats, the value will be a positive number. For opportunities, enter a negative value. This part of the analysis can be difficult and may take experience to become comfortable with the process. The MDT Cost Analyst and/or Highways Design Engineer can assist the group with this discussion. <ul style="list-style-type: none"> <li>• Minimum – The lowest cost to the project (dollars or months) if the risk event occurs. If the risk event occurs, the risk impact will not be lower than this value. For opportunities, think in absolute terms (i.e. the minimum value is \$1,000 to be saved) and then enter the value as a negative (-\$1,000 impact on the total project risk amount).</li> </ul>

	<ul style="list-style-type: none"> <li>• <b>Maximum</b> – The highest value (dollars or months) to the project if the risk event occurs. If the risk event occurs, the risk impact will not be higher than this value. This value is the maximum cost or time impact possible. For opportunities, think in absolute terms (i.e. the maximum is \$7,000 to be saved) and then enter the value as a negative (-\$7,000 impact on the total project risk amount).</li> <li>• <b>Most Likely</b> – The most probable cost or time impact value. This is the highest value represented on a frequency curve (mode), and it can take place anywhere between MIN and MAX (i.e. it isn't necessarily in the middle). Using the probability scale from Table 3-1, estimate the value based on the minimum and maximum. Listen to the group discussion and decide whether the curve is loaded to the left (more chance of hitting a value on the minimum side) or right loaded (leaning toward the maximum value). If unsure, use 50%.</li> </ul>
<p><b>Expected Impact (12)</b></p> <p>Quantitative Analysis component</p>	<p>The expected impact of the risk event is quantified automatically using the Program Evaluation Review Technique (PERT) formula, which weighs the lowest, highest, and most likely costs:</p> $EXPECTED\ IMPACT = \left( \frac{MIN + 4 \times MOSTLIKELY + MAX}{6} \right) \times PROBABILITY$ <p>The estimated monetary and time impacts are displayed in the green shaded area of the upper right portion of the RMP in red text. The totals of the leverage (sum of the impacts of the opportunities) and the exposure (sum of the impacts of the threats) are shown at the bottom of Qualitative Analysis columns. For cost ranges: the maximum expected cost or time schedule would be the estimated cost or time plus the exposure. The minimum expected cost or time schedule would be the estimate minus the leverage. The most likely value would be the sum of the estimate with leverage and exposure. See the “Overall Project Risk” worksheet.</p>
<p><b>Probability (13)</b></p>	<p>For risk events using a Qualitative Analysis, the probability can be entered manually using Table 3-1 for guidance. Acceptable entries are:</p> <ul style="list-style-type: none"> <li>Very High</li> <li>High</li> <li>Medium</li> <li>Low</li> <li>Very Low</li> </ul>

	For risk events using a Quantitative Analysis, the qualitative probability will automatically populate based on the inputs for the Probability percent entered in column 10.
<b>Impact (14)</b>	The qualitative impact to cost and/or schedule will automatically populate based on the inputs for Risk Impact in column 11. The cost impact is qualitatively determined based on a comparison to the estimated construction cost. The schedule impact is qualitatively determined based on a comparison to the total project time remaining (design plus construction). If Risk Impacts are not quantified, one of the following qualitative values can be entered, using Table 3-1 for guidance. Very low Low Medium High Very high
<b>Risk Matrix (15)</b>	The risk matrix will automatically populate based on the entries in the Probability and Impacts columns (13 and 14). Impacts to project cost will be depicted with a "\$" and impacts to schedule, in months, will be depicted with "Mo." If the risk impact is minor to the overall project, no symbols will be displayed. This visual will help prioritize risks when developing the Risk Response (Chapter 4).  The values for Relative Risk in the bottom left corner represent the magnitude of the cost risks and schedule risks separately. Values greater than 20 are high, values between 8 and 20 are medium, and values less than 8 are low risk. These values will also help with risk prioritization.
<b>Priority (16)</b>	After all of the risks are identified, use the risk matrices and risk impacts to prioritize risk response and management. This will help focus the risk management efforts efficiently on lessening the impacts of the worst threats and improving the chances for opportunities with the biggest payback. Note that if the estimated project construction cost or project schedule changes, the impacts will change also.

### ***Risk Meeting***

For medium risk projects, a risk meeting comprised of the project team and/or key project team members, and other participants (such as specialty groups involved with critical items) may suffice. Low risk projects can be evaluated during the Preliminary Field Review or a team meeting.

### ***Risk Workshop***

A formal risk workshop should be held with the project team for high risk projects.

## Risk Analysis “How to”

Risk Management Planning	Risk Identification	<b>Risk Analysis</b>	Risk Response	Risk Monitoring and Control
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### How to perform a Risk Analysis

Once a risk event is identified and recorded in the RMP, including a thorough description of the risk and risk triggers, it can be characterized in terms of probability of occurrence and the consequence if it does occur. A Risk Analysis can be scaled according to the complexity of the project and can be performed in an informal setting or in a formal Cost Risk Assessment workshop. Regardless of the setting, use the tools and techniques described previously to develop the Risk Management Plan. Refer to Figure 3-1.

1. Gather the project team and subject matter experts, as appropriate to the project complexity, to discuss project risk. Some projects may only require the Project Design Manager and the designer.
2. Review the risk information from the risk identification step.
3. Discuss the risk with the group.
4. Determine whether the risk will impact cost or schedule or both.
5. Assign the **Probability** of occurrence: evaluate the likelihood of the risk occurring by asking the group “How likely is it that this risk will occur?” Record the agreed-upon result. Be deliberate in your considerations.
6. For high risk projects and for significant risks to smaller projects<sup>6</sup>, determine minimum, maximum, and most likely values for the risk impact. Subject matter experts and the MDT Engineering Cost Analyst should be consulted as necessary.
7. For medium risk projects, assign the **Impact** of occurrence: evaluate the consequences if the risk does occur by asking the group “What will be the impacts if this risk does occur?” Record the agreed-upon result. Again, consider this carefully.
8. Evaluate the Risk Matrix and Relative Risk costs and determine if the portrayal of the risk event makes sense. Note that if the risk event impacts both cost and schedule, the projected impacts could be in different parts of the matrix.
9. Perform a sensitivity analysis by varying the numbers input for risk impact (min, max, most likely) to determine the impact on the results. The amount of change to the matrix will help determine how much time should be spent coming up with the impact values.
10. After all the risks have been identified, prioritize the risks based on the graphical representations in the matrices or relative risk values. Risks plotted in red should be the highest priority, yellow next, and green lowest. If there are a substantial number of risks, they can also be grouped according to the RBS Group and ranked within each category. If there are many risk events identified, perform a data sort by priority.

<sup>6</sup> The Project Design Manager should use engineering judgment to determine the appropriate level of analysis for a given risk. There may be potential risk events for a smaller (in terms of construction cost) project that could jeopardize the project. This would indicate the need for a full, quantitative risk analysis.

Quantitative Analysis					Qualitative Display of Most Likely Impact														
Type	Probability	Risk Impact (\$K or M) (Month)		Expected Impact (\$K) [most likely X probability]	Probability	Impact	Risk Matrix			Priority   Strategy									
(9)	(10)	(11)	(11a)	(12)	(13)	(14)	(15)			(16)									
Cost	70%	MIN	\$1.0	\$4.8	High	Very High	Probability	VH	Mo	H	M	L	VL	Relative risk	64	4	Impact	Avoid	Finaliz impac ag
		MAX	\$12.0																
		Most Likely	\$7.0																
Schedule	70%	MIN	0.0Mo	1.9Mo	High	Very Low	Probability	VH	Mo	H	M	L	VL	Relative risk	64	4	Impact	Avoid	Finaliz impac ag
		MAX	4.0Mo																
		Most Likely	3.0Mo																
Cost	40%	MIN	\$0.2	\$0.6	Medium	Very High	Probability	VH	Mo	H	M	L	VL	Relative risk	48	3	Impact	Avoid	Finaliz impac ag
		MAX	\$4.8																
		Most Likely	\$1.6																
Schedule	40%	MIN	1.0Mo	1.2Mo	Medium	Very Low	Probability	VH	Mo	H	M	L	VL	Relative risk	48	3	Impact	Avoid	Finaliz impac ag
		MAX	5.0Mo																
		Most Likely	3.0Mo																
	min	\$0.2	Leverage	\$0.0	0 Months	Relative risk	Probability X Impact												
	max	\$4.8	Exposure	\$0.6	1.2 Months	48	3	Probability factors = 1,2,3,4,5 (VL to VH)											
	most lil	\$1.6	Most likely	\$0.6	1 Months	cost	schedule	Impact factors = 1,2,4,8,16 (VL to VH)											
		Total		Est	Est														
		Est		Exp Val	Exp Value														
		Cost		of	of														
var		Impacts		Cost	Time														
		(range)		Impacts	Impacts														

**Risk Management Plan Spreadsheet Example - Risk Analysis Figure 3-1**

## Risk Analysis Considerations

Assigning values for probability and impact relies on the expertise and professional judgment of experienced participants. With experience, professionals develop intuition and an ability to understand projects to a greater degree than those not involved with project development and delivery.

There may be smaller projects with higher than expected levels of risks and consequences. While performing the qualitative risk analysis, the project team should be open to recognizing that a qualitative analysis is not adequate to thoroughly describe the risks as necessary to assign a risk-response strategy. If the Project Design Manager feels that additional analysis is needed, the team can perform a quantitative analysis instead or in addition to the qualitative analysis. Politically important projects or those with significant work zone safety and mobility concerns would be examples of such projects.

Risk analyses should be conducted several times throughout project development. The risk profile of a project evolves and changes as the project is developed and knowledge is gained, design changes occur, and mitigation strategies are implemented and monitored.



### Hints for Risk Analysis

- ◆ Invite the *appropriate* participants (not too many, not too few). Impress upon them the importance of their participation.
- ◆ Define terms.
- ◆ Be prepared and organized. Know what needs to be evaluated, be able to clearly describe the scope of the project, have up-to-date cost estimates and project schedule.
- ◆ Discuss probability of and impacts of risk occurrence to both cost and schedule, as appropriate.
- ◆ Stay focused. Put a time limit on the discussion if necessary.
- ◆ Perform a sensitivity analysis to help determine the level of discussion necessary for fine tuning impact values (min, max, most likely).
- ◆ Recognize when a project's risks require a higher level of analysis.
- ◆ Be aware of optimistic bias that can affect a real view of project schedule and cost.
- ◆ Make sure all participants are involved and are heard.
- ◆ For the formal risk workshops, prepare the participants ahead of time. See Appendix C for more information.
- ◆ Review the risk analysis at each project meeting and document findings and proposed solutions in the reports (i.e. Alignment & Grade, Scope of Work, Plan-in-Hand, Final Plan Review).



## Chapter 4: Risk Response

**Risk response** is the formalized process of taking action to manage identified risks. The RMP worksheet provides a structured way to document, evaluate and analyze the information, and emerge with a well-organized and prioritized list of project risks. Prioritization enables the project team to account for more effectively and manage the unknowns. First, potential risk events are identified. Then a qualitative and/or quantitative risk analysis is performed and risk events prioritized. The next step is to develop risk response strategies by assigning risk response actions to project team members. Project managers and design team members must take action in response to the identified project risks, focusing on risks of most significance, in order to shift the odds in favor of project success.

### Risk Response: Actions

For Threats	For Opportunities
<b>Avoid.</b> Risk can be avoided by removing the cause of the risk or executing 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. However, this should be the first strategy considered.	<b>Exploit.</b> The aim is to ensure that the opportunity is realized. This strategy seeks to eliminate the uncertainty associated with a particular upside risk by making the opportunity definitely happen. Exploit is an aggressive response strategy, best reserved for those “golden opportunities” having high probability and impacts.
<b>Transfer.</b> 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.	<b>Share.</b> Allocate risk ownership of an opportunity to another party who is best able to maximize its probability of occurrence and increase the 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 be allowed to share in the potential benefits.
<b>Mitigate.</b> Risk mitigation reduces the probability and/or impact of an adverse risk event to an acceptable threshold. Taking early action to reduce the probability and/or impact of a risk is often more effective than trying to repair the damage after the risk has occurred. Risk mitigation may require resources or time and thus presents a tradeoff between doing nothing versus the cost of mitigating the risk.	<b>Enhance.</b> This response aims to modify the “size” of the positive risk. The opportunity is enhanced by increasing its probability and/or impact, thereby maximizing benefits realized for the project. If the probability can be increased to 100 percent, this is effectively an exploit response.
<b>Accept.</b> This strategy is adopted when it is not possible or practical to respond to the risk by the other strategies, or a response is not warranted by the importance of the risk. When the project manager and the project team decide to accept a risk, they are agreeing to address the risk if and when it occurs. A contingency or workaround plan may be developed for that eventuality.	

## Risk Response: Tools

After we have identified and analyzed the risks, we know where to focus our efforts. The output from the risk analysis provides a ranked risk listing with the risks of greatest significance to project objectives determined. Appropriate 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. The project manager and project team identify which action or strategy is best for each risk, and then design specific actions to implement that strategy. Assigning the ownership of the risk to a person will ensure risk response action is taken.

### *Risk Management Plan (RMP)*

Continuing on the work performed in the Risk Analysis; fill in the rest of the RMP with actions to ensure that the risks will be managed appropriately. See Figure 4-2.

Column Name (#)	Contents
<b>Strategy</b> (16)	Choose the strategy that is most likely to be effective for each risk. The available choices are: Avoid, Transfer, Mitigate, Accept, Exploit, Share, or Enhance.
<b>Priority</b> (16)	After all of the risks are identified, use the risk matrices, risk impacts, and relative risk costs to prioritize risk response and management.
<b>Response Actions</b> (17)	Discuss and document a detailed description of the response action that will meet the intent of the chosen strategy. Document the response action by describing the action and the work activities it will affect.
<b>Risk Response Owner</b> (18)	Assign a person to be responsible for the response action. This person would be the appropriate functional area expert with the most reasonable ability to ensure that the action is taken. The Project Design Manager will be responsible for communicating the action and deadline information to risk owners who are not present during the risk analysis meeting.
<b>Risk Review Dates</b> (19)	Assign a deadline for the risk response to be implemented or completed. Additional dates can be added when the Project Manager is monitoring the status of risk response actions.
<b>Date, Status, Review Comments</b> (20)	Date and comments to document the action taken and the results.
<b>Near or Long Term?</b> (21)	Should this risk be addressed soon, or is it something to consider later in the project design? Choices are Near, Long.
<b>Response Cost and Cost Avoidance</b> (22-25)	For tracking purposes and to measure the effectiveness of response strategies, enter an estimated cost to respond to the risk in the yellow box. An estimated minimum, maximum, and most likely cost avoided calculates to help the team decide whether a planned strategy is worth the cost and effort. If the cost to respond is estimated to be more than the cost avoided, then the strategy may need to be adjusted. When the risk is retired, an actual cost for avoidance can be entered.

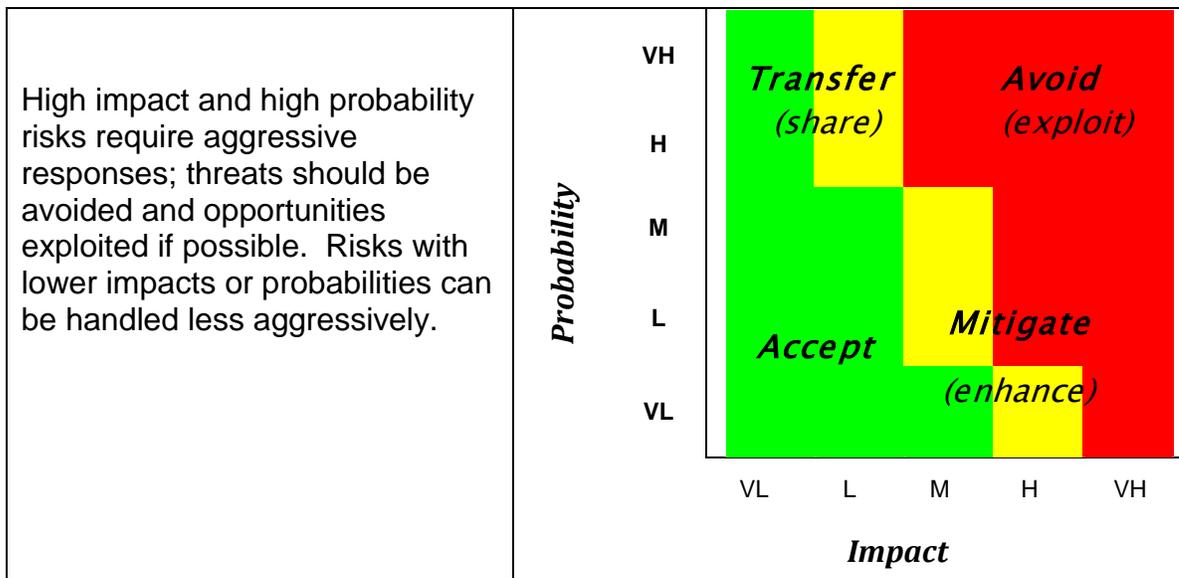
## Risk Response “How to”

Risk Management Planning	Risk Identification	Risk Analysis	<b>Risk Response</b>	Risk Monitoring and Control
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### How to perform Risk Response

Once risks are identified, evaluated, and prioritized the risk management can proceed. Recall that identification includes a thorough description of the risk and risk triggers. Next, the probability of occurrence and consequence if the risk event occurs is documented. Now, the first step toward managing the risk is developing risk response strategies, and assigning the response actions to specific people.

Select a response action, as described earlier in the chapter. The action selected is influenced by the level of the risk. Consider Figure 4-1 showing a simple risk response matrix:



**Risk Response Matrix  
Figure 4-1**

For threats:

- If a risk has an extremely high probability of occurrence, it may be best to assume the condition as part of the base conditions. The decision to assume the condition will depend on the cost and/or time involved to avoid or mitigate the risk.
- Risks with high impacts (over a given limit) can compromise the success of a project; these risks must be avoided. The team may decide to change the project plan to eliminate the risk or to protect the project objectives from its impact. The team might

achieve this by changing scope, adding time, or adding resources (thus relaxing the so-called “triple constraint”).

- Mitigation is an option for risks with lower probabilities. The team may seek to reduce the probability or consequences of a risk event to an acceptable threshold. They accomplish this via many different means that are specific to the project and the risk. Mitigation steps, although costly and time-consuming, may still be preferable to going forward with the unmitigated risk.
- Insignificant risks can be accepted; passive response. The project manager and the project team will decide to accept certain risks. They do not change the project plan to deal with a risk, or identify any response strategy other than agreeing to address the risk if it occurs.
- Transferring is an option for risks with higher probabilities. The team may transfer the financial impact of the risk event by contracting out some aspect of the work. Transference reduces the risk only if the contractor is more able to take steps to reduce the risk and does so.
- For risks with higher impact, the team may choose to accept actively by mitigating and/or preparing contingency plans in the event of its occurrence.
- All negative risks should be mitigated where practical and be cost-effective.

For opportunities:

- If a risk has an extremely high probability of occurrence, it may be best to assume the condition as part of the base. In such a case, the base cost estimate would be lowered to assume the condition will occur.
- Risks with high impacts should be exploited whenever possible.
- Enhance is a viable response for risks with lower probability. The project team may be able to change the plans or do additional design work to improve the odds of the opportunity arising.
- Insignificant risks can be accepted; passive response. There may not be enough of a benefit to the project cost or schedule to try to make opportunities with low impacts and probabilities occur.
- Sharing opportunity is an option for higher probability risks. Value Engineering is one way that MDT shares opportunities with contractors. Another method of sharing may be to involve the local government or stakeholders.
- For risks with higher impact, we accept actively by preparing plans in the event of its occurrence – how will we take advantage of a fortunate occurrence?
- All positive risks should be enhanced where practical and cost-effective.

### ***Documentation of Response Actions***

The RMP section for Risk Response is shown in Figure 4-2

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

		Estimated Monetary Impact of Significant Project Risks	\$0.6	Estimated Time Impact of Significant Project Risks	1.2Mo	Response Cost & Cost Avoidance (based on most likely values)			
Response		Monitoring and Control			Critical Issue	Estimated Response \$ Entered	Calculated Est. Cost Avoidance	Actual Response \$ Entered	Calculate Actual Cost Avoidance
Strategy	Response Actions ACTION TO BE TAKEN including advantages and disadvantages include date	Risk Response Owner	Risk Review Dates	Date, Status, and Review Comments (Do not delete prior comments, therefore providing a history)	Near or Long Term?	Planned Cost to Respond [\$K or M] (enter single number estimate)	Est Cost Avoided [\$K/M] (Expected Value of Risk) - (Est. Cost to Respond)	Actual Cost to Respond [\$K or M]	Est. Actual Costs Avoided [\$K or M]
		(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
	wetlands that are with the outside mitigation ratio.	Design Leader/Enviro. mgr	2007-Jan-2	As of Nov. 15, 2005 there are only two potential areas where there could be additional wetland impacts. As of Dec. 2, 2005 agency has initially determined that mitigation ratio would be 4:1.	NEAR	EXAMPLE	\$0.7		\$0.0
			2006-Dec-2				\$8.4		\$0.0
							\$4.9		\$0.0
Mitigate	Conduct thorough inspections of all 6 bridge decks and determine a more likely number of deck replacements needed. Not all information will be known until deck rehabilitation begins.	Mary Missoula, Bridge Bureau	6/21/2014		NEAR	\$0.0	\$0.1		\$0.0
							\$1.9		\$0.0
							\$0.6		\$0.0

Detailed description of response action that will be taken; the response action should be reflected in project management plan and work activities.

Journal entries for date and status of risk – track effectiveness of response action.

Name of person who owns the risk and is responsible for implementing the response actions.

Risk response requires an effort and investment of resources – enter the planned cost of the response here.

Type of Response action	
Threats	Opportunities
Avoid	Exploit
Transfer	Share
Mitigate	Enhance
Accept	

RMP Example – Risk Response  
Figure 4-2



### Hints for Risk Response

- ◆ Define the risk strategies for the team.
- ◆ Thoroughly address risk response strategies with team.
- ◆ Discuss probability of and impacts of risk occurrence to both cost and schedule, as appropriate, and in the context of response strategies. Use the simple matrix graphic in Figure 4-1 as an aid.
- ◆ Look at cumulative and related risk events when focusing on the highest priorities.
- ◆ Make sure all participants are involved and are heard.
- ◆ Be aware of optimistic bias that can affect a real view of project schedule and cost.
- ◆ Risk allocation tips (taken from NCHRP Report 658):
  - Explore alternatives to traditional risk allocation techniques in both delivery and contract packaging strategies.
  - Gain industry input concerning risk allocation whenever possible.
  - For each risk that cannot be avoided or fully mitigated, examine the affected contract provisions closely. Risks allocated to the contractor will result in higher bid costs.
  - Follow the four fundamental tenets of sound risk allocation:
    - Allocate risks to the party best able manage them.
    - Allocate the risk in alignment with project goals.
    - Share risk when appropriate to accomplish project goals.
    - Ultimately seek to allocate risks to promote team alignment with customer-oriented performance goals.

# Chapter 5: Risk Monitoring and Control

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**Risk monitoring and control** is the final piece of the formalized process of taking action to manage identified risks. Following identification and analysis of project risks, project managers and team members must take action in response to the identified project risks, focusing on risks of most significance, in order to shift the odds in favor of project success. Monitoring and controlling the risk response is critical to managing the risk. Monitoring will ensure that risk actions are being undertaken and staying on track. Controlling the risk response involves making adjustments to the strategies or actions and documenting their effectiveness.

Risk Response requires effort to develop and implement response actions; we must ensure the implementation goes as planned, or make adjustments as necessary. The RMP worksheet is a valuable tool for tracking and documenting actions for risk response.

## Risk Monitoring and Control: Techniques and Tools

### Risk Monitoring and Control Techniques

As we continue through project development, the project risk profile will change. Typically, as we successfully respond to risks and our project knowledge increases, our risk exposure will diminish. Risk Monitoring and Control is the formal process of checking with the owners of the risk response actions, documenting the date, status and review comments, and then tracking the costs of the response strategies in the RMP.

Successful risk response actions result in a retired risk status. Other potential risk events may become dormant. Unsuccessful risk response strategies may turn out to be inappropriate as additional information becomes available; these will have to be modified or dropped depending on the impact to overall project risk. Changes or additions to risk response actions are documented in the RMP and may change the overall risk priorities.

Monitoring involves:

- Risk owners reporting periodically to Project Design Manager
  - Effectiveness of planned risk response action
  - Unanticipated effects of risk response (if any)
  - Mid-course corrections needed
- Project Design Manager updating the RMP spreadsheet
  - Date of risk response action review
  - Describe status of risk response
  - Document additional comments
  - Change the Risk Status (column 2) as appropriate (i.e. retire successfully mitigated risk events)

Risk Control involves:

- Choosing alternative response strategies
- Implementing a contingency plan
- Taking corrective action
- Follow-up reviews

The primary benefit of risk management is to pre-empt the threat and/or maximize the opportunity by taking action as soon as possible after the risk event has been identified. Risk management is not a recovery plan that is implemented after a risk event occurs but is an action plan to be utilized long before the risk event occurs. *Note: Even if the response actions are successful, residual risk may remain.*

### **Documentation of Response Actions**

Adequate documentation will ensure risk response actions are followed through. As monitoring and reporting of the effect of the risk response action occurs, status information will also be documented. The risk review dates should be identified as well as the status of each review. The list of project risks changes as the project matures, new risks develop, or anticipated risks disappear (trigger point is passed without risk event happening). Periodic project risk reviews repeat the tasks of identification, analysis, and response strategies. The project manager regularly schedules project risk reviews, and ensures that project risk is an agenda item at all milestone project team meetings. Risk ratings and prioritization commonly change during the project lifecycle.

### **Monitoring and Controlling Project Risk**

As Project Design Managers manage the overall project development, it will be important also to monitor the project risk status by looking for trends that can indicate variations (good and bad) in the project execution. As with all aspects of project management, communication with the project team and Management is critical to effectively managing the risks. If the need to change a risk response action is indicated, the risk team may have to reconvene to discuss new strategies.

Thorough documentation is key to tracking active and retired projects. The RMP is set up to record all status and review comments. Actively maintain this column with comments until the project is completed or the risk is retired. Don't delete earlier comments or the tracking will be lost.

Costs of the response efforts can be tracked as well. Estimated costs to respond are entered to determine whether or not a strategy is worthwhile. When the final costs for a retired response action are determined, they are entered in the RMP. This will result in a summary of cost effectiveness for overall project risk response, broken down by functional area (risk breakdown structure). These summaries are shown in Figure 5-3.

## Risk Monitoring and Control Tools

### *Risk Management Plan*

The Monitoring and Control section of the RMP worksheet is devoted to documenting and measuring project risk management performance and determining whether a project is tracking to plan or deviating in a negative manner. This will require a blend of qualitative judgments and quantitative measures to determine the health of the project. The RMP provides a section to record and track the projected and actual costs of responding to the risk event. Also consider the time impacts of the response action and how the risk response may affect the overall project and/or other risks.

<b>Column Name (#)</b>	<b>Contents</b>
<b>Risk Review Dates (19)</b>	During the Risk Response determination, a review date or deadline was set for the response action. As the risk management process moves into monitoring and control, additional dates will be entered in the RMP as a reminder for future reviews/rechecks.
<b>Date, Status, and Review Comments (20)</b>	The Project Manager will record and maintain a history of the risk response status, including the status check date, and any associated comments. These comments should be detailed enough to be helpful for tracking and control.
<b>Critical Path (21)</b>	Document whether or not the risk related to activities on the project's critical path. The drop-down choices are Yes or No.
<b>Response Cost &amp; Cost Avoidance (22-25)</b>	For tracking purposes and to measure the effectiveness of response strategies, enter an estimated cost to respond to the risk. When the risk is retired, an actual cost for avoidance can be entered.
<b>RISK MANAGEMENT SUMMARY RESULTS (Header)</b>	The estimated costs for risk impacts are compared to the estimated avoidance costs. If the costs to avoid or mitigate a risk are greater than the estimated cost of the impact, the project team should consider accepting the risk. The actual costs to respond to the risk are included for tracking purposes after the project is complete.
<b>Risk Status (2)</b>	Update the risk status using the drop-down menu to reflect the effects of the risk response: <ul style="list-style-type: none"> <li>• Active, when the risk is still being actively monitored and controlled, or it is a newly-identified risk</li> <li>• Dormant, when the risk is low priority but may become high priority in the future</li> <li>• Retired, when the risk is managed or conditions change to eliminate the risk</li> </ul>

### *Communication*

The best way to ensure a successful program is to communicate! Management staff must communicate with design teams to ensure that budget information, project priorities, and risk tolerance levels are fully understood. Design team members need to communicate back to management regarding project health, budgets, and risk status. Timely communication within design teams is critical whenever there are changes in risk events, expected response strategy successes or delays, and other project concerns or opportunities. Communication tools include:

- In-person visits
- Phone calls
- Project or program coordination meetings
- Email
- Reports

Response		Monitoring and Control			Critical Issue	Estimated Cost
Priority	Strategy	Risk Response Owner	Risk Review Dates	Date, Status, and Review Comments (Do not delete prior comments, therefore providing a history)	Near or Long Term?	Planned Cost to Respond
(16)	(17)	(18)	(19)	(20)	(21)	
Avoid	Finalize design to identify all wetlands that are impacted. Early coordination with the outside agencies to determine mitigation ratio.	Design Leader/Enviro. mgr	2006-Dec-2 2007-Jan-2	As of Nov. 15, 2005 there are only two potential areas where there could be additional wetland impacts. As of Dec. 2, 2005 agency has initially determined that mitigation ration would be 4:1.	NEAR	EXAMPLE
Mitigate	Conduct thorough inspections of all 6 bridge decks and determine a more likely number of deck replacements needed. Not all information will be known until deck rehabilitation begins.	Mary Missoula, Bridge Bureau	6/21/2014	As of June 15, 2014, 5 of the bridges have been inspected. It appears that the level of corrosion is higher than expected in one of the 5 inspected bridge decks. Additional information will be included in the plans and the CN estimate will be increased accordingly prior to PIH.	NEAR	
1						

**Date, Status and Review Comments**  
 Insert date of review, status, and any comments that would be helpful for risk tracking and control.

**Risk Response, Monitoring and Control Sections of RMP  
 Figure 5-1**

Response Cost & Cost Avoidance (based on most likely values)			
Estimated Response \$ Entered	Calculated Est. Cost Avoidance	Actual Response \$ Entered	Calculated Actual Cost Avoidance
<b>Planned Cost to Respond</b> [\$K or M] (enter single number estimate)	<b>Est Cost Avoided</b> [\$K/M] (Expected Value of Risk) - (Est. Cost to Respond)	<b>Actual Cost to Respond</b> [\$K or M]	<b>Est. Actual Costs Avoided</b> [\$K or M]
(22)	(23)	(24)	(25)
	\$0.4		\$0.6
	\$8.1		\$8.3
\$0.3	\$4.6	\$0.1	\$4.8

Enter actual cost to respond. Avoided costs are estimated and returned as minimum, maximum, and most likely.

**Actual Response Costs and Estimated Avoidance Costs**  
Figure 5-2

RISK MANAGEMENT SUMMARY RESULTS				# Risks Identified	RELATIVE RISK	Proactive Risk Management: Develop an action response strategy; assign risk owners to implement action; monitor and record effectiveness of the risk response action.	Risk Breakdown Structure (functional assignment)	Planned Response Cost	Likely Cost Avoidance
Planned and Actual	MIN	MAX	LIKELY	4	13				
Planned Cost to Respond			\$0.3			Right-of-Way	\$0.0	\$0.0	
Est. \$ of Cost Avoided (via risk management)	-\$0.2	\$1.6	\$0.3			Environmental	\$0.0	\$0.0	
Actual Cost to Respond			\$0.1			Engineering	\$0.3	\$0.3	
Est. Actual \$ Cost Avoided (via risk mgmt)	\$0.0	\$1.8	\$0.5			Traffic	\$0.0	\$0.0	
						<b>Estimated Monetary Impact of Significant Project Risks</b>		<b>\$0.6</b>	
	-\$0.2		\$0.0						
	\$1.6		\$1.8						
\$0.3	\$0.3	\$0.1	\$0.5						
▲	▲	▲	▲						
<b>Total</b>	<b>Total</b>	<b>Total</b>	<b>Total</b>						
<b>Est Cost to Respond most likely</b>	<b>Calculated Est Cost to Respond</b>	<b>Actual Cost to Respond</b>	<b>Calculated Est Cost to Respond</b>						
	<b>(range)</b>		<b>(range)</b>						

Planned and actual costs to respond with probable cost savings

Planned costs and likely savings assigned to functional area

Totals of costs and totals of estimated savings listed at bottom of spreadsheet

**Summary of Risk Management Costs**  
**Header and Footer Information**  
Figure 5-3

## Risk Monitoring and Control “How to”

Risk Management Planning	Risk Identification	Risk Analysis	Risk Response	<b>Risk Monitoring and Control</b>
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### How to perform Risk Monitoring and Control

Risk Identification, Analysis, and Response must be completed before the final step of risk management can begin. Risk Monitoring and Control is the actual management of the risks and responses. The Project Design Manager is responsible for performing the monitoring and enlisting others as necessary to control the risk. Communication with Program Managers and District Administrators is vital, especially on high risk projects.

1. Project Design Manager periodically reviews the RMP and checks with Risk Owners for status on risk response actions on or near the Risk Review Date. Status is recorded, including date, status of the risk response, and any additional comments.
2. Evaluate the effectiveness of the response action and consider unanticipated effects of the risk response (if any). Perform mid-course corrections if necessary. The goal is for the risk response actions to have a positive effect on achieving project objectives.
3. Control the risk by:
  - a. Choosing alternative risk response strategies
  - b. Implementing a contingency plan
  - c. Taking corrective action
  - d. Follow-up reviews
4. Schedule another Risk Analysis meeting if necessary to identify new risks and/or revised risk response strategies.
5. Retire or reactivate risk events as appropriate.
6. Record and track estimated costs for risk response.



#### Hints for Risk Response

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

## Chapter 6: Documentation & Reporting

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**Documenting and reporting** the cost estimate consistently throughout the life of the project and with all projects in the program is critical to communicating issues and maintaining the budget. Used properly as an actively updated tool, the Risk Management Plan is the best form of documentation. Milestone reports help to communicate assumptions, potential risks, and the estimated cost.

Quantitative analysis produces a cost estimate range. The methods described in this guidance are simplified forms of probabilistic estimating that should adequately meet the needs for MDT. More complex methods involve modeling and a deeper understanding of statistics. Contingencies can be used to develop a cost estimate range and a single value. The qualitative and quantitative analysis methods described in this guidance can also be used to determine appropriate contingency levels to use for reporting the estimate.

The RMP includes worksheets to assist the project team in determining appropriate contingency ranges for the project cost estimate. Currently, MDT reports a single value for the estimated project cost. If decisions are made in the future to report costs as a range to better represent the impact of risk on project budget, the current tools are still appropriate.

### **Risk Documentation: Tools**

#### *Risk Management Plan*

The intent of the RMP is to serve as an aide to guide project teams through the risk management process as well as be the key source for documentation. This is the first document in which to record changes to project risk, to add risk events, or to update risk.

#### *Milestone Reports*

Project reports are the most widely distributed document. These serve as the file documentation of all aspects of the project status, scope, budget, and health and include discussion on risk.

#### *Communication*

Personal communication is the best way to ensure that your message is received and understood. In addition, there are many other means to communicate. The key to program and project success is to communicate concerns and opportunities, as well as updated information, early and often.

# Appendix A: Project Risk Management Plan (RMP)

The [Risk Management Plan \(RMP\) spreadsheet](#) is the primary tool for keeping track of and managing project risk. The spreadsheet can be separated into the following groups:

- Project header information
- Risk Management Summary Results
- Risk Breakdown Structure totals
- Risk Identification
- Risk Analysis (Quantitative Analysis and Qualitative Display of Most Likely Impact)
- Response, Monitoring and Control
- Response Cost and Cost Avoidance

Most input boxes are colored to highlight the need for input values. Many of the cells contain an input message that will pop up when the cell is activated to let the user know what is expected for an input value.

## Project Header Information

The header includes project information, including estimated costs. A total of the estimated impact of the significant project risks is populated after Risk Analysis information is populated. Specify the magnitude of dollar value costs that are displayed: thousands or millions.

Input messages for the project header information:

Input Message Title	Input Message
Project Title	Project number and name as listed in PPMS. If project is in the planning stage and not yet programmed, include route and milepost information as well as location name.  To add a second line, use ALT+Enter.
Last Review Date	Date of last update for the Risk Management Plan
Target Let Date	Enter the target Letting Date
Cost Magnitude	Select the magnitude of costs: thousands or millions.
Estimated Construction Duration	Enter the estimated total construction duration (Months)
Estimated PE Cost	Enter the total cost of all preliminary engineering activities.
Estimated R/W Cost	Enter the estimated cost value of R/W activities including R/W acquisition
Estimated Construction Cost	Enter the total cost of all construction activities. It should include the Mobilization, Construction Engineering, and IDC.

## Risk Management Summary Results

The estimated costs for risk impacts are compared to the estimated avoidance costs. If the costs to avoid or mitigate a risk are greater than the estimated cost of the impact, the project team should consider accepting the risk. The actual costs to respond to the risk are included for tracking purposes after the project is complete.

Relative risk is a quick method to help the project team determine Users can input the number of risks identified on the worksheet, both to cost and to schedule. The relative risk will then be

displayed based on the overall relative risk amounts calculated for the project. This is a quick gauge of the overall amount of risk identified for the project:

≤6	Low overall risk
>6 and <15	Medium overall risk
≥15	High overall risk

Input messages for the risk management summary results:

Input Message Title	Input Message
Risks Identified	Enter the total number of risks identified, to both cost and schedule
Project Overall Risk	The relative overall effect of identified risk on the project objectives: Low ≤ 6; Medium >6 and <15; High ≥15

### Risk Breakdown Structure Totals

Risk elements are grouped by functional area, with subgroups assigned to help the project team categorize the risk. This is the Risk Breakdown Structure (RBS). Figure 2-1 and Appendix C go into more detail about the Risk Breakdown Structure. The RMP header includes totals of the planned response costs and the likely avoidance costs, separated out into the main RBS element categories.

### Estimated Monetary Impact of Significant Project Risks

The total of the estimated cost impacts of the risks. The costs of opportunities are subtracted from the costs of the risks.

### Estimated Month Impact of Significant Project Risks

The total of the estimated schedule impacts of the risks. The costs of opportunities are subtracted from the costs of the risks.

### Risk Identification

The Risk Identification section is the first part of the Risk Management process. As discussed in Chapter 1, thorough identification of potential project risks is critical to managing the risks. Risk identification can begin in the planning stages of a project and continue throughout the life of the project.

Input messages for the Risk Identification section:

Input Message Title	Input Message
Identification	Risk Identification involves determining which risks might affect the project and documenting their characteristics
Risk Status	This is the current status of the risk element Active = Risk is being actively monitored and controlled Dormant = Risk is not currently a high priority, but may become active in the future Retired = Risk is no longer a threat to project objectives
Risk Breakdown Structure (RBS)	Select the Risk Breakdown Structure group from the pull down menu; options are: ROW, ENV, ENG, TRF, STK, UNF, MKT, UTL
RBS code	Enter the Risk Breakdown Structure code number from Figure B-1. Number must be between 0 and 10.
Date Identified	Date that the risk is identified

Project Phase	Phase of the project when the risk was first identified. Valid entries are Planning, Survey, Design, ROW, or Construction.
Functional Assignment	Please select functional area responsible for response action from the drop down menu. Choices: Bridge, Consult., CTEP, District, Environmental, Helena, MSU, Safety, Traffic, R/W, Utilities, Geotech, Survey, Construction, Legal.
Cost	Choose between threat and opportunity
Risk Description	Summary explanation of the risk
Schedule	Choose between threat and opportunity
Risk Description Column	Detailed description must include the cause, the risk, and the impact that could occur.
Risk Trigger	Event that indicates the risk is likely to occur. Used to determine when to implement the risk response strategy.

**Risk Analysis**

The Quantitative Analysis and Qualitative Display of Most Likely Impact is the heart of the Risk Analysis. This is where the team enters the probabilities and costs (money and/or time) of risk events occurring and the probable impact of the risk event, if it occurs. The expected impact of the risk event is quantified automatically using the Program Evaluation Review Technique (PERT) formula, which weighs the lowest, highest, and most likely costs:

$$EXPECTED\ IMPACT = \left( \frac{MIN + 4 \times MOSTLIKELY + MAX}{6} \right) \times PROBABILITY$$

The totals of the leverage (sum of the impacts of the opportunities) and the exposure (sum of the impacts of the threats) are shown at the bottom of Qualitative Analysis columns. The minimum expected cost or time schedule would be the estimate minus the leverage. The most likely value would be the sum of the estimate with leverage and exposure. See the “Overall Project Risk” worksheet. A display of the significance of the risk event is portrayed with a graph; the dollar costs are shown with a “\$” symbol and the schedule costs are shown with “Mo.” This graphic aids the team in prioritizing risks for developing risk response actions.

Input messages for the Risk Analysis section:

Input Message Title	Input Message
Probability of occurrence	How Likely it is that the risk will occur. Very Low=5% Low=25% Medium (As likely as not)=50% High=75% Very High=95%
Risk's Min Value	Enter a value that if the risk occurs the risk impact will not be lower than it. Think in term of extremes.  For threats, enter a positive value; for opportunities enter a negative value.
Risk's Max Value	Enter a value that if the risk occurs the risk impact will not be higher than it. Think in term of extremes.  For threats, enter a positive value; for opportunities enter a negative value.
Most Likely Cost Impact	It represents the highest frequency cost impact value given by the event (the mode). It can take any value between MIN and MAX values.  For threats, enter a positive value; for opportunities enter a negative value.

Most Likely Schedule Impact	It represents the highest frequency duration impact value given by the event (the mode). It can take any value between MIN and MAX values.  For threats, enter a positive value; for opportunities enter a negative value.
Cost Expected Impact	This value is calculated. For retired risk it is zero.
Schedule Expected Impact	This value is calculated. For retired risk it is zero.
Probability	This cell is automatically updated based on the quantitative analysis. If doing qualitative analysis only, override the field with one of the following choices: Very High, High, Medium, Low, Very Low.
Cost Impact	This cell is automatically updated. For qualitative analysis, override this value with the following choices: Very High, High, Medium, Low, Very Low.
Schedule Impact	This cell is automatically updated. For qualitative analysis, override this value with the following choices: Very High, High, Medium, Low, Very Low.

**Response, Monitoring and Control**

The Response section is a continuation of the Risk Analysis – the necessary step for managing the risks. The team develops and enters appropriate response actions to be taken to minimize the impacts of threats and maximize the potential for opportunities. It is important to focus efforts on the most significant risks as depicted in Table 4-1. Response actions need to be detailed, and dates set for status reviews.

The Monitoring and Control overlaps with the Response because often the response actions must be adjusted as the project develops and initial response actions are started. The Project Design Manager is responsible for managing the risk by reviewing and discussing the status of risk response actions with the risk owners.

Input messages for the Risk Response, Monitoring and Control sections:

Input Message Title	Input Message
Priority	After all the risks have been identified and analyzed, determine a priority for managing this risk event.
Strategy	The strategy that is most likely to be effective for each risk.  Valid entries for THREATS are Avoid, Transfer, Mitigate, and Accept. Valid entries for OPPORTUNITIES are Accept, Exploit, and Share.
Response Action	Detail the action you will undertake in response to the identified risk.
Responsibility	Name of manager responsible for this risk.
Risk Review Dates	Type the dates when the risk should be visited (review, re-evaluate, add new risks that relate to this one)
Date, Status and Review Comments	Insert date of review, status, and any comments that would be helpful for risk tracking and control.
Near or Long Term Concern?	Select NEAR if the risk is a more immediate concern. Select LONG if the risk will materialize later in the project.

**Response Cost and Cost Avoidance**

The final section of the RMP is related to the controlling and tracking of the risk responses. Planned costs to respond are input when the response actions are developed, and updated as needed when the response status is entered. These estimated costs are by RBS and for the entire project to assist with the risk management decisions. A range and likely cost to respond is shown in the header.

When the project is completed or a risk is retired, the actual response cost is entered. The final costs for responding to the risk are used for tracking purposes and for future risk management.

Input messages for the Risk Analysis section:

<b>Input Message Title</b>	<b>Input Message</b>
Risk Response Planned Cost	Enter the estimated amount (single number - not a range) that will be spend to respond to the risk; either to minimize the threat or exploit the opportunity. NOTE: Not all response actions eliminate all of the risk, often there can be residual risk.
Planned Cost Avoidance--MIN	This is calculated by subtracting the "Estimated Cost to Respond" from the product of the " Risk Impact Value" and "Probability of Occurrence."
Planned Cost Avoidance--MAX	This is calculated by subtracting the "Estimated Cost to Respond" from the product of the " Risk Impact Value" and "Probability of Occurrence."
Planned Cost Avoidance--Likely	This is calculated by subtracting the "Estimated Cost to Respond" from the product of the " Risk Impact Value" and "Probability of Occurrence."
Actual Cost to Respond	Type how much has been spent at the time of entry. Ultimately, when the project is closed this value represents how much the actual risk response cost.
Actual Cost Avoidance-MIN	This is calculated by subtracting the Actual Cost to Respond from the Risk Impact.
Avoidance-MAX	This is calculated by subtracting the Actual Cost to Respond from the Risk Impact.
Actual Cost Avoidance-LIKELY	This is calculated by subtracting the Actual Cost to Respond from the Risk Impact.

## Appendix B: Risk Breakdown Structure

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MDT’s research project, *Highway Project Cost Estimating and Management (Alavi, 2009)*, recommended a tracking system to help MDT manage risk for future construction projects. The basis for the tracking system is a breakdown of risks into categories. These categories are listed in Figure B-1. As MDT implements risk-based cost estimating and management, we will begin to identify risks and assign a risk breakdown category to each major risk.

The Risk Elements Categories that are discussed in Chapter 2 and shown in Figure 2-1 were developed from the tracking spreadsheet that was developed as part of the 2009 research report. Some of the subgroups were combined and additional sub groupings have been added to provide a good starting point for identifying potential risk events on a project and then categorizing those risks into functional areas. The project team will be expected to use their judgment when assigning risks to categories. It will be important to remember that categorizing can be tricky. For example, a risk involving wetland mitigation may seem to be an Environmental risk, when in reality it is a Right-of-Way issue.

As the team discusses the risk and attempts to identify risk events for a project, the Project Design Manager may need to focus the discussion in a meaningful direction. Stepping through Table B-1 is one way to lead discussion to help the team describe and categorize the identified risk.

Figure B-1 contains additional information to create the Risk Breakdown Structure (RBS) coding to assist MDT in developing a database for tracking risks in the future. The header row contains a three-letter abbreviation for the functional component of the category. The initial column contains a numeric coding to identify the breakdown of the functional category into subgroups. The resulting RBS for a given risk event will be recorded with the alpha-numeric coding. For example, the potential for right-of-way acquisition issues jeopardizing wetland mitigation would fall under the Right-of-Way functional area, and would fit into the “Acquisition issues” subgroup. Thus, the RBS coding would be ROW-03.

	<b>Risk Trigger</b>	<b>Risk Event</b>	<b>Consequence</b>	<b>Threat or Opportunity</b>	<b>RBS Code</b>
<b>As a result of...</b>	District R/W supervisor's pending retirement	the remaining District R/W staff may not be able to negotiate with landowners before the anticipated letting date	which will delay the project letting, adding additional inflationary costs and schedule delays.	Threat	<b>ROW-04</b>
<b>Because of...</b>	Extensive storm drain work under the existing roadway	there will be need to close down two lanes of traffic for more than 3 continuous days	resulting in the need for a full TMP, including extra design time for mitigation strategies and developing lane closure charts.	Threat	<b>ENG-06</b>
<b>As a result of...</b>	pending legislation to create jobs by providing additional federal funding	this project may be let to contract two years ahead of schedule	freeing up staff and funds to work on new projects.	Opportunity	<b>UNF-05</b>

**Sample Risk Breakdown Identification  
Table B-1**

	<b>ROW</b>	<b>ENV</b>	<b>ENG</b>	<b>TRF</b>	<b>STK</b>	<b>UNF</b>	<b>MKT</b>	<b>UTL</b>
	<b>Right-of-Way</b>	<b>Environmental</b>	<b>Engineering/Construction</b>	<b>Traffic</b>	<b>Stakeholders</b>	<b>Unforeseen Events</b>	<b>Market Conditions</b>	<b>Utilities</b>
<b>01</b>	Disagreement on highway access	Permits /agency actions delayed	Sufficiency of plans and specifications	Design change	Objections from local communities	Forest fires	Labor	Coordination with local utilities efforts
<b>02</b>	Objections to R/W appraisal	Agency disputes not resolved in a timely manner	Change in seismic criteria	Traffic growth	Late changes requested by stakeholders	Weather related incidents	Fuel	Utility negotiations
<b>03</b>	Acquisition issues	New information required for permits	Soil and other geotechnical conditions / mat'l availability	Land use changes/ developments	New stakeholders demanding new work	Earthquake	Materials	Delay caused by utility conflict
<b>04</b>	Volatile real estate market	Environmental regulations change	Soil contamination		Threats of lawsuit	Man-made disasters	Land	Railroad involvement
<b>05</b>		Additional environmental analysis required	Contractors / subcontractors capability		Stakeholders choose time and/or cost over quality	Economic changes / funding availability		
<b>06</b>		Design changes initiated by Resource Agency	Work zone safety and mobility		Tribal Employment Rights Office (TERO) fee			
<b>07</b>		Tribal issues	Site specific requirements		Overlapping Governmental Jurisdictions			
<b>08</b>			Drainage / hydraulic issues					
<b>09</b>	Staffing issues	Staffing issues	Staffing issues	Staffing issues				Staffing issues
<b>10</b>	Other	Other	Other	Other	Other	Other	Other	Other

**Risk Breakdown Structure Categories  
Figure B-1**

## Appendix C: Formal Risk Workshop

Appendix C provides guidelines for holding a formal Risk workshop, which is required for high risk projects.

Coordinate with the Highways Engineer as soon as you know that a project will require a formal workshop and we can work through the process together.

When is the best time to conduct a risk workshop? The following are indications that the project is far enough along for an efficient risk analysis:

- Project scope is well defined and can be communicated and comprehended
- Project schedule is set and up to date (OPX2)
- Project cost estimate is founded on good assumptions and major items are quantified, typically around Alignment and Grade Review
- A Value Analysis workshop is scheduled (note that combined workshops may be viable)

Table C-1 contains general information on a formal Risk Workshop.

<b>Workshop length</b>	1 day. in-person
<b>Subject Matter Experts</b>	Project design team and others as necessary. Other experts may include Headquarters or District Construction staff, MDT Engineering Cost Analyst, and external cost experts.
<b>Timing (when to hold workshop)</b>	Anytime. Typically updated when design changes or other changes to the project warrant an updated assessment.
<b>General</b>	An assessment of risks with an evaluation and update of costs and schedule estimates.

### General Workshop Information Table C-1

Setting up a formal workshop will require at least two months lead time, and more for projects that may need outside expertise. Table C-2 contains more specific information for setting up, preparing for, conducting, and finalizing the workshop.

	<b>Time Factor</b>	<b>Steps Involved</b>	<b>Staffing/other Considerations</b>
<b><u>Set up</u></b>	3 months ahead	<ol style="list-style-type: none"> <li>1. Determine attendees</li> <li>2. Schedule attendees</li> <li>3. Schedule resources<sup>7</sup></li> </ol>	<ul style="list-style-type: none"> <li>• Outside expertise needed?</li> <li>• Travel restrictions</li> <li>• Construction season conflicts</li> <li>• Keep meeting to manageable size</li> <li>• Include facilitator and note taker</li> </ul>
<b><u>Prepare</u></b>	2 weeks ahead	<ol style="list-style-type: none"> <li>1. Review and update project cost estimate</li> <li>2. Compile project information<sup>8</sup>; make/distribute copies as necessary</li> <li>3. Review previous risk analyses and VA study reports</li> <li>4. Prepare a list of issues</li> <li>5. Review Risk Management Guidelines</li> </ol>	<ul style="list-style-type: none"> <li>• If outside experts are attending, provide them with Risk Management Guidelines</li> </ul>
<b><u>Conduct</u></b>	1-2 days	<ol style="list-style-type: none"> <li>1. Review expectations: <ol style="list-style-type: none"> <li>a. Participation</li> <li>b. Respect</li> <li>c. Workshop activities</li> <li>d. Workshop outcomes</li> </ol> </li> <li>2. Review project scope, history, environmental document</li> <li>3. Introduce visual aids</li> <li>4. Risk Identification process</li> <li>5. Risk Analysis</li> <li>6. Risk Response assignments</li> <li>7. Thank participants and review timeline for reports and comments</li> </ol>	<ul style="list-style-type: none"> <li>• Team members must commit their time for the full workshop</li> <li>• Allow adequate time to fully identify all significant risks</li> <li>• Review and validate risk analysis results throughout workshop</li> <li>• Ensure participation from all attendees</li> <li>• Keep workshop focused and on task; limit discussions if needed</li> </ul>
<b><u>Conclude</u></b>	1 week after  Within 1 month	<ol style="list-style-type: none"> <li>1. Distribute draft RMP and workshop minutes</li> <li>2. Allow 2 weeks for review and comment period</li> <li>3. Follow-up as necessary</li> <li>4. Distribute final report and RMP</li> </ol>	<ul style="list-style-type: none"> <li>• Remember that this is a dynamic process that will be revisited over the life of the project</li> </ul>

**Risk Workshop Steps  
Table C-2**

This workshop is a formal process. It’s important to run the workshop professionally. For complex projects that require outside expertise or that have complicated potential risk events, consider bringing in a facilitator to run the workshop and assist with brainstorming.

<sup>7</sup> Conference room (MDT or off-site)

<sup>8</sup> See Table C-3 for possible workshop resources

Project Information	Visual Aids
Validated base cost estimate	Plan and profile sheets
Cost estimate assumptions	Cross sections
OPX2 schedule	As-built drawings
Environmental documentation	Aerial photos
R/W information	Road Image Viewer shots
R/W cost estimate	Photographs or videos from project reviews
Geotechnical reports	R/W exhibits
Hydraulic reports	
Bridge information	
Public meeting summaries	

### Workshop Resources Table C-3

Risk management is ongoing and iterative. Periodically workshop members can regroup to evaluate the project and associated uncertainty and risks, **workshops or reviews should occur for a project every 12 to 24 months or at key project milestones**. Project risks and mitigation efforts must 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 a cost and schedule savings to the project.

In order to fully understand our project we must determine what we know and what we do not know about a project. In our industry, Civil Engineering – Transportation, a lot of resources have been devoted to clearly explain what is known of a project. We have many specialty offices that gather and provide data in support of project delivery, many of which are listed in Figure 2-1. However, it’s just as important is to devote some energy and resources to assess what is unknown 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.*

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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.

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