Washington State Department of Transportation

# Risk Based Estimate Self-Modeling (RBES)

A Quick Guide to Risk and the RBES Self-Modeling Tool

Strategic Analysis and Estimating Office

September 2016

# Important Terms Risk Management to know

| | |
|---|---|
| Base Cost Estimate | The term "base cost estimate" is a term developed by WSDOT for cost risk analysis and represents the reviewed and/or validated project cost estimate to be used in the quantitative risk analysis for the project. The base cost represents the cost which can reasonably be expected if the project materializes as planned, including PE, RW, and CN costs. The base cost estimate is unbiased and neutral- it is not optimistic and it is not conservative. The base cost estimate does not include any risks, but does include the WSDOT standard construction contingency, since that amount is based upon historical usage. Base costs reported to program management shall be in current-year dollars (the un-inflated estimate). |
| Base Variability | Inherent in the base estimate. Base variability is always present and is not caused by risk events. Variability exists even if no risk events are present. Base variability is captured as a modest symmetric range about the estimated value; that is of the form: base value +x%. (typically from +5% to +15% depending on level of project development and complexity of the project). The variability represents quantity and price variations about the estimated base). |
| Estimate | An estimate is comprised of two components: the base cost estimate component and the risk/uncertainty component. An estimate is more appropriately expressed not as a single number but as a range.<br>A quantitative assessment of the likely amount or outcome. Usually applied to project costs, resources, effort, and durations and is usually preceded by a modifier (i.e. preliminary, conceptual, order-of-magnitude, etc.). It should always include some indication of accuracy (e.g. + x percent). |
| Mitigation | Any action taken to reduce the impact of an undesirable risk event.<br>The term 'mitigation' is often used to refer to all responses to threats but some practitioners use the term to refer specifically to proactive risk responses and others specifically to reactive risk responses |
| Opportunity | An event risk that has the potential to positively impact project objectives.<br>Examples include strategies to reduce cost or accelerate schedule, beneficial funding decisions, improved revenue projections etc. |
| **Probability** | An estimate of the likelihood that a particular risk event will occur, usually expressed on a scale of 0 to 1 or 0 to 100 percent. In a project context, estimates of probability are often subjective, as the combination of tasks, people and other circumstances is usually unique. |
| **Qualitative assessment** | An assessment of risk relating to the qualities and subjective elements of the risk – those that cannot be quantified accurately. Qualitative techniques include the definition of risk, the recording of risk details and relationships, and the categorization and prioritization of risk relative to each other. |
| **Quantitative Analysis** | Modeling of numerical outcomes by combining actual or estimated values with an assumed or known relationship between values, using arithmetic or statistical techniques, to determine a range of likely outcomes of a variable or to understand how variance in one or more values is likely to affect others. |
| **Risk** | The effect of uncertainty on objectives. |
| **Risk Events** | Uncertain events that affect the defined project resulting in impacts to cost, schedule, safety, performance or other characteristic but do not include the minor variance inherent in Base Costs. |

| | |
|---|---|
| **Risk Register** | The risk register serves as a repository for identified project risks. The risk register includes detailed information about the risk and is a "living" document that evolves as the project evolves. |
| **Risk Response** | Risk response strategy is the process of developing options and determining actions to enhance opportunities and reduce threats to the project's objectives. |
| **Threat** | An event risk that has the potential to negatively impact project objectives. |
| **Uncertainty** | The lack of knowledge of the outcome for a particular element or value. |
| **YOE** | Year Of Expenditure. The estimated year that money will be spent to complete project work elements. |

Additional terms for Risk Management may be found in the "WSDOT Glossary for Cost Risk Estimating Management"

# Contents

## Getting to Know the RBES


Risk Modeling ..... 2

Input Sheets ..... 3

Risk Treatment Options..... 3

Output Sheets ..... 5


## Using the RBES


Getting Started ..... 7

Base Sheet ..... 7

Risk Sheet ..... 9

Risk Matrix... ..... 12

Modeling Pre-Mitigated Risk Data ..... 13

Pre-Mitigated Modeled Results ..... 14

Modeling Post-Mitigated Risk Data ..... 15

Post-Mitigated Modeled Results ..... 16

Managing and Monitoring the Risks ..... 17

Sections of the Risk Register ..... 18


## Appendix


Risk Breakdown Structure ..... A1

# Risk Modeling

Risk modeling is about simulating events that may occur in the real world, the effect those events may have on the cost and duration of the project, then quantifying the impact those risks, both as opportunities and threats will present.

The Risk Based Estimating Spreadsheet (RBES) tool was developed to facilitate the integration of cost and scheduling factors when considering the overall project costs. The RBES performs Monte Carlo simulations, a powerful mathematical process widely used to conduct quantitative risk analysis. This simulation runs thousands of scenarios of each risk realization while factoring combinations of cost and schedule inputs, risk probabilities and impacts.

It is essential to identify and separate the costs associated with risk from the base cost of any project. By separating and quantifying likelihood and impacts of project risks, they may be managed appropriately.

The RBES provides for modeling of up to 24 individual risks capturing all project phases. Quantitative analysis cost and distribution models will be created for each of these phases: Preliminary Engineering (PE); Right of Way (ROW); Construction (CN) and Total project cost, both in Current Year (CY) dollars and in Year of Expenditure (YOE) dollars. Additionally, the RBES will calculate a range for the probable project advertisement and completion of construction dates.

# RBES Workbook Elements

The RBES tool contains data input sheets for output to the analysis sheets

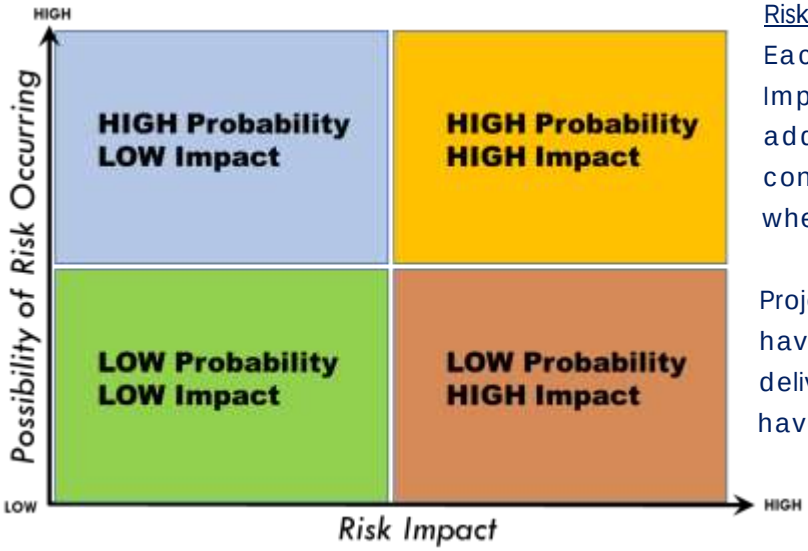
## Input Sheets

BASE (1)
This worksheet captures the "Base Cost" or what the project is expected to cost if the project goes as planned. The BASE Cost is an unbiased neutral accounting of cost and schedule; it should not contain figures padded to cover "just in case" occurrence's and care should be taken that information entered is neither conservative nor optimistic.
*Cost figures entered on this sheet are in Current Year (CY) dollars.*

RISK sheets (*24 worksheets available*)
The Risk sheets record the risks associated with the project under study. These sheets record each risk in its pre-mitigated state (*the initially identified risk*). Below the pre-mitigated risk sheet is provided an area for the risks' post-mitigated state, (*a response strategy that provides controls applied to the risk*).

RMP/RMPSuppl (*Risk Management Plan*)
Risk Management Plan provides a table of identified and quantified risks for the Project Team to pursue and manage. These threats and opportunities have been identified and quantified, to the extent possible, at the stage in the design process for which the model was developed. The Project Team needs to identify possible ways that these threats or opportunities will be mitigated or exploited for the major risk events.

RMPM/RMPSuppIM (*Risk Response Strategy Monitoring* )
The Risk Response Plan Monitoring table will be used by the project team address the identified risks. In these worksheets the risks may be carefully evaluated for tactics to mitigate negative risks (threats) and exploit positive risks (opportunities). Risk treatment options applied, will be monitored for effectiveness and adjusted when necessary.




Risk Treatment Options

Each individual risk has a Probability and Impact profile. All risks need to be addressed based on the associated conditions surrounding the risk and where they fall within that profile.

Project risks can either pose a Threat that have negative impacts on project delivery or present Opportunities that have a positive impact.

There are four actions that may be taken by the project team when planning risk response strategies:

| Risk Response Strategies | |
|---|---|
| Threat | Opportunity |
| Avoid | Exploit |
| Adopting changes to the project plan intended to eliminate the risk or protecting the project objectives from the risk's impact. This can be achieved by changing the scope, adding time or resources, thus relaxing the so-called "triple constraint." | If the risk is an Opportunity, Risk response actions should be taken that ensure its fruition. |
| Transfer | Share |
| Transferring the financial impact of the risk by contracting out some work. The success of this action depends on the contractor's ability to assume and reduce the risk. | Opportunity risks may be shared. Allocating ownership of the risk to a party with the skills and resources needed to realize the opportunity is one measure that may be taken. |
| Mitigate | Enhance |
| Reducing the probability of occurrence and the consequences of the risk's impact to an acceptable level. Available risk mitigation measures are specific to each project and the risk posed; be mindful that risk mitigation is usually costly and time consuming. | Opportunity risks can be enhanced, by reinforcing actions and events that will trigger the opportunity. |
| Accept | Accept |
| Acceptance of the risk. The planned project is not changed due to the possibility of the risk occurring, nor is any response strategy adopted other than agreeing to address the risk if it occurs. | |

EV (*Expected Value*)

*The expected value of individual random variables is the probability-weighted average of all possible values.*

This worksheet displays bar charts or *Tornado diagrams* of the identified risks and their associated cost impact to the project. This at-a-glance representation of the risks provide the project team with a depiction of those risks that would be the best candidates for "active" risk management and those that should just be monitored.
The first two graphs in this worksheet, present the risks as they stand with no mitigation applied. Charts three and four show the risks probable impact to the project cost once a risk response strategy has been applied.

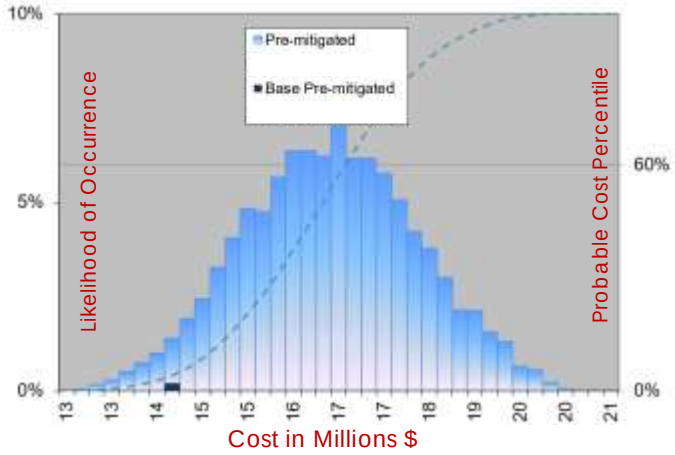
Calc (*Advanced feature*)

Please contact the Strategic Analysis and Estimating Office (SAEO) for assistance.

*NOTE*: Project conditions change with time: Risks are mitigated and market conditions change, there are a multitude of factors that will impact a project during its development. A risk analysis should be performed every one to two years for effective risk management.

## Output Analysis Sheets

The Project cost, schedule and risk information entered in the input sheets, provide the data necessary to model the most probable scenarios for the impact each risk will have on the project.
The modeled results will be presented in a distribution range for the likelihood of occurrence of cost in Current Year (CY) dollars and for year of expenditure (YOE) dollars.




The YOE output sheets will create normal distribution with a cumulative or "S" curve of project cost at the 60th percentile for each of the project phases; PE, ROW and CN phases as well as the Total project cost.

*SEE "VIEWING THE RESULTS"*

Output sheets (*results sheets*)

*The output sheets are displayed as Cost distribution histograms and a statistical distribution of cost table.*

- Total-Cost (CY) - This is the expected Total Cost of project in current year dollars
- PE-Cost (CY) - This is the expected Preliminary Engineering Cost in current year dollars
- ROW-Cost (CY) - This is the expected Right of Way Cost in current year dollars
- CN-Cost (CY) - This is the expected Construction Cost in current year dollars
- Total-Cost (YOE) - This is the expected Total Cost of project in Year of Expenditure dollars
- PE-Cost (YOE) - This is the expected Preliminary Engineering Cost in Year of Expenditure dollars
- ROW-Cost (YOE) - This is the expected total Cost of Right of Way in Year of Expenditure dollars
- CN-Cost (YOE) - This is the expected total Cost of Construction in Year of Expenditure dollars

# Using the RBES Modeling Tool

The RBES Modeling tool has two main functions, the first of these functions is to assist the project team in identifying and quantifying project risks and their influence on cost and schedule of the project; second, is to monitor and manage those risks.

The Risk input sheets are essential for the Team in identifying and quantifying possible project risk. The Cost distribution sheets expand on that information graphically by providing visually what the impact of those risks will have on the cost of the project during each phase. Finally, the RMP sheets provide a risk register to facilitate prioritization, monitoring and management of these risks.

## Getting Started

### BASE

To Begin the RBES workbook, Start with the BASE worksheet* and complete the entry fields. The yellow highlighted fields are critical information that the model will need to calculate results. Yellow fields with cost inputs should be left blank if there is no associated cost.
(*Do Not enter Zero in the entry fields*)

*NOTE: Figures entered in the BASE sheet will be displayed in "Millions" of dollars and "Months". Entries less than a million dollars or one month, must be entered as a decimal.*

Critical information fields include:

- Project Title, Enter the complete project title as programmed.
- Estimate Date, The last date the current project estimate was last updated
- Target AD Date, The planned Advertisement date of the project
- Ad/Bid/Award (A/B/A) duration, How many months From the AD date until it is awarded.
- Estimated Construction duration, How many months will the project be in Construction.
- Estimated Cost (PE, ROW, CN), Base Cost for each project phase (PE, ROW, CN) do not include ANY misc. allowances in these. If project dollars have already been spent on any of the phases, use the fields at the far right of the phase rows to record the amount expended to date.
- Risk Markups, Project Markup percentages for:
  - → Mobilization (Mob)
  - → Tax Rate
  - → Construction Engineering (CE)
  - → Preliminary Engineering (PE)
  - → Change Order Contingency (COC)

* See figure 1

BASE

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Project Title | SR 123 /N County Line to City Limits – Widening | | | Value | Variability | Risk Markups | | WSDOT inflation tables built-in. | | |
| Estimate Date | 06/21/16 | | Target AD date | 03/20/18 | 10% | Mob | 10.0% | A/B/A Duration | | 3Mo |
| Project PIN # | 522301X | * The above macro should be activated to generate the final results. Do not stop it if it is running. | Estimated CN Duration | 12.0Mo | 10% | Tax | 8.3% | Non-WSDOT rates | | Spent to date |
| Last Review Date | 06/23/16 | | Estimated PE Cost | 0.95 $M | 10% | CE | 15.0% | PE | | 0.2$M |
| Project Manager | John Smith | | Estimated ROW Cost | | | PE | 7.4% | ROW | | |
| | | | Estimated CN Cost | 12.83 $M | 10% | C.O.C | 4.0% | CN | | |
| **Inflation Points** | | | Base Cost Market Conditions | | | | | | | |
| Define inflation point of the activity cost. For example 50% means that the inflation point for that activity is the mid-point activity. 50% is the default value. If it is decided that the inflation point is at three quarters of respective activity | | | Better than planned | 30% | 10% | Update the pre-mitigated base cost and risks data | | | | |
| | | | Worse than planned | 20% | 10% | | | | | |
| | | | | Probability | Impact | | | | | |
| Preconstruction activities (ROW and PE) | | 0.5 | | | | | | | | |
| Construction | | 0.5 | | | | | | | | |

*Figure 1*

• Base Variability is calculated for the project and entered equally for the "variability" of; PE, ROW and CN phase costs and for construction duration and Ad date.
This figure is commonly entered as +/-10%.

• Base Cost Market Conditions are the characteristics or trends in the current market place; cost and availability of labor and materials or the number of contractors available to bid the work will all effect the market conditions. (*These figures reflect our assessment of the bidding environment*)
Market conditions are entered as a percentage of the base cost; these figures will reflect the opinion of the team on the Probability of how much better, or worse the project cost could be than "as planned", and the extent of impact those conditions will have on the overall project cost.

• Inflation Points are initially displayed as blank, however the RBES by default, begins applying inflation to the midpoint of each phases' duration, i.e. 0.5. Separate inflation point fields are provided for PE/ROW and Construction activities. If needed these inflation points may be entered to reflect inflation earlier or later in the project phase.
Please contact the Strategic Analysis and Estimating office (SAEO) for assistance.

* *This note refers to the "Click it" update macro on the RMP and RMPM sheets.*

## What is a "Risk"

Exposure to the consequences of uncertainty…

Risk is the chance there will be an occurrence of events which will impact the outcome of the final project. These impacts can be either positive "Opportunities", or negative "Threats". Impacts may have the effect that they, add or reduce the cost and/or schedule of the project.

There are two elements associated with Risk:

Probability – the likelihood that the risk event will occur

Impact – The weight of that occurrence on project cost or schedule.

The RBES *Pre-mitigated* Risk sheets, are used to record the identified risks along with probability and impact of their occurrence within a range of dollars and time.
The RBES uses the information entered into the completed risk sheets to model the probable cost distribution for the projects'; PE Phase, ROW Phase, CN phase as well as total project cost.

The RBES *Post-mitigated* sheets, are used to record the application of mitigation data to the risk once a risk response strategy has been adopted. This data is then modeled separately for the team to compare the effectiveness of the risk responses on cost and schedule.

### Sections of the Risk sheets

The Risk sheets are comprised of five areas of information. The top half of the worksheet has eleven columns for the entry of data.

RISK

Pre-mitigated

| Risk # | Status | Dependency | Project Phase | Summary Description Threat and/or Opportunity | Detailed Description of Risk Event (Specific, Measurable, Attributable, Relevant, Timebound) [SMART] | Risk Trigger | Type | Probability Correlation | Risk Impact ($M or Mo) | |
|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (5) | (6) | (7) | (8) | (9) | (10) | [10a] | (11) |
| 6 | Active | | Pre-construction | Threat<br>Permit or Agency timelines<br>Threat | Permit timelines have been aggressively condensed during project scheduling. Risk that permit delays could delay AD. | Experience delays to permit schedule or NEPA approval | Cost<br>6<br>Schedule | 25%<br>Positive correlation | MIN<br>MAX<br>Most Likely<br>0<br>MIN<br>MAX<br>Most Likely | 0.10$M<br>0.30$M<br>0.20$M<br><br>1.0Mo<br>12.0Mo<br>5.0Mo |

JARPA PERMITS: Corps of Engineers 404 (Permit #14)
Coastal Zone Management Certification
Water Quality Certification 401 (Dept of Ecology)
Shoreline Permit (substantial development)
Hydraulic Project Approval (HPA)

OTHER STATE/FEDERAL:
Temporary Erosion Sediment Control Plan (TESC)
Section 4(f)/6(f): Wildlife Refuges, Recreation Areas, Historic Properties (recerational access will be maintained during construction)

LOCAL/OTHER Permits:
Critical Area Ordinance The project is in both Island and Snohomish Counties.
Flood Plain Development Permit
ENV 30

Risk Matrix

| Probability | VL | L | M | H | VH |
|---|---|---|---|---|---|
| VH | | | | | |
| H | | | | | |
| M | | | | | |
| L | | $ | Mo | | |
| VL | | | | | |

Impact

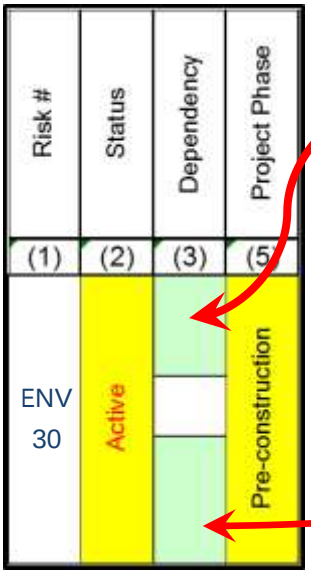
Risk Information

Columns 1-5 will be filled out with basic information about the status of the Risk.

(1) Risk Number – This is the number assigned by the project team from the Risk Breakdown Structure (RBS), it corresponds to the discipline this risk is associated with.
(see Risk Breakdown Structure template Appendix 1)
For small jobs where the RBS was not used to identify the risk categories, the numeric sequence of the risk may be used.

(2) Status – The current Status of the risk (*drop-down list*)

a. Active: This risk is to be monitored and controlled.
b. Dormant: Low priority risk, could become active in the future if conditions change.
c. Retired: Risk has been mitigated or is no longer relevant.




(3) Dependency – These fields represent interdependency and correlation or relationship to the previous risk in the workbook.
The TOP field represents the interdependency with the previous risk.

a. BLANK – leave this field blank if the occurrence of the previous risk has no impact to manifestation of the current risk. (*independent risk*)
b. DEP-INCL. (dependency inclusive) Used when the current risk will only occur if the previous risk is triggered. (*dependent risk*)
c. DEP-EXCL. (dependency exclusive) Used when the current risk occurs only if the previous risk does NOT occur. (*dependent risk*)

The BOTTOM field used when a risk is "dependent", represents correlation or relationship to the previous risk.

a. BLANK – leave this field blank if there is no correlation
b. POSITIVE - When the risk value of the previous risk is either High or Low it will cause the likelihood of the current risk to be the same.
c. NEGATIVE - When the risk value of the previous risk High, the current risks' value will be Low. Alternately if the risk value of the previous risk is Low, the current risks' value will be high.

(4) NOT USED

(5) Project Phase (*drop-down list*) – The Phase of the project in which the risk is likely to occur; Pre-construction, ROW activities, during Construction.

Risk Descriptions

Columns 6-8, Describe the risk, risk triggers and the threat/opportunity posed to the Cost and Schedule.

| Summary Description Threat and/or Opportunity | Detailed Description of Risk Event (Specific, Measurable, Attributable, Relevant, Timebound) [SMART] | Risk Trigger |
|---|---|---|
| (6) | (7) | (8) |
| Threat<br>Permit or Agency timelines<br>Threat | Permit timelines have been aggressively condensed during project scheduling. Risk that permit delays could delay AD. | Experience delays to permit schedule or NEPA approval |

(6) Contains three fields.

The top (*cost*) and bottom (*schedule*) fields will be populated with either "Threat" or "Opportunity" representing the positive or negative effect the risk will have on the cost and schedule of the project.

It is possible that either one may be a Threat while the other may be an Opportunity.

Leave the field blank if either Cost or Schedule do not apply.

The Middle field is the Summary Description. Enter a concise descriptive title for the risk.

(7) This is a Detailed Description of the risk. Describe the risk in enough detail so that the nature of the risk is clear to stakeholders that may not have been present at the time the risk was discussed. This description must be, Specific, Measurable and Attributable. The note fields on the bottom half the worksheet may be used to provide additional details.

(8) Risk Trigger – A brief description of the event that must occur to initiate the occurrence of the risk.

| Type | Probability Correlation | Risk Impact ($M or Mo) | |
|---|---|---|---|
| (9) | (10) | [10a] | (11) |
| Cost | 25% | MIN | 0.10$M |
| | | MAX | 0.30$M |
| | | Most Likely | 0.20$M |
| 6 | Positive correlation | 0 | |
| Schedule | | MIN | 1.0Mo |
| | | MAX | 12.0Mo |
| | | Most Likely | 5.0Mo |

Risk Impacts

Columns 9-11, record the probability and impacts of the risks occurrence to the project.

(9) *No Entry Fields.*

The top field, labels the "Cost" rows for range of impact,

The bottom field, labels the "Schedule" rows for range of impact and the middle field is a calculated value that represents cumulative duration. If there is no cumulative factor is present, the risk tab number will populate the field. (Cumulative Duration is and *Advanced Feature – Please contact the Strategic Analysis and Estimating office (SAEO) for assistance.)*

(10) Probability and Correlation – the top field is Probability. This is the likelihood of the risk occurring. Entry values for this field determined by the team.

Guidelines for Probability %

5% - Very Low

25% - Low

50% - Medium – could go either way

75% - High

95% - Very High

(10a) *No Entry Fields*

The grey field is a calculated value representing the associated duration risk number. If the is no risk associated, the field will display "0" (*Advanced Feature - Please contact the Strategic Analysis and Estimating office (SAEO) for assistance.)*

The "MIN", "MAX" and "MOST LIKELY" fields are labels for column (11).

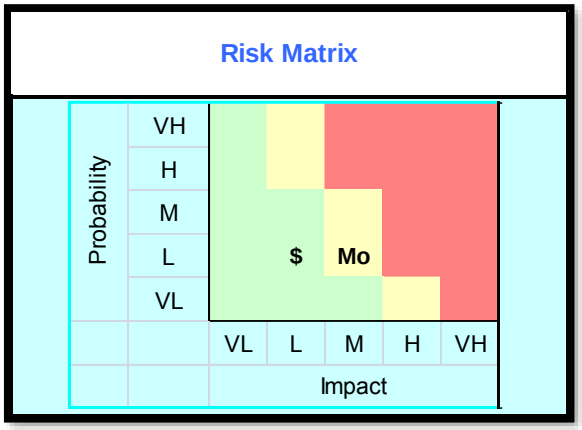
(11) These fields quantify the probable Cost and Time/schedule impacts if the risk occurs. For each, Cost and Schedule enter (in millions of dollars or in months) the probable values for "Minimum" , "Maximum" and the most likely impacts.

- MIN. (value) Represents the LEAST dollars or months that would occur if the risk was realized.
- MAX. (value) Represents the MOST dollars or months that would occur if the risk was realized.
- MOST LIKELY (value) Represents the EXPECTED dollars or months that would occur if the risk was realized.

Risk Matrix

The risk matrix offers a qualitative view of the quantitative data.

It uses the data provided about the probable risk impacts to generate a graphical display visually depicting the influence it may have on the cost and schedule.



*Upload Button*

Use this button located on the "RISK1" sheet to Display the Risk $ and Mo probability and impact. This button will initiate charting on the Risk Matrix graph for either the Pre or Post mitigated sections of the all the Risk sheets.

| |
|---|
| JARPA PERMITS: Corps of Engineers 404 (Permit #14)<br>Coastal Zone Management Certification<br>Water Quality Certification 401 (Dept of Ecology)<br>Shoreline Permit (substantial development)<br>Hydraulic Project Approval (HPA) |
| OTHER STATE/FEDERAL:<br>Temporary Erosion Sediment Control Plan (TESC)<br>Section 4(f)/6(f): Wildlife Refuges, Recreation Areas, Historic Properties (recerational access will be maintained during construction) |
| LOCAL/OTHER Permits:<br>Critical Area Ordinance The project is in both Island and Snohomish Counties.<br>Flood Plain Development Permit<br>ENV 30 |

Risk Informational Notes

Use these fields to expand on and add clarity to the Risk description and/or risk triggers.

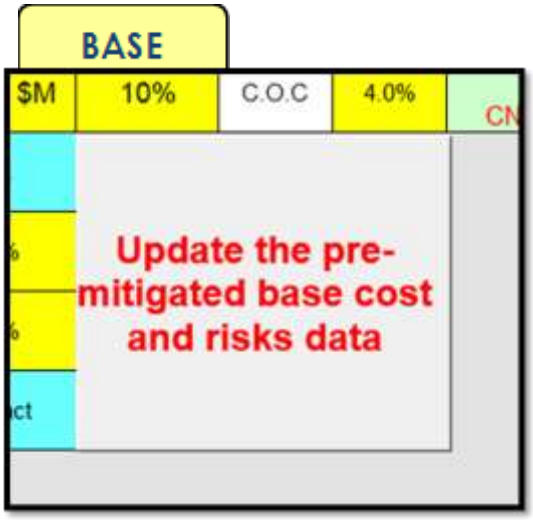
For Post-Mitigated risk worksheets these fields may also be used to explain potential risk response strategies.

# Modeling the Pre-Mitigated Risk Data

The output of RBES risk modeling is a valuable tool that informs decision making and provides the team with a general understanding of the risks and opportunities affecting a project. Each simulation ran, characterizes the probability of occurrence of a risk event. A cumulative probability distribution of all the simulations will be calculated, these will be used to interpret the probable range of cost for the project.

## Running the Model

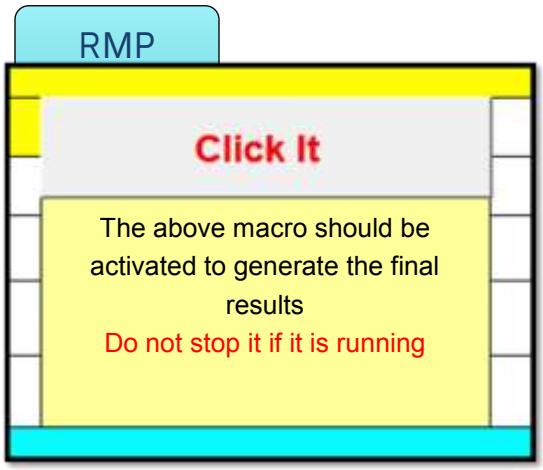
Once the BASE information and identified risks have been entered into the RISK sheets and the validated base estimated project costs into the BASE sheet, the project risk base estimate may be modeled.




STEP 1

Go back to the BASE sheet and CLICK the "Update the Pre-mitigated base and risk cost" button. This step will copy all the base estimate costs and identified risk to the RMP sheet.

Should more than 12 risks exist, the first 12 risks will be copied to the RMP sheet and risks 13 thru 24 will be copied to the RMPSuppl.




STEP 2

Go to the RMP sheet and CLICK the "Click It" button this will initiate the Monte Carlo simulation of the data.

The generated results will be displayed on the Output sheets.

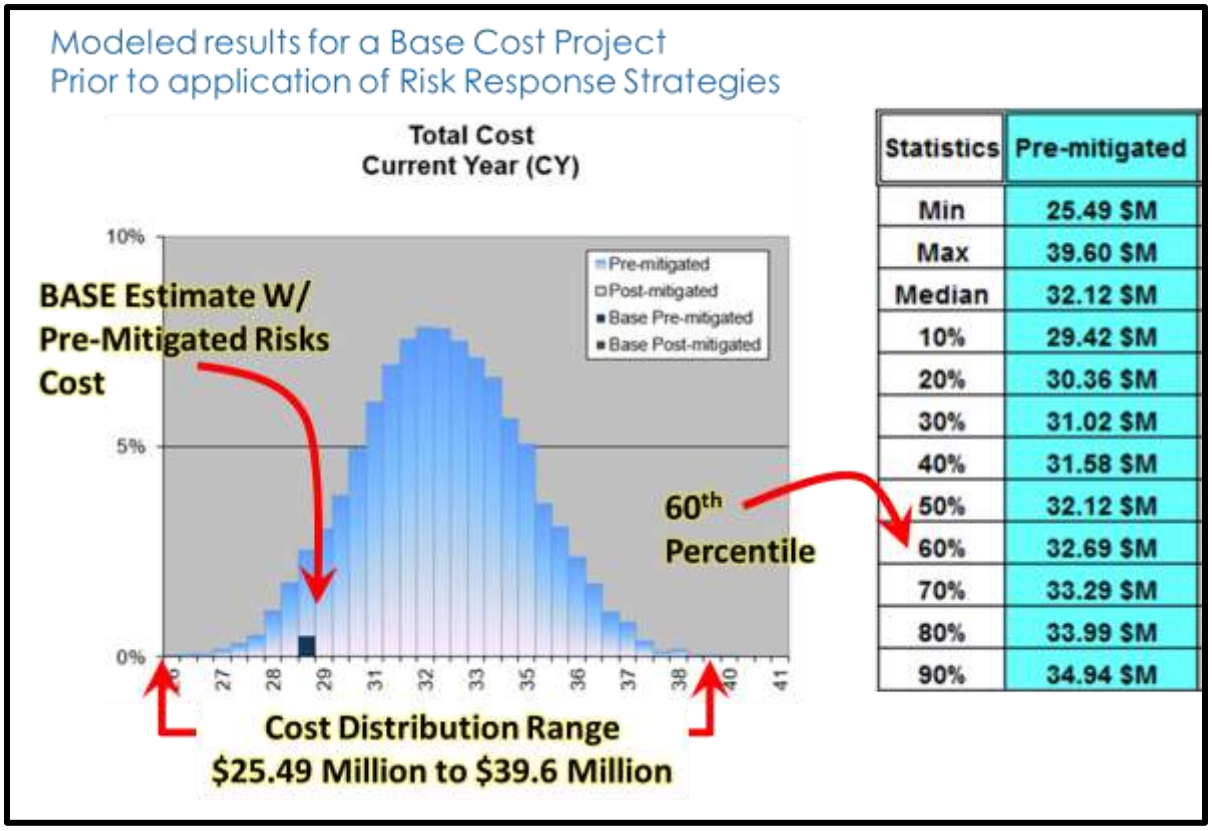
# Viewing the Results

The RBES tool performs simulations for possible outcomes using identified risk data from the estimated Base Cost values and the Risk Impact values entered by the team.
The results are presented in a histogram that displays the distribution frequency of probable cost, accompanying this histogram is the cost percentile data table.

The data table illustrates the probability of project cost coming in at, or below cost threshold amounts from the 10th to the 90th percentile, with the 60th percentile being the measuring stick used by WSDOT.

The Output sheets for (CY) dollars and (YOE) dollars in the RBES workbook, allow the team to evaluate the Pre-Mitigated *or* Pre-Response strategy - Base project, for range and likelihood of probable cost.

Pre-Mitigated modeled results

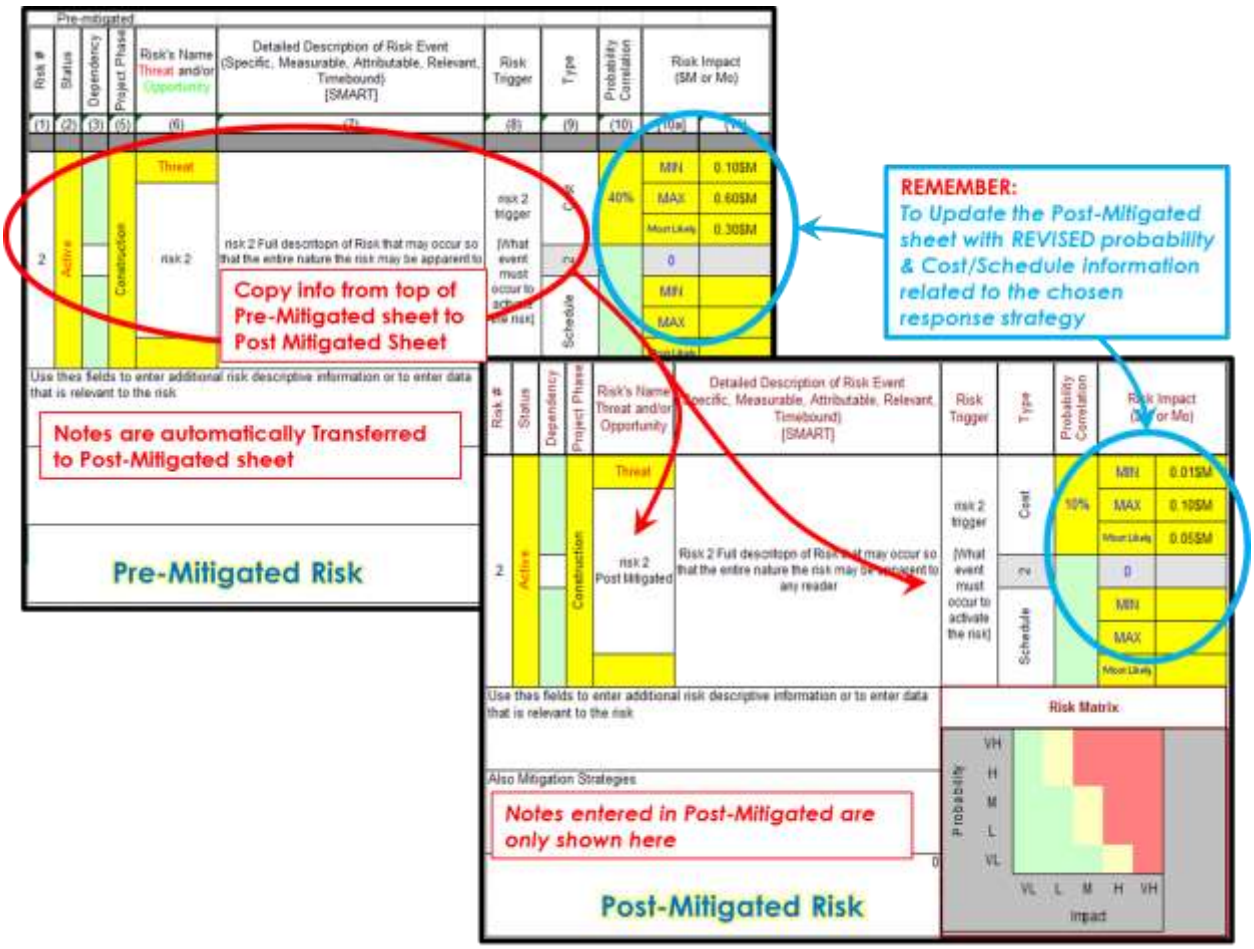



| Statistics | Pre-mitigated |
|---|---|
| Min | 25.49 $M |
| Max | 39.60 $M |
| Median | 32.12 $M |
| 10% | 29.42 $M |
| 20% | 30.36 $M |
| 30% | 31.02 $M |
| 40% | 31.58 $M |
| 50% | 32.12 $M |
| 60% | 32.69 $M |
| 70% | 33.29 $M |
| 80% | 33.99 $M |
| 90% | 34.94 $M |

# Modeling the Post-Mitigated Risk Data

Once the team has identified project risks and risk response strategies are developed to address individual risks, the Post-Mitigated information is entered into the Post-Mitigated (bottom half) of the worksheets.

The process is the same for entering data into the Post-Mitigated as for the Pre-Mitigated



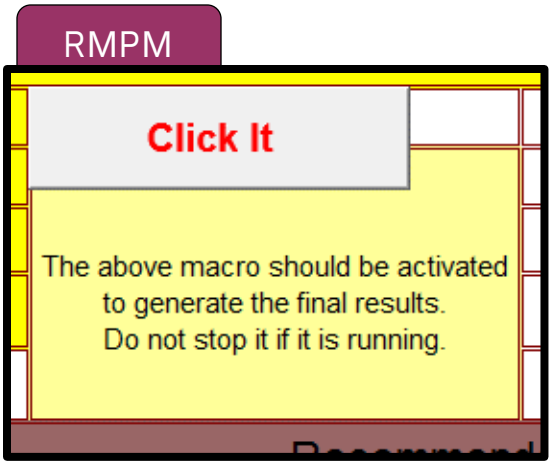
STEP 1

Use the POST-MITIGATED Upload button on the BASE sheet after all Risk information has been copied to the Post-Mitigated area.

Prior to uploading the Post-Mitigated Risk Matrix, verify that the Post-Mitigated Response strategy revised data for - Probability, Cost and Schedule information have been entered.

This step will copy all the base estimate costs and identified risk to the RMPM sheet.

Should more than 12 risks exist, the first 12 risks will be copied to the RMPM sheet and risks 13 thru 24 will be copied to the RMPSupplM



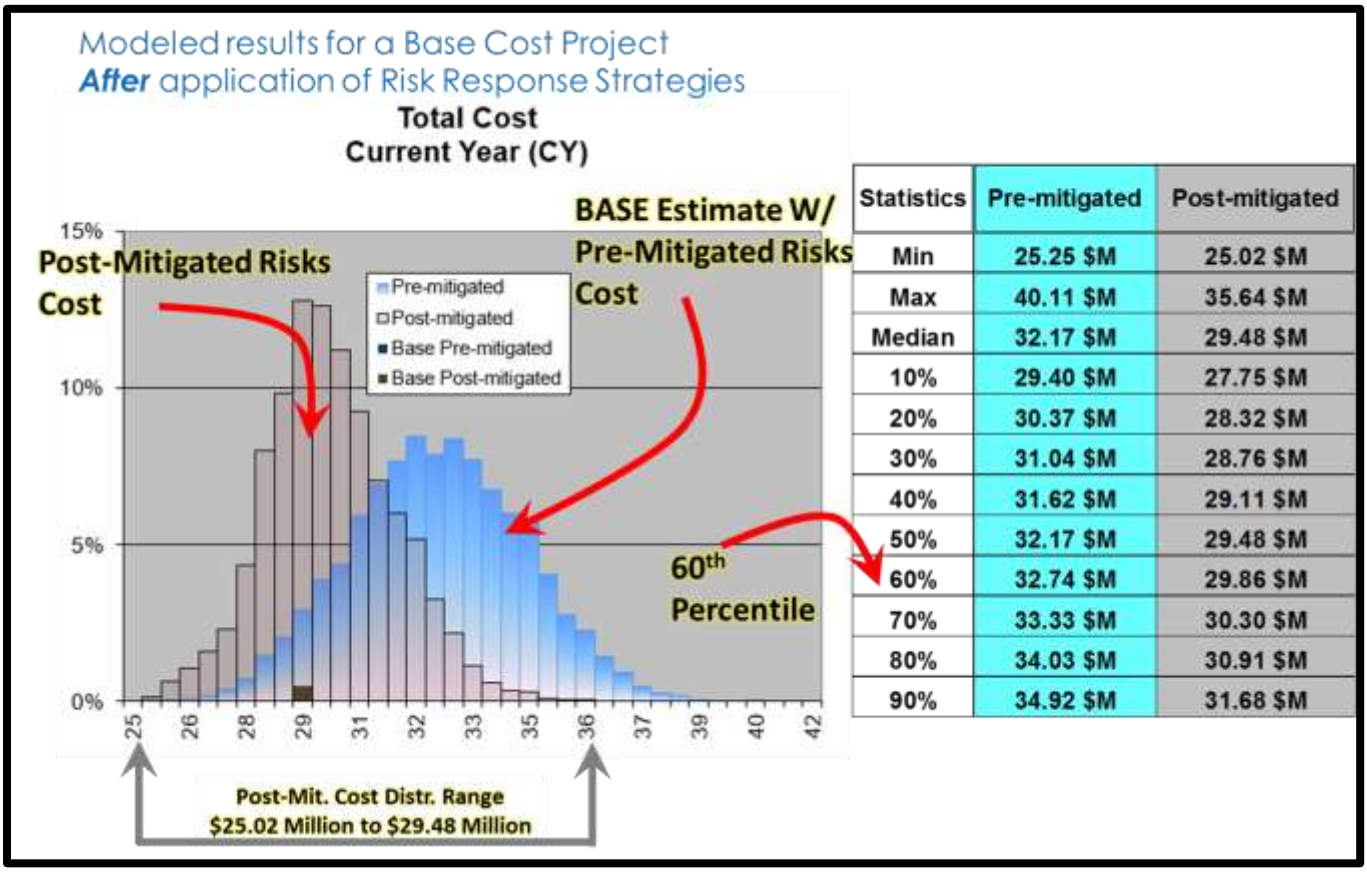

STEP 2

Go to the RMPM sheet and CLICK the "Click It" button.

This will initiate the Monte Carlo simulation on the data.

The generated results will be displayed on the Output sheets.

Post-Mitigated modeled results




| Statistics | Pre-mitigated | Post-mitigated |
|---|---|---|
| Min | 25.25 $M | 25.02 $M |
| Max | 40.11 $M | 35.64 $M |
| Median | 32.17 $M | 29.48 $M |
| 10% | 29.40 $M | 27.75 $M |
| 20% | 30.37 $M | 28.32 $M |
| 30% | 31.04 $M | 28.76 $M |
| 40% | 31.62 $M | 29.11 $M |
| 50% | 32.17 $M | 29.48 $M |
| 60% | 32.74 $M | 29.86 $M |
| 70% | 33.33 $M | 30.30 $M |
| 80% | 34.03 $M | 30.91 $M |
| 90% | 34.92 $M | 31.68 $M |

Post Mitigated results are added to each of the output sheets providing a side by side comparison with the BASE project. This comparison provides the team with information on Risk Response Strategy performance.

# Managing and Monitoring the Risks

The RMP & RMPSuppl (pre-mitigated) and RMPM & RMPMSuppl (post-mitigated) sheets are a risk register.
The risk register is a tool that the project team can use to address and document project risks throughout the project life. This living document is a list of risks and the approaches used to address each risk as part of the project risk management process.
The risk register is maintained as part of the project file that also includes information related to uncertainties in the cost estimate and schedule.

Why use a risk register?
The risk register communicates project risks and helps the team members understand the status of the risks as a project moves from initiation toward completion.

Project team members, conditions, and knowledge over the course of a project change and sustained communication among project team members about the project objectives, costs, risks, etc., is vital.

The risk register is a management tool. Project managers should continuously review and update processes to identify, assess, manage, and reduce risks to acceptable levels.

RBES Risk Register

The RMP sheets are easy to use and provide an effective way to summarize project risk management activities for projects that have conducted a quantitative risk analysis.
The spreadsheet is typically used for the most significant risks as determined by this analysis.

The RBES copies over information located in columns 1 thru 11 from each of the Risk sheets and information from the Base sheet. All the risks are laid out sequentially in this worksheet and columns 12 thru 21 have been added to allow the team to monitor and manage risks.

## Sections of the Risk Register

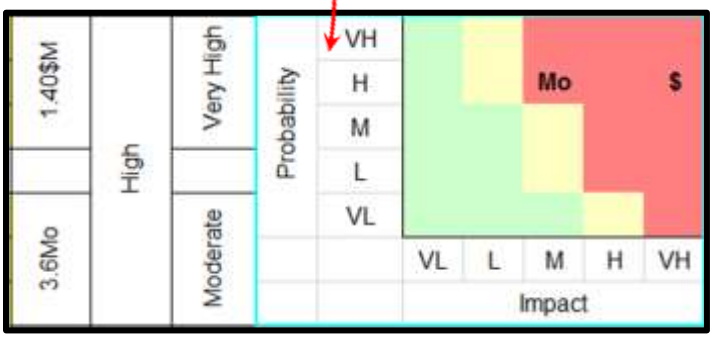
The top most fields of the risk register display figures for probable total cost of project in Current Year dollars, Year of Construction dollars, as well as the probable Ad and Construction end dates at the 50th thru 90th percentiles. These figures will automatically be updated when the model is re-ran to incorporate risk management actions.

Level of percentile for COST and DATE

| Risk Markups | | WSDOT inflation tables built-in. | | % | Total Cost CY [$M] | Total Cost YOE [$M] | Escalation rates update | Ad Date | ® | End Construction date | WSDOT Ovidiu Cretu 360-705-7599 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mob | 10.0% | A/B/A Duration | 3Mo | 50 | 32.17 | 34.29 | | May 14, 2020 | 50% | June 16, 2021 | |
| Tax | 5.0% | Non-WSDOT | Spent to date | 60 | 32.74 | 34.85 | | June 22, 2020 | 60% | July 25, 2021 | |
| CE | 2.0% | PE | | 70 | 33.33 | 35.47 | | August 4, 2020 | 70% | September 4, 2021 | |
| PE | 15.0% | ROW | | 80 | 34.03 | 36.18 | | September 15, 2020 | 80% | October 17, 2021 | |
| C.O.C | 4.0% | CN | | 90 | 34.92 | 37.10 | | October 26, 2020 | 90% | November 29, 2021 | |

If you know what you are doing. !!!!!!! Existing (Pre-Mitigated) Design!!!!!!!!!!Created and Maintained by WSDOT, contact Ovidiu Cretu 360-705-7599, cretuo@wsdot.wa.gov

| Qualitative Display of the Best Guess Impact | | | | Risk Response Plan | | Monitoring and Control | | | Critical Issue |
|---|---|---|---|---|---|---|---|---|---|
| Expected Impact ($M) | Probability (%) | Impact | Risk Matrix (Probability of Occurrence by Expected Impact) | Strategy | ACTION TO BE TAKEN Response Actions including advantages and disadvantages include date | Risk Owner | Risk Review Dates | Date, Status and Review Comments (Do not delete prior comments, therefore providing a history) | Is Risk on Critical Path? |
| (12) | (13) | (14) | (15) | (16) | (17) | (18) | (19) | (20) | (21) |
| 1.40$M / 3.6Mo | High | Very High / Moderate | Probability: VH, H, M, L, VL; Impact: VL, L, M, H, VH; Mo, $ | Mitigation | Finalize design to identify all wetlands that are impacted. Early coordination with the outside agencies to determine mitigation ratio. | Design Leader/Enviro. mgr | 2007-Jan-2 / 2006-Dec-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 | YES |




Impact & Probability

Columns 12 thru 15 display the probably and impact of the associated risk in dollars and time.

| | |
|---|---|
| Mitigation | Finalize design to identify all wetlands that are impacted. Early coordination with the outside agencies to determine mitigation ratio. |

Mitigation Strategy & Response Action Columns 16 & 17

Use the drop-down menu to select a risk response action as previously described; Mitigate, Avoid, Transfer or Accept. Should the risk be an opportunity, select the action that corresponds to the opportunity alternative.

Risk Owner | Milestone Date | Risk tracking comments & Critical Path - Columns 18 thru 21

(18) Enter the Risk Owner. This is the person with the authority and accountability to manage a particular risk.

| | | | |
|---|---|---|---|
| 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 | YES |

(19) Risk Review Dates and (20) Date, Status and Review

Enter the milestone dates to review activities have been or that are to be carried out for the associated risk.

It is important to review the effectivness of solutions implemented in order to determine whether treatment has been suitable, adequate, or effective in achieving established objectives.

It is also important identify new risks that may have occurred that impact the existing risk.

Enter comments about the risk actions that need to be, or have been performed in the management of the risk.

(21) Is Risk on the Critical Path?

Use the drop-down menu to select Yes or No to indicate whether or not this risk effects an activity that has impact on the critical path of the project schedule.

# Appendix 1 - Risk Breakdown Structure (RBS)

The Breakdown provides a way to organize risks in appropriate categories to allow for effective monitoring and management of the project risks.

It is not necessary to complete the RBS prior to conducting a risk workshop, however is provides a helpful starting point to begin the preliminary assessment of potential risks effecting the project.

For more information regarding the RBS, please see the Project Risk Management Guide Chapter 7-3.2 for additional details, Identifying Risk Events

RBS Categories

Potential project risk that may occur in the category

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

ENV 10.1 MMPA Concurrence

ENV 10.2 Section 4(f)

ENV 10.3 Late Change to project definition

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

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

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

example